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Biophysical and Ecological Overview of the Offshore Haida Gwaii Network Zones

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

The Offshore Haida Gwaii Network Zones were delineated as part of the Northern Shelf Bioregion Marine Protected Area (MPA) Network planning process and represent candidate areas of importance to protect by the network partners (Canada, Province of British Columbia (BC), Council of the Haida Nation and 14 other First Nations in BC). This Biophysical and Ecological Overview summarizes the knowledge and existing data available on the ecosystems present within seven offshore zones in close proximity to **X̱aadáa Gwáay X̱aaydag̱a Gwaay.yaay** *Haida Gwaii* to inform the potential creation of a marine protected area. The report summarizes the physical and biological oceanography, ecological diversity, human use, and conservation value of the seven zones that make up the Offshore Haida Gwaii Network Zones. It additionally synthesizes the available knowledge to highlight known and potential connectivity among zones within the Offshore Haida Gwaii Network Zones, as well as the contributions of the zones to the whole proposed Marine Protected Area Networks for the Northern Shelf Bioregion. Data presented in this report incorporate information gathered in the data compilation step of the MPA network planning process, in addition to regionally specific data and knowledge. The information came from annual research surveys, expert opinion, ecological and oceanographic model outputs, published literature, and Haida knowledge. Key ecosystem components described within the report include complex benthic terrain, rocky outcrops, seamounts and mud volcanoes, and high taxonomic diversity, including invertebrates, groundfishes, elasmobranchs, **X̱edíit Siigaay x̱idid** *marine birds* and mammals. Furthermore, the report includes a synopsis of some predicted changes in the region under two climate change scenarios. The information presented and referenced here can also inform the development of research, management and monitoring plans should the zones be established as Marine Protected Areas under Canada's *Oceans Act*.

1. PREFACE

Throughout the document, names of places and species are provided in Haida dialects and English where possible. To differentiate between the two Haida dialects in the report, **X̱aad kíl** is in blue text, and **X̱aayda kil** is in green text. The Haida names referenced in this report and their dialects are listed in Appendix C, including a pronunciation reference. The lack of a X̱aad kíl or X̱aayda kil equivalent should not be interpreted to mean that the word does not exist. This document should not be used as a language reference. All inquiries should be directed to the respective language authorities **X̱aad Kíl Nee** for X̱aad kíl or **Hlg̱aagilda X̱aayda kil Naay** for X̱aayda kil.

The Haida knowledge presented in this report should not be considered complete. It is only an indication of some of the traditional Haida marine knowledge that has been recorded and published about the habitats and species found in these zones and around Haida Gwaii. Despite the fact that a substantial amount of information has been documented during various studies, it is important to recognize that this report in no way represents the totality of Haida knowledge regarding marine species and the marine environment.

2. REGIONAL CONTEXT

2.1. HAIDA GWAII AND THE HISTORY OF MARINE PLANNING IN THE NORTHERN SHELF BIOREGION (NSB)

X̱aadáa Gwáay X̱aaydag̱a Gwaay.yaay *Haida Gwaii* is the homeland of the Haida Nation. Physically, it is an archipelago on the edge of the continental shelf on the west coast of British Columbia. Stewardship of the **X̱aadáa Gwáay X̱aaydag̱a Gwaay.yaay** marine areas has been ongoing since Time Immemorial.

> "The Haidas' intimate relationship with the marine environment spans countless generations; one of [many] long-told creation stories from the northernmost beaches of Haida Gwaii describe Haidas emerging from a giant clamshell to populate the islands. Due to this long and unbroken presence, Haidas are as much a part of the landscape [and seascape] as the other species with whom we share it... In part, it is the Haida knowledge of the land and ocean that has ensured our continued success. Each generation passes inherited and experiential knowledge of fishing grounds and harvesting methods to nieces, nephews, children and grandchildren. From their earliest memories Haida children recall digging shellfish, gathering seaweed, learning how to spear octopus, and helping to prepare and preserve fish. Always underlying the lessons is a profound message of respect and recognition of the Haida responsibility in maintaining balance in the natural world."
>
> (Haida Marine Traditional Knowledge Study Participants et al. 2011a).

The Council of the Haida Nation[1] (CHN) has been involved in marine planning processes since the 1990s, including the development of the Haida Marine Traditional Knowledge Study (Haida Marine Traditional Knowledge Study Participants 2011a), the basis of much of the Haida

[1] Council of the Haida Nation was formed in 1974 to organize citizens into one political entity. Part of the vision was a clear mandate to settle the [title] question. (Council of the Haida Nation 2022).

Nation's marine planning work. The subsequent sections describe the regional processes from the **X̲aadáa Gwáay** **X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* sub-regional perspective.

The CHN has supported regional planning initiatives in the Northern Shelf Bioregion[2] (NSB) (Figure 1), in partnership with many other coastal First Nations, the Government of Canada, and/or the Province of British Columbia (BC). The Pacific North Coast Integrated Management Area (PNCIMA) plan was a decade-long collaborative process endorsed by Canada, British Columbia, the Council of the Haida Nation and multiple coastal First Nations in 2017 (PNCIMA Initiative 2017). The PNCIMA plan is a high-level strategic document that commits to integrated, ecosystem-based management of marine activities and resources and delineates the NSB into four sub-regions based on First Nations territories. Additionally, the PNCIMA plan identifies marine protected area network planning as a priority within the region.

In 2011, the CHN, along with other coastal First Nations and the Province of BC launched the Marine Plan Partnership (MaPP)[3] process, which led to the development of four sub-regional marine plans that cover the extent of the NSB. The Haida Gwaii Marine Plan is an ongoing collaborative planning process enabled through a Government-to-Government arrangement involving the CHN, BC, Haida and island communities, local governments, stakeholders and the broader public. The Haida Gwaii Marine Plan includes marine zoning and recommended policy and management direction regarding marine uses, activities and values that fall within the jurisdictional authority of the CHN and within the provincial mandate. The marine zoning includes Protection Management Zones (PMZ), which allocate space primarily for conservation purposes. Though they are not designated marine protected areas, PMZs make important contributions to the Marine Protected Area (MPA) Network planning process in the Northern Shelf Bioregion. The areas under discussion in this document all fall within the boundaries of the MaPP Haida Gwaii Marine Plan (MaPP 2015).

In addition to the above processes, between the 11 CHN – BC Protected Areas established under the **Kunst'aa Guu – Kunst'aayah** Reconciliation Protocol (2011)[4] and the Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site, over 52% of the land area and 87% of the shoreline is protected and managed by the Haida Nation and provincial and federal governments.

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[2] The Northern Shelf Bioregion (NSB) is one of twelve ecologically distinct bioregions in the oceans, which provide boundaries for marine spatial planning initiatives across the country. It covers an area of almost 102,000 km^2, extending from Quadra Island/Bute Inlet in British Columbia to the Canada-Alaska border and out to the base of the continental slope (Figure 1). It encompasses a wide variety of land- and sea-scapes including narrow glacial-fed fjords, shallow intertidal areas, high current activity, broad shelf waters, gyres and upwelling areas. Note the boundary extends into the Strait of Georgia bioregion (capturing Bute Inlet) to align with boundaries of previous marine planning initiatives and territorial boundaries of partner First Nations.

[3] MaPP | Marine Plan Partnership for the North Pacific Coast

[4] **Kunst'aa Guu** – **Kunst'aayah** Reconciliation Protocol

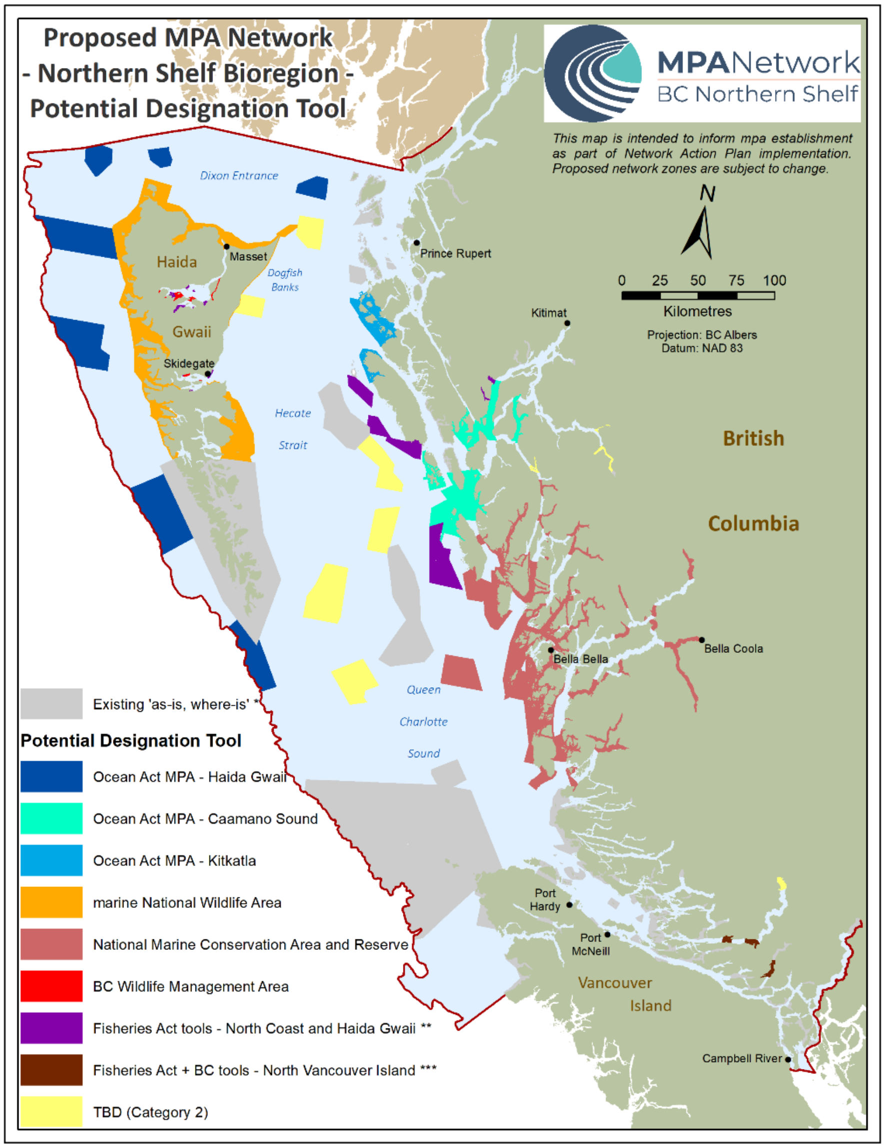

Figure 1. The proposed Marine Protected Area (MPA) Network of zones in the Northern Shelf Bioregion (NSB; red outline). The Offshore Haida Gwaii Network Zones (OHGNZ) are the seven zones shown in dark blue and are a proposed Oceans Act *MPA.*

Building from the efforts of the PNCIMA and MaPP initiatives, the Government of Canada, the Province of British Columbia, the Council of the Haida Nation and 14 other First Nations have worked together to develop a proposed Marine Protected Area Network within the Northern Shelf Bioregion (NSB MPAn). The tripartite technical team developed the NSB MPAn scenario[5] following a systematic conservation planning approach (Figure 2; Margules and Pressey 2000). This planning involved several steps, including developing MPA Network goals (Canada –

[5] Marine Protected Area Technical Team (MPATT) members: Canada, Province of BC, Gitga'at, Gitxaala, Haisla, Kitselas, Kitsumkalum, Metlakatla, Heiltsuk, Kitasoo/Xai'xais, Nuxalk, Wuikinuxv, Da'naxda'xw Awaetlala, Mamalilikulla, K'ómoks, Kwiakah, Tlowitsis, and Wei Wai Kum First Nations; and the Council of the Haida Nation.

British Columbia Marine Protected Area Network Strategy 2014), setting network conservation objectives (mpanetwork.ca), selecting conservation priorities (Gale et al. 2019; DFO 2017a), compiling existing spatial data, and setting spatial conservation targets and design strategies (Martone et al. 2021; DFO 2019a). Finally, zones for the network scenario were selected and revised using these inputs together with analytical outputs from the Marxan decision-support tool, internal review by the governance partners, and stakeholder input (Figure 2; see the MPA Network website for more details). The MPA Network Technical Team (MPATT) developed a Network Action Plan that includes the draft network scenario. This draft details the conservation objectives for each zone in the network, including ecological and cultural conservation objectives. Such conservation objectives span the protection of species significant to First Nations and coastal communities, representative areas of every marine habitat type, areas of high biological diversity or rare, unique, threated, and/or endangered species and their habitats, and ecologically significant geological features. The draft network scenario also identifies zone-specific human "activities of concern" that may impact conservation priorities and potentially interfere with meeting zone-specific and network-level objectives.

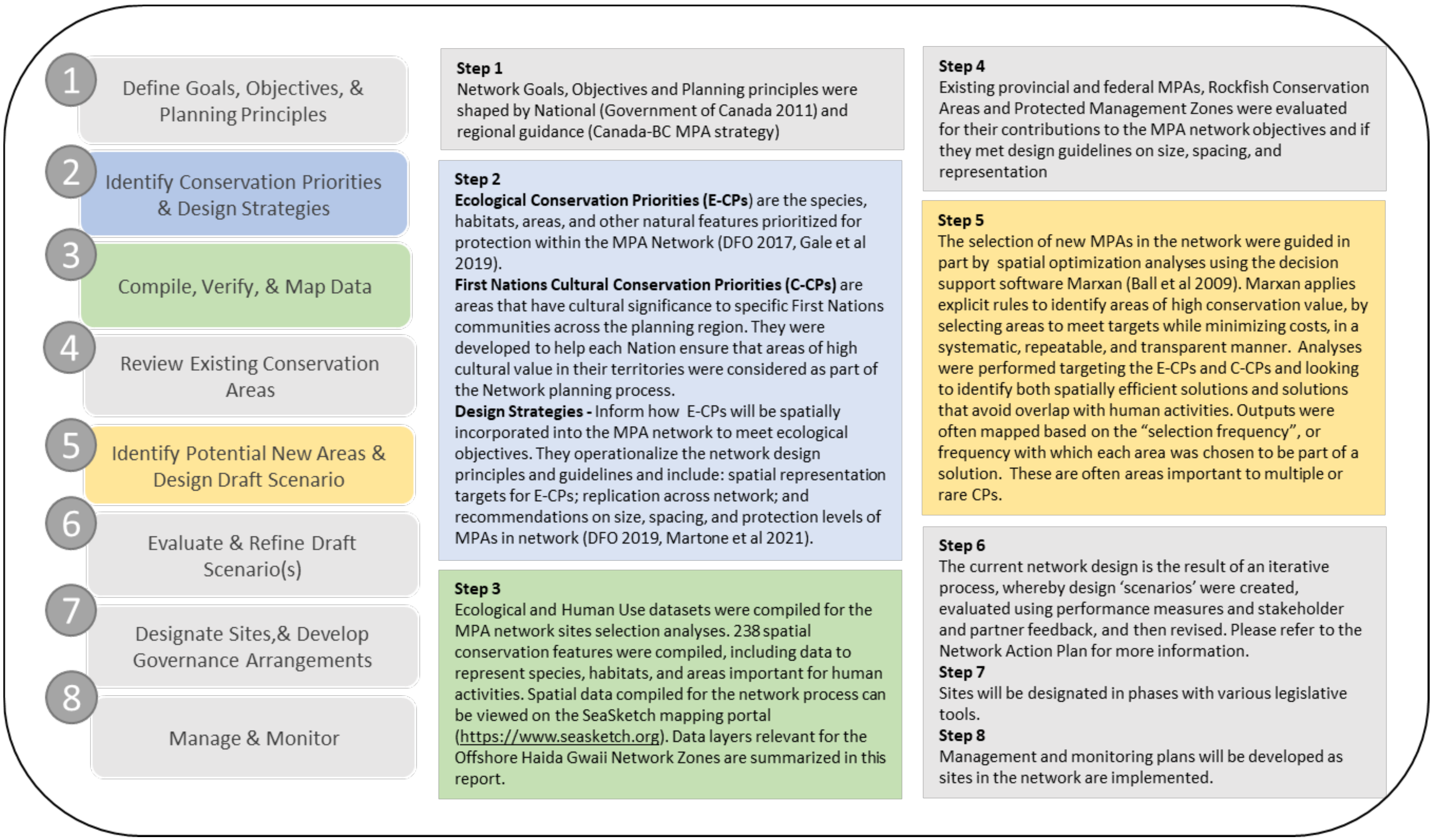

Figure 2. Summary of steps in the NSB MPA Network Planning process. Coloured boxes are particularly relevant for this report, including defining key terminology of the network process. For more information on each step refer to publications within the Network Action Plan, or [the NSB MPA Network website](#).

2.2. OFFSHORE HAIDA GWAII NETWORK ZONES

The seven zones representing the Offshore Haida Gwaii Network Zones (OHGNZ; Figure 3) are a subset of the NSB MPA Network scenario sites and therefore contribute to the overall MPA Network goals and objectives. A brief description of the boundary delineation considerations for individual zones and zone-specific contributions to the broader MPA network goals and objectives are presented/summarized in Appendix D. At the time of writing this report, the proposed MPA Network, including the seven zones that make up the Offshore Haida Gwaii Network Zones (Figure 3), was out for public engagement and ongoing consultation with First Nations. The Biophysical Overview Report is thus unique among most Biophysical Overview Reports for several reasons:

1. these areas were identified as individual zones that work in complement with other individual existing and potential MPAs to contribute to conservation objectives at the MPA Network scale;
2. network level ecological conservation priorities (E-CPs; DFO 2017a), cultural conservation priorities (C-CPs[6]), and draft zone-specific conservation objectives have already been identified, a step that usually follows the creation of a Biophysical Report for an area of interest (AOI) for an *Oceans Act* MPA; and
3. "activities of concern" or activities that may affect conservation objectives at the zone level have already been identified in the Network Action Plan.

This allows this report to focus more specifically on the contribution of these areas to the overall MPA Network while also highlighting zone-specific or locally important ecological, cultural and physical components. This report will help provide information that may assist in identifying and/or refining conservation objectives and help inform the development of a management plan for the OHGNZ and subsequent advice on monitoring.

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

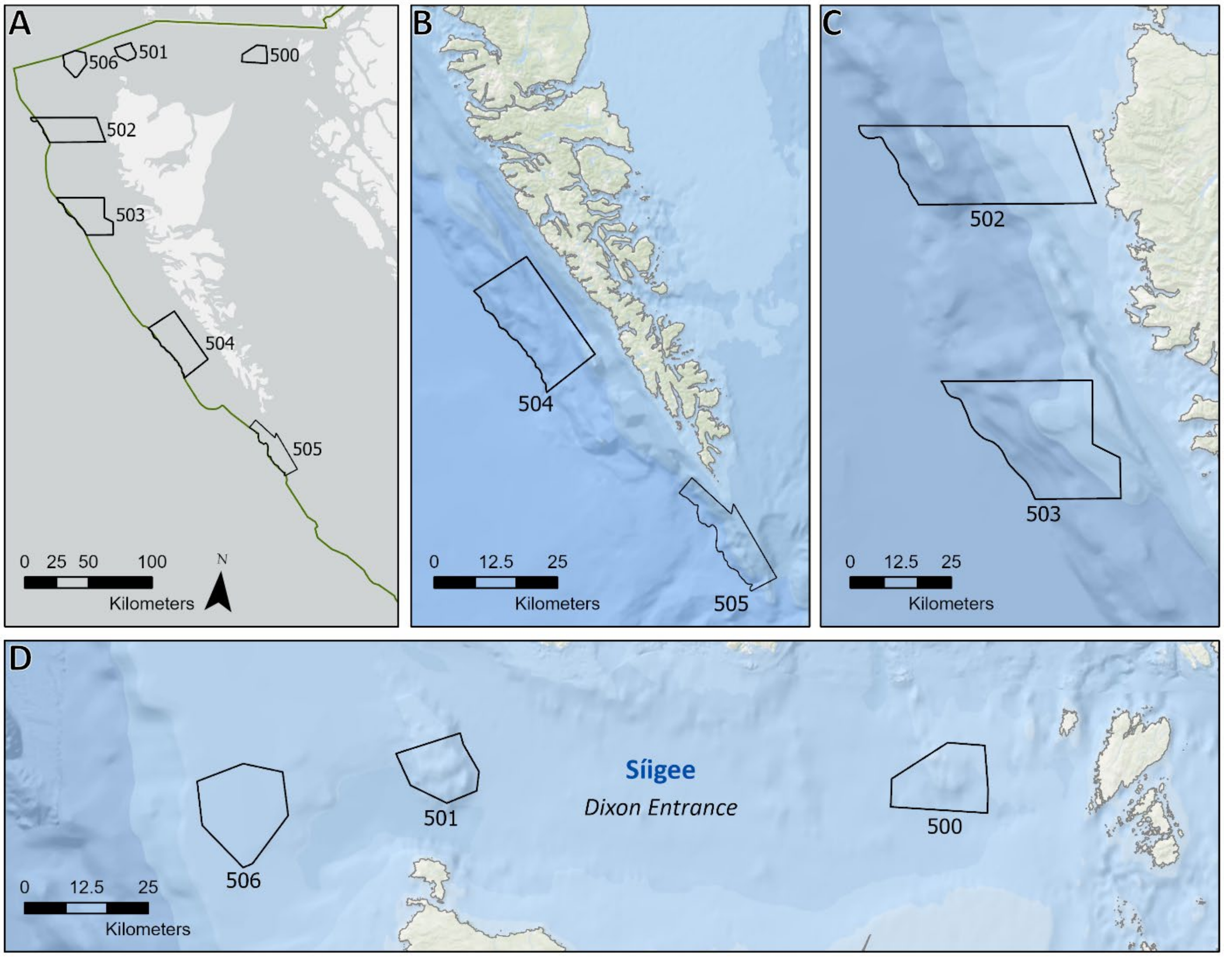

Figure 3. The Offshore Haida Gwaii Network Zones (black polygons): (A) All seven zones within the Offshore Haida Gwaii Network Zone group and the Northern Shelf Bioregion boundary (green outline); (B) ***G̲angx̲id Kun Sg̲aagiidaay*** *Cape St. James (Zone 505) and Gwaii Haanas Extension (Zone 504) in the southwest of Haida Gwaii; (C)* ***Ginda Kun Sg̲aagiidaay*** *Offshore Continental Slope South (Zone 503) and* ***Sasga K̲'ádgwii*** *Offshore Continental Slope North (Zone 502) in the Northwest of* ***X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay*** *Haida Gwaii; and (D) Offshore Northwest Dixon (Zone 506),* ***Tsaan K̲waay*** *Offshore Learmonth Bank (Zone 501) and* ***K̲adlee*** *Offshore Celestial Reef (Zone 500) in* ***Síigee*** *Dixon Entrance to the North of* ***X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay****.*

The OHGNZ is located along **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* in the **Tang.G̲wan** *Pacific Ocean* from the southern point of **G̲angx̲id Kun** *Cape St. James* to the northern end of **K̲'íis Gwáay** *Langara Island* and East into **Síigee** *Dixon Entrance* to the eastern boundary of the **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** subregion. While the seven zones are mostly offshore and in deeper water, they were intentionally chosen to encompass considerable physical and biological variation. The continental slope located on the westernmost side of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** experiences an upwelling current. It is characterized by many oceanic ridges, steep sloping walls, troughs, and the only known seamount in the NSB. The offshore zones along the west coast support many different species of conservation concern, species at risk and unique species: including **X̲aguu X̲aaguu** *Pacific Halibut*, various **K̲'ats Sgaadang.nga** *rockfishes* and groundfishes, various whales, **'Waahúu Tang.g̲wan Siiga** *Leatherback Sea Turtles*, **K̲áay K̲ay** *Steller Sea Lions*, Pacific White-sided Dolphins, **X̲edíit Siigaay x̲idid** *marine birds*, as well as corals and sponges. The zones within Síigee represent two prominent bathymetric features, **Tsaan K̲waay** *Learmonth Bank* and **K̲adlee** *Celestial Reef*. These zones also support many species of cultural importance, conservation concern and species at risk, including a variety of rockfishes, whales, and **X̲edíit** *marine birds*.

The OHGNZ overlap, or are in close proximity to, seven Ecologically and Biologically Significant Areas (EBSAs; some are provided in Figure 4a), including Cape St. James, Shelf Break, Learmonth Bank, Continental Slope, Haida Eddies, cold seeps, and seamounts (Clarke and Jamieson 2006; Ban et al. 2016; DFO 2018a). The Cape St. James EBSA partially overlaps with Zone 505, and is noted for its offshore eddies and strong currents connecting **K̲andaliiG̲wii** *Hecate Strait* with offshore regions, and for its **X̲aaguu** *halibut*, rockfish and coral populations, **K̲ay** *Steller Sea Lion* pupping and foraging, whale aggregations (**SG̲ap** *Humpbacks*, Blue Whales, Sei Whales, **Kun Xyapxyandal** *Fin Whales*), and **Siigaay x̲idid** *marine bird* foraging areas (DFO 2013a). The Shelf Break EBSA, overlapping with Zones 502 to 505, the largest of the three EBSAs in the OHGNZ, is notable for a variety of features, including its circulation features and plankton aggregations, coral diversity, **X̲edíit Siigaay x̲idid** *marine bird* colonies, mammal feeding and migration areas, and rockfish spawning (DFO 2013a). The Learmonth Bank EBSA, also the location of Zone 501, is an isolated bank with concentrated plankton aggregations that serves as a **X̲edíit** *marine bird* foraging area, abundant corals, and large aggregations of **Kún** *Fin Whales* (DFO 2013a). The conservation objectives for each zone are itemized in the Conservation Significance Of Area section of this report, and discussed in detail throughout the body of the report. For more information on the boundaries of the seven Offshore Haida Gwaii Network Zones refer to Appendix C.

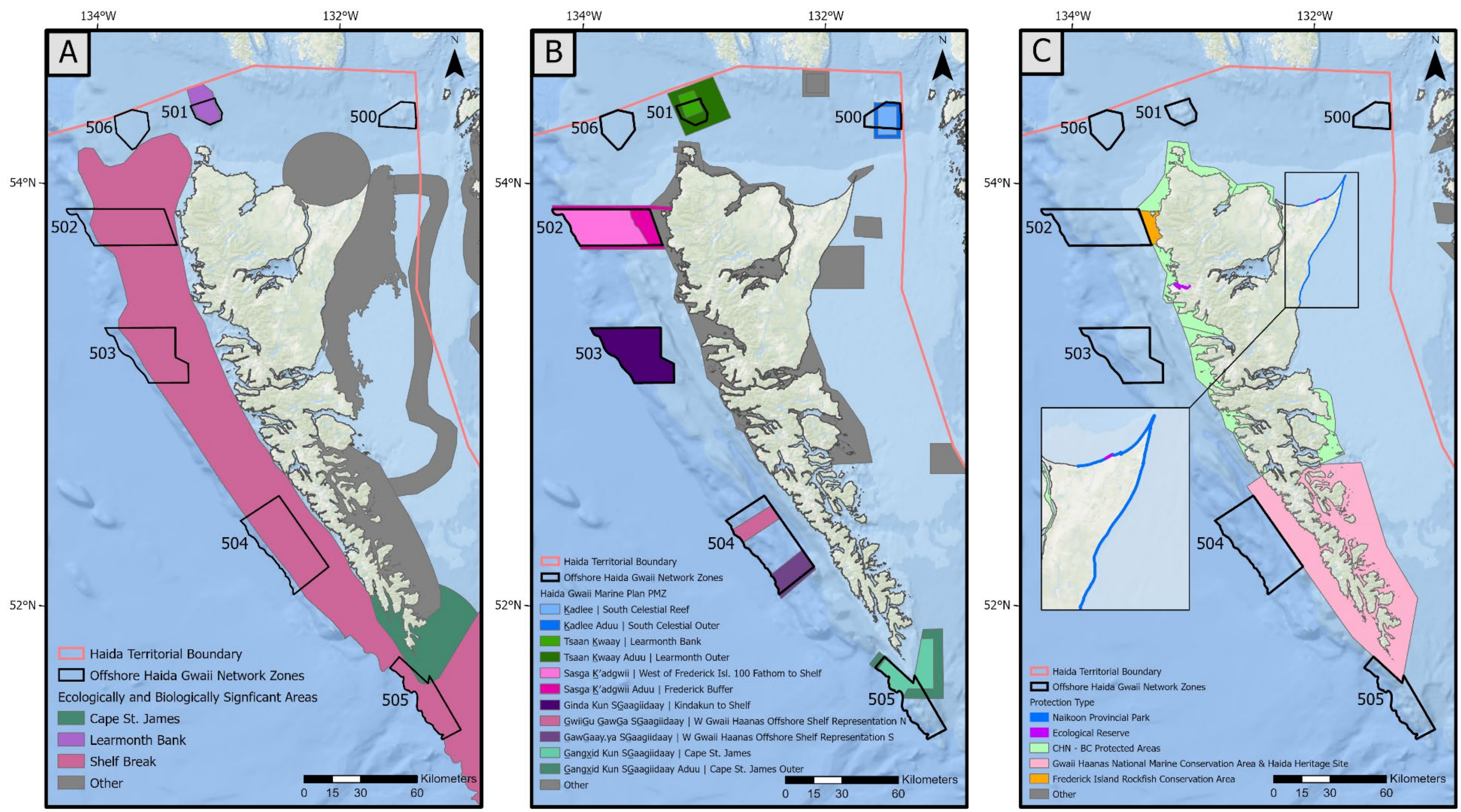

Figure 4. Overlap and coinciding conservation areas with the Offshore Haida Gwaii Network Zones. (A) Zone (black lines) overlap with Ecologically and Biologically Significant Areas (EBSAs) and the Haida Nation's Territorial Boundary; (B) Zone (black lines) overlap with Protection Management Zones (PMZ) identified by the Haida Nation and the Haida Nation's Territorial Boundary; (C) Additional conservation measures present in or near the Offshore Haida Gwaii Network Zones (black lines) and the Haida Nation's Territorial Boundary.

Table 1. Naming schema for, and area (km^2) of the seven zones within the Offshore Haida Gwaii Network Zones. Zones are shown in the order described in this document from the southernmost zone going clockwise from Southwest to northeast. Haida names are in bold (blue indicates X̲aad kíl, green indicates X̲aayda Kil) and English names are in italics.

Zone Number	Zone Name	Area (km^2)
Offshore Continental Slope Network Zones off **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* (hereafter Duu Gúusd Daawxuusda Zones)		
505	**G̲angx̲id Kun Sg̲aagiidaay** *Cape St. James*	532.12
504	*Gwaii Haanas Extension*[7]	1072.07
503	**Ginda Kun Sg̲aagiidaay** *Offshore Continental Slope South*	830.90
502	**Sasga K̲'ádgwii** *Offshore Continental Slope North*	901.06
Síigee *Dixon Entrance* Zones (hereafter Síigee Zones)		
506	*Offshore Northwest Dixon*[8]	267.86
501	**Tsaan K̲waay** *Offshore Learmonth Bank*	152.03
500	**K̲adlee** *Offshore Celestial Reef*	219.91

2.3. REPORT ORGANIZATION AND CONTENT CONSIDERATIONS

The objectives of this biophysical report are to:

1. Evaluate, describe, and map, where possible, the identified key biophysical and ecological features of the selected sites, including:
   - predominant and/or unique physical and biological oceanographic characteristics;
   - predominant, unique, and/or sensitive habitat features with a specific focus on habitats selected as conservation priorities for the MPA Network; and
   - ecologically and/or culturally significant species, and species of conservation concern with particular focus on species that occur in the area that were identified as cultural and/or ecological conservation priorities for the MPAn process.
2. Identify known areas of overlap with potential anthropogenic stressors and species and habitats of interest within the selected sites. Include sensitivity of species of known conservation concern, if available.
3. Identify key uncertainties and knowledge gaps as they pertain to the current understanding of the existing environment and species of interest within the selected sites, and recommend measures to address these gaps, where possible.

[7] Gwaii Haanas Extension encompasses two PMZs in the Haida Gwaii Marine Plan. **GwiiG̲u G̲aw G̲a Sg̲aagiidaay** *West Gwaii Haanas Offshore Shelf Representation North* and **G̲awg̲aay.ya Sg̲aagiidaay** *West Gwaii Haanas Offshore Shelf Representation South* (Figure 2c). Work to confirm the name of the amalgamated site is to be completed during the designation process.

[8] Work to confirm the name for the Northwest Dixon zone will be completed during the designation process.

As such, this biophysical report is comprised of five major sections. The first describes the OHGNZ's oceanographic setting, focusing on the physical and biological oceanographic systems and geological structure. The second section details the ecological setting and cultural relationships within the OHGNZ, focusing on unique ecosystems, biodiversity patterns, species and habitats identified for their ecological importance, and ecological connectivity. The third section details the human uses of the region, including active and potential threats to key physical and biological features in the NZ, and briefly summarizes some of the area's cultural significance to the Haida Nation. The fourth section describes the current and anticipated climate change impacts to the OHGNZ, and finally the fifth section details the conservation significance of the OHGNZ. Furthermore, where applicable, information gaps and data limitations are highlighted throughout.

Spatially explicit regional and local data applicable to the OHGNZ were compiled from a variety of sources, including Fisheries and Oceans Canada (DFO) data and publications, and the Haida Marine Traditional Knowledge Study. Spatial overlay analyses were used to summarize species occurrences, environmental variables, climate change projections, and human activities across the OHGNZ and compare the seven zones to each other and the surrounding area. The data used to inform this process were generated through a variety of research programs and a literature review synthesized by the group of co-authors and collaborators. Species and site-specific Haida knowledge shared by Elders and knowledge holders is included throughout the report.

3. OCEANOGRAPHIC SETTING

The open ocean of the northeast Pacific forms the western boundary of the Northern Shelf Bioregion (NSB). A brief description of aspects of the oceanography of the northeast Pacific and the upper continental slope is relevant to the areas that are the subject of this report. For a more comprehensive overview of the marine environment of the northern coast of British Columbia, see Burd et al. (2019).

3.1. NORTHEAST PACIFIC

British Columbia is at the eastern end of the large-scale circulation pattern where both the subpolar gyre and subtropical gyre transport water from west to east (the Subarctic Current and the North Pacific Current; Figure 5). These currents are the mechanism that brought tsunami debris to British Columbia for several years after the 2011 Fukushima tsunami. However, these large-scale currents do not directly impinge on the continental shelf. The Subarctic Current turns north and becomes the Alaska Current, and the North Pacific Current turns south and becomes the California Current. The divergence, or bifurcation, of the currents coming across the North Pacific means that the ocean offshore of the British Columbia shelf is a region of “Variable Currents” (Figure 6a).

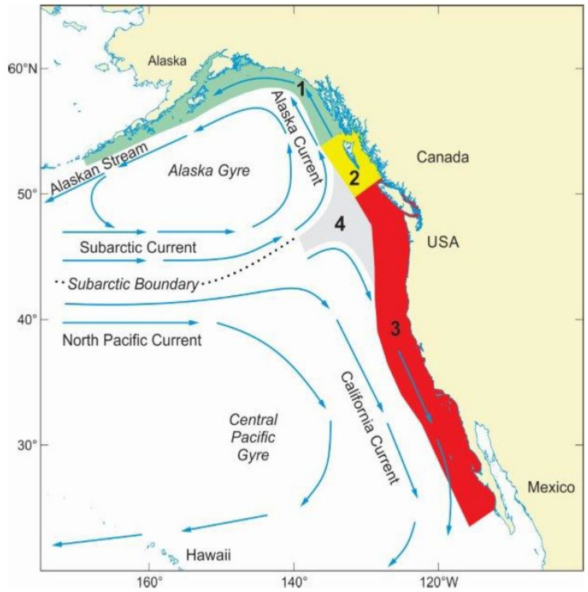

Figure 5. Taken from Biophysical and Ecological Overview of the Offshore Pacific Area of Interest report (DFO 2019b). "Ocean Circulation in the Northeast Pacific. Area 1 Coastal Downwelling Zone, Area 2 Upwelling/Downwelling Transition Zone (transition in wind-generated currents), Area 3 Coastal Upwelling Zone, and Area 4 Bifurcation Zone."

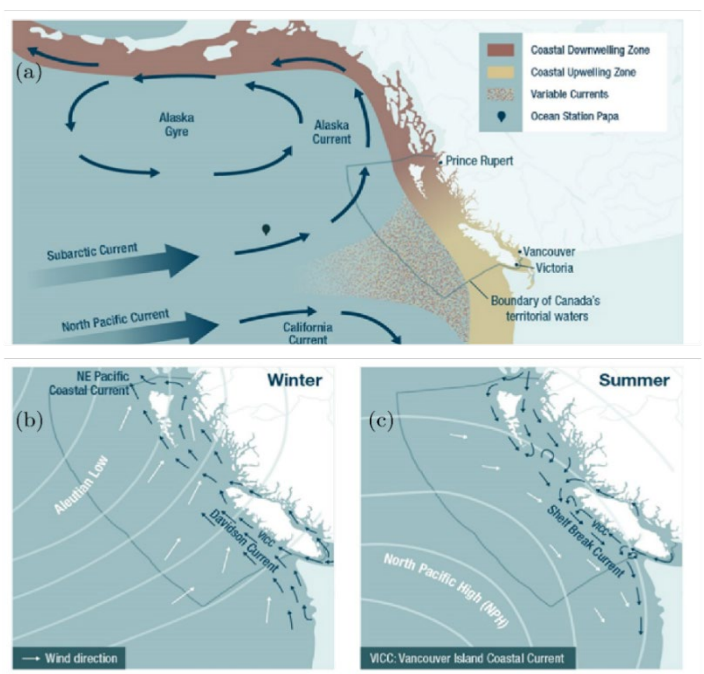

Figure 6. The Northeast Pacific regional current systems (used with permission; DFO 2021). (a) Large scale current systems in Canada's Northeast; (b) Winter season currents and wind direction within Canada's territorial waters; (c) Summer season current and wind direction within Canada's territorial waters. The grey bounding box denotes Canada's territorial waters. The dark blue arrows represent current direction, and the white arrows represent wind direction.

The seasonal variability in the Northeast Pacific is brought primarily by changes in the large-scale atmospheric weather patterns. The Aleutian Low dominates winter, whereas the North

Pacific High dominates summer (Thomson 1981). These seasonal changes result in different mean wind patterns (Figure 7). In the winter, the winds generally blow towards the northeast (or north) along the coast. In the summer, winds along the BC south coast are usually from the northwest, while mean winds along the north coast are weaker and generally from the west. The southern region, with northwesterly summer winds, typically corresponds to the ‘Coastal Upwelling Zone’ (Figure 6a).

On timescales of about two to seven years, the El Niño Southern Oscillation (ENSO) plays an important role in the Northeast Pacific. Variations in the atmosphere-ocean coupling in the tropical Pacific cause ENSO. During the warm phase of ENSO (El Niño), the Aleutian Low strengthens and moves southwards, while storm tracks extend further 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 La Niña years. The Aleutian Low weakens and moves northwards, making surface waters cooler. The Aleutian Low variations largely dictate the Pacific Decadal Oscillation index (PDO; Newman et al. 2016). This index amalgamates the effects of many processes and provides an indicator of the Northeast Pacific climate on decadal time scales. The index is the leading mode of monthly sea surface temperature (SST) variability in the North Pacific (20–70°N; Newman et al. 2016). A positive PDO is associated with anomalously warm waters along the North American coast (eastern North Pacific) and below-average SSTs in the western Pacific Ocean. The opposite occurs during years of negative PDO.

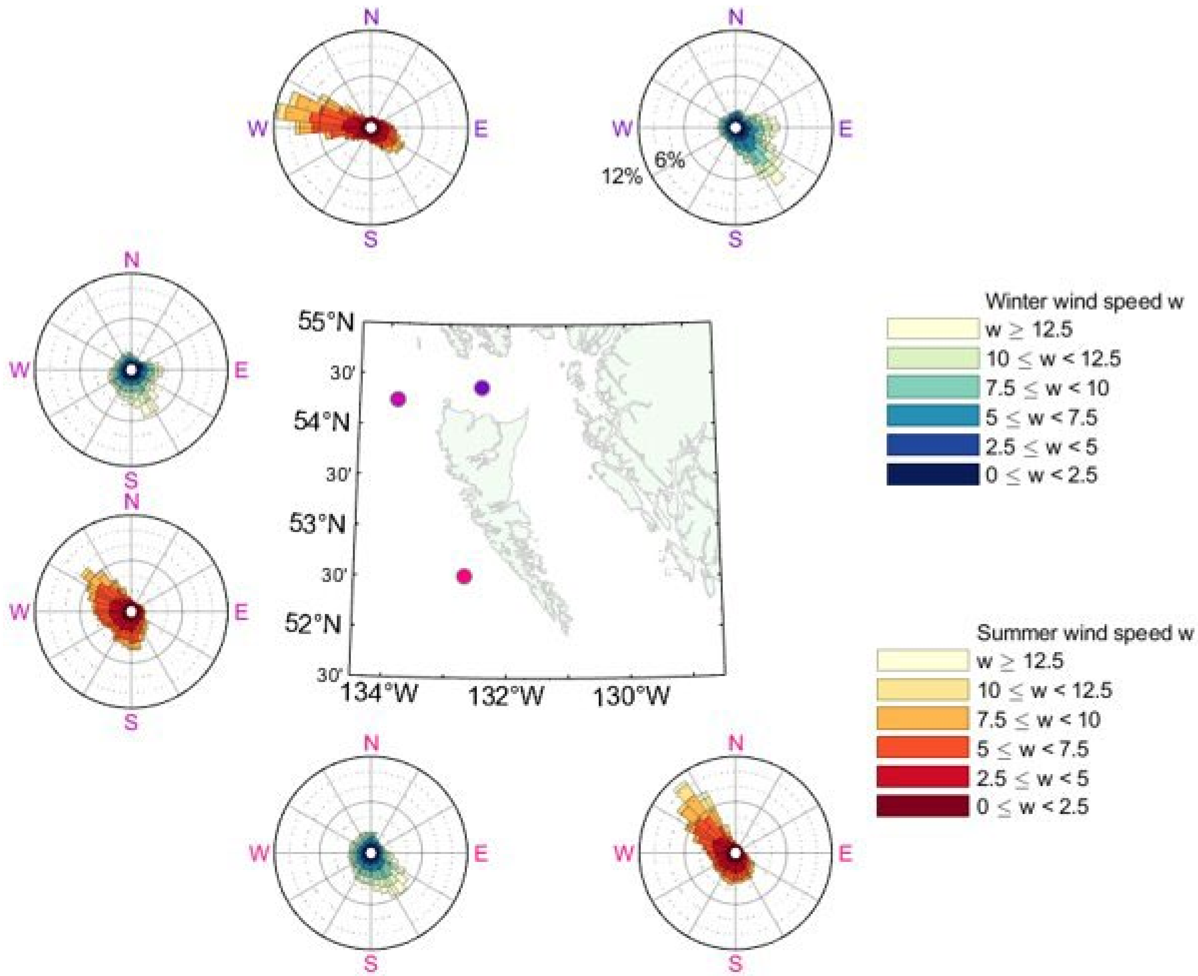

*Figure 7. The monthly mean wind roses at marine weather buoys within the region of OHGNZ. The panels are organized from **Síigee** Dixon Entrance in the upper left to offshore **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** Haida Gwaii in the bottom. The spokes indicate the direction which the wind blows from, while the spoke length indicate the proportion of time the wind blows from that specific direction. The winter observations (blues) are the averages for the month of January, while the summer observations (reds) are the averages for the month of July.*

Along the continental slope of British Columbia and Alaska, eddies dominate the ocean circulation (Thomson and Gower 1998; Crawford 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 two ocean gyres; the subtropical and subpolar gyres represented by the Subarctic Current and the North Pacific current, respectively (Whitney et al. 2005). Observations show that 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 at “Ocean Station Papa” (Figure 6a; hereafter “Station P”) in the subpolar gyre. This connection is the signature of the California Undercurrent.

The California Undercurrent and its extension north to Alaska delivers relatively warm, high salinity, nutrient-rich, low oxygen water from the equatorial Pacific to Alaska along the upper continental slope (Thomson and Krassovski 2010; Crawford and Peña 2016). Over the BC continental slope, the California Undercurrent extension flows poleward between 150 and 400 m depth (Thomson and Krassovski 2010). At the southern end of the mouth of Queen Charlotte Sound, about 30–40% of the water between 100 m and 300 m depth is Pacific Equatorial Water (between density surfaces of 26 and 26.75 kg m^{-3}; Thomson and Krassovski 2010) and at the mouth of **Síigee** *Dixon Entrance*, the same water mass comprises 25–35% Pacific Equatorial Water. This California Undercurrent water is the source for most of the bottom water on the BC shelf and deep inlets. As such, temporal trends of its water properties can be expected to impact protected areas along the BC coast. Crawford and Peña (2016) showed oxygen levels on the continental shelf were low in the 1950s, and higher in the 1970–80s, before declining through to 2012, when their analysis ended. Since then, oxygen levels have started moderately increasing (Cummins and Ross 2020).

Around Queen Charlotte Sound and **K̲andaliiG̲wii** *Hecate Strait*, currents are largely wind-driven (Crawford et al. 1985, 1988; Hannah et al. 1991). In the winter, the prevailing winds are from the south, and the flow is almost always northward through the Queen Charlotte Sound and K̲andaliiG̲wii (Thomson 1989; see Figure 6b). This flow transports relatively warm water northwards through K̲andaliiG̲wii and offshore **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii* (Figure 6a). In summer, the flow tends to follow variable winds (Figure 7). In addition to the wind-driven flow, topography, freshwater inflows, and tidal mixing generate complex flow patterns (Crawford et al. 1995). For example, a clockwise gyre has been observed around Goose Bank (Crawford et al. 1985), and there is a recirculation pattern at the southern end of K̲andaliiG̲wii (Crawford et al. 1990, 1988).

The local currents around **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii* are highly seasonal and change from summer to winter. During summer, cool water from the upwelling of nutrient-rich waters along the continental shelf dominates the waters off the west coast. In contrast, the north-flowing Haida current forms on this coast during the colder months from October to April due to the prevailing winds (Thomson and Emery 1986). At the southern end of X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay, around **G̲angx̲id Kun** *Cape St. James*, Haida Eddies are formed each winter (Crawford 2002; Di Lorenzo et al. 2005), advecting nutrient-rich coastal water into the Gulf of Alaska (Whitney and Robert 2002; Crawford et al. 2005).

North of **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii* is **Síigee** *Dixon Entrance*. This roughly 50 km wide strait 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 Síigee. The Rose Spit Eddy, a cyclonic (anti-clockwise rotating) eddy, occupies the eastern end of Síigee near **K̲adlee** *Celestial Reef* (Zone 500). A second, anti-cyclonic eddy, is also often present at the western end of Síigee over **Tsaan K̲waay** *Learmonth Bank* (Zone 501; Crawford and Greisman 1987; Ballantyne et al. 1996). These eddies are responsible for how surface waters such as freshwater from the Skeena and Nass rivers are transported through Síigee (see Fig. 2 in Thomson and Emery 1986). Given the relatively shallow connection with the northern end of **K̲andaliiG̲wii** *Hecate Strait* (20 m) via **Née Kún** *Rose Spit* Sill, the deep water of Síigee must come from the west, the upper continental slope, and perhaps the shelf off western X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay.

The mean sea surface temperature (SST) patterns derived from satellite data are shown for January (winter) and July (summer) in Figure 8. These illustrate the basic seasonal features of the SST averaged over 30 years of satellite SST observations. In winter, the SST ranges from 8–9°C at the entrance to Queen Charlotte Sound to 6–7°C further north at **Síigee** *Dixon Entrance* (Figure 8a). In summer, the SST ranges from 13–14°C at the mouth of Queen Charlotte Sound to 10–11°C in some coastal regions with upwelling-favorable winds (Figure 8b).

Higher resolution imagery may reveal lower mean temperatures in some coastal areas, and higher mean temperatures are possible in some inlets that the satellite observations cannot resolve at this coarse resolution. While satellite-measured SST values are reliable in the northeast Pacific Ocean, as shown in analysis by Hardy et al. (2021), frequent and widespread cloud coverage is a limitation for this type of data. When imaged daily, individual pixels at 4 km spatial resolution yield data between 1 and 10% of the time, but lower in winter and summer, and higher in spring and fall due to the seasonality of cloud cover. Thus, spatial and temporal averaging is required to derive useful datasets and can limit observing short-lived events in the northern shelf bioregion.

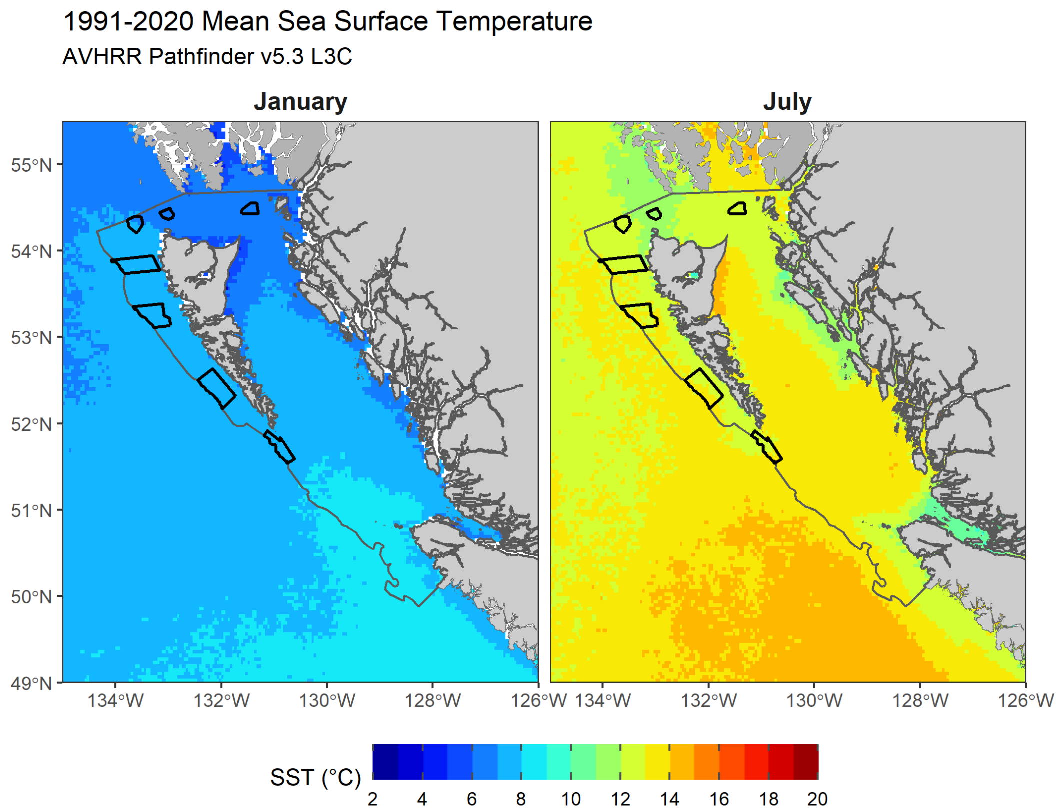

Figure 8. Satellite-derived sea surface temperature for (a) winter, and (b) summer for the Northern Shelf Bioregion. These surface temperatures are the monthly means computed from 1990 to 2020. These images are based on a 4 km spatial resolution dataset using the methods described by Hardy et al. 2021. The Offshore Haida Gwaii Network Zones are outlined in black and the Northern Shelf Bioregion is outlined in grey.

3.2. LOCAL CONDITIONS

3.2.1. Geology and Sediments

X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay *Haida Gwaii* is an archipelago of rugged mountains and lowlands located near the western boundary of the North American plate. These islands, along with Vancouver Island to the south and Alexander Archipelago to the north, are part of the Insular Belt of the Canadian Cordillera. Much of the regional geology is volcanic and plutonic in origins, beginning in the Late Triassic, with intercalated sedimentary sequences that have undergone extensive faulting and deformation (Sutherland Brown 1968). Terrestrial geology is well studied, unlike the surficial geology offshore. Onshore bedrock geology is complex; the west coast of Graham Island (see Figure 4) is primarily composed of the basaltic Masset Formation (Hickson 1991), while western Moresby Island (see Figure 4) is broadly characterized by plutonic rocks (Anderson and Reichenbach 1991). The region experiences the highest rate of seismic activity in Canada due to its position along the offshore Queen Charlotte fault (QCF; Figure 9). The fault is a major transpressive transform boundary between the Pacific and North American plates. It extends well over 1,000 km from Yakutat, Alaska, to beyond the southern tip of Moresby Island. The narrow continental shelf ends abruptly at the fault, and the surficial geology is heavily influenced by ongoing fault activity (Brothers et al. 2019). The fault zone is likely an area of concentration for fluid flow, as evidenced by observations of gas venting in numerous locations (Barrie et al. 2018).

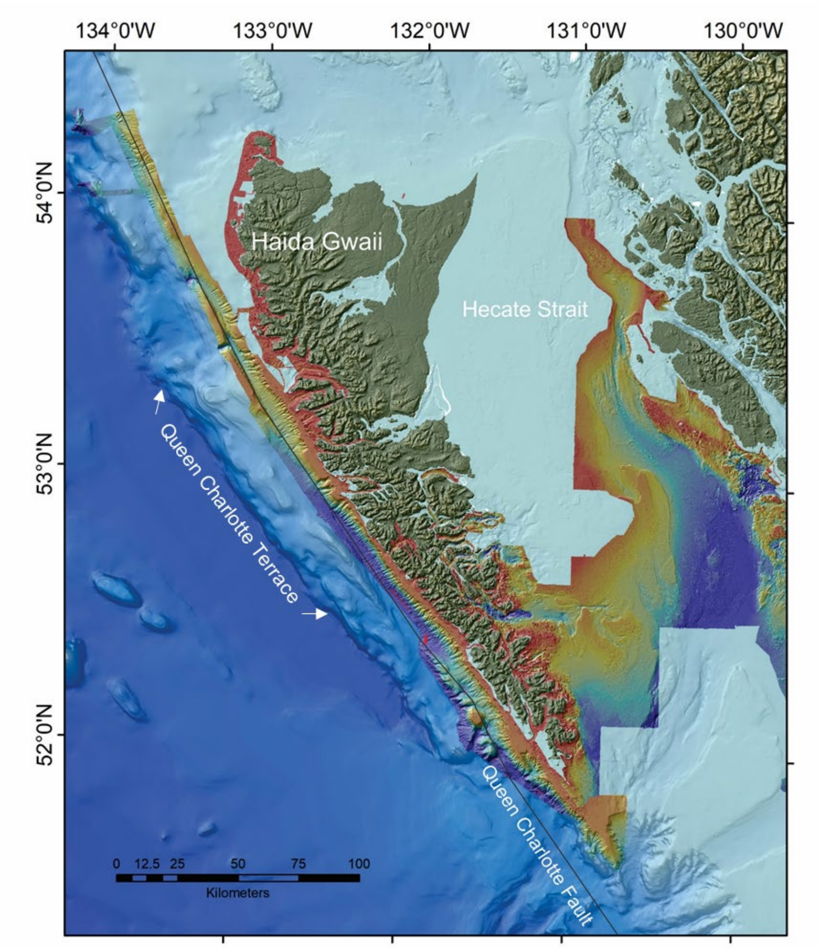

*Figure 9. Map showing the location of the Queen Charlotte Fault (black line) and the Queen Charlotte Terrace (area between white arrows) on the western edge of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** Haida Gwaii. The multi-coloured region indicates an area of multibeam sonar mapping as of 2022.*

During the last glacial maximum (*c.* 17 ka), the cordilleran ice sheet covered most of British Columbia. The glacial maximum corresponded with a time when global sea levels were at their lowest, 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 **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* and Vancouver Island (Figure 10). The Hecate glacier occupied what is now **K̲andaliig̲wii** *Hecate Strait*, flowing south, parallel to the modern coast, then across the shelf through Moresby trough, possibly reaching the shelf edge (Josenhans et al. 1993; Shaw et al. 2019). Several convergent ice flows occupied **Síigee** *Dixon Entrance*, extending west to the shelf break (Barrie and Conway 1999). The terminus of shelf-crossing ice flows acted as areas of extreme sediment deposition from outwash during melt stages, creating major canyon and depositional fan systems over relatively short periods. An independent ice cap formed on X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay (Blais et al. 1990; Clague and James 2002), however the shelf west of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay was cut off from cordilleran ice flows and thus did not experience the same level of rapid deposition (Barrie et al. 2021). Beginning 16 to 15 thousand years ago, ice retreated across the shelf to the mainland coast by *c.* 14.5–13.0 ka (Barrie and Conway 1999; Hetherington et al. 2004). The weight of the cordilleran ice sheet produced a crustal forebulge, elevating the continental shelf 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 K̲andaliiG̲wii and Síigee (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 the shelf in water depths that are currently less than 100 m. Relict large-scale seabed features include wave-cut platforms and large sand spits in Síigee and exposed bedrock on much of the shelf west of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay and in Síigee (Barrie and Conway 1996; Barrie and Conway 1999).

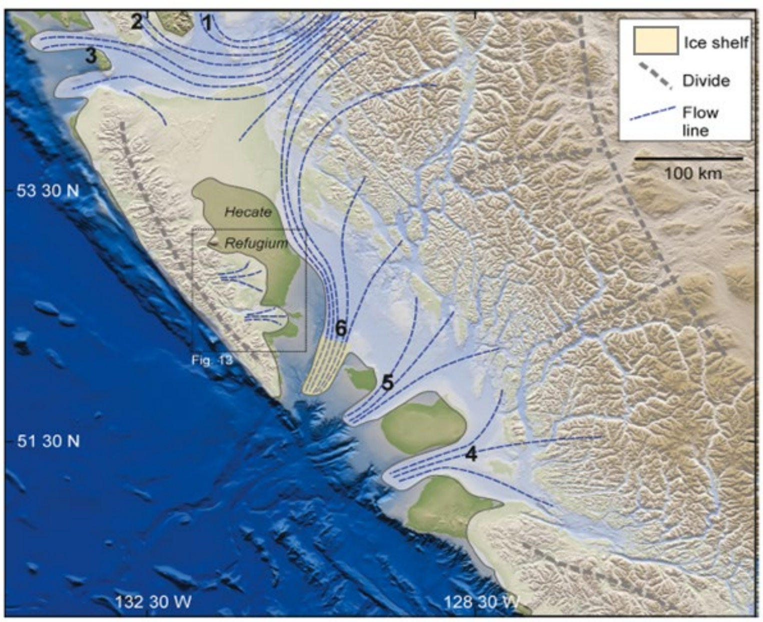

Figure 10. Glacial extent at last glacial maximum (Shaw et al. 2019). Figure shows 1=Northward flow away from ***Síigee*** *Dixon Entrance; 2=A diversion of grounded ice out of Síigee and northward; 3=* ***Tsaan K̲waay*** *Learmonth Bank; 4=Grounded ice in Goose Island Trough; 5=tongue of grounded ice in Mitchell's Trough; and 6=grounding line of ice in Moresby Trough, with a postulated ice shelf seaward.*

Seabed processes remain very active in the modern-day oceanographic setting. Storm activity is frequent and results in the reworking of shelf sediments, as is the case on many of the shallow banks of the continental shelf. Seismic activity associated with the QCF system also profoundly affects the slope and shelf west of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*. Several distinct morphological units can be differentiated in this region, each experiencing different depositional processes. Examples of such units are the shelf west of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay, the continental slope, Queen Charlotte Terrace and

Síigee *Dixon Entrance*. The characteristics of the shelf and slope units are summarized in the Biological Communities of the Continental Shelf and Slope section.

3.2.1.1. Queen Charlotte Terrace

Geological data, including surficial geology from this region, is sparse. Queen Charlotte Terrace (Figure 9) is a broad plateau formed due to the oblique convergence of the Pacific Plate relative to the North American Plate. The presence of a subduction boundary is disputed, although it would explain the terrace's formation. The terrace is comprised of accreted marine sediment and possibly fragments of oceanic crust (Prims et al. 1997). Regardless of formational history, there is a good possibility of further venting sites associated with the QCF. Furthermore, gas hydrates observed offshore Vancouver Island on the Cascadia subduction zone could also be a considerable source of methane venting in deep water portions of the terrace. The Cold Seeps section of this report has further detail on this topic.

3.2.1.2. Síigee Dixon Entrance

Síigee *Dixon Entrance* has not been thoroughly mapped. General glacial history and surficial geology have been documented. During the last glacial maximum Síigee hosted a major grounded ice flow that extended from the continental cordilleran ice sheet to the shelf edge. Ice flows were redirected around major topographic features, including the prominent **Tsaan K̲waay** *Learmonth Bank* (Shaw et al. 2019). At the shelf edge, the Makluk fan was deposited during times of very high sedimentation (Dobson et al. 1998). As ice receded, thick units of diamict were exposed, and glaciomarine muds were deposited. At lowstand, the relative sea level fell to *c.* 150 m below present in central Síigee (Barrie and Conway 1999). The lowstand and subsequent transgression produced highly energetic hydrodynamic conditions, resulting in the deposition of a thick sand unit to depths greater than 450 m. Holocene muds have been deposited locally in low-energy environments; however, most of the mapped seafloor are sand and gravel (Barrie and Conway 1999). Bedrock outcrops are rare in shelf crossing troughs of the continental shelf. Tsaan K̲waay (Zone 501) and **K̲adlee** *Celestial Reef* (Zone 500) are the most prominent marine features in Síigee and are the largest rock outcrops. Multibeam bathymetry data covers most of Tsaan K̲waay, showing a highly faulted and fractured granodiorite bedrock surface. Sediment infill is apparent in bathymetric lows based on surface morphology.

3.2.2. Bathymetry and Geomorphic Classifications

3.2.2.1. Bathymetry

The OHGNZ is bathymetrically complex, encompassing a wide range of ocean floor depths and geomorphic units (Figure 11, Figure 12), resulting in a heterogeneous benthic environment. The three deepest OHGNZ are the three southernmost offshore zones (505, 504, 503; Figure 11, Figure 12). The three northernmost zones in **Síigee** *Dixon Entrance* have the shallowest depth distribution (506, 501, 500). Given the similarity of depth profiles and largescale oceanography, the Offshore Haida Gwaii Network Zones can be subdivided into two groups: three zones in Síigee (506, 501, 500) and four slope zones off **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* (505, 504, 503, 502). Importantly, Zone 502 is unique among all zones, given the presence of a seamount that will affect local oceanography and the biological community. However, given its recent discovery, little is currently known at a fine scale. During the NSB MPA Network Process, the Offshore Haida Gwaii Network Zones were partly selected to meet a key MPA network design criteria – ecological representativity. These zones ensure steep slope habitats on the westernmost edge of the Northern Shelf Bioregion are represented in the MPA network. Consequently, the depth profile, particularly of Zone 502 to 505 is wide and spans the continental shelf, slope, and troughs present offshore of X̱aadáa Gwáay X̱aaydag̱a

Gwaay.yaay. The deepest zone is Gwaii Haanas Extension (504), with a maximum depth of 2,900 m and a mean depth of 2,009.31 m. Due to the depth profile of Zone 504 there is a paucity of data describing its ecology, as the majority of DFO surveys and research have been confined to depths less than 1,500 m (Appendix E). For example, the highest resolution bathymetric data is compiled from multibeam data collected up to a maximum depth of 1,700 m (V. Barrie, personal communication, May 12, 2022). The range of depths in the OHGNZ also means each zone will have different predicted climate change scenarios as the benthic surface layer predictions of temperature and oxygen will be varied (see the Climate Change Impacts section). The Síigee zones (506, 501, 500) were also selected in part to incorporate shelf habitat into the overall network design. They were also chosen for their rich biodiversity and to ensure the incorporation of Learmonth Bank EBSA into the MPA network. The following section further discusses the zones' biological communities.

