

Biophysical and Ecological Overview of the Kitkatla Inlet Network Zones

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by

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ABSTRACT

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The Kitkatla Inlet Network Zones were identified as areas of ecological and cultural significance as part of the Northern Shelf Bioregion Marine Protected Area Network planning process (co-led by the Government of Canada, Province of British Columbia, and 15 First Nations). These Network Zones are situated in the nearshore North Coast region in the 'n luutiks laxyuubm Gitxaala (Gitxaala Sacred Hereditary Territories of the Gitxaala Nation). This Biophysical and Ecological Overview report compiles available knowledge and data on the physical and biological oceanography, projected climate changes, human uses, and ecological diversity of the four Network Zones. Network-level Ecological and Cultural Conservation Priorities within Kitkatla Inlet are highlighted throughout the report. Data presented in this report includes information gathered in the data compilation phase of the Northern Shelf Bioregion Marine Protected Area Network planning process, in addition to regionally-specific knowledge. Knowledge gaps, recommendations, and the sensitivities of ecological features and taxonomic groups are detailed throughout. This group of Network Zones encompasses an area characterized by a convoluted coastline of exposed coast, broken islands, inlet protected waters, and a highly productive marine ecosystem. It has complex bathymetry, seasonal flow patterns and a connected land-sea interface that have all contributed to important habitat for biodiverse ecological communities. Priority species and taxonomic groups of ecological and cultural importance in the Northern Shelf Bioregion found in these Network Zones include **Gadza k'aw**/eelgrass and kelp, **bilhaa**/abalone, **hats'al**/octopus, **tskah**/herring, **hoon**/salmon, groundfish, **ibuun**/whales, **üüla**/seal, **T'iibn**/Steller sea lions, marine birds, and others. The Gitxaala Nation's relationship with the marine environment is key to its sustainable harvest and use of marine resources in the Kitkatla Inlet Network Zones, which provide key food sources, and are part of the Gitxaala Nation's governance, trading and sharing economy, culture, and the retention of the Sm'algyax language. This report is intended to inform research, monitoring, policy, management, and subsequent steps in developing a proposed Marine Protected Area under Canada's *Oceans Act*.

RÉSUMÉ

Bannar-Martin, K.H., Vanderjagt, A., Bluteau, C.E., Liu, A.D., Hilborn, A., Proudfoot, B., Beaty, F., Denley, D., Stacey, C.D., Sastri, A., Herbert, J., and Rubidge, E. 2026. Biophysical and Ecological Overview of the Kitkatla Inlet Network Zones. Can. Tech. Rep. Fish. Aquat. Sci. 3668: xvii + 345 p. <https://doi.org/10.60825/2y44-vp69>

Dans le cadre du processus de planification du réseau d'aires marines protégées (AMP) de la biorégion du plateau Nord (dirigé conjointement par le gouvernement du Canada et la province de la Colombie-Britannique, ainsi que par 15 Premières Nations), on a déterminé que les zones de réseau du bras Kitkatla sont des zones d'importance écologique et culturelle. Ces zones de réseau sont situées dans la région littorale de la côte nord, dans les 'n łuutiks laxyuubm Gitxaala (territoires sacrés héréditaires de la Nation Gitxaala). 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 changements climatiques prévus, les activités humaines et la diversité écologique au sein des quatre zones du réseau. Les priorités en matière de conservation écologique et culturelle du réseau à l'intérieur du bras Kitkatla sont mises en lumière tout au long de ce rapport. Les données présentées dans ce rapport comprennent des renseignements recueillis dans le cadre de la phase de compilation des données du processus de planification du réseau d'aires marines protégées de la biorégion du plateau Nord, ainsi que des connaissances spécifiques à la région. Les lacunes dans les connaissances, les recommandations, ainsi que la sensibilité des caractéristiques écologiques et des groupes taxonomiques sont présentées de façon détaillée. Ce groupe de zones de réseau englobe une zone caractérisée par un littoral alambiqué de côtes exposées, des îles brisées, des eaux protégées des bras de mer et un écosystème marin hautement productif. Il présente une bathymétrie complexe, des schémas de débits saisonniers et une zone de contact entre la terre et la mer qui ont tous contribué à la création d'un habitat important pour des communautés écologiques biodiversifiées. Les espèces prioritaires et les groupes taxonomiques d'importance écologique et culturelle dans la biorégion du plateau Nord trouvés dans ces zones du réseau sont notamment les suivants : **Gadza k'aw**/zostère et varech, **bilhaa**/ormeaux, **hats'al**/pieuvres, **tskah**/harengs, **hoon**/saumons, poissons de fond, **łbuun**/baleines, **üüla**/phoques, **T'iibn**/otaries de Steller, oiseaux marins et autres. La relation de la Nation Gitxaala avec l'environnement marin est essentielle à la récolte et à l'utilisation durables des ressources marines dans les zones de réseau du bras Kitkatla, qui constituent des sources alimentaires essentielles et font partie de la gouvernance, de l'économie de commerce et de partage, de la culture et de la conservation de la langue Sm'algyax de la Nation. Le présent rapport vise à orienter la recherche, la surveillance, les politiques, la gestion et les étapes subséquentes pour l'élaboration d'une zone de protection marine proposée en vertu de la *Loi sur les océans du Canada*.

1 PREFACE

As Fisheries and Oceans Canada (DFO) undertakes the development of the Marine Protected Area (MPA) Network in partnership with the Province of British Columbia and 17 First Nations, and more specifically, the Kitkatla Inlet Network Zones and subsequent Biophysical and Ecological Overview Report, it is important for the DFO and external audiences to be aware of Gitxaala Nation's inherent jurisdiction and authority within which this work is situated.

The development of the Marine Protected Areas Network is occurring within **Laxyuubm Gitxaala** (the Gitxaala Traditional Territories), which are located along the northwest coast of what is referred to as British Columbia (**Figure 1**). These **Laxyuubm Gitxaala** include the air, land and water – including fresh water, salt water, and water covered lands such as seabed (Nees Hiwaas Aff. ¶ 6, October 21, 2021).

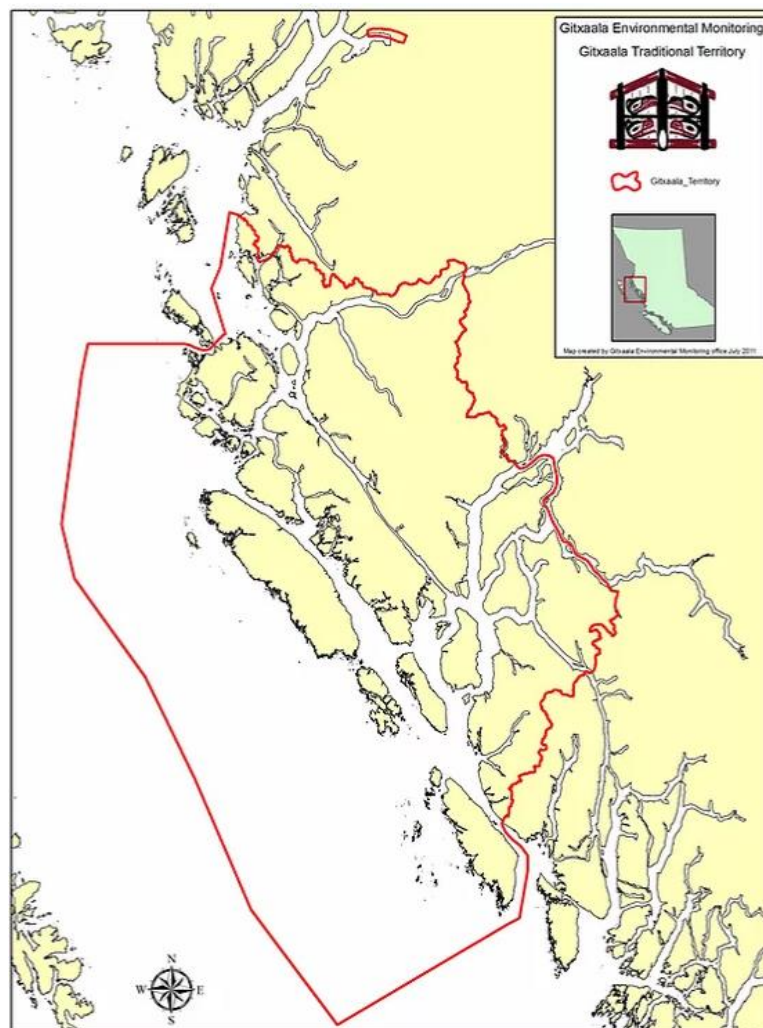


Figure 1. Laxyuubm Gitxaala (Gitxaala Territory) Map. The Gitxaala Nation claims the lands, waters and resources within the boundary marked in red.

Gitxaala Nation has governed the Laxyuubm Gitxaala for thousands of years and have maintained exclusive jurisdiction and occupation through the authority of the **smgyigyey** (chiefs)

under the **ayaawx** (Gitxaala law) (Nees Hiwaas Aff. ¶ 7, October 21, 2021). This system is intact and robust despite colonial impositions through the assertion of Crown Sovereignty and through imposition of the *Indian Act* (Nees Hiwaas Aff. ¶ 8, October 21, 2021).

Gitxaala Nation's political structure is a location-based, hereditary system with descent reckoned through the maternal line (Conacher et al. 2021). This means that territories, names, titles, ceremonies, resource use knowledge, are generally (although not exclusively) traced through the mother, her brother, and their maternal ancestors and members are encouraged to marry exogamously, or outside of their clan (Halpin and Seguin 1990). Although the Nation collectively refers to itself as 'Gitxaala,' within this collective there are also clan and house systems. Each of these structures of authority, namely, the clans and houses, have autonomy and separate decision-making power (Conacher et al. 2011). Gitxaala traditional governance has four clans: the **Gisbutwada** (killer whale), the **Lax Sgyiik** (eagle), the **Lax Gyibu** (wolf) and the **Ganhada** (raven) clan (Conacher et al. 2011). Within these clans there are 23 houses that are led, depending on their rank or status, by either a **sm'ooygit** (house chief) if the house is of appropriate status, or a "councillor" in some cases. In the past, the highest-ranking house's leader was understood to be the ranking Gitxaala chief and the other house leaders were ranked in descending order below him, irrespective of the clan (Menzies and Butler 2007). Gitxaala Nation traditional governance has a Hereditary Table which consists of the **smgyigyeyet** and other high-ranking men and women of Gitxaala houses and this ranking Gitxaala chief. Currently, this is blended with the colonial governance system of an elected council under the *Indian Act* which are responsible for reserve land base and on-reserve services (Nees Hiwaas Aff. ¶ 10, October 21, 2021). The Gitxaala traditional governance system includes many facets including **gugwilx'ya'ansk** (the process, structure and tradition of passing names and territory to future generations), **ayaawx** (Gitxaala laws), **adaawx** (storytelling), feasting, and resource management principles, a traditional economy (including sharing and trade) (Conacher et al. 2021).

While **ayaawx** guides the governance of Gitxaala Nation in this hereditary system, it also expresses Gitxaala's relationship with **naxnanox** (plural or **naxnox** which means spiritual being or nature spirit) and their **spanaxnanox** (plural of **spanaxnox** which means a **naxnox** den or territory) (Nees Hiwaas Aff. ¶ 28, October 21, 2021). All living things in Laxyuubm Gitxaala have their own **naxnox** and Gitxaala ancestors learned their values and beliefs through experiences they had with **naxnanox** which have formed the protocols and harvesting practices Gitxaala follows. These **naxnox** are also the source of hereditary names and hereditary crests. These **naxnanox** must be treated with the greatest respect and reverence (Nees Hiwaas Aff. ¶ 28, October 21, 2021).

Biophysical and ecological aspects of the environment are important to Gitxaala, not just for subsistence purposes, but also as aspects of this intact governance structure. Disturbance of, or interference with, resources or sites within the Laxyuubm Gitxaala can lead to potential impacts to Gitxaala rights, cultural identity, and overall well-being (Conacher et al. 2021).

While harvesting of these biological components are a regular and everyday part of the Gitxaala way of life, they are nonetheless comprised of a highly complex set of rules and protocols that govern seasonality, resource management, and personal & collective responsibilities (Conacher et al. 2021). These protocols have evolved over generations, and the sharing of such knowledge and guidelines are a critical component of Gitxaala cultural transmission and teachings (Conacher et al. 2021). Gitxaala have laws that inform how and when they harvest the resources in their territory. This **ayaawx** is passed down through generations and provide the basis for how Gitxaala sustain and manage resources (Butler 2010).

Gitxaala harvesters have principles that regulate the biophysical and ecological aspects of the Laxyuubm Gitxaala including seasonal timing windows, traditional practices, and ways of being and knowing. For example, in relation to **bilhaa**/abalone, Gitxaala only gather **bilhaa** when the **aks**/tide is down; further, they only harvest to the edge of the **aks**, thus ensuring that there are more **bilhaa** in future years. This varies from western approaches where divers typically strip the kelp off the rock resulting in impacts to the **bilhaa** population. This western approach is contrary to Gitxaala **ayaawx** (Conacher et al. 2021).

Overall, an understanding and acknowledgement of Gitxaala governance and resource management principles must be interwoven into the development of the Marine Protected Areas and this Biophysical and Ecological overview to ensure Gitxaala's Indigenous Knowledge and western knowledge are presented alongside one another. This is of crucial importance as activities that do not follow Gitxaala **ayaawx**, threaten the relationship between Gitxaala and **naxnanox**, which can result in a withdrawal of resources by the **naxnanox** (Nees Hiwaas Aff. ¶ 33, October 21, 2021). By ensuring this understanding and acknowledgement, these processes can ensure a holistic view of the **Laxyuubm Gitxaala**, **ayaawx**, and allow for representative management of the Kitkatla Inlet Network Zones. Initial steps toward developing understanding and promoting acknowledgement include the ongoing involvement of Gitxaala Nation in the MPA process and collaboration on the development of this Biophysical and Ecological Overview Report.

1.1 Use of Sm'algyax and Gitxaala Knowledge

This document contains names of places and species in the Sm'algyax language, highlighted in **green text** from now on, and in English (terms are separated by a forward slash).¹ Sm'algyax words referenced in this report and their source are listed in **Appendix A Table 1**. The lack of a Sm'algyax word should not be interpreted to mean that the word does not exist. Similarly, the use of English equivalents for Sm'algyax terms should not be taken as direct translations as, in many cases, the associated English term is only a rough approximation since the English language does not have equivalent terms. For example, the term **sm'ooygit** (plr. smgyigyet) does not directly translate to the English term "chief", but there is no direct English term that captures that nature and being of the Sm'algyax term, so the rough approximation of "chief" is used as this document is not meant to be a language reference of Sm'algyax. The Gitxaala Nation Culture & Language Department is currently developing a "Gitxaala First Voices" website and a community language archive. This, in addition to other Sm'algyax-based initiatives are working to preserve and expand Sm'algyax use, retention and expansion ([Gitxaala Nation Website 2023](#)). Incorporation of Sm'algyax and any other traditional languages in this document is ongoing and flexible to change.

All unreferenced information from Gitxaala Harvesters/land users are personal observations housed within the Gitxaala Nation GIS database. This database includes numerous spatialized references per species/personal observation collected from multiple harvesters for multiple regulatory projects. The database is housed by Gitxaala Territorial Management Agency and contributes to various Gitxaala Use Reports. It is cited throughout this paper as Gitxaala Nation GIS database. This database is not open to the public and any information requests regarding it must be directed to the Gitxaala Territorial Management Agency, 280-110 1st Street West, Prince Rupert, BC, V8J 3S1, (P) 250-624-3339. Furthermore, specific locations for species

¹ Note the first time the Sm'algyax term is used in a paragraph the equivalent English term will be provided, after that only the Sm'algyax term will be used in the same paragraph.

occurrences or Gitxaala observations are available, but have not been reported here to protect community sensitive information. Please contact the Gitxaala Territorial Managements Agency if more detailed information is needed.

Indigenous knowledge presented in this report should not be considered complete and only represents a limited 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 Gitxaala Nation.

2 REGIONAL CONTEXT

2.1 History of Marine Planning in Kitkatla Inlet and the Northern Shelf Bioregion

Gitxaala **adaawx**/oral history teach that **Git lax m'oon** or Gitxaala, People of the Saltwater, are the original coastal people of the northwest coast. The Gitxaala's ancestry and occupation of their territory predates the time of a "great flood". The Gitxaala Nation territorial lands and waters stretch from **Kxeen**/Prince Rupert Harbour, south to Aristazabal Island including **Tgii Xsw'aanx**/Porcher Island, **Lax k'naga dzol**/Banks Island, McCauley Island, Pitt Island, the western side of Campania Island, portions of the mainland adjacent to Grenville Channel and the surrounding waterways and an **ha'limootk**/oolichan fishing station on the Nass River (**Figure 1**) (Conacher 2016). Laxyuubm Gitxaala include air, lands and waters, including all fresh and salt water and water-covered lands such as seabed (Nees Hiwaas Aff. ¶ 6, October 21, 2021). "Contemporary Lach Klan, the home village of Gitxaala, has been continuously occupied for millennia, over ten thousand years according to oral tradition, at least five thousand according to science" (Menzies 2016). The Gitxaala Nation's main village is **Lach Klan**, located on Dolphin Island. Geographically, the Kitkatla Inlet area is located in the North Coast regional district of mainland British Columbia (BC) in the Pacific Region of Canada and includes the north end of **Lax k'naga dzol**, and the area north of McCauley Island up to **Tgii Xsw'aanx**. The area is geographically heterogeneous and made up of sheltered inlets and passages and exposed coastlines. It is an area of significant cultural and ecological importance, and the Gitxaala Nation provided and continue to provide stewardship for the sustainability and long-term resource use of their terrestrial and marine environment. This flows from the jurisdiction and occupation of the Laxyuubm Gitxaala through the authority of Gitxaala **smgyigyet**/chiefs under the **ayaawx**/Gitxaala laws (Nees Hiwaas Aff. ¶ 7, October 21, 2021).

The Gitxaala Nation 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 Nation specific 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)², the Gitxaala Nation, the Province of British Columbia, 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"². As a signatory of

² [Reconciliation Framework Agreement for Bioregional Oceans Management and Protection](#)

the Convention on Biological Diversity (CBD)³, Canada has committed to safeguarding biodiversity through “...equitably managed, ecologically representative and well-connected systems of protected areas...”³, and planning processes are underway in [five priority marine bioregions](#).

The Northern Shelf Bioregion (NSB) (**Figure 2**) is one of five priority bioregions identified to develop MPA networks and includes the Kitkatla Inlet area. The NSB is the largest bioregion in BC, extending from the northern end of Vancouver Island, including an area of 102,000 km², from Quadra Island and Bute Inlet, northward to the border of Alaska, United States. The NSB has been the focus of multiple marine planning initiatives over the past several years, including 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 process⁴ (MPA Network BC Northern Shelf Initiative 2023). The NSB MPA Network planning process has a tripartite governance structure, co-led with 17 partner First Nations, the Government of Canada, and the Province of BC. The following section describes the region's past and ongoing planning processes and the participating members.

³ Convention on Biological Diversity (CBD). 2011. Strategic plan for biodiversity 2011-2020. IUNEP/CBD/COP/10/INF/12/Rev.1.

⁴ [MPA Network – Network Action Plan](#)

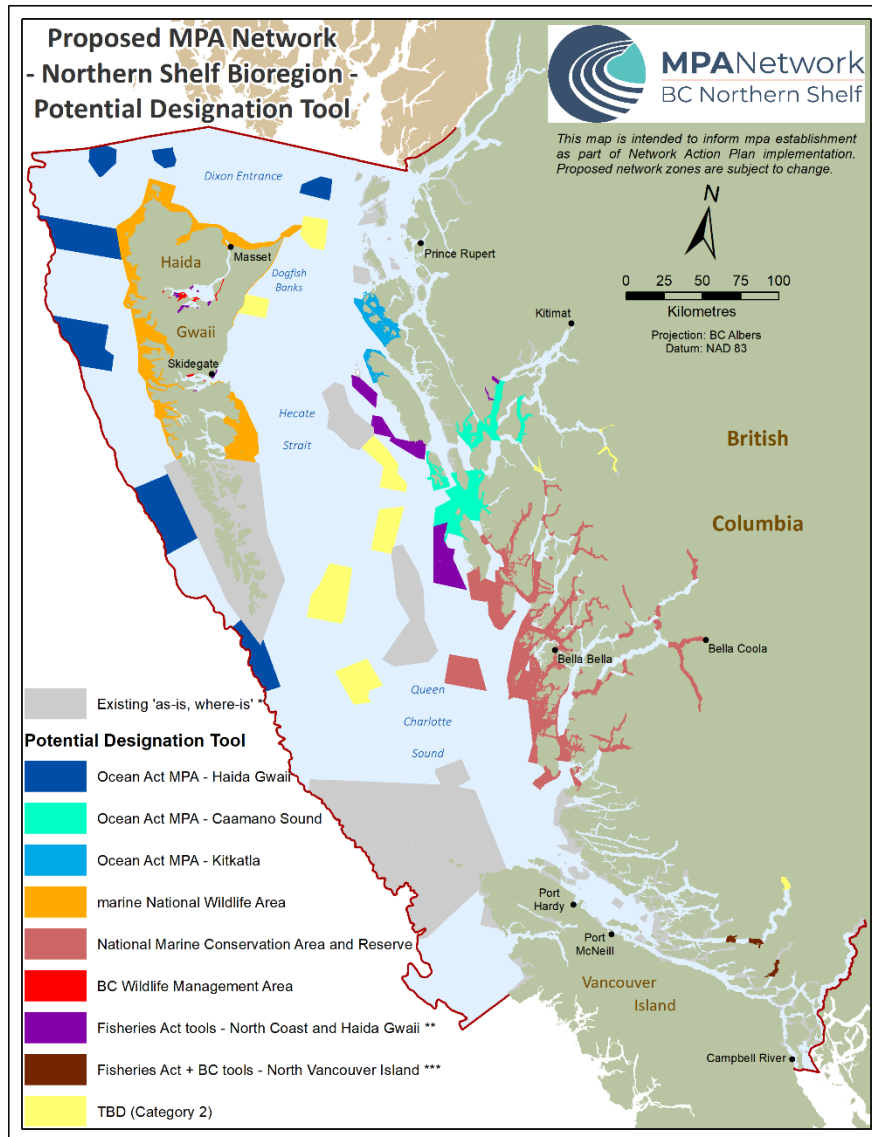


Figure 2. The proposed Marine Protected Area Network of Zones in the Northern Shelf Bioregion (red outline). The four polygons that comprise the Kitkatla Inlet Network Zones are shown in light blue and are proposed to become an Oceans Act MPA.

The NSB shares boundaries with the PNCIMA, one of the five national Large Ocean Management Areas in Canada's 2005 Oceans Action Plan (DFO 2005). 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). MPA network planning was identified as one of five short-term implementation priorities. 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 – Great Bear Initiative⁵, North Coast - Skeena First Nations Stewardship Society⁶) in 2017.

Building on the previous work, the MaPP process was launched in 2011. This partnership involves 17 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 2**). It encompasses many unique ecosystems and oceanographic features of the NSB, from significant upwelling and tidal mixing areas to estuaries and fjord inlets, and includes Kitkatla Inlet. The North Coast Marine Plan (MaPP 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 (Lausche 2011) as high protection (IUCN Ib and II) or medium protection (IUCN IV), or existing protection (MaPP 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 (Government of Canada 2011) guided the network planning process which began in 2015 (Figure 3). 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. The areas proposed for the MPA Network were identified based on the MPA Network goals and objectives, ecologically important species, habitats, and features (Gale et al. 2019), cultural conservation priorities⁷, 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

⁵ Including the Council of the Haida Nation, Skidegate, Old Massett, Metlakatla, Heiltsuk, Nuxalk, Gitga'at, Kitasoo/Xai'xais, and Wuikinuxv First Nations.

⁶ Including the Gitxaala Nation, Gitga'at Nation, Kitsumkalum Nation, and Kitselas Nation.

⁷ 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].

Shelf Initiative 2023). The draft MPA Network footprint is 30,493 km² (around 30% of the NSB), of which 38% is new proposed MPAs, and the remaining 62% is made up of existing MPAs and PMZs, as well as existing rockfish conservation areas (RCAs; Yamanaka and Logan 2010), which are long-term fisheries closures. On February 5th 2023, 15 First Nations, the federal, and provincial governments officially endorsed the Network Action Plan for the NSB. Altogether, the MPA Network aims to preserve species, habitats, and cultural areas of importance, provide access to social activities, and sustainably provide and manage economic opportunities.

In the Network Action Plan (MPA Network BC Northern Shelf Initiative 2023), MPATT identified and proposed three aggregates of Network Zones to be designated as MPAs under Canada's *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 Kitlatla Inlet Network Zones, the subject of this report (**Figure 2**). All three aggregates are Category 1 Zones proposed to have MPA designation by 2025 (MPA Network BC Northern Shelf Initiative 2023). 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 management⁸. This Biophysical Overview Report is part of the second step, feasibility assessment and policy development, and provides a foundation for subsequent planning (see Report Organization and Content Considerations). In November 2022, the Offshore Haida Gwaii Network Zones Biophysical Overview Canadian Science Advisory Secretariat (CSAS) Regional Peer Review Meeting occurred. In April 2023 a peer review workshop for the Biophysical and Ecological Overview of the Caamaño Sound and Douglas Fjord System Network Zones report occurred. Species and habitat information, spatial datasets, and area descriptions from both processes 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 so much 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 3**). Because the Network Zones discussed here result from the NSB regional network planning process described earlier, these Zones have already been integrated into a Network Action Plan (MPA Network BC Northern Shelf Initiative 2023). Therefore, conservation objectives, ecological conservation priorities (E-CPs), cultural conservation priorities (C-CPs²), 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. This report for the Kitkatla Inlet Network Zones will provide information that may assist in identifying and/or refining conservation objectives and help inform the development of a management plan and subsequent advice on monitoring.

⁸ [Establishing new Marine Protected Areas \(dfo-mpo.gc.ca\)](https://dfo-mpo.gc.ca)

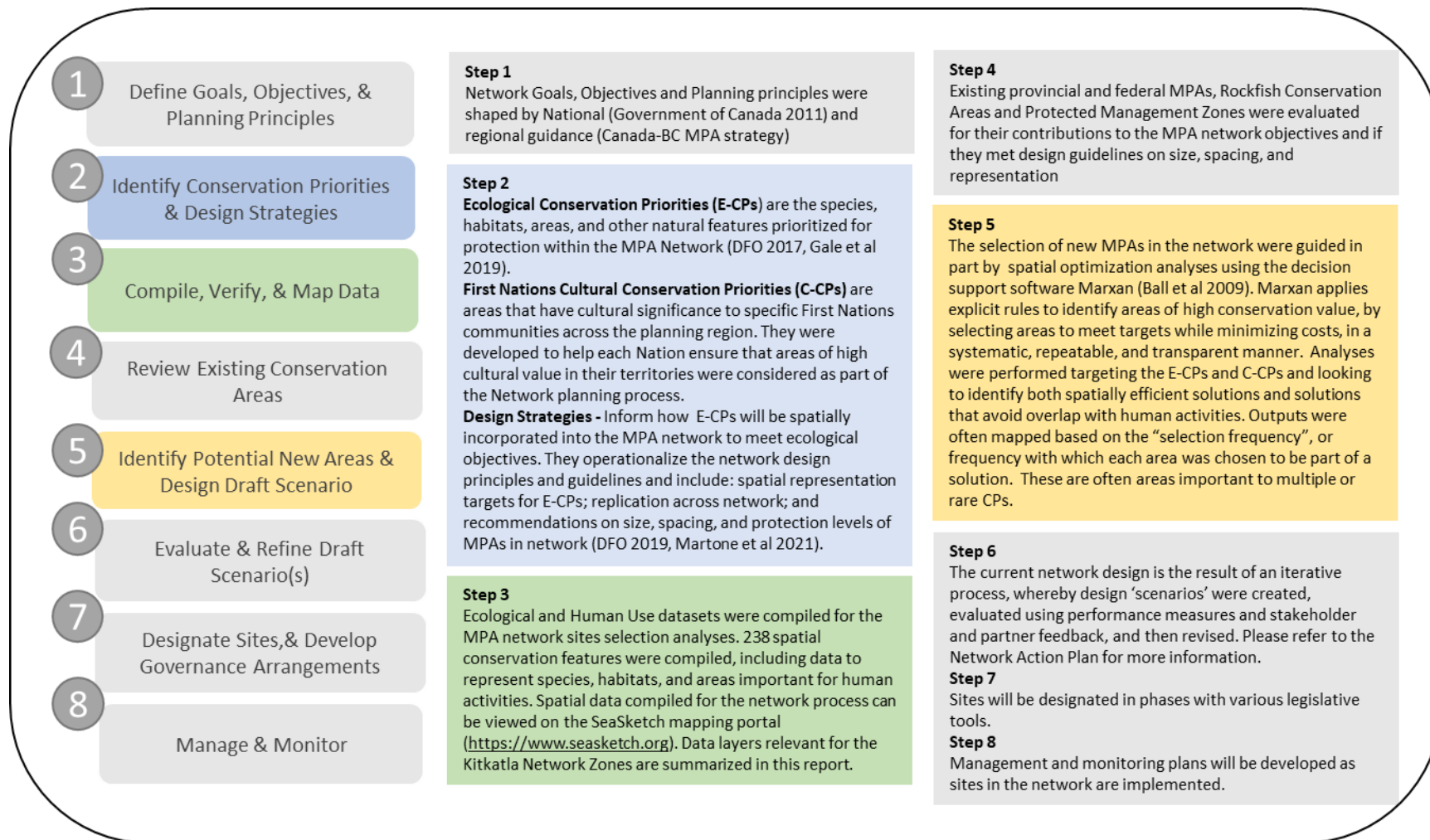


Figure 3. Summary of steps in the Northern Shelf Bioregion (NSB) Marine Protected Area (MPA) Network planning process. Coloured boxes are particularly relevant for this report, including defining key terminology of the network process. For more information on each step refer to publications within the [NSB MPA Network website](#). Edited from Figure 2 of Bannar-Martin et al. (2025).

2.2 Kitkatla Inlet Network Zones

The Kitkatla Inlet Network Zones (previously referred to as the Kitkatla Inlet; MPA Network BC Northern Shelf Initiative 2023) are one of three NSB MPA aggregate network areas proposed for implementation under the federal *Oceans Act*. The region is represented as four Zones (numbered 330 through 333, **Figure 4**; **Table 1**) that contribute to the overall ecological, cultural, social, and economic objectives of the entire MPA Network (**Figure 2**). Potential Network Zones were identified by the Marine Protected Area Technical Team (MPATT) as part of the draft MPA Network scenario during the summer of 2021 (MPA Network BC Northern Shelf Initiative 2023). For full details on the determinants of each Zone's boundary refer to **Appendix D**.

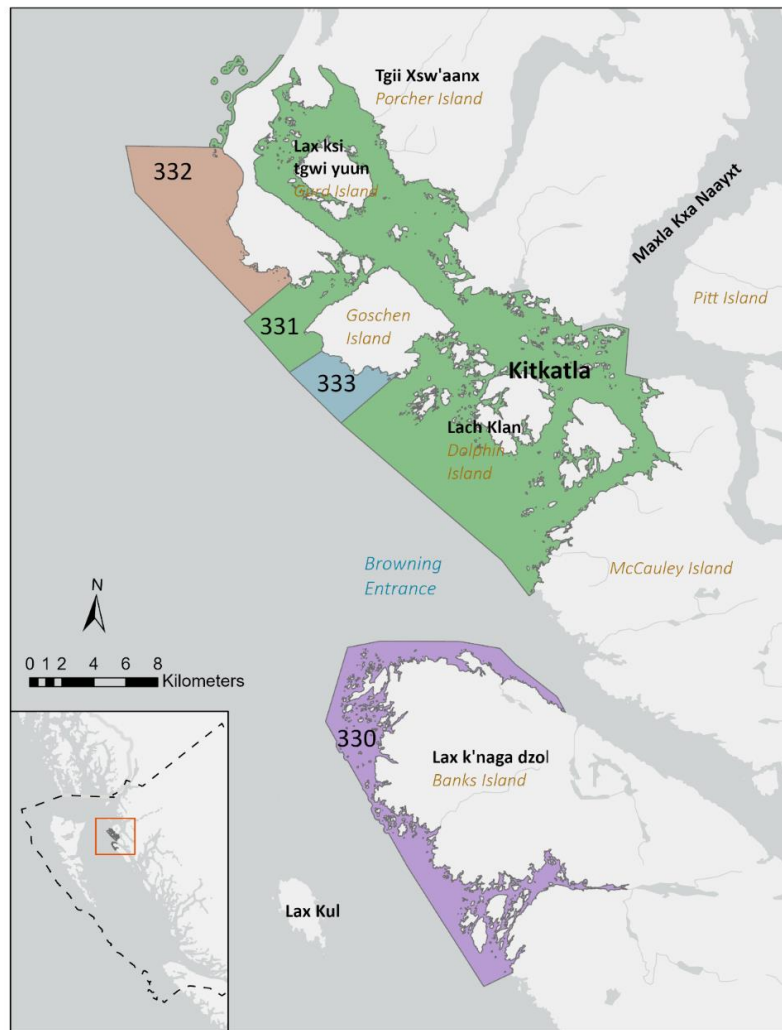


Figure 4. The four Kitkatla Inlet Network Zones (coloured polygons). The inset map shows the area in the Northern Shelf Bioregion (dotted line), British Columbia. Gitxaala place names are provided where possible in bold black text. English settler names are provided in italicized coloured text. Please note that Zone numbers and names are described for this report and are subject to change in later discussions of the proposed marine protected area process. See **Table 2** and **Figure 5** for more details on each zone.

Table 1. Kitkatla Inlet Network Zones and area (km²) listed according to the Network Action Plan designated Network Zone numbers. Overlapping existing protected areas (see **Figure 6** and **Figure 7**) correspond to each of the four Network Zones. Please note that Zone numbers and names are subject to change in later discussions of the proposed marine protected area process.

Zone Number	Total Zone Area (km ²)	Overlap with existing protected areas
330	69.01	Banks Nii Luutiksm Conservancy (marine) is contained within this zone
331	270.19	Gitxaala Nii Luutiksm/Kitkatla Conservancy (marine) overlaps a portion of this zone
332	47.04	Gitxaala Nii Luutiksm/Kitkatla Conservancy (marine) overlaps a portion of this zone Porcher Peninsula RCA overlaps the entire zone.
333	14.16	Gitxaala Nii Luutiksm/Kitkatla Conservancy (marine) overlaps a portion of this zone Goschen RCA overlaps this entire zone

The zones in this group stretch from the top of MacAuley Island to the western coast of the Porcher Peninsula, including Kitkatla Inlet, and the islands and marine areas surrounding the village of **Lach Klan**/Kitkatla on Dolphin Island (**Figure 5**). It also includes the northwest coast of **Lax k'naga dzol**/Banks Island. Increased productivity from coastal upwelling and tidal mixing in these four Kitkatla Inlet 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, which all contributed to the selection of Zone boundaries. The Kitkatla Inlet Network Zones area supports many species of conservation concern and species with at-risk status; as well as species of importance to Gitxaala Nation. The area includes a variety of habitats and both exposed and sheltered shorelines, which are important to **bilhaa**/Northern abalone, **tskah**/herring, Pacific sand lance, and **hoon**/salmon, etc. The northern and western marine coastline of **Lax k'naga dzol** promotes extensive canopy-forming **gyoós**/giant kelp and **Mo'ox**/bull kelp stands and provides important habitat for a diversity of marine fish and invertebrates. This area is of critical importance to the Gitxaala Nation. Because of the cultural importance of a broad suite of species, overall biodiversity in the area and the interest in dynamically and sustainably managing species in these zones, the cultural conservation objectives identify multiple species within these zones that are of consequence to the Gitxaala Nation. The ecological conservation objectives focus on those habitats and habitat features to be protected in the potential MPA.

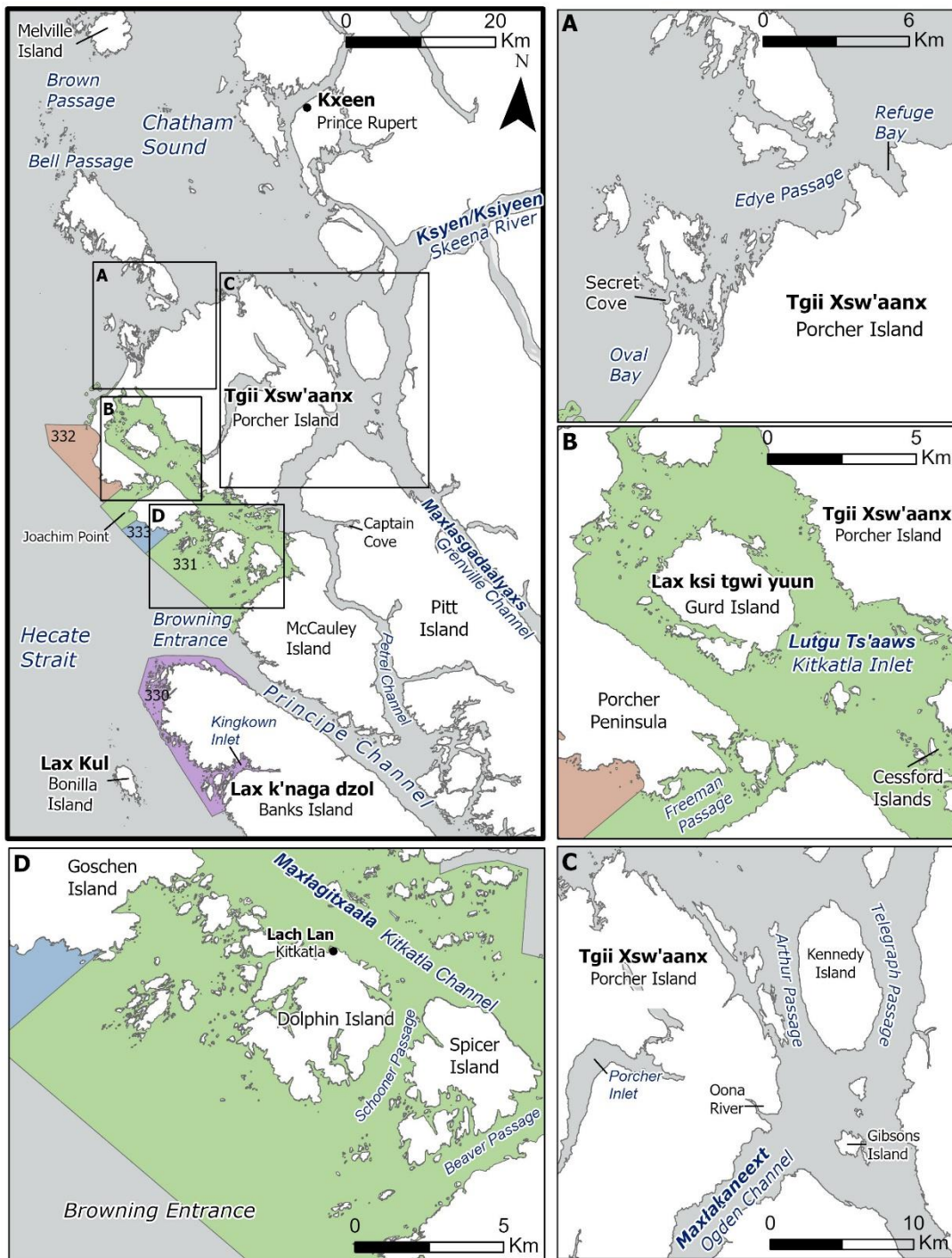


Figure 5. Names and locations of geographic features in and around the Kitkatla Inlet Network Zones. This figure is for georeferencing geographic locations throughout the report and will be cited often. This is not an exhaustive visual depiction of features or their naming.

The boundaries of the Kitkatla Inlet Network Zones were in part chosen because of other nearby conservation areas that have also been identified in the MPA Network (**Table 1; Figure 6**), overlap with North Coast Marine Plan (MaPP) Protection Management Zones (**Table 2**), and overlap with EBSAs (**Figure 6**). Zone 330 has significant overlap with North **Lax k'naga dzol**/Banks Island (PMZ-13, IUCN Type IV), seeking to protect marine species, intertidal habitat, and archaeological sites in an important First Nations harvest area. The area also contains the entire marine portion of the Banks Nii Luutiksm Conservancy and is adjacent to the terrestrial Banks Nii Luutiksm conservancy, providing opportunity to enhance protection in these areas (**Figure 6B**). Zone 331 has significant overlap with Browning Entrance/Dolphin Island (PMZ-28, IUCN Type Ib), seeking to protect marine biodiversity and culturally important species adjacent to First Nations communities. The area also contains the majority of the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy and is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy. Zone 332 contains part of the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy and is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy. Additionally, the entirety of the zone overlaps with the Porcher Peninsula RCA (**Figure 6A**), providing another opportunity to enhance existing protection. Zone 333 contains part of the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy and is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy (**Figure 6B**). The entirety of the zone also overlaps with the Goschen RCA (**Figure 6A**). The three zones in Kitkatla Inlet (331-333) overlap with the Chatham Sound Ecologically and Biologically Significant Area (EBSAs; Clarke and Jamieson 2006; Rubidge et al. 2018, 2020), and Zone 330 overlaps with the Central Mainland EBSA (**Figure 6A**). As such, the zones build off nearby conservation efforts to extend protection into intertidal areas and the terrestrial/marine interface.

Table 2. Kitkatla Inlet Network Zones associated Protection Management Zone (PMZ) zone descriptions. See **Figure 6A** for locations on map.

Zone Number	Overlap with existing Protection Management Zones
330	Significant overlap with an existing North Coast Marine Plan (MaPP) Protection Management Zone: • North Lax k'naga dzol/Banks Island (PMZ-13, IUCN Type IV) – ○ Area description: North Lax k'naga dzol/Banks Island PMZ includes an area important to the Gitxaala First Nation for harvest of intertidal marine resources, as well as cultural education. The area has a long history of use Gitxaala Nation, and continues to make a significant contribution to the economy of Gitxaala. Several archaeological sites are registered (17), including fish traps, fish weirs, and historical fishing camps. Extensive canopy-forming gyoós/giant kelp and Mo'ox/bull kelp stands occur in the northern and western marine coastline of Lax k'naga dzol/Banks Island, and provide important habitat for a diversity of marine fish and invertebrates. Other natural features include small estuaries, and seabird and shorebird feeding and moulting areas. There are high tourism values in the area, with nine identified marine campsites and a number of scenic, sheltered inlets suitable for anchoring. ○ Objective: To protect marine species, intertidal habitat and archaeological sites in an ancient and contemporary First Nations harvest area.
331	Significant overlap with an existing North Coast Marine Plan (MaPP) Protection Management Zone: • Browning Entrance/Dolphin Island (PMZ-28, IUCN Type Ib) – ○ Area description: This PMZ surrounds the Kitkatla/Gitxaala community, whose members use the marine waters daily to harvest more than 30 marine species, including la'ask/seaweed, bilhaa/abalone, hoon /salmon, txaw/halibut, seal, and hats'al/octopus, etc. The marine ecosystem is highly productive and includes provincially significant seabird and shorebird habitat. The PMZ includes significant Gitxaala Nation cultural area and harvesting sites, including six RAAD identified archaeological sites. The PMZ is adjacent to a federal Rockfish Conservation Area. ○ Objective: To protect marine biodiversity and culturally important species and abundances. To protect marine areas adjacent to First Nations communities to support cultural and traditional harvest values.
332	Porcher Peninsula - No overlap with MaPP PMZ
333	Goschen Island - No overlap with MaPP PMZ

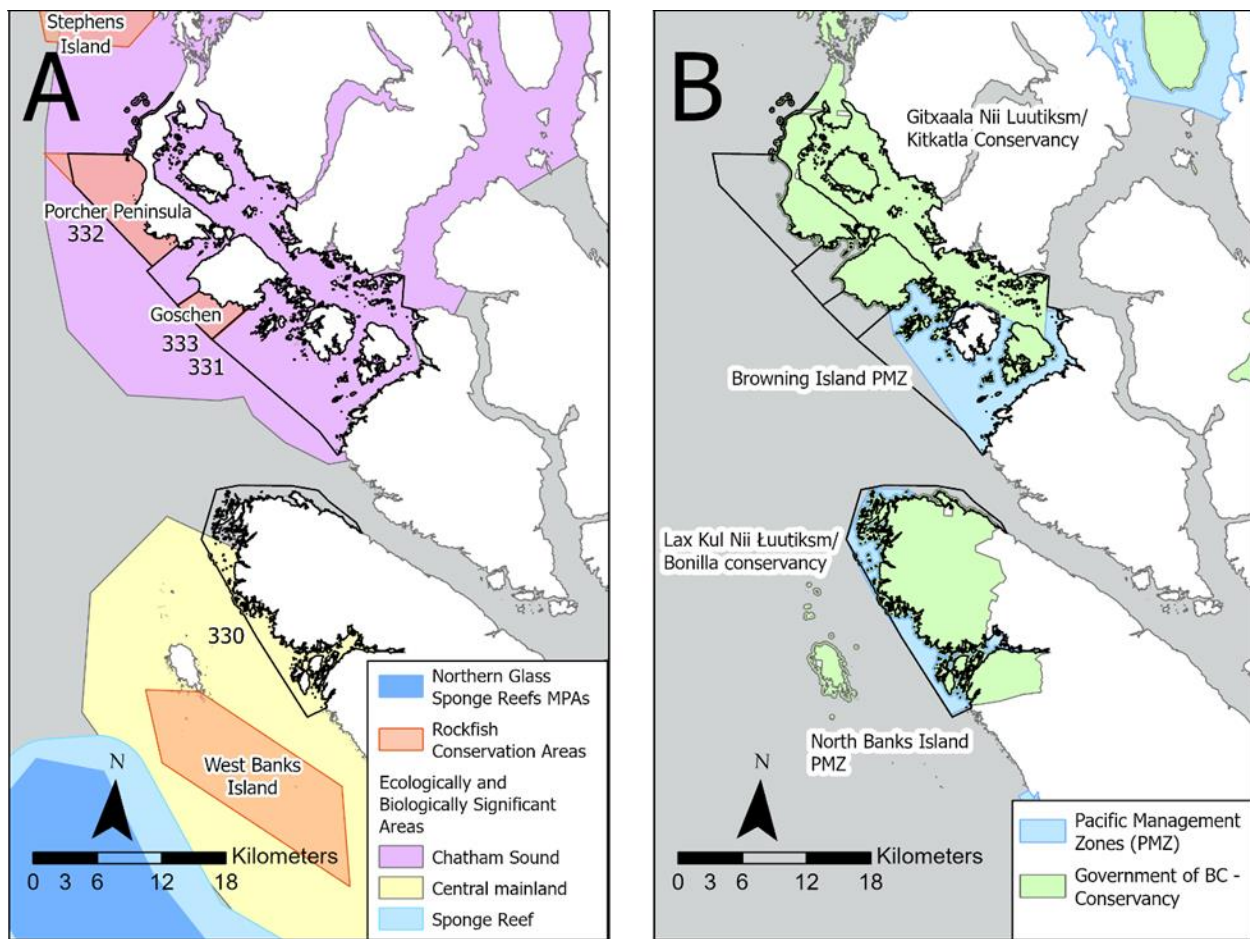


Figure 6. Nearby and overlapping important spatial management measures with the Kitkatla Inlet Network Zones. (A) The Central mainland Ecologically and Biologically Significant Area (EBSA) is coloured in yellow and Chatham Sound EBSA is coloured in purple. The northern Glass Sponge Marine Protected Area (MPA) and the sponge reef EBSA are shown in blue, and nearby Rockfish Conservation Areas are shown in red. (B) The Pacific Management Zones are shown in blue, and the Government of BC Conservancies are shown in green. Kitkatla Inlet Network Zones are outlined in black.

This area is also critically important to Gitxaala Nation culturally and spiritually (MPA Network BC Northern Shelf Initiative 2023). Gitxaala **Nii Luutiksm**/Kitkatla Conservancy provides safe boat anchorages for boaters travelling along the North Coast, and good opportunities for recreation activities and wildlife viewing. The many inlets can be sheltered and calm, with landing beaches available. With the ecological diversity present in this area comes opportunities for several fisheries. **Hoon**/salmon, **geega tskah**/herring spawn, groundfish (**txaw**/halibut, rockfish, **wat'ukw**/lingcod) and shellfish (**gyenti**/sea cucumber, geoduck, **k'almoos**/crab, **gasgos**/shrimp, and **ts'akwe'ats**/red sea urchin) can be found throughout the area and contribute towards Gitxaala, subsistence, cultural or commercial fisheries (MPA Network BC Northern Shelf Initiative 2023). These Zones are used as waterways to access terrestrial sites of cultural and spiritual significance, fishing camps, **spanaxnox**/homes of spiritual beings, teaching areas, and archaeological sites, and also for the harvest and usage of marine resources. The nearshore location provides for many recreational activities, including scuba diving, kayaking,

recreational boating, fishing and camping. Other human uses, including sheltered anchorages, harbours, and log handling tenures, are intermittently present. Commercial fisheries for groundfish, shellfish, and **hloong** are found throughout the Zones.

2.3 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 two previous reports written for the Offshore Haida Gwaii Network Zones (Bannar-Martin et al. 2025) and Caamaño Sound and Douglas Fjord System Network Zones (Liu et al. *In press*), we have reproduced sections here to ensure each report stands alone with permission from the primary authors of each report. As such, certain overlapping sections may have duplicate or similar descriptions, data, and figures as the previous two reports.

The biophysical overview technical report's objectives are to:

1. Describe the contribution of the Kitkatla Inlet Network Zones to bioregional MPA Network's goals, objectives and conservation priorities, including ecological and cultural conservation priorities.
2. Evaluate, describe and map, where possible, the identified conservation priorities and other key biophysical and ecological features of the study area, including:
 - i. predominant and/or unique physical and biological oceanographic characteristics;
 - ii. predominant, unique, ecologically⁹ important, and/or sensitive habitat features; and
 - iii. ecologically⁹ significant species; and species of conservation concern.
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 sensitivities, and where possible the potential recoverability of species and resilience of habitats of interest.
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 research activities to address these gaps, where possible.

Following these objectives, this biophysical report includes six sections focusing on the Kitkatla Inlet Network Zones and surrounding area. The first describes the Network Zones' oceanographic setting, focusing on the physical 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 Indigenous uses and 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

⁹ "ecologically" includes traditional knowledge and western knowledge

Zones to the NSB MPA Network as a whole. Information gaps and data limitations, where applicable, are highlighted throughout and summarized in the final section of the report.

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 Kitkatla Inlet Network Zones area is described, with some repetitions from the previous biophysical review of Haida Gwaii (Bannar-Martin et al. 2025) and of Caamaño Sound and Douglas Fjord System (Liu et al. *inpress*). 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, **dooyaks**/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 7**). These **dooyaks**/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 **dooyaks**. 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 **dooyaks** 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 **baask**/wind patterns and, thus, **dooyaks**. The divergence, or bifurcation, in the **dooyaks** coming across the North Pacific leads to the oceanic region offshore of the BC shelf being a region with 'Variable Currents' (**Figure 7**). Many Gitxaala harvesters have specific knowledge of the **aks**/tides and **dooyaks** and often plan their trips based on this knowledge (Conacher and McGarvey 2014).

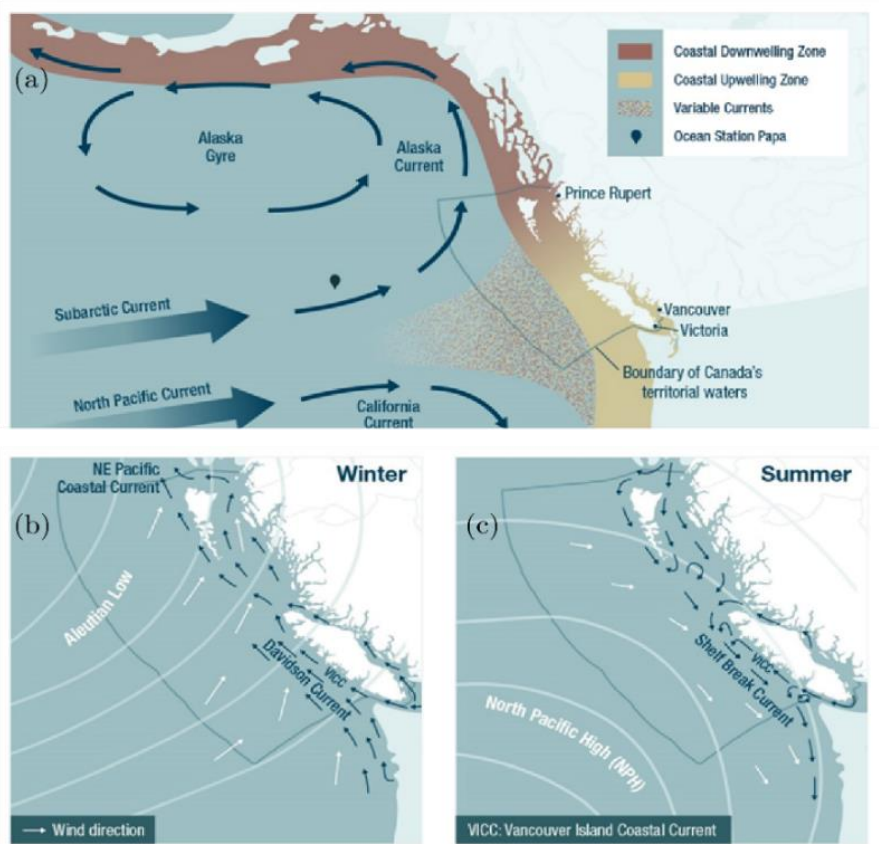


Figure 7. The Northeast Pacific regional current systems (used with permission; DFO 2021). (a) Large scale current systems in Canada's Northeast; (b) Winter season *dooyaks*/currents and *baask*/wind direction within Canada's territorial waters; (c) Summer season current and *baask* direction within 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 *baask* 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 *baask*/wind patterns (Figure 8). In the winter, the *baask* generally blow towards the northeast (or north) along the coast. But in the summer, *baask* along the BC south coast are usually from the northwest, while mean *baask* along the North Coast are weaker and generally from the west. The southern region, with northwesterly summer *baask*, typically corresponds to the 'Coastal Upwelling Zone' (Figure 7a). The sea surface temperature (SST) patterns vary among seasons because of the changes in air temperatures, solar radiation, and local *baask*. 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 9a). 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 *baask* (Figure 9b). During the 2013-2014 winter, anomalously warm SSTs were observed throughout the NE Pacific and persisted into late 2016 (Bond et al. 2015, Hobday et al. 2018). The persistent warm temperatures were associated with an unprecedented extended marine heatwave, referred to as "the Blob," which manifested as an extended temperature anomaly exceeding 3°C in the upper 200 meters of the water column and disrupted Pacific ecosystems

(Bond et al. 2015; Suryan et al. 2021). A record high sea level pressure system in the NE Pacific is attributed to causing the marine heatwave, which preceded the onset of the warm phase of the El Niño Southern Oscillation (ENSO).

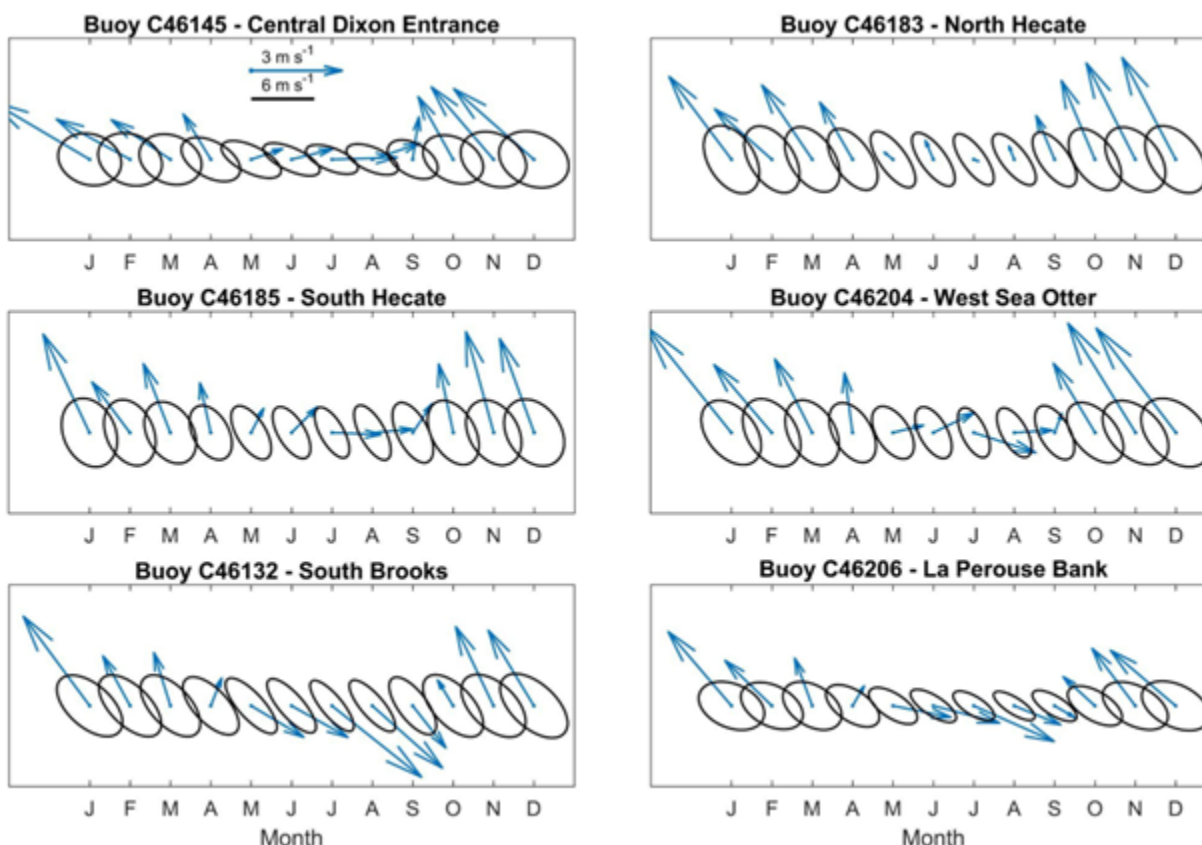


Figure 8. The monthly mean *baask*/wind vectors and the standard deviation ellipses at marine weather buoys along the BC coast. The panels are organized from Dixon Entrance in the upper left to the southern Vancouver Island Shelf in the lower right.

Atmosphere-ocean coupling variations in the tropical Pacific cause ENSO. ENSO plays an important role in the Northeast Pacific on time scales of about 2 to 7 years. The ENSO index has been negative (La Niña) since 2020 and recently changed signs in 2023 to positive. During the warm ENSO phase (El Niño), 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 Niña years. The Aleutian Low weakens and moves northwards, making surface waters colder. Another index is the Pacific Decadal Oscillation Index (PDO; Newman et al. 2016). The index amalgamates the effects of many physical processes and partly describes the Northeast Pacific climate on a decadal time scale. This index is the leading mode of monthly SST variability in the North Pacific (20--70°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. The PDO has been negative

since 2020, but was positive during the “blob” years that brought anomalously warm waters on the BC coast.

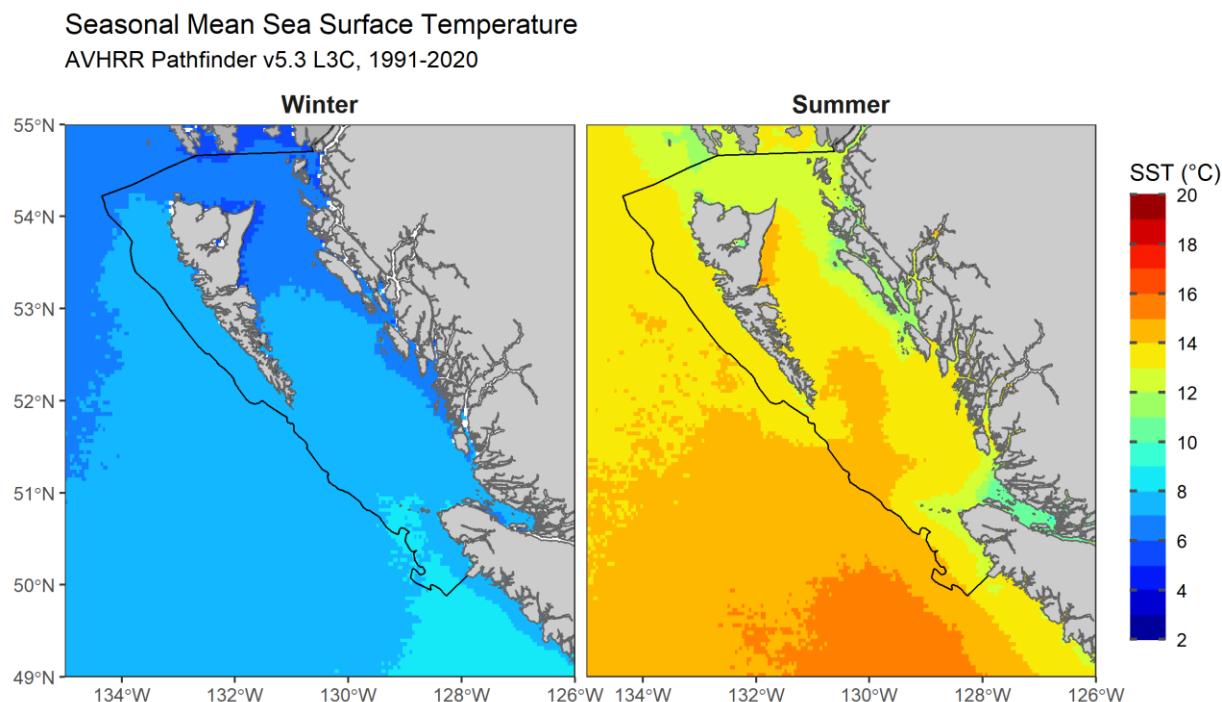


Figure 9. Sea surface temperature (SST) averaged by season over the period 1991-2020, showing winter (the months January to March) and summer (July to September). The black line indicates the NSB boundary. These maps were calculated from night-time AVHRR SST at 4 km spatial resolution with colours shown 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). These processes generate two eddies (gyres) that dominate the surface circulation in Dixon Entrance. The Rose Spit Eddy, a cyclonic (anti-clockwise rotating) eddy, occupies the eastern end of Dixon Entrance near *Celestial Reef*. A second, anti-cyclonic eddy, is also often present at the western end over *Learmonth Bank* (Crawford and Greisman, 1987; Ballantyne et al. 1996). These eddies transport most freshwater from the Skeena and Nass Rivers towards Dixon Entrance (see Figure 2 in Thomson and Emery 1986). The shallow Rose Spit Sill, north of Haida Gwaii, limits deep water exchanges between Hecate Strait and Dixon Entrance. However, the Moresby Trough extends north of **Tgii Xsw’aanx**/Porcher Island and reaches a maximum depth of 80 m just west of Porcher Peninsula. Water can move freely up to a depth of about 50 m around **Tgii Xsw’aanx**, Chatham Sound, Grenville Channel, Dixon Entrance and Hecate Strait.

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 7**; hereafter “Station P”) in the subpolar gyre. This connection is the signature of the California Undercurrent.

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.

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 the more exposed Kitkatla Inlet Network Zones 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 northwest offshore of **Lax k’naga dzol**/Banks Island and **Tgii Xsw’aanx**/Porcher Island that are within the Kitkatla Inlet Network Zones.

Remote sensing studies along the BC coast have provided moderate-resolution (300 m to 4 km per pixel) estimates of satellite Chlorophyll-a concentration (Chl-a), a proxy for phytoplankton biomass, which are further used to estimate the presence and timing of phytoplankton blooms. Within the Northern Shelf Bioregion, surface Chl-a is higher in northern Hecate Strait, and Dixon Entrance is higher than the west coast of Haida Gwaii and central Hecate Strait. In northern Hecate Strait, which includes the area offshore of the Kitkatla Inlet Network Zones, the spring bloom typically starts in April and peaks in May (Jackson et al. 2015). Another lower-magnitude bloom usually occurs in late August through mid-September. On average, the maximum surface Chl-a is about 6 mg m⁻³, much lower than the Strait of Georgia, exhibiting the highest Chl-a along the BC coast.

Giannini et al. (2021) analyzed and validated suspended particulate matter (SPM) and coloured-dissolved organic matter (CDOM) estimates from satellites along the BC coast. SPM surface concentrations peaked in spring near the Skeena River, exceeding 10 g m^{-3} . These spring concentrations are two to four times lower than further south, where the Fraser River discharges into the Strait of Georgia. Unlike other large rivers along the BC coast, SPM concentrations near the Skeena River remain elevated until declining to $< 5 \text{ g m}^{-3}$ in autumn (see Figures 7 and 8 in Giannini et al. 2021). Seasonal patterns of coloured-dissolved organic matter (CDOM) near the Skeena River are consistent with SPM. The highest CDOM occurs in spring, lowering through summer to near zero in autumn. In contrast, the Strait of Georgia showed higher CDOM absorption in spring that remained $> 4 \text{ m}^{-1}$ through to summer, declining to $< 2 \text{ m}^{-1}$ in autumn (see Figure 11 in Giannini et al. 2021). Thus, the Skeena River provides less SPM and CDOM than areas further south along the BC coast.

3.2 Kitkatla Regional Conditions

3.2.1 Bathymetry

From an ocean circulation point of view, shallow sills and banks hinder deep water exchanges between the Kitkatla Inlet Network Zones and adjoining areas such as Hecate Strait to the west, Chatham Sound to the north and the Caamaño-Douglas Network Zones to the southeast (**Figure 10**).

Lax k'naga dzol/Banks Island (Zone 330) is the shallowest of all zones with depths less than 50 m (**Figure 11**), except for the steep walls along the northern bank of Principe Channel, which reach depths greater than 200 m. The next deepest area is Beaver Passage within Zone 331, which reaches depths of 225 m at the northern end of McCauley Island. A 100 m deep sill separates Beaver Passage from Principe Channel (**Figure 10**), restricting deep exchanges with northward flowing water from the Caamaño-Douglas Network Zones (Liu et al. *in press*). West of the junction between Beaver Passage and Principe Channel is a 60 m deep channel in Browning Entrance (between Zone 330 and 331). It separates Moresby Trough in Hecate Strait from the deeper water offshore of Dolphin and Spicer islands (eastern islands Zone 331). This junction is the deepest area where water from Hecate Strait connects with the south shore of these islands within the Kitkatla Inlet Network Zones.

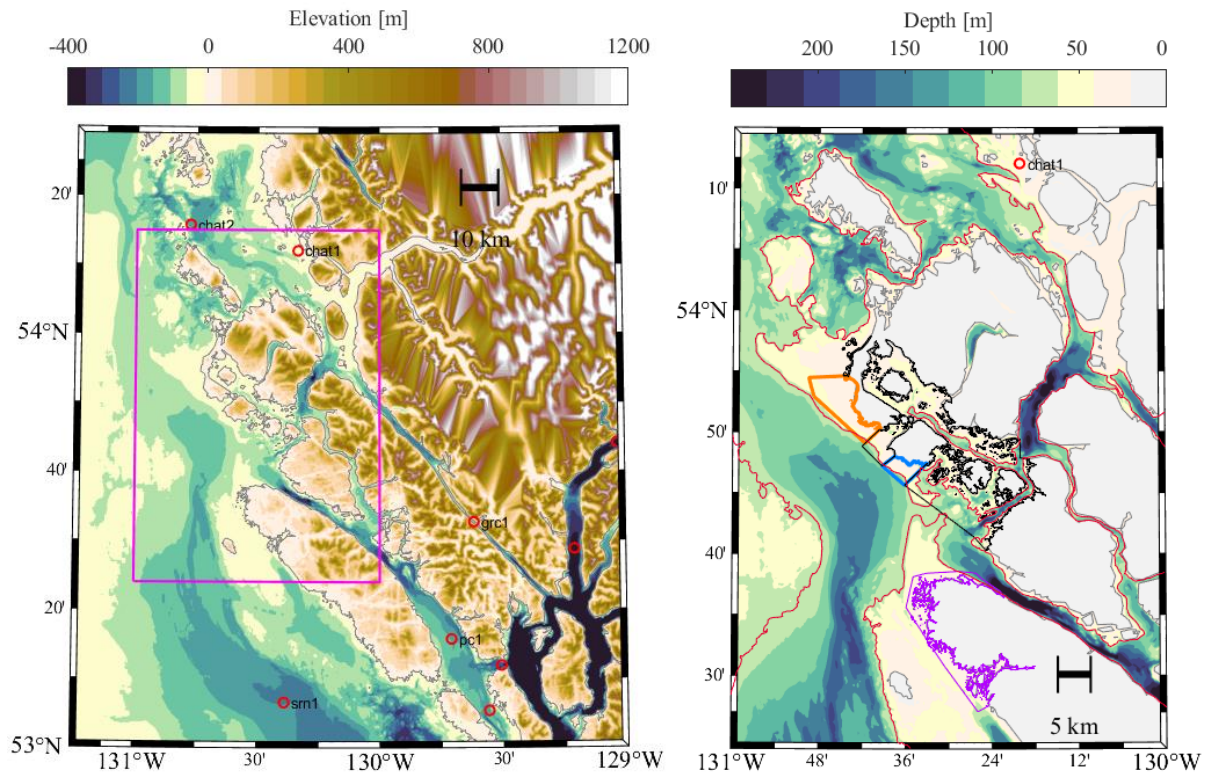


Figure 10. Left is the region's topography and bathymetry, including Hecate Strait, Chatham Sound and the western end of the Caamaño -Douglas area. The magenta inset represents the extent of the right panel, which shows the bathymetry for the Kitkatla Inlet Network Zones : Zone 330 (purple), Zone 331 (black), Zone 332 (orange) and Zone 333 (blue). The dark red line denotes the 60 m depth contour. Historical mooring locations are illustrated with red circles on both panels. Place names are shown in Figure 5.

Moving northeast, other constrictions hinder deep water exchanges between Kitkatla Inlet Network Zones and adjoining regions. For instance, at the north end of Beaver Passage, there is a 75 m sill at the constriction west of Spicer Island (**Figure 10**). This sill limits exchanges from the deep waters in Beaver Passage with those north of Spicer Island in Kitkatla Channel (Zone 331). The deep water on the north side of this constriction thus likely originates from Ogden Channel, given the deeper 110 m sill further north where Ogden Channel enters Zone 331 near Kitkatla Channel. Once water enters Kitkatla Channel, it can move freely towards **Lax ksi tgwi yuun**/Gurd Island up to a depth of 70 m along a channel north of Spicer, Dolphin, and Goschen Island. The remaining areas in Kitkatla Inlet (Zone 331) around **Lax ksi tgwi yuun** are much shallower (**Figure 10**).

The remaining two Kitkatla Inlet Network Zones (332 and 333) are the shallowest and the least connected to Principe and Ogden Channel. Their average depths are less than 30 m (**Figure 11**), and both sit near Moresby Trough in Hecate Strait. The shallow bank at the southeast corner of Zone 333 hinders exchanges between this Zone with Principe Channel and Beaver Passage. Water along the southwest coast of **Tgji Xsw'aanx**/Porcher Island (Zones 331 and 332) is thus better connected with water from Hecate Strait or exiting Chatham Sound via Edye

Passage. However, these Kitkatla Inlet Network Zones are very shallow compared to nearby passages.

Chatham Sound also connects with Kitkatla Channel (Zone 331) around the northeast **Tgii Xsw'aanx**/Porcher Island. For example, a 75 m deep sill limits exchanges through Malacca and Arthur Passages, which connect Chatham Sound to Ogden Channel, and thus the northern entrance of Kitkatla Channel (Zone 331). The regions northeast of Malacca and Arthur Passages are much shallower, as they form part of the Skeena River delta. The regional bathymetry also shows that Kitkatla Channel is connected to the Caamaño-Douglas region via Grenville Channel (**Figure 10**). The deepest passage between Grenville and Ogden Channel is about 60 m deep southeast of Gibson Island. The region directly east of this island is much shallower, owing again to sandbars formed by the Skeena River. Kitkatla Channel (Zone 331) connects with waters entering Ogden Channel from Chatham Sound and the Caamaño-Douglas region.

The regions further south are the most exposed to Hecate Strait, although parts south of Dolphin and Spicer Islands (Zone 331) are connected with the Caamaño-Douglas area via Principe Channel. From the regional bathymetry, only water up to a depth of 60 m can freely move across the Kitkatla Inlet Network Zones. Hence, deeper waters can only cross sills via vertical mixing processes from **baask**/wind and **aks**/tides interacting with topography.

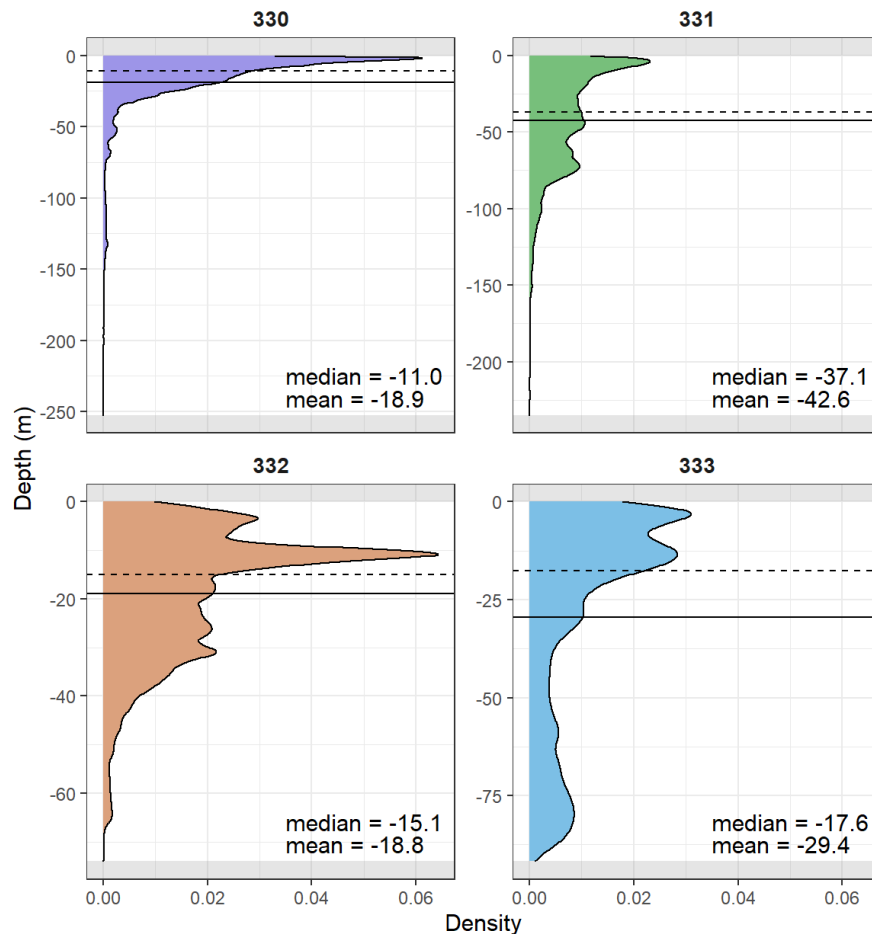


Figure 11. Density plot of bathymetry in each Zone. The mean depth is indicated as a solid line, and the median as a dashed line. All Zones extend to the coastline, i.e., a depth of zero meters. Colours correspond to the four Zones shown in Figure 10.

3.2.2 Geological setting

Porcher and **Lax k'naga dzol**/Banks Island form part of the Hecate Lowland, which is a narrow (<40 km) strip of low-lying terrain (< 700 m) comprising primarily islands and archipelagos south of **Kxeen**/Prince Rupert (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). Bedrock geology is highly variable and complex in this region due to a long history of accretionary tectonics. Large-scale structural features trend northwest, with notable examples including the Grenville, Principe-Laredo and Kitkatla faults that affected the location and orientation of waterways such as Grenville, Principe, Petrel, and Kitkatla Channel (Nelson et al. 2014). The geological features of **Lax k'naga dzol** and **Tgii Xsw'aanx**/Porcher Island comprise Devonian, Late Jurassic and Cretaceous intrusives with small zones of Devonian metasediments. Ordovician Volcanic rocks make up the northern ends of Goschan Island and part of the Porcher Peninsula (Nelson et al. 2014).

The terrain in this region is 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 a eustatic sea level low-stand 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. Thick ice streams occupied areas of low topography, creating a regime of intense erosion.

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, 2002; 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; Hetherington and Barrie, 2004; Shugar et al. 2014). The effects were highly variable, with local sea level lowering of up to 95 m on Cook Bank (Luternauer et al. 1989) and up to 150 m in Hecate Strait and Dixon Entrance (Barrie et al. 1991; Barrie and Conway, 1999; Hetherington et al. 2004). The general effect of this dramatic sea-level lowering was the removal, or non-deposition, of fine sediment on many parts of the shelf in water depths that are currently less than 100 m. Numerous large seabed features in Hecate Strait have been interpreted as drowned accretionary terraces, sand bars and deltas from the period of sea level transgression (Josenhans et al. 1995; Barrie and Conway, 2002). These features are characterized by thick sand and gravel deposits that experience varying degrees of redistribution by **aks**/tide and storm wave activity. Locally, the Skeena Valley was the location of a major ice flow that reached the coast. The Chatham Moraine stretches from Brown Passage (Dixon Entrance) in the north to Browning Entrance in the south – likely emplaced in a late glacial stage during a standstill (Darvill et al. 2018) as the ice receded toward the Skeena Valley and Portland Inlet.

In this coastal environment, glacial remnants are represented in several forms. Glacial diamicton was deposited by grounded ice, particularly the extensive Chatham moraine (**Figure 12**). The glacial diamicton unit forms many of the hard, sometimes mixed gravel to boulder substrate that is important for benthic habitat. The unit has been mapped across the entire western entrance to Chatham Sound and may extend from Porcher Peninsula to McCauley Island. This feature hosts several glass sponge reefs at the entrance to Brown Passage and Edye Passage. Elsewhere in other British Columbia fjords, this unit is known to host large glass sponge reefs (e.g. Howe Sound, Milbanke Sound, Portland Inlet, Gardner Canal). The second major glacial deposit around **Tgii Xsw'aanx**/Porcher Island is sand/gravel material that was deposited as outwash during deglaciation. Glacial outwash deposits were reworked during the rapid sea-level rise that occurred in the late glacial stages. Reworked sand deposits are common in much of Hecate Strait. However, there are limited instances where this sand unit results in extensive beach deposits at modern sea level. The Oval Bay beach on western **Tgii Xsw'aanx** has a morphology consistent with a strandplain-type system with back-barrier dunes and lakes. The seafloor offshore Oval Bay has not been mapped. However, it is likely to consist of sand and gravel deposits with rock outcrops, primarily associated with islands. Seabed gravel was dredged in the Secret Cove area and elsewhere around Chatham Sound for construction material originating from the glacial outwash unit (Good et al. 2007).

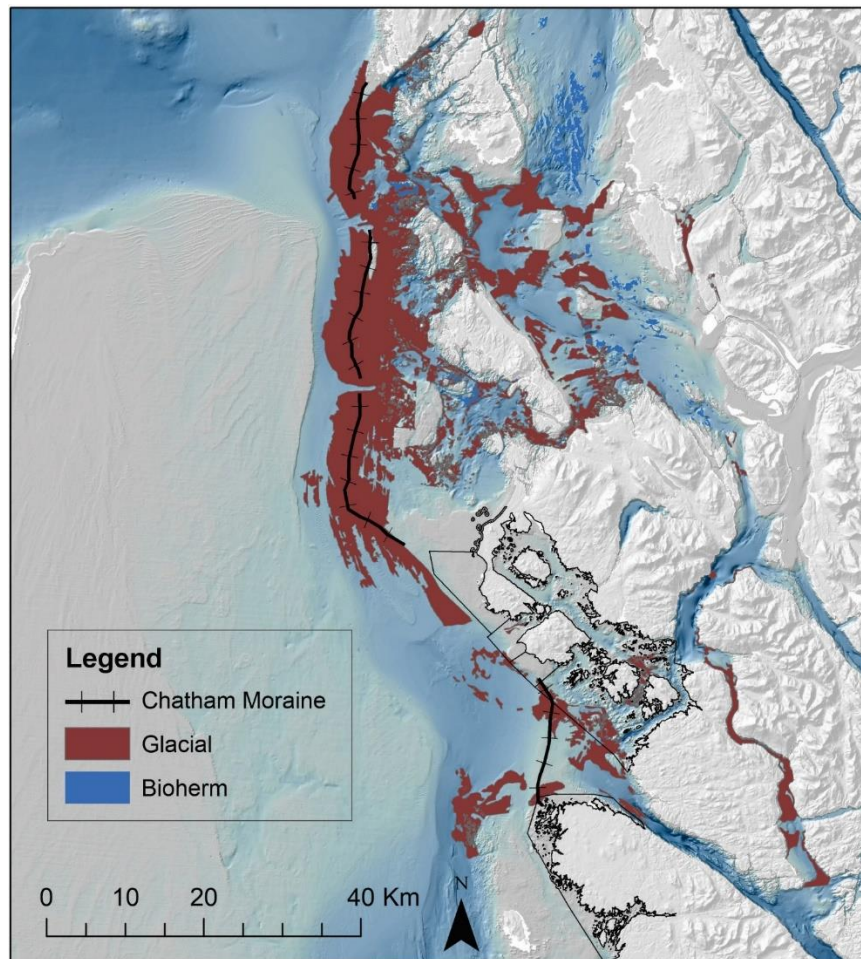


Figure 12. Morphological map of the Chatham Sound area (modified from Shaw and Lintern 2023) showing the regional Chatham Moraine which consists of glacial diamicton and hosts glass sponge reefs (bioherms) in Brown Passage and Edye Passage. The moraine may extend through zones 331-333.

The Geological Survey of Canada produced a geomorphology map for the marine environment near Chatham Sound (Shaw and Lintern 2023). The map shows the surficial units around **Tgii Xsw'aanx**/Porcher Island and the north end of **Lax k'naga dzol**/Banks Island (**Figure 13**). Starting north of **Tgii Xsw'aanx**, the Skeena River forms a delta that extends 12 km south of Kennedy Island around Gibson and Marrack Islands (Conway et al. 1996), indicating that water with high suspended matter frequently flows south through Telegraph Passage towards Ogden Channel. Sedimentation in the Skeena Delta has been summarized by Wild (2020) and Wild et al. (2022). The surficial units on the bottom of Ogden Channel are comprised mainly of postglacial sandy mud until this channel joins Petrel Channel, where the bottom becomes exposed bedrock (**Figure 13**). Near the northeast corner of Spicer Island, the exposed bedrock is limited to near the sidewalls of Beaver Passage (Zone 331). Postglacial sandy mud is found in the middle of the passage. The exposed bedrock in Ogden Channel, at the northern entrance of Zone 331, coincides with a constricted and shallow passage (**Figure 10**). This area east of Kitkatla Channel likely has fast-moving **dooyaks**/currents, given the lack of loose material on the bottom.

Between Spicer and Dolphin Island in Schooner Passage (Zone 331), the bottom is covered with glacial sediment – an irregular mixture of sandy and bouldery gravel and exposed bedrock (**Figure 13**). Sediment samples in the area are sparse, and the available data show fine sand and silty sand at a sample location just offshore Joachim Point (Zone 331). Between Goschen Island and Porcher Peninsula (Zone 331), the postglacial sand unit is interspersed with the glacial unit and bedrock. Seabed conditions in much of the exposed waters between Gochen Island, Dolphin Island and Spicer Island have not been well mapped, but are likely to have interspersed postglacial sand, coarse glacial material and bedrock (Zones 331 and 332). On the southern exposed side of Porcher Peninsula and the group of broken islands (offshore of Zones 331 to 333), the surficial units include glacial sediment (sandy gravel and bouldery gravel), with finer postglacial muddy sand further south of the islands (**Figure 13**). Although there is no data within Kitkatla Channel and Kitkatla Inlet (Zone 331), the information between the broken group of islands suggests finer bottom material in the sheltered areas further west.

West of **Tgii Xsw'aanx**/Porcher Island, in the Oval Bay area (offshore Zone 331), sediment samples show sandy gravel on Oval Bank, just north of Zone 332. These samples and others collected in Secret Cove show predominantly gravel. The seafloor offshore Oval Bay has not been mapped. However, it is likely to consist of sand and gravel deposits with rock outcrops, especially associated with islands.

Another moraine spans Browning entrance between **Lax k'naga dzol**/Banks Island and Dolphin and Goschen Island (between Zones 330 and 331; **Figure 12**). This feature shallows up to 60 m. The areas east and west of this differ somewhat in their geomorphology. The surficial units are more variable on the west side, offshore of Porcher Peninsula and Goschen Island (**Figure 13**). They include bedform fields of reworked glacial sediments that consist of ridges of medium sands with wavelengths of tens to hundreds of meters and heights as high as 10 m. These ridges are mobilized by tidal and storm-driven **dooyaks**/currents in Hecate Strait (Shaw and Lintern 2023). This type of morphology also exists offshore of the northwest tip of **Lax k'naga dzol** (Zone 330), along with some glacial sediment. East of the moraine, along **Lax k'naga dzol**'s northern coast, surficial units also include glacial sediment (sandy gravel and bouldery gravel), finer postglacial muddy sand and bedrock along the north and south shore of Principe Channel (Zone 330). The other notable bedrock area is west of McCauley Island (**Figure 13**), where Principe Channel meets Beaver Passage, east of Browning Entrance.

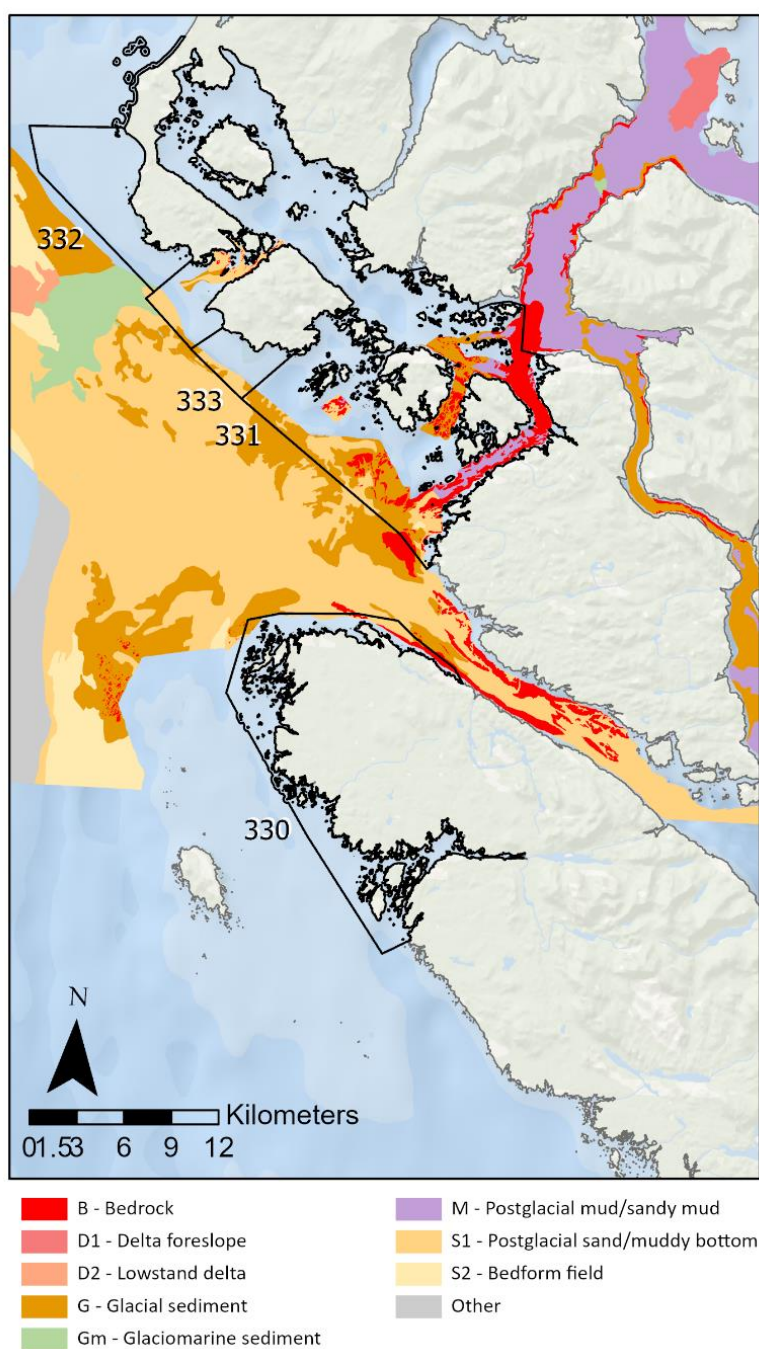


Figure 13. Geomorphological map of Chatham Sound and parts of the Kitkatla Inlet Network Zones. The map was adapted from Shaw and Lintern 2023. An adjoining map for the Caamaño-Douglas area also exists (Shaw and Lintern 2016) but does not cover the southern area of Zone 330 around Lax k'naga dzol/Banks Island.

3.2.3 Freshwater inputs and **aks**/tides

3.2.3.1 Freshwater inputs

The freshwater in the region is provided by local precipitation and melting snow cover from the mountains in the watershed's upper reaches. Rainfall is typically higher near the coast, with more snowfall further north and inland (**Figure 14**). **Kxeen**/Prince Rupert receives more snow than **Lax Kul**/Bonilla Island within the Kitkatla Inlet Network Zones. In more inland locations, such as Terrace, a large proportion of the precipitation still falls as **Waas**/rain during winter. Freshwater is thus discharged into Chatham Sound throughout the year owing to the confluence of three large watersheds: the Nass, the Skeena, and Caamaño (Morrison et al. 2012). The Kitkatla Inlet Network Zones are contained within the northern extent of the Caamaño watershed, extending as far south as Milbanke Sound (Morrison et al. 2012). However, the Skeena River flows directly into the northeastern side of the Kitkatla Inlet Network Zones (Morrison et al. 2012). Freshwater from the Nass River enters the northern end of Chatham Sound via Portland Inlet north of **Kxeen** and thus quite north from the Kitkatla Inlet Network Zones. During freshet, the furthest south that the Nass River plume has been recorded is around Melville Island, northwest of **Kxeen** (Trites 1956). However, this river provides significant freshwater into Chatham Sound that will influence flow patterns at the southern end near Kitkatla.

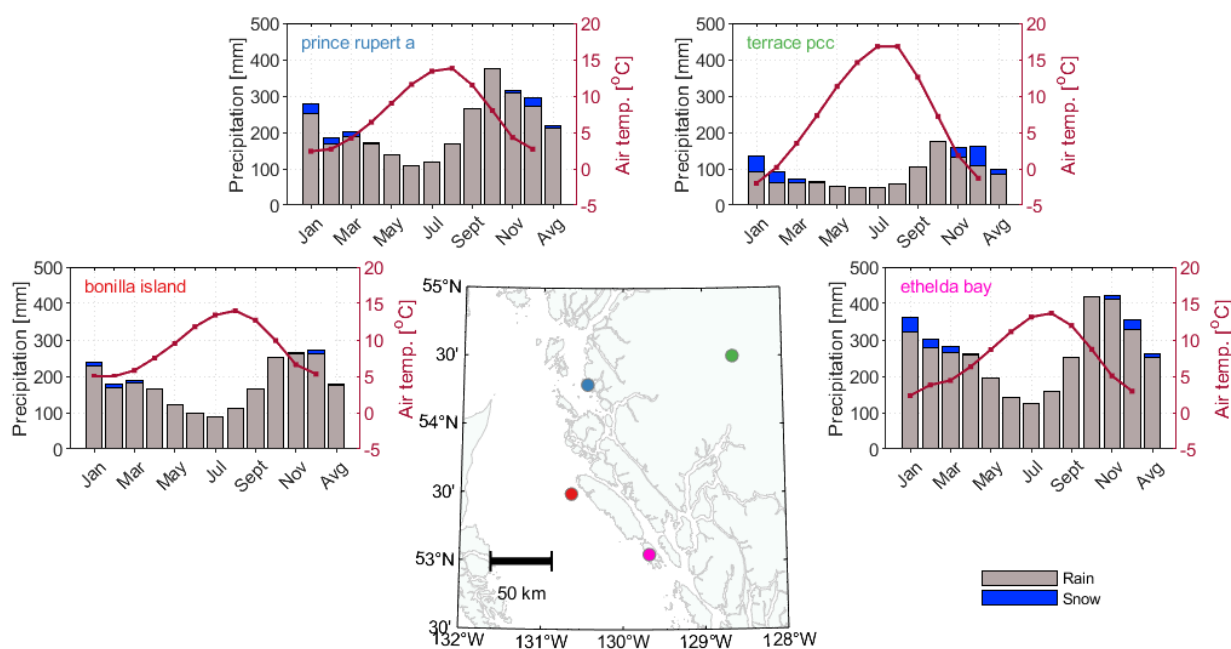


Figure 14. Monthly average precipitation and air temperatures from ECCC's climatic normals (1981-2010) of regional stations, except for station Ethelda Bay, which shows the available monthly averages from 1957 to 1994. Snowfall is presented as equivalent water, i.e., 10 cm snow = 10 mm water.

The Skeena and Nass watersheds are comparable in size (~55000 km²). However, the Nass watershed generates 1.8 m of freshwater annually, double the amount of the Skeena's (**Figure 15**). Their total annual flow rates are about 3000 and 1500 m³s⁻¹, respectively. The Fraser River

catchment provides, on average, 0.5 m of freshwater per km² of watershed per year, which translates to about 3500 m³s⁻¹ due to its large catchment. The Nass watershed is much wetter because nearly half its watershed drains pluvial rivers near the coast, where it also rains more (**Figure 14**). Pluvial rivers' discharge tracks the local rainfall, which increases during late fall and winter (e.g., Porcher and BanksNW in **Figure 15**). In contrast, Skeena's watershed drains mostly nival rivers (Morrison et al. 2012), characterized by large discharges in late spring and early summer because of the melting snowpack (**Figure 15**). On average, the Skeena's runoff exceeds 2500 m³s⁻¹ from May to July, when its discharges become more comparable with those from the Nass watershed (Morrison et al. 2012, and **Figure 15**).

The Kitkatla Inlet Network Zones drain the northwest of the Caamaño watershed. This watershed provides an average of almost 2500 m³s⁻¹ of freshwater annually despite being much smaller (30,858 km²) than the Skeena and Nass Rivers (Morrison et al. 2012). The Caamaño watershed generates 2.5 m of freshwater annually because of the local topography and ample rainfall near the coast, especially south of Caamaño Sound (Morrison et al. 2012, Liu et al. *in press*). The freshwater inputs into Caamaño Sound increase during spring and late summer because of snowmelt, just like the Nass and Skeena watersheds (**Figure 15**). However, runoff peaks during the rainy fall and winter because two-thirds of the Caamaño catchment drains pluvial rivers – a higher proportion than the Nass watershed (Morrison et al. 2012). The annual minimum flow rate in all three watersheds (Nass, Skeena, and Caamaño) is late winter. However, the discharges for the Caamaño and the Nass watersheds are still relatively high, with monthly averages reaching 1300 and 1800 m³s⁻¹ in February (**Figure 15**).

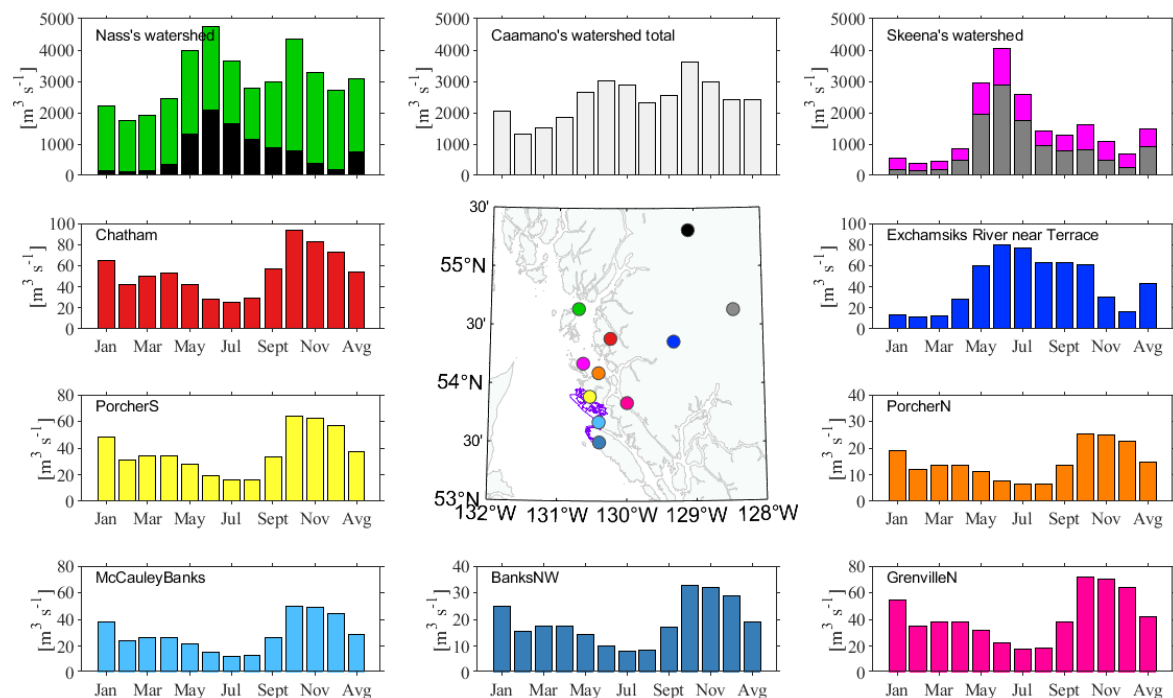


Figure 15. Summary of estimated climatological monthly mean freshwater runoff into the nearby catchments based on Morrison et al. 2012 along with the historical averages measured by the Water Survey of Canada (WSC) in the upper reaches of the Skeena River at Usk (top right, dark grey, #08EF001) and the Nass River above Shumal Creek (top left, black, #08DB001) during the same period as the reconstructed flows (1970 to 2009). The additional contributions from the coastal, rain-dominated parts of the watershed for the Skeena' and Nass watersheds are shown in purple and green, respectively. The WSC data from the smaller catchment (370 km²) of Exchamsiks River near Terrace (#08EG012) that flows into the Skeena River is also illustrated. The remaining histograms give the reconstructed runoff at various discharge locations, mapped using the same colours as the histograms. The extent of the Kitkatla Inlet Network Zones is also delineated in purple. Note the differing scale between the different panels.