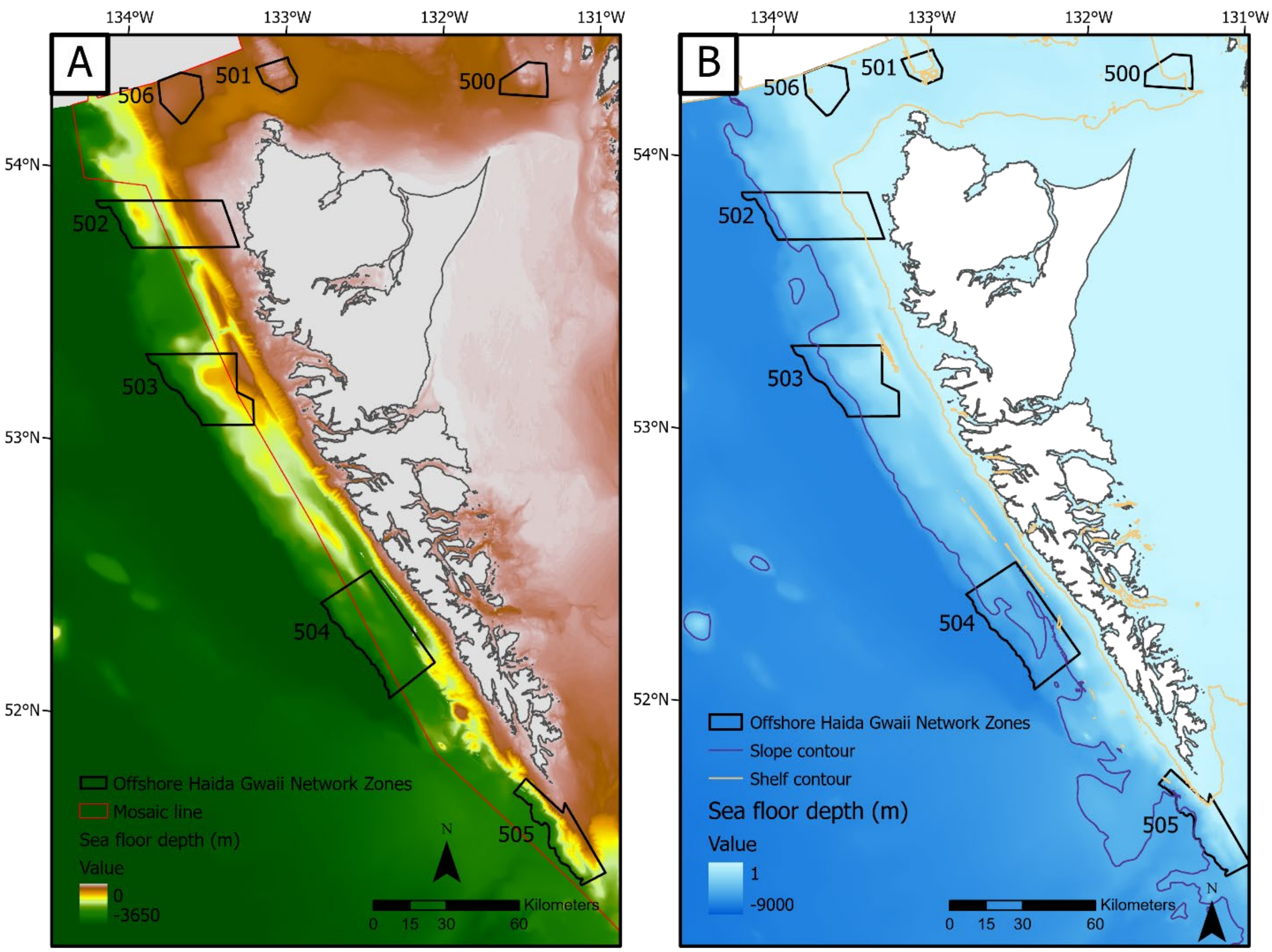

Figure 11. (a) Bathymetry of the Offshore Haida Gwaii Network Zones. Bathymetry is a mosaiced raster of a high-resolution digital elevation model accurate to 2 m (right of the red line) and a raster with a resolution of 100 m (left of the red line). The red line shows the mosaic line. Colours chosen to emphasize the bathymetric highs and lows but blue shading is otherwise used throughout the report. (b) Edge of the continental shelf indicated by yellow 200 m contour line and edge of Continental Slope indicated by the blue 2,000 m contour line. Black outlines are zones within the Offshore Haida Gwaii Network Zones.

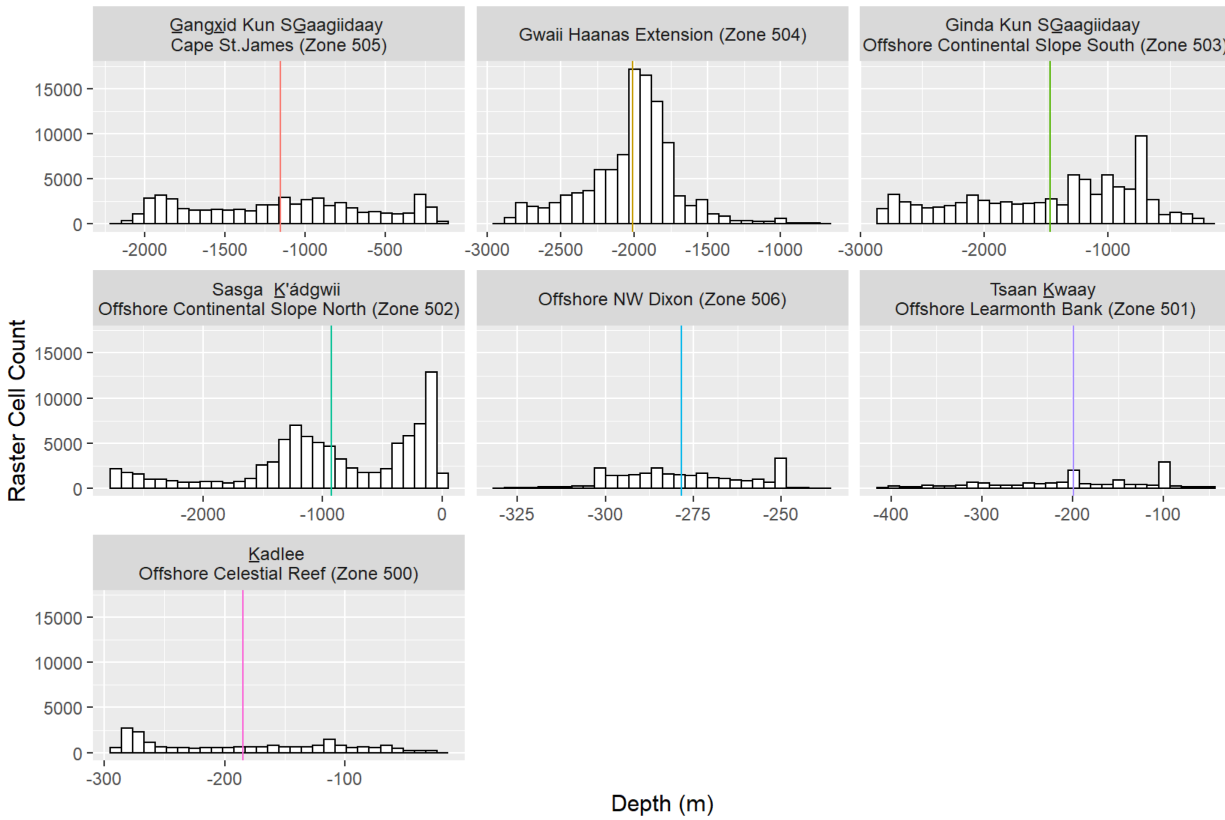

Figure 12. Histograms by zones of bathymetric depth profiles (in metres) for the Offshore Haida Gwaii Network Zones. Vertical lines indicate the mean depth for each zone. Note the x-axis depth ranges vary between zones.

3.2.2.2. Continental Shelf West of Xaadáa Gwáay Xaaydaga Gwaay.yaay Haida Gwaii

The continental shelf describes the marine waters up to the 200-metre depth: the conventional delineation of BC's continental shelf (Thomson 1981). OHGNZ 506, 501, and 500 overlap entirely with the continental shelf, which is captured by the easternmost edges of the remaining zones west of **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* (Figure 11b). Limited geological surveys have occurred on the shelf west of Xaadáa Gwáay Xaaydaga Gwaay.yaay, and existing data suggest that exposed bedrock primarily characterizes it (Barrie and Conway 1996; Barrie et al. 2021). Several deep channels extend from the fjords on Graham and Moresby Islands onto the shelf, primarily characterized by exposed bedrock. Sparse, mobile coarse sediment may fill local depressions. Localized temperate carbonate sands (skeletal remains) have been recovered from the inner shelf of southern Xaadáa Gwáay Xaaydaga Gwaay.yaay (Barrie et al. 2021).

3.2.2.3. Continental Slope/Fault Valley

The continental slope includes all outside waters between 200 m and 2,000 m depth on the westernmost edge of the OHGNZ (Figure 11a). Several studies focused on the Queen Charlotte Fault in recent years have improved geological insight into this region. Multibeam bathymetry data has been acquired covering most of the fault valley, revealing a large-scale linear fault line that can be traced from south of the southern tip of Moresby Island north into the Alaskan Fairweather fault. The slope is characterized by a series of steeply crenulated canyons and gullies that extend downslope from the shelf break west to the QCF valley. Most of these features were formed during past glacial cycles when the ice reached the shelf edge from **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii*. Under modern oceanographic conditions, little to no sediment is delivered from X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay to the shelf edge to feed the canyons (Barrie et al. 2021). Any active sedimentation that occurs is likely a result of slope processes, including landslides and turbidity currents, as evidenced by slide blocks and debris fields in multibeam data (Barrie et al. 2013, 2021). Sediments on the upper slope are primarily indurated pre-glacial sands, making sediment sampling difficult (Barrie et al. 2013; Greene et al. 2019). Canyons terminate at the base of the fault valley, where fault processes can be episodically active. Several hanging canyons are perched above the valley, displaced by fault motion such that the lower end of the canyon has been sheared away from the upper reaches. Several cores collected in the fault valley show that sediment deposition in the fault valley is extremely limited, indicating that any sediment being delivered by the canyons is effectively transported through the valley, exiting through an outlet at the southern end (Barrie et al. 2013).

The waters of the continental slope range from highly exposed surface water to depths where the effects of wind and storms are not felt, although tidal currents may sweep through some gullies (Thomson 1981). These steep-walled oceanic areas have nutrient-rich, upwelling currents. Offshore from **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii*, the slope areas are influenced by the northward-flowing Haida Current in the winter months and by the generally northerly flowing Alaska Current in the summer months. It is a steep-walled slope that extends from the shore of X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay to Queen Charlotte Trench (Demarchi 2011).

3.2.2.4. Geomorphic Units

Geomorphic units represent broad-scale (100s of km) discrete geomorphological structures (Rubidge et al. 2016) that characterize the continental shelf and slope in the NSB. By using bathymetry data at 75 m resolution, a grid cell's elevation was compared with the mean elevation of surrounding grid cells (benthic positioning index) to classify the NSB into ten different geomorphic units (Rubidge et al. 2016). The NSB was split into three analysis regions, two of which are relevant to the OHGNZ – the continental slope and the continental shelf (see also "Biological Communities of the Continental Shelf and Slope" later in the report). Overlay analyses were used to calculate the areal extent of existing geomorphic units in each zone polygon. Eight geomorphic units occur within the continental shelf and slope of the OHGNZ (Table 2). Of the seven zones within the OHGNZ, **G̲angx̲id Kun SG̲aagiidaay** *Cape St. James* (Zone 505) and **Sasga K̲'adgwii** *Offshore Continental Slope North* (Zone 502) have the greatest number of differing geomorphic units (Table 2), both encompassing the continental shelf to the toe of the continental slope and similar habitat heterogeneity within that expanse (Figure 11). Gwaii Haanas Extension (Zone 504) and **Ginda Kun SG̲aagiidaay** *Offshore Continental Slope South* (Zone 503) have very similar geomorphic units, both being offshore areas of ridges, canyons and steep slopes located off the western edge of **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii*. Zones 500, 501 and 506 are also very similar to each other, all located on the continental shelf within **Síigee** Dixon Entrance, with crests, lesser depressions, gentle slopes and troughs for Zones 506 and 500 (Table 2).

Table 2. Presence of geomorphic units by zone. 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.

Geomorphic Unit	**Gangxid Kun Sgaagiidaay** *Cape St.James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**
Crest	X	-	-	X	X	X	X
Steep slope	X	X	X	X	-	-	-
Lesser depression	X	-	-	-	X	X	X
Ridge	X	X	X	X	-	-	-
Gentle slope	X	X	X	X	X	X	X
Canyon or valley bottom	X	X	X	X	-	-	-
Lesser rise	X	-	-	X	X	X	X
Trough bottom	X	-	-	X	X	-	X
Total number of units	8	4	4	7	5	4	5

3.2.3. Currents and Tides

3.2.3.1. Duu Gúusd Daawxuusda the west coast of Haida Gwaii

The ocean setting of **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* is unique because of its location at the transition between the summer upwelling region to the south (the California Currents) and the persistent downwelling zone to the north (the Alaskan Currents; Figure 5). The elongated narrow slope, dropping to 2,500 m within roughly 30 km of the shore, extends approximately 300 km from Queen Charlotte Sound to a relatively broad shelf northwest of Graham Island. As with the large-scale oceanography described above, the local system's ecology is affected by its exposure to the prevailing wind-driven currents. The expansion or retreat of two major regional atmospheric pressure systems, the cyclonic Aleutian Low and the anticyclonic North Pacific High, largely dictate the wind-driven currents.

Due to the remote location, only limited observations of the dominant oceanic variability are available. One of the few long-term measurements is the North Coastal Ocean Dynamics Experiment (NCODE), conducted by Fisheries and Oceans out of the Institute of Ocean Sciences (Huggett et al. 1992). During this four-stage experiment from 1983 to 1985, hourly time series of water temperature, salinity and current velocity were collected in Zones 504, 505, 501, 502, and 506 (Figure 4). One main finding of NCODE was the presence of Haida Current along **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* during winter (Thomson and Emery 1986). This winter current is forced by prevailing winds (Figure 7) and according to NCODE, it is one of the most energetic open-ocean currents, with speeds peaking up to ~60 cm/s over the slope west of Graham Island (Wang et al. 2021). During the other seasons, currents depend more on the variable local winds.

Haida Eddies also typically form near **G̲angx̲id Kun** *Cape St. James* during winter by merging smaller eddies. These clockwise rotating mesoscale eddies, characterized by warmer and less saline water, are baroclinic features. Their generation mechanism is associated with pressure-driven advection from **K̲andaliiɢwii** *Hecate Strait* encountering a narrow and steep bathymetry (Crawford et al. 2002; Di Lorenzo et al. 2005). The interaction of the tidal currents with the steep topography likely contributes to the eddies' formation (Callendar et al. 2011). The Haida Eddies have a horizontal scale of the order of 100 km and extend down to depths of approximately 1,000 m (Callendar et al. 2011). These eddies bring water from **K̲andaliiɢwii** *Hecate Strait* and Queen Charlotte Sound to **SG̲áan K̲ínghlas**-Bowie (SK̲-B) Seamount before moving towards the southwest (Crawford et al. 2005). A Haida Eddy was recently observed near Station P, about 1,000 km offshore (Tetjana Ross, personal communication. 2021; see Figure 6 for the location of Station P). The Haida Eddies bring iron, a vital micronutrient, from the shelf into the iron-deficient North Pacific (Whitney et al. 2005; Ladd et al. 2009). The Haida Eddies are expected to impact marine ecosystems on **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii,* by carrying pockets of nutrient and plankton-rich surface water into the area. These eddies can transport heat and nutrients to the open northeast Pacific by advecting hundreds of kilometers into the Gulf of Alaska from their origin. They are empheral and transient features in the region with their track varying from year to year, but the Haida Eddies have been identified as EBSAs (Ban et al. 2016). Their known trajectories cover Zones 505, 504 and 503, ie the southern two-thirds of **Daawxuusda** *the west coast of Haida Gwaii.*

The coastal bathymetry, stratification, and tidal forcing further modify the regional ocean conditions. The diurnal (daily) and semidiurnal (twice per day) barotropic tides have significant amplitudes along the coast of BC. The strongest currents are found south of **G̲angx̲id Kun** *Cape St. James* and appear to result from pronounced tidal rectification (Thomson and Wilson 1987). The diurnal tides can propagate alongshore as coastally trapped waves over the slope because their period exceeds the local inertial period (~15 h near 52ºN). The semidiurnal motions give rise to internal tides whose strength and propagation direction are determined by the stratification and topographical gradient (e.g., Prandle 1982; Morozov 1995; Cummins and Oey 1997). The interaction of the barotropic (astronomical) tides with stratified water over sloping bathymetry generate those baroclinic (internal) motions. These baroclinic motions can amplify tidal currents and cause significant mixing that can transfer heat, nutrients and material across density interfaces. The baroclinicity results in tidal currents that vary with the stratification and are inherently less predictable than the tidal heights.

3.2.3.2. Síigee Dixon Entrance

Síigee *Dixon Entrance* (where the shallow/shelf Zones 506, 501, and 500 are situated; Figure 3) is a wide strait (about 50 km) that separates the northern end of **X̲aadáa Gwáay** *Haida Gwaii* (Graham Island) from the southern end of the Alaskan Panhandle. It is the primary shipping route for the many northern ports, including the Port of Prince Rupert, Port of Stewart and Kitimat LNG facility. The western end of Síigee connects directly to the open north Pacific. Here the shallow **Tsaan K̲waay** *Learmonth Bank* (50 m depth) occupies the middle of the mouth of Síigee, while the central trough is typically more than 300 m deep. Síigee is deep compared to Queen Charlotte Sound and **K̲andaliiɢwii** *Hecate Strait* to the south. The shallow 20 m deep **Née Kún** *Rose Spit* Sill separates the southeast of Síigee from K̲andaliiɢwii. Síigee provides the conduit to the open ocean for an extensive network of channels and inlets, including the Alaska Panhandle channels to the north, Portland Inlet and Chatham Sound to the east, and the K̲andaliig̲wii to the south. Síigee is the primary conduit by which the freshwater from the Skeena and Nass rivers leaves the coast.

Síigee *Dixon Entrance* is remote but not isolated. For example, in the winter of 2020–21, a surface drifter travelled from the vicinity of Tofino on Vancouver Island to the northern side of Síigee in 3 weeks. In the spring of 2014, a surface drifter travelled from the mouth of Douglas Channel (near Hartley Bay, BC) to the eastern end of Síigee in 4 weeks (Hourston et al. 2021).

Two eddies (or gyres) dominate the surface circulation in **Síigee** *Dixon Entrance*. The Rose Spit Eddy, a cyclonic (anti-clockwise rotating) eddy, occupies the eastern end of Síigee near **K̲adlee** Celestial Reef. This eddy is persistent throughout the seasons and is created from buoyancy-driven coastal currents and mean currents generated by the interaction of the tides with the steep topography of the **Née Kún** *Rose Spit* Sill (Bowman et al. 1992; Ballantyne et al. 1996). Modelling and observations have suggested that this eddy may move westwards when it is not summer (Ballantyne et al. 1996). A second, anti-cyclonic eddy is also often present at the western end of Síigee over **Tsaan K̲waay** *Learmonth Bank* (Crawford and Greisman 1987; Ballantyne et al. 1996).

The two eddies meet roughly south of Cape Chacon, carrying surface water southwards across **Síigee** *Dixon Entrance* with a significant portion then transported westwards to the Pacific (Bowman et al. 1992). One segment would be responsible for transporting a substantial amount of the surface water westwards to the Pacific; the remainder would recirculate eastwards within the Rose Spit Eddy. As a result of these eddies, the surface outflow from Síigee is on the southern side (near **K̲'íis Gwáay** *Langara Island*), and the primary surface flow pathway from the northeastern corner to the southwest corner (confirmed by several drifters over the years). Moored observations indicate that near-bottom water in Síigee tends to flow up the strait (eastwards) east of K̲'íis Gwáay (Crawford and Greisman 1987). Given the relatively shallow connection with the northern end of **K̲andaliig̲wii** *Hecate Strait* (20 m) via **Née Kún** *Rose Spit* Sill, the deep water of Síigee must come from the west, the upper continental slope, and perhaps the shelf off western **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*.

3.2.4. Water Properties

The longest oceanographic time series in the region is the sea surface temperature and salinity monitoring at **K̲'íis Gwáay** *Langara Island* at the mouth of **Síigee** *Dixon Entrance*, in closest proximity to Zone 506 and 501, and provides the most relevant data for all OHGNZ. The sea surface temperature (SST) trend increased by 0.75°C per century over the period 1940–2012, although the 95% confidence interval is larger at ±0.86°C (Cummins and Masson 2014). Similar trends were identified at Bonilla Island (located on the central coast of BC) and Pine Island, located in Johnstone Strait near Vancouver Island (see Table 1 of Cummins and Masson 2014), suggesting that although highly variable, the trend is increasing. A recent unpublished analysis showed an SST trend of 1.7±0.9°C per century when considering only January data (over the period 1940–2019). The trend for July was much smaller (0.4±0.7°C per century) and not significant at 95% confidence. This shows that SST warming is especially evident during the winter months.

By analyzing 70 years of lighthouse observations, Cummins and Masson (2014) found that more than half of the SST variability is spatially coherent and temporally consistent along the northern BC shelf bioregion. They also showed that the bulk of the SST variability (leading mode) strongly correlates with the Pacific Decadal Oscillation (PDO), which is responsible for interannual and decadal 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 (Newman et al. 2016). A positive PDO occurred between 2014 and 2017, coinciding with the warm SSTs in Figure 13.

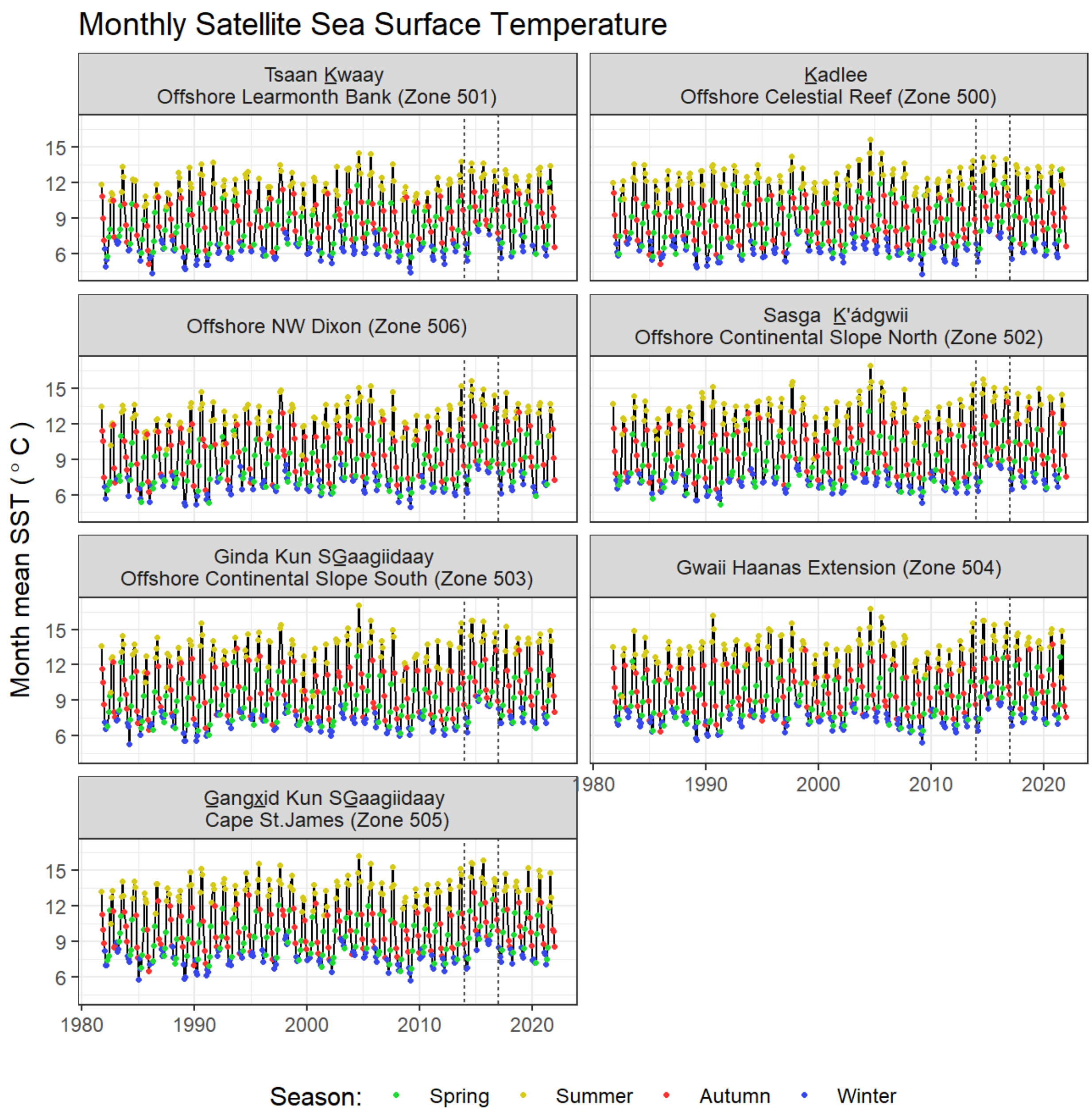

Figure 13. Seasonal time series of satellite sea surface temperature (SST, degrees Celsius) for the Offshore Haida Gwaii Network Zones. Satellite data is at 4 km resolution covering 1981 to December 2021. The time series are coloured by season: winter in blue (January, February, March), spring in green (April, May, June), summer in yellow (July, August, September), and autumn in red (October, November, December). The dotted lines indicate Jan 1, 2014, on the left and Jan 1, 2017, on the right, indicating the anomalously warm period.

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 heat wave, referred to as "the Blob," which manifested as an extended temperature anomaly exceeding 3°C in the upper 200 m 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 heat wave, which preceded the onset of the warm phase of ENSO (El Niño). The BC coast's surface waters typically warm in late winter during El Niño (Crawford et al. 2011). The **X̲aadáa Gwáay X̲aaydaga̲ Gwaay.yaay** *Haida Gwaii* region exhibited warm winter SSTs throughout the 2015–2016 El Niño, while unusually warm summer SSTs were observed at the onset of the marine heat wave in 2014 (Figure 13).

An analysis of satellite sea-surface temperature data, provided by the National Oceanic and Atmospheric Administration (NOAA) at 4 km spatial resolution from Pathfinder Advanced Very High-Resolution Radiometer (AVHRR) and extracted for these regions, illustrates the temporal and spatial variability for the region (Figure 13). The surface mixed layer's properties differ markedly with the seasons because of the atmospheric forcing. The salinity is typically about 32% in the top 50 m of the water column, and the near-surface water temperature varies between 7~15°C (Wang et al. 2021). **Tsaan K̲waay** *Learmonth Bank* (Zone 501) and **K̲adlee** *Celestial Reef* (Zone 500) exhibit similar winter SST of 6–7°C. During winter, coastal downwelling and intense wind-driven mixing occur. These large-scale winter processes are much more consistent along **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii,* than the upwelling-favorable summer winds. During summer, the SST tends to be higher near K̲adlee than at Tsaan K̲waay, with 14°C surface water along the northeast coast of **X̲aadáa Gwáay X̲aaydaga̲ Gwaay.yaay**. Although waters are coldest around **Síigee** *Dixon Entrance,* influencing the three zones in this area, the coldest summertime surface waters along Duu Gúusd Daawxuusda are often at the southernmost point around **G̲angx̲id Kun** *Cape St. James*, where Zone 505 is located (Figure 13). Another feature of Duu Gúusd Daawxuusda is the summer SST being lower near the coast than offshore (Figure 6e). Northwesterly (alongshore) winds during summer cause upwelling, which moves surface water away offshore while deeper nutrient-rich water ascends. However, these upwelling-favorable winds are more intermittent along **X̲aadáa Gwáay X̲aaydaga̲ Gwaay.yaay** than further south along the BC coast (Figure 7).

The oxygen minimum zone (OMZ) also impacts the water properties in the northeast Pacific. Ross et al. (2020) examined in detail the oxygen and ocean acidification environment (calcite saturation horizon) within the **Tang.ɢwan ḥačxʷiqak Tsigis** *Offshore Pacific Area of Interest* (AOI). As a result of climate change, the OMZ's bottom boundary has been deepening 3 m per year, whereas the calcite saturation horizon has been shoaling at about 1.7 m annually since the 1980s, potentially threatening deep sea life on seamounts in the **Tang.ɢwan ḥačxʷiqak Tsigis** *Offshore Area of Interest* (Ross et al. 2020). It is reasonable to assume that their conclusions hold for the continental slope, and in particular, the deepest Offshore Haida Gwaii Network Zones (Zones 502 to 505) of the Northern Shelf Bioregion until monitoring provides evidence to the contrary.

The OMZ forms part of the Offshore Haida Gwaii Network Zones, resulting in hypoxic conditions between 480 and 1,700 m depths (Cummins and Ross 2020; Ross et al. 2020; Whitney et al. 2007; Figure 14). The vertical oxygen distribution is quite similar **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*, below 500 m (Figure 14b). Above this depth, sites further north along the coast have progressively more dissolved oxygen (Figure 14c). This variation most likely results from the progressive dilution of nutrient- and oxygen-poor waters transported northwards by the California Undercurrent. This undercurrent transports Pacific Equatorial Water along the coast. It represents about 25-35% of water between 100 and 300 m at the mouth of **Síigee** *Dixon Entrance* (Thomson and Krassovski 2010). The California Undercurrent water thus contributes significantly to the composition of bottom waters in Duu Gúusd Daawxuusda and

Síigee. The highest oxygen values in the upper 100 m are at Zone 500 (**K̲adlee** *Offshore Celestial Reef*) and 505 **Gangx̲id Kun Sg̲aagiidaay** *Cape St. James*), the two zones with the strongest connections to the shelf.

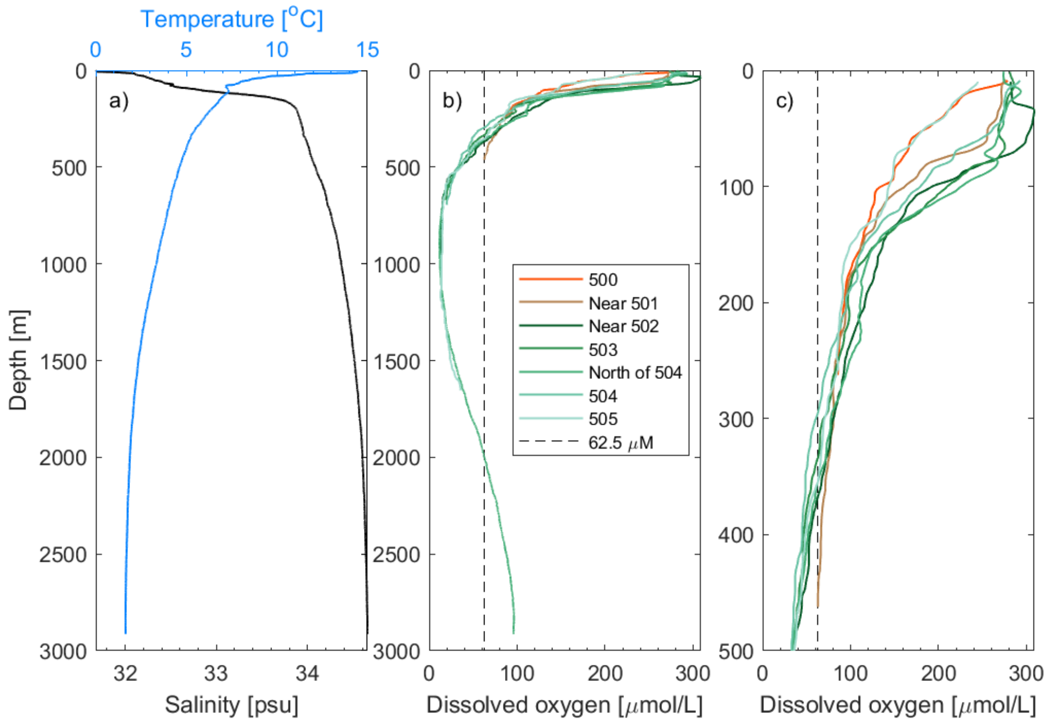

Figure 14. (a) Vertical distribution of temperature and salinity in the deepest areas of the proposed network zones. (b) Vertical profiles of dissolved oxygen for several network zones. (c) Same profiles as in (b) but showing only the upper 500 m of the water column. The dashed line represents dissolved O_2 of 62.5 uM, a threshold of which below is often used to delineate hypoxia. The profiles were collected in July 2020. The orange and brown profiles are from ***Síigee*** *Dixon Entrance (Zones 500 and 501), while the greens are zones along* ***Duu Gúusd Daawxuusda*** *the west coast of* ***X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay*** *Haida Gwaii (502 to 505), with the darkest furthest north.*

Additional information on marine water properties (including temperature, oxygen concentration, salinity, and chlorophyll) are collected through the C-PROOF Glider program run out of the University of Victoira, which is increasing the amount of sampling occurring off the coast of Haida Gwaii and into the southern OHGNZ (Zones 505 and 504). For further information and data access see the C-PROOF Glider Deployments website. Repeated glider lines and visual surveys in all OHGNZ would provide more data on the water properties that characterize the region and could be used to ground truth satellite observations.

3.2.5. Plankton

3.2.5.1. Phytoplankton

Using satellite imagery from 2003 to 2018, Hardy et al. (2021) investigated historical phytoplankton biomass in four regions around the southern tip of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* (Figure 15), with the waters surrounding Gwaii Haanas divided into east, west and south regions. Chlorophyll-a concentration (Chl-a), the proxy for phytoplankton biomass, was calculated using 4 km spatial resolution satellite data acquired by the Aqua MODerate Resolution Imaging Spectroradiometer (MODIS-Aqua). The coastal area of Gwaii

Haanas had the highest Chl-a values (up to 7.5 mg m^3) in 2018. Hardy et al. (2021) found that the Chl-a dynamic differed in the three Gwaii Haanas regions, where the spring season had the highest Chl-a concentration from 2003 to 2009 (Figure 15). Following that period, the highest Chl-a concentrations were observed in summer until 2015, when spring was again the season where Chl-a concentration was highest. This pattern was consistent with sea-surface temperature for the same period. Consequently, they inferred a strong relationship between physical forcing and the biological response. Additionally, the authors found that the eastern Gwaii Haanas region had the highest mean cumulative Chl-a, which was 40% and 60% higher than the southern and western regions, respectively. Hardy et al. 2021 found no significant trends for Chl-a concentration except for the western Gwaii Haanas region in fall, which significantly increased from 2003 to 2018.

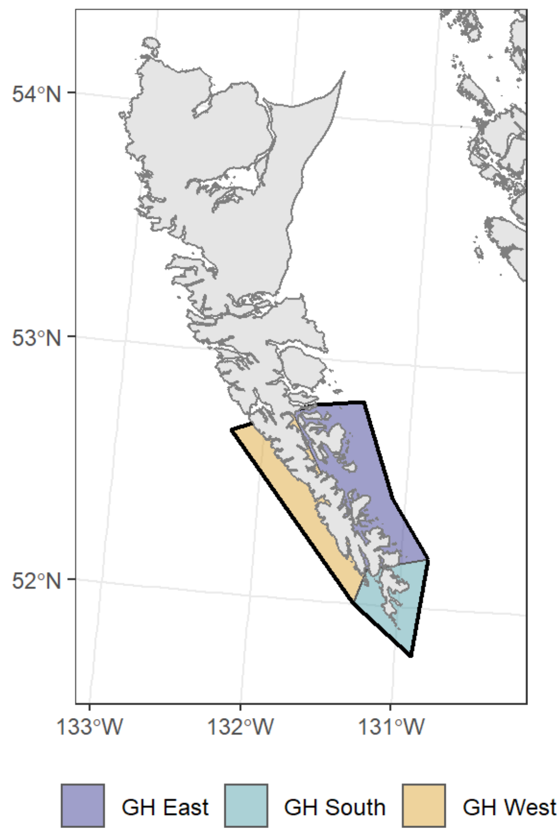

Figure 15. Analysis regions on the southern tip of ***X̱aadáa Gwáay X̱aaydaga̱ Gwaay.yaay*** *Haida Gwaii used by Hardy et al. 2021. The black line indicates the "Gwaii Haanas" region from the Hardy et al. 2021 report, with three further subdivisions in colour (for a total of four regions).*

More recent data acquired from the same satellite sensor from the OHGNZ (Figure 16), but spanning the years 2003 to 2021, showed that the highest Chl-a values occurred in the northern zones of **Tsaan K̲waay** *Offshore Learmonth Bank* (Zone 501) and **K̲adlee** *Offshore Celestial Reef* (Zone 500). These regions also had the highest variability in the timing of annual peak Chl-a, which occurred from April through June for Tsaan K̲waay, and May through June for K̲adlee; the remaining regions, on the other hand, had the highest variability of Chl-a consistently occurring in May. Offshore Northwest Dixon (Zone 502) also showed high phytoplankton biomass in bloom conditions, typically in April or May. The remainder of the regions remained below 3 mg m^{-3} year-round, excepting occasional increases in Chl-a above this concentration that were observed in **Sasga K'ádgwii** *Offshore Continental Slope North* (Zone 502) and Gwaii Haanas Extension (Zone 504, which is adjacent to the regions of Hardy et al. 2021) zones.

Figure 16. Monthly time series of satellite chlorophyll-a concentration (Chl-a, mg m³) for the Offshore Haida Gwaii Network Zones. Data is at a 4 km resolution covering 2003 to January 2022. The time series are coloured by season: winter in blue (January, February, March), spring in green (April, May, June), summer in yellow (July, August, September), and autumn in red (October, November, December). November, December and January are excluded due to the low sun angle preventing the acquisition of sufficient quality data.

These time series are also corroborated by the Chl-a analysis of Jackson et al. 2015, using satellite data spanning the years 1997–2010, which divided this area of the NSB into two regimes. “Regime 1”, with a higher Chl-a peak in spring than in fall, spatially overlapped with the

Offshore Northwest Dixon, **Tsaan Kwaay** *Offshore Learmonth Bank*, **Kadlee** *Offshore Celestial Reef*, and part of **Gangxid Kun Sgaagiidaay** *Cape St. James* Zones, and further extended north throughout coastal Alaska, and south into **Kandaliigwii** *Hecate Strait* and Queen Charlotte Sound. “Regime 2” in their results, on the other hand, corresponded to waters on the western side of the **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* archipelago, here overlapping with the **Sasga K'ádgwii** *Offshore Continental Slope North*, **Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* and Gwaii Haanas Extension Zones, characterized by low Chl-a throughout the year. Both of these regimes exhibited spring and fall phytoplankton blooms, the spring being the greater of the two, with an average annual start occurring in April (see Table 1 of Jackson et al. 2015), also shown here.

3.2.5.2. Zooplankton

Understanding zooplankton distribution and abundance in the Northern Shelf Bioregion is much less advanced than for the Southern Shelf and Strait of Georgia bioregions, where there have been sustained monitoring programs for several decades (the La Perouse Program and the Strait of Georgia Program). The best-studied part of the NSB is the southern end of Queen Charlotte Sound, where the La Perouse program has made routine measurements twice a year since 1990 (Figure 17). In addition, the DFO Pacific plankton program has been able to piece together a zooplankton time series (2000–present) in **Kandaliigwii** *Hecate Strait* from various sources.

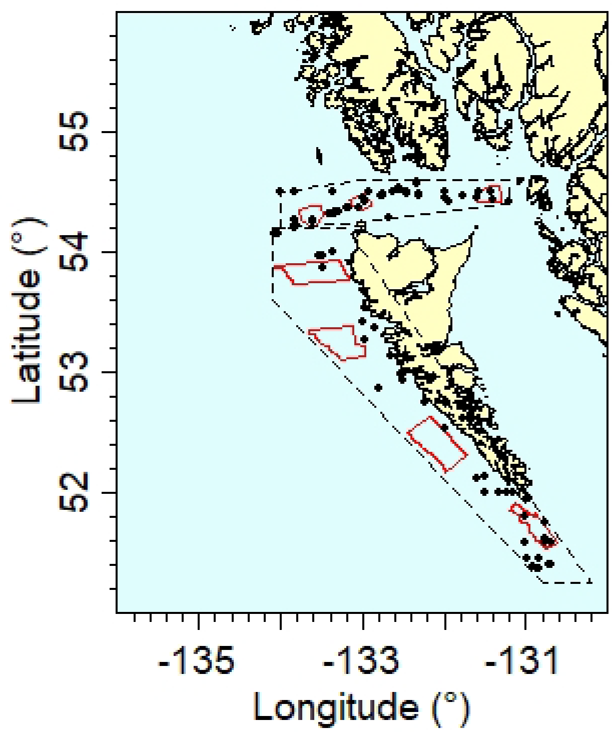

Figure 17. Spatial distribution of zooplankton sampling events within and in the vicinity of the Offshore Haida Gwaii Network Zones along ***Duu Gúusd Daawxuusda*** *the west coast of Haida Gwaii and in* ***Síigee*** *Dixon Entrance (1980–2021).*

All zooplankton sampling events in the broad vicinity of and including the OHGNZ were extracted from the ‘DFO Pacific Zooplankton Database’ maintained at the Institute of Ocean Sciences. Sampling events consist of 236 μm mesh bongo nets towed vertically from a maximum depth of 250 m or 10 m above the seafloor. The database output included samples collected using comparable methods from DFO oceanographic, DFO fisheries, and academic programs between 1980 and 2021. Most of the 133 samples within the vicinity of the OHGNZ were collected after 1990. Sampling resolution within the OHGNZ is poor (Figure 17; Table 3) and unsuitable for characterizing seasonal or interannual trends. However, pooling observations within two broader regions: **Síigee** *Dixon Entrance* (including Zones 505, 504, 503, and 502, Figure 17); and **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* (Zones 506, 501, and 500; Figure 17) provides some improved temporal resolution (Figure 17; Table 3). In June 2022, the first unique sampling event (Northeast Pacific Deep-Sea Diversity Expedition, Pac2022-035) was performed at Zone 504, and within Zone 502. However, these samples have yet to be processed and are excluded from this analysis.

*Table 3. Number of unique zooplankton sampling events within the Offshore Haida Gwaii Network Zones (OHGNZ) and more broadly along **Duu Gúusd Daawxuusda** the west coast of Haida Gwaii and **Síigee** Dixon Entrance (1980–2022). Note broad areas include sampling events within the Offshore Haida Gwaii Network Zones. Grey shading with a dash indicates unsampled sites.*

Area	**Gangxid Kun Sgaagiidaay** *Cape St.James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**
OHGNZ	4	1	0	2	4	6	**3**
Duu Gúusd Daawxuusda *West coast of Haida Gwaii*	65			-			
Síigee *Dixon Entrance*	-			71			

Species compositions for **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* and **Síigee** *Dixon Entrance* are similar to the southern Queen Charlotte Sound. However, the relative biomass dominance of species/groups between the two areas differs for both crustacean and non-crustacean zooplankton (Figure 18, Figure 19). Within-group biomass for each broad area was averaged within each survey and within seasons across years to construct a composite seasonal cycle without correcting for varying sampling efforts. The mean seasonal biomass is lowest in the winter and comparable in the Síigee area and along the Duu Gúusd Daawxuusda area (1.98 and 1.64 g dry weight m^{-2}). Both areas are dominated by euphausiids, medium- and large-calanoid copepods, and chaetognaths and pteropods to a lesser extent. The mean annual biomass maximum (13.77 g dry weight m^{-2}) in the Síigee Area occurs in the spring (April, May, June) and is dominated by medium-sized calanoid copepods, gelatinous plankton (cnidarians and ctenophores), euphausiids, and chaetognaths. The large copepod biomass also reaches its seasonal maximum during the spring but contributes more to the total spring biomass along Duu Gúusd Daawxuusda (>20%). This group includes large lipid-rich subarctic copepods such as *Neocalanus* spp. important to the breeding success of auklets in the northern shelf bioregion (Bertram et al. 2017a; Hipfner et al. 2020). *Neocalanus* spp. descend to overwintering depth as pre-adults in the late summer where they eventually moult to adult stage and reproduce. These overwintering animals do not return to the surface and represent and significant export of pelagic production to the benthos (Kobari et al. 2008; De Leo et al. 2018). Euphausiid biomass in both areas is dominated by adults during the winter and larvae and juveniles, developing into adults through the summer and fall. Euphausiids (>40%) dominated the mean spring biomass along the continental shelf and slope and are important in the diet of **SG̲idaanáa Sg̲iin x̲aana** *Ancient Murrelets* (Gaston 1994) and early marine phase juvenile **Tsíi.n Chiina** *salmon*. Euphausiids dominate the biomass in both areas but are more important along Duu Gúusd Daawxuusda in the summer and fall. Salp biomass is negligible in Síigee *Dixon Entrance* but important to total and non-crustacean zooplankton biomass along Duu Gúusd Daawxuusda, especially in the summer. Small jellyfish (Cnidarians) and ctenophores dominate the biomass of non-crustacean zooplankton during spring in Síigee and summer along Duu Gúusd Daawxuusda (Figure 18, Figure 19).

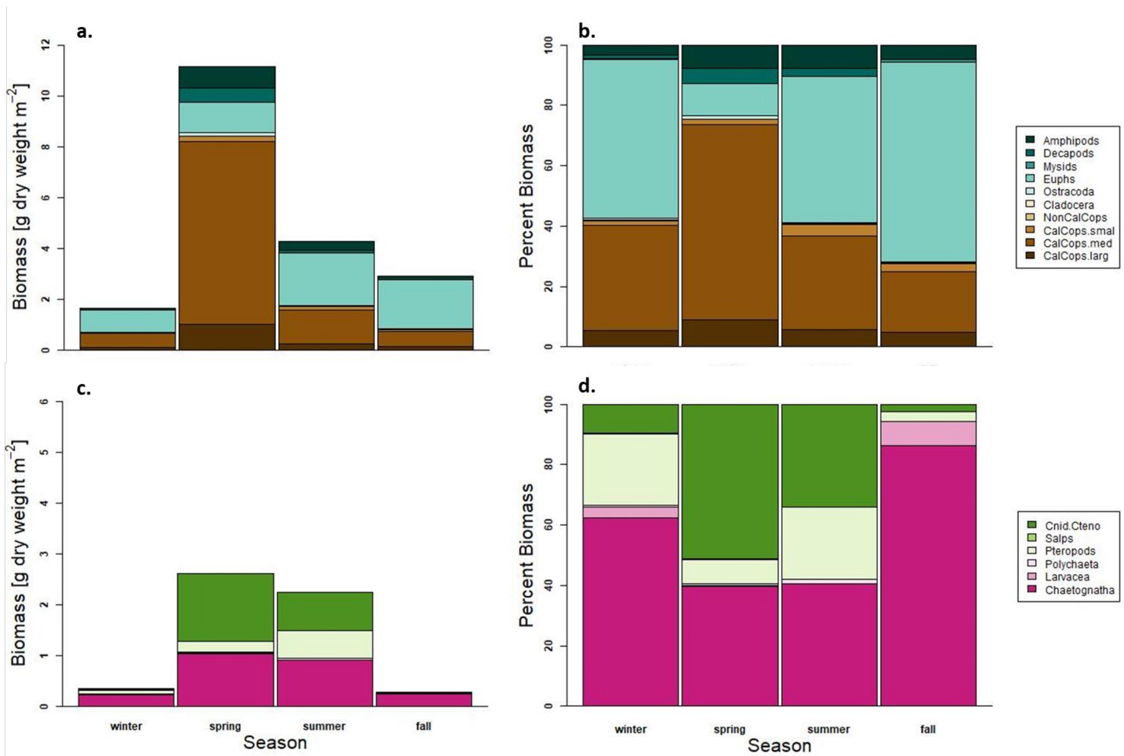

Figure 18. Seasonally averaged biomass (g dry weight m^{-2}) and relative biomass (%) of major crustacean (a,b) and non-crustacean (c,d) zooplankton groups sampled periodically in Síigee Dixon Entrance between 1980–2021.

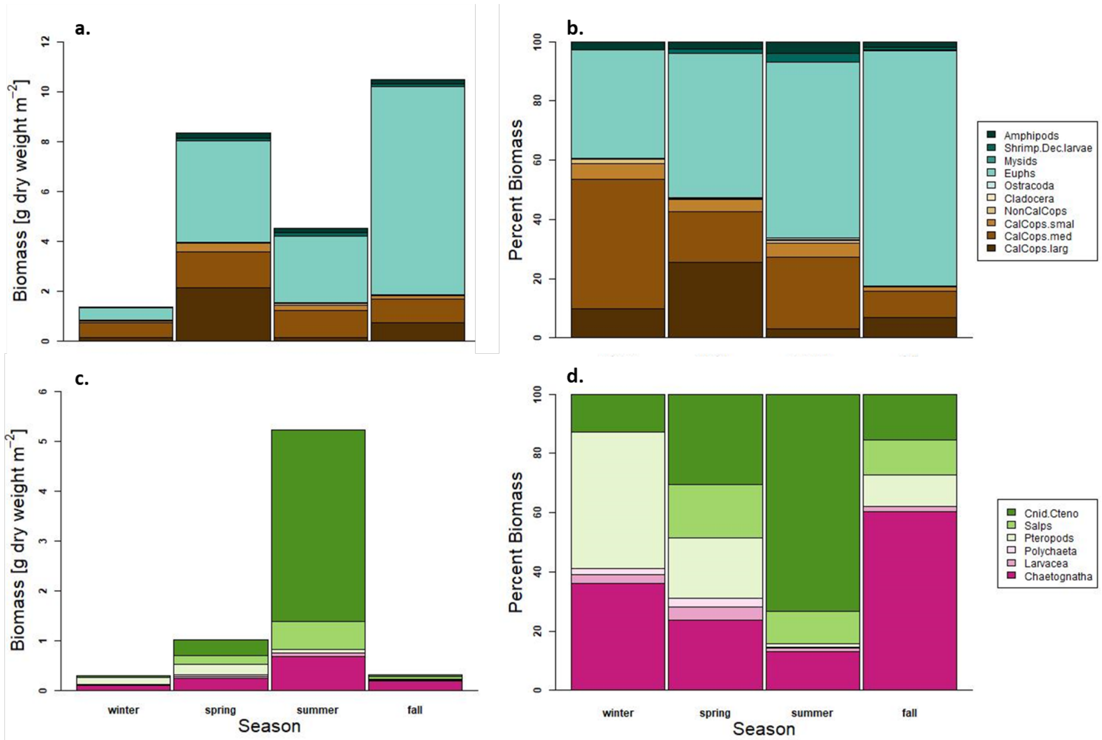

Figure 19. Seasonally averaged biomass (g dry weight m^{-2}*) and relative biomass (%) of major crustacean (a,b) and non-crustacean (c,d) zooplankton groups sampled periodically along* ***Duu Gúusd Daawxuusda*** *the west coast of Haida Gwaii between 1980–2021.*

Groupings of copepods based primarily on shared geographic affinity have been used as climate-ocean-food web indicators along Canada's west coast (Mackas et al. 2004). Copepods with a 'southern' California Current affinity are sensitive indicators of warmer than average conditions along the southern Vancouver Island shelf (see Galbraith and Young 2021). This indicator group's biomass increases during warmer than average periods (especially extreme years) along **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*, and **Síigee** *Dixon Entrance*. For example, the summer biomass of 'southern' copepods along Duu Gúusd Daawxuusda is generally elevated during PDO-positive (warm-water state) years and was up to 10 times greater during the 1997–1998 and 2015–2016 El Niño events relative to recent cooler (La Niña) conditions in 2020–2021. While conversely, the mean biomass of copepod indicators (boreal and large subarctic animals) of cool and productive conditions (negative PDO-index, see Hipfner et al. 2020) was low during these hot periods and increased more recently with the return of cooler conditions.

4. ECOLOGICAL SETTING

4.1. UNIQUE ECOSYSTEMS

4.1.1. Chaan Tlat’a.awée *Seamounts*

Seamounts have considerable scientific and economic interest because of their distinct oceanography and ecology. These seafloor features are ranked high in EBSA criteria on uniqueness, vulnerability, productivity, diversity, naturalness, and ranked medium on importance for species aggregation (Ban et al. 2016). Individual seamounts are roughly circular or elliptical submarine mountains with summit elevations over 1,000 m above the seafloor (United States Board of Geographic Names 1981). Nearby seamounts can form chains. Overlapping seamounts can form large and/or long continuous features. While geologists and oceanographers often define seamounts as extinct volcanoes, ecologists generally include any abrupt peak that exhibits similar biophysical properties (Pitcher et al. 2007). Within the Pacific Region, there are 65 known seamounts, all associated with the tectonic activity of the Pacific oceanic plate (Du Preez and Norgard 2022). It is notable that there are no known seamounts in the Atlantic or Arctic Regions (Du Preez and Norgard 2022).

The NSB has only one known seamount, which is within **Sasga K̲'ádgwii** Offshore Continental Slope North (Zone 502), SAUP 5494[9] (Figure 20). It is a seamount of 1,120.95 km^2 total area and a maximum height of 1,876 m at its peak, with a base depth of 2,778 m (DFO 2019b) and a summit depth of 840 m (C. Du Preez, personal communication, October 11, 2022). The summit is within Zone 502, but the elongated seamount extends north and south of the boundary (Figure 20). The area of the seamount captured by the OHGNZ is 359 km^2, 32.03% of the seamount and 39.84% of the Zone 502 polygon (Table 5).

[9] Currently unnamed – Sea Around Us Project (SAUP) 5494 is a placeholder name assigned by Kitchingman et al. 2008.

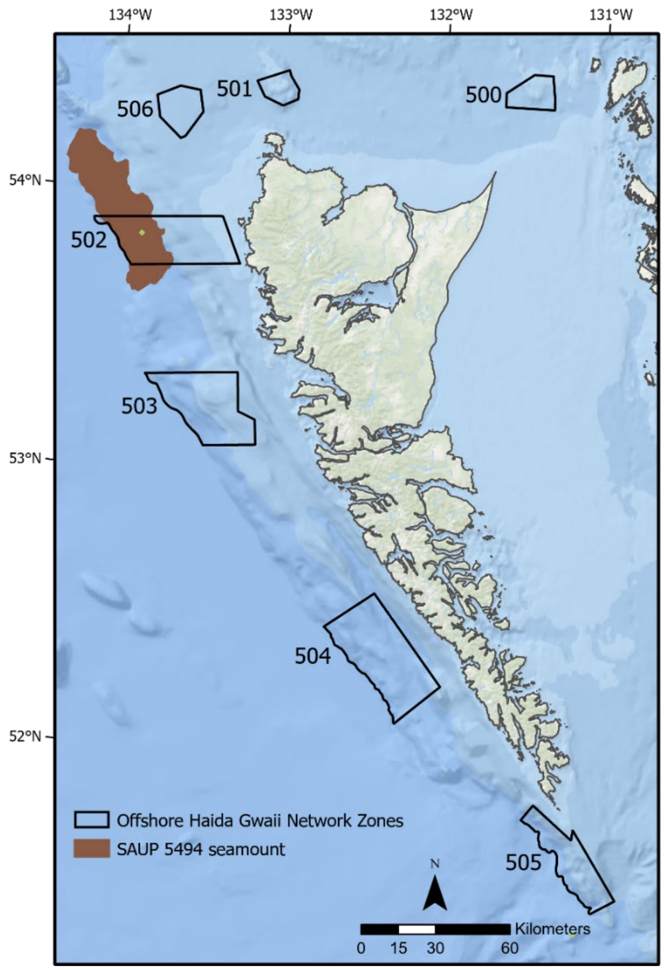

Figure 20. Location of the SAUP 5494 seamount in the Offshore Haida Gwaii Network Zones. The green dot indicates the summit of the seamount and the brown fill the full area of the seamount. The Offshore Haida Gwaii Network Zones are outlined in black with the zone numbers provided in text.

Seamounts are characterized by complex topography and are sources of habitat heterogeneity in the deep sea (Rowden et al. 2010; DFO 2019b). Their height, shape, and orientation can also impact local circulation patterns (Ban et al. 2016). Limited data is available for SAUP 5494 (ranked as 'low' existing data among seamounts; Du Preez and Norgard 2022). Still, its height and breadth could contribute to alterations in local currents, upwelling, and entrainment of eddies which can enhance biological productivity in contrast to its surroundings (White et al. 2007). Seamount summits can trap prey near the surface, providing a food source, but this phenomenon depends on its depth and the vertical migration of a variety of marine animals. Seamounts provide feeding grounds for many predators, including fishes, **X̲edíit Siigaay x̲idid** *marine birds*, and marine mammals (Kaschner 2008; Santos et al. 2008; Thompson 2008). Taxonomic groups found on the surveyed Pacific Region seamounts include over 770 taxa of bony fishes, elasmobranchs, corals and sponges, gastropods, bivalves and other invertebrates (for entire species inventory: Du Preez and Norgard 2022), which can attract high abundances of pelagic species (including tuna and **K̲'aad aw K̲'aax̲ada awg̲a** *sharks*), as well as mammals and X̲edíit Siigaay x̲idid (Rowden et al. 2010; Du Preez and Norgard 2022). Species assemblages on seamounts are similar to those found on nearby continental shelves and slopes, in that they are a subset of those communities (O'Hara 2007; Lundsten et al. 2009; McClain et al. 2009; Howell et al. 2010). Compared to the continental shelf and slope populations, seamount populations can have distinctly different relative abundances, distributions, interactions, etc. (Du Preez et al. 2015; Du Preez and Norgard 2022). Owing to the steep seamount flanks, populations tend to exist in relatively compressed depth-related patches with high turnover and, therefore, seamounts host high beta biodiversity (Du Preez et al. 2015; Du Preez and Norgard 2022).

SAUP 5494 is one of eleven 'H2' seamounts, a classification system based on export productivity to its summit ('high' at 26 C m-2 d-1), summit depth (deep), and oxygen at summit ('low' at 0.439 ml/l [O2]) (Du Preez and Norgard 2022). Compared to the other 64 seamounts in the Pacific Region, SAUP 5494 is unique for its flat top and close proximity to shore, occurring on the continental slope (Du Preez and Norgard 2022). However, the most notable characteristic of SAUP 5494 is that its origin and composition may be unlike any of the other seamounts. There is mounting evidence that this seamount is not an igneous volcano (i.e., it is not lava and was not necessarily created by magmatic activity). Instead, the working hypothesis is that this seamount is a chain of interconnected mud volcanoes (similar to those near the Mariana Trench, Fryer et al. 2017; for more information, see the Cold Seeps section below). Seamounts usually provide stable hard substratum on which corals, sponges, and other species settle and grow (Watling and Auster 2017; e.g., the Northeast Pacific Deep-sea Exploration Project (NEPDEP) 57 and 58 seamounts in the Tuzo Wilson complex ~6 km south of Zone 505; for more information on these seamounts, see the Ecological Connectivity section below). However, the surface of SAUP 5494 appears to be predominantly mud, with sparse black basalt and light-coloured carbohydrate rocks (Northeast Pacific Deep-Sea Diversity Expedition Pac2022-035 video and annotations available on the Ocean Networks Canada Expedition Management website under Department of Fisheries and Oceans Canada>2022>DFO Expedition 2022-06 (Jun 2022)>OY079 – 2022-Jun-19 14:36:00 – SAUP5494; Figure 21). The importance of this geological distinction on the ecosystem functions provided by SAUP 5494 is significant. Rather than filter feeders anchored to hard substratum, the community on SAUP 5494 appears dominated by scavengers and deposit feeders. Animals observed at SAUP 5494 in 2022 included corals, carnivours sponges, sea pigs, brittle stars, snails, Deep-sea Snailfish, Deepsea Sole, stalked barnacles, Carnivourous Tunicates, corals, jellyfish, **Huuga Huuga** *Tanner Crabs*, sea pens, anemones, Thornyheads Deep-sea Skates and Northern Fur Seals (Northeast Pacific Deep-Sea Diversity Expedition Pac2022-035).

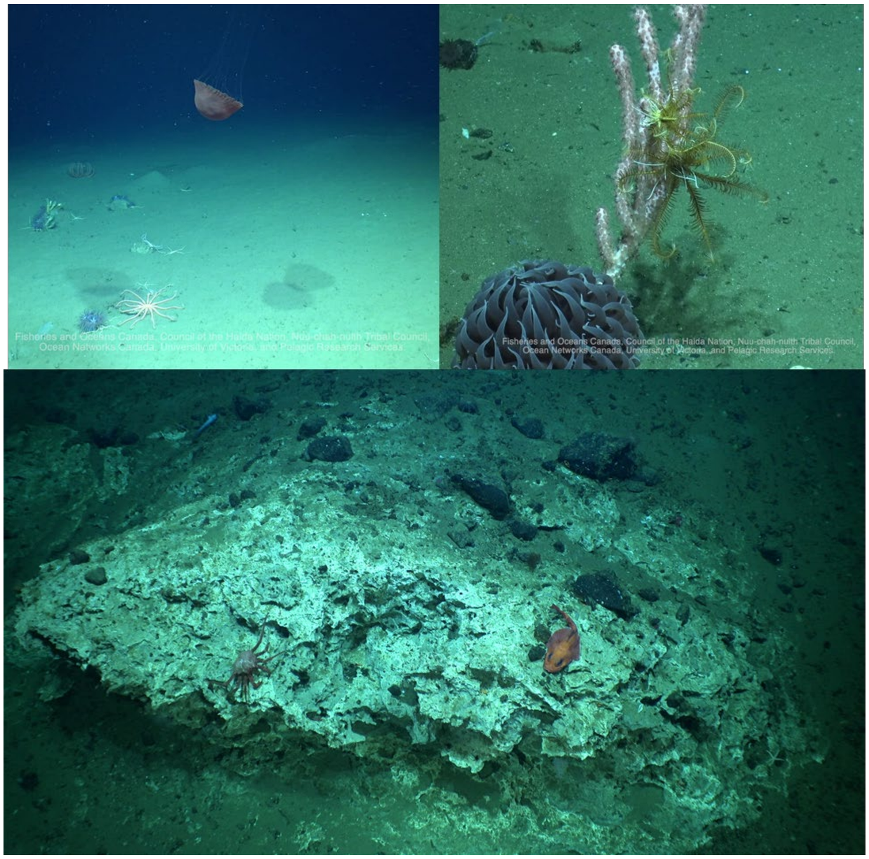

*Figure 21. Photos from the recent Northeast Pacific Deep-Sea Diversity Expedition Pac2022-035 of the seamount SAUP 5494 (Zone 502) showing examples of its muddy bottom and carbonate structures. From upper left clockwise: Poralia jelly (*Poralia rufescens*), brisingid sea star (order Brisingida), brittle stars (Class 0phiuroidea), and a species of unknown anemone (order Actinaria) over muddy bottom; Pom Pom Anemone (*Liponema brevicornis*) and Bubblegum Coral (*Paragorgia cf. jamesi*) with attached crinoids (*Florometra serratissima*) on muddy bottom; Scarlet King Crab (*Lithodes couesi*) and Thornyhead (*Sebastolobus *spp.) on carbonate structure. Images from Northeast Deep Sea Diversity Expedition Partners (Fisheries and Oceans Canada, Council of the Haida Nation, Nuu-chah-nulth Tribal Council, Ocean Networks Canada, University of Victoria, Pelagic Research Services).*

In general, the tectonic and volcanic settings of seamounts may also support chemosynthetic communities through hydrothermal vent or cold seep activity, and the presence of these chemosynthetic ecosystems is considered an important distinguishing feature among seamount (Clark et al. 2010, 2011). While there is no hydrothermal venting documented on any seamount in the Pacific Region, there are two cold seep sites documented on SAUP 5494 (north of the 2022 transect; see Cold Seeps section). While no chemosynthetic animals were observed during the 2022 transect, cold seep carbonate rocks were, as well as a seep-associated snail *Neptunea* sp. sitting atop egg towers (common observation around cold seeps; DFO 2018a). It is anticipated a more extensive visual survey of the seamount will find chemosynthetic bacteria and animals, which will be a novel community for the seamounts in the Pacific Region (for more information, see the Cold Seeps section below).

Based on the documented cold seeps, carbonate rocks, and extensive surficial mud alone, SAUP 5494 is a geologically and ecologically unique seamount. Future iterations of the Pacific Region seamount classification system should identify SAUP 5494 in a new seamount class by itself (previous iterations published in DFO 2019b and Du Preez and Norgard 2022).

4.1.2. Cold Seeps

Cold seeps are benthic marine habitats where reduced chemicals (e.g., hydrogen sulphide and methane) emanate from the seafloor, supplied by subsurface hydrocarbon reservoirs. Microbes metabolize these chemical compounds and form the base of biological communities. Cold seeps are chemosynthetic ecosystems where biological communities rely on bacteria to generate chemical energy rather than photosynthesis for growth (Tunnicliffe et al. 2003). They provide high levels of habitat heterogeneity (Cordes et al. 2010; Grupe et al. 2015) through various seafloor substrates (e.g., carbonate rocks) and biogenic habitat types (e.g., complex forests of tubeworms; DFO 2018a). They are rare and rich in situ-produced food sources in the deep sea, leading to high levels of diversity, large animals, dense populations, and production that can be exported to surrounding ecosystems on the continental margin (Levin et al. 2016). When they are no longer active, cold seep structures provide important ecosystem functions and beneficial services, such as essential cold-water coral, sponge, and fish habitats (Levin et al. 2016). In the USA, cold seeps are designated and protected as groundfish Essential Fish Habitat and are part of fisheries management plans (e.g., Grupe et al. 2015; Pacific Fishery Management Council 2022). Unique biological communities exist at the sites of the cold seep carbonate chimneys and surrounding benthic surface (Barrie et al. 2011). Within Canada, cold seeps in Pacific waters have been identified as EBSAs for their unique geomorphological characteristics, rarity, the critical habitat they provide and its vulnerability, and for their high rates of biological productivity, especially compared with other regions in the deep sea (DFO 2018a).

Fluid flow processes are active in the Queen Charlotte Fault (QCF) valley on the west side of **X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay** *Haida Gwaii* (Figure 9), resulting in cold seeps in several known locations (Figure 22). The area is believed to be under-sampled, and cold seeps are likely vastly underrepresented in existing datasets. Although cold seeps have been identified elsewhere on the shelf, the QCF is a unique feature, likely acting as a conduit for fluid flow. Venting sites are concentrated along the fault zone and tend to show high-intensity gas venting (Barrie et al. 2018). Barrie et al. (2018) have documented multiple mud volcanos and other gas seeps associated with the fault. Samples recovered from carbonate crust were dated to 14–30 ka (unpublished data), and active venting over several surveys (2015–2017) also indicates persistent flow (Barrie et al. 2018, 2021). The carbonate crusts documented in association with QCF mud volcanos provide hard substrate habitats on an otherwise soft sediment slope (Barrie et al. 2020). Venting sites in the fault valley also occur at great depths (>1,000 m), well below the storm wave base, that tend to affect documented cold seeps on the shallow (<150 m) shelf. Barrie et al. (2020) document rich chemosynthetic biological communities associated with carbonate crusts at QCF venting sites.

Cold seeps can be located by surveying the seafloor for specific bathymetric features and/or the water column for gas plumes (also known as bubble streams or flares). Confirming a cold seep requires a direct visual observation or physical sample. In the NSB, cold seeps have been discovered by Natural Resources Canada (NRCan) researchers employing drop camera systems targeting specific geophysical features at the southern tip of **X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay** *Haida Gwaii* (~800 m) and in **Síigee** *Dixon Entrance* (~1,000 m) (DFO 2018a). Single- and multi-beam echo-sounders have detected many gas plumes, suggesting the existence of dozens to hundreds of yet-explored seeps (Riedel et al. 2016; J.V. Barrie personal communication, November 3, 2022). Plumes have already been observed near **Ginda Kun SG̱aagiidaay** *Offshore Continental Slope South* (Zone 503) of the OHGNZ. These plumes are along the continental margin between **G̱angx̱id Kun SG̱aagiidaay** *Cape St. James* (Zone 505) and Gwaii Haanas Extension (Zone 504; Figure 22). Even if they are not directly observed in the future within the OHGNZ, they are likely providing aggregates of food resources for marine species throughout the offshore westmost OHGNZ. Chemosynthetic bacteria can be free-living microbes (e.g., thick mats around seeps or drifting in the water column) or farmed within seep-endemic animals (i.e., endosymbionts).

Cold seep activity can vary in magnitude, intensity, chemical composition, and location on short to long timescales. Seeping can be stable for thousands of years and support complex community succession (Levin et al. 2016). However, it can also abruptly shut off, redirect to a new location, and restart the community succession process over and over. While individual cold seeps can be ephemeral and dynamic, a network of seeps may persist within a region over geological timescales forming massive bathymetric features. Connectivity between active seeps over time and space is essential to the sustainability of the chemosynthetic-endemic species (Levin et al. 2016). In the Pacific Region, cold seep ecosystems are generally characterized by two types of endemic megafauna: tubeworms and bivalves (summarized in DFO 2018a and references therein).

Mud volcanoes, a type of cold seep, are bathymetric features created when the mass upward movement of cold seep gas transports a slurry of mud, water, and rocks from deep within the Earth to the seafloor surface (Tinivella and Giustiniani 2012). The resulting eruption of sedimentary material can form a cone-like edifice with craters, similar to a true igneous volcano. Mud volcanoes with active seeping can support the same chemosynthetic ecosystems described above, depending on the gas composition. Mud volcanism is not one specific process and the activity is strongly controlled by the geological environment in which they occur (Tinivella and Giustiniani 2012). There are six submarine mud volcanoes known in the Pacific Region, and all six occur in the NSB associated with the Cascadia subduction zone and QCF (Figure 22). An additional mud volcano is located just north of the Economic Exclusion Zone associated with a cold seep (Figure 22). Mud volcanoes may range in size from metres to kilometres wide and metres to hundreds of metres high (Tinivella and Giustiniani 2012). Sometimes a mud volcano forms on top of another feature because the gas and mud slurry travels upwards using the subsurface conduits of the original feature (e.g., igneous volcano). Sometimes, mass seeping creates a mud volcano so large that it meets the geomorphological criteria of a seamount (Tinivella and Giustiniani 2012).

As mentioned in the Seamounts section above, there is mounting evidence that SAUP 5494 seamount is a chain of interconnected mud volcanoes (and not an igneous volcano). This working hypothesis is supported by the new visual observations of extensive surficial mud with large pieces of carbonate crust and sparse basaltic rocks, cold seep-associated animals (snail *Neptunea* sp.; Northeast Pacific Deep-Sea Diversity Expedition Pac2022-035; Figure 21), and the documentation of active mud volcano craters on two of the northern pinnacles on the feature (Barrie et al. 2018; Figure 21). Furthermore, the movement of the Pacific plate is causing SAUP 5494 to progress northward. If passing over a mud volcanism hotspot, it would account for the north-south elongated shape of SAUP 5494 as a chain of interconnected mud volcanoes (V. Barrie, personal communication, November 3, 2022). Mud volcanoes are some of the least studied geological features in the world (Tinivella and Giustiniani 2012). Assuming SAUP 5494 is a large mud volcano seamount, it is one of the few places where such features have been confirmed and surveyed. Other places include the Mediterranean (e.g., Limonov et al. 1994) and the Marianas (e.g., Fryer et al. 2017).

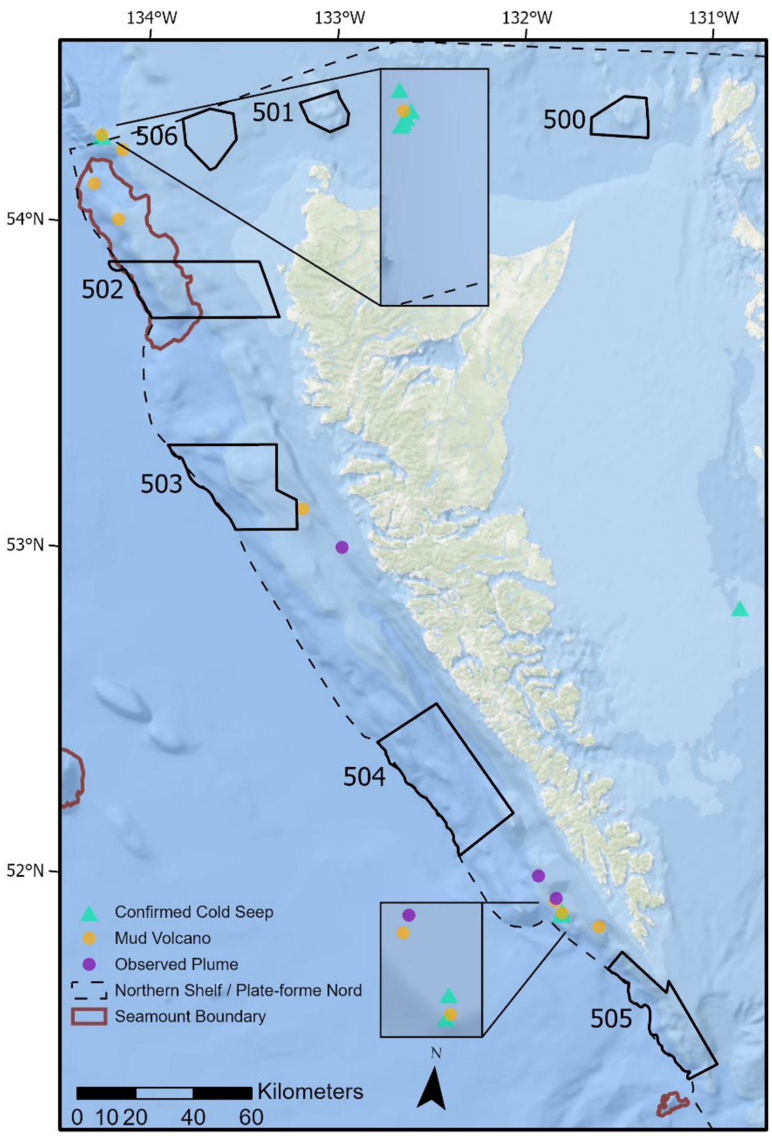

Figure 22. Cold seeps, mud volcanoes, and plumes observed in the Offshore Haida Gwaii Network Zones. Note two zoomed in windows of tight overlapping locations of cold seeps and mud volcanoes. The outline of the SAUP 5494 seamount has been provided to show the close association between the seamount and mud volcanoes. Note the northernmost mud volcano may be in USA. waters. Data comes from NRCAN and DFO underwater multibeam observations on surveys.

4.1.3. Rocky Outcrops

As mentioned previously in this report **Síigee** *Dixon Entrance* hosts two prominent rocky bathymetric features: **Tsaan Kwaay** *Learmonth Bank* (Zone 501) and **Kadlee** *Celestial Reef* (Zone 500) (Figure 23). Associated with outcrops are high benthic and taxonomic diversity. While the previous sections have detailed the oceanography of these areas, their unique ecological components deserve further mention.

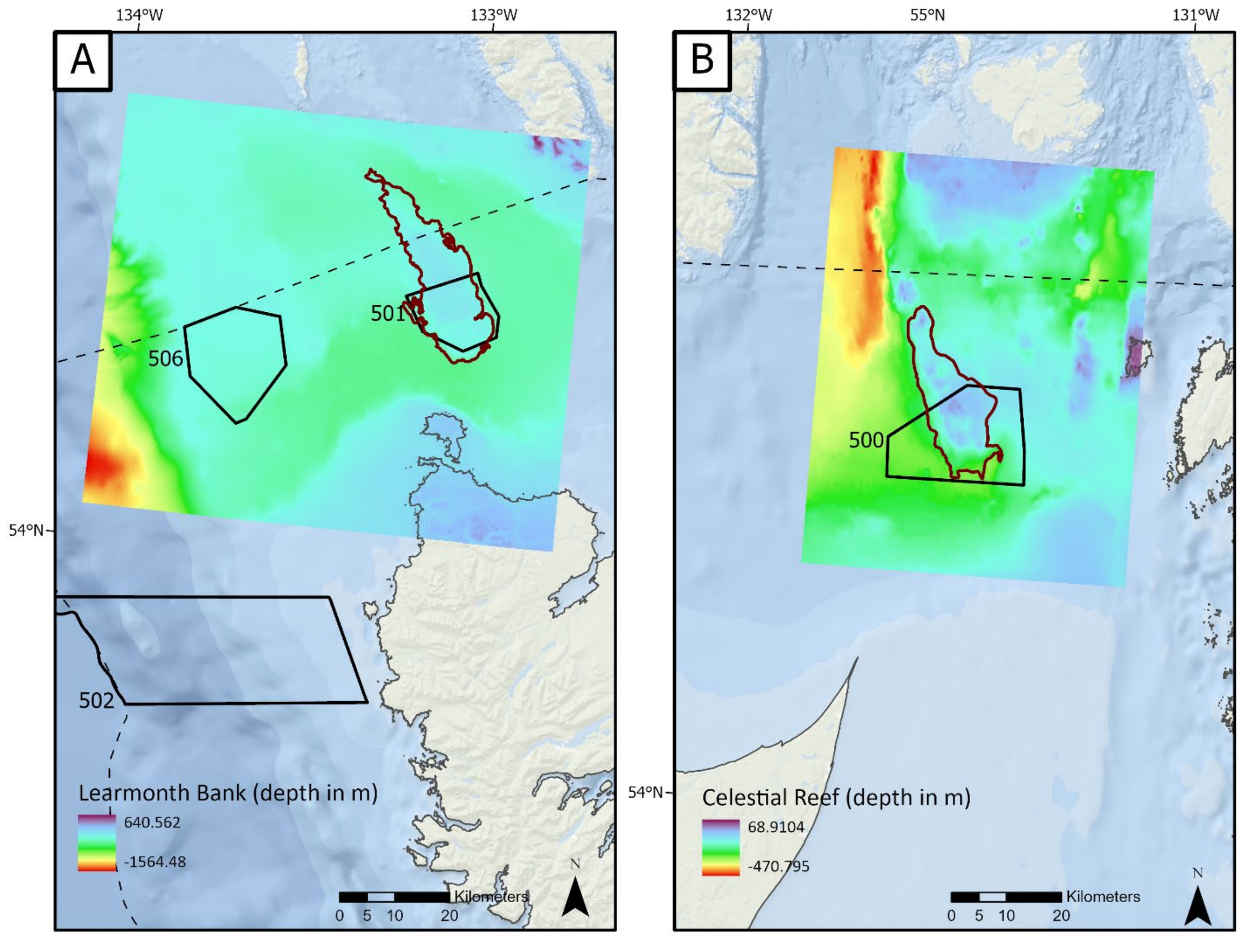

Figure 23. Location and multibeam imaging for the two rocky outcrops in the Offshore Haida Gwaii Network Zones. (a) The boundary of ***Tsaan Kwaay*** *Learmonth Bank is indicated by a dark red outline. (b) the boundary of* ***Kadlee*** *Celestial Reef is indicated by a dark red outline. Note that the two map panels are at slightly different spatial scales. The coloured multibeam portion of the maps shows the depth in metres above or below sea level. The black outline polygons indicate the Network Zones, and the dotted line indicates the Northern Shelf Boundary.*

Tsaan Kwaay *Learmonth Bank*, where Zone 501 is located (Figure 23), spans approximately 37 km across the opening of **Síigee** *Dixon Entrance* North of **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* (Figure 3). It is a submerged volcanic rocky outcrop on the continental shelf. It is characterized by highly heterogenous benthic surfaces that range from muddy flat areas with large erratic boulders (dropstones from icebergs) to mixed sediments (moraines of glacier deposits), to highly iceberg scoured, faulted, and fractured bedrock slopes and plateau (Du Preez and Tunnicliffe 2011; Neves et al. 2014; also see Oceanographic Setting of this report). This bank rises from 480 to 25 metres below the surface (Du Preez 2015). Furthermore, a clockwise eddy encompasses the mouth of Síigee (Crawford and Greisman 1987; Ballantyne et al. 1996) that facilitates the accumulation of plankton (Clarke and Jamieson 2006). The combination of habitat heterogeneity and currents has created a landscape that hosts high demersal fish abundance (Sinclair et al. 2003), high in rockfish species (Du Preez and Tunnicliffe 2011), and abundance of cold-water corals and sponges (Ardron and Jamieson 2006; Du Preez and Tunnicliffe 2011; Neves et al. 2014; Rubidge et al. 2018), and multiple substrates for biogenic structures (Du Preez and Tunnicliffe 2011; Neves et al. 2014). Tsaan

Kwaay is an area of much research activity due to a combination of: vulnerable coral and sponge marine ecosystems (Du Preez and Tunnicliffe 2011; Neves et al. 2014), hotspots for demersal fish trawling (Sinclair et al. 2005), and potential as a marine protected area (Ardron 2003; Network Action Plan). Tsaan Kwaay has also been designated as an EBSA (Clarke and Jamieson 2006; Rubidge et al. 2018) and is associated with the following “important species” for which the area is an important feeding area (Alcids), migration route (**Kún** *Grey Whales*), or area of aggregation (**Kún** *Fin Whales* and coral). Despite being considered a hotspot for commercial fishing activity, fishing is limited in the area to the basin due to the rugose seafloor, which bottom trawl surveys avoid (Sinclair et al. 2003). An unresolved maritime boundary dispute (Gray 1997) results in almost zero fishing activity in the disputed area (Figure 24; Neves et al. 2014). However, lost and abandoned fishing gear is present in the area (see Figure 2 in Du Preez and Tunnicliffe 2011) similar to lost fishing gear on Cobb Seamount (Du Preez et al. 2020).

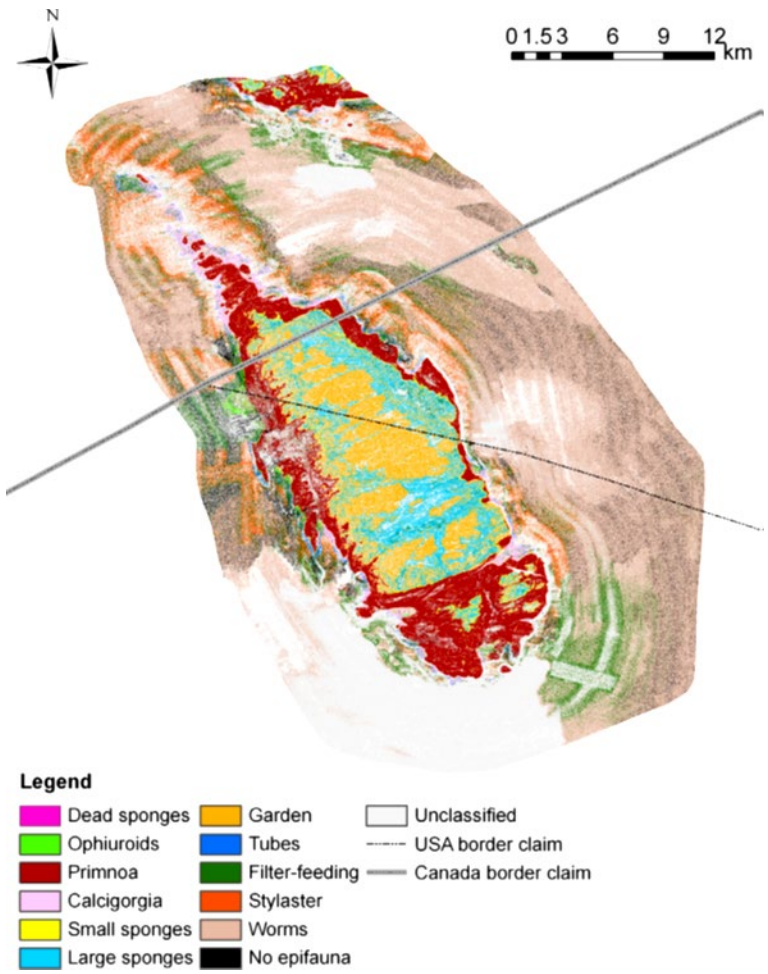

*Figure 24. **Tsaan Kwaay** Learmonth Bank biotope distribution taken from from Neves et al. 2014 (Figure 9). Biotope distribution was predicted using a combination of video data, backscatter, bathymetry, slope and predicted substrate types. The triangular area at centre-right experiences relatively little fishing, due to a border dispute between Canada and the USA.*

Using a remotely operated vehicle (ROV) to survey **Tsaan Kwaay** *Learmonth Bank*, Du Preez and Tunnicliffe (2011) found that Shortpsine Thornyhead (*Sebastolobus alascanus*) and rockfish species (*Sebastes* spp.) accounted for 78% of the demersal fish over the sampled area. Shortspine Thornyhead species (a target commercial species) were randomly distributed over featureless substrata and their abundance increased with depth (Du Preez and Tunnicliffe 2011), whereas the nine rockfish species occurred in clumped distributions that favoured rougher benthic habitat, or habitat with higher rugosity (Du Preez 2015; also see section below on High Rugosity Areas). Sponges (Demospongiae and **Gin gii hlk'uuwaansdlagangs** *Hexactinellida*) were abundant on the bedrock and boulders of the bank and adjacent rugose areas (moraine). Rockfish species were found in greatest abundance (80% of surveyed individuals) with corals and sponges in contrast to inert substrata with no large epifauna. Consequently, rough benthic terrain on its own is an inadequate shelter for rockfish species (Du Preez and Tunnicliffe 2011), and intact and diverse ecological communities require intact epifaunal communities. Further analyses of the ROV footage found that Red Tree Coral (*Primnoa pacifica*), small styasterids (especially *Stylaster parageus*), demosponges and Gin gii hlk'uuwaansdlagangs *hexactinellid sponges* predominate (Figure 24; Neves et al. 2014). Other groups observed included tube worms, brittle stars, tubular sponges, calcareous sponges, gorgonian corals, and large glass sponge bioherms (but no sponge reefs) (Neves et al. 2014). Furthermore, a significant correspondence between coral and sponge distribution (biotopes; Figure 24) and substrate types was found, as substrate type for colonization and growth can highly influence benthic organisms (Neves et al. 2014). Depth best distinguished the biotopes, likely because bathymetry/depth is a key physical surrogate for benthic habitat, as many variables directly influence benthic species diversity and distribution are depth-dependent (Harris 2012).

The boundaries of Zone 501 capture little slices of the surrounding Learmonth Basin (to the west and east). While this area appears relatively flat, it too has habitat heterogeneity and supports an abundance of low-relief filter-feeder complexes (e.g., sponges and *Stylaster* corals) and deposit feeders (brittle star mats; Neves et al. 2014). Unsurprisingly, areas around large bathymetric feeders are heavily influenced by enhanced flow, mixing, sedimentation rates, and organic carbon flux (e.g., Yang et al. 2020; Ota et al. 2022). Furthermore, the local environment is transformed around the abundantly scattered glacier erratics (Du Preez and Tunnicliffe 2011, Du Preez and Tunnicliffe 2012). These giant boulders provide rare hard substrata and relief in the basin and support the growth of massive colonies of the Red Tree Coral *Primnoa pacifica*, other cold-water corals, and sponges. In turn, these prominent features (metres wide and tall) provide valuable ecosystem functions (e.g., food, shelter, nursery grounds, access to enhanced flow) and host assemblages distinct from their surroundings. For example, the coral-covered erratics supported the highest **K'ats** rockfishes density in all of the **Tsaan Kwaay** *Learmonth Bank* region (Du Preez and Tunnicliffe 2011, 2012). A higher rockfish density than comparably sized boulders alone and comparably sized coral-boulder features on the Bank. This phenomenon is likely driven by the rarity of tall structures in the basin, leading to a higher level of attracting and maintaining associates. Since bottom trawling occurs in the Learmonth Basin and not the Bank, it is likely that the glacier erratics associated communities are a significant contributing factor to the area's high bycatch of cold-water corals and sponges and possibly feeds into the sponge graveyards (Neves et al. 2014) (among the highest reported coral/sponge bycatch in BC, Ardron and Jamieson 2006).

Kadlee *Celestial Reef*, where Zone 500 is located (Figure 23), is a productive fishing ground (e.g., Táayii Taay.yii *Coho Salmon*, GSGislason & Associates Ltd. 2020). However, there is little high-resolution biological and bathymetric sampling of the area, and no focused research program is currently fulfilling knowledge gaps about the area. As **Tsaan Kwaay** *Learmonth Bank* is a documented area of high productivity and diversity, it is likely that further work on Kadlee will reveal diverse demersal fish populations and biogenic habitat structures associated with at least part of its heterogeneous rocky floor.

4.1.4. Biological Communities of the Continental Shelf and Slope

For more details on the geology and bathymetry of the continental shelf and slope within the OHGNZ please refer to the previous sections Bathymetry and Geomorphic Units. These two physical features' unique biological associations are highlighted below. Using the Pacific Marine Ecological Classification System (PMECS; DFO 2016a; Rubidge et al. 2016), Rubidge et al. 2016 used a two-step process to identify large-scale biophysical units in British Columbia. Biophysical units are areas of distinct physiographic and oceanographic conditions and processes that shape species composition at spatial extents of 1,000s of km. First, a cluster analysis based on the similarity of species composition was used to group sites with similar species into distinct biological assemblages. Second, a random forest analysis was used to identify environmental correlates of the biological assemblages identified by the cluster analysis and to predict the biological assemblage present in areas with too few biological data. Indicator species for each assemblage (biophysical unit) were also identified. Presence-absence marine species data was aggregated into four km grid cells, and environmental data were resampled (details in Rubidge et al. 2016). Three large-scale biophysical units were identified, of which two occur in the OHGNZ: Shelf and Slope. Biophysical units differed most in their depth, salinity and temperature range and were characterized by different top indicator species.

Sasga K̲'ádgwii *Offshore Continental Slope North* (Zone 502) has the largest continental shelf area (254.39 km^2) of the zones in the OHGNZ, and **Tsaan K̲waay** *Offshore Learmonth Bank* (Zone 501) has the highest proportion of area defined as the continental shelf (85%). Gwaii Haanas Extension (Zone 504) in the OHGNZ is notable for being entirely made up of slope habitat, with 100% of its area (1,072.07 km^2, Table 4) classified as slope. Zones 502 to 505 on the westernmost edge of the OHGNZ all have high proportions of slope habitat compared to the three northernmost zones with no slope habitat (Table 4). Rubidge and colleagues (2016) determined that the top two indicator species for the shelf biophysical unit were **SG̲an** **Sg̲an** Yelloweye Rockfish (*Sebastes ruberrimus*) and Petrale Sole (*Eopsetta jordani*). The slope biophysical unit was characterized by the presence of the Grooved **Huuga** **Huuga** *Tanner Crab* (*Chionoecetes tanneri*), Giant Grenadier (*Albatrossia pectoralis*), and Pacific Grenadier (*Coryphaenoides acrolepis*). Additional species found in high frequency in the slope habitat were Longspine Thornyhead (*Sebastolobus altivelis*) and **Sk̲íl** **Sk̲il** *Sablefish* (*Anoplopoma fimbria*). Although these grenadier species are only found in slope habitat (Rubidge et al. 2016), they were not selected as conservation priorities for the network, so their occurrence in the OHGNZ are not summarized further in the Taxonomic Diversity section of this report.

Table 4. Shelf and Slope classifications (PMECS) by zone within the Offshore Haida Gwaii Network Zones. Bold text indicates the highest value for each habitat metric. Note that these features often extend beyond the boundaries of the zone.

Shelf and Slope classification	**Gangxid Kun Sgaagiidaay** *Cape St.James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**
Shelf							
Area (km^2)	49.30	0	3.76	**254.39**	33.60	130.04	107.97	579.06
Proportion of zone	0.093	0	0.0045	0.28	0.12	**0.85**	0.49	0.14
Slope							
Area (km^2)	410.14	**1072.07**	493.71	527.76	0	0	0	2803.68
Proportion of zone	0.77	**1**	0.95	0.59	0	0	0	0.70

The shelf and slope biophysical units support different, albeit potentially overlapping, biological communities (Rubidge et al. 2016). Biologically, the continental shelf is a habitat for many of BC's flatfish communities and numerous other fishes and invertebrates (Ardron 2003; Rubidge et al. 2016; Thompson et al. 2022). The continental slope includes areas of localized seasonal upwellings, which increase and concentrate prey and/or primary production for a variety of surface and near-surface species, including **Xediit Siigaay xidid** *marine birds* and plankton communities (Crawford and Thomson 1991; Croll et al. 1998; Yen et al. 2004). These areas of habitat complexity and productivity offer habitat and refuge to a wide variety of **K'ats Sgaadang.nga** *rockfishes* (*Sebastes* spp.) and have very different species assemblages to the adjacent continental shelf regions (Fargo and Tyler 1991; Rubidge et al. 2016; Thompson et al. 2022).

4.1.4.1. High Rugosity Areas

The varying bathymetry of the OHGNZ and the continental shelf and slope within the OHGNZ results in areas of high rugosity. Areas of high rugosity have a complex terrain and are often indicative of areas of high biodiversity (e.g., Gregr et al. 2021). Rugosity is a measure of the roughness of seafloor terrain, defined as the ratio of surface area to planar area (Du Preez 2015). Areas of high rugosity can create localized increases in productivity, aid in prey capture, and provide migration cues (Bouchet et al. 2015) for marine flora and fauna. There is a strong correlation between either rugosity or benthic complexity and reef fish assemblages

(Knudby et al. 2007), **K̲'ats Sgaadang.nga** *rockfish* assemblages (Yoklavich et al. 2000), and gastropod abundance and diversity (Beck 2000).

High rugosity areas in this report were developed by the British Columbia Marine Conservation Analysis (BCMCA) Project Team (2011) using a 75-metre bathymetric model and the NOAA Benthic Terrain Modeler (BTM) toolbox. These areas are the top of five quantiles of the rugosity output. The surface area of each polygon classified as having high rugosity was calculated and summarized in Table 5. Note that this measure of rugosity is both correlated with and confounded by slope, and can result in larger rugosity measures than alternative measures, such as the arc-chord ratio (ACR) method (Du Preez 2015). In the OHGNZ, **Ginda Kun Sg̲aagiidaay** *Offshore Continental Slope South* (Zone 503) has the largest amount of benthic habitat with high rugosity (510.04 km^2), and **Gangx̲id Kun Sg̲aagiidaay** *Cape St. James* (Zone 505) has the highest proportion of high rugosity benthic surface (0.78). Offshore Northwest Dixon (Zone 506) in the Northwest of the OHGNZ has no benthic habitat classified with high rugosity (Table 5) and the lowest range of depths (Table 2). While **Tsaan K̲waay** *Learmonth Bank* has the second lowest proportion of high rugosity habitat, it has been the subject of research efforts to characterize its rugosity and test different rugosity measures (e.g., Du Preez 2015), which found that the steepest parts of the bank had the highest rugosity. Furthermore, Du Preez (2015) suggested that an ACR rugosity index may be more appropriate than the surface ratio rugosity measure utilized here due to its ability to decouple rugosity from slope.

Table 5. Area (km^2) classified as having high rugosity (upper of five quantiles) within the Offshore Haida Gwaii Network Zones. Bold text indicates the highest value for each metric.

Area	**Gangx̲id Kun Sg̲aagiidaay** *Cape St. James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sg̲aagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K̲'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan K̲waay** *Offshore Learmonth Bank* **Zone 501**	**K̲adlee** *Offshore Celestial Reef* **Zone 500**
Area (km^2)	416.36	409.69	**510.04**	401.04	0	43.33	0.0077
Proportion of zone	**0.78**	0.38	0.61	0.44	0	0.28	0.000035

4.2. TAXONOMIC DIVERSITY

Though there have been no targeted studies within the OHGNZ to determine the biological diversity of the areas, through DFO surveys (detailed in subsequent tables), HMTK (Haida Marine Traditional Knowledge Study 2011a, b, c), and data compiled from Global Biodiversity Information Facility (GBIF 2022) we know that at least 647 unique taxa have been observed within the OHGNZ (species included in this report are provided in Appendix F). This list is not comprehensive of the taxa that live within the OHGNZ but does indicate a high biological diversity to be protected within these conservation areas and includes many of the E-CPs targeted for the network (Appendix F). Detailed in the subsequent sections are highlights of these taxonomic groups, their distributions, and implications for conservation within the context of the OHGNZ.

Zones 502 to 505 may include areas that have limited data available for deep-sea surveys on the continental shelf and slope (for depth profiles see Bathymetry). Recent surveys on adjacent seamounts may provide species assemblage context as many seamounts include a subset of species found along the continental slope. Several of the zones overlap the same depths as these seamounts (up to 2,200 m). Therefore, the seamount species list and depth distribution may help fill knowledge gaps for the deep-sea areas within the zones (e.g., 771 taxa in Du Preez and Norgard 2022; SK-B subset in Du Preez et al. 2024).

4.2.1. Invertebrates

4.2.1.1. Cold-Water Coral, Sponges and Sea Pens

British Columbia is home to over 80 species of cold-water corals and ~250 species of sponges (Gardner 2009). Cold-water corals and sponges are ecologically significant species (ESS; DFO 2006; Rice 2006) and, through their complex three-dimensional structure, serve as biogenic habitats used by other species (Rooper et al. 2019a). As long-lived sessile foundation species (15 to 115 years; Boutillier et al. 2019), they are sensitive to physical disturbance and bottom-contact fishing gear (Du Preez et al. 2020), which makes them species of conservation concern. Their presence may indicate that an area has a high degree of naturalness (or low disturbance) and a low degree of resilience (DFO 2004). Cold-water corals serve as important recorders of past oceanographic and climate conditions, providing information regarding changes in the ocean environment and the effects of climate change (Smith et al. 1997). Given their vulnerability and ecological role as habitat-forming species, a suite of coral and sponge species were identified as ecological conservation priorities for MPA network planning (Table 6, DFO 2017a).

Cold-water corals and sponges exist in both shallow coastal and deep offshore waters and provide several ecosystem functions (Diaz et al. 2003). By providing a complex three-dimensional structure, coral and sponges act as substrates for attachment, provide shelter, spawning habitat, water filtration, carbon sequestration and basal support for food webs (Auster 2005; Etnoyer and Morgan 2005; Fuller et al. 2008; Buhl-Mortensen et al. 2010; Miller et al. 2012; Dunham et al. 2018), and support high levels of biodiversity and productivity (Buhl-Mortensen et al. 2010). For example, in the Atlantic, sea pens (Pennatulacea) have recently been found to be important as nursery habitats for fishes, including redfish (*Sebastes* sp.) (Baillon et al. 2012) suggesting that sea pens in the Pacific may also provide habitat for Pacific *Sebastes* sp. (i.e., rockfishes) and crustaceans, and are used by suspension feeders (e.g., basket stars, anemones, and sponges) as perches to access higher-flow waters (Krieger and Wing 2002). Corals, including *Primnoa spp.,* increase **K’ats Sgaadang.nga** *rockfish* abundance at **Tsaan Kwaay** *Learmonth Bank* and **Síigee** *Dixon Entrance* (Du Preez and Tunnicliffe 2011). Sponges also provide habitat and shelter for fishes and other species (Brancato et al. 2007; Fuller et al. 2008; Miller et al. 2012). Large sponge aggregations also provide important biogenic habitats for other species (Gale et al. 2019).

The OHGNZ has all the major coral and sponge groups located throughout its footprint (Table 6). Observations from groundfish trawl research surveys and fishery observations indicate all coral and sponge groups occur in most of the zones (Table 6), except for Gwaii Haanas Extension (Zone 504), for which there are only occurrence records for soft coral, gorgonian corals, and glass sponges. However, as noted previously (section on Bathymetry), fewer research datasets are available for Zone 504, given its depth (as noted above data from comparable seamount data at similar depths does suggest presence of these habitat forming species; e.g., see Appendix F for glass sponge depth distribution data in Du Preez and Norgard 2022). Details on species specific information is limited but it is noteworthy that the reef forming species, *Farrea occa,* has been observed in **Tsaan Kwaay** *Offshore Learmonth Bank* Zone 501, and *Callogorgia* spp. (Gorgonian), *Isidella tentaculum* (Gorgonian), *Paragorgia cf. jamesi* (Gorgonian), *Swiftia simplex* (Gorgonian), and *Umbellula lindahlii* (sea pen) were observed during on SAUP 5494 in Zone 502 during an ROV dive (Northeast Pacific Deep-Sea Diversity Expedition Pac2022-035).

Table 6. Coral and sponge occurrences for each zone in the Offshore Haida Gwaii Network Zones obtained from occurrence point records from Fisheries and Ocean Canada (DFO) research databases. Occurrence is indicated by an 'X', a dash indicates no occurrence data (not the same as an absence). Common names and scientific groupings in bold are conservation priority species (see Gale et al. 2019).

Common Name	Scientific Grouping	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source*
		505	504	503	502	506	501	500		
Soft corals	**Order Alcyonacea**	X	X	X	X	X	X	X	Obs.	DFO
Gorgonian	**Order Alcyonacea**	X	X	X	X	X	X	X	Obs.	DFO
Black coral	**Order Antipatharia**	X	-	X	X	X	X	X	Obs.	DFO
Stony corals	**Order Scleractinia**	X	-	X	X	X	X	X	Obs.	DFO
Hydrocorals	Order Stylasterina	X	-	X	X	X	X	X	Obs.	DFO
Calcareous sponge	Class Calcarea	X	-	X	X	X	X	X	Obs.	DFO
Demosponges	**Class Demospongiae**	X	-	X	X	X	X	X	Obs.	DFO
Glass sponges	**Class Hexactinellida**	X	X	X	X	X	X	X	Obs.	DFO
Sea pens	**Order Pennatulacea**	X	-	X	X	X	X	X	Obs.	DFO

*DFO: point locations from DFO synoptic groundfish trawl surveys (2003–2016) and from groundfish trawl fishery observations (2007–2017).

The Fisheries and Agriculture Organization (FAO) of the United Nations recognizes cold-water coral reefs, aggregations and individual corals as vulnerable marine ecosystems (VME). VMEs are areas of organisms that are likely to experience significant adverse impacts from fishing activities (FAO 2009). Chu and colleagues (2019) used species distribution modelling to create maps predicting coral and sponge distributions in the NSB and produced a raster of VME values (Figure 25). A VCI (vulnerable composite index) value of 6 indicates a suitable habitat for all cold-water sponge and coral groups used in their analysis (glass sponges, demosponges, soft corals, stony corals, sea pens, and black corals). Of the seven OHGNZ, all but one (Offshore Northwest Dixon, Zone 506) contained habitat with a VCI value of 6 (Table 7), and Zone 506's highest value was 4, thus still supporting diverse coral and sponge occurrences in some of its extent (Table 7, Figure 25). However, model coverage (as seen in Figure 25) is unequal among zones (Table 7), ranging from 3 to 97 percent. The model was limited to the depth range of presence records for each coral and sponge group and the availability of high-resolution bathymetric data (Chu et al. 2019), therefore higher coral diversity may be expected in zones with low coverage. **G̲angx̲id Kun Sg̲aagiidaay** *Cape St. James* (Zone 505) had the highest proportion of habitat with a VCI value of 5 or 6 (Table 7), followed by **Tsaan K̲waay** *Offshore Learmonth Bank* (Zone 501) and **Ginda Kun Sg̲aagiidaay** *Offshore Continental Slope South* (Zone 503). Furthermore, although Zone 504 had the lowest model coverage, the entire area covered has a VCI value of 5 or 6. Offshore Northwest Dixon (Zone 506) and **K̲adlee** *Offshore Celestial Reef* (Zone 500) had the highest model coverage and two of the lowest proportions of habitat with a VCI value of 5 or 6. From this it appears that the Duu Gúusd Daawxuusda Zones (Zones 502 to 505) and Tsaan K̲waay (Zone 501) in **Síigee** *Dixon Entrance* provide the best sites and habitat location for coral and sponge diversity in the OHGNZ. High coral diversity has been documented at Tsaan K̲waay in previous ROV research and is detailed in the Rocky Outcrops section of this report.

Table 7. Vulnerable Marine Ecosystem (VME) model coverage and Vulnerable Composite Index (VCI) value for corals and sponge species distribution (Chu et al. 2019) by zone within the Offshore Haida Gwaii Network Zones. Bold text indicates the highest value for each metric. Note that the model coverage is unequal across zones.

Metric	**Gangxid Kun Sgaagiidaay** *Cape St. James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**
Area (km^2) of zone covered by model	351.02	33.69	446.50	**722.40**	261.16	146.02	214.12
Proportion of zone covered by model	0.66	0.03	0.54	0.80	**0.97**	0.96	**0.97**
VCI mean value	**5.43**	5.42	5.36	3.56	1.67	4.8	2.89
VCI min-max	3-6	**5-6**	1-6	0-6	0-4	3-6	0-6
Proportion of zone with VCI value ≥ 5	**0.58**	0.03	0.45	0.39	0	0.53	0.07

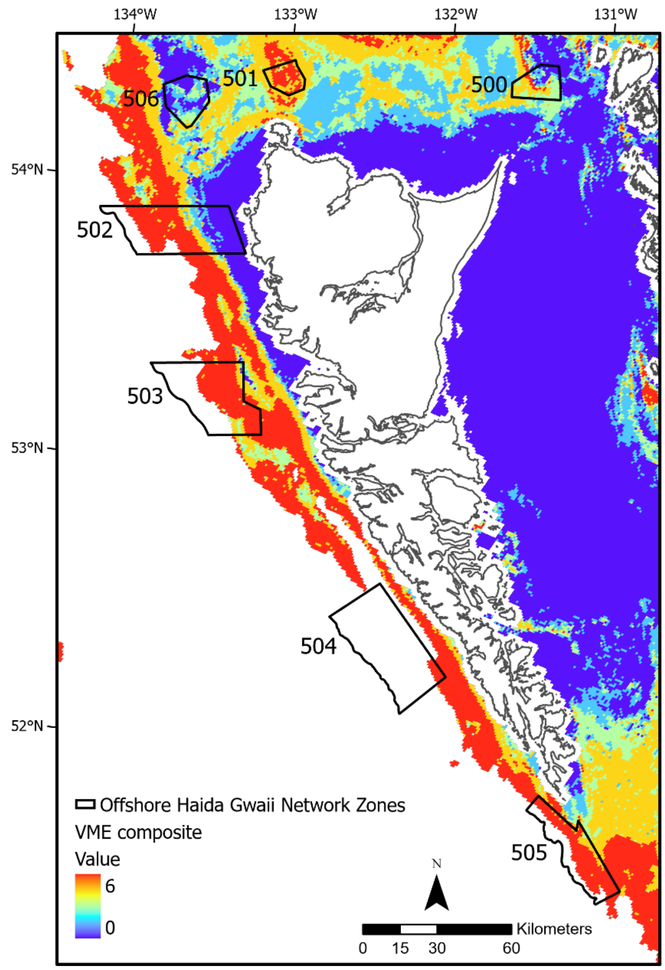

Figure 25. VME composite index of habitat suitability for multiple cold-water coral and sponge groups, from Chu et al. 2019. Values range from 0 to 6, indicating the number of coldwater coral/sponge groups that each raster is suitable habitat for; i.e., 6 indicates suitable habitat for all coral and sponge groups, and 0 indicates no suitable habitat.

The OHGNZ provide important habitat for cold-water coral and sponge populations, and these invertebrate groups appear to well distributed throughout the area. In part this is the result of the breadth of depths that the OHGNZ were selected to represent, consequently encompassing key habitat types for these benthic organisms throughout. Despite their widespread occurrence in the OHGNZ, many aspects of cold-water coral and sponge biology and ecology are not well studied or understood and are often based on comparisons of similar traits with warm, shallow-water species (Jamieson et al. 2007). In addition, knowledge of the distribution of these invertebrate groups is incomplete, with only a few areas in BC identified through video equipment and submersibles as potential habitats for cold-water corals or sponges (e.g., on DFO ROV and Remotely Operated Platform for Ocean Sciences and other research surveys; DFO 2015). Consequently, future field surveys will likely discover new areas of cold-water coral and sponge concentrations and/or new species.

4.2.1.2. Crustaceans

At least six crustacean species that were selected as MPA Network Conservation Priorities are known to occur within the Offshore Haida Gwaii Network Zones (Table 8). One of the two crab species, **Huuga Huuga** *Deepwater Grooved Tanner Crab*, is the most ecologically important.

K̲'ust'áan K̲'uust'an *Dungeness Crab* is the other crab species, in addition to 3 shrimp species (Sidestripe Shrimp, *Pandalopsis dispar*; Smooth Pink Shrimp, *P. jordani*; Spiny Pink Shrimp, *P. borealis*), and one **Daga 'íiwaans Guudagiig̲ayd** *prawn* (Spot Prawn*, P. platyceros*) documented in the OHGNZ. Crustacean occurrence data came from a combination of DFO sources, including Shellfish Fishery Logs (2000–2017), Shellfish Research Surveys (1963–2017), and DFO Groundfish and other Research Surveys (2003–2016). Table 8 is not considered an exhaustive list of the crustacean diversity present in the OHGNZ but instead provides occurrence data for species known to occur and which are also considered ecological conservation priorities in the NSB (Table F.1; Gale et al. 2019).

Huuga Huuga *Deepwater Grooved Tanner Crab* (*Chionoecetes tanneri*) is one of the crustacean species identified as an Ecological Conservation Priority species within the NSB due to their vulnerability (Gale et al. 2019; Table F.1). This species has important habitat areas in the four Offshore Haida Gwaii Network Zones that make up the western shelf (Zones 505, 504, 503, and 502) and have been caught during sablefish trap research surveys (2003–2016) in Zones 505, 504, 503, 502 and 506 (Table 8, Figure 25). This crab species is notable due to its low reproductive output, restricted geographic range in the NSB (only found on the continental slope), and strong aggregation behaviour (Gale et al. 2019). Huuga Huuga provide food resources for a variety of fauna living in the OHGNZ, including **Kyaa.n Sg̲aahlan** *Pacific Cod* and Roughtail Skate (Gale et al. 2019).

Although there are two occurrences of **K̲'ust'áan** *Dungeness Crab* (*Metacarcinus magister*) in **K̲adlee** *Offshore Celestial Reef* (Zone 500) (Table 8), this zone is not considered part of the K̲'ust'áan important areas, identified during the EBSA process (Clarke and Jamieson 2006; DFO 2013a). Instead, K̲'ust'áan important areas are indicated on the east side of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*, not within any of the Offshore Haida Gwaii Network Zones.

Daga 'íiwaans Guudagiig̲ayd *prawn* and shrimp species are key food resources for many fishes, including flatfishes, rockfishes, Pacific Hake and **Ts'íit'aa Ts'iig̲a** *Skates* (Pearcy and Hancock 1978; Buckley and Livingston 1997; Love et al. 2002; Brown et al. 2012). Four Daga 'íiwaans Guudagiig̲ayd and shrimp species occur in at least three OHGNZ (Table 8), of which Offshore Northwest Dixon (Zone 506) is an area of high density and has been identified as a conservation objective within the network process.

Table 8. Crustacean species occurrences for each zone in the Offshore Haida Gwaii Network Zones were obtained from occurrence point records from Fisheries and Ocean Canada (DFO) commercial catch and research databases and Global Biodiversity Platform Information Data (GBIF 2022). Occurrence is indicated by an 'X', a dash indicates no occurrence data (not the same as an absence). Common names and scientific groupings in bold are conservation priority species (see Gale et al. 2019 and Table F.1).

Common Name	Scientific Grouping	Duu Gúusd Daawxuusda Zones				Síigee Zones		
		505	**504**	**503**	**502**	**506**	**501**	**500**
Deepwater Grooved Tanner Crab	***Chionoecetes tanneri***	X	X	X	X	X	-	-
Dungeness Crab	***Metacarcinus magister***	-	-	-	-	-	-	X*
Sidestripe Shrimp	***Pandalopsis dispar***	-	-	-	X	X	-	X
Smooth Pink Shrimp	***Pandalus jordani***	-	-	-	X	X	-	X
Spiny/Northern Pink Shrimp	***Pandalus borealis***	-	-	X	X	X	-	X
Spot Prawn	***Pandalus platyceros***	-	-	-	X	X	-	X
	Species richness	1	1	2	5	5	0	5

*from Commercial Shellfish Fishery Log data from DFO for the period of 2007 to 2018.

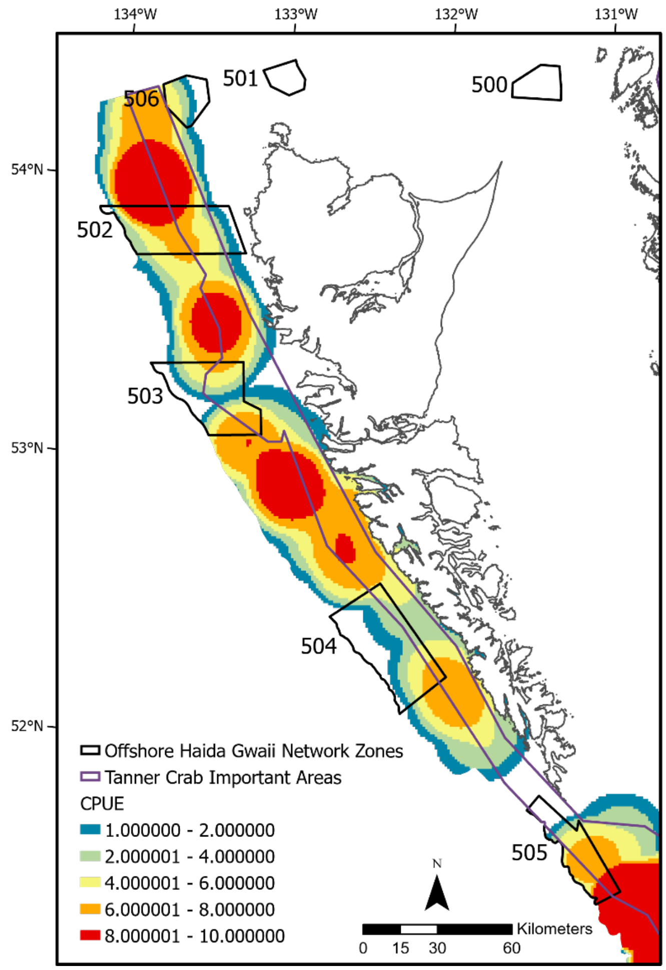

*Figure 26. **Huuga Huuga** Tanner Crab catch per unit effort (CPUE) from research surveys (DFO sablefish trap 2003–2016) displayed as deciles and Important Areas (DFO sablefish trap 2003–2016).*

4.2.1.3. Other Invertebrates

Other invertebrate species of conservation priority for the NSB (Gale et al. 2019; Table F.1) with occurrence records in the Offshore Haida Gwaii Network Zones include two cephalopod species (**Núu Naw** *Giant Pacific Octopus* (*Enteroctopus dofleini*) and Opal Squid (*Loligo opalescens*)), and two echinoderm species (Sunflower Sea Star (*Pycnopodia helianthoides*) and **Gúudangee Guuding.ngaay** *Red Urchin* (*Mesocentrotus franciscanus*)). Similar to the Crustaceans section above, data sources for occurrence records come from a combination of commercial and research data provided by DFO, including Shellfish Fishery Logs (2000–2017), Shellfish Research Surveys (1963–2017), DFO Groundfish and other research surveys (2003–2016), and the Global Biodiverisity Information Facility (GBIF 2022).

There was a single occurrence record for **Núu Naw** *Giant Pacific Octopus* (*Enteroctopus dofleini*) in Zone 503, with additional records near Zones 502, 506, 501, and 500. However, most Núu Naw records occurred nearshore or in **K̲andaliig̲wii** *Hecate Strait*. A single Opal Squid (*Loligo opalescens*) record occurred in Zone 503, with additional records in proximity to Zone 500. Sunflower Sea Star (*Pycnopodia helianthoides*) occured in Zones 505, 502, 506, with a large density of observations in Zone 500. Sunflower Sea Stars are notable for being upper-level predators that prey on herbivorous sea urchins and help maintain the abundance and diversity of algae (Schultz et al. 2016). Additional records of Sunflower Sea Star occurrences are in proximity to Zones 503 and 501. The presence of *P. heliathoides* may be particularly important in these deeper offshore areas if they have persisted through the mass die-off of this species in coastal areas from sea star wasting disease. Their population declined by more than 90% in recent years and they were listed as Critically Endangered on the International Union for the Conservation of Nature (IUCN) Red List in December 2020 (Gravem et al. 2021). Finally, **Gúudangee Guuding.ngaay** *Red Urchins* (*Mesocentrotus franciscanus*) are found between Zones 506 and 501, but no records occur within any of the Offshore Haida Gwaii Network Zones.

4.2.2. Fishes

Fish are a diverse taxonomic group that form an important part of the biodiversity of the OHGNZ and which transfer energy through the benthic and pelagic food chain to higher trophic levels, including marine mammals, seabirds, and humans. The fish species found in the OHGNZ are detailed in the following sections and have been organized by bony and cartilaginous fishes and then further by their habitat use. Bony fishes have been grouped as follows: groundfishes (rockfish, flatfish, roundfish, and other), and pelagic fishes (forage fish, **Tsíi.n Chiina** salmonids, and other). Cartilaginous fishes have been separated into demersal fishes (**K̲'aad aw K̲'aax̲ada awg̲a** *sharks*, **Ts'íit'aa Ts'iig̲a** *skates*, and **Sgagwíid Kaaun** *ratfish)* and pelagic K̲'aad aw K̲'aax̲ada awg̲a. The following sections briefly summarize key features and species for each grouping. Species are featured for their ecological and/or cultural conservation importance for the NSB.

Data for fish species occurrence comes from up to three sources:

1. species distributions from known observations (research surveys or commercial fisheries);
2. predicted occurrences through a multispecies distribution model (Thompson et al. 2022, 2023a); and/or
3. published occurrences in the literature, and are detailed in the following tables.

Additional information on the ecology, diet and migration of the fish species found in the Northern Shelf Bioregion can be found in Gale et al. (2019).

When available, the most recent stock assessment or species population reports were summarized within the Pacific fisheries management area of **K̲andaliig̲wii** *Hecate Strait* (Area 5D) and/or **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* (Area 5E) or for all of the coastal waters of British Columbia if regional data was not available. Summaries presented here are meant to portray a quick understanding of the most recently assessed trends, and the citations provided should be consulted for full details. General caveats to be considered for interpreting generalized trends from these reports include: time-sensitive series within the range of the latest stock assessments, region-specific trends, dataset uncertainties, and changes that may occur from current or future temperature and environmental shifts. Species stock assessments should not be compared across species, as each model uses unique datasets with their own caveats, assumptions, and uncertainties.

4.2.2.1. Bony Fishes

Groundfishes

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

The Thompson et al. (2023b) 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. Data for the model came from three fisheries-independent scientific surveys conducted within Canadian Pacific Waters: the Fisheries and Oceans Canada (DFO) Groundfish Synoptic Bottom Trawl Surveys (Sinclair et al. 2003; Anderson et al. 2019), the DFO Groundfish Hard bottom Longline Surveys (Lochead and Yamanaka 2006, Lochead and Yamanaka 2007, Doherty et al. 2019), and the International Pacific Halibut Commission Fisheries Independent Setline Survey (Stewart and Hicks 2022). Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Their model leverages available data from multiple government surveys to estimate how species respond to environmental gradients while accounting for differences in catchability by the different surveys.

For information on population trends of groundfish biomass from surveys and commercial catch data, see the species synopses (Anderson et al. 2019, DFO 2022a). Note these are the same species detailed in the Thompson et al. (2023a) multi-species groundfish distribution model and the Thompson et al. (2023a,b) groundfish community changes projected under different climate change scenarios.

K̲'ats Sgaadang.nga Rockfishes

K̲'ats Sgaadang.nga *Rockfish* (*Sebastes* and *Sebastolobus spp.*) are culturally, ecologically, and commercially valuable fish species with a large diversity of life histories and behaviors. Age of maturity can vary, but are generally recorded between five and seven years, and maximum lifespans range from 22 years (Puget Sound Rockfish) to 205 years (**K'aalts'adaa** *Rougheye-Blackspotted* complex) (Leaman 1991; Love et al. 2002). Trophic levels can range from planktivores (Pacific Ocean Perch) to preying on crustaceans and fish (Quillback Rockfish) (Love et al. 2002; Olson et al. 2020). K̲'ats Sgaadang.nga are viviparious and yearly fecundity in species can range from thousands of larvae (Puget Sound Rockfish) to nearly three million (**SG̲an Sg̲an** *Yelloweye Rockfish*) (Love et al. 2002). Species distributions differ by depth and habitat type (e.g., rock type and biocover; Haggarty et al. 2016). About 65 species of rockfish occur along the west coast of North America (Yamanaka et al. 2012). Twenty six K̲'ats Sgaadang.nga species occur in the OHGNZ (Table 9), including the K'aalts'adaa Complex, which is of conservation concern. The heterogeneous bathymetric terrain of the OHGNZ provides ideal habitat for species-rich rockfish communities. K̲'ats Sgaadang.nga can be classified into three broad groups for management purposes:

1. inshore rockfish, which includes species residing in rocky habitats to a maximum depth of 200 m (Yamanaka and Logan 2010);
2. shelf rockfish, which includes species found in deep waters of the continental shelf (Stanley 1999); and
3. slope rockfish, which includes species found in deeper waters of the continental shelf and continental slope (Schnute et al.1999).

Haidas have harvested rockfish as fresh food while targeting other species, and **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* is an important **K̲'ats Sgaadang.nga** *rockfish* area (Haida Marine Traditional Knowledge Study Participants et al. 2011c). K̲'ats Sgaadang.nga were more commonly fished by southern and west coast Haidas, as opposed to the northern communities. Many rockfish species are considered vulnerable to fishing pressures due to slow recovery and population growth from their slow maturity (Cheung et al. 2005; Haggarty et al. 2016; Gale et al. 2017). Notably, **SG̲an Sg̲an** *Yelloweye Rockfish* and Quillback Rockfish are highly prized food fish and are important to traditional, commercial and recreational fisheries. (Yamanaka et al. 2012). These two rockfish species have extremely long lifespans (95 and

115 years, respectively), are slow to mature, and experience sporadic high recruitment. Several studies have shown SG̲an Sg̲an biomass has decreased throughout British Columbia from 1918–2019 (Keppel and Olsen 2019; Cox et al. 2020; DFO 2020a; Thompson et al. 2022, 2023a), although recent survey data shows more stable populations for the last 20 years, representing half of their generation time (COSEWIC 2020). Similarly, Quillback Rockfish population surveys have shown at least a 50% decline in their abundances throughout British Columbia since the mid-1980s (COSEWIC 2009a). Consequently, these species are of conservation concern and the impetus for the designation of Rockfish Conservation Areas (RCAs; Figure 4; Yamanaka et al. 2012).

Rockfish Conservation Areas prohibit commercial and recreational hook and line fisheries and bottom trawl fisheries (Yamanaka and Logan 2010). Currently, the Frederick Island RCA is located at the northwestern end of Graham Island on the easternmost border of Zone 502, while two previous RCAs, South Moresby and Lyell Island, were superseded and replaced by the Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site (see Figure 4). Protected areas, including RCAs and MPAs, between 50 km and 100 km apart are thought to maintain rockfish larvae dispersal distance and population connectivity (Dunham et al. 2020). Frederick Island is the most isolated RCA, making it difficult for fish larvae from other protected areas to disperse into it (Dunham et al. 2020). Tagging studies of four adult **K̲'ats Sgaadang.nga** *rockfish* species reported fish movements of less than 5 km (Freiwald 2012; Buonaccorsi et al. 2002; Matthews 1990), suggesting that an area of protection of at least 78.5 km^2 could be sufficient to encompass their movement (Dunham et al. 2020). K̲'ats Sgaadang.nga with higher movement ranges may still benefit from spatial protections from RCAs (Claudet et al. 2010). The OHGNZ includes a wide range of depths and habitats suited for many rockfish species that would enhance the connectivity and protection between existing RCAs, and other marine conservation areas.

With regards to the genetic diversity of **K̲'ats Sgaadang.nga** *rockfish* species, many studies have shown only one genetic population of at least three K̲'ats Sgaadang.nga species exists throughout BC, including Quillback (Yamanaka et al. 2006), Bocaccio (Buonaccorsi et al. 2012), and Greenstriped Rockfish (Hicks et al. 2006). Other species lack official genetic assessments in Canadian waters. Rosethorn (Rocha-Olivares and Vetter 1999) and Darkblotched (COSEWIC 2009b) rockfish exhibit isolation by distance effects throughout their range, where populations are more genetically distinct with increased distance. Of note, a study by Dick et al. (2014) investigated the fine-scale genetic variation in **Xaadxadey** *Copper Rockfish* and found more differentiation between heads of inlets and outer coast habitats than among the same habitats on the west coast of Vancouver Island. Three populations of Pacific Ocean Perch were identified using five microsatellite loci, with two co-existing but distinct populations along the western and southern waters of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* (Withler et al. 2001). Furthermore, the **K'aalts'adaa** *Rougheye and Blackspotted rockfish* are physically indistinguishable species identified as a 'species complex'. The northern stocks surrounding the OHGNZ (5DE) are reported to be primarily Blackspotted Rockfish, although there is known hybridization in the Central Coast/Hecate Strait stock assessment area (5C) (DFO 2020b). The OHGNZ overlaps with two distinct populations of Pacific Ocean Perch, and the northern K'aalts'adaa stock, and encompasses a wide enough area to potentially account for spatial genetic variation. Contemporary population genetics studies of rockfish may unravel further species complexes and regional diversity (DFO 2017b).