3.2.3.2 Aks/Tides

Like most of the BC coast, **aks**/tides in the Kitkatla Inlet Network Zones are classified as mixed with larger amplitudes associated with the semidiurnal (twice/day) constituents than the diurnal (once/day) ones (Cummins and Oey 1997). The tidal range increases from 2 to 7 m over the 14-day spring and neap tidal cycles. The main semidiurnal constituent (M2) has an amplitude of 1.90 m near Kitkatla. The main diurnal (K1) constituent is weaker, with tidal amplitudes of about 0.50 m (Foreman et al. 1993; Foreman et al. 2000). The K1 constituent's magnitude varies much less than the semidiurnal constituent throughout the system. Tidal variations at higher frequencies (3, 4, 5, and 6 cycles per day) have also been measured from a tidal gauge in the Kitkatla Inlet Network Zones. These nonlinear tidal variations are expected anywhere the flow is constricted or where there is increased friction, i.e., when water becomes shallower near the coast.

When the **aks**/tides interact with sloping bathymetry in stratified waters, baroclinic (internal) motions are generated (Baines 1982). These baroclinic motions can amplify tidal **dooyaks**/currents and cause significant mixing that can transfer heat, nutrients, and material across density interfaces. Numerical modelling shows a relatively weak baroclinic response in the measured **dooyaks** around **Lax k'naga dzol**/Banks Island (Zone 330, Cummins and Oey 1997). There are likely areas within the Kitkatla Inlet Network Zones with amplified tidal **dooyaks**, given the presence of constrictions and sills, such as near the entrance of Kitkatla Channel in Beaver Passage and Ogden Channel (Zone 331).

3.2.4 baask/Winds and surface Goop/waves

3.2.4.1 Baask/Winds

The **baask**/wind patterns impact the physical dynamics in the region. When the **baask** blows towards the northeast, surface water is pushed onshore, resulting in downward transport near the coast. These downwelling-favorable **baask** are prevalent along the entire BC coast during winter. They are a year-round feature off the Alaska coast ('coastal downwelling Zone' in **Figure 7**). Offshore of the Kitkatla Inlet Network Zones, the winter **baask** are generally from the southeast at the North Hecate marine weather buoy. These **baask**, with speeds often exceeding 10 m/s, are downwelling **baask** (**Figure 16**). Further north, in **Kxeen**/Prince Rupert (**Figure 16**) and Dixon Entrance (**Figure 8**), winter **baask** also blow from the southeast with occasional strong **baask** from the east. The summer **baask** patterns differ more across the region. At the North Hecate buoy, offshore of the north end of **Lax k'naga dzol**/Banks Island (Zone 330), summer **baask** from the southeast and northwest occur with equal frequency and strength

(Figure 16). Closer to shore on **Lax Kul**/Bonilla Island (west of Zone 330), the summer **baask** tend to blow from the north rather than the northwest. The summer **baask** occasionally blow from an upwelling-favorable direction offshore of **Lax k'naga dzol** (Figure 16 and Figure 17). In **Kxeen**/Prince Rupert, north of the Kitkatla Inlet Network Zones, the summer **baask** are relatively weak, with speeds generally less than 5 m/s (Figure 16). They blow as often from the northwest than the southeast. From these regional patterns, the **baask** are downwelling-favourable except during the summer when the **baask** are typically weaker and occasionally blow in an upwelling-favourable direction.

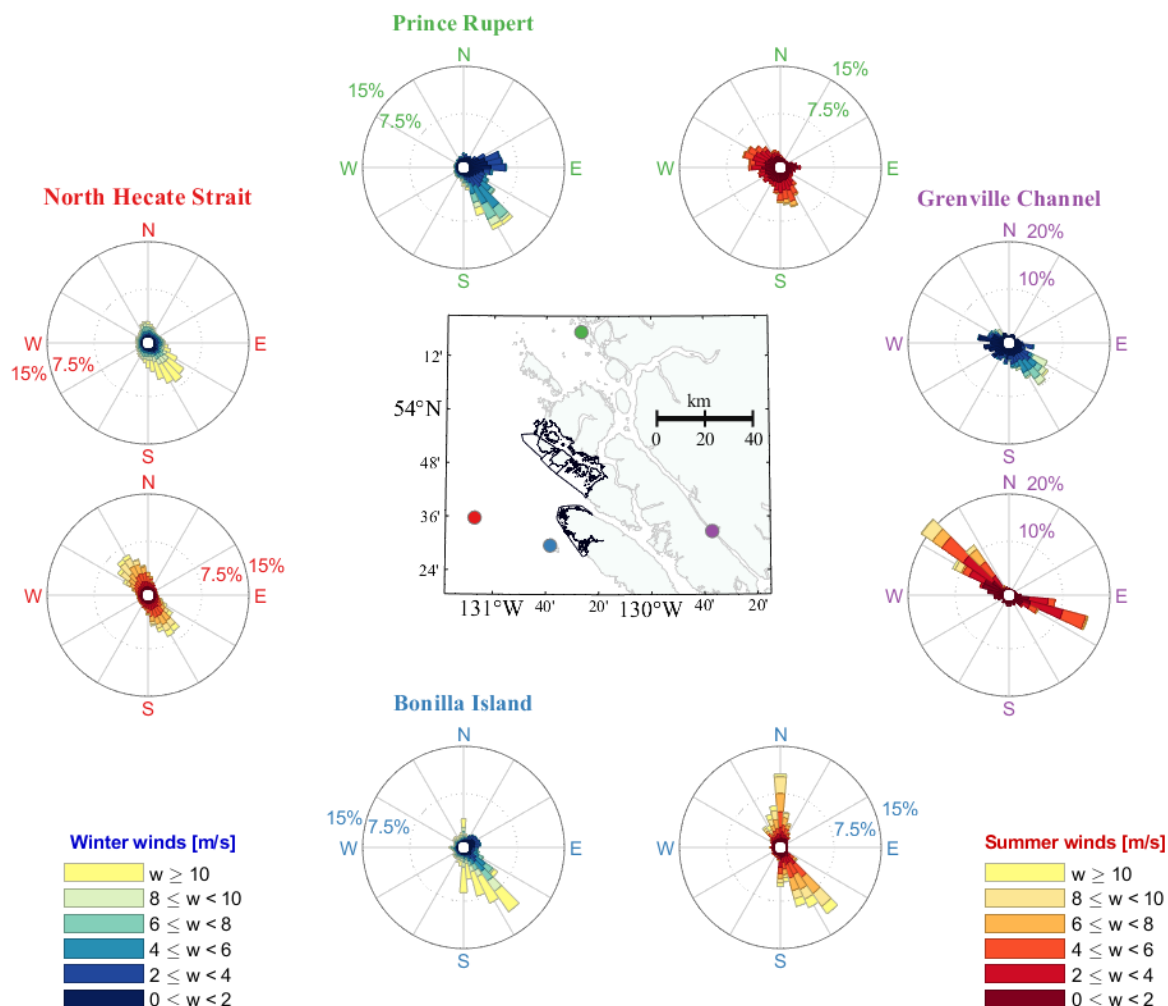


Figure 16. Local **baask**/wind roses were obtained from land-based meteorological stations (Prince Rupert and Lax Kul/Bonilla Island #1060R0K) and marine weather buoys during winter (January) and summer (July) across the region. The data is presented from 1991-2022, except for Prince Rupert's, which combines hourly data from ECCC's stations #1066481 (1991-2006) and #1066483 (2006-2012). Grenville Channel's meteorological station has been operational since February 2023, so the winter data spans mid-February to late March. The spokes' length indicates how often the **baask** blows from that direction, while the colours show how often the **baask** blows at those speeds (in m/s) from that direction. The strongest **baask** are shown in yellow and are generally stronger during winter than in winter. Downwelling-favorable **baask** blow from the SSE, and upwelling-favorable from the NNW. This was confirmed by Gitxaala Indigenous Knowledge, which indicated southeast and northwest **baask**. When travelling, it is often necessary to hug the shoreline in Principe Channel because the **baask** move up the channel quickly (Conacher et al. 2011).

Gitxaala harvesters also noted that the Gitxaala traditional territory is predominantly affected by southeast or northwest **baask**/winds (Conacher et al. 2011). Within the inlets, the **baask** patterns differ from the coastline directly exposed to Hecate Strait. The higher mountains steer the **baask** to blow along the axis of the waterways, such as Grenville Channel, where the **baask**' direction is much more consistent than around **Kxeen**/Prince Rupert (**Figure 16**). This topographical **baask** steering was confirmed by Gitxaala Indigenous Knowledge, which indicated southeast and northwest **baask** along channels (Conacher et al. 2011). When travelling, it is often necessary to hug the shoreline in Principe Channel because the **baask** move up the channel quickly.

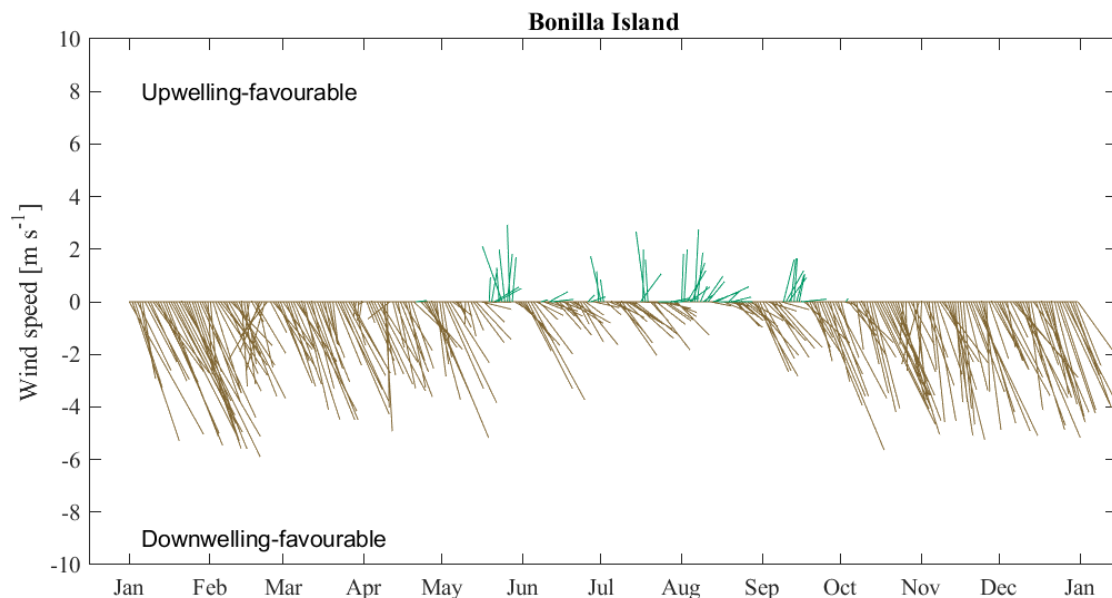


Figure 17. Average daily **baask**/wind speeds measured at ECCC's Lax Kul/Bonilla Island weather station (#1060902) for the available records between 2004 and 2023. On average, the **baask** are weakly upwelling-favourable during parts of the summer. The lines' length indicates the speed while they point in the direction the **baask** is blowing from.

3.2.4.2 **Goop**/Waves

The North Hecate marine meteorological buoy, northwest of **Lax k'naga dzol**/Banks Island, also provides **Goop**/wave heights and periods (**Figure 18**). The fetch is much longer in winter

since the **baask**/wind blows from the southeast (**Figure 16**). The longer fetch and stronger winds create large **Goop**/waves with periods typically less than 10 seconds, i.e., **baask**-generated “seas” (**Figure 18**). The median wave height is 1.5 m, with **Goop** exceeding 4 m about 5% of the time. Gitxaala members have noted that travel routes are often chosen with two considerations in mind: 1) the type of weather and water conditions they were experiencing (rough vs calm seas) and 2) the ability to stop and hunt, gather or fish along the way. For example, Gitxaala harvesters are more likely to travel along the inside of Principe Channel in rough weather than along the west coast of **Lax k’naga dzol** because of the large **Goop**. During summer, there is evidence of swell-generated **Goop** with periods greater than 10 seconds, but their wave heights are always small (<0.5 m **Figure 18**). The median wave height is 0.6 m, with values exceeding 1.6 m about 5% of the time. The wave heights are thus much larger during winter storms. The **Goop** are thus generated by local **baask** patterns rather than being dominated by swells generated by large atmospheric pressure systems in the NE Pacific.

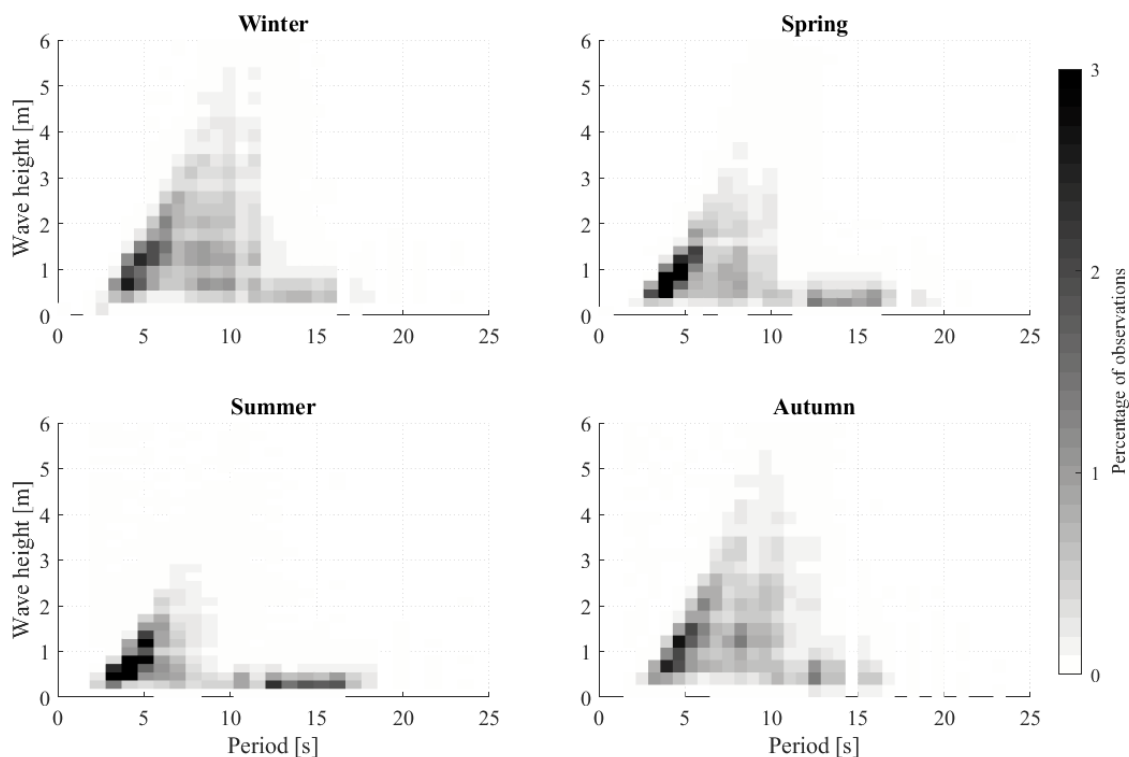


Figure 18. Probability of occurrence of wave heights relative to wave periods from hourly measurements collected at the North Hecate marine weather buoy (#46183) between 1991-2022 (see **Figure 16** for the buoy location).

Surface **Goop**/waves evolve as they move into shallower water. They become steeper as they shoal until they dissipate through breaking and bottom friction processes. The nearshore areas of the Kitkatla Inlet Network Zones are shallow, but not all are impacted in the same way by surface **Goop**. The intensity of wave action impacts the presence of biota along shorelines, which can be seen from aerial surveys (Cook et al. 2017). These surveys and the known wave fetch can be used to categorize beaches' biological wave exposure (Coastal and Ocean Resources 2020). The sheltered Kitkatla Inlet (Zone 331) is less susceptible to large **Goop** than

those directly exposed to Hecate Strait (**Figure 19**). A broken group of islands – Porcher Peninsula, Goschen, Dolphin, and Spicer Islands – shelter Kitkatla Inlet and Channel. These islands reduce the wave fetch and, thus, the maximum height that local **baask**/winds can generate in Kitkatla Inlet and Channel (Zone 331). However, the south shore of these islands (Zones 331, 332 and 333) – is the most exposed to wave impacts amongst the northern Kitkatla Inlet Network Zones (**Figure 19**). The west coast of Porcher Peninsula (Zone 331) is considered semi-protected, given that its orientation protects its shore against the prevailing **baask** (**Figure 16**). Most of the remaining shorelines around the broken group of islands are deemed protected from **baask** impacts. The most exposed areas are those furthest south along the south shore of **Lax k'naga dzol**/Banks Island within Zone 330 and just south of it (**Figure 19**). Further north along this shore, the coast is classified as semi-exposed, just like the northwest coast **Lax k'naga dzol** (Zone 330), given their orientation relative to Hecate Strait. Exceptions are Kingkown Inlet (Zone 330) and the northwest coast of **Lax k'naga dzol** (Zone 330), which are semi-protected from wave exposure because of sheltering provided by small islands along the shoreline (**Figure 19**).

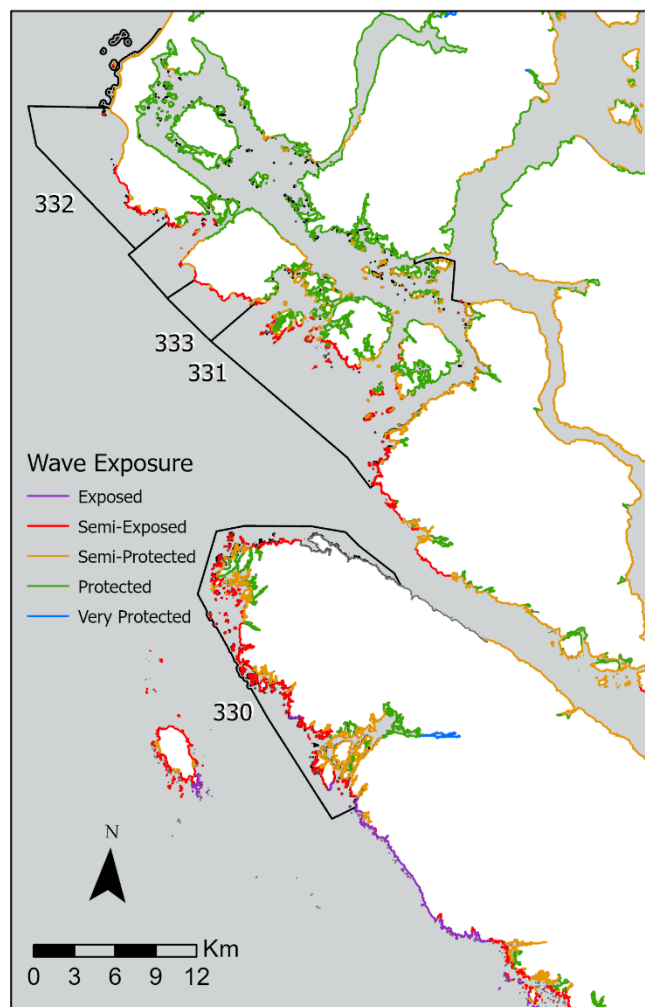


Figure 19. Biological wave exposure of the Northern BC coastline (Coastal and Ocean Resources 2020, Cook et al. 2017).

Ship-generated **Goop**/waves may still impact sheltered channels. These **Goop** depend on ship speed, drawdown, and overall hill shape and size -- the more significant the volume displaced, the larger the **Goop** (Bluteau et al. 2023). How the **Goop** dissipate depends on the shoreline characteristics, particularly the slope and distance over which the **Goop** interact with the bottom. **Goop** do not dissipate as effectively in areas with steep, low-friction shores as along shallow beaches. For example, Gitxaala members have noticed that with the more frequent passage of large ships in Principe Channel, ship-generated **Goop** can be amplified as they bounce back from shoreline to shoreline (Gitxaala Nation 2016). Ship-generated **Goop** are expected to interact with the shorelines along **Lax k'naga dzol**/Banks Island 's north shore (Zone 330) and through Ogden Channel and Beaver Passage as they pass through Zone 331, given the ship traffic information (see Vessel traffic and vessel types).

3.2.5 **Dooyaks**/currents

3.2.5.1 Surface drifter observations

Drifter studies indicate that the surface waters in Kitkatla Inlet Network Zones are connected year-round with the Caamaño-Douglas area and Hecate Strait (Page et al. 2019; Hourston et al. 2021). The western zones offshore of the broken group of islands (Zones 332, 331 and 333) are better connected than the eastern islands (e.g., Dolphin and Spicer) with surface water around **Lax k'naga dzol**/Banks Island (Zone 330) and Hecate Strait. Drifters moving offshore of **Lax k'naga dzol** (Zone 330) tend to approach the southwestern end of the Kitkatla Inlet Network Zones – notably offshore of Porcher Peninsula (Zone 332), Goschen Island (Zone 333) or Freeman Passage (Zone 331) in between these islands. They rarely travel west through Browning Entrance between Zone 330 and 331 (**Figure 19**), so surface waters from Hecate Strait does not usually reach Kitkatla Channel (Zone 331) via this route. Instead, surface waters within Kitkatla Channel and Kitkatla Inlet (Zone 331) are connected with surface waters from Grenville Channel, the Skeena River and, to a lesser extent, Principe Channel (**Figure 19**).

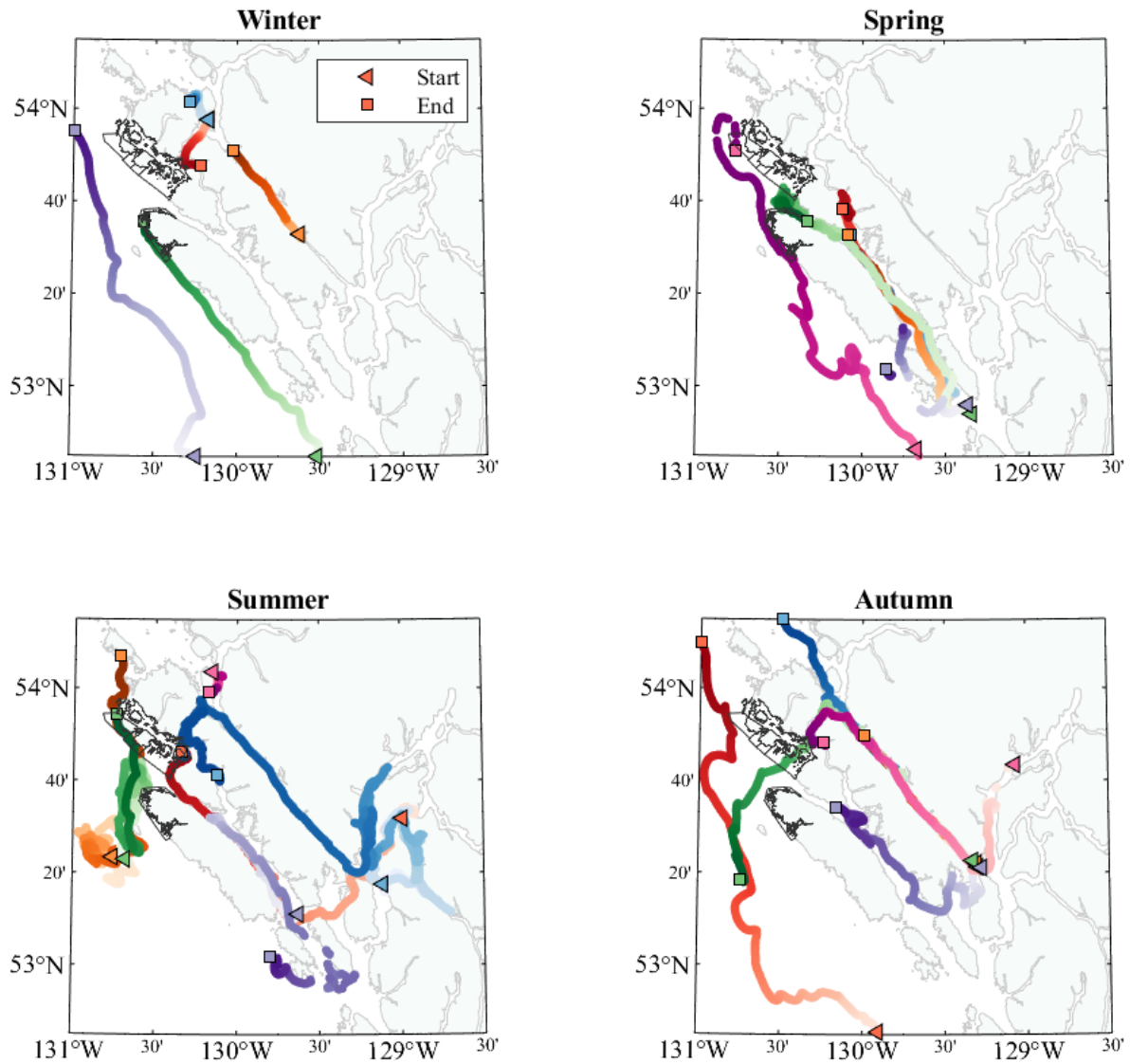


Figure 20. Surface drifter tracks during different seasons (Page et al. 2019; Hourston et al. 2021). Each colour represents another track and becomes darker as time progresses once the drifter enters the mapped limits. Only a subset of the available drifters' observations are shown to focus on those that enter the bounding box around the Kitkatla Inlet Network Zones shown in **Figure 10**.

The high freshwater inputs from the Skeena and Caamaño watershed (Morrison et al. 2012) cause seasonal variations of where drifters travel once they reach the northwest end of Pitt Island in Grenville Channel (**Figure 20**). No drifters were deployed during the spring freshet, but from those deployed in summer and fall, drifters flowed southwest into Ogden Channel towards Kitkatla Channel (Zone 331) or northwest towards Arthur Passage. Surface drifters entering Ogden Channel flow southeast into Petrel Channel or southwest towards Kitkatla Channel and onto the north shore of Spicer Island and Dolphin Island (Zone 331, **Figure 20**). The drifter tracks also illustrate that some freshwater from the Skeena River flows south through Telegraph Passage into Ogden Channel. However, some bifurcate west towards Arthur Passage as they

meet water flowing northwest from Grenville Channel (winter **Figure 20**). The northern entrance of Kitkatla Channel (Zone 331) receives surface water from Grenville Channel and the Skeena River.

Surface waters also enter Kitkatla Channel (Zone 331) from the south side of Spicer Island via Beaver Passage. Drifters that enter here typically originate from the Caamaño-Douglas area, in particular, Principe Channel; although drifters from the Caamaño-Douglas area do not always reach the Kitkatla Inlet Network Zones, some occasionally return to Caamaño Sound before exiting towards Hecate Strait (**Figure 20**). Amongst those that reach the north end of **Lax k'naga dzol**/Banks Island, some remain trapped in Browning Entrance between Zones 330 and 331, while some flow north into Beaver Passage until reaching Kitkatla Channel (**Figure 20**).

The drifter tracks indicate limited surface flow through Browning Entrance and some flow restriction near Spicer Island, where Beaver Passage meets Kitkatla Channel (**Figure 20**). Surface waters south of Porcher Peninsula and Goschen Island (Zone 331 to 333) are more connected with the south shore of **Lax k'naga dzol**/Banks Island than the south shore of Dolphin and Spicer Islands. These eastern islands are more connected with Principe Channel and, thus, the north shore of **Lax k'naga dzol** than Hecate Strait (Zone 330). The constrictions around Spicer Islands appear to restrict surface exchanges from the south shore of the broken island group into Kitkatla Channel and Inlet (Zone 331). Surface waters from Grenville Channel and the Skeena River thus enter Kitkatla Channel and Inlet more freely than surface water from the south in Beaver Passage.

3.2.5.2 Subsurface velocity observations

Regional moorings provide information about the flow direction of subsurface waters (**Figure 21**). Ogden Channel brings water towards the northern entrance of Kitkatla Channel (Zone 331). Water below the surface layer can enter Ogden Channel from Grenville Channel, Arthur Passage, and Petrel Channel. During winter, water from Grenville Channel tends to flow northwest towards Ogden Channel throughout the entire water column (**Figure 21**). On the north side of Ogden Channel, water below 50 m from Chatham Sound flows southeast towards Arthur Passage and onto Ogden Channel (**Figure 21**). At other times of the year, water from Chatham Sound flowing into Arthur Passage tends to be confined to depths greater than approximately 75 m. In comparison, an intermediate layer at about 20 to 50 m depth also flows in the same direction towards the Caamaño-Douglas area via Grenville Channel. From ship-based vertical profile measurements, relatively fresh water from the Skeena River can also be identified halfway up Grenville Channel during spring and summer.

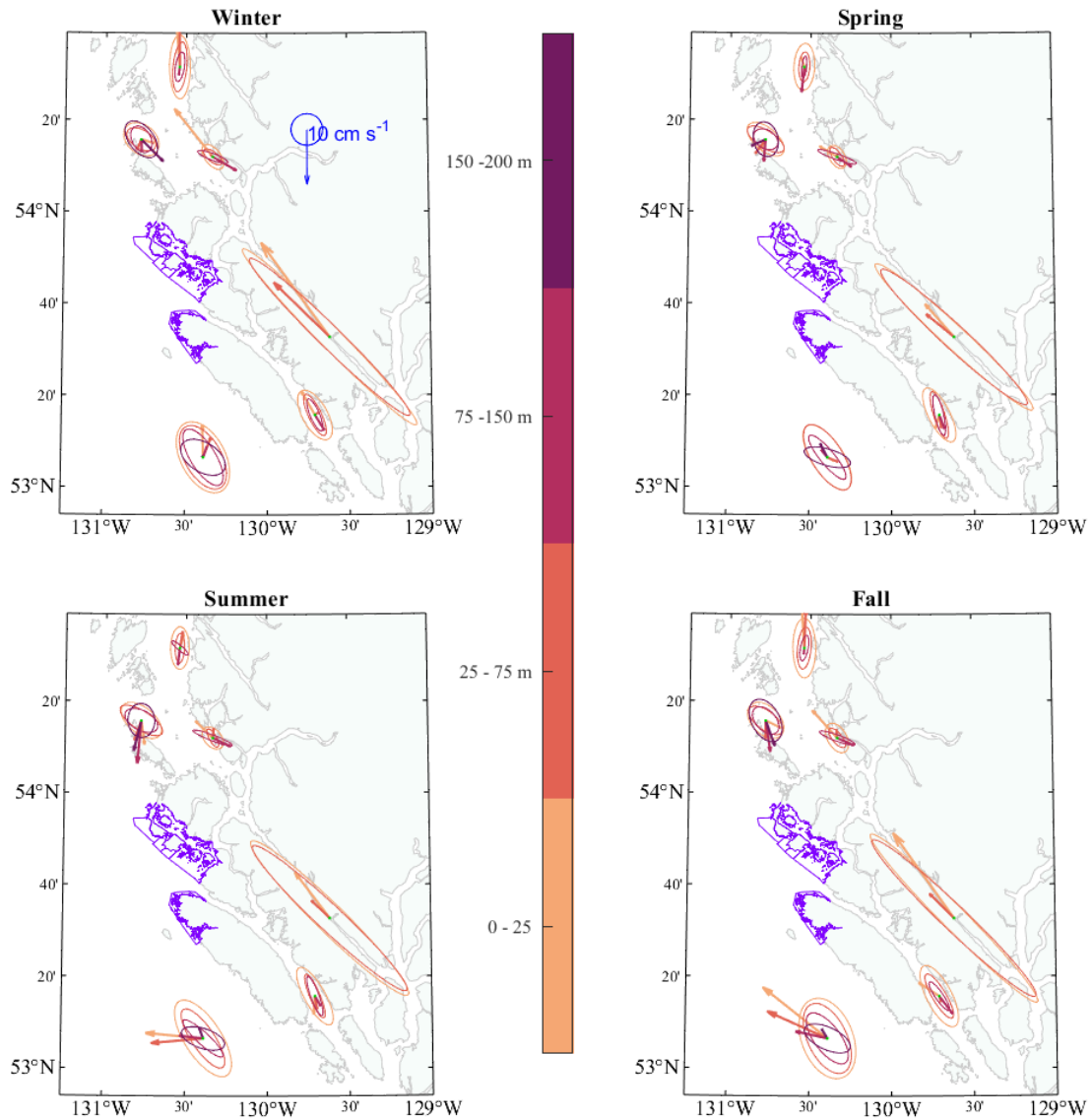


Figure 21. Median *dooyaks*/currents (arrows) from principal component analysis on a seasonal basis. The winter, spring, summer, and fall months include January to March, April to June, July to September, and October to December, respectively. The different colours indicate the depth ranges used for the analysis, provided the measurements cover at least 40% of the depth range. These analyses were done on one year of continuous *dooyaks* measured between 2014 and 2022. The Kitkatla Inlet Network Zones are delineated in violet.

On the southern end of the Kitkatla Inlet Network Zones, surface waters in Principe Channel (Zone 330) tend to flow northwest towards Beaver Passage except during freshet when the surface flow reverses towards the Caamaño-Douglas region (**Figure 21**). Deeper in the water column, an intermediate layer from about 50 to 150 m depth tends to flow towards the Caamaño-Douglas region. The transport in this layer strengthens during winter (**Figure 21**). However, the deepest layers in Principe Channel flow year-round towards Browning Entrance between Zones 330 and 331. Southwest of *Lax k'naga dzol*/Banks Island (Zone 331) in Hecate

Strait, water in the upper 75 m tends to flow either northwest (e.g., autumn) or to the west (e.g., summer, **Figure 21**). Deeper **blooms**/currents tend to be weaker and flow northwest along Moresby Trough towards Browning Entrance between Zones 330 and 331.

3.2.6 Surface water properties

3.2.6.1 Sea surface temperature (SST)

SST is monitored daily at more than ten locations along the BC coast. Near the Kitkatla Inlet Network Zones, one marine weather buoy and one lighthouse station provide long-term data. The buoy in North Hecate measures hourly surface water temperature with records beginning in 1991. The **Lax Kul**/Bonilla Island lighthouse has measured temperature and salinity at the shore once per day since 1960. SSTs during the winters of 2015 and 2016 remained $> 1.2^{\circ}\text{C}$ above the 1991-2020 climatology, with correspondence to the timing of the “blob” marine heatwave that impacted BC coastal waters (Bond et al. 2015; Cavole et al. 2016) as well as El Niño conditions (**Figure 22**; Leising et al. 2016).

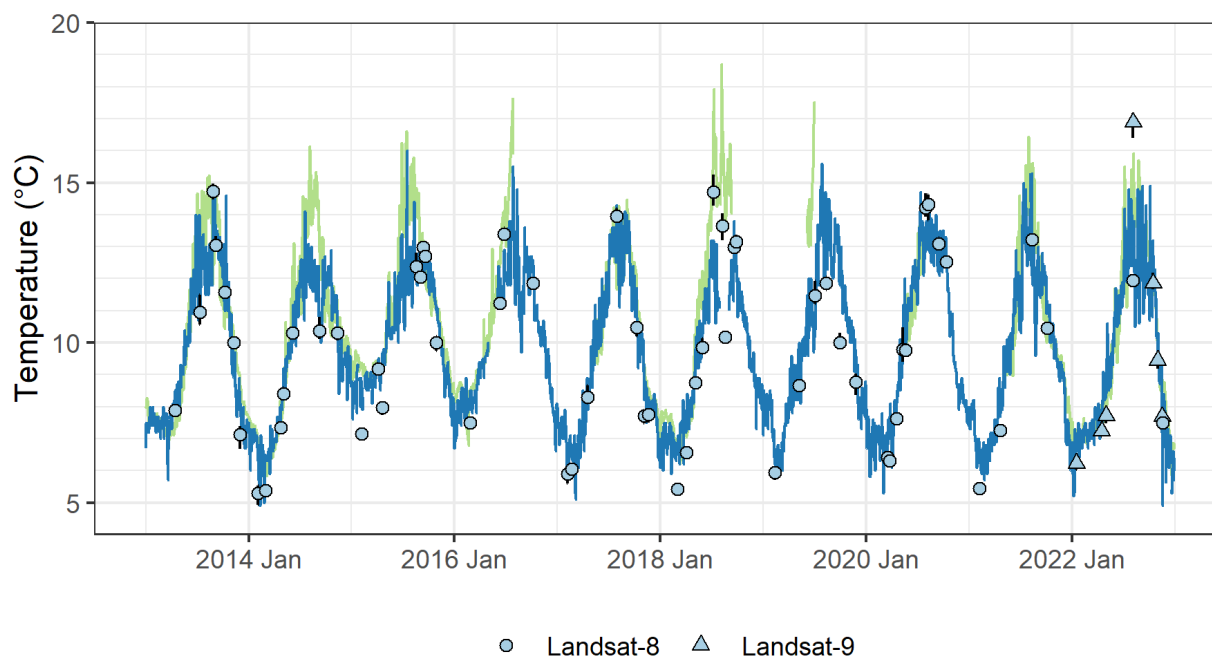


Figure 22. Daily temperature observations from the North Hecate buoy (light green), Lax Kul/Bonilla Island Light station (blue), and SST from Landsat-8 and -9 TIRS/TIRS-2 instruments averaged in a 1 km box centred on Lax Kul/Bonilla Island Lightstation (light blue points) (USGS 2022). Discrepancies between the values indicate small-scale processes, e.g. solar heating, **baask**/wind, or imperfect cloud/shadow masking, leading to differing temperatures, particularly as each are usually sampled at a different time of day.

Moderate and low resolution (e.g., 300-m to 4 km per pixel) satellite data supplement these in-situ observations by providing higher spatial coverage but at lower temporal resolution. The ocean surface is obstructed by cloud cover and conditions such as low sun angles that cause data loss. These data losses impact the most data time and space coverage during winter.

Numerous studies have analyzed moderate-resolution remotely sensed SST in the BC Exclusive Economic Zone (e.g., climatology shown in **Figure 3**). However, there are no SST studies in the narrow inlets and channels of the Kitkatla Inlet Network Zones area and direct surroundings. Thus, this report provides seasonal composites using the methods described in **Appendix E**. Composites on shorter timescales (i.e., monthly) are not possible due to the low time resolution of the Landsat satellites. Landsat-8 satellite provides images at 30-m spatial resolution on average every 19 days in this region since 2013. The launch of Landsat-9 in late 2021 has improved the revisit times to every eight days. Landsat SST has shown accurate results compared to *in situ* sensors in other coastal regions (Jang and Park, 2019; Vanhellemont, 2020; Vanhellemont et al. 2022), while preliminary analysis shows the in-situ surface temperatures at **Lax Kul**/Bonilla Island and the North Hecate Strait buoy agree well with those derived from the satellites (**Figure 22**).

Composite Landsat SST images depict the seasonal variations in SST around the Kitkatla Inlet Network Zones (**Figure 23**). In winter, the regional SST is approximately 6°C with colder water near major freshwater sources (e.g., the mouth of Skeena River) and sheltered areas such as Kitkatla Inlet (Zone 331) and Kingkown Inlet (Zone 330). Their winter SSTs are about 5°C, consistent with the average air temperature of nearby meteorological stations (**Figure 14**). In spring, sheltered areas such as Kitkatla Inlet warm faster than water in Hecate Strait (**Figure 23A**). During summer, areas west of Browning Entrance (between Zones 330 and 331) and thus well connected to Hecate Strait are relatively warmer than those within the Kitkatla Inlet Network Zones (**Figure 23C**). Notable exceptions are sheltered areas such as Kitkatla Inlet (**Figure 23C**) or surface waters dominated by local river discharges, which are warmer than elsewhere. During fall, the areas west of Browning Entrance (between Zones 330 and 331) remained warmer than those within the Kitkatla Inlet Network Zones (**Figure 23D**). The most sheltered areas, Kitkatla Inlet near **Lax ksi tgiw yuun**/Gurd Island (Zone 331) and Kingkown Inlet (Zone 330) experience the largest seasonal temperature variations.

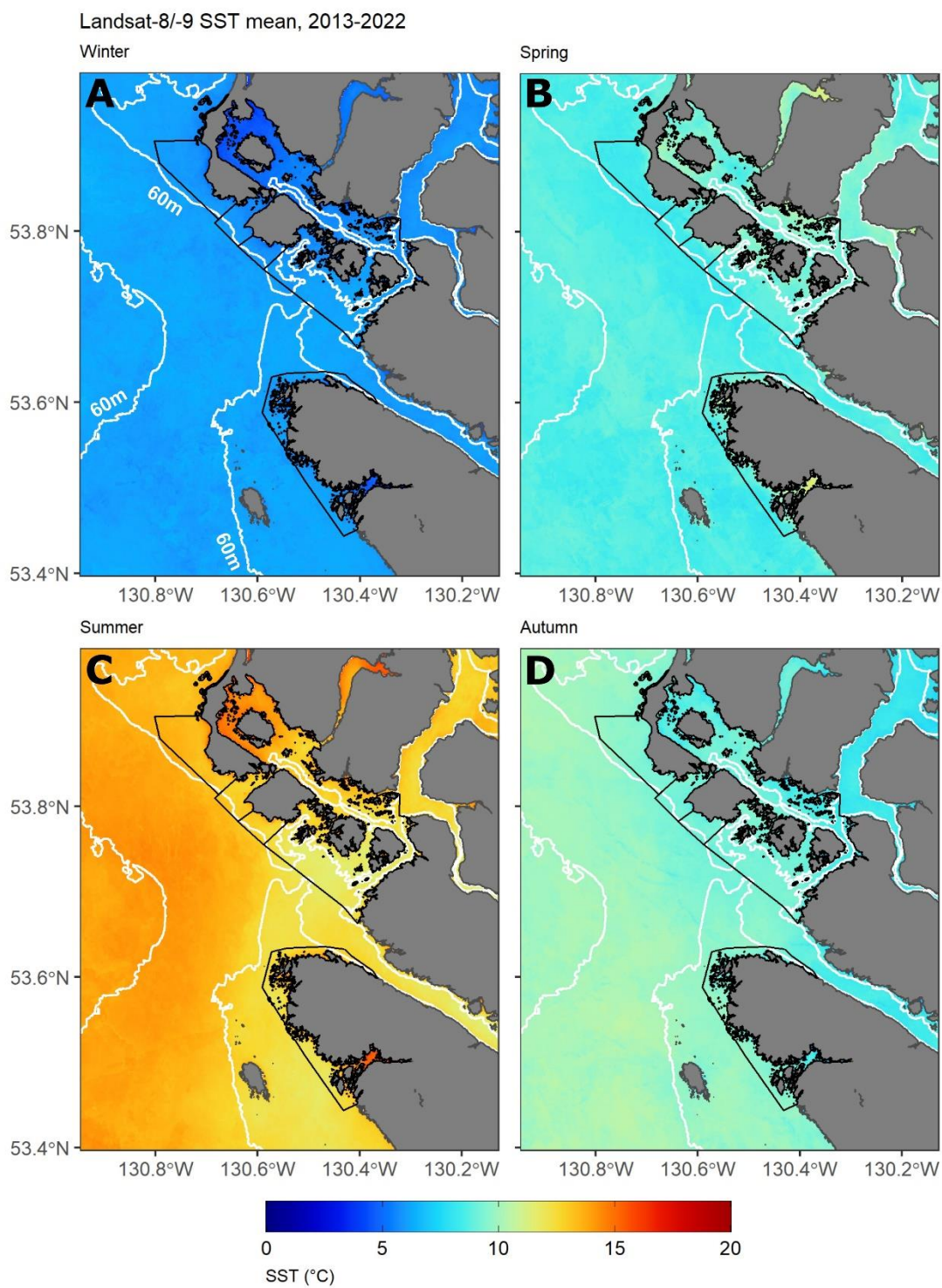


Figure 23. Seasonal SST composites from the Landsat-8 and -9 satellites showing the Kitkatla Inlet Network Zones (black lines) and 60 m isobath (white lines). Each season has a unique 6°C legend to reflect the SST range of the given period.

The starkest spatial gradients of SST are observed during summer in Browning Entrance offshore of Zone 333. SSTs west of Browning Entrance, in Hecate Strait, are on average 2.5°C warmer than those east where Principe Channel meets Beaver Passage (**Figure 23C**). However, the coolest temperatures appear on the south shore of Dolphin and Spicer Islands and in the passages between these islands (Zone 331). These areas are more exposed and constricted — vertical exchanges with deeper waters may cause cooler surface waters. In autumn, the east-west spatial gradient observed during summer in Browning Entrance persists, with surface water temperatures in Principe Channel (Zone 330) remaining cooler than those west of Browning Entrance (**Figure 23D**).

3.2.6.2 Suspended particulate matter (SPM)

Concentrations of suspended particulate matter (SPM) in surface waters include particles of terrestrial origin, resuspended material, and phytoplankton cells. SPM can reduce light available in the water column, and provide food for zooplankton. Lazin et al. (2017) estimated SPM concentrations across the area encompassing the Kitkatla Inlet Network Zones and the Caamaño-Douglas Network Zones using satellite remote sensing. Their analysis provided monthly averaged surface SPM from Medium Resolution Imaging Spectrometer (MERIS) and MODerate-Resolution Imaging Spectroradiometer (MODIS) satellite images. MERIS and MODIS collected several images per day between 2002 to 2012 (MERIS) and to 2014 (MODIS) and were processed at 250 m spatial resolution. Their estimates were not validated against in-situ observations, although the algorithms used were compared between satellites.

The estimated SPM varied seasonally across the region spanning Chatham Sound, Kitkatla and Caamaño-Douglas Network Zones (Figure 48 to 53 of Lazin et al. 2017). From the monthly-averaged images, high SPM ($> 3 \text{ g m}^{-3}$) were found at the mouths of major rivers, notably the Kitimat, Kitlope and Skeena Rivers, in particular when river discharges were higher than average (**Figure 15**). High SPM were found near the mouth of the Skeena River in Arthur Passage throughout most of the year (Figure 48 to 53 of Lazin et al. 2017). The plume of elevated SPM ($> 3 \text{ g m}^{-3}$) from the Skeena River reached the entrance of Kitkatla Channel and Beaver Passage only during spring freshet (Figure 50 of Lazin et al. 2017) when the Skeena River's discharge was at its annual maximum (**Figure 15**). At this time, monthly-averaged SPM reached 1 g m^{-3} in Kitkatla Channel (Zone 331) and on the exposed side of Dolphin and Spicer Islands (Figure 50 of Lazin et al. 2017). SPM was lower for the remaining Kitkatla Inlet Network Zones, albeit the monthly-averaged SPM did reach values close to 1 g m^{-3} during winter in the areas most exposed to Hecate Strait – offshore of Goschen and Porcher Peninsula (Zones 331, 332 and 333). The shallow water ($< 60 \text{ m}$) and deepening of the mixed surface layer make the bottom sediment more susceptible to resuspending during storms.

3.2.6.3 Light availability and optical conditions

Satellite imagery can estimate the depth at which light penetrates the ocean's surface. The maximum depth is wavelength-dependent and varies based on the optical properties and constituents in the water column. Numerous factors impact the optical conditions of surface waters in these regions, called coastal "Case-2" waters. "Case-2" broadly defines waters with high primary productivity with terrestrial inputs of CDOM and SPM (Morel and Prieur, 1977), which includes much of the world's coastal ocean and waters within the Kitkatla Inlet Network Zones. Factors other than CDOM and SPM that impact light availability include recurring **Geega**

tskah/herring spawn events in the surroundings of **Tgii Xsw'aanx**/Porcher Island and the Kitkatla Inlet Network Zones in late winter and early spring (see Forage Fishes). The milt (herring sperm fluid) has a unique spectral signature and can reduce the water clarity for days to weeks in areas spanning many square kilometres (Qi et al. 2021). Coccolithophore (phytoplankton) blooms in late summer may temporarily impact the light availability in the Kitkatla Inlet Network Zones by reducing the transmissivity of photosynthetically available radiation (PAR) and darkening and slowing heating in the waters below (Xu et al. 2016).

Satellite images are used here to estimate light availability from absorbing and scattering components using the diffuse attenuation coefficient for downwelling irradiance at 490 nm (K_d490 , see **Appendix F**). This coefficient depends on the ambient light field and optically active water column constituents (Mobley, 1994). Studies have related K_d490 , a measure of light attenuation, to the diffuse attenuation coefficient for the photosynthetically available radiation K_dPAR (Son and Wang, 2015) required to run numerical ocean models. K_dPAR is also used to define the euphotic (well-lit) maximum depth $Zeup$, corresponding to where light has attenuated to 1% of its surface value, translating $Zeup=4.6/ K_dPAR$ (Pierson et al. 2008). The relationship between the satellite-derived K_d490 and the in-situ K_dPAR changes in coastal turbid waters, and is site-specific. Thus, seasonal composites of light attenuation K_d490 is shown for the Kitkatla Inlet Network Zones (**Figure 24**), noting that $K_dPAR \approx K_d490$ for coastal waters (Son and Wang, 2015).

When the Skeena River's discharge is highest, light attenuation K_d490 in surface waters is also high ($> 0.3 \text{ m}^{-1}$) in areas nearer to the river mouth, such as the northern entrance to Kitkatla Channel (Zone 330, **Figure 24B**). In the autumn, the waters in **Maxla Kxa Naayxt** / Ogden Channel are slightly more transparent than in spring and reach their lowest values in winter when the Skeena River's discharge is at its annual minimum. Throughout the year, the lowest light availability within the Kitkatla Inlet Network Zones is where Ogden Channel meets Kitkatla Channel (Zone 331). The lowest average light attenuation K_d490 is about 0.3 m^{-1} , translating to a euphotic depth of less than 15 m. Also notable, the sheltered Kingkown Inlet and Kitkatla Inlet have higher diffuse attenuation ($> 0.17 \text{ m}^{-1}$, euphotic depth less than 25 m) compared to the open-ocean waters throughout the year (**Figure 24**).

The above estimates for the euphotic zone depth are less or of the same order as the surface layer. The surface layer is typically less than 20 m in the channels adjoining the Kitkatla Inlet Network Zones (see Water exchanges and properties with neighboring areas). Thus, the growth of phytoplankton in the areas nearest to the Skeena River may be light-limited during the warmer season.

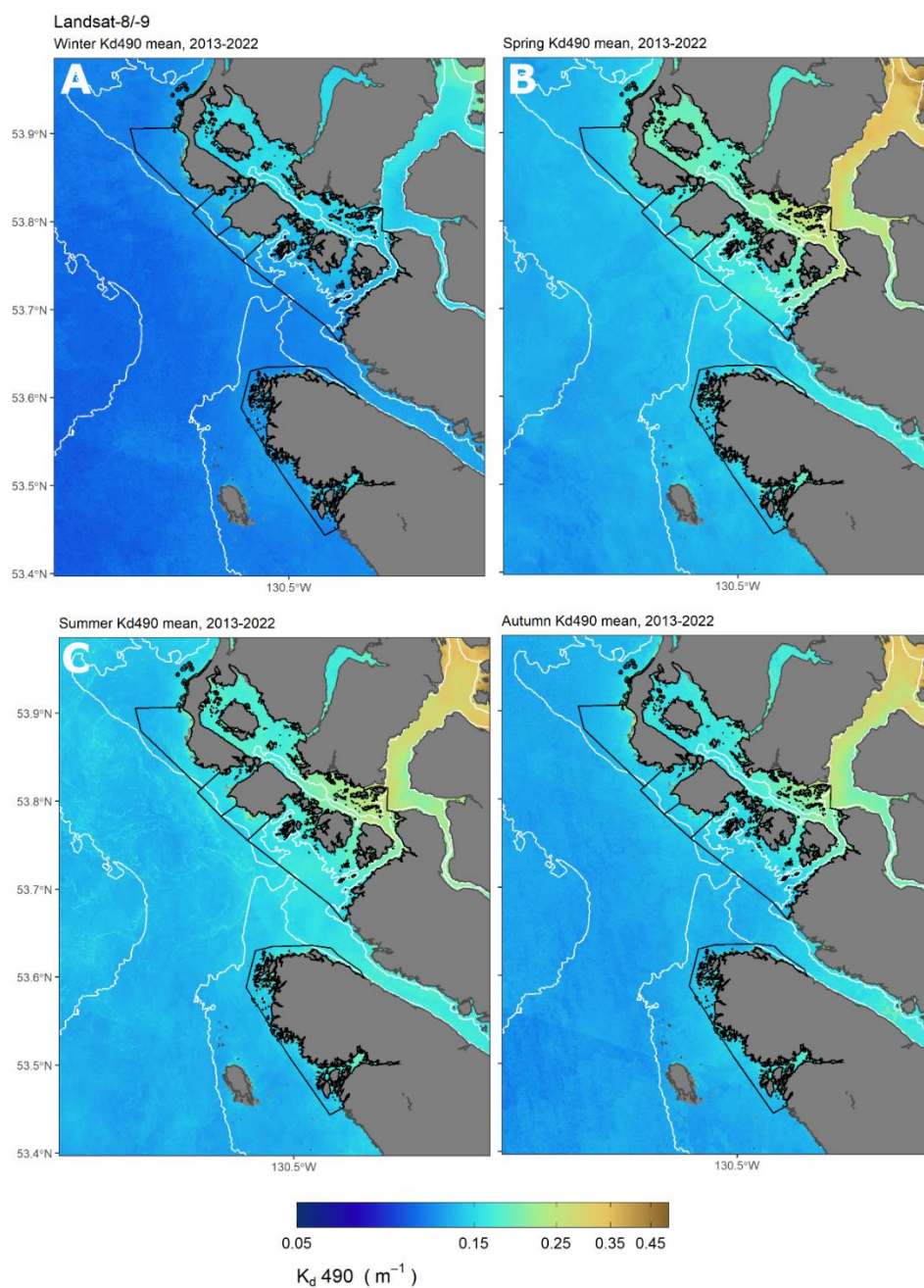


Figure 24. Seasonal mean $K_d 490$ for the Kitkatla Inlet Network Zones; note that colours are log-scaled. The standard deviation factor was used instead of standard deviation as it more appropriately describes variation in parameters with a log-normal distribution; Kirkwood, 1979).

3.2.7 Water exchanges and properties with neighboring areas

We describe subsurface water exchanges at the northern and southern entrances to Kitkatla Channel before inferring possible routes for subsurface exchanges within the Kitkatla Inlet Network Zones. These routes are interpreted from ship-based profiles (**Figure 25**) and moored observations (**Figure 10**) from adjoining areas that supply water to the Kitkatla Inlet Network Zones. More observations and modelling studies exist in the areas bordering the Kitkatla Inlet Network Zones than within, e.g., Lin and Fissel (2018) for Chatham Sound and Blanken et al. (2023) for Caamaño-Douglas. In particular, there are more observations in Hecate Strait and Chatham Sound during spring and summer and, to some extent, in Chatham Sound during fall (**Figure 25**). In contrast, Principe and Grenville Channel observations have not been collected during spring. Very few profiles and no moorings have provided measurements of water properties or **dooyaks**/currents within the Kitkatla Inlet Network Zones.

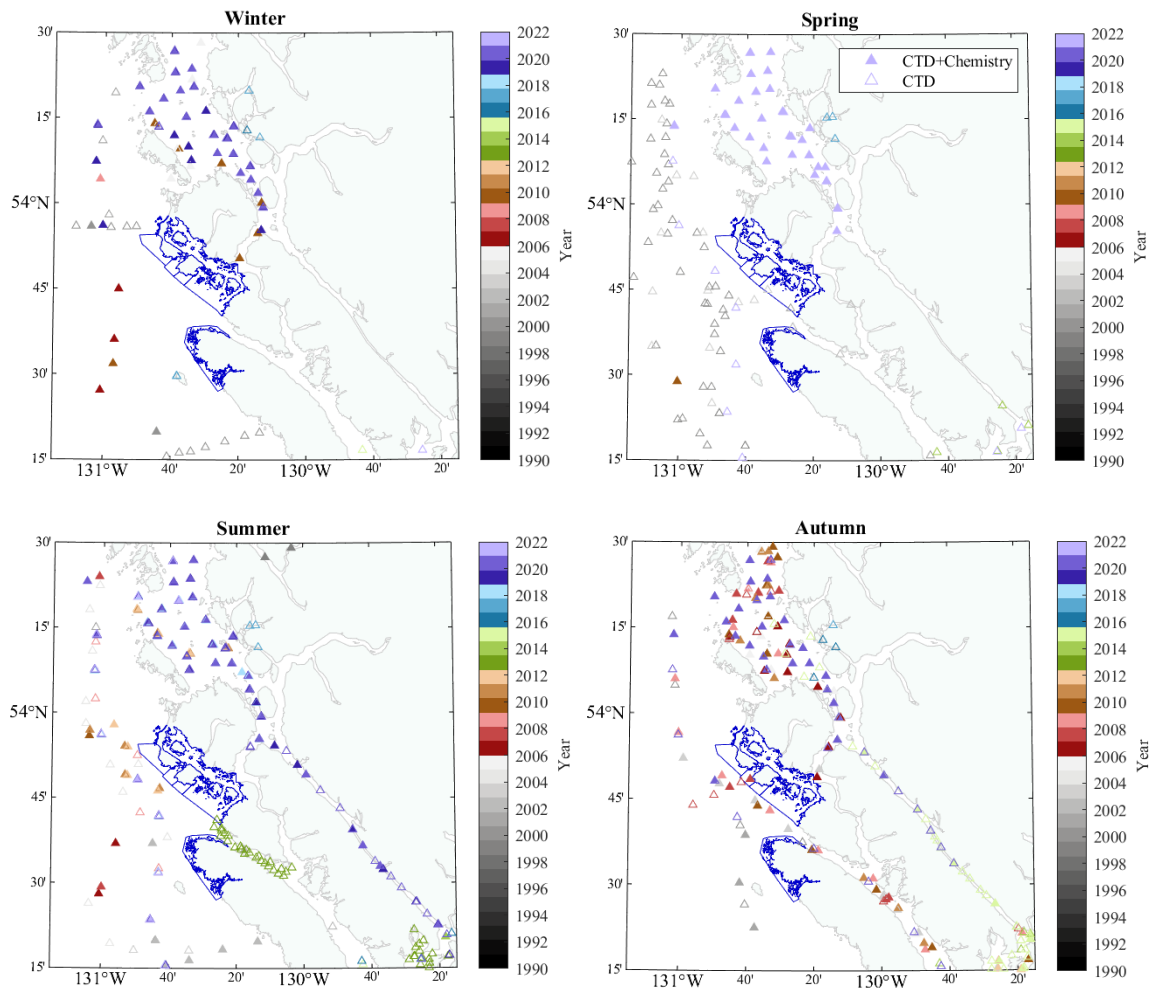


Figure 25. Spatial distribution of ship-based vertical profile measurements for each season. The conductivity-temperature-depth (CTD) profiler typically also measured fluorescence since the late 1990s and dissolved oxygen since 2009. The chemistry stations include water samples collected at discrete depths typically from a rosette equipped with a CTD. Occasionally, chemistry data is collected only from

the surface (e.g., nutrients from Ogden Channel in 2007). The Kitkatla Inlet Network Zones are delineated in purple.

Prevailing **baask**/winds, the earth's rotation, sills, and constrictions influence the Kitkatla Inlet Network Zones' exchanges with Chatham Sound, Hecate Strait, and the Caamaño-Douglas region via Grenville and Principe Channels. In the northern hemisphere, rotation tends to move water in a direction where shallower water is on the right. An estuarine circulation also affects water exchanges in the northern Kitkatla Inlet Network Zones (Zones 331, 332, and 333), supported by the significant snowmelt and rainfall in the region (**Figure 14** and **Figure 15**). However, the circulation differs from the simplest of estuaries because several large rivers' discharges peak at different seasons (**Figure 15**). During the freshet period from May to July, the Skeena River is a significant source of freshwater north of **Tgii Xsw'aanx**/Porcher Island (**Figure 15**), while the Caamaño watershed contributes significant freshwater during the rainy months (**Figure 14**). These difference in the timing of peak flows, along with prevailing **baask** strength and direction (**Figure 16**), influences Chatham and Caamaño-Douglas exchanges into Ogden Channel – the northern entrance of Kitkatla Channel (Zone 331). These same processes impact exchanges between Principe Channel (Zone 330) and Beaver Passage – the southern entrance to Kitkatla Channel (Zone 331).

In a typical estuarine circulation, a relatively fresh surface water outflows 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. The depth-averaged salt content increases towards the sea. Strong **baask**/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. Sills and constrictions hinder the lateral exchanges of deep water. However, the interaction of the strong tidal flows with sills may help redistribute heat, salinity, dissolved oxygen, and nutrients vertically because of locally enhanced mixing. The surface layer around the Kitkatla Network Inlet Zones is typically less than 20 m. In comparison, the subsurface (intermediate) layer extends to a 60 m depth, which coincides with the maximum depth at which water can flow freely around the area (see Bathymetry).

Generally, the deepest waters have relatively low oxygen and are nutrient-rich compared to the surface. 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 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, although the streams in northern BC are considered oligotrophic given their low nutrient concentrations. For example, nitrate concentrations peak during freshet but are always below 0.22 mg/L of N at the Skeena River's water quality monitoring station (#BC08EF0001). This station's nitrate concentrations are below the 0.7 mg/L threshold used by the provincial government to define a waterway as oligotrophic (Dodds et al. 1998). When the land-based nutrient supply is low, the estuarine circulation and sill-induced mixing can replenish some of the lost dissolved oxygen in deeper layers while transporting nutrients toward the surface.

3.2.7.1 Water properties in neighbouring areas

There are multiple entrances into the Kitkatla Inlet Network Zones (**Figure 10**), with each pathway having different salinity (density) gradients (**Figure 26**). These spatial density gradients drive the estuarine circulation as surface water moves from lower-density (fresher) areas toward saltier regions while an undersurface layer moves in the opposite direction. The existence and relative strength of the density gradients across the region influence the direction of flow and the rate of lateral exchanges and, thus, the composition of water that enters the sheltered inlets (Zones 331, 332, and 333) via Beaver Passage and Ogden Channel. The composition in these waters is also tightly linked with the vertical exchanges caused by the estuarine circulation exchanges and localized mixing where Principe Channel meets Beaver Passage and where Grenville Channel meets Arthur Passage. This mixing renders deep waters (below 60 m) in Arthur Passage and Ogden Channel warmer than in Chatham Sound and Grenville Channel (**Figure 27**). Other notable areas with likely intense mixing are where Beaver Passage meets Kitkatla Channel in Zone 331 and the exposed coastline south of **Tgii Xsw'aanx**/Porcher Island and around **Lax k'naga dzol**/Banks Island. From the existing observations, water enters Kitkatla Channel (Zone 331) from the south and north via Beaver Passage and Ogden Channel, respectively.

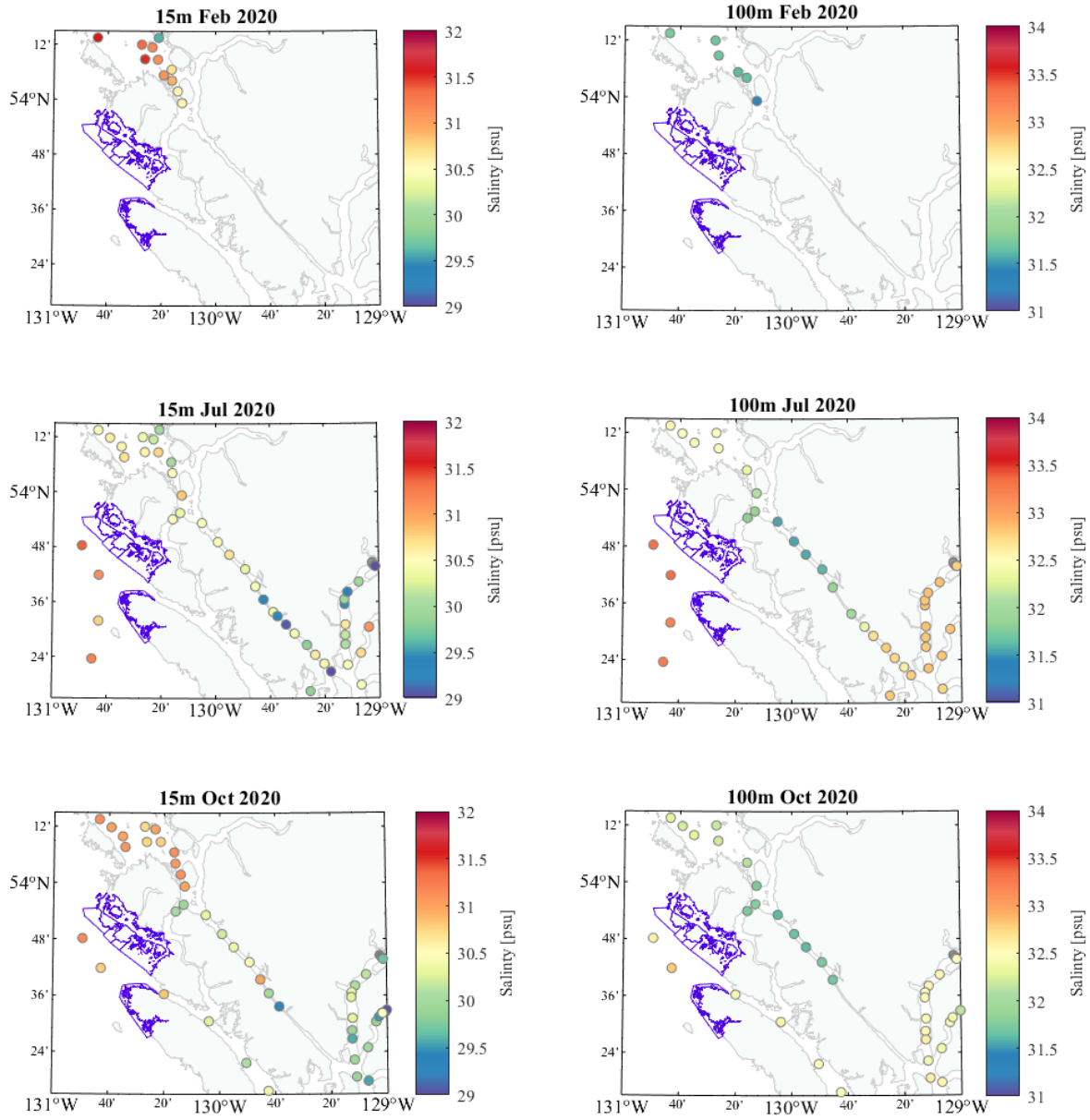


Figure 26. Spatial and seasonal variations of salinity measured at 15 m (left) and 100 m (right) depth during 2020 from a conductivity-temperature-depth profiler to illustrate density gradients that drive the estuarine circulation. The Kitkatla Inlet Network Zones are delineated in violet. Note the differing colour scales between the two depths shown. The shallow depth of 15 m was selected to identify the most likely direction of the estuarine circulation given the competing freshwater sources in the region.

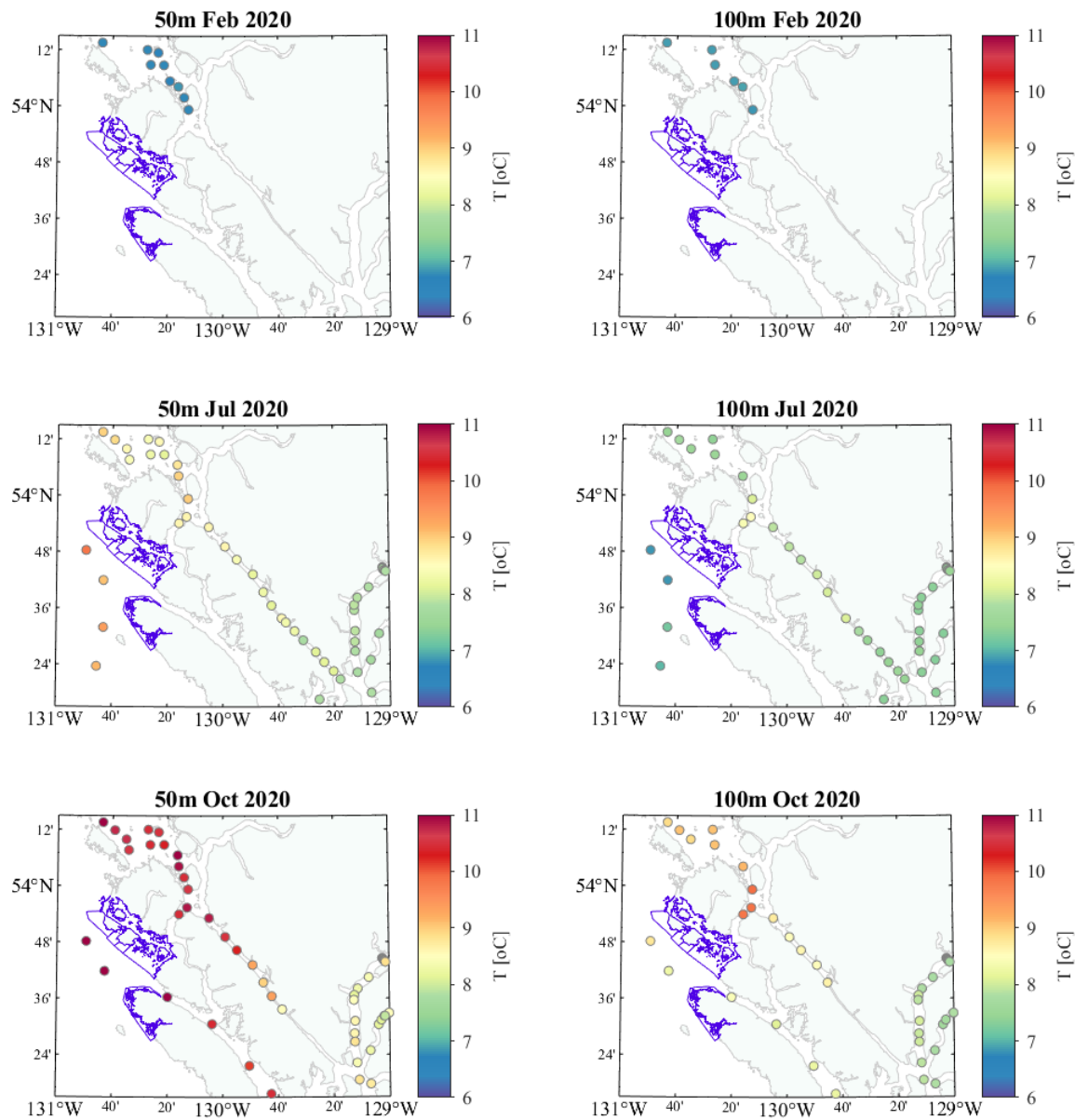


Figure 27. Spatial and seasonal variations of water temperatures measured at 50 m (left) and 100 m (right) depth during 2020 from a conductivity-temperature-depth profiler. The Kitkatla Inlet Network Zones are delineated in violet. The depths chosen are different from **Figure 26** to illustrate temperature differences between the water column's intermediate (< 60 m) and deep layers, in particular, the warm deep waters generated by vertical mixing at the intersection of Arthur Passage and Ogden Channel.

Geographical variations in dissolved oxygen concentration help to identify where hypoxia is more likely under current and future climate conditions (see Climate change impacts on coastal nearshore and inlet areas). In summer and fall, oxygen concentrations below 100 m are typically lowest in Chatham Sound and Hecate Strait and highest in Principe and Grenville Channel (**Figure 28**). The concentrations in Ogden Channel are somewhere between those found in neighbouring channels (**Figure 28**, summer). These deep waters are a mixture of Chatham's

deep and relatively low-oxygenated water and relatively more oxygenated deep water leaving the Caamaño-Douglas area.

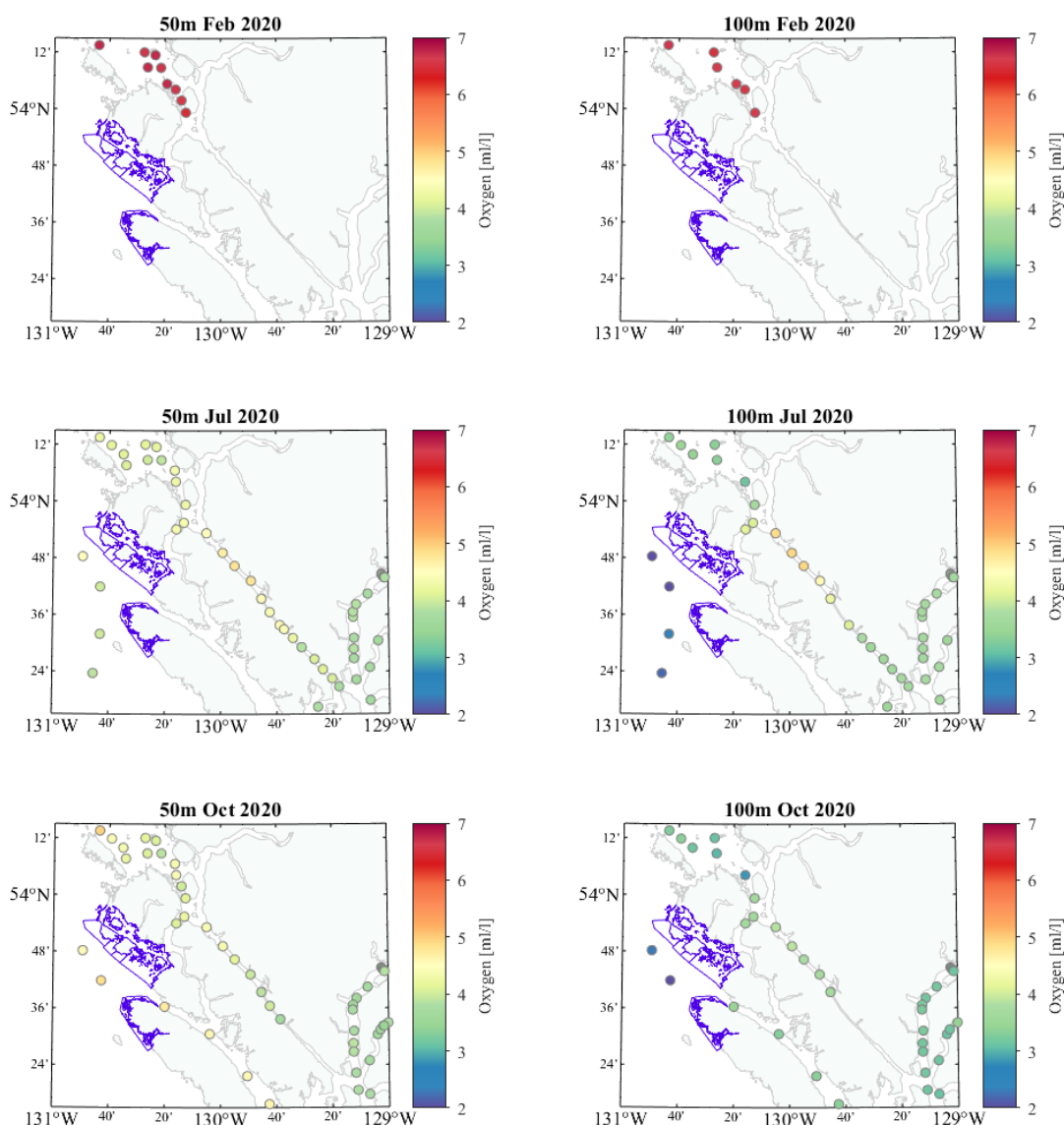


Figure 28. Spatial and seasonal variations of dissolved oxygen concentrations measured at 50 m (left) and 100 m (right) depth from a conductivity-temperature depth profiler. The Kitkatla Inlet Network Zones are delineated in violet. The depths chosen are different from **Figure 26** to illustrate oxygen differences between the water column's intermediate (< 60 m) and deep layers, in particular the elevated deep oxygen during summer at the intersection of Arthur Passage and Ogden Channel, and at the northwest end of Grenville Channel.

Deep oxygen near the Kitkatla Inlet Network Zones varies seasonally, like other areas along the BC coast (**Figure 28**). Concentrations are highest at the end of winter, with values exceeding 6.5 ml/l throughout the entire water column according to the limited observations collected in Ogden Channel (Mar 2010, not shown) and Arthur Passage (**Figure 28**). Deep oxygen

concentrations then drop steadily throughout the spring and summer because of biogeochemical consumption and reduced vertical exchanges. Oxygen concentrations at depth reach their annual minimum in the fall (**Figure 28**). The deeper areas measured (< 100 m) are not hypoxic and are always higher than those found at equivalent depths in Moresby Trough, offshore of **Lax k'naga dzol**/Banks Island (Zone 330) and **Tgii Xsw'aanx**/Porcher Island (exposed coastline of Zones 331, 332, 333). The cause of higher oxygen levels within the inlets near the Kitkatla Inlet Network Zones is challenging to ascertain. It is likely attributed to localized mixing at constrictions and sills (see Bathymetry), which transports down the well-oxygenated, relatively fresh surface waters that have recently flowed into the area from local watersheds. Oxygen is likely also provided by the intense winter mixing and intrusions of the well-oxygenated surface waters of Chatham Sound at intermediate depths in Ogden Channel (see next section).

3.2.7.2 Property diagrams to identify water sources and exchanges

We use property diagrams to identify and track water masses moving throughout the areas surrounding the Kitkatla Inlet Network Zones (**Figure 29** to **Figure 31**). These diagrams present water properties, typically potential temperature, as a function of salinity since these two parameters dictate water density (potential temperature accounts for pressure effects). Each water mass has unique properties, and by plotting observations collected from vertical profiling instruments across a broad region, one may identify the water's origin. As an example of how these are interpreted, a property diagram would show two groups of points if the water column had only two layers that did not mix. In reality, some vertical exchanges and mixing occur between layers, manifesting as a “mixing line” that joins the two water masses on a property diagram. A property diagram will exhibit two mixing lines when the surface layer is directly exposed to the atmosphere and receives considerable freshwater inputs, i.e., estuarine systems such as those along the BC coast. The lines intersect at the interface between the surface and deeper layers. Subsurface intrusions manifest themselves in the property diagrams as a sudden change in temperature over a short salinity range, e.g., the 10°C and 30.5 psu water in Arthur Passage (**Figure 29a**). The amplitude of this change will subside and cover a thicker layer of water in the opposite direction of where the water originated from. Hence, the property diagrams along with the mapped density gradients (**Figure 26**) show that a subsurface intermediate layer intrudes from Browning Passage into Principe Channel (**Figure 30**) and Chatham Sound into Arthur Passage and Grenville Channel (**Figure 29** and **Figure 30**).

The property diagrams can also present non-conservative substances, such as oxygen and nutrients consumed or cycled through biogeochemical processes. The “mixing line” may become curved because of these processes. A concave shape indicates consumption, while a convex shape typically indicates replenishment. This report presents dissolved oxygen to assess whether water masses have elevated oxygen relative to their salinity (density), as density differences drive flows in fjords and inlets. The nutrient property diagrams (nitrate+nitrite) and dissolved oxygen profiles are also used for identifying zones of more intense vertical mixing, e.g., Arthur Passage near Ogden Channel (**Figure 29c** and **Figure 30c**).

3.2.7.2.1 Water exchanges into the north entrances of Kitkatla Channel (Zone 331)

In Chatham Sound, the earth's rotation will tend to force freshwater discharges to flow northward with the coast to its right (Trites 1956). However, differing freshwater discharges, both in quantity and timing of peak flows of the Nass and Skeena rivers (**Figure 15**), influence

how and where this freshwater exits Chatham Sound. During average river flow conditions, up to 30% of the freshwater from the Skeena is transported through the central and south passages towards Hecate Strait (Trites 1956). Of this 30%, about half goes through the central passages, i.e., Brown and Bell Passages. The remaining freshwater exits south through Eddy Passage (west of **Tgii Xsw'aanx**/Porcher Island near Zone 331), Ogden and Grenville Channel (Trites 1956). During the spring freshet, more of the Skeena's river flow may flow through the south passages towards the Kitkatla Inlet Network Zones and southwest in Grenville Channel than during winter, which translates into elevated suspended material near the surface (Figure 50 and 53 of Lazin et al. 2017).

From the summer and fall property diagrams, a subsurface intrusion enters Ogden Channel from Arthur Passage (**Figure 29** and **Figure 30**), which feeds the northern entrance of Kitkatla Channel. This intermediate intrusion is relatively warm compared to shallower and deeper waters (**Figure 30a,d**). It originates from Chatham Sound and creates a subsurface nutrient minimum with elevated oxygen during fall and summer in Arthur Passage (e.g., red triangles in **Figure 30c**). The low nutrients and elevated dissolved oxygen are attributable to freshwater inputs from the Nass and Skeena Rivers. Given the limited concurrent observations throughout the neighbouring channels (**Figure 26**), the origin of deep waters in Ogden Channel is more difficult to ascertain. Existing observations suggest that the deep water partially originates from Chatham Sound (**Figure 30a CEB17**). The property diagrams indicate that the deep waters of Ogden Channel may include more contributions from Grenville Channel in summer than in fall. Overall, deep exchanges between Ogden Channel, Grenville Channel, and Arthur Passage vary seasonally.

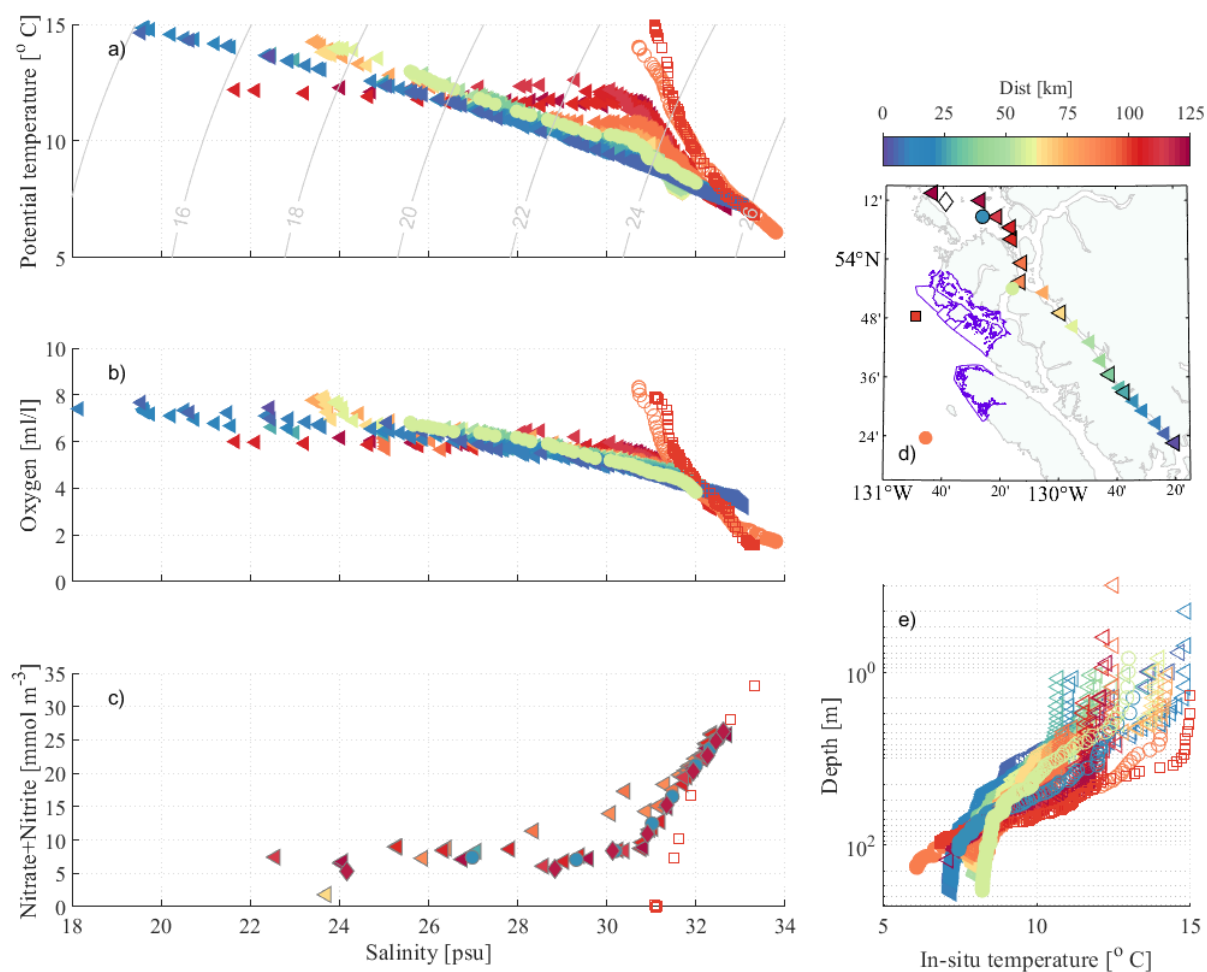


Figure 29. Property diagrams for (a) potential temperature, (b) dissolved oxygen, (c) nitrate+nitrite (nutrients) as a function of salinity during summer (between July 23 2020 and August 4 2020). The vertical profiles for water temperature measured by the conductivity-temperature vertical profiler are shown in (e). Profile locations are illustrated in (d) with those outlined in black indicating where nutrient bottles were collected. The solid grey contours in (a) represent lines of constant potential density minus 1000 kg/m³. The Kitkatla Inlet Network Zones are delineated in (d) with violet polygons.

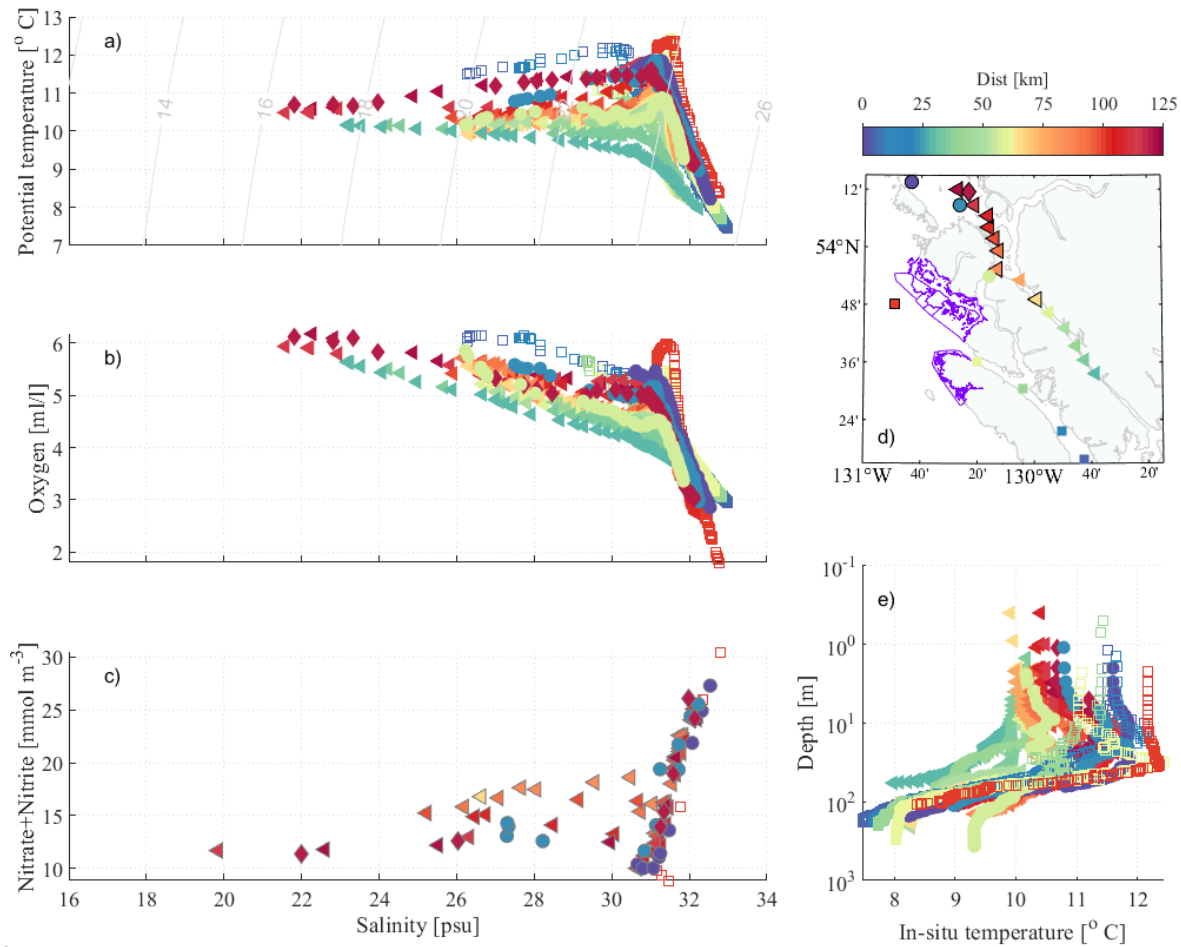


Figure 30. Property diagrams for (a) potential temperature, (b) dissolved oxygen, (c) nitrate+nitrite (nutrients) as a function of salinity during October 2020. The vertical profiles for water temperature measured by the conductivity-temperature vertical profiler are shown in (e). Profile locations are illustrated in (d), with those outlined in black indicating where nutrient bottles were collected. The solid grey contours in (a) represent lines of constant potential density minus 1000 kg/m³. The open symbols in (a-c) are to differentiate data along Principe Channel and Browning Entrance from those north of the Kitkatla Inlet Network Zones delineated in (d) with violet polygons.

During winter, the existing ship-based observations indicate that convective and storm-related mixing creates a thick and well-mixed surface layer in Chatham Sound (**Figure 31e**). In this season, water below approximately 80 m is warmer than at the surface (**Figure 31e**). Like the Caamaño-Douglas region, oxygen levels are highest throughout the waterways adjoining the Kitkatla Inlet Network Zones during winter than at other times of the year (**Figure 31b**). Nutrient concentrations also reach their annual maximum in winter, although nitrate is only fully consumed during summer in Browning Entrance west of the 60 m constriction (**Figure 29**). During winter, the deepest waters in Chatham Sound become well-oxygenated, providing oxygen to the deep waters in Arthur Passage and Ogden Channel.

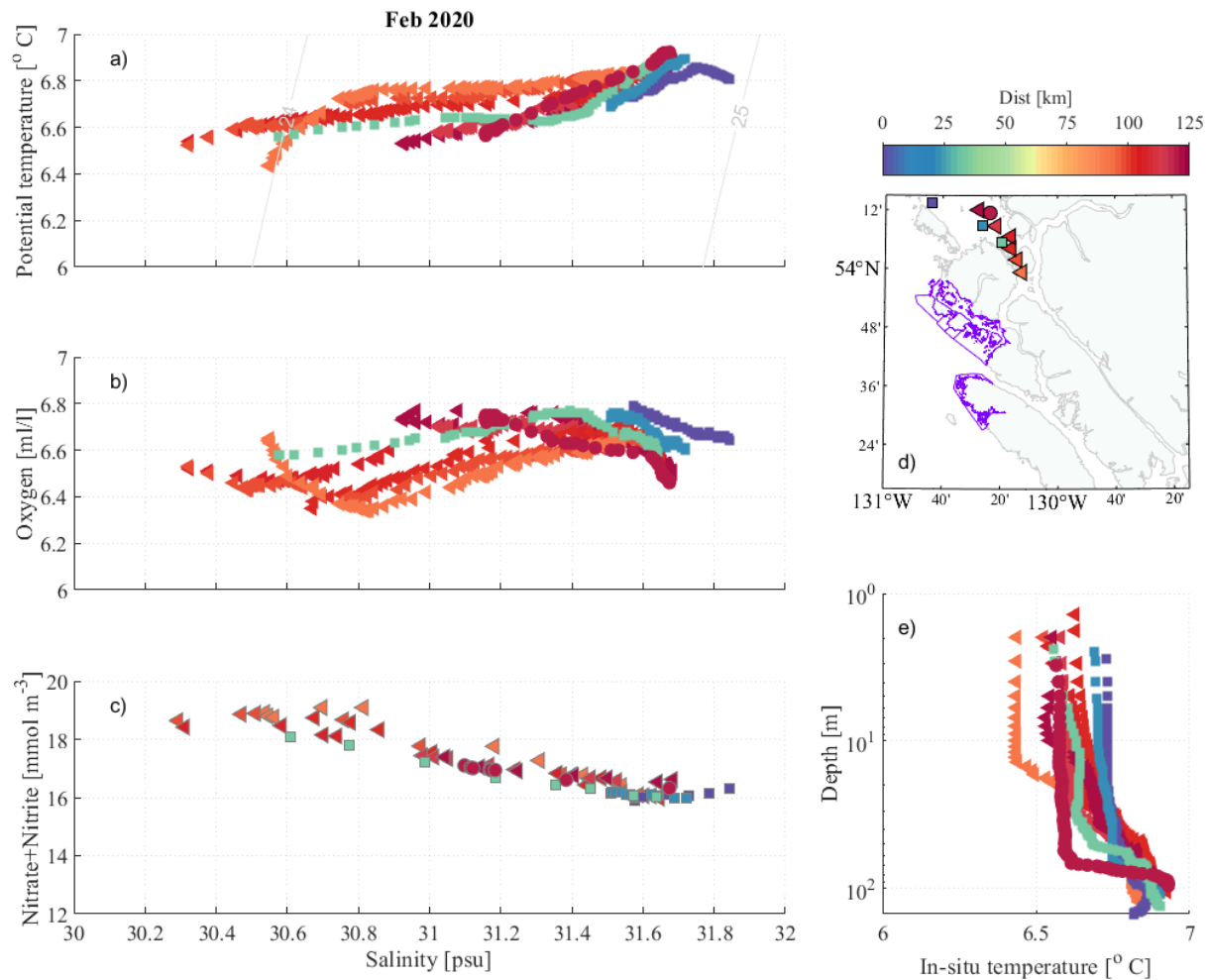


Figure 31. Property diagrams for (a) potential temperature, (b) dissolved oxygen, (c) nitrate+nitrite (nutrients) as a function of salinity during February 2020. The vertical profiles for water temperature measured by the conductivity-temperature vertical profiler are shown in (e). Profile locations are illustrated in (d), with those outlined in black indicating where nutrient bottles were collected. The solid grey in (a) represents a line of constant potential density of 1024 kg m⁻³ and 1025 kg m⁻³. The Kitkatla Inlet Network Zones are delineated in (d) with violet polygons.

Other important features in the region are constriction and shallowing areas that induce vigorous mixing and vertical exchanges. For example, the 60 m deep constriction in Arthur Passage near the intersection of Grenville and Ogden Channel (**Figure 10**) induces significant mixing between the surface and intermediate waters. Vertical conductivity-temperature depth profiles through this area show elevated nutrients at depths with salinities of 28 to 30 psu (orange triangles in **Figure 30c** and **Figure 31c**). The increased nutrients in Ogden Channel are not associated with the Skeena River's discharge since the increase is more pronounced in October when this river's discharge is low (**Figure 15**), and the river's nutrient loads are also low according to provincial water quality monitoring. The limited observations in Oct 2007 and Mar 2010 (not shown) indicate that the relatively high nutrient concentrations persist further south in Ogden Channel, with potentially higher concentrations near the entrance of Kitkatla Channel

(Zone 331). The shallow areas at both entrances to Ogden Channel appear to induce strong vertical mixing.

3.2.7.2.2 Water exchanges into the south entrances of Kitkatla Channel (Zone 331)

Water properties west of the 60 m constriction in Browning Entrance between Zones 330 and 331 (**Figure 10**) are distinctly different from those east of the constriction (**Figure 23C**). West of this constriction, offshore of Zones 332 and 333, water properties are more similar to those in Hecate Strait. The water column is better mixed, saltier, and warmer near the surface (Nov 2009, not shown). There are also less surface nutrients in western waters connected with Hecate Strait than in Principe Channel. The eastern region encompasses the northern coastline in Zone 330 and the west coastline of Zone 331. These eastern areas are strongly influenced by water leaving the Caamaño-Douglas region via Principe Channel and thus have much more nutrients in the euphotic zones than offshore waters south of **Lax k'naga dzol**/Banks Island (Zone 330).

Like Grenville Channel, Principe Channel exhibits warm intrusion (30-80 m) of well-oxygenated water (**Figure 30a**). This intrusion shares properties similar to Ogden Channel that originated from Chatham Sound and water at shallower depths in Browning Entrance (**Figure 30a**). Thus, subsurface water from Hecate Strait enters the 60 m deep constriction in Browning Entrance and flows towards Principe Channel and Beaver Passage. However, existing observational and modelling datasets cannot estimate the subsurface exchanges through this pathway or any seasonal changes in this flow pattern. Nonetheless, Kitkatla Channel (Zone 331) water likely represents a mixture of water from Beaver Passage that is connected with Principe Channel and Hecate Strait and water from Ogden Channel that is connected to Chatham Sound and the Caamaño-Douglas Network Zones.

3.2.8 Knowledge gaps for water exchanges and properties within the Kitkatla Inlet Network Zones

There are few in-situ observations about the water properties and **dooyaks**/currents within the Kitkatla Inlet Network Zones (**Figure 25**). The lack of observations prevents making assertions about the subsurface conditions in the sheltered inlets such as Kitkatla and Kingkown Inlet (Zone 331 and 330), the shallow areas around Porcher Peninsula (Zone 331), and Goschen, Dolphin and Spicer Islands in Zone 331 to 333. The water properties, such as nutrient and oxygen concentrations in the shallower areas north of these islands in Kitkatla Inlet, depend partly on properties in Kitkatla Channel (Zone 331). The deep water properties in Kitkatla Channel (~70 m) must be determined, although it is likely a mixture of water from Beaver Passage and Ogden Channel. These waterways are connected to channels with differing properties – Principe and Grenville Channels (see **Figure 26** to **Figure 28**). To infer the source of deep water in Kitkatla Channel (Zone 331), oceanographic observations (e.g., CTD profiles) should be collected across these four channels. Given the differences in freshwater inputs throughout the region, these measurements should be obtained at different seasons, or a minimum, during early summer and late fall.

Satellites can significantly improve spatial and temporal monitoring of surface water properties, particularly for remote areas where physical sampling is challenging, but there are many limitations and considerations. Data availability, spatial and temporal resolution of satellite

imagery all have implications for what marine variables can be described by the imagery. Landsat-8 and -9 imagery are detailed in this report as they have greatly improved spatial resolution compared to legacy moderate-resolution, high revisit time sensors (e.g., daily or greater). Secondly, the instruments on these satellites allow concurrent imaging of thermal and optical wavelengths, allowing the parameters detailed here (Chl-a, K_d490 , SPM, SST) to be examined simultaneously in time and space. An additional key knowledge gap with relation to the Kitkatla Inlet Network Zones is the collection of *in situ* samples that can be used to validate satellite algorithms. Several studies have validated satellite parameters in coastal BC waters, though the majority focus on Chl-a or optical parameters in the Strait of Georgia (Carswell et al. 2017; Clay et al. 2019; Komick et al. 2009; Pramlall et al. 2023). Giannini et al. (2021) additionally validated SPM and CDOM. However, more sampling and satellite validation are needed, particularly considering that similar efforts have not been undertaken for Ocean Colour variables from higher-resolution satellites, including Landsat-8/-9 or Sentinel-2. At this time, we know very little about the optical properties, including the relative contributions of the Chl-a, CDOM and SPM mentioned here, to absorption and scattering in the water column of the Kitkatla Inlet Network Zones.

Another question is how deep water mingles with those nearshore (depths < 20 m) in the Kitkatla Inlet Network Zones, in addition to local biogeochemical properties. For example, Kitkatla Inlet is sheltered from significant surface wave activity and has considerably different surface water temperatures (**Figure 23**) than deeper areas directly east in Kitkatla Channel (Zone 331). Thus, are the sheltered inlets like Kitkatla Inlet high in nutrients compared to adjacent areas, and what are nutrient sources in the region? Are they upwelled from the deeper areas through the interaction of the **aks**/tides with topography at the west end of Kitkatla Channel, or do they originate from local biogeochemical cycling? Similar knowledge gaps exist for the areas south of Goschen, Dolphin and Spicer Islands (Zones 331 to 333) and Kingkown Inlet (Zone 330). However, these areas are more directly connected with Hecate Strait than Kitkatla Inlet. Kingkown and Kitkatla Inlets have unique surface water properties, and their biogeochemistry likely depends on an amalgamation of local physical and biogeochemical processes. Their biogeochemical properties and exchanges with adjoining areas in the Kitkatla Inlet Network Zones are currently unknown. To remedy these knowledge gaps, nutrients, oxygen, and photosynthetic active radiation (PAR), i.e. the amount of sunlight diffusing through the water column, should be measured within the Kitkatla Inlet Network Zones. The adjoining areas appear to have relatively high nutrients, although the amount consumed in the Kitkatla Inlet Network Zones remains unknown. The current information cannot tell us with certainty whether any Kitkatla Inlet Network Zones are light-limited. In-situ PAR measurements would be required at the very least to validate any remotely sensed estimates of light attenuation, if not to provide the information about light directly throughout the water column.

Another potential resource would be numerical (hydrodynamic) modelling outputs. Those that exist, however, have an insufficient spatial resolution (>1km), or they have not been validated for the Kitkatla Inlet Network Zones because of a lack of data or because their boundaries are too close to the Kitkatla Inlet Network Zones. For example, ECCC's "Coastal Ice-Ocean Prediction System for the West Coast of Canada" (CIOPS-West) provides 48-hour ocean forecasts every 6 hours and a spatial resolution of 1/36th degree. The freshwater forcing is obtained from climatological data as opposed to current discharges. A higher resolution model (500 m) exists around the Caamaño-Douglas region (Blanken et al. 2023). However, its northwest boundary is too close to the Kitkatla Inlet Network Zones to accurately predict the

zones' **dooyaks**/currents and water properties. Another model was created for the World Class Tanker Safety Program with a horizontal resolution of up to 200 m in the narrow channels (Shan et al. 2019; Shan et al. 2020). **aks**/Tides, **baask**/winds, and river discharges force the model. Still, it has yet to be validated against the limited water properties observations in the Kitkatla region since its purpose was to reproduce conditions and investigate exchanges in the Caamaño-Douglas region.

The exchanges between sheltered and less sheltered areas must be quantified to remedy these knowledge and data gaps. This quantification requires, in the first instance, field observations of water properties (dissolved oxygen, nutrients, salinity, and temperature) and current measurements, especially around **Lax ksi tgwi yuun**/Gurd Island in Kitkatla Inlet (Zone 331). Detailed measurements would enable the establishment of the main processes that control conditions in the sheltered areas. Another possible tool would be setting up and validating a high-resolution numerical model for **dooyaks**/currents and basic properties such as salinity and temperature. This tool would still necessitate field measurements for setting up and validating the model across different seasons. Once set up, various scenarios and forcings could be investigated to confirm which processes control the system so that future changes could be more easily monitored.

Additional Gitxaala Indigenous Knowledge may also help understand some of the dynamics described above, however knowledge collection studies conducted to date have not focused on water exchanges and properties within the Kitkatla Inlet Network Zones. Further, across British Columbia, RCA's are largely free of oceanographic data highlighting a data gap that could be filled by local knowledge. Future research projects conducted will include specific reference to these gaps and may be used in addition to the suggested research above.

4 CLIMATE CHANGE

Climate change is altering the ocean's physio-chemical properties as global temperatures and atmospheric carbon dioxide increase. These changes in seawater temperature, chemistry, and oxygen 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), as well as by Indigenous land users. The long-term warming rate of stations with data beginning in 1935 is estimated to be 0.99°C per century in **Lax Kul**/Bonilla Island adjacent to the Kitkatla Inlet Network Zones, in comparison to a coast-wide value of 0.96°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). Like many other coastal regions in the world, BC's coastal seawater is warming more rapidly than the global average warming rate of sea surface temperature (Amos et al. 2015). Additionally, a warming trend is projected into 2070 by two different regionally downscaled climate change models (Peña et al. 2019; Holdsworth et al. 2021) detailed below. Alongside increases in mean seawater temperature, climate change is causing an increased frequency and intensity of extreme heat events, including aerial and marine heatwaves (Oliver et al. 2021). These events can cause mass mortality events across

intertidal and marine systems (Raymond et al. 2022). As air and water temperatures rise, the dissolved oxygen content of the ocean declines and oxygen demand from organisms increases. In addition, rising atmospheric carbon dioxide levels increase the seawater acidity as carbon dioxide is absorbed, lowering the pH. Marine species generally shift their ranges in response to environmental change, tracking favourable conditions (e.g., deeper, colder waters, where their physiological tolerances and dispersal abilities allow); however, low oxygen will limit how deep they can shift (Magris et al. 2016; Lenoir et al. 2021; Thompson et al. 2023a). Finally, climate change is leading to rising sea levels, which can disrupt shoreline biophysical processes and lead to reduced habitat and altered ecosystem function.

Below we present some future projected climate changes within the Kitkatla Inlet region through changes to ocean environmental variables and a short literature review of inland and nearshore changes and freshwater inputs. invertebrate

4.1 Projected changes to ocean environmental variables

Projected future seasonal environmental conditions in the Kitkatla Inlet 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 **dooyaks**/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 regions of the Kitkatla Inlet Network Zones (**Figure 32**) due to the uncertainty involved with the models in nearshore areas not accounting well for bathymetry, narrow channels between islands, and varying flow. **Figure 32** shows the difference between a mask extent with higher data confidence and the full extent of the netcdf files in the Kitkatla Inlet Network Zones area. 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 Kitkatla Inlet 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.

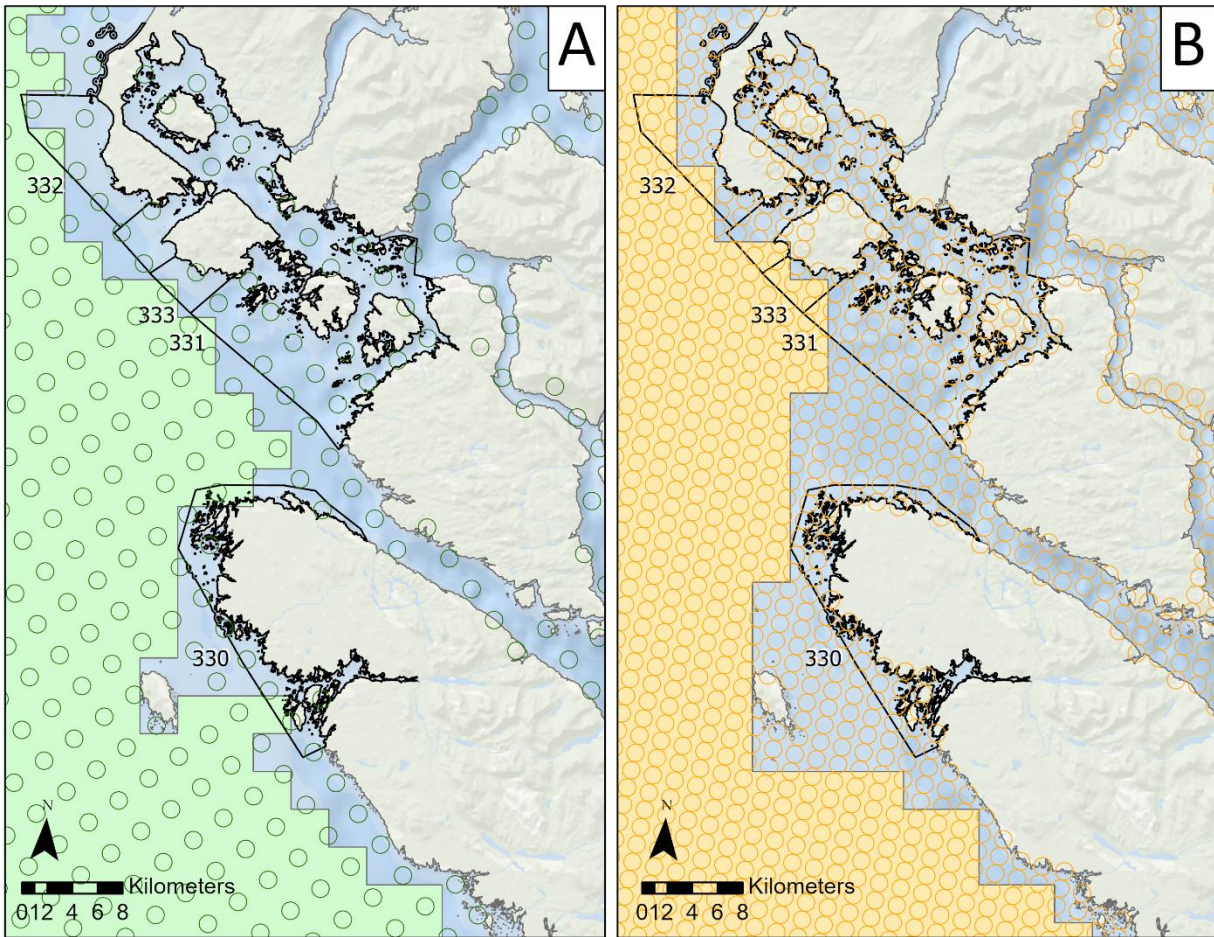


Figure 32. (A) BCCM mask extent shown as a green filled polygon; BCCM NetCDF extent shown by green outlined circles. (B) NEP36 mask extent shown as an orange filled polygon; BCCM NetCDF extent shown by orange outlined circles.

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 and alteration of intertidal ecosystems and increased salinity in salt marshes (Thorne et al. 2012) (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), coastal squeeze in regions with coastal development or hard shorelines, and increased inundation and flooding (Thorne et al. 2012). Within the Kitkatla Inlet Network Zones, sea level rises of between 0.66 and 0.69 m are projected for 2099 compared to the base year of 2006 throughout the coastline (**Figure 33A**). 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 Kitkatla Inlet Network Zones have a Coastal Sensitivity Index of 2 (with 5 being the highest sensitivity) (Manson et al. 2019).

Wave height is a potentially changing environmental variable with climate change. Warming ocean temperatures and extreme **baask**/wind speeds increase wave energy and can result in 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 1.43 and 1.92 m for the Kitkatla Inlet Network Zones (**Figure 33B**) and have a Coastal Sensitivity Index of 3 to 4 (Manson et al. 2019). This is a neutral change in significant wave heights modelled for 1996 to 2005 of 1.43 to 1.92 m for the Kitkatla Inlet Network Zones. Projected increases in wave height are lowest for the southwestern portions of the Zone aggregate. The highest values occur in the northeastern edge of **Tgii Xsw'aanx**/Porcher Island and in the northern part of the Inlet (Zone 331). 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).

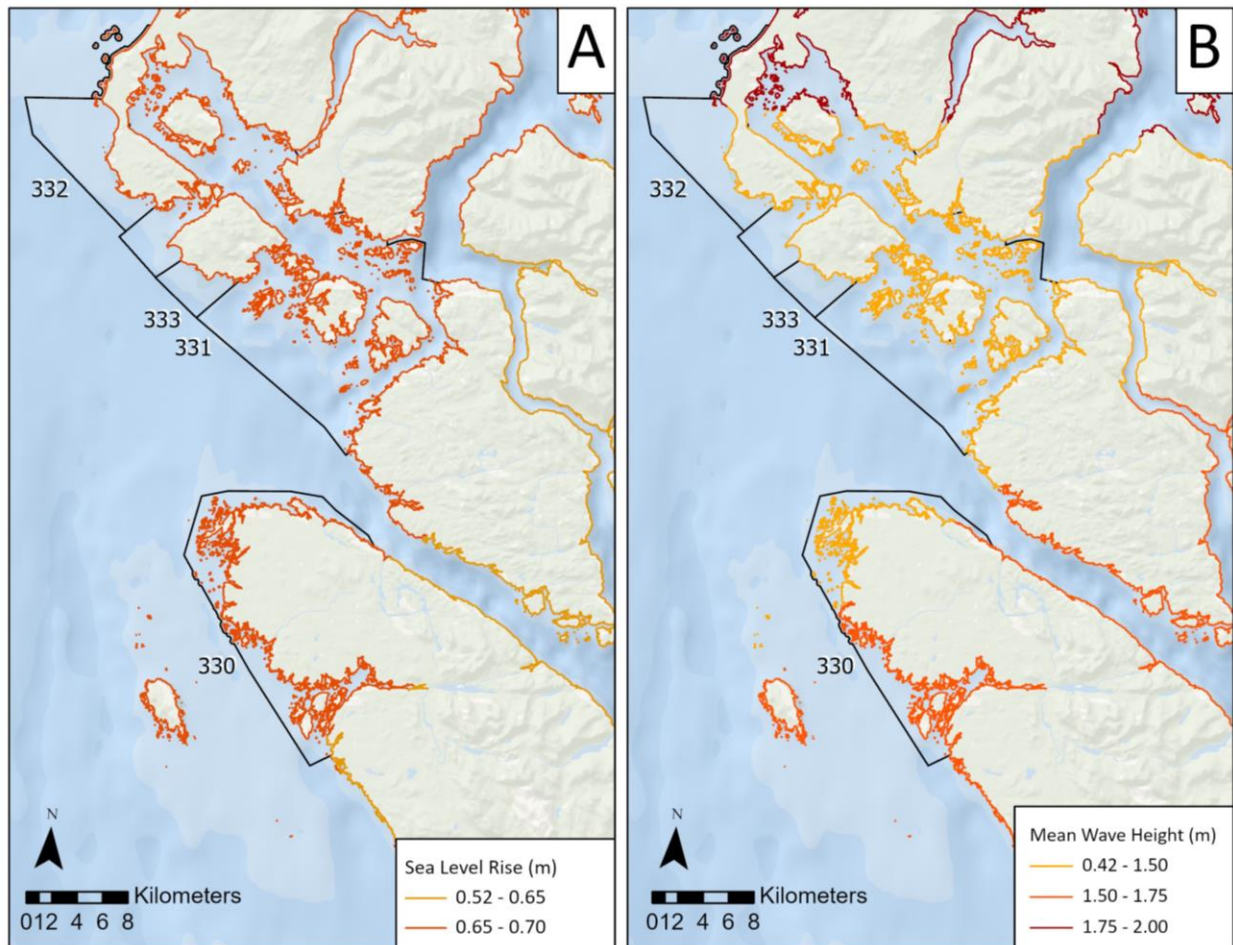


Figure 33. (A) Sea level rise, in meters, between 2006 and 2099, for the Kitkatla Inlet region. The sea-level change used here combines a global sea-level change model (RCP 8.5) and a model of vertical land motion for Canada (CanCoast 2.0; Manson et al. 2019). (B) Decadal mean significant wave height, 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 Kitkatla Inlet Network Zones.

4.1.2 Ocean temperature

Ocean temperatures are warming, the frequency and severity of extreme heat events (e.g., marine heatwaves) is increasing (Oliver et al. 2021). 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), and warming associated with climate change has negative impacts on marine organismal performance and survival (Harvey et al. 2013). Consequently, marine organisms will have to acclimate, genetically adapt, or adjust their geographic distributions to match their physiological tolerances and habitat requirements to rising water temperatures (Schiffers et al. 2013). 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. 2014). However, increasing ocean temperatures do not affect marine fauna and flora in isolation. Instead, the interactive effects of temperature,

hypoxia, hypercapnia, and other climate-related properties can lead to unexpected ecosystem shifts and varied impacts on the abundance and distribution of marine taxa (Côté et al. 2016; Kroeker et al. 2017). 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). Overall, species vulnerability depends upon both organismal traits (e.g., calcification, developmental strategy, life-stage, and mobility), and environmental context (e.g., how quickly local environments are changing and in what ways). Community-based knowledge shared during a number of community sessions hosted by Gitxaala Nation have confirmed shifts in ecosystem function, species' behavior and species' ranges have been observed within **Laxyuubm Gitxaala**. Examples of shifts provided included changes in marine and terrestrial plant species growth and seasonality, changes in timing of fish species migration and breeding patterns, and a number of other noticeable changes to the established seasonal patterns recognized by generations of Gitxaala members throughout their territories (James Herbert *pers. comm.* December, 2023).

Two climate models have been used within the Pacific Region to investigate projected changes to oceanic physical variables under two different climate change scenarios (BCCM: Peña et al. 2019, and NEP36-CanOE: Holdsworth et al. 2021). However, as mentioned, these models are limited in their spatial coverage and are reliable only for the outermost regions of the Kitkatla Inlet Network Zones and even with these, have little overlap (**Figure 32**). Projections from the BCCM regional ocean model (Peña et al. 2019) predict mean seawater temperatures to increase by at least 0.75°C before 2070 in the benthic layer and 1.29°C in the surface layer for all four seasons of Zones 330 and 332 under the RCP 4.5 and RCP 8.5 emissions scenario (**Table 3**). The NEP36-CANOE (Holdsworth et al. 2021) projections are for higher seawater warming, with increases in mean seawater temperatures of at least 1.36°C before 2065 in the benthic layer and 1.49°C in the surface layer for Zones 330-332 across seasons (**Table 4**). The RCP 4.5 scenario is more conservative than the RCP 8.5 scenario, so the bottom and surface layers have lower projected warming. However, temperature change values are higher than threshold values for most seasons and both projections. Despite these differences, both models show a warming trend in the Kitkatla Inlet Network Zones (330 and 332) across seasons and deep and shallow depths (**Table 3; Table 4**).

Table 3. Seasonal mean sea temperature (°C; sea bottom and sea surface) within the outermost areas of two of the Kitkatla Inlet 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. The change in value between these two time periods 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 °C between the historical and projected future values. Yellow shading highlights Zones with a temperature change of > 1 °C and < 2 °C between the historical and projected future values.

Zone	Sea Bottom Temperature (°C)								Sea Surface Temperature (°C)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)				Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)			
330	7.79	9.46	10.03	7.83	1.58	0.79	1.17	1.44	8.21	13.02	11.07	7.51	1.61	1.43	1.66	1.47
332	7.86	9.53	10.08	7.84	1.57	0.75	1.14	1.44	8.25	12.98	11.23	7.50	1.61	1.29	1.64	1.50
Zone	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)				Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)			
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)				Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)			
330	7.79	9.46	10.03	7.83	2.05	1.05	1.79	2.08	8.21	13.02	11.07	7.51	2.21	2.22	2.54	2.12
332	7.86	9.53	10.08	7.84	2.04	0.98	1.76	2.08	8.25	12.98	11.23	7.50	2.20	1.98	2.52	2.15

Table 4. Seasonal mean sea temperature (°C; sea bottom and sea surface) within the outermost areas of three of the Kitkatla Inlet 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. The change in value between these two time periods 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 °C between the historical and projected future values. Yellow shading highlights Zones with a temperature change of > 1 °C between the historical and projected future values.

Zone	Sea Bottom Temperature (°C)								Sea Surface Temperature (°C)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 4.5)				Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 4.5)			
331	7.22	11.32	10.64	6.16	2.04	1.43	1.82	2.01	7.22	11.48	10.66	6.13	2.04	1.49	1.83	2.01
332	7.07	8.96	10.09	6.81	2.03	1.36	1.66	1.92	7.24	12.21	10.85	6.39	1.99	1.52	1.84	1.98
333	7.21	11.62	10.70	6.03	2.05	1.49	1.84	2.04	7.21	11.70	10.71	6.02	2.05	1.52	1.84	2.04
Zone	Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 8.5)				Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 8.5)			
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 8.5)				Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 8.5)			
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
331	7.22	11.32	10.64	6.16	2.54	1.57	2.31	2.43	7.22	11.48	10.66	6.13	2.55	1.65	2.32	2.43
332	7.07	8.96	10.09	6.81	2.50	1.51	2.00	2.39	7.24	12.21	10.85	6.39	2.57	1.74	2.35	2.43
333	7.21	11.62	10.70	6.03	2.56	1.66	2.33	2.46	7.21	11.70	10.71	6.02	2.56	1.70	2.34	2.43

4.1.3 Ocean acidification and aragonite

Ocean acidification is the chemical process where carbon dioxide enters the marine environment and forms carbonic acid and hydrogen ions, leading to increased seawater acidity (pH declines) and a reduction in the availability of carbonate ions (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 and increase in hydrogen ions decreases these organisms' ability to form and maintain hard carbonate structures, particularly for larvae and juveniles (Fabry et al. 2008, Przeslawski et al. 2015). 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, bivalves, 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). Species that belong to this at-risk group and which occur in the Kitkatla Inlet Network Zones area include King **k'almoos**/crab, **Yaans**/chitons, **aswit**/urchins, **gyenti**/Sea cucumbers, Littleneck **Ts'a'ax**/clams, **Sa'mx**/Butter clams, and **Bilhaa**/Northern abalone (see Invertebrates). 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). Currently, signals for ocean acidification (including increased hydrogen ion concentrations and reduced aragonite saturation states) are greater on average along BC's coast than the global average (Evans et al. 2022). Additionally, many Gitxaala community members have reported changes in the behavior and locations of both **Bilhaa**/Northern abalone and **Aswit**/urchins (James Herbert *pers. comm.* December 2023).

Aragonite levels are projected to decrease in both the bottom and surface layers of the Kitkatla Inlet Network Zones (330-332). The NEP36-CanOE regional ocean model projected a larger decrease than the BCCM regional ocean model, although neither model projects values below the threshold value of $\Omega_a < 1$, the aragonite saturation state (**Table 5; Table 6**). Note that as with ocean temperature the model coverage is limited to the outer areas of the Kitkatla Inlet Network Zones for ocean aragonite concentrations (**Figure 32**). The BCCM and NEP36-CanOE model results do not cover the nearshore or inlet area of the Kitkatla Inlet Network Zones area. Fjords with less connectivity to ocean basins are more sensitive to ocean acidification, as demonstrated in two coastal fjords on the Central Coast (Bute and Rivers Inlet to the south of the Kitkatla Inlet Network Zones area) (Hare et al. 2020). The region north of the broken islands within the Kitkatla Inlet Network Zones (part of Zone 331, Zones 332 and 333) is less connected with deep waters in Hecate Strait than those in the Caamaño -Douglas area (see Liu et al. *in press*). However, these waters may be more connected to Dixon Entrance than Hecate Strait below the surface layer. The 60 m constriction in Browning Entrance and relatively fresher water in Principe Channel makes it difficult for deep Hecate Strait to cross Browning Entrance and reach the north shore of **Lax k'naga dzol**/Banks Island (Zone 330) (see Oceanographic setting). There appears to be extensive mixing at various entrances in the Kitkatla Inlet Network Zones area, along with high freshwater inputs (see Freshwater inputs). Aragonite projections are not concerning offshore for the area, but we don't know the biogeochemical cycling, particularly for the sheltered inlets. Thus, the species in the coastal fjords, including Kitkatla Inlet Network Zones area species, may be susceptible to acidification, especially for the larval stages of shellfish species (DFO 2021), but this is a considerable knowledge gap.

Table 5. Seasonal mean aragonite saturation state (sea bottom and sea surface) within the outermost areas of two of the Kitkatla Inlet 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 $\Omega_a < 1$, a critical threshold value; no cells meet this requirement.

Zone	Sea Bottom Aragonite Saturation State (Ω_a)								Sea Surface Aragonite Saturation State (Ω_a)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1981-2010)				Projected Future Value (2041-2070; RCP 4.5)				Historical Value (1981-2010)				Projected Future Value (2041-2070; RCP 4.5)			
330	1.68	1.63	1.62	1.55	1.42	1.26	1.29	1.28	1.88	2.39	1.93	1.50	1.61	2.03	1.64	1.26
332	1.73	1.65	1.64	1.56	1.45	1.26	1.31	1.29	1.97	2.38	2.04	1.55	1.69	1.98	1.72	1.30
	Historical Value (1981-2010)				Projected Future Value (2041-2070; RCP 8.5)				Historical Value (1981-2010)				Projected Future Value (2041-2070; RCP 8.5)			
330	1.68	1.63	1.62	1.55	1.27	1.11	1.19	1.19	1.88	2.39	1.93	1.50	1.51	1.91	1.54	1.17
332	1.73	1.65	1.64	1.56	1.3	1.11	1.2	1.19	1.97	2.38	2.04	1.55	1.56	1.84	1.61	1.20

Table 6. Seasonal mean aragonite saturation state (sea bottom and sea surface) within the outermost areas of three of the Kitkatla Inlet 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 $\Omega_a < 1$, a critical threshold value; no cells meet this requirement.

Zone	Sea Bottom Aragonite Saturation State (Ω_a)								Sea Surface Aragonite Saturation State (Ω_a)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1986-2005)				Projected Future Value (2046-2065; RCP 4.5)				Historical Value (1986-2005)				Projected Future Value (2046-2065; RCP 4.5)			
331	1.88	2.09	1.96	1.65	1.53	1.70	1.61	1.33	1.88	2.11	1.97	1.65	1.54	1.72	1.61	1.33
332	1.84	1.83	1.85	1.68	1.49	1.45	1.50	1.35	1.89	2.19	1.98	1.67	1.53	1.80	1.63	1.35
333	1.88	2.11	1.97	1.65	1.54	1.72	1.62	1.33	1.88	2.12	1.97	1.65	1.54	1.73	1.62	1.33
	Historical Value (1986-2005)				Projected Future Value (2046-2065; RCP 8.5)				Historical Value (1986-2005)				Projected Future Value (2046-2065; RCP 8.5)			
331	1.88	2.09	1.96	1.65	1.40	1.53	1.47	1.20	1.88	2.11	1.97	1.65	1.40	1.55	1.48	1.41
332	1.84	1.83	1.85	1.68	1.36	1.30	1.36	1.22	1.89	2.19	1.98	1.67	1.41	1.63	1.49	1.44
333	1.88	2.11	1.97	1.65	1.40	1.54	1.48	1.19	1.88	2.12	1.97	1.65	1.40	1.56	1.48	1.41

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 the upper value of < 157 $\mu\text{mol/L}$ to describe hypoxic bottom waters, although higher or lower oxygen levels will varyingly impact marine life (Rabalais et al. 2010). Again, model coverage is limited to the outer areas of the Kitkatla Inlet Network Zones for ocean oxygen concentrations (Zone 330 and 332). Hypoxic bottom waters < 157 $\mu\text{mol/L}$ are not observed in the historical period, nor are they projected to occur in future periods (**Table 7, Table 8**). The Kitkatla Inlet Network Zones are located on the continental shelf within a narrow bathymetric depth range of 0 to 252 m max depth, with mean depths between 19 and 43 m (see Bathymetry); and the benthic oxygen concentrations do not drop below the 62.5 $\mu\text{mol/L}$ threshold. While depth-related oxygen loss between 300 and 1000 m is projected to impact marine species negatively, causing some species to shift to shallower depths, model selection influences the projected oxygen changes, and considerable uncertainty exists for this region (Thompson et al. 2023a). Furthermore, changes in sedimentation in inner fjords and inlets can lead to hypoxic habitat (see Climate change impacts on coastal nearshore).

Table 7. Seasonal mean sea bottom dissolved oxygen ($\mu\text{mol/L}$) within the outermost areas of two of the Kitkatla Inlet 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 $\mu\text{mol/L}$, a critical threshold value; no cells meet this requirement.

Zone	Sea Bottom Dissolved Oxygen ($\mu\text{mol/L}$)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)			
330	286.27	233.73	229.17	280.44	278.80	218.19	218.29	273.38
332	286.77	230.62	229.56	279.13	278.84	215.25	218.14	272.06
Zone	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)			
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)			
330	286.27	233.73	229.17	280.44	272.03	209.04	213.95	270.90
332	286.77	230.62	229.56	279.13	272.26	205.39	213.38	269.32

Table 8. Seasonal mean sea bottom dissolved oxygen ($\mu\text{mol/L}$) within the outermost areas of three of the Kitkatla Inlet 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 $\mu\text{mol/L}$, a critical threshold value; no cells meet this requirement.

Zone	Sea Bottom Dissolved Oxygen ($\mu\text{mol/L}$)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1986-2005)				Projected Future Value (2046-2065; RCP 4.5)			
331	317.70	286.02	280.21	312.88	303.88	274.55	268.50	299.19
332	315.54	271.21	270.35	306.07	301.65	256.21	255.76	293.05
333	317.99	286.63	280.67	313.72	304.11	275.46	269.05	299.86
Zone	Historical Value (1986-2005)				Projected Future Value (2046-2065; RCP 8.5)			
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
	Historical Value (1986-2005)				Projected Future Value (2046-2065; RCP 8.5)			
331	317.70	286.02	280.21	312.88	301.64	273.06	266.11	296.81
332	315.54	271.21	270.35	306.07	301.33	277.43	266.43	290.65
333	317.99	286.63	280.67	313.72	301.82	273.05	266.29	297.44

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. 2011). 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). While hypoxic conditions are not projected for the Kitkatla Inlet Network Zones, the model coverage is extremely low and cannot be used to characterize the region. Furthermore, hypoxic conditions are conditional on a variety of factors including sedimentation, water flow/mixing and depth (Gobler and Baumann 2016; Jørgensen et al. 2022), and ecological thresholds vary by species (Thompson et al. 2023a). We discuss potential changes to oxygen levels within the nearshore and inlet areas below.

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.

4.2 Climate change impacts on coastal nearshore and inlet areas

The convoluted coastline and shallow depths within the Kitkatla Inlet Network Zones make this region's oceanography and topography unique, influencing their responses to anthropogenically-driven climate change. The area includes an exposed coastline, many nearshore, and protected waters such as Kitkatla and Kingdown Inlets and Kitkatla Channel. As stated in earlier sections, the shallowness of the zones, convoluted shorelines, and low spatial and temporal data resolution warrant more models of projected changes to physical environmental variables under a warming climate and increased atmospheric carbon dioxide within these environments. However, we can draw general expectations for the area using the literature and our current understanding of this region.

The Kitkatla Inlet Network Zones are within the North Coast Fjords ecoregion, which is 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 deeper channels 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 associated with *Waa*s/rain (Wild et al. 2022). Compared to Hecate Strait, water is generally cooler in the Kitkatla Inlet Network Zones area, mainly east of Browning Entrance (between Zone 330 and 331) and within Ogden Channel, which provides water to the entrance of Kitkatla Channel (Zone 330). Conservative expectations for the influence of a warming climate on this area are that the cooler water brought towards the surface within Principe and Grenville channels may mitigate surface warming. However, warm surface waters from Chatham Sound also travel towards the Kitkatla Channel and Inlet as a subsurface intrusion (see Water exchanges into the north entrances of Kitkatla Channel). Vertical exchanges from mixing may cool the surface, but it would also warm deeper layers. What is more certain is that a warming climate will impact shallower and sheltered waters that characterize the Kitkatla Inlet Network Zones. This change will warm surface waters, stressing the organisms that inhabit this part of the water column and those nearshore. The nearshore regions least likely to be impacted by warming temperatures are those offshore of Dolphin and Spicer Islands (Zone 331), east of Browning Entrance. The surface water from Principe Channel tends to flow northwards towards Kitkatla Channel (Zone 331) rather than out towards Hecate Strait (**Figure 20**). This “trapping” of cool water in Browning Entrance, along with strong *aks*/tides and exposed coastline, ensures that the southern coast of Dolphin and Spicer Islands remain cooler during the hottest months of the year (**Figure 23**; **Figure 27**).

Alongside ocean warming, shallow and intertidal ecosystems are also directly affected by increases in air temperature caused by climate change. Increased air temperatures, particularly during summer months and aerial heatwaves, can heighten local seawater temperatures and expose ecologically and culturally important intertidal organisms to alternating aerial and aquatic thermal stress during low- *aks*/tide series (Harley et al. 2006, Raymond et al. 2022). Marine heatwaves, such as “the Blob” (2014-2016), have been shown to have minimal effects on fish assemblages in *gadza k’aw*/eelgrass meadows in British Columbia (Robinson et al. 2022) but

was associated with die-offs of several marine bird species, including the Marbled Murrelet (Drever et al. 2021). However, the lingering warm conditions from these heatwaves can have substantial impacts on coastal ecosystems, with warm conditions persisting below the surface mixed layer through at least March 2018 after “the Blob” in Rivers Inlet, a glacial-fed fjord on BC’s central coast (Jackson 2018). From June 26 to 28, 2021, an unprecedented atmospheric heatwave coincided with the lowest low **aks**/tides of the year within coastal intertidal systems of the Salish Sea. The heatwave resulted in extensive mortality reports of marine organisms, including barnacles, mussels, **Ts’a’ax**/clams, and oysters, on intertidal beaches throughout the Pacific Northwest, with far-reaching and potentially multiyear effects on nearshore ecology, cultural connections, and fisheries (Raymond et al. 2022). Due to the long convoluted coastline, shallow bathymetry, and high occurrence of intertidal habitat, the Kitkatla Inlet Network Zones area may be particularly susceptible to the deleterious effects of marine heatwaves, particularly on marine invertebrate populations with high ecological and cultural value.

Deeper inlets are typically vulnerable to reductions in oxygen, with the deeper hypoxic basins having a delicate water chemistry that is already near tipping points for resident species’ ecological tolerances (Okey et al. 2012). However, the marine waters from the channels leading towards the Kitkatla Inlet Network Zones are relatively well-oxygenated compared to deep areas offshore of Porcher and **Lax k’naga dzol**/Banks Island (**Figure 28**), particularly Principe Channel. Although no mixing measurements exist, the higher oxygen is due to mixing at constrictions and sills, and the intense winter mixing increases dissolved oxygen throughout the region encompassing Chatham Sound and the Caamaño-Douglas area. The intrusions of the well-oxygenated surface waters of Chatham Sound at intermediate depths in Ogden Channel may also help mitigate hypoxia of deeper waters. Consequently, hypoxic conditions are unlikely, as the area the most susceptible to having low oxygen (**Lax k’naga dzol**) is not projected to become hypoxic with climate change (see above). However, the sheltered inlets (e.g., Kitkatla and Kingkown) and estuaries within the Kitkatla Zone boundaries (see Estuaries and salt marshes), are more susceptible to local biogeochemical processes. For example, increased **Waas**/rain from terrestrial areas increases siltation and nutrient/organic enrichment (Okey et al. 2012). Given the current lack of knowledge or data about current water chemistry and biogeochemical cycling, we cannot predict their chemistry with a projected warming climate.

The Kitkatla Inlet Network Zones is a hybrid zone where large volumes of freshwater runoff from the Caamaño and Skeena River watersheds flow towards the area. The estuarine circulation supported by this runoff depends partly on the magnitude and timing of peak discharges from these watersheds, as this alters the resulting salinity gradients in the adjoining channels such as Principe and Grenville (see Water exchanges and properties with neighboring areas). A recent analysis of climate change impacts for the nearby Skeena River watershed, which partly flows into the northeastern side of the Kitkatla Inlet Network Zones (see the Oceanographic setting), 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. 2022). 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. 2022). 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. The increased sediment transport would reduce light availability in Kitkatla Channel.

Light availability is a known limiting factor for important habitats, including seagrasses and kelp (Beheshti and Ward 2021).

A comparative study of four coastal inlets in the Pacific Region's central and northern coast investigated deep-water trends in oxygen and temperature (Jackson et al. 2021). Their northernmost inlet analyzed was Douglas Channel to the south **Lax k'naga dzol**/Banks Island, and they showed that deep-water temperatures had increased significantly over 70 years (1.2 to 1.3°C) – twice the global average rate for open ocean waters at the same depths. This may in part be because areas with high mixing will result in a cooler surface at the expense of the bottom becoming warmer with increasing air temperatures. Oxygen levels in the three inlets south of Douglas Channel have dropped by up to 20%, necessitating the redistribution of species pushed to their physiological limits. Deoxygenation trends were not statistically significant for Douglas Channel (Jackson et al. 2021). Their analysis is relevant for waters deeper than 60 m in the Kitkatla Inlet Network Zones, as this is the maximum depth at which water can flow freely around the Kitkatla Inlet Network Zones and adjoining channels (see Bathymetry). Considering the evidence of intense mixing throughout the Kitkatla Inlet Network Zones, and in the waterways that bring water to the zones, and the comparisons of current conditions with those in Douglas Channel, deoxygenation of deep waters is expected to be even weaker than in Douglas Channel and warmer temperatures are expected. Lower or stable deep salinity might also be expected for the same reason (**Figure 26**). However, deep water temperatures are expected to warm faster than the other inlets investigated along the central coast (**Figure 27**). Therefore, bottom dissolved oxygen and salinity refugia will likely exist within the area for species displaced by smaller in situ changes in temperature, salinity, oxygenation, or acidification. 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). Impacts should not be considered in isolation from each other or in isolation of the increased warming rates the region is projected to experience.

4.3 Data and Knowledge Gaps

Several data and knowledge gaps exist within our knowledge of projected climate changes and their impacts for Kitkatla Inlet and area. First, there is a need for additional models that project changes to physical environmental variables specifically within the shallow, convoluted shorelines of the Kitkatla Inlet Network Zones. Additionally, there is a significant gap in knowledge regarding the current water chemistry and biogeochemical cycling in these regions, impeding the ability to predict the future chemistry of sheltered inlets and estuaries under projected climate warming scenarios. Uncertainty also persists concerning the biogeochemical cycling in sheltered inlets, which complicates the assessment of species susceptibility to acidification, particularly during the larval stages of shellfish species. Furthermore, the available models for ocean oxygen concentrations are limited and inadequate for characterizing the Kitkatla Inlet Network Zones. To address these gaps, further research and data collection is needed to explore the interactions between climate change impacts on environmental variables and other forms of anthropogenic disturbance. Lastly, an in-depth understanding of how the unique oceanography and topography of the Kitkatla Inlet Network Zones influences their responses to anthropogenically-driven climate change is critical for informing effective management and conservation strategies.

5 HUMAN USES OF AREA

One 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 Kitkatla Inlet Network Zones boundaries.

5.1 First Nations Activities

“[Ayaawx] is not only about how we look after our territory, but also about how we interact with creator and nature itself: how we look after it, how we respect it, how we treasure it, and how we make sure that we only take what we need to ensure sustainability for generations to come.” (Nees Hiwaas Aff. ¶ 27, October 21, 2021)

Gitxaala Nation citizens have unique and enduring governance structures and protocols that are tied to the lands and waters within the Kitkatla Inlet Network Zones boundaries. **Smgyigyeyet** and **Sigidmna’ax** have managed the resources in Gitxaala territory since time immemorial. This is a responsibility to their **laxuulp**/territory to ensure that future generations will benefit from the lands and resources (Gitxaala Nation 2022). The Kitkatla Inlet Network Zones Boundaries includes many sites used in maintenance and enhancement of spirituality, customs, governance or laws including for food harvest, continuance of clans, houses, and territories, transfer of names and territories, feasting and status, sharing of resources and trade, etc (**Table 9**).

Gitxaala Nation members rely heavily on marine species for food and most residents of **Lach Klan**/Kitkatla consume local Gitxaala foods daily; and for some, 80% of their protein is harvested in Laxyuubm Gitxaala. In particular, zone 330, **Lax k’naga dzol**/Banks Island is often referred to as “the table of the Chiefs” with a richness of species to support Gitxaala Nation members diet. Gitxaala Nation harvests from many habitats in the Kitkatla Inlet Network Zones boundaries including the beaches and exposed and sheltered shorelines, the intertidal, the subtidal, inlets, the canopy forming **gyoós**/giant kelp, and **Mo’ox**/bull kelp stands, etc. Typical gear types include gill nets, long line, and jig in zone 330; **k’almoos**/crab pots, gill nets, jig, long line and trolling in zone 331; long line in zone 332; and gill nets, long line and trolling in zone 333. Harvested resources are important to Gitxaala, not just for consumption purposes, but also as components of governance structures and activities, trading and sharing economy, members well-being, and other cultural and ceremonial purposes (Vanderjagt et al. 2021).

Gitxaala Nation is a strong leader for sustainable harvest. These practices have been passed down for generations and are enshrined in Gitxaala **ayaawx**/laws. These **ayaawx** are passed down through generations and provide the basis for how Gitxaala sustain and manage resources (Butler 2010).

The continuation of Gitxaala harvesting practices and connection to Laxyuubm Gitxaala are also critical components for transmission and retention of their culture. In the Kitkatla Inlet, this is illustrated by the Gitxaala requirement for the conservation and restoration of an abundant **Tskah**/herring run for generational harvesting. Harvesting practices also play a major role in retention of the Sm’algayx language. Gitxaala **Sm’ooygit Txagyeyet** (Clarence Innis) noted *“Going by someone’s land and letting your young ones know who this belongs to what house they belongs to, is how you pass on culture. You actually go and live it”*.

A crucial aspect of Gitxaala law is also the stewardship of Laxyuubm Gitxaala. Sm'ooygit Nees Hiwaas (Matthew Hill) explained that under Gitxaala law, Gitxaala stewardship is about how Gitxaala interacts with the creator and nature itself. It is "...how we look after it, how we respect it, how we treasure it, and how we make sure that we only take what we need to ensure sustainability for generations to come" (Nees Hiwaas Aff. ¶ 27, October 21, 2021). Gitxaala **ayaawx**/laws also expresses Gitxaala Nation's relationship with **naxnanox** (plural of **naxnox**, which means a supernatural being or nature spirit) and their **spanaxnanox** (plural of **spanaxnox**, which means a **naxnox** den or territory) within Laxyuubm Gitxaala. All living things in the Laxyuubm Gitxaala have their own **naxnox**. **Naxnanox** are a key source of the values and principles that led Gitxaala ancestors to develop the harvesting protocols and practices that have allowed Gitxaala Nation to flourish (Nees Hiwaas Aff. ¶ 28, October 21, 2021).

Table 9. Important sites for Gitxaala Nation intersecting with the Kitkatla Inlet Network Zones. This table is not meant to be an exhaustive list of Gitxaala use or activities.

Location	Name	Usage/Indigenous Knowledge
Zone 330	North Lax k'naga dzol (Banks Island)	Travel routes, anchorages/haul-outs, camps, bait fishing, archaeological and cultural sites, named places, spanaxnox , bilhaa /abalone, hadanii /black cod, mihaa /blueberry, k'ayeey /bullhead, chinese slipper, 'yaans/chiton/sea prune, gayniis /chum salmon, ts'a'ax /clams, gaboox /cockles, üüx /coho salmon, wan /deer, an'ana /duck, frog berry, ha'ax /goose, giant gyels /mussels, txaw /halibut, tskah /herring, walaas /huckleberry, humpback whale, gyoos /kelp, wat'ukw /ling cod, lis'yaan /mink, gyels /mussels, hats'al /octopus/devil fish, sti'moon /pink salmon, dziw /porpoise, ts'mhoon /red snapper, rock cod, k'al'on /scallops, gyenti /sea cucumber, gaguum /sea gull eggs, t'iibn /sea lion, ts'akwe'ats /sea urchin, üüla /seal, la'ask /seaweed, k'ayadzen (grey) or ts'mhoon (red)/snapper, misoo /sockeye salmon, yee /spring salmon, meliit /steelhead trout, gibaaw /wolf
Zone 331	Browning Entrance/Dolphin Island	Lax Gyibu (Wolf Clan) Territory, travel routes, anchorages/haul-outs, fish migration, ibuun /whale migration, area of strong tidal action, camps, driftwood collection, medicine tree, noxnox , sacred and important places, spanaxnox , anchorages, settlement sites, bilhaa /abalone*, sts'ool /beaver, hadanii /black cod, amgyiik /black duck, mihaa /blueberry, chinese slipper, 'yaans/chiton/sea prune, gayniis /chum salmon, ts'a'ax /clams, gaboox /cockles, üüx /coho salmon, k'almoos/galmoos /crab, dahdee (lowbush) and laaya (highbush)/cranberry, wan /deer, wooms /devil's club, dzawas /salal berries/laughing berries, frog berry, ha'ax /goose, giant gyels /mussels, txaw /halibut, tskah /herring, walaas /huckleberry, humpback whale, huulens /hellbore, gyoos /kelp, 'naaxl/blackfish/killer whale, wat'ukw /ling cod, nanaa /mallard, yeni /marten, lis'yaan /mink, gyels /mussels, hats'al /octopus/devil fish, ploon /sea otter, sti'moon /pink salmon, dziw /porpoise, gasgos /prawns, ts'mhoon (red)/snapper, rock cod, k'al'on /scallops, ahoo /scoter, gyenti /sea cucumber, gaguum /sea gull eggs, t'iibn /sea lion, ts'akwe'ats /sea urchin, üüla /seal, la'ask /seaweed, ksah /shark, gasgos /shrimp, k'ayadzen (grey) or ts'mhoon (red)/snapper, misoo /sockeye salmon, yee /spring salmon, sperm whale, xbihats'al /squid, dasx /squirrel, meliit /steelhead trout, gak /swan, maksiil /weasel, gibaaw /wolf, sahakwdak /yew wood/yew tree

Location	Name	Usage/Indigenous Knowledge
Zone 332	Porcher Peninsula	Lax Gyibu (Wolf Clan) Territory, travel routes, anchorages/haul-outs, fish migration, lbuun /whale migration, camps, driftwood collection, medicine tree, sacred places, house territory, spanaxnox , amgyiik /black duck, 'yaans/chiton/sea prune, gayniis /chum salmon, ts'a'ax /clams, gaboox /cockles, üüx /coho salmon, k'almoos/galmoos /crab, wan /deer, dzawas /salal berries/laughing berries, ha'ax /goose, txaw /halibut, tskah /herring, gyoos /kelp, 'naaxl/blackfish/killer whale, nanaa /mallard, lis'yaan /mink, gyels /mussels, ploon /sea otter, sti'moon /pink salmon, rock cod, gyenti /sea cucumber, t'iibn /sea lion, ts'akwe'ats /sea urchin, üüla /seal, la'ask /seaweed, ksah /shark, misoo /sockeye salmon, yee /spring salmon, dasx /squirrel, gak /swan, maksiil /weasel
Zone 333	Goschen Island	Travel routes, fish migration, lbuun /whale migration, anchorages/haul-outs, driftwood collection, medicine tree, winter camps, bilhaa /abalone*, amgyiik /black duck, gayniis /chum salmon, ts'a'ax /clams, gaboox /cockles, üüx /coho salmon, k'almoos/galmoos /crab, wan /deer, ha'ax /goose, txaw /halibut, tskah /herring, gyoos /kelp, wat'ukw /ling cod, gyels /mussels, sti'moon /pink salmon, dziw /porpoise, ts'mhoon (red)/snapper, gyenti /sea cucumber, t'iibn /sea lion, 'yaans/chiton/sea prune, ts'akwe'ats /sea urchin, üüla /seal, la'ask /seaweed, misoo /sockeye salmon, yee /spring salmon, gak /swan

* there is currently [no allowable harvest](#) of **bilhaa**/abalone in British Columbia.

5.2 Fisheries and Subsistence Activities

Commercial, recreational and traditional fishing (described above, also known as Food, Social and Ceremonial fisheries) occurs throughout the Kitkatla Inlet Network Zones area. The commercial fisheries are a larger scale fishery extracting more marine resources and a typically larger marine footprint than recreational and traditional fishing. However, FSC fishing may occur in RCAs with commercial gear, wherein it can have a similar impacts to commercial fisheries in the area being fished. Data for traditional fishing are not provided within this report but traditional fishing does occur within the Kitkatla Inlet Network Zones area. Commercial fishery and recreational fishery data are presented separately below, as the scale and associated impacts of each fishery classification is widely different. Furthermore, the direct overlap of two of the Kitkatla Inlet Network Zones with RCAs (Zones 332 and 333) shapes the fisheries present in the Zones.

RCAs are designed to help alleviate rockfish population decline. Within [RCAs](#), inshore rockfish are protected from mortality associated with recreational and commercial fisheries. [Prohibited fisheries activities](#) include commercial harvest of: groundfish by bottom trawl, hook and line, mid-water trawl, or trap, salmon by troll, tuna by hook and line, and shrimp by trawl. Recreation harvest of any species by spearfishing, groundfish by angling, salmon by trolling, jigging or

mooching, octopus by angling, and squid by jigging are also prohibited. As such only the following fisheries are allowed to occur in these areas: (1) Commercial fishing of invertebrates by hand picking or dive; **k'almoos**/crab by trap; **gasgos**/prawn by trap; **k'a'lon**/scallops by trawl; **hoon**/salmon by seine or gillnet; **Tskah**/herring by gillnet, seine and spawn-on-kelp; sardine by gillnet, seine, and trap; smelt by gillnet; euphausiid (krill) by mid-water trawl; and groundfish by mid-water trawl; and (2) Recreational fishing of invertebrates by hand picking or dive; **k'almoos**/crab by trap; **gasgos**/shrimp/prawn by trap; and smelt by gillnet. RCAs in the NSB are currently under review by [Fisheries and Oceans Canada](#), with ongoing engagement plans to guide potential changes to the fisheries management measures and the boundaries in these areas.

Fishing activities in Kitkatla Inlet play a significant role in the local economy and culture, but also poses various risks to marine ecosystems. Direct mortality of target and non-target fish (bycatch) removes individuals from populations with impacts on population dynamics, local biodiversity and ecological interactions. Mortality can also occur through entanglements of non-target species with active fishing gear (abandoned fishing gear is detailed in Pollutants). Habitat degradation through benthic habitat disturbance from fishing gear and noise pollution from vessel traffic also affect the quality of fish habitats and other species influencing the productivity of impacted areas (see Vessel traffic and vessel types and Pollutants). Consequently, an understanding of the range and relative proportion of fishery activities in the area are key to long term sustainable harvest practices and mitigating conservation risks.

5.2.1 Commercial Fishery

Currently, the waters in and around the Kitkatla Inlet Network Zones support diverse commercial fisheries for groundfish, all **hoon**/salmon species, and a variety of crustaceans and invertebrates. Within the Kitkatla Inlet Network Zones, 15 commercial fisheries have operated since at least 2012 (**Table 10**). While the majority of NSB's fishing occurs outside of the Kitkatla Inlet Network Zones, all the Zones are fished to some extent (see **Figure 34 to 38** for fishing areas within the Network Zones). **Txaw**/Halibut, Rockfish, **Ts'akwe'ats**/Red Sea Urchin, **Xs'waanx**/Herring Roe, and **k'almoos**/crab are commercially fished in all four Zones of the Kitkatla Inlet Network Zones (**Table 10**). Zone 331 is fished by the most types of fishing groups (15, **Table 10**). Zones 332 and 333 have the fewest number of fisheries within their boundaries (**Table 10**), as is expected for RCAs, which restrict some fisheries in order to protect rockfish and lingcod and their habitats. There are no documented aquaculture sites within the Kitkatla Inlet Network Zones region.

Table 10. Presence of different types of commercial fishing in the Kitkatla Inlet Network Zones. with fishing periods provided in parentheses. Data for groundfish comes from validated and spatialized logbook records. Tuna data come from expert interviews regarding validated logbook records to determine "important fishing areas for commercial tuna." 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 330	Zone 331	Zone 332 <i>Porcher Peninsula RCA</i>	Zone 333 <i>Goschen RCA</i>	Total # Zones with Fishery

Trawl					
Bottom Groundfish Trawl (2014-2018)*	A	P	A	P	2
Gasgos /Shrimp Trawl (2007-2018)**	A	P	A	A	1
Groundfish Hook and Line					
Txaw /Halibut (2007-2021)	P	P	P	P	4
Wat'ukw /Lingcod (2014-2021)	P	P	A	A	2
Rockfish (2007-2021)	P	P	P	P	4
Gillnet***					
Üüx /Coho salmon (2011-2018)	P	P	A	A	2
Sti'moon /Pink salmon (2011-2018)	P	P	A	A	2
Misoo /Sockeye salmon (2011-2018)	P	P	A	A	2
Seine***					
Sti'moon /Pink salmon (2011-2018)	A	P	A	A	1
Other					
Gyenti /Sea Cucumber dive (2010-2021)	P	P	A	A	2
Ts'akwe'ats /Red Sea Urchin dive (2010-2021)	P	P	P	P	4
Gasgos /Prawn trap (2007-2018)	A	P	A	A	1
Xs'waanx /Herring Roe Seine (BCMCA)	P	P	P	P	4
Geoduck dive (2010-2021)	P	P	A	A	2
k'almoos /crab trap (2007-2018)	P	P	P	P	4
Total # Fishing Groups per Zone	11	15	5	6	

* overlap with the trawl footprint is very small compared to the entire footprint (~1.05 sqKm overlap compared to the entire footprint of 15,432 sqKm); there is not a significant presence of groundfish trawl in the area

****gasgos**/Shrimp species include Humpback shrimp, Pink shrimp, and Sidestripe shrimp

***Note that the commercial 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.

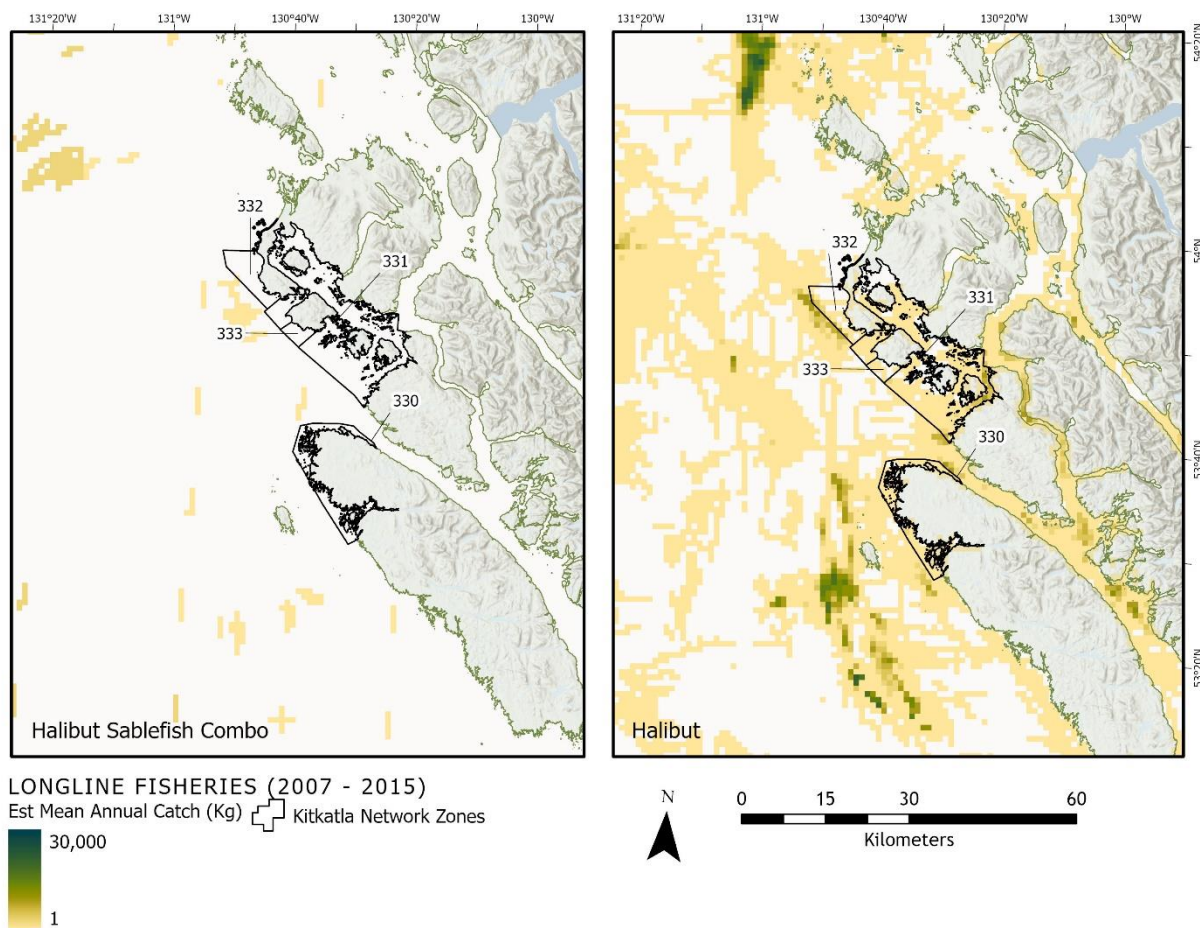


Figure 34. Presence and distribution of commercial fishing for groundfish in Kitkatla Inlet Network Zones using longline from 2007 to 2015. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on [Seasketch](#).

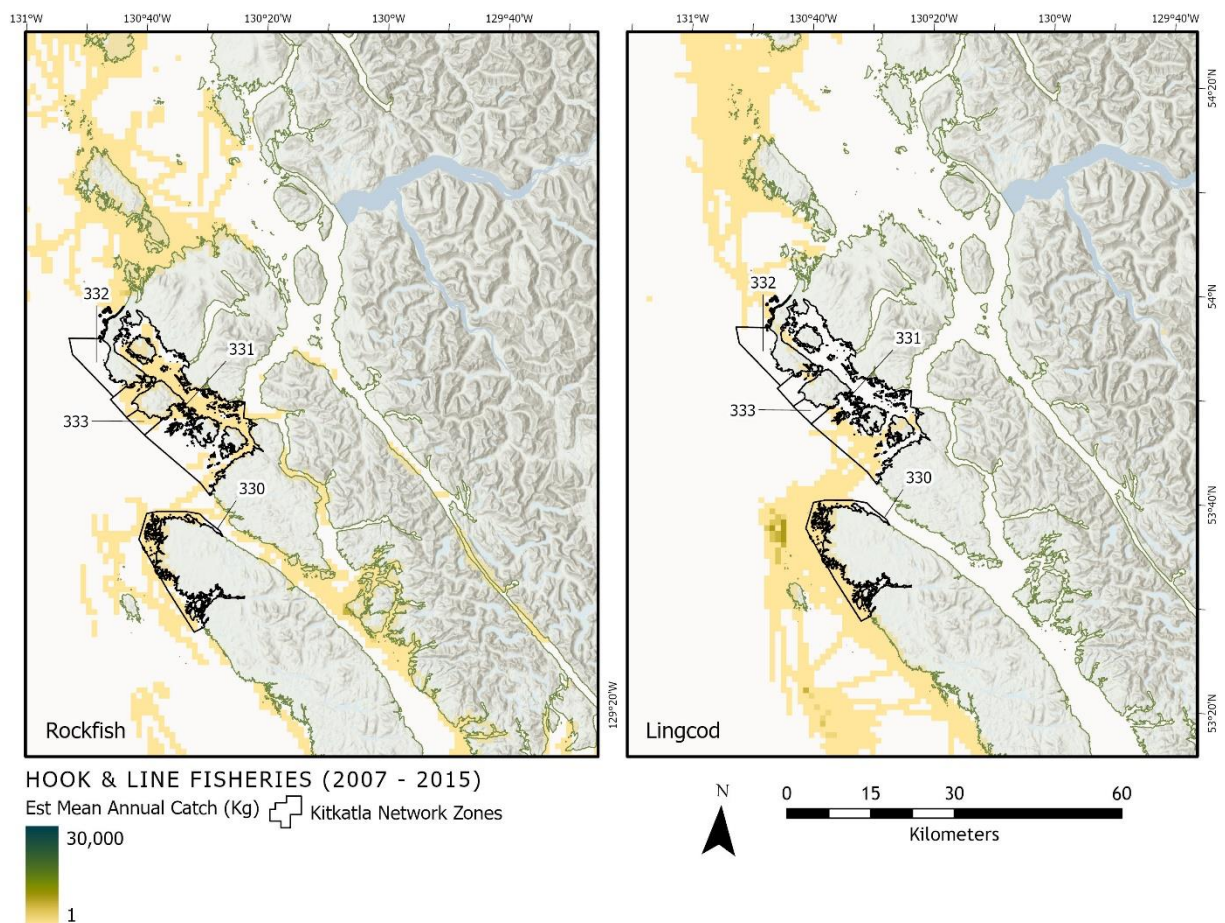


Figure 35. Presence and distribution of commercial fishing for groundfish in Kitkatla Inlet Network Zones using hook and line from 2007 to 2015. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on [Seasketch](#).

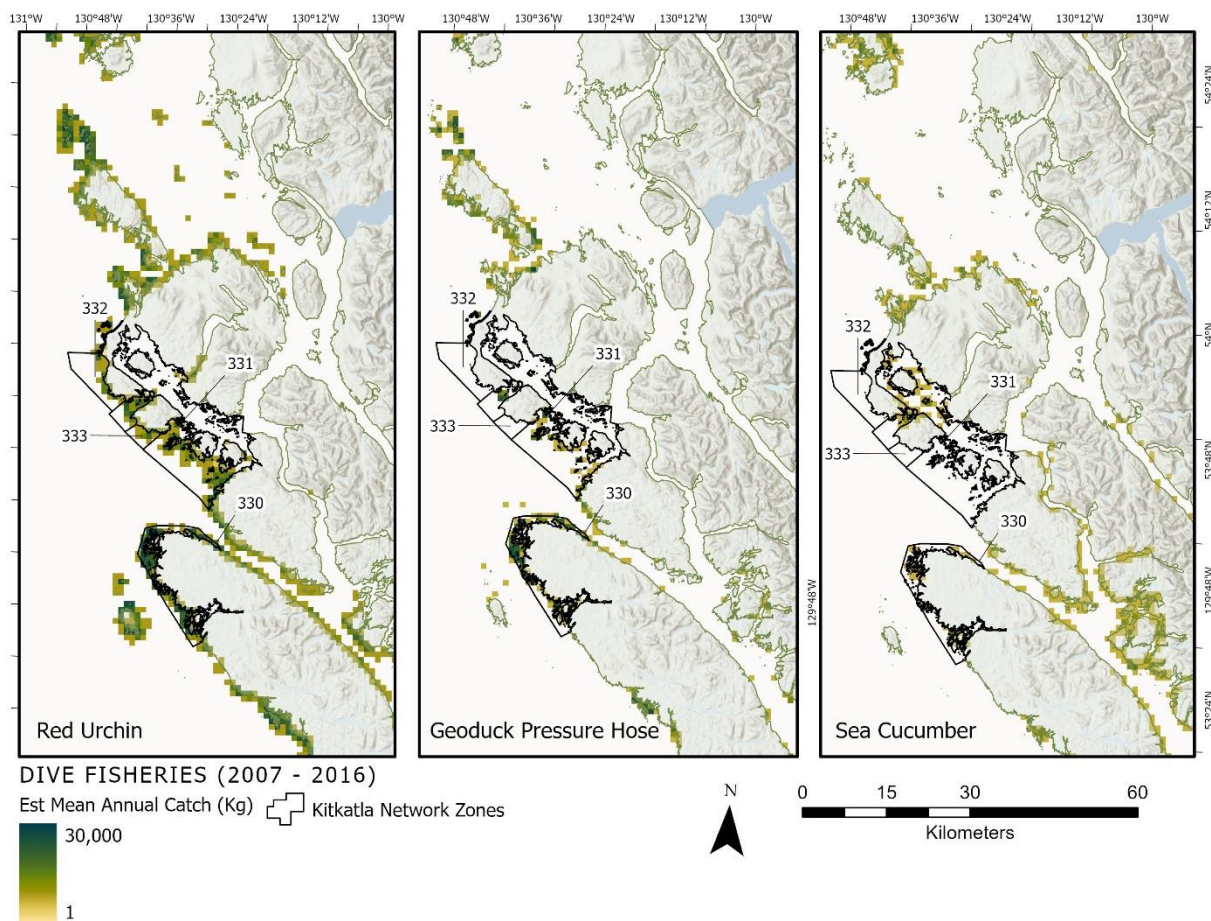


Figure 36. Presence and distribution of commercial dive fishing in Kitkatla Inlet Network Zones from 2007 to 2016. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on [Seasketch](#).

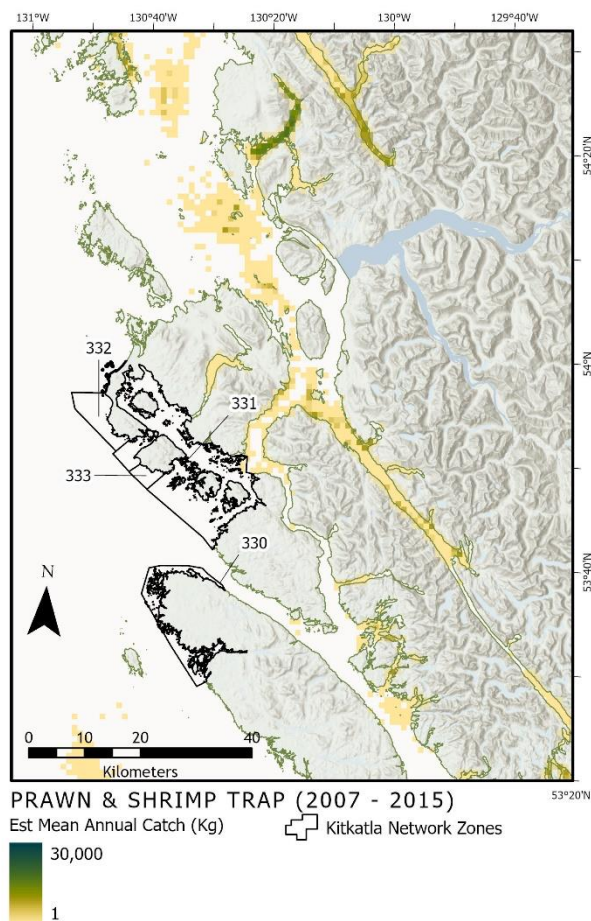


Figure 37. Presence and distribution of commercial *gasgos*/prawn and shrimp trap fishing for groundfish in Kitkatla Inlet Network Zones from 2007 to 2015. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on [Seasketch](#).

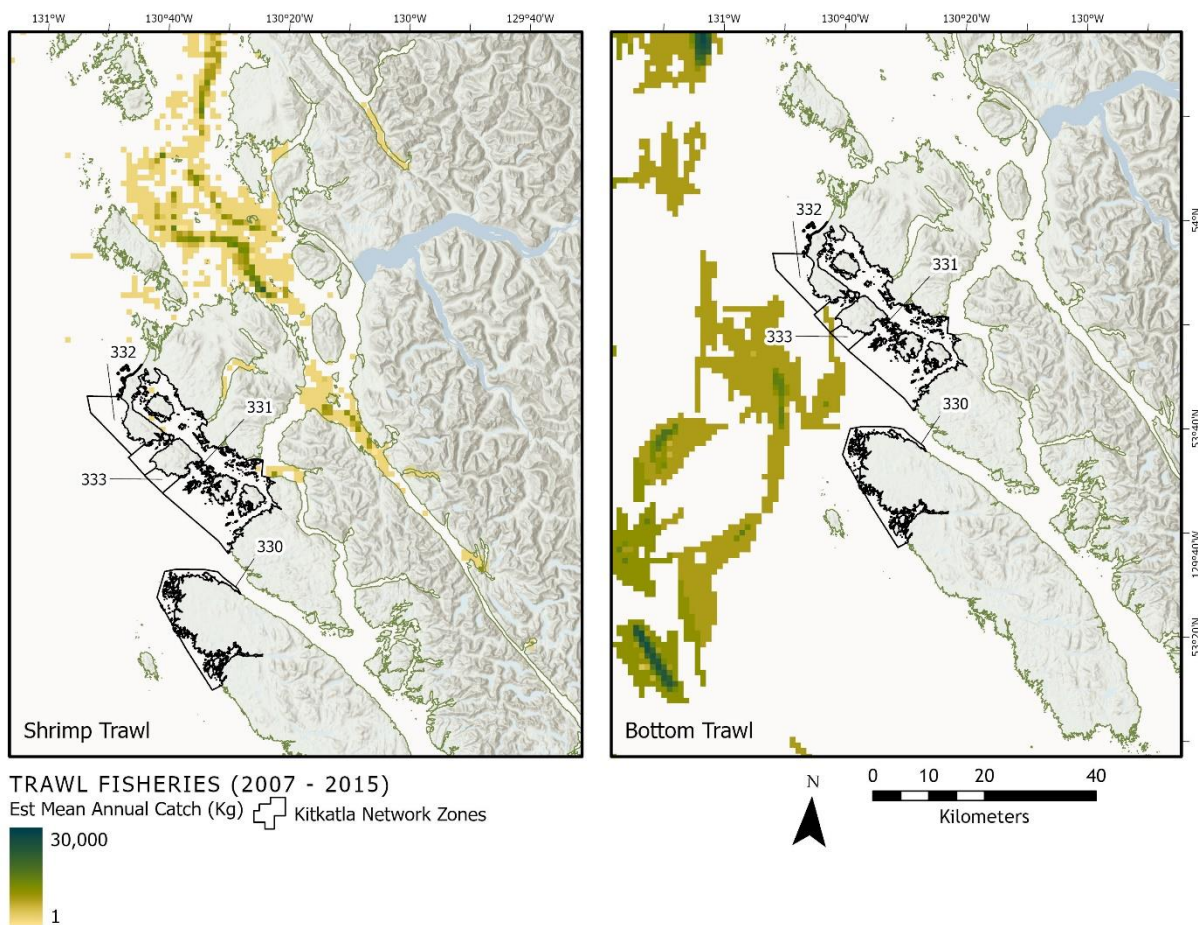


Figure 38. Presence and distribution of commercial trawl fishing in Kitkatla Inlet Network Zones using data from 2007 to 2015. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on [Seasketch](#).

The highest mean annual commercial harvests are from the Red Sea Urchin and geoduck fisheries (**Table 11 to 13**). Note that for the analyses of the DFO Commercial Logbook data presented in **Tables 11 to 13**, annual means are presented calculated for the date ranges DFO has access to. However fisheries have existed outside of this time range. 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 average 94,000 KG per year (over 9 years; **Table 13**) 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 15.0 distinct vessels present (**Table 13**).

Table 11. 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 Kitkatla Inlet 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 330	Zone 331	Zone 332 Porcher Peninsula RCA	Zone 333 Goschen RCA
Gill net	<1,000	<1,000	-	-
txaw /Halibut	<1,000	5,000	*	*
wat'ukw /Lingcod	1,000	*	-	-
ts'mhoon /Rockfish	*	*	*	*
Seine	-	<1,000	-	-
Troll	-	-	<1,000	-
k'almoos /Crab	1,000	47,000	<1,000	*
Geoduck	69,000	24,000	-	-
gasgos /Prawn	-	*	-	-
ts'akwe'ats /Red Sea Urchin	132,000	71,000	17,000	8,000
gyenti /Sea Cucumber	24,000	26,000	-	-
gasgos /Shrimp Trawl	-	1,000	-	-

[†] Date ranges for each fishery: Gill net (2012-2021); Halibut (2017-2021), Lingcod (2017-2021), Rockfish (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 Kitkatla Inlet Network 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 AOI 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 12. 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 Kitkatla Inlet 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)
Gill net	17	<1,000	5.4
txaw/Halibut	15	5,000	5.0
wat'ukw/Lingcod	6	1,000	2.4
ts'mhoon/Rockfish	4	*	1.8
Seine	5	<1,000	5.0
Troll	8	<1,000	2.3
k'almoos/Crab	30	49,000	14.2
Geoduck	35	94,000	15.0
gasgos/Prawn	4	*	1.4
ts'akwe'ats/Red Sea Urchin	41	229,000	20.3
gyenti/Sea Cucumber	22	51,000	14.0
gasgos/Shrimp Trawl	9	1,000	2.0
Fisheries will < 5 vessels	17	6,000	-
All Fisheries	169	436,000	49.7

† Date ranges for each fishery: Gill net (2012-2021); Halibut (2017-2021), Lingcod (2017-2021), Rockfish (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 13. 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 Kitkatla Inlet 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	4	*	2.25
Gill net	14	3,000	5.25
txaw /Halibut	30	23,000	12
wat'ukw /Lingcod	10	5,000	4.2
ts'mhoon /Rockfish	10	7,000	3.8
Seine	5	13,000	5
Troll	7	<1,000	2.33
k'almoots /Crab	65	356,000	30.5
Geoduck	35	98,000	15
gasgos /Prawn	12	4,000	3.3
ts'akwe'ats /Red Sea Urchin	41	318,000	21.67
gyenti /Sea Cucumber	24	67,000	10.5
gasgos /Shrimp Trawl	18	2,000	3.5
All Fisheries	237	905,000	81.9

† Date ranges for each fishery: Gill net (2012-2021); Halibut (2017-2021), Lingcod (2017-2021), Rockfish (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 Kitkatla Inlet Network Zones with the DFO PFMA SUBAREAS geodatabase (4-3, 5-2, 5-3, 5-4, 5-5, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-12, 5-13, 5-20, 5-21, 104-3). 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.

5.2.2 Recreational Fishing

Recreational and sustenance fisheries occur throughout the Kitkatla Inlet Network Zones area. Three data sources provided information about the intensity of recreational fishing activities in the Kitkatla Inlet 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 and groundfishes throughout the Kitkatla Inlet Network Zones area (**Figure 39**). **Gasgos**/Prawn and **gasgos**/shrimp recreational fishing also occurs in proximity to the area and overlap with **k'almoots**/crab fishing spots, which occur in the Northeastern portion of Zone 331 in Kitkatla Inlet near **Tgii Xsw'aanx**/Porcher Island (**Figure 39A**). Recreational **hoon**/salmon fishing is shown to occur in Zone 332 and in the outside regions of **Tgii Xsw'aanx** and up to Stephens Island (**Figure 39B**). However, **hoon** fishing is prohibited in the Porcher Peninsula RCA within Zone 332, so this map should be interpreted

cautiously. Groundfish recreational fishing is concentrated to the heterogeneous outer coastline of Zone 331 near Spicer Island and throughout Zone 330 off **Lax k'naga dzol/Banks Island**. It does not occur in the protected RCAs that occur in Zones 332 (Porcher Peninsula RCA) and 333 (Goshen RCA).

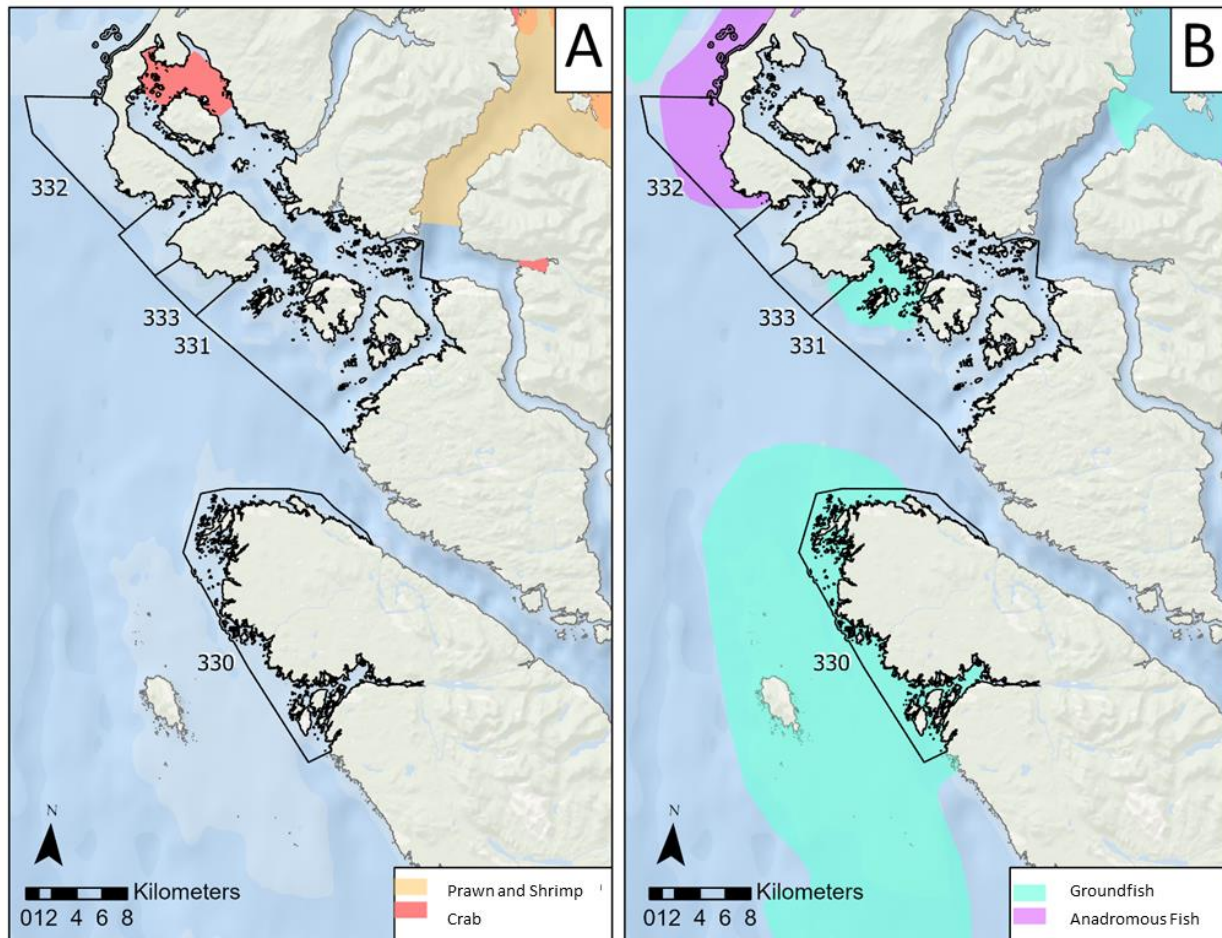


Figure 39. *Overlap of areas where recreational (sport) fishing for (A) **gasgos**/prawn and **gasgos**/shrimp, and **k'almoos**/crab, and (B) groundfish (primarily **txaw**/halibut, **wat'ukw**/lingcod and rockfish) and hoon/salmon and other anadromous fish occurs within the Kitkatla Inlet Network Zones area. 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 Kitkatla Inlet Network Zones area occurs in the Pacific Fishery Management Areas (PFMAs) 4 and 5 (**Figure 40**). 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 14**). 1488 recreational fishing days were documented between January 2020 and June 2022 within both PFMAs. However, specific fishing locations are not known, highlighting a knowledge gap and are likely an underestimation of fishing pressure, especially as the number

of fishing days are not a direct measure of effort or catch. PFMA 4 is a more popular recreational and sustenance fishing region compared to PFMA 5 (**Table 14**), however the area of overlap of PFMA 4 with the Kitkatla Inlet Network Zones is minor (1.67%), in comparison to the overlap with PFMA 5 (19.65%). Angling and shellfish trapping from boats were the most common recreational fishing activities (**Table 14**) with a total of 1014 and 279 fishing days, respectively, between 2020 and 2022.

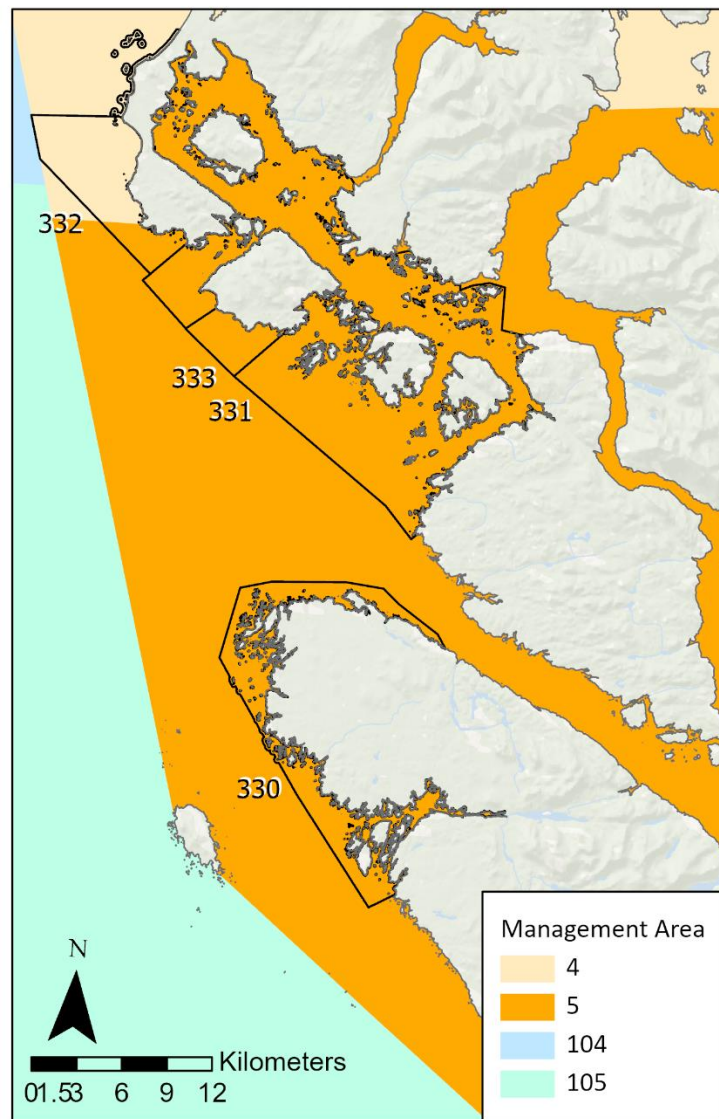


Figure 40. Pacific Fishery Management Areas within Kitkatla Inlet Network Zones area.

Table 14. 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 Kitkatla Inlet Network 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 Kitkatla Inlet Network Zones and their surface area is within PFMA 5.

Fishing Activity	PFMA 4			PFMA 5		
	2020	2021	2022	2020	2021	2022
Angling from boat	317	360	169	65	73	30
Angling from shore	44	23	18	2	4	0
Beach digging or hand picking	3	3	1	3	4	3
Dive-based or other	2	0	0	0	0	0
Shellfish trapping from boat	83	94	59	16	15	12
Shellfish trapping from shore or dock	31	29	16	1	6	2
Total Fishing Days	480	509	263	87	102	47

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 Kitkatla Inlet Network Zones area, with the highest numbers of recreational vessels (or pleasure craft) in Zone 331 (Burke et al. 2022; see also **Figure 49** and **Figure 50** in Vessel traffic and vessel types).

5.3 Human coastal and nearshore activities

5.3.1 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, habitat modification, and nutrient flushing (Hodgson et al. 2020; 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 Kitkatla Inlet Network Zones, a few relatively small (3.06 – 13.05 ha) forestry cutblocks are located on the coast of Zones 330, 331 and 332. A small cutblock (1.43 ha) is located in the south-central region of Goschen Island and a cluster of cutblocks (2.43 ha and 7.88 ha) are located in the central area of Dolphin Island (**Figure 41**). No log handling (including log booms, log dumps, log sorting, and log storage) occurs within the Kitkatla Inlet Network Zones. However, log handling sites are located outside the Kitkatla Inlet Network Zones in closer proximity to forestry cutblocks. These log handling sites are located in the Oona River estuary, Captain Cove and Porcher Inlet (**Figure 41**). Gitxaala harvesters and land users have

previously identified the collection of driftwood from sandy beaches for personal use or for Elders which may be a secondary result of forestry activities (Gitxaala Nation 2016).

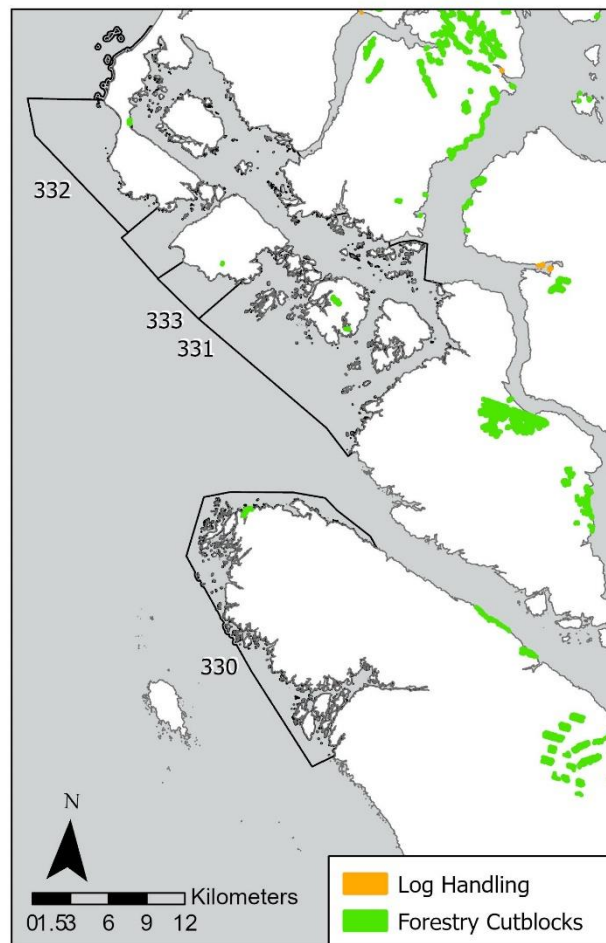


Figure 41. Log handling and storage (including log booms, log dumps and log sorting areas) and forestry cutblocks within and in close proximity to the Kitkatla Inlet Network Zones. Data on log handling areas comes from the British Columbia Crown Land Registry (Tantalis). Data on forestry cutblocks comes from the Province of BC - Forest Analysis and Inventory current until 2021. Note that features are shown larger than their actual spatial area for visualization.

5.3.2 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. However, the extent to which submarine cables negatively impact juvenile **hoon**/salmon in estuaries is unclear (Hodgson et al. 2020). Underwater development can also contribute to benthic habitat modification, habitat disturbance and pollution. Underwater development within the Kitkatla Inlet Network Zones has occurred in Zone 331 (**Figure 43**). An underwater electric power line and telecommunication line are clustered

near the community of Kitkatla (Zone 331). Note that the telecommunication line tenure is not a continuous line feature. This is likely a data quality issue and not representative of the full extent of the underwater development in Zone 331.

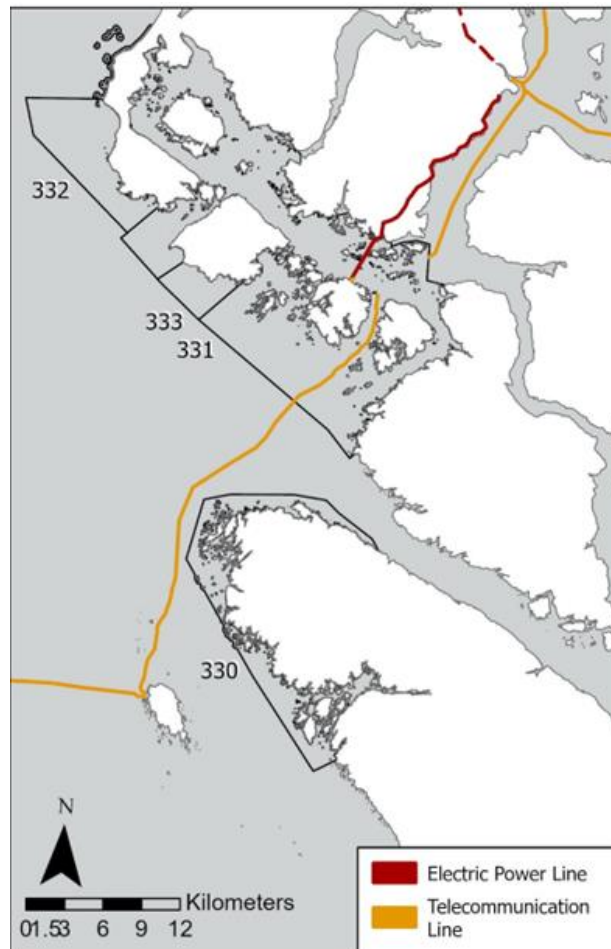


Figure 43. Tenures for underwater development near the Kitkatla Inlet Network Zones. Data comes from the British Columbia Crown Land Registry (Tantalis). It includes Utility Crown land tenures for telecommunication lines, submerged power lines, sewer effluent lines, oil and gas pipelines, water lines, and transmission line tenures issued for waterpower purposes overlapping marine BC areas.

5.3.3 Tourism and recreation

Tourism is one of the main economic activities in BC ([Province of BC Tourism Research](#), 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 important sector, and includes a growing ecotourism and cultural tourism industry ([North Coast Marine Plan 2015](#)). Marine recreational activities in this area include scuba diving, kayaking, recreational boating, fishing and camping. In particular, **Lax k'naga dzol**/Banks Island (Zone 330) was identified as having high tourism

values in the area, including marine campsites and scenic, sheltered inlets suitable for anchoring (see Table 28 in [North Coast Marine Plan 2015](#)).

Spatial data representing tourism and recreation activities compiled by the British Columbia Marine Conservation Analysis (BCMCA) team were used to visualize and quantify the extent of tourism activities in the Kitkatla Inlet Network Zones area (**Figure 44**). Please see [the BCMCA Atlas](#) for a complete list of data sources for each layer and feature, including original data, interviews, and surveys from 1992 to 2009. Note that spatial features may not represent the current distribution of tourism and recreation activities as the data were compiled for the BCMCA Analysis program, which operated from 2006-2013, highlighting a contemporary data gap. Relative importance (low, medium, high) of recreational boating and kayak routes in the Kitkatla Inlet Network Zones area is not shown in the figures (to prevent cluttering) but is described in the following paragraph. The Feature Count spatial layer was created by overlaying and summing 64 tourism and recreation features occurring in, or directly adjacent to (i.e., campsites onshore), the Kitkatla Inlet Network Zones in 2 km by 2 km units (**Figure 44B**). The highest number of overlapping activities in the Kitkatla Inlet Network Zones occurred in the Cessford Islands area (n= 5). All Kitkatla Inlet Network Zones have tourism and recreation features, with Zone 331 having the highest tourism and recreation feature count (n = 42) and Zone 333 having the lowest (n=2). Outside the Kitkatla Inlet Network Zones, there are noted areas with high recreational feature counts (primarily anchorages and campsites) on the northeast coast of **Tgii Xsw'aanx**/Porcher Island, and in the Refuge Bay area.

Within the Kitkatla Inlet Network Zones, campsites and anchorages were noted throughout the area, with the exception of Zones 332 and 333 which do not have identified anchorages on their more exposed coastlines. Anchorages (and haul-outs) are key to the exercise of Gitxaala rights and interests; allowing harvesters to safely stop in key harvesting areas, camps or territories and access resources. Anchorages were also noted to be weather dependent and required for access should harvesters be caught out on the water during a storm (Gitxaala Nation 2016).

Recreational boating routes were noted to be of moderate, and moderate-high relative importance throughout the southeast portion of Zone 331 (around Spicer Island), and of moderate importance within and around Zone 330 (**Lax k'naga dzol**/Banks Island). Sea kayaking routes are present in Zones 331 and 332, however the relative importance and usage of these routes is not recorded (BCMCA Atlas). Several kayak campsites and day destinations are also noted throughout the Kitkatla Inlet Network Zones, and are relatively evenly distributed across the zones (British Columbia Marine Conservation Analysis (BCMCA) Project Team 2011).

Few marinas and docks are located in the Kitkatla Inlet Network Zones. The Kitkatla Harbour is located on Dolphin Island, and a private dock is located in Zone 330 (Iacarella et al. 2019).

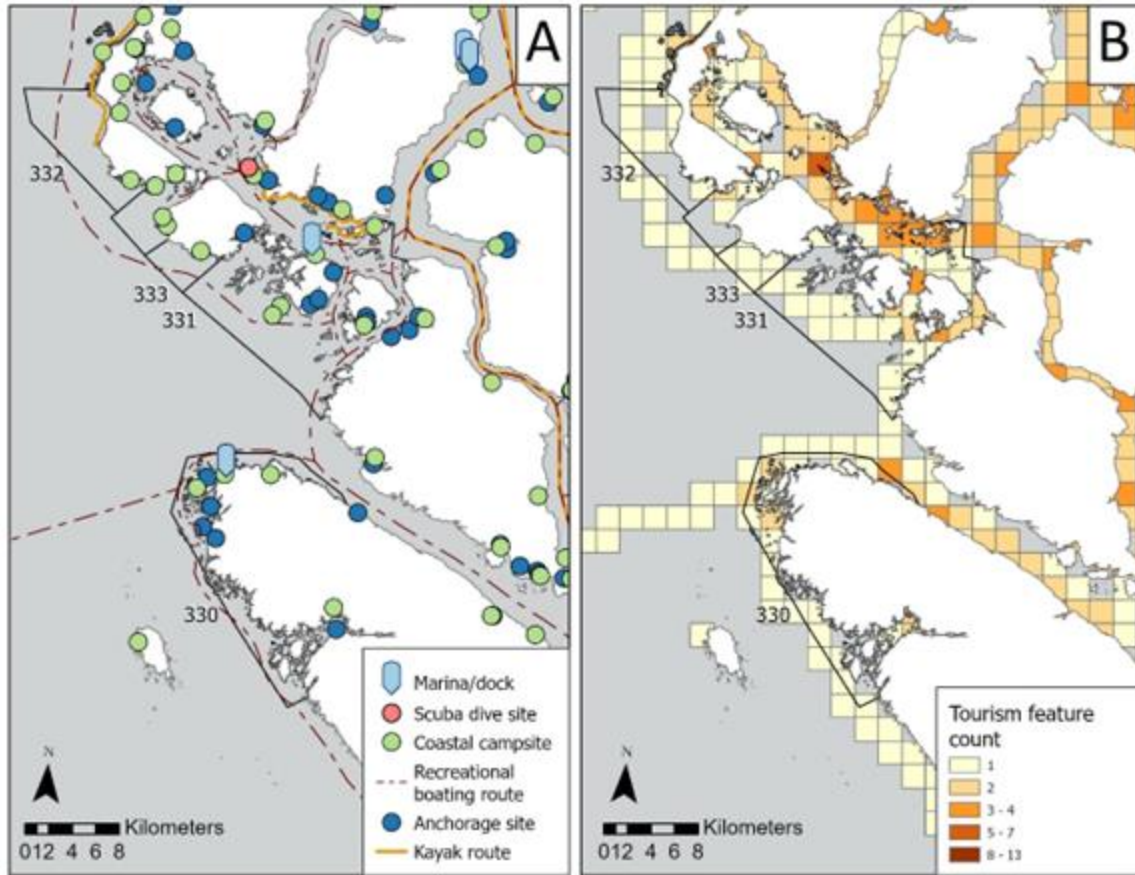


Figure 44. Tourism and recreational features in the Kitkatla Inlet Network Zones showing their A) general distribution and B) total counts in a 2 km by 2 km unit. These feature layers originate from BCMCA (2011) with datasets merged from 1992-2009.

5.3.4 Ocean Energy

Natural energy resources in the NSB, such as areas with high **baask**/winds, **aks**/tides, and **Goop**/waves, can be potentially used for renewable energy development (British Columbia Marine Conservation Analysis (BCMCA) Project Team 2011). While tidal energy projects in BC remain in the inception phase due to infrastructure costs and a lack of supporting policy (Dalhquist-axe 2020), a few areas of interest have been identified in the NSB. Porcher Narrows, an area bordering Zone 331 and connecting it Porcher Inlet, was identified as having high potential for future tidal energy projects ([North Coast Marine Plan 2015](#)). Wave energy was investigated as a resource by the [West Coast Wave Initiative](#) project team.

There are currently nine **baask**/wind turbine sites in terrestrial locations across BC ([Canada Wind Turbine Database](#)). Relatively high annual mean **baask** energy potential (measured in watts per m²) was identified on the outer areas of the Kitkatla Inlet Network Zones, particularly in Hecate Strait and along the western edge of **Lax k'naga dzol**/Banks Island (Zone 330; British Columbia Marine Conservation Analysis (BCMCA) Project Team 2011; **Figure 45**). The annual **baask** 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](#). Several crown tenures for **baask** energy (investigative phase) exist within and adjacent to the Kitkatla Inlet Network Zones, with expiration dates of November 2023. The tenures are located in the northern region

of the Kitkatla Inlet Network Zones in both marine and terrestrial areas. Approximately 78% of Zone 332 is covered by a **baask** energy tenure (**Figure 45**). Elsewhere in the NSB, a proposed [offshore wind turbine project](#) in Hecate Strait is in development that would provide renewable power to north coast communities.

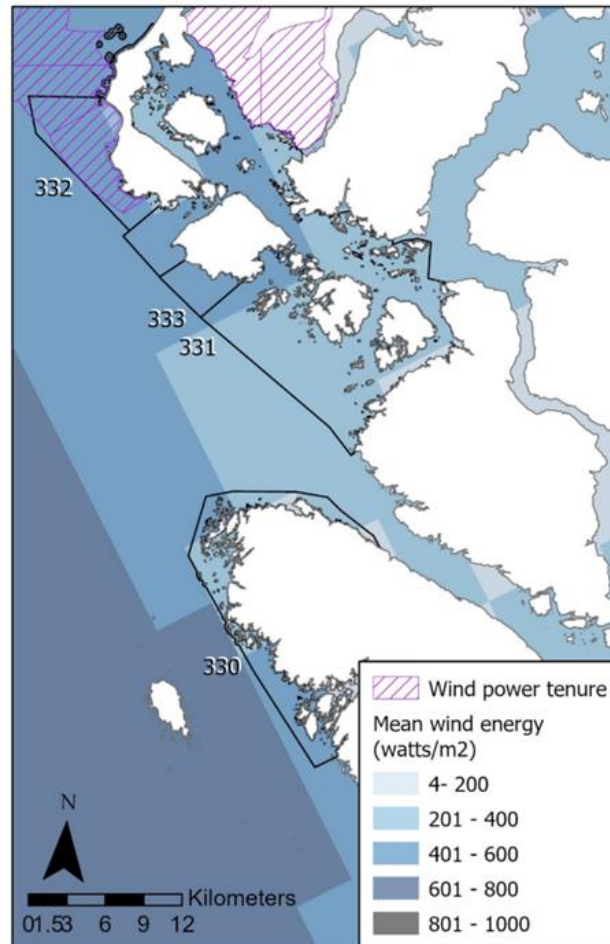


Figure 45. Mean **baask**/wind energy in watts per meter squared (W/m^2) and **baask** power tenure locations in the Kitkatla Inlet Network Zones and area.

Non-renewable energy resources in the NSB include petroleum and offshore oil and gas. The provincial and federal government issued tenures to various companies in the 1960s. Federal and provincial moratoriums were 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. The three companies that historically held federal tenures that partially overlapped with the Kitkatla Inlet Network Zones, [Suncor](#), [Shell](#), and [Chevron](#), have recently relinquished their licenses to the Federal Government.

5.4 Vessel traffic and vessel types

Even though the Kitkatla Inlet Network Zones area is sparsely populated, the Kitkatla Inlet Network Zones are situated between busy ports in **Kxeen**/Prince Rupert (Port of Prince Rupert

and Port Edward) and Kitimat (Port of Kitimat). This area is a thoroughfare for vessel use, although not all of it goes directly through the Zones. The Port of Prince Rupert is North America's closest shipping port to Asia and the third busiest seaport in Canada. The private Port of Kitimat is the third largest port in BC, after Vancouver and **Kxeen**, 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 all the Kitkatla Inlet Network Zones. Vessels traveling through the marine waters of the Kitkatla Inlet Network Zones range from kayaks and recreational vessels to larger ferries and cruise ships.