Of the 26 **K̲'ats Sgaadang.nga** *rockfish* species that occur in the OHGNZ, 21 species are considered ecological conservation priorities in the NSB (DFO 2017a; Gale et al. 2019; Table 9, Table F.1) and have been assigned high or very high vulnerability status (Gale et al. 2019). Isolated hotspots of Yellowmouth Rockfish (DFO 2022a) are found west of **X̲aadáa Gwáay**

X̲aaydag̲a Gwaay.yaay *Haida Gwaii*. Short-term projections for the stock, based on recently estimated recruitments, is expected to remain healthy for the next 5–10 years, with recommendations for a full re-assessment within 10 years (DFO 2022b). Both long-term yields and estimates of absolute stock size, however, were uncertain (DFO 2022b). Dense concentrations of the **K'aalts'adaa** *Rougheye/Blackspotted rockfish* complex (DFO 2020b) are found northwest of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** and suggest stable and productive stocks. Other species of rockfish with healthy stock assessments coastwide or outside the area of interest include the Widow (DFO 2019c), Redstripe (DFO 2018b), Canary (DFO 2023), Yellowtail (MPO 2015) and Silvergray Rockfish (Starr et al. 2016). Bocaccio Rockfish experienced a large recruitment event in the 2016 cohort and coastwide population numbers are recovering back to a healthy assessment (DFO 2020c, 2022c). The following K̲'ats Sgaadang.nga species lack data or recent assessments to make concrete conclusions about the stock trends: Shortspine Thornyhead (DFO 2016b), **Xaadxadey** *Copper* (Stocker and Fargo 1995), Shortraker (Schnute et al. 1999), and Darkblotched (COSEWIC 2009b). There are currently no official stock assessments for Longspine Thornyhead, Greenstriped, Vermilion, China, Tiger or Rosethorn rockfish in British Columbia. Catch per unit effort was used as an approximate measure for Longspine Thornyhead abundances, for which a large decline was reported in **Duu Gúusd Daawxuusda** *the west coast* of *Haida Gwaii* from 2000 to 2004 (COSEWIC 2007). Nevertheless, the species was recently predicted to have high biomass density around the OHGNZ (Williams et al. 2018; Anderson et al. 2019). High biomass density predictions also exist for Shortraker Rockfish (Williams et al. 2018; Anderson et al. 2019).

Of the 26 **K̲'ats Sgaadang.nga** *rockfish species* found in the OHGNZ, seven occur in all seven zones, all of which are ecological conservation priorities: Greenstriped Rockfish, Rosethorn Rockfish, Silvergray Rockfish, **SG̲an Sg̲an** *Yelloweye Rockfish*, Yellowtail Rockfish, Shortspine Thornyhead, and the **K'aalts'adaa** *Rougheye/Blackspotted Rockfish* complex. These well-distributed species have either known occurrences through distribution data or a high probability of predicted occurrences (higher than 0.5, Table 9) within the zones. Rockfish species of particular cultural importance to the Haida Nation that fulfill cultural conservation objectives and are important for cultural use and food security include: Shortspine and Longspine Thornyhead, K'aalts'adaa, Rosethorn, SG̲an Sg̲an, Yellowmouth, Yellowtail, Shortraker, Widow, and Darkblotched Rockfish. Rockfish species of conservation concern that occur in the OHGNZ include Bocaccio, **Kaa** *Canary Rockfish*, Quillback Rockfish, SG̲an Sg̲an, and Yellowmouth Rockfish (Table F.1).

Table 9. ***K’ats Sgaadang.nga*** *Rockfish species occurrence by zone in the Offshore Haida Gwaii Network Zones. Two types of data are presented: (1) Obs., which represents direct observation of the species (e.g., catch data), denoted by an X; and (2) SDM, the predicted occurrence of groundfish species according to the Thompson et al. 2023a multispecies distribution model. Notes: (1) only those species for which at least one zone had a maximum predicted occurrence of ≥0.7 in at least one cell are reported, or an Obs. source of data indicated their occurrence; and (2) the Thompson model only applies to groundfish species and the model only covered 3% of the Zone 504 surface area. Common and scientific names in bold are conservation priority species for the NSB (see Gale et al. 2019 and Table F.1). Cells shaded in green and marked with an asterisk (*) are known or predicted occurrences with a value >0.5. Dashes in cells denote no data, or predicted or known species absence.*

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source**
		505	504	503	502	506	501	500		
Bocaccio	***Sebastes paucispinis***	X*	X*	X*	X*	X*	-	-	Obs.	DFO survey; HMTK vol 3 pages 84, 88
		0.18	0.00	0.44	0.54*	0.60*	0.14	0.02	-	Thompson
Canary Rockfish	***Sebastes pinniger***	X*	X*	-	X*	X*	X*	X*	Obs.	DFO survey; HMTK vol 3 page 88; GBIF
		0.26	0.00	0.20	0.90*	0.03	0.64*	0.84*	SDM	Thompson
China Rockfish	***Sebastes nebulosus***	X*	X*	-	X*	-	-	X*	Obs.	DFO survey
		0.00	0.00	0.00	0.94	0.00	0.94*	0.75*	SDM	Thompson
Copper Rockfish	***Sebastes caurinus***	-	-	-	X*	X*	-	X*	Obs.	DFO survey
		0.00	0.00	0.00	0.70*	0.00	0.38	0.36	SDM	Thompson
Darkblotched Rockfish	***Sebastes crameri***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.71*	0.02	0.09	0.53*	0.19	0.12	0.15	SDM	Thompson
Dusky Rockfish	*Sebastes ciliatus*	-	-	-	X*	-	-	-	-	HMTK vol 3 page 88
Greenstriped Rockfish	***Sebastes elongatus***	X*	X*	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.61*	0.00	0.94*	0.89*	0.51*	0.77*	0.25	SDM	Thompson

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source**
		505	504	503	502	506	501	500		
Harlequin Rockfish	*Sebastes variegatus*	X*	-	-	X*	X*	-	-	Obs.	GBIF
		0.50	0.00	0.60*	0.84*	0.55*	0.86*	0.12	SDM	Thompson
Pacific Ocean Perch	***Sebastes alutus***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey; HMTK vol 3 page 84
		1.00*	0.05	0.99*	0.96*	0.99*	0.98*	0.90*	SDM	Thompson
Pygmy Rockfish	*Sebastes wilsoni*	-	-	-	X*	X*	-	-	Obs.	GBIF
		0.63*	0.00	0.26	0.91*	0.06	0.93*	0.07	SDM	Thompson
Quillback Rockfish	***Sebastes maliger***	X*	X*	-	X*	-	X*	X*	Obs.	DFO survey
		0.08	0.00	0.01	0.99*	0.00	0.97*	0.98*	SDM	Thompson
Redbanded Rockfish	*Sebastes babcocki*	X*	-	X*	X*	X*	X*	X*	Obs.	GBIF
		0.96*	0.00	0.41	0.88*	0.95*	0.86*	0.99*	SDM	Thompson
Redstripe Rockfish	***Sebastes proriger***	X*	-	X*	X*	X*	-	X*	Obs.	DFO survey
		0.93*	0.00	0.95*	0.99*	0.80*	0.96*	0.31	SDM	Thompson
Rosethorn rockfish	***Sebastes helvomaculatus***	X*	X*	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.96*	0.00	0.97*	0.90*	0.98*	0.97*	0.34	SDM	Thompson
Sharpchin Rockfish	*Sebastes zacentrus*	X*	-	X*	X*	X*	-	-	Obs.	GBIF
		0.98*	0.00	0.58*	0.94*	0.97*	0.98*	0.19	SDM	Thompson
Shortraker Rockfish	***Sebastes borealis***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.78*	0.34	0.51*	0.67*	0.14	0.29	0.16	SDM	Thompson

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source**
		505	504	503	502	506	501	500		
Silvergray Rockfish	***Sebastes brevispinis***	X*	X*	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.98*	0.00	0.99*	0.98*	0.97*	0.99*	0.54*	SDM	Thompson
Tiger Rockfish	***Sebastes nigrocinctus***	X*	-	-	X*	-	X*	X*	Obs.	DFO survey
		0.01	0.00	0.00	0.50	0.01	0.74*	0.66*	SDM	Thompson
Vermillion Rockfish	***Sebastes miniatus***	X*	X*	-	X*	-	-	-	Obs.	DFO survey
		0.00	0.00	0.00	0.56	0.00	0.05	0.10	SDM	Thompson
Widow Rockfish	***Sebastes entomelas***	X*	-	X*	X*	X*	X	-	Obs.	DFO survey; GBIF
		0.73*	0.00	0.63*	0.82*	0.30	0.71*	0.07	SDM	Thompson
Yelloweye Rockfish	***Sebastes ruberrimus***	X*	X*	-	X*	X*	X*	X*	Obs.	DFO survey; HMTK vol 3 page 88
		0.97*	0.00	0.71*	0.99*	0.70*	0.99*	0.95*	SDM	Thompson
Yellowmouth Rockfish	***Sebastes reedi***	X*	-	X*	X*	X*	X*	-	Obs.	DFO survey
		0.98*	0.00	0.92*	0.50	0.79*	0.07	0.01	SDM	Thompson
Yellowtail Rockfish	***Sebastes flavidus***	X*	X*	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.23	0.00	0.14	0.80*	0.03	0.58*	0.46	SDM	Thompson
Longspine Thornyhead	***Sebastolobus altivelis***	-	-	X*	X*	X*	-	-	Obs.	DFO survey
		1.00*	1.00*	1.00*	1.00*	0.00	0.02	0.00	SDM	Thompson
Shortspine Thornyhead	***Sebastolobus alascanus***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey; HMTK vol 3 page 84

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source**
		505	504	503	502	506	501	500		
		1.00*	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*	SDM	Thompson
Rougheye/Blackspotted Rockfish Complex	***Sebastes spp.***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey
		1.00*	0.97*	0.83*	0.88*	0.71*	0.99*	0.90*	SDM	Thompson
	Species richness	23	13	17	26	21	21	17	-	-

**DFO survey: DFO data from synoptic trawl surveys (2003–2016) and outside hard-bottom longline surveys (2006–2016); HMTK: Haida Marine Traditional Knowledge Study Participants et al. 2011c; Thompson: Thompson et al. 2023a; GBIF: Global Biodiversity Information Facility (GBIF 2022).

Gaps in our understanding of **K'ats Sgaadang.nga** *rockfish* biology suggest that some species may move in and out of the NSB as adults, but seasonal and demographic migrations are anecdotal without detailed tagging studies (Dunham et al. 2020). For example, large travel distances have been suggested for adult Bocaccio and Canary rockfish, but other K'ats Sgaadang.nga, such as China, maintain high site fidelity (Love et al. 2002). Rockfish Conservation Areas were created to protect inshore K'ats Sgaadang.nga species because those species are caught commercially by longline and trawl fishing, and recreationally using hook-and-line fishing, with evidence of historic and contemporary overfishing (Yamanaka and Logan 2010). Little population data is available for K'ats Sgaadang.nga that are not caught by recreational and commercial fisheries, and some slope and shelf K'ats Sgaadang.nga species. Non-fishery style survey methods, such as the use of submersibles, may provide insight into populations of areas difficult to reach by fishing methods and also additional information such as rockfish behaviours. For example, K'ats Sgaadang.nga populations, and the connectivity between southern **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* and SGáan Kínghlas-Bowie by Haida Eddies, were examined using submersible technology (and compared to long-line fishing results) in 2000 in areas adjacent to Zone 505 (Yamanaka 2005).

Flatfishes

Flatfish (Order *Pleuronectiformes*) are a group of benthic fish that live on continental shelf habitats, including off Canada's Pacific and Atlantic coasts, in sandy and mud flat bottoms. Twelve flatfish species occur in the OHGNZ, of which six species are ecological conservation priorities within the NSB (Gale et al. 2019; Table 10, Table F.1). Of these, **T'ál T'aal** *Arrowtooth Flounder*, **Xaguu Xaaguu** *Pacific Halibut* and Dover Sole occur in all seven OHGNZ. Xaguu Xaaguu is highlighted below for its cultural and ecological importance.

Xaguu Xaaguu *Pacific Halibut* (*Hippoglossus stenolepis*), a culturally, recreationally and commercially valuable species (Weatherdon et al. 2016), may be found at depths of up to 1,200 m on various bottom types (Eschmeyer et al. 1983) and is found in all the OHGNZ (Table 10). Haidas have harvested Xaguu Xaaguu for thousands of years, utilizing highly specialized size-selective hooks, with the purpose of sustainability by allowing the largest halibut to breed (Smythe 2018). Haidas deeply respect the spirits of harvested animals, as expressed throughout ceremonies, harvesting methods, preparation, and the language used to refer to the animals. For example, in the words of the late Sk'adaga Leeyga *Stephen Brown*, "All our old people used to do that; they all talked to the halibut when they were fishing. Every time they pull on their line. They used to call it '**K'aagaay**' [*Elder*]" (Haida Marine Traditional Knowledge Study Participants et al. 2011a). Haidas traditionally and commercially harvest Xaguu Xaaguu all around **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii*, including the areas in **Síigee** *Dixon Entrance* and **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*. **Ts'alj** *dried halibut* is often traded with other Nations for **Sáaw Taw** *Eulachon* grease (Haida Marine Traditional Knowledge Study Participants et al. 2011a). Xaguu Xaaguu also provide an important role as keystone species, as they are among the highest trophic level fish in NE Pacific ecosystems (Haggan et al. 1999; Gaichas et al. 2010; Lee et al. 2010). Juvenile Xaguu **Xaaguu** are also high-level predators, preying on shrimp, benthic invertebrates, and occasional fish. (Gaichas et al. 2010). Juvenile Xaguu Xaaguu likely have substantial migrations eastward from Alaska to BC, which potentially transfer nutrients or energy into the NSB from more northern areas (Gale et al. 2019). Adult Xaguu Xaaguu undergo seasonal migrations across the shelf, from shallower summer feeding grounds to deeper winter spawning grounds on the slope (inshore to offshore) (Loher and Seitz 2008). Stock assessment on Xaguu Xaaguu is conducted annually, with the most recent of four large Pacific regions showing a population decline from the 1990s to 2012 and a smaller decline from 2017 onwards (Stewart and Hicks 2022). While there was an increase in the Xaguu Xaaguu population of 15% from 2020 in the large Pacific regions of Southwestern Alaska, Canada, and the United States, recent years showed a proportion of X̲aguu X̲aaguu moving away from these regions (Stewart and Hicks 2022). The same report showed decreasing sizes of X̲aguu X̲aaguu catch from the 1990s to 2012, although the size-at-age trend for the younger age 2012 cohort shows increasing trends coastwide.

Population trends of flatfish species in the waters of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* are limited by the availability of current, regionally relevant, and data-rich stock assessments. Distinct populations of Dover Sole (DFO 1999) and Petrale Sole (Starr 2009) may have been identified around Hecate Strait and **Duu Gúusd Daawxuusda** *the west coast Haida Gwaii*, however details are sparse and studies have not been reported. The Rex Sole has no official stock assessments in BC. Two species of Rock Sole (genus *Lepidopsetta*), separated into Northern (*L. polyxystra*) and Southern (*L. bilineata*) Rock Soles, are found in BC. Most Northern Rock Soles reside in nearshore waters, such as inlets of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay**, and thus most commercial catches are reported to be primarily Southern Rock Sole (Holt et al. 2016). Both species are not a target species in the OHGNZ; therefore, Duu Gúusd Daawxuusda was not assessed (Holt et al. 2016). However, this species showed population increases from 2006 in other assessed regions in BC (Holt et al. 2016), and the Northern Rock Sole species (L. polyxstra) have been found in inlets of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay**. The stock assessments for Arrowtooth Flounder (Grandin and Forrest 2017), Dover Sole (DFO 1999), and Petrale Sole (Starr 2009) are currently outdated or have high data uncertainty. Recent declines in **T'ál T'aal** *Arrowtooth Flounder* have been observed in BC since 2014 (e.g., Thompson et al. 2022, 2023a), which are similar to observed declines in the Gulf of Alaska (Spies et al. 2019). These declines are associated with an increase in targeted commercial fishing effort associated with new markets opening for T'ál T'aal following the development of more advanced fish processing technologies (Anderson et al. 2019; Spies et al. 2019). A stock assessment for this species is currently underway in British Columbia.

Table 10. Flatfish species probability of occurrence by zone in the Offshore Haida Gwaii Network Zones. Two types of data are presented: (1) Obs., which represents direct observation of the species (e.g. catch data), denoted by an X; and (2) SDM, the predicted occurrence of groundfish species according to the Thompson et al. 2023a multispecies distribution model. Notes: (1) only those species for which at least one zone had a maximum predicted occurrence of ≥0.7 in at least one cell are reported, or an Obs. source of data indicated their occurrence; and (2) the Thompson model only applies to groundfish species and the model only covered 3% of the Zone 504 surface area. Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1). Cells shaded in green and marked with an asterisk (*) are known occurrences or predicted occurrences with a value >0.5. Dashes in cells denote no data, or predicted or known species absence.

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source**
		505	504	503	502	506	501	500		
Arrowtooth	***Atheresthes stomias***	X*	X*	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.91*	0.18	0.86*	0.98*	0.98*	0.99*	1.00*	SDM	Thompson
Butter Sole	*Isopsetta isolepis*	0.00	0.00	0.05	0.01	0.00	0.37	0.74*	SDM	Thompson
Curlfin Sole	*Pleuronichthys decurrens*	0.77*	0.00	0.00	0.47	0.00	0.45	0.18	SDM	Thompson
Darkfin Sculpin	*Malacocottus zonurus*	X*	-	X*	X*	X*	X*	X*	Obs.	GBIF
		0.89*	0.00	0.72*	0.37	0.63*	0.90*	0.21	SDM	Thompson
Dover Sole	***Microstomus pacificus***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.99*	0.99*	0.92*	0.92*	0.97*	0.99*	1.00*	SDM	Thompson
English Sole	*Parophrys vetulus*	0.02	0.00	0.02	0.92*	0.07	0.07	0.76*	SDM	Thompson
Flathead Sole	*Hippoglossoides elassodon*	-	-	-	X*	-	-	X*	Obs.	GBIF
		0.00	0.00	0.01	0.26	0.00	0.01	0.92*	SDM	Thompson
Pacific Halibut	***Hippoglosus stenolepis***	X*	X*	X*	X*	X*	X*	X*	Obs.	DFO survey; HMTK vol 2 page 98
		0.99*	0.12	0.97*	1.00*	0.97*	1.00*	1.00*	SDM	Thompson
Petrale Sole	***Eopsetta jordani***	-	-	X*	X*	X*	-	X*	Obs.	DFO survey

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source**
		505	504	503	502	506	501	500		
		0.34	0.00	0.09	0.89*	0.27	0.75*	0.77*	SDM	Thompson
Rex Sole	***Glyptocephalus zachirus***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.87*	0.22	0.80*	0.99*	0.98*	1.00*	1.00*	SDM	Thompson
Rock Sole	***Lepidopsetta bilineata***	X*	-	-	X*	-	X*	X*	Obs.	DFO survey; GBIF
		0.06	0.00	0.01	0.89*	0.00	0.97*	0.95*	SDM	Thompson
Slender Sole	*Lyopsetta exilis*	-	-	X*	X*	X*	-	X*	Obs.	GBIF
		0.40	0.00	0.30	0.92*	0.64	0.06	0.28	SDM	Thompson
	Species Richness	7	3	7	9	7	7	11	-	-

**DFO survey: DFO data from synoptic trawl surveys (2003–2016), outside hard-bottom longline surveys (2006–2016), and random-stratified sablefish trap surveys (2003–2016); HMTK: Haida Marine Traditional Knowledge Study Participants 2011b; Thompson: Thompson et al. 2023a; GBIF: Global Biodiversity Information Facility (GBIF 2022).

Roundfishes

Roundfish species are generally categorized by their fusiform body shape – a rounded form in the middle that tapers off at both ends. Three species of ecologically and/or culturally significant roundfish occur in the NSB: **Kyaa.n Sg̲aahlan** *Pacific Cod* (*Gadus macrocephalus*), Pacific Hake (*Merluccius productus*), and Walleye Pollock (*Theragra chalcogramma*) (Gale et al. 2019). All three species occur throughout the OHGNZ and are considered ecological conservation priorities in the NSB (Table 11, Table F.1). Although these species have been grouped into the groundfish section in this report, they utilize both benthic and pelagic habitats.

Kyaa.n Sg̲aahlan *Pacific Cod* are large generalist predators that feed on benthic invertebrates as well as forage fish and flatfish (Albers and Anderson 1985; Love 2011; Yang 2004) and have been observed in all but one of the OHGNZ (Not in Zone 503, Table 11), although the Thompson model predicted no presence of Kyaa.n Sg̲aahlan in Zone 505. Kyaa.n Sg̲aahlan may compete with **Sk̲íl Sk̲il** *Sablefish*, **T'ál T'aal** *Arrowtooth Flounder*, and **K̲'aad K̲'aaxada** *Spiny Dogfish* for resources (McCain et al. 2005; Pearsall and Fargo 2007). Kyaa.n Sg̲aahlan are an important prey species to many, including T'ál T'aal, **T'áaw'un TaaG̲un** *Chinook Salmon*, **X̲aguu X̲aaguu** *Pacific Halibut*, Sk̲íl Sk̲il, Walleye Pollock, **G̲úud G̲uud** *eagles*, **K̲wa.anaa K̲uux̲aana** *puffins*, auklets, seals, **K̲áay K̲ay** *Steller Sea Lions*, **SG̲áan Sg̲aana** *Killer Whales* and other whales (Love 2011). Kyaa.n Sg̲aahlan generally show site fidelity with limited directed migrations (Cunningham et al. 2009). There is no commercial stock on **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*. However, all recently assessed stocks elsewhere in BC have declined over the past decade (Forrest et al. 2020).

Pacific Hake have been directly observed in all of the OHGNZ, despite low occurrences predicted by the Thompson model (Thompson et al. 2022, 2023a) for Zone 503 and 506 (Table 11). Due to their abundance, Pacific Hake are arguably “one of the most ecologically important fish species on the west coast of North America” (Love 2011) and hold important ecological roles as both predator and prey species (Taylor et al. 2015). Almost 60 species feed on Pacific Hake, including Walleye Pollock, **Kyaa.n Sg̲aahlan** *Pacific Cod*, **K̲'aad K̲'aaxada** *Spiny Dogfish*, auklets, cetaceans, and pinnipeds (Coad 1995; Love 2011). Pacific Hake are highly migratory, with juveniles occupying nearshore areas and older individuals moving into deeper water (McCain et al. 2005), even going as far as southern Alaska in some warm (El Niño) years (Taylor et al. 2015). Due to the species migration from outside the NSB, they are considered important sources of nutrients and biomass in the NSB in general, although not much is known about their contributions to the OHGNZ and surrounding areas specifically (Gale et al 2019).

Pacific Hake have been identified as a potential emerging fishery opportunity for **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* (Haida Gwaii Marine Plan 2015). In Canada, the Pacific Hake fishery makes up more catch than all other roundfish and groundfish fisheries combined (Edwards et al. 2022). A yearly international stock assessment is conducted by the Joint Technical Committee of the Pacific Hake/Whiting Agreement between the Governments of the United States and Canada. Coastwide stock assessments for both countries were found to be in the healthy zone with respect to reference metrics set by DFO (Edwards et al. 2022). Populations in the Strait of Georgia and Puget Sound, however, showed diminishing abundances and body size over the last several decades (Chittaro et al. 2022). An acoustic backscatter survey tracking Pacific Hake of 2+ years showed variability in cohorts around **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay**, possibly due to annual migrations (Edwards et al. 2022). The highly variable recruitment rate of Pacific Hake and the fluctuations in population biomass were sources of high uncertainty for population modelling (Edwards et al. 2022).

Walleye Pollock are heavily piscivorous (Love 2011), and their diet varies seasonally with prey abundance (Dwyer et al. 1987). Walleye Pollock are an important food resource in the NSB, with at least 78 species predating on them, including marine mammals, **Xedíit Siigaay xidid** *marine birds*, and fish (Coad 1995; Love 2011). Walleye Pollock are acknowledged as important components in many North Pacific ecosystems (Bailey and Ciannelli 2007), although more research is required to understand how Walleye Pollock influence ecosystem dynamics in light of environmental change (Springer 1992). For example, large declines in the Xedíit Siigaay xidid and marine mammal populations in the Bering Sea and the Gulf of Alaska since the 1970s have been linked to changes in Walleye Pollock abundances (e.g., Springer 1992; Rosen and Trites 2000; Fritz and Hinckley 2005). The depth distribution of Walleye Pollock changes with season and age, with movements into deeper waters in summer months and individuals moving into deeper waters as they age (Love 2011). The population of Walleye Pollock in **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* was assessed to be above the average spawning biomass estimated from 1967 to 2016 and the upper stock reference point, which means conservation action is not yet considered necessary by federal management (DFO 2018c). Despite this, the population was projected to decline over the next three years (DFO 2018c). As of this report, an updated population assessment of Walleye Pollock has not yet been conducted; therefore, these projections are less certain for recent years. This species is found in all OHGNZ except Zone 504.

Table 11. Roundfish species occurrence by zone in the Offshore Haida Gwaii Network Zones. Two types of data are presented: (1) Obs., which represents direct observation of the species (e.g., catch data), denoted by an X; and (2) SDM, the predicted occurrence of groundfish species according to the Thompson et al. (2023a) multispecies distribution model. Notes: (1) only those species for which at least one zone had a maximum predicted occurrence of ≥0.7 in at least one cell are reported, or a Obs. source of data indicated their occurrence; and (2) the Thompson model only applies to groundfish species and the model only covered 3% of the Zone 504 surface area. Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1). Cells shaded in green and marked with an asterisk (*) are known occurrences or predicted occurrences with a value >0.5. Dashes in cells denote no data, or predicted or known species absence.

Common Name	**Scientific Name**	**Duu Gúusd Daawxuusda Zones**			**Síigee Zones**				**Data Type**	**Source****
		505	**504**	**503**	**502**	**506**	**501**	**500**		
Pacific Cod	***Gadus macrocephalus***	X*	X*	-	X*	X*	X*	X*	Obs.	DFO survey
		0.87*	0.00	0.18	0.81*	0.86*	0.93*	0.99*	SDM	Thompson
Pacific Hake	***Merluccius productus***	X*	X*	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.91*	0.95*	0.26	0.66*	0.19	0.93*	0.54*	SDM	Thompson
Walleye Pollock	***Gadus chalcogrammus***	X*	-	X*	X*	X*	X*	X*	Obs.	DFO survey
		0.54*	0.01	0.11	0.96*	0.71*	0.97*	0.99*	SDM	Thompson
	Species richness	3	2	2	3	3	3	3	-	-

**DFO survey: Observations from DFO synoptic trawl surveys (2003–2016) and outside hard-bottom longline surveys (2006–2016); Thompson: Thompson et al. 2023a.

Other Groundfishes

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 gravelly habitats. Of the other groundfish species found within the OHGNZ, two species are ecological conservation priorities in the MPA network, **Skáaynang Skaynang** *Lingcod* and **Sk̲íl Sk̲il** *Sablefish* (Gale et al. 2019; Table 12, Table F.1). There is little genetic evidence of Sk̲íl Sk̲il population structuring in BC waters (Jasonowicz et al. 2016). Skáaynang Skaynang have been managed as one stock inside Strait of Georgia, and four outside stocks (including Hecate Strait and **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*; King et al. 2012). A recent study using DNA sequencing to investigate lingcod population structuring from Alaska to Baja California, Mexico found little to no differences in samples from BC (Longo et al. 2020). More details on Skáaynang Skaynang and Sk̲íl Sk̲il cultural use, ecology and distribution are provided below.

Skáaynang Skaynang *Lingcod* (*Ophiodon elongatus*) are high-level piscivorous predators in rocky habitats (Haggan et al. 1999; Wallace 1999; Pearsall and Fargo 2007; Beaudreau and Essington 2009). Skáaynang Skaynang are thought to be generally sedentary and have strong site fidelity to their local spawning grounds (Freiwald 2012). Tagging studies of Skáaynang Skaynang revealed a majority of high site fidelity in addition to a mix of frequent and large-scale movement behaviors (Starr et al. 2011). Females can grow up to 120–150 cm (Cass et al. 1990). Large populations of Skáaynang Skaynang are found throughout British Columbia, including near the coast of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* in all of the OHGNZ (Table 12). Historically, Haidas traditionally fished Skáaynang Skaynang, typically within **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*, and ate it fresh while out on fishing trips targeting other species, or preserved through drying. Skáaynang Skaynang remains an important traditional food, however, dried Skáaynang Skaynang is less common today (Haida Marine Traditional Knowledge Study Participants et al. 2011c). A long history of commercial fisheries exists for the Skáaynang Skaynang, starting around 1860 (Cass et al. 1990). Skáaynang Skaynang are also notable for recreational fisheries, which includes present-day fishing charters in X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay (Cass et al. 1990). Stock assessment for offshore Skáaynang Skaynang indicated healthy stocks with high confidence in the region of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay (King et al. 2012). However, at the scale of the NSB, there is evidence of moderate declines in Skáaynang Skaynang, though trends are variable suggesting the need for further assessment (Thompson et al. 2022, 2023a).

Sk̲íl Sk̲il *Sablefish* (*Anoplopoma fimbria*) are high trophic level opportunistic predators throughout BC and Alaska (Pauly and Christensen 1996; Haggan et al. 1999; Gaichas et al. 2010), and like Skáaynang Skaynang are found in all of the OHGNZ (Table 12). Sk̲íl Sk̲il, also known as Black Cod, are an important fish for Haida harvesting and traditionally were fished with highly-selective Sk̲íl Sk̲il specific hooks (Haida Marine Traditional Knowledge Study Participants et al. 2011b). While Haidas fish for Sk̲íl Sk̲il throughout all the zones, the more frequented areas are within **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* and **Tsaan K̲waay** *Learmonth Bank*. Sk̲íl Sk̲il movements are linked to demography, with juvenile Sk̲íl Sk̲il migrating from the continental slope to nearshore waters to mature and adults returning to the continental slope to spawn (Beamish et al. 2006). Furthermore, Sk̲íl Sk̲il may move on and off seamounts from nearby coastal areas, and Sk̲íl Sk̲il recruitment to seamounts may be the result of this movement as juveniles (Whitaker and McFarlane 1997; Beamish and Neville 2002). Sk̲íl Sk̲il have shown population declines in the past three decades, leading to reduced harvesting opportunities. Every three years, the Sablefish management strategy evaluation process is revised with the most recent data to provide guidance for sustainable harvest. The most recent fisheries management plan from DFO (2020d) showed an increase from a “Cautious” stock status to “Healthy” stock status under DFO’s Precautionary Approach

Framework (DFO 2009). Further updates to operating models and management procedures are scheduled for 2022–2024 (DFO 2020d).

Table 12. Other groundfish species occurrence by zone in the Offshore Haida Gwaii Network Zones. Two types of data are presented: (1) Obs., which represents direct observation of the species (e.g., catch data), denoted by an X; and (2) SDM, the predicted occurrence of groundfish species according to the Thompson et al. 2023a multispecies distribution model. Notes: (1) only those species for which at least one zone had a maximum predicted occurrence of ≥0.7 in at least one cell are reported, or a Obs. source of data indicated their occurrence; and (2) the Thompson model only applies to groundfish species and the model only covered 3% of the Zone 504 surface area. Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1). Cells shaded in green are known occurrences or predicted occurrences with a value >0.5.

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source*
		505	504	503	502	506	501	500		
Kelp Greenling	*Hexagrammos decagrammus*	0.00	0.00	0.00	0.53	0.00	0.73	0.65	SDM	Thompson
Lingcod	***Ophiodon elongatus***	X	X	X	X	X	X	X	Obs.	DFO catch; HMTK vol 2 pages 47,98
		0.96	0.00	0.53	0.99	0.44	0.98	0.87	SDM	Thompson
Sablefish	***Anoplopoma fimbria***	X	X	X	X	X	X	X	Obs.	DFO catch; HMTK vol 2 page 98
		1.00	1.00	1.00	1.00	0.81	0.90	1.00	SDM	Thompson
	Species richness	2	2	2	3	2	3	3	-	-

*Thompson: Thompson et al. 2023a; DFO catch: DFO synoptic trawl surveys (2003–2016) and outside hard-bottom longline surveys (2006–2016); HMTK: Haida Marine Traditional Knowledge Study Participants 2011b.

Pelagic Fishes

Pelagic fishes 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 fishes, salmonids, and other.

Forage Fishes

Forage fish are small to intermediate-sized marine fish that are consumed by a wide variety of marine predators, including fish, marine mammals, reptiles and **Xedíit Siigaay xidid** *marine birds*. Forage fish are a crucial group of species in marine food webs, providing an essential link between upper and lower trophic levels by feeding on lower trophic level organisms such as phytoplankton and zooplankton, and transferring the energy to higher trophic level predators. Forage fish are relatively short-lived, highly abundant and productive species that undergo large natural population fluctuations influenced by environmental variability, fishing, system productivity, the carrying capacity of ecosystems and a variety of other factors that impact survival and recruitment to the adult population (Boldt et al. 2019; Guénette et al. 2014). Forage fish are culturally and commercially important.

In the NSB, key forage fish species include **'íináang iinang** *Pacific Herring* (*Clupea pallasii*), **Sáaw Saaw** *Eulachon* (*Thaleichthys pacificus*), Northern Anchovy (*Engraulis mordax*), Pacific Sand Lance (*Ammodytes personatus*), Surf Smelt (*Hypomesus pretiosus*), Pacific Sardine (*Sardinops sagax*) and Pacific Saury (*Cololabis saira*). Capelin, Sáaw Saaw, 'íináang iinang, Pacific Sand Lance, Surf Smelt, and Pacific Sardine were all identified as ecological conservation priorities for the MPA Network (DFO 2017a; Gale et al. 2019). Limited information on forage fish for the OHGNZ is available. Non-commercial species (e.g., Pacific Sand Lance and Capelin) typically have limited survey and assessment data, resulting in knowledge gaps in the literature about their life history and habitat associations (Boldt et al. 2019). The life history and habitat preferences for the key forage species are variable, with some species, such as Sáaw Saaw and 'íináang iinang being highly migratory. In contrast, other species, such as Pacific Sand Lance, do not appear to migrate and have strong site fidelity, staying within 5 km of their spawning/burying habitat (Huard et al. 2022).

Sáaw Saaw *Eulachon* are distributed from northern California to the eastern Bering Sea (Hay and McCarter 2000). They are an anadromous species known to spawn in approximately 33 rivers in British Columbia with spring freshets and glacial or snow-pack headwaters (Hay and McCarter 2000). There are no known current spawning rivers on **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* (Hay and McCarter 2000; COSEWIC 2011a), but historically, there were runs in Masset Inlet (Haida Marine Traditional Knowledge Study Participants et al. 2011b). Elsewhere in coastal British Columbia, multiple populations have been designated as either endangered or threatened due to declines in the last 30 to 40 years. Many traditional Sáaw Saaw spawning rivers report 10% or less abundance than historical numbers (COSEWIC 2011a). Genetic differentiation of Eulachon are primarily separated among populations of:

1. Northern California to the Fraser River,
2. southeast Alaska and the central and north coast, and
3. the Gulf of Alaska (Sutherland et al. 2020).

Sáaw Saaw *Eulachon* is highly valued for its rich oil, which is often traded between Nations; therefore, while there are no **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* Sáaw Saaw rivers, it remains an important cultural food for Haidas. Sáaw Saaw spend most of their lives in marine environments and typically occupy demersal areas at moderate depths (20–200 m; Hay and McCarter 2000; Dealy and Hodes 2021). According to modelling by Thompson et al. (2022, 2023a), Sáaw Saaw are predicted to occur in Zones 501 (0.13) and 500 (0.99, Table 13) in the OHGNZ.

'íináang iinang *Pacific Herring* is an important pelagic forage species with a wide distribution extending from California to the Bering Sea (Hay et al. 2009). 'íináang iinang are migratory, moving between summer feeding grounds on the continental shelf, overwintering areas and spawning habitats. 'íináang iinang spawn in intertidal and shallow subtidal areas throughout the BC Coast, including along **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*, primarily in March and April (Beacham et al. 2008; Hay et al. 2009). Recent genomic studies 'íináang iinang spawning aggregations conducted by Petrou et al. (2021) found differences in population structuring driven by reproductive timing and spawning seasons. Notably, herring sampled in Northern **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* were found to spawn between May and June, whereas herring from Southern X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay had an earlier March to April spawning date (Figure 1 in Petrou et al. 2021). 'íináang iinang likely plays an important role as a mid-trophic level forage fish in X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay marine food webs through a complex network of top-down and bottom-up interactions with numerous predators and prey as well as competing with other small planktivorous fish (Surma et al. 2019). **K'áaw K'aaw** *herring spawn on kelp* fronds or cedar boughs are an important cultural food for many coastal Nations. Some 'íináang iinang are not migratory, residing close to spawning grounds throughout the year (Beacham et al. 2008). The highest catches of 'íináang iinang biomass are reported on the continental shelf at depths of <185 m in areas with high abundances of zooplankton prey (Godefroid et al. 2019). 'íináang iinang in the X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay area are a species of conservation concern due to significant declines and depressed stocks. 'íináang iinang are important to Haida food security, traditions, and well-being, as K'áaw K'aaw is considered a rich food of high status.

'íináang iinang *Pacific Herring* in the **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* area has been managed as a major stock assessment region and are a species of conservation concern due to significant declines in biomass and depressed stocks since 2000 (Fisheries and Oceans Canada 2022a). Known spawning locations around coastal X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay are compiled from the DFO Pacific Herring Spawn and Catch Records and include cumulative habitat spawn index for every spawning event from 1928 to 2016.The Council of the Haida Nation, Fisheries and Oceans Canada and Parks Canada are collaborating on a rebuilding plan for 'íináang iinang in X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay[10]. In the OHGNZ, 'íináang iinang have been documented in **Sasga K̲'ádgwii** *Offshore Continental Slope North* (Zone 502) and **K̲adlee** *Offshore Celestial Reef* (Zone 500; Table 13). Although the OHGNZ does not overlap with any nearshore spawning habitat, areas where zooplankton aggregate (e.g., **G̲angx̲id Kun Sg̲aagiidaay** *Cape St. James*, **Ginda Kun Sg̲aagiidaay** *Offshore Continental Slope South* and **Sasga K̲'ádgwii** *Offshore Continental Slope North*, **Tsaan K̲waay** *Offshore Learmonth Bank Site*) likely provide critical foraging opportunities for 'íináang iinang.

Pacific Sardine have been identified as a potential emerging fishery opportunity for **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* (MaPP 2015). Pacific Sardine are highly migratory forage fish, spawning in southern California and migrating northwards to southeast Alaska to feed (Schweigert 1988). The distribution and abundance of Pacific Sardine are influenced by environmental conditions and population dynamics of northern anchovy (Rodriguez-Sanchez et al. 2002). Their historic distribution encompasses the OHGNZ, although abundances are mainly found in southern BC (Culley 1971; COSEWIC 2002). Due to these factors, Pacific Sardines may be found in the present-day OHGNZ, but there is a lack of survey or commercial catch data to confirm this. Since 2015, the United States National Marine Fisheries Service has assessed the entire Pacific Sardine stock from southeast Alaska to Baja California. The Pacific Sardine is currently considered overfished, and the stock has declined by over 95% in the last ten years (Kuriyama et al. 2020). The commercial fishery was closed in 2015, and rebuilding plans (Pacific Fishery Management Council 2021) and harvest advice (DFO 2022d) are in progress.

Northern Lampfish (*Stenobrachius leucopsarus*) is a mesopelagic forage fish that has been observed in Zones 503, 502, and 506 (Table 13). This species is an important oceanic food web component and a species of conservation priority in the NSB (Gale et al. 2019; Appendix F). A fatty food resource—it is prey to commercial fishes such as Pacific Halibut (*Hippoglossus stenolepus*) and Pacific salmon (*Oncorhynchus* spp.) (Kline 2010). As a mesopelagic fish species it makes diel vertical migrations from it's daytime mesopelagic foraging area to its epipelagic habitat at night (Kline 2010). It is commonly found on the continental slope, as supported by its occurrence in the offshore continental slope zones.

[10] The Draft "Haida Gwaii 'íináang | iinang Pacific Herring: An Ecosystem Overview and Ecosystem-based Rebuilding Plan" is available online, for more information, see Fisheries and Oceans Canada | Fishery Notices.

No survey or commercial catch data support the occurrence of many other forage fish species in the OHGNZ. The following paragraph briefly summarizes known trends of stocks and populations in regions outside the OHGNZ. Stock assessment data for Pacific Saury, Surf Smelt, Pacific Sand Lance, and Capelin in BC are limited. Evaluations of Surf Smelt stocks in Burrard Inlet suggest a decline in the past four decades (Therriault et al. 2002). The Pacific Region Integrated Fisheries Management Plan (Fisheries and Oceans Canada 2012) reviewed that Surf Smelt conservation objectives have been met due to low commercial fisheries activity and closure during spawning periods in the summer. Pacific Saury are not abundant in Canadian waters, and stocks in the northwest Pacific are considered overfished by the North Pacific Fisheries Commission (Kitakado 2021). A recent study on non-commercial Capelin population dynamics revealed highly variable annual abundances in the Gulf of Alaska (McGowan et al. 2020). Population data for Pacific Sand Lance and Capelin remain extremely limited.

Table 13. Forage fish species occurrence by zone in the Offshore Haida Gwaii Network Zones. Two types of data are presented: (1) Obs., which represents direct observation of the species (e.g., catch data), denoted by an X; and (2) SDM., the predicted occurrence of groundfish species according to the Thompson et al. (2023a) multispecies distribution model. Notes: (1) only those species for which at least one zone had a maximum predicted occurrence of ≥0.7 in at least one cell are reported, or an Obs. source of data indicated their occurrence; and (2) the Thompson model only applies to groundfish species and the model only covered 3% of the Zone 504 surface area. Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1). Cells shaded in green are known occurrences or predicted occurrences with a value >0.5. Dashes in cells denote no data, or predicted or known species absence.

		Duu Gúusd Daawxuusda Zones				**Síigee Zones**				
Common Name	**Scientific Name**	**505**	**504**	**503**	**502**	**506**	**501**	**500**	**Data Type**	**Source***
Eulachon	***Thaleichthys pacificus***	0.00	0.00	0.00	0.01	0.00	0.13	0.99	SDM	Thompson
Herring	***Clupea pallasii***	-	-	-	X	-	-	X	Obs.	HMTK Vol 2 p. 102; GBIF
Northern Lampfish	***Stenobrachius leucopsarus***	-	-	X	X	X	-	-	Obs.	GBIF

*HMTK: Haida Marine Traditional Knowledge Study Particapants 2011b; Thompson: Thompson et al. 2023a; GBIF: Global Biodiversity Information Facility (GBIF 2022).

Tsíi.n Chiina Salmonids

To support earlier work on the PNCIMA planning process, a comprehensive overview of **Tsíi.n Chiina** *salmonids*, their ecological importance, habitat linkages, and historical catch within the NSB was compiled (Hyatt et al. 2007). Tsíi.n Chiina are cultural and ecological keystone species, with Haida sustainable harvesting occurring for millenia via complex management and selective gear. Tsíi.n Chiina hold high relevance to Haida culture, traditions, and the rhythms of seasonal harvesting for specific Tsíi.n Chiina species in particular areas, crucial as both fresh and preserved cultural food. Tsíi.n Chiina species, including **T'áaw'un Taagun** *Chinook* (*Oncorhynchus tshawytscha*), **Sk'aga Sk'aagii** *Chum* (*Oncorhynchus keta*), **Táayii Taay.yii** *Coho* (*Oncorhynchus kisutch*), **Ts'ataan Ts'iit'an** *Pink* (*Oncorhynchus gorbuscha*), and

SG̲wáagaan Sg̲waagan *Sockeye* (*Oncorhynchus nerka*) as well as **Tak'áal Taatl'ad** *Cutthroat Trout (Oncorhynchus clarkii clarkii)*, **Tayáng Taay.ying.nga** *Steelhead* (*Oncorhynchus mykiss*), and Dolly Varden Char (*Salvelinus malma*), are all ecological conservation priorities in the NSB (DFO 2017a; Gale et al. 2019). All five Pacific Salmon species are ecologically and culturally significant throughout the Pacific Northwest. Juveniles migrate to the ocean for feeding and growth, and adults return to freshwater to spawn only once and die. This large seasonal migration provides food for many coastal species and contributes to healthy marine and riparian ecosystems (Lucas et al. 2007). Notably, Tsíi.n Chiina are one of the main transporters of important marine nutrients, such as marine nitrogen, into freshwater and terrestrial ecosystems by being captured and consumed by predators, as well as being dragged throughout streams and adjacent areas on land for their carcasses to decompose (Reimchen et al. 2003). Tsíi.n Chiina, as well as salmonids that are known to reproduce multiple years including coastal Tak'áal Taatl'ad, Tayáng Taay.ying.nga, and Dolly Varden Char, are all ecological conservation priorities in the NSB (DFO 2017a; Gale et al. 2019).

Tsíi.n Chiina data are scarce for the offshore regions of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*, coming primarily from Haida Marine Traditional Knowledge and commercial fishery data points. There are also few bycatch data records within the OHGNZ from the DFO Synoptic Bottom Trawl Surveys and midwater trawl programs (Table 14). These datapoints are useful for modelling when combined with province-wide datasets, but occurrences are too limited for summarizing distribution within the OHGNZ. Most of our scientific knowledge regarding Tsíi.n Chiina populations in the NSB comes from estuary and river sampling of adult fish returning to spawn, termed escapements. DFO's salmon escapement database (NuSEDS 2020; Fisheries and Oceans Canada 2022b) shows escapements for five species of salmon (**T'áaw'un Taag̲un** *Chinook*, **Sk'aga Sk'aagii** *Chum*, **Táayii Taay.yii** *Coho*, **Ts'ataan Ts'iit'an** *Pink* (odd and even year), and **SG̲wáagaan Sg̲waagan** *Sockeye*) within stream networks along the east, west and north coasts of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay. A report prepared by the Gowgaia Institute (Broadhead 2009) used escapement data, juvenile salmon sampling results, and information on stream size, stream gradients, fish barriers, and drainage area to assess the riparian fish forests of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay and rank stream networks for their relative 'fishyness', i.e., those streams likely to contain the most Tsíi.n Chiina, and identified over 1,000 Tsíi.n Chiina populations on X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay. The most comprehensive database on Tsíi.n Chiina populations in British Columbia can be accessed using the Pacific Salmon Explorer tool (Pacific Salmon Foundation 2020). Out of the 29 Conservation Units assessed in X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay within the last decade, six Ts'ataan Ts'iit'an and 13 SG̲wáagaann Sg̲waagan conservation units show increasing population trends, three Táayii Taay.yii and five Sk'aga Sk'aagii conservation units show declining population trends, and a lack of information to determine T'áaw'un Taag̲un trends (Pacific Salmon Foundation 2020). In contrast to most other locations in BC, Ts'ataan Ts'iit'an populations on X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay are dominated by even-year returns (Hyatt et al 2007). Freshwater habitat degradation from deforestation and road construction was noted to be major issues for Tsíi.n Chiina populations on X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay (Pacific Salmon Foundation 2021). Tsíi.n Chiina populations with natal streams in Oregon, Washington, British Columbia, and Alaska have been shown to migrate along the west coast of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay and through **Síigee** *Dixon Entrance* (Figure 26).

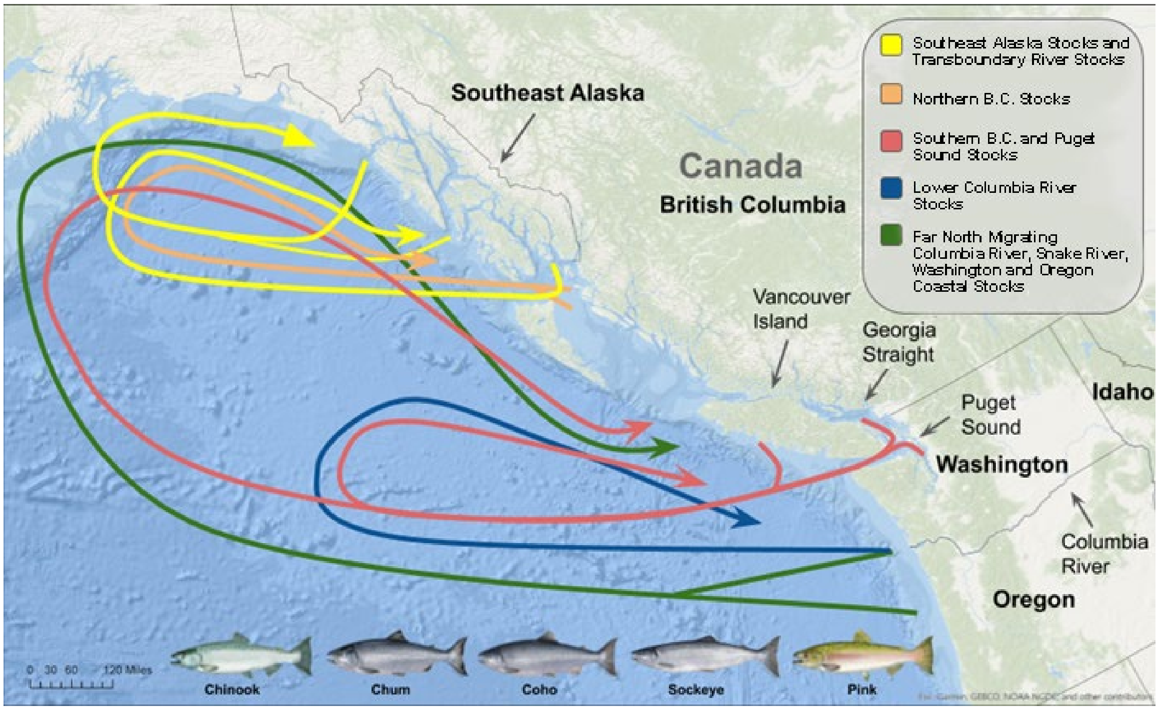

*Figure 27. Migration patterns of **Tsíi.n Chiina** Pacific salmon populations. Source: NOAA Fisheries.*

Consequently, **Tsíi.n Chiina** *salmonids* are likely to migrate through the OHGNZ on their migrations out to the open ocean as juveniles and back to their natal streams as adults, but the relative importance of the network zones to their ecology or population dynamics is unknown. The Haida Marine Traditional Knowledge Study supports the occurrence of three **Tsíi.n Chiina** *Salmonid* species within the OHGNZ: **T'áaw'un Taag̲unn** *Chinook Salmon* in Zones 501 and 502, and **Táayii Taay.yii** *Coho Salmon* and **SG̲wáagaan Sg̲waagan** *Sockeye Salmon* in Zone 502 (Table 14). Commercial catch data from 2007 to 2016 and DFO surveys provide further support for the presence of **Tsíi.n Chiina** *salmonids* in some of the OHGNZ (Table 14), but catch levels are variable. No Tsíi.n Chiina species are currently documented to occur in Zone 505, and only **T'áaw'un Taag̲unn** *Chinook Salmon* are currently documented to occur in Zone 504.

*Table 14. **Tsíi.n Chiina** Salmonid species occurrence by zone in the Offshore Haida Gwaii Network Zones. Occurrence data comes from direct observations of species (Obs., e.g., catch data), denoted by an X and shaded in green. Common and scientific names in bold are species of conservation priority (see Gale et al. 2019 and Table F.1). Dashes in cells denote no data, or predicted or known species absence.*

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source*
		505	504	503	502	506	501	500		
Chinook Salmon	***Oncorhynchus tschawytscha***	-	-	-	X	-	X	-	Obs.	HMTK Vol. 2, p. 43, 95
		-	X	X	X	X	X	X	Obs.	DFO catch
Chum Salmon	***Oncorhynchus keta***	-	-	-	X	X	X	X	Obs.	Midwater trawl survey; Bottom trawl survey
Coho Salmon	***Oncorhynchus kisutch***	-	-	-	X	-	-	-	Obs.	HMTK Vol. 2, p. 95
		-	-	X	X	X	X	X	Obs.	DFO catch; Midwater trawl survey
Pink Salmon	***Oncorhynchus gorbuscha***	-	-	-	X	X	X	X	Obs.	DFO catch; Midwater trawl survey
Sockeye Salmon	***Oncorhynchus nerka***	-	-	-	X	-	-	-	Obs.	HMTK Vol. 2, p. 95
		-	-	-	X	X	X	X	Obs	Midwater trawl survey
	Species Richness	0	1	2	5	5	5	5	-	-

*HMTK: Haida Marine Traditional Knowledge Study Participants et al. 2011b; DFO catch: DFO provided commercial catch data (2007 to 2016); Midwater trawl survey: DFO programs include High Seas Salmon (1995–2015) and Basin and Coastal Scale Interactions (BCSI, 2016–Present); Bottom trawl survey: West Coast Haida Gwaii Synoptic Bottom Trawl Survey (2004–2021).

Other Pelagic Fishes

Distribution and/or occurrence data for the pelagic fishes listed in this section are limited. However, they are briefly mentioned because these species may occur in the OHGNZ and are considered conservation priorities for the NSB (Gale et al. 2019; Table F.1). More sampling is required to establish their presence.

Albacore Tuna (*Thunnus alalunga*) are high-level pelagic predators (Kitchell et al. 1999; Dambacher et al. 2010) that feed on forage fishes (e.g., **'iináang iinang** *Pacific Herring*, Northern Anchovy, sauries), as well as lanternfishes, **K'ats Sgaadang.nga** *rockfishes*, squid, and euphausiids (Coad 1995). Typically offshore, some have been found to migrate inshore and northward during the warmer summer months (Beamish et al. 2005). Currently, there is no spatially specific data to support their occurrence in any of the OHGNZ; however in the summer months, Albacore Tuna have been found in surface waters around the continental shelf break of BC, including off the west coast of Vancouver Island and **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* (Hannah and McKinnell 2016). Albacore Tuna may contribute to nutrient transfer between nearshore and offshore marine ecosystems when feeding in coastal areas during such migrations (Beamish et al. 2005). Additionally, all seven of the OHGNZ occur within a large spatial region described as a relatively heavily fished area by the commercial tuna fishery from 1995 to 2016 (logbook fishing events; see Commercial Fisheries section of the report). Albacore Tuna stocks encompassing the North Pacific are assessed every three years by the International Science Committee's Albacore Working Group. The most recent report suggests that overfishing is not likely occurring according to the biological reference points (Albacore Working Group 2020).

Ocean Sunfish (*Mola mola*) are large-bodied pelagic fish that are found during summer months in BC waters (Coad 1995). They occupy a similar niche to **'Waahúu Tang.g̲wan Siiga** *Leatherback Sea Turtles*, as sea jelly-feeding specialists (Houghton et al. 2006), eating primarily gelatinous zooplankton, as well as fishes, squid, molluscs, and some benthic invertebrates (Coad 1995; Love 2011). They are typically found in offshore oceanic habitats (Schweigert et al. 2007), similar to Albacore Tuna, but aggregations have been observed on the northern continental shelf, including a productive area within Queen Charlotte Sound (Williams et al. 2010). Thys and Williams (2013) used point locations of observed Ocean Sunfish from shipboard and line-transect surveys to model the presence/absence of Ocean Sunfish in British Columbia; however, only the waters north, east, and south of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* were surveyed. Data spanned three consecutive summers between 2004 and 2006 and the spring of 2007. They found a high-density region of Ocean Sunfish at the western edge of Queen Charlotte Sound during the summer months only, associated with elevated water temperature and complex bathymetry. This density area may overlap with the **G̲angx̲id Kun Sg̲aagiidaay** *Cape St. James* (Zone 505) OHGNZ.

4.2.2.2. Cartilaginous Fishes

K̲'aad aw K̲'aax̲ada awg̲a *Sharks*, **Ts'íit'aa Ts'iig̲a** *skates*, and **Sgagwíid Kaaun** *ratfish* belong to the order Elasmobranchs, which are an ancestral clade of fishes characterized by their cartilaginous skeletal structure as opposed to bone. This group encompasses a wide range of ecological roles, from top level pelagic predators to benthic detritivores to planktivorous filter feeders. They are described below in two groups: demersal K̲'aad aw K̲'aax̲ada awg̲a, Ts'íit'aa Ts'iig̲a, and Sgagwíid Kaaun; and pelagic K̲'aad aw K̲'aax̲ada awg̲a, Ts'íit'aa Ts'iig̲a.

Demersal K̲'aad aw K̲'aax̲ada awg̲a Sharks, Ts'íit'aa Ts'iig̲a Skates, and Sgagwíid Kaaun Ratfish

Many demersal cartilaginous fish species are found in the OHGNZ, including four demersal **K̲'aad aw K̲'aax̲ada awg̲a** *shark* species, seven species of **Ts'íit'aa Ts'iig̲a** skate/ray, and one **Sgagwíid Kaaun** ratfish (Table 15). Nine of these 14 species are considered conservation priorities for the NSB MPA Network (Table 15, Table F.1). Slow maturity, reproduction, and long lifespan (Love 2011) compared to many other fish species are common characteristics of K̲'aad aw K̲'aax̲ada awg̲a, Ts'íit'aa Ts'iig̲a, and Sgagwíid Kaaun, and as a result, all nine species are considered of high or very high priority (Gale et al. 2019). Two species of conservation priority are also specified in the conservation objectives outlined in the network process for the Offshore Haida Gwaii Network Zones: Big Skate (Zones 500 and 506) and **K̲'aad K̲'aaxada** *Spiny Dogfish* (Zone 505). More information on these two species is detailed below.

K'aad K'aaxada *Spiny Dogfish* (*Squalus suckleyi*) are common in BC (Love 2011) and are found in all of the OHGNZ. They opportunistically feed on midwater and benthic species, including fish, crustaceans and other invertebrates (Love 2011). Larger individuals will also feed on fish, including **'íináang iinang** *herring*, **Tsíi.n Chiina** *salmonids*, Pacific Sand Lance and Pacific Hake (Love 2011). Most K'aad K'aaxada do not undergo large migrations, although there is some movement of individuals in and out of the NSB (McFarlane and King 2003). K'aad K'aaxada are a valuable cultural species, as a food source and included in Haida stories, crests, and art. K'aad K'aaxada have important economic value, supporting a commercial K'aad K'aaxada fishery in **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii*, and have had a history of being harvested in a lucrative fishery for the oil in their livers (Haida Marine Traditional Knowledge Study Participants et al. 2011b). Additionally, K'aad K'aaxada are noted as a potentially important food resource for **Xaguu Xaaguu** *Pacific Halibut* (Haida Marine Traditional Knowledge Study Participants et al. 2011b). Dogfish biomass is concentrated in northeastern waters surrounding Xaadáa Gwáay Xaaydaga Gwaay.yaay (Anderson et al. 2019). Outside stock assessments from various commercial and research data were unable to reach consensus to determine official stock status (COSEWIC 2011b). This was in part due to a short time series relative to generation time, and many trends were found to be non-significant. A stable population in BC was suggested from low fishing pressure estimates (Wallace et al. 2009). There has been, however, a noticeable decrease in length and size composition of Dogfish catches throughout time (COSEWIC 2011b). In the United States, K'aad K'aaxada stocks are reported as above target population levels, although no assessment reports are available and stock reproductive output has been in decline since the 1940s (NOAA Fisheries 2022).

Big Skate (*Raja binoculata*) are commonly found in British Columbia (McFarlane et al. 2010) and are upper-level predators feeding on crustaceans, Pacific Sand Lance and other flatfish (Pearsall and Fargo 2007; Yang 2004)). Big Skates do not appear to undergo long migrations in BC (King and McFarlane 2010) and have been found in Alaska to move variable distances along the coast (Farrugia et al. 2016). Big Skates have been reported in catches in **Síigee** *Dixon Entrance* and around **K'íis Gwáay** *Langara* (longline fishing), in addition to **Ginda Kun** *Kindakun Point* (fishing unspecified) in the summer months (Haida Marine Traditional Knowledge Study Participants et al. 2011c). Recent stock assessments and survey data, including trawl and longline data from the west and north coast of **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii*, were unable to provide reliable biomass and trend estimates for all areas surveyed due to uninformative catch and abundance time series data (King et al. 2015).

*Table 15. **K'aad aw K'aaxada awga** Shark, **Ts'íit'aa Ts'iiga** skate, and **Sgagwíid Kaaun** ratfish species occurrence by zone in the Offshore Haida Gwaii Network Zones. Two types of data are presented: (1) Obs., which represents direct observation of the species (e.g., catch data), denoted by an X; and (2) SDM, the predicted occurrence of groundfish species according to the Thompson et al. (2023a) multispecies distribution model. Notes: (1) only those species for which at least one zone had a maximum predicted occurrence of ≥0.7 in at least one cell are reported, or an Obs. source of data indicated their occurrence; and (2) the Thompson model only applies to groundfish species and the model only covered 3% of the Zone 504 surface area. Common and scientific names in bold are species of conservation priority (see Gale et al. 2019 and Table F.1). Cells shaded in green are known occurrences or predicted occurrences with a value >0.5. Dashes in cells denote no data, or predicted or known species absence.*

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source*
		505	504	503	502	506	501	500		
				Demersal Sharks						
Brown Cat Shark	*Apristurus brunneus*	X	-	X	X	-	-	-	Obs.	DFO catch
Bluntnose Sixgill Shark	***Hexanchus griseus***	X	-	-	X	-	-	-	Obs.	DFO catch
Pacific Sleeper Shark	***Somniosus pacificus***	X	-	X	X	-	X	-	Obs.	DFO catch
Spiny Dogfish	***Squalus suckleyi***	X	X	X	X	X	X	X	Obs.	DFO catch; HMTK vol 2 p. 98
		0.78	0.09	0.40	0.77	0.66	0.41	0.97	SDM	Thompson
Skates										
Abyssal Skate	*Bathyraja abyssicola*	X	-	X	X	X	-	X	Obs.	DFO catch
Alaska Skate	*Bathyraja parmifera*	X	-	-	X	-	X	X	Obs.	DFO catch
Aleutian Skate	*Bathyraja aleutica*	X	-	X	X	X	-	X	Obs	DFO catch
Big Skate	***Beringraja binoculata***	X	-	X	X	X	X	X	Obs.	DFO catch
		0.55	0.00	0.23	0.81	0.08	0.30	0.88	SDM	Thompson

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones			Síigee Zones				Data Type	Source*
		505	504	503	502	506	501	500		
		Demersal Sharks								
Longnose Skate	***Beringraja rhina***	X	X	X	X	X	X	X	Obs.	DFO catch
		0.93	0.94	0.91	0.95	0.88	0.96	0.99	SDM	Thompson
Roughtail Skate	***Bathyraja trachura***	X	-	X	X	X	-	X	Obs.	DFO catch
Sandpaper Skate	***Bathyraja interrupta***	X	X	X	X	X	X	X	Obs.	DFO catch
		0.73	0.62	0.63	0.46	0.13	0.40	0.73	SDM	Thompson
Ratfish										
Spotted Ratfish	*Hydrolagus colliei*	-	-	-	X	X	X	X	Obs.	GBIF
		0.71	0.08	0.23	1.00	0.76	1.00	1.00	SDM	Thompson
	Species richness	12	3	9	12	8	7	9	-	-

*DFO catch: DFO synoptic trawl surveys (2003–2016) and outside hard-bottom longline surveys (2006–2016), and DFO provided incidental shark catch data (2010 to 2022); HMTK: Haida Marine Traditional Knowledge Study Participants et al. 2011b; Thompson: Thompson et al. 2023a; GBIF: Global Biodiversity Information Facility (GBIF 2022).