Marine travel routes are extremely important to the Gitxaala way of life, and include critical travel between Lach Klan/Kitkatla Village and **Kxeen**/Prince Rupert and Gitxaala harvester routes to areas of use (Gitxaala Nation 2016). Travel within the Kitkatla Inlet occurs mainly on smaller vessels, which use haul-outs rather than anchorages for harvesting activities (Gitxaala Nation 2016). Route use also depends on **aks**/tides to maximize travel time, and time to set gear during the tidal slack (Gitxaala Nation 2016). Harvested resources along travel routes include towing wood in calm weather to village bays for firewood or smoking fish (Gitxaala Nation 2016).

However, as economic growth and trade are poised to expand, shipping traffic and vessel size are expected to grow (GS Gislason & Associates Ltd. 2007). For example, the Kitkatla Inlet Network Zones area may face additional large vessel traffic due to two Liquid Natural Gas (LNG) projects underway in Kitimat. The "LNG Canada" project aims to build Canada's first liquefied natural gas export terminal in Kitimat, and the first phase is on track to ship by 2025 ([Business in Vancouver, 2022](#)). 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 November 2022, the [North Coast Waterway Management Guideline](#) was implemented for the waterways of the Gitga'at and Gitxaala Nations. The guideline applies to all vessels navigating the following areas: Douglas Channel, Wright Sound, Lewis Passage, Otter Channel, Nepean Sound, and Principe Channel (**Figure 46**). The proposed LNG shipping passage will pass through a similar route. The Management Guidelines provide voluntary guidance on identifying Gitga'at and Gitxaala areas of concern, information on avoiding transit or operations such as dates and times to avoid transit, speed reduction for **ibuun**/whales or fishing gear, passing and meeting, routing, and communications (Liu et al. *in press*). It also provides guidance on emergency response for equipment failure. For example, navigation guidelines suggest reducing speed when **ibuun**, small craft, or community vessels operated by First Nations are nearby.

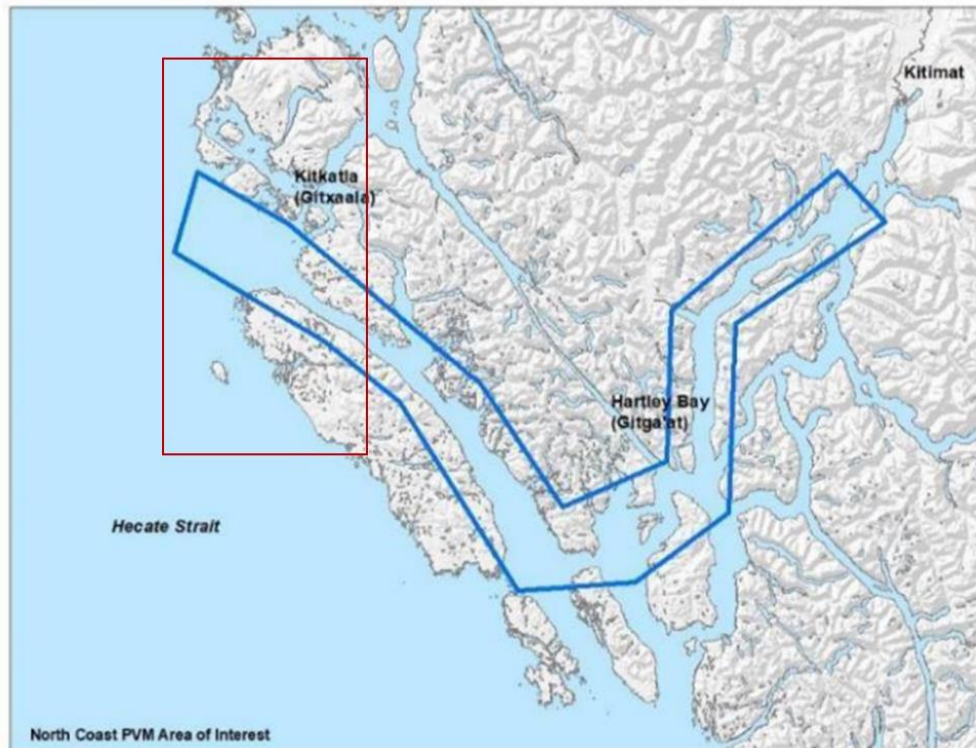


Figure 46. Areas under the North Coast Waterway Management Guidelines, shown in blue outline. The red rectangle shows the Kitkatla Inlet Network Zones area, including Kitkatla Inlet and Lax k'naga dzol/Banks Island. Map modified from original figure from [Transport Canada Ship Safety Bulletin RDIMS No. 18946498](#).

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, marine debris, see Pollutants), disruptions to fishing gear and **la'ask**/seaweed harvest due to increased wave action on intertidal **la'ask** 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). Gitxaala Nation have major concerns with increases to tanker traffic throughout the Laxyuubm Gitxaala. Concerns related to these increases include interfering with the ability to travel and Nation member safety, pollution from the ships (e.g., operational discharges and potential for invasive species); wake impacting the shoreline (e.g., making **Goop**/waves and stirring up the water can impact sensitive species such as **la'ask**); and lights on the tankers at night which could impact navigation; noise from vessel traffic which can impact marine life, interference with fishing equipment, interference with harvesting, the visual impacts of tankers, and the potential for tanker accidents, etc. (Conacher et al. 2014). Cetaceans and pinnipeds are susceptible to the harmful byproducts of increased marine traffic (Kucey 2005; Johnson and Acevedo-Gutierrez 2007), especially when large vessels travel fast in areas where they aggregate. Examples of mitigating collision risk for cetaceans include limiting speeds to less than 10 knots while in the area and limiting LNG and other large vessel traffic (> 180 m) during nighttime (to avoid behaviours when **ibuun**/whales are in shallow waters) and seasons when **ibuun** are most active in the area (Keen et al. 2023).

For more ship-strike information, please refer to Liu et al. (*in press* and Keen et al. 2023). Finally, ships can also be a prominent method of introduction and connection for non-indigenous or invasive species to be transported into and between marine protected areas (Iacarella et al. 2019). It was noted that vessel biofouling regulations were needed in addition to MPA network plans on invasive species monitoring and prevention (Iacarella et al. 2019).

Gitxaala have experience with existing marine traffic, including container ships, ferries, cruise ships, recreational traffic, and other commercial vessels. Shipping related concerns from these and larger vessels were described by Gitxaala Nation members in a report regarding their thoughts on the construction of the Kitimat LNG Terminal Project and the proposed travel routes for the LNG tankers, which would go through **Laxyuubm Gitxaala**. Gitxaala Nation participants have previously outlined several potential issues, including increased wake, decreased access to resource sites, pollution, and interferences with gear (Gitxaala Nation 2016). Wake from large ships is much more powerful and loud than naturally occurring **Goop**/waves and they hit the shoreline more directly. Vessel wakes were also reported to be steeper and faster. Furthermore, large ships created **Goop** from the bow, the middle, and stern, with the middle wave being the largest of the three. Participants also indicated that wave return after breaking on shore from large vessels can be dangerous to people and boats on or near the shore. Gitxaala mariners have also reported that wake does not get lost in the natural swells; rather they have a different angle and are noticeably different from the natural wave action. The concern is that this could be dangerous for Gitxaala harvesting activities, which primarily occur at low **aks**/tide (Gitxaala Nation 2016), especially as most Gitxaala harvesting is dictated by the weather as well as the **aks**. The **aks** has to be low for most intertidal species to be harvested, so timing is critical. Additionally, use of specific anchorages or travel routes also depends on the weather. Large vessel traffic could impede Gitxaala harvesters from accessing resource sites with the **aks** or from anchoring safely. The workshop participants also indicated that they had experienced loss/interference of gear from the existing marine traffic and are concerned how any additional traffic may exacerbate this. In addition to access to marine and terrestrial resources, Gitxaala members expressed concern regarding increased shipping would wash the **la'ask**/seaweed off the rocks or change its availability. Gitxaala members have reported that, cruise ships have increased the turbidity of the water in the Kitkatla Inlet Network Zones area, which interfered with harvest of certain species, including **Bilhah**/abalone, that are sensitive to an increase in silt in the water (Gitxaala Nation 2016).

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 Kitkatla Inlet Network Zones.

Many ships have AIS transponders that provide information such as the vessel's identity, position, and activity to other AIS devices and 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 or 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 ([MPATT vessel traffic density grids 2015-2019 metadata](#)) were used to summarize total vessel counts and vessel types within each Network Zone in 2019 per 1 square kilometer.

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 (Burke et al. 2022; Iacarella et al. 2023). C&P flyover data within the Kitkatla Inlet Network Zones were compiled from the C&P flyovers database for 2019 and 2020 and were used to summarize vessel counts and vessel types along with fishing gear type.

Vessel traffic density and type

Two routes in the Kitkatla Inlet Network Zones area have the densest vessel traffic: 1) an outer passage route that travels outside of the zones from Port Edward around the northwest side of **Tgii Xsw'aanx**/Porcher Island and down between **Lax k'naga dzol**/Banks Island and McCauley Island in Principe Channel, which is adjacent to all four Zones and 2) an inside route that travels from Port Edward around the eastern edge of **Tgii Xsw'aanx** through Malacca Passage and Kitkatla Inlet out to **Lax k'naga dzol** by the eastern edge of McCauley Island via Petrel Channel, intersecting with Zone 331 (**Figure 46**). Most vessels were observed in Zone 331, which encompasses part of Kitkatla Inlet (**Figure 48**). Fishing vessels, followed by pleasure craft were the most common vessel type in all Kitkatla Inlet Network Zones. Cargo vessels were unique to Zone 330.

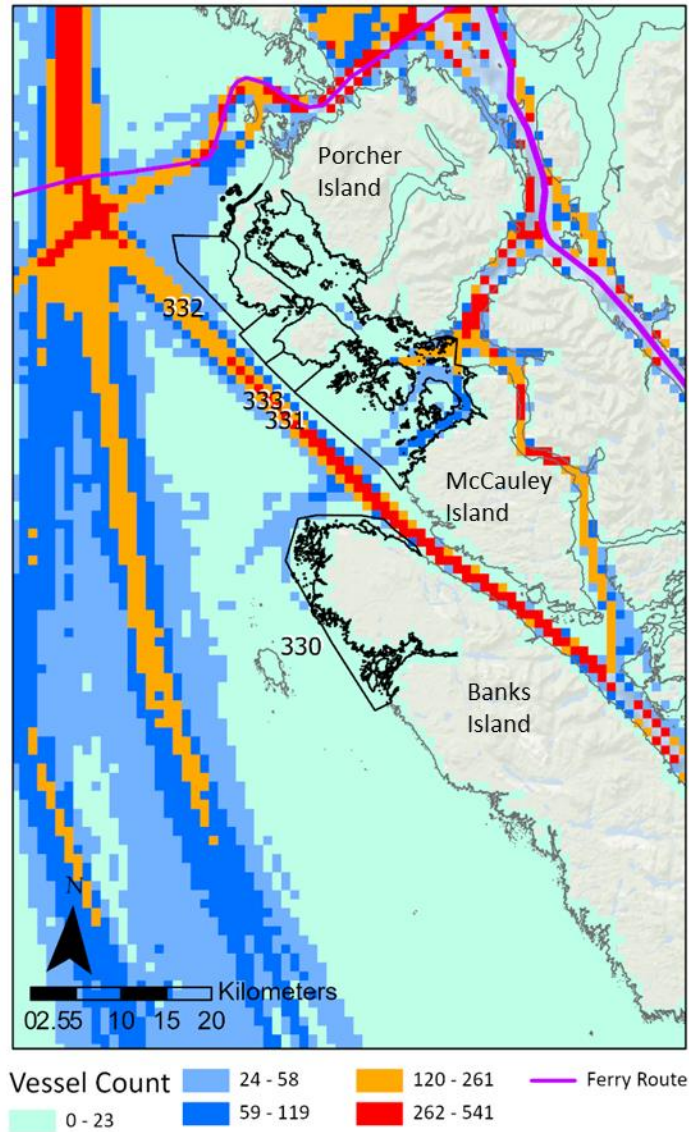


Figure 46. Total annual estimated vessel traffic in 2019, and ferry route, in the Kitkatla Inlet Network Zones area of the Northern Shelf Bioregion, British Columbia. Vessel traffic counts are the total number of vessels per 1 km² grid cell based on AIS data. For a breakdown of each vessel type per Network Zone see Figure 44.

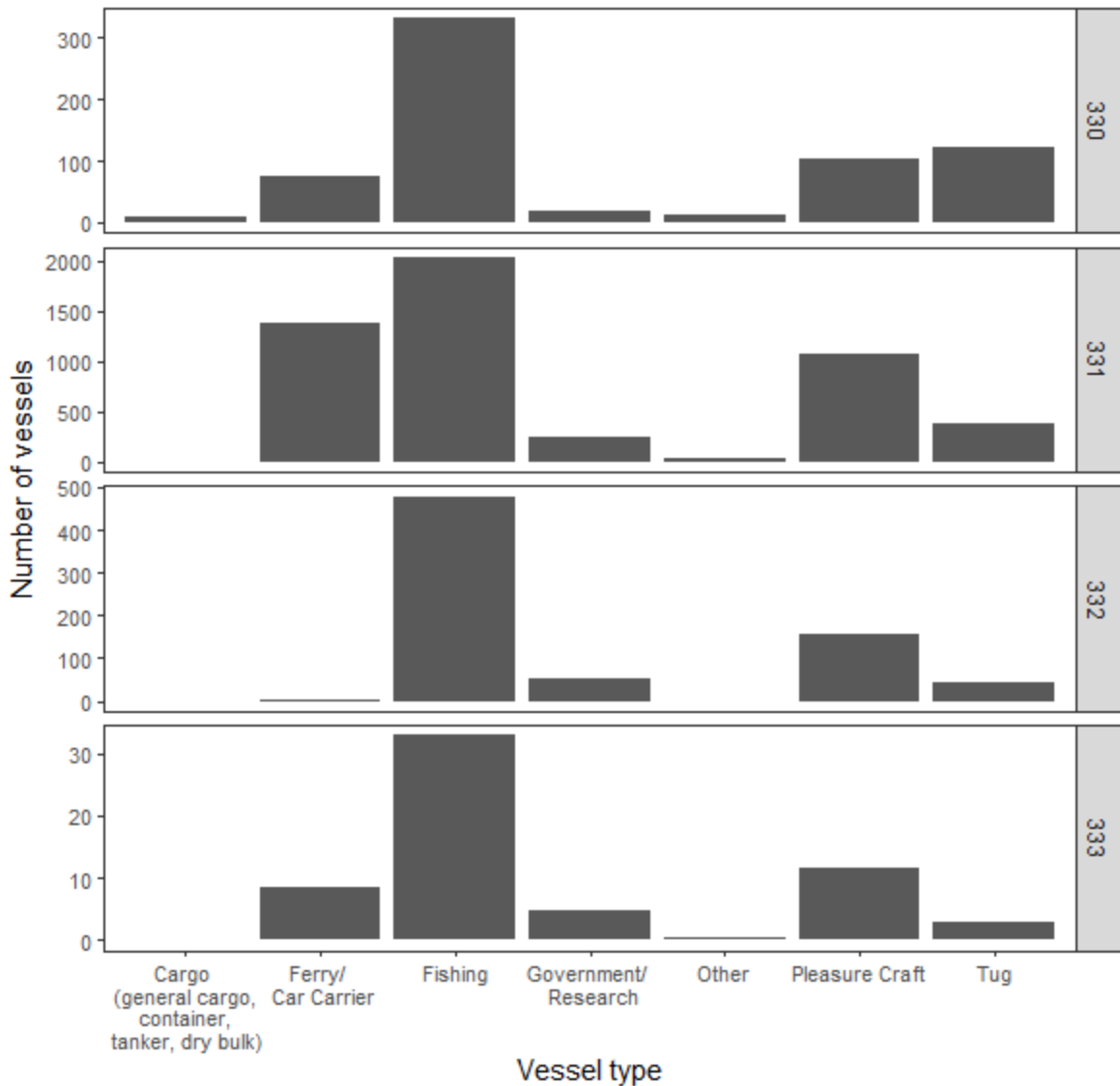


Figure 48. Number of vessels by type per 1km² in the Kitkatla Inlet Network Zones detected by Automatic Identification System. Note the different magnitudes of y-axis in each Zone. For attribute information on vessel types please refer to [the metadata provided by the Marine Protected Area Network Technical Team](#). A visual summary of total vessel numbers detected in each Network Zone shown in Figure 43.

Vessel activity observed on C&P flyovers in 2019 and 2020 in the Kitkatla Inlet Network Zones was highest in zones 330 and 331, and few vessels were detected in the remaining zones (i.e., 332 and 333) (**Figure 49**). Most vessels detected on the flyovers in 2019 and 2020 were commercial fishing vessels, and of these vessels, most were commercial dive vessels fishing for **aswit**/sea urchin (**Figure 50**), which is consistent with the overlap information from commercial logbooks. Vessels detected per unit effort (i.e., # of C&P flyovers in the zones per month) was highest in February in 2019 and in September in 2020 (**Figure 51**).

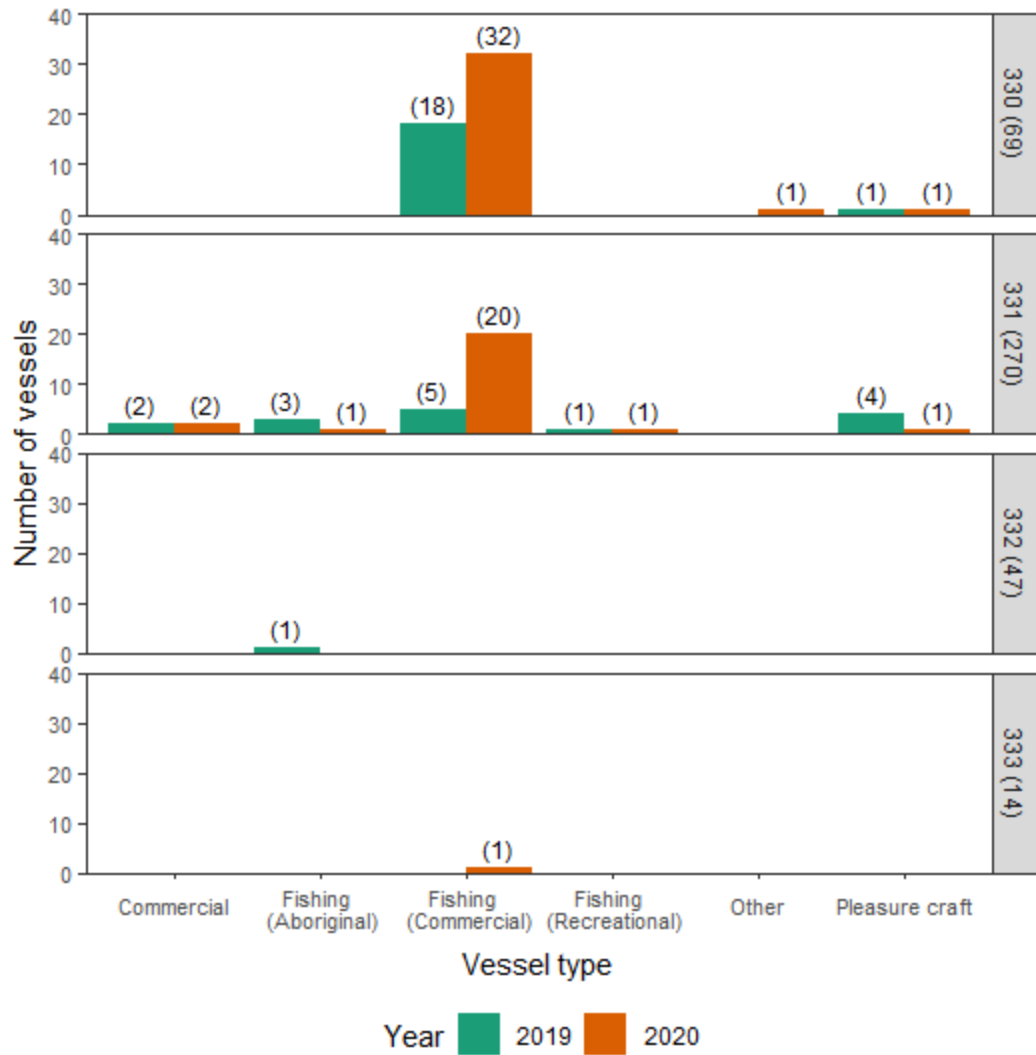


Figure 49. Vessel types detected in the Kitkatla Inlet Network Zones in 2019 and 2020. Data comes from the Conservation & Protection Aerial Surveillance Program flyovers per year (Burke et al. 2022 and Iacarella et al. 2023).

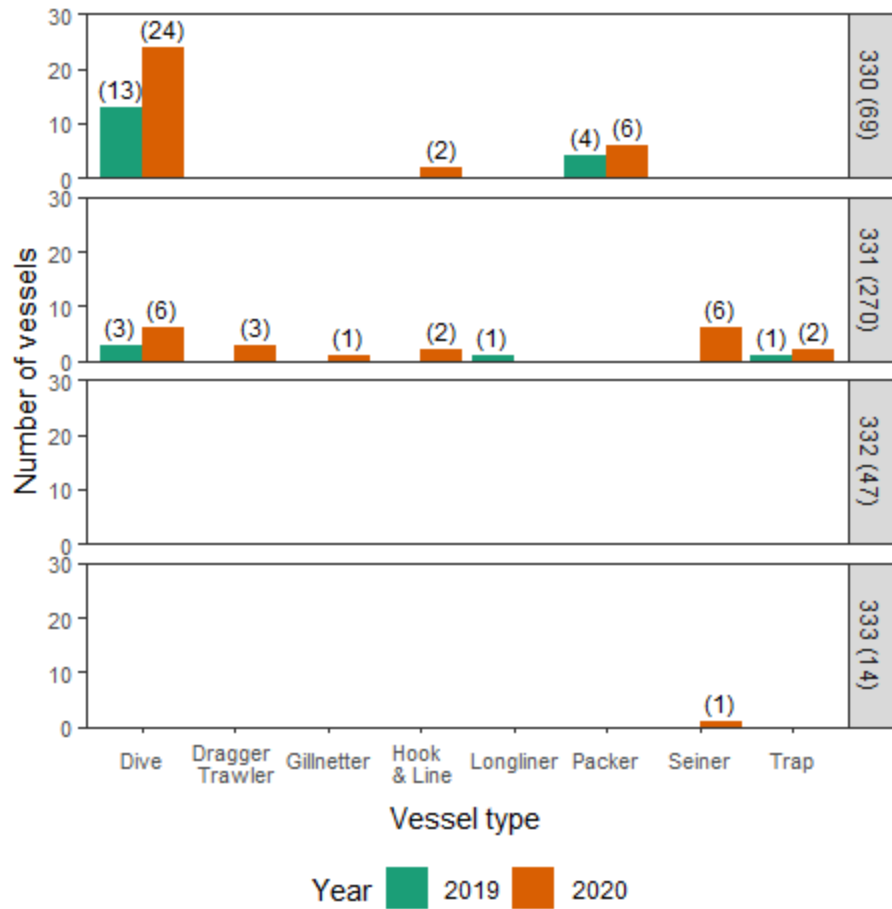


Figure 50. Fishing vessel gear types detected in the Kitkatla Inlet Network Zones in 2019 and 2020. Data comes from the Conservation & Protection Aerial Surveillance Program flyovers per year (Burke et al. 2022 and Iacarella et al. 2023).

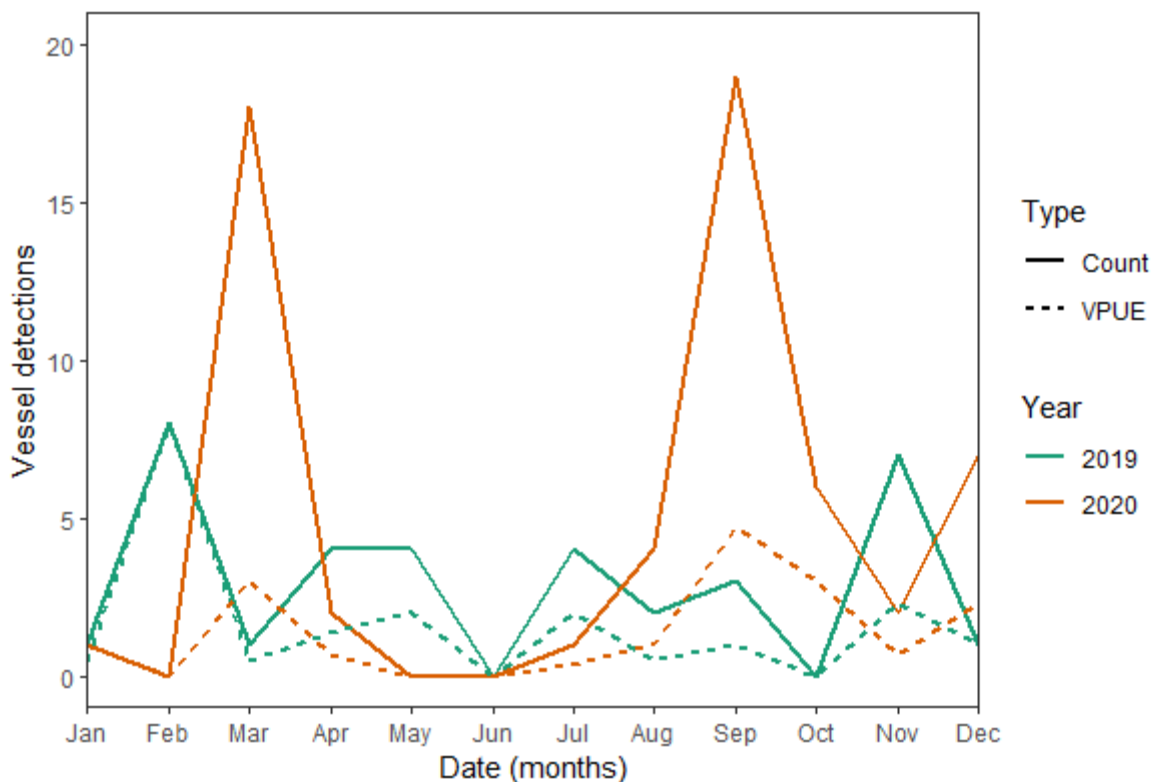


Figure 51. Number of vessels per month in the Kitkatla Inlet Network Zones in 2019 and 2020. Data comes from the DFO Conservation & Protection Aerial Surveillance Program (Burke et al. 2022 and Iacarella et al. 2023).

5.5 Pollutants

Pollution (chemical, thermal and sound) from anthropogenic activities can enter marine environments directly or indirectly and can harm human health and marine species, habitats and environments. Sources of pollution include resource extraction, vessel emissions and spills, sedimentation, sewage, dredging, non-degradable debris and litter (e.g., plastics) and organic deposition from upstream or nearby agricultural and aquaculture operations. Pollution can also affect access to valuable habitats and resources to Indigenous groups and coastal communities that rely on a healthy marine environment for subsistence, knowledge transmission and preservation of cultural values.

High vessel traffic occurs through Principe Channel and Browning Entrance and north to Hecate Strait, directly adjacent to all zones within the Kitkatla Inlet Network Zones. High vessel traffic also occurs through **Maxla Kxa Naayxt**/Ogden Channel and around **Tgii Xsw'aanx**/Porcher Island (**Figure 46**). Pollutants that originate from vessels (particularly larger ships such as cargo and cruise ships) include sewage, greywater, and scrubber washwater. While detailed information is lacking regarding the extent of vessel discharge and its effects within the Kitkatla Inlet Network Zones, the activities associated with marine pollution that overlap with the Kitkatla Inlet Network Zones are discussed below.

Greywater is generated from human usage onboard, such as sinks and laundry, but excludes sewage. 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 (*Canada Shipping Act* 2001). 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 (WWF-Canada 2022). Nearby Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs (the northern Glass Sponge Reef MPA is southwest of Zone 330) is the third most polluted MPA, mostly due to scrubber washwater (). Sewage discharge threatens commercial and recreational shellfish beds and affects water quality, particularly in areas with low tidal exchange. (Campos and Lees 2014). New [environmental regulations](#) for the 2022 season require that cruise ships discharge treated sewage and greywater at least three nautical miles from shore. “Scrubbers” on larger vessels are systems that aid in cleaning engine exhaust after burning heavy fuel oils to prevent atmospheric pollution. The scrubbing process creates washwater that 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; Teuchies et al. 2020). An assessment on scrubber washwaters by Clear Seas Centre for Responsible Marine Shipping (2022) supported limiting and restricting discharge in coastal and inlet waters.

Marine litter is synthetic debris found in the marine environment with anthropogenic origins that may negatively affect local ecosystems. Concerns from Gitxaala Nation members about discarded waste and debris from large LNG vessels transiting Principe Channel were discussed at a workshop (Gitxaala Nation 2016). Workshop participants expressed concerns about the impacts of the wakes from large vessels on the shoreline and marine riparian zone – important areas where people gather medicinal plants and berries. The large **Goop**/waves and wakes can push garbage and waste high into bush, and participants noted that Gitxaala harvestors have found debris (e.g., five gallon buckets, coils of rope) along the forest edge, particularly in the **Lax Kul**/Bonilla Island area. A number of [shoreline clean-up projects](#) organized by the Gitxaala Nation confirmed these reports. Lost, abandoned, or discarded fishing gear (also called ghost gear) harms marine life and habitats, sheds microplastics, and presents hazardous obstacles for 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 microplastic bioaccumulation across the food web is a concern across the coast (Alava 2012), especially for Gitxaala Nation, First Nations and coastal communities that depend on marine resources for subsistence and 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. Williams et al. (2011) modelled the distribution of marine debris and its overlap with marine mammal species in BC waters. In the study, styrofoam, plastic bags, and plastic bottles were the most common observed debris throughout the coast, and marine debris was observed on the transect that occurred near the Kitkatla Inlet Network Zones (Figure 2 in Williams et al. 2011).

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 **Ibuun**/whales and dolphins that rely on acoustic signals for communication, foraging, and navigation (see Marine Mammals). Other sources of underwater sound that could negatively impact marine animals, such as **Naaxl**/killer whales, include military and commercial sonars, seismic survey air guns, tidal turbines, underwater explosions, acoustic devices used for pinniped deterrence, and pile-driving operations (Ford et al. 2013a).

A wastewater treatment facility in the community of Kitkatla ([Site reference number E286769, Ministry of Environment, Province of BC, 2011](#)) discharges treated waste water into Zone 331, which is regularly tested.

Pollution and infrastructure associated with an inactive and bankrupt mine on **Lax k'naga dzol**/Banks Island continues to affect creeks and nearshore areas. In 2015, the Provincial Ministry of Energy and Mines ordered operations at the Yellow Giant Mine (located in the central west region of **Lax k'naga dzol**, south of Zone 330) to cease and desist after effluent and tailings were illegally discharged into a waterways and wetlands. In 2016, Gitxaala Nation retained an environmental services provider to perform an initial assessment and human health risk assessment relating to the Yellow Giant mine spills (Nees Hiwaas Aff. ¶ 48, October 21, 2021). These reports identified unacceptable risks to humans from potential exposure to discharge contaminants, specifically arsenic, cadmium, copper and lead (Nees Hiwaas Aff. ¶ 52, October 21, 2021). Despite the findings of these reports, there had been no remediation of impacted areas to date (Nees Hiwaas Aff. ¶ 48, October 21, 2021). In 2016, the Hereditary Table developed a victim impact statement which expressed that the cultural impacts of this contamination of a valued Gitxaala heritage site cannot be measured (Nees Hiwaas Aff. ¶ 49, October 21, 2021). The Gitxaala Nation is currently undertaking legal action to reform the Provincial Mineral Tenures Act, which allows mineral rights to be granted Indigenous Territory without the consent, consultation or notification (Gitxaala Nation 2023a, 2023b).

5.6 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 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 updated¹⁰. 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 **Kxeen**/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. 2015b).

We present the activities and stressors that have any spatial area coverage in the Kitkatla Inlet Network Zones identified through the latest cumulative effect assessment (**Table 14**). Cumulative effect scores are shown in **Figure 52** and were last updated on October 13, 2023. For further details on the datasets refer to Clarke Murray et al. (2015a and their Supplementary tables). Note that the data presented in **Table 14** are current from 2011 to October 2021, depending on the data layer. SST, Cutblocks, commercial harvest of **ts'akwe'ats**/red urchin and

¹⁰ Selina Agbayani, Cathryn Murray, Craig Schweitzer. Cumulative impact mapping for marine habitats: 2023 update. Unpublished data.

txaw/halibut, and recreational boat routes impacts all the Kitkatla Inlet Network Zones. Zone 331 has the highest number of potential activities within its bounds, for a total of 23 (**Table 14**). The combined cumulative effect scores are highest in northern region of Zone 330 off **Lax k'naga dzol**/Banks Island, in the northwest side of Zone 331 and throughout Kitkatla Inlet in Zone 331. These areas are characterized by long convoluted coastlines and broken islands with higher terrestrial-marine interfaces. Furthermore, it's key to highlight that climate change is projected to affect every square kilometer of British Columbia's marine waters, leading to potential cumulative effects in various depth classes and habitats (Clarke Murray et al. 2015a). The cumulate effect scores calculated for the Kitkatla Inlet Network Zones are comparable to other nearshore regions along the BC coast, and are in mid to mid-high end of the ranges (see Figures 2 and 3 in Clarke Murray et al. 2015a and Figure 1 in Clarke Murray et al. 2015b).

Table 14. Human activities and climate change stressors documented in the Kitkatla Inlet Network Zones, based on the data compiled for cumulative effects assessments by Clarke Murray et al. 2015a. 'X' indicates presence of activity or stressor in each zone; "-" indicates absence. Activities are shown in order of increasing proportion of area coverage.

Human Activity	Zone				Proportion of Area
	330	331	332	333	
Climate Change					
Sea Surface Temperature	X	X	X	X	1.00
Coastal					
Marinas	X	-	-	-	0.01
Roads	-	X	-	-	0.16
Cutblocks	X	X	X	X	0.30
Ports	X	X	X	-	0.92
Cities	X	X	X	X	1.00
Fishing					
Commercial: Hoon /Salmon Seine	-	X	-	-	< 0.01
Commercial: gasgos /Prawn	-	X	-	-	< 0.01
Commercial: Hoon Troll	-	X	X	-	0.01
Commercial: Gasgos /Shrimp	-	X	-	-	0.01
Commercial: Bottom Groundfish Trawl	-	X	-	X	0.01
Commercial: Gyenti /Sea cucumber	X	X	-	-	0.13
Commercial: k'almoos /crab	X	X	X	-	0.16
Commercial: Geoduck	X	X	-	-	0.17
Commercial: Wat'ukw /Lingcod	X	X	X	-	0.29
Commercial: Hoon Gillnet	X	X	-	-	0.37
Commercial: Ts'akwe'ats /Red Sea Urchin	X	X	X	X	0.39
Commercial: Rockfish	X	X	-	X	0.50
Commercial: Xs'waanx /Herring Spawn on Kelp	X	X	X	-	0.70
Commercial: Txaw /Halibut	X	X	X	X	0.73
Commercial: xs'waanx /Herring Roe Seine	X	X	X	X	0.90
Commercial: Fishing Vessels	X	X	X	X	1.00
Marine					
Shipping	X	X	X	X	0.62
Recreational Boat Routes	X	X	X	X	0.89
Total Count of Activities	18	23	14	11	
Minimum Cumulative Effect Score	13.13	13.68	10.35	19.53	
Maximum Cumulative Effect Score	41.07	41.75	35.34	28.30	
Mean Cumulative Effect Score	28.62	28.36	17.76	25.93	

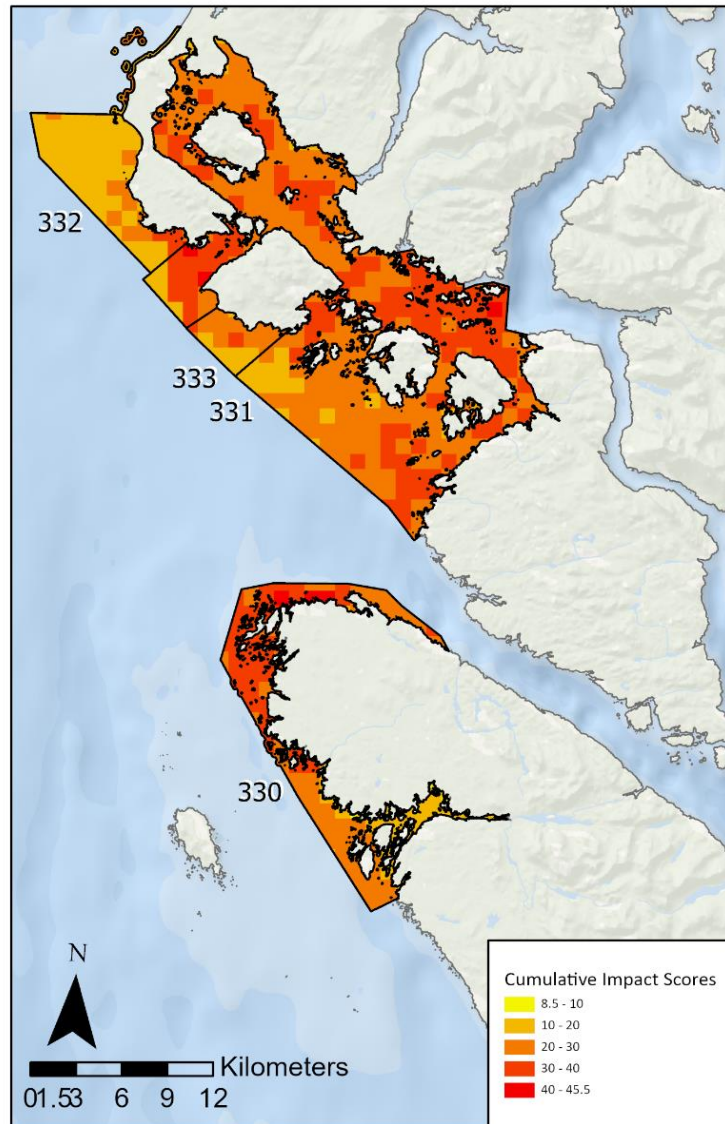


Figure 52. Cumulative effect scores for all combined current activities and climate stressors in the Kitkatla Inlet Network Zones (see **Table 14** for activities and stressors included).

5.7 Data and Knowledge Gaps

Several knowledge gaps regarding the scope of human uses in the Kitkatla Inlet Network Zones exist, spanning fishing activities tourism and recreation and vessel traffic. Commercial fishing data for some fisheries are summarized at the PFMA scale, which is too coarse and needs to be updated, particularly for adaptive management and monitoring of MPAs. However, spatialized logbook data for the commercial fleet was used in this report at a scale smaller than the PFMA to address this issue. For the recreational fleet iRec data is only available at the PFMA scale described as the number of fisher days; specific fishing locations are not known. Finer scale reporting of recreational fisheries is required to understand the geographic distribution of the fishery and potential associated stressors. The spatial data on the distribution of tourism and recreation features used in this report is not up to date and may underrepresent tourism and recreation activity in the region (dataset used in this report is from 1992-2009). Updated local

tourism data is needed and could be collated from various local sources. Additionally, the impacts of sediment on nearshores systems from coastal activities, including forestry and the range of potential avenues for renewable energy are unknown at this time for the area.

While there are plenty of vessel tracking data in the Kitkatla Inlet Network Zones area, particularly near Port Edward, 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 from noise and increased **Goop**/waves along shorelines, may be the largest and most direct source of anthropogenic stressors on the habitats, species, and areas of cultural importance in the Kitkatla Inlet Network Zones. This is especially true following further construction and growth in the nearby ports of **Kxeen**/Prince Rupert and Kitimat. Analyzing vessel numbers, location density, and time (by month or year) would be informative for predicting long-term trends. Further, detailed information is lacking regarding the extent and effects of vessel pollution and discharge in the Kitkatla Inlet Network Zones. 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. Current research and analysis are being undertaken jointly between Gitxaala and Transport Canada as part of the [Cumulative Effects of Marine Shipping](#) initiative that may address these gaps.

Several knowledge gaps and research recommendations concerning human activities within the Kitkatla Inlet Network Zones exist. First, commercial fishing data for certain fisheries (e.g. salmon) are summarized at the Pacific Fishery Management Area (PFMA) scale, which is too broad to inform adaptive management and monitoring of Marine Protected Areas (MPAs). For the recreational fleet, iRec data is available only at the PFMA scale, which represents fisher days but lacks specificity regarding fishing locations, highlighting the need for more detailed reporting of recreational fisheries to understand their geographic distribution and the associated stressors. Furthermore, the spatial data on tourism and recreation activities in the region is outdated, as it is based on data from 1992-2009, which may not accurately reflect current tourism trends. There is a need for updated local tourism data, potentially sourced from various regional stakeholders. Additionally, the impacts of sediment on nearshore systems due to coastal activities, such as forestry, and the potential for renewable energy development in the region remain unknown.

Despite the availability of vessel tracking data in the Kitkatla Inlet Network Zones, there is still a significant gap in understanding both the direct and indirect effects of vessel traffic on the local ecosystem. Moreover, detailed information is lacking regarding the extent and effects of vessel pollution and discharge in the region. To address these gaps, further research analyzing vessel numbers, location density, and temporal factors (monthly or yearly) would be useful for predicting long-term trends and understanding their effects on future research, surveys, and models. The ongoing joint research between Gitxaala and Transport Canada, part of the Cumulative Effects of Marine Shipping initiative, holds promise for addressing many of these knowledge gaps and informing effective conservation policies.

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 and taxonomic diversity present within the scale of the Kitkatla Inlet Network Zones. This description includes the marine area within the boundaries of the Kitkatla Inlet Network Zones (330-333) and the surrounding marine area that may be affected by management within the Kitkatla Inlet Network Zones to consider ecological linkages and connectivity. When available, data sources, knowledge and data gaps for the Kitkatla Inlet Network Zones are also described. Details of data sources are further described in the **Appendix G**, and key knowledge and data gaps are listed in **Section 8.2 Knowledge gaps and recommendations**.

Importantly, this section also summarizes the ecological Sensitivities and Recoverability of relevant ecosystem features and all taxonomic groups and species of interest to inform downstream decision-making processes and risk assessments. Currently, there is no formal framework for evaluating and describing Sensitivities and Recoverability of habitat features or taxonomic groups in the context of Marine Conservation Targets in the NSB. This report's scope is set using definitions of ecological sensitivities, resiliency, stressors, and recoverability informed by other reports and is presented below. These definitions were first written in the Caamaño Sound and Douglas Fjord Systems Network Zones Biophysical overview report (Liu et al. *in press*) and subsequently guide the ecological summary writing for this report. Future documents in the Marine Planning process may not have the same descriptive guidelines.

Sensitivities are the traits of a habitat or species that make them more vulnerable when interacting with a stressor (O et al. 2015). **Stressors** include naturally occurring physical or environmental disturbances or anthropogenic disturbances such as the effects of climate change (see Climate Change) and other human activities (see Human Uses Of Area) that may negatively impact habitats or species (O et al. 2015). These stressors may directly affect the sensitivity of a species or habitat or indirectly through the food web or other ecosystem interactions. For example, a species might be sensitive to a stressor like overexploitation if they are susceptible to degradation or decline and slow recovery. Furthermore, a local population might be more sensitive than other regional populations if their prey are depleted or their abundance is already low from previous disturbances. **Resilience**, on the other hand, is the ability, or flexibility, of a habitat or species to return to pre-impact conditions and functions after exposure to a stressor (O et al. 2015). For example, a species with life history traits such as fast growth or high fecundity may be more resilient after a population decline than those with slow growth and/or low fecundity. In addition, a habitat or stressor could be described as resilient to a specific stressor if an interaction shows no adverse effects or trends. **Recoverability** is another aspect of resilience referring to the ability of a species or population to return to preexisting states once the stressor has been removed (O et al. 2015). This includes details of restoration efforts and trends over time (Hunter et al. 2014). Recoverability is included in the description of resilience when this information is available. Knowledge of these various aspects of species or ecosystem responses to change vary and should be regionally or locally specific. For example, data pre and post impact is required to assess resilience and is not available for all types of impact or species and ecosystems present in Kitkatla Inlet. We provide information on Sensitivities (to stressors) and Recoverability (including resilience) where data allows.

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 2016, 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 richness and habitat complexity, and are also briefly described.

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; Convention of Biological Diversity 2008¹¹). EBSAs are identified using eight criteria that contrast to the locations outside of the area of interest. 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.

Two EBSAs overlap with the Kitkatla Inlet Network Zones: The Central Mainland (Zone 330) and Chatham Sound EBSAs (Zones 331-333; **Figure 6A**). Reef-forming cold-water coral and sponges have been identified as EBSAs throughout BC's waters, and some of these areas have received Marine Protected Area designations such as the Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs. Although there are no EBSA-level coral or sponge reefs in the immediate Kitkatla Inlet Network Zones area, the northern Glass Sponge Reef MPA is southwest of Zone 330 and the Chatham Sound Sponge Reefs are located north of Kitkatla Inlet (see Cold water corals and sponges). Nearshore habitats, including estuaries, canopy-forming kelps, and **gadza k'aw**/eelgrass also have been recommended as designations for EBSAs (Rubidge et al. 2020). We describe estuaries and associated salt marshes as EBSAs here. The other biogenic habitats of importance (kelp forests, **gadza k'aw**, coral and sponge aggregations) are summarized below in the Taxonomic Diversity section.

6.1.1 Oceanic regions and geomorphic units of the Continental Shelf

Geomorphic units are a level of PMECS at the scale of hundreds of kilometers 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., Ferdana 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 (Rubidge et al. 2016). The NSB was classified into geomorphic units using bathymetry data at 75 m 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).

Marine boundary classifications known as "Ecosections" and "upper ocean sub-regions" are used to classify oceanic regions of British Columbia. Ecosections were classified by the Province of BC according to physical, oceanographic, and biological characteristics (BC Marine

¹¹ Convention on Biological Diversity (CBD). 2008. Conference of the Parties to the Convention on Biological Diversity (COP9). Annex I, decision IX/20.

Ecological Classification, Province of British Columbia 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](#)).

The Kitkatla Inlet Network Zones are split between two categories of geomorphic units and marine boundary classifications. Zones 330, 332, and 333 overlap with the Continental shelf geomorphic units (**Figure 53** and **Table 15** for details) whereas the eastern areas of Zone 331 and a small portion of Zone 330 are Fjord classification and geomorphic units. This may indicate biological assemblages associated with fjord ecosystems to be more pronounced in the protected areas of Zones 331 and 330 compared to Zones 332 and 333.

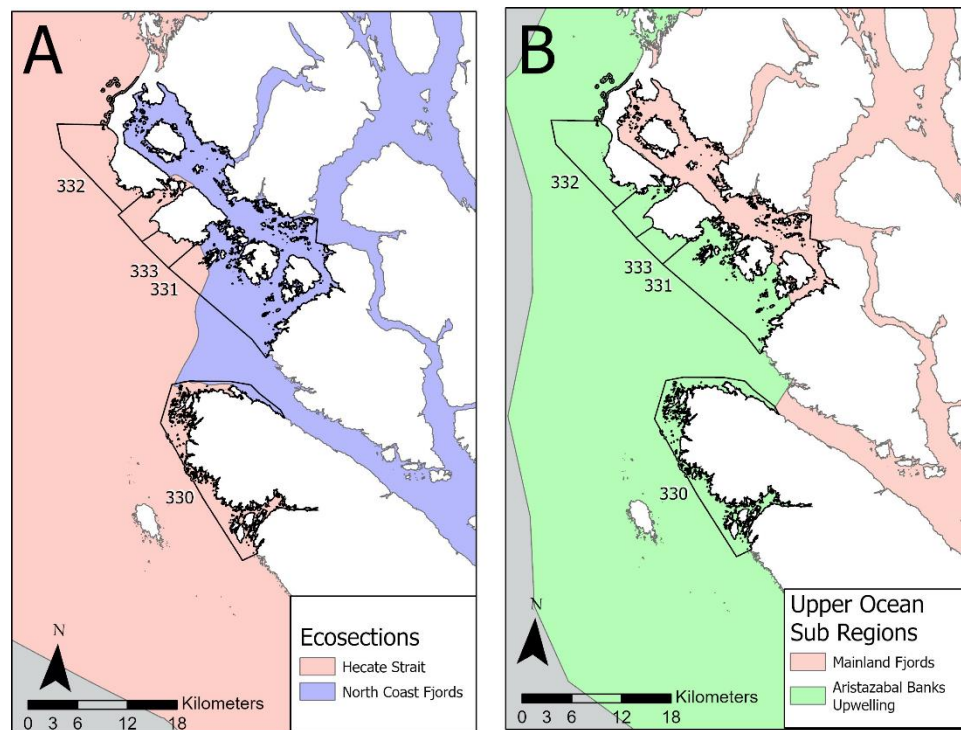


Figure 53. The Kitkatla Inlet Network Zones overlapping with A) The “Ecosection” boundaries classified by Province of BC and B) The “Upper ocean subregions” classified by Parks Canada.

Table 15. Presence of geomorphic units in the Kitkatla Inlet Network Zones. 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 Zone polygons, therefore the proportion total of each Zone may not add up to 1.

Percentage of Zone	Zone 330	Zone 331	Zone 332	Zone 333
Continental Shelf – Gentle Slope	X	X	X	X
Continental Shelf - Crest	X	X	X	X
Continental Shelf - Lesser depression	X	X	-	X
Continental Shelf - Lesser rise	X	X	X	-
<i>Continental Shelf proportion of each Zone</i>	<i>0.79</i>	<i>0.15</i>	<i>0.99</i>	<i>0.97</i>
Continental Shelf (fjords) - Crest or fjord wall	X	X	-	-
Continental Shelf (fjords) - Fjord or channel bottom	-	X	-	-
Continental Shelf (fjords) - Lesser depression	X	X	-	-
Continental Shelf (fjords) - Lesser rise	X	X	-	-
Continental Shelf (fjords) - Steep slope	X	X	-	-
<i>Continental Shelf (fjords) proportion of each Zone</i>	<i>0.11</i>	<i>0.80</i>	<i>0</i>	<i>0</i>

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. This analysis calculated coastwide areas of high rugosity using a 75-meter bathymetric model and the [NOAA Benthic Terrain Modeler \(BTM\) toolbox](#) (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 these 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. While the dataset for high rugosity is an effective way to visualize general patterns of rugosity throughout the Kitkatla Inlet Network Zones area, the arc-chord ratio (Du Preez 2015) is more accurate for modelling three-dimensional surfaces. The 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](#) and could additionally be used for mapping the Kitkatla Inlet Network Zone features for spatial planning.

High rugosity areas are found around the Kitkatla Inlet Network Zones area and most prevalent in the largest Zone 331 – consisting of 23% of the total area (**Table 16**). Zone 333 and Zone 332 completely overlaps with the Porcher Peninsula and Goschen Rockfish Conservation areas, although Zone 333 has a higher proportion of habitat complexity than 332.

Table 16. Area (km²) classified as having high rugosity (upper of five quantiles, [BCMCA project team 2011](#)) within the Kitkatla Inlet Network Zones. Bolded numbers indicate the highest value for each metric.

	Zone 330	Zone 331	Zone 332	Zone 333
Area of high rugosity (km ²)	8.20	63.24	0.34	2.44
Proportion of Zone	0.12	0.23	0.01	0.17

6.1.3 Ecologically and Biologically Significant Areas

Two Ecologically and Biologically Significant Areas (EBSA) first described and proposed in DFO (2013a) overlap with the boundaries of the Kitkatla Inlet Network Zones (**Figure 6A**). Chatham Sound EBSA overlaps with Zones 331, 332, and 333, whereas the Central Mainland EBSA overlaps with Zone 330. The Chatham Sound EBSA extends northward into the Skeena River estuary and ends near the mouth of the Naas River estuary resulting in major river outflows into the area. Chatham Sound was first identified as an EBSA through several instances of biological significance including 'naaxi/Killer Whale aggregations in the summer to fall for feeding, Humpback whale aggregations in the fall to winter for feeding, and a stopover area for black and white winged ahoo/scoters during migration (Clarke and Jamieson 2006). A major spawning and rearing area for tskah/herring exists within the boundaries. A review on Chatham Sound showed frequent and high concentrations of primary productivity and high aggregations within the area compared to outside for species such as ts'akwe'ats/red sea urchin and aswit/green sea urchin, Dungeness k'almoos/crab, and gasgos/shrimp (Rubidge et al. 2018). Support for other aggregations include bilhaa/Northern Abalone, Geoduck, gyenti/giant sea cucumbers, Rhinoceros Auklets and sponge reefs (Rubidge et al. 2016).

The Central Mainland EBSA was first described and proposed in DFO (2013) and encompasses the southwestern boundaries of Zones 330 down to the Caamaño Sound area. This EBSA overlaps with several Rockfish Conservation Areas and the northern Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs MPA. This area was identified as having strong tidal mixing, tidal fronts and freshwater plumes (DFO 2013a; see Oceanographic setting). In addition, the Central Mainland EBSA is specifically important for marine mammals (ibuun/whale feeding grounds, offshore ibuun migrations, ploon/sea otter aggregations, t'iibn/Steller sea lion rookery), fish (ts'mhoom/rockfish diversity, spawning area for Walleye Pollock and Hadanii/sablefish), Marine birds (moulting and sheltering areas, seabird aggregations notably Rhinoceros Auklet, shearwaters, and Pigeon Guillemot), and several benthic invertebrates (e.g. ts'akwe'ats, gyenti/giant sea cucumbers, gasgos/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 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**/salmon, **Ha'limootk**/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**/salmon smolts (Clarke and Jamieson 2006). Marine survival rates were found to be reduced for juvenile **hoon** 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**/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 **k'almoos**/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 two Kitkatla Inlet Network Zones: Zone 330 and 331 (**Table 17** and **Figure 54**).

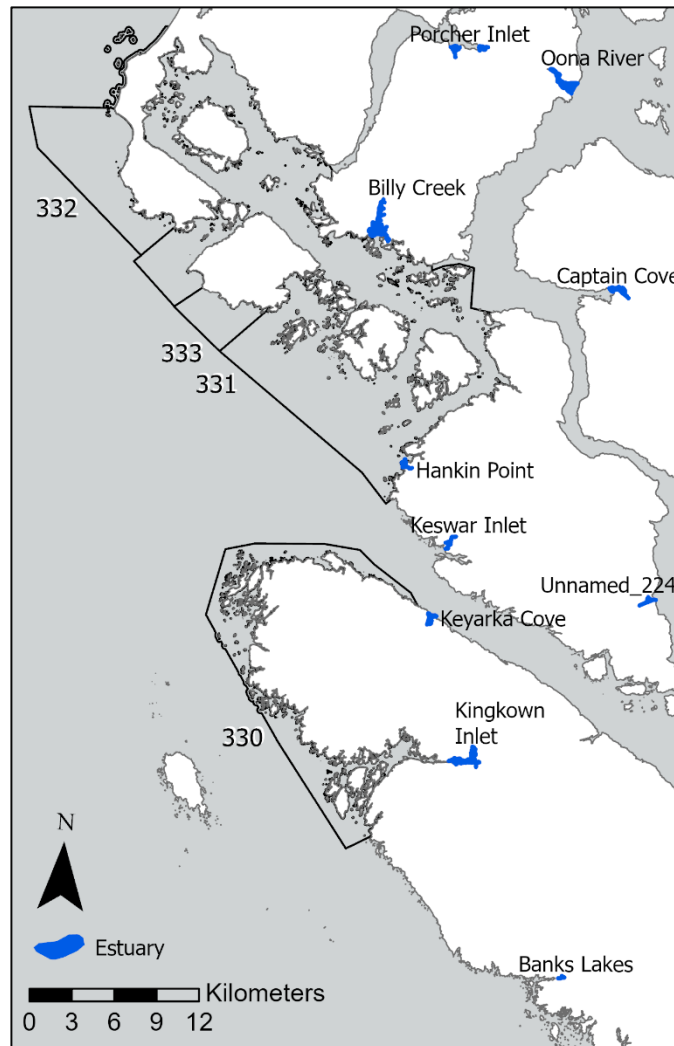


Figure 54. Estuaries in the Kitkatla Inlet Network Zones area, note only 2 are within the Zone boundaries: Kingkown Inlet, and Hankin Point. Billy Creek is adjacent to Zone 331 but not within the polygon. Data are from Robb et al. (2025) based on the [Pacific Estuary Conservation Program \(PECP\) Estuary Ranking Report, 2021](#).

Salt marshes are coastal wetland habitats found within estuaries, which contain grasslands exposed at low **aks**/tide and covered at high **aks**. 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 km²; 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 the Nass and Skeena rivers) to set up fishing camps for **Ha'limootk**/eulachon (Marsden, 2011).

Data sources

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) ([Pacific Birds Habitat Joint Venture Team 2021](#)). The ranking system assessed estuaries based on the cumulative score on five biophysical variables: estuary size, species rarity, waterbird density, **Geega tskah**/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 salmon that transit through BC's estuaries has also recently been assessed.¹² Additionally, a recent analysis of BC's estuaries and associated human activities provides insight into the degree of human impact each estuary is exposed to (DFO 2023k, Robb et al. 2025).

Ten estuaries exist in the Kitkatla Inlet Network Zones area, but only two are within the Kitkatla Inlet Network Zones: Kingkown Inlet (Rank 2) in Zone 330, and Hankin point (Rank 2) in Zone 331 (**Figure 54** and **Table 17**). Billy Creek (Rank 1) is located adjacent to Zone 331 but not within the polygon. Other estuaries found outside of the polygons include Oona River (Rank 2), Keswar Inlet (Rank 4), Keyarka Cove (Rank 4), and an unnamed estuary (Rank 3). Beyond the Kitkatla Inlet Network Zones area within Chatham Sound, the Skeena River estuary is classified as Rank 1.

¹² Robb, C.K., Proudfoot, B., Thompson, P.L., and Rubidge E.M. Salmon biomass and richness – implications for the relative importance of estuaries in British Columbia, Canada. In review.

Table 17. The name, area size (km²), and Importance class (1 = highest) of estuaries located from the Kitkatla Inlet Network Zones area. Estuaries within the four Kitkatla Inlet Network Zones are bolded. Data are from the [Pacific Estuary Conservation Program \(PECP\) Estuary Ranking Report, 2021](#). Salmon biomass are summed values from 1990 to Fall 2020 from the [NuSEDS-New Salmon Escapement Database System](#).

Name	Size (km ²)	Importance class	Zones present	Salmon biomass (kg)
Porcher Inlet	0.24	Not Ranked	Outside	53,916
Oona River	0.65	2	Outside	36,007
Billy Creek	0.86	1	Adjacent 331	12,920
Captain Cove	0.26	2	Outside	29,160
Hankin Point	0.08	2	Zone 331	50,565
Keswar Inlet	2.04	4	Outside	11,535
Unnamed 224	0.07	3	Outside	8,553
Keyarka Cove	0.08	4	Outside	18,890
Kingkown Inlet	0.36	3	Zone 330	8,023
Skeena River	195.40	1	Outside	9,951,230*

*Skeena/Ecstall/McNeil River Complex

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 Kitkatla Inlet Network Zones area was conducted from 2014 to 2016 ([ShoreZone Protocol, 2017](#)). Salt marsh bioband feature from the BC Shorezone mapping system includes the *Salicornia virginica* ('goose grass' or 'pickleweed') and the dune grass biobands. These biobands were used as salt marsh indicator species, including salt-tolerant herbs, grasses, and sedge ([BC Marine Conservation Analysis, 2011](#)). Salt marsh habitats are found throughout the Kitkatla Inlet Network Zones area and within all the Kitkatla Inlet Network Zones (**Figure 55**).

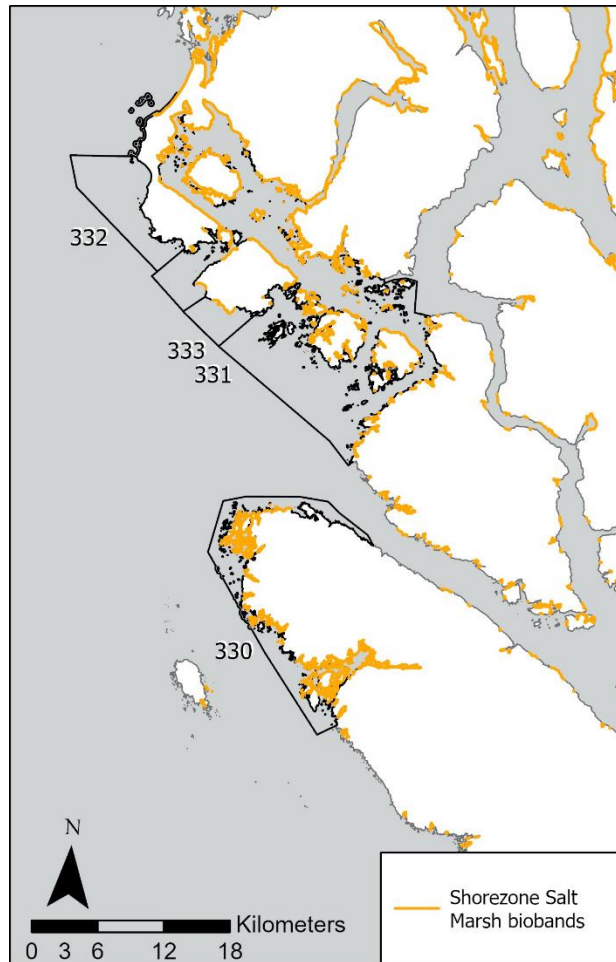


Figure 55. Salt marsh shorezone biobands (in orange) present in the Kitkatla Inlet Network Zones area.

6.1.5 Sensitivities and Recoverability

Ecologically and Biologically Significant Areas

The EBSAs are ranked in part for their “Vulnerability, fragility, sensitivity, or slow recovery” as no information, low, medium or high (DFO 2016). EBSAs rated high for this category are areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery (DFO 2016). Additionally, they can be host habitats used by ecologically and biologically significant species who are sensitive to external stressors and may be limited in their recoverability to perturbation due to long life spans or slow reproductive rates (e.g. corals, whales; see Taxonomic diversity). To our knowledge, the Continental Shelf off Barkley Sound, the Juan de Fuca Eddy, and Juan de Fuca Strait EBSAs have not been evaluated using this ranking system, or specifically evaluated for vulnerability, fragility, sensitivity, or slow recovery. Cold seeps in the Offshore Pacific, Northern Shelf, and Southern Shelf bioregions were assessed against EBSA criteria and were rated “High” for the “Vulnerability, fragility, sensitivity, or slow recovery (CBD)” criterion (DFO 2018).

Estuaries and Salt Marshes

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 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 & Weis 2004). The Nature Trust of BC launched a five-year assessment, monitoring and research project to look at resilience to climate change for 15 estuaries on Vancouver Island, Haida Gwaii, and the Central Coast ([About | Estuary Resilience](#)). This assessment project will use the Marsh Resilience to Sea-Level Rise (MARS) monitoring tool and approach ([NOAA National Estuarine Research Reserve System, 2012](#)).

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 can provide 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 (Elliot 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 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).

A recent coastwide classification of estuaries based on anthropogenic activities was completed (DFO 2023k; Robb et al. 2025). As part of this classification, anthropogenic activities and associated stressors relevant to estuary habitats were identified through a literature review and used to guide the compilation of spatial datasets. The spatial datasets were then used to enumerate the type of activities each estuary is exposed to and to cluster estuaries that share similar activity types and levels of use. We present here the first part of this analysis - the number and type of activities in each estuary and its associated watershed. There were 29 possible marine activities and 12 possible terrestrial activities analyzed. Of the three estuaries within the Kitkatla Inlet Network Zones Hankin Point is exposed to the highest number of human activities (7; **Table 18**; **Figure 56**), and outside of the Zones, Oona River estuary is exposed to 15. Billy Creek is the largest estuary in the Kitkatla Inlet Network Zones, and Kingkown Inlet has the largest associated watershed (**Table 18**). There are more quantified terrestrial activities than marine activities potentially impacting the estuaries in the area, and no marine activities were

counted as occurring within the estuary bounds that occur in the Kitkatla Inlet Network Zones. Note that a count of activities is not a measure of the relative impact of each activity on the estuary, and this is not an exhaustive list of potential stressors on estuaries. For more details on the analysis please see DFO 2023k and Robb et al. (2025). However, knowledge of activity locations, associated stressors, and potential impacts to estuarine habitats can help identify estuaries that face similar concerns, such as those in the Kitkatla Inlet Network Zones, potential mitigation options, and the partners and stakeholders needed for successful management (DFO 2023k).

Table 18. Estuaries and associated activities within the Kitkatla Inlet Network Zones area. Activities and activity count are from analysis presented in Robb et al. (2025). Bolded values indicate highest values for the Network Zones, and the surrounding area. 'A' denotes an absence of that activity, 'P' a presence. See **Figure 52** for estuary locations.

Estuary Name	Kingkown Inlet	Hankin Point	Billy Creek	Captain Cove	Keswar Inlet	Unnamed 224	Keyarka Cove	Banks Lakes	Oona River	Porcher Inlet
Zone overlap	330	331	331	No	No	No	No	No	No	No
Estuary area (km²)	0.36	0.07	0.86	0.26	0.04	0.07	0.08	0.01	0.65	0.24
Watershed area (km²)	84.39	21.50	37.84	55.20	47.69	27.66	49.53	100.59	21.36	21.07
Marine activities										
Underwater infrastructure	A	A	A	A	A	A	A	A	P	A
Anchorage - recreational	A	A	A	P	A	A	A	A	A	A
Docks	A	A	A	A	A	A	A	A	P	A
Derelict vessels	A	A	A	A	A	A	A	A	P	A
Log handling	A	A	A	P	A	A	A	A	P	A
Commercial fishing - trawl	A	A	A	A	A	A	A	A	P	A
Commercial fishing - pressure hose	A	P	A	A	A	A	P	A	A	A
Commercial fishing - hook and line	P	P	P	A	A	P	P	A	A	A
Commercial fishing - dive	A	P	A	A	A	P	P	A	A	A
Commercial fishing - trap	A	A	A	A	A	A	A	A	P	P
Commercial fishing - salmon gillnetting	A	P	P	P	P	A	P	A	P	A
Commercial fishing - salmon seine	A	P	P	P	P	A	P	A	P	A

Estuary Name	Kingkown Inlet	Hankin Point	Billy Creek	Captain Cove	Keswar Inlet	Unnamed 224	Keyarka Cove	Banks Lakes	Oona River	Porcher Inlet
Recreational fishing - anadromous	A	A	A	A	A	A	A	A	P	A
Recreational fishing - k'almoos/crab	A	A	A	P	A	A	A	A	A	A
Recreational fishing - groundfish	A	A	A	A	A	A	A	A	P	A
Recreational boating	P	P	P	P	P	P	P	P	P	P
Shipping	P	P	P	P	P	P	P	P	P	P
<i>Terrestrial Activities</i>										
Forestry cutblocks	A	A	P	A	A	A	A	A	P	P
Shoreline development	A	A	P	P	A	A	A	P	P	P
General development	A	A	P	A	A	A	A	P	P	P
Marine activity count	3	7	5	7	4	4	7	2	12	3
Terrestrial activity count	0	0	0	1	0	0	0	2	3	3
Total activity count	3	7	5	8	4	4	7	4	15	6

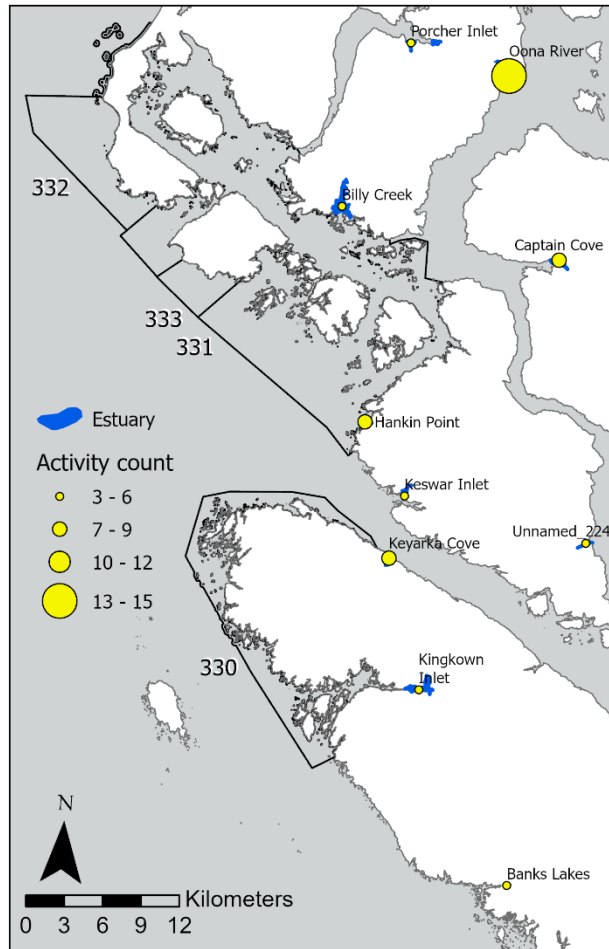


Figure 56. Estuaries and associated activity count within the Kitkatla Inlet Network Zones area. Activities and activity count is from analysis presented in Robb et al. (2025). For details on activities see **Table 18**.

6.1.6 Data and Knowledge Gaps

The source identifies several data and knowledge gaps, as well as research recommendations, concerning critical ecosystems within the Kitkatla Inlet Network Zones. First, while the existing dataset for high rugosity effectively visualizes general patterns of rugosity across the region, the arc-chord ratio is suggested as a more accurate method for modeling three-dimensional surfaces. This arc-chord ratio rugosity index decouples the relationship with slope, making it a valuable tool for more precise mapping of the Kitkatla Inlet Network Zone features, particularly for spatial planning purposes. Additionally, more detailed information on Ecologically and Biologically Significant Areas (EBSA) is needed to better understand the ecological importance of specific areas within the region. Regarding estuaries and salt marshes, further research is required to assess the extent of human impact on each estuary, as this will help gauge the degree of vulnerability of these ecosystems. Lastly, gaps in spatial data remain, as the current dataset does not cover the entirety of certain Zone polygons, which limits the comprehensiveness of spatial analyses in these areas.

6.2 Taxonomic diversity

Taxonomic diversity 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, Marine Plants, Phytoplankton, Zooplankton, Invertebrates, Fishes, Marine Birds, and Marine Mammals. Here, each feature's ecological significance, occurrence and trends, and/or cultural usage, data sources and distributions, and knowledge gaps are described within the Kitkatla Inlet Network Zones and nearby area when available. Each taxonomic group section briefly summarizes the general ecological importance, life history, fishery or cultural uses, and occurrence of species within that taxonomic group within the Kitkatla Inlet Network Zones. A “Data sources” subsection is provided where data sources are varied and require further explanation or introduction. Recent patterns of occurrences of marine species in the Kitkatla Inlet Network Zones area or surrounding regions are presented where available. Finally, a summary of “Sensitivities and Recoverability” is reported for each taxonomic grouping and marine species of interest.

6.2.1 Plankton

Plankton play a vital ecological role in British Columbia's marine environment, influencing nutrient dynamics and supporting the marine food web. Understanding the dynamics of plankton communities in this region is essential for assessing the overall health and productivity of British Columbia's marine ecosystems. Plankton contribute to biodiversity and are an important food source for various organisms, including fish, mammals, and marine birds. Changes in plankton populations can signal shifts in oceanographic conditions, nutrient availability, and climate, providing valuable information for long-term monitoring. The following subsections summarize what is currently known about the phytoplankton and zooplankton communities found within the Kitkatla Inlet Network Zones area.

6.2.1.1 Phytoplankton

Phytoplankton are the basis of the marine food web. In addition to providing a critical resource base, phytoplankton absorb carbon dioxide during photosynthesis, playing a significant role in carbon sequestration and helping mitigate climate change's impacts. Additionally, phytoplankton contribute to oxygen production through photosynthesis, supporting marine life and maintaining the ecosystem's overall health. Data describing the phytoplankton present in the Kitkatla Inlet Network Zones area come from three sources: Chlorophyll-a (Chl-a) inferred from remote sensing, in-situ fluorescence profiles, and taxonomy from preserved water samples. The phytoplankton patterns associated with each data source are described separately below.

6.2.1.1.1 Chlorophyll-a

Chl-a, a parameter measured by optical satellites, and is a proxy for phytoplankton biomass in the surface ocean. This parameter monitors phytoplankton phenology and bloom events and provides estimates of primary productivity (Platt and Sathyendranath, 1988).

To retrieve the spatial and seasonal variability of Chl-a within the Kitkatla Inlet Network Zones, imagery from the Operational Land Imager (OLI) sensor on the Landsat-8 and -9 satellites were used to calculate Chl-a using an empirical band-ratio method applied to blue and green

wavelengths (see **Appendix E**). The quality control methods used here are similar to Caballero et al. (2020) and Caballero et al. (2022), using the same software and Chl-a algorithm. Similarly, the Chl-a algorithm used here has been validated in other areas of the Pacific at coarser spatial resolutions (Clay et al. 2019).

Winter and autumn Chl-a, as observed by satellite, are generally low, indicating the lower productivity and biomass compared to spring and summer (**Figure 57A,B**). A threshold of 1 mg m^{-3} is often used as an approximate transition between lower and higher-biomass waters, which may occur during seasonal growth, or between offshore and coastal waters with higher productivity (e.g., Jackson et al., 2015). In Spring, the coastal area shows a large increase in phytoplankton biomass ($> 1 \text{ mg m}^{-3}$) while the Hecate Strait waters remain at a lower concentration. Some regions, including the northern fjords remain low Chl-a in Spring, while elevated Chl-a is present through Grenville Channel, Ogden Channel, Petrel Channel, and particularly the eastern end of Zone 331 through Beaver Passage and around the islands at the east side of Kitkatla Inlet, including the Kitkatla Islands, Gilbert Island and Peltham Islands (**Figure 57B**). The spatial pattern is very similar in the summer, where higher Chl-a is contained within Ogden Channel, Petrel Channel and the eastern end of Zone 331, while the remaining Kitkatla Inlet Network Zones and area, including Porcher Inlet, generally have low Chl-a ($< 1.0 \text{ mg m}^{-3}$; **Figure 57C**). During autumn, the spatial patterns stay though the concentration of phytoplankton in the upper water column recedes (**Figure 57D**).

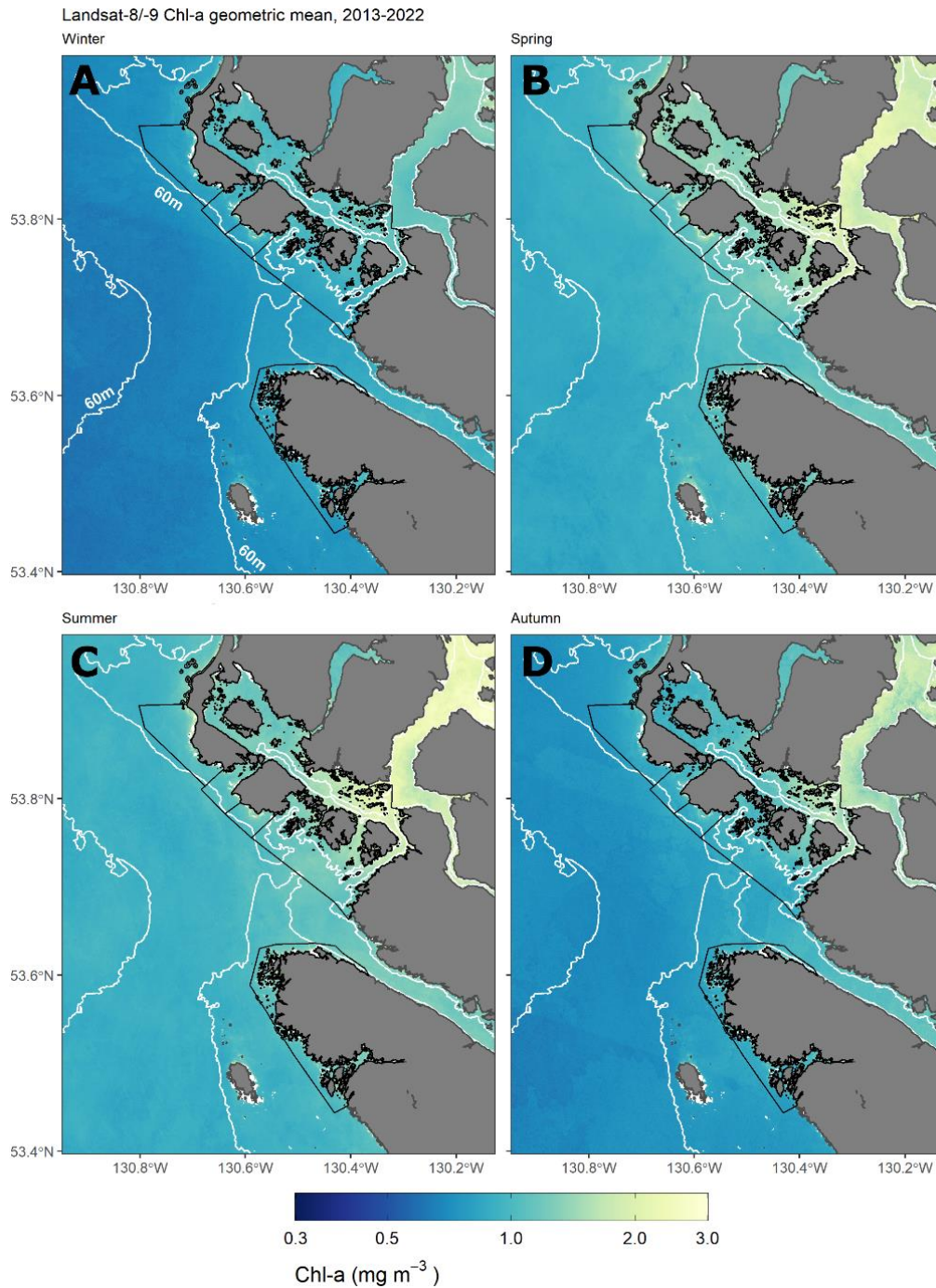


Figure 57. Landsat-8 and -9 Chl-a in the Kitkatla Inlet Network Zones averaged seasonally over the period 2013-2022, with the 60 m isobath indicated with a white line. Note the log scale of colouring. White indicates areas with data removed for quality control. Winter includes January to March, Spring includes April to June, etc.

An opportunity for further research lies in using different satellite imagery for monitoring phytoplankton in the Kitkatla Inlet Network Zones. The [European Space Agency's Sentinel-2](#) satellites, with the MultiSpectral Instrument (MSI) that can be used for Ocean Colour

applications, were not used in this report but are ideal to also include in ongoing monitoring of the area (e.g. Caballero et al. 2020; 2022). Their improved spatial resolution (10-m) facilitates analysis of smaller-scale phytoplankton blooms (Detoni et al. 2023). Further, the enhanced temporal resolution at this latitude allows images to be acquired every 2-3 days, improving monitoring for shorter-lived events like phytoplankton blooms and pulses of sediment into the marine environment. Though they cannot monitor SST, their MSI instrument has an additional red band that can help monitor Harmful Algae Blooms (HABs; Detoni et al. 2023; Gernez et al. 2023; Rodríguez-Benito et al. 2020).

In addition to inferring chlorophyll-a concentrations from satellite image, fluorescence is regularly collected from ship-based profilers during the DFO sampling cruise and used as a proxy for chlorophyll-a concentrations after comparisons with in-situ chlorophyll water samples. A subset with the highest spatial coverage from the summer and fall of 2020 is discussed below. Other water properties from these profiles were presented in the OCEANOGRAPHIC SETTING (**Figure 29** and **Figure 30**). Profiles were collected in Browning Entrance and along Grenville Channel and Arthur Passage during the summer, while the fall dataset includes additional profiles along Principe Channel (**Figure 58**).

The fluorescence of surface waters was almost ten times greater in summer than in fall (**Figure 58**). The highest summer fluorescence was observed at the north end of Grenville Channel near the junction with Telegraph Passage and Ogden Channel (**Figure 58A**), which corresponds to the same area with elevated subsurface nutrients (**Figure 29C**). Surface fluorescence was lowest in Chatham Sound, where subsurface maximums ($< 3 \text{ mg m}^{-3}$) were evident at approximately 15 m depth. Directly southwest of Kitkatla Inlet Network Zones 331, 332 and 333, one profile displayed similarly high fluorescence ($> 5 \text{ mg m}^{-3}$) to the junction at Grenville and Telegraph Passage, though missing data shallower than 10 m. At this location, Chl-a fluorescence was highest at a greater depth than the remainder of the profiles. During fall, the highest surface fluorescence ($< 1.3 \text{ mg m}^{-3}$) was observed in Principe Channel for the station nearest to Caamaño Sound (**Figure 58B**). Like summer, the highest fluorescence was observed along Grenville Channel near the junction of Telegraph Passage with Arthur Passage and Ogden Channel. The increased fluorescence also coincides with the area with elevated nutrients (**Figure 30C**).

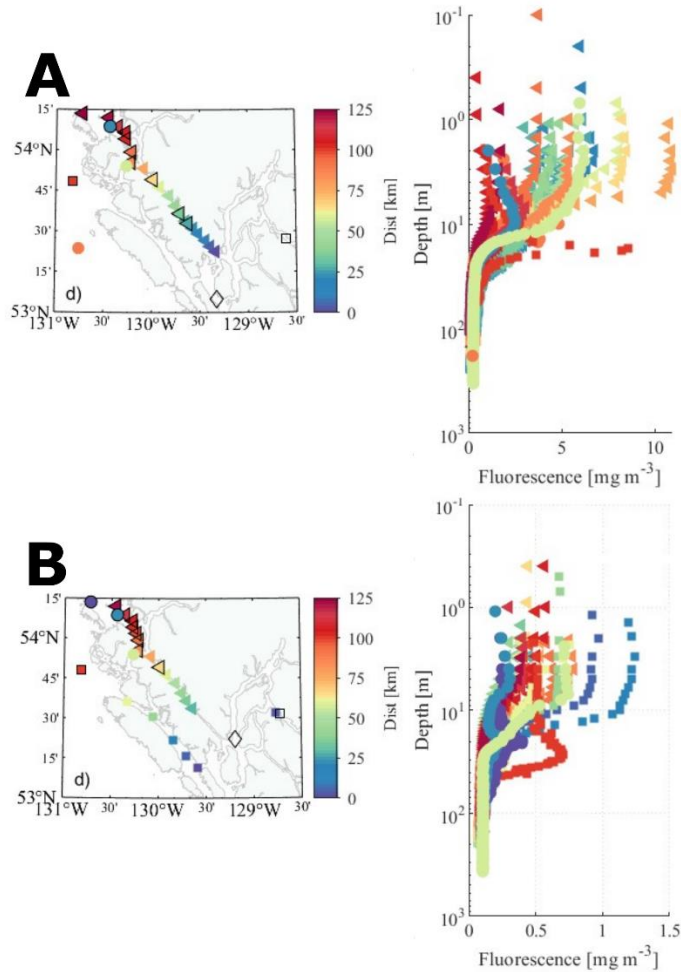


Figure 58. Spatial distribution of fluorescence profiles from July-August 2020 (A) and October 2020 (B). Grenville Channel stations are indicated with triangles, while Principe Channel and southeast of Tgii Xsw'aanx/Portcher Island are indicated with squares. Two stations in Chatham Sound are marked with circles.

6.2.1.1.2 Phytoplankton taxonomy

While taxonomic phytoplankton sampling has occurred throughout the Northern Shelf Bioregion in DFO cruises, no samples exist within the Kitkatla Inlet Network Zone boundaries. Phytoplankton data were available at 15 stations from six cruises within the area bounded in **Figure 59**, which includes eastern Hecate Strait and southern Chatham Sound. Most samples were collected in Chatham Sound and Hecate Strait during summer over the upper 200m of the water column (**Figure 59**). The two closest stations to the Kitkatla Inlet Network Zones were HECS4 in Browning Entrance (offshore of Zone 332) and CH8 offshore of Lax k'naga dzol/Banks Island (Zone 330). Taxonomic information from the stations closest to the Kitkatla Inlet Network Zones (HECS4, CH8, CH27, CHAT1 and PRHR74) are provided in **Appendix H**.

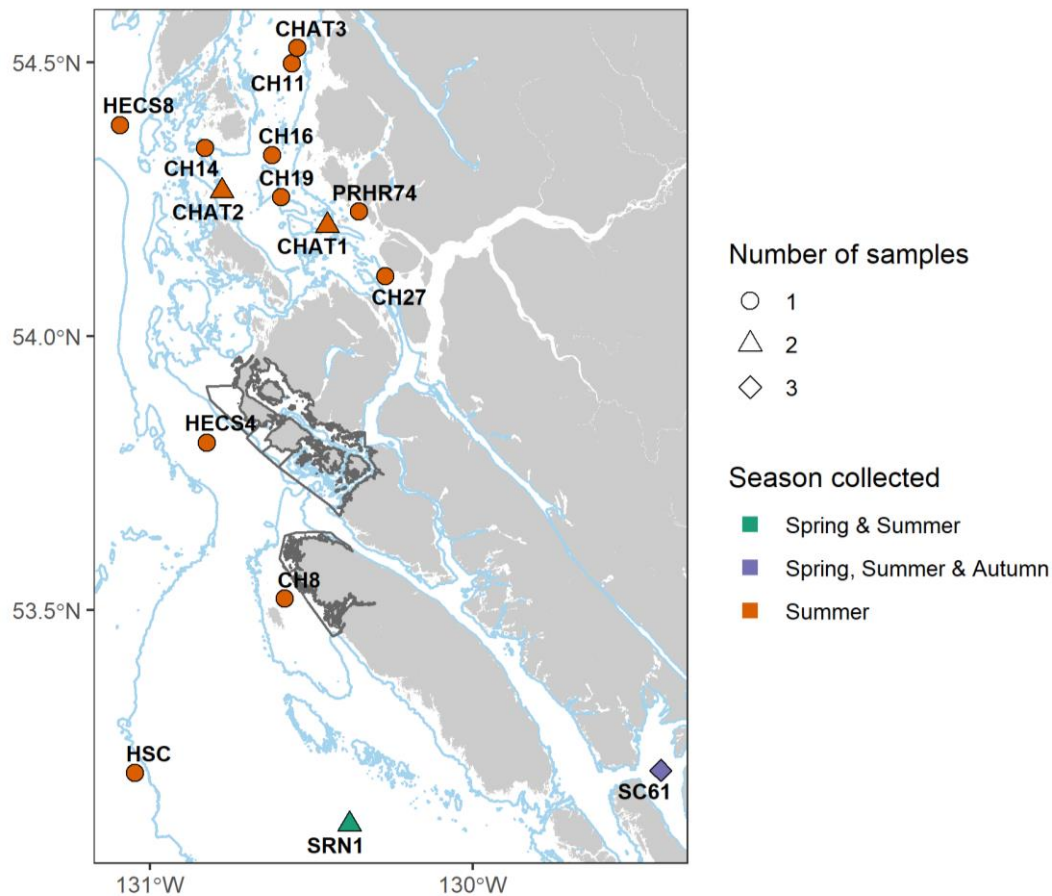


Figure 59. Stations with taxonomic phytoplankton samples collected between 2010 and 2023 showing the Kitkatla Inlet Network Zones (dark grey lines) and 60 m isobath (light blue lines). Stations SRN1 and SC61 were the only stations visited during spring. Station SC61, near the Caamaño-Douglas Network Zones, was the only station also visited during autumn.

During the 2021 spring cruise, 13 centric diatom species were observed at station SC61 (27 in total), as well as harmful algae *Pseudo-nitzschia* spp. (< 30 cells/mL), while other phytoplankton groups had low numbers of species observed. The most abundant species were *Chaetoceros* spp., notably *Chaetoceros socialis* (> 1000 cells/mL). Station SRN1, further offshore in Hecate Strait, had fewer species (16 identified) observed during the same cruise, though there were numerous cryptophytes and heterotrophic flagellates (> 300 cells/mL).

Station HSC, southwest of the Kitkatla Inlet Network Zones, was sampled during the summer of 2010 and had the highest abundance of *Chaetoceros* spp. (>207 cells/mL), as well as *Skeletonema costatum* (86 cells/mL) and toxin-producing *Pseudo-nitzschia* sp. (121 cells/mL). In the summer of 2016, station SC61 was revisited in July, and the most dominant phytoplankton groups were a mix of cryptophytes, flagellates and centric diatoms. *Teleulax* spp. were in highest abundance (> 200 cells/mL) and notably *Dinophysis acuminata* (a toxin-producing species that may cause Diarrhetic Shellfish Poisoning, here 2.4 cells/mL); the freshwater centric diatom species *Aulacoseira* sp. were also present in > 30 cells/mL.

In the summer of 2018, samples were collected at twelve stations (all summer stations except HSC, indicated in Figure AH4); centric diatoms were the most dominant algal class at all

stations except HECS8, where the fewest species were observed. HECS4, adjacent to the Kitkatla Inlet Network Zones, had the greatest number of species observed. Here, the centric diatom *Rhizosolenia setigera* was the dominant species (>500 cells/mL), which has been observed to cause fish mortality in BC waters (Haigh and Esenkulova, 2011). At station CH16, which had the second highest species diversity, *Alexandrium* spp. (a toxic dinoflagellate species which may cause Paralytic Shellfish Poisoning) were present with 8.3 cells/mL. Spatially, most of the stations adjacent to or directly in Hecate Strait had mixed phytoplankton groups and differing dominant species (HECS8, CH14, CH8 and SRN1). In contrast, fewer species dominated the stations in shallower, more protected areas. For example, a collection of stations in southern Chatham Sound and Brown Passage (CHAT1, CH19, CH16), including the Prince Rupert Harbour (PRHR74), were dominated by the centric diatom *Eucampia zodiacus*. CH11, located further north in Chatham Sound, was the only station dominant with *Skeletonema costatum*. Centric diatom *Leptocylindrus danicus* was in highest abundance (836 cells/mL) at HECS4, and *Chaetoceros debilis* was abundant at CH16 and PRHR74 (> 350 cells/mL). Stations CH27 and HECS8, while being very spatially separated, had similarly high concentrations of flagellate species (> 500 cells/mL). Finally, the dinoflagellate *Noctiluca scintillans*, which are reactive to varied oxygen concentrations and may indicate hypoxic conditions, were also observed at stations CH14, CHAT1 and CH16 (0.1 cells/mL).

CHAT1 and CHAT2 were re-sampled the following year, in addition to station CHAT3 further north in Chatham Sound. CHAT1 and CHAT3 had the highest and lowest number of observed species, respectively. Flagellate heterotrophs were in the greatest abundance of all algal classes at CHAT3, while species at CHAT1 and CHAT2 were more mixed in abundance and dominated by miscellaneous flagellates, cryptophytes, and autotrophs. *Heterosigma/Chattonella*, which may have harmful effects on fish at high cell concentration, were biologically dominant at CHAT3 (> 300 cells/mL), and abundant at CHAT 2 (> 100 cells/mL). *Noctiluca scintillans* were also observed at CHAT3, but only at a concentration of 0.2 cells/mL.

Finally, the sample available from autumn, again from station SC61, had fewer (16 identified) species observed and a dominant mix of cryptophytes, flagellates, chlorophytes and dinoflagellates. The cryptophyte *Teleaulax* spp. was present in greatest abundance (129 cells/mL). Also notable was the dinoflagellate *Heterocapsa rotundata* (> 50 cells/mL), which has been documented to form large blooms in a range of environments, including during the winter (Millette et al. 2015; Millette et al. 2016).

6.2.1.2 Zooplankton

Zooplankton distribution and abundance in the Northern Shelf Bioregion (NSB) is less studied than in the Southern Shelf and Strait of Georgia bioregions which have had sustained monitoring through the La Perouse and Strait of Georgia programs. The best-studied part of the NSB is the southern end of Queen Charlotte Sound, where the La Perouse program has made routine measurements at least twice a year since 1990. However, other DFO survey programs focused on the NSB have periodically and opportunistically collected zooplankton samples through the years. In some cases, the DFO Pacific Plankton Ecology program has been able to compile zooplankton data sets within or in the vicinity of the Kitkatla Inlet Network Zones from various sources (Bannar-Martin et al. 2025; Liu et al. *in press*).

The Pacific Plankton Ecology program at the Institute of Ocean Sciences (IOS) maintains an archival zooplankton database of sampling events and associated taxonomic enumeration for all samples collected by DFO and contributing non-government survey programs within coastal

BC. No sampling events were identified within any of the Kitkatla Inlet Network Zones. However, 27 events were identified near the area (see **Figure 60** and **Table 19**). Unfortunately, only four of these events have been enumerated, and these lack sufficient spatial or temporal (particularly seasonal) resolution to describe patterns confidently. **Table 19** provides the month and year inventory of events in **Figure 60**.

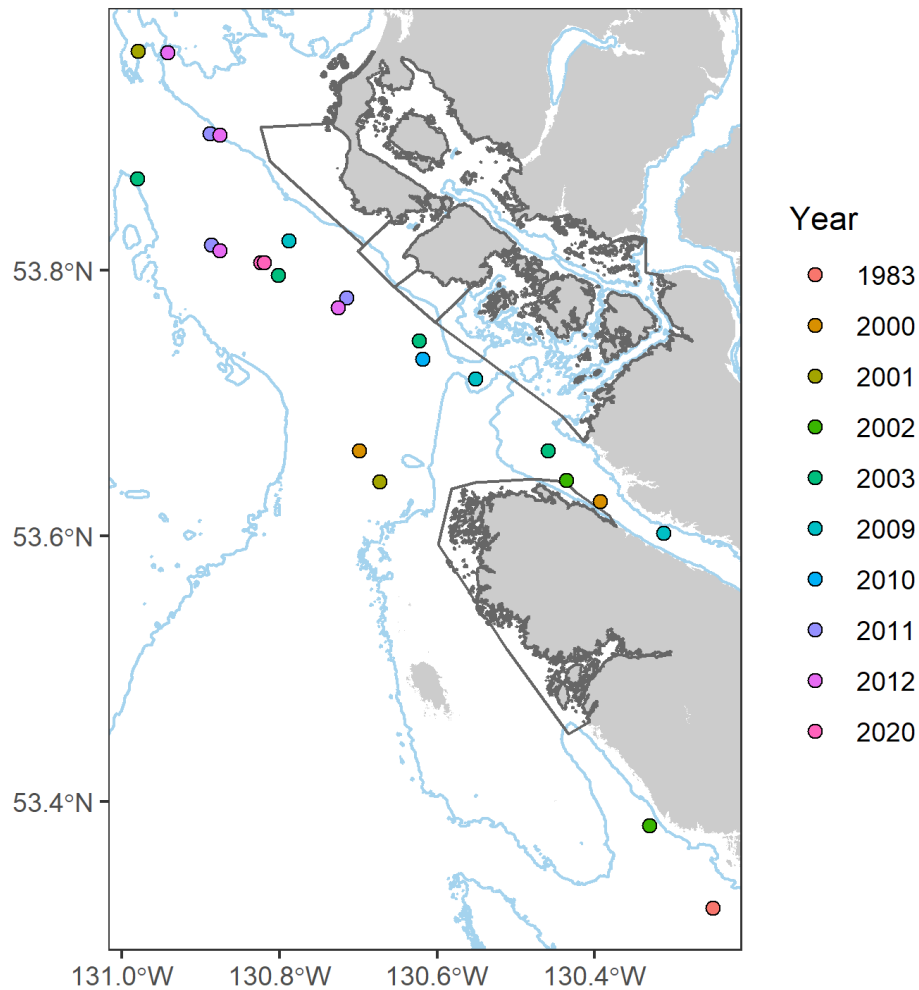


Figure 60. DFO zooplankton sampling events (1983-2020) in the vicinity of the Kitkatla Inlet Network Zones. The symbol's colour indicates the sampling year; note the absence of sampling events within the zones.

Table 19. Number of zooplankton sampling events by month and year in the vicinity of the Kitkatla Inlet Network Zones. Note: No sampling events are within any of the designated zones. See **Figure 56** for the spatial pattern of sampling events.

Month/Year	1983	2000	2001	2002	2003	2009	2010	2011	2012	2020
February	-	-	-	-	3	-	-	-	-	-
March	-	-	1	-	-	-	-	-	-	-
June	-	-	-	2	-	-	-	3	4	-
July	1	-	-	-	-	-	-	-	-	1
October	-	2	1	-	4	-	-	-	-	1
November	-	-	-	-	-	3	1	-	-	-

The seasonal timing of peak zooplankton production in coastal British Columbia is highly variable but typically takes place during spring and summer and is available to planktivorous fish, birds, and mammals as it is mostly limited to the upper water column (Bertram et al. 2017). The amount of zooplankton biomass within the Kitkatla Inlet Network Zones, both total and group-specific, can be expected to vary with season, mesoscale and local conditions (water column properties and water mass interaction with bathymetry) and community composition. Therefore, it is challenging to address biomass patterns without detailed taxon-specific abundance information for the area. However, we can approach the likely zooplankton community composition for the area with information from the Caamaño-Douglas areas (Liu et al. *in press*) given the geographic proximity and common water mass composition (see Water exchanges and properties with neighboring areas for a description of water masses and sources to the Kitkatla Inlet Network Zones).

The zooplankton section of the Caamaño-Douglas Biophysical Overview (Liu et al. *in press*) provides a detailed description of methods, the seasonal pattern, and relative biomass composition for crustacean and soft-bodied zooplankton (jellies, larvaceans, chaetognaths, etc.). Here, we provide a brief overview of that seasonal pattern and composition. 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). Total zooplankton biomass is greatest in July through August and dominated (~50%) by medium-sized calanoid copepods across all seasons but with an increased relative contribution of small calanoid copepods, amphipods and adult euphausiids during the late fall and winter. Euphausiids are the second most important contributor to zooplankton biomass and are numerically dominated by *Euphausia pacifica* and *Thysannoessa spinifera*. The biomass of these groups increases from winter through late summer as the populations develop through larval to adult stages. Biomass of euphausiids is lowest during the fall when adults dominate. Large calanoid copepod biomass reaches a seasonal maximum during the spring and summer but only contributes a relatively small part of the total biomass during both seasons. The average non-crustacean zooplankton biomass is low relative to crustaceans in the Caamaño-Douglas area, representing < 13% of total zooplankton biomass across seasons. Broad gelatinous groups, cnidarians, and ctenophores are also seasonally important, making up ~5% of the total zooplankton biomass in the Caamaño-Douglas area. The

seasonal cycles of non-crustacean and crustacean zooplankton are similar: a seasonal minimum in winter increases through spring to a maximum in summer. 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.

6.2.1.3 Sensitivities and Recoverability

Marine plankton in British Columbia are subject to various environmental and anthropogenic stressors that influence their biomass, productivity, and contaminant levels. Freshwater-associated bulk turbidity, a common result of human activities, can negatively impact the plankton ecosystem, leading to delayed spring blooms and decreased production rates (e.g. Le Fouest 2010). Similarly, eutrophication and climatic change, often driven by human activities, can disturb pelagic communities, including plankton (e.g. Tett 1992). UVB radiation, which can be exacerbated by the erosion of the stratospheric ozone layer due to human activities, can also significantly affect plankton community production (Regaudie-de-Gioux et al. 2014). Studies on the impact of ultraviolet radiation (UV) on marine organisms have mostly focused on marine plankton, showing that increased levels of UV affect photosynthetic activity, growth and metabolic rates, impair nitrogen assimilation, inhibit the motility and orientation of freely motile organisms and bleach photopigments (El-Sayed et al., 2007).

Changes in ocean currents can have significant effect on the productivity of plankton and other marine organisms, affecting the dispersal of early life history stages. In general, high currents improve circulation conducive to well-mixing areas linked to high biological productivity zones. Significant shifts in poleward (winter) and equatorward (summer) currents along the coast of BC can alter abundance and distribution of plankton and other migratory species (Hunter and Wade 2015).

Fish predation and trophodynamics also affects plankton populations (Robinson and Ware 1994). Unusual atmospheric conditions, such as those observed in 2005, can lead to significant changes in oceanographic conditions, resulting in reduced prey biomass (euphausiid crustaceans) and subsequent reproductive failures in planktivorous marine birds. This highlights the sensitivity of plankton populations to climate variability and its cascading effects on higher trophic levels (Sydeman et al. 2006).

Furthermore, ocean warming influences vertical mixing and stratification patterns, altering nutrient cycles, plankton production, and aquatic food webs. Climate warming can lead to fluctuations in plankton production. Zooplankton play a crucial role in aquatic food webs and global biogeochemical cycles, serving as food sources for economically valuable fishes and driving carbon and nutrient cycles. Changes in temperature can influence zooplankton productivity, with higher temperatures potentially leading to increased productivity. Moreover, ocean acidification, driven by increased carbon dioxide absorption, poses additional challenges to marine ecosystems, particularly affecting calcifying organisms such as corals, mollusks, and some plankton species. Species composition of phytoplankton and pteropods abundance may also shift as a result of ocean acidification, affecting the food web and impacting species dependent on them as a food source (e.g. pink salmon, rockfish and flatfish) (Haigh et al. 2015). The alteration of ocean chemistry can disrupt shell formation in marine organisms, affecting their growth, survival, and overall ecological function. Additionally, changes in pH levels may impact the behavior, physiology, and distribution of marine species, potentially leading to shifts in community structure and species composition. Consequently, the combined effects of ocean warming and acidification exacerbate the vulnerabilities of marine ecosystems. Continuous monitoring of plankton populations through surveillance programs is essential to

understand future changes in marine ecosystems and serve as ecological indicators of climate change impacts (Azani et al. 2021).

6.2.1.4 Data and Knowledge Gaps

The source identifies several data and knowledge gaps, as well as research recommendations, related to plankton in the Kitkatla Inlet Network Zones. For phytoplankton, there is a need for more consistent year-round sampling at various depths in the water column to better understand community composition. Preliminary analyses suggest that the Kitkatla Inlet Network Zones may experience high phytoplankton biodiversity, with potential risks from Harmful Algae Blooms (HABs) during the summer months, as well as blooms occurring from spring through summer. Further investigation is required into coccolithophore blooms, which have been observed in the area, and samples must be properly preserved for this analysis. Current satellite data, based on surface waters, fail to capture features such as deep chlorophyll maxima, and optically complex waters and atmospheric correction challenges introduce uncertainties in satellite parameter retrievals, particularly in highly turbid waters, which can lead to inaccuracies in algorithms like the Chl-a index. Given that phytoplankton blooms occur on relatively short time scales, integrating Sentinel-2 data is essential for accurate monitoring of bloom timing and magnitude. For zooplankton, most samples remain unanalyzed, with enumeration being a key priority. A focused, seasonal sampling program over one to two years within each zone would provide valuable data on community composition, seasonal biomass development, and inter-comparison of biomass across the network. This data would be crucial for identifying periods and locations of elevated zooplankton production, which is vital for ongoing conservation efforts and the foraging needs of seabirds, fish, and cetaceans.

Phytoplankton

To understand phytoplankton community composition in the Kitkatla Inlet Network Zones, more sampling throughout the year at consistent depths in the water column is needed. The preliminary analyses shown here, using satellite Chl-a and limited fluorescence and phytoplankton samples, suggest that the Kitkatla Inlet Network Zones may experience high phytoplankton biodiversity and potential impacts from Harmful Algae Blooms (HABs) in the summer (data from Station HECS4), and blooms during spring through summer months (**Figure 58**). Further, blooms of coccolithophore species have been observed in the area (mentioned in Light availability and optical conditions), but further examination of samples preserved appropriately is needed.

The satellite data described in this report only represent surface waters, so features including deep chlorophyll maxima (as seen in **Figure 58**) are missed. Further, optically complex waters and atmospheric correction difficulties add uncertainties to retrieving satellite parameters (Melin et al. 2007). For example, highly turbid waters increase the reflectance across a broad range of wavelengths, leading to inaccuracies in some algorithms, including band ratios like the Chl-a algorithm used here. Phytoplankton bloom events, which take place on relatively short time scales (e.g., days to weeks), make the Landsat satellites inappropriate for monitoring phenology alone. With the addition of Landsat-9, the capabilities of the optical OLI sensors are improved, but integrating Sentinel-2 data is necessary for monitoring the timing and magnitude of phytoplankton blooms.

Zooplankton

As mentioned, the Kitkatla Inlet Network Zones and vicinity are poorly represented in the archived DFO zooplankton database. Some sampling has occurred with annual sampling between 2000-2003 and 2009-2012. However, these are primarily unique events, and the sampling distribution across months or seasons is poor (**Table 19**). Most of these samples remain unanalyzed, and enumeration is a priority. Nevertheless, a focused sampling program within each of the Kitkatla Inlet Network Zones across seasons for even one to two years would provide important context for 1) characterization of community composition, 2) seasonal biomass development of the zooplankton community, and 3) inter-comparison of biomass/composition within each network to identify the timing and areas of elevated production critical to continued conservation efforts and foraging by seabirds, fish, and cetaceans.

6.2.2 Macroalgae and Marine Plants (eelgrass/surfgrass)

6.2.2.1 Canopy-forming kelps

Kelp is the common name for marine brown algae belonging to the order Laminariales, which is 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**/Bull kelp (*Nereocystis leutkeana*) and **gyoós**/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, meet several EBSA criteria (Rubidge et al. 2020). **Gyoós** prefer low- to moderate-energy areas of water, leading to their distribution in more semi-protected or protected areas. In contrast, **mo'ox** are found in more varied locations, preferring areas with moderate or strong **dooyaks**/currents (Springer et al. 2010). Where the two kelps co-occur, **gyoós** are typically found inshore surrounded by **mo'ox** in higher energy and exposed waters (Springer et al. 2010; Rubidge et al. 2020). **Gyoós** and **mo'ox** were identified as a Zone-level network conservation objectives (MPA Network BC Northern Shelf Initiative 2023) for Zones 330, 331 and 332, and **mo'ox** was also identified as a Zone-level network conservation objective for Zone 333.

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 is consumed by an abundance of lower trophic detritivores and grazers, which attract and feed higher trophic level organisms. Kelp and other macroalgae also transfer nutrients from marine to terrestrial ecosystems by washing ashore as beach-cast (wrack) (Dugan et al. 2011). In addition, the vast heterogeneous 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 (summarized in Rubidge et al. 2020). 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 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**/salmon (**yee**/Chinook and **üüx**/Coho), and forage fishes (**Tskah**/Pacific Herring, Surf Smelt, and Pacific Sand Lance) in kelp forests. Many other species identified as conservation priorities in the NSB, such as invertebrates, **hoon**, rockfish, **'naaxl**/orcas, **ploon**/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 can ameliorate localized 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. Kelps are harvested for cultural and commercial purposes, and preserving kelp forests leads to higher productivity of culturally and economically important species such as **yee**/Chinook and **üüx**/Coho salmon (Daly et al. 2009). A traditional fishery practice called roe-on-kelp (ROK) allows the harvest of **xs'waanx**/herring eggs attached to Feather Boa kelp (*Egregia*) for food, social, and ceremonial (FSC) purposes and **gyoós** blades for both FSC and commercial fisheries, during spawning season. **Mo'ox**/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 2003; Calloway et al. 2020). For example, the long stipe and bulb can be processed and shaped into tools such as fishing lines, anchors, and containers for storing **smk'awtsii**/eulachon oil (Halpin and Seguin 1990; Turner 2003). Kelp forests are also vital habitats for the proliferation and recovery of culturally important and endangered species of concern, such as **bilhaa**/Northern Abalone (Sloan and Breen, 1988; COSEWIC 2009a; DFO 2012a) and **ts'mhoom**/rockfish (Markel and Shurin 2015; Tolimieri et al. 2023). Managing and preserving kelp forest ecosystems ensures the connection for many important cultural and ecological practices.

Gitxaala Nation members are concerned with the disappearance of **mo'ox**/Bull kelp in particular. Based on local knowledge, the current issue is thought to be caused by changes in the salinity of the water. It was noted that there is a notable decline in kelp populations throughout the Laxyuubm Gitxaala (James Herbert *pers. comm.* December, 2023).

Data sources

Four datasets were merged to create the spatial layer for viewing the general distribution of canopy-forming kelp polygons in the Kitkatla Inlet Network Zones area. These datasets included the [ShoreZone Bull kelp and Giant kelp bioband lines](#) and the BC Marine Conservation Analysis (BCMCA) kelp bed polygons. The BCMCA includes **mo'ox**/Bull kelp, **gyoós**/Giant kelp, general kelp, and occurrence points from DFO's Benthic Habitat Mapping (BHM) and Multispecies dive surveys. The third source is a Canadian Hydrographic Society (CHS) record of historical occurrence of kelp 1904-2004 ([Distribution of kelp on the coast of British Columbia extracted from CHS source data: 1904 - 2004 - Open Government Portal \(canada.ca\)](#)). The final dataset is a digital map of canopy-forming kelp presence from 1858 to 1956 that shows the historical presence of kelp (Costa et al. 2020). Imagery mapping in the Kitkatla Inlet Network Zones area was conducted from 2014 to 2016 ([ShoreZone Protocol, 2017](#)).

The three kelp polygon layers from BCMCA, **gyoós**/Giant kelp, **Mo'ox**/Bull kelp, and [general kelp](#), 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 before 2009 (see respective metadata). The general kelp layer includes data where species information was not

always recorded. However, it mainly contains canopy-forming kelp species and polygons from understory kelps *Pterogophora* and *Laminaria* (BCMCA, 2008).

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 **mo'ox** and **gyoós**/Giant kelp in the Kitkatla Inlet Network Zones area were collected from 2013-2015 (Figure 1 in 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 represent the surface distribution of kelp; therefore, there is not much information about sub-surface distributions. 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** and **mo'ox**) in the NSB as part of a coordinated Regional Kelp Monitoring Program ([Regional Kelp Monitoring on the North Pacific Coast \(arcgis.com\)](https://arcgis.com); [MaPP Kelp Monitoring Methods 2021.pdf \(mappocean.org\)](https://mappocean.org)). As part of this monitoring, Tier 1 and Tier 2 [in situ kelp surveys](#) were conducted at 29 sites in the area, many focused around **Tgii Xsw'aanx**/Porcher Island, in 2018, and satellite imagery was acquired to evaluate canopy-forming kelp extent in some sections of the Kitkatla Inlet Network Zones area in 2017, 2018 and 2022. Satellite imagery revealed notable declines in canopy-forming kelp extent off the west coast of **Tgii Xsw'aanx**/Porcher Island in 2018 and 2022 compared to provincial aerial surveys conducted in 1976. However, these surveys use different methods and represent only three snapshots in time; therefore, trends should be interpreted cautiously.

Discrete areas with canopy-forming kelp forests are common throughout BC. Within the Kitkatla Inlet Network Zones area, mapped areas of **mo'ox** and **gyoós** are present in shallow areas throughout the four zones and clustered around the island of Lax Kul, southwest of Zone 330 (Figure 61). **Mo'ox** is found in more exposed areas, such as the northern and western end of **Lax k'naga dzol**/Banks Island, although in these areas, its distribution overlaps with **gyoós**. The only species identified for **mo'ox** was found on the island of Lax Kul. In Zone 331, both **mo'ox** and **gyoós** are present around Freeman Passage and near Spicer Island in Schooner and Beaver Passage, although there are more occurrences for **gyoós**. **Gyoós** occurrence dominates Principe channel. According to historical CHS data, many kelp occurrences are around Lax Kul and throughout Zone 332 and northward to Porcher Peninsula up to Oval Bay outside the Kitkatla Inlet Network Zones. The historical chart kelp data from 1858-1956 (Costa et al. 2020) show a similar distribution to the CHS data. The historical distribution of kelp shows occurrence in **MaxlaGitxaala**/Kitkatla Channel (Zone 331) that the CHS dataset does not.

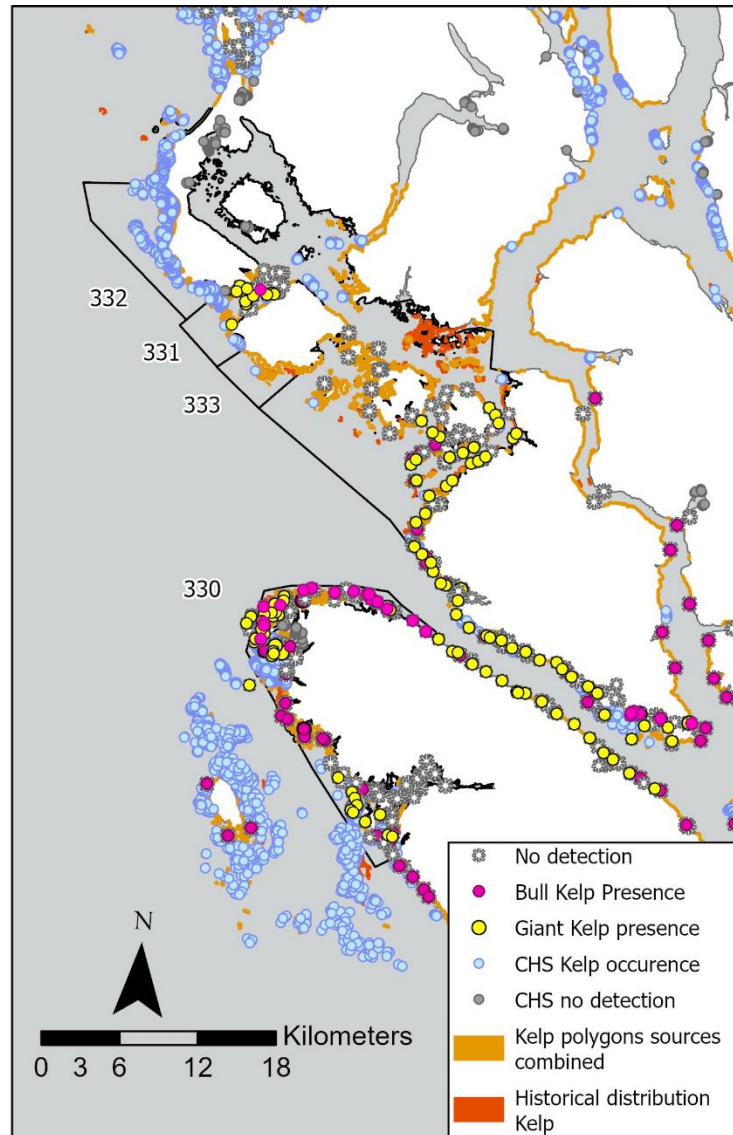


Figure 61. Canopy-forming kelp layers (*Mo'ox*/Bull Kelp and *gyoós*/Giant Kelp) in the Kitkatla Inlet Network Zones area. The Canadian Hydrographic Society (CHS) Kelp data shows historical occurrences from 1904-2004, historical kelp distribution is from digitized charts from 1858-1956, and the Kelp polygon sources combined from various sources (Shorezone kelp bioband data from 2014-2016, BCMCA kelp bed polygons, and other sources from FN and community groups). These layers include kelp occurrences where the species of kelp was not recorded. *Mo'ox* and *gyoós* occurrences from two DFO dive surveys (Benthic Habitat Mapping 2015-current and Multispecies 2016-2021) are shown as points.

Kelp is noted by Gitxaala harvesters off the west coast of the **Tgii Xsw'aanx**/Porcher Island Kitkatla Inlet, Goschen Island, Freeman Passage and the north end of **Lax k'naga dzol**/Banks Island (Gitxaala Nation GIS database). Kelp found in Kitkatla Inlet is used for **xs'waanx**/herring roe on kelp; the actual locations can vary from year to year. The outer coast **Tgii Xsw'aanx**/Porcher Island has most recently been the location spawning locations. Some kelp beds off the west coast of **Tgii Xsw'aanx** and Goschen Island have been wiped out; however, no cause was noted by Gitxaala harvesters.

6.2.2.2 Diversity of marine macroalgae

Marine macroalgae, also commonly known as **la'ask**/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 Kitkatla Inlet 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 (Springer et al. 2010; summarized in Rubidge et al. 2020). Understory kelp in the NSB may serve similar ecosystem engineering functions to canopy-forming species of **mo'ox**/Bull Kelp and **gyoós**/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 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** 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** fronds may provide more food and shelter for fishes than understory kelp. While only **gyoós** and **mo'ox** 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).

Coralline 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 (Kelaheer et al. 2002). 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**/Northern Abalone, and adults have been 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'almoots**/crabs compared to unvegetated areas (Wilson et al. 1989).

Lastly, certain algae species have important uses for humans. The red algae, **la'ask** *Pyropia abbotiae*, for example, grows on intertidal rocks and is commonly harvested, dried, and used as snacks and meals by many coastal First Nations, including the **Gixaala** (Turner, 2003). **La'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 **la'ask**/seaweeds traditionally or contemporarily eaten or have food-related uses by nearby coastal First Nations include Rockweed, Sea lettuce, and Pacific Dulse (*Palmaria mollis*) (Kuhnlein and Turner, 1991).

Data sources

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 H**; Davies et al. 2018). While additional species were noted, they were excluded from subsequent analyses in the dive surveys. Dive surveys on the North Coast were conducted in 2015 (Davies et al. 2018). Algae information is also collected as habitat and substrate information from the Multispecies dive surveys using quadrats and transect lines (Lochhead et al. 2023). Species and their groups (e.g. “Red Branched algae”) were categorized into green (Chlorophyta), red (Rhodophyta), brown (Phaeophyceae), 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 are highly variable even within groups. The Global Biodiversity Information Facility database also supplemented the occurrence data for the Network Zone polygons.

Results from the BHM and Multispecies dive surveys (Lochhead et al. 2023) recorded 27 macroalgae species (23 species and 4 groups) within the Kitkatla Inlet Network Zones (**Appendix H**). This list excludes two canopy-forming kelps: **mo'ox**/Bull kelp and **gyoós** /Giant kelp. Only two Zones have data from the dive surveys, with 22 macroalgae species recorded from Zone 330 and 16 species from Zone 331. There is a lack of macroalgae DFO survey data for Zones 332 and 333. Understory Kelp as well as habitat and reef-forming algae species and groups, such as Rockweed, Sea Lettuce, and Articulated Corraline algae, were present in both Zone 330 and 331. The red edible algae **la'ask** was found in Zone 330. A probability distribution model based on observations from dive survey data and habitat suitability (Nephin et al. 2020) for the understory kelp *Pterygophora* is shown in **Figure 62**, where a higher probability of occurrence surrounds Zone 330 and the western side of **Lax k'naga dzol**/Banks Island, throughout the island of **Lax Kul**/Bonilla Island, and the **Tgii Xsw'aanx**/Porcher Island Peninsula.

6.2.2.3 **Gadza k'aw** / Marine plants: eelgrass and surfgrass

Seagrasses are a unique flowering plant group that dominates 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.). Eelgrass was identified as a Zone-level Network Conservation Objective for Zone 331 (MPA Network BC Northern Shelf Initiative 2023). Eelgrass is usually found in soft substrates such as shallow, flat, sandy, or muddy areas that have low exposure to **Goop**/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 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. The decomposition of this wrack supplies food for herbivores and detritivores (Heck et al. 2008).

Two **gadza k'aw**/eelgrass species are found in BC: the native Common **gadza k'aw** (*Zostera marina*), which is the primary **gadza k'aw** found throughout the NSB, and the introduced Dwarf **gadza k'aw** (*Zostera japonica*). Dwarf **gadza k'aw** has not been documented to spread within NSB boundaries due to temperature limits (Shafer et al. 2014). The non-native Dwarf **gadza k'aw** would likely form mixed-species meadows with Common **gadza k'aw** if the spread of non-native Dwarf **gadza k'aw** 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 Zone 331.

Gadza k'aw/eelgrass 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**/salmon (all species), **wat'ukw**/Lingcod, **Tskah**/Pacific Herring, Dungeness **k'almoos**/crabs (Moore et al. 2015; Sharpe et al. 2021), and are important for multiple life stages of 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).

Three species of *Phyllospadix* are 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 excluding other vegetation (Turner 1985; Turner and Lucas 1985). Aggregations of surfgrass meadows can provide refuge from **Goop**/waves on rocky shores and accumulate sediments in their rhizome and stem structure, supporting habitats for infaunal invertebrates (Phillips 1979). Surfgrass meadows are understudied compared to **gadza k'aw** because they grow in wave-exposed areas that are sometimes inaccessible. Thus, surfgrass did not meet the criteria of a nearshore EBSA due to lacking information about its importance and usage by other E-CP species, besides **Tskah**/Pacific herring, which uses both **gadza k'aw**/eelgrass and surfgrass as spawning habitats (Barto 2008; Rubidge et al. 2020).

Like many coastal First Nations, Gitxaala Nation depend on seagrass meadows to produce many fish and invertebrate resources, such as **xs'waanx**/herring eggs. Without seagrass

meadows (especially **Gadza k'aw**), the harvest of many important marine resources and their associated cultural values would be lost (Satterfield et al. 2012).

Data sources

Spatial data for seagrasses in the Kitkatla Inlet Network Zones area were provided as biobands and polygons. **Gadza k'aw**/eelgrass surveys and polygon datasets have been updated throughout the years (e.g., [MPATT 2017 metadata](#)), and the Shorezone biobands from the Kitkatla Inlet Network Zones area are from 2014 to 2016 (NOAA 2017), and therefore, spatial datasets for **gadza k'aw** and surfgrass in the Kitkatla Inlet Network Zones area are somewhat dated.

gadza k'aw/Eelgrass monitoring within Network Zone 331 and the broader Kitkatla Inlet Network Zones area has been ongoing since 2017 at 10+ sites in support of the MaPP/ESI North Coast Cumulative Effects (NCCE) Program. As part of the NCCE Program, a current condition report for the Skeena Estuary Assessment Area (SEAA), which includes Zones 331 and 333, is forthcoming ([Cumulative Effects - North Coast Skeena First Nations](#)). The report examines the spatial distribution of cumulative pressures on estuarine habitats of the Skeena River Estuary, including **gadza k'aw** meadows, tidal marshes, and kelp beds. Kitkatla Inlet was identified as a comparatively low-pressure area where all three valued biotic habitat types (**gadza k'aw**, marsh, and kelp) occur in relatively high abundance, and the **gadza k'aw** field monitoring program revealed **gadza k'aw** meadows in Kitkatla Inlet to be in relatively good condition.

To supplement the original bioband spatial layers, a species distribution model (SDM) for **gadza k'aw**/eelgrass was also mapped for the area (Nephtin 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, **gyenti**/sea cucumber survey, **ts'akwe'ats**/red sea urchin survey, and **Bilhah**/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 for **gadza k'aw** that considers freshwater input is currently in development (A. Park, pers. comm. 2023).

ShoreZone biobands (**Figure 63**) and **gadza k'aw**/eelgrass species distribution models (**Figure 64**) show that there is a high probability of **gadza k'aw** and surfgrass occurrences around the Kitkatla Inlet Network Zones area. Sheltered areas such as Kitkatla Inlet, Kitkatla Channel, and Porcher Inlet in and around Zone 331 are likely to harbour more **gadza k'aw** beds. Whereas, surfgrass occurs in exposed areas such as the coastlines facing Hecate Strait in all four Zones (including the island of **Lax Kul**/Bonilla Island). The shallow depths and nearshore features of Kitkatla Inlet could indicate ideal **gadza k'aw** and surfgrass habitats, as there are fewer occurrences in deeper inlets such as Principe Channel, Gasboat Passage and Ogden Channel.

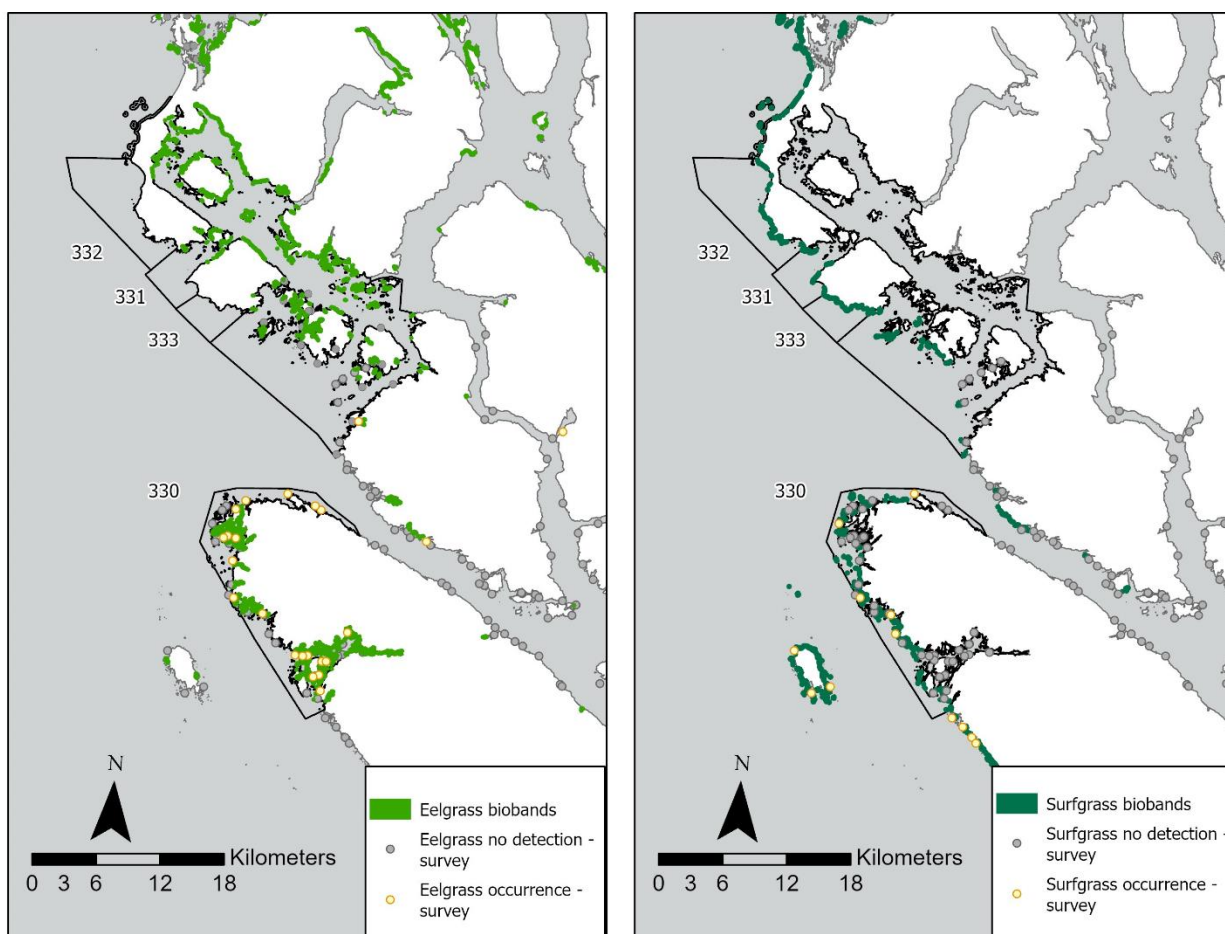


Figure 63. Shorezone Bioband data and DFO dive survey for Left) *gadza k'aw*/eelgrass and Right) surfgrass collected in the Kitkatla Inlet and North Coast area from 2014-2016. Generally, *gadza k'aw* is found in protected areas with soft substrates, whereas surfgrass is uniquely found on rocky substrates with higher wave action. Dive surveys in the area include Benthic Habitat Mapping and Multispecies and are shown in points for both occurrences and no detection.

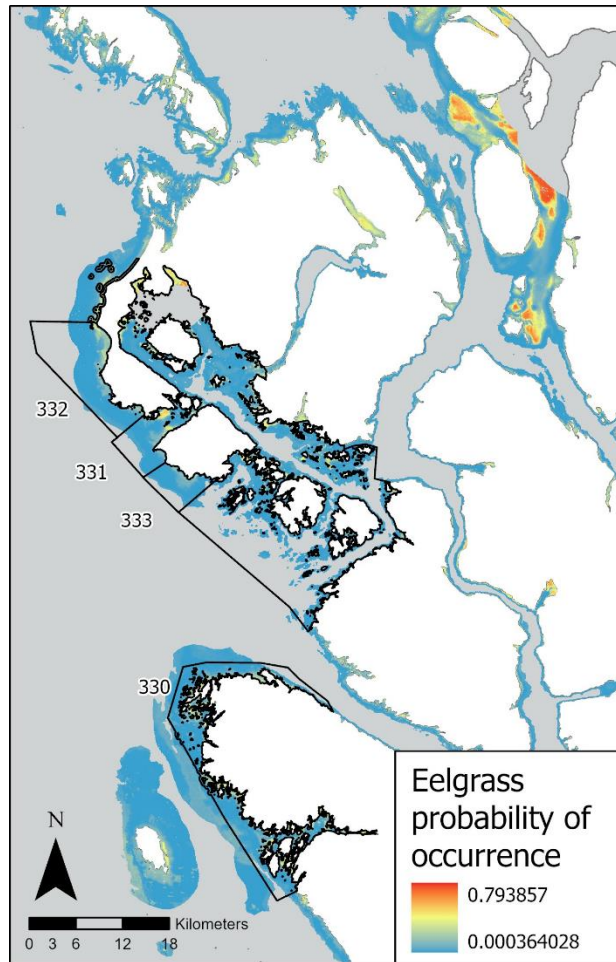


Figure 64. Eelgrass species distribution model throughout the Kitkatla Inlet Network Zones area. The areas with high probability of occurrence are located in sheltered nearshore areas such as Kitkatla Inlet and Kitkatla Channel (Zone 331), around Porcher Peninsula (Zone 332), Lax Kul and nearshore Lax k'naga dzol (Banks Island; Zone 330).

6.2.2.4 Sensitivities 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 ($\leq 12^{\circ}\text{C}$ for **mo'ox**/Bull kelp, $\leq 15^{\circ}\text{C}$ for **gyoós**/Giant kelp), high salinity ($\geq 28\text{‰}$), 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 heatwaves) 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. 2022).

Sedimentation can inhibit the establishment of kelp spores (Geange et al. 2014). The density of both canopy-forming (**gyoós**/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, which can be influenced by land-use practices including the removal of terrestrial vegetation (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** may be more sensitive to warming ocean temperatures than **gyoós** (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 enormously 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 **ploon**/sea otter occupation (Stevenson 2016, Lee et al. 2016, 2018), and the loss of a key mid-level trophic predator, the sunflower **gamaats**/sea star, due to **gamaats** 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 \(arcgis.com\)](https://arcgis.com)). This 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, **dooyaks**/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 km) variations in seawater temperature of ~1-3°C drive the recovery of **gyoós** from harvest (Krumhansl et al. 2017) and the resistance of **gyoós** and **mo'ox** 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. **baask**/Wind and tidal-driven mixing can promote favourable conditions for kelp persistence by providing cooler, nutrient-rich water, potentially providing refugia for regional kelp diversity in the southern areas of Zones 331 to 332 (Berry et al. 2021; see Large-scale circulation, **dooyaks**/currents and climate, and Freshwater inputs).

Local-scale variation in current speed, temperature, and substrate type may influence trends in **mo'ox** 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, kelp persistence in thermal refugia is constrained by biotic interactions, mainly intensive grazing by increasing **aswit**/urchin populations (Starko et al. 2022).

The ecological success of kelp forest/bed restoration is highly variable and difficult to predict, with disturbance events like **aswit**/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** barrens or turf algae has occurred (Filbee-Dexter and Scheibling 2014; Filbee-Dexter and Wernberg et al, 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** predators and maintaining trophic complexity and functional redundancy (Starko 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 Kitkatla Inlet Network Zones area is sparsely populated, vessel traffic transiting through the Inside Passage and around **Tgii Xsw'aanx**/Porcher Island in Ogden Channel could impact local seagrass ecosystems (see Vessel traffic and vessel types).

Invasive species, such as green **k'almoos**/crabs (Garbary et al. 2014; Matheson et al. 2016) and introduced Pacific oysters (Kelly and Volpe, 2007), are known to impact **gadza k'aw**/eelgrass health by altering fish communities and water properties respectively. In BC, high densities of green **k'almoos** can also directly contribute to declines in **gadza k'aw** shoot density by shredding **gadza k'aw** blades and consuming both blades and rhizomes (Howard et al. 2019). This disturbance mechanism differs from that exerted by **Ploon**/sea otters digging in **gadza k'aw** meadows, which can promote **gadza k'aw** genetic diversity, however no **Ploon** currently occur in the Kitkatla Inlet Network Zones area (see **Ploon** / Sea otters). Physical disturbances relating to human activities, such as frequent trampling, boating, logging, coastal construction, and coastline alterations, impact **gadza k'aw** negatively. Zone 331 and 330 have many anchorage sites, and recreational boating routes are found in every Zone, which could affect **gadza k'aw** and seagrass distributions through boating, anchoring, and beachcombing activities (See Tourism and recreation). 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 they naturally prefer wave-exposed habitats (Turner and Lucas 1985). Surfgrass are, however, affected by desiccation and heat stress during low **aks**/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 stressors mentioned above (Orth et al. 2006).

While **gadza k'aw**/eelgrass are perennial species with 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 the vegetative growth of new meadows can be slow or non-existent. Environmental conditions, site suitability, and the condition of neighbouring natural **gadza k'aw** meadows sites were found to be most important in predicting restoration success rather than restoration method type (Wright, 2005; Beheshti and Ward 2021). Uprooted surfgrass beds have slowly recovered due to highly variable recruitment success and seed viability (Turner and Lucas 1985, Wyllie-Echeverria et al. 2007). Two studies demonstrated low seedling recruitment and high mortality rates in experimental plots (Turner 1983, Turner and Lucas 1985). This difficulty in recruitment may be partially explained by predation on seeds by **k'almoos**/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**/eelgrass in suitable habitats or partially damaged meadows are more effective than restoring meadows that have been completely lost. Notably, partially restored **gadza k'aw** ecosystems have been shown to increase the presence of certain juvenile fish species (such as **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 depend on healthy **gadza k'aw** communities (Orth et al. 2006; Unsworth et al. 2019; Knutsen et al. 2022).

Gadza k'aw/eelgrass 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 2002; Wright 2005). Future monitoring of this species in the Kitkatla Inlet Network Zones and any conservation tools in the area should align with existing kelp monitoring in the region, including the [Regional Kelp Monitoring on the North Pacific Coast](#).

6.2.2.5 Data and Knowledge Gaps

Canopy-forming kelps

Information on canopy-forming kelp persistence and drivers of change in BC are 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 is 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**/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/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 coastal fjords and inlet areas such as Kitkatla Inlet (see Climate change impacts on coastal nearshore and inlet areas), 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.

Marine macroalgae

Many macroalgae research surveys focus on **mo'ox**/Bull kelp and **gyoós**/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). The BHM and Multispecies dive surveys do not cover the full extent of Kitkatla Inlet Network Zones area, specifically Zones 332 and 333 and sampling within the Kitkatla Inlet is sparse compared to the seaward coastlines. Few studies also compare the community composition and ecosystem function of **mo'ox** and **gyoós** kelp-dominated habitats to other macroalgae, such as understory kelp. When surveys are infrequent, seasonal and interannual variation in macroalgae distribution is also unclear. Algae variation and trends can be supplemented through traditional knowledge, and local community surveys can inform baselines and long-term monitoring.

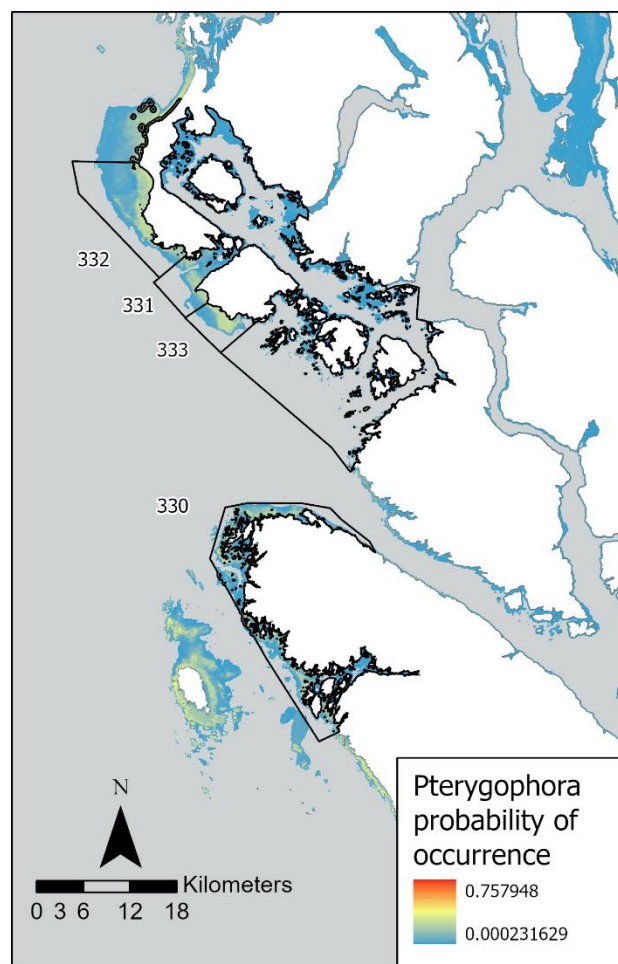


Figure 62. *Pterygophora* species distribution model shown in the Kitkatla Inlet Network Zones area (Nephin et al. 2020).

Further research on surfgrass in BC is needed to understand its habitat preference, environmental tolerance, and importance for species of conservation priorities. Local knowledge, spatial imagery, and monitoring programs can supplement species distribution models and occurrence information. The National Eelgrass Task Force was created to produce dynamic maps of **gadza k'aw**/eelgrass 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.

6.2.3 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. The colloquial term 'shellfish' also refers to these diverse species, except for corals and sponges. Each section briefly summarizes the general ecological importance, life history, fishery or cultural uses, and occurrence within the Kitkatla Inlet Network Zones. Recent patterns of occurrences in the Kitkatla Inlet Network Zones area or surrounding regions are presented where available. Finally, a summary of Sensitivities and Recoverability is reported for marine invertebrate groups and species of interest.

Data sources

The following occurrence records used in the subsequent invertebrate sections (except for cold-water corals and sponges, which has a separate data sources heading) have been extracted from several sources: The DFO shellfish survey database, which includes Commercial Harvest fishery logs (2000-2022) and research surveys (1963-2023), the DFO groundfish and other research surveys (2003-2023), DFO Benthic Habitat Mapping dive surveys (2015-ongoing; Davies et al. 2018), DFO Multispecies dive surveys (2016-2021; Lochhead et al. 2023), the Global Biodiversity Information Facility (GBIF) and iNaturalist open databases, personal communications and local knowledge. Occurrences of species from surveys are shown as 1 km by 1 km grids and are pulled from many datasets (See **Appendix H**) unless specified differently. Because species occurrences were collated from multiple databases with different protocols, target species, and survey methods, survey areas where there was 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 metadata of the [SeaSketch – Marine Protected Area Network Planning](#) layers (For example, [Spot Prawn locations](#)). **Bilhaa**/Abalone and Geoduck occurrence data are only summarized within the Kitkatla Inlet Network Zones but are not included in maps due to the *Species At Risk Act* clause and a confidentiality clause, respectively.

6.2.3.1 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 as reef-forming communities or aggregating groups (also called “gardens”). The reefs 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). 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 rockfish larvae (Baillon 2012), and stony corals (order Scleractinia) providing spawning habitats for juvenile **Ksah**/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). However, many species can also be found in shallow and intertidal zones (ICES, 2009).

Four Orders of Cold-water Corals were listed as ecologically conservation priorities (E-CPs) for the NSB which includes Black Corals (Antipatharia), Hard or Stony Corals (Scleractinia), Sea Pens (Pennatulacea), and Soft Corals (Alcyonacea) (Gale et al. 2019). Sponges listed as E-CPs include Glass Sponges (Order Hexactinellida), Demosponges (Order Demospongiae), two species of Glass Sponge: *Farrea occa* and *Heterochone calyx*, and the Cloud Sponge (*Aphrocallistes vastus*) (Gale et al. 2019).

Data sources

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 (**Figure 65A**). Coral and sponge group observations throughout BC were compiled by Nephin and Chu (2020) from DFO and external databases through different survey methods and gear types, including dive, ROV, traps, longline, and bottom trawls (**Figure 65B**). Finally, the spatial layer 'Sponge Reef Areas of the Pacific Region' from Natural Resources Canada (Shaw et al. 2018; [Sponge Reef Areas of the Pacific Region - Open Government Portal \(canada.ca\)](https://open.canada.ca/data/open/m2018-082)) was used to show the nearby Chatham Sound Sponge Reefs and its proximity to Kitkatla Inlet (**Figure 65B**).

The VME composite map did not overlap with any boundaries of the Kitkatla Inlet Network Zones besides Zone 331, which shows high habitat suitability around Browning Entrance (**Figure 65A**). There were also sparse occurrences of corals and sponges in the Network Zone polygons (**Figure 65B**). In Zone 330, there were only 30 occurrences of Stony Corals (Order Scleractinia), 6 occurrences of Sea Pens (Order Pennatulacea), 2 occurrences of Glass Sponges (Class Hexactinellida) and 1 occurrence of Demosponges (Class Demospongiae). Compared to other well-surveyed areas like Caamaño Sound, the Kitkatla Inlet polygons do not have enough data to confirm the VME composite map predictions. There do, however, appear to be many coral and sponge occurrences throughout the Principe Channel and Browning Entrance. Additional ground truthing (i.e., direct observation, survey, and measurement) within the Network Zone boundaries is needed to describe and confirm the presence of more coral and sponge communities.

Glass sponge reefs (Class Hexactinellida) are unique and fragile communities in the Northeast Pacific Ocean (DFO 2009a; Shaw et al. 2018). Two sponge reefs are located in the surrounding area: The Chatham Sound Reef, located approximately 30 km north of Zone 331 (Figure 1B), and the Northern Reef of the Hecate Strait/Queen Charlotte Sound Sponge Reef MPA, about 25 km southwest of Zone 330 (see **Figure 6A**). The Chatham Sound Sponge Reef is among the largest reef complexes in BC waters. This reef was surveyed in 2017 using remotely operated vehicle transects and observations to describe reef ecology, morphology and benthic communities. These findings, along with further information about BC's Sponge Reefs, are summarized in Chapter 17 of *Pacific Margin Sponge Reefs: Geomorphology and Ecology* (Conway et al. 2018).

Three coral and Sponge catch per unit effort (CPUE using kg/hr) maps (Corals, Sponges, and corals excluding Sea Pens) were generated from observations from the DFO synoptic groundfish trawl surveys (2003-2016) and commercial groundfish trawl fishery observations (2007-2017). This information does not cover nearshore areas and inlets, which includes most of the Kitkatla Inlet Network Zones, although the layer can provide insights into the waters adjacent to the Zones. The CPUE maps can be found on the [Seasketch website](#) and show high CPUE for Sponges and Sea Pens (Order Pennatulacea) surrounding Browning Entrance into Hecate Strait and the north tip of **Lax k'naga dzol**/Banks Island, which corresponds to the coral and sponge occurrences in **Figure 61B**. The Sea Pen CPUE map has high values throughout Hecate Strait, all outside or adjacent to the Network Zones. The CPUE for corals (excluding sea pens) is comparatively lower in the Browning Entrance/Hecate Strait area.

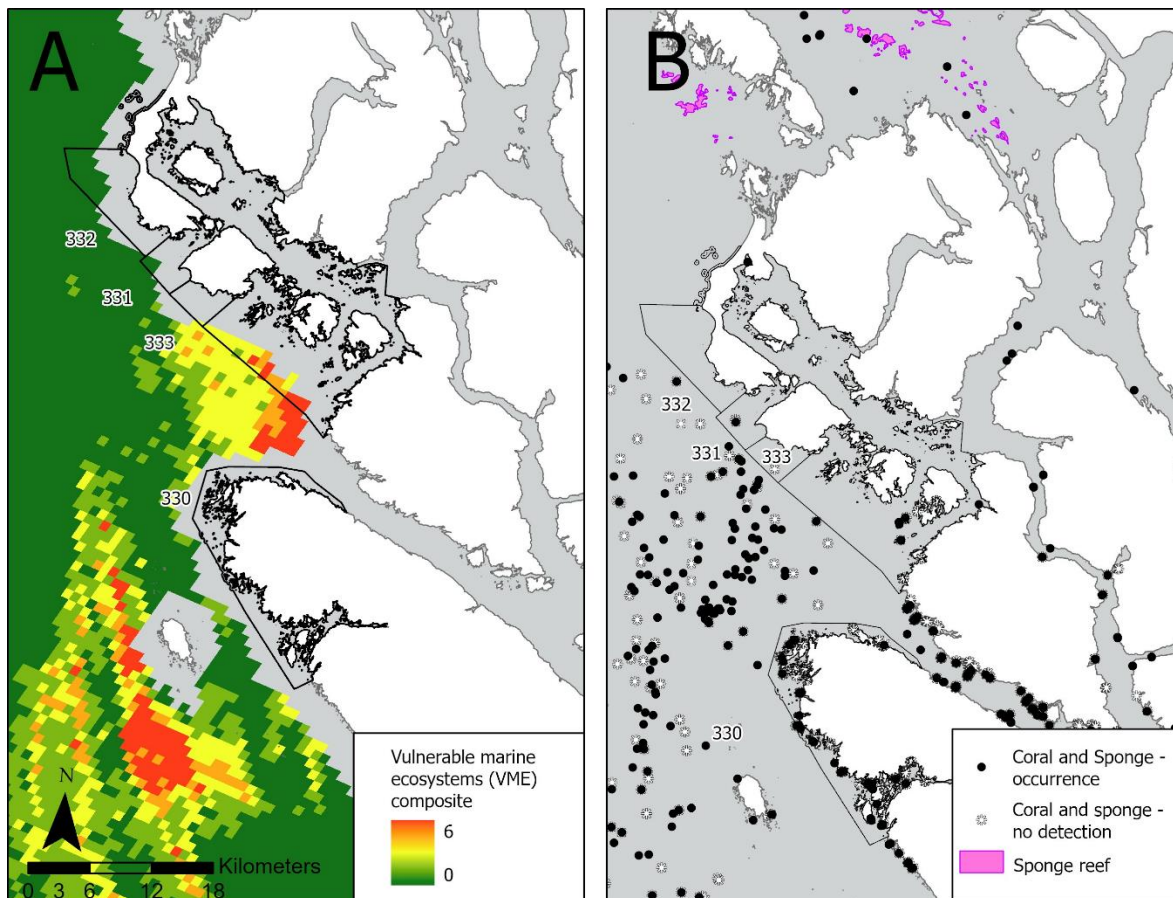


Figure 65. A) VME composite index of habitat suitability for cold-water coral and sponge groups, from Chu et al. 2019. Values range from 0 to 6, indicating the number of cold-water coral/sponge groups for which each raster is a suitable habitat; i.e., 6 is suitable for all coral and sponge groups, and 0 is no suitable habitat. **B)** Occurrence counts of Sponge and Coral groups in the Kitkatla Inlet Network Zones area. Black dots indicate point occurrence, although this figure does not differentiate between groups. Data was collected from DFO and external surveys and databases by Nephin and Chu (2020). Sponge reef polygons mapped by Natural Resources Canada show the Chatham Sound Sponge Reef north of Kitkatla Inlet (Shaw et al. 2018)

6.2.3.2 Molluscs

6.2.3.2.1 Infaunal 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**/clams and **gaboox**/cockles spend most of their lives buried in benthic substrates such as sand and mud. Epibenthic species, such as **k'a'on**/scallops, mussels, and oysters, instead settle on top of hard benthic substrates. These species support important ecological processes 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. Certain epibenthic bivalves, such as mussels and oysters, aggregate and form hard, complex biogenic habitats that can influence species abundance and diversity in intertidal and subtidal environments (Commuto 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**/clams and **gaboox**/cockles settle on beaches, whereas mussels and **k'a'on** can form beds or aggregations on rocky substrates. Bivalves are found in the diet of many macrofauna, including marine birds (Cox et al. 2020), **ploon**/sea otters (Ford 2014), Giant Pacific **hats'al**/Octopus (Scheel and Anderson 2012), Dover and Rock Soles (Buckley et al. 1999), Dungeness **k'almoos**/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. 2020), and bears, raccoons and **lis'yaan**/mink are known predators of intertidal invertebrate prey (Suraci et al. 2017). Commercial, recreational, and First Nations fisheries exist for both infauna and epibenthic bivalves. Harvest for the **sa'mx**/butter clam (*Saxidomus gigantea*), littleneck clam (*Leukoma staminea*), and **gaboox**/cockle (*Clinocardium nuttalli*) is conducted by hand digging during low **aks**/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).

Gitxaala harvesters previously indicated that **gaboox**/cockles are only harvestable in a short seasonal window (Conacher and McGarvey, 2014). This means Gitxaala harvesters must collect enough during this window to support their diet. Further, Gitxaala harvesters note that sand will be inside the shell if harvested too early and that **Ts'a'ax**/clams were best harvested in areas “where the **aks**/tide moves all the time”, which could indicate strong **dooyaks**/currents or strong tidal action. This is where they are most healthy, strong and present as white inside. Gitxaala harvesters note that if **ts'a'ax** are harvested where the tidal **dooyaks** slack and don't run all the time, **ts'a'ax** can present as black inside (Gitxaala Nation GIS database).

Gitxaala harvesters note that **ts'a'ax**/clams and **gaboox**/cockles are often found in complementary locations and can be found along the west and north coasts of **Lax k'naga**

dzol/Banks Island, **Tgii Xsw'aanx**/Porcher Island, the mouth of Porcher Inlet, Lach Klan, the north end of **Lax k'naga dzol**, in and around Kitkatla Inlet, the south end of **Lax ksi tgwi yuun**/Gurd Island, around Shakes Island, south of the Phoenix Islands, around the Pelham Islands and many other locations nearby Kitkatla Inlet (Gitxaala Nation GIS database). The presence of shells through exposed and eroding archaeological sites in Kitkatla Inlet, indicate the presence of robust **ts'a'ax**/clam and **gaboox**/cockle populations and harvest going back generations (James Herbert *pers. comm.* December, 2023).

The largest **ts'a'ax**/clam species found in BC, Geoducks (*Panopea generosa*) and **loon**/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 2023c). Eelgrass beds were identified as important habitats for their life cycles, and harvesting is prohibited in **gadza k'aw**/eelgrass beds (DFO 2023c). Geoduck harvest is separated into three areas throughout the coast of BC, rotating annually, whereas the West Coast of Vancouver Island is harvested annually. The rotation for harvest in the Kitkatla Inlet Network Zones area is in 2023-2024, followed by 2026-2027, and every subsequent three years. According to the 2020 stock status update, total coastwide biomass for sub-beds was above the Limit Reference Point and placed in the Healthy Zone. There is a lack of information regarding stock assessments for **loon**, and the latest Integrated Fisheries Management Plan reports a limited commercial fishery (DFO 2023c).

Both infaunal and epibenthic bivalves are abundant throughout the coast of BC. Six **ts'a'ax**/clams, one **gaboox**/cockle 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 Kitkatla Inlet Network Zones area (**Figure 66; Appendix H**). The Network Action Plan (MPA Network BC Northern Shelf Initiative 2023) prioritizes bivalves as Zone-level network conservation objectives in all Zones. Most species occurrences are recorded on the west-facing coasts of Kitkatla Inlet, mostly within Zone 331 and throughout Zone 330 and the Principe Channel.

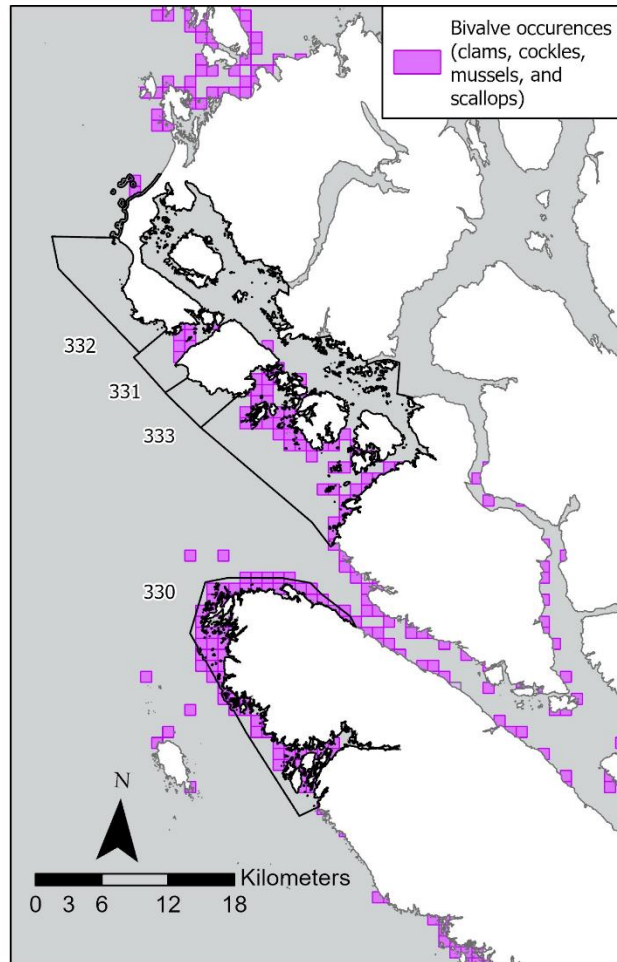


Figure 66. Occurrences of infauna and epibenthic bivalves in the Kitkatla Inlet Network Zones area represented by 1 km x 1 km grids. These 9 species include: Geoduck, **loon**/Horse Clam, **Sa'mx**/Butter Clam, Littleneck Clam, **Gaboox**/Cockle, **Gyels**/Blue Mussel, **Hagwn**/California Mussel, Pink Scallop, and Purple-hinged Rock Scallop.

6.2.3.2.2 Marine snails and **Yaans** / chitons

Marine snails (Class Gastropoda) and **'yaans**/chitons (Class Polyplacophora) have a variety of feeding behaviours. However, many species are foragers and grazers, such as the Red Turban Snail (*Pomaulax gibberosus*), which feeds and seeks shelter on **gyoós**/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' Moon snail (*Neverita lewisii*), on the other hand, mainly predares on infaunal bivalves, such as butter, littleneck, and **loon**/Horse clams/Pacific gaper clams (Harbo, 2011). In turn, marine snails and **'yaans** are predated upon by a variety of other invertebrates such as **aswit**/urchins, **gamaats**/sea stars, **hats'al**/octopus, and vertebrates such as marine birds (O'Clair and O'Clair 1998), rockfish (Love et al. 2002), and **ploon**/sea otters (Ford 2014). As benthic slow-moving creatures, most snails and **'yaans** prefer rocky and hard substrates, with semi-exposed coastlines. The Lewis' Moon snail is often found ploughing through finer substrates such as mud or sand (Harbo 2011).

Two **'yaans**/chiton species, **'yaans**/Black leather chiton (*Katharina tunicata*) and **ts'ak**/Gumboot chiton (*Cryptochiton stelleri*; also known as China Slipper), have important usages for coastal

First Nations. They are regularly harvested, consumed as food, and 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). Both **'yaans** and **ts'ak** in the Kitkatla Inlet Network Zones area were reported to prefer semi-protected to exposed intertidal areas with boulders and cobble and avoid areas with muddy and sandy shorelines (Gitxaala Nation 2016).

Gitxaala Nation members report picking **'yaans** /Black leather chiton throughout the Laxyuubm Gitxaala (Conacher and McGarvey, 2014). **'Yaans** are typically harvested from intertidal rocks during low **aks**/tide, and because they are known as algae eaters, they can often be found where kelp is present but not with mussels. Harvesters prefer **ts'ak**/Gumboot chiton of smaller sizes (8-10 cm) and are harvested year-round in areas with **la'ask**/seaweed and **'yaans** (Gitxaala Nation, 2016). **'Yaans** are prepared for consumption by soaking them in cold water (Conacher and McGarvey, 2014). This causes the shell to open up and soften. Gitxaala harvesters noted that **'yaans** can be found at multiple locations around Kitkatla Inlet and **Lax k'naga dzol**/Banks Island, **Tgii Xsw'aanx**/Porcher Island, Goschen Island, McCauley Island and around the Christie Islands and Ralph Islands (Gitxaala Nation GIS database).

'Yaans/Chitons are Zone-level network conservation objectives for all Kitkatla Inlet Network Zones, mostly as important cultural use and food security. In the Kitkatla Inlet Network Zones area, most occurrence data (from the Multispecies and BHM dive surveys) for **Yaans** and snails are on the western side of Zone 331 and throughout 330, Principe Channel, and the island of **Lax Kul**. There is no survey data for Zones 333, 332, and Kitkatla Inlet in Zone 331 (**Figure 67**). Many marine snails listed as E-CPs are abundant throughout BC's coasts, especially those with strong aggregating behaviours, such as the Littorina snail and Black Turban (*Tegula funebris*) 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, it can be inferred that they occur in most if not all, of the Kitkatla Inlet Network Zones.

Bilhaa/Northern Abalone (*Haliotis kamtschatkana*), an ecologically and culturally important and highly vulnerable species (COSEWIC 2009a), is present within the Kitkatla Inlet Network Zones. **Bilhaa** are currently listed as endangered (COSEWIC 2009a) and are being re-evaluated for the 2024 COSEWIC status report. At this point, there is no commercial harvest of **bilhaa**. The North and Central Coast geospatial areas have been identified as critical habitats for survival and recovery efforts (DFO 2012a). **Bilhaa** are consumed as food, depicted in traditional stories, and used as cultural symbols such as jewelry and decorations. **Bilhaa** has been described as "worth its weight in gold" (Satterfield et al. 2012). Diet preferences for adult **bilhaa** include **Mo'ox**/Bull kelp and **gyoós**/Giant kelp, both found extensively throughout the Kitkatla Inlet Network Zones area, as well as diatoms, algae, and kelps (Sloan and Breen 1988; Neuman et al. 2018). Population genetics of **bilhaa** using microsatellites indicated low regional differentiation throughout 16 coastal BC populations but higher variation within samples from all populations (Withler et al. 2001). **Bilhaa** 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 occurs more often at night and during the spring and summer (Sloan and Breen 1988). **Bilhaa** densities and average shell lengths have decreased considerably from 1978 to 2007. A survey in 2016 in the Central Coast region estimated lower mortality rates compared to 2006 and 2011 and increased mean total density for all sizes (J. Lessard pers. comm. from Neuman et al. 2018). There are **bilhaa** occurrences from DFO surveys in Zones

330 and 331. 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).

Gitxaala Nation members know and help manage the at-risk species in the **Laxyuubm Gitxaala** (Conacher and McGarvey, 2014). Before the limited harvest of this species, it was an important food source and source of regalia components. **Bilhaa** requires specific conditions for harvest, and it is typically undertaken following a big **aks**/tide. Kelp is used to identify the presence of **bilhaa** as they usually occur together (Gitxaala Nation GIS database). Occurrences of **bilhaa** were identified previously by Gitxaala harvesters along **Lax k'naga dzol**/Banks Island, **Lax Kul**/Bonilla Island, McCauley Island, and a number of other locations in **Laxyuubm Gitxaala** (Gitxaala Nation GIS database).

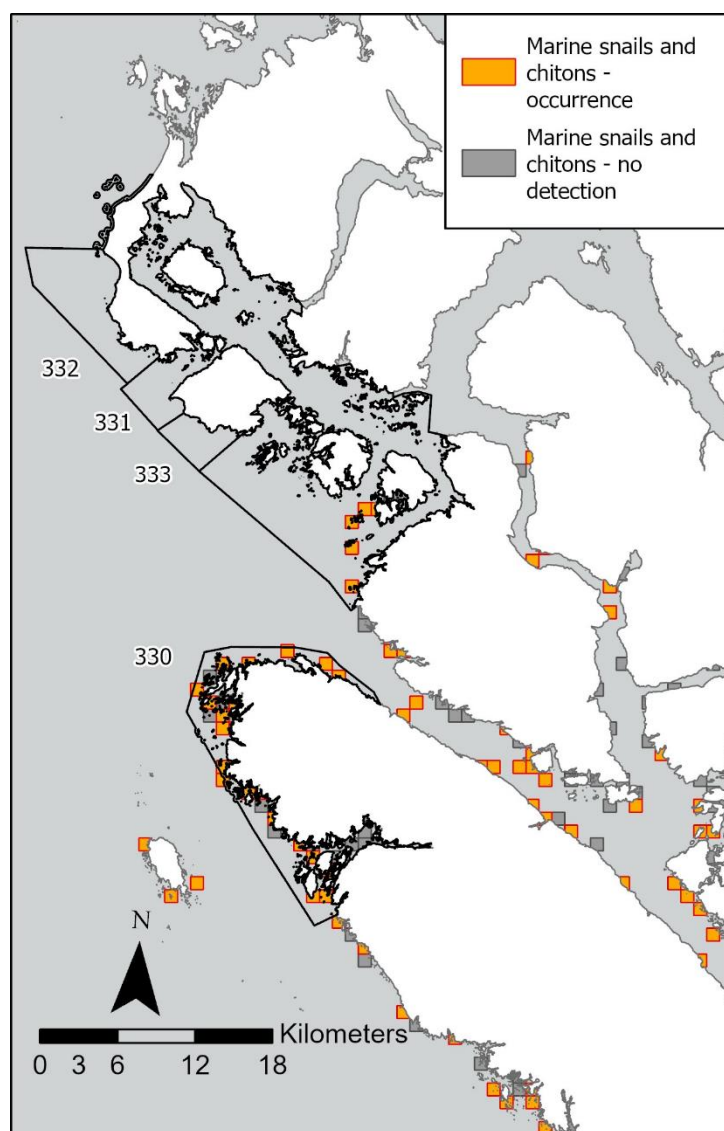


Figure 67. Occurrence represented by 1 km x 1 km grids of marine snails and chitons in the Kitkatla Inlet Network Zones area. All occurrences are from the Benthic Habitat Dive Transect surveys (Davies et al. 2018). These 5 species include: Red Turban Snail, Black Turban Snail, Lewis' Moonshell, **Ts'ak**/Gumboot Chiton, and **Yaans**/Black Leather Chiton.

6.2.3.2.3 Cephalopods

Class Cephalopoda (hereafter, cephalopods) includes **hats'al**/octopus and **Xbihats'al**/squids. The Giant Pacific **hats'al** and Opal squids are abundant throughout BC's coasts. There are no current fisheries for Opal **Xbihats'al** and Giant Pacific **hats'al** in BC, although Opal **Xbihats'al** were fished for bait in the 2000s (Wade and Curtis 2016). The Giant Pacific **hats'al**, 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 mainly of crustaceans (**k'almoos**/crabs), bivalves, other cephalopods, and sometimes fish and fish eggs (Gillespie et al. 1998; Scheel and Anderson 2012). In turn, they are prey for **wat'ukw**/Lingcod, Rockfish, Pacific Sleeper **Ksah**/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**/sea lions, fish, and birds (Walthers and Gillespie 2002; Enticknap et al. 2011). Information about the distribution and movements of pelagic Opal **Xbihats'al** 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 (Gale et al. 2019) due to their low reproductive output, unpredictable recruitment in life history traits, and aggregating behaviour and importance as forage species for Opal **Xbihats'al**.

Hats'al/octopus are Zone-level Network Conservation Objectives for Zones 331, 332, and 333 for cultural use and food security. **Hats'al** occurrences from DFO surveys appear throughout the Kitkatla Inlet Network Zones area, with aggregations in Porcher Inlet, Gasboat passage, and Grenville Channel (**Figure 68**). Outside of the Kitkatla Inlet Network Zones area, there are many occurrences throughout Chatham Sound. Opal **Xbihats'al**/Squid are commonly found in Hecate Strait; therefore, there are few occurrences within the nearshore Kitkatla Inlet Network Zones.

Gitxaala harvesters often encounter **hats'al** while harvesting **Ts'a'ax**/clams and **Gaboox**/cockles, especially in rocky shorelines, **aks**/tide pools, and rock platforms (Gitxaala Nation TERMPOL report, 2016). **Hats'al**/octopus are available for harvest year-round through jigging or collection at low **aks**. Harvesters noted occurrences of **hats'al** around **Lax k'naga dzol**/Banks Island. **Hats'al** were also noted to occur at **Tgii Xsw'aanx**/Porcher Island, and McCauley Island (Gitxaala Nation GIS Database).

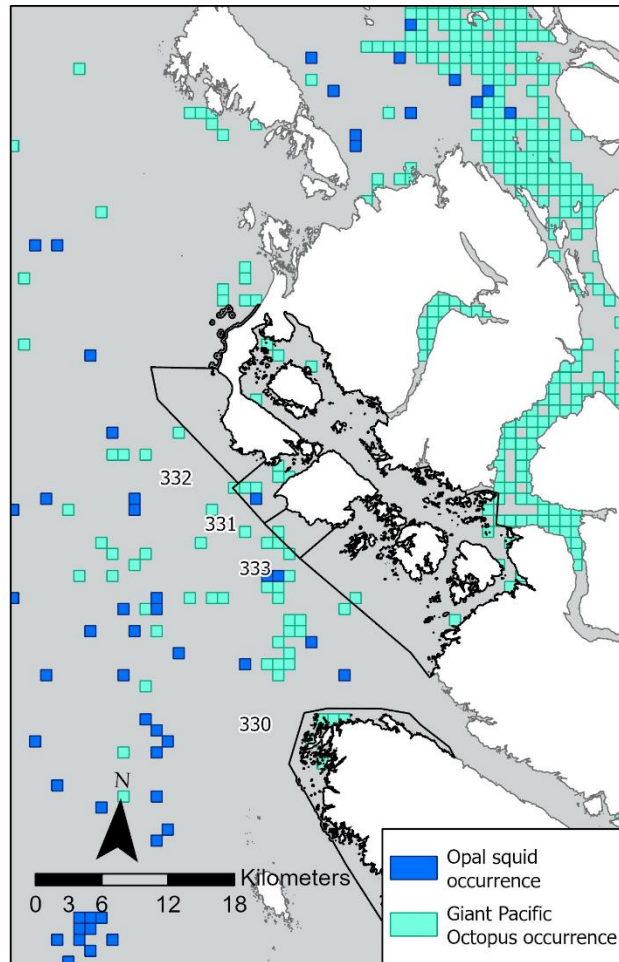


Figure 68. Occurrences of Opal **Xbihats'al**/Squid (dark blue) and Giant Pacific **hats'al**/Octopus (light blue) in the Kitkatla Inlet Network Zones area represented by 1 km x 1 km grids.

6.2.3.3 Crustaceans

The Subphylum Crustacea (hereafter crustaceans) includes a diversity of species, such as barnacles, **k'almoos**/crab, **gasgos**/prawns, and **gasgos**/shrimps, characterized by their segmented bodies and a hard exterior (exoskeleton). Over 90 **gasgos** and 35 **k'almoos** species are found in BC (DFO 2022b). For detailed summaries of Dungeness **k'almoos** and spot **gasgos** in BC, please refer to Hunter and Wade (2015).

6.2.3.3.1 **K'almoos** / Crabs and the goose barnacle

K'almoos/Crabs are important prey for many species, including fish (flatfish, rockfish, **balaas**/Pacific Hake, and **gandeh**/skates), **ploon**/sea otters, and **hats'al**/octopus (Pearcy and Hancock 1978, Buckley and Livingston 1997, Love et al. 2002, Brown et al. 2012). Dungeness **k'almoos**/crab (*Metacarcinus magister*) and Red Rock **k'almoos**/crab (*Cancer productus*) are prolific species throughout coastal BC and are targets for commercial, recreational, and First Nations fisheries. Dungeness **k'almoos** are harvested by Gitxaala year-round, although it was noticed that the taste of these **k'almoos** was different depending on where they were harvested (Marsden 2011). Dungeness **k'almoos** make up the largest proportion of catch for the commercial shellfish fishery in BC and 99.9% of the **k'almoos** fishery (DFO 2023a). The North Coast region is one of the most abundant areas for **k'almoos** (Hunter and Wade 2015). Stock

assessments of Dungeness **k'almoos** are conducted using commercial **k'almoos** -trapping gear. Assessments in remote regions are usually outsourced and scarce (DFO 2023a). Less information is available for **k'almoos** that do not have ongoing fisheries, such as the Puget Sound King **k'almoos** (*Lopholithodes mandtii*) and Inshore Tanner **k'almoos** (*Chionoecetes bairdi*). Both **k'almoos** are found in shallow to subtidal waters, up to 137 m for Puget Sound King **k'almoos** and 10 - 475 m for Tanner **k'almoos** (Jensen 1995, Fong et al. 2005). There are no confirmed sightings of the invasive European Green **k'almoos** around the Kitkatla Inlet Network Zones area. However, planktonic larvae of the Green **k'almoos** were detected near **Kxeen**/Prince Rupert ([Invasive Species- Green Crab \(larva\) Found in Lax Kw'alaams Traditional Waters – Lax Kw'alaams Band \(laxkwalaams.ca\)](#)). Confirmed sightings have occurred in the Central Coast and eastern Haida Gwaii as of August 2021 ([Strait of Georgia data center, University of British Columbia](#))

Gitxaala Nation harvesters identified occurrences of Dungeness **k'almoos**/crabs throughout Kitkatla and Porcher Inlet, by Pelham Islands, on the small islands around Lach Klan, **Lax ksi tgwi yuun**/Gurd Island, Dries Inlet, and Cessford Islands (Gitxaala Nation GIS database; Gitxaala Nation TERMPOL Report 2015).

Dungeness **k'almoos**/crab larvae, a form of pelagic zooplankton, make up an important part of the diet of several animals, including Pacific salmon, flatfish, and Grey Whales (Pearcy and Hancock 1978; Quinn 2005; Ford 2014). **K'almoos** 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** prefer these shallow coastal and estuarine areas and 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 of prey such as small fish, Molluscs, **gasgos**/shrimps, bivalves, and other **k'almoos** (Stevens et al. 1984; Pauley et al. 1989; DFO 2023a).

There are no occurrences of Inshore Tanner **k'almoos**/Crabs in the Kitkatla Inlet Network Zones area, although they are present in Chatham Sound from the mouth of the Skeena River up to the mouth of the Nass River. This may be due to a lack of survey effort in the Kitkatla Inlet Network Zones, as there are sparse occurrences throughout the Central Coast and Hecate Strait. Although, it may also be due to lack of habitat suitability, as many occurrences of Tanner **k'almoos** are found in inlets and fjords. Puget Sound King **k'almoos** have a few occurrences around McCauley Island and Principe Channel and the western coast of **Lax k'naga dzol**/Banks Island. Red Rock **k'almoos** are common in the shallow subtidal, and their occurrences have been recorded around McCauley Island (Zone 331) and **Lax k'naga dzol** (Zone 330) using the BHM and Multispecies dive surveys. Dungeness **k'almoos** are incredibly abundant in the area, especially in inlets and estuaries (**Figure 69A**). Aggregations of Dungeness **k'almoos** occurrences are found in Kitkatla Inlet around **Lax ksi tgwi yuun**/Gurd Island, Oval Bay, Porcher Inlet, and offshore Hecate Strait (which overlaps Zones 331, 332 and 333). Species distribution models predict a very high probability of occurrence in Chatham Sound and the mouth of the Skeena River estuary (**Figure 69B**).

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 biogenic habitats, similar to 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).

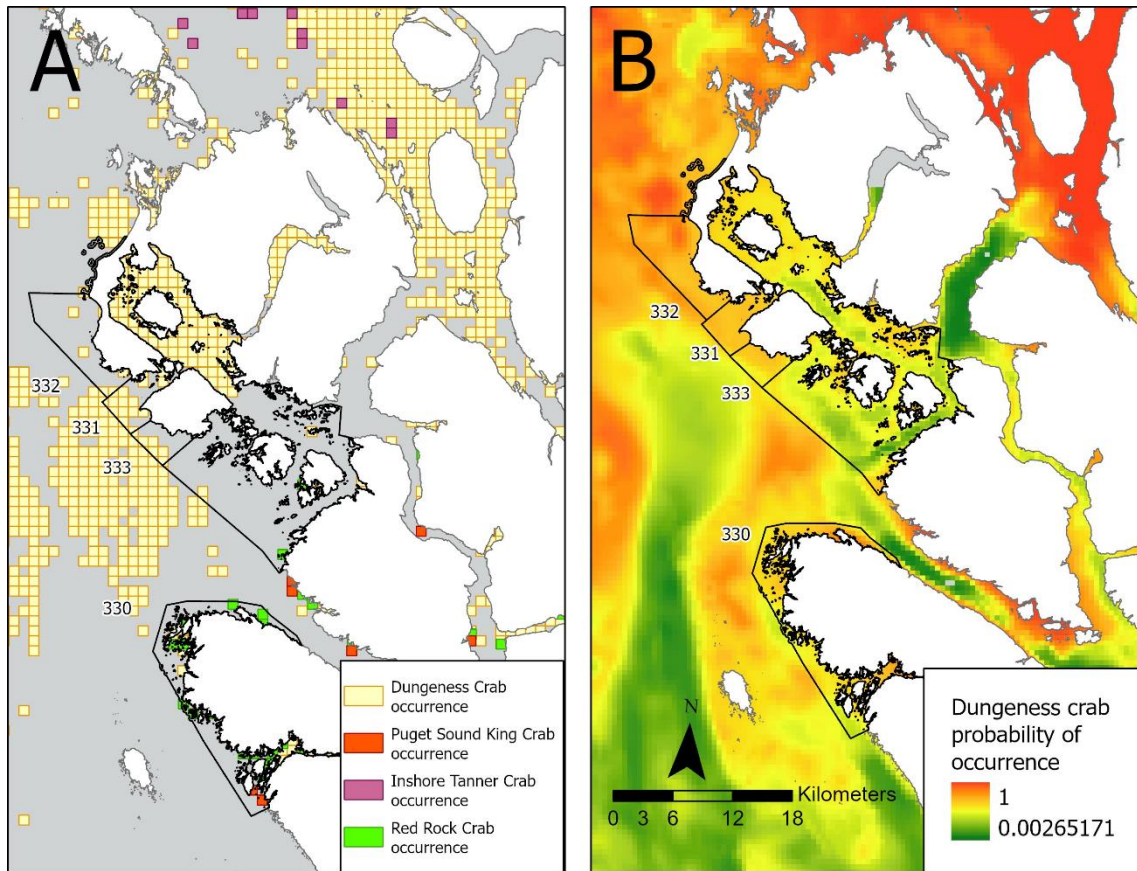


Figure 69. A) Occurrence of four *k'almoo*s /crab species in the Kitkatla Inlet Network Zones area from various DFO surveys, represented by 1 km x 1 km grids B) Dungeness *k'almoo*s probability of occurrence model.

6.2.3.3.2 Gasgos / Shrimps and Prawns

Seven **gasgos**/shrimp species (Family Pandalidae), including the spot **gasgos** (*Pandalus platyceros*), are considered E-CPs (Gale et al. 2019). All seven species of **gasgos** are present within the seven Kitkatla Inlet Network Zones (**Appendix H**). **Gasgos** fisheries in BC use trawl nets and traps for harvest, whereas Spot **gasgos** are only harvested by trap. The most common targets for trawl are Spiny/Northern Pink **gasgos** (*Pandalus borealis*) and Smooth Pink **gasgos** (*Pandalus jordani*) (DFO 2022c). Over 97% of the trap gear fishery catches Spot **gasgos** (DFO 2022c).

Gasgos/shrimp 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, rockfish, **balaas**/Pacific Hake, and **gandeh**/skates (Percy and Hancock 1978, Buckley and Livingston 1997; Love et al. 2002; Yang et al. 2006; Brown et al. 2012). During the day, **gasgos** are found on benthic sand and muddy substrates (including the Fjord System) and swim through the water column at night to feed on pelagic zooplankton (DFO 2022c). Spot **gasgos** are BC's largest species of **gasgos** and prefer rocky or hard bottoms. All Pandalid species of **gasgos** start their lives as males, mature around 18-24 months, and eventually change sexes to females around three years (Butler 1980; DFO 2022c). 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).

Population surveys are conducted in the fall season to ensure enough female spawners are available (DFO 2022c). Annual estimated abundances have shown highly variable trends. The Kitkatla Inlet Network Zones area overlaps with three **gasgos**/Shrimp Management Areas, 5IN, 6IN, and 6OFF and these areas are not considered major **gasgos** production areas in BC. These areas are infrequently surveyed. Annual **gasgos** trawl surveys in the nearby Chatham Sound assessing Smooth Pink, Spiny Pink, and Sidesripe **gasgos** (*Pandalopsis dispar*) showed biomass indices in the Healthy Zone for the past two years after falling below the Limit reference Point in 2019. Commercial **gasgos** landings are used as a proxy for stock abundance, and the latest coastwide trends have increased between 2018 and 2020 (DFO 2022c). The Prawn Spawner Index from 1995 to 2020 for each Fishery Management Area is available on the [Open Government database](#).

Aggregations of **gasgos**/shrimp are common in Fjord and Inlet habitats such as Ogden Channel and Chatham Sound, outside of the Kitkatla Inlet Network Zones. Within the polygons, Humpback **gasgos** (*Pandalus hypsinotus*), Coonstripe **gasgos**, and Smooth Pink have occurrences within Zone 331. Sidesripe **gasgos** and Spot **gasgos** have one occurrence in Zone 332. Humpback, Coonstripe **gasgos** (*Pandalus danae*), and Spot **gasgos** are found in aggregates around Porcher Inlet. Many occurrences of Spot **gasgos** are also found around **Lax ksi tgwi yuun**/Gurd Inlet (**Figure 70**) in Zone 331. Spot **gasgos** are most abundant in inlets, fjords and estuaries. Gitxaala harvesters noted that **gasgos**, specifically prawns, occur in Gasboat Passage, near Spicer Island, in Porcher Inlet, near Billy Bay, in the Kitkatla Inlet, Ogden Channel, and off Gilbert Island. **gasgos** were noted in Ogden Channel, Gasboat Passage, off Gilbert Island, and west of Lach Klan.

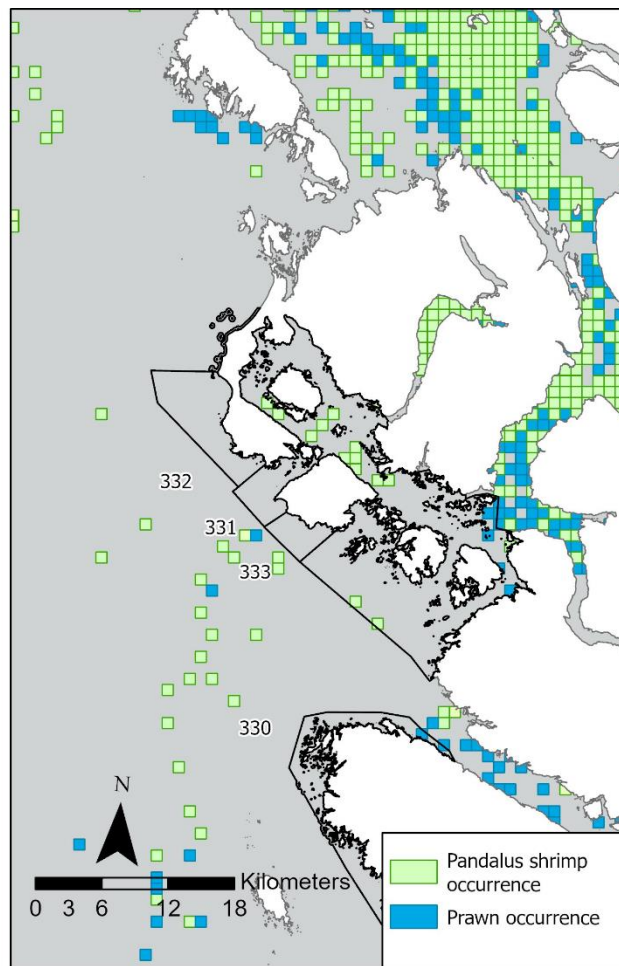


Figure 70. Occurrences of Spot *gasgos*/Prawn (*Pandalus platyceros*) are in blue, and the other seven *gasgos*/shrimp (Family Pandalidae) species in green in the Kitkatla Inlet Network Zones area represented by 1 km x 1 km grids.

6.2.3.4 Echinoderms

Phylum Echinodermata (hereafter echinoderms) consists of prolific, slow-moving epibenthic or benthic invertebrates, which include *gyenti*/sea cucumbers (Class Holothuroidea), *gamaats*/sea stars (Class Asteroidea), *aswit*/urchins and sand dollars (Class Echinoidea). Two *gamaats* and two *aswit* species were characterized as E-CPs (Gale et al. 2019) in the NSB. In addition, *gyenti*/giant California sea cucumber (*Apostichopus californicus*, formerly *Parastichopus californicus*) was identified as Zone-level network conservation objectives for all four Zones for cultural use and food security (MPA Network BC Northern Shelf Initiative 2023; **Figure 71**). Echinoderms occupy a diversity of ecological niches and serve many different ecosystem functions, with consequences for species distributions and diversity. If unchecked by predators, for example, *aswit* can overgraze algae and kelp beds, destroying important habitats and leading to barren patches stretching kilometres across coastlines (Filbee-Dexter and Scheibling 2014). Voracious yet keystone predators such as Ochre *gamaats*/sea stars (*Pisaster ochraceus*) and Sunflower *gamaats*/sea stars (*Pycnopodia helianthoides*) help mediate

invertebrate diversity, including preying upon **aswit** in the intertidal and subtidal, respectively (Schultz et al. 2016). Sunflower **gamaats** can also promote kelp abundance by limiting sea urchin abundance, behavior, and grazing rates through predation pressure (Schultz et al 2016). The excreted waste of detritivores such as **gyenti** redistributes sediment loads, provides inorganic nitrogen and phosphorus for nutrient cycling, and increases benthic communities' productivity (Hughes et al. 2016). Echinoderms are prey to various E-CP species, including **ploon**/sea otters, **hats'al**/octopuses, fishes, and marine birds (Gale et al. 2019).

Since 2013, many **gamaats**/sea star populations throughout the Pacific Northwest coast have declined due to **gamaats** wasting disease, with areas as far north as Juneau, Alaska (Miner et al. 2018). The Sunflower **gamaats** (*Pycnopodia helianthoides*) population has declined 87.8% from the Salish Sea to the Gulf of Alaska (Hamilton et al. 2021) and were listed as Critically Endangered on the International Union for the Conservation of Nature (IUCN) Red List in December 2020 (Gravem et al. 2021). Sunflower **gamaats** inhabit various substrates in kelp forests, seagrass beds, and the lower rocky intertidal zone, including sand, mud, gravel, rocky bottoms, and boulders (Heady et al. 2022) and are found in the nearshore areas of Zone 331. 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 **gamaats** pre-2012 and current years (2017-2020) across the entire coastline. Despite this trend, recovery in certain **gamaats** species has been shown in localized populations (Miner et al. 2018). Four intertidal observations in 2021 by Triton Environmental Consultants near **Kxeen**/Prince Rupert observed both Sunflower, Ochre, Leather, and Mottled **gamaats** with no **gamaats** wasting disease present ([Sea star map – Multi-Agency Rocky Intertidal Network](#); accessed 2023).

Dive harvesting fisheries exist for **ts'akwe'ats**/red (*Mesocentrotus franciscanus*), **aswit**/green sea urchins (*Strongylocentrotus droebachiensis*), and **gyenti**/sea cucumbers. **Ts'akwe'ats** are usually found in shallow areas with rocky substrates and moderate to strong **dooyaks**/currents. Quota Areas for harvesting **ts'akwe'ats** exist in Zones 330 and 331 (Appendix 10 in **ts'akwe'ats** IMFP, DFO 2023b). **Ts'akwe'ats** are found throughout all four Zones in Kitkatla Inlet, around the island of Lax Kul, and throughout the west coast of **Lax k'naga dzol**/Banks Island and Principe channel. There are fewer occurrences in the protected waters of Kitkatla Inlet and up to Gasboat Passage and **Maxla Kxa Naayxt**/Ogden Channel. Stock surveys to measure density, size, and populations throughout BC are being piloted, though **ts'akwe'ats** populations are considered to be abundant throughout the BC coast, except in areas with rapid **ploon**/sea otter expansions (DFO 2023b).

Aswit/urchin prefer rocky, gravel, or shell substrates and aggregate in kelp forests (DFO 2022d). Most Commercial **aswit** locations are located on Vancouver Island, whereas First Nations and recreational harvest occur coastwide (DFO 2022d). Historically, **aswit** populations were far more limited due to **ploon**/sea otter predation than commercial harvesting.

Aswit/urchin are harvested by Gitxaala Nation members at specific times of year (Conacher and McGarvey, 2014). It was noted that the **aks**/tide appears orange when **aswit** are spawning. While **aswit** are spawning, Gitxaala members refrain from harvesting them. Occurrences of **aswit** were noted by Gitxaala Nation members around **Lax k'naga dzol**/Banks Island, around Lach Klan to Goschen Island, all around **Tgii Xsw'aanx**/Porcher Island, the Pelham Islands, and Gilbert Island (Gitxaala Nation GIS database).

Gyenti are BC's largest sea cucumbers and are abundant in complex hard substrates with moderate **dooyaks**/currents. There are **gyenti** harvest by dive Quota Management Areas for

Lax k'naga dzol/West **Lax k'naga dzol**/Banks Island South **Tgii Xsw'aanx**/Porcher Island (5D) that overlaps with Zone 330 and 331, respectively (See Appendix 9 and 10 in **gyenti** IFMP, DFO 2023d). **Gyenti** stocks are conservatively managed and considered healthy now (DFO 2023d). Density transect surveys estimated a baseline density of 6.0 **gyenti** per meter shoreline in the North and Central coast, which is higher than the baseline assumption of 2.5 **gyenti** per meter shoreline (DFO 2023d). Gitxaala Nation harvesters previously indicated presence of **gyenti** around **Lax k'naga dzol**, around Lach Klan, through Freeman Passage, in Edye Pass, the west coast of McCauley Island, around **Tgii Xsw'aanx**, and **Lax ksi tgwi yuun**/Gurd Island.

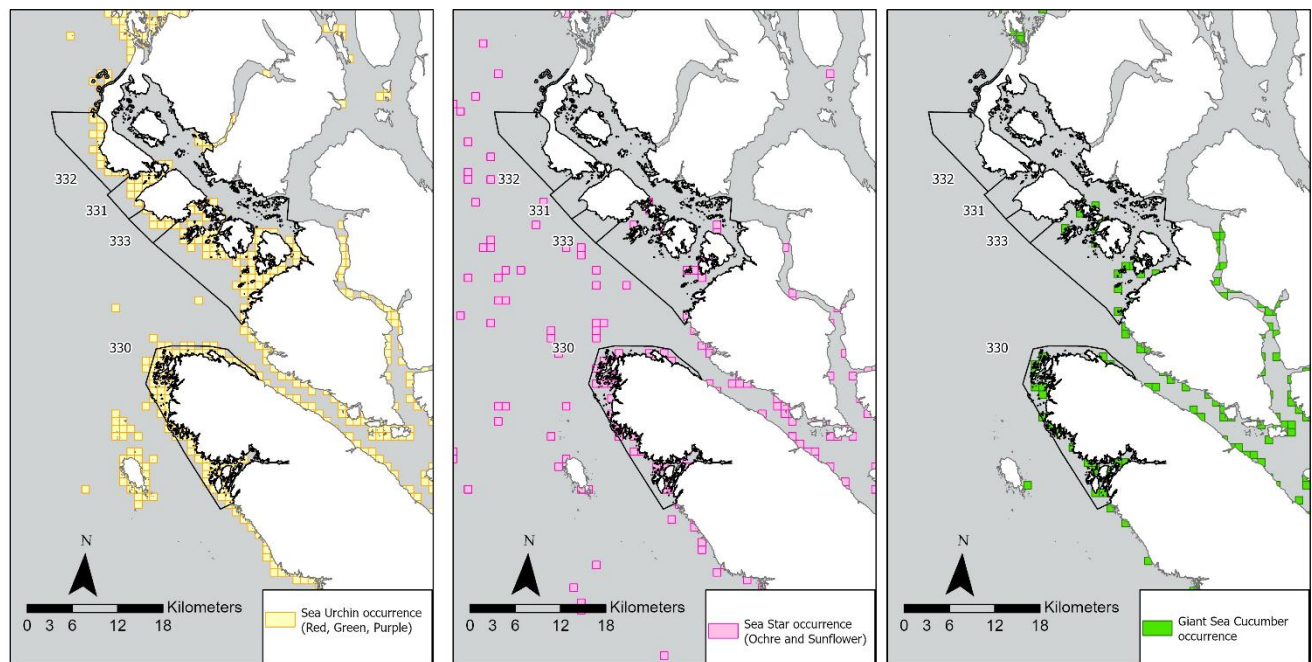


Figure 71. Occurrence of five Echinoderm species represented by 1 km x 1 km grids: A) Green, Red and Purple **aswit**/urchin, B) Ochre and Sunflower **gamaats**/sea star, C) Giant **gyenti**/Sea Cucumber in the Kitkatla Inlet Network Zones area.

6.2.3.5 Sensitivities 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). Generally, species with high reproductive output, larval settlement and recruitment rates, and a 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, high larval and juvenile mortality rates, predation, disease, environmental variables, and oceanographic conditions (Hunter and Wade 2015).

Climate change, including ocean acidification and global sea surface temperature increases, poses 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 Globler 2010). For

example, crustaceans such as Dungeness **k'almoos**/crabs and Spot **gasgos**/prawns are likely impacted through all stages of their life history by changes in sea surface temperature, ocean acidification, ocean current change, nutrient availability and dissolved oxygen (Hunter and Wade 2015). Rising sea levels, changing freshwater discharge, and changes in native and non-native abundances also 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).

Cold water corals and sponges

Cold-water coral and sponge communities are vulnerable to physical habitat disturbances like 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, impairing 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 of 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 the slow growth and settlement of many species and their long lifespans (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 broader range of oceanic temperatures (Hanz et al. 2019; Dorey et al. 2020). Rather than relying on algae symbionts, cold-water coral communities were modelled 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 2010). 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 need to protect various populations and networks (Addamo et al. 2020).

Molluscs

Infauna, epibenthic bivalves, marine snails, and **Yaans**/chitons mostly exhibit limited movement and aggregating behaviours. These traits make these groups of Molluscs more sensitive to 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 Kitkatla Inlet Network Zones area reduce the likelihood of overharvesting, although illegal poaching of Geoduck and **Bilhaa**/Abalone is a concern due to their high values (Zhang et al. 2007). Other natural events, such as freezing conditions in the winter, can affect clam abundance on local beaches (DFO 2023c). 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). In a study examining juvenile geoducks across **gadza k'aw**/eelgrass and unvegetated habitats, the authors found greater tolerance of geoduck growth and survival when compared to other abiotic factors such as temperature, dissolved oxygen, and salinity (Spencer et al. 2019). 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**/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** 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** to be found in shallow waters (Babcock and Keesing 1999; COSEWIC 2009a). The North Coast and Central area, which includes **Lax k'naga dzol**/Banks Island (Zone 330), was identified as critical **Bilhaa** habitats because of their hard substrates and high rugosity for attachment, moderate to high wave exchange, and ocean salinity greater than 30 ppt (DFO 2012a). Encrusting coralline algae are thought to aid in larval settlement rates by providing food for juveniles and acting as shelter (Roberts, 2001; DFO 2012a). The abundance of herbivores and grazers like **aswit**/urchins, on the other hand, can prevent the growth and settlement of algae and lead to reduced **Bilhaa** larval settlement (COSEWIC 2009a). The health and abundance of canopy-forming kelp forests have been shown to increase growth rates and may be linked to population recovery in **Bilhaa** (Sloan and Breen, 1988; COSEWIC 2009a; DFO 2012a).

Crustaceans

The abundance of crustaceans depends 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., **dooyaks**/currents, ocean acidification) and biotic interactions (e.g., predation) (Brand et al. 2007). Recruitment and stock declines in offshore pandalid **gasgos**/shrimps have been associated with warmer-than-usual oceanic conditions in the Pacific (Anderson 2000) and the Atlantic (Richards and Hunter 2021). Water temperatures can influence larval, juvenile, and adult development, growth, survival, and reproductive capacities in **gasgos** (shrimp and 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 **gasgos** fecundity is lower than other Pandalid **gasgos** (See table 2-2 in King 1997; Lowry et al. 2007; Hunter and Wade 2015). However, inshore fjord and inlet abundance have been relatively stable compared to offshore populations (Otto and Jamieson 2001).

Crustaceans depend on exoskeleton shell formation to protect and molt that shell for growth. Therefore, ocean acidification can impair the development of calcareous structures (Feely et al. 2004). Decreased pH conditions impaired Dungeness **k'almoos** /crab adults and larvae's development, growth, and survival (Bednaršek et al. 2020; Berger et al. 2021). Low oxygen, on the other hand, severely impacts adult life stages specifically, which can affect population numbers (Berger et al. 2021). A study on the coast of Oregon showed higher **k'almoos** 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 **k'almoos** aggregate in estuaries (Gunderson et al. 1990; Rasmusson 2013), and spot **gasgos** 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**/urchin populations are highly correlated with rates of Sea Otter predation rather than harvesting. Disease and effects from climate change can make local populations more susceptible to other stressors. The most prevalent example is the recent coastwide decline of **gamaats**/sea star populations from **gamaats** wasting disease (Miner et al. 2018). Laboratory experiments comparing temperature treatments with the onset of disease and death of adult **gamaats** showed faster mortality rates with increased temperatures (Eisenlord 2016; Kohl et al. 2016). Intertidal surveys of **gamaats** health and temperature loggers from San Juan Island to Puget Sound and the west coast of Washington state showed high-temperature anomalies correlated with mass **gamaats** die-offs in the summer of 2014 in the Pacific Northwest (Eisenlord 2016). These results may suggest that frequent ocean warming events can lead to further population declines (Eisenlord 2016). As **gamaats** are apex invertebrate predators, their distribution and abundance changes may lead to cascading effects on prey abundance and assemblages in localized habitats and ecosystems (Galloway et al. 2023; Paine 1966; Konar 2019). Furthermore, The unchecked growth of sea urchin populations due to the absence of sunflower sea stars has led to widespread overgrazing of kelp forests, resulting in a 30% decrease in kelp forest densities in some areas and the formation of urchin barrens (Burt et al. 2018). However, in areas where multiple urchin predators exist (e.g. sea otters), especially within marine protected areas, the impact of the sunflower sea star's disappearance has been less severe. Maintaining a diverse array of urchin predators, particularly within protected areas, appears to be crucial for ecosystem resilience and the prevention of urchin barrens.

6.2.3.6 Data and Knowledge Gaps

Coral and Sponges

Nearshore coral and sponge occurrences are still sparse within the Kitkatla Inlet Network Zones and in the North Coast of BC. Conducting a similar study to Frid et al. 2021 applied to the North Coast may identify and confirm hotspots for habitat-forming corals and sponges. Shallow diver transects, mid-water and deep video transects of the Network Zones, as well as adjacent areas, can fill in data gaps of coral and sponge cover, colony sizes, and habitat associations with other

species of interest in the area. 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

All three Mollusc groups: Cephalopods and Infaunal and epibenthic bivalves have fewer occurrences within Kitkatla Channel and Kitkatla Inlet in Zone 331, which may be due to lack of surveys rather than true absences. The exception are Giant Pacific Octopus occurrences which are found throughout Zones 331, especially in Porcher Inlet. Despite the occurrence counts, DFO population estimates of Molluscs in the Kitkatla Inlets Network Zones are scarce or outdated. Intertidal clam surveys of Kitkatla Inlet in the 1990s were reported in a technical reports from Bourne and Cawdell (1992) and Gillespie and Bourne (1998). Stock assessment in DFO is extremely limited for populations outside the Scallop Management Areas (all found in Southern BC) and Clam Management Areas according to the Integrated Fisheries Management Plan (IFMP) for Intertidal Clams (DFO 2022a). Less is known about Marine snails and 'yaans/chitons from DFO (with the exception of Abalone), all of which are currently not commercially harvested species and do not have IFMPs.

Crustaceans

While Dungeness Crab surveys are extensive, there are less occurrence data for other crabs identified as E-CPs (Gale et al. 2019) such as Puget Sound King Crabs, and Tanner crabs (See Figure 65A). Another E-CP is the Goose barnacle which also lacks barnacle occurrence information from DFO databases and from the Global Biodiversity Information Facility (GBIF) database for the Kitkatla Inlet Network Zones area. For Gasgos, there is uncertainty around the lack of occurrences in Zone 330 and in the waters of Hecate Strait northward of Goschen Island, likely due to the lack of survey effort in the Rockfish Conservation Area (330 and 331) and northward.

Echinoderms

The multispecies benthic marine invertebrate dive survey program for stock monitoring has surveyed in the Kitkatla Inlet Network Zones, but only in Zone 330 by Kitkatla Channel, Beaver Passage, and Schooner Passage (Lochead et al. 2023). Information on Echinoderm density in Zones 330, 332, and 333 are a data gap.

There is a need to monitor population trends and note recovery effects of Sunflower gamaats, a recently endangered species listed by the International Union for Conservation of Nature (IUCN; Gravem et al. 2021), and their effects on the broader ecosystem in the Northern Shelf Bioregion, and continuation of the DFO multispecies benthic dive survey program can contribute to baseline knowledge in the Network Zones

6.2.4 Fish

This section features fish species previously identified as Zone-level network conservation objectives from the Network Action Plan (MPA Network BC Northern Shelf Initiative 2023). These species include rockfish (many species), txaw/halibut, wat'ukw/lingcod, tskah/herring, Ha'limootk/eulachon, and hoon/salmon (gayniis/chum, misoo/sockeye, 'yee/chinook,

üüx/coho, sti'moon/pink). 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 in this section for each group of fish include known information on occurrence within the Kitkatla Inlet Network Zones or Kitkatla Inlet Network Zones area, important ecological or life history traits, local or regional population trends and population genetics, and knowledge gaps. Occurrence tables for each zone (**Appendix H**) do not indicate true absence or the measure of abundance for a zone. They should be used as a guideline for species distribution throughout the Kitkatla Inlet Network Zones. Finally, a summary of Sensitivities and Recoverability is 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, 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. Details about DFO groundfish survey data used for species occurrences are provided in the appendix data source table of this report (**Appendix G**) and in the IFMP summary for Groundfish [Groundfish 2023 Integrated Fisheries Management Plan summary | Pacific Region | Fisheries and Oceans Canada \(dfo-mpo.gc.ca\)](https://www.dfo-mpo.gc.ca/pacific-region/fisheries-oceans-canada/dfo-mpo.gc.ca). Additional descriptions of 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 profiles on txaw/Pacific Halibut, balaas /Pacific Hake, Sablefish, tskah/Pacific Herring, and their climate vulnerabilities, please refer to Hunter and Wade (2015).