*Pelagic K'aad aw **K'aaxada awga** Sharks*

Two pelagic **K'aad aw K'aaxada awga** *shark* species occur in the OHGNZ, the Blue Shark (*Prionace glauca*) and the Salmon Shark (*Lamna ditropis*), both of which are a conservation priority for the NSB (Gale et al. 2019; Table F.1). Blue Sharks are common in BC, particularly in summer months (McFarlane et al. 2010) and are found in Zones 505, 503, 502, 506 and 500 of the OHGNZ (Table 16). They are top predators in the Central North Pacific (Kitchell et al. 1999), and heavy fishing or bycatch of Blue Sharks could destabilize oceanic ecosystems (Markaida and Sosa-Nishizaki 2010). Salmon Sharks are found in Zones 505 and 502 (Table 16) and are significant predators of salmon in the Pacific Ocean (Nagasawa 1998). Salmon Sharks undergo large migrations throughout the North Pacific (Nagasawa 1998; Love 2011), and are common in BC. While most reports of their occurrence are in the Strait of Georgia and offshore (including Zones 505 and 502), they have been reported in Queen Charlotte Sound, **Kandaliigwii** *Hecate Strait*, and off West Coast Vancouver Island (Weng et al. 2008; McFarlane et al. 2010).

*Table 16. Pelagic **K'aad aw K'aaxada awga** Shark species occurrence by zone in the Offshore Haida Gwaii Network Zones. Data comes from direct observations of the species (e.g., catch data), denoted by an X. Common and scientific names in bold are species of conservation priority (see Gale et al. 2019 and Table F.1). Cells with an X and shaded in green are known occurrences. Dashes in cells denote no data, or predicted or known species absence.*

		Duu Gúusd Daawxuusda Zones				**Síigee Zones**			
Common Name	**Scientific Name**	**505**	**504**	**503**	**502**	**506**	**501**	**500**	**Source***
Blue Shark	***Prionace glauca***	X	-	X	X	X	-	X	DFO catch
Salmon Shark	***Lamna ditropis***	X	-	-	X	-	-	-	DFO catch
Species richness		2	0	1	2	1	0	1	-

*DFO catch: DFO synoptic trawl surveys (2003–2016) and outside hard-bottom longline surveys (2006–2016), and DFO provided incidental shark catch data (2010–2022).

4.2.2.3. Fish Species Diversity

Sixty-four fish species have been identified in the OHGNZ, using available data from multiple sources as detailed in the above sections of this report, although it is important to note that this report focuses on documenting the occurrence of species that are conservation priorities for the NSB (Table F.1; Gale et al. 2019). This estimate is also conservative because small fishes and pelagic fishes are not always caught or well-represented in the sampling and data sources presented. In addition, some areas (e.g., Zone 504) are under-sampled. Furthermore, occurrence data does not indicate the relative abundance or density of a species in an area, but only as present at specific moments in time. Species richness, as opposed to an abundance metric is reported here because of its ease of use across sampling methods. Furthermore, the relative proportion of each habitat type in each zone will further influence the number and type of species recorded as occurring there. Note however, that due to the variety of sampling methods used to record species occurrence in the earlier sections, the number of species per zone does not account for the different proportion of sampled areas, as in many cases that information is unavailable. Sampling is likely more frequent across the shelf and slope, however, so zones with high shelf and slope proportions will have more accurate species richness values (Zone 505, Zones 501 to 503, and Zone 506). Zone 504 is consistently undersampled as it has a higher proportion of its area in deeper undersampled waters. Consequently, the species richness presented here is not considered an exhaustive list and likely under-represents the number of species found in each zone. Despite these limitations, general conclusions regarding the species richness patterns for the OHGNZ can be drawn.

Table 17. Fish species richness for each Offshore Haida Gwaii Network Zone. Total species richness is the total number of fish species found to occur in each zone collated from the text and occurrence tables presented in this report, and does not account for the area of each zone. Bold text indicates the highest value for each diversity metric.

	Duu Gúusd Daawxuusda Zones				**Síigee Zones**		
Grouping	**Zone 505**	**Zone 504**	**Zone 503**	**Zone 502**	**Zone 506**	**Zone 501**	**Zone 500**
Bony Fishes (BF)	35	21	30	**45**	36	37	38
- Groundfishes	35	20	28	**41**	33	34	34
- Pelagic BF	0	1	2	**4**	3	3	**4**
Cartilagionous Fishes (CF)	**14**	3	10	**14**	9	7	10
- Demersal CF	12	3	9	**12**	8	7	9
- Pelagic CF	2	0	1	**2**	1	0	1
Total Fish Species Richness	49	24	40	**59**	45	44	48
Total Fish Species Richness per km^2	0.092	0.022	0.048	0.065	0.178	**0.289**	0.186

Groundfish species, especially **K̲'ats Sdaagang.nga** *rockfishes*, are the most diverse group in terms of the number of species present in the OHGNZ dataset, with a total of 27 species (including the **K'aalts'adaa** *Rougheye/Blackspotted Rockfish* complex; Table 9). 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, 2023a). Then a spatial overlay was used to compute the mean and associated species density metrics for each of the OHGNZ (Table 18). Mean groundfish species density was highest in **Tsaan K̲waay** *Offshore Learmonth Bank* (Zone 501) with 18.88 species. **Sasga K̲'ádgwii** *Offshore Continental Slope North* (Zone 502) has the highest groundfish species density (22.39) and also the highest total fish species richness (58 species; Table 18). The high fish species diversity observed in Zone 502 is likely a product of a combination of factors, including high productivity with high habitat heterogeneity. The zone captures a portion of the Shelf Break EBSA (Figure 4a), supports aggregations of microzooplankton, has a high diversity of geomorphic units, and has high rugosity (see previous report sections). It is also near an existing Rockfish Conservation Area (Figure 4c) that could supplement its fish populations through spillover effects (e.g., Baetscher et al. 2019).

Table 18. Predicted groundfish species density (number of species per area) for each Offshore Haida Gwaii Network Zone. Predicted species density values per grid cell are available for groundfish species only using the Thompson et al. (2023a) model. Note the model only covered 3% of the Zone 504 surface area. Bold text indicates the highest value for each diversity metric.

	Duu Gúusd Daawxuusda Zones				**Síigee Zones**		
Metric	**505**	**504**	**503**	**502**	**506**	**501**	**500**
Zone Coverage Proportion	0.61	0.03	0.53	0.75	0.99	1	1
Minimum SD	5.42	6.76	4.70	4.42	**15.59**	12.60	10.89
Maximum SD	21.29	8.46	16.89	**22.39**	19.05	21.98	19.42
Mean SD	10.37	7.56	6.37	12.56	17.41	**18.88**	17.11

Depth was found to be a strong covariate of groundfish species density (Thompson et al. 2022, 2023a). Regionally, Thompson et al. (2022, 2023a) found the highest groundfish species density (SD = 16.0) occurred at mid-depths around 210 m, while lower species densities (SD = 9.9 and 8.2, respectively) occurred in both shallower depths around 40 m and deeper waters at around 1,000 m. The deepest zones in the OHGNZ are Gwaii Haanas Extension (Zone 504), which as mentioned previously, is data-poor and deeper than the extent of the Thompson et al. 2022 and 2023a models, and **Gangx̱id Kun Sg̱aagiidaay** *Cape St. James* (Zone 505) and **Ginda Kun Sg̱aagiidaay** *Offshore Continental Slope South* (Zone 503). Similar to Thompson et al. (2022, 2023a) findings, lower species densities are found in these zones, associated with the deeper depths (Figure 27), but because of the inclusion of mid-continental shelf and slope depths, they also have relatively high maximum species densities. Furthermore, the zones in the **Síigee** *Dixon Entrance* (Zones 506, 501, 500) all have seafloor depths in the mid-range (182.45 m to 246.91 m mean depth; Figure 12) with the narrowest depth ranges and highest mean groundfish species densities (17.11 to 18.88 mean SD; Table 18). While depth is an important covariate of groundfish species' community structure, the distribution and abundance of fish are more likely to be determined by correlates of depth, including temperature, dissolved oxygen, and pressure (Brown and Thatje 2015).

The fish species occurrences presented in this report do not represent changes in species richness with time. However, Thompson et al.'s (2023a) analysis of groundfishes correlates in the North Pacific showed that there have been increases in species density since 2003, and this increase is consistent with the ongoing recovery of groundfish communities from the reduced commercial fishing intensity in comparison to historic levels.

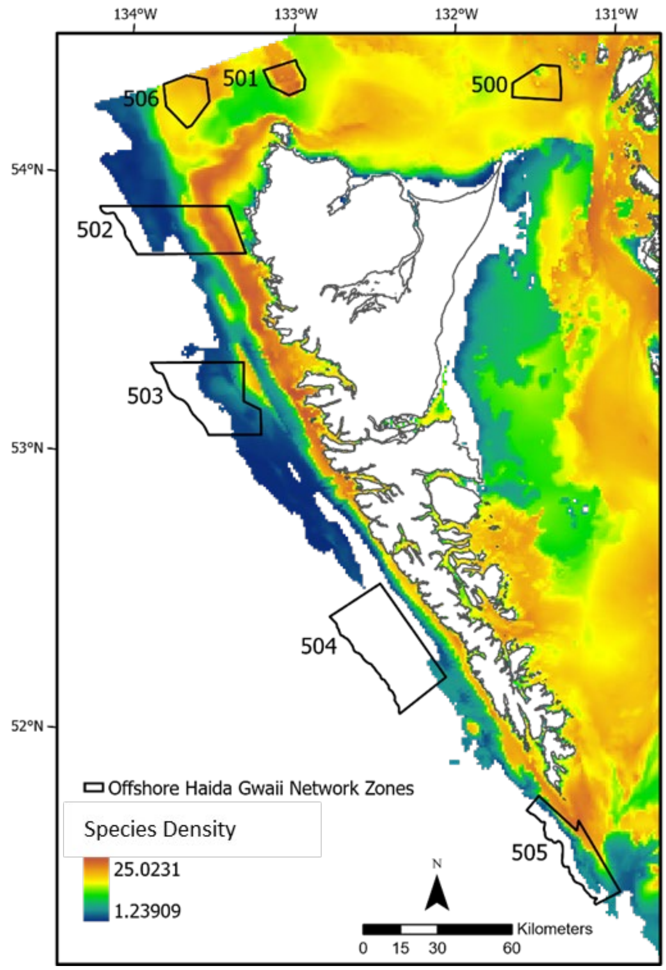

Figure 28. Estimated variation in species density according to the Thompson et al. (2022) model for groundfish species in the Offshore Haida Gwaii Network Zones (black outline).

Total fish species richness is lowest for the Gwaii Haanas Extension (Zone 504; Table 18). However, because of the scarcity of survey work and sampling in this zone, this number is likely not an accurate representation of the fish species richness. This also highlights a consistent data deficiency within this report, where deeper offshore waters are not well sampled, and more research is required to address this knowledge gap.

4.2.3. Marine Mammals and Reptiles

4.2.3.1. Marine Mammals

Eleven cetacean species (five baleen and six toothed) and two pinniped species have been documented to occur within the OHGNZ (see following sections). Whales are culturally important to Haidas and are included in many stories; the Haida name for Orca/Killer Whale is **SG̲áan Sg̲aana**, the same Haida word as *Supernatural Being*. While whales were not typically hunted by Haidas, **K̲áay K̲ay** *sea lions* were harvested for their meat and oil, though not in recent generations. K̲áay K̲ay are also noted to often compete with humans for **Tsíi.n Chiina** *salmon* (Haida Marine Traditional Knowledge Study Participants 2011b). The abundance and distribution of cetacean species is shaped mainly by the distribution and abundance of their food resources, which are indirectly related to oceanographic features and environmental variables

(Bowen and Siniff 1999; Stevick et al. 2002). Areas with physical geography that enhances primary productivity and prey biomass, or makes prey more accessible at the surface, are likely to be important habitat for cetaceans (Gomez et al. 2020), including the highly productive plankton aggregation areas within the Shelf Break EBSA (overlapping Zones 502 to 505). The Haida Marine Traditional Knowledge study (Haida Marine Traditional Knowledge Study Participants et al. 2011b) documented high abundance of **Sgagúud** *Humpback Whales*, **SG̱áan** *Killer Whales* and **K̲áay** *sea lions* in **Síigee** *Dixon Entrance* (where Zones 506, 501, and 500 are located), and **Sk̲ál sk̲ul** *Harbour Porpoise*, dolphins, **Kún k̲aj G̲ajaaw Kun k̲aajii G̲aajaawuu** *Sperm whales*, **SG̱áan SG̱aana** *Killer Whales*, K̲áay K̲ay and increasing amounts of seals on **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* (where Zones 502, 503, 504, and 505 are located).

Data for marine mammal species occurrence comes 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)); and/or
4. local published occurrences in the literature.

Predicted occurrences were produced from predicted abundance maps of four cetacean species (Wright et al. 2021)—**Sgagúud SG̱ap** *Humpback Whales*, **Kún Kun Xyapxyandal** *Fin Whales*, **K̲'áang K̲'aang** *Dall's Porpoises*, and **Sk̲ál sk̲ul** *Harbour Porpoise*—based on survey data and environmental covariates (location, depth, slope, terrain ruggedness, and distance to shore). 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 in July and September of 2018. The spatial coverage of the model did not include Zones 506 and 501 for all four cetacean species, and that of the **Sk̲ál** *Harbour Porpoise* model only included Zone 500. Within the OHGNZ, **G̲angx̲id Kun SG̱aagiidaay** *Cape St. James* (Zone 505) and **Sasga K̲'ádgwii** *Offshore Continental Slope North* (Zone 502) have the highest mammal species richness, with 11 and 10 of the 13 mammal species in the OHGNZ, rescpectively, with documented occurrences.

Marine mammals are described as three separate groups in the following sections based on their feeding ecology and biology: baleen whales (Mysticetes), toothed whales (Odontocetes), and pinnipeds. Baleen and toothed whales differ in their diet. Baleen whales primarily feed on copepods, euphausiids, amphipods, and small schooling fishes (Kawamura 1980), in contrast with toothed whales who feed on fishes and cephalopods (Gaskin 1982; Bowen and Siniff 1999). Consequently, baleen whales are associated with areas of high primary and secondary productivity, whereas toothed whales are more likely to be associated with areas high in fish and squid.

Baleen Whales

Collectively, the OHGNZ provide key foraging habitat, and areas of aggregation for baleen whales (Mysticetes), particularly in southwest X̲aadáa Gwáay X̲aaydaG̱a Gwaay.yaay *Haida Gwaii* and in **Síigee** *Dixon Entrance*. Five baleen whale species are known to occur in the OHGNZ (Table 19), all of which are conservation priority species for the NSB (Table F.1; Gale et al. 2019). These whale species generally have lower trophic levels than toothed whales (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 whales due to the abundance of small pelagic fishes and zooplankton (Takahashi et al. 2022).

Furthermore, baleen whales export energy and nutrients from high latitudes to low latitudes when they excrete urea (nitrogen) during their extensive migrations (Roman et al. 2014). Notable characteristics of each species distribution in the NSB and occurrence within the OHGNZ are provided below.

Table 19. Baleen whale occurrences or expected distribution in the Offshore Haida Gwaii Network Zones. Three types of data are presented: (1) Obs., which represents a combination of direct observation of the species (e.g., visual survey) and their estimated densities per survey grid cell; (2) Pred., where the predicted density of cetacean species was greater than 0.5 according to the Wright et al. 2021 model; and (3) Exp., where the occurrence of the species is indicated by expert opinion (e.g., Aggregation). Note that where more than one source of data provides differing information they are provided as separate rows. Species occurrence is denoted with an X. Cells shaded in green are known occurrences, predicted densities with a value >0.5, or expert opinion habitat areas of importance. Dashes in cells denote no data, or predicted or known species absence. Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1).

		Duu Gúusd Daawxuusda Zones				**Síigee Zones**			**Data Type**	**Source***
Common Name	**Scientific Name**	**505**	**504**	**503**	**502**	**506**	**501**	**500**		
Blue Whale	***Balaenoptera musculus***	Aggregation							Exp.	PNCIMA
		X	X	X	X	X	X	X	Obs.	DFO
Fin Whale	***Balaenoptera physalus***	Aggregation							Exp.	PNCIMA
		X	X	-	-	X	X	X	Obs.	DFO
		X	-	-	-	-	-	-	Pred.	Wright
Minke Whale	***Balaenoptera acutorostrata***	-	-	-	X	-	X	X	Obs.	DFO
Sei Whale	***Balaenoptera borealis***	Aggregation						-	Exp.	PNCIMA
		X	X	X	X	X	X	-	Obs.	DFO
Humpback Whale	***Megaptera novaeangliae***	Feeding Area	-	-	Aggregation	-	-	-	Exp.	PNCIMA
		X	X	X	X	X	X	X	Obs.	DFO; GBIF
		X	-	-	-	-	-	-	Pred.	Wright
Total Species Richness		4	4	4	5	4	5	4	-	-

*PNCIMA: Pacific North Coast Integrated Management Area (PNCIMA) data were collected between 2007–2012 and reflect the best information available during that time frame; DFO: Observations and normalized density estimates of marine mammals from three data sources: Fisheries and Oceans Canada (DFO; 2002–2017), Raincoast Conservation Foundation (2004–2008), and the North Pacific Pelagic Seabird Database (NPPSD; 1975–2012). **Kún Kun Xyapxyandal** Fin Whale, **Sgagúud Sg̲ap** Humpback Whales, and **Kun K'uuan** Minke Whale are derived from all three data sources; Wright: Wright et al. 2021; GBIF: Global Biodiversity Information Facility (GBIF 2022). Sei, Kún Kun Xyapxyandal and Blue Whale "Important Areas" were determined by expert opinion from the Pacific North Coast Integrated Management Area data (2007–2012). Humpback Whale habitats were determined by expert opinion from the *Species at Risk Act* recovery strategy meeting (2009–2013). Kún Kun Xyapxyandal habitats of special importance were identified as important for foraging/feeding, as well as possible courtship/mating and calving habitat (DFO 2017c).

Important areas for blue whales (*Balaenoptera musculus*) and **Kún Kun Xyapxyandal** *Fin Whales* occur in all seven Offshore Haida Gwaii Network Zones (Clarke and Jamieson 2006; Figure 29). However, distribution data for Kún Kun Xyapxyandal do not exist for Zones 503 and 502, and they have low to no predicted densities in 4 of the 5 modelled zones; the highest predicted density for the OHGNZ was in Zone 505 of 1 individual (Table 19; Wright et al. 2021). Both blue whales and **Kún Kun Xyapxyandal** feed primarily on euphausiids (Pauly et al. 1998), and migrate between high-latitude summer feeding areas and low-latitude breeding areas in winter (COSEWIC 2002; Ford 2014). While Blue Whales are rare in the North Pacific, they have been observed in BC 16 times south and west of **X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay** *Haida Gwaii* during surveys from 2002 to 2013 (Ford 2014). The majority of Blue Whale records are in deep waters, but a few sightings have occurred in **K̲andaliiG̱wii** *Hecate Strait* and **Síigee** *Dixon Entrance* (Ford 2014). Recent acoustic and visual surveys in the southern portion of X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay, in close proximity to Zones 505 and 504, documented Kún Kun Xyapxyandal particularly in the winter months (Frouin-Mouy et al. 2022). In the Pacific Region, Kún Kun Xyapxyandal gather along the continental slope, particularly in areas with localized concentrations of euphausiids (COSEWIC 2019). Detailed migration patterns are unknown for Kún Kun Xyapxyandal, but BC is likely a migration corridor and may also be a summer feeding destination for some of the population (Gregr et al. 2000; COSEWIC 2005; Ford 2014). Current abundance estimates for the Kún Kun Xyapxyandal are less than 1,000 mature individuals on the continental shelf. However, beyond the continental shelf substantial numbers of Kún Kun Xyapxyandal were observed in 2018 and USA populations have been documented as increasing (COSEWIC 2019).

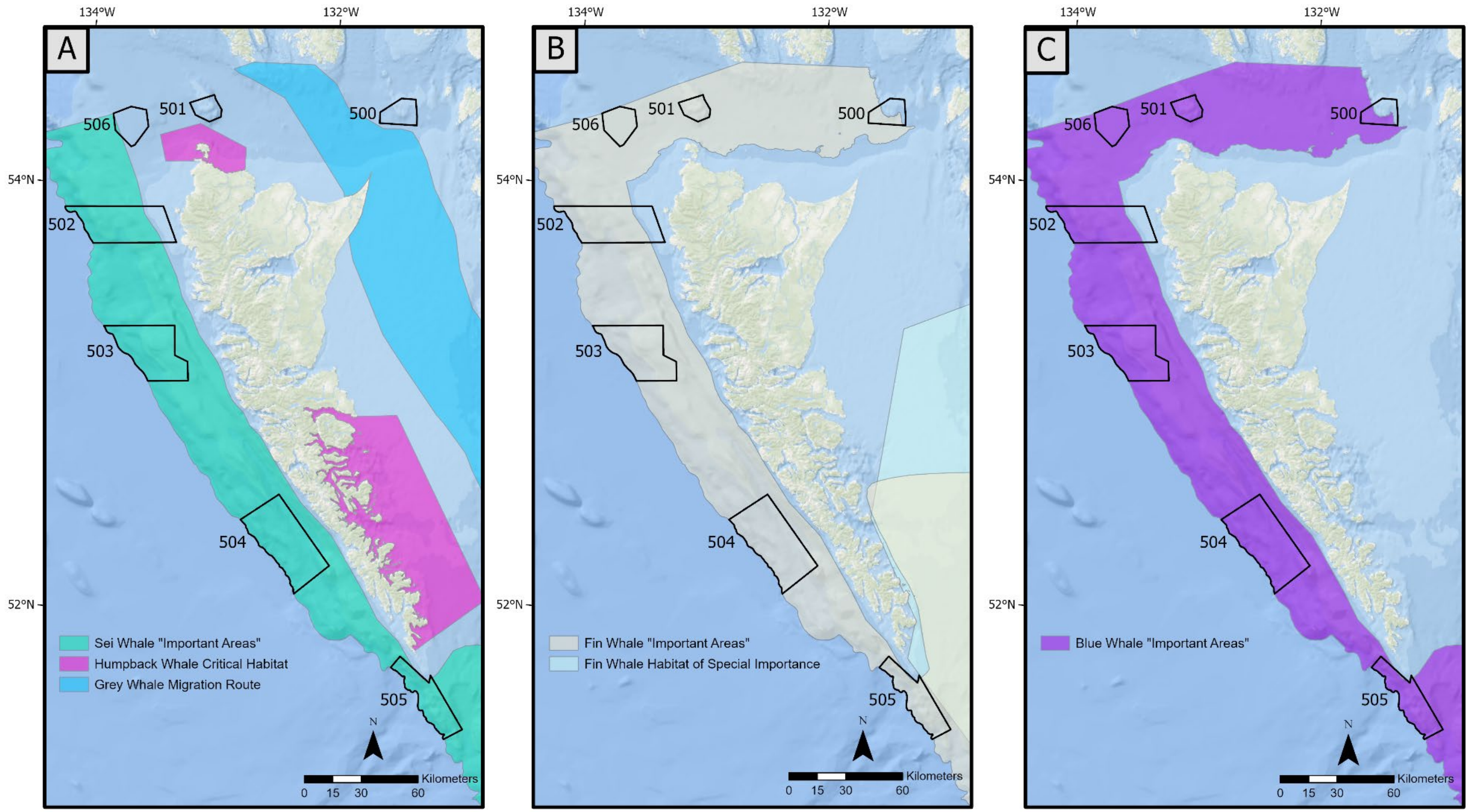

Figure 29. Baleen whale habitats of importance (A) Sei, ***Sgagúud Sg̲ap*** *Humpback and* ***Kún Kun*** *Grey Whales; (B)* ***Kún Kun Xyapxyandal*** *Fin Whales; and (C) Blue Whales. Sei,* ***Kún Kun***, ***Kún Kun Xyapxyandal****, and Blue Whale "Important Areas" were determined by expert opinion from the Pacific North Coast Integrated Management Area data (2007–2012). Sgagúud Sg̲ap habitats were determined by expert opinion from the* Species at Risk Act *recovery strategy meeting (2009–2013). Kún Kun migration route is a spatial polygon drawn around location points of satellite-tagged Kún Kun (Ford et al. 2013a). Kún Kun Xyapxyandal habitats of special importance were identified as important for foraging/feeding, as well as possible courtship/mating and calving habitat (DFO 2017c).*

Sei Whales (*Balaenoptera borealis)* have been observed in six of the OHGNZ (Table 19, Figure 29a). Their diet comprises large amounts of fishes (Pikitch et al. 2014; Takahashi et al. 2022), and they occupy the middle trophic level (Gale et al. 2019). In BC, Sei Whale diets have consisted of copepods and euphausiids and fishes (including Pacific Saury, Pacific Hake, lantern fishes, **'íináang iinang** *Pacific Herring*; Flinn et al. 2002). This species undertakes seasonal migrations between high-latitude summer foraging grounds and low-latitude winter breeding grounds (Ford 2014). Sei Whales are typically found offshore in areas more than 1,000 m deep and rarely occur in coastal waters (Workman et al. 2007; Ford 2014). In the NSB, historical records of Sei Whale occurrences exist for deep slope areas (Heise et al. 2007). Sei Whales are designated as Endangered (IUCN, COSEWIC, SARA; Table F.1). Due to its current low abundance, the species is unlikely to be an ecologically important ecosystem component in the NSB (Gale et al. 2019).

Sgagúud Sg̲ap *Humpback Whale* (*Megaptera novaeangliae*) diets are more varied than the other baleen species in the NSB, feeding on schooling fishes (**'íináang iinang** *Pacific Herring* in northern BC) and zooplankton, including copepods, crab larvae and their main prey of euphausiids (Ford 2014). The species is not predicted to occur within any of the five modelled zones. However, the southernmost zone, 505, is close to the submarine canyons with increasing predicted densities. Expert opinion a decade ago suggested Sgagúud Sg̲ap aggregations in Zones 505 and 502, and distribution data also supports this species' occurrence in Zones 504, 506, 501, and 500. Sgagúud Sg̲ap critical habitat areas as of 2013 (Figure 29) were identified in proximity to Zones 505, 506, and 501. Furthermore, compared to previous models Wright and colleagues (2021) conclude that the Sgagúud Sg̲ap *Humpback Whale* population is moderately increasing due to immigration or population growth, particularly in **Síigee** *Dixon Entrance* and south of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*. Sgagúud Sg̲ap *Humpback Whales* are a highly migratory species, travelling between temperate summer feeding areas (e.g., northern BC) and warm winter breeding areas (e.g., Hawaiian waters; Ford 2014). The time spent feeding in BC and Alaska on herring during the summer months is thought to be one, albeit small, reason for the delayed recovery of 'íináang iinang stocks in these areas (NMFS 2014; Surma and Pitcher 2015). Despite their increasing population size, Sgagúud Sg̲ap *Humpback Whales* are increasingly exposed to anthropogenic impacts, including vessel strikes, entanglements, acoustic pollution, oil spills and a reduction in food resources (Calambokidis *et al*. 2008; Ford *et al*. 2009; Pêches et Océans Canada 2013).

Although distribution data for **Kún Kun** *Grey Whales* (*Eschrichtius robustus*) in the OHGNZ does not suggest its occurrence overlapping with any of the seven zones, Zone 500 is in close proximity to a migration corridor for this species (Ford et al. 2013a; Figure 29a). Kún Kun are highly migratory, with winter breeding areas near Baja California and summer feeding areas in the North Pacific (Ford 2014), similar to **Sgagúud Sg̲ap** *Humpback Whales*. Kún Kun have relatively high abundances in the waters around **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*, particularly off the north and south coasts (see Gavrilchuk and Doniol-Valcroz 2021). Kún Kun primarily use coastal habitats for breeding, calving, migrating and feeding. Kún Kun occupy the middle-trophic level and primarily eat benthic and epibenthic invertebrates (Pauly et al. 1998; Gaichas et al. 2010; Ford et al. 2013a, Ford 2014) but occasionally feed in surface waters on pelagic zooplankton (Ford 2014). When foraging on amphipods and crustaceans, Grey Whales have been observed in shallow bays and water (ranging from less than 3 m to less than 35 m; Gavrilchuk and Doniol-Valcroz 2021). Kún Kun *Grey Whales* can impact benthic communities through their feeding method of sieving large amounts of benthic sediments—during which the mixing and resuspension of sediments result in changes in benthic community diversity, composition and abundance (Oliver and Slattery 1985; Coyle et al. 2007; Feyrer and Duffus 2011; Burnham and Duffus 2016). The Kún Kun *Grey Whale* is a species of "Special Concern" in Canada (COSEWIC 2004) and is a species of conservation priority in the NSB

(Table F.1; Gale et al. 2019). Three populations of Grey Whales have been assessed by COSEWIC that transit the Pacific Region: the Northern Pacific migratory population (Not at Risk), the Pacific Coast feeding group (Endangered), and the Western pacific (Endangered, COSEWIC 2017). Of these populations, the Northern Pacific migratory and the Pacific Coast feeding group use X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay's marine waters. The Pacific Coast feeding group feeds in the waters between Alaska and northern California, and utilizes the same feeding sites annually.

Kun K'uuan *Minke Whales* (*Balaenoptera acutorostrata*) were observed in three of the OHGNZ, including those in **Síigee** *Dixon Entrance* (Zones 501 and 500). Kun K'uuan feed primarily on fishes (e.g., **'íináang iinang** *Pacific Herring*, Pacific Saury, Northern Anchovy, Walleye Pollock, and Pacific Sand Lance) and euphausiids (Pauly et al. 1998; Ford 2014). Occurrences within the OHGNZ and throughout the BC coast of Kun K'uuan are likely to be limited to summer months (July and August) before migrating from BC waters in the winter months to southern breeding areas (Ford 2014), similar to both **Sgagúud SG̲ap** *Humpback* and **Kún Kun** *Grey Whales.*

Toothed Whales

Six toothed whale (Odontocetes) species are found in the OHGNZ (Table 20), which are all conservation priorities for the NSB (Table F.1; Gale et al. 2019). The **Kún k̲aj G̲ajaaw Kun k̲aajii G̲aajaawuu** *Sperm Whale* (*Physeter macrocephalus*) is the only non-Delphinid toothed whale found in the OHGNZ. **Kún k̲aj G̲ajaaw Kun k̲aajii G̲aajaawuu** are top predators occurring mainly along the continental shelf break (Ford 2014), and found in aggregations in Zones 502–506 of the OHGNZ (Table 20, Figure 30), occupying the waters of **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii.*

While beaked whale species could occur in the OHGNZ, due to a lack of available data and their relative rarity (Gale et al. 2019), they are not presented here. Note however, that Baird's Beaked (*Berardius bairdii*) Whale kills have been observed offshore of **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii* (Heise et al. 2003). More recently, Baird's Beaked Whales have been visually observed to the south of X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay, and Cuvier's Beaked Whale (*Ziphius cavirostris*) and Baird's Beaked Whale clicks were identified in acoustic surveys near Zone 504 (Gowgaia Slope hydrophone; Frouin-Mouy et al. 2022).

The **SG̲áan SG̲aana** *Orcas/Killer Whales* (*Orcinus orca*) are primarily composed of three distinct ecotypes within **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii* waters—Northern Resident Killer Whales (COSEPAC 2008; Pêches et Océans Canada 2018), Offshore Killer Whales (Pêches et Océans Canada 2018), and west coast Transient Killer Whales (also known as Bigg's Killer Whales; Pêches et Océans Canada 2018). SG̲áan SG̲aana are long-lived apex predators, however the three ecotypes differ in diet and foraging behaviour, acoustic behaviour, morphology, and genetic characteristics (Ford 2014). Despite having overlapping ranges, these ecotypes do not mix and are thus socially and reproductively isolated from each other.

Table 20. Toothed whale species occurrences or expected distribution in the Offshore Haida Gwaii Network Zones. SG̲áan Sg̲aana Killer Whales (Orcinus orca) are represented by three ecotypes within the OHGNZ and their occurrence is listed separately. Three types of data are presented: (1) Obs., which represents a combination of direct observation of the species (e.g., visual survey) and their estimated densities per survey grid cell; (2) Pred., where the predicted density of cetacean species was greater than 0.5 according to the Wright et al. 2021 model; and (3) Exp., where the occurrence of the species is indicated by expert opinion (e.g., Aggregation, Rookery). Note that where more than one source of data provides differing information they are provided as separate rows. Species occurrence is denoted with an X. Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1). Cells shaded in green are known occurrences, predicted densities with a value >0.5, or expert opinion habitat areas of importance. Dashes in cells denote no data, or predicted or known species absence.

		Duu Gúusd Daawxuusda Zones				**Síigee Zones**			**Data Type**	**Source***
Common Name	**Scientific Name**	**505**	**504**	**503**	**502**	**506**	**501**	**500**		
Northern Right Whale Dolphin	***Lissodelphis borealis***	X	-	-	-	-	-	-	Obs.	DFO
Pacific White Sided Dolphin	***Lagenorhynchus obliquidens***	X	X	-	X	-	-	-	Obs.	DFO
Killer Whale	***Orcinus orca***	X	-	-	X	-	X	X	-	See sources below
Northern Resident Killer Whale ecotype		-	-	-	-	-	Potential Critical Habitat	Socialization Migration	Exp.	PNCIMA
		-	-	-	-	-	X	X	Obs.	DFO
Transient Killer Whale ecoytpe		-	-	-	Habitat of Special Importance	-	-	-	Exp.	PNCIMA
		-	-	-	X	-	-	-	Obs.	DFO
Offshore Killer Whale ecoytpe		X	-	-	-	-	X	-	Obs.	DFO 2018d
Sperm Whale	***Physeter***	Aggregation					-	-	Exp.	PNCIMA

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones				Síigee Zones			Data Type	Source*
		505	504	503	502	506	501	500		
	macrocephalus	X	X	X	X	X	-	-	Obs.	DFO
Harbour Porpoise	***Phocoena phocoena***	X	-	-	-		-	-	Obs.	DFO
		-	-	-	-	-	-	X	Pred.	Wright
Dall's Porpoise	***Phocoenoides dalli***	X	X	X	X	-	X	X	Obs.	DFO
		X	X	X	X	-	-	X	Pred.	Wright
Total Species Richness		6	3	2	4	1	2	3	-	-

*PNCIMA: Pacific North Coast Integrated Management Area (PNCIMA) data were collected between 2007–2012 and reflect the best information available during that time frame. DFO: Observations and normalized density estimates of marine mammals from three data sources: Fisheries and Oceans Canada (DFO; 2002–2017), Raincoast Conservation Foundation (2004-2008), and the North Pacific Pelagic Seabird Database (NPPSD; 1975–2012). K'áang K'aang Dall's Porpoise, Kún Kun Xyapxyandal Fin Whale, Skál skul Harbour Porpoise, Sgagúud Sgap Humpback Whales, Pacific White-sided Dolphin, and Kun K'uuan are derived from all three data sources; Kún Kun Grey Whales and Kún kaj Gajaaw Kun kaajii Gaajaawuu Sperm Whale are derived from the DFO and NPPSD data; and Northern Right Whale Dolphin is derived only from the DFO data. Wright: Wright et al. 2021.

SG̲áan Sg̲aana *Northern Resident Killer Whales* prey mainly on salmon (**T'áaw'un Taag̲un** *Chinook* and some **Sk'aga Sk'aagii** *Chum*), other demersal fishes and some squid. T'áaw'un Taag̲un are the least abundant but most energy-rich salmon species, which they feed on during summer, switching to Sk'aga Sk'aagii in the fall (Ford and Ellis 2006). Although the pelagic salmon data for the OHGNZ is sparse (see previous "Pelagic Fishes" section), **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* provides key salmon-bearing rivers for T'áaw'un Taag̲un and Sk'aga Sk'aagii populations. SG̲áan Sg̲aana have been documented in Zones 501 and 500 in **Síigee** *Dixon Entrance* (Table 20, Figure 30a). SG̲áan Sg̲aana move to coastal areas to feed on spawning salmon in the summer and fall and move out to deeper outer coast waters off Vancouver Island in the winter months (Ford 2014; Ford et al. 2017). Their known range is from Alaska to Washington, and they occur over much of the continental shelf (COSEWIC 2008). SG̲áan Sg̲aana population size increased by 2.5% from 2020 to 2021, with an increasing population size of various magnitude noted since 2011 (DFO 2022e).

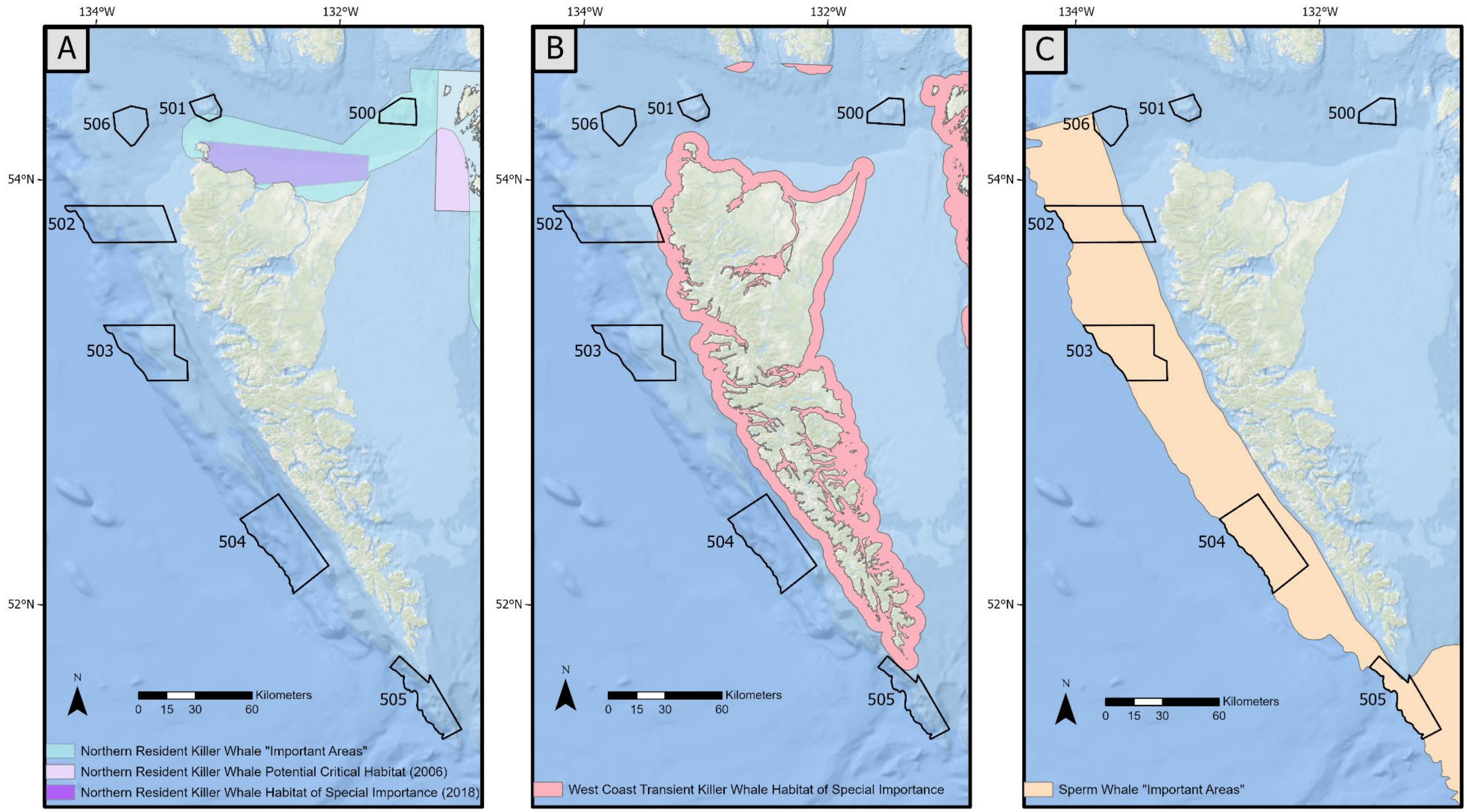

Figure 30. Toothed whale habitats of importance (A) Northern Resident Killer Whale; (B) West Coast Transient Killer Whale; and (C) Sperm Whales. Northern Resident Killer Whale and Sperm Whale "Important Areas" determined by expert opinion from the Pacific North Coast Integrated Management Area data (2007–2012). Northern Resident Killer Whale Potential Critical Habitat (Ford 2006) and habitats of Special Importance (DFO 2018e). West Coast Transient Killer Whale Habitat of Special Importance as suggested by Ford et al. 2013b to be marine waters up to 3 NM from shore.

The Offshore Killer Whale population occurs throughout Canadian Pacific waters, representing approximately one-fifth of their known range. Offshore Killer Whales also feed on fishes and may specialize on **K'aad aw K'aaxada awga** *sharks*, including Pacific Sleeper Sharks, Blue Sharks and **K'aad K'aaxada** *Spiny Dogfish* (Ford 2014), all of which occur in the OHGNZ (Table 15). Although direct observations of Offshore Killer Whales are rare due to their pelagic nature and large ranges (Ford 2014), they have been observed within the OHGNZ in Zones 505 and 501 (Table 20). Rarely found in inshore water, their range is thought to be, at minimum, from coastal waters to the continental shelf-edge (Ford *et al*. 2014; DFO 2018). In 2013, the population abundance of Offshore Killer Whales was estimated to be approximately 300 animals (range of 257 to 373), and the population trend appears to be stable (Ford et al. 2014).

Transient Killer Whales – also known as Bigg's Killer Whales – specialize on marine mammal prey, although they occasionally kill and eat **Xedíit Siigaay xidid** *seabirds* as well, and are the most genetically divergent of the three ecotypes, warranting distinct species status. Two subpopulations of West Coast Transient (WCT) Killer Whales likely occur within the OHGNZ – the "inner coast" WCT Killer Whales and the "outer coast" WCT Killer Whales. Together, these two subpopulations make up a population of about 500 individuals. The "inner coast" WCT Killer Whales are commonly found in inshore, protected waters and in nearshore waters along the exposed west coasts of Vancouver Island and **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii*, and the "outer coast" WCT Killer Whales that are that rarely encountered, occur mostly in deeper waters closer to the continental shelf break (DFO 2013b). The West Coast Transient population is found in waters from Alaska to Oregon, including all coastal areas of BC to an unknown distance offshore (COSEWIC 2008; Ford 2014). Transient Killer Whales may be found in or near Zones 505, 501, and 500 (*sensu* encounter observations DFO 2013b) and have been documented in Zone 502, which also provides a habitat of particular importance (Table 10). West Coast Transient Killer Whale habitats of special importance are suggested to be marine water up to 3 NM from shore (Ford et al. 2013b), in close proximity to Zones 505 and 502 (Figure 30). As opportunistic apex predators of marine mammals, including **Skál Skul** *Harbour Porpoises*, **Káay Kay** *Steller Sea Lions* and **K'áang K'aang** *Dall's Porpoises,* WCT Killer Whales are important components of local food webs (DFO 2013b). WCT Killer Whales tend to move continuously and do not remain long in particular locations due to the wide distribution of their primary prey species in nearshore waters and vulnerability to local resource depression as prey becomes alert to the whales' presence and less vulnerable to predation (DFO 2013b).

K'áang K'aang *Dall's Porpoises* (*Phocoenoides dalli*) are found across coastal and offshore areas of BC throughout the year. They are upper-level predators on fishes (e.g., **'íináang iinang** *Pacific Herring*, Walleye Pollock, Northern Anchovy, Pacific Saury, and sardine, lanternfishes), and squid (Pauly et al. 1998; Ford 2014). K'áang K'aang have high predicted densities of 1 to 5 individuals in the five modelled zones, with the highest densities predicted for Zone 500. Distribution data further supports their occurrence in Zone 501 (Table 10). In BC, K'áang K'aang may shift inshore during summer and offshore during winter, but little information is available supporting this (Ford 2014). In general, K'áang K'aang feed on deeper-water species than **Skál Skul** *Harbour Porpoises* (Ford 2014), which have low occurrence in the OHGNZ. Low densities of Skál Skul (1 individual) are predicted to occur in Zone 500, the only zone included in the model for the OHGNZ. Distribution data have their occurrence in Zone 505 of the OHGNZ and in no other zone (Table 10). By contrast, Skál Skul *Harbour Porpoises* (*Phocoena phocoena*) are typically found in shallower water (< 150 m deep), and are upper-level predators on of squid and fishes (e.g., 'íináang iinang, Walleye Pollock, **Sáaw Saaw** *Eulachon*, Pacific Sand Lance, Pacific Hake, and Northern Anchovy; Pauly et al. 1998; Ford 2014). Skál Skul *Harbour Porpoises* are found year-round in BC (COSEWIC 2003a; Ford 2014). While there is limited evidence of Skál Skul *Harbour Porpoises* migrating, most research has been limited to their behaviour in the Salish Sea (COSEWIC 2003a). The Skál Skul *Harbour Porpoise* is listed as a species of "Special Concern" in Canada's Pacific waters (COSEWIC 2003a). It is a conservation priority species in the NSB (Table F.1, Gale et al. 2019).

The Northern Right Whale Dolphin (*Lissodelphis borealis*) occurs in **Gangxid Kun Sgaagiidaay** *Cape St. James* (Zone 505), and the Pacific White-sided Dolphin is found in Gangxid Kun Sgaagiidaay (Zone 505), Gwaii Haanas Extension (Zone 504) and **Sasga K'ádgwii** *Offshore Continental Slope North* (Zone 502). Northern Right Whale Dolphins feed primarily on fishes and squid (Pauly et al. 1998; Ford 2014). They form large schools in deeper waters, beyond the continental slope, and are rarely found on the continental shelf in BC (Ford 2014). Due to their preference for deep oceanic waters, they are not thought to be a consistently important ecosystem component in the NSB (Gale et al. 2019). When they occur in offshore BC waters (like those off **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* in the OHGNZ), it is more likely to occur during the summer and warm-water years (Ford 2014). Pacific White-sided Dolphins (*Lagenorhynchus obliquidens*) 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 fishes (**'íináang iinang** *Pacific Herring*, adult and juvenile salmon Capelin, **Skíl Skil** *Sablefish*, Walleye Pollock), squid, and shrimp in BC (Morton 2000; Ford 2014).

Pinnipeds

Káay Kay *Steller Sea Lions* (*Eumetopias jubatus*) and Northern Fur Seals (*Callorhinus ursinus*) are the only documented pinnipeds within the OHGNZ. Káay Kay are documented to occur in **Gangxid Kun Sgaagiidaay** *Cape St. James* (Zone 505), a rookery site (Figure 31; Olesiuk 2018). Káay Kay are upper-level predators, feeding on a variety of fishes (**'íináang iinang** *Pacific Herring*, Pacific Hake, Pacific Sand Lance, **K'aad K'aaxada** *Spiny Dogfish,* **Sáaw Saaw** *Eulachon*, Pacific sardine, and **Ts'íi.n Chiina** salmon) and invertebrates (COSEWIC 2003b; Ford 2014). They have also been noted to eat demersal fishes (**K'ats Sgaadang.nga** *rockfishes*, **T'ál T'aal** *Arrowtooth*, **Ts'íit'aa Ts'iiga** *skates*), cephalopods, seal and fur seal pups, and gulls (Ford 2014). Although a non-migratory species, individual Káay Kay feed up to 200 km offshore from their haulout sites (Bigg 1985; COSEWIC 2003b; Ford 2014), and males will move seasonally northward from California and Oregon into BC and Alaska (Bigg 1985; COSEWIC 2003b). Káay Kay come from two populations in British Columbia – eastern stock (California to Southeast Alaska) and western stock (Gulf of Alaska, Bering Sea, Aleutian and Commander Islands, and Sea of Okhotsk). Káay Kay are listed as ''Special Concern'' in the *Species at Risk Act* (SARA) because of human disturbance, risk of oil spills and environmental contaminants (COSEWIC 2003a; Olesiuk 2018) and are a species of conservation priority in the NSB (Table F.1, Gale et al. 2019). While the western stock of the species, north of the NSB, has declined by 80% during the last three decades across its entire range (National Research Council 2003), the eastern population of Káay Kay in British Columbia has increased approximately four-fold since the early 1900s and with the species' protection in 1970 (DFO 2020e). Recolonization and expansion of rookeries, as well as expansion of year-round and winter haulouts has occurred within the Pacific Region. Káay Kay abundance in BC is now estimated to be higher than levels thought to have been present in the early 1900s before any large-scale kills (DFO 2020e).

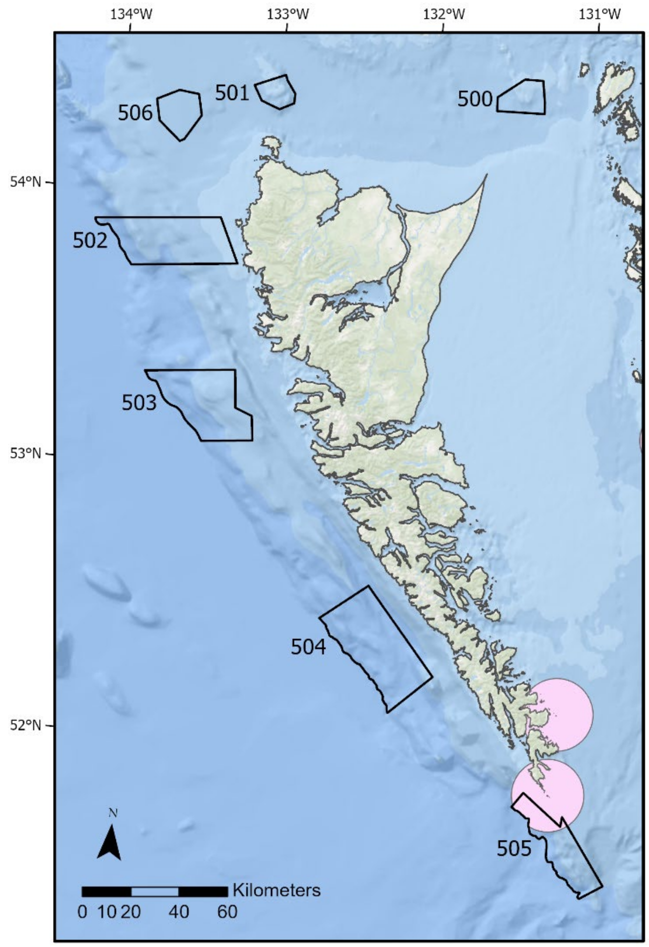

*Figure 31. Steller Sea Lion (*Eumetopias jubatus*) rookery locations (pink circles) from DFO surveys (Olesiuk 2018). Point locations of rookeries were digitized and buffered by 15 km to account for foraging behaviour of females feeding their young.*

Northern Fur Seals (*Callorhinus ursinus*) were recently documented to occur in visual observation over the SAUP 5494 seamount in **Sasga K'ádgwii** *Offshore Continental Slope* (Zone 502; Northeast Pacific Deep-Sea Diversity Expedition 2022, see Observations at Sea in 2022 section). The species is abundant and well distributed in BC, although categorized as threatened (COSEWIC 2006), and not well documented in the OHGNZ. They are often sighted offshore travelling through BC between California and their breeding colonies in Alaska and Russia (Ford 2014).

4.2.3.2. Reptiles

'Waahúu Tang.gwan Siiga *Leatherback Sea Turtle* (*Dermochelys coriacea)*, the only reptile documented to occur in the OHGNZ, is a large, pelagic, highly migratory reptile which makes foraging migrations to British Columbia from nesting sites in the Western and Eastern Pacific. The population that occurs seasonally in coastal BC waters is genetically distinct, and nationally significant (Équipe de rétablissement de la tortue luth 2006). Adult individuals can be found in cooler waters, including the continental shelves off Canada (Shoop and Kenney 1992), following oceanic frontal systems where high productivity results in increased concentrations of prey (Lutcavage 1996). Although observations of 'Waahúu Tang.gwan Siiga have only occurred in Zone 506 and close to Zones 505 and 502 (Figure 32), the offshore region of the OHGNZ is considered to be an important feeding area for 'Waahúu Tang.ḵwan Siiga. Six of the seven zones provide important food resources for migrating turtles (Figure 32; Table 21). 'Waahúu Tang.ḵwan Siiga have a unique diet, focusing on soft-bodied pelagic invertebrates like jellyfish and tunicates (Bleakney 1965; Davenport and Balazs 1991). Jellyfish are very high in water content and low in nutritional value, consequently, 'Waahúu Tang.ḵwan Siiga must range widely to find jelly aggregations, which are often along coastal upwelling areas and oceanic frontal systems (Lutcavage and Lutz 1986; Shoop and Kenney 1992). Furthermore, conclusions about population trends cannot be drawn since the documentation of sightings in British Columbia's coastal waters is extremely limited (Équipe de rétablissement de la tortue luth 2006). However, the adult leatherback turtles that forage in Canadian waters are the largest, most cold-tolerant and most fecund individuals of the species and are, therefore a key component of the species' viability despite limited observations (Équipe de rétablissement de la tortue luth 2006). The OHGNZ provides an important feeding area for 'Waahúu Tang.ḵwan Siiga, and the limited direct observation of the species within the seven zones does not rule out this utility area to the species' population growth.

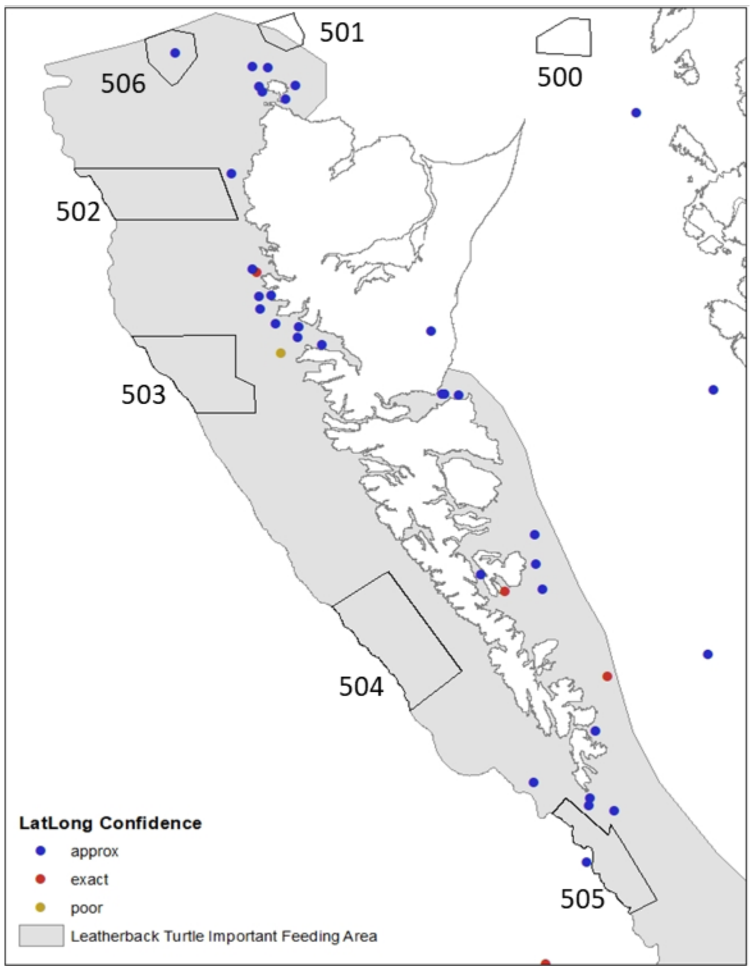

*Figure 32. '**Waahúu Tang.ḵwan Siiga** Leatherback Sea Turtle (*Dermochelys coriacea*) sightings (data comes from DFO/BCCSN questionnaires, surveys, hotline reporting, and publications; data provided by Lisa Spaven) and important feeding areas (grey shaded area; PNCIMA Atlas) in the Offshore Haida Gwaii Network Zones (black outlined areas). Most locations are approximations and may include dead individuals that drifted from their original location. Zone numbers are provided in text outside each zone polygon.*

Table 21. 'Waahúu Tang.ga̲wan Siiga Leatherback Sea Turtle occurrences or expected distribution in the Offshore Haida Gwaii Network Zones. Two types of data are presented: (1) Obs., which represents of direct observations of the species (e.g., visual survey); and (2) Exp., where the occurrence of the species is indicated by expert opinion (e.g., Important Feeding Area). Note that where more than one source of data provides differing information they are provided as separate rows. Species occurrence is denoted with an X, predicted or known absence is denoted with a dash. Dashes in cells denote no data indicating occurrence. Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1). Cells shaded in green are known occurrences, or expert opinion habitat areas of importance.

Common Name	Scientific Name	Duu Gúusd Daawxuusda Zones 505	504	503	502	Síigee Zones 506	501	500	Data Type	Source*
Leatherback Sea Turtle	***Dermochelys coriacea***	Important Feeding Area	Important Feeding Area	Important Feeding Area	Important Feeding Area	Important Feeding Area	Important Feeding Area	-	Exp.	PNCIMA
		-	-	-	-	X	-	-	Obs.	DFO; see Figure 31

*PNCIMA: Pacific North Coast Integrated Management Area (PNCIMA) data were collected between 2007–2012 and reflect the best information available during that time frame; DFO: data comes from DFO/BCCSN questionnaires, surveys, hotline reporting, and publications; provided by Lisa Spaven.

4.2.4. X̲edíit Siigaay x̲idid Marine Birds

X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay *Haida Gwaii* supports globally, nationally, and regionally important concentrations of **X̲edíit Siigaay x̲idid** *marine birds*. Nearshore and offshore marine habitats support millions of X̲edíit Siigaay x̲idid, such as **Sk'áay Sk'aay** *albatrosses*, petrels, shearwaters, waterfowl, and shorebirds during migration and non-breeding periods. In addition, approximately 1.5 million X̲edíit Siigaay x̲idid breed on the islands and islets of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay, including alcids (auklets, guillemots, murrelets, murres, **K̲wa.anaa K̲uux̲aana** puffins), gulls, loons, shorebirds, storm-petrels, and waterfowl (Harfenist 2003). At least 35 species of X̲edíit Siigaay x̲idid have been observed within the OHGNZ (Table 22), however, this species list is considered by experts to underrepresent the species that use these habitats (C. Fox, K. Morgan, ECCC-CWS, personal communication, 2022). Furthermore, of those 35 species, all but 12 are considered conservation priorities within the NSB (Gale et al. 2019; Table 22, Table F.1).

Table 22. Xediít Siigaay xidid Marine bird species occurrence by zone within the Offshore Haida Gwaii Network Zones. Species occurrence is denoted by an X. Occurrence data was compiled from the North Pacific Pelagic Seabird Database (Drew and Piatt 2015), ECCC-CWS unpublished data (2018), eBird (2022), and Global Biodiversity Information Facility (GBIF 2022). Common and scientific names in bold are conservation priority species (see Gale et al. 2019 and Table F.1). Note the absence of an X does not necessarily mean the bird species or group is absent from that zone. Dashes are used to indicate no data.

		Duu Gúusd Daawxuusda Zones				Síigee Zones		
Common name	**Scientific name**	**505**	**504**	**503**	**502**	**506**	**501**	**500**
Albatrosses, Petrels, Storm-petrels, and Shearwaters								
Black-footed Albatross	***Phoebastria nigripes***	X	X*	X	X*	X	X	X
Laysan Albatross	***P. immutabilis***	X	X	-	X	-	X	-
Fork-tailed Storm-petrel	***Hydrobates furcatus***	X	X	X	X	X	X	X
Leach's Storm-petrel	***Hydrobates leucorhous***	X	X	X	X	X	X	X
Mottled Petrel	***Pterodroma inexpectata***	X	X	-	-	-	-	-
Northern Fulmar	***Fulmarus glacialis***	X	X	X	X	X	X	X
Buller's Shearwater	***Ardenna bulleri***	-	-	-	-	-	X	-
Pink-Footed Shearwater	***Ardenna creatopus***	X	X	X	X	-	-	X
Short-tailed Shearwater	***Ardenna tenuirostris***	X	X	-	-	-	-	X
Sooty Shearwater	***Ardenna grisea***	X	X	X	X	X	X	-
Alcids								
Ancient Murrelet	***Synthliboramphus antiquus***	-	X	X	X	X	-	X
Cassin's Auklet	***Ptychoramphus aleuticus***	X	X	X	X	X	X	X
Parakeet Auklet	***Aethia psittacula***	X	-	-	-	-	X	-
Common Murre	***Uria aalge***	X	X	X	X	-	X	X
Marbled Murrelet	***Brachyramphus marmoratus***	-	X	-	X	-	-	X
Pigeon Guillemot	***Cepphus columba***	X	X	-	X	-	-	X

		Duu Gúusd Daawxuusda Zones				Síigee Zones		
Common name	**Scientific name**	**505**	**504**	**503**	**502**	**506**	**501**	**500**
Rhinoceros Auklet	***Cerorhinca monocerata***	X	X	X	X	X	X	X
Tufted Puffin	***Fratercula cirrhata***	X	X	X	X	X	X	X
Guadalupe or Scripp's Murrelet	*Synthliboramphus hypoleucus or S. scrippsi*	X	-	-	-	-	-	-
Cormorants								
Pelagic Cormorant	***Urile pelagicus***	X	-	-	-	-	-	X
Gulls, Skuas, and Terns								
Black-legged Kittiwake	*Rissa tridactyla*	X	X	-	-	X	-	X
Bonaparte's Gull	*Chroicocephalus philadelphia*	X	-	-	-	-	-	-
California Gull	***Larus californicus***	-	X	-	X	X	-	X
Glaucous-winged Gull	*Larus glaucescens*	X	X	-	X	X	X	X
Herring Gull	*Larus argentatus*	X	X	-	-	-	-	X
Iceland Gull/Thayer's Gull	***Larus glaucoides***	-	X	-	-	-	-	-
Short-billed Gull	*Larus brachyrhynchus*	-	-	-	-	-	-	X
Sabine's Gull	*Xema sabini*	X	-	-	X	X	-	-
Western Gull	*Larus occidentalis*	X	X	-	-	-	-	-
South Polar Skua	*Stercorarius maccormicki*	X	X	X	-	-	-	X
Long-tailed Jaeger	*Stercorarius longicaudus*	X	X	-	X	-	-	-
Arctic Tern	*Sterna paradisaea*	X	X	X	-	-	-	-
Loons								
Pacific Loon	***Gavia pacifica***	-	X	X	-	-	-	X
Ducks, geese, and swans								

Common name	Scientific name	Duu Gúusd Daawxuusda Zones 505	504	503	502	Síigee Zones 506	501	500
Snow Goose	*Anser caerulescens*	-	-	-	-	-	X	-
Shorebirds								
Red-necked Phalarope	***Phalaropus lobatus***	X	-	X	-	-	X	X
Zone Species Richness		27	26	15	18	13	15	22

*Also observed in the 2022 Northeast Pacific Deep-Sea Diversity Expedition (Pac2022-035).

X̲edíit Siigaay x̲idid *Marine birds* are upper-level predators within marine food webs. Their habitat use is reflective of ocean productivity and the distribution and availability of lower trophic prey, such as zooplankton and fishes, across both temporal and spatial scales (Serratosa et al. 2020). X̲edíit Siigaay x̲idid abundance, distribution, and species richness is associated with areas of high productivity and bathymetric features that result in concentrations of prey (such as the continental slope and shelf break, seamounts, canyons, troughs, and eddies), as well as proximity to breeding colonies (Yen et al. 2004; Clarke and Jamieson 2006; Kenyon et al. 2009; Santora et al. 2018). Availability of macrozooplankton such as krill and copepods are important drivers for breeding phenology, productivity, and distribution of planktivorous X̲edíit Siigaay x̲idid that breed and use marine habitat in **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* such as **Hajaa Hajaa** *Cassin's Auklet* (Bertram et al. 2005; Bertram et al. 2017a; Bertram et al 2017b). Zooplankton species are also prey for fish species eaten by X̲edíit Siigaay x̲idid, such as Pacific Sand Lance, Pacific Saury, **'íináang iinang** *Pacific Herring*, juvenile **K̲'ats Sgaadang.nga** *rockfishes*, and juvenile **Ts'íi.n Chiina** *salmon* (Burger et al 2011). Consequently, climate-driven variation in the distribution, abundance, and phenology of low trophic-level organisms can have cascading effects within marine food webs (Hipfner et al. 2020). X̲edíit Siigaay x̲idid provide an integrated response to climate change because their breeding phenology, productivity, and distribution are so closely linked to marine resources. Similarly, X̲edíit Siigaay x̲idid can be valuable indicators of ocean health because their breeding habitats remain static, while the availability of their food resources is dynamic in both time and distribution (Sydeman et al. 2015; Sydeman et al. 2021).

Although **X̲edíit Siigaay x̲idid** *marine bird* abundance and distribution have been documented in the terrestrial and nearshore areas of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*, there is an ongoing need for information on abundance, distribution, population trends, and foraging and movement ecology (Rodway 1991; Harfenist et al. 2002; Rodway et al. 2016). Baseline scientific data on the distribution, abundance, and species composition of X̲edíit Siigaay x̲idid at sea further offshore from X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay is more limited, primarily due to variability in survey effort and methodology, as well as daily, seasonal, and annual fluctuations in numbers that are common for many X̲edíit Siigaay x̲idid species (Harfenist et al. 2002). Species occurrence data in the OHGNZ (Table 22) were obtained from several sources, including the North Pacific Pelagic Seabird Database (which includes data from the Environment and Climate Change Canada Canadian Wildlife Service (ECCC-CWS) Pelagic Seabird Atlas Database), eBird, and recent unpublished ECCC-CWS data (Drew and Piatt 2015; eBird 2022; ECCC-CWS unpublished data). Species such as **Sk'áay Sk'aay** *albatrosses*, petrels, shearwaters, and fulmars travel vast distances across the Pacific during their non-breeding periods to utilize the marine resources along the continental shelf and shelf break, over seamounts, and other areas with steep bathymetry along the X̲aadáa Gwáay

Xaaydaga Gwaay.yaay and BC coast (Kenyon et al. 2009). Habitats on **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* and the rest of BC are known to support these species for significant proportions of their annual cycle (Beal et al. 2021). Several OHGNZ are located along the length of the continental shelf and shelf break (Zones 505, 504, 503, and 502) and these pelagic Xedíit Siigaay xidid species have been recorded in all zones in the OHGNZ (Table 22). Additionally, an analysis of pelagic Xedíit Siigaay xidid density, conservation status and species richness resulted in a relative grid cell importance score for the pelagic Xedíit Siigaay xidid population of the Pacific Region (Atlas of Pelagic Seabirds off the West Coast of Canada and Adjacent Areas 2009). Within the OHGNZ high values of grid cell importance for pelagic Xedíit Siigaay xidid are present in Zones 505, 504, 502, 506 and 500 (Figure 33). Furthermore, the distribution of high grid cell values along the length of the continental shelf and into **Síigee** *Dixon Entrance* provide further evidence of the importance of Xaadáa Gwáay Xaaydaga Gwaay.yaay's marine waters to pelagic Xedíit populations in the Pacific Region.

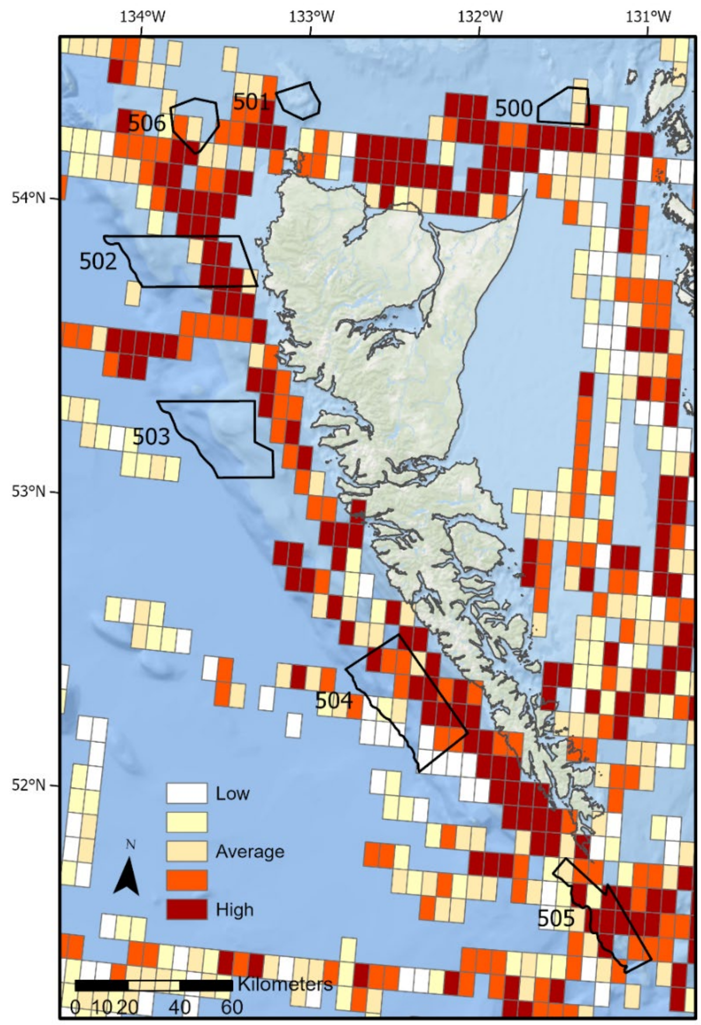

Figure 33. Relative grid cell importance for pelagic ***Xedíit Siigaay xidid*** *marine birds within the Offshore Haida Gwaii Network Zones. For each grid cell, the grid cell importance score was the sum of three standardized values (total bird density, species richness value, species at risk score). Grid shading represents five quantiles, with high being the upper 20% of the cells with the highest grid cell importance values. Data from the Atlas of Pelagic Seabirds off the West Coast of Canada and Adjacent Areas (2009).*

During the boreal breeding season, many marine bird species that nest in **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* are considered central place foragers that feed at sea and then return to colonies to provision young, so foraging areas are often associated with terrestrial breeding colonies. Several of the OHGNZ (Zones 505, 504, 503, and 502) are located along the length of the continental shelf and shelf break and are adjacent to large breeding colonies along **Duu Gúusd Daawxuusda** *the west coast* of *Haida Gwaii*. Some of the larger colonies include those on **Sasga Gwáay** *Frederick Island*, **Nasduu Gwaayee** *Hippa Island*, **Gwaaygiids** *Marble Island*, islands in **Kaysuun Kaahlii** *Englefield Bay*, and **Sgang Gwaay** *Anthony Island*. Species breeding on these islands includes **SGidaanáa Sgin xaana** *Ancient Murrelet*, **Hajaa Haaja** Cassin's Auklet, **Sk'in** *Glaucous-winged Gulls*, Leach's and Fork-tailed Storm-petrels, **Hla.gwaats' Hlaagwaats'ii** *Rhinoceros Auklet*, and **Kwa.anaa Kuuxaana** *Tufted Puffin* (Clark and Jamieson 2006).

Nesting **Xedíit Siigaay xidid** *marine birds* and their eggs are also important to traditional Haida diets, especially **SGidaanáa Sgin xaana** *Ancient Murrelets*. In times of higher bird abundance, Elders recall fondly harvesting SGidaanáa **Sgin xaana** and their eggs in **K'íis Gwáay** *Langara Island*, and Gwaii Haanas (Haida Marine Traditional Knowledge Study Participants et al. 2011c). The adult Xedíit Siigaay xidid were considered a delicacy, and SGidaanáa Sgin xaana and seagull eggs were boiled or used in baking. Xedíit Siigaay xidid observations would indicate forage fish associations, as well as location in the ocean, providing fishers orientation in the fog through knowledge of bird species (Haida Marine Traditional Knowledge Study Participants 2011c). Haida knowledge keepers noted the recent declines in **Xedíit Siigaay xidid** as a result of invasive species (rats and raccoons), large fishing lodge development on nesting sites, and declines in their food.

Siigaay xidid *Marine bird* concentrations around **Sgang Gwaay**, Kerouard Islands, and St. James Island adjacent to the **Gangxid Kun Sgaagiidaay** *Cape St. James* (Zone 505) are particularly diverse with globally and nationally significant numbers of at least seven species of Siigaay xidid recorded in the area[11] and large aggregations of shearwaters observed in the waters near the Haida Eddy (Clarke and Jamieson 2006). Using the data compiled for this report (Table 22), Gangxid Kun Sgaagiidaay (Zone 505) has a Siigaay xidid species richness of 27 species, the highest of all the zones. **Tsaan Kwaay** *Offshore Learmonth Bank Site* (Zone 501) is known for high concentrations of zooplankton and alcids, many likely from nearby colonies on **K'íis Gwáay** *Langara Island*. **Sasga K'ádgwii** *Offshore Continental Slope North* (Zone 502) overlaps the marine component of an internationally recognized Important Bird Area, which is centred around the largest **Xedíit** *seabird* colony in **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* on **Sasga Gwáay** *Frederick Island* (IBA Canada). **Kadlee** *Offshore Celestial Reef* (Zone 500) hosts a wide diversity of Xedíit, including shearwaters, alcids, loons, and waterfowl. This offshore area is adjacent to important feeding and migration stopover areas at McIntyre Bay and **Ja.a Xwii Xyaang** *Dogfish Banks*, which for wintering and migrating waterfowl, including sea ducks and brant (IBA Canada, Bowman et al. 2022). Xedíit surveys and remote sensing information were used by Fox et al. (2017) to generate seasonal and overall predictions of areas important to Xedíit along the north and east coasts of Xaadáa Gwáay Xaaydaga Gwaay.yaay. These models provide support for the importance of Xedíit habitats within the Tsaan Kwaay (Zone 501) and Kadlee (Zone 500), particularly in spring months when use by migrants is greatest.

[11] Important Bird Areas (IBA) Canada. Site summary: Kerouard and St. James Islands, Haida Gwaii, British Columbia.

Recent research studies using tracking technology have improved understanding of foraging behavior and habitat use in offshore areas, with **SG̲idaanáa Sg̲in x̲aana** *Ancient Murrelet* foraging maximum distances varying from 80–107 km from colonies on east coast of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* (Pattison 2020), and **Hajaa Haaja** *Cassin's Auklets* foraging a maximum average distance of 75 km from Triangle Island, BC (Domalik et al. 2018). Recent studies on Leach's and Fork-tailed Storm-petrels in X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay and the west coast of Vancouver Island indicate that these birds fly thousands of kilometres from colonies to forage (Halpin et al. 2018; G. McClelland, ECCC-CWS, personal communication, 2022). Although there are few observed locations from these tracking studies within the OHGNZ, it is likely that the same species breeding at colonies on **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii* are using offshore zone habitats in similar ways.

4.2.5. Observations at Sea in 2022

Recent field surveys in the summer of 2022 occurred within the Offshore Haida Gwaii Network Zones; logbook records and direct observations of species through various surveys (direct observation, ROV imagery, etc.) further confirm continued use of the network zones by different species. Some highlights are detailed following. The Northeast Pacific Deep-Sea Diversity Expedition (Pac2022-035) occurred from June 7–28, 2022, as a partnership between the Council of the Haida Nation, Fisheries and Oceans Canada, Nuu-chah-nulth Tribal Council and Ocean Networks Canada. Two zones in **Duu Gúusd Daawxuusda** *the west coast* of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* were surveyed for oceanography (**Sasga K̲'ádgwii** *Offshore Continental Slope North* and Gwaii Haanas Extension), and the first remotely-operated vehicle (ROV) dive was conducted at the SAUP 5494 seamount in Sasga K̲'ádgwii. Opportunistic observations of **X̲edíit Siigaay x̲idid** marine birds and mammals were recorded in these zones, and **Sk'áay Sk'aay** *Black footed albatrosses* were observed in both zones. Marine mammal sightings at Gwaii Haanas Extension included either **K̲'áang K̲'aang** Dall's Porpoises or Pacific White-sided Dolphins, and Northern Fur Seals at Sasga K̲'ádgwii. The ROV dive at SAUP 5494 seamount included observations (and some sampling) of crustaceans (**Huuga Huuga** *Tanner Crabs*, stalked barnacles), gastropods, echinoderms (brittle stars, crinoids, sea pigs), polychaetes, corals, carnivorous sponges, jellyfish, sea pens, anemones, snailfish, Deep-sea Sole and **Tsíit'aa Ts'iig̲a** *skates*. The Northeast Pacific Deep-Sea Diversity Expedition 2022 report is not yet published; however, the ROV footage and dive log annotation data are openly-available on Ocean Network Canada's SeaTube V3 website.

4.2.6. Ecological Sensitivities, Resilience and Recoverability

In the following sections we provide a general overview of the ecological sensitivities, resilience and potential recoverability of significant species and taxonomic groups that occur within the OHGNZ, which have been documented in earlier sections of this report. Sensitivities in this context is defined as "highly susceptible to degradation or depletion by human activity or by natural events". This definition may apply to species and/or habitat features (DFO 2019b). Resilience for this report is the "capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"; and/or "the ability of an ecosystem to return to an equilibrium or steady-state following a perturbation" (O et al. 2015, as used in DFO 2019b). Recoverability is "the time required for a component to return to a pre-stress level once the stressor is removed" (O et al. 2015). Resilience and recoverability were not determined for each species, and are only generally referred to where information for that species or taxonomic group is readily available. The taxonomic groupings for this section are as follows: invertebrates, fishes (demersal (groundfishes and demersal sharks and skates) and pelagic (pelagic fishes and pelagic sharks and skates)), marine mammals and reptiles, and marine birds.

4.2.6.1. Invertebrates

Marine invertebrates experience natural and anthropogenic stressors that differentially affect their sensitivities and resiliences based on their taxnomy and life history. Corals and sponges are characterized by a relatively slow growth rate (<1 cm per year to few cm per year; Leys and Lauzon 1998), long lifespan (decades up to over 2,000 years; Leys and Lauzon 1998), physical fragility, and late age of sexual maturity, which make them particularly sensitive or vulnerable to changes in their environment through either anthropogenic or natural means (DFO 2015). Impacts on cold-water corals and sponges caused by anthropogenic activities occur through either direct removal or damage, indirect damage, or climate change and ocean acidification-related threats (DFO 2015). These threats may kill or damage the organism or parts of a colony, or leave them more susceptible to disease or parasites. They may also act together with additive or multiplicative consequences. Key anthropogenic activities in the OHGNZ threatening sponge and coral populations include fishing, climate change and ocean acidification, potential oil and gas exploration, and potential pollution, among others (DFO 2010).

Bottom-contact fishing, such as bottom trawling, bottom long-line fishing and bottom trap fishing, has caused the greatest direct impact to cold-water corals and sponges through removal or damage. Of the corals, Scleractinians (stony corals) are both ecologically important and vulnerable to fishing activities (Fuller et al. 2008) because of their life history characteristics highlighted above. Black corals (Antipatharia) and soft corals (Alcyonacea, including Gorgonians) also have traits that make them vulnerable to disturbance, including slow growth rates, low fecundity, low recruitment, and low natural mortality (Fuller et al. 2008). Cold-water coral and sponge biomass recovery after habitat disturbance can take decades due to slow growth and settlement, and the long lifespans of many species (Leys and Lauzon 1998; Rooper et al. 2011; Baco et al. 2019). Bottom contact fishing activities may also have indirect negative impacts on sponges by creating suspended sediments in the water column (e.g., Jamieson and Chew 2002; Ardron and Jamieson 2006) that can clog their filtration systems (Leys 2013), further hindering their resilience and ability to recover from disturbance.

In addition to the direct and indirect damage caused by fishing activities, climate change is expected to influence the distributions and abundances of corals, sponges and other marine invertebrates. Warming ocean temperatures are thought to be a stressor for cold-water corals and sponges due to their reliance on zooplankton as a primary food source, which may change composition to less energy-rich species and/or be reduced in availability due to warming waters. In addition, warming water and ocean acidification may decrease the availability of carbonate ions and change the depths where carbonate is available in usable form (carbonate is usable; calcium bicarbonate is not usable) for skeleton building, forcing coral populations to disperse or perish (Orr et al. 2005). Similarly, ocean acidification is expected to have a physiological effect on all life stages of crustaceans, echinoderms, bivalves, molluscs, zooplankton, and other organisms that form calcium carbonate shells or exoskeletons (Fabry et al. 2008). The waters at the high latitudes where **Huuga Huuga** *Tanner Crabs* live (as far north as the Bering Sea) are expected to acidify more rapidly than elsewhere (Fabry et al. 2009), and juvenile Huuga Huuga exhibited decreased growth, survival, and calcification under near-future levels of CO_2 in an artificial laboratory setting (Long et al. 2013). Furthermore, mobile benthic invertebrate communities in the North Sea have needed to shift their distributions at different rates and in different directions to respond to changing ocean temperatures, showing movement that lags behind most temperature measures (Hiddink et al. 2015). Such lag effects will have implications for benthic community richness over time as some species will respond quickly and others may not respond in time or be able to tolerate changes in their thermal habitats (Hiddink et al. 2015).

4.2.6.2. Demersal Fishes

Demersal fishes documented in OHGNZ include groundfishes and demersal sharks and rays. Groundfishes are subject to direct and indirect mortality associated with fishing and vessel activities within the OHGNZ. Direct mortality occurs through target and non-target (bycatch) fishing catch, while indirect mortality could occur through many mechanisms, including habitat disturbance, noise pollution, injury from fishing gear, and physiological stress on fishes that escape fishing gear, or are caught and released, that make them more prone to predation risk or disease.

Rockfishes are sensitive to habitat disturbance and fishing activity, as their life history and physiology contribute to high mortality rates. Many rockfish species, particularly shelf and slope rockfishes, are inherently highly vulnerable to fishing activities due to their slow growth rates, episodic recruitment, and long lifespans. In addition, rockfishes have a closed gas bladder and experience barotrauma when brought to the surface from depth (Parker et al. 2006), consequently discarded rockfishes suffer high mortality rates (Hannah and Matteson 2011) and catch-and-release may not help their populations. **K'ats Sgaadang.nga** *Rockfishes* site fidelity and low movement rates also means that once an area has been fished out, it may take many years for the local population to recover via new recruitment (Parker et al. 2000). In addition, fishers will serially deplete populations as they move from one fishing area to another while maintaining high catch rates (Kronlund and Yamanaka 2001). Because of their growth, many K'ats Sgaadang.nga species reach marketable size prior to becoming sexually mature (Parker et al. 2000). As a result, K'ats Sgaadang.nga have little buffering against the effects of reduced lifespan from fishing (Leaman 1991). Furthermore, their high fecundity rates do not appear to enable more rapid recovery from fishing or mitigate extinction risk (Dulvy et al. 2003). Using a combination of life history and ecological parameters Cheung and co-authors (2005) calculated vulnerability of fish species on a scale of 1 to 100, with 100 being the most vulnerable; most inshore rockfish species had scores above 60 and as high as 78 for **SGan Sgan** *Yelloweye Rockfish* (Magnuson-Ford et al. 2009). Long-lived fishes such as K'ats Sgaadang.nga benefit from management of the age structure of their populations through the use of interconnected networks of MPAs (Berkeley et al. 2004; Beamish et al. 2006), such as MPAn which includes the OHGNZ.

The large majority of shelf rockfishes that are caught in fisheries are taken by bottom trawl, with some caught in midwater trawls (Driscoll 2016). Bottom trawling involves dragging heavy weighted nets across the seafloor, in comparison to midwater trawling which is known to sometimes make contact with the seafloor, but generally occurs above the bottom of the ocean. Bottom trawling can account for over 80% of the total catch of some **K'ats Sgaadang.nga** *rockfish* species, including Bocaccio, Canary Rockfish, and Yellowmouth Rockfish. Of the suite of shelf K'ats Sgaadang.nga, Canary Rockfish, Greenstriped Rockfish, Silvergray Rockfish, Widow Rockfish, and Yellowtail Rockfish are caught in midwater trawls. Widow Rockfish are considered more vulnerable to midwater trawling than the other K'ats Sgaadang.nga species due to their propensity to form nighttime aggregations in shoals (DFO 2019c). In addition to direct fishing mortality, both bottom trawling and midwater trawling have the potential to negatively impact biogenic habitat and substrate when fishing gear contacts the seabed (e.g., dislodging and destroying sponges, corals, sea pens, and other biogenic benthic habitats, and severely modifying inorganic substrate relief) which can reduce the suitability of bottom habitat for future generations of rockfishes and may contribute to future population declines (Wallace et al. 2015).

Although much less is known about the effects of vessel noise on fishes than on marine mammals, there is a small but growing body of literature demonstrating that such ocean noise can have multiple effects on fishes including: increased stress hormones, temporary loss of hearing, change in territorial and social behaviour, change in spatial movement and orientation, decreased detection of communication signals, reduced growth, reduced fitness, damaged eggs, and direct mortality (Panigada et al. 2008; Nichols et al. 2015; Shannon et al. 2016). Although most existing studies have been conducted with fish species that are not in the NSB, evaluation of their interactions with vessel noise were mostly found to be negative or with mixed conclusions (e.g., Holles et al. 2013; Nedelec et al. 2017). Negative impacts on fish populations from recreational vessels can include direct and indirect impacts from propellers, increased propeller wash, increased turbidity on local scales, increased stress responses, and changes in behaviour due to vessel noise (Panigada et al. 2008). The impacts of recreational boating are expected to be the greatest within coastal areas where recreational activity is concentrated, rather than in the OHGNZ. However, large vessel traffic is present and widespread in the Offshore Haida Gwaii Network Zones, and is summarized in the Vessel Traffic section of this report.

Climate change impacts on groundfishes are detailed in the Projected Changes In Groundfish Communities section.

4.2.6.3. Pelagic Fishes

Fishing activity in the Pacific region threatens pelagic fish species through the direct catch, bycatch, and habitat disturbance. The troll fishery in Pacific Canada for Albacore Tuna is considered well-managed and highly selective (Morgan 2014). In addition, the status of Albacore Tuna stocks is currently considered to be at low risk. It is expected to remain stable for the foreseeable future at current exploitation rates (Fisheries and Oceans Canada 2013; Morgan 2014). Although Ocean Sunfish comprise a large percentage of bycatch in gillnet and trawl fisheries worldwide (Thys et al. 2015), there are no known records of fisheries interactions with Ocean Sunfish in BC. The primary target species of salmon troll fisheries in BC are **T'áaw'un Taaga̲un** *Chinook Salmon* (*Oncorhynchus tshawytscha*) and **Táayii Taay.yii** *Coho Salmon* (*Oncorhynchus kisutch*) (Walters et al. 2008). Based on estimates of spawner abundance in recent years, both T’aaw’un Taaga̲un and Táayii Taay.yii are generally abundant and of low conservation and management risk (Connors et al. 2013). Of the **K̲'aad aw K̲'aaxada awga̲a** *shark* species, the Blue Shark (*Prionace glauca*) and Salmon Shark (*Lamna ditropis*), are considered common in BC and occur in **X̲aadáa Gwáay X̲aaydaga̲a Gwaay.yaay** *Haida Gwaii* waters, while presumably the remainder of the K̲'aad aw K̲'aaxada awga̲a species are considered rare in the region (McFarlane et al. 2010). The bycatch of Salmon Sharks in the Eastern and Western Central Pacific has significantly reduced since the elimination of the drift gillnet fishery, and the population appears to have rebounded to its former levels (Goldman et al. 2008).

4.2.6.4. Marine Mammals and Reptiles

Marine mammals, including cetaceans and pinnipeds, are vulnerable to anthropogenic habitat disturbance, including climate change and commercial fisheries (COSEWIC 2008; DFO 2018d). At least 13 mammal species use the OHGNZ for migration, feeding, and reproduction. Due to the combination of small population size and low reproductive potential of many cetacean species (e.g., **SG̲áan Sga̲aana** *Killer Whales*, **Kún Kun Xyapxyandal** *Fin Whales*; COSEWIC 2008; DFO 2018d), and despite increasing populations (e.g., **Kún Kun** *Grey Whales*, COSEWIC 2017), they remain vulnerable to anthropogenic disturbance. The three ecotypes of Killer Whales in **X̲aadáa Gwáay X̲aaydaga̲a Gwaay.yaay** *Haida Gwaii*'s offshore waters have small populations, making them vulnerable to anthropogenic threats. Offshore Killer Whales, for instance, have a very small estimated Potential Biological Removal (PBR = 0.55) and often travel in large groups of 50–100 animals (Ford et al. 2014), so exposure to anthropogenic stressors in the OHGNZ could have a large effect on the population as a whole.

Current threats in Canada to marine mammals include: entanglement in fishing gear, ship strikes, disruption or destruction of feeding habitat or prey availability, physical disturbance, acute and chronic noise, disease agents, inbreeding depression, pollutants, and disturbance resulting from some scientific research activities (MPO 2018d; COSEPAC 2003a; Pêches et Océans Canada 2009; COSEPAC 2017; COSEPAC 2019). Potential threats include toxic spills and future food, social, or ceremonial harvest if Indigenous groups that traditionally harvested species renew their interest in this activity, and mass stranding or natural entrapment (DFO 2018d). Because marine mammals are often at or near the top of marine food webs, stressors that negatively impact key prey species can also decrease their survivability.

Within the OHGNZ increased vessel traffic, anthropogenic noise, and entanglement risks pose significant challenges to marine mammal species. While the Voluntary Protection Zone (see Vessel Traffic section) helps ameliorate the number of vessels impacting marine biodiversity, **Síigee** *Dixon Entrance* is a heavily trafficked area. **Kún Kun** *Grey Whales*, and other benthic feeders, are thought to be at particular risk from potential oil spills from oil and gas extraction and the associated shipping traffic (Pêches et Océans Canada 2018). A modelling study of the potential risk of vessel strikes to **Kún Kun Xyapxyandal** *Fin*, **Sgagúud Sg̱ap** *Humpback* and **SG̱áan Sg̱aana** *Killer Whales* found that areas of relatively high risk of ship strikes, especially for **Kún** *Fin Whales*, existed in Síigee where ship traffic is concentrated (Williams and O'Hara 2009; where Zones 506, 501 and 500 are located). Acoustic disturbances from marine traffic also impact whales' behaviors and communication. Acute noise exposure is potentially lethal for baleen whales (Gailey et al. 2007; Harris et al. 2018), and chronic ambient noise can contribute to stress, acoustic masking, hearing loss, behavioral disturbance, and displacement from habitat (Croll et al. 2001; Weilgart 2007; Wright et al. 2007). In particular, most ship noise energy is concentrated at a low frequency which is similar to the frequency at which Kún Kun Xyapxyandal communicate (< 100 Hz) (Clark et al. 2009; Erbe et al. 2016). Resting mother-calf pairs of Sgagúud Sg̱ap 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 echosounders (e.g., depth sounders and fish finders), is also likely to disrupt the natural behaviors of SG̱áan Sg̱aana (Burnham et al. 2022). In particular, Resident Killer Whales and Offshore Killer Whales may experience reduced foraging efficiency, given their reliance on echolocation for finding and capturing fish (Wright et al. 2021; Dahlheim et al. 2008). Vessel noise could also disrupt communication calls between individuals (Holt et al. 2009) and thus prevent Killer Whales from locating one another within the OHGNZ, potentially reducing reproductive opportunities and interfering with important cooperative behaviors, such as prey sharing or coordinated hunting.

Oil spills and marine pollution can have devastating effects on marine mammals, and **SG̱áan Sg̱aana** *Killer Whales* are also vulnerable to pollutants from vessel exhaust (Ross 2006; Alava et al. 2012; Alava et al. 2016; Lundin et al. 2018). Furthermore, entanglement in fishing gear is a significant threat to whales, particularly for humpbacks in BC (C. McMillan, unpublished report cited in Liu et al. 2025 *In Press*[12]), and SG̱áan Sg̱aana may be at risk of ingesting fishing gear when in proximity to active fishing for the same resource (Pêches et Océans Canada 2018). Pinnipeds in BC (and worldwide) also frequently become entangled in fishing gear and marine debris (Jepsen and Nico de Bruyn 2019). In addition, in 2019 a large number of **Kún Kun** *Grey*

[12] Liu, A.D., Bannar-Martin K.H., Bluteau, C.E., Hilborn, A., Clifton, K., C., Burke, L., Wright, B., Wray, J., Keen, E., Baer, G., Pilkington, J., Nichol, L., Denley, D., Stacey, Herbert, J. C., Vanderjagt, A., Robb, C., and Rubidge, E.M. In Press. Biophysical and Ecological Overview of the Caamaño Sound and Douglas Fjord System Network Zones. Can. Tech. Rep. Fish. Aquat. Sci. 3664: viii + 320 p.

Whales were stranded along the west coast of North America, and declared an unusual mortality event with approximately 500 deaths recorded to date that are still under investigation putting them at considerable endangerment risk (Consultations on the Grey Whale, Pacific Coast Feeding Group and Western Pacific Populations). Furthermore, fisheries can induce indirect ecological effects on prey availability and interspecific competition among predators (Guilpin et al. 2020). Northern Resident Killer Whales and Offshore Killer Whales may be impacted in the OHGNZ by competition from commercial and recreational fisheries that affect the availability of key prey resources, such as **T'áaw'un Taag̲un** *Chinook Salmon*.

While pinnipeds generally have shorter generation times and higher fecundity than cetaceans, they also aggregate in large groups (on haul-outs or in rafts, such as in Zone 505) and thus could be disproportionately impacted by anthropogenic stressors compared to less gregarious species (Liu et al. 2023 In revisions[12]). Pinnipeds are most vulnerable to anthropogenic disturbances when stressors are near rookeries and haul-outs, or during breeding season (COSEWIC 2013). Pinnipeds may be more disturbed by vessel noise and presence than vessel strikes, although strikes are still possible. Approaching vessels and vessels changing gear have been known to cause pinnipeds to flush (i.e., quickly rush back into the water) (Erbe et al. 2019). Juvenile **K̲áay K̲ay** *Steller Sea Lions* have high mortality rates, which may have contributed to delayed population recovery in BC (Hastings et al. 2011; COSEWIC 2013). The abundance and trophic level of K̲áay K̲ay have the potential to influence and be influenced by the population dynamics of both their primary prey through top-down processes and their main predators via bottom-up limitation.

Understanding marine mammal sensitivities and recoverability based on life history traits is crucial, particularly in relation to the potential significance of OHGNZ habitats. Further research and conservation efforts are essential to safeguard these vulnerable species and their critical habitats within the OHGNZ. The impacts of climate change on prey availability can further compound these challenges, making conservation efforts crucial for their survival. Climate change (current and projected) affects prey availability for marine mammals, leading to potential declines in key prey species like krill (Okey et al. 2014) and herring (Villalobos et al. 2020) for **Kún Kun Xyapxyandal** *Fin Whales* and **Sgagúud Sg̲ap** *Humpback Whales*. Rising sea surface temperatures could also negatively impact the survival of salmon (Abdul-Aziz et al. 2011; Crozier et al. 2021), which are a preferred prey for **SG̲áan Sg̲aana** *Killer Whales*.

'Waahúu Tang.g̲wan Siiga *Leatherback Sea Turtles* globally are threatened with extinction from many factors, including accidental capture, nesting beach habitat loss, killing of nesting females and harvest of eggs (Équipe de rétablissement de la tortue luth 2006). 'Waahúu Tang.g̲wan Siiga populations in Pacific waters have decreased by over 90% in the last generation (BC Conservation Data Centre). In British Columbia, the major threats are likely accidental capture and entanglement (Kleiber 1998), collision with boats, and debris ingestion (Équipe de rétablissement de la tortue luth 2006), coastal and offshore resource development, and climate change (BC Conservation Data Centre). 'Waahúu Tang.g̲wan Siiga vulnerability to even small increases in mortality rates of adults and older juveniles are due to their long lifespan, very high rates of egg and hatchling mortality, and late maturity (COSEPAC 2012). Individuals can move hundreds to thousands of kilometres between nesting beaches and marine waters, consequently increasing their vulnerability to incidental take. Within the 'Waahúu Tang.g̲wan Siiga Pacific Canadian range, however, our knowledge of the species' occurrence, distribution, behaviour and interaction with fishing gear is limited. Within Pacific Canadian waters, there may be fewer than 100 individuals (COSEPAC 2012). Consequently spatial protection of any marine habitat they utilize may be key refugia for their continued survival.

4.2.6.5. X̲edíit Siigaay x̲idid *Marine Birds*

X̲edíit Siigaay x̲idid *Marine birds* have diverse life history strategies, including use of terrestrial and marine environments. Therefore, X̲edíit Siigaay x̲idid 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 X̲edíit Siigaay x̲idid, with alcid species experiencing significant mortality events in recent marine heatwaves (Jones et al. 2018; Piatt et al. 2020). X̲edíit Siigaay x̲idid 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 OHGNZ may threaten many pelagic bird species, including **Sk'áay Sk'aay** *albatrosses* (Gilman and Freifeld 2003; Bull 2007), 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. Rat eradication efforts have been undertaken in **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* on **K̲'íis Gwáay** and in Gwaii Haanas, to reduce pressure on **X̲edíit k̲áw Siigaay x̲idid k̲aw** *seabird eggs* in ground-level nests, such as the culturally and ecologically valuable **SG̲idaanáa Sg̲in x̲aana** *Ancient Murrelet*. 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.

4.3. ECOLOGICAL CONNECTIVITY AND EXTERNAL FEATURES TO OHGNZ

The OHGNZ are part of the wider dynamic ocean and are connected to marine features both within and outside of the NSB. As noted, these zones were selected to function as part of a network of MPA sites throughout the NSB, and therefore complement other zones proposed for protection to meet a variety of ecological and cultural conservation objectives within the NSB. Ecological connectivity – the exchange of individuals, genes and/or nutrients between the network zones and the surrounding habitat – is particularly likely with ecosystems in close proximity to the OHGNZ and highly influenced by dominant oceanographic currents and eddies. As a result, we highlight examples of the OHGNZ ecological connectivity to various ecosystem components and species in the following subsections, including pelagic and benthic linkages, features outside the zones, Haida Eddies, bathymetric features, and finally the MPA Network.

4.3.1. Pelagic and benthic linkages

Most benthic ecosystems exist below the reach of sunlight. In the dark, these ecosystems rely on the vertical migration of animals and falling 'marine snow' (i.e., the export flux of primary productivity and detritus from sunlit waters) for energy. Bathymetric features with high relief, such as seamounts and rocky outcrops, can act as conduits, facilitating direct and indirect pelagic-benthic coupling, the degree of which depends on the depth of the feature. Therefore, the influence of high-relief bathymetric features on surface productivity is a significant driver of benthic spatial ecology. As previously mentioned, shallow conditions can trap the vertical migration of the deep scattering layer, directly delivering energy into the benthic ecosystem. Shallow pinnacles can also act as an offshore pathway for species that undertake ontogenic migrations from the pelagic to the shallow seafloor and the deeper surrounding ecosystems (i.e., a nursery ground). High-relief bathymetric features influence the vertical and horizontal delivery of nutrients, productivity, and recruits by altering local currents. Eddies or circular flow can advect remote material while upwelling nutrient-rich deep water, accelerated flow, mixing, and turbulence can support local productivity and recruitment. Mobile animals can redistribute energy from these features (e.g., transient predators use seamounts as feeding grounds) and mobile eddies and jets can deliver materials downstream (e.g., the Haida Eddies; for more information, see the Haida Eddies section below).

4.3.2. Noteworthy features not included in OHGNZ

Representativity of habitats is a central aspect of the OHGNZ. While it is impractical for discrete spatial management measures to capture every type of habitat in a system, some noteworthy habitat types and features are outside the current zone boundaries. For example, as previously mentioned, there are no documented cold seeps within the OHGNZ and very little of Learmonth Basin inside of Zone 501. Additionally, there is one other EBSA and VME nearby but outside the OHGNZ. Because SAUP 5494 is not an “average” submarine volcano (e.g., it doesn’t provide steep flanks of exposed igneous rock), the OHGNZ does not contain a typical seamount. There are two very nearby, but due to current proposed boundaries, they fall outside the NSB. That said, they are detailed below because of their proximity to Zone 505 and their potential role in linking nearshore and offshore habitats.

Less than four nautical miles from the border of Zone 505 (approximately 60 km from the tip of **G̲angx̲id Kun SG̲aagiidaay** *Cape St. James*) are the NEPDEP 57 and 58 seamounts in the Tuzo Wilson complex (Figure 33). The two seamounts are side-by-side and are currently referred to as NEPDEP 58 in the west of the Tuzo Wilson complex and NEPDEP 57 in the east of the Tuzo Wilson complex (Advisory Committee on Undersea Feature Names, pers. comm. August 8, 2021), but have been known as Tuzo Wilson “west” and Tuzo Wilson “east” (Du Preez and Norgard 2022) and as the Tuzo Wilson Knolls (Chase 1977) and the Tuzo Wilson Volcanic Field (Allan et al. 1993) (all are unofficial names). The seamounts rise from over 3,000 m depth to 1,588 m (West; 51.401564 N -131.015961 W) and 1,301 m (East; 51.457137 N -130.840584 W) summit depth (unpublished data Northeast Pacific Seamount Expedition PAC2021-036). The volcanic origin of the seamounts are disputed (Chase 1977; Cousens et al. 1985; Carbotte et al. 1989; Allan et al. 1993), but the geomorphology is pillow basalts and capped by hawaiite (Chase 1977; Cousens et al. 1985).

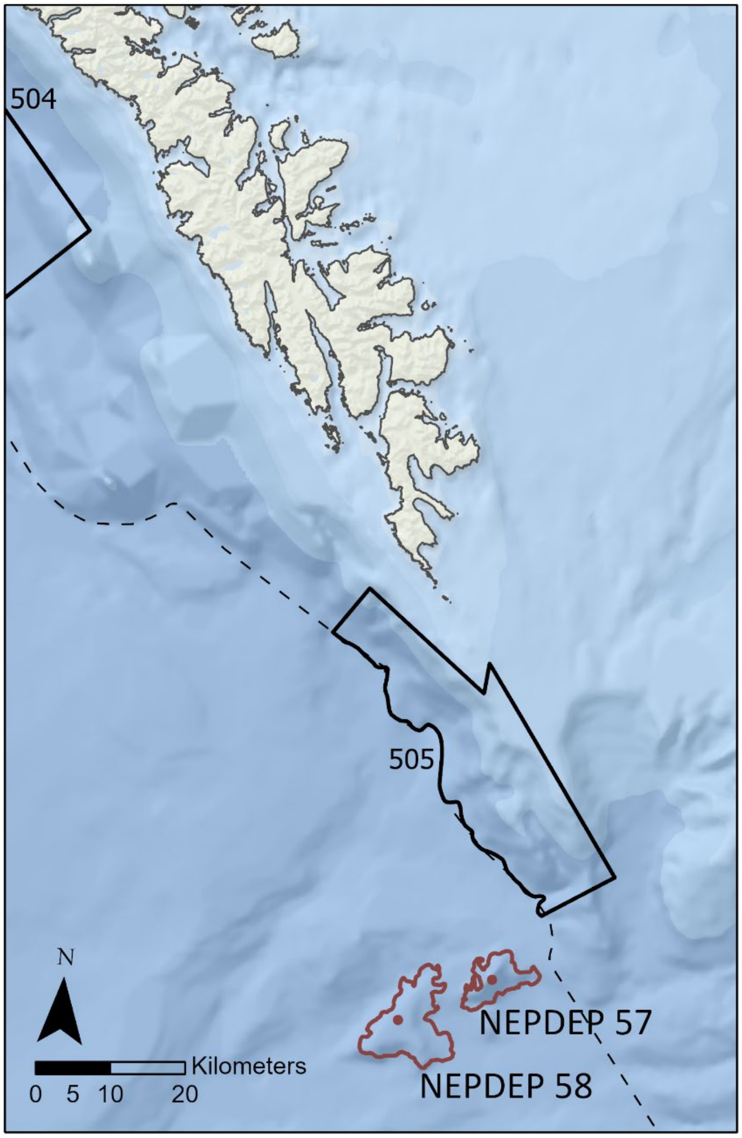

Figure 34. NEPDEP 57 (east) and 58 (west) seamounts in the Tuzo Wilson complex (brown outline; brown points indicate summits) to the southwest of ***G̲angx̲id Kun Sg̲aagiidaay*** *Cape St. James (Zone 505) in the OHGNZ. Dotted line shows the Northern Shelf Bioregion Boundary.*

The NEPDEP 57 and 58 seamounts in the Tuzo Wilson complex are unique in the context of the 65 Pacific Region seamounts in that they are small, isolated from other seamounts (>65 km away) but within 2 km of the base of the continental slope (Du Preez and Norgard 2022), and located on the active triple junction of the Pacific, Explorer, and North American plates (Carbotte et al. 1989). The seamounts are within an area of high sedimentation rate and high export productivity (Chase 1977; Allan et al. 1993) ("H2" class seamounts, Du Preez and Norgard 2022). However, while there are muddy areas (Denton 1986), the lava cones, volcanic ridges, and seamount summits are unsedimented (Chase 1977; Allan et al. 1993). This indicates the seamounts experience high energy input and enhanced flow, a combination ideal for supporting a high abundance of habitat-forming filter feeders.

There has been a little bit of research on the animals of the NEPDEP 57 and 58 seamounts in the Tuzo Wilson complex – two visual surveys 36 years apart, both using deep towed cameras. The first expedition, in 1985, surveyed NEPDEP 58 at 2,500 and 1,500 m (Denton 1986). The second expedition, in 2021, surveyed both seamounts from 2,220 m to their summits (video available on SeaTube). Despite the vast difference in technology, both expeditions documented the occurrence of abundant cold-water corals, fishes, and other invertebrates (especially considering the depth), including a uniquely dense and extensive field of carnivorous sponges and forests of bamboo corals observed in 2021. Unfortunately, detailed data on the fauna from the first expedition was never published (Denton 1986). However, one of the few photos that were published shows a large “skate or stingray” (Denton 1986), likely a Pacific White Skate (*Bathyraja spinosissima*). Observations of this **Ts’iiga̲** *skate* species were the highlight of the 2021 expedition (annotated transcript available on SeaTube). This deep-sea Ts’iiga̲ was unknown to occur in BC until recently (Orr et al. 2019) when the identification was made from a single bycatch specimen. In 2021, dozens of large adult Ts’iiga̲ were observed actively swimming slowly over the seafloor, on and around the ~1,600 m deep summit of NEPDEP 58 over the tall forests of cold-water corals and sponges. Closer inspection of the seafloor and coral branches revealed the area as a skate nursery ground. There were thousands of Ts’iiga̲ eggs at varying stages of incubation (different colours, some intact, some open, etc.). The working hypothesis is the eggs are Pacific White Skate, but spawning was not directly observed, and sampling was not possible. Pacific White Skate have a depth range of ~3,000 to 800 m (Orr et al. 2019), are associated with volcanic seafloor (Kuhnz et al. 2019), and, like many other deep-sea skate species, likely migrate to shallower narrow depth bands to spawn (Rooper et al. 2019b). Despite visually surveying dozens of volcanic seamounts in the Pacific Region, this is the first documentation of a deep-sea Ts’iiga̲ spawning and nursery ground in the region (Du Preez and Norgard 2022). In the Western Pacific, a Pacific White Skate nursery ground was discovered among the complex and warm-water environment of hydrothermal vents at ~1,600 m depth. Deep-sea Ts’iiga̲ have some of the longest egg incubation times reported in the animal kingdom, and species in this genus are known to have incubation periods of ~1,500 days or 4 years (Salinas-de-León et al. 2018). It is very likely spawning Pacific White Skate migrate up the flanks of NEPDEP 58, concentrating over its small summit where the combination of depth, high flow, and structural complexity within the summit coral and sponge forest provides optimal conditions for the required long incubation. This Ts’iiga̲ nursery ground on NEPDEP 58 highlights the connectivity between different human-delineated zones and ecosystems.

4.3.3. Haida Eddies

As previously mentioned, the Haida Eddies (Figure 35) transport water, heat, nutrients, productivity, and recruits from the continental shelf and slope environments to the open northeast Pacific Ocean. However, eddies that travel over seamounts can temporarily become trapped, causing a greater exchange between the vortex and the seamount environment. This phenomenon has been opportunely documented at SK̲-B Seamount twice. In both cases, the Haida Eddy persisted above the seamount for approximately three months before it was shed off (White and Mohn 2004; T. Ross, personal communication, November 5, 2022). The size and speed of the Haida Eddies are thought to allow for the episodic recruitment of larvae from coastal populations to the offshore seamount and genetic homogeneity (Siegle et al. 2013). Because open ocean currents can sweep local propagules off the seamount (Parker and Tunnicliffe 1994), the source-sink relationship between **X̲aadáa Gwáay X̲aaydaga̲ Gwaay.yaay** *Haida Gwaii* and SK̲-B Seamount populations may be an important consideration for the conservation efforts in both places (i.e., SK̲-B MPA and the OHGNZ). In addition, this may only be the first ‘stepping-stone,’ with the Haida Eddies indirectly facilitating dispersal to other offshore seamounts (Rowden et al. 2010). The source-sink relationship is likely not a one-way street. Some seamounts can be refugia, supporting relatively high-density populations with the ability to seed and rescue declining slope and shelf populations (Rowden et al. 2010). A large Haida Eddy passing SK-B Seamount could transport seamount water towards the coast. This mechanism could play a critical role in the recovery of critically endangered sea stars, decimated by the sea star wasting disease on the shelf but seemingly unaffected on the seamount (H. Gartner, personal communication, November 5, 2022).

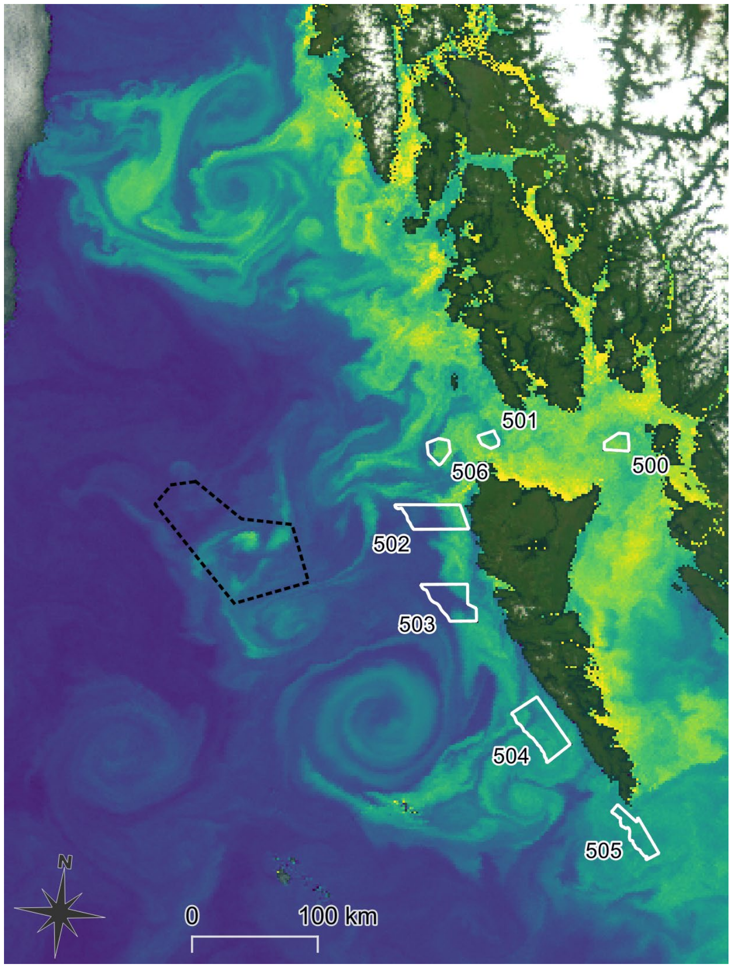

*Figure 35. Chlorophyll-a concentration satellite image (chlorophyll-a being a proxy used to represent phytoplankton biomass in milligrams per cubic metre of seawater) from June 13 2002, using the SeaWiFS sensor at a 1 km spatial resolution. This image shows several Haida Eddies, with the largest to the southwest of **X̱aadáa Gwáay X̱aaydag̱a Gwaay.yaay** Haida Gwaii. These eddies transport nutrient-rich coastal water into the open waters offshore. The OHGNZ are shown with white outlines, and the **SG̱áan Ḵínghlas**-Bowie Seamount is shown with a black dotted outline.*

4.3.4. Bathymetric features and ecosystem functioning

The OHGNZ EBSA bathymetric features were assessed as complex individual ecological units (e.g., **Tsaan Ḵwaay** *Learmonth Bank*, Rubidge et al. 2018; seamounts, Ban et al. 2016). As such, it is unclear what ecosystem functions will be conserved by zones with incomplete protection (i.e., spatial overlap) of an EBSA. For example, assessments and management measures for the protection of entire seamounts are common practice and used globally (e.g., Johnston and Santillo 2004; Davies et al. 2007; Clark et al. 2011; Clark and Dunn 2012;

Wedding et al. 2013), and management measures for entire seamount features have higher compliance than fine-scale closures, especially in the case of deep-sea bottom fishing (e.g., Clark and Dunn 2012). In late 2006, United Nations General Assembly called upon member states and regional fisheries management organisations to protect the areas where seamounts and other features (e.g., features with cold-water corals) are known or are likely to occur based on scientific information (UN GA, Draft resolution of the 61st session of the General Assembly, 6th December 2006, A/61/L.38). Bathymetric features with incomplete protection by the OHGNZ, include:

- SAUP 5494 seamount: Zone 502 overlaps a section of the southern half of the seamount, including the shallowest summit but misses the southern tip, the northern half, and all known cold seep (mud volcano) sites.
- **Tsaan Kwaay** *Learmonth Bank*: Zone 501 overlaps most of the southern half of Tsaan Kwaay but misses the southern tip, the northern extent within Canada, and the Canada-USA disputed northern section (which would require a multi-lateral agreement across borders to be protected). While Zone 501 captures ~1 km wide slices of the basin to the west and east of the bank, it does not capture the full diversity of the basin biotopes, including the known areas of erratics and giant coral stands, fields of Stylaster corals, and brittle star mats (Neves et al. 2014; described above in the Ecological Setting section for Rocky Outcrops).
- **Kadlee** *Celestial Reef*: Zone 500 runs into the disputed fishing area between Canada and the USA, which has implications for the ease of implementation and successful management of a protected area in this location.

4.3.5. Network

Marine biodiversity in the NSB, is threatened by multiple stressors, including habitat alteration, resource use pressure, land and sea-based pollutants, and invasive species, as well as larger scale impacts related to global climate change (Canada and BC 2014). Multiple species and habitats are declining in the NSB, which is exacerbating other systemic impacts on cultures, food security and future economic opportunities in the region (Moody 2008; Frid et al. 2016; Ban et al. 2017; McGreer and Frid 2017; Eckert et al. 2018; Whitney et al. 2020). MPA networks are a conservation tool useful for protecting important habitats and species from localized pressures. The benefits of MPAs can be enhanced when they are part of larger scale connected networks, which focus on the protection, recovery, and enhanced resilience of functional ecosystems. Using scientific design criteria, including representation, replication, and connectivity, networks provide more comprehensive biodiversity protection than is possible with single MPAs (Badman and Bomhard 2008).

As previously mentioned in this report, the OHGNZ were selected as part of the MPA Network in the Northern Shelf Bioregion. The zones in the MPAn were selected “to protect and maintain marine biodiversity, ecological representation and special natural features” (Canada and BC 2014, p. 9), while also providing social, economic, and cultural benefits. As such, the OHGNZ were selected to work in concert with other zones in the network to meet a variety of network-level goals, objectives, and conservation priorities (species and habitats that the network will protect), which are available in the Network Action Plan (MPA Network BC Northern Shelf Initiative 2023). The total area of the NSB is approximately 102,000 km^2, of which the proposed Network encompasses 30,493 km^2 (30%) (Figure 3). Of this, 16,615 km^2 (or 16%) of the NSB is already protected in existing MPAs (this number increases to 18,760 km^2, or 19%, when Rockfish Conservation Areas—RCAs—are included). The proportion of each sub-region that is included in the proposed Network varies from 25% of **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* subregion, to 41% of the Central Coast subregion (MPA Network BC

Northern Shelf Initiative 2023). The proposed Network captures additional inlet, nearshore, and offshore habitats, and improves the representation of those broad habitat types across sub-regions, and regionally. The proposed Network comprises 357 zones, further aggregated into either existing MPAs or potential designation tools (MPA Network BC Northern Shelf Initiative 2023). Some of the features that have targets that are highly met by the OHGNZ include the Shelf Break EBSA and Longspine Thornyhead populations (see NSB Network Ecological Conservation Priorities for more details). In this way they contribute to network-wide objectives.

5. HUMAN USE OF AREA

5.1. HAIDA USE

Historical and contemporary Haida traditional use of important marine species and the offshore areas are inseparable from the ecology and are thus interwoven throughout the above sections. In summary, Haidas have been intimately connected with the marine environments surrounding **X̲aayda Gwaay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* and all the marine animals since the beginning of time. "Haida culture is intertwined with all creation in the land, sea, air and spirit worlds. Life in the sea around us is the essence of our well-being, and so our communities and culture" (CHN 2007). The Haida value of **Ginn 'wáadluwan gud .ahl k̲wáagíidang Gina 'waadlux̲an gud ad k̲waagid** *everything depends on everything else* asserts that every animal holds an important role within the ecosystems and it is crucial to maintain **Gin 'waadluwaan daman tl' k̲inggang Giid tlljuus** *balance*.

While every species is intrinsically valuable, certain species are also critical food sources and/or are tightly tied to the continuity of Haida cultural traditions, stories, ceremonies, and language. Cultural species briefly described in this report include fishes: e.g., **Tsii.n Chiina** *salmon*, **X̲aguu X̲aaguu** halibut, **Sk̲íl Sk̲il** *Black Cod/Sablefish*, **Skáaynang Skaynang** Lingcod, herring, **Sáaw Saaw** *Eulachon*, rockfishes; **X̲edíit Siigaay x̲idid** marine birds (e.g., **SG̲idaanáa Sg̲in x̲aana** *Ancient Murrelets*), and whales. Traditional harvesting and relationships with non-human beings are integral to Haida way of life. This report highlights some of the important cultural aspects of these species and areas throughout the text, and is not intended to capture the entirety of their cultural importance. The cultural knowledge included is limited to the published Haida Marine Traditional Knowledge Study Volumes 1-3, and any absence of information does not necessarily indicate a lack of knowledge.

5.2. FISHERIES ACTIVITIES

Commercial, recreational and traditional fishing (described above) occurs within the offshore areas on the west and north coast of **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*. The commercial fisheries are a larger scale fishery extracting more marine resources with a larger marine footprint than recreation and traditional fishing. Data for traditional fishing Is not provided within this report but does occur within X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay's marine waters. Commercial fishery and recreational fishery data are presented separately below, as the scale and associated impacts of each fishery classification is widely different. Commercial fishing occurs in all of the OHGNZ across a greater depth profile, whereas recreational fishing is more likely limited to the shallower shelf and slope depths. However data regarding recreational fishing in the area is limited and at a poor spatial resolution.

5.2.1. Commercial Fisheries

Currently, the waters in and around **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii* support commercial fisheries for all salmon species, **K̲'ust'áan K̲'uust'an** *Dungeness Crab*,

Gúudangee Guuding.ngaay *Red Sea Urchin* and Geoduck, **K'amaahl K'aamahl** *Razor Clams*, **K'áaw K'aaw** *Pacific Herring roe-on-kelp*, **Daga 'íiwaans Guudagiigayd** *prawn*, many groundfish species, Albacore Tuna, **Xaguu Xaaguu** *Pacific Halibut* and **Skíl Skil** *Sablefish* and shrimp. Within the OHGNZ, nine different commercial fisheries have operated since at least 2012 (Table 23). While the majority of fishing in the NSB occurs outside of the OHGNZ, all the zones are fished to some extent (see Figure 36 for groundfish fishing areas). Zones 503 and 500 in particular have fishing activities under all nine license types. Xaguu Xaaguu, **K'ats Sgaadang.nga** *Rockfish*, Skíl Skil, and Tuna fishing occurs in all seven of the offshore zones.

Table 23. Presence of different types of commercial fishing in the Offshore Haida Gwaii Network Zones. with fishing time periods provided in parentheses. Data for groundfish comes from validated logbook records on a 1 km x 1 km planning grid with a privacy filtering Rule of Five. Tuna data comes from expert interviews regarding validated logbook records to determine "important fishing areas for commercial tuna." 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 time period.

Fishing Type	**Gangxid Kun Sgaagiidaay** *Cape St. James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**	**Total # Zones with Fishery**
Groundfish Trawls								
Bottom (2012-2018)	P	A	P	P	P	A	P	5
Midwater (2012-2018)	P	A	P	A	A	A	P	3
Groundfish Hook and Line, and Trap								
Halibut Hook and Line (2007–2018)	P	P	P	P	P	P	P	7
Halibut and Sablefish Hook and Line Combo Trips (2012–2016)	P	A	P	P	P	P	P	6
Lingcod Hook and Line (2007–2018)	P	P	P	P	A	P	P	6
Rockfish Hook and Line (2007–2018)	P	P	P	P	P	P	P	7
Sablefish Trap (2007–2018)	P	P	P	P	P	P	P	7
Trolling								
Tuna (1995–2016)*	P	P	P	P	P	P	P	7
Salmon (2007–2016)**	A	P	P	P	P	P	P	6
Total	8	6	9	8	7	7	9	

*Note that the commercial tuna data does not have a fine spatial resolution and the entire offshore region of **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* is deemed as a "relatively heavily fished area by commercial tuna fishery" (SeaSketch).

**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 very large offshore areas.

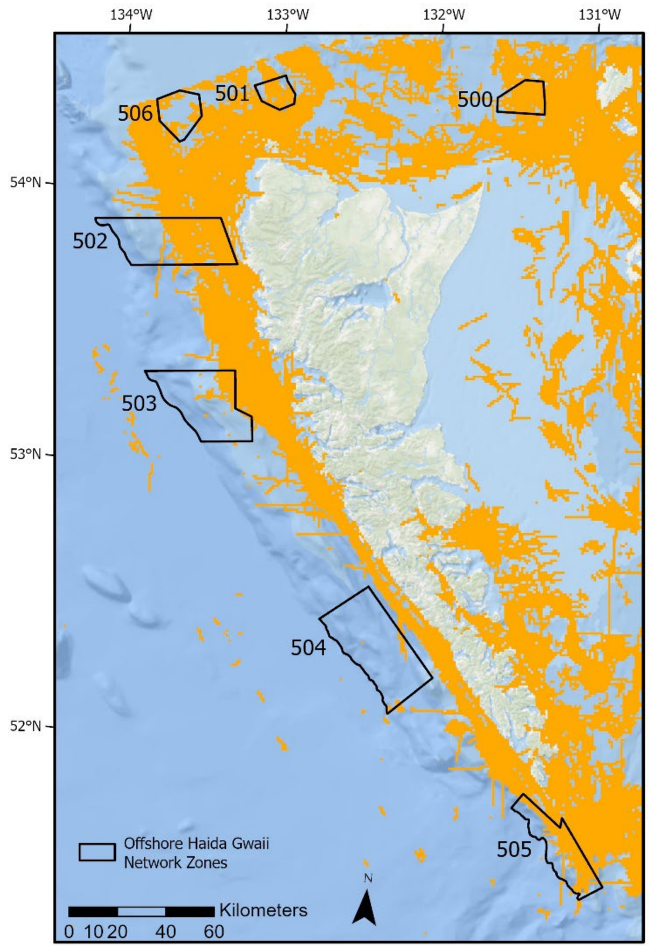

*Figure 36. Presence and distribution of commercial fishing for groundfish in **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** Haida Gwaii marine waters from 2014 to 2018 on a 1 km x 1 km planning grid. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied to each 1 km x 1 km planning unit. Fishing methods and target species include: Bottom trawl, Midwater trawl, **X̲aguu X̲aaguu** Halibut, **K̲'ats Sgaadang.nga** Rockfish, **Skáaynang Skaynang** Lingcod, and **Sk̲íl Sk̲il** Sablefish.*

Fishing effort (hours that vessels spent actively fishing) and gear type were tracked on vessels carrying Automatic Identification Systems and estimated using convolutional neural network algorithms by Global Fishing Watch (McCauley et al. 2016; Kroodsma et al. 2018). In 2019, fishing was observed in all Offshore Haida Gwaii Network Zones and consisted of troller, trawler, set longlines, other purse seines (i.e., purse seines that are often smaller and operating nearer the coast than tuna purse seines) and other fishing gear classes (Table 24, Figure 37). Most fishing effort within the OHGNZ was found in Zone 505 (49% of total annual fishing effort in OHGNZ), followed by Zone 502 (31%), and little fishing effort was detected in the remaining zones (% total annual fishing effort by zone: 500 (10%), 503 (8%), 501 (1%), 506 (1%), and 504 (<1%)) (Table 24, Figure 37). The total annual fishing effort by gear class in the OHGNZ, from highest to lowest, was 41% trawler, 22% troller, 19% other fishing, 13% set longlines, and 4% other purse seines; most of the trawlers were observed in Zone 505 (62%) (Table 24).