An important data gap for the Kitkatla Inlet Network Zones area is the lack of sampling near Zones 332 and 333, as they are Rockfish Conservation Areas, and the narrow inner areas of Kitkatla Inlet, such as Serpentine Inlet, Porcher Inlet, and Freeman Passage. There is also a survey data gap around the island of Lax Kul/Bonilla Island and nearshore Lax k'naga dzol/Banks Island, encompassing the Banks Nii Luutiksm conservancy.

When available, recent published documents describing the trends of fish stock and populations were briefly summarized within the relevant management area that overlaps with the Kitkatla Inlet Network Zones area. Different fisheries have different ways of categorizing their management areas, described in their respective sections. Generally, the Pacific Fisheries Management Area (PFMA) of [Area 5 - Greenville Channel, Principe Channel](#) and overlaps with four of five Kitkatla Inlet Network Zones and throughout the Kitkatla Inlet Network Zones area (5-2 to 5-12, 5-20, and 5-21). There is a slight overlap of Zone 332 with [Area 4 - Chatham Sound, Tgii Xsw'aanx/Porcher Island](#) (4-3). Groundfish fisheries in DFO are separated into several management units. The Kitkatla Inlet Network Zones area is covered by the Hecate Strait management unit 5D (See [Map of Pacific groundfish management areas](#)). 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. As described in the Offshore Haida Gwaii (Bannar-Martin et al. 2025) and the Caamaño-Douglas Biophysical Reports (Liu et al. *in press*), 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 caveats, assumptions, and uncertainties.

6.2.4.1 Bony Fishes

6.2.4.1.1 Groundfish

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

Thompson et al. (2022a) developed a groundfish distribution model 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, non-groundfish species such as **Tskah**/herring and **Ksah**/sharks are predicted in the model. The spatial extent of this model does not overlap with some nearshore regions, so the model does not provide a comprehensive assessment of predicted groundfish occurrence across the four zones. The groundfish distribution model was created 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 2022). 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. 2022; **Figure 72**). Within the Kitkatla Inlet Network Zones area, groundfish species density or species richness is modelled to be highest in Zone 331, specifically near Dolphin Island down to Principe Channel. Outside of the Kitkatla Inlet Network Zones, Hecate Strait, Browning Entrance, **Maxla Kxa Naayxt**/Ogden Channel and Oval Bay are predicted to have higher groundfish species richness.

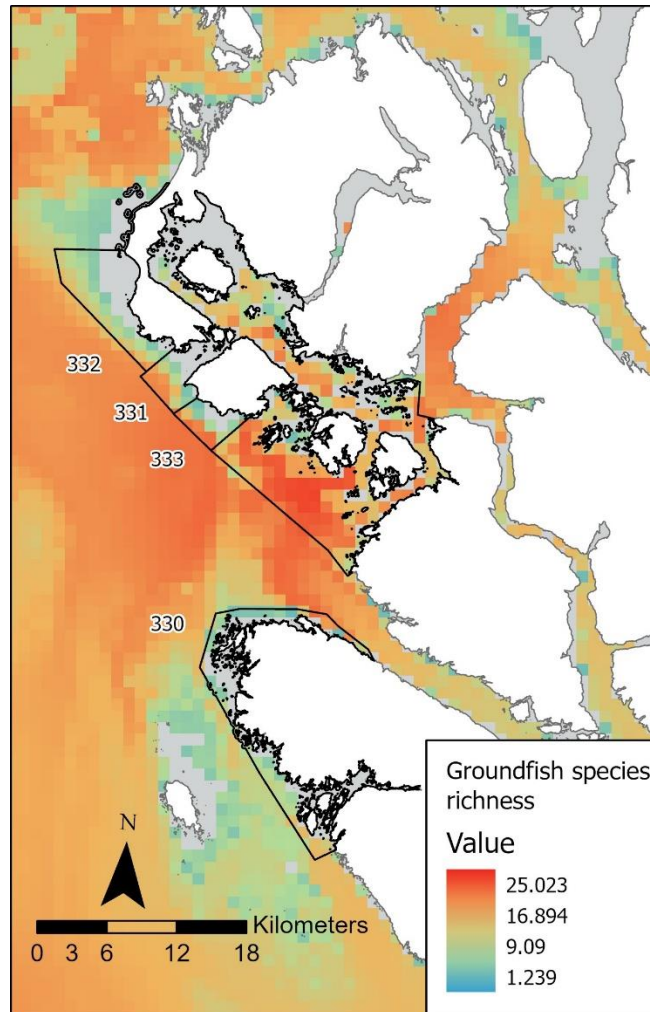


Figure 72. Estimated variation in species density values per grid cell (Species Richness) for all 64 groundfish species in the Kitkatla Inlet Network Zones using the Thompson et al. (2022a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across 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 Kitkatla Inlet Network Zones area, where survey data are 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.

6.2.4.1.2 Ts'mhoon / Rockfish

Ts'mhoon/Rockfish (*Sebastes* and *Sebastolobus* spp.) are ecologically, commercially, and culturally valued fishes on the West Coast of North America with a diversity of life histories and behaviours. There are at least 65 species described, ranging from Alaska to Baja California (Yamanaka et al. 2012). In BC, at least 36 species are found throughout the coast (Yoklavich et al. 2002). Conservation of multiple **ts'mhoon** species and their habitats was identified as a Zone-level network conservation objective for all Zones by the Network Action Plan (MPA Network BC Northern Shelf Initiative 2023). Because the Network Action Plan did not define the

list of species, rockfish identified as important from other ecological and conservation assessments (e.g., Gale et al. 2019; COSEWIC 2007a, b; 2008; 2009b, c; 2010a; 2011 SARA) will be used to guide this section. At least 14 species occur in the Kitkatla Inlet Network Zones (**Appendix H**). These species are listed as Ecological conservation priorities (E-CPs) (Gale et al. 2019) with the exception of Redbanded Rockfish (not recommended as a Conservation Priority) and Harlequin Rockfish (no information in document).

Ts'mhoon are classified into three groups for broad management purposes in Canada. Inshore rockfish describes nearshore species between 0 to 200 meters deep (Yamanaka and Logan, 2010). Whereas shelf and slope **ts'mhoon** include species found deeper in the continental shelf and the continental shelf and slope, respectively, species lists for these categorizations may be outdated and vague for current classifications (Stanley 1999; Schnute et al. 1999). Most of the Kitkatla Inlet Network Zones are shallow (average of less than 50 m in depth). However, some areas are deeper than 200 m in Zones 330 and 331, as well as fjord inlets in Principe Channel and **Maxla Kxa Naayxt/Ogden Channel**. Two distinct units of rockfish populations in coastal BC are further categorized into inside waters (from Vancouver Island to the Vancouver mainland) and outside waters (the rest of the BC coast, including the Kitkatla Inlet Network Zones 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 range in maximum lifespans from 22 years (Puget Sound Rockfish) to 205 years (Rougheye-Blackspotted complex) (Leaman 1991; Love et al. 2002). Trophic levels for various species range from planktivores (Pacific Ocean Perch) to piscivores (Quillback Rockfish) (Love et al. 2002; Olsen et al. 2020). **Ts'mhoon** are viviparous, and yearly fecundity in species can range from thousands of larvae (Puget Sound Rockfish) to nearly three million (Yelloweye Rockfish) (Love et al. 2002). Their distributions can differ by habitat type (e.g. rock type and biocover; Haggarty et al. 2016) and 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 rockfish are prey to many ecologically important invertebrates, fishes, marine mammals (Pinnipeds; Olesiuk 1993; Tollit et al. 2009), and marine birds (Gale et al. 2019). **Ts'mhoon** have 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).

Important habitats and Rockfish Conservation Areas in the Kitkatla Inlet Network Zones area

Important **ts'mhoon**/rockfish habitats have been identified as structurally complex – which includes variations 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. Within the Kitkatla Inlet Network Zones area are many **Mo'ox**/Bull Kelp and **gyoós**/Giant Kelp occurrences throughout the coasts of Zones 330 and 331 along McCauley Island and **Lax k'naga dzol**/Banks Island. Eelgrass and Surfgrass occur throughout **Lax k'naga dzol**, whereas surfgrass biobands are common on the outside coasts (**Figure 57**). From an ecosystem perspective, the Kitkatla Inlet Network Zones area appears to be an important area for **ts'mhoon** habitat and biodiversity, although there is a current lack of targeted **ts'mhoon** sampling and analysis to confirm the effectiveness of RCAs within the Kitkatla Inlet Network Zones (*sensu* Dunham et al. 2020).

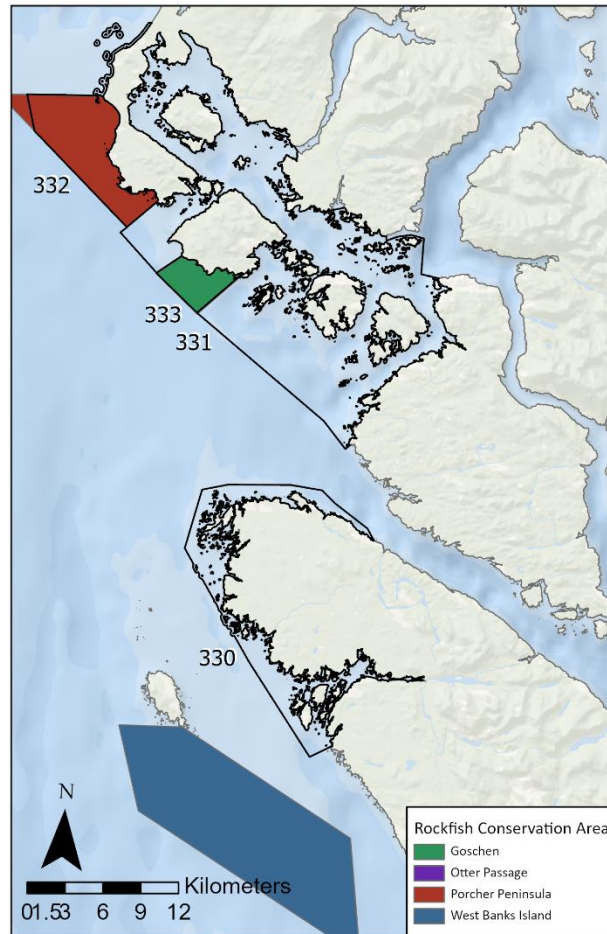


Figure 73. Rockfish Conservation Areas in the Kitkatla Inlet Network Zones Area. Network Zones are shown as black outlined polygons.

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 et al. 2013). Three RCAs are located near the Kitkatla Inlet Network Zones (See **Figure 69**). Goschen and Porcher Peninsula RCA overlap completely with Zone 333 and 332, respectively. West **Lax k'naga dzol**/Banks Island RCA is southwestward of Zone 330, close to the island of **Lax Kul**. 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, with Porcher Peninsula and West **Lax k'naga dzol**/Banks Island RCA ranked 4 and 3, respectively (Table 19 in Dunham et al. 2020).

The report also summarized that protected areas such as RCAs and MPAs between 50 and 100 km would maintain **ts'mhoon**/rockfish 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 (Buanaccorsi et al. 2002), Quillback Rockfish (Matthews 1990), reported movement of less than 5 km (Freiwald 2012; Buanaccorsi 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 km² could be sufficient to account for movement (Dunham et al. 2020). Nonetheless, spatial protection can still benefit rockfish with high mobility (Claudet et al. 2010). Individually, Goschen (14.5 km²) and Porcher Peninsula (50.1 km²) RCAs are smaller than the recommended protection areal extent. The Kitkatla Inlet Network Zones would provide connectivity between the two RCAs through Freeman Passage and the larger Zone 331. West **Lax k'naga dzol**/Banks Island RCA has an overall size of 154.4 km² and is 5 km from the nearest RCA. The proximity to **Lax k'naga dzol** and Zone 330 could be beneficial to protect dispersal and movement.

Occurrence and population trends

Almost all **ts'mhoon**/rockfish with known occurrences in the Kitkatla Inlet Network Zones are E-CPs and have been assigned high or very high vulnerability status (Gale et al. 2019). There are detection records for many rockfish species for Zones 330 and 331. Occurrences are scarce for Zones 332 and 333, which are presently Rockfish Conservation areas and rarely sampled. Gitxaala records have recorded common names “rock cod” and “Red Snapper” for occurrences in Zones 330, 331, and 333, although there is no detail regarding species. The multi-species distribution model (Thompson et al. 2022) predicts higher species richness in Zones 331 near Dolphin Island, **Maxla Kxa Naayxt**/Ogden channel, and near the island of **Lax Kul** (Figure 74).

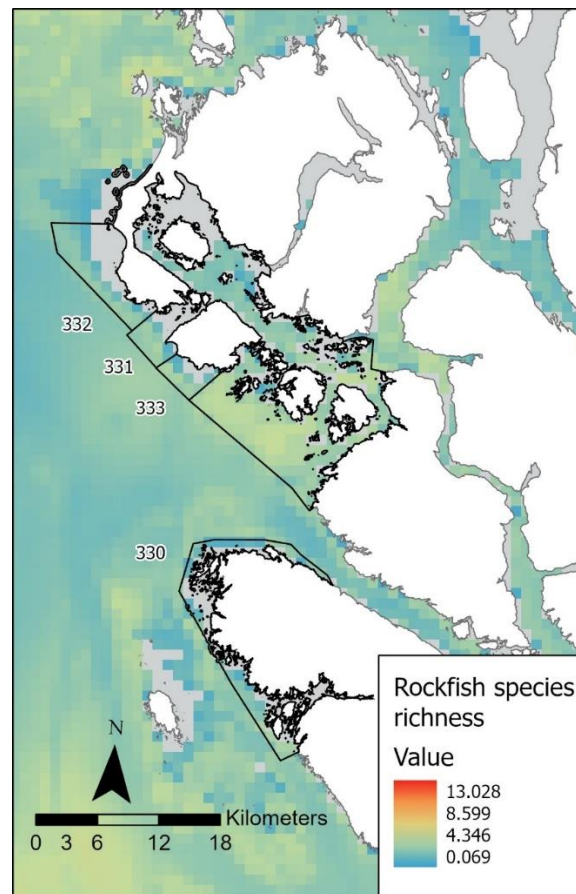


Figure 74. Summed predicted species density values per grid cell (Species Richness) for rockfish in the Kitkatla Inlet Network Zones using the Thompson et al. (2022a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, 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 Rockfish species.

Population trends and stock assessments of **ts'mhoon** are reported at the groundfish management area level (Hecate Strait, area 5D) or the provincial level.

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 Yelloweye populations have rebuilding strategies in place to guide management procedures (Haggarty et al. 2022; Cox et al. 2020; DFO 2023f). These recent evaluations found that the Yelloweye 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 both inside and outside stocks fell in the Cautious zone (DFO 2012b), although there was considerable variation for that assessment (Haggarty et al. 2022). A recent workshop was held to discuss conservation objectives for the Outside Quillback Rockfish stock (Haggarty et al. 2022) and an application of management procedure framework was created (DFO 2023g) with findings that the current stock biomass is above the Limit Reference Point. The objective moving forward was to maintain this target, and there were no changes to the 'cautious' stock designation (DFO 2023e). The threatened Canary rockfish also showed an 86% population decline over 30 years and was placed in DFO's 'Cautious zone' (COSEWIC 2008). A recovery assessment document (DFO 2009b) included additional trawl survey observations and catch data into their models, subsequently placing the stocks in the 'Healthy zone'. The most recent stock assessment (DFO 2022e) 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.

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 is forecast to decline with current harvesting levels (DFO 2015). Silvergray (DFO 2014), Rougheye/Blackspotted (DFO 2020a), Bocaccio (Starr and Haigh 2022) and Redstripe (DFO 2018a) rockfish also showed a 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 (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). The following **ts'mhoon** lack genetic assessments: Silvergray, Yellowtail, Shortspine and Longspine Thornyhead (COSEWIC 2007a), Tiger, Canary, and China rockfish. Ongoing studies on **ts'mhoon** population genetics may reveal insights into species complexes and regional diversity.

6.2.4.1.3 Flatfish

Flatfish (Order *Pleuronectiformes*) are a group of benthic fish that live on continental shelf habitats, generally in sandy and mud flat bottoms. Flatfish species are predicted to occur throughout the Kitkatla Inlet Network Zones and have the highest richness around Zones 331-333 (**Figure 75**). 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 has 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. **Txaw**/Pacific Halibut is highlighted below for its cultural and ecological importance.

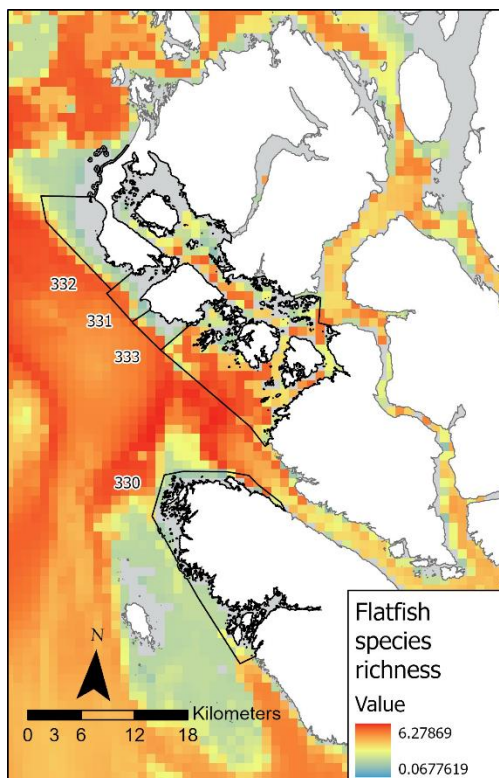


Figure 75. Summed predicted species density values per grid cell (Species Richness) for flatfish in the Kitkatla Inlet Network Zones using the Thompson et al. (2022a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, 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 / Pacific Halibut

Txaw/Pacific Halibut (*Hippoglossus stenolepis*) is considered an E-CP (Gale et al. 2019), a Zone-level cultural conservation objective in all four Zones, a major commercial species in BC, and described as a significant species for First Nations and coastal communities for cultural use and food security (MPA Network BC Northern Shelf Initiative 2023). Adult **txaw** have a high trophic position, a wide variety of diets, and juveniles are important prey for larger animals (Best and St-Pierre 1986; Ford 2014). **Txaw** is found in all four Kitkatla Inlet Network Zones and noted in the following areas: Kitkatla Inlet, Beaver Passage, Schooner Pass, Freeman Passage,

Beaver Passage, west of **Tgii Xsw'aanx**/Porcher Island, west of Goschen Island, the Prager Islands, **Lax Kul**/Bonilla Island and around **Lax k'naga dzol**/Banks Island, and Principe Channel (Gitxaala Nation GIS database). For a detailed species profile on **txaw** please refer to Hunter and Wade (2015).

The largest of all flatfish species in BC, many adult **txaw**/Pacific Halibut reside in demersal waters up to 1500 m in the outer continental shelf and slope. **Txaw** will use the inner continental shelves and inlets as nurseries and migrate into deeper waters as early as two years old. Although this is outside the Kitkatla Inlet Network Zones boundaries, Hecate Strait was identified as an important spawning area for **txaw**. The areas around the Chatham Sound EBSA (including Kitkatla Inlet and **Lax k'naga dzol**/Banks Island), however, do show increased **txaw** density (See Figure 5A in Rubidge et al. 2016). Spawning season occurs from November to March. Recruitment of juvenile **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** in nearby Hecate Strait include Pacific Sand Lance, **Tskah**/Pacific Herring, and **k'almoos**/crabs (Best and St-Pierre 1986). Larval **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 **Ksah**/sharks.

Occurrence and population trends

Txaw/Pacific Halibut 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** 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, 2022). The distribution of surveys for **txaw** catch within the Kitkatla Zones is variable. The DFO groundfish longline surveys have samples within Zones 330, 331, and 332, and the DFO groundfish trawl surveys have sample points in Hecate Strait, near the Zone polygons. Thompson et al. (2023b) examined changes in **txaw** distribution according to future climate scenarios, specifically temperature and dissolved oxygen concentration changes. Their results suggested a decrease in BC **txaw** populations as a response to decreased dissolved oxygen concentration in shallow coastal waters, similar to habitats in the Outer Coastal Zones.

Besides **txaw**, the other flatfish identified as E-CPs are: Arrowtooths (*Atheresthes stomias*), Dover Sole (*Microstomus pacificus*), Petrale Sole (*Eopsetta jordani*), Rex Sole (*Glyptocephalus zachirus*), and Rock Sole (*Lepidosetta bilineata*) (Gale et al. 2019). Dover and Rex Soles are among the commercial catch flatfish in the area. Commercial trawl fisheries catch many flatfish in Hecate Strait and BC. Trawling activities, however are restricted to the deeper waters of the Kitkatla Inlet Network Zones area.

Although there may be regional trends for the whole coast, population trends of flatfish species are limited at the spatial scale of the Kitkatla Inlet Network Zones and surrounding area. The Rex sole has no official stock assessments in BC. Southern Rock Sole biomass from 2014 in the Hecate Strait area 5D had a high probability of being above the biomass reference points (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. Browning Entrance/Hecate Strait near Kitkatla Inlet has a high commercial catch of Arrowtooth flounders (DFO 2023e). Recent declines in Arrowtooth Flounder spawning biomass and recruitment have been observed in BC

since 2011-2014 (DFO 2023e; Thompson et al. 2022), similar to observed declines in the Gulf of Alaska (Spies and Palsson 2019). These declines are associated with increased targeted commercial fishing efforts with the development of more advanced fish processing technologies (Anderson et al. 2019; Spies and Palsson 2019).

6.2.4.1.4 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**/Pacific Cod (*Gadus macrocephalus*), **balaas**/Pacific Hake (*Merluccius productus*), Walleye Pollock (*Theragra chalcogramma*) (Gale et al. 2019). All three species occur throughout the Kitkatla Inlet Network Zones (**Figure 76**) and are considered E-CPs in the NSB (Gale et al. 2019). Although these three species do not have zone-level network conservation objectives, their variable abundance affects many other species in the ecosystem and is an important stock for commercial fisheries. Walleye Pollock, **k'a'wts**, are mainly caught by midwater and bottom trawl gears, whereas **balaas** are primarily caught by midwater trawl in BC.

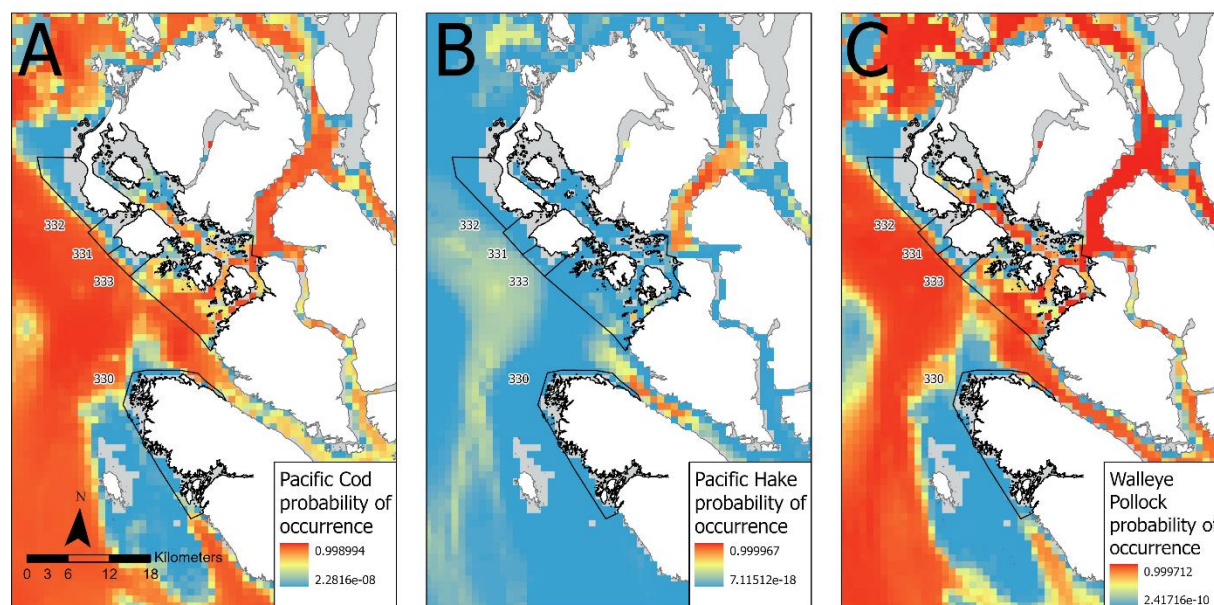


Figure 76. Probability of occurrence of each grid cell for roundfish species A) Pacific Cod, B) Pacific Hake, and C) Walleye Pollock in the Kitkatla Inlet Network Zones using the Thompson et al. (2022a) groundfish species integrated model. Highest probability are shown in red/orange and lowest probability are shown in blue. Gray shows no assessed value. 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.

K'a'wts / Walleye Pollock

K'a'wts/Walleye Pollock undergo diurnal (daily) vertical migrations along the water column. Although nearshore survey sampling is limited, **K'a'wts** are found throughout Hecate Strait and Kitkatla Inlet, including all four Zones. Their prey species include crustaceans, **balaas**/hake, **Xbihats'al**/squid, sand lance, and **Tskah**/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).

Balaas / Pacific Hake

Balaas/Pacific Hake is the most abundant commercial stock in the California Current system (Edwards et al. 2022). **Balaas** occurrences are mainly found near Ogden Channel and Principe Channel, with few occurrences in Zones 331-333. **Balaas** are highly migratory and are important for nutrient transport in and out of the NSB region. However, not much is known about their contributions to the Kitkatla Inlet Network Zones 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 the increased abundance of their predator, Humboldt **Xbihats'al**/squid (Stewart et al. 2014, Taylor et al. 2015).

k'a'wts / Pacific Cod

K'a'wts/Pacific Cod is a fast-growing fish found in depths under 200 m and have limited migrations. Their diets include marine invertebrates (**k'almoos**/crabs and **gasgos**/shrimps), Pacific Sand Lance, and **Tskah**/Pacific Herring (Westrheim 1996). Variation in **k'a'wts** predation may affect **Tskah** abundance and recruitment (Walters et al. 1986). In turn, they are eaten by **txaw**/halibut, **gagaats**/dogfish, and pinnipeds (Westrheim 1996). Although nearshore survey sampling is limited, **k'a'wts** are commonly found throughout Hecate Strait and Kitkatla Inlet, including all four Zones.

Occurrence and Population Trends

The Chatham Sound EBSA was indicated as an important area for Walleye Pollock fitness (Rubidge et al. 2016) Stock status for the BC North stock (which includes area 5D) in 2017 indicated a high probability of being above the Limited Reference Point and Upper Stock Reference, meaning conservation action is not yet considered necessary by federal management (Starr and Haigh, 2021).

The population of **Balaas**/Pacific Hake 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 upper stock 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).

Poor recruitment since the 1990s may be linked to a recent decline in Hecate Strait stocks, and the most recent assessment placed **k'a'wts** stocks in the Cautious Zone (Forrest et al. 2020). Genetic population differentiation was uncertain for BC **K'a'wts**/Pacific Cod stocks (Forrest et al. 2015).

6.2.4.1.5 Other Groundfish

In addition to the 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. **Wat'ukw**/Lingcod and **Hadani**/Sablefish are E-CPs (Gale et al. 2019) and **wat'ukw** are Zone-level cultural conservation objectives (**Figure 77**).

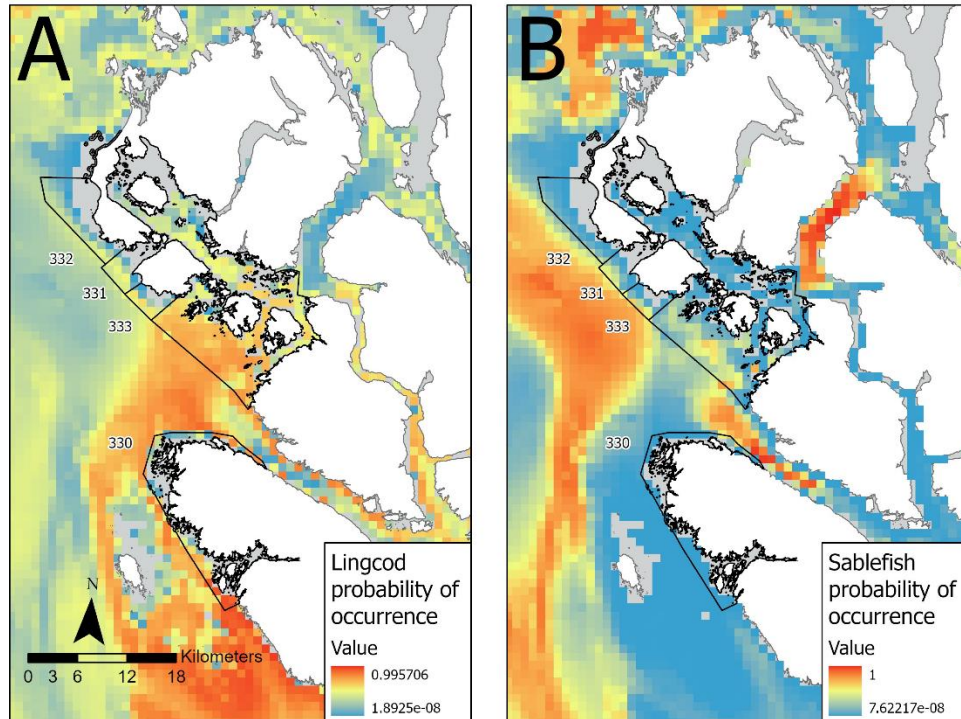


Figure 77. Summed predicted species density values per grid cell (Species Richness) for Lingcod and Sablefish in the Kitkatla Inlet Network Zones using the Thompson et al. (2022a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys 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 two species.

Wat'ukw / Lingcod

Wat'ukw/Lingcod (*Ophiodon elongatus*) are commonly found in nearshore rocky habitats between 10 to 100 m, although their range goes to 450 m. **Wat'ukw** diet was found to be highly variable and includes many fish species, including **Tskah**/Pacific herring and English Sole in Hecate Strait (Pearsall and Fargo 2007), crustaceans, cephalopods, and other **wat'ukw** (Cass et al. 1990, Beaudreau and Essington 2009). Predators include seals and **t'iibn**/sea lions (Cass et al. 1990). A unique characteristic of **Wat'ukw** is parental care for their egg masses, which are deposited in shallow (< 100 m) nearshore waters from December until March. **Wat'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 **wat'ukw** (Cass et al. 1990, Petrie and Ryer 2006). Shallow

areas with these features throughout the Kitkatla Inlet Network Zones may be important habitats for **wat'ukw**, such as inner Kitkatla Inlet, Schooner Passage, and shallow waters around **Lax k'naga dzol**/Banks Island. **Wat'ukw** was identified northwest of **Lax k'naga dzol**, within Kitkatla Inlet, in Beaver Pass, aroundf McCauley Island, the small islands around Lach Klan (Gitxaala Nation GIS database).

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 stayed 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 **wat'ukw** 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 a shorter time in spawning grounds (Cass et al. 1990).

Wat'ukw/Lingcod are commercially caught using trawl gear, which has limited presence within nearshore Kitkatla Inlet. The other catch method is using hook and line gear (including handline, longline, and troll), which are present within Zones 330 and 331 (**Table 10**).

Hadanii / Sablefish

Hadanii/Sablefish (also known as black cod; *Anoplopoma fimbria*) are one of the seven main BC commercial groundfish sectors, mainly caught by longline hook and trap gear (Lacko et al. 2021). The [Canadian Sablefish Association](#) conducts annual surveys across British Columbia. The Central Mainland EBSA was identified as an important **hadanii** spawning area (See Map 19 in Clarke and Jamieson 2006). However, this area refers westward to the Caamaño-Douglas area and does not include Zones 330-333.

Juvenile **hadanii**/sablefish feed on crustaceans, midwater fish, and, most importantly, **Tskah**/Pacific Herring (Laidig et al. 1997, Buckley et al. 1999, Coutr   et al. 2015). Adult **hadanii** will feed on demersal fish, cephalopods, and other fish species including juvenile **hoon**/salmon, rockfish, and **balaas** /Pacific Hake (Coutr   et al. 2015). While adult **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** drift shoreward to coasts such as the Kitkatla Inlet Network Zones area. Juvenile **hadanii** remain over winter and migrate offshore to slope habitats in the late summer once they reach 400 - 600 mm (Rutecki and Varosi 1997). For a detailed species profile on **hadanii**, please refer to Hunter and Wade (2015).

Occurrence and Population Trends

Outside stocks for **Wat'ukw**/Lingcod in area 5D were last assessed over a decade ago and determined with high confidence to be in the Healthy Zone based on an upper stock reference of at least 80% of optimal stock size at maximum sustainable yield (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 **wat'ukw** in BC waters is unknown.

Hadanii/Sablefish population declines were seen in the past three decades, leading to reduced harvesting opportunities. The most recent fisheries management plan from DFO (2020d) showed an increase from a "Cautious" stock status to a "Healthy" stock status under DFO's Precautionary Approach Framework (DFO 2009c). Similarly, a revised Sablefish operating model estimated BC's Sablefish stock to have a high probability of being the upper stock reference (DFO 2023e). Research by Stocker et al. (2001) shows 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).

6.2.4.2 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

6.2.4.2.1 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 various 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/Herring spawning habitats and Pacific Sand Lance habitats have been identified as E-CPs and Zone-level Ecological Conservation Objectives (Gale et al. 2019; MPA Network BC Northern Shelf Initiative 2023). **Ha'limootk**/Eulachon is another culturally important forage fish, although it was not identified as a Zone-level Ecological Conservation Objective for the Kitkatla Inlet Network Zones. For a detailed species profile on **Ha'limootk**, please refer to Hunter and Wade (2015).

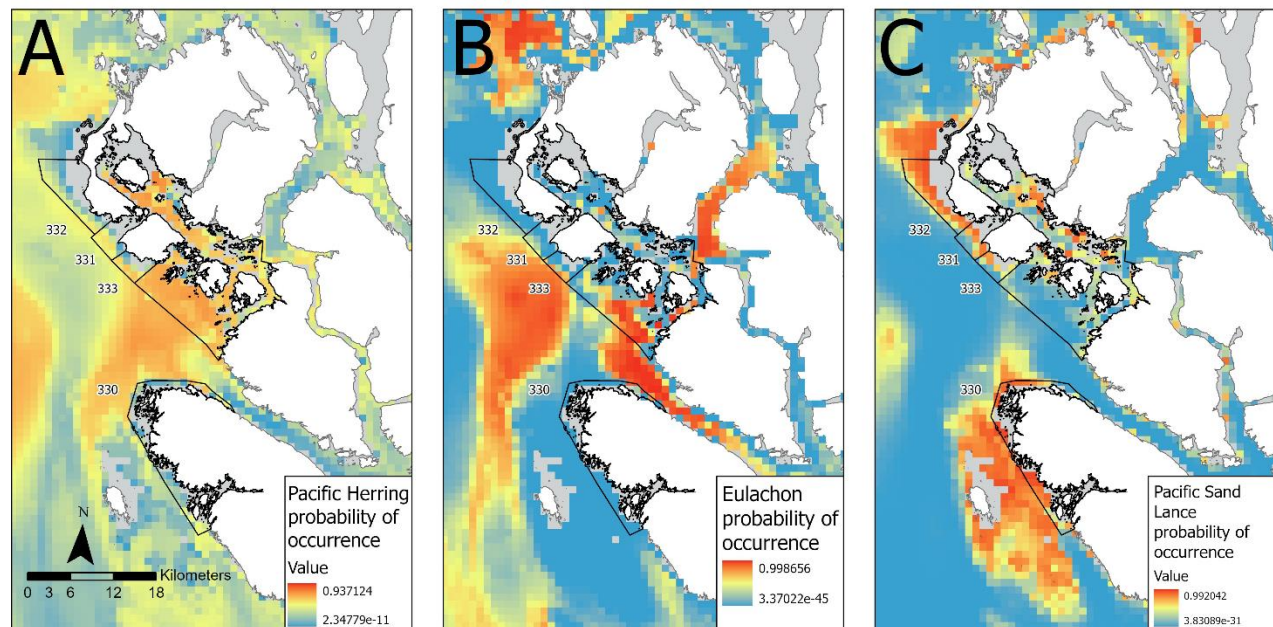


Figure 78. Summed predicted species density values per grid cell (Species Richness) for A) **Tskah**/Pacific Herring, B) Eulachon and C) Pacific Sand Lance in the Kitkatla Inlet Network Zones using the Thompson et al.

(2022a) 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.

Tskah / Herring

Tskah/Pacific Herring (*Clupea pallasii*) are among the most important fish in the Pacific Northwest marine food web and for coastal First Nations. The ongoing conservation and restoration of an abundant **Tskah** run for generational harvesting is of crucial importance to Gitxaala Nation. Harvest for **xs'waanx**/herring roe generally occurs between mid-February and the end of June, with peak spawning occurring in March (Gitxaala Nation, TERMPOL report 2015). **Tskah** was noted with both historical and current occurrences within Kitkatla Inlet, with Gitxaala harvesters noting Tskah present near Sheldon Islet, Hankin Point and Willis Bay before 1980, and a contemporary **Tskah** spawn was noted within the northeast portion of the inlet (Gitxaala Nation GIS database).

The high lipid content in every life stage makes **tskah**/Pacific Herring important prey to many groundfish, marine mammals, and birds who prey on **tskah** in all life stage forms due to their high lipid content (Logerwell and Schaufler 2005). There are at least 52 species that eat **tskah** in the Northern California Current ecosystem (Szoboszlai et al. 2015). **Tskah** 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. Kitkatla Inlet was identified as an important fitness location for spawning **tskah** (Rubidge et al. 2016; MPA Network BC Northern Shelf Initiative 2023), and Zones 330 and 331 were identified as Zone-level Ecological Conservation Objectives. Zone 331, specifically within Lutgu Ts'aaws/Kitkatla Inlet, has been recognized for its high cumulative spawn habitat index. Annual **tskah** spawns significantly contribute to the productivity of the ecosystem. Approximately 1.8% or around 300-600 km of BC's coastline are used by **tskah** spawners in a typical season (Hay and McCarter, 2015). **Tskah** 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).

Known spawning locations were compiled from the DFO Pacific Herring Spawn and Catch Records ([McCarter 2016](#)). The cumulative habitat spawn index for every spawning event from 1928 to 2015 was mapped for the Kitkatla Inlet Network Zones area (**Figure 79**). 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 \(canada.ca\)](#).

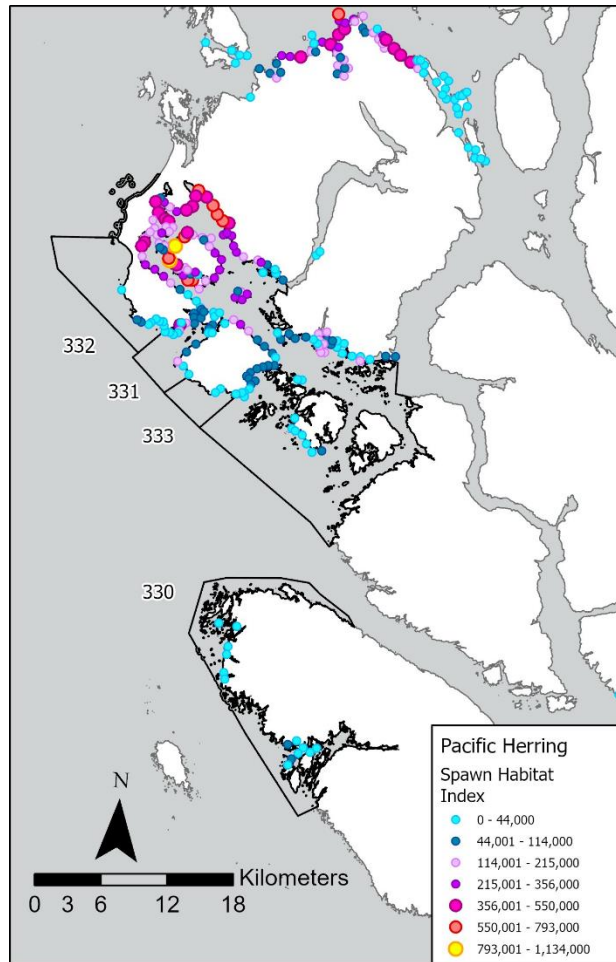


Figure 79. Surveyed *Geega tskah*/Pacific Herring spawn sites in the Kitkatla Inlet Network Zones area. Cumulative Spawn Habitat Index from 1928-2015 is shown (Hay and McCarter 2015). Spawn Habitat Index is calculated as the measured spawn length (m), product of spawn width (m), and egg layers as percent 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 / Eulachon

Both **Ha'limootk** and **Wah** are used in Sm'algyax to refer to Eulachon (also Oolichan and candlefish; *Thaleichthys pacificus*). For clarity and simplicity, **Ha'limootk** is used in this document. Gitxaala Nation members do not currently fish for **Ha'limootk** within their territory; however, **smk'awtsii** (eulachon grease) is an important trade item with neighbouring Nations (Conacher et al. 2011). **Smk'awtsii** is used for cooking and as a supplement to improve bone health. **Ha'limootk** can be eaten whole when smoked or dried and is considered a delicacy. 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** a highly desired fish for both people and their predators (Willson et al. 2006). For many First Nations, **Ha'limootk** grease is a culinary and medicinal ingredient and trade item with inland Nations. They are also prey species for many fishes (**hoon**/Salmon, **txaw**/Pacific Halibut, Walleye Pollock, Rockfish, etc.), marine mammals (Sea lions, porpoises, humpbacks), and marine birds. **Ha'limootk** 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). Non-spawning **Ha'limootk** are found in the continental shelf in depths of 50 to 200 m.

Pacific Sand Lance

Pacific Sand Lance (*Ammodytes personatus*) are short-living, high lipid-containing, schooling fish that are important for the diets of species from various trophic levels, including predators such as Killer Whales, **Yee**/Chinook Salmon, and **txaw**/Pacific Halibut (Hart 1973; Szoboszlai et al. 2015). The availability of Sand Lance in Seabird diets has been documented to correlate with breeding success (Borstad et al. 2011; Hedd et al. 2006). Despite their ecological importance, there is a lack of research and understanding of Pacific Sand Lance populations in Northern British Columbia; most research is focused on the Salish Sea (Huard et al. 2022) and Vancouver Island (DFO 2020b). Pacific Sand Lance are E-CPs (Gale et al. 2019) and important Pacific Sand Lance habitats in Zone 331 were identified as a Zone-level Ecological Conservation Objective.

Shallow sandy habitats are important for Sand Lance's life history, such as developing gonads, spawning, and laying eggs (DFO 2020b). Adult Sand Lance are considered non-migratory and have high site fidelity; therefore, these habitats are important to identify and conserve. Suitable habitats are described as containing coarse substrates, uniform grain sizes, and low silt content in shallow water (< 80 m) (See details in Huard et al. 2022).

Occurrence and Population Trends

There is a High probability of forage fish occurrence throughout the Kitkatla Inlet Network Zones, notably in Zone 331 which encompasses most of Kitkatla Inlet proper (**Figure 78**). The highest concentration of Herring Spawn Index is within Zone 331, surrounding **Tgii Xsw'aanx** /Porcher Island and **Lax ksi tgwi yuun**/Gurd Island.

The **tskah**/Pacific Herring fishery comprises four components: 1) Roe, 2) Spawn on Kelp, 3) Food and bait, and 4) Special Use. Common gears for whole **tskah** harvest include seine, gillnet, rake, dip net, and jig. All four Kitkatla Inlet Network Zones are within the **Kxeen**/Prince Rupert District (PRD) major stock assessment regions. For the PRD stock assessment area, stock biomass and growth have shown modest growth in recent years compared to the early 1980s, although not at the same historic high abundances as the 1960s (DFO 2023h). In all management areas, the mean number of egg layers has decreased since the mid-1980s (Hay et al. 2011), and a declining trend for weight-at-age has been observed (Irvine and Crawford 2012). Despite the different stock assessment regions for **tskah**, the population structure of in British Columbia appears to be largely the same with the slight exception of the Johnstone Strait population near Northern Vancouver Island (Beacham et al. 2001).

There are 25 known **Ha'limootk**/Eulachon spawning rivers in BC, with a possible additional 15 based on anecdotal information (DFO 2023i). This site fidelity creates genetic population structuring in BC from different river populations (Beacham et al. 2005). Across the coast, **Ha'limootk** populations have declined in the past 30-40 years. However, locations with a high probability of occurrence include Principe Channel, Ogden Channel, Gasboard Passage, and Hecate Strait near Browning Entrance, as well as parts of Kitkatla Inlet (**Figure 78B**). The nearby Nass and Skeena Rivers are major **Ha'limootk** spawning systems, and these populations were described as Special Concern status despite the population appearing stable as threats could cause this population to become Threatened in a short period of time (COSEWIC 2013a).

The groundfish model prediction shows a high probability of occurrence for Pacific Sand Lance in all three zones (**Figure 78C**), specifically in areas that match the shallow bathymetry of 50 m or less (e.g. near the island of **Lax Kul** and Porcher Peninsula described in Geological setting), and where postglacial sediments (sandy and bouldery gravel) and finer muddy sand provide suitable habitats for the Pacific Sand Lance (**Figure 13**). There is a knowledge gap on the population genetics of Sand Lance in British Columbia.

6.2.4.2.2 Salmonids

The five species of **Hoon**/Pacific Salmon (*Onchorynchus* sp.) are among the most recognizable and important species for the entire Pacific Northwest region. Hyatt et al. (2007) provide a comprehensive summary of **hoon** in the NSB, including their life histories, habitat context, ecological linkages, and information gaps. In summary, Pacific Salmon are represented by five species, **yee**/Chinook (*O. tshawytscha*), **gayniis**/Chum (*Oncorhynchus keta*), **üüx**/Coho (*Oncorhynchus kisutch*), **misoo**/Sockeye (*Oncorhynchus nerka*), and **sti'moon**/Pink (*Oncorhynchus gorbuscha*), and are all E-CPs for the NSB and identified as Zone-level Cultural Conservation Objectives for all four Zones. **Hoon** are important prey species to many charismatic mammals of the Pacific Northwest, such as eagles, bears, and **Naaxl**/killer whales. Northern and Southern Resident Killer Whales, 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** production are from the Northern Nass and Skeena River and the Fraser River in the South (DFO 2022f). Therefore, most information about migration patterns is from those areas.

Throughout their life history, **hoon** will use 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 and rivers. These habitats are found throughout the Kitkatla Inlet Network Zones. This extensive migration transports many marine nutrients to freshwater and terrestrial ecosystems. Maintaining healthy **hoon** 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 **hoon**/Pacific Salmon, **meliit**/Steelhead trout (*O. clarkii*), **laaw**/Rainbow trout (*O. mykiss*), and Dolly Varden char (*Salvelinus malma malma*) are also E-CPs identified for the NSB (Gale et al. 2019). Other Salmonids are also harvested as resources and are mostly caught in recreational fisheries. Abundance, distribution, life history, and ecological research in the NSB for other salmonids are scarce compared to **hoon**. All five **hoon**/Pacific Salmon are critically important food, ceremonial, and cultural resources for coastal First Nations.

The [Salmon Integrated Fisheries Management Plan – Northern BC](#) (DFO 2022f) has a recent comprehensive summary of the **hoon**/salmon fishery and management measures which includes Pacific Fishery Management Areas (FMA) 4 and 5. The Wild Salmon Policy classifies BC **hoon** 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 **hoon** 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 two CUs each for **üüx**/Coho, **gayniis**/Chum, river **misoo**/Sockeye, and **sti'moon**/Pink (odd and even years) **hoon** in the Kitkatla Inlet Network Zones area, whereas there are three **yee**/Chinook CUs (**Figure 80**). Every lake **misoo** population is a distinct unit and is outlined in **Figure 80**.

Occurrence and Population Trends

Trends of CUs from DFO and the Pacific Salmon Foundation (2017) are summarized throughout BC. All five species of **hoon** likely traverse through all Zones of the Kitkatla Inlet Network Zones area, although confirmed catch occurrence from surveys may not be accessible for these areas (**Table 20**). For the latest updates and trends in Salmon stocks in the North Coast, including the Kitkatla Inlet Network Zones area, please refer to the Integrated Fisheries Management Plan for Salmon in Northern BC.

Gayniis/Chum salmon were identified through Edye Pass, around **Tgii Xsw'aanx**/Porcher Island to Principe Channel, Porcher Inlet, the east coast of **Lax k'naga dzol**/Banks Island, at Browning Entrance and Principe Channel, around McCauley Island with a specific **hoon** creek noted at the north end of Lax k'naga dzol/Banks Island (Gitxaala Nation GIS database). Gitxaala harvesters also noted **misoo** in Kitkatla Inlet, Principe Channel, Deadman's Inlet, Kingkown Inlet, Bonilla Arm, **Lax k'naga dzol** (with a **misoo** creek noted), around McCauley Island and **Tgii Xsw'aanx**/Porcher Island (Gitxaala Nation GIS database).

Üüx were identified in Fisheries Management Area 5-10, in Kitkatla Inlet and the coasts of Porcher Inlet, Goschen, **Lax k'naga dzol**/Banks Island, through Ogden Channel, Edye Pass and Oval Bay, around Lach Klan, and Browning Entrance Principe Channel, and Spicer Island; additionally there are **üüx**/Coho creeks identified on **Lax k'naga dzol** (Gitxaala Nation GIS database).

Sti'moon were reported on the east side of **Lax k'naga dzol**/Banks Island, in Kingkown Inlet, the northwest side of **Tgii Xsw'aanx**/Porcher Island, Principe Channel, Kitkatla Inlet, Edye Pass, Porcher Inlet, Browning Entrance. Additionally, **Sti'moon** can be found in creeks on the eastern shore of Kitkatla Inlet (Gitxaala Nation GIS database).

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 (NUSEDS) was used to summarize the total estimated spawning abundance in creeks and streams within and surrounding the Kitkatla Inlet Network Zones area (Region Sub-Districts 4A and 5) from 2019 – 2021. The status of the Salmon CUs in the Kitkatla Inlet Network Zones area are summarized in **Table 20**.

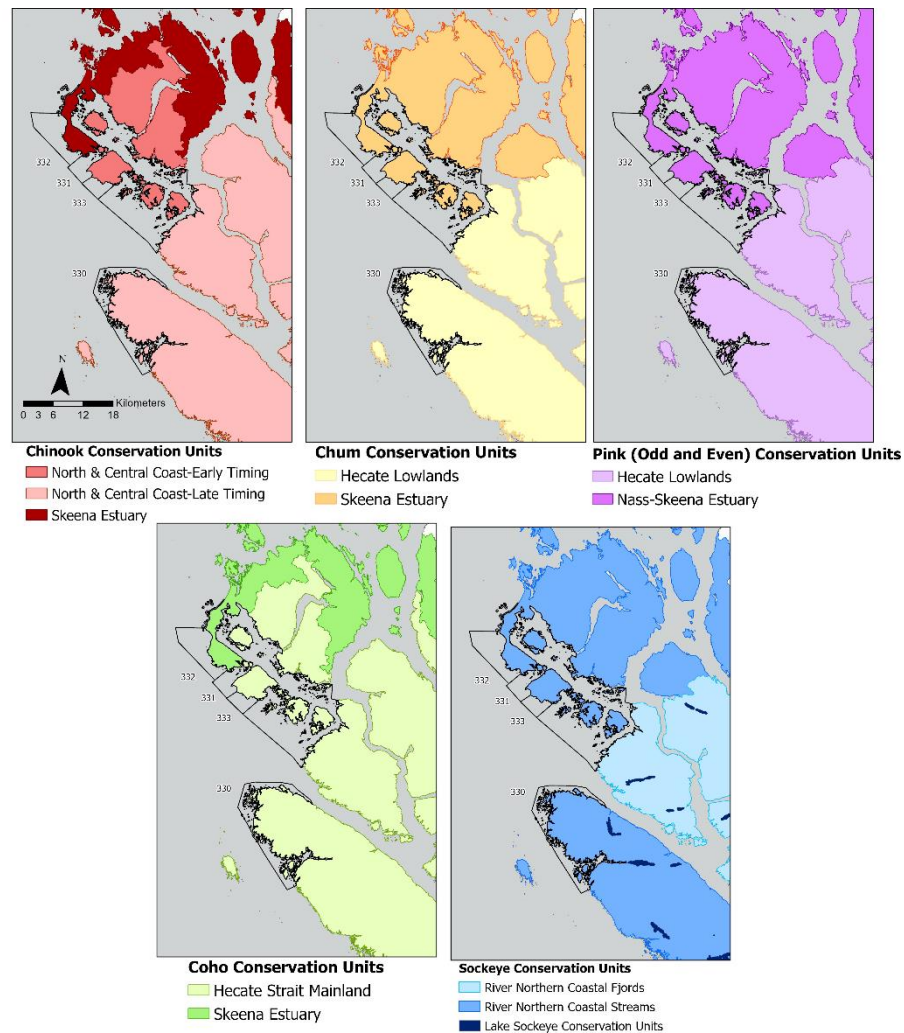


Figure 80. Conservation Units for Pacific Salmon in the Kitkatla Inlet Network Zones area. Note that each Lake Sockeye Conservation Units are distinct and names are detailed in **Table 20**. Caamaño Sound and Douglas Fjord System Network Zones are outlined in black. Spatial data can be accessed from the [Pacific Salmon Foundation – Salmon Watersheds Program \(2017\)](#) and [Pacific Salmon Conservation Units, Sites & Status - Open Government Portal \(canada.ca\)](#)

Table 20. Pacific Salmon Conservation Unit (CU), status of CUs (and year assessed), and total spawners (observed) within the CUs in Pacific Region Sub-Districts 4A and 5 which contains the whole Kitkatla Inlet Network Zones area and watersheds outside of the Network Zones. 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 nearby Network Zones) are described below. Please refer to **Figure 76** for spatial distributions of each CU. The most recent assessments of CUs are categorized as Good/Fair/Poor for benchmarks determined by Pacific Salmon Foundation ([PSF](#)) or DFO ([Wild Salmon Policy – Fisheries and Oceans Canada](#)).

Species	Conservation Unit (CU) Name	Status of CU (Organization benchmark - Year)	CU FMA 4A and 5 Spawners (2019-2021)
yee/Chinook	North and Central Coast early-timing	Not Assessed (DFO - 2023)	Data deficient
	North and Central Coast late-timing	Not Assessed (DFO - 2023)	152
	Skeena Estuary	Not Assessed (DFO - 2023)	100
gayniis/Chum	Skeena Estuary	Not Assessed (PSF - 2021)	12
	Hecate Lowlands	Poor (PSF - 2021)	1,510
üüx/Coho	Skeena Estuary	Not Assessed (DFO - 2023)	28
	Hecate Strait Mainland	Fair (PSF – 2021)	410
sti'moon/Pink (Odd)	Nass-Skeena Estuary	Not Assessed (PSF – 2021) Good/Fair (DFO - 2014)	46,035
	Hecate Strait - Lowlands	Good (PSF – 2021, DFO - 2014)	13,305
sti'moon/Pink (Even)	Nass-Skeena Estuary	Not Assessed (PSF – 2021) Good/Fair (DFO - 2014)	6,707
	Hecate Lowlands	Fair (PSF- 2021) Fair/Poor (DFO - 2014)	1,522
River misoo/Sockeye	Northern Coastal Fjords	Poor (PSF - 2021)	6,289
Lake misoo/Sockeye	Northern Coastal Streams	Not Assessed (DFO – 2023)	59
	Spencer Creek	Not Assessed (DFO – 2023)	Data deficient

6.2.4.3 Cartilaginous Fishes

Ksah/Sharks, **gandeh**/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 to benthic detritivores and planktivorous filter feeders. Many cartilaginous fishes have slow growth rates, large sizes, long lifespans, and delayed sexual maturity. Newborn and juvenile **ksah** and **gandeh** may use inlets and shallow waters for protection before migrating to deeper waters in the continental slope (Ebert 2003). These characteristics make them vulnerable to exploitation and population declines. Historical eradication of large **ksah** as pests or for liver harvest were common in the 20th century and led to declines in abundance.

Cartilaginous Fish species were not identified as Zone-level Conservation Objectives for Kitkatla Inlet (MPA Network BC Northern Shelf Initiative 2023), although many are still considered as E-CPs (Gale et al. 2019). Notably, the endangered Basking **ksah** (*Cetorhinus maximus*) (DFO 2018b), and Bluntnose Sixgill **ksah** (*Hexanchus griseus*) (DFO 2022g) are listed under the Canadian Species at Risk Act (SARA). **Gagaats**/Pacific Spiny Dogfish (Special concern, COSEWIC 2012), Big (*Raja binoculata*) and Longnose **gandeh**/Skates (*Raja rhina*), are managed under the groundfish Integrated Fisheries Management Plan (IFMP). Salmon **ksah** /Sharks (*Lamna ditropis*) are the only other **ksah** species allowed for recreational fishing.

Occurrence and Population Trends

Internal DFO Shark and Rays commercial and research catch and the groundfish prediction model (Thompson et al. 2022) were used to describe the occurrences of cartilaginous fishes in the Kitkatla Inlet Network Zones area. **Gagaats** are among the also common prey for Offshore Killer Whales and are regularly by-caught in longline fisheries in all the Kitkatla Inlet Network Zones (Ford et al. 2014). Numerous occurrences of **Gagaats** were recorded in **Maxlasadaalyaxs**/Grenville Channel, Gasboat passage, Principe Channel, and beside Zone 332. Longnose **gandeh**/Skates and Big **gandeh** were common in Zones 330 and 331, as well as outside of the RCA Zones 332 and 333, which makes it likely for their occurrences in those Zones as well.

Within the Kitkatla Inlet Network Zones area, Pacific Sleeper **Ksah**/Sharks and Bluntnose Sixgill **Ksah** have been caught in Principe Channel, and Sandpaper **gandeh**/Skates occur in Browning entrance, Principe Channel, **Maxla Kxa Naayxt**, and south of Zone 330 near Kingkown Inlet. Two pelagic **Ksah**, Blue **Ksah** (*Prionace glauca*) and Salmon **Ksah** (*Lamna ditropis*), were not detected within the Kitkatla Inlet Network Zones area. According to the groundfish prediction model (Thompson et al. 2022), the species richness for cartilaginous fishes is highest in Zone 331, Hecate Strait, and nearby channels (**Figure 81**). Compared to nearby areas such as Caamaño-Douglas (Liu et al. *in press*), Chatham Sound, and Dixon Entrance, the Cartilaginous fish species richness and occurrences in Kitkatla Inlet appear to be lower.

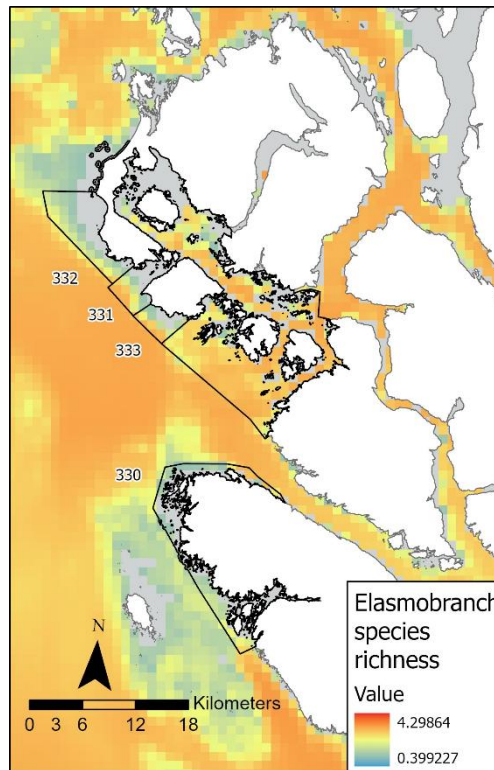


Figure 81. Summed predicted species density values per grid cell (Species Richness) for elasmobranchs in the Kitkatla Inlet Network Zones using the Thompson et al. (2022a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear 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.

6.2.4.4 Sensitivities and Recoverability

Please refer to Hunter and Wade (2015) for a comprehensive summary of species profiles and climate vulnerabilities on **txaw**/Pacific Halibut, **balaas**/Pacific Hake, Sablefish, **tskah**/Pacific Herring, and Pacific Sardine in the waters of BC.

Sensitivities to anthropogenic and environmental stressors can depend on species' life history traits. Unlike many bony fishes, **Ksah**/sharks and **gandeh**/rays have comparatively low reproductive output, and survey data and assessments are extremely limited. **Ksah**/sharks, in particular, have undergone population declines in the second half of the 20th century due to previous fisheries pressures or eradication efforts (Basking **ksah**) This combination of slow growth and low reproductive output results in slow recovery, which in turn implicates high sensitivity for many cartilaginous fish species. Furthermore, the lack of information on these fishes suggests a large knowledge gap in our understanding.

In contrast, Roundfish and Flatfish tend to have intermediate life histories (early maturation, fast growth rate, long lifespans, and high reproductive outputs), making them more resilient to fishing pressures than certain species of Rockfish/**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. High fecundity and periodic high recruitment events have helped with population recovery and growth. Furthermore, there

are federal mitigation efforts in place to assist the recovery and maintenance of **ts'mhoon** populations, including lowered fishery catch quotas and the implementation of Rockfish Conservation Areas (RCAs) between 2002 and 2006 (Thornborough et al. 2020; DFO 2023e). These efforts in lowering anthropogenic stressors in combination with the high fecundity and periodic high recruitment events of **ts'mhoon** may provide local recovery and spillover to adjacent areas. Ongoing restoration plans exist for species of interest, such as Yelloweye (Haggarty et al. 2022; Cox et al. 2020) and Quillback **ts'mhoon** (DFO 2012b).

Many groundfish species show one genetic population in the waters of BC (e.g., Jasonowicz et al. 2017), 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 Kitkatla Inlet Network Zones area (such as kelp forests and **gadza k'aw**/eelgrass beds) 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**/lingcod and **ts'mhoon**.

Another potential threat to the Kitkatla Inlet Network Zones area's fishes comes from vessel traffic: ship strikes, vessel noise, and oil spills. Increased development and density of marine traffic (such as the proposed LNG shipping passage that passes through Principe Channel into Browning Entrance) will increase vulnerability for fish. Larger species, such as basking **Ksah**/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 salmon and **tskah**/herring showed heightened anti-predatory behaviour (Van der Knaap et al. 2022). Oil spills on **gadza k'aw**/eelgrass and kelp habitats can harm the abundance of forage and juvenile fishes (groundfish, salmonids). Fishes that are less mobile and rely on biogenic habitats, such as adult rockfish and **wat'ukw**/lingcod, 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. The Kitkatla Inlet Network Zones area contains several **tskah**/herring spawning sites, and the Kitkatla Inlet Network Zones are close by to Chatham Sound and the Skeena River mouth. The Kitkatla Inlet Network Zones area has been identified as productive habitat for **hoon**/Salmon (MPA Network BC Northern Shelf Initiative 2023), and spawning grounds for **tskah** (data from Thompson et al. 2022) and Sand Lance (MPA Network BC Northern Shelf Initiative 2023).

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., **Geega ts kah**/herring spawn and **k'a'wts**/Pacific cod) have higher sensitivities than those with consistent recruitment (e.g., sablefish). 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 **ts kah**) with the highest average risk scores, and flatfish with the lowest scores (Hunter et al. 2014).

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 1000 km by 2100 in Pacific North America due to climate change (Morley et al. 2018). A recent study by Thompson and colleagues (Thompson et al. 2023b) provided projections of groundfish community (for 34 groundfish species; 15 of which are CPs (**Appendix H**)) 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 Projected changes to ocean environmental variables. They found that groundfish vary in their sensitivity to warming and dissolved oxygen (Thompson et al. 2023b). Consequently, the distribution or occurrence of some species may increase while others decrease.

Generally, 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. 2023b). 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 depths. Within the Kitkatla Inlet Network Zones, the redistribution of groundfish species due to climate change is projected to result in species richness changes from 0.9 to 1.97 species lost per grid cell (**Figure 82**). The RCP 8.5 scenario in the NEP36-CanOE model projects the highest species losses (**Figure 83**). While the model coverage for this groundfish model is poor and does not include the majority of the Kitkatla Inlet Network Zones, 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). Bottom dissolved oxygen and salinity refugia are thought to be possible within the Kitkatla Inlet Network Zones area for species displaced by smaller in situ changes in temperature, salinity, oxygenation, or acidification (see Climate Change).

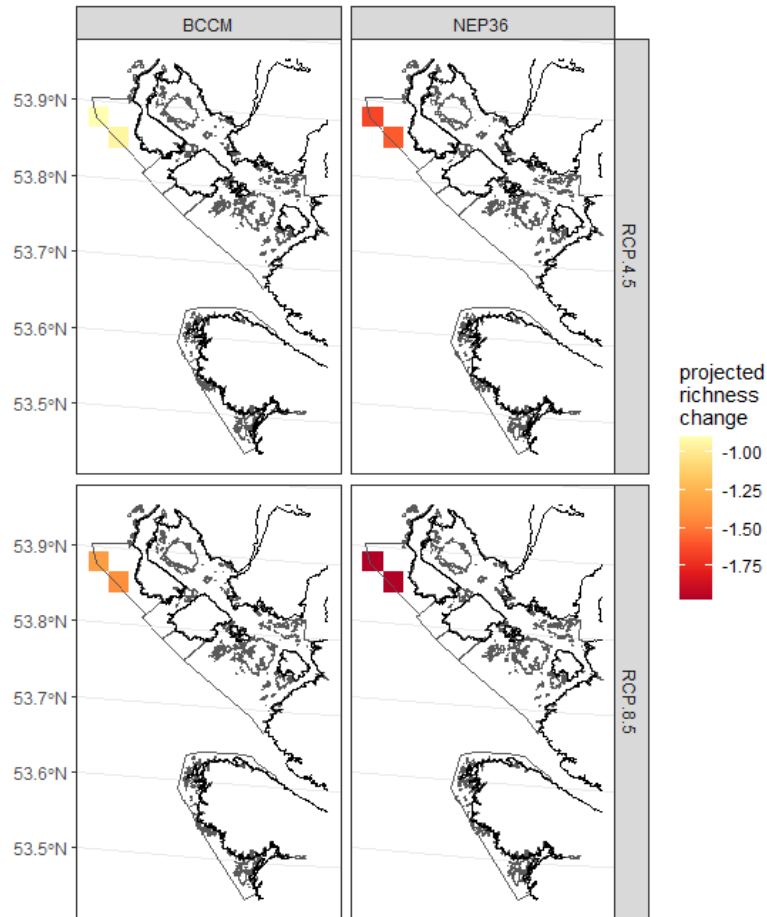


Figure 82. Projected species richness change in the groundfish communities (total of 40 groundfish species on the Pacific coast) in the outermost areas of Zone 3332 in the Kitkatla Inlet Network Zones based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 emissions scenario (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). Note the incomplete coverage of the models in the figure indicated by a white background within the polygons (Thompson et al. 2023b).

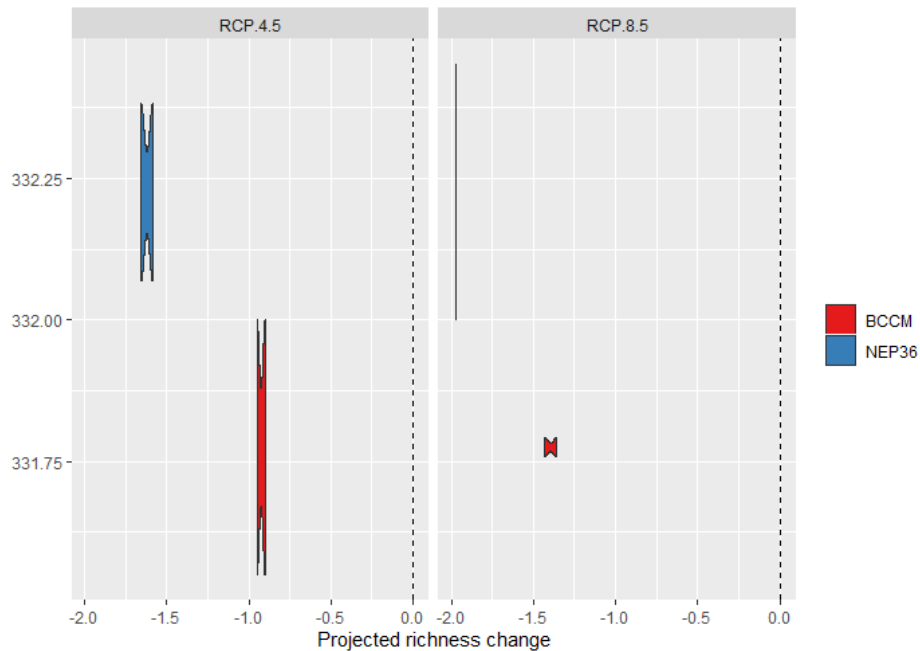


Figure 83. Distributions of projected change in occurrences across the outermost areas of Zone 332 in the Kitkatla Inlet Network Zones for groundfish communities (total of 40 groundfish species on the Pacific coast) based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 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 Kitkatla Inlet Network Zones area (**Figure 82**; Thompson et al. 2023b).

6.2.4.5 Data and Knowledge Gaps

Groundfish

DFO groundfish survey data extends to partial coverage of all Kitkatla Inlet Network Zones and is limited to nearshore areas. 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; therefore, specific groundfish species trends are unclear for the Northern Shelf Bioregion or the inshore Kitkatla Inlet Network Zones area scale. For example, *wat'ukw/Lingcod* 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). Furthermore, *Balaas/Pacific Hake* are highly migratory and may be important for nutrient transport in and out of the NSB region (Gale et al. 2019). However, not much is known about their specific ecosystem effects, and their contributions to the Kitkatla Inlet Network Zones area specifically. These uncertainties present a challenge and knowledge gap when understanding Kitkatla Inlet at the Network Zone spatial scale without more focused surveys.

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 (Starr and Haigh 2017), Copper (Stocker and Fargo, 1995), Shortraker (Schnute et al. 1999), and Darkblotched rockfish (COSEWIC 2009b). The stock assessments for Dover Sole (DFO 1999) and Petrale Sole (Starr 2009) are currently outdated or have high data uncertainty. Genetic population structuring was

uncertain for many fish species, including BC **K'a'wts**/Pacific Cod stocks (Forrest et al. 2015) and for **wat'ukw**/Lingcod. Ongoing studies for groundfish population genetics may reveal insights into species complex resolution (such as Rockfish), regional diversity, and stock management.

There is also a lack of coast-wide monitoring plans for RCAs, as well as a data gap for baseline trends and diversity before the RCAs were established (Dunham et al. 2020). Therefore, the effectiveness of RCAs for Rockfish populations requires additional long-term monitoring and research.

Cartilaginous Fish

There are limited research and survey data in British Columbia on the abundance, trends, and knowledge of cartilaginous fishes especially throughout the North Coast (MPA Network BC Northern Shelf Initiative 2023). Observations are usually opportunistically recorded as bycatch or as point observations from other surveys (groundfish, marine mammal) or reported from anecdotal encounters through the Shark Sightings Network (<https://www.dfo-mpo.gc.ca/species-especes/sharks/info/sightings-eng.html>). Recently, Spatial Distribution Models of Blue, Salmon, Pacific Sleeper, and Bluntnose Sixgill **ksah** were published by Proudfoot et al. 2024 using data from two fishery independent scientific surveys, and other research and commercial surveys (See Figure 1 in Proudfoot et al. 2024). While this model can inform general trends throughout BC, areas with few data points such as nearshore areas like Kitkatla Inlet may still present as knowledge gaps.

6.2.5 Marine birds

The diverse habitats of the Kitkatla Inlet Network Zones area support globally 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 in spring and fall, following food to fuel their journeys while heading to breeding areas and returning to overwintering sites. The protected and productive inlet habitats within the Kitkatla Inlet Network Zones support large concentrations of seabirds, waterbirds, waterfowl, and shorebirds during migration, moulting, and non-breeding periods. During the spring and summer, islands and islets outside the **Lax k'naga dzol**/Banks Island (Zone 330) and surrounding productive waters support small colonies of breeding marine birds. At least 43 species of marine birds have been observed within the Kitkatla Inlet Network Zones, and 28 species are considered conservation priorities within the NSB (Gale et al. 2019; **Appendix H**).

Species occurrence data in the Kitkatla Inlet Network Zones (**Appendix H**) were obtained from several sources, including the Gitxaala Nation GIS database, the 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 the Global Biodiversity Information Facility (GBIF 2023).

Using the data compiled for this report (**Appendix G**), Zone 331 has a marine bird species richness of 43 species, the highest of all the Zones. Zones 331, 332, and 333 overlap with much of the marine component of the internationally recognized Kitkatla Channel, Goschen Island North to **Tgii Xsw'aanx**/Porcher Island Important Bird Area, which is recognized for globally significant waterfowl concentrations ([IBA Canada](#)). Waterfowl species observed here include

ha'ax/goose, **amgyiik**/black duck (scoters), **nanaa**/mallard and **gak**/swan. Although there are few recorded marine bird breeding colonies within the Kitkatla Inlet Network Zones, Zones 330 and 331 are noted as important places to harvest **gaguum**/sea gull eggs, and there are records of breeding individuals or nesting pairs on several islands west of Zone 330. Species breeding on these islands include including Glaucous-winged Gull (*Larus glaucescens*), Pigeon Guillemot (*Cephus columba*), and Black Oystercatcher (*Haematopus bachmani*).

Marine bird abundance, distribution, and species richness are associated with areas of high productivity and bathymetric features that result in concentrations of prey, as well as proximity to breeding colonies (Clarke & Jamieson 2006; Kenyon et al. 2007; Kenyon et al. 2009; Santora et al. 2018; Yen et al. 2004). 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**/Pacific Herring, juvenile **ts'mhoon**/rockfish, and juvenile **hoon**/salmon (Burger et al. 1993, Hedd et al. 2006). The Kitkatla Inlet Network Zones include a variety of habitats and sites of ecological value for marine birds throughout their annual cycles, particularly as a migratory stopover. These habitats include rocky shorelines, coastal islands, protected inlets, estuaries, **gadza k'aw**/eelgrass beds, and nearshore and inshore waters (Kenyon et al. 2007). Estuaries are known to be particularly important habitats to a diverse complex of birds for breeding and foraging and for associations with **gadza k'aw** beds and **tskah** spawning habitat; ecological importance of estuaries for waterbirds has been ranked by the Pacific Estuary Conservation Program ([Pacific Habitat Joint Venture 2020](#)). Ranked estuaries within the Kitkatla Inlet Network Zones include Billy Creek (Rank 1) and Hankin Point (Rank 2), both located in Zone 331.

Both adult **tskah**/ Pacific Herring and **xs'waanx**/herring roe are important food sources for many bird species, and the relative seasonal predictability of **tskah** spawn events and the seasonal pulse of energy-rich food makes them important habitats for large numbers of both overwintering and migrating marine birds (Willson and Womble 2006, Lok et al. 2012). All Kitkatla Inlet Network Zones have known records of **tskah**/Pacific Herring spawning, and Zone 331 in particular hosts notable concentrations of **tskah** spawning sites during late winter and early spring months ([McCarter 2016](#)). Additional information on **tskah** is found in Forage Fishes. Waterfowl, including **amgyiik**/black ducks (scoters) and other sea ducks, are known to congregate in large numbers at **tskah** spawn events; up to 350,000 Surf **ahoo**/scoters (*Melanitta perspicillata*) have been recorded in the Kitkatla Inlet Network Zones during the late winter and spring ([IBA Canada](#)). Surf **ahoo** and White-winged **ahoo** (*Melanitta deglandi*) marked with satellite tags have been recorded using habitat in Zones 331, 332, and 333 during spring migration ([movebank.org](#), study name "ECCC_Surf scoter_White-winged scoter_Salish Sea_GPS-GSM ", study ID 2017291177 accessed on November 15, 2023."

Throughout the Kitkatla Inlet Network Zones 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 Kitkatla Inlet Network Zones area predicted marine habitat in Zones 330 and 331 (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).

6.2.5.1 Sensitivities and Recoverability

The coastal waters of British Columbia (BC) are critical habitats for various marine bird species, many of which are sensitive to human activities and the effects of climate change. 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 grounds, 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 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 conducted in the Kitkatla Inlet area may threaten marine bird species, including albatrosses, shearwaters, auklets, murrelets, and murre (Gilman and Freifeld 2003, Bull 2007, Bertram et al. 2021, Fox et al. 2021), which are killed incidentally as bycatch in some fisheries and are likely slow to recover from population declines due to their long life span and delayed slow reproduction. Small vessel traffic in coastal protected areas can significantly disturb marine birds, and variability in vessel traffic characteristics affects different bird communities differently. Noise from vessels is a notable stressor, with one in six vessels classified as 'noisy' (Blight et al. 2023). 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.

6.2.5.2 Data and Knowledge Gaps

The abundance and distribution of marine birds have been documented to some extent in the Kitkatla Inlet Network Zones 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 Kitkatla Inlet Network Zones 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.

6.2.6 Marine mammals

The Kitkatla Inlet Network Zones area provides habitat for a wide variety of marine mammal species. Cetacean species found within this broad region include the Fin whale (*Balaenoptera physalus*), Humpback whale (*Megaptera novaeangliae*), Grey whale (*Eschrichtius robustus*), common Minke whale (*Balaenoptera acutorostrata*), Sperm whale (*Physeter macrocephalus*), 'naaxi/Killer whale (*Orcinus orca*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Harbour porpoise (*Phocoena phocoena*), and Dall's porpoise (*Phocoenoides dalli*). West of Lax k'naga dzol/Banks Island and around Tgii Xsw'aanx/Porcher Island have been noted as important by Gitxaala harvesters for a variety of Ibuun/whales (species not identified) in the fall, and fishermen must take care with their nets during this time (Gitxaala Nation GIS database). Gitxaala harvesters have noted porpoises north of Lax k'naga dzol/Banks Island and Goschen Island and indicated past occurrences within Ogden Channel (Gitxaala Nation GIS database). Pinniped species that regularly occur in the Kitkatla Inlet Network Zones area include the üüla/Harbour seal (*Phoca vitulina*), Northern Fur seal (*Callorhinus ursinus*), and t'iibn/Steller sea lion (*Eumetopias jubatus*). A single species of marine mammal from the mustelid family, the ploon/sea otter (*Enhydra lutris*), is currently not documented in the Kitkatla Inlet Network Zones

area. However, the region may become part of **ploon**'s expanding range in BC in the future. Recovery of previously extirpated species or increased survey effort/data collection may reveal more mammal species in the area. The species featured below in this report have documented or likely distributions in the Kitkatla Inlet Network Zones area and may be more vulnerable to anthropogenic impacts in the region. Thus, they are most likely to benefit from a marine protected area network that seeks to protect this ecosystem's physical and biological underpinnings from anthropogenic threats.

Data for marine mammal species occurrence come from up to four sources: (1) species distributions from known observations (surveys or direct observation), (2) predicted occurrences through distribution modelling, (3) expert opinion of distribution (mainly from guidance obtained in the process of identifying EBSAs for the Northern Shelf Bioregion (Clarke and Jamieson 2006)), (4) published occurrences in the literature, and/or (5) Gitxaala knowledge. Predicted occurrences were obtained from predicted density maps of four cetacean species (Wright et al. 2021a) - Humpback whales, fin whales, Dall's porpoises, and Harbour porpoises – based on survey data and environmental covariates). The models used cetacean observation data collected in the Pacific Region International Survey of Marine Megafauna (PRISMM; line transect survey for cetaceans) that occurred in the coastal and offshore waters of British Columbia between July and September of 2018. A modelling and hotspot analysis of multiple marine mammal species in BC from data collected in 2004-2008 used generalized additive models combining systematically surveyed species information with environmental variables to predict marine mammal distribution and density (**Figure 84**). Marine mammal hotspots were identified from the density surfaces (**Figure 85**), and high-density regions were generally clustered in areas exhibiting oceanographic characteristics that may promote concentrated food resources (Harvey et al. 2017). Note that these models only include the outer coast of the Kitkatla Inlet Network Zones area but still cover all four Zones. While not all of the analyzed nine marine mammal species occur in high densities within this area (e.g., Fin whales and Minke whales; **Figure 84**), regardless of how conservative the hotspot measure, the Kitkatla Inlet Network Zones area contains multiple marine mammal hotspots, particularly for cetacean species (**Figure 85**).

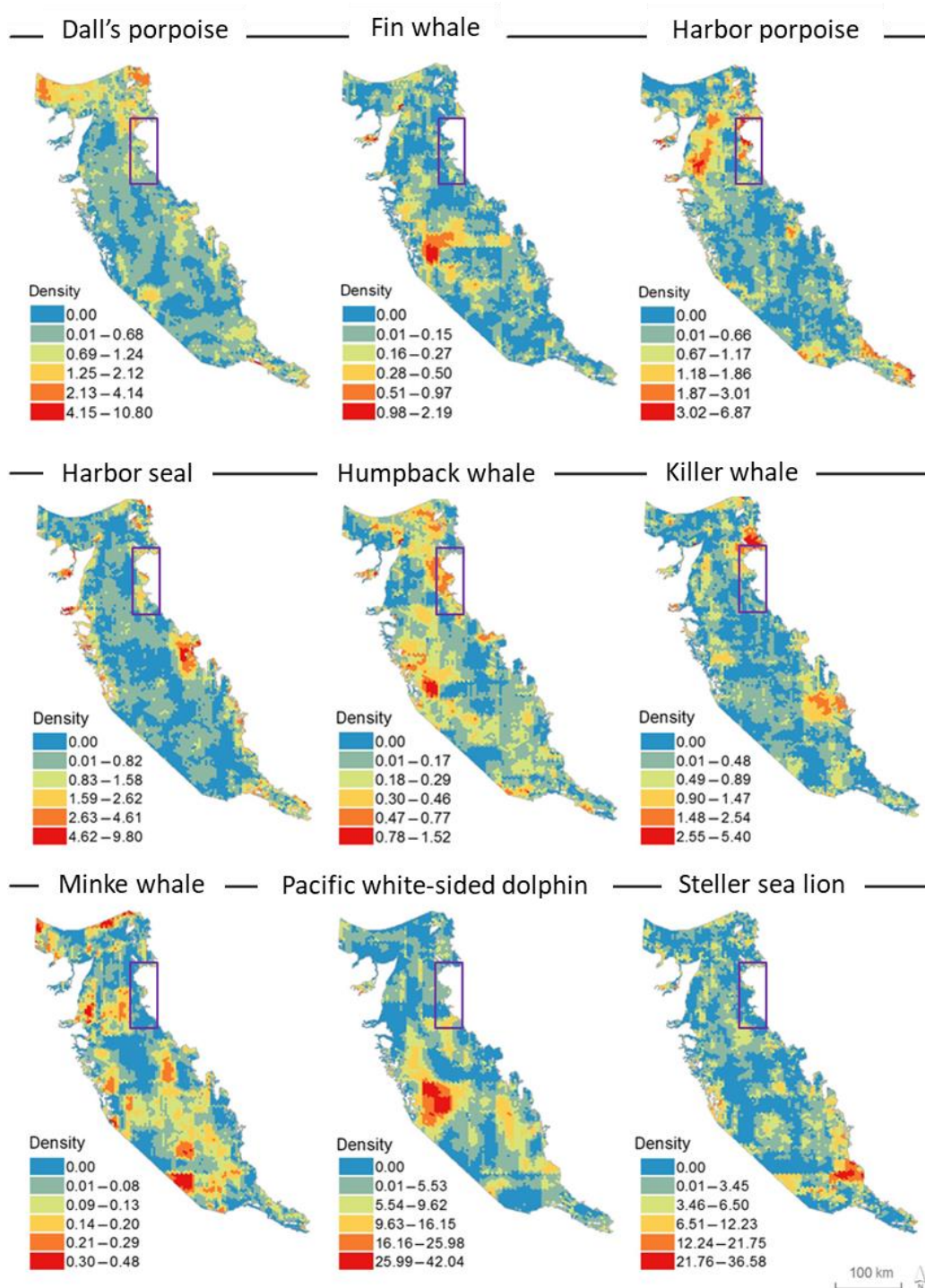


Figure 84. Continuous density surfaces generated from species-specific generalized additive models. Density is defined as the number of individuals per km² displayed on a hexagon grid (each hexagon is 13.86 km²). Purple rectangle indicates Kitkatla Inlet Network Zones area including the outer coast of Tgii Xsw'aanx/Porcher Island and the northern to central outer coast of Lax k'naga dzol/Banks Island. Note that the predicted densities vary by each species. These maps were modified from Harvey et al. 2017 Figure 4. For survey locations, refer to Figure 1 in Harvey et al. 2017.

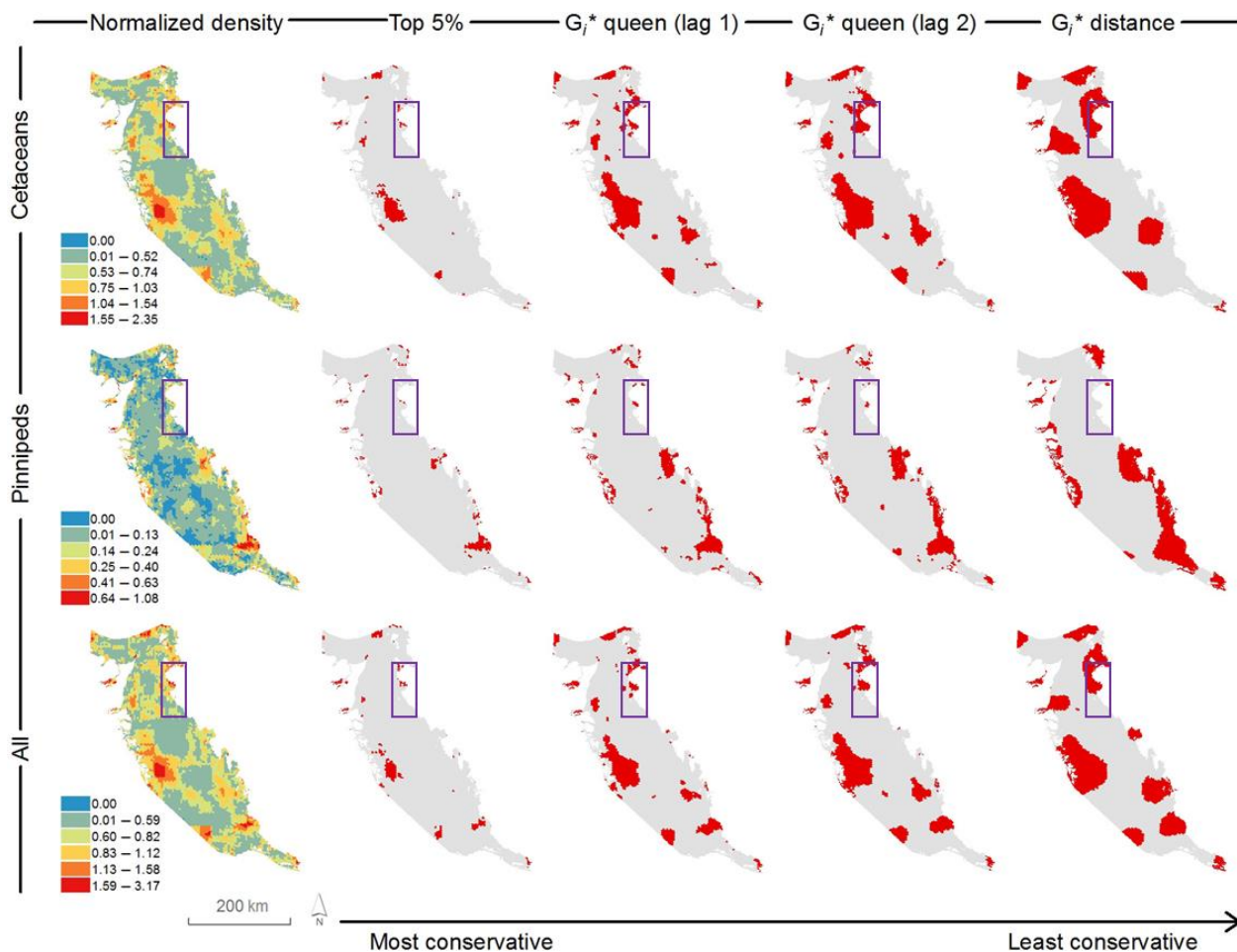


Figure 85. Four hotspot outputs (top 5%, G_i^* queen [lag 1], G_i^* queen [lag 2], and G_i^* distance) were generated from normalized and summed density maps (first column) for cetaceans, pinnipeds and all species combined. The red spots/polygons in the maps in the four columns on the right-hand side indicate the hotspots. The purple rectangle on each map outlines the Kitkatla Inlet Network Zones area, including the outer coast of Tgii Xsw'aanx/Porcher Island and the northern to central outer coast of Lax k'naga dzol/Banks Island. Note that the normalized densities vary by species group. Maps modified from Harvey et al. 2017 Figure 4. For survey locations, refer to Figure 1 in Harvey et al. 2017.

Marine mammals are described as four separate groups in the following sections based on their feeding ecology and taxonomy: baleen **ibuun**/whales (Mysticetes), toothed **ibuun** (Odontocetes), pinnipeds, and **ploon**/sea otters. Baleen and toothed **ibuun** differ in their mode of feeding and diet. Baleen **ibuun** primarily feed on copepods, euphausiids, amphipods, and/or small schooling fishes (Kawamura 1980), in contrast to toothed **ibuun** that feed on fishes, cephalopods, or other marine mammals (Gaskin 1982, Bowen and Siniff 1999). Consequently, baleen **ibuun** are associated with areas of high primary and secondary productivity, whereas toothed **ibuun** are more likely to be associated with areas high in fish and **Xbihats'al**/squid. Pinnipeds and **ploon** are grouped separately due to their phylogenetic differences from cetaceans.

6.2.6.1 Baleen **ibuun**/Whales

The Kitkatla Inlet Network Zones area provides habitat for at least four species of baleen **ibuun**/whale (Mysticetes), particularly around **Lax k'naga dzol**/Banks Island and the outer

regions of the Kitkatla Inlet Network Zones. The region's two most commonly encountered species, Fin whales and Humpback whales are both conservation priorities for the NSB (Table A1, Gale et al. 2019). These **lbuun** species generally have lower trophic levels than toothed **lbuun** (Pauly et al. 1998) and occupy middle trophic levels in the NSB (Gale et al. 2019). The northern regions, including the North Pacific Ocean, are important feeding grounds for baleen **lbuun** due to the abundance of small pelagic fishes and zooplankton (Takahashi et al. 2022). Furthermore, some baleen **lbuun** export energy and nutrients from higher to lower latitudes when they excrete urea (nitrogen) during their extensive migrations (Roman et al. 2014). Notable characteristics of each species distribution within the Kitkatla Inlet Network Zones area are provided below.

6.2.6.1.1 Fin whales

Important Fin whale habitat exists on the west side of **Lax k'naga dzol**/Banks Island (**Figure 86**), overlapping with Zone 330 of the Kitkatla Inlet Network Zones. This habitat of special importance encompasses Hecate Strait, Queen Charlotte Sound and Greater Caamaño Sound (to the south of Kitkatla Inlet). It is important for foraging/feeding, as well as possible courtship/mating and calving (see Figure 1 in DFO 2017). A recent modelling effort of the abundance of cetacean species throughout the North Coast found low predicted densities of Fin whales in the Kitkatla Inlet Network Zones area (**Figure 87**; Wright et al. 2021a). However, it is important to note that the data used in the model were collected during a single summer survey in 2018 (Wright et al. 2021a), and Fin whales that actually utilize the area may, therefore, not have been encountered due to chance or poor observation conditions at the time of the survey. A slightly higher abundance of Fin whales was modelled for the outermost regions of the Kitkatla Inlet Network Zones area (**Figure 84**; Harvey et al. 2017) from 2004-2008 survey data. However, the highly nearshore nature of the Kitkatla Inlet Network Zone boundaries makes it unlikely that these zones are particularly important for fin whales and are not observed there often (Brianna Wright pers. comm. September 2023).

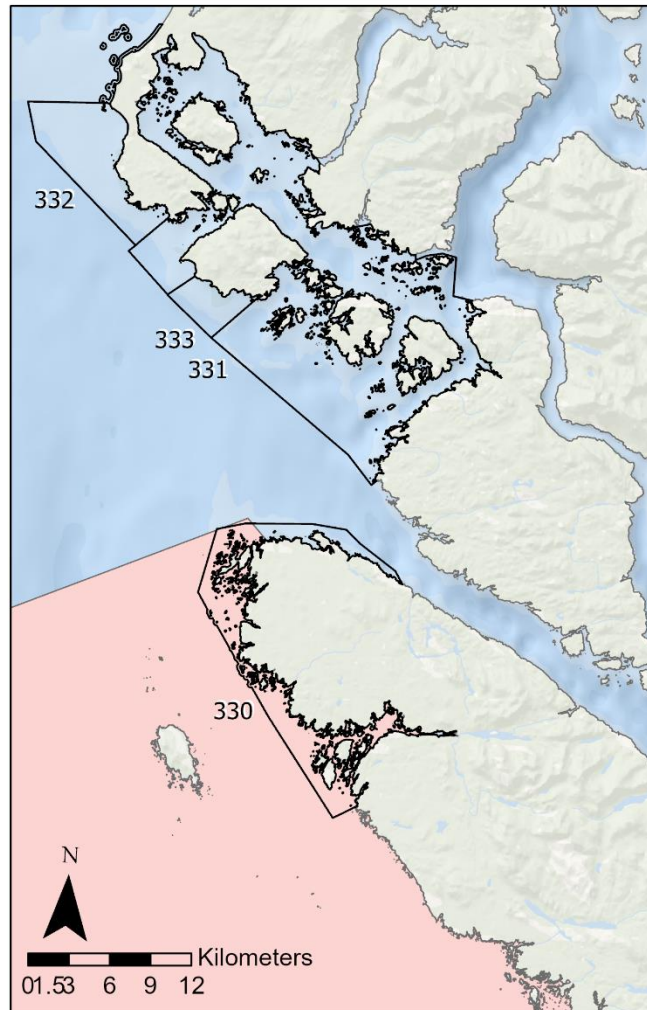


Figure 86. Fin whale habitats of special importance (pink); identified as important for foraging/feeding, as well as possible courtship/mating and calving habitat (DFO 2017).

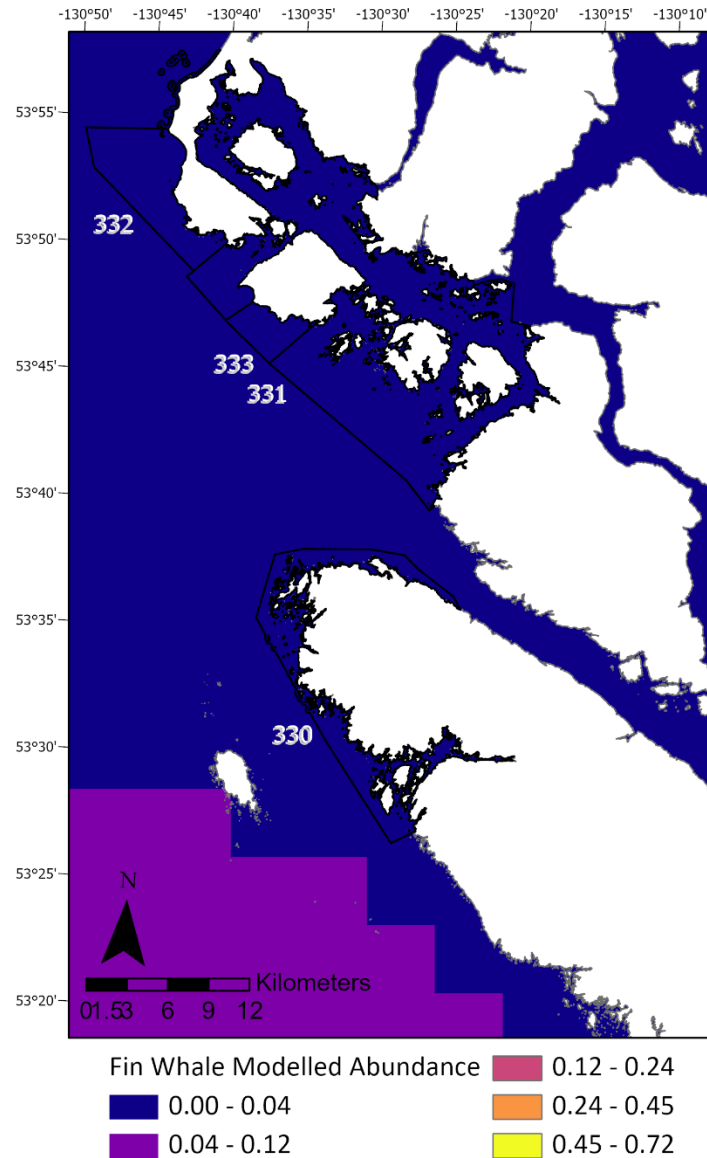


Figure 87. Modelled densities (per 25 km² grid cell) of Fin Whales in the Kitkatla Inlet Network Zones area. The model used cetacean observation data collected during the Pacific Region International Survey of Marine Megafauna (PRISMM; line transect surveys for cetaceans) that occurred in the coastal and offshore waters of British Columbia between July and September of 2018. Network Zones are indicated with black outlines and Zone numbers. These modelled density estimates should be interpreted with caution, as they are based on a single summer survey and predicted over a relatively large scale (5 x 5 km grid cells), using a smoother of sightings locations as the only model covariate. Predicted densities close to shorelines, including inside Kitkatla and Porcher Inlets and Petrel Channel, are therefore likely to be biased low, as these areas were not surveyed during the PRISMM effort. Data from Wright et al. 2021a.

The fin whales using the Kitkatla Inlet Network Zones 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 **lbuun**/whale in the ocean (Christensen 2010), including in Canada's waters, but today, the Canadian Pacific stock remains depleted at less than 50% of historical levels before commercial

whaling (1908-1967 in Canadian waters; COSEWIC 2019; Nichol et al. 2002.). During this time, the fin whale was the most harvested **ibuun** species in Canada and worldwide (Gregs 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, Caamaño Sound and Dixon Entrance; Wright et al. 2021a). The primary diet of Fin whales is (sometimes exclusively) euphausiids, but the relative proportion of this prey in the diet could change significantly over the 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). For more information on Fin whale behaviour in the nearby Caamaño Sound area, please see Liu et al. *in press*.