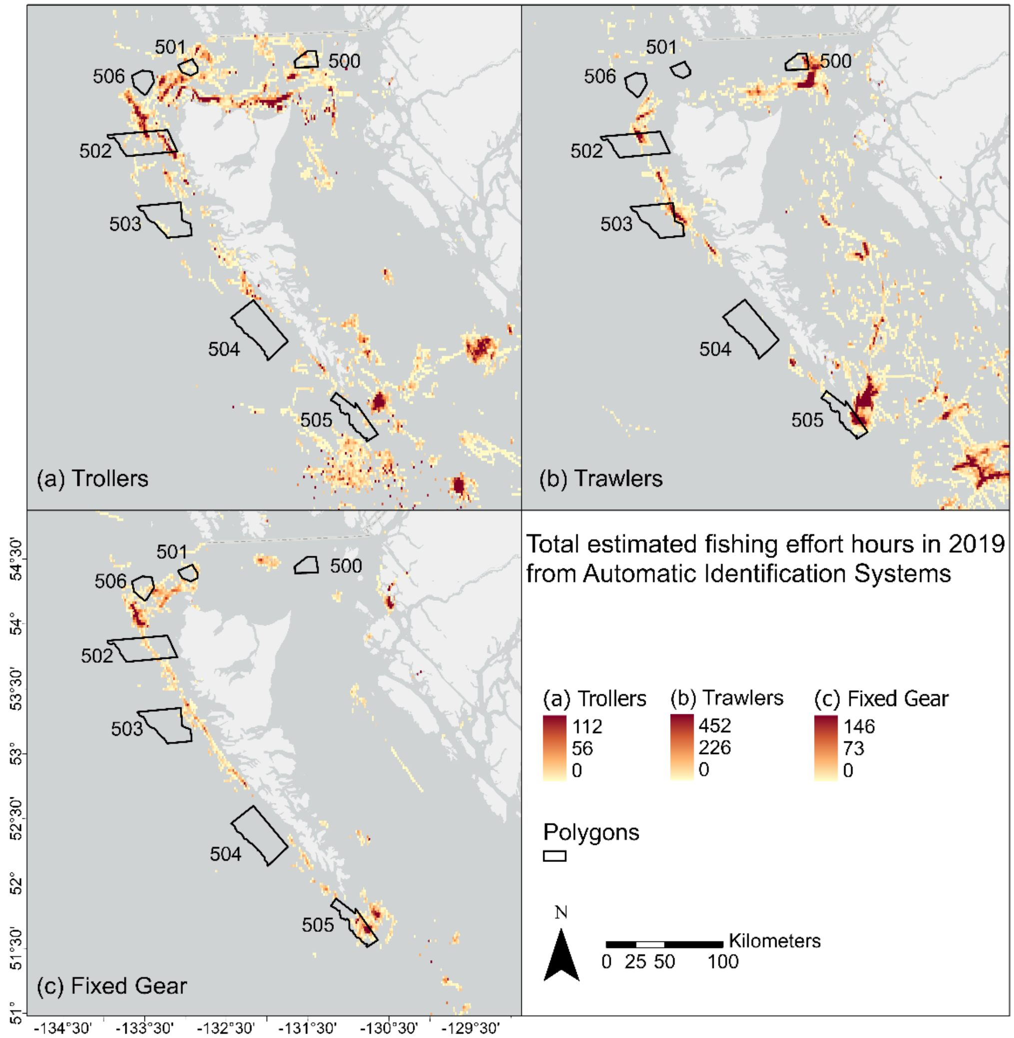

Figure 37. Fishing effort (vessel hours) in the Offshore Haida Gwaii Network Zones in 2019 for (a) trollers, (b) trawler, and (c) fixed gear classes (i.e., set longlines, set gillnets, and pots and traps) as detected by Automatic Identification Systems and estimated using algorithms by Global Fishing Watch. Zone numbers are in black text near the polygon edges. Data provided by J. Iacarella (Iacarella et al. 2023a, 2023b); see Appendix G.

Table 24. Total hours vessels spent actively fishing in 2019 by gear class within each of the Offshore Haida Gwaii Network Zones as detected by Automatic Identification Systems and estimated using algorithms by Global Fishing Watch. Data provided by J. Iacarella (Iacarella et al. 2023a, 2023b); see Appendix G. Bolded values indicate highest values by zone. Dashes indicate no data.

Zone	trollers	trawlers	set longlines	other fishing	other purse seines	total hours
Gangxid Kun Sgaagiidaay *Cape St. James* (Zone 505)	15.08	**635.68**	257.34	302.66	-	1210.76
Gwaii Haanas Extension (Zone504)	**0.43**	-	-	-	-	0.43
Ginda Kun Sgaagiidaay *Offshore Continental Slope South* (Zone 503)	5.63	**122.10**	2.07	57.57	1.35	188.72
Sasga K'ádgwii *Offshore Continental Slope North* (Zone 502)	**457.77**	180.40	40.42	63.24	16.43	758.26
Offshore Northwest Dixon (Zone 506)	-	-	**23.00**	3.12	2.02	28.14
Tsaan Kwaay *Offshore Learmonth Bank* (Zone 501)	**18.39**	-	10.83	2.39	-	31.61
Kadlee *Offshore Celestial Reef* (Zone 500)	57.56	**81.83**	-	32.17	81.14	252.7
Total hours	554.86	1020.01	333.66	461.15	100.94	2470.62

Using DFO commercial fishery data from bottom trawls from the years 2007 to 2019, Gale et al. (2022) computed a utilization ratio (i.e., before versus after comparison) of fishing opportunities in the Pacific Region (Figure 38). The trawl footprint was frozen in 2012 by DFO management to minimize damage to seafloor habitat and cold-water coral and sponge populations. Six discrete categories of utilization were applied to compare the use of fishing opportunities before (2007–2011) and after (2013–2019) the trawl footprint was frozen in 2012. Utilization categories of Abandoned or Strongly Negative indicate active avoidance of fishing opportunities post-2012 or an overall decrease in fishing effort. In contrast, utilization categories of Strongly Positive or New indicate more used or newly used opportunities post-2012. Within the OHGNZ, the fleet shifted fishing effort away from **Tsaan Kwaay** *Learmonth Bank* (Zone 501) and more heavily towards the eastern end of **Síigee** *Dixon Entrance* near **Kadlee** *Celestial Reef* (Zone 500). Fishing opportunities in the shallower depth ranges on the continental shelf in the Offshore Duu Gúusd Daawxuusda grouping of zones were also increasingly used post-2012, with an accompanying decreased use of the zones themselves. **Gangxid Kun Sgaagiidaay** *Cape St. James* (Zone 505), by contrast, has seen increased use since the freezing of the trawl footprint in 2012, particularly in the eastern edge. While no new fishing opportunities are noted in the OHGNZ, fishing opportunities in **Sasga K'ádgwii** *Offshore Continental Slope North* (Zone 502) and **Tsaan Kwaay** *Offshore Learmonth Bank* (Zone 501) have been abandoned. Understanding shifts in the spatial distribution of the commercial fleet with changes in management has implications for the effectiveness of protected areas, and the relative impact of the fleet on specific habitats and fishing opportunities. Furthermore, these results show evidence of active avoidance of areas with high cold-water coral and sponge density, and identifies several areas of potential conservation concern where effort and catch have not decreased, including in Síigee (Gale et al. 2022; Figure 37).

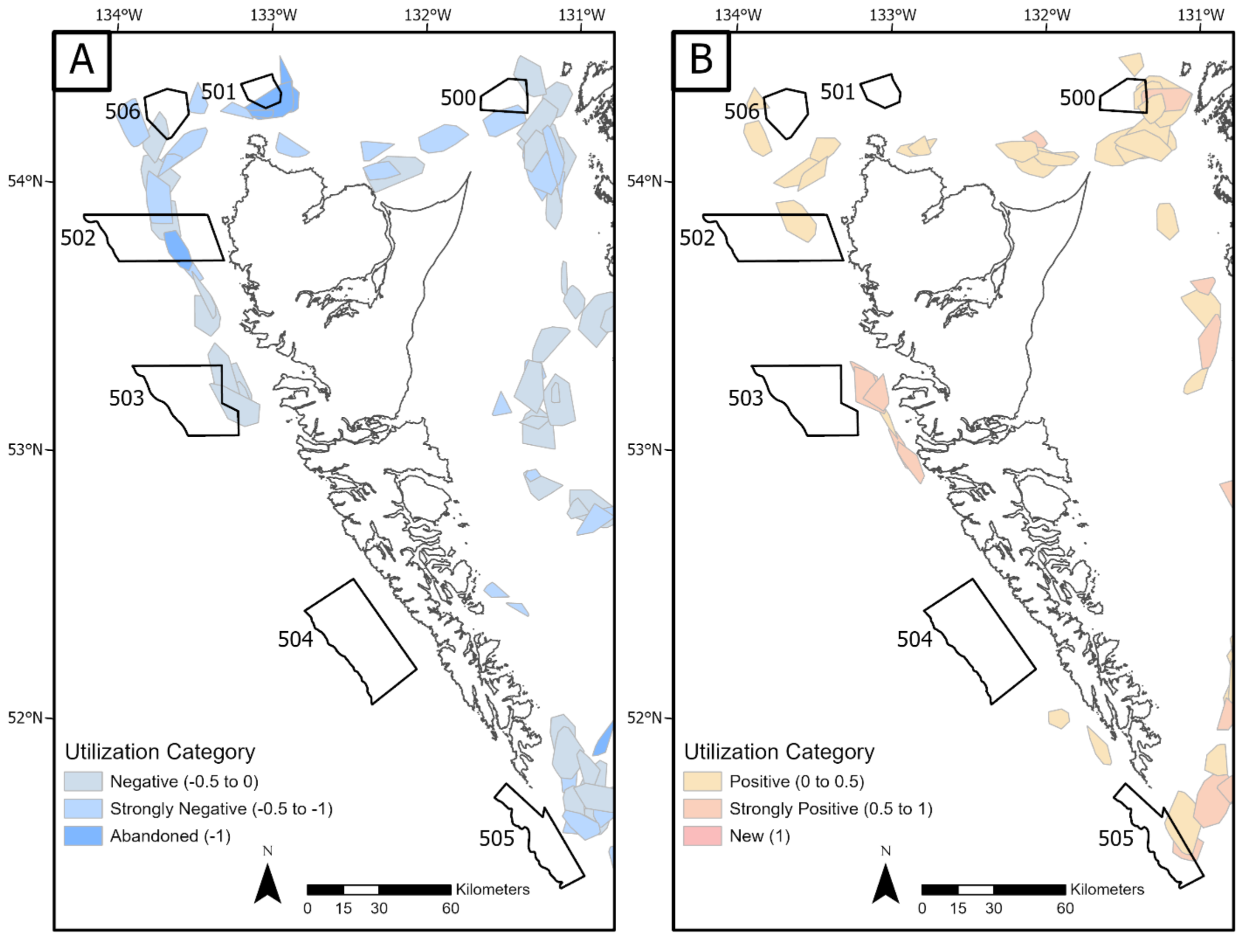

Figure 38. Distribution of bottom trawl fishing opportunities by utilization category, comparing use of fishing opportunities before (2007–2011) the freezing of the trawl footprint in 2012 and after (2013–2019). (A) Negative utilization (< 0) and (B) Positive utilization (> 0) of fishing opportunities are shown separately because of spatial overlap. Fishing opportunities used by fewer than four vessels are not shown in this figure due to privacy rules. Data from Gale et al. 2022.

5.2.2. Recreational Fishing

Recreational fisheries with local and off-island participants occur throughout the coastal areas and freshwater habitats of **X̱aadáa Gwáay X̱aaydaga̱ Gwaay.yaay** *Haida Gwaii*, and provide a source of tourism. Anglers typically target **T'áaw'un Taaga̱n** *Chinook* and **Táayii Taay.yii** *Coho Salmon*, **X̱aguu X̱aaguu** *Pacific Halibut*, **Skáaynang Skaynang** *Lingcod*, and rockfish species. Most of this activity is concentrated around **K̲'íis Gwáay** *Langara Island* (near Zone 501) and along the north and west coast of Graham Island, where there are several fishing lodges and charter boat operations. Three sources of data are currently available that provide some information about the intensity of recreational fishing activities in the Offshore Haida Gwaii Network Zones: BCMCA, the DFO's Internet Recreational Effort and Catch (iREC) database, and the DFO Conservation and Protection Aerial Surveillance Program (ASP). The BCMCA data (BCMCA Project Team 2011) identifies broad regions of recreational fishing based on expert and local knowledge and showed some evidence of recreational fishing activities for groundfishes in Zones 502 and 500 (Figure 39).

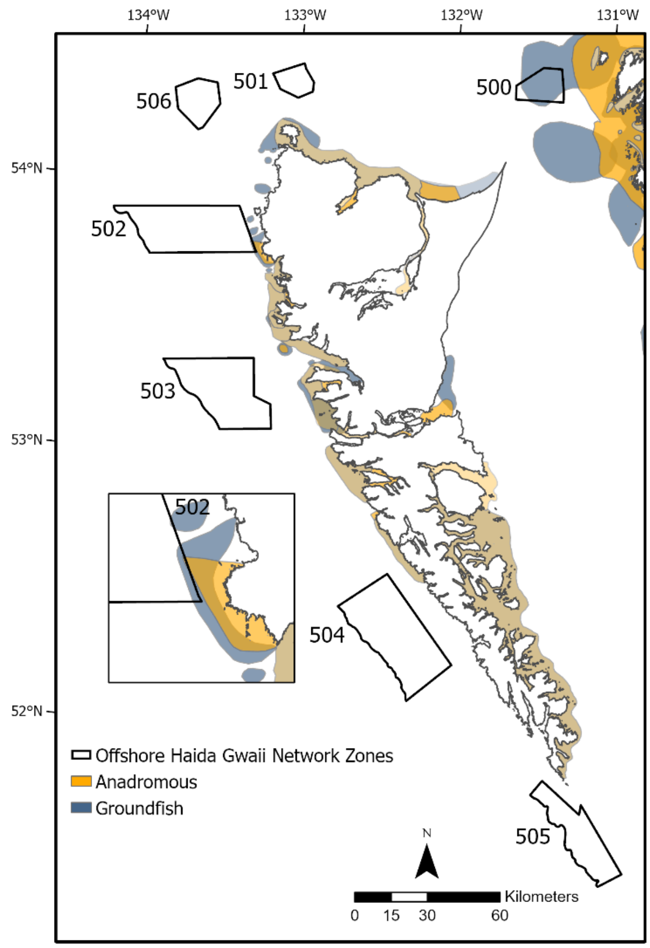

*Figure 39. Overlap of areas where recreational (sport) fishing for **Tsíi.n Chiina** Salmon and other anadromous finfish or groundfish (primarily **X̱aguu X̱aaguu** halibut, **Skáaynang Skaynang** Lingcod and rockfish) occurs with the Offshore Haida Gwaii Network Zones. Recreational fishing areas were identified by participants in 19 local and regional Sport Fishing Advisory Board meetings, as well as through other local knowledge (BCMCA Project Team 2011). Note the close-up inset of Zone 502 to show the slight area of overlap.*

The OHGNZ occur in three Pacific Fishery Management Areas (PFMAs; 101, 142, and 130). 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; Figure 40) included angling from boat, shellfish trapping from boat and dive-based or other fishing. 535 fishing events were observed from January 2020 to June 2022. Due to the large spatial scale of the PFMAs and low regional specificity, shore and dock-based recreational fishing was excluded from the spatial overlay analysis to omit coastal fishing activity. Figure 40 shows the number of recreational fishing days that occurred from boats in each PFMA between 2020 and 2022; however, specific fishing locations are not known.

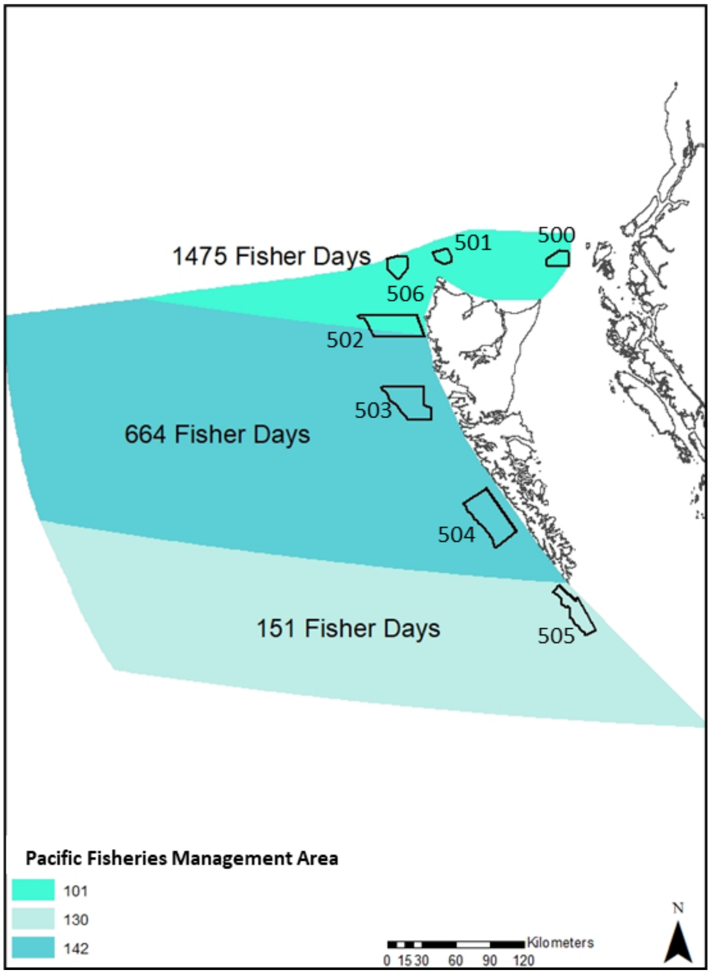

Figure 40. iREC fishing effort estimates for the period between January 2020 and June 2022. Fisher days are the total number of licencee days reported by licencees. The large shaded regions are PFMAs and each fishing estimate is for the entire shaded region, however it is understood that these fishing activities do not occur throughout each shaded area due to the limitations of recreational fishing boats and fish distributions. Licencee days = 1 day trip by one licencee to fish via one method in one area and are not mutually exclusive (i.e., the same licencee can participate in more than one method in the same day, or in multiple areas in one day). Offshore Haida Gwaii Network Zones are represented as black outlined polygons with their zone numbers provided in text.

DFO's Conservation and Protection program runs the Aerial Surveillance Program (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). In 2019, aerial surveillance detected six recreational fishing vessels in Zone 500 and one in Zone 502; in 2020, two recreational fishing vessels were detected in Zone 500 (Burke et al. 2022; see also Figure 43 in the Vessel Traffic section).

5.3. TOURISM

Fishing, ecotourism and visits to residents of **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii* are the primary reasons for tourism in X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay (Misty Isles Economic Development Society 2020). However, most marine ecotourism occurs on the island's east coast into Hecate Strait. Marine tourism on the west coast of X̲aadáa Gwáay X̲aaydaG̲a

Gwaay.yaay is mostly restricted to recreational fishing and boating (cultural boat tours and guided kayaking trips), and is primarily limited to nearshore marine areas. Tuna fishing is an exception, which is a growing recreational and guided activity that occurs around 20 nm offshore (J. Braun, CHN, personal communication, November 9, 2022). Figure 41 shows the proximity of the OHGNZ to diving sites, recreational boating routes, anchorages, and ocean kayaking routes based on datasets collated by the BCMCA (BCMCA Project Team 2011). Zone 502 is the closest in proximity to these recreational activities. Overall, due to the offshore nature of the OHGNZ tourism activities are thought to be infrequent or limited in spatial coverage. For details of recreational fishing and other non-commercial boating activities, see the Fisheries Activities and Vessel Traffic sections of this report.

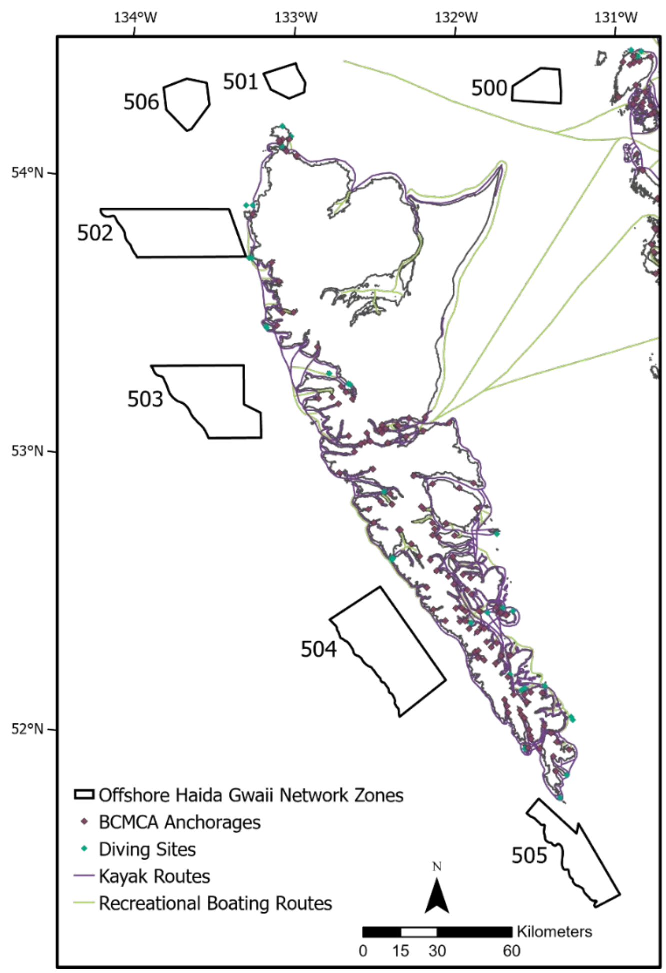

*Figure 41. Offshore Haida Gwaii Network Zones and their proximity to documented tourism locations and routes in **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** Haida Gwaii, including anchorages, diving sites, and recreational boating (motorized boats and kayaks) available from the BCMCA (BCMCA Project Team 2011).*

5.4. VESSEL TRAFFIC

Vessel traffic has increased globally in recent decades, and is the most pressing contemporary source of anthropogenic underwater noise, with vessel engines likely being the most ubiquitous source of anthropogenic noise in all aquatic habitats (Panigada et al. 2008). Over the past century, large vessel traffic has dramatically increased background noise levels at frequencies below 200 Hz in the northern hemisphere (Panigada et al. 2008; Nedelec et al. 2017). Ship traffic produces a diffuse and continuous noise that may affect vast areas, meaning animals over a wide radius are likely to suffer repeated exposures over time (Panigada et al. 2008; Nedelec et al. 2017). Small recreational vessels, which can move nearly anywhere with very few restrictions, can cause significant disturbance to marine life. In shallower waters where recreational vessel operations are concentrated, boating activities are likely to affect local fish populations (Panigada et al. 2008; Hardiman and Burgin 2010). Ubiquitous and continuous noise from ships may have chronic effects ecosystem-wide, with even subtle responses such as avoidance and signal masking potentially leading to long-term population consequences if exposure is continuous (Panigada et al. 2008). Increased ship traffic is a threat to all of the OHGNZ and can result in increased noise that may affect marine mammal behaviour and disrupt migration and feeding (Richardson et al. 1995; Erbe et al. 2014; Erbe et al. 2019). Vessel traffic also impacts marine mammals through direct strikes (Williams and O'Hara 2009). For a comprehensive review of the pathways of effects of marine shipping and vessel activity on marine biological and ecological endpoints please refer to this national document (DFO 2020f).

Vessel traffic in the OHGNZ consists of commercial (shipping and fishing), recreational (cruise ships, recreational boating and recreational fishing) and government (research and Coast Guard) vessels, and occurs throughout the area (Figure 42). The largest vessels to utilize the offshore marine waters of **X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay** *Haida Gwaii* are cargo vessels (container ships, bulk carriers, vehicle carriers, and other cargo ships), cruise ships and tankers. Shipping and cruise traffic in this part of the NSB transits along a Pacific Northwest Route (Southeast Alaska, Washington, British Columbia Ports) or along a Great Circle Route to Asia.

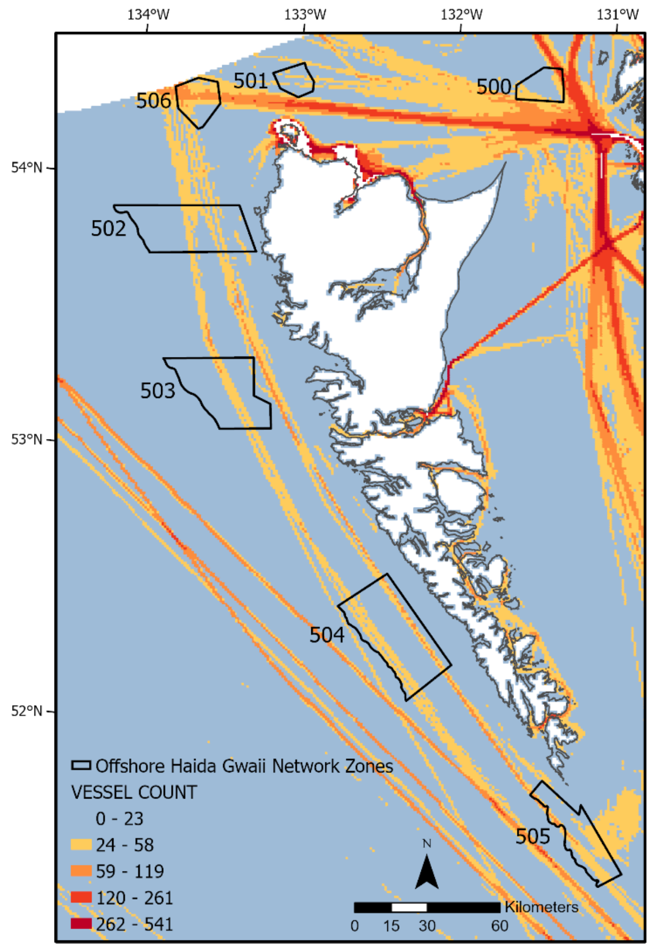

Figure 42. Total annual estimated vessel traffic for 2019 in the ***X̲aadáa Gwáay X̲aayda***g̲***a Gwaay.yaay*** *Haida Gwaii region of the NSB at a spatial resolution of 1 km^2. Data provided by Transport Canada and are from Terrestrial Automatic Identification System (AIS) via Canadian Coast Guard and Satellite AIS via Maerospace. Vessel types included in these tracks are: cargo, container, dry bulk, ferry, fishing, government research, passenger, pleasure, special ships, tanker, tug, and other. Vessel Count is the total number of transits per grid cell.*

DFO's Conservation and Protection Aerial Surveillance Program detected vessels in all the OHGNZ in 2019 and all zones except for 501 in 2020 (Burke et al. 2022). Combined 2019 and 2020 vessel counts were highest in Zone 500, followed by Zones 502 and 505 (Figure 43). Very little vessel activity was observed in the remaining zones. Most vessels detected on the flyovers were fishing vessels, followed by commercial vessels (i.e., other than fishing) and government vessels. In 2019 and 2020, vessel activity increased in the summer months (i.e., July and August) (Figure 44; Burke et al. 2022).

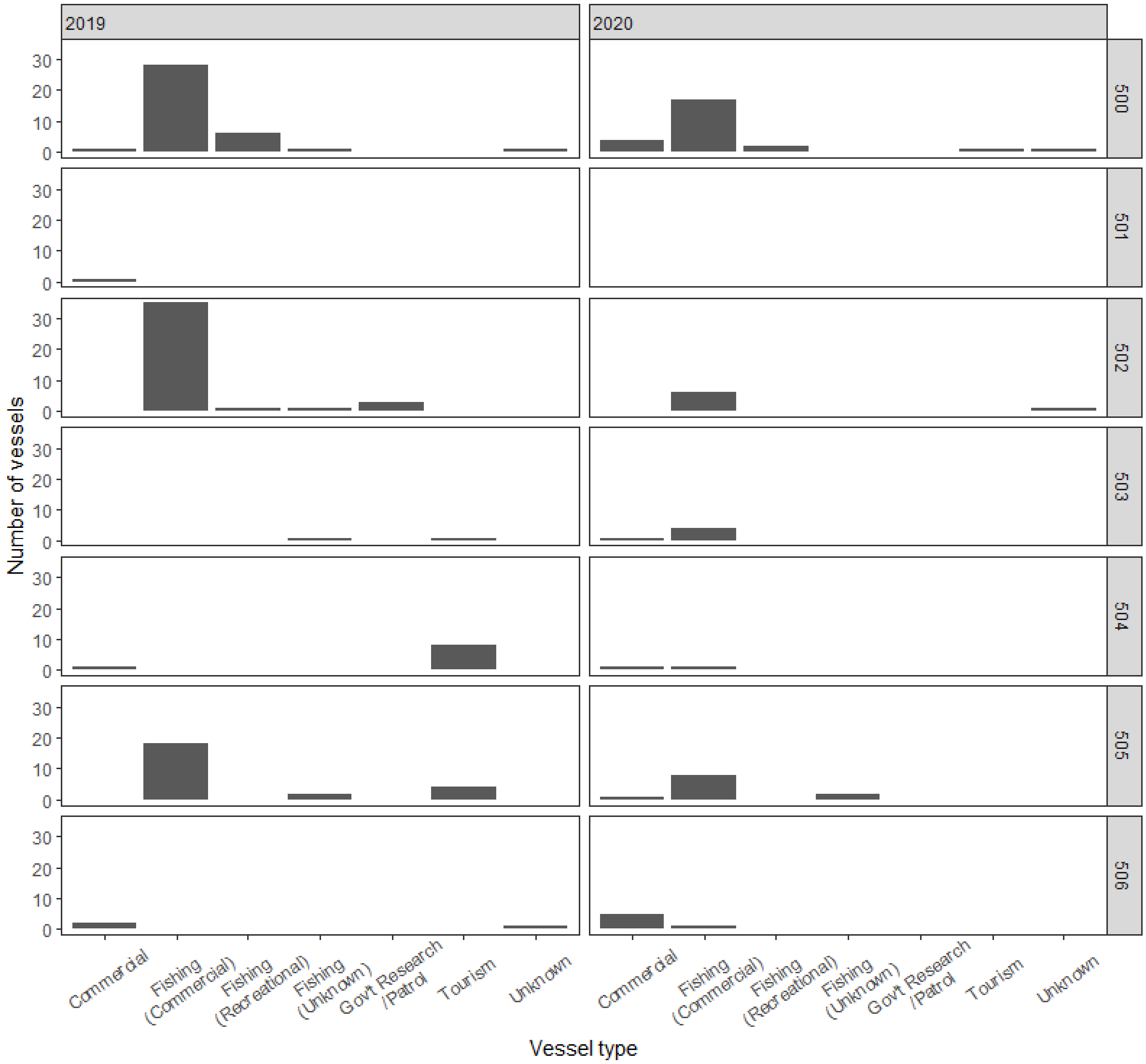

Figure 43. Number of vessels by vessel type in the Offshore Haida Gwaii Network Zones for the years 2019 and 2020. Data comes from DFO's Conservation and Protection Aerial Surveillance Program (Burke et al. 2022).

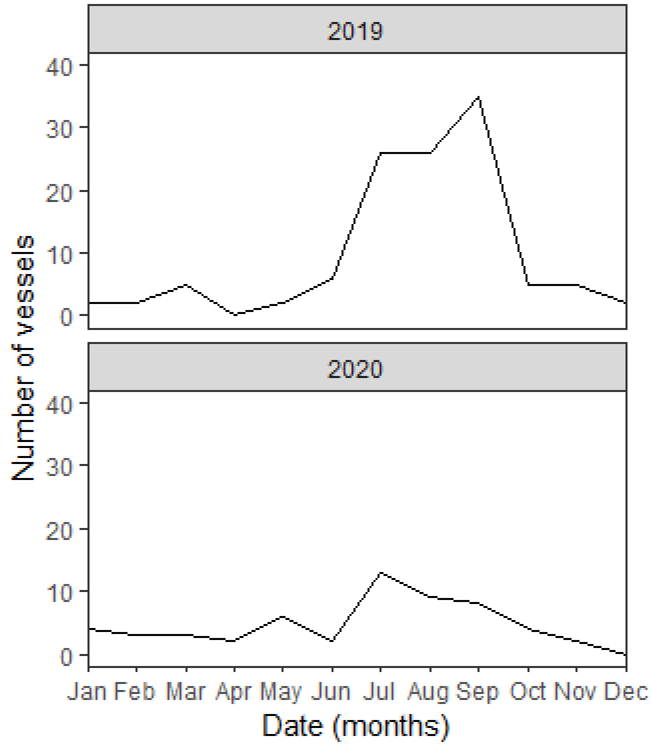

Figure 44. Number of vessels per month in the Offshore Haida Gwaii Network Zones in 2019 and 2020. Data comes from the Conservation and Protection Aerial Surveillance Program (Burke et al. 2022).

There are some US-based tugs that transit **Duu Gúusd Daawxuusda** *the west coast of Haida Gwaii*, while ferries generally do not transit the west coast (Robertson et al. 2020). Due to X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay's position as an archipelago on the edge of the continental shelf with ecologically significant biodiversity and habitats, the risk of oil spills from large vessels is of concern and the Duu Gúusd Daawxuusda including all the western most Offshore Haida Gwaii Network Zones are considered a high risk (Task Force 2002, cited in Robertson et al. 2020). Various management tools are used to direct this traffic including the *Oil Tanker Moratorium Act* that limits the amount of oil that can be carried by tankers stopping at ports in northern BC (Bill C-48), the Voluntary Tanker Exclusion Zone that requires loaded oil tankers travelling between Washington State and Alaska to travel west of a zone determined by the drift rate of disabled vessels (Transport Canada), and the Voluntary Protection Zone (VPZ; Figure 45) for Shipping on the Duu Gúusd Daawxuusda, detailed below.

Figure 45. Map of the Voluntary Protection Zone on ***Duu Gúusd Daawxuusda*** *the west coast of Haida Gwaii (left panel) in the Pacific Region of BC (right panel) (image taken from the Voluntary Protection Zone for Shipping West Coast of Haida Gwaii website.*

The VPZ (Figure 45) was established on September 1, 2020, and remains in effect until further notice. The VPZ is a unique and significant collaboration between the Council of the Haida Nation, the Government of Canada, and the maritime shipping industry, along with other advisors and partners, and is the result of an analysis of multi-year vessel traffic patterns and potential impacts on industry operations. The VPZ applies to vessels of ≥ 500 tons gross tonnage, except for tugs, barges, and fishing vessels. Participation in the VPZ is voluntary, and adherence is reviewed monthly using traffic pattern Automatic Identification System data. Since September 2020, there have been 362 passages inside the VPZ (7 cruises, 23 vessels transiting between Pacific Northwest ports and 332 vessels travelling the Great Circle Route between North America and Asia) and 3,366 vessels outside the VPZ (July 2022 Progress Report).

5.5. OCEAN ENERGY

Within the OHGNZ, ocean energy sources include offshore oil and gas (tenures, wells and prospection), wave and wind energy areas, or areas of high wave power (BCMCA Project Team 2011; Figure 46, Figure 47, Figure 48). From these data, it is unclear how much of the area is being used to produce energy. Still, these areas have the potential for multiple energy sources, suggesting the possibility of future development and associated traffic and environmental pressures.

As of 2010, federal gas tenures exist in all but one of the zones (Zone 504) and all zones are considered as areas for oil and gas prospection (Figure 46). While there is no active oil and gas extraction, a tenure does suggest the potential to extract it. However, most tenures were issued in the 1960s, and moratoria on offshore oil and gas exploration and development were imposed by the Government of Canada in 1972 and by the Province of BC in 1989 (BCMCA Project Team 2011, Marine Protected Areas (MPA) Protection Standard). Furthermore, there have been relinquishments of oil and gas licenses in recent years (e.g., Suncor and Shell).

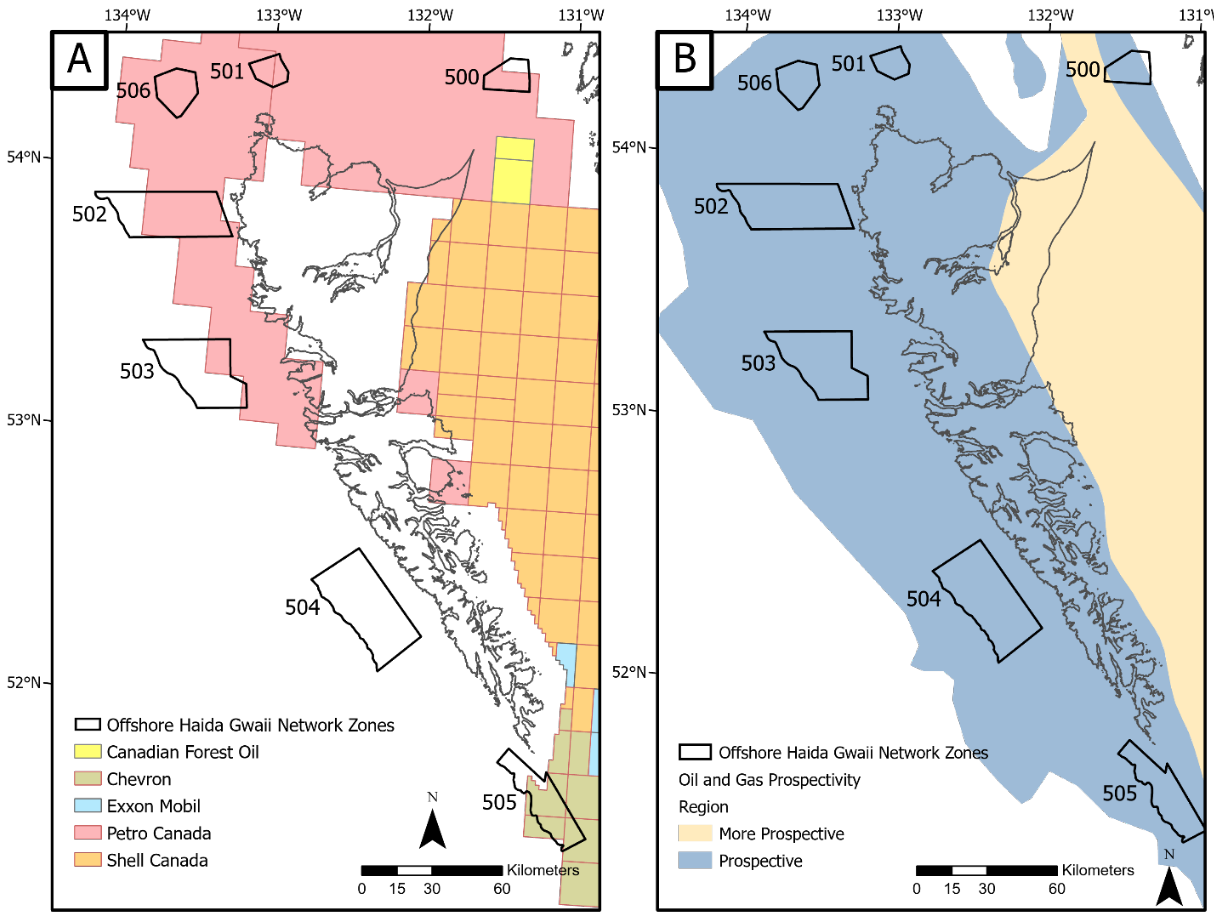

Figure 46. Oil and Gas exploration in the Offshore Haida Gwaii Network Zones: (A) Federal Offshore Oil and Gas Tenures, and (B) Oil and Gas Prospection as of 2010. Data obtained from BCMCA (BCMCA Project Team 2011).

Wind waves and swell are also important in the area (Figure 46, Figure 47). Robertson et al. (2014) show that the west coast of British Columbia ranks as one of the highest wave energy areas in the world and has excellent potential to leverage wave energy as a clean, renewable energy source. Wave energy areas of interest overlap with two zones within the OHGNZ – Zone 503 and 506 (Figure 47A), and wave power is highest in Zones 501 to 504 and decreases into **Síigee** *Dixon Entrance* (Figure 47b). Wind energy is high in all the OHGNZ, with the highest values in Zone 500 (Figure 47).

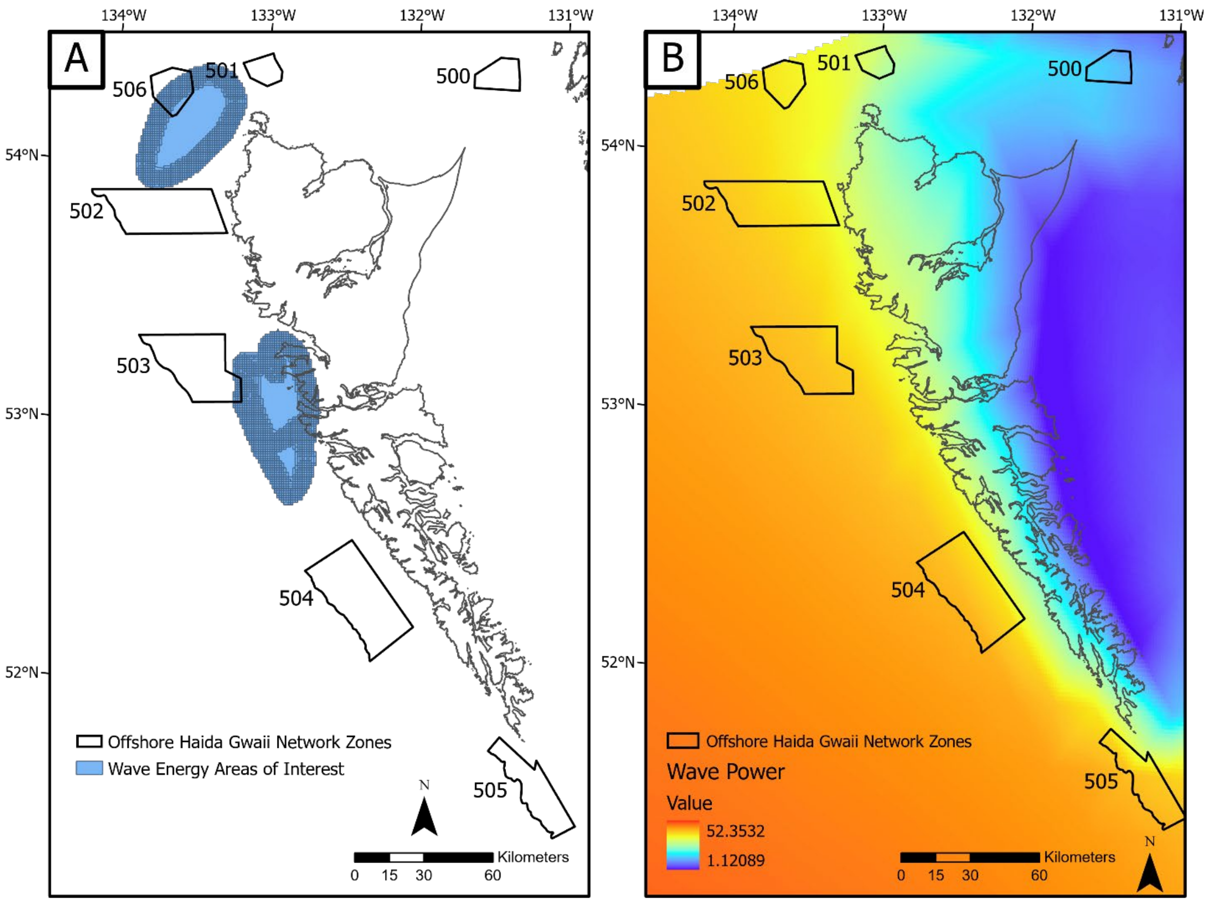

Figure 47. Potential wave power in the Offshore Haida Gwaii Network Zones: (A) Wave energy areas of interest, obtained from BCMCA; and (B) wave power (kW/m) obtained from BCMCA (BCMCA Project Team 2011).

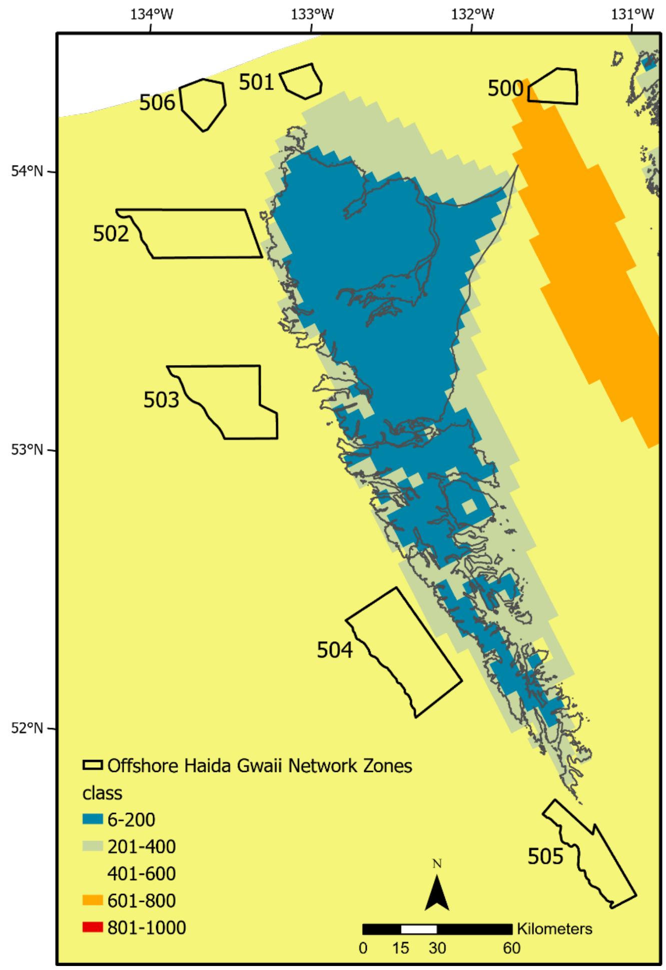

Figure 48. Wind energy in the Offshore Haida Gwaii Network Zones, w/m^2, obtained from BCMCA (BCMCA Project Team 2011).

5.6. POLLUTANTS

Marine pollutants enter the ocean from anthropogenic sources, including sewage, litter, effluent discharge, and marine spills. Documented sources of pollutants within **X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay** *Haida Gwaii*'s marine waters are sewage discharges into coastal waters from septic fields, municipal outfalls, vessels and float camps (MaPP 2015). Small and large vessels can regularly discharge oily bilge water, sewage and litter, and large vessels can also discharge ballast water.

Marine litter through incidental and unintended fishery (commercial, recreational and First Nation) gear loss may occur due to inclement weather, gear failure, or entanglement with underwater obstacles (Huntington 2019; Richardson et al. 2018). Intentionally discarded gear may also occur through illegal, unreported, and unregulated fishing, or gear conflict (Gilman 2016; Richardson et al. 2019). The marine environment is impacted in several ways by lost gear including through: ghost fishing, where gear continues to capture marine animals; habitat disturbance and damage upon impact or entanglement; and as undetectable marine hazards to mariners and SCUBA divers (Huntington 2019; Macfadyen et al. 2009). Data collected from 2020 workshops with fishers found that the highest region suspected of trap gear loss on the BC coast surrounds **Née Kún** *Rose Spit*, at the northeast corner of **X̲aadáa Gwáay X̲aaydag̲a**

Gwaay.yaay *Haida Gwaii*, and longline gear was specifically reported on the north and west sides of X̲aadáa Gwáay X̲aaydag̲a Gwaay.yaay (Eadie and Bright 2020).

Vessel traffic is a key concern as a source of pollutants, particularly in the form of oil spills. Furthermore, the development of infrastructure, such as oil pipelines and natural gas facilities, could result in increased risks from increasing vessel traffic and associated pollutant discharge (oil, bilge, cargo) and ocean noise (see Vessel Traffic section above for more details). Marine pollution and contamination can negatively impact marine life and directly jeopardize individual species' health and habitats. Chronic and acute toxicity of petroleum compounds is detrimental for fishes, and in studies looking at toxicity from contaminants in Alaska, it has been shown to increase mortality, reduce growth, and increase deformations in salmon (Levy 2009).

Coastal human populations, vesels and future infrastructure can also be sources of light pollution with potential negative effects on seabirds and marine life. While light pollution from coastal cities is not in close proximity to the OHGNZ (Figure 49), increased human density or infrastructure development could lead to higher levels of light pollution and affect the marine environment (e.g., Kyba et al. 2017; Marangoni et al. 2022). In addition, as shown in the vessel activity section of this report, we know that vessels utilize the OHGNZ and can be sources of light pollution (Marangoni et al. 2022; in addition to noise), with negative impacts on marine biodiversity, including marine birds (Lyons and De Olivera Menezes 2020), turtles and coastal ecosystems (Marangoni et al. 2022).

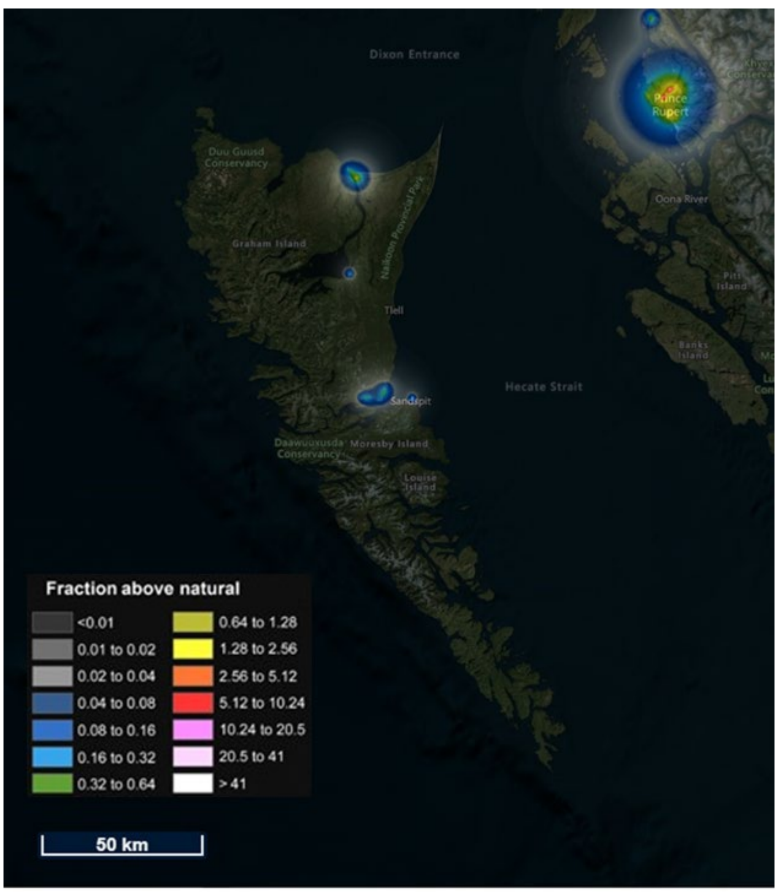

Figure 49. Light pollution from terrestrial infrastructure expressed as a ratio to natural brightness. Data from World Atlas 2015 (Falchi et al. 2016).

5.7. HUMAN USE SUMMARY

Known and suspected human activities and their projected risks for the OHGNZ have been documented in the sections above. Ongoing cumulative effects mapping at DFO estimates the impact of multiple stressors to aid ecosystem-based management and spatial planning to protect biodiversity and ecosystem services (Sala et al. 2000; Crain et al. 2008). Spatial data on the location and intensity of marine, coastal and land-based human activities and climate change stressors were compiled previously by Clarke Murray and co-authors (2015a) and have recently been updated[13]. 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.

We present the activities and stressors that have more than five percent area coverage in the OHGNZ identified through the latest cumulative effect assessment (Table 25). Cumulative effect scores are not reported as they are currently being updated, instead activities with more than 5 percent area coverage are indicated as present in the Network Zones. For further details on the datasets refer to Clarke Murray et al. (2015a and their Supplementary tables). Note that the data presented in Table 11 are current from 2011 to October 2021, depending on the data layer. SST impacts all the Network Zones. **K̲adlee** *Offshore Celestial Reef* (Zone 500) has the highest number of marine and coastal human activities and climate change stressors documented (n = 9) followed by **Sasga K̲'ádgwii** *Offshore Continental Slope North* (Zone 502; n = 8), and **G̲angx̲id Kun SG̲aagiidaay** *Cape St. James* (Zone 505; n = 7; Table 25). While this isn't an exhaustive list of climate change stressors or human activities, and only the presence of activities are reported here, this information provides hints regarding the potential cumulative impacts each zone is exposed to and the stressors that future protection may be able to mitigate (see Table 1 in Clarke Murray et al. 2015b).

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

Table 25. Marine and coastal human activities and climate change stressors documented in the Offshore Haida Gwaii Network Zones. Only those human activities that impact >5% of the surface area of each zone are included in the table below. X indicates the presence of that activity in each zone; a dash indicates absence.

Human Activities and Climate Change Stressors	Zones						
	505	504	503	502	506	501	500
Climate Change							
Sea Surface Temperature	X	X	X	X	X	X	X
Coastal							
Industrial Tenures	-	X	-	-	-	-	-
Ports	-	-	-	-	-	X	-
Fishing							
Commercial: Sablefish Trawl	X	-	X	X	X	-	X
Commercial: Lingcod	-	-	-	X	-	X	X
Commercial: Red Urchin	-	-	-	-	-	-	-
Commercial: Salmon Troll	X	-	X	X	-	X	X
Commercial: Rockfish	X	-	-	X	-	X	X
Commercial: Bottom Groundfish Trawl	X	-	X	X	X	-	X
Commercial: Crab	-	-	-	-	-	-	X
Commercial: Halibut	X	-	-	X	X	X	X
Commercial: Tuna	X	X	X	X	-	-	-
Marine							
Recreational Boat Routes	-	-	-	-	-	-	X
Total Number of Stressors	7	3	5	8	4	6	9

In addition, Activities of Concern were identified through the NAP process (Network Action Plan), including harvest of marine resources, and boating activities. All seven zones in the OHGNZ share the same suite of Activities of Concern: Commercial harvest (bottom longline/demersal hook and line, invertebrate trap, Sablefish trap, gill nets, pelagic and mid-water trawl, purse seine, trolling for salmon), Recreational harverst (jigging, invertebrate trap, trolling by rod and reel), Industrial projects (oil and gas activities, mining, dumping), and Boating. Additional trolling for tuna occurs in Zones 500 to 503 and Zone 506.

The human uses that are currently creating the greatest sources of environmental pressure on habitats and biodiversity in the OHGNZ are commercial fishing and ongoing and projected climate change (detailed in the next section).

6. CLIMATE CHANGE IMPACTS

6.1. PROJECTED CHANGES TO OCEAN ENVIRONMENTAL VARIABLES

Climate change alters the ocean's distribution of heat, alkalinity and oxygen. These changes will have notable consequences for marine life, impacting their distribution, fitness and survival, and phenology (Cheung et al. 2009; Poloczanska et al. 2016). The waters of the Northern Shelf Bioregion are warming and have been since at least 1981 (Figure 13). Additionally, a warming trend is projected into 2070 by two separate climate change models detailed below. As air and water temperatures rise the dissolved oxygen content of the ocean declines, and oxygen demand from organisms increases; further, increased atmospheric carbon dioxide levels increase the acidity of oceanic waters as it is absorbed, lowering the pH. Marine species will generally shift their habitats towards deeper, colder waters at higher latitudes, where their physiological tolerances and dispersal abilities allow (Pinsky et al. 2020). However, oxygen loss at depth (300–1,000 m) is projected to also negatively impact marine species, likely causing some species to shift to shallower depths (Thompson et al. 2023b).

Cummins and Masson (2014) analyzed surface temperatures and salinity measured at lighthouses throughout BC since the 1930s and 1940s. At **K'íis Gwáay** *Langara Island*, which is at the northwest corner of **X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay** *Haida Gwaii*, measurements began in 1940. The 73-year record showed surface water warming at about 0.75°C per century (Table 2 of Cummins and Masson 2014). Other stations, such as Bonilla Island (**K̲andaliiG̲wii** *Hecate Strait*, 53 years record) and Pine Island at the mouth of Queen Charlotte Strait (76 years record), showed similar warming. For comparison, Cummins and Ross (2020) report trends of about 1.5°C per century in the upper 50 m at Station P. Hardy et al. (2021) show, using satellite imagery, that winter temperatures in four regions around southern X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay increased by 0.15–0.26°C per decade over the last four decades (Figure 13). They further found that the number of days with Sea Surface Temperature (SST) less than 11°C within the Gwaii Haanas National Marine Conservation Area Reserve (NMCAR) and Haida Heritage Site (HHS) increased significantly over the previous four decades at a rate of 0.766 day/year. Hardy et al. 2021 recommend using high-resolution imagery for this region to ensure higher-quality results in future analyses. Additionally, further work is required to reconcile the trend estimates from different studies by accounting for the different periods of each analysis. In the Northeast Pacific, estimated trends depend highly on the chosen years and analysis methods.

Projected future seasonal environmental conditions in the OHGNZ were calculated using two regional ocean models that downscale the global climate model projection under two Representative Concentration Pathways (RCP) emissions scenarios (RCP 4.5 and RCP 8.5) while considering the complex bathymetry and ocean currents in this region. The Northeastern Pacific Canadian Ocean Ecosystem Model (NEP36-CanOE; Holdsworth et al. 2021) provides a historical baseline for 1986–2005 and a future projection for 2046–2065, and the British Columbia 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 the benthic and sea surface layers in each zone and dissolved oxygen for the benthic layer (sensu Friesen et al. 2021). RCP 4.5 is a moderate scenario in which emissions peak around 2040 and then decline. RCP 8.5 is the highest baseline emissions scenario in which emissions continue to rise throughout the twenty-first century. We prioritize describing the RCP 4.5 values in this report, as the RCP 8.5 projection has been criticized for being too unrealistic (e.g., Hausfather and Peters 2020); the RCP 8.5 values are available in Appendix H. A subsequent analysis of the two regional ocean models was run for two sets of parameters – zones and biophysical units. Two large-scale biophysical units (shelf and slope) were chosen for further analysis because they host different assemblages of species and were chosen to represent unique complements of physiographic and ocean conditions such as bathymetry, temperature, salinity, and currents (see previous section Biological Communities of the Continental Shelf and Slope; Rubidge et al. 2016; DFO 2016a). Note that the boundaries between the Shelf and Slope units should be considered transition zones where the biological and environmental conditions vary across gradients.

6.1.1. Ocean Temperature

Temperature affects physiological processes (Huey et al. 2012), and since many marine organisms already live close to their thermal tolerances (Pinsky et al. 2020), increases in temperature can negatively impact their performance and survival. Consequently, when exposed to warming ocean temperatures marine organisms will need to either acclimate or adjust their geographic distributions to match their physiological tolerances and habitat requirements. The biological importance of rising temperature varies within and among species, as physiological tolerances vary and developmental stages are differentially susceptible to environmental stress (reviewed in Hu et al. 2022). Examples of rising temperature acclimation in the marine environments are rare (Gunderson et al. 2016), but increasingly range shifts are being observed across multiple marine taxa, including marine birds (Poloczanska et al. 2013), fishes (Kleisner et al. 2017) and benthic invertebrates (Hiddink et al. 2015). However, increasing ocean temperatures do not affect marine fauna and flora in isolation—instead the synergistic effects of temperature, hypoxia and other climate related properties lead to ecosystem shifts and varied impacts on the abundance and distribution of marine taxa. For example, a meta-analysis of climate change studies (Hu et al. 2022) suggests that higher trophic level marine species have a higher tolerance for ocean acidification (see Ocean Acidification and Aragonite section below) but a greater sensitivity for increasing ocean temperatures. Furthermore, marine herbivores are the most vulnerable to both acidification and warming (Hu et al. 2022).

The BCCM regional ocean model projects temperature changes of greater than 1°C for all four seasons in the surface layer of all zones and biophysical units under the RCP 4.5 emissions scenario (Table 26) and changes greater than 2°C under the RCP 8.5 emissions scenario (Appendix H). The model projects the highest surface water temperatures in the summer and fall (1.42–1.86°C increase RCP 4.5; 2.3–2.89°C increase RCP 8.5). The coolest surface water temperatures are projected in the Spring and Winter (1.43–1.73°C increase RCP 4.5; 2.18–2.34°C increase RCP 8.5). The NEP36-CanOE regional ocean model is slightly more negative under the RCP 4.5 scenario with Zones 504 and 503 projected to have temperature increases greater than 2°C in fall months (Table 27). By contrast the NEP36-CanOE regional ocean model is slightly more conservative under the RCP 8.5 scenario, with a handful of zones during some seasons experiencing a less extreme temperature change of 1 and 2°C in the surface layer (Appendix H). Bottom temperatures are expected to have less overall temperature change, however, smaller temperature changes will have potentially large effects on benthic chemistry, fauna and flora (Hiddink et al. 2015). Temperature change increases observed in the bottom layer of the OHGNZ zones range from 0.00°C to 1.08°C (Table 26) with the BCCM model and range from 0.00°C to 1.54°C (Table 27) with the NEP-36 model under RCP 4.5. The BCCM model projects changes of 1–2°C in the benthic layer during spring and winter in the shelf biophysical unit under RCP 4.5, and additionally in Zones 501 and 500 under RCP 8.5 (Table H.1). The NEP-36 model projects larger temperature changes in the bottom layer, and Zones 506, 501 and 500, and the shelf biophysical unit all have projected temperature changes of greater than 1°C (Table 27).

Table 26. Seasonal mean sea temperature (°C; sea bottom and sea surface) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii Network Zones using BCCM (Peña et al. 2019) regional ocean model outputs. The historical time period is 1981–2010, for which mean sea temperature 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 sea temperature is provided. Seasons were delineated as: spring (Spr; Mar-Apr-May), summer (Sum; Jun–Jul–Aug), fall (Sep–Oct–Nov), and winter (Win; Dec–Jan–Feb). Red shading and an asterisk (*) highlight zones with a temperature change >2°C for surface waters, and >1°C for bottom waters between the historical values and projected future values. Yellow shading and a circumflex (^) highlight zones with a temperature change >1°C and <2°C for surface waters between the historical values and projected future values.

	Sea Bottom Temperature (°C)								**Sea Surface Temperature (°C)**							
	Historical Value (1981–2010)				**Projected Future Change (2041–2070; RCP 4.5)**				**Historical Value (1981–2010)**				**Projected Future Change (2041–2070; RCP 4.5)**			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	3.28	3.27	3.35	3.33	+0.20	+0.19	+0.19	+0.21	8.69	13.35	12.31	8.20	+1.58^	+1.42^	+1.51^	+1.50^
Zone 504	2.08	2.09	2.11	2.10	+0.00	+0.00	+0.00	+0.01	8.33	13.09	12.17	7.92	+1.64^	+1.52^	+1.63^	+1.53^
Zone 503	2.56	2.56	2.60	2.58	+0.08	+0.07	+0.07	+0.09	8.02	13.09	12.25	7.67	+1.68^	+1.70^	+1.72^	+1.60^
Zone 502	3.90	3.87	4.01	4.05	+0.40	+0.32	+0.30	+0.40	7.92	12.98	12.06	7.55	+1.68^	+1.77^	+1.81^	+1.58^
Zone 506	5.10	4.94	5.08	5.29	+0.70	+0.62	+0.58	+0.67	7.78	12.67	11.60	7.37	+1.73^	+1.85^	+1.86^	+1.62^
Zone 501	5.41	5.25	5.46	5.74	+0.80	+0.66	+0.61	+0.79	7.83	12.42	11.00	7.22	+1.63^	+1.63^	+1.68^	+1.52^
Zone 500	5.85	5.77	6.05	6.22	+0.93	+0.72	+0.67	+0.87	8.11	12.93	10.81	7.08	+1.59^	+1.57^	+1.62^	+1.43^
Shelf	6.79	6.74	7.20	7.26	+1.08*	+0.78	+0.81	+1.06*	8.67	13.29	11.66	8.00	+1.57^	+1.46^	+1.66^	+1.49^
Slope	2.71	2.71	2.76	2.74	+0.09	+0.08	+0.08	+0.10	8.49	13.26	12.38	8.04	+1.61^	+1.44^	+1.68^	+1.56^

Table 27. Seasonal mean sea temperature (°C; sea bottom and sea surface) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii Network Zones using NEP36-CanOE (Holdsworth et al. 2021) regional ocean model outputs. The historical time period is 1986–2005, for which mean sea temperature values are provided. The projected future time period is 2046–2065 under the RCP 4.5 emissions (no climate mitigation) scenario, for which the projected change in mean sea temperature is provided. Seasons were delineated as: spring (Spr; Mar–Apr–May), summer (Sum; Jun–Jul–Aug), fall (Sep–Oct–Nov), and winter (Win; Dec–Jan–Feb). Red shading and an asterisk (*) highlight zones with a temperature change of >2ºC for surface waters, and >1ºC for bottom waters between the historical and projected future values. Yellow shading and a circumflex (^) highlight zones with a temperature change >1°C and <2°C for surface waters between the historical values and projected future values.

	Sea Bottom Temperature (°C)								**Sea Surface Temperature (°C)**							
	Historical (1986–2005)				**Projected Future (2046–2065; RCP 4.5)**				**Historical (1986–2005)**				**Projected Future (2046–2065; RCP 4.5)**			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	3.23	3.15	3.18	3.27	+0.23	+0.25	+0.26	+0.25	7.89	13.78	11.85	7.66	+1.79^	+1.60^	+1.50^	+1.70^
Zone 504	2.04	2.04	2.04	2.04	-0.01	0.00	0.00	0.00	7.00	13.07	11.60	7.14	+1.92^	+1.77^	+2.09*	+1.70^
Zone 503	2.89	2.86	2.90	2.94	+0.17	+0.18	+0.19	+0.18	7.00	13.86	12.00	7.00	+1.87^	+1.65^	+2.05*	+1.81^
Zone 502	4.23	4.39	4.57	4.34	+0.64	+0.56	+0.52	+0.61	7.00	13.01	11.49	6.99	+1.92^	+1.69^	+1.91^	+1.76^
Zone 506	5.92	5.17	5.64	6.00	+1.01*	+0.94	+0.97	+0.97	7.00	12.67	11.00	7.00	+1.84^	+1.59^	+1.53^	+1.70^
Zone 501	5.99	5.40	5.82	6.00	+1.00	+0.91	+0.91	+1.02*	7.00	12.70	11.00	7.00	+1.84^	+1.77^	+1.65^	+1.69^
Zone 500	6.00	6.02	6.17	6.40	+1.20*	+0.99	+0.90	+1.05*	6.35	13.00	11.00	6.00	+1.98^	+1.56^	+1.56^	+1.76^
Shelf	6.72	6.99	7.43	7.22	+1.54*	+1.13*	+1.09*	+1.50*	7.45	13.01	11.35	7.50	+1.90^	+1.68^	+1.86^	+1.83^
Slope	2.75	2.74	2.76	2.79	+0.12	+0.13	+0.14	+0.13	7.40	13.35	11.87	7.46	+1.89^	+1.53^	+1.91^	+1.79^

6.1.2. Ocean Acidification and Aragonite

As excess carbon dioxide enters marine waters and forms carbonic acid, water acidifies and lowers carbonate ion concentrations (Fabry et al. 2008). Aragonite is a measure of carbonate ion concentration, which is a soluble form of calcium carbonate that is widely used by marine organisms with calcium carbonate structures. Carbonate ions are used by organisms with carbonate structures to create their shells and skeletons. Decreases in carbonate ions decrease these organisms' ability to form hard carbonate structures, particularly for juveniles (Fabry et al. 2008. Consequently, Aragonite serves both as a measure of ocean acidification (in relation to carbon dioxide levels) and as a measure of available carbonate ions to organisms such as corals, clams, oysters, and some plankton. Corals and other calcifiers are more likely to have their shells and other carbonate structures begin to dissolve at aragonite levels of less than 1 (undersaturation; Miller et al. 2009). However, it is important to note that saturation states change with latititude (highest in tropics) because the solubility of calcium carbonate increases with increasing pressure and decreasing temperature (Fabry et al. 2008) and it may also vary by species (Miller et al. 2009).

Aragonite levels are projected to have the greatest decreases in the bottom layer. This projection was larger with the BCCM regional ocean model (Table 28) than the NEP36-CanOE regional ocean model (Table 29). The average aragonite saturation state (ΩA) below 100 m decreases in all zones and biophysical units of the OHGNZ throughout the year with the future BCCM model (lower ΩA). Of note was the historical scenario, which showed sea bottom aragonite undersaturation in all zones except for 500 in the spring and winter, in addition to the slope biophysical unit. Aragonite undersaturation is projected to be greater in Zone 503 under RCP 4.5 (0.52; Table 28). While the NEP-36 model is more conservative regarding projected aragonite undersaturation, the general observation of undersaturation being greater in Zone 503 also holds under RCP 4.5 (Table 29). Despite the generalized negative impacts of increased aragonite levels for organisms with carbonate structures, other organisms are expected to do well in an acidifying ocean. For example seagrass (although absent from the OHGNZ) and some plankton species use carbon dioxide to photosynthesize but do not use carbonate ions to survive (Koch et al. 2012).

Table 28. Seasonal mean aragonite saturation state (sea bottom and sea surface) within the seven zones and two large-scale biophysical unit areas of the Offshore Haida Gwaii 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 and an asterisk (*) highlight zones with W_A <1.

	Sea Bottom Aragonite Saturation State								Sea Surface Aragonite Saturation State							
	Historical Value (1981–2010)				Projected Future Change (2041–2070; RCP 4.5)				Historical Value (1981–2010)				Projected Future Change (2041–2070; RCP 4.5)			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	0.60*	0.60*	0.60*	0.60*	-0.05*	-0.05*	-0.05*	-0.05*	2.07	2.36	2.17	1.75	-0.36	-0.39	-0.40	-0.33
Zone 504	0.53*	0.54*	0.53*	0.53*	-0.01*	-0.01*	-0.01*	-0.01*	2.07	2.39	2.20	1.73	-0.35	-0.42	-0.39	-0.33
Zone 503	0.54*	0.54*	0.54*	0.54*	-0.02*	-0.02*	-0.02*	-0.02*	2.08	2.44	2.30	1.78	-0.36	-0.40	-0.40	-0.33
Zone 502	0.72*	0.70*	0.69*	0.72*	-0.09*	-0.08*	-0.09*	-0.09*	2.06	2.48	2.31	1.76	-0.35	-0.39	-0.38	-0.32
Zone 506	0.83*	0.83*	0.80*	0.81*	-0.14*	-0.13*	-0.14*	-0.15*	2.06	2.46	2.25	1.74	-0.34	-0.37	-0.35	-0.30
Zone 501	0.91*	0.88*	0.84*	0.90*	-0.16*	-0.14*	-0.15*	-0.16*	2.01	2.36	2.07	1.62	-0.31	-0.35	-0.33	-0.28
Zone 500	1.03	0.97*	0.94*	1.01	-0.19*	-0.18*	-0.17*	-0.18*	2.00	2.21	2.00	1.56	-0.28	-0.30	-0.30	-0.26
Shelf	1.19	1.07	1.05	1.19	-0.22*	-0.22*	-0.22*	-0.24*	2.01	2.32	2.05	1.64	-0.30	-0.34	-0.32	-0.28
Slope	0.56*	0.56*	0.56*	0.52*	-0.02*	-0.03*	-0.03*	-0.03*	2.07	2.4	2.24	1.77	-0.37	-0.39	-0.39	-0.35

Table 29. Seasonal mean aragonite saturation state (sea bottom and sea surface) within the seven zones and two large-scale biophysical unit areas of the Offshore Haida Gwaii Network Zones using NEP36-CanOE (Holdsworth et al. 2021) regional ocean model outputs. The historical time 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 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 and an asterisk (*) highlight zones with W_A <1.

	Sea Bottom Aragonite Saturation State								**Sea Surface Aragonite Saturation State**							
	Historical (1986–2005)				**Projected Future (2046–2065; RCP 4.5)**				**Historical (1986–2005)**				**Projected Future (2046–2065; RCP 4.5)**			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	1.00	0.96*	0.98*	1.00	-0.07*	-0.06*	-0.07*	-0.07*	2.00	2.00	2.00	2.00	-0.40	-0.41	-0.44	-0.37
Zone 504	0.94*	1.00	1.00	1.00	-0.04*	-0.01*	-0.02*	-0.01*	2.00	2.00	2.00	2.00	-0.35	-0.41	-0.32	-0.35
Zone 503	0.92*	0.70*	0.79*	1.00	-0.04*	-0.03*	-0.04*	-0.04*	2.00	2.00	2.00	2.00	-0.33	-0.41	-0.35	-0.32
Zone 502	1.17	1.00	0.85*	1.19	-0.13	-0.13*	-0.14*	-0.13	2.00	2.00	2.00	2.00	-0.34	-0.42	-0.39	-0.32
Zone 506	1.00	1.00	1.00	1.00	-0.24*	-0.22*	-0.21*	-0.26*	2.00	2.00	2.00	2.00	-0.35	-0.38	-0.46	-0.32
Zone 501	1.00	1.00	1.00	1.00	-0.27*	-0.23*	-0.26*	-0.29*	2.00	2.00	2.00	2.00	-0.33	-0.39	-0.41	-0.32
Zone 500	1.08	1.00	1.00	1.15	-0.30*	-0.29*	-0.33*	-0.32*	2.00	2.00	2.00	2.00	-0.33	-0.43	-0.40	-0.35
Shelf	1.60	1.26	1.35	1.71	-0.31*	-0.31*	-0.34	-0.34	2.00	2.00	2.00	2.00	-0.37	-0.38	-0.34	-0.36
Slope	0.94*	0.89*	0.84*	1.00	-0.04*	-0.04*	-0.04*	-0.04*	2.00	2.00	2.00	2.00	-0.37	-0.42	-0.36	-0.36

6.1.3. Ocean Oxygenation

Most water-breathing animals have a critical oxygen tension or 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 can differ greatly among species, as the physiological threshold varies greatly among them (Rabalais et al. 2010). Furthermore, the physiologically relevant level of hypoxia can differ between oceans (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 to define the threshold (Gobler and Baumann 2016). This report uses a conservative measure of <62.5 µmol/L to describe hypoxic bottom waters, although higher or lower oxygen levels will varyingly impact marine life (Rabalais et al. 2010). Hypoxic bottom waters are found in Zones 505, 504, and 503 and along the slope biophysical unit throughout the year (historical model), with projected values ranging between 39.10 to 155.74 µmol/L (Table 30) for the BCCM model, and 41.26 to 239.86 µmol/L (Table 31) for the NEP36 model. Model selection influences the projected oxygen changes, and considerable uncertainty exists for this region regarding projected bottom-layer oxygen levels (Thompson et al. 2023b), and the BCCM model projects increases in dissolved oxygen for some zones and seasons and across the slope biophysical unit (Table 30), in contrast to the NEP36 model (Table 31). Deoxygenation has been documented globally in ocean basins and coastal waters (Diaz and Rosenberg 2008; Ito et al. 2017; Keeling et al. 2010; Whitney et al. 2007). Contributors to deoxygenation include changing ocean circulation, decreasing ventilation, stronger stratification, reduced oxygen solubility in warmer water, and intensifying natural and anthropogenic eutrophication that increases microbial respiration at depth (Rabalais et al. 2010; Ito et al. 2017; Breitburg et al. 2018; Levin 2018).

Table 30. Seasonal mean sea bottom dissolved oxygen (µmol/L) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii Network Zones using BCCM (Peña et al. 2019) regional ocean model outputs. The historical time period is 1981–2010, for which mean sea bottom dissolved oxygen 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 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). Red cells with an asterisk (*) highlight dissolved oxygen < 62.5 µmol/L.

	Sea Bottom Dissolved Oxygen (µmol/L)							
	Historical Value (1981–2010)				Projected Future Change (2041–2070; RCP 4.5)			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	42.16*	41.31*	43.56*	43.77*	+0.04*	+0.17*	-1.34*	-0.50*
Zone 504	45.31*	45.17*	44.84*	44.73*	+0.14*	+0.07*	+0.10*	+0.12*
Zone 503	38.62*	39.08*	38.79*	38.50*	+0.73*	+0.96*	+1.03*	+1.28*
Zone 502	73.36	66.80	61.06	72.16	-0.42	+1.43	-1.60*	+0.04
Zone 506	108.05	105.68	94.23	99.47	+0.56	+3.20	-0.27	+0.29
Zone 501	128.56	113.19	100.65	124.68	-1.61	+0.90	-1.38	+0.04
Zone 500	152.14	129.20	116.81	146.38	-3.54	-2.92	-2.42	-1.57
Shelf	178.88	144.13	133.86	182.51	-1.45	-5.24	-5.66	-2.54
Slope	43.84*	43.61*	43.63*	43.77*	+0.53	+0.60	+0.29	+0.60

Table 31. Seasonal mean sea bottom dissolved oxygen (µmol/L) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii 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 time period is 2046–2065 under the RCP 4.5 emissions (no climate mitigation) scenario, 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). Red cells with an asterisk (*) highlight dissolved oxygen <62.5 µmol/L.

	Sea Bottom Dissolved Oxygen (µmol/L)							
	Historical Value (1986–2005)				**Projected Future Change (2046–2065; RCP 4.5)**			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	57.38*	55.77*	59.05*	60.64*	-9.27*	-10.67*	-11.50*	-10.25*
Zone 504	47.86*	48.15*	48.21*	47.95*	-5.15*	-4.92*	-5.93*	-5.69*
Zone 503	48.53*	47.66*	48.92*	50.33*	-5.78*	-6.13*	-6.38*	-6.41*
Zone 502	110.40	97.97	96.83	112.84	-9.33	-11.60	-11.84	-10.08
Zone 506	164.58	133.43	138.55	183.57	-12.62	-20.91	-17.35	-14.88
Zone 501	183.68	139.51	152.76	204.84	-10.62	-22.99	-24.50	-16.78
Zone 500	254.70	191.30	188.08	244.11	-14.78	-21.35	-26.88	-14.88
Shelf	256.68	205.66	209.24	260.34	-9.29	-17.91	-21.20	-12.02
Slope	46.85*	46.37*	47.33*	47.84*	-7.79*	-8.20*	-8.67*	-8.37*

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; Thompson et al. 2023b). 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 such migration is energetically expensive and may make them more vulnerable to fishing or predators as species move to shallower oxygenated water (Stramma et al. 2011; Gilly et al. 2013). Climate-induced species redistributions and diminishing size result in a global reduction in fish biomass (14 to 24%) and a shift in species distributions away from lower latitudes (Cheung et al. 2013).

The oxygen loss expected to occur between 300–1,000 m are projected to cause deep benthic fish species to shift to shallower waters. This is particularly relevant to the OHGNZ on the slope (Zones 502 to 505) where there is a steep depth gradient and species could potentially move out of a protected zone to avoid low O_2 environments. This highlights the importance of representativity in the overall network where both deep and shallow environments are well captured and connected. For example, Zones 502 and 504 are placed adjacent to other MPA network zones identified with either existing (Gwaii Haanas NMCAR and HHS) or proposed new zones all the way to the shoreline of **X̱aadáa Gwáay X̱aaydaG̱a Gwaay.yaay** *Haida Gwaii* ensuring the land sea connection and space for species to shift depths while remaining in a protected area. This highlights the importance of an MPA network over individual sites where connectivity between zone and across spatial protection legislative tools can increase the ecological benefits of MPAs.

Increasing ocean temperatures do not affect marine fauna and flora in isolation – instead synergistic effects of temperature, hypoxia and other climate related properties resulting in ecosystem shifts and varied impacts on marine taxa. These climate variable should not be measured or understood in isolation of each other, but instead viewed as a combination of effects to which varied distributional responses are expected.

6.2. PROJECTED CHANGES IN GROUNDFISH COMMUNITIES

Under a no-mitigation scenario (RCP 8.5), groundfish species are expected to shift their distribution by as much as 1,000 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) 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 bathymetry distribution based on fisheries independent trawl surveys. They found a tradeoff in depth, temperature and oxygen and that distribution changes depend on groundfish species' physiology (Thompson et al. 2023b). For example, Silvergray Rockfish, found in all seven OHGNZ, are projected to deal with ocean warming by shifting to deeper water, and so their abundance will decrease in shallow waters and increase in deeper waters. **Kyaa.n Sg̲aahlan** *Pacific Cod* found in six of the seven zones (Table 9), by contrast, are sensitive to warming, but low oxygen in deeper waters is projected to limit their ability to shift deeper (Thompson et al. in revision). Finally, some species, including Greenstriped Rockfish, found in all seven OHGNZ (Table 9), can be depth-limited and unable to re-distribute by moving to deeper waters. Since they can tolerate warmer conditions, they are not projected to be negatively affected by projected warming and deoxygenation (RCP 4.5; Thompson et al. 2023b). Consequently, some species' distribution or occurrence is expected to increase, while others will decrease (Thompson et al. 2023b).

Warming in shallow water and hypoxia in deeper waters is likely to push species to mid-depths, where the tradeoff between oxygen levels and temperature is compatible with their physiology (Thompson et al. 2023b). Within the OHGNZ, the redistribution of groundfish species due to climate change is projected to increase species richness in at least part of six of the seven zones (Figure 49), except for Zone 504 for which data are limited, and model coverage was lowest only covering the shallowest depths. The greatest projected species richness gains occur in the northernmost **Síigee** *Dixon Entrance* zones (506, 501, and 500; Figure 49, Figure 50) and under the NEP36 model and the RCP 8.5 emissions scenario. The highest species richness losses occur in Zone 502, which incidentally also experiences the greatest range of species richness changes (Figure 50). This result is unsurprising, considering this zone has the highest depth profile from 20 to 2,750 m (Figure 12), resulting in high species losses from the shallower warmer areas and greater species gains in the mid-depths of the continental shelf and slope areas—ideal rockfish habitat. The climate change analyses highlight the importance of including the range of available depths with the MPA network and within the OHGNZ. Had these zones not been designed across the depth profile of the slope, more of them may lose species.

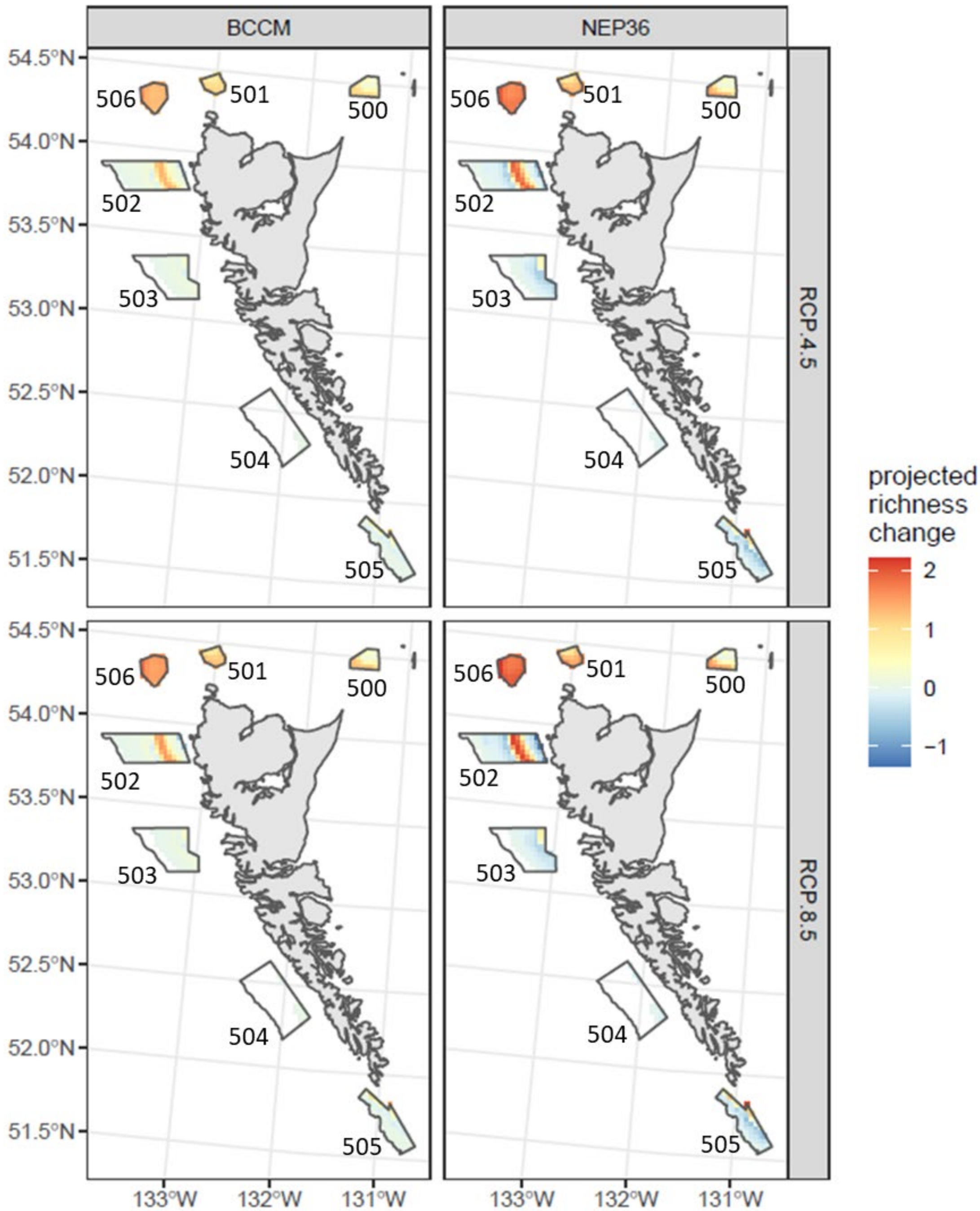

Figure 50. Projected species richness change in the groundfish communtiies (total of 40 groundfish species on the Pacific coast) in the Offshore Haida Gwaii Network Zones based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 emissions scenario (top row) and the RCP 8.5 emissions scenario (bottom row) for both the BCCM climate model (first column) and the NEP36 climate model (second column). Zone numbers are indicated on the outside of each polygon. Note that the projections for Zone 504 (Gwaii Haanas Extension) are only for the shallowest part of the polygon (Thompson et al. 2023b).

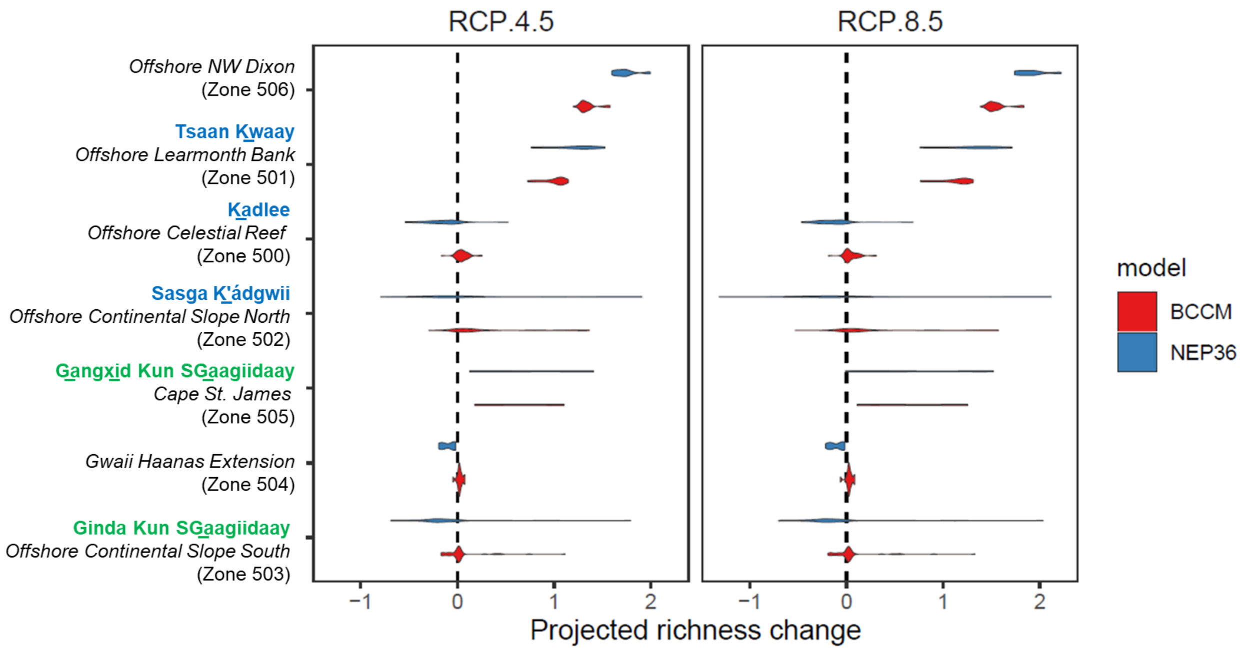

Figure 51. Distributions of projected change in occurrences across the Offshore Haida Gwaii Network Zones for groundfish communities (total of 40 groundfish species on the Pacific coast) based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 emissions scenario (left panel) and the RCP 8.5 emissions scenario (right panel) for both the BCCM climate model (in red) and the NEP36 climate model (in blue). Note that the projections for Gwaii Haanas Extension (Zone 504) are only for the shallowest part of the polygon (Thompson et al. 2023b).

7. CONSERVATION SIGNIFICANCE OF AREA

The OHGNZ is made up of offshore slope and shelf waters, which are exposed to different threats. Offshore waters experience fewer direct impacts from human activity than coastal or on-shelf pelagic waters because they are less accessible (DFO 2019b). However, increasing ship traffic and human use of offshore areas and the seafloor pose an emerging threat (DFO 2019b). The largest effects on pelagic offshore waters are thought to be from climate change and fishing. Climate change may also have unpredictable impacts when compounded with fishing activity and pollution (Strömberg 1997; Winder and Schindler 2004; Schiedek et al. 2007). Anthropogenic stressors and implications for species distributions and sensitivities are summarized in earlier sections of this report:

1. Specific sensitivities of some of the species found in the OHGNZ are detailed in the Taxonomic Diversity section;
2. Human use of the area and the potential stressors that anthropogenic activities pose to the OHGNZ are detailed in the Human Use Of Area section; and
3. The ramifications of two different climate change scenarios on fish communities are described in the Climate Change Impacts section.

Below, a suite of ecological conservation priorities is presented for the seven OHGNZ zones and further indicates the conservation significance of this unique area within the NSB.

Highlights describing the conservation significance of the OHGNZ are briefly summarized by zone in the bullets below.

7.1. GANGXID KUN SGAAGIIDAAY (ZONE 505)

- High habitat heterogeneity – one of three replicate representative bands of slope habitats across depth strata from toe of slope to nearshore when coupled with the 'strict protection' zone in the Gwaii Haanas National Marine Conservation Area Reserve (NMCAR) and Haida Heritage Site (HHS)
- Captures portion of both Cape St. James, Shelf Break and Continental Slope EBSAs
- Representation of multiple groundfish and slope rockfish species
- Representation of a range of cold-water corals and sponges
- Representation of both Continental Slope Ecosection and the Cape St. James Tidal Mixing Region – Upper Ocean Subregion
- Overlaps with areas of very high (**Gangxid Kun** *Cape St. James*) and high (South Moresby Trough) Haida cultural conservation priorities
- Includes the Haida Eddy EBSA

7.2. GWAII HAANAS EXTENSION (ZONE 504)

- High habitat heterogeneity – one of three replicate representative bands of slope habitats across depth strata from toe of slope to nearshore when coupled with the 'strict protection' zone in Gwaii Haanas NMCAR and HHS
- Captures portion of Shelf Break and Continental Slope EBSAs and includes the Haida Eddy EBSA
- Representation of both Continental Slope Ecosection and the Duu Gúusd Daawxuusda Upwelling Region - Upper Ocean Subregion

7.3. GINDA KUN SGAAGIIDAAY (ZONE 503)

- Captures portion of Shelf Break and Continental Slope EBSAs and includes the Haida Eddy EBSA
- Captures western portion of a benthic feature
- Representation of multiple groundfish and slope rockfish species
- Representation of a range of cold-water corals and sponges
- Representation of both Continental Slope Ecosection and the Coastal Mixing Region - Upper Ocean Subregion
- Overlaps with areas of high Haida cultural conservation priorities (**Ginda Kun** *Kindakun*, and and Ginda Kun to slope)

7.4. SASGA K'ÁDGWII (ZONE 502)

- High habitat heterogeneity – one of three replicate representative bands of slope habitats across depth strata from toe of slope to nearshore when coupled with existing Rockfish Conservation Area (**Sasga Gwaay** *Frederick Island*)
- Captures a portion of Shelf Break, Continental Slope, and seamount EBSAs
- Representation of multiple groundfish and slope **K'ats Sgaadang.nga** *rockfish* species

- Representation of a range of cold-water corals and sponges
- Representation of both Continental Slope Ecosection and the Southeast Alaska Mixing Region – Upper Ocean Subregion
- Captures summit and portion (33%) of only known seamount, which is ecologically unique among seamounts, in the Northern Shelf Bioregion
- Overlaps with an area of high Haida cultural conservation priority (Sasga Gwaay to slope)

7.4.1. Offshore Northwest Dixon (Zone 506)

- Representation of multiple slope rockfish species
- Captures portions of identified Shelf fish and invertebrate biomass hotspots
- Representation of both Dixon Entrance Ecosection and the Southeast Alaska Mixing Region – Upper Ocean Subregion

7.4.2. Tsaan Kwaay (Zone 501)

- Captures southern portion of Learmonth Bank EBSA
- Representation of multiple groundfish and K'ats Sgaadang.nga *rockfish* species
- Representation of both Dixon Entrance Ecosection and the Southeast Alaska Mixing Region – Upper Ocean Subregion
- Overlaps with an area of high Haida cultural conservation priority (Tsaan Kwaay)

7.5. KADLEE (ZONE 500)

- Captures southern portion of Kadlee benthic feature
- Captures portions of identified Shelf invertebrate biomass and diversity hotspots
- Representation of multiple groundfish and shelf K'ats Sgaadang.nga *rockfish* species
- Representation of both Dixon Entrance Ecosection and the Dixon Entrance Coastal Flow Region – Upper Ocean Subregion
- Overlaps with an area of high Haida cultural conservation priority (Kadlee)

7.6. NSB NETWORK ECOLOGICAL CONSERVATION PRIORITIES

The seven zones that comprise the OHGNZ are part of a greater network of existing and proposed sites within the Northern Shelf Bioregion. Through the MPA Network planning process, sites were identified for protection based on various factors, including their contribution to capturing a representation of the network's E-CPs (DFO 2017a). E-CPs for the NSB 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 Longspine Thornyhead habitat; DFO 2019a). Consequently, the relative proportion of conservation priorities that each polygon contributes to the OHGNZ can be examined and compared to the overall ecological conservation targets for the entire network.

The following presents the summary results of an overlay analysis on the draft network scenario (Network Action Plan) for individual ecological conservation priorities (E-CPs). Spatial features representing E-CPs have been assessed at the zone level (500–506) for proportion of coverage. The proportions provided represent the proportional amount of each feature contained in the network scenario footprint without considering the potential consequence of human activities. For this analysis, only those spatial features with at least 5% coverage are included (Table 32).

Sasga K'ádgwii *Offshore Continental Slope North Zone* (Zone 502) includes the highest proportional value of E-CPs for both species features and for habitat features (Table 32). The highest species feature proportions occurred for Longspine Thornyhead and Roughtail Skate populations observed during DFO research surveys in Sasga K'ádgwii and **Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* (Zone 503). Sasga K'ádgwii is also remarkable because it is the only zone with a seamount (SAUP 5494, also see the Seamounts section of this report). Overall the OHGNZ provides high spatial coverage (over 10%) of species features for **'Waahúu Tang.gwan Siiga** *Leatherback Sea Turtle,* **Huuga Huuga** *Deepwater Tanner Crab*, Blue Whales, Black coral, Sei Whales, **Kún kaj Gajaaw Kun kaajii Gaajaawuu** *Sperm Whales*, Shelf fish, Roughtail Skate and Longspine Thornyhead (Table 32). Gwaii Haanas Extension (Zone 504) has the second highest proportion of habitat-level E-CPs, because of its large slope coverage. The OHGNZ provides high spatial coverage (over 10%) of habitat features for the Continental Slope (ecosections, geomorphic and biophysical units), EBSAs (Shelf Break, Cape St. James, Seamount, Learmonth Bank), ocean subregions (West Coast QCI Upwelling and Cape St. James Tidal Mixing), and a seamount summit.

Table 32. Summary results for individual ecological conservation priorities (E-CPs) in the Offshore Haida Gwaii Network Zones. The total proportion is the sum of the proportions of each E-CP for the Offshore Haida Gwaii Network Zones, without consideration of the potential consequence of human activities within the zone. Only those features for which there is at least 5% coverage in the Offshore Haida Gwaii Network Zones are included. Sum of proportions are provided in increasing order for 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 Table I.1 (Appendix I).

E-CP Feature Name	**Total proportion**	**Gangxid Kun Sgaagiidaay** *Cape St. James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**
Species features								
Widow Rockfish Research CPUE	5.0%	0.3%	-	1.0%	2.2%	1.4%	-	-
Sablefish Research CPUE	5.0%	1.0%	0.3%	1.3%	1.4%	0.5%	0.0%	0.4%
Yellowmouth Rockfish Research CPUE	5.0%	0.9%	-	0.9%	1.5%	1.2%	0.5%	-
Rosethorn Rockfish Research CPUE	5.1%	0.9%	0.0%	0.6%	1.7%	1.0%	0.5%	0.3%
Corals Survey and Fishery CPUE	5.5%	0.7%	-	1.1%	1.2%	1.2%	0.6%	0.7%
Rougheye/Blackspotted Rockfish Research CPUE	5.7%	0.7%	-	1.0%	1.8%	0.8%	0.6%	0.7%
Darkblotched Rockfish Research CPUE	5.7%	1.0%	-	0.4%	2.4%	1.4%	0.0%	0.5%
Shelf Invertebrate biomass hotspot	6.6%	-	-	-	-	4.0%	-	2.6%
Sea pens predicted habitat	6.7%	0.6%	0.9%	2.4%	2.5%	0.2%	0.1%	0.2%
Northern Right Whale Dolphin density	7.3%	7.3%	-	-	-	-	-	-
Shortraker Rockfish Research CPUE	7.3%	0.3%	-	1.8%	3.4%	1.3%	0.1%	0.3%
Shortspine Thornyhead Research CPUE	7.3%	0.4%	-	2.0%	2.8%	1.2%	0.1%	0.8%
Soft corals predicted habitat	7.8%	1.3%	1.5%	2.0%	2.0%	0.6%	0.2%	0.2%
Sperm Whale density	8.6%	4.4%	-	-	4.2%	-	-	-

E-CP Feature Name	Total proportion	**Gangxid Kun Sgaagiidaay** *Cape St. James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**
Leatherback Sea Turtle Important Areas	10.4%	1.5%	3.0%	2.4%	2.6%	0.7%	0.2%	-
Deepwater Tanner Crab Research CPUE	11.4%	2.4%	2.2%	2.6%	3.8%	0.5%	-	-
Blue Whale Important Areas	13.0%	1.9%	3.8%	2.9%	2.6%	0.9%	0.5%	0.4%
Black corals predicted habitat	14.1%	1.3%	5.3%	4.2%	3.3%	0.0%	0.0%	0.0%
Sei Whale Important Areas	14.2%	2.4%	4.8%	3.7%	3.2%	0.1%	-	-
Sperm Whale Important Areas	14.2%	2.4%	4.8%	3.7%	3.2%	0.1%	-	-
Shelf Fish biomass hotspot	15.1%	-	-	1.3%	5.2%	8.0%	-	0.7%
Roughtail Skate Research CPUE	16.5%	-	-	7.8%	8.6%	0.2%	-	-
Longspine Thornyhead Research CPUE	17.1%	-	-	8.4%	8.4%	0.3%	-	-
Sum of species features	-	31.7%	26.6%	51.5%	**68.2%**	25.5%	3.4%	7.8%
Habitat features								
Dixon Entrance Ecosections	6.1%	-	-	-	0.3%	2.4%	1.4%	2.0%
Coastal Mixing Region Upper Ocean Subregion	7.0%	0.3%	0.8%	3.2%	2.7%	-	-	-
High Rugosity polygons	8.7%	2.0%	2.1%	2.4%	1.9%	-	0.2%	0.1%
SE Alaska Mixing Region Upper Ocean Subregion	9.0%	-	-	-	2.9%	3.9%	2.3%	-
Continental Slope Ecosections	11.4%	2.5%	2.4%	2.4%	4.1%	-	-	-
Shelf Break EBSA	12.1%	2.1%	3.9%	2.8%	3.3%	-	-	-
Cape St. James EBSA	13.3%	13.3%	-	-	-	-	-	-
Slope canyon floor Geomorphic Units	15.5%	4.9%	5.0%	2.6%	3.1%	-	-	-
Slope ridge Geomorphic Units	15.8%	4.0%	5.8%	2.7%	3.4%	-	-	-

E-CP Feature Name	Total proportion	**Gangxid Kun Sgaagiidaay** *Cape St. James* **Zone 505**	*Gwaii Haanas Extension* **Zone 504**	**Ginda Kun Sgaagiidaay** *Offshore Continental Slope South* **Zone 503**	**Sasga K'ádgwii** *Offshore Continental Slope North* **Zone 502**	*Offshore Northwest Dixon* **Zone 506**	**Tsaan Kwaay** *Offshore Learmonth Bank* **Zone 501**	**Kadlee** *Offshore Celestial Reef* **Zone 500**
Slope wall steep Geomorphic Units	16.3%	1.6%	5.5%	5.4%	3.8%	-	-	-
West Coast QCI Upwelling Region Upper Ocean Subregion	16.7%	-	16.7%	-	-	-	-	-
Slope wall sloping Geomorphic Units	17.1%	-	9.1%	5.3%	2.7%	-	-	-
Slope Biophysical Units	17.4%	2.5%	6.6%	4.9%	3.3%	-	-	-
Cape St. James Tidal Mixing Upper Ocean Subregion	20.4%	20.4%	-	-	-	-	-	-
Seamount EBSA	33.0%	-	-	-	33.0%	-	-	-
Learmonth Bank EBSA	53.8%	-	-	-	-	-	53.8%	-
Seamount summit	100.0%	-	-	-	100.0%	-	-	-
Sum of habitat features	-	53.6%	57.9%	31.7%	**164.5%**	6.3%	57.6%	2.1%

7.7. NSB NETWORK CULTURAL CONSERVATION PRIORITIES

The Haida have chosen these sites as they offer a direct link to the ancestors, through stories passed down over the ages from time immemorial. These peaks and reefs not only offer cultural opportunities for Haidas but also a spiritual connection to place, as these sites house Supernatural Beings, they are the sites of legends passed down through generations since the time when the **Kandaliig̱wii** *Hecate Strait* was a savannah. These sites are a testament to the Haida's ability to withstand changes, changes not only to landscape but also to what was hunted and collected for food.

Two-eyed seeing refers to learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of western knowledges and ways of knowing, and learning how to use both these eyes together, for the benefit of all. With this in mind and in support of the MPA Network planning for the Northern Shelf Bioregion, First Nations partners identified cultural conservation priorities (C-CPs[14]) as one way of representing culturally and spiritually important areas in the Network. Informed by Indigenous and cultural data collected by individual First Nations, C-CPs helped each Nation ensure that areas of high cultural and/or spiritual value in their territories were considered part of the Network development process, recognizing that all areas in a Nation's territory are culturally significant. C-CPs include areas important for traditional harvesting, as these areas have been identified as important for the continuum of knowledge transfer from Elders to youth, as well as culturally significant species, and for overall cultural and spiritual well-being of Nations. The C-CPs identified in this planning process are for the territories of partner First Nations in the planning process; they do not capture the interests of all First Nations communities in the NSB. Each zone in the Offshore Haida Gwaii Network Zones has at least a "Moderate" C-CP rating (Table 27). **G̱angx̱id Kun Sg̱aagiidaay** *Cape St. James* (Zone 505) and **Sasga Ḵ'ádgwii** *Offshore Continental Slope North* (Zone 502) each have C-CP ratings as high as "Very High" due to particular areas of high spiritual and cultural importance (Table 27): **G̱angx̱id Kun** *Cape St. James*, and Frederick to Hippa, respectively.

Table 33. Summary results for individual cultural conservation priorities (C-CPs) in the Offshore Haida Gwaii Network Zones. The area is the surface area coverage of each C-CP for the Offshore Haida Gwaii Network Zones.

Zone	C-CP (rating)	Area (km²)
G̱angx̱id Kun Sg̱aagiidaay *Cape St. James* Zone 505	South Moresby Trough (High)	766.78
	G̱angx̱id Kun *Cape St. James* (Very High)	734.99
Gwaii Haanas Extension Zone 504	(Moderate)	1072.07
Ginda Kun Sg̱aagiidaay *Offshore Continental Slope South* Zone 503	**Ginda Kun** *Kindakun* (High)	453.32
	Kindakun to Slope (High)	657.89
	Frederick to Hippa (Very High)	268.05

[14] 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. In preparation.

Zone	C-CP (rating)	Area (km²)
Sasga K'ádgwii *Offshore Continental Slope North* Zone 502	Frederick to Slope (High)	900.34
Offshore Northwest Dixon Zone 506	(Moderate)	267.86
Tsaan Kwaay *Offshore Learmonth Bank* Zone 501	**Tsaan Kwaay** Learmonth Bank (High)	267.77
Kadlee *Offshore Celestial Reef* Zone 500	**Kadlee** Celestial Reef (High)	220.96

8. SUMMARY

The Offshore Haida Gwaii Network Zones provide a group of seven offshore marine zones off the west and north side of the **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* archipelago. The zones extend west from the continental shelf to the toe of the continental slope on the western edge of the Northern Shelf Bioregion. The Offshore Haida Gwaii Network Zones cover areas of steep terrain and transition from shelf to slope habitat with distinct oceanography and ecological processes, providing habitat to unique assemblages of marine species (Figure 52). The seven zones can be broadly separated into two groups. The first includes the four offshore zones that make up the western edge of **Xaadáa Gwáay Xaaydaga Gwaay.yaay** *Haida Gwaii* and have both shelf and slope habitats and cover a larger depth range (Zones 505, 504, 503 and 502). The second group consists of the three northern zones located in **Síigee** *Dixon Entrance* that are located on the shelf and have the shallowest depth distribution (Zones 506, 501 and 500). Brief summaries of the unique and/or notable characteristics of each zone within the OHGNZ are provided in Table 34. Further information on the boundaries of each zone are provided in Appendix D. Knowledge gaps and uncertainties for the OHGNZ and area are provided in the next subsection.

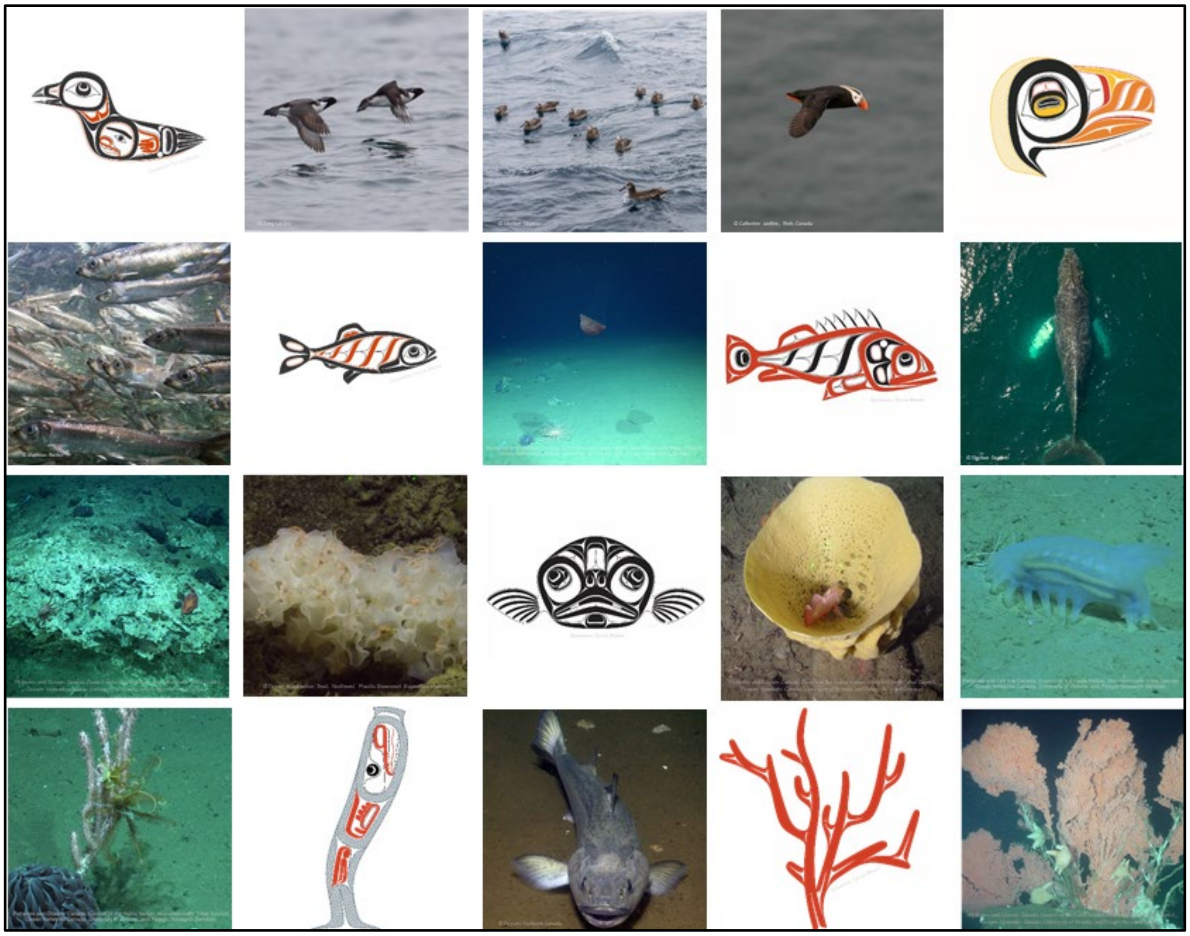

Figure 52. Some of the ecological diversity found within the OHGNZ. From top-left to bottom-right: Haida formline of ***SGidaanáa Sginn xaana*** *Ancient Murrelet (*Synthliboramphus antiquus*);* ***SGidaanáa Sginn xaana****;* ***Sk'áay*** *Black-footed Albatross (*Phoebastria nigripes*) over the pinnacle of SAUP 5494 seamount (Zone 502)****; Kwa.anaa Kuuxaana*** *Tufted Puffin (*Fratercula cirrhata*); Haida formline of* ***Kwa.anaa Kuuxaana; 'íináang iinang*** *Herring (*Clupea pallasii*); Haida formline of* ***'íináang iinang****; Poralia jelly (*Poralia rufescens*) over muddy bottom of seamount SAUP 5494 (Zone 502); Haida formline of* ***K'ats Sgaadang.nga*** *Rockfish****; Sgagúud Sgap*** *Humpback Whale (*Megaptera novaeangliae*); Scarlet King Crab (*Lithodes couesi*) and Thornyhead (*Sebastolobus *spp.) on carbonate structure on SAUP 5494 seamount (Zone 502)****; Gin gii hlk'uuwaansdlagangs*** *glass sponge (class Hexactinellida); Haida formline of* ***Skíl Skil*** *Sablefish (Blackcod,* Anoplopoma fimbria*); Demosponge (*Mycale *sp.) with a Sharpchin Rockfish (*Sebastes zacentrus*) on the rocky outcrop* ***Tsaan Kwaay*** *Learmonth Bank (Zone 501); Sea pig (*Scotoplanes *sp.) on muddy bottom of SAUP 5494 seamount (Zone 502); Pom Pom Anemone (*Liponema brevicorne*), Paragorgia coral (*Paragorgia cf. jamesi*) with crionids (*Florometra serratissima*) on SAUP 5494 seamount (Zone 502); Haida formline of* ***Gin gii hlk'uuwaansdlagangs; Skíl Skil****; Haida formline of red tree coral; red tree coral (family Primnoidae) and sea stars (*Hippasteria *spp.) on the rocky outcrop* ***Tsaan Kwaay*** *Learmonth Bank (Zone 501). Images from Greg Lasley, Shelton Dupreez, Catherine Jardine, Matthias Breiter, Northeast Deep-Sea Diversity Expedition Partners (Fisheries and Oceans Canada, Council of the Haida Nation, Nuu-chah-nulth Tribal Council, Ocean Networks Canada, University of Victoria, Pelagic Research Services), and Oceans Exploration Trust, Northeast Pacific Seamount Expedition Partners (Council of the Haida Nation, Fisheries and Oceans Canada, Ocean Networks Canada, Oceana). Haida formline by* ***Iljuuwaas*** *Tyson Brown.*

Table 34. Report summary highlights for each zone within the Offshore Haida Gwaii Network Zones. Table is organized chronologically by report section; more information on each point is available in the relevant text section.

Zone (area (km²))	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
Gangxid Kun Sgaagiidaay *Cape St.James* Zone 505 (531.12 km²)	• Haida Eddies typically form near **Gangxid Kun** *Cape St. James* during winter. They carry warmer, less saline water, and nutrients over hundreds of kilometers into the Gulf of Alaska. They have sizes in the order of 100 km with a core depth of about 1,000 m • Coldest summertime surface waters • Upwelling-favourable winds less frequent compared to further south along BC coast • With Zone 500, has highest oxygen in upper 100 m given its connections with the shelf • Surface Chl-a remains low year-round	• Overlap with Cape St. James, Shelf Break and Continental Slope EBSAs and includes the Haida Eddy EBSA • Corals and sponges, **Sgaadang.nga** *rockfish* (Shortspine Thornyhead, Yellowmouth, Darkblotched, Pacific Ocean Perch), groundfish (**Skil** *Sablefish*, **Xaaguu** *Pacific Halibut*, **T'aal** *Arrowtooth Flounder*, **K'aaxada** Spiny Dogfish), marine mammals (Sperm, **Kun Xyapxyandal** *Fin*, Sei, Blue, and **Sgap** *Humpback Whales*; Northern Right Whale Dolphin, **Kay** *Steller Sea Lion*, **Skul** *Pacific White-Sided Dolphin*, **K'aang** *Dall's Porpoise*), **Tang.gwan Siiga** *Leatherback Sea Turtle*, **Siigaay xidid** *marine birds* (**Sk'aay** *Albatross*, gulls, small alcids, storm petrels, and shearwaters and fulmars)	• Has high cultural and historical value, including important Haida spiritual relationship to area and an area that provides food security, including **Xaaguu** *Pacific Halibut* and various **Sgaadang.nga** *rockfish* (Shortspine Thornyhead, Yellowmouth Rockfish, Darkblotched Rockfish) • Activities of Concern: Commercial harvest (bottom longline/demersal hook and line; invertebrate trap; Sablefish trap; gill nets; pelagic and mid-water trawl; purse seine; trolling for salmon), Recreational harverst (jigging; invertebrate trap; trolling by rod and reel), Industrial projects* (oil and gas activities; mining; dumping), Boating and shore use/intertidal exploration, Boating	• Projected sea surface temperature changes > 2°C • Sea bottom aragonite undersaturation • Hypoxic water (historically and predicted) • Linkage to existing 'strict protection zone' in Gwaii Haanas NMCAR&HHS (toe of slope to nearshore) • E-CPs: Continental Slope Ecosection, Slope and Trough Biophysical Units, a range of Geomorphic units, the Cape St. James Tidal Mixing Region, corals and sponges. • C-CPs: South Moresby Trough (High importance), and **Gangxid Kun** *Cape St. James* (Very High importance)
Gwaii Haanas Extension Zone 504 (1,072.07 km²)	• Upwelling-favourable winds less frequent compared to further south	• Overlap portion of Shelf Break and Continental Slope EBSAs and includes the Haida Eddy EBSA	• Has high cultural and historical value, including important Haida spiritual relationship to area	• Projected sea surface temperature changes > 2°C

Zone (area (km²))	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	along BC coast during summer • North-flowing Haida current forms on along this coast during the colder months from October to April due to the prevailing winds • Surface Chl-a typically below 3 mg m-3 year-round	• Various whales (**Kun kaajii Gaajaawuu** *Sperm*, Sei, Blue, **Kun Xyapxyandal** *Fin*, **Sgap** *Humpback*), **Tang.gwan Siiga** *Leatherback Sea Turtle*, and **Siigaay xidid** *marine birds* (gulls, small alcids, storm petrel, murres/large alcids)	• Activities of Concern: Commercial harvest (bottom longline/demersal hook and line; invertebrate trap; Sablefish trap; gill nets; pelagic and mid-water trawl; purse seine; trolling for salmon), Recreational harverst (jigging; invertebrate trap; trolling by rod and reel), Industrial projects* (oil and gas activities; mining; dumping), Boating and shore use/intertidal exploration, Boating	• Sea bottom aragonite undersaturation • Hypoxic water (historically and predicted) • High spatial coverage for both species and habitat E-CP features: Continental Slope Ecosection, Slope Biophysical Unit, and the West Coast HG Upwelling Region. • Linkage to existing 'strict protection zone' in Gwaii Haanas NMCAR&HHS (toe of slope to nearshore)
Ginda Kun Sgaagiidaay *Offshore Continental Slope South* Zone 503 (830.90 km²)	• Upwelling-favourable winds less frequent compared to further south along BC coast during summer • North-flowing Haida current forms on along this coast during the colder months from October to April due to the prevailing winds • Surface Chl-a below 3 mg m^{-3} year-round • No unique zooplankton sampling events in this Zone	• Overlap portion of Shelf Break and Continental Slope EBSAs and includes the Haida Eddy EBSA • Corals and sponges, **Sgaadang.nga** *rockfish* (Longspine Thornyhead, Shortspine Thornyhead, Shortraker, Widow, Yellowmouth, Rougheye/Blackspotted, Bocaccio), groundfish (**Skil** *Sablefish*, Dover Sole), whales (**Kun kaajii Gaajaawuu** *Sperm*, Sei, Blue, **Kun Xyapxyandal** *Fin*, **Sgap** *Humpback*), **Tang.gwan Siiga** *Leatherback Sea Turtle*	• Hosts all 9 commercial fishing licenses • Has high cultural and historical value, including important Haida spiritual relationship to area and an area that provides food security, including **Xaaguu** *Pacific Halibut*, various **Sgaadang.nga** *rockfish* (Longspine Thornyhead, Shortspine Thornyhead, Shortraker, Widow, Yellowmouth, Rougheye/Blackspotted), and **Skil** *Sablefish*. • Activities of Concern: Commercial harvest (bottom longline/demersal hook and line; invertebrate trap; Sablefish trap; gill nets; pelagic and mid-	• Projected sea surface temperature changes > 2°C • Sea bottom aragonite undersaturation • Hypoxic water (historically and predicted) • E-CPs: Continental Slope Ecosection, Slope and Trough Biophysical Units, Coastal Mixing Region, corals and sponges. • C-CPs: **Ginda Kun** *Kindakun* (High importance), **Ginda Kun** to Slope (High importance)

Zone (area (km²))	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
			water trawl; purse seine; trolling for salmon, trolling for tuna), Recreational harverst (jigging; invertebrate trap; trolling by rod and reel), Industrial projects* (oil and gas activities; mining; dumping), Boating	
Sasga K'ádgwii *Offshore Continental Slope North* Zone 502 (901.06 km²)	• Upwelling-favourable winds less frequent compared to further south along BC coast during summer • North-flowing Haida current forms on along this coast during the colder months from October to April due to the prevailing winds • Surface Chl-a typically below 3 mg m^{-3} year-round	• Overlap with portion of Shelf Break, Continental Slope, and seamount EBSAs • Seamount (SAUP 5494) • Highest fish species richness, modeled and actual • Corals, **K'ats** *rockfish* (Longspine Thornyhead, Shortraker, Shortspine Thornyhead, Bocaccio, Darkblotched, Widow, Pacific Ocean Perch), groundfish (Rex Sole, **Skíl** *Sablefish,* **Xaguu** *Pacific Halibut*), whales (**Kún kaj Gajaaw** *Sperm*, Sei, Blue, **Sgagúud** *Fin, Humpback*), **'Waahúu** *Leatherback Sea Turtle*, **Sk'áay** *Albatross*, small alcids, **Kwa.anaa** *puffins*	• Recreational groundfish fishery • Closest to recreational tourism activities • Has high cultural and historical value, including important Haida spiritual relationship to area and an area that provides cultural use and food security, including **Xaguu** *Pacific Halibut*, various **K'ats** *rockfish* (Longspine Thornyhead, Shortraker, Shortspine Thornyhead, Darkblotched, Widow) and **Skíl** *Sablefish* • Activities of Concern: Commercial harvest (bottom longline/demersal hook and line; invertebrate trap; Sablefish trap; gill nets; pelagic and mid-water trawl; purse seine; trolling for salmon, trolling for tuna), Recreational harverst (jigging; invertebrate trap; trolling by rod and reel), Industrial	• Projected sea surface temperature changes > 2°C • Sea bottom aragonite undersaturation • Largest range of projected groundfish species richness changes • Linkage to existing Rockfish Conservation Area (toe of slope to nearshore) ensuring multiple depth ranges available within protected zones if species move as predicted under climate change • E-CPs: Continental Slope ecosection, Slope, Shelf and Trough Biophysical Units, SE Alaska Mixing and Coastal Mixing Regions, corals and sponges, and the only known seamount in the NSB • C-CPs: area of high Haida cultural conservation priority (Sasga to slope)

Zone (area (km²))	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
			projects* (oil and gas activities; mining; dumping), Boating and shore use/intertidal exploration, Boating	
Offshore Northwest Dixon Zone 506 (267.86 km²)	• Upwelling-favourable winds less frequent compared to further south along BC coast during summer • North-flowing Haida current forms on along this coast during the colder months from October to April due to the prevailing winds • Surface Chl-a typically below 3 mg m^{-3} year-round, except during bloom conditions usually in May	• Shelf invertebrate and fish species; including various **K'ats** *rockfish* (Darkblotched, Widow, Shortraker, Shortspine Thornyhead, Redstripe, Yellowmouth, Rosethorn, **K'aalts'adaa** *Rougheye/Blackspotted*, Bocaccio, **SGan** *Yelloweye*, Pacific Ocean Perch), corals, sponges, Rex Sole, Dover Sole, Walleye Pollock, **Kyaa.n** *Pacific Cod*, **Skáaynang** *Lingcod*, **Xaguu** *Pacific Halibut*, Big Skate, **Sgagúud** *Fin Whale*, Blue Whale, **Xedíit** *marine birds* (**Sk'áay** *Albatross*), **'Waahúu** *Leatherback Sea Turtles*, and **Daga 'íiwaans** *prawns* and shrimp (Smooth Pink, Sidestripes, and Spot Prawn).	• Recreational groundfish fishery • Closest to recreational tourism activities • Has high cultural and historical value, including important Haida spiritual relationship to area and an area that provides food security, including **Xaguu** *Pacific Halibut*, various **K'ats** *rockfish* (Longspine Thornyhead, Shortraker, Shortspine Thornyhead, Darkblotched, Widow) and **Skíl** *Sablefish* • Activities of Concern: Commercial harvest (bottom longline/demersal hook and line; invertebrate trap; Sablefish trap; gill nets; pelagic and mid-water trawl; purse seine; trolling for salmon, trolling for tuna), Recreational harverst (jigging; invertebrate trap; trolling by rod and reel), Industrial projects* (oil and gas activities; mining; dumping), Boating and shore use/intertidal exploration, Boating	• Projected sea surface temperature changes > 2°C • Projected sea bottom temperature changes > 1°C • Sea bottom aragonite undersaturation • High projected groundfish species richness gains

Zone (area (km²))	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
Tsaan Kwaay *Offshore Learmonth Bank* Zone 501 (152.03 km²)	• **Tsaan Kwaay** *Learmonth Bank* and **Kadlee** *Celestial Reef* are the most prominent marine features in **Síigee** *Dixon Entrance* and are the largest rock outcrops. Multibeam bathymetry data covers most of **Tsaan Kwaay** *Learmonth Bank*, showing a highly faulted and fractured granodiorite bedrock surface • Deep water enters **Síigee** *Dixon Entrance* mostly through this region and flows eastwards given the shallow 20 m sill separating **Síigee** *Dixon Entrance* from **Kandaliiɢwii** *Hecate Strait* near **Kadlee** *Celestial Reef* • An anti-cyclonic (clockwise) eddy is often present in this area. The primary surface flow pathway is south near **K'íis Gwáay** *Langara Island* • Winter SST is typically 6-7°C; this and **Kadlee** (Zone 500) have coldest winter SST • Upwelling-favourable winds less frequent compared to further south	• Overlap with Learmonth Bank EBSA • Corals, **K'ats** *rockfish* (Tiger, **K'aalts'adaa** *Rougheye/Blackspotted,* Rosethorn, Yellowmouth, **SGan** *Yelloweye*, Silvergray, Yellowtail), **Skáaynang** *Lingcod*, **Xaguu** *Pacific Halibut*, whales (Kun K'uuan Minke, Blue, **Sgagúud** *Fin*), **Xedíit** *marine birds* (**Sk'áay** *Albatross*, Storm Petrel, **Kwa.anaa** *Puffins*)	• Has high cultural and historical value, including important Haida spiritual relationship to area and an area that provides cultural use and food security, including various **K'ats** *rockfish* (Tiger, **K'aalts'adaa** *Rougheye/ Blackspotted*, Rosethorn, Yellowmouth, **SGan** *Yelloweye*, Silvergray, Yellowtail) and **Skáaynang** *Lingcod*. • Activities of Concern: Commercial harvest (bottom longline/demersal hook and line; invertebrate trap; Sablefish trap; gill nets; pelagic and mid-water trawl; purse seine; trolling for salmon, trolling for tuna), Recreational harverst (jigging; invertebrate trap; trolling by rod and reel), Industrial projects* (oil and gas activities; mining; dumping), Boating and shore use/intertidal exploration, Boating	• Projected sea surface temperature changes > 2°C • Projected sea bottom temperature changes > 1°C • Sea bottom aragonite undersaturation • High projected groundfish species richness gains • E-CPs: Dixon Entrance Ecosection; Shelf and Trough Biophysical Units; SE Alaska Mixing Region; Corals and sponges • C-CP: **Tsaan Kwaay** *Learmonth Bank* (High importance)

Zone (area (km²))	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	along BC coast during summer • Highest satellite-measured surface Chl-a throughout the year, similar to **Kadlee** (Zone 500), and highest variability in timing of annual maximum • Region with the greatest number of zooplankton sampling events			
Kadlee *Offshore Celestial Reef* Zone 500 (219.91 km²)	• **