6.2.6.1.2 Humpback whales

Sightings of humpback whales in 2019, including within the Kitkatla Inlet Network Zones area, are displayed in **Figure 88** (Birdsall and Dracott 2020). Modelled densities of 0.60-1.08 individuals (per 25 km² grid cell) in all the Kitkatla Inlet Network Zones (**Figure 89**; Wright et al. 2021a) were predicted from the summer 2018 PRISMM survey data. Furthermore, a 2004-2008 coastwide modelling effort showed the highest Humpback whale densities in the outermost regions of the Kitkatla Inlet Network Zones area (**Figure 84**; Harvey et al. 2017), particularly to the west of Porcher and **Lax k'naga dzol**/Banks Island. Additionally, Gitxaala harvesters note the presence of humpback whales in Ogden Channel, the west side of **Lax k'naga dzol**, and in Hecate Strait (Gitxaala Nation GIS database).

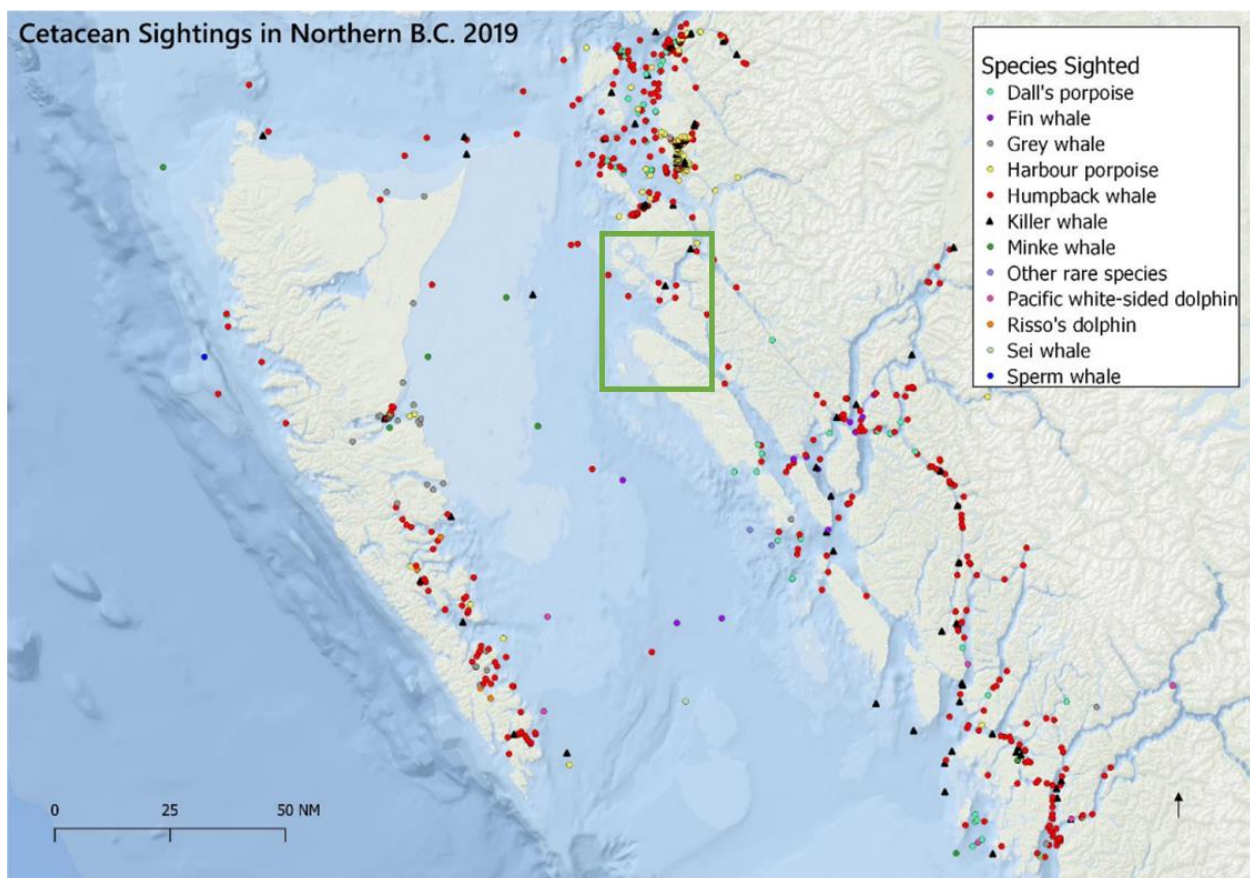


Figure 88. Map of all cetacean sightings in the North Coast of BC during 2019, totalling 1,387 (this map has not been corrected for effort). Green rectangle indicates Kitkatla Inlet Network Zones area. Map modified from Birdsall and Dracott 2020.

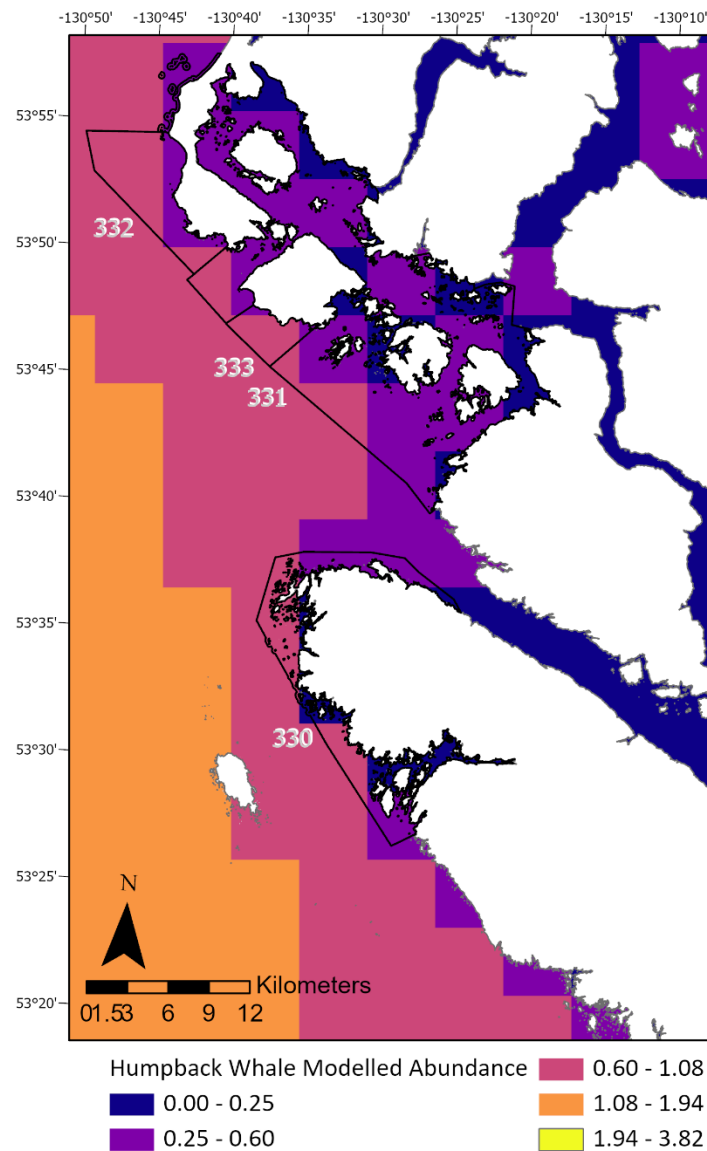


Figure 89. Modelled densities (per 25 km² grid cell) of Humpback Whales in the Kitkatla Inlet Network Zones area. The model used cetacean observation data collected during the Pacific Region International Survey of Marine Megafauna (PRISMM; line transect surveys for cetaceans) that occurred in the coastal and offshore waters of British Columbia between July and September of 2018. Network Zones are indicated with black outlines and Zone numbers. These modelled density estimates should be interpreted with caution, as they are based on a single summer survey and predicted over a relatively large scale (5 x 5 km grid cells), using a smoother of sightings locations as the only model covariate. Predicted densities close to shorelines, including inside Kitkatla and Porcher Inlets and Petrel Channel, are therefore likely to be biased low, as these areas were not surveyed during the PRISMM effort. Data from Wright et al. 2021a.

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 (DFO 2013b), with province-wide population estimates increasing from 2,145 individuals (95%CI = 1,970 – 2,331) in 2006 (Ford et al. 2009) to 7,030 individuals (95%CI = 5,733 – 8,620) in 2018 (Wright et al. 2021a). The abundance estimated for the north coast of BC (spanning northern Vancouver Island, the north and central mainland coasts, and Haida Gwaii) in 2018 was 1,816 humpback whales (Wright et al. 2021a), indicating an increase from a 2004-2008 estimate of 1,092 humpback whales in this region (Best et al. 2015). For more information on Humpback whales, particularly those that use the Caamaño Sound area to the south, see Liu et al. *in press*.

Humpback whales exhibit seasonality in their presence in BC waters because they migrate to warm water and low-latitude habitats in winter for calving and breeding and return to temperate waters at higher latitudes in the late spring or early summer for the primary purpose of feeding. Humpback whales have a broad diet. A recent study of foraging humpback whales in southern BC indicates **Tskah**/Pacific herring and euphausiids (*Euphausia pacifica*, *Thysanoessa spinifera*, and *T. raschii*) are primary prey species. Additional prey species include **gasgos**/shrimp (*Sergestes similis* and *Eualus avinus*), juvenile **balaas**/North Pacific hake, **Ha'limootk**/eulachon, juvenile **hoon**/salmon, and juvenile **Hadanii**/sablefish (Reidy et al. 2022). **Tskah** and euphausiids are important prey species for humpback whales in the Caamaño-Douglas area to the south, as evidenced by observations of bubble net feeding (BNF) and by the distribution of feeding individuals and the diving behaviour they exhibit, respectively (Keen 2017; Liu et al. *in press*). Additionally, BNF behaviour of Humpback whales has been observed by DFO scientists in the greater Kitkatla Inlet Network Zones area around northwest **Lax k'naga dzol**/Banks Island and **Lax Kul**/Bonilla Island (**Figure 90**). Bubble net feeding 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 forage fish, such as **Tskah** (D'Vincent et al. 1985; Leighton et al. 2007; Wiley et al. 2011). Single **ibuun**/whales have also been documented to bubble net feed. During these events, one individual potentially performs all roles that would typically be partitioned among larger groups (Liu et al. *in press*).



Figure 90. Humpback whale bubble-net feeding activity in the Kitkatla Inlet Network Zones area. Photos taken south of Lax Kul/Bonilla Island on McHarg Bank on July 12, 2023 by Brianna Wright.

6.2.6.1.3 Grey Whales

Like Humpback whales, Grey whales are also present seasonally in northern BC. They migrate to Baja, California, for calving and breeding during the winter but return through BC waters in the spring on their northward migration to summer feeding grounds in the Arctic. Evidence from land-based observations made from **Lax Kul**/Bonilla Island and satellite tag tracks suggests that

the northward migration path of grey whales passes through Hecate Strait, including the Kitkatla Inlet Network Zones area (Ford et al. 2013b). Although little is known about the route that grey whales take on their southerly migration back to the breeding grounds in late fall/early winter, there is no reason to assume that it differs from that taken during the northward migration. For this reason, the Kitkatla Inlet Network Zones are likely important as a migratory corridor for grey whales in both the late spring/early summer and the early winter. However, they do not appear to remain in the area for extended periods. Grey whales have also been observed near shore in Oval Bay on the west side of **Tgii Xsw'aanx**/Porcher Island, where they may have been feeding (John Ford, pers. comm. November 2023). Photo-identification of the five grey whales tagged between 2009-2011 indicated that three of them belonged to the Pacific Coast Feeding Group (PCFG) (Ford et al. 2013b); the remaining two likely belonged to the much larger North Pacific Migratory population (see COSEWIC 2017 for details about the three recognized grey whale DUs). The best available range-wide abundance estimate for the North Pacific Migratory population is 20,990 based on shore counts conducted during the southerly migration off of California in the winter of 2010-11 (Durban et al. 2013; Caretta et al. 2015) and the PCFG population was estimated at 237 individuals in 2014 (Calambokidis et al. 2017).

6.2.6.1.4 Common Minke Whales

Minke whales are the smallest baleen **ibuun**/whales found in BC waters and are widespread across shallow coastal habitats throughout the province. Still, knowledge of their abundance or distribution patterns is limited. They are infrequently encountered but seem to have high site fidelity, and thus, the total population is thought to be quite small (Ford 2014). Near the Kitkatla Inlet Network Zones, they have been sighted along the northwest side of **Lax k'naga dzol**/Banks Island and off the south and west sides of **Tgii Xsw'aanx**/Porcher Island (Ford 2014; Ford et al. 2010; DFO unpublished data from PRISMM). They feed on small forage fish such as **tskah**/Pacific herring, Pacific sandlance, and zooplankton (Towers et al. 2019; Ford 2014).

6.2.6.2 Toothed Whales

Five species of toothed **ibuun**/whale (Odontocetes) are found in the Kitkatla Inlet Network Zones area, which are all conservation priorities for the NSB (Table A1, Gale et al. 2019). Killer whales are further summarized by the three ecotypes present in the area.

6.2.6.2.1 Sperm whales

Sperm whales are widely distributed in the North Pacific (Mizroch and Rice 2013). They are deep divers that feed primarily on **Xbihats'al**/squid but may also feed on large demersal and mesopelagic **Ksah**/sharks, **gandeh**/skates, and bony fishes (Gosho et al. 1984). They are top predators that occur mainly along the continental shelf break and the offshore waters to the west of Vancouver Island and Haida Gwaii (Ford 2014; Bannar-Martin et al. 2025), outside the Kitkatla Inlet Network Zones area. However, there have been occasional sightings of sperm whales west of **Tgii Xsw'aanx**/Porcher Island near the Kitkatla Inlet Network Zones (Ford 2014). Most sightings of sperm whales in northern BC are of solitary males (or occasionally, small groups of several males) (Ford et al. 2010; Ford 2014). Most sperm whales are located south of 40°N in the winter when mating occurs (Caretta et al. 2009), after which males migrate to higher latitudes in the summer to feed. Groups of females and young are seldom encountered north of 51°N and typically remain in warmer tropical and temperate regions throughout the year (Gregs et al. 2000). Consequently, the Kitkatla Inlet Network Zones area could be important to a small number of male sperm whales in spring and summer. However, the majority of the individuals found in BC waters occur outside of these zones. For

management purposes, the International Whaling Commission (IWC) recognizes two management units of sperm whales in the North Pacific (eastern and western). However, the IWC has not reviewed its sperm whale stock boundaries in recent years (Donovan 1991). Gitxaala harvesters have reported an instance of a sperm whale feeding in Kitkatla Inlet in 2010 (Gitxaala Nation GIS database).

6.2.6.2.2 'naaxl / Killer whales

The 'naaxl Orcas/Killer Whales (*Orcinus orca*) are composed of three distinct ecotypes within the NSB marine waters - Northern Resident Killer Whales (NRKW; COSEWIC 2003a, Fisheries and Oceans Canada 2018), Offshore Killer Whales (Fisheries and Oceans Canada 2018), and west coast Transient Killer Whales (also known as Bigg's Killer Whales; Fisheries and Oceans Canada 2018). 'naaxl are long-lived apex predators, however the three ecotypes differ in diet and foraging behaviour, acoustic behaviour, morphology, and genetic characteristics (Ford 2014). Despite overlapping ranges, these ecotypes do not mix and are thus socially and reproductively isolated from each other. All three ecotypes occur within the Kitkatla Inlet Network Zones area. Gitxaala harvesters note the presence of 'naaxl in Ogden Channel, around the Fan Islands, and in proximity to Lach Klan (Gitxaala Nation GIS database).

6.2.6.2.2.1 Resident Killer Whales

The Northern Resident Naaxl/killer whale (NRKW) population ranges coastally from southeast Alaska to Washington state (Ford 2006). The population is small but increasing in size (2.2% mean annual growth from 1973 to 2022) and was estimated at 341 individuals as of the 2022 photo-identification census (DFO 2023j). It is currently listed as Threatened under Canada's Species at Risk Act. The NRKW population contained about 117 individuals at the beginning of census efforts in 1973, and had been previously impacted in the 1960s by the removal of 14 whales for the live-capture aquaria trade (Bigg 1982). Pre-census historical abundance is not known. After the closure of live-capture fisheries, the population has generally grown annually except for a period of decline between 1998-2001 due to increased mortality that has been attributed to reduced abundance of their preferred Chinook salmon prey (Ford et al. 2010). This population will likely continue to be fairly small given their late age at maturation and relatively low fecundity, and is also disproportionately vulnerable to anthropogenic impacts due to their tendency to remain philopatric and travel together in large matrilineal groups. They also do not interbreed with any other killer whale populations, and thus are very unlikely to be stabilized by rescue effects. An overview of the estimated population size for NRKW since 1973, including an update of the current population status, is available annually as a Fisheries and Oceans Canada Science Response document (DFO 2023j).

The entirety of the Kitkatla Inlet Network Zones and surrounding area have been previously proposed as potential critical habitat for NRKW (**Figure 91**). This designation was never made official, however, citing a need for more data. Detailed information on the behaviour and abundance of NRKW in the Kitkatla Inlet Network Zones is currently unknown due to data collection gaps for the Kitkatla Inlet Network Zones area. Analysis of data from a passive acoustic recorder deployed in the southwest portion of Browning Entrance (north of White Rocks) in the summer of 2013 indicated that NRKW were detected on ~46% of recording days (22 of 48 d; DFO, unpublished data). All three acoustic clans, including all subclans, were present, with G and R clans being the most frequently detected on these recordings. R clan is rarer at most other acoustic deployment locations in BC, so it is notable that R clan uses the area around the Kitkatla Inlet Network Zones. The frequency and diversity (in terms of group membership) of NRKW calls in this short span of analyzed data indicate that the Kitkatla Network Zone area may represent an important travel and/or feeding area for NRKW. At this

time, observations by Gitxaala members of Killer whales in the area are not ecotype-specific. However, the Kitkatla Inlet Network Zones provide important habitat for feeding and beach rubbing for NRKW, as detailed below.

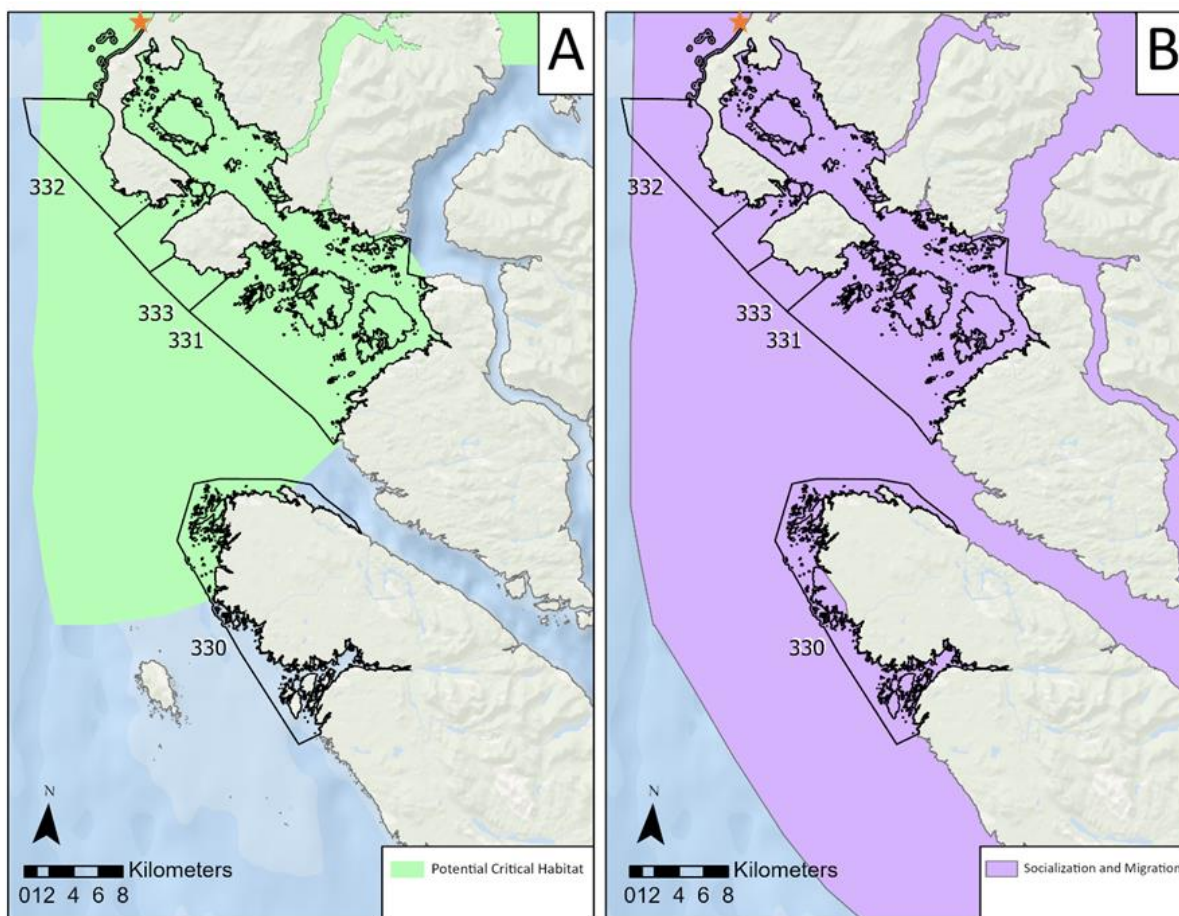


Figure 91. Northern Resident Killer Whale habitats of importance determined by expert opinion from the Pacific North Coast Integrated Management Area data (2007-2012). The orange star indicates Oval Bay, a location used by Northern Resident Killer Whales for beach rubbing. (A) Northern Resident Killer Whale Potential Critical Habitat for Aggregations and Fitness, which is seasonal from May to July (Ford 2006), and (B) habitats of Special Importance ([Important Areas for Cetaceans in PCNIMA](#)).

The seasonal distribution and movement patterns of NRKW are strongly associated with the availability of their preferred prey, **Yee**/Chinook Salmon, and secondarily, **Gayniis**/Chum Salmon (Ford 2006; Ford and Ellis 2006; Ford et al. 2010; Hanson et al. 2010). Thus, habitats that are important for the survival and recovery of Resident Killer Whales provide profitable foraging opportunities for these key prey species (Ford et al. 2017). **Yee** salmon are the preferred prey of NRKW due to their large size and high lipid content (Ford et al. 1998; Ford and Ellis 2006), and the abundance of **yee** is vital to their ongoing survival and long-term population viability (Ford et al. 2010; Clarke Murray et al. 2021). **Yee** 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), providing critical food resources to NRKW (Liu et al. *in press*), before making their way to their

natal streams for the fall spawn, at which time **Yee** are typically distributed closer to their region of origin (Shelton et al. 2019). DFO has recorded 13 predation events (6 **Yee** and 7 **Gayniis**) by NRKW in the Kitkatla region in June and July (between 2005-2015; **Figure 92**; DFO unpublished data). Of these predation events, the vast majority involved **Naaxl**/killer whales from G clan (n=11). **Hoon**/Salmon were taken by NRKW both inside and just outside of the boundaries of the Kitkatla Inlet Network Zones, including off of northwestern **Lax k'naga dzol**/Banks Island, in Principe Channel, off the west side of **Tgii Xsw'aanx**/Porcher Island, and in Beaver Passage and Ogden Channel (**Figure 92**). All **Yee** and **Gayniis** captured by northern Residents in this region were 4-6 year old fish, consistent with a coast-wide diet analysis that found that NRKW preferentially targets older, larger **hoon** (Ford and Ellis 2006). **Yee** captured by NRKW in this area belonged to the following stocks: Fraser River early (n=1), northern BC/southeast Alaska (n=1), Strait of Georgia (n=2) and West Coast Vancouver Island (n=2). Although the sample size of this opportunistic dataset is very small, they still point to the area's importance as a foraging ground for NRKW for both **Yee** and **Gayniis**. The small sample size is primarily due to a relative lack of effort; the region does not receive a lot of visual survey attention by DFO's Cetacean Research Program due to its remote northern location and exposed coastline that can only be surveyed effectively in good weather.

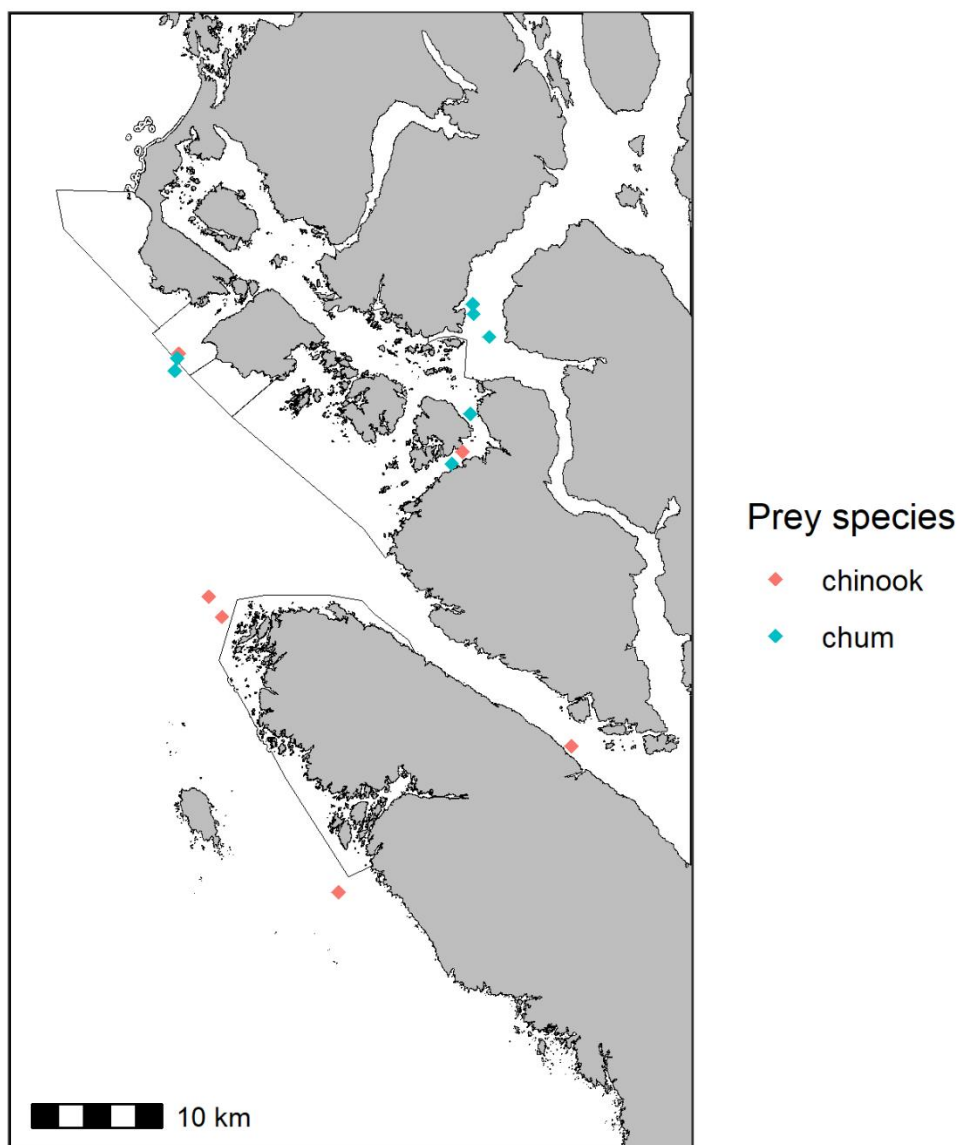


Figure 92. Salmonid predation events (point colour indicates prey species) involving NRKW recorded by DFO in June and July between 2005 and 2015 ($n=13$). The black lines indicate Kitkatla Inlet Network Zone boundaries.

A key NKRW behaviour has been observed within Zone 332 – beach rubbing (**Figure 93**). Beach rubbing is an important pattern of habitat use by NRKWs, which involves regular visits to particular beaches where the **Naaxl**/killer whales repeatedly rub their bodies on smooth pebbles in the shallows for periods averaging 0.2 h (Jacobsen 1986; Ford 1989; Briggs 1991). Beach rubbing appears to be a culturally learned behaviour that has not been observed among other Killer Whale ecotypes or populations, including the closely related Southern Resident Killer Whales (Heimlich-Boran 1988; Ford et al. 2000). Research on the functional role of beach rubbing has been inconclusive. It is believed to be a form of socialization or recreational activity (Ford et al. 1996; Williams et al. 2009), with the number of vocalizations during rubbing reported at similar levels to vocalizations during social behaviours (Ford 1989). The behaviour has been

observed in Johnstone Strait, Queen Charlotte Strait and northern Vancouver Island, as well as on the central and north mainland BC coasts (Ford et al. 2017). Unlike feeding, beach rubbing is strictly associated with particular geographic locations and only occurs at specific sites (Ford 2006). Consequently, the location of Oval Bay within close proximity of the Kitkatla Inlet Network Zones is notable (**Figure 93**) and indicates important habitat for NRKW socialization. Furthermore, NRKW are highly susceptible to disturbance while beach rubbing (Ford et al. 2017). Vessel presence negatively affects the frequency and duration of beach rubbing among NRKWs, with reduced vessel presence correlated with increased beach rubbing activity in Johnston Strait (Konrad Clarke et al. 2024), suggesting that minimizing human disturbance is crucial for the conservation of this behavior. These rubbing sites – which may qualify as critical habitat – should be further investigated using autonomous underwater acoustic recorders (Ford et al. 2017).

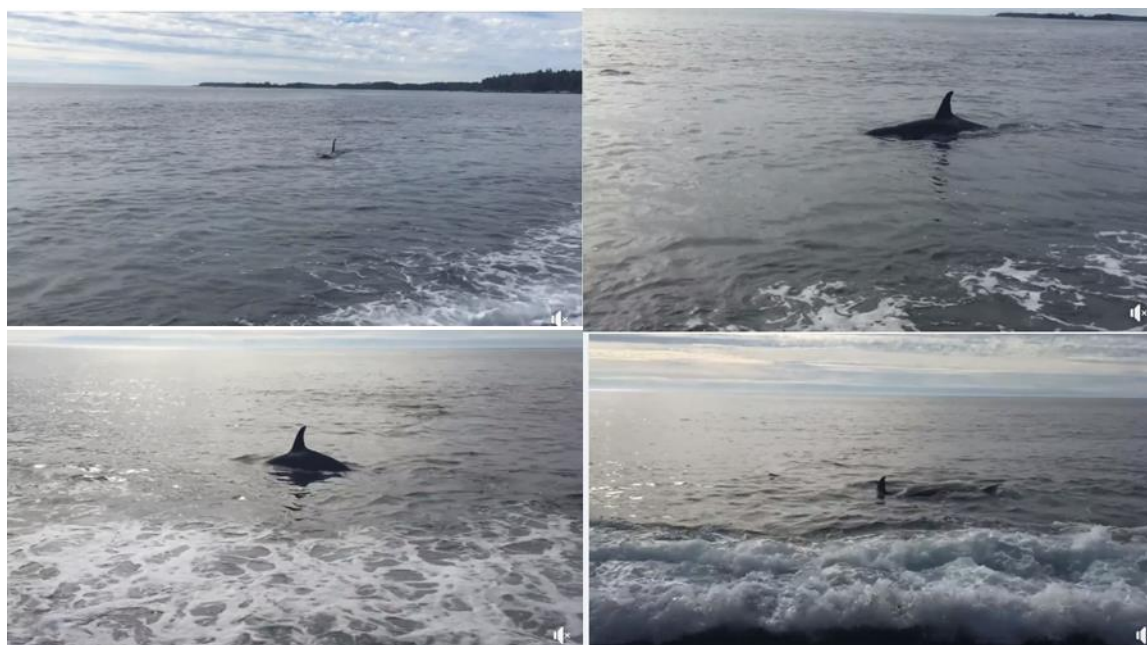


Figure 93. Killer whales beach rubbing in Oval Bay, BC; see **Figure 86** for location. Pictures are stills from a North Coast Eco Tours, *Kxeen*/Prince Rupert, BC, video on their Facebook page. Pictures are in video order from top left to bottom left in a clockwise direction.

6.2.6.2.2 Bigg's Killer Whale

Several genetically distinct and partially sympatric populations of Bigg's (also known as Transient) *Naaxl*/killer whales (BKW) have been described in the eastern North Pacific (Barrett-Lennard and Ellis 2001; Towers et al. 2019; Parsons et al. 2013). The Kitkatla Inlet Network Zones and surrounding area are situated within an identified habitat of special importance (**Figure 94**). To the south of the Kitkatla Inlet Network Zones, in the Caamaño-Douglas area, all BKW that typically frequent the area belong to the putative "inner-coast" sub-population of the larger West Coast Transient population (Liu et al. *in press*), which ranges coastally from southern California to southeast Alaska (Towers et al. 2019). Within the Kitkatla Inlet Network Zones area, both inner and outer coast transient *Naaxl* are observed (**Figure 95**; Ford et al. 2013b), with outer coast BKW north of *Lax k'naga dzol*/Banks Island and inner coast BKW found in Kitkatla Inlet and Channel. Inner-coast BKW was estimated to number 349 individuals as of 2018, and average annual population 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). While BKW were not detected as frequently as NRKW on the Browning Entrance hydrophone analysis from the summer of 2013, they were acoustically present in both July and August on 7 of 48 recording days (DFO, unpublished data). BKW tend to vocalize less often than RKW because they do not want to alert prey (pinnipeds and small cetaceans) to their presence (Deecke et al. 2005), so acoustic detections of BKW likely represent a minimum estimate of habitat use in the region.

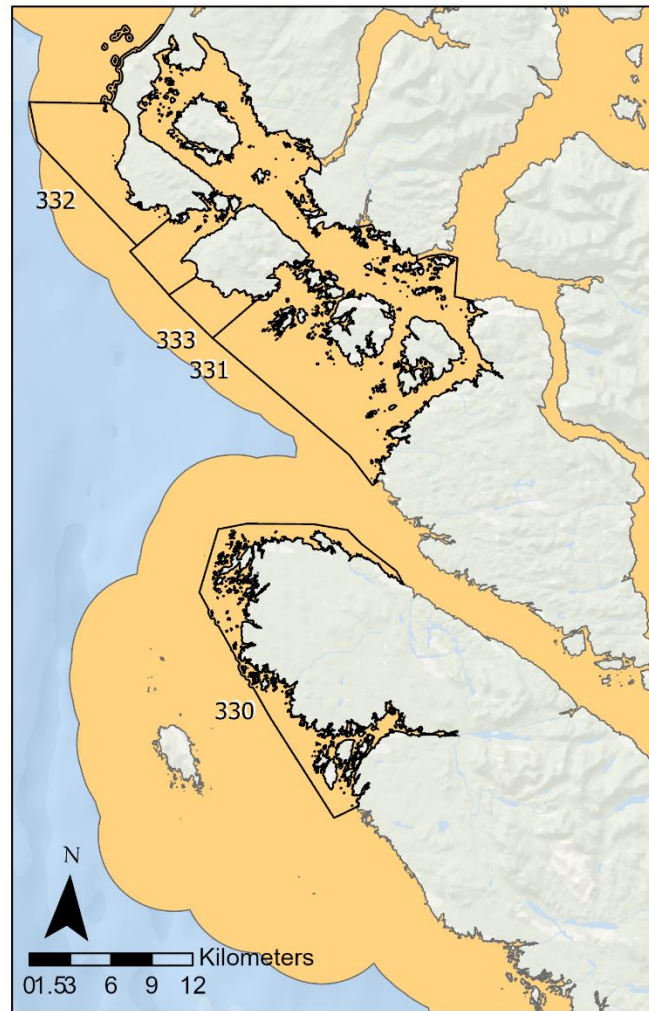


Figure 94. West Coast Transient Killer Whale (Bigg's Killer Whale) Habitat of Special Importance as suggested by Ford et al. 2013b, are marine waters up to 3 NM from shore.

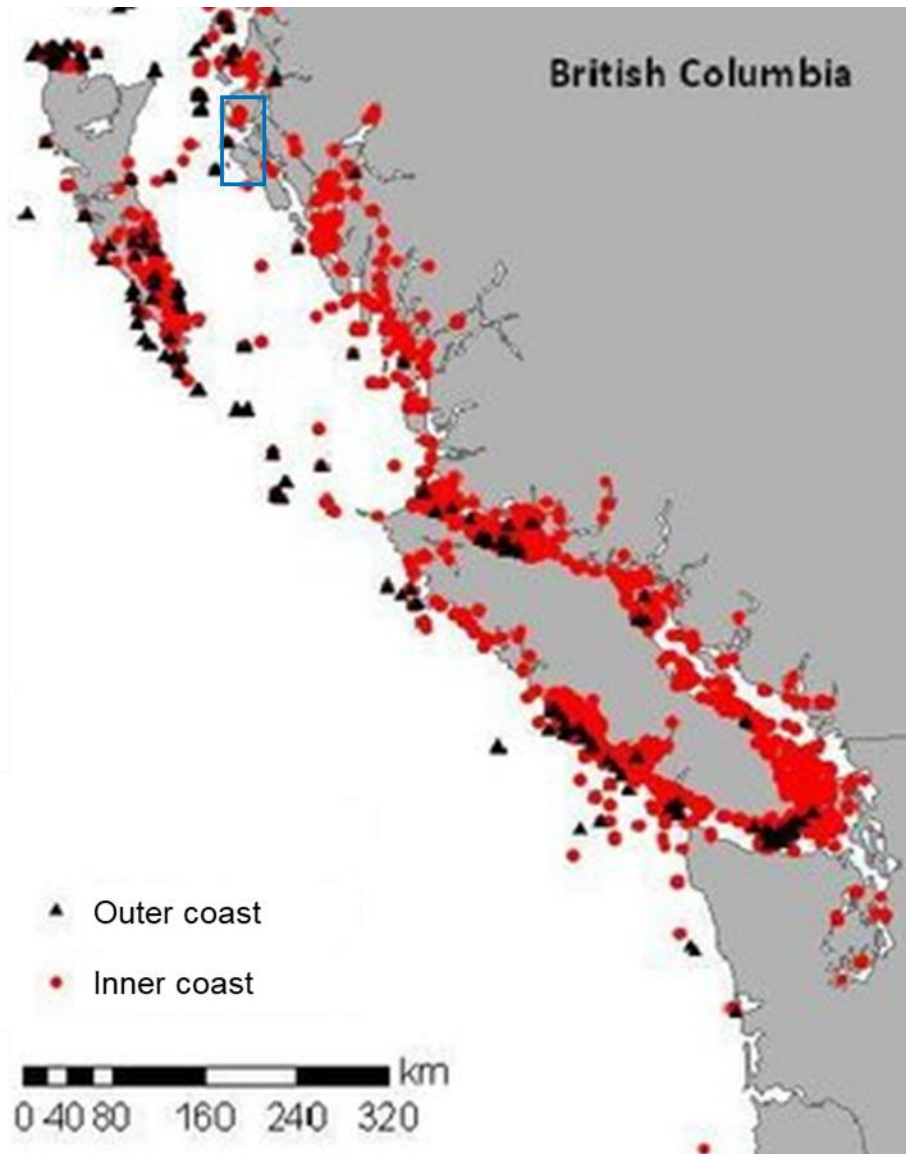


Figure 95. Locations of encounters with Bigg's **Naaxl**/Killer Whales (West Coast Transient killer whales). Individuals belonging to the inner coast WCT subpopulation are shown with red circles, and outer coast WCT individuals are shown with black triangles. Blue rectangle indicates Kitkatla Inlet Network Zones area. Map modified from Figure 2 in Ford et al. 2013.

Like resident **Naaxl**/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. 2013b). BKWs primarily feed on marine mammals (but occasionally also consume **Xbihats'al**/squid and seabirds), with **üüla**/harbour seals comprising over 50% of documented kills and harassments (Ford et al. 1998; Ford et al. 2013b; Hanson and Walker 2014; Ford 2019). The next most-commonly recorded prey species are the harbour porpoise, **t'iibn**/Steller sea lion, and Dall's porpoise (Ford et al. 2013b), all of which are present in the Kitkatla Inlet Network Zones area (see sections below). There are numerous **üüla** haul-outs throughout the region (**Figure 100**) and it is likely that BKW hunt seals when moving through the area, although they tend to take seals that are dispersed in open water rather than

in close proximity to the haul-outs themselves (Ford et al. 2013b). Peaks in BKW presence during periods of consistent summer effort in southeast Alaska and southeast Vancouver Island have been tied to the timing of **üüla** pupping in those regions (Ford et al. 2013b), and a similar pattern could also exist within the Kitkatla Inlet Network Zones area.

6.2.6.2.2.3 Offshore Killer Whales

Offshore **Naaxl**/killer whales (OKW) are the least well-known and least encountered (representing only ~1% of more than 10,000 photo-identification encounters archived by DFO) of the three **Naaxl** ecotypes found in BC (Ford et al. 2014). An average annual range-wide (southern California to Prince William Sound, Alaska) population abundance of 300 **Naaxl** 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 (1988-2012) (Ford et al. 2014). OKW 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).

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, Wright et al. 2025). **Gagaats**/Pacific Spiny Dogfish, a common prey species for Offshore Killer Whales are found throughout the Kitkatla Inlet Network Zones, in addition to Longnose **gandeh**/Skates (*Raja rhina*) and Big **gandeh** (*Raja binoculata*; see Cartilaginous Fishes). Although not within the Kitkatla Inlet Network Zones themselves, DFO has one observation of OKW presence (September 2013) and two observations (both from the same day in July 2016) of OKW feeding events on **txaw**/Pacific halibut, just west of **Lax Kul**/Bonilla Island (Wright et al. 2025). The proximity of the Kitkatla Inlet Network Zones area to the Moresby Trough submarine canyon in Hecate Strait probably provides connectivity between this region and the deeper, more pelagic habitats that OKW often frequent.

6.2.6.2.3 Pacific White-sided Dolphins

Pacific White-sided Dolphins (*Lagenorhynchus obliquidens*; PWSD) are one of the most abundant cetacean species in BC and the North Pacific and are found in offshore, shelf, and inshore habitats (Ford 2014). During the summer months, they may move offshore or into deeper waters, as they are less common in nearshore areas during those months (Morton 2000, Ford 2014). They are upper-level predators which opportunistically feed on fish (**Tskah**/Pacific Herring, adult and juvenile **hoon**/salmon, Capelin, Sablefish, Walleye Pollock), **Xbihats'al**/squid, and **gasgos**/shrimp in BC (Morton 2000, Ford 2014). The species has been documented in Chatham Sound waters northeast of **Tgii Xsw'aanx**/Porcher Island, just outside of the Kitkatla Inlet Network Zones area as of 2015 (Stantec Consulting Ltd. 2019). Historically, the species has occurred in Ogden Channel within the Kitkatla Inlet Networks Zones area (Gitxaala Nation GIS database). Modelled abundances for the species in the outermost coastal regions of the Kitkatla Inlet Network Zones show densities of greater than one individual per each 13.86 km² hexagonal grid cell **Lax k'naga dzol**/Banks Island (**Figure 84**). Kernel density analyses of opportunistic sightings collected by the BC Cetacean Sightings Network, as well as of systematic DFO cetacean surveys from 2002-2010, indicate that the area may be important to PWSD during multiple seasons of the year, but particularly in the fall and winter (see Figures 2.12 and 2.4 in Rechsteiner 2012). More data are needed within the Kitkatla Inlet Network Zones area to document the distribution, abundance, and seasonal usage of the area by this species.

6.2.6.2.4 Harbour Porpoises

Harbour porpoises have been documented in the Kitkatla Inlet Network Zones area as recently as 2010 (**Figure 96**; Ford et al. 2013a), although it is hard to tell in which zones they occur. Furthermore, Williams et al. (2007) have recorded occurrences near the area, and large numbers of harbour porpoises (> 10 individuals) were observed in Oval Bay (near Zone 332) in June 2008 (Graeme Ellis pers. comm. November 2023). Effort-corrected density surface models built using visual, ship-based survey data (collected mainly during the summer months) suggest that Harbour porpoises occur at higher densities in the outer coastal areas of the Kitkatla Inlet Network Zones (**Figure 97**; Wright et al. 2021a). However, the lower densities extremely close to shore at this scale are partially an artifact of the survey design and the model used, which does a relatively poor job of predicting densities close to shore because the ship platform can't get in that close, and density is being predicted by sightings locations (Brianna Wright pers.comm. November 2023).

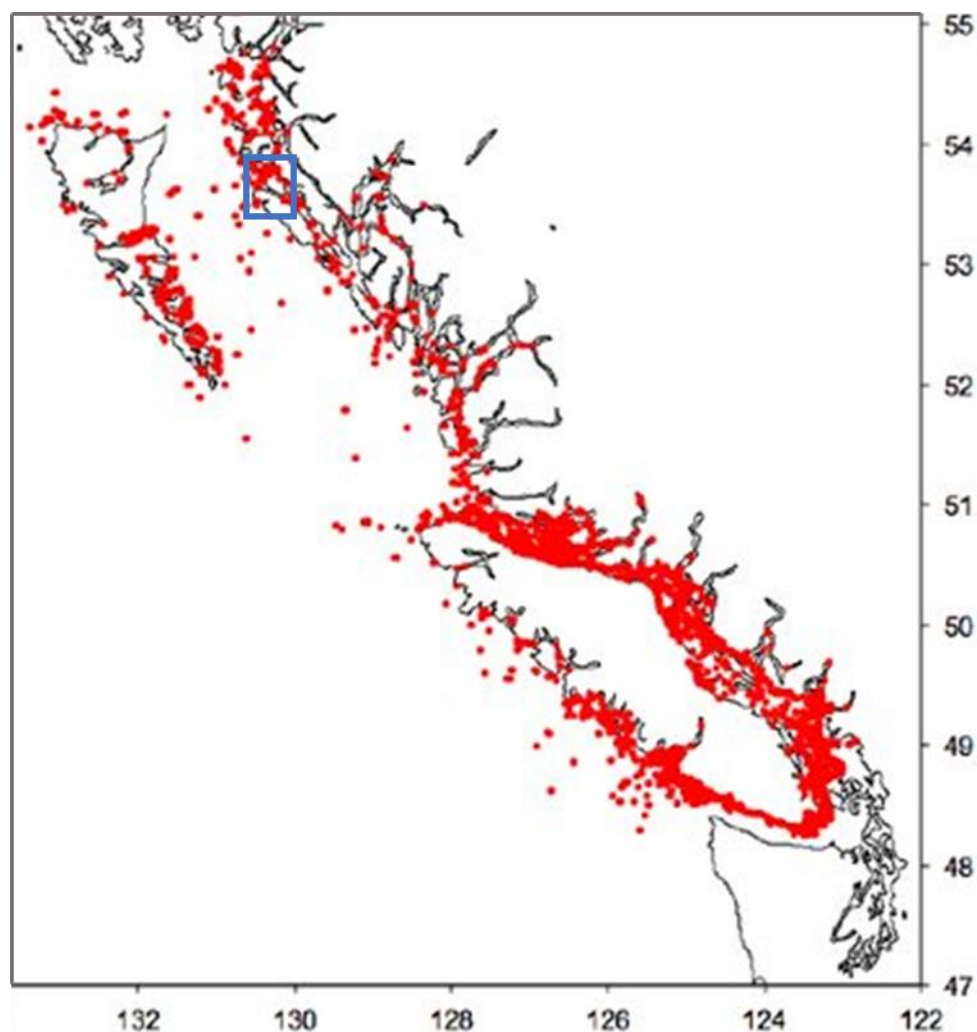


Figure 96. Map of sightings of harbour porpoises in British Columbia. Sighting data from Ford et al. (2010) and BC Cetacean Sightings Network. The blue rectangle indicates the Kitkatla Inlet Network Zones area. Adapted from Figure 18 in Ford et al. 2013a.

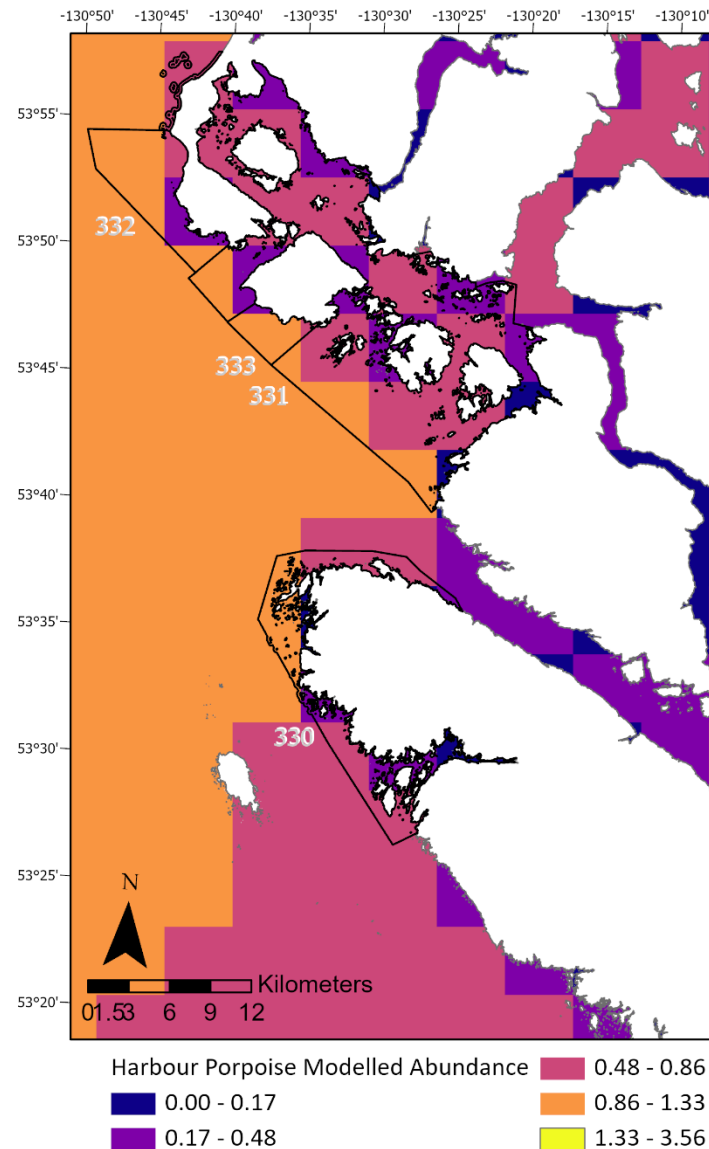


Figure 97. Modelled densities (per 25 km² grid cell) of Harbour Porpoises in the Kitkatla Inlet Network Zones area. The model used cetacean observation data collected in the Pacific Region International Survey of Marine Megafauna (PRISMM; line transect surveys for cetaceans) that occurred in the coastal and offshore waters of British Columbia between July and September of 2018. Network Zones are indicated with black outlines and Zone numbers. These modelled density estimates should be interpreted with caution, as they are based on a single summer survey and predicted over a relatively large scale (5 x 5 km grid cells), using a smoother of sightings locations as the only model covariate. Predicted densities close to shorelines, including inside Kitkatla and Porcher Inlets and Petrel Channel, are therefore likely to be biased low, as these areas were not surveyed during the PRISMM effort. Data from Wright et al. 2021a.

Harbour porpoises are typically found in shallower water (< 150 m deep) and are upper-level predators of **Xbihats'al**/squid and fishes (e.g. **Tskah**/Pacific Herring, Pacific sardine, Walleye Pollock, **Ha'limootk**/Eulachon, Pacific Sand Lance, **balaas**/Pacific Hake, Shiner perch and Northern Anchovy; Pauly et al. 1998, Walker et al. 1998; Ford 2014; Nichol et al. 2013). Harbour porpoises are found year-round in BC (COSEWIC 2005, Ford 2014). While there is limited

evidence of Harbour porpoises migrating, most research has been limited to their behaviour in the Salish Sea (COSEWIC 2005). The Harbour porpoise is listed as a species of “Special Concern” in Canada’s Pacific waters (COSEWIC 2005). It is a conservation priority species in the NSB (**Appendix H**, Gale et al. 2019).

6.2.6.2.5 Dall’s Porpoises

Dall’s porpoises are found across coastal and offshore areas of BC throughout the year. They are upper-level predators of fishes (e.g., **Tskah**/Pacific Herring, Walleye Pollock, **balaas**/Pacific hake, Northern Anchovy, Pacific Saur, sardine, lanternfishes) and **Xbihats'al**/squid (Pauly et al. 1998, Walker et al. 1988; Ford 2014, Nichol et al. 2013). Dall’s porpoises have intermediate to high predicted densities (from summer 2018 PRISMM survey data) of up to more than three individuals per 25 km² in the four modelled zones, with the highest densities predicted for Zone 332 and the westmost part of Zone 331 (**Figure 98**; Wright et al. 2021a). Sighting data further support their occurrence in the Kitkatla Inlet Network Zones area (**Figure 99**; Ford et al. 2013), as does the predicted density map (from systematic 2004-2008 surveys conducted by Raincoast) for the outermost regions of the Kitkatla Inlet Network Zones (**Figure 84**). In BC, Dall’s porpoises may shift inshore during summer and offshore during winter, but little information is available to support this (Ford 2014). Dall’s porpoises generally feed on deeper-water species than Harbour porpoises (Ford 2014).

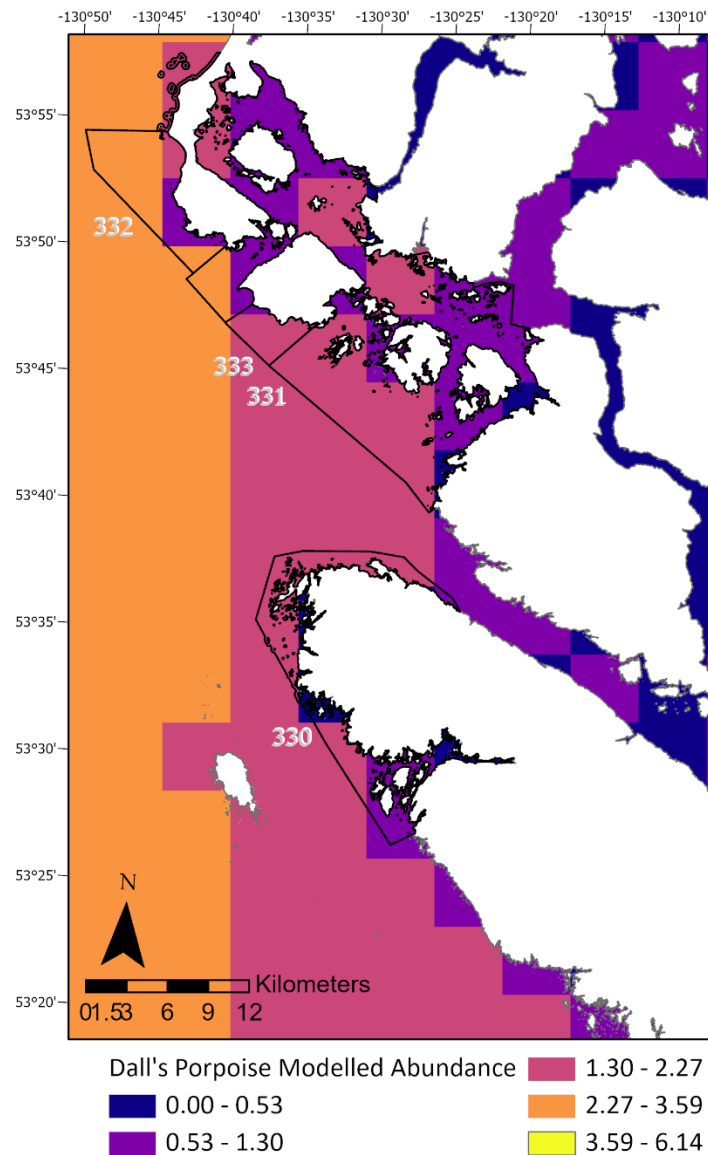


Figure 98. Modelled densities (per 25 km² grid cell) of Dall's Porpoises in the Kitkatla Inlet Network Zones area. The model used cetacean observation data collected in the Pacific Region International Survey of Marine Megafauna (PRISMM; line transect surveys for cetaceans) that occurred in the coastal and offshore waters of British Columbia between July and September of 2018. Network Zones are indicated with black outlines and Zone numbers. These modelled density estimates should be interpreted with caution, as they are based on a single summer survey and predicted over a relatively large scale (5 x 5 km grid cells), using a smoother of sightings locations as the only model covariate. Predicted densities close to shorelines, including inside Kitkatla and Porcher Inlets and Petrel Channel, are therefore likely to be biased low, as these areas were not surveyed during the PRISMM effort. Data from Wright et al. 2021a.

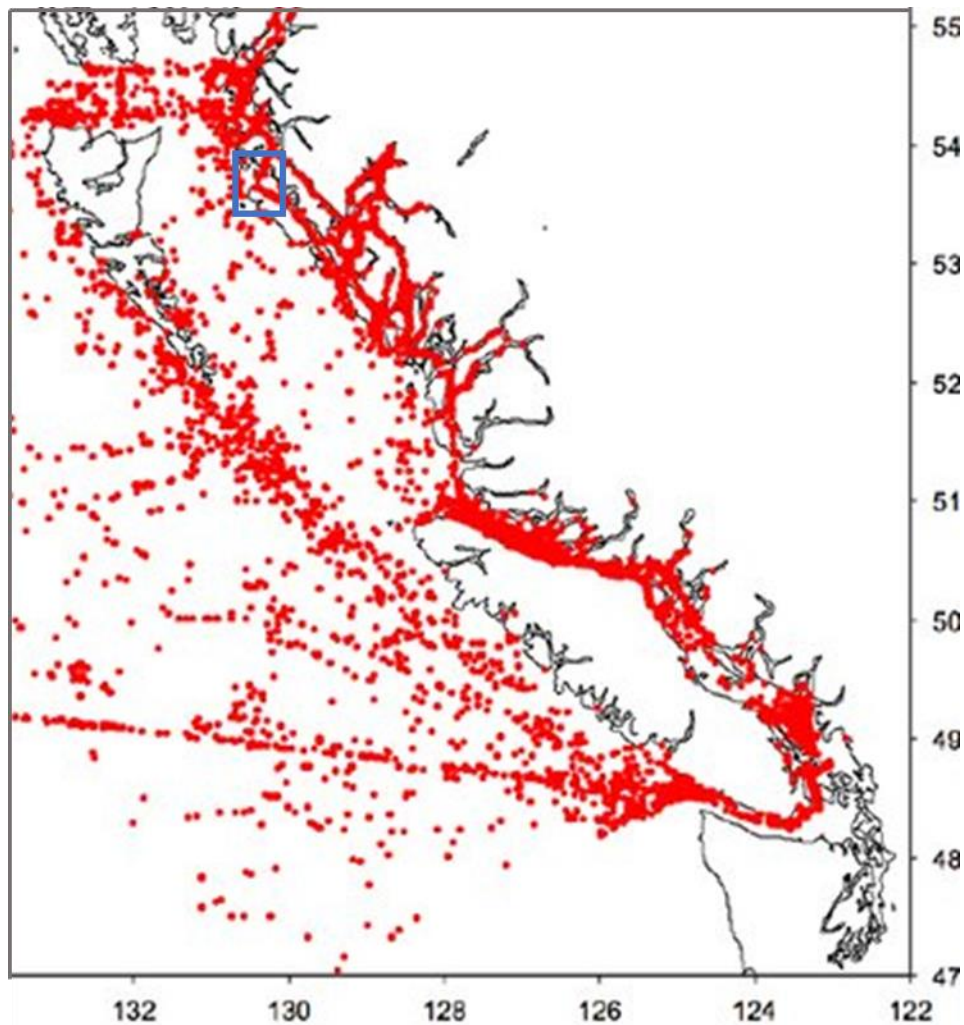


Figure 99. Map of sightings of Dall's porpoises in British Columbia. Sighting data from Ford et al. (2010) and BC Cetacean Sightings Network. The blue rectangle indicates the Kitkatla Inlet Network Zones area. Adapted from Figure 19 in Ford et al. 2013a.

6.2.6.3 Pinnipeds

The presence of seals (species not determined) in the Kitkatla Inlet was confirmed by Gitxaala harvesters, as the seals often follow the **Geega tskah**/herring spawn into the inlet. Seals were also noted to occur in proximity to McCauley Island, Pitt Island, Barren Rocks, the narrow pass by the Ness Islands, around the Cessford Islands, Prager Islands, Absalom Island, Coquitlam Island, Christie Island, off the west coast of **Lax k'naga dzol**/Banks Island, Spicer Island, Freeman Pass, Willis Bay, and the Petrel Channel. Seals were also noted across from Robert's Island on the Porcher Peninsula (Gitxaala Nation GIS database).

6.2.6.3.1 **Üüla** / Harbour seals

Üüla/Harbour seals (*Phoca vitulina*) are one of BC's most abundant pinniped species. They 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.

Üüla/Harbour Seals were most recently assessed in BC following a multi-year aerial survey covering 90% of the coast from 2015 – 2019 (DFO 2022h). A notable number of Harbour seal haul-outs are within and just outside the Kitkatla Inlet Network Zones (**Figure 100**). Therefore, waters within the Zones likely support more seals than counts solely obtained from haul-outs within the polygons. While Üüla 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 centred around low aks/tides when haul-out substrates are available.

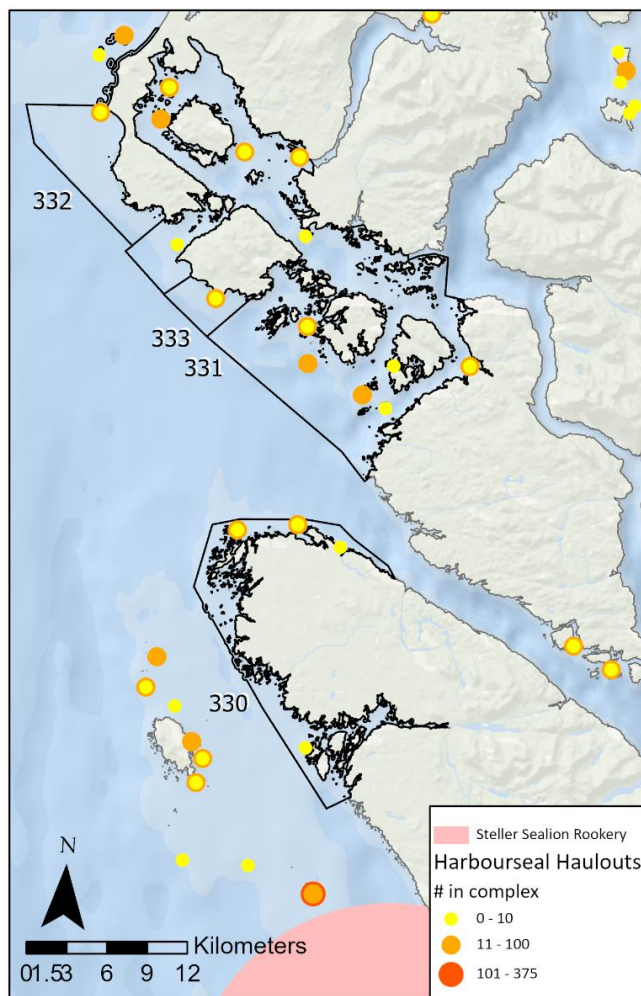


Figure 100. Harbour seal haul-out locations collected from 1966-2016 during DFO aerial surveys. Number of individuals in each haulout complex is indicated by the size and colour of the yellow to red circles. A single large Steller sealion rookery is shown in pink to the south of Zone 330 off Lax k'naga dzol/Banks Island.

Üüla/Harbour Seals are generalist carnivores with high site fidelity. Recent telemetry data from 33 Üüla instrumented in the spring/summer in the central Strait of Georgia (2019 - 2021) show

ÜÜla typically remain within 10 - 15 km of the haul-out at which they were tagged (Liu et al. *in press*). While no tagging data are available for BC ÜÜla outside of the Strait of Georgia, there is no reason to suspect that movement patterns for seals in the Kitkatla Inlet Network Zones differ from observations in southern BC or from other ÜÜla studies globally (Liu et al. *in press*). Studies from southern BC and Washington State show ÜÜla to be generalist feeders that consume a wide variety of fish and cephalopod prey (Thomas et al. 2022, Liu et al. *in press*). Gadids (e.g., **balaas**/Pacific hake) and small forage fish (e.g., **Tskah**/Pacific herring) make up the bulk of their diet, with flatfish and salmonids being seasonally important. There are no specific diet studies of ÜÜla 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, are a knowledge gap throughout BC. As marine mammals, ÜÜla are among the top piscivorous predators in the ecosystem but are themselves the main prey species for *Bigg's* Killer Whales and occasionally prey for larger **Ksah**/shark species.

6.2.6.3.2 Fur seals

Northern Fur Seals (*Callorhinus ursinus*) are another abundant pinniped in BC, although categorized as threatened (COSEWIC 2010b). They are often sighted offshore, travelling through BC between California and their breeding colonies in Alaska and Russia (Ford 2014). All four Kitkatla Inlet Network Zones overlap with a large area identified as important for fur seal aggregation and feeding within the NSB (**Figure 101**). Although we could not find documented species occurrences within the area, they are thought to occur in the area, but little is known (*sensu* Liu et al. *in press*).

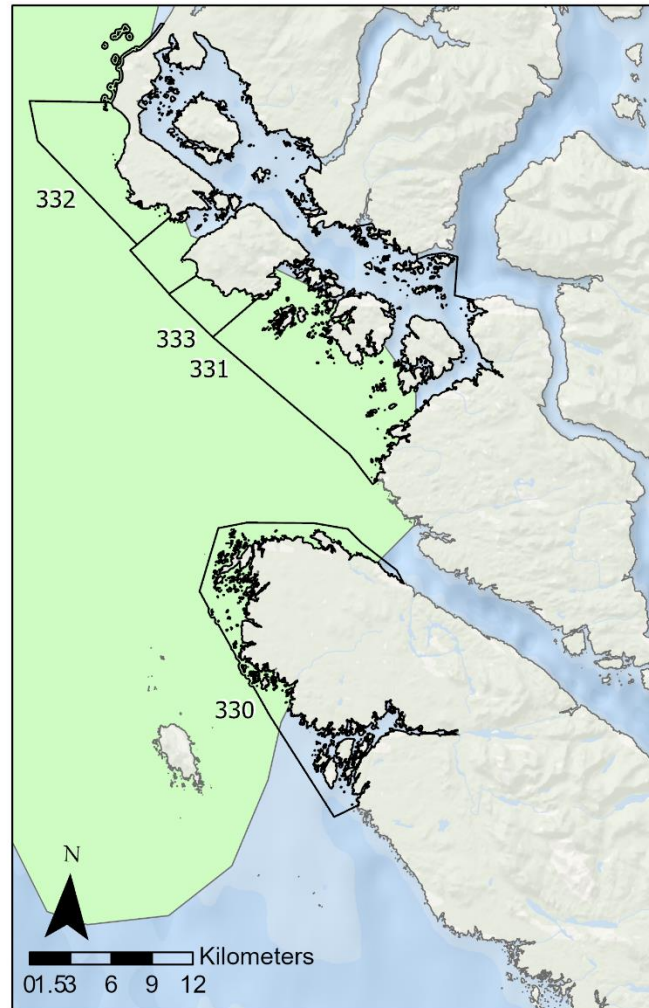


Figure 101. Important Area for aggregation and a feeding ground for Fur Seals in the Kitkatla Inlet Network Zones area. BCMCA

6.2.6.3.3 T'iibn /Steller Sea lions

T'iibn/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. The species was documented year-round in Chatham Sound waters to the northeast of **Tgii Xsw'aanx**/Porcher Island (just outside of the Kitkatla Inlet Network Zones area) in 2015 (Stantec Consulting Ltd. 2019). Individuals were observed exhibiting a range of behaviours, including feeding, looking, milling, travelling and resting. Furthermore, there is a large rookery off the midwest coast **Lax k'naga dzol**/Banks Island (**Figure 100**) south of Zone 330 and a year-round haul-out on **Lax Kul**/Bonilla Island to the west of Zone 330 (COSEWIC 2003b). Local observations of **t'iibn** in the Kitkatla Inlet Network Zones include Kitkatla Inlet, along the west coast of **Tgii Xsw'aanx**, southeast of Cape George on Porcher Peninsula of **Tgii Xsw'aanx**, along the shore of **Lax k'naga dzol** (Gitxaala Nation GIS database). Many of these observations are from Gitxaala harvesters hunting sealions **Tgii Xsw'aanx** and the north shore of **Lax k'naga dzol**. Hunting of sealions west of **Tgii Xsw'aanx** occurs just before the roe on kelp fishery in March/April (Gitxaala Nation GIS database). Sea lions have been documented

coming to area just north of Freeman pass (in Zone 332) to feed on roe on kelp (Gitxaala Nation GIS database).

In general, **t'iibn**/Steller sea lions have a diverse diet, with major contributions from gadids (e.g., walleye pollock, **k'a'wts**/Pacific cod), forage fish (e.g., **Tskah**/Pacific herring, **Ha'limootk**/eulachon), cephalopods (e.g., Giant Pacific **hats'al**/octopus), flatfish (e.g., starry flounder, English sole, sand sole) and lesser contributions from salmonids (**sti'moon**/Pink, **Gayniis** /Chum, **misoo**/Sockeye) and rockfish (various species) (Liu et al. *in press*). Like **üüla**/Harbour seals, **t'iibn** are top piscivorous predators in the ecosystem while also being an important prey species for *Bigg's* **Naaxl**/killer whales and occasional prey for larger **Ksah**/shark species. Summer diets of **t'iibn** along the central coast have not been previously described (Liu et al. *in press*).

6.2.6.4 **Ploon** / Sea otters

Ploon/Sea otters are recognized as a keystone species because they alter nearshore subtidal community structure due to their metabolic need to consume large quantities of food (primarily invertebrates). In rocky exposed areas, the relationship between **ploon**, **aswit**/urchins, and kelps is well documented (Estes and Palmisano 1974, Estes and Duggins 1995, Watson and Estes 2011). As of 2017, BC's **ploon** population was estimated at 8,110, of which 1,847 occur along the central and northern BC coast (Nichol et al. 2020). In the recent Caamaño Sound and Douglas Fjord System report (Liu et al. *in press*). DFO's 2017 **ploon**/sea otter survey results were reported, where over 200 animals were counted off the west side of Aristizabal Island, just to the south of the Kitkatla Inlet Network Zones (**Figure 102**). Furthermore, it has been hypothesized that the **ploon** population and range will expand northward and could be expected to occur along **Lax k'naga dzol**/Banks Island and into Chatham Sound within the Kitkatla Inlet Network Zones area (**Figure 103**; Gregr et al. 2008; Nichol et al. 2020). For more information on **ploon** behaviour and ecology, please refer to Liu et al. *in press*.

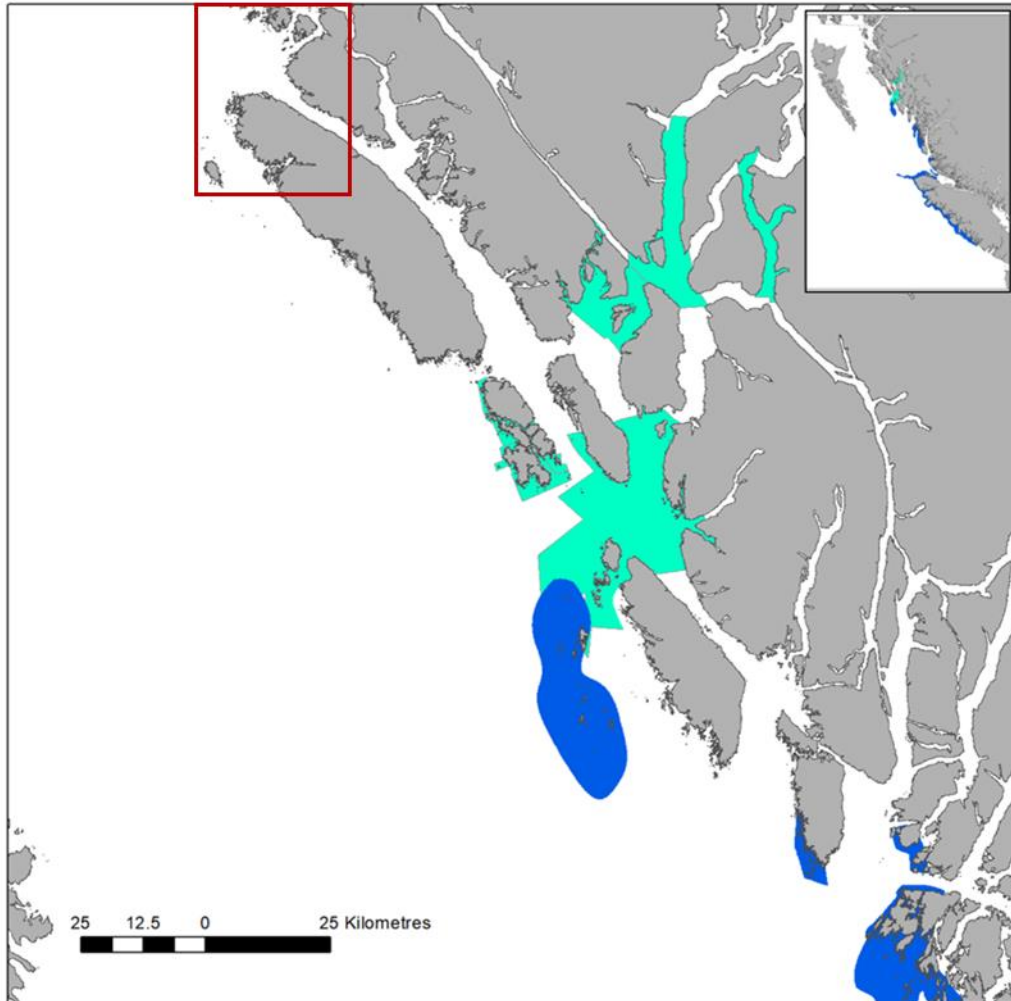


Figure 102. *ploon*/Sea otter population range (blue polygons) in British Columbia and the overlap with the Caamaño Sound Douglas Fjord System Network Zones (turquoise). The red polygon box to the north shows where the Kitkatla Inlet Network Zones are located. The Inset map presents the whole range of the *ploon* in BC as of 2017 and the Caamaño Sound Douglas Fjord System Network Zones. The *ploon* range is represented by large contiguous polygons that include broad areas around observed raft locations. Map is modified and taken from Liu et al. in press.

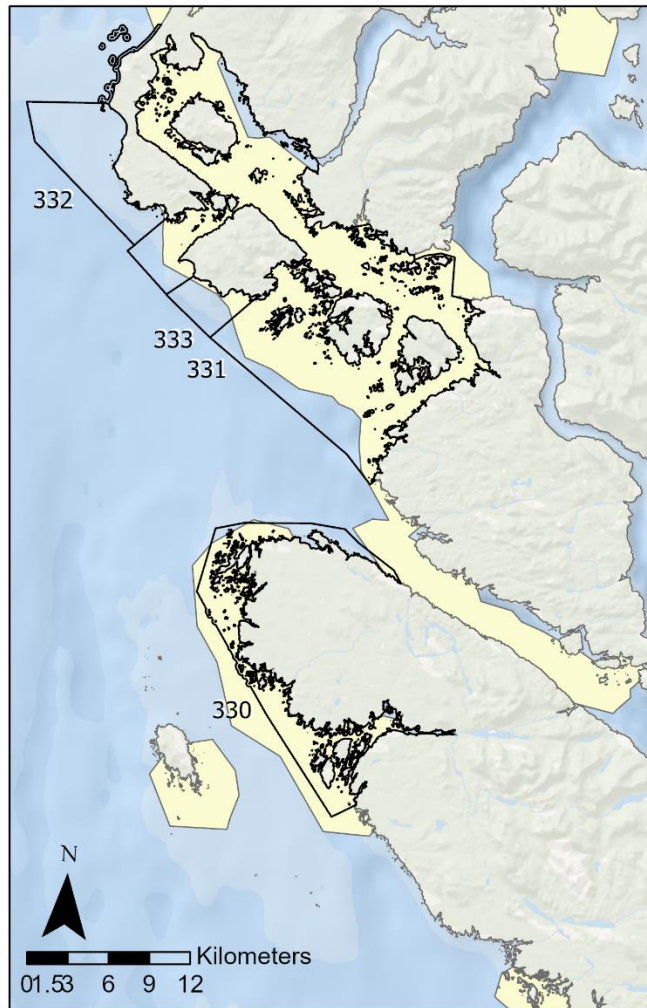


Figure 103. *ploon*/Sea otter modelled habitat overlaps with the Kitkatla Inlet Network Zones area. The habitat model (Gregar et al. 2008) was developed from the complexity of nearshore intertidal and sub-tidal bathymetric contours. This area is as yet unoccupied by *ploon* but may provide an appropriate habitat for sustaining populations—data from BCMCA.

6.2.6.5 Sensitivities 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 vulnerabilities due to their increased overlap with and frequency of exposure to human activities in nearshore habitats. Below is a brief overview of the characteristics of marine mammal populations in the Kitkatla Inlet Network Zones area that make them sensitive to and resilient to anthropogenic stressors.

The relatively long generation time and low fecundity of all *ibuun*/whale species make them particularly sensitive to the impacts of anthropogenic stressors. Baleen *ibuun*, such as fin and humpback whales, are found throughout the northern BC coast and the broader Canadian Pacific (Dalla Rosa et al. 2012; Best et al. 2015; Wright et al. 2021a). In addition to the sensitivities caused by generation time and fecundity, all three *Naaxl*/killer whale ecotypes that use the Kitkatla Inlet Network Zones area also have quite small population sizes (several

hundred or less) that may make them less resilient to anthropogenic threats. While pinnipeds and **ploon**/sea otters generally have shorter generation times and higher fecundity than cetaceans, they also aggregate in large groups (on haul-outs or rafts). They thus could be disproportionately impacted by anthropogenic stressors compared to less gregarious species.

Notable stressors for marine mammal species in the Kitkatla Inlet Network Zones 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 risk (Williams et al. 2011), and hydrocarbon spills. Pinnipeds are most vulnerable to anthropogenic disturbances when stressors are near rookeries and haul-outs or occur during the breeding season (COSEWIC 2013b). Pinnipeds may be more disturbed by vessel noise and presence than vessel strikes, although strikes are still possible. Vessels approaching haul-outs and vessels changing gear have been known to cause pinnipeds to flush (i.e., quickly rush back into the water) (Erbe et al. 2019). 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) and other anthropogenic threats (e.g., fisheries competition, microplastics, oil spills, persistent pollutants, etc.). Because marine mammals are often at or near the top of marine food webs, stressors that negatively impact key prey species (e.g. climate change stressors) 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 into 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 these species 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, **üüla**/harbour seals were also depleted in BC due to predator control programs and harvesting in the late 1800s through the mid-1900s (reduced to an estimated ~10,000 animals; DFO 2022h). This population had fully recovered by the early 2000s to just over 100,000 animals following a complete ban on hunting that began in the 1970s. Harbour seal populations have been stable or declining for the last 20 y, probably because they have reached carrying capacity in most regions of the BC coast. Juvenile **t'iibn**/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 **üüla** and **t'iibn** have the potential to influence and be influenced by the population dynamics of both their primary prey (through bottom-up limitation) and their main predators (via top-down processes). Predator control is the main stressor limiting many pinniped populations in the 20th century (Allen and Angliss, 2012; COSEWIC 2013b). However, predator removal licenses for **t'iibn** are no longer being distributed in BC, and there is a proposal to remove the “nuisance seal” license in Canada ([DFO consultation and reviews, 2021](#)).

Information on the aforementioned anthropogenic stressors is provided in detail in Liu et al. *in press*. We highlight marine traffic as a specific example below regarding proposed LNG development in the area and how it affects marine mammals.

Marine Traffic

Anywhere marine traffic overlaps with marine mammal habitat, there is a risk of collision (Nichol et al. 2017). The Kitkatla Inlet Network Zones are part of a key travel route between **Kxeen**/Prince Rupert and Kitimat. The Zones are at risk of increased marine traffic, with increased Liquefied Natural Gas (LNG) Canada ship traffic proposed to commence in 2025. Vessel strikes are a major source of mortality and injury for baleen **ibuun**/whales globally (Laist et al. 2001, Pirotta 2018). Two sets of surveys in the sound between Stephens Island and Port Edward north of **Tgii Xsw'aanx**/Porcher Island were completed in light of the proposed increase in LNG traffic. Populations of harbour porpoises, humpback whales, **Naaxl**/killer whales, **üüla**/harbour seals, and **t'iibn**/Steller sea lions were found in the immediate vicinity and are at risk from vessel-associated impacts ([Pacific NorthWest LNG Project Marine Mammal Program Interim Report](#)).

To the south, 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, with an average rate of two (95% CI = 0-5) and 18 mortalities (95% CI = 12-25) per year for fin whales and humpback whales, respectively (Liu et al. *in press*). 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 (Liu et al. *in press*). For humpback whales, these mortalities in the Caamaño-Douglas Area will likely exceed PBR for the portion of this population in the North Coast region of BC. They will also exceed 50% of PBR for the entire Canadian population as a whole (Keen et al. 2023).

Like fin and humpback whales, **Naaxl**/killer whales are vulnerable to vessel strikes in the 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 **Naaxl** mortalities were recorded between 1974 and 2016 (Clarke Murray et al. 2021). One of Bigg's **Naaxl** mortality in 2007 was 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 **Naaxl** to leave an area.

Harbour seals and **t'iibn**/Steller sea lions show disturbance reactions and flush into the water when vessels (including unpowered craft, such as kayaks) approach their haul-outs (Johnson & Acevedo-Gutiérrez 2007; Kucey 2005), which may have physiological implications related to energetics and stress. Low-flying aircraft, including Unmanned Aerial Vehicles (UAVs), will have similar disturbance impacts on hauled-out pinnipeds (Liu et al. *in press*).

Noise disturbance is considered a significant threat for **ibuun**/whales in general and is noted as a key concern with increased marine traffic by Gitxaala Nation (Gitxaala Nation GIS database). Acute noise exposure is potentially lethal for baleen **ibuun** (Gailey et al. 2007, Dunlop et al. 2017, Harris et al. 2018), and chronic ambient noise can contribute to 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 low frequencies, which are similar to the frequency at which fin whales communicate (< 100 Hz) (Tasker et al. 2010; Clark et al. 2009; Erbe et al. 2016). Resting mother-calf pairs of humpback whales are sensitive to increases in anthropogenic noise levels and respond by spending less time resting, swimming faster, and increasing their respiration rates (Sprogis et al. 2020).

Vessel noise, which includes both engine noise and high-frequency noise from echo sounders (e.g., depth sounders and fish finders), is also likely to disrupt the natural behaviours of **Naaxl**/killer whales (Burnham et al. 2022). In particular, resident **Naaxl** may experience reduced foraging efficiency, given their reliance on echolocation for finding and capturing fish (Wright et al. 2021b; Dahlheim et al. 2008). Resident **Naaxl** 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. Bigg's **Naaxl** rely on silence and stealth attacks for hunting marine mammals, so underwater noise also impacts their foraging efficiency by interfering with prey detection via passive listening (Barrett-Lennard et al. 1996; Ford et al. 2013a). Vessel noise could also disrupt communication calls between individuals (Holt et al. 2009) and thus prevent **Naaxl** from locating one another, potentially reducing reproductive opportunities and interfering with important cooperative behaviours, such as prey sharing or coordinated hunting.

6.2.6.6 Data and Knowledge Gaps

Information regarding marine mammal distribution and behaviour within the Kitkatla Inlet Network Zones area is patchy. It primarily comes from the Gitxaala Nation GIS database or previously identified important areas by experts collated during the NSB Network process. Surface density models (largely using summer data) also indicate the abundance and distribution of cetacean species in the area (Harvey et al. 2017; Wright et al. 2021a). Furthermore, at least part of the Kitkatla Inlet Network Zones area has been identified as cetacean hotspots (*sensu* Harvey et al. 2017; **Figure 85**), illustrating the relevant importance of the Kitkatla Inlet Network Zones area to the distribution of cetaceans in the Pacific Region. Data is particularly sparse for Minke whales and Pacific White Sided dolphins in the area. Of key interest is Zone 332, the site of critical Northern **Naaxl**/Killer whale habitat – and in close proximity to Oval Bay, where beach rubbing activity has been observed.

The Kitkatla Inlet Network Zones are within a key travel corridor between the northern and central/southern coasts for cetaceans, and for vessel traffic between ports. More research is needed to understand patterns of cetacean distribution in the region. This includes surveys designed for tracking both seasonal and long-term changes in the abundance, distribution and behaviour of marine mammals using Kitkatla Inlet and area. This information is key to addressing anthropogenic impacts on populations and monitoring the area's importance to the continued health and abundance of marine mammal populations that utilize the Zones. For instance, there is currently no monitoring of underwater noise or its potential impact on marine mammal populations in the region despite increased marine traffic. Given the relative remoteness of the area and the difficulty of conducting visual surveys in seasons other than summer due to unfavourable weather conditions, there would also be a great benefit to further analyses of acoustic recording data to understand the region's cetacean presence better.

7 CONSERVATION PRIORITIES

7.1 Conservation Significance

The Kitkatla Inlet Network Zones are individual sites within the NSB MPA network. Through the MPA Network planning process, zones were identified for protection based on various factors, including their contribution to representing the network's cultural conservation priorities (C-CPs) and ecological conservation priorities (E-CPs; Gale et al. 2019). This section describes the

conservation significance of the Kitkatla Inlet Network Zones area based on the presence of these Network-level C-CPs and E-CPs identified during the NSB MPA planning process. As part of the collaborative MPA network design process in the NSB, Partner First Nations identified areas within the NSB of high cultural and spiritual significance called C-CPs (MPA Network BC Northern Shelf Initiative 2023). Representation of C-CPs within the Network Zones includes harvesting areas, knowledge transference sites, areas containing species of cultural significance, places of recreational use, archaeological sites, and abandoned or contemporary village sites. The importance of C-CPs in the NSB and within the specific Network Zones area was informed by First Nation partners in relation to their territories; the C-CPs do not capture the interests of all First Nations communities in the NSB⁴. By contrast, 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**/Bull Kelp biobands; Gale et al. 2019). Cultural conservation priorities were also assigned protection targets based on rankings assigned independently by each First Nation. Ecological and cultural conservation targets were incorporated into Marxan analyses to inform Network scenario development. Consequently, the relative proportion of conservation priorities that the Kitkatla Inlet Network Zones contribute can be examined and compared to target achievement for the entire network.

Below are the cultural and ecological conservation priorities for the four Kitkatla Inlet Network Zones. Additional characteristics of each zone that contribute to their conservation importance are outlined in the **Summary** of this report.

7.2 Network Cultural Conservation Priorities

The Kitkatla Inlet Network Zones area is abundant with culturally and spiritually significant sites for the Gitxaala First Nation. Gitxaala Nation has governed the Laxyuubm Gitxaala for thousands of years and has maintained exclusive jurisdiction and occupation through the authority of the **smgyigyeyet** (chiefs) under the **ayaawx** (Gitxaala law) (Nees Hiwaas Aff. ¶ 7, October 21, 2021). Preservation of these cultural components can ensure the resources and environment tied to cultural and spiritual wellbeing are abundant for generations.

Kitkatla Inlet Network Zones that overlap with C-CPs evaluated as 'high', 'very high' and 'critical' are summarized in **Table 21** and overlap up to 64% of the Kitkatla Inlet Network Zones area. The village of **Lach Klan** also referred to as Kitkatla is located on Dolphin Island. This village has been occupied for over 10,000 years and is currently home to 450 Gitxaala citizens. This central village was established from smaller villages on Pitt Island, **Lax k'naga dzol**/Banks Island, and the mainland from Lowe Inlet. The longstanding occupation of the Kitkatla Inlet Network Zones means that these areas are the location of significant cultural sites, origin stories, and harvesting activities.

Table 21. Summary results for individual cultural conservation priorities (C-CPs) in the Kitkatla Inlet 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)	Proportion of Zone area
330	North Lax k'naga dzol /Banks Island (Critical)	25.53	0.37

331, 332, 333	Browning Entrance/Dolphin Island (Critical)	230.25	0.69*

*Zone areas are summed (331.39 km²).

7.3 Network Ecological Conservation Priorities

The contribution of the Kitkatla Inlet Network Zones to the coverage of the relevant E-CPs in the NSB MPA Network is summarized in **Table 22**. The proportions provided represent the proportional amount of each feature found within the Network scenario footprint contained in the Network Zones without considering the potential consequence of human activities. For this analysis, only those spatial features with at least 2% total coverage are included (**Table 22**). It is important to note that this summary is based on available data and will likely underestimate zone-specific conservation contributions due to patchy spatial data on conservation features, given this area lacks a history of comprehensive biological surveys, and the DFO surveys that do occur in the area are limited in spatial scope and target species. 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. Zones 330 and 331 include the highest proportional value of E-CPs for both species and habitat features. The highest total species feature proportions (> 8%) occurred for loon/grebe winter density; **tsk^{ah}**/Pacific Herring spawn habitat index, sea duck density in winter, **gyoós**/Giant Kelp distribution, and **Mo'ox**/Bull Kelp distribution. The highest habitat feature total proportions (≥ 10%) occurred for sand flat coastal classes, and Chatham Sound EBSAS. Zone 331 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 its surface area, including **gadza k'aw**/eelgrass priority polygons, **ploon**/sea otter modelled habitat, loon/grebe winter density, **tsk^{ah}**/Pacific Herring spawning habitat, sea duck winter density, sand flat coastal classes, and the Chatham Sound EBSA (**Table 22**). The higher coverage of ECPs is not surprising for Zone 331 due to its size, long contiguous coastline, broken islands, and depth ranges. Zone 333 has very low E-CP coverage, corresponding to this zone's small size.

Table 22. Summary results for individual ecological conservation priorities (E-CPs) in the Kitkatla Inlet Network Zones. The total proportion is the sum of the proportions of each E-CP in the network scenario footprint found in the Kitkatla Inlet Network Zones, without considering the potential consequence of human activities within the Zone. Only those features for which there is at least 2% coverage in the Network Zones are included. The 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 I. Total Prop. is the total proportion of each E-CP feature captured by the Kitkatla Inlet Network Zones. Dash indicates no data or percent coverage < 0.0%.

E-CP Feature Name	Zone 330	Zone 331	Zone 332	Zone 333	Total Prop.
Species Features					
Green sea urchin records	1.4%	0.7%	-	-	2.1%
Goose/Swan year round density	0.6%	1.7%	0.0%	-	2.3%
Surfgrass Biobands	1.0%	-	0.4%	0.3%	1.6%
Marbled Murrelet year round density	-	2.2%	0.0%	0.3%	2.5%
Sea duck, unspecified staging density	0.1%	2.3%	0.0%	0.2%	2.6%
Littleneck clam records	1.0%	1.7%	-	-	2.7%
General Kelp Distribution	1.6%	0.5%	0.5%	0.0%	2.8%
Butter clams records	0.6%	2.3%	-	-	2.9%
Important Bird Areas polygons	-	2.5%	0.4%	0.1%	3.0%
Horse clam records	2.0%	1.0%	-	-	3.1%
Cockles records	0.7%	2.5%	-	-	3.1%
Goose/Swan winter density	0.9%	2.3%	-	-	3.2%
Loon/Grebe year round density	0.1%	2.8%	0.1%	0.2%	3.3%
Bull Kelp Biobands	0.8%	2.3%	0.1%	0.1%	3.4%
Purple-hinged rock scallop records	3.5%	-	-	-	3.5%
Harbour Porpoise density	-	3.6%	-	0.4%	4.0%
Red sea urchin records	1.4%	2.3%	0.5%	0.2%	4.3%
Geoduck records	2.4%	2.1%	-	0.0%	4.5%
Ochre sea star records	4.5%	-	-	-	4.5%
Eelgrass Distribution	-	4.7%	-	-	4.7%
Murres/Large Alcids winter density	0.1%	3.7%	0.6%	0.3%	4.7%
Giant Kelp Biobands	1.6%	3.0%	0.1%	0.1%	4.8%
Eelgrass Priority Polygons	-	5.2%	-	-	5.2%
Great Blue Heron winter density	-	4.3%	1.2%	-	5.6%
Eelgrass Biobands	3.1%	3.3%	-	-	6.4%
Sea Otter Modeled Habitat	1.4%	5.4%	0.0%	0.1%	6.9%
Puget Sound king crab records	6.9%	-	-	-	6.9%
Loon/Grebe winter density	0.1%	7.8%	0.1%	0.2%	8.2%
Pacific Herring Spawn Habitat Index	0.1%	8.2%	0.1%	0.0%	8.4%
Sea duck, unspecified winter density	1.3%	6.0%	0.9%	0.4%	8.5%
Giant Kelp Distribution	3.7%	1.7%	2.8%	0.3%	8.5%
Bull Kelp Distribution	3.1%	2.8%	3.4%	1.0%	10.3%
Habitat Features					

E-CP Feature Name	Zone 330	Zone 331	Zone 332	Zone 333	Total Prop.
Fjord wall steep Geomorphic Units	0.1%	2.0%	-	-	2.1%
North Coast Fjords Ecosections	0.1%	2.4%	-	-	2.5%
Rock Ramp Coastal Classes	0.6%	1.9%	-	0.0%	2.6%
Sand and Gravel Beach Coastal Classes	1.1%	2.2%	0.4%	0.0%	3.7%
Hard substrate Bottom Patches	0.8%	1.8%	0.7%	0.2%	3.4%
Sand and Gravel Flat or Fan Coastal Classes	2.2%	1.4%	-	-	3.6%
Aristazabal Banks Upwelling Upper Ocean Subregion	1.2%	2.2%	0.8%	0.2%	4.4%
Fjord mound Geomorphic Units	0.1%	4.4%	-	-	4.5%
Rock Platform Coastal Classes	1.7%	2.4%	0.2%	0.2%	4.5%
Habitat Richness nearshore	2.0%	3.0%	0.0%	0.0%	5.0%
Sand Flat Coastal Classes	3.0%	6.8%	0.2%	-	10.0%
Chatham Sound EBSAS	-	9.9%	1.8%	0.5%	12.2%

8 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, potential climate changes, human uses, and ecological diversity present within the four Kitkatla Inlet Network Zones. Furthermore, habitat and species-level vulnerabilities and potential recoverability from disturbance were identified where possible. Knowledge gaps and opportunities for further research were highlighted throughout. Together, this report outlines the conservation importance of the Kitkatla Inlet Network Zones and area, both locally and regionally to the whole Northern Shelf Bioregion Marine Protected Area Network. This summary provides a brief overview of the report and its conclusions, knowledge gaps, and recommendations for future research activities for the four Kitkatla Inlet Network Zones.

8.1 Summary

The four Kitkatla Inlet Network Zones 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, culturally, and ecologically important invertebrates and fish, and an abundance of marine birds and marine mammals (notably killer 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 Kitkatla Inlet Network Zones area has interesting oceanography characterized by varying flow and connection between waterbodies. Drifter tracks indicate limited surface flow through Browning Entrance and some flow restriction near Spicer Island, where Beaver Passage meets Kitkatla Channel. The surface waters south of Porcher Peninsula and Goschen Island (Zone

331 to 333) are more connected with the south shore of **Lax k'naga dzol**/Banks Island than the south shore of Dolphin and Spicer Islands. These eastern islands are more connected with Principe Channel and, thus, the north shore of **Lax k'naga dzol**/Banks Island (Zone 330). The constrictions around Spicer Islands appear to restrict surface exchanges from the south shore of the broken island group into Kitkatla Channel and Inlet (Zone 331). The surface waters from Grenville Channel and the Skeena River thus enter Kitkatla Channel and Inlet more freely than surface water from the south in Beaver Passage.

The following summary bullets outline the conservation importance of each of the Kitkatla Inlet Network Zones, summarizing existing conservation tools, representation of habitat and species features, human uses and cultural importance, among other important characteristics identified within the report.

8.1.1 North **Lax k'naga dzol**/Banks Island (Zone 330)

- Overlaps with North **Lax k'naga dzol**/Banks Island (PMZ-13, IUCN Type IV), the Banks Nii Luutiksm Conservancy and is adjacent to the terrestrial Banks Nii Luutiksm conservancy.
- Overlaps with the Central Mainland EBSA.
- Overlaps with an area of critical cultural conservation priority.
- Representation of Bull and Giant kelp biobands, nearshore habitat richness, Pacific Herring spawn habitat, and **Bilhaa**/Northern Abalone.
- Includes features important to Gitxaala Nation and coastal communities: travel routes, anchorages/haul-outs, camps, bait fishing, archaeological and cultural sites, named places, **spanaxnox**, **la'ask**, **hoon**, **tskah**, **txaw**, rockfish, and invertebrates (**k'almoos/galmoos**, **yaans**, **ts'akwe'ats**, **gyenti**, **ts'a'ax** and **gaboox**, **bilhaa**), etc.
- Has a low occurrence of forestry cutblocks in adjacent terrestrial area.
- Relatively high annual mean **baask**/wind energy potential on outer area.
- Overlaps with areas with high vessel traffic (Principe Channel and Browning Entrance).

8.1.2 Kitkatla (Zone 331)

- Overlaps with Browning Entrance/Dolphin Island (PMZ-28, IUCN Type Ib), the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy, and is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy.
- Overlaps with the Chatham Sound EBSA.
- Overlaps with the Kitkatla Channel, Goschen Island North to **Tgii Xsw'aanx**/Porcher Island Important Bird Area (BC119).
- Overlaps with an area of critical cultural conservation priority.
- Representation of important Pacific Herring spawn habitat, Pacific Sand Lance habitat, estuaries important for **hoon**/salmon, nearshore habitat richness, areas of high rugosity, **gadza k'aw**/eelgrass, Bull and Giant kelp forests and biobands, sand and gravel beaches, and **Bilhaa**/Northern Abalone.
- Includes features important to Gitxaala Nation and coastal communities : **Lax Gyibu** (Wolf Clan) Territory, travel and kayak routes, anchorages/haul-outs, scuba dive site, fish migration, **ibuun**/whale migration, area of strong tidal action, camps, driftwood

collection, medicine tree, **noxnox**, sacred and important places, **spanaxnox**, anchorages, settlement sites, **la'ask**, **hoon**, **xs'waanx**, groundfish (**txaw**, **wat'ukw**), rockfish, invertebrates (**hats'al**, **'yaans**, **asut/ts'akwe'ats**, **gyenti**, **ts'a'ax**, **gaboox** and **gyels**, **k'almoos/galmoos**, **bilhaa**), **t'iibn**, **üüla**, and marine birds (Sea ducks and **ha'ax**), etc.

- Important migratory stopover and feeding area for marine bird species.
- High tourism and recreation feature count.

8.1.3 Outer **Tgii Xsw'aanx**/Porcher Island (Zone 332)

- Overlaps with the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy, is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy, and overlaps with the Porcher Peninsula RCA.
- Overlaps with the Chatham Sound EBSA.
- Overlaps with the Kitkatla Channel, Goschen Island North to **Tgii Xsw'aanx**/Porcher Island Important Bird Area (BC119).
- Overlaps with an area of critical cultural conservation priority.
- Representation of Bull kelp and Giant kelp biobands, rockfish, and **Bilhaa**/Northern Abalone.
- Includes features important to Gitxaala Nation and coastal communities: **Lax Gyibu** (Wolf Clan) Territory, travel and kayak routes, anchorages/haul-outs, coastal campsites, fish migration, **ibuun**/whale migration, camps, driftwood collection, medicine tree, sacred places, house territory, **spanaxnox**, **hoon**, **la'ask**, groundfish (**txaw**, **wat'ukw**), rockfish, invertebrates (**bilhaa**, **hats'al**, **k'almoos/galmoos**, **'yaans**, **asut/ts'akwe'ats**, **gyenti**, **ts'a'ax**, **gaboox** and **gyels**), **t'iibn**, and **üüla**, etc.
- Important migratory stopover and feeding area for marine bird species associated with large **Geega tskah**/herring spawns.
- Relatively moderate mean **baask**/wind energy potential; overlaps with **baask** power tenures.
- Additionally, Zone is in close proximity to Oval Bay (but does not overlap) – a key Northern resident **Naaxl**/killer whale beach rubbing beach, which is critical habitat for socialization. Also, the Oval Bay beach and strandplain has a series of sand dunes and small back-beach lakes, whose morphologies are unusual along the west coast.

8.1.4 Outer Goschen Island (Zone 333)

- Overlaps with the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy, is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy, and overlaps with the Goschen RCA.
- Overlaps with the Chatham Sound EBSA.
- Overlaps with the Kitkatla Channel, Goschen Island North to **Tgii Xsw'aanx**/Porcher Island Important Bird Area (BC119).
- Overlaps with an area of critical cultural conservation priority.

- Representation of Bull kelp beds, Pacific Sand Lance habitat, rockfish, and **Bilhaa**/Northern Abalone.
- Includes features important to Gitxaala Nation and coastal communities: Travel routes, fish migration, **lbuun**/whale migration, anchorages/haul-outs, coastal campsites, driftwood collection, medicine tree, winter camps, **la'ask**, **hoon**, groundfish (**txaw**, **wat'ukw**), rockfish, invertebrates (**hats'al**, **k'almoos/galmoos**, **'yaans**, **asut/ts'akwe'ats**, **gyenti**, **ts'a'ax**, **gaboox** and **gyels**, **bilhaa**), **t'iibn**, and **üüla** haulouts and associated foraging habitat.
- Important migratory stopover and feeding area for marine bird species associated with large **Geega tskah**/herring spawns.

8.2 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 by section heading in the report and provide some recommendations for future work to address these gaps.

8.2.1 Oceanographic Setting

- Seabed geological data are limited within the proposed boundaries and Seafloor substrate for most of the proposed protected area has not been mapped; collection and interpretation of high resolution bathymetry (multibeam bathymetry or bathymetric LiDAR), sub bottom profiles and sediment samples and further mapping work is required.
- A long submerged moraine extends around Chatham Sound from Brown Passage to Browning entrance. This feature hosts large glass sponge reef at the entrances to Brown Passage and Edye Passage. The same feature may extend through Porcher Peninsula, Goschen Island and Dolphin Island (areas 331, 332, and 333) but mapping has not been completed in this area. Further evaluation is required for the presence of additional glass sponge reefs.
- Much of the exposed coast along eastern Hecate Strait and Queen Charlotte Sound is sediment starved due to lack of sediment supply. The northern Hecate Strait and Kitkatla area have abundant sand and gravel deposits in the marine environment due to glacial outflow deposits from the last glacial cycle. The Kitkatla Inlet is also close to the Skeena River and receives some amount of modern sediment. Light availability in the area is most impacted by the river plume (east end of the Kitkatla Channel) and the area may be light-limited as a result. Modern sediment transport is poorly constrained for the Kitkatla Inlet and Porcher Peninsula area and thus represents a significant data gap.
- The Oval Bay beach and strandplain has a series of sand dunes and small back-beach lakes; these morphologies are unusual along the west coast (another example is Rose Spit). Very little data have been collected in the area, but the offshore is likely sand and gravel with rocky islands. Further mapping is required.
- A combination of **baask**/winds, **aks**/tides, and freshwater inputs forces circulation. The freshwater from afar in the Caamaño-Douglas Network Zones, and near the Kitkatla Inlet Network Zones (e.g., Skeena) influences the estuarine circulation, particularly

subsurface exchanges. The timing and amount of freshwater from these watersheds alters the estuarine circulation as the relatively fresh layers “compete” to dictate where water in Kitkatla Inlet Network Zones is sourced.

- Kitkatla Inlet Network Zones are well connected to adjoining regions, especially above the 60-m isobath. There are subsurface intrusions of water from Chatham Sound into the northern entrance to Kitkatla Channel. Subsurface water from Hecate Strait intrudes into Browning Entrance and Principe Channel and thus passes through the more exposed southern coast of Zones 331 to 333. Water travels towards the Kitkatla Inlet Network Zones from Caamaño-Douglas through Grenville and Principe Channel.
- The water properties, such as nutrient, light, and oxygen concentrations, in the shallower areas north of Goschen, Dolphin and Spicer Islands and Kitkatla Inlet depend partly on those in the Kitkatla Channel. However, the subsurface water properties in the Kitkatla Channel are currently unknown, although they are a mixture of water from Beaver Passage and Ogden Channel, which are themselves connected to channels with differing properties – Principe and Grenville Channels. To infer the source of deep water in Kitkatla Channel (Zone 331), oceanographic observations should be collected across these four channels. Given the differences in freshwater inputs throughout the region, measurements of nutrient, light, temperature and salinity should be obtained at different seasons, or a minimum, during early summer and late fall. In particular, a transect of CTDs across Beaver-Ogden, and then entering Kitkatla Channel-Inlet is recommended.
- High-resolution (30 metres) Landsat-8 and -9 satellite data was shown here for estimating seasonal sea-surface temperature (SST), suspended particulate matter (SPM), and the diffuse attenuation coefficient concentration (K_d490) in the surface waters, but is not frequent enough for monitoring the development of short-lived events. SPM and K_d490 , in particular, need further validation with *in situ* samples in this region. Validation, and integration of further satellite data for ocean colour (e.g., Sentinel-2, 10 meters resolution; Sentinel-3, 300 meters resolution) and SST (e.g., MODIS-Aqua processed to 250 metres resolution) monitoring in the Network Zones should be explored further. These data can be an important part of monitoring light availability trends and developing events, such as marine heatwaves, and thus improve response times to biological impacts (Hartog et al. 2023).

8.2.2 Climate Change

- Projected climate models (BCCM and NEP36-CanOE) have limited resolution near the coast, where bathymetric changes occur over short spatial scales. There is a research need to develop finer scale or regional climate change projections that work in nearshore environments with complex flows and freshwater inputs.
- While offshore aragonite projections are not concerning, the biogeochemical cycling, especially within sheltered inlets, is unknown. Species in coastal fjords, such as those in the Kitkatla Inlet Network Zones, may be susceptible to acidification, particularly shellfish larvae.
- Lack of knowledge about ocean **Goop**/waves’ impact on nearshore ecosystems. Thus, how those systems would be affected by a changing wave climate is also unknown.

Studies on regional effects of wave impact on nearshore ecosystems are needed for the area.

- Deep waters may be more susceptible to warming, but also less susceptible to hypoxia owing to the intense mixing caused by **aks**/tides interacting with topography in the channels feeding water to the Kitkatla Inlet Network Zones (e.g., Grenville Channel and Arthur Passage). However, additional studies are required in Kitkatla Channel to confirm that this trend persists within the deepest waters within Zone 330.
- Surface waters are generally cooler in summer than Hecate Strait except in the shallow and sheltered areas (Kitkatla and Kingkown Inlets) that will be most susceptible to warming air temperatures in a changing climate.
- Rates of environmental change are increasing with predicted impacts on marine species being pushed beyond their physiological thresholds. There are considerable knowledge gaps on species-specific vulnerability to climate change, and also for how the ecosystems in the Kitkatla Inlet Network Zones area will respond to physical changes associated with global warming that further research could address to inform adaptation and climate resilience.
- Extreme climate events (marine heatwaves) and their increasing frequency have immediate and potentially long-term impacts on marine environments, particularly in coastal areas and intertidal ecosystems with shallow or exposed bathymetry, with health and mortality effects on local biodiversity of high ecological and cultural value (including invertebrate communities). A better understanding of finer spatial scale climate change impacts in complex habitat regions, like the Kitkatla Inlet Network Zones area, are needed in the Pacific Region.
- How climate change will impact cultural and economic values is also a knowledge gap for the area and should be considered in future discussions regarding conservation. For example, whether sea level rise is projected to impact specific cultural sites remains a knowledge gap.

8.2.3 Human Uses of Area

- Commercial fishing data for some fisheries (e.g. salmon) and recreational fisheries are summarized at the PFMA level which is at a coarse spatial scale and needs to be updated, particularly for adaptive management and monitoring of MPAs.
 - iRec data is at the PFMA scale, and specific fishing locations are not known.
- Detailed information is lacking regarding the extent and effects of vessel pollution and discharge in the Kitkatla Inlet Network Zones.
- Spatial data on the distribution of tourism and recreation features is not up to date and may underrepresent tourism and recreation activity in the region (dataset used in this report is from 1992-2009).
 - Updated local tourism data is needed and could be collated from various local sources.
- There are many gaps related to other human stressor categories (e.g., impacts of sediment on nearshore systems from forestry, renewable energy).

8.2.4 Ecological Setting

- There is a lack of phytoplankton and zooplankton data within all Kitkatla Inlet Network Zones in the DFO databases, which prevent further defining the seasonality and magnitude of production. Analysis and enumeration of existing samples near the Network Zones is a priority. Focused sampling across seasons and Network Zones would provide valuable data for characterizing phytoplankton and zooplankton community composition, biomass, and allow inter-comparisons between Network Zones. Phytoplankton samples from these efforts would further help defining the timing and spatial distribution of Harmful Algae Blooms in the Network Zones.
- Similarly, collection of phytoplankton samples should be coordinated with chlorophyll-a fluorescence profiles to define the seasonality and distribution in the water column of primary producers. Currently, data exist in the vicinity surrounding the Network Zones (e.g., in Ogden Channel, offshore Hecate Strait and Chatham Sound), but more profiles within the Network Zones are needed given evidence of strong phytoplankton blooms nearby in the spring and summer months. Chlorophyll-a, when estimated from satellite, only captures the upper ocean (< 10 m) but can be paired with fluorescence profiles to both validate the satellite estimates and verify sub-surface conditions.
- High-resolution (30 metres) Landsat-8 and -9 satellite data was shown here for estimating seasonal chlorophyll-a concentration but is not frequent enough for monitoring the development of short-lived phytoplankton blooms, and has not been validated with *in situ* samples in this region. Validation, and integration of further satellite data for ocean colour (e.g., Sentinel-2, 10 meters resolution; Sentinel-3, 300 meters resolution) is needed for monitoring phytoplankton phenology and inter-annual bloom timing within the Network Zones.
- Additional ground truthing (i.e., direct observation, survey, and measurement) within the Network Zone boundaries is needed to describe and confirm the presence of more coral and sponge communities. 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).
- Current spatial datasets regarding biogenic habitats such as **gadza k'aw**/eelgrass, surfgrass, kelp, and salt marshes include surveys with limited extent in Kitkatla Inlet (such as the Benthic Habitat Mapping and Multispecies dive surveys in the area), Shorezone biobands (2014-2016), or species distribution maps. From the available datasets, there is limited information about seasonal and annual habitat variability or long-term baseline conditions in the area. Continual long-term or seasonal monitoring efforts, insights from traditional knowledge and oral history, and fine-scale spatial models for nearshore communities could provide a clearer understanding of ecosystem health.
 - Information on canopy-forming kelp persistence and drivers of change in British Columbia (BC) is limited to geographically constrained case studies. Continue and build on collaborative kelp monitoring programs that couple community-based field surveys of canopy-forming kelp and associated stressors at local to

sub-regional scales with satellite and aerial imagery and remote/modelled stressor data at sub-regional to regional scales.

- There is uneven and/or limited survey sampling within the Network Zones, specifically nearshore locations in or surrounding Zone 330 and 331 (e.g. inner **Lutgu Ts'aaws**/Kitkatla Inlet, **Tgii Xsw'aanx**/Porcher Inlet, nearshore northwestern **Lax k'naga dzol**/Banks Island), and throughout the two Rockfish Conservation Areas Zone 332 and 333. The coverage of most surveys extends to Hecate Strait and Browning Entrance, which means species occurrences in these areas could be used to infer occurrences in Zones 330-333.
- The following taxa also have limited DFO survey coverage in the Network Zones (occurrences absent from at least two Network Zones): Sponges and Corals, Infauna and epifauna bivalves, Gastropods (marine snails and **Yaans**/chitons), **gamaats**/Sea Stars and **gyenti**/Sea Cucumbers, forage fish (Pacific Sand Lance, Surf Smelt, Pacific Sardine), Sablefish, and **balaas**/Pacific Hake.
 - Stock assessment in the Department of Fisheries and Oceans (DFO) is extremely limited for populations outside the Scallop Management Areas and Clam Management Areas.
 - Additional ground truthing within the Network Zone boundaries is needed to describe and confirm the presence of more coral and sponge communities.
- Extensive dive surveys from 1978-present record **Bilhaa**/Northern Abalone populations in Zones 330 and 331, however there are no surveys in Zones 332 and 333. One research recommendation is to increase the number of index site quadrat dive surveys (Hansen et al. 2020). Continued long-term monitoring and data collection of the biodiversity of the Kitkatla Inlet Network Zones area is recommended, particularly for species of high cultural and ecological importance, including **Tskah**/herring and **Bilhaa**.
- Notably, the diversity and abundance of Rockfish species within and surrounding the Rockfish Conservation Areas Zones 332 and 333 are not well known and present an empirical data gap for evaluating conservation efforts. In addition, nine out of fourteen Salmon conservation units that included the Kitkatla Inlet Network Zones area were identified as data deficient by DFO or the Pacific Salmon Foundation since 2021. Knowledge on local Rockfish and **Hoon**/salmon trends and abundances may be supplemented by traditional knowledge, anecdotal information from harvesters, and oral history.
 - Zones 332 and 333, shallow areas of Kitkatla Inlet (Zone 331) and nearshore areas of Zone 330 have data gaps for fish surveys.
 - There is a lack of coast-wide monitoring plans for Rockfish Conservation Areas (RCAs), including data on baseline trends and diversity before the RCAs were established.
 - Most of the information about salmon migration patterns comes from the Northern Nass and Skeena Rivers, and the Fraser River.
- Survey data and assessments are extremely limited in estimating population sizes and trends of sharks and rays.
- The small sample sizes for cetacean surveys is primarily due to a relative lack of effort; the region does not receive a lot of visual survey attention by DFO's Cetacean Research

Program due to its remote northern location and exposed coastline that can only be surveyed effectively in good weather. Consequently, detailed information on the behavior and abundance of Northern Resident Killer Whales (NRKW) in the Kitkatla Inlet Network Zones is currently unknown due to data collection gaps.

- Winter diets of sea otters, in addition to any potential seasonal effects of their prey on the movements or population dynamics of sea otters, are a knowledge gap throughout BC.
- Although undocumented within the area, Northern Fur Seals are thought to occur there, but little is known.
- While the abundance and distribution of marine birds in the Kitkatla Inlet Network Zones have been documented to some extent, there is a continued need for abundance, distribution, population trend, and foraging and movement ecology data. Gaps in baseline scientific data on distribution, abundance, and species composition at sea within the Kitkatla Inlet Network Zones exist due to variability in survey efforts and methodology, as well as daily, seasonal, and annual fluctuations in numbers.

8.2.5 General Research Opportunities and Methodologies

- SDMs are being developed for a few marine species, but data for inputs are limited. There is uncertainty associated with species distribution models, particularly in areas with limited sampling.
- Leveraging the use of ROVs, BRUVs, smaller vessel sampling, Guardian programs, eDNA and benthic mapping for substrate types will be key to better refine SDMs and understand local and seasonal distributions of marine species.
- Supplement marine species data with traditional knowledge, anecdotal information from harvesters, and oral history. Coordinate a data synthesis approach between fisheries, nations, and science sampling.
- Conduct visual and acoustic surveys for marine mammals.
- Leverage existing platforms for long-term monitoring.
- Undertake creel surveys.

The Kitkatla Inlet Network Zones area is characterized by a long and complex convoluted coastline of exposed coast, broken islands, and protected nearshore inlets and fjords. It has complex bathymetry, seasonal flow patterns and a connected land-sea interface that have all contributed to important habitat for an array of taxonomic groups of ecological and conservation importance. The natural productivity of the area attracts seasonal populations of highly mobile marine birds and marine mammals, further connecting marine and terrestrial ecosystems beyond the Northern Shelf Bioregion. 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 the Gitxaala Nation further supports prioritizing the Kitkatla Inlet Network Zones for conservation.

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Table 23. Name and affiliation of report content contributors and reviewers. The listed contributors and reviewers provided datasets, figures or expert reviews on specific section(s) of the report. DFO = Fisheries and Oceans Canada. ECCC = Environment and Climate Change Canada.

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11 APPENDICES

11.1 Appendix A. Sm'algyax names and sources

Online language resources:

[Sm'algyax Living Legacy Talking Dictionary](#) (Last updated 2018)

[Sm'algyax Dictionary - \(webonary.org\)](#)

[HOME | Sm'algyax \(smalgyax.ca\)](#)

References used:

Gitga'at Marine Use Plan 2012.

Gitxaala Nation GIS database

Satterfield, T. Robertson, L., Turner, N. Pitts, A. 2012. Being Gitka'a'ata: A Baseline Report on Gitka'a'ata Way of Life, a Statement of Cultural Impacts Posed by the Northern Gateway Pipeline, and a Critique of the ENGP Assessment Regarding Cultural Impacts.

Table A1. *Sm'algyax language and use in the report. Please note that this document and table is not meant to be used as a language reference.*

Sm'algyax name	English word	Category
Ahoo	Scoter	Bird
Amgyiik	Black Duck	Bird
an'ana	Duck	Bird
gaguum	Sea gull	Bird
gak	Swan	Bird
Hq'ax	Canada Goose	Bird
lii'wn	Snow Goose	Bird
Nanaa	Mallard	Bird
Xsgyiik	Bald eagle	Bird
balaas	Pacific Hake	Fish
gagaats	Dogfish	Fish
gandeh	Skates	Fish
Gayniis	Chum	Fish
Geega tskah	Herring spawn	Fish
Hadanii	Sablefish/black cod	Fish
Ha'limootk or 'Wah	Eulachon	Fish
hoon	Salmon	Fish
k'a'wts	Pacific cod	Fish
K'ayeey	Bullhead	Fish
Ksah	Shark	Fish

Sm'algyax name	English word	Category
Meliit	Steelhead Trout	Fish
misoo	Sockeye	Fish
sti'moon	Pink Salmon	Fish
Tskah	Pacific herring	Fish
ts'mhoon	Red Snapper	Fish
txaw	Halibut	Fish
üüx	Coho	Fish
wat'ukw	Lingcod	Fish
Xbihats'al	Squid	Fish
xs'waanx	Herring roe	Fish
Yee	Chinook	Fish
Yee	Spring Salmon	Fish
gyaaks	ocean's extreme edge	Geography
K'distsauk	Turtle point	Geography
K'duwaadz	Tuwartz Inlets	Geography
Ksyen/Ksiyeen	Skeena River	Geography
Kt'ii	Racey Inlet	Geography
Kwelts'uu	Cornwall Inlet	Geography
Kxeen	Prince Rupert	Geography
Lax gal'tsap	Old Town	Geography
Lax Ka'gaas	Campania	Geography
Lax k'naga dzol	Banks Island	Geography
Lax ksi tgwi yuun	Gurd Island	Geography
Lax Kul	Bonilla Island	Geography
Lax Kwil Dziidz	Fin Island	Geography
laxyuup Gitxaala	Gitxaala territory	Geography
Lutgu Ts'aaws	Kitkatla Inlet	Geography
Maxla Kxa Naayxt	Ogden Channel	Geography
Maxlagitxaala	Kitkatla Channel	Geography
Maxlakaneext	Ogden Channel	Geography
Maxlasgadaalyaxs	Grenville Channel	Geography
Maxtaktsm'aa	Union passage	Geography
Tgii Xsw'aanx	Porcher Island	Geography
aswit	Urchin (general), green sea urchin	Invertebrate
Bilhaa	Abalone	Invertebrate
Gaboox	cockles	Invertebrate
gamaats	sea star	Invertebrate
gasgos	Shrimp and prawn	Invertebrate
Gyels	Blue mussel	Invertebrate
gyenti	sea cucumber	Invertebrate

Sm'algyax name	English word	Category
Hagwn	California Mussel	Invertebrate
k'al'on	scallops	Invertebrate
k'almoos/galmoos	Crab	Invertebrate
loon	horse clam	Invertebrate
Sa'mx	butter clam	Invertebrate
Ts'a'ax	clams (general)	Invertebrate
Ts'ak	Gumboot Chiton	Invertebrate
ts'akwe'ats	red sea urchin	Invertebrate
Yaans	Black leather chiton, and general chiton	Invertebrate
Dasx	Squirrel	Mammal
dziiw	dolphin	Mammal
Gibaaw	Wolf	Mammal
lbuun	Whale, general	Mammal
Lis'yaan	Mink	Mammal
maksiit	Weasel	Mammal
Naaxl	Killer whale	Mammal
ploon	sea otter	Mammal
Sts'ool	Beaver	Mammal
t'iibn	Steller sea lion	Mammal
üüla	harbour seal	Mammal
wan	Deer	Mammal
Yeni	Marten	Mammal
gadza k'aw	eelgrass	Marine algae and plants
gyoós	Giant Kelp	Marine algae and plants
la'ask	Seaweed (general)	Marine algae and plants
Mo'ox	Bull Kelp	Marine algae and plants
Hats'al	Octopus/Devil Fish	Mollusc
Dahdee	Low Bush Cranberry	Plant
Dzawas	Salal Berries/Laughing Berries	Plant
huulens	Hellbore	Plant
laaya	High Bush Cranberry	Plant
Mihaal	Blueberry	Plant
sahakwdak	Yew Wood/Yew Tree	Plant
walaas	Huckleberry	Plant
wooms	Devil's Club	Plant
adaawx	storytelling	Term
aks	Tide	Term
Ayaawx	Gitxaala Laws	Term
baask	Wind	Term

Sm'algyax name	English word	Category
Dooyaks	Currents	Term
G̱oop	Waves	Term
Lax Gyibu	Wolf Clan	Term
Naxnanox (plural) naxnox (singular)	Supernatural being or nature spirit	Term
Sigidmna'ax	Matriarch	Term
Smgyigyeyet (plural) Sm'ooygit (singular)	Chiefs	Term
Spanaxnanox (plural) Spanaxnox (singular)	<u>N</u> axnox Den or Territory	Term
Waas	Rain	Term

11.2 Appendix B. Terms Used

Certain terms are adapted with permission from Bannar-Martin et al. (*in review*)

Baroclinic - pressure is not constant on surfaces of constant density.

Caamano-Douglas area – This term is undefined by boundaries and broadly refers to the geographic region which encompasses the Caamano Sound and Douglas fjord system network zones and nearby surrounding areas (see Liu et al. *in review*).

Rugosity - a measure of benthic complexity or roughness. Generally calculated as the ratio between the contoured distance/area between two points (i.e., over the surface) and the corresponding planar distance/area (Du Preez 2015; Rubidge et al. 2016).

Ecologically and Biologically Significant Areas (EBSA) – an area worthy of enhanced management or risk aversion. An area can be identified as an EBSA if it ranks highly on at least one of three dimensions, Uniqueness, Aggregation and Fitness Consequences, and can be weighted by two other dimensions, Naturalness and Resilience (DFO 2004, Clarke and Jamieson 2006).

Network Zones – These zones exist as part of a network, this includes within the local area, to other nearby Network Zones, and as part of the greater Marine Protected Area

Northern Shelf Bioregion (NSB) – The Northern Shelf Bioregion covers 102,000 km² and is one of four bioregions located in the Pacific Region. Bioregions are identified based on oceanographic and bathymetric similarities, important characteristics that help define habitats and their associated species assemblages.

Marine Protected Area (MPA) - part of the ocean that is legally protected and managed to achieve the long-term conservation of nature

11.3 Appendix C. Acronyms

AIS	Automatic Identification System
AOI	Area of Interest
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
C-CP	Cultural Conservation Priority
CCIRA	Central Coast Indigenous Resource Alliance
CDOM	Coloured Dissolved Organic Matter
CH	Critical Habitat
Chl-a	Chlorophyll-a pigment concentration
CITES	Convention on International Trade of Endangered Species of Wild Fauna and
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CP	Conservation Priority
CPUE	Catch per unit effort
CSAS	Canadian Science Advisory Secretariat
CTD	Conductivity-temperature-depth
CU	Conservation Unit
DFO	Fisheries and Oceans Canada
E-CP	Ecological Conservation Priority
EBSA	Ecologically and Biologically Significant Area

ECCC-CWS	Environment and Climate Change Canada Canadian Wildlife Service
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscillation
ESS	Ecologically Significant Species
FMA	Fisheries Management Area
IFMP	Integrated Fisheries Management Area
IUCN	International Union for the Conservation of Nature
iREC	DFO's Internet Recreational Effort and Catch database
K _d 490	Diffuse Attenuation Coefficient at 490 nanometres
KINZ	Kitkatla Inlet Network Zones
LNG	Liquid Natural Gas
MaPP	Marine Plan Partnership
MODISA	MODerate Resolution Imaging Spectroradiometer on Aqua satellite
MPA	Marine Protected Area (note: when capitalized the marine protected area has an official designation through a conservation tool, when in lowercase marine protected areas are being referred to generally)
MPATT	Marine Protected Area Technical Team
NCCS	North Coast Cetacean Society
NCODE	North Coastal Ocean Dynamics Experiment
NEP36-CanOE	Northeastern Pacific Canadian Ocean Ecosystem Model
NMCA	National Marine Conservation Area Reserve
NRKW	Northern Resident Killer Whale
NSB	Northern Shelf Bioregion
OLI	Operational Land Imager instrument
OMZ	Oxygen Minimum Zone
PAM	Passive Acoustic Monitoring
PDO	Pacific Decadal Oscillation

PECP	Pacific Estuary Conservation Program
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
RCP	Representative Concentration Pathway
RFA	Reconciliation Framework Agreement
SD	Species Density
SPM	Suspended Particulate Matter
SST	Sea Surface Temperature
Station P	Ocean Station Papa
SWIR	Shortwave Infrared wavelengths
TIRS	Thermal InfraRed Sensor on Landsat-8
TIRS-2	Thermal InfraRed Sensor-2 on Landsat-9
UAV	Unmanned Aerial Vehicle
UV	Ultraviolet light
VCI	Vulnerable Composite Index
VME	Vulnerable Marine Ecosystem
VPZ	Voluntary Protection Zone

11.4 Appendix D. Kitkatla Inlet Network Zones Boundaries

Please see the [MPA Network website](#) and [Network Action Plan](#) for more details.

Below are high-level descriptions of some of the drivers and rationale behind the current zone boundaries for the Kitkatla Inlet Zones. 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 Marine 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 330:

The boundaries for this zone capture a marine area that contributes towards the representation of myriad nearshore ecological and cultural conservation priorities, evidenced by moderate and significant Marxan 'hotspots' present in both the ecological only and combined ecological and cultural (FNCCP) Marxan analysis outputs. Majority of the zone covers area identified as 'critical' ranked cultural conservation priorities. This area contributes toward the representation of nearshore ecological conservation priorities, including extensive canopy-forming giant kelp and bull kelp forests, eelgrass meadows, Pacific herring spawn habitat, invertebrates, and important areas for marine mammals. This zone also supports rare and/or endangered species, including Northern abalone, and culturally important upper subtidal and intertidal invertebrate species. This area also contributes toward the replication targets of network habitats and areas, including the Central Mainland EBSA, the Aristazabal Banks Upwelling Upper Ocean Subregion, and the Hecate Strait Ecoregion and a small portion of the North Coast Fjords Ecoregion. The area builds on existing conservation efforts in the region including significant overlap with a North Coast Marine Plan (MaPP) Protection Management Zone: North Banks Island (PMZ-13, IUCN Type IV), seeking to protect marine species, intertidal habitat, and archaeological sites in an important First Nations harvest area. The area also contains the entire marine portion of the Banks Nii Luutiksm Conservancy and is adjacent to the terrestrial Banks Nii Luutiksm conservancy, providing opportunity to enhance protection in these areas, including intertidal areas and the terrestrial/marine interface.

Zone 331:

The boundaries for this zone capture a marine area that contributes towards the representation of nearshore ecological and cultural conservation priorities, evidenced by a large and significant Marxan 'hotspot' present in both the ecological only and combined ecological and cultural (FNCCP) Marxan analysis outputs. The southern half of the zone and the portion of the zone between Goschen Island and Porcher peninsula covers area identified as 'critical' ranked cultural conservation priorities. A portion of the zone is adjacent to the Gitxaala First Nation community of Kitkatla. The zone contributes toward the representation of important areas for marine mammals and myriad nearshore ecological conservation priorities, including Pacific herring spawn habitat, Pacific sand lance habitat, estuaries important for salmon, nearshore habitat richness, eelgrass, bull and giant kelp forests and biobands, and sand and gravel beaches, and Northern abalone (a rare/endangered species). The area also contributes toward the replication targets of network habitats and areas, including the Chatham Sound EBSA, Aristazabal Banks Upwelling and Mainland Fjords Upper Ocean Subregion, the North Coast Fjords marine Ecoregion and a small portion of the Hecate Strait Ecoregion. The area builds

on existing conservation efforts in the region including significant overlap with a North Coast Marine Plan (MaPP) Protection Management Zone: Browning Entrance/Dolphin Island (PMZ-28, IUCN Type Ib), seeking to protect marine biodiversity and culturally important species adjacent to First Nations communities. The area also contains majority of the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy and is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy, providing opportunity to enhance protection in these areas, including intertidal areas and the terrestrial/marine interface.

Zone 332:

The boundaries for this zone capture a marine area that contributes towards the representation of nearshore ecological and cultural conservation priorities, evidenced by moderate Marxan 'hotspots' present in the combined ecological and cultural (FNCCP) Marxan analysis output. The entire zone, and slightly beyond the zone's western boundary, covers area identified as 'critical' ranked cultural conservation priorities. The zone contributes toward the representation of ecological conservation priorities, including bull and giant kelp biobands, rockfish species, important areas for marine mammals, and the endangered/rare Northern abalone. It also contributes toward the replication of network habitats and areas, including the Chatham Sound EBSA, the Aristazabal Banks Upwelling Upper Ocean Subregion, and the Hecate Strait Ecosection. The area also contains part of the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy and is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy, providing opportunity to enhance existing protection in these areas, including intertidal areas and the terrestrial/marine interface. The entirety of the zone overlaps with the Porcher Peninsula RCA, providing another opportunity to enhance existing protection. This RCA's boundaries are being considered under the DFO RCA boundary review process given the opportunity to merge the Porcher Peninsula and Goschen RCAs.

Zone 333:

The boundaries for this zone capture a marine area that contributes towards the representation of nearshore ecological and cultural conservation priorities, evidenced by Marxan 'hotspots' present in the combined ecological and cultural (FNCCP) Marxan analysis output. The entire zone covers area identified as 'critical' ranked cultural conservation priorities. The zone contributes toward the representation of ecological conservation priorities, including bull kelp biobands, Pacific sand lance habitat, rockfish species, important areas for marine mammals, and the endangered/rare Northern abalone. It also contributes toward the replication of network habitats and areas, including the Chatham Sound EBSA, the Aristazabal Banks Upwelling Upper Ocean Subregion, and the Hecate Strait Ecosection. The area also contains part of the marine portion of the Gitxaala Nii Luutiksm/Kitkatla Conservancy and is adjacent to the terrestrial Gitxaala Nii Luutiksm/Kitkatla Conservancy, providing opportunity to enhance protection in these areas, including intertidal areas and the terrestrial/marine interface. The entirety of the zone overlaps with the Goschen RCA – this RCA's boundaries are being considered under the DFO RCA boundary review process given the opportunity to merge the Porcher Peninsula and Goschen RCAs.

11.5 Appendix E. Remote Sensing Processing Details

Satellite images from the Operational Land Imager (OLI) and Thermal InfraRed Scanner (TIRS) instruments on the Landsat-8 and -9 satellites (30 metre pixel resolution, mentioned in the Oceanography section and Phytoplankton section of the report) were acquired from the United States Geological Survey (USGS) EarthExplorer site (<https://earthexplorer.usgs.gov>; see Appendix E Data Table). Landsat-8 and -9 data are distributed in “scenes”, which represent static, approximately square locations on the earth surface; scenes intersecting rows 053022, 053023, 054022, and 054023 were downloaded provided that the network zones were not fully obscured by cloud cover. For SST, the Level-2 (processed satellite product) Surface Temperature USGS product (USGS, 2022) images were downloaded. The corresponding Level-1 (unprocessed, georeferenced radiance) files were also downloaded and processed with the open-source dark spectrum fitting atmospheric correction software ACOLITE (Vanhellemont and Ruddick, 2018; Vanhellemont, 2020) to produce Remote Sensing Reflectance (R_{rs}) for all available bands, quality control flags, and the parameters mentioned in Appendix Table 2. The quality control layer was applied to all products, including the SST. Further pixels were removed where the surface reflectance of the short-wave infrared (SWIR) band at ~1614 nm exceeded 0.005, which more effectively removed cirrus clouds. Land was removed using a high resolution coastline polygon from the province of B.C. Freshwater Atlas (<https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/freshwater>; See Appendix E Data Table) These quality control steps were similarly applied to the SST dataset in the Surface Water Properties section of the report (nested in Oceanographic Setting - Kitkatla Regional Conditions), as the USGS quality control layers did not sufficiently remove thin clouds, cirrus and sun-glint affected pixels.

Further, the 10-m resolution bathymetry layer (Appendix E Data Table) was used to remove SPM, K_d490 and Chl-a pixels where the depth was less than 2 meters to remove tidal artifacts and bottom-reflectance (where error is introduced into the satellite estimate from bright sand or substrate). When calculating satellite Chl-a, corresponding pixels where SPM exceeded 7 g m^{-3} were removed as a distinct flattening and saturation of the Chl-a algorithm was observed. This mainly removed pixels within the Skeena River and plume waters directly adjacent to the outlet of the river. As a final step, images were visually screened in order to remove any impacted by factors not controlled for by quality flags; a number of images were removed altogether as they were impacted by forest fire smoke and high aerosols which led to very large or very small incorrect values in the final products.

Appendix Table 2. Algorithms used with ACOLITE software to process Level-1 Landsat-8 and -9 OLI images.

Parameter	Algorithm
Chl-a	OC3, coefficients from Franz et al., 2015
K_d490	QAA v5 from Lee et al., 2002
SPM	Nechad et al., 2010 with 2016 re-calibration

11.6 Appendix F. Supplementary Remote Sensing Figures

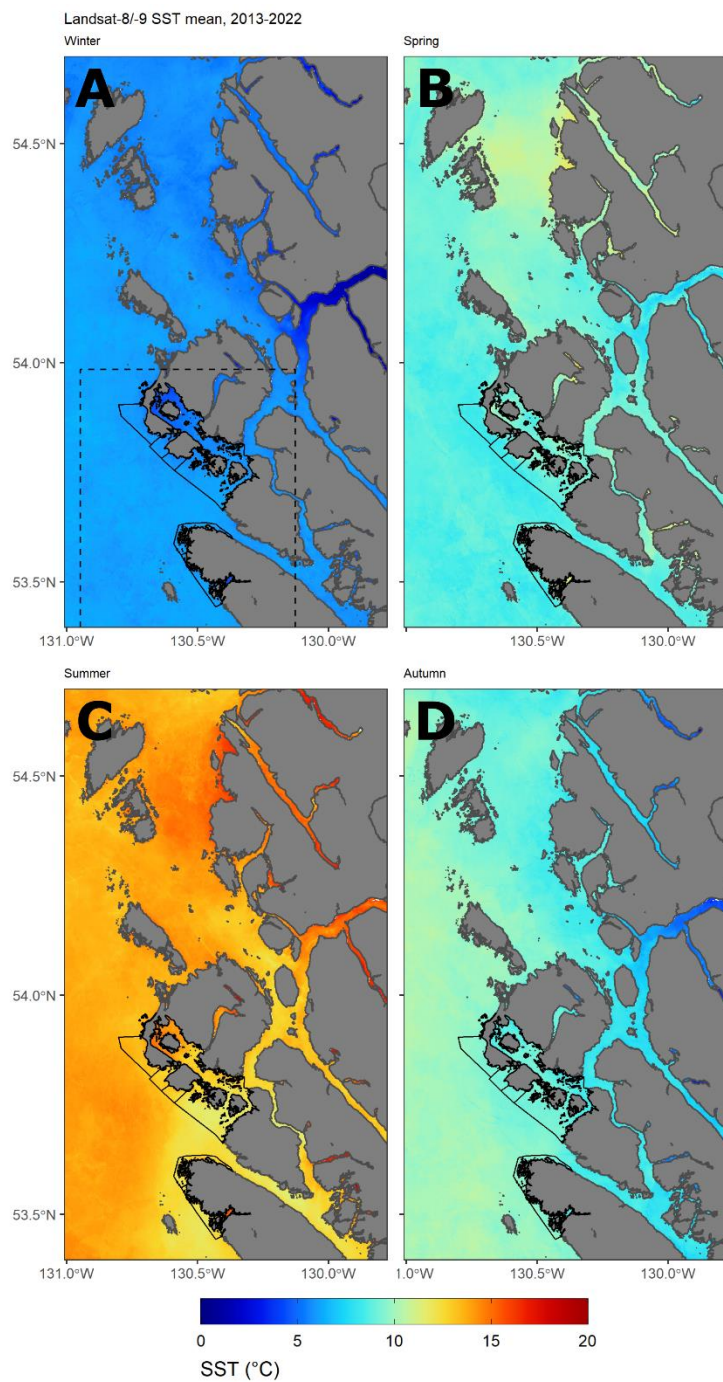


Figure A1. Seasonal mean sea surface temperature (SST) with Network Zones indicated with black lines.

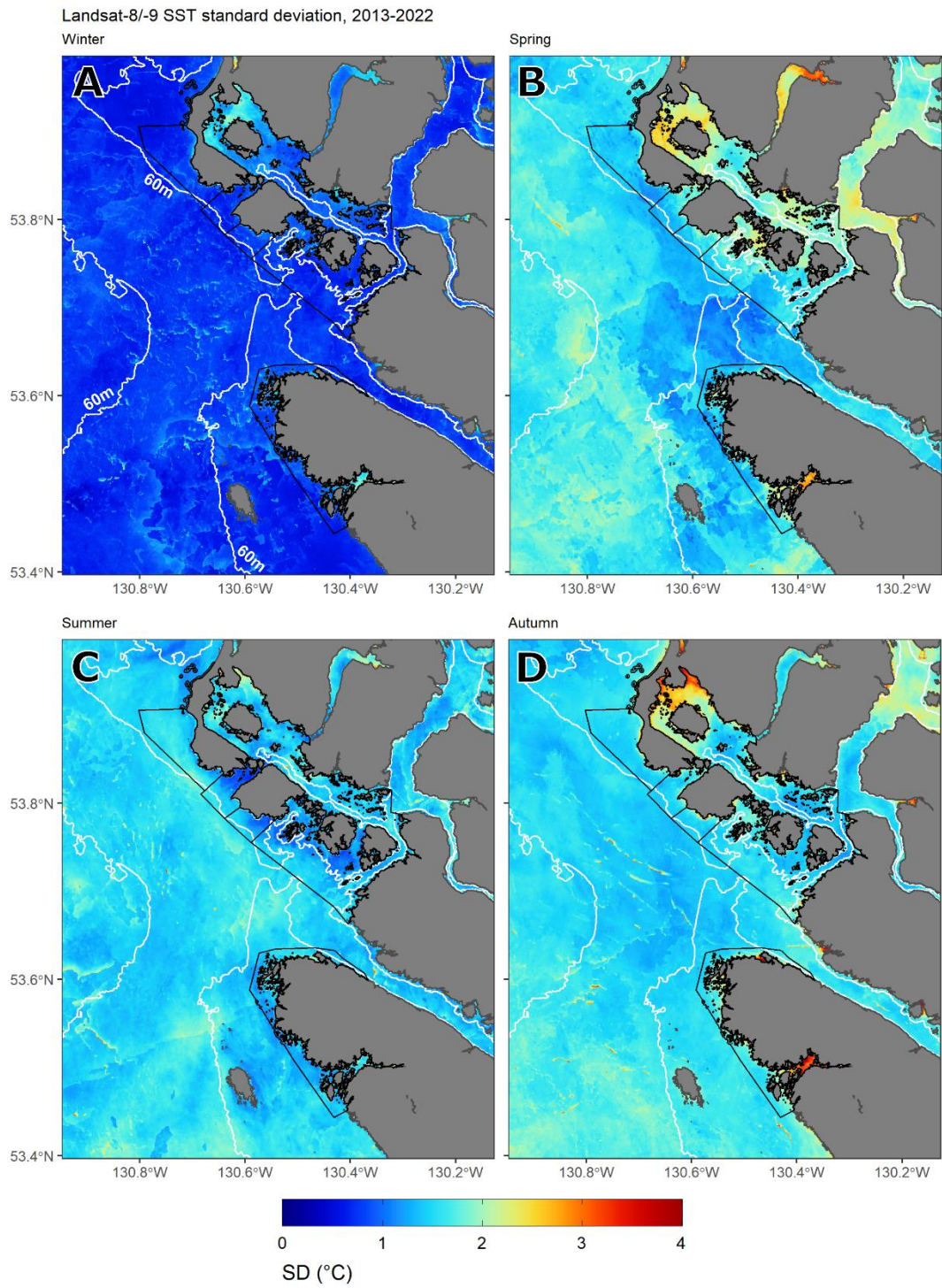


Figure A2. Seasonal standard deviation of remotely sensed SST observations, with Network Zones indicated with black lines.

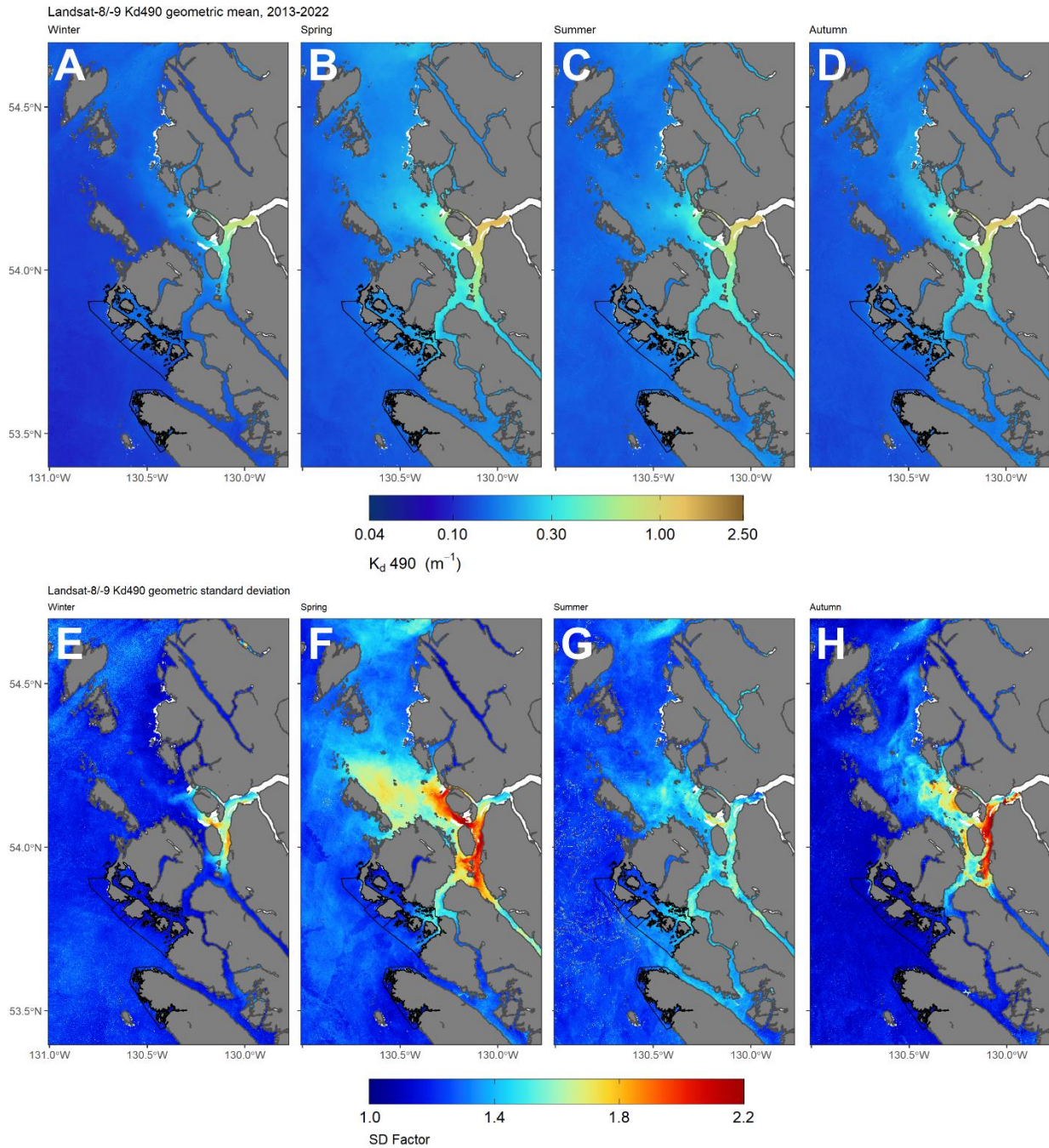


Figure A3. Seasonal mean $K_d 490$ for the region surrounding the Network Zones (A-D) and seasonal standard deviation factor (E-H). Note that these parameters are represented in log scale. White indicates shallow areas (<2 m) where data was removed. Network Zones are indicated in black.

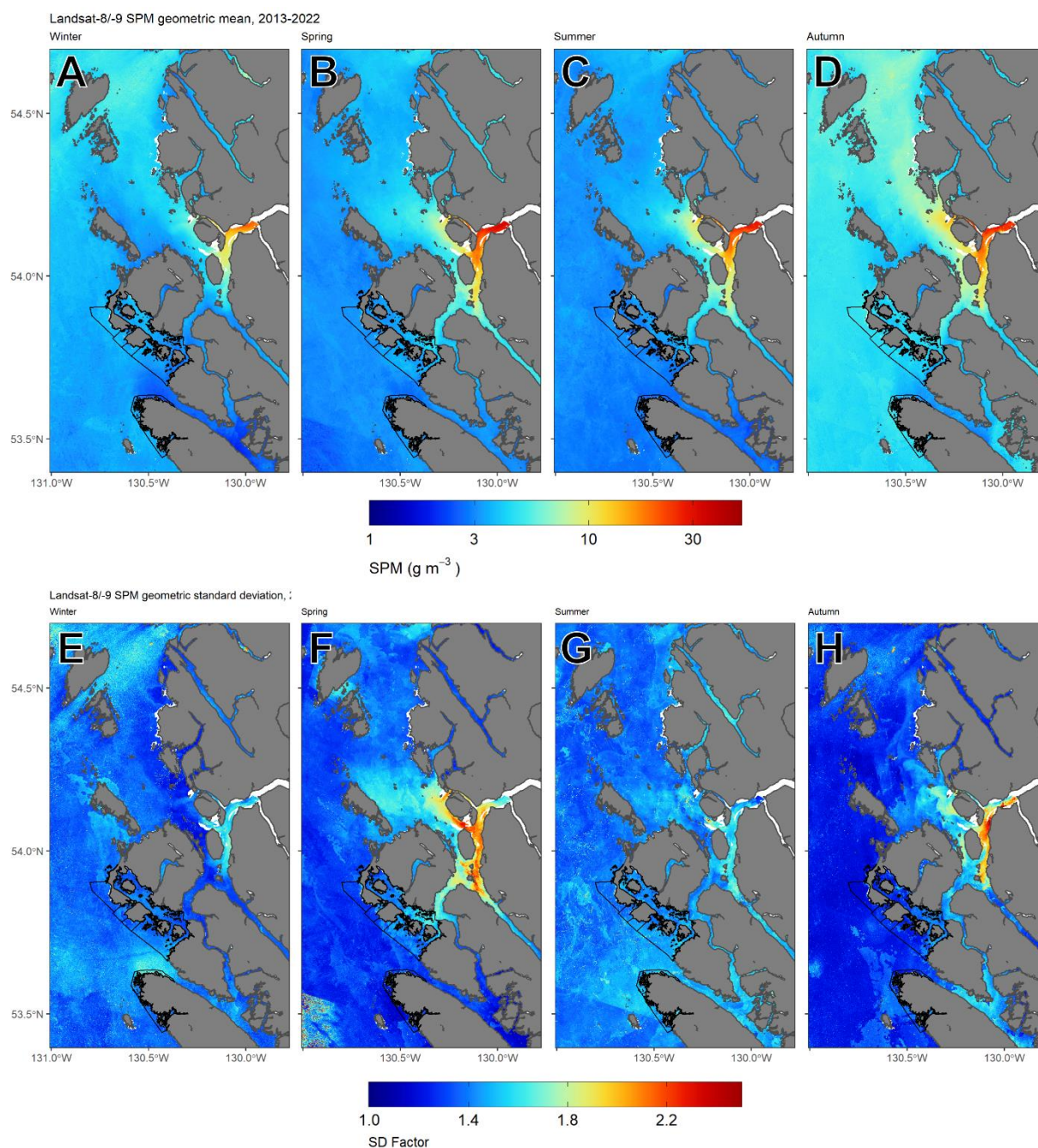


Figure A4. Landsat-8 and -9 seasonal mean SPM for the region surrounding the Network Zones (A-D) and seasonal standard deviation factor (E-H). Note that these parameters are represented in log scale. White indicates shallow areas (<2 m) that were removed.

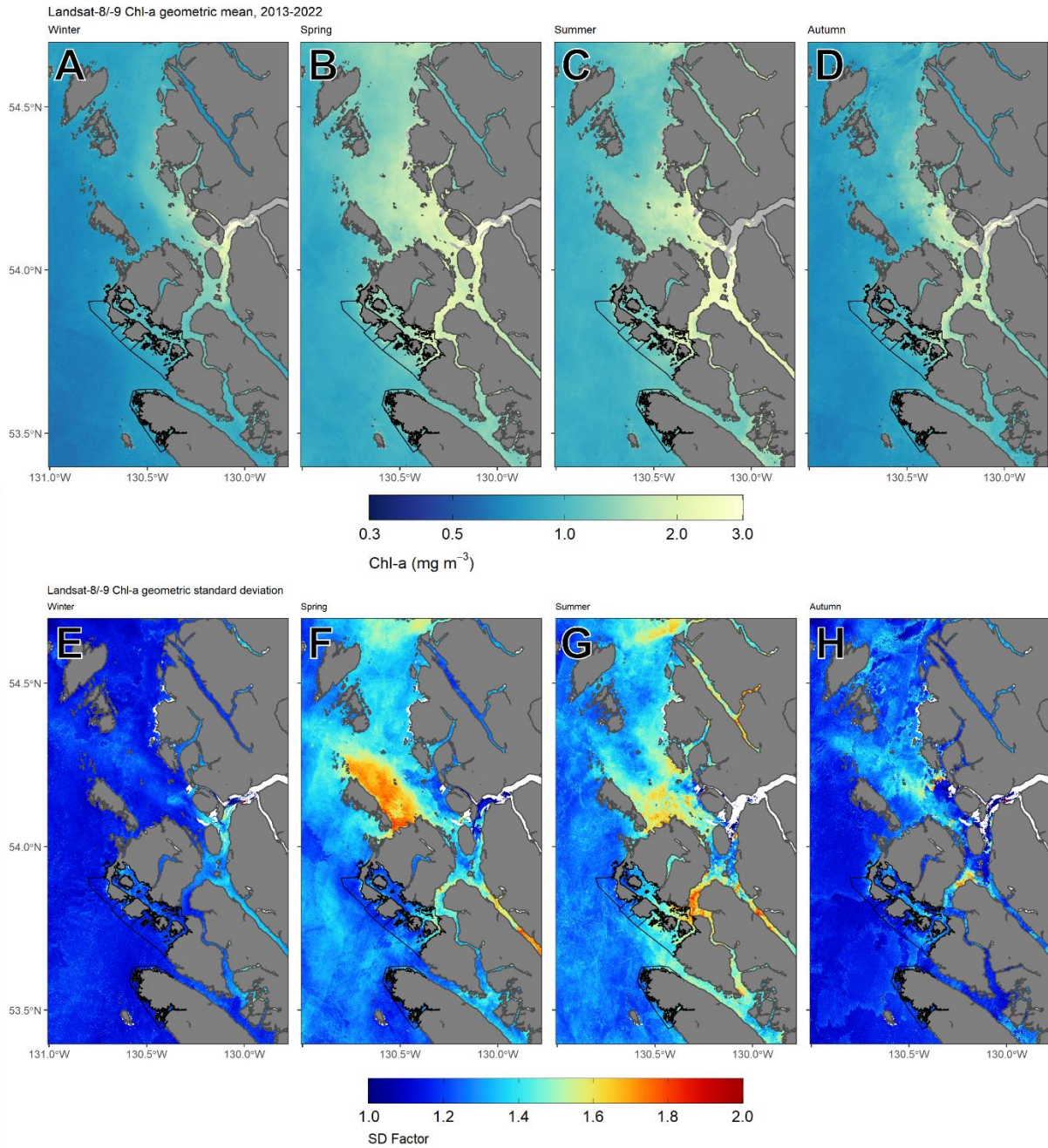


Figure A5. Seasonal geometric mean Chl-a (A-D) and standard deviation factor (E-H) with the Network Zones indicated in black. Note that the colours are log-scaled. A higher value indicates a larger seasonal fluctuation of phytoplankton and helps identify locations of blooms. Light grey (A-D) and white areas (E-H) indicate shallow pixels (< 2 m) that were removed.

11.7 Appendix G. Data Source Tables

Table A3. Data source table for the Oceanography section of the report.

Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source	Citation/Notes
Continental shelf and coastal inlets of British Columbia's coast	The bathymetric maps were generated from a digital elevation model developed for research and science purposes (non-navigational)	Last issued in 2021	https://open.canada.ca/data/en/dataset/e6e11b99-f0cc-44f7-f5eb-3b995fb1637e	Natural Resources Canada	Kung et al., 2023. https://doi.org/10.4095/331539
Geomorphological units near Chatham Sound	Geomorphological map and shapefiles	-	https://doi.org/10.4095/329405	Natural Resources Canada	Shaw, J. / Lintern, D. G. Marine geology, geomorphology of Chatham Sound, British Columbia, parts of NTS 103-G, H, I, and J 2023 Natural Resources Canada
Weather and climate	Monthly average precipitation and air temperatures from ECCC's climatic normals	1981-2010	https://climate.weather.gc.ca/	Government of Canada	Collated and interpreted data for the report
Reconstructed freshwater discharges	Reconstructed monthly mean freshwater runoff based on Morrison et al. 2012	1970 to 2009 hindcasts	Morrison et al. 2012: http://dx.doi.org/10.1080/07055900.2011.637667	DFO- IOS	Morrison J., Foreman M. G. G., and Masson D. A Method for Estimating Monthly Freshwater Discharge Affecting British Columbia Coastal Waters. 2012. Atmos. Ocean. Vol. 50, No. 1

Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source	Citation/Notes
Measured freshwater discharges at upstream gauging stations on the Nass and Skeena's Rivers, as well as local catchment (Exchamsiks) near Terrace	Climatological monthly mean runoff for these rivers	1970 to 2009 (to match Morrison time period)	https://wateroffice.ec.gc.ca/mainmenu/historical_data_index_e.html	Water Survey of Canada	Collated and interpreted data for the report
Regional winds rose, wave heights and periods	Weather buoys maintained by DFO	1991-2022	https://www.meds-sdmm.dfo-mpo.gc.ca/isdm-qdsi/waves-vagues/data-donnees/index-eng.asp	Government of Canada	Collated and interpreted data for the report
Regional wind speed and direction	Wind measured from land-based meteorological stations maintained by ECCC	1991-2022	Historical Climate Data - Climate - Environment and Climate Change Canada (weather.gc.ca)	Government of Canada	Collated and interpreted data for the report
Biological wave exposure of the coastline	Biological wave exposure, which considers wave fetch and the presence of biota along shorelines, as seen from aerial surveys	-	<u>ShoreZone</u>	Coastal and Ocean Resources	Coastal and Ocean Resources, "ShoreZone Habitat Mapping Cumulative Summary Report: North Coast of British Columbia. Produced for the Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, BC."

Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source	Citation/Notes
Drifter tracks from deployed drifters	Drifters deployed by DFO	2014-2022	DM Apps (waterproperties.ca)	Government of Canada	Drifters downloaded via waterproperties.ca like CTD and ADCP observations below. See also figures in Hourston et al. 2021. Surface ocean circulation tracking drifter data from the Northeastern Pacific and Western Arctic Oceans, 2014-2020. Canadian Data Report of Hydrography and Ocean Sciences, Vol. 215, Institute of Ocean Sciences, Sidney, BC, p. vi+36p Page et al. 2019. Surface circulation tracking drifter data for the Kitimat Fjord system in northern British Columbia and adjacent continental shelf for April, 2014 to July, 2016 Canadian Data Report of Hydrography and Ocean Sciences , Vol. 206. Institute of Ocean Sciences, Sidney, BC, p. vi+33p
Moored current-meters	Principal component analysis of velocities and quiver plots after quality-controlling measurements collected by DFO	One year from available data within 2014 to 2022 period (some moorings were deployed several years but not all).	https://www.waterproperties.ca/	DFO- IOS	Processed data for the report

Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source	Citation/Notes
British Columbia Lightstation Sea-Surface Temperature and Salinity Data (Pacific), 1914-present	Ongoing daily SST and salinity observations from lightstations along the B.C. coast. Records span as far back as the 1910's.	1914-present	https://open.canada.ca/data/en/dataset/719955f2-bf8e-44f7-bc26-6bd623e82884	DFO	(No official citation) British Columbia Lightstation Sea-Surface Temperature and Salinity Data (Pacific), 1914-present. Government of Canada. Accessed August, 2023. URL: https://open.canada.ca/data/en/dataset/719955f2-bf8e-44f7-bc26-6bd623e82884
Satellite sea-surface temperature, chlorophyll-a, secchi depth, diffuse attenuation coefficient (490 nm), and reflectance	30-m spatial resolution satellite data processed using open-source software, and distributed by the U.S. Geological Survey (https://earthexplorer.usgs.gov/)	2013-2022	Landsat-8 and Landsat-9 level-1 and level-2 satellite data	U.S. Geological Survey	Processed "Landsat-8 and Landsat-9 data courtesy of the U.S. Geological Survey"
Ship-based conductivity, temperature, oxygen, nutrients, pressure and chemistry data	CTD and chemistry spatial and temporal data coverage around Kitkatla	1948-2023	https://www.waterproperties.ca/	DFO- IOS	Collated and interpreted data for the report
Ship-based conductivity, temperature, salinity, and oxygen at different depths below the surface	Spatial scatter plots at a constant depth	2020	https://www.waterproperties.ca/	DFO- IOS	Interpreted data for the report from the database created from CTD data spanning 1949 to 2023 in water properties. The time periods with the highest spatial coverage was selected to highlight gradients.

Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source	Citation/Notes
Water Quality (nitrate) observations for the Skeena River at USK	Used to highlight low nutrient loadings from the Skeena River	2005-2014	SKEENA RIVER AT USK (BC08EF0001) (gov.bc.ca)	BC government	Trends and graphs are viewable online. The WQ station coincides with the hydrological station maintained by the Water Survey of Canada.
Ship-based conductivity, temperature, oxygen, nutrients, pressure and chemistry data	Property diagrams of water properties (temperature, oxygen and nutrients) during winter, summer, and fall 2020	2020	https://www.waterproperties.ca/	DFO- IOS	Interpreted data for the report from the database created from CTD data spanning 1949 to 2023 in water properties. The time periods with the highest spatial coverage was selected to highlight gradients.
Coastal Ice-Ocean Prediction System for the West Coast of Canada	Large-scale numerical modeling forecast that occurs 4x per day at 1/360 resolution	2021-12-02 - ongoing	Coastal Ice-Ocean Prediction System for the West Coast of Canada (CIOPS-West) - Open Government Portal	ECCC	Dataset would be useful for forcing regional hydrodynamic models in the region

Table A4. Data source table for the Human Uses of Area section of the report.

Sections described	Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source
6.3 Fisheries and Subsistence Activities	Conservation & Program Aerial Surveillance Program (C&P ASP)	Commercial fishing gear types per zones detected on C&P ASP flyovers in the Network Zones in 2019 and 2020	2019 and 2020	The Society for Conservation Biology (wiley.com)	DFO (Iacarella et al. 2023b)
6.3 Fisheries and Subsistence Activities	Global Fishing Watch AIS fishing estimates per gear class	Fishing effort hours in 2019 for fishing gear classes as detected by AIS and estimated using algorithms by Gloabl Fishing Watch.	2019	Monitoring Pacific marine conservation area effectiveness using aerial and RADARSAT-2 (Synthetic Aperture Radar) vessel detection (publications.gc.ca)	DFO (Burke et al 2022)
6.5 Vessel traffic and vessel types	Conservation & Protection Aerial Surveillance Program (C&P ASP)	Vessels detected on C&P ASP flyovers in the Network Zones in 2019 and 2020. Includes information on vessels detected per month and vessels types per zones.	2019 and 2020	Monitoring Pacific marine conservation area effectiveness using aerial and RADARSAT-2 vessel detection	DFO (Burke et al 2022; Iacarella et al. 2023a)
6.4.1	Forestry cutblocks	Province of British Columbia forest analysis and inventory	1900-2021	Harvested Areas of BC (Consolidated Cutblocks) - Datasets - Data Catalogue (gov.bc.ca)	Province of British Columbia - Lands Branch
6.4.1	Log storage and log tenures	British Columbia Crown Land Registry (Tantalis), which includes tenures and business applications.	Current Land act tenures and applications	TANTALIS - Crown Tenures - Datasets - Data Catalogue (gov.bc.ca)	Province of British Columbia

Sections described	Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source
6.4.2	Underwater development	British Columbia Crown Land Registry (Tantalis), which includes tenures and business applications.	Current Land act tenures and applications	TANTALIS - Crown Tenures - Datasets - Data Catalogue (gov.bc.ca)	Province of British Columbia
6.4.3	Tourism and recreation	Tourism and recreation features. Includes point locations, line features and activity counts (in 2km by 2km grid).	1992-2009	BC Marine Conservation Analysis: browse or search (bcmca.ca)	British Columbia Marine Conservation Atlas (BCMCA)
6.4.4	Wind power tenures	British Columbia Crown Land Registry (Tantalis), which includes tenures and business applications.	Current Land act tenures and applications	TANTALIS - Crown Tenures - Datasets - Data Catalogue (gov.bc.ca)	Province of British Columbia
6.4.4	Wind energy potential	Mean wind energy potential (watts per square meter at 30 meters above the surface) from Environment Canada's Canadian Wind Energy Atlas	2008	https://bcmca.ca/data/hu_oceanenergy_windenergy/; http://www.windatlas.ca/index-en.php	British Columbia Marine Conservation Atlas (BCMCA); Canadian Wind Energy Atlas, Environment Canada

Sections described	Survey or Spatial Feature Name	Brief Description	Date Range	Data, Metadata, or Publication Link	Institutional Source
6.6	Pollution	Pollutants Affecting Whales and their Prey Inventory Tool (PAWPIT). Estimates of pollutatn released by all identified sources within the habitats of Northern and Sourthern Resident Killer Whales and their primary prey, Chinook Salmon.	2017	PAWPIT-OIPABP	Environment and Climate Change Canada
Climate Change	Coastwide Temperature Changes	Temperature changes collected at lighthouses and by Indigenous land users	1935-	https://ios-osd-dpg.github.io/bc_light_station_sst	DFO

Table A5. Data source table for the Ecological Setting section of the report.

Sections described	Survey or Spatial Feature Name	Date Range	Data, Metadata, or Publication Link	Institutional Source
Ecological habitats	Ecologically and Biologically Significant Areas of Canada	2016 to ongoing	https://open.canada.ca/data/en/dataset/d2d6057f-d7c4-45d9-9fd9-0a58370577e0	DFO
Ecological habitats	Freshwater Atlas coastline, rivers, lakes and streams		https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/freshwater	Government of BC
Taxonomic Diversity	GBIF Species Occurrences from a variety of data sources	2000-2023	https://www.gbif.org/occurrence/search	Global Biodiversity Information Facility
Macroalgae and plants	Canadian Hydrographic Society historical Kelp data	1904-2004	Distribution of kelp on the coast of British Columbia extracted from CHS source data: 1904 - 2004 - Open Government Portal (canada.ca)	-
Macroalgae and plants	Historical kelp distribution from digitized charts from Costa et al. 2020	1858-1956	Historical distribution of kelp forests on the coast of British Columbia: 1858–1956 - ScienceDirect	-
Macroalgae and plants	ShoreZone Bull Kelp and Giant Kelp bioband lines	-	Shorezone Biobanding Lines - Open Government Portal (canada.ca)	-
Macroalgae and plants	BCMCA (Bull Kelp, Giant Kelp, General Kelp)	Up to 2009	https://bcmca.ca/maps-data/browse-or-search/?cat=24	-
Macroalgae and plants	Pterygophora Species Distribution Model	2020	https://publications.gc.ca/collections/collection_2020/mp-o-dfo/fs70-5/Fs70-5-2020-004-eng.pdf	-
Macroalgae and plants	Eelgrass Species Distribution Model	2020	https://publications.gc.ca/collections/collection_2020/mp-o-dfo/fs70-5/Fs70-5-2020-004-eng.pdf	-
Macroalgae and plants	ShoreZone Eelgrass bioband lines	2014-2016	-	-
Macroalgae and plants	ShoreZone Surfgrass bioband lines	2014-2016	-	-

Sections described	Survey or Spatial Feature Name	Date Range	Data, Metadata, or Publication Link	Institutional Source
Phytoplankton	Phytoplankton taxonomy samples	2010, 2015, 2016, 2018, 2019, 2021	Not publicly available	DFO - IOS
Invertebrates and Fishes	Hard bottom longline hook survey - outside north	2006 - 2021	Outside North Hard Bottom Longline Surveys - Open Government Portal (canada.ca)	DFO
Invertebrates and Fishes	International Pacific Halibut Comission (IPHC) fishery independent setline survey	2003-2022	IPHC Secretariat Data IPHC IPHC	International Pacific Halibut Commission
Invertebrates and Fishes	Joint Canada/US Hake Acoustic Survey	1998-2023	not publicly available	DFO
Invertebrates and Fishes	Sablefish trap survey	2002-2022	not publicly available	DFO
Invertebrates and Fishes	Groundfish synoptic bottom trawl surveys - Hecate Strait	2005 - 2021	Groundfish Synoptic Bottom Trawl Surveys - Open Government Portal (canada.ca)	DFO
Invertebrates and Fishes	Multispecies dive survey	2016-2022	not publicly available	DFO
Invertebrates and Fishes	Small Mesh multispecies bottom trawl survey	1989-2023	Pacific Multispecies Small Mesh Bottom Trawl Survey (gbif.org)	DFO
Invertebrates and Fishes	Benthic habitat mapping dive survey	2013-2022	Not publicly avialble	DFO
Invertebrates and Fishes	Integrated Pelagic Ecosystem Survey	2005-2023	not publicly available	DFO
Invertebrates	Vulnerable marine ecosystems composite for corals and sponges	Up to 2019	Modelling the environmental niche space and distributions of cold-water corals and sponges in the Canadian northeast Pacific Ocean - ScienceDirect	DFO

Sections described	Survey or Spatial Feature Name	Date Range	Data, Metadata, or Publication Link	Institutional Source
Invertebrates	Occurrences of coral and sponge groups	Up to 2019	Not publicly available	DFO
Invertebrates	Red sea cucumber density survey	1997-2023	not publicly available	DFO
Invertebrates	Geoduck density survey	1992-2023	not publicly available	DFO
Invertebrates	Red sea urchin density survey	1996-2016	not publicly available	DFO
Invertebrates	Crab by trap survey	1987-2022	not publicly available	DFO
Invertebrates	Prawn by trap survey	1999-2023	not publicly available	DFO
Cetaceans	Spatial density models of cetaceans in the Canadian Pacific estimated from 2018 ship-based surveys	2018	https://open.canada.ca/data/en/dataset/39546277-b33e-4f80-8a2d-3ca1ce5b1401	DFO
Pinnipeds	Harbour seal (<i>Phoca vitulina</i>) counts and haulout locations along BC coast - Harbour seal counts and haulout locations	2000-2019 used for Kitkatla Area	https://open.canada.ca/data/en/dataset/be5a4ba8-79dd-4787-bf8a-0d460d25954c	DFO

11.8 Appendix H. Taxonomic Diversity Tables

Table A6. Plankton species or groups observed at recording stations with a cell count > 0 in the Kitkatla Inlet Network Zones Area.

Class	Scientific Name	Recording stations where Observed at cell count > 0	
Bacillariophyceae	<i>Asteromphalus hepactis</i>	HECS4	CHAT1
Bacillariophyceae	<i>Asteromphalus sarcophagus</i>	PRHR74, HECS4	CHAT1
Bacillariophyceae	<i>Attheya</i> sp.	CH8	-
Bacillariophyceae	<i>Ceratulina pelagica</i>	-	CHAT1
Bacillariophyceae	<i>Chaetoceros concavicornis/convolutus</i>	HECS4	-
Bacillariophyceae	<i>Chaetoceros cf. danicus</i>	-	CHAT1
Bacillariophyceae	<i>Chaetoceros debilis</i>	CH8, HECS4, PRHR74, CHAT1	-
Bacillariophyceae	<i>Chaetoceros eibonii</i>	CHAT1	-
Bacillariophyceae	<i>Chaetoceros lorenzianus</i>	PRHR74	-
Bacillariophyceae	<i>Chaetoceros similis</i>	HECS4	-
Bacillariophyceae	<i>Chaetoceros socialis</i>	CH8, HECS4	-
Bacillariophyceae	<i>Chaetoceros subtilis</i>	CHAT1	-
Bacillariophyceae	<i>Chaetoceros vanheurckii</i>	CH8	-
Bacillariophyceae	<i>Chaetoceros</i> spp. (<i>hyalochaete</i>)	CH8, HECS4, CH27, PRHR74, CHAT1	CHAT1
Bacillariophyceae	<i>Chaetoceros tenuissimus</i>	CH27, CHAT1	CHAT1
Bacillariophyceae	<i>Dactyliosolen fragilissimus</i>	HECS4	-
Bacillariophyceae	<i>Detonula pumila</i>	HECS4	-
Bacillariophyceae	<i>Ditylum brightwellii</i>	HECS4, CHAT1, PRHR74	CHAT1
Bacillariophyceae	<i>Eucampia zodiacus</i>	CH8, HECS4, PRHR74, CHAT1, CH27	CHAT1
Bacillariophyceae	<i>Guinardia delicatula</i>	HECS4, CH27	CHAT1
Bacillariophyceae	<i>Guinardia striata</i>	CH8, HECS4, PRHR74	-

Class	Scientific Name	Recording stations where Observed at cell count > 0	
Bacillariophyceae	<i>Leptocylindrus danicus</i>	CH8, HECS4, PRHR74	-
Bacillariophyceae	<i>Leptocylindrus minimus</i>	PRHR74	-
Bacillariophyceae	<i>Proboscia alata</i>	HECS4, PRHR74	-
Bacillariophyceae	<i>Rhizosolenia setigera</i>	HECS4, PRHR74, CHAT1	-
Bacillariophyceae	<i>Rhizosolenia styliformis</i>	HECS4	-
Bacillariophyceae	<i>Skeletonema spp.</i>	CH8	CHAT1
Bacillariophyceae	<i>Thalassiosira nordenskiöldii</i>	CH8	-
Bacillariophyceae	<i>Thalassiosira rotula</i>	CH8	-
Bacillariophyceae	<i>Thalassiosira spp.</i>	HECS4, CHAT1	CHAT1
Bacillariophyceae	<i>Cylindrotheca closterium</i>	CH8, HECS4, CH27, PRHR74, CHAT1	CHAT1
Bacillariophyceae	<i>Haslea wawriake</i>	CH8, HECS4	-
Bacillariophyceae	<i>Pleurosigma normanii</i>	-	CHAT1
Bacillariophyceae	<i>Pseudo-nitzschia americana</i>	CH8, HECS4, PRHR74, CHAT1, CH27	-
Bacillariophyceae	<i>Pseudo-nitzschia cf. australis</i>	HECS4	-
Bacillariophyceae	<i>Pseudo-nitzschia cf. fraudulenta</i>	CH8	-
Bacillariophyceae	<i>Pseudo-nitzschia cf. pseudodelicatissima</i>	HECS4	-
Bacillariophyceae	<i>Pseudo-nitzschia cf. pungens</i>	HECS4	-
Bacillariophyceae	<i>Pseudo-nitzschia cf. seriata</i>	HECS4	-
Bacillariophyceae	<i>Pseudo-nitzschia sp.</i>	PRHR74	-
Bacillariophyceae	<i>Thalassionema nitzschoides</i>	CH8, HECS4	-
Bacillariophyceae	<i>Tropidoneis antarctica</i>	HECS4	-
Bacillariophyceae	<i>Tropidoneis sp.</i>	HECS4	-
Bacillariophyceae	Unidentified centric diatoms	CH27, HECS4	CHAT1
Bacillariophyceae	Unidentified pennate diatoms	CH8, HECS4	CHAT1

Class	Scientific Name	Recording stations where Observed at cell count > 0	
Dinophyceae	<i>Akashiwo sanguinea</i>	HECS4	CHAT1
Dinophyceae	<i>Amphidinium sphenoides</i>	HECS4	
Dinophyceae	<i>Ceratium cf. macroceros</i>		CHAT1
Dinophyceae	<i>Ceratium furca</i>	CH8	
Dinophyceae	<i>Ceratium fusus</i>	-	CHAT1
Dinophyceae	<i>Ceratium lineatum</i>	PRHR74, HECS4	CHAT1
Dinophyceae	<i>Dinophysis acuminata</i>	CH8, PRHR74	
Dinophyceae	<i>Dinophysis norvegica</i>	HECS4	
Dinophyceae	<i>Dinophysis parva</i>	CH8, HECS4, PRHR74	
Dinophyceae	<i>Heterocapsa rotundata</i>	HECS4, CH27, PRHR74, CHAT1	CHAT1
Dinophyceae	<i>Gymnodinium breve</i>	CH8, CH27, PRHR74, CHAT1	
Dinophyceae	<i>Gymnodinium sp.</i>	CH8, HECS4	CHAT1
Dinophyceae	<i>Katodinium glaucum</i>	CH8, HECS4, PRHR74, CHAT1	CHAT1
Dinophyceae	<i>Gyrodinium spirale</i>	CHAT1, CH27	-
Dinophyceae	<i>Gyrodinium sp.</i>	CH27, CH8, HECS4, PRHR74	-
Dinophyceae	<i>Noctiluca scintillans</i>	CHAT1	-
Dinophyceae	<i>Oxyphysis oxytoxoides</i>	HECS4	-
Dinophyceae	<i>Prorocentrum micans</i>	HECS4	CHAT1
Dinophyceae	<i>Protoperidinium steinii</i>	-	CHAT1
Dinophyceae	<i>Protoperidinium spp.</i>	PRHR74, HECS	CHAT1
Dinophyceae	Unidentified autotrophic dinoflagellates	-	CHAT1
Dinophyceae	Unidentified dinoflagellates	CH27, PRHR74, CHAT1, CH8, HECS4	CHAT1

Class	Scientific Name	Recording stations where Observed at cell count > 0	
Dinophyceae	Dinoflagellate cysts	CH8, HECS4	
	Unidentified flagellates	CH8, HECS4, CH27, PRHR74, CHAT1	CHAT1
	Autotrophs	CH8, HECS4, CH27, PRHR74, CHAT1	
Choanoflagellata	Choanoflagellates	CH8, HECS4, CH27, PRHR74, CHAT1	CHAT1
	Chlorophyte		CHAT1
Chrysophyceae	Chrysophyte	CH8, HECS4, PRHR74, CHAT1	-
	Ciliate	CH8, HECS4, PRHR74, CHAT1, CH27	CHAT1
Cryptophyceae	Cryptophyte	CH8, HECS4, CH27, PRHR74, CHAT1	CHAT1
Dictyochophyceae	Dictyophyte	CH8, HECS4, PRHR74, CH27, PRHR74, CHAT1	CHAT1
Euglenophyceae	Euglenophyte	CHAT1	CHAT1
Prasinophyceae	Prasinophyte	CH8, HECS4, CH27, PRHR74, CHAT1	CHAT1
Prymnesiophyceae	Prymnesiophyte	CH8, HECS4, CH27, PRHR74, CHAT1	CHAT1
Rapidophyceae	Rapidophyte	HECS4, PRHR74, CHAT1	CHAT1

Table A7. Marine plants species or groups observed in the Kitkatla Inlet Network Zones . ** Additional lists regarding the conservation status of birds do exist (e.g. ANMU, CAAU, MAMU, BFAL, PFSH) but are not included in the Conservation Priority assessment provided (Gale et al. 2019). * Conservation Status Acronyms: App.: Appendix, CR: Critically Endangered, DD: Data Deficient, E: Endangered, LC: Least Concern, NR: Not at Risk, NT: Not Threatened, SC: Special Concern, T: Threatened, V: Vulnerable

Class	Common Name	Scientific Name	Cons. Priority**	Zone 330	Zone 331	Zone 332	Zone 333
Phaeophyceae	Ribbon Kelp	<i>Alaria nana</i>	-	X	X	-	-
Alariaceae	Ribbon Kelp	<i>Alaria Sp.</i>	-	X	X	-	-
Phaeophyceae	Sieve Kelp	<i>Agarum clathratum</i>	-	X	X	-	-
Florideophyceae	Articulated Corraline Algae	<i>Order Corallinales</i>	-	X	X	-	-
Phaeophyceae	Fringed Sieve Kelp	<i>Agarum fimbriatum</i>	-	-	X	-	-
Phaeophyceae	Winged Kelp	<i>Alaria marginata</i>	-	X	X	-	-
Phaeophyceae	Sieve Kelp	<i>Agarum sp</i>	-	X	-	-	-
Florideophyceae		<i>Bossiella cretacea</i>	-	X	X	-	-
Ulvophyceae		<i>Cladophora</i>	-	X	X	-	-
Phaeophyceae	Five-ribbed Kelp	<i>Costaria costata</i>	-	X	X	-	-
Phaeophyceae	Desmarest's flattened weed	<i>Desmarestia aculeata</i>	-	X	X	-	-
Phaeophyceae	Flattened acid Kelp	<i>Desmarestia ligulata</i>	-	X	X	-	-
Phaeophyceae	Feather boa Kelp	<i>Egregia menziesii</i>	-	X	-	-	-
Phaeophyceae	Southern Sea Palm	<i>Eisenia arborea</i>	-	X	-	-	-
Rhodymeniophycidae	Red spaghetti ogo	<i>Gracilaria pacifica; Sarcodiotheca spp</i>	-	X	-	-	-
Rhodymeniophycidae	Sea sacs	<i>Haloscaccion glandiforme</i>	-	X	X	-	-

Class	Common Name	Scientific Name	Cons. Priority**	Zone 330	Zone 331	Zone 332	Zone 333
Bangiophyceae	Nori	<i>Pyropia</i>	-	X	-	-	-
Phaeophyceae	Stipeless Kelp	<i>Saccharina sessilis</i>	-	X	X	-	-
Phaeophyceae	Sugar Kelp	<i>Saccharina latissima</i>	-	X	X	-	-
Phaeophyceae	Suction-Cup Kelp	<i>Laminaria yezoensis</i>	-	X	-	-	-
Phaeophyceae	Southern Stiff-stiped Kelp	<i>Laminaria setchellii</i>	-	X	X	-	-
Phaeophyceae	Oar Weed	<i>Laminaria farlowii</i>	-	X	X	-	-
Phaeophyceae	Woody Stalked Kelp	<i>Pterygophora californica</i>	-	X	X	-	-
Ulvophyceae	Sea Lettuce	<i>Ulva species</i>	-	X	X	-	-
Phaeophyceae	Rockweed	<i>Fucus</i>	-	X	X	-	-
Phaeophyceae	Bull Kelp	<i>Nereocystis leutkeana</i>	Y	X	X	X	X
Phaeophyceae	Giant Kelp	<i>Macrocystis sp.</i>	Y	X	X	X	X

Table A8. Invertebrate species or groups observed in the Kitkatla Inlet Network Zones . * Conservation Status Acronyms: App.: Appendix, CR: Critically Endangered, DD: Data Deficient, E: Endangered, LC: Least Concern, NR: Not at Risk, NT: Not Threatened, SC: Special Concern, T: Threatened, V: Vulnerable

Class	Common Name	Scientific Name	CITES List	IUCN List	Cons. Priority	Zone 330	Zone 331	Zone 332	Zone 333
Asteroidea	Sunflower Sea Star	<i>Pycnopodia helianthoides</i>	-	CR	Y	X	X		X
Cephalopoda	Opal Squid	<i>Doryteuthis opalescens</i>	-	LC	Y		X		
Cephalopoda	Giant Pacific Octopus	<i>Enteroctopus dofleini</i>	-	LC	Y	X	X		X
Demospongiae	Demosponges	Demospongiae	-	-	Y	X	X		
Hexacorallia	Black Corals	Antipatharia	App. II	-	Y		X		
Hexacorallia	Hard or Stony Corals	Scleractinia	App. II		Y	X	X		
Hexactinellida	Glass sponges	Hexactinellida	-	-	Y	X			
Malacostraca	Inshore Tanner crab	<i>Chionoecetes bairdi</i>	-	-	Y				X
Malacostraca	Deepwater Grooved Tanner Crab	<i>Chionoecetes tanneri</i>	-	-	Y				
Malacostraca	Dungeness Crab	<i>Metacarcinus magister</i>	-	-	Y	X	X	X	X
Malacostraca	Sidestripe Shrimp	<i>Pandalopsis dispar</i>	-	-	Y		X	X	
Malacostraca	Spiny/Northern Pink Shrimp	<i>Pandalus borealis</i>	-	-	Y		X		
Malacostraca	Coonstripe/Dock Shrimp	<i>Pandalus danae</i>			Y		X		
Malacostraca	Humpback Shrimp	<i>Pandalus hypsinotus</i>			Y		X		
Malacostraca	Smooth Pink Shrimp	<i>Pandalus jordani</i>	-	-	Y		X		

Class	Common Name	Scientific Name	CITES List	IUCN List	Cons. Priority	Zone 330	Zone 331	Zone 332	Zone 333
Malacostraca	Spot Prawn	<i>Pandalus platyceros</i>	-	-	Y	X	X		
Octocorallia	Gorgonian and Soft Corals	Alcyonacea	-	-	Y		X		X
Octocorallia	Sea Pens	Pennatulacea	-	-	Y	X			

Table A9. Fish species observed in the Kitkatla Inlet Network Zones . * Conservation Status Acronyms: App.: Appendix, CR: Critically Endangered, DD: Data Deficient, E: Endangered, LC: Least Concern, NR: Not at Risk, NT: Not Threatened, SC: Special Concern, T: Threatened, V: Vulnerable

Class	Common Name	Scientific Name	CITES List	IUCN List	SARA	COSEWIC	Cons. Priority**	Zone 330	Zone 331	Zone 332	Zone 333	In Area - no Zone ID
Actinopterygii	Arrowtooth	<i>Atheresthes stomias</i>	-	-	-	-	Y	X	X		X	
Actinopterygii	Dover Sole	<i>Microstomus pacificus</i>	-	DD	-	-	Y	X	X	X	X	
Actinopterygii	Pacific Halibut	<i>Hippoglossus stenolepis</i>	-	LC	-	-	Y	X	X	X	X	
Actinopterygii	Petrable Sole	<i>Eopsetta jordani</i>	-	LC	-	-	Y	X	X	X	X	
Actinopterygii	Rex Sole	<i>Glyptocephalus zachirus</i>	-	LC	-	-	Y	X	X	X	X	
Actinopterygii	Rock sole	<i>Lepidopsetta bilineata</i>	-	LC	-	-	Y	X	X	X	X	
Actinopterygii	Eulachon	<i>Thaleichthys pacificus</i>	-	LC	-	E	Y		X		X	
Actinopterygii	Pacific Herring	<i>Clupea pallasii</i>	-	DD	-	-	Y				X	
Actinopterygii	Northern Lampfish	<i>Stenobranchius leucopsarus</i>	-	LC	-	-	Y					
Actinopterygii	Lingcod	<i>Ophiodon elongatus</i>	-	-	-	-	Y	X	X	X	X	
Actinopterygii	Sablefish	<i>Anoplopoma fimbria</i>	-	-	-	-	Y	X	X	X	X	
Actinopterygii	Chinook Salmon	<i>Oncorhynchus tshawytscha</i>	-	-	-	E	Y					X
Actinopterygii	Chum Salmon	<i>Oncorhynchus keta</i>	-	-	-	-	Y	X	X			
Actinopterygii	Coho Salmon	<i>Oncorhynchus kisutch</i>	-	-	-	T	Y	X	X			

Class	Common Name	Scientific Name	CITES List	IUCN List	SARA	COSEWIC	Cons. Priority**	Zone 330	Zone 331	Zone 332	Zone 333	In Area - no Zone ID
Actinopterygii	Pink Salmon	<i>Oncorhynchus gorbusha</i>	-	-	-	-	Y	X	X			
Actinopterygii	Sockeye Salmon	<i>Oncorhynchus nerka</i>	-	LC	-	E	Y	X				
Actinopterygii	Bocaccio	<i>Sebastes paucispinis</i>	-	CR	-	E	Y					X
Actinopterygii	Canary Rockfish	<i>Sebastes pinniger</i>	-	-	-	T	Y	X	X		X	
Actinopterygii	China Rockfish	<i>Sebastes nebulosus</i>	-	-	-	-	Y		X			
Actinopterygii	Copper Rockfish	<i>Sebastes caurinus</i>	-	-	-	-	Y	X	X			
Actinopterygii	Darkblotched Rockfish	<i>Sebastes crameri</i>	-	-	-	SC	Y					
Actinopterygii	Greenstriped Rockfish	<i>Sebastes elongatus</i>	-	-	-	-	Y		X			
Actinopterygii	Harlequin Rockfish	<i>Sebastes variegatus</i>	-	-	-	-	-		X			
Actinopterygii	Pacific Ocean Perch	<i>Sebastes alutus</i>	-	-	-	-	Y					
Actinopterygii	Quillback Rockfish	<i>Sebastes maliger</i>	-	-	-	T	Y	X	X		X	
Actinopterygii	Redbanded Rockfish	<i>Sebastes babcocki</i>	-	-	-	-	N		X			
Actinopterygii	Redstripe Rockfish	<i>Sebastes proriger</i>	-	-	-	-	Y		X			
Actinopterygii	Rosethorn rockfish	<i>Sebastes helvomaculatus</i>	-	-	-	-	Y					

Class	Common Name	Scientific Name	CITES List	IUCN List	SARA	COSEWIC	Cons. Priority**	Zone 330	Zone 331	Zone 332	Zone 333	In Area - no Zone ID
Actinopterygii	Shortraker Rockfish	<i>Sebastes borealis</i>	-	-	-	-	Y					
Actinopterygii	Silvergray Rockfish	<i>Sebastes brevispinis</i>	-	-	-	-	Y		X			
Actinopterygii	Tiger Rockfish	<i>Sebastes nigrocinctus</i>	-	-	-	-	Y		X			
Actinopterygii	Vermillion Rockfish	<i>Sebastes miniatus</i>	-	-	-	-	Y					
Actinopterygii	Widow Rockfish	<i>Sebastes entomelas</i>	-	-	-	-	Y					
Actinopterygii	Yelloweye Rockfish	<i>Sebastes ruberrimus</i>	-	-	SC	SC	Y	X	X			
Actinopterygii	Yellowmouth Rockfish	<i>Sebastes reedi</i>	-	-	-	T	Y					
Actinopterygii	Yellowtail Rockfish	<i>Sebastes flavidus</i>			-		Y	X	X			
Actinopterygii	Longspine Thornyhead	<i>Sebastolobus altivelis</i>	-	-	SC	SC	Y					
Actinopterygii	Shortspine Thornyhead	<i>Sebastolobus alascanus</i>	-	E (A2d)	-	-	Y		X			
Actinopterygii	Rougheye/Blackspotted Rockfish complex	<i>Sebastes aleutianus/melanostichus</i>	-	-	SC	SC	Y					
Actinopterygii	Pacific Cod	<i>Gadus macrocephalus</i>	-	-	-	-	Y	X	X		X	
Actinopterygii	Pacific Hake	<i>Merluccius productus</i>	-	LC	-	-	Y	X	X	X	X	
Actinopterygii	Walleye Pollock	<i>Gadus chalcogrammus</i>	-	-	-	-	Y		X		X	

Class	Common Name	Scientific Name	CITES List	IUCN List	SARA	COSEWIC	Cons. Priority**	Zone 330	Zone 331	Zone 332	Zone 333	In Area - no Zone ID
Elasmobranchii	Bluntnose Sixgill Shark	<i>Hexanchus griseus</i>	-	NT	SC	SC	Y					X
Elasmobranchii	Pacific Sleeper Shark	<i>Somniosus pacificus</i>	-	NT	-	-	Y					X
Elasmobranchii	Spiny Dogfish	<i>Squalus suckleyi</i>	-	-	-	SC	Y	X	X	X	X	
Elasmobranchii	Blue Shark	<i>Prionace glauca</i>	-	NT	-	NR	Y					
Elasmobranchii	Salmon Shark	<i>Lamna ditropis</i>	-	LC	-	-	Y					
Elasmobranchii	Big Skate	<i>Beringraja binocularata</i>	-	NT	-	NR	Y	X	X	X		
Elasmobranchii	Longnose Skate	<i>Beringraja rhina</i>	-	LC	-	NR	Y	X	X	X		
Elasmobranchii	Roughtail Skate	<i>Bathyraja trachura</i>	-	LC	-	-	Y					
Elasmobranchii	Sandpaper Skate	<i>Bathyraja interrupta</i>	-	LC	-	NR	Y				X	
Chondrichthyes	Spotted Ratfish	<i>Hydrolagus colliei</i>	-	LC	-	-	-					

Table A10. Marine mammal species (Class Mammalia) observed in the Kitkatla Inlet Network Zones. Conservation Status Acronyms: App.: Appendix, CR: Critically Endangered, DD: Data Deficient, E: Endangered, LC: Least Concern, NR: Not at Risk, NT: Not Threatened, SC: Special Concern, T: Threatened, V: Vulnerable

Common Name	Scientific Name	CITES List	IUCN List	SARA	COSEWIC	Cons. Priority	Zone 330	Zone 331	Zone 332	Zone 333	In Area - no Zone ID
Fin Whale	<i>Balaenoptera physalus</i>	App. I	V	-	SC	Y	X				X
Humpback Whale	<i>Megaptera novaeangliae</i>	App. I	LC	SC	SC	Y	X	X	X	X	X
Grey Whale	<i>Eschrichtius robustus</i>	App. I	LC	NR	E	Y	-	-	-	-	X
Minke Whale	<i>Balaenoptera acutorostrata</i>	App. I & II	LC	-	NR	Y	-	-	-	-	X
Sperm Whale	<i>Physeter macrocephalus</i>	App. I	V	-	NR	Y	-	-	-	-	X
Pacific White Sided Dolphin	<i>Laegenorhynchus obliquidens</i>	-	-	-	-	Y	-	-	-	-	X
Killer Whale (Orca)	<i>Orcinus orca</i>	App. II	DD	T	T	Y	X	X	X	X	X
Harbour Porpoise	<i>Phocoena phocoena</i>	App. II	LC	SC	SC	Y	-	X	-	-	X
Dall's Porpoise	<i>Phocoenoides dalli</i>	App. II	LC	-	NR	Y	-	X	-	-	X
Harbour Seal	<i>Phoca vitulina</i>	-	LC	NR	NR	Y	X	X	X	X	--
Steller Sea Lion	<i>Eumetopias jubatus</i>	-	NT	SC	SC	Y			X		X
Northern Fur Seal*	<i>Callorhinus ursinus</i>	-	V	-	T	Y	X	X	X	X	-

*Observations from Station from Cruise 2018-025; and 2019-069

Table A11. Marine bird species (Class Aves) observed in the Kitkatla Inlet Network Zones. Additional lists regarding the conservation status of birds do exist (e.g. ANMU, CAAU, MAMU, BFAL, PFSH) but are not included in the Conservation Priority assessment provided (Gale et al. 2019).

Common Name	Scientific Name	IUCN List*	SARA*	COSEWIC*	Cons. Priority	Zone 330	Zone 331	Zone 332	Zone 333
Leach's Storm-petrel	<i>Hydrobates leucorhous</i>	VU	-	-	Y	-	X	-	-
Northern Fulmar	<i>Fulmarus glacialis</i>	LC	-	-	Y	-	X	-	-
Short-tailed Shearwater	<i>Ardenna tenuirostris</i>	LC	-	-	Y	-	X	-	-
Sooty Shearwater	<i>Ardenna grisea</i>	NT	-	-	Y	-	X	-	-
Common Murre	<i>Uria aalge</i>	LC	-	-	Y	X	X	-	-
Marbled Murrelet	<i>Brachyramphus marmoratus</i>	E	T	T	Y	X	X	-	-
Pigeon Guillemot	<i>Cephus columba</i>	LC	-	-	Y	-	X	X	-
Rhinoceros Auklet	<i>Cerorhinca monocerata</i>	LC	-	-	Y	-	X	-	-
Double-crested Cormorant	<i>Nannopterum auritum</i>	LC			Y	-	X	X	X
Pelagic Cormorant	<i>Urile pelagicus</i>	LC	-	-	Y	-	X	X	X
Black-legged Kittiwake	<i>Rissa tridactyla</i>	VU	-	-	-	-	X	-	-
Bonaparte's Gull	<i>Chroicocephalus philadelphia</i>	LC	-	-	-	-	X	-	-
California Gull	<i>Larus californicus</i>	LC	-	-	Y	-	X	-	-
Glaucous-winged Gull	<i>Larus glaucescens</i>	LC	-	-	-	X	X	X	X
Herring Gull	<i>Larus argentatus</i>	LC	-	-	-	-	X	-	-
Mew Gull/Short-billed Gull	<i>Larus brachyrhynchus</i>	-	-	-	-	-	X	-	-
Common Loon	<i>Gavia immer</i>	LC			Y	-	X	X	X
Pacific Loon	<i>Gavia pacifica</i>	LC	-	-	Y	-	X	X	X
Horned Grebe	<i>Podiceps auritus</i>	VU	SC	SC	Y	-	X	X	

Common Name	Scientific Name	IUCN List*	SARA*	COSEWIC*	Cons. Priority	Zone 330	Zone 331	Zone 332	Zone 333
Red-necked Grebe	<i>Podiceps grisegena</i>	LC			-	-	X	X	X
Western Grebe	<i>Aechmophorus occidentalis</i>	LC			Y	-	X	-	-
Black Oystercatcher	<i>Haematopus bachmani</i>	LC			Y	-	X	X	-
Red-necked Phalarope	<i>Phalaropus lobatus</i>	LC	SC	SC	Y	-	X	-	-
Surfbird	<i>Calidris virgata</i>	LC	-	-	Y	-	X	-	-
Barrow's Goldeneye	<i>Bucephala islandica</i>	LC	-	-	Y	-	X	-	-
Black Scoter	<i>Melanitta americana</i>	NT	-	-	Y	-	X	X	X
Bufflehead	<i>Bucephala albeola</i>	LC	-	-	N	-	X	X	-
Common Goldeneye	<i>Bucephala clangula</i>	LC	-	-	Y	-	X	-	-
Common Merganser	<i>Mergus merganser</i>	-	-	-	-	-	X	X	X
Harlequin Duck	<i>Histrionicus histrionicus</i>	LC	-	-	Y	-	X	X	X
Hooded Merganser	<i>Lophodytes cucullatus</i>	LC	-	-	-	-	X	X	
Long-tailed Duck	<i>Clangula hyemalis</i>	VU	-	-	Y	-	X	X	X
Red-breasted Merganser	<i>Mergus serrator</i>	LC	-	-	N	-	X	X	X
Surf Scoter	<i>Melanitta perspicillata</i>	LC	-	-	Y	-	X	X	X
White-winged Scoter	<i>Melanitta deglandi</i>	LC	-	-	Y	-	X	X	X
Green-winged Teal	<i>Anas crecca</i>	LC	-	-	N	-	X	-	-
American Wigeon	<i>Anas americana</i>	LC	-	-	N	-	X	-	-
Canada Goose	<i>Branta canadensis</i>	LC	-	-	Y	X	X	-	-
Greater Scaup	<i>Aythya marila</i>	LC	-	-	N	-	X	-	-
Mallard	<i>Anas platyrhynchos</i>	LC	-	-	N	-	X	-	-
Trumpeter Swan	<i>Cygnus buccinator</i>	LC	-	-	Y	-	X	X	X
Great Blue Heron	<i>Ardea herodias fannini</i>	LC	SC	SC	Y	-	X	-	-

Common Name	Scientific Name	IUCN List*	SARA*	COSEWIC*	Cons. Priority	Zone 330	Zone 331	Zone 332	Zone 333
Bald Eagle	<i>Haliaeetus leucocephalus</i>	LC	-	-	-	-	X	-	-

* Conservation Status Acronyms: App.: Appendix, CR: Critically Endangered, DD: Data Deficient, E: Endangered, LC: Least Concern, NR: Not at Risk, NT: Not Threatened, SC: Special Concern, T: Threatened, V: Vulnerable

11.9 Appendix I: E-CP data sources

Table A12. Ecological Conservation Priority (E-CP) data sources for the Network Ecological Conservation Priorities section 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
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	
Red Sea Urchin locations	Presence-only records of Red Sea Urchin, collated from a variety of research and commercial sources.	1967-2016	DFO	

Spatial Feature Name	Brief Description	Date Range	Institutional Source	Citation
Harbour Seal Haul-outs	Locations of haul-outs used by Harbour Seals	up to 2016	DFO	
Humpback Whale Critical Habitat (2009-2013)	Critical habitat for humpback whales (2009-2013). CH in the NSB includes: 1) the waters surrounding Langara Island; 2) coastal waters along the south eastern side of Moresby Island and Kunghit Island; 3) the mainland 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.	2009	DFO	Nichol et al. 2010
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
Bull Kelp Beds	Polygons delineating Bull Kelp (<i>Nereocystis integrifolia</i>) beds compiled by the BCMCA.	1976-2004	British Columbia Marine Conservation Analysis (BCMCA)	
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)	
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	

Spatial Feature Name	Brief Description	Date Range	Institutional Source	Citation
Surfgrass Biobands	Coastline segment surveyed for patchy or continuous presence of surfgrass by the Province of BC.	1979-2012	ShoreZone, Province of BC, BCMCA	
<i>Habitat Features</i>				
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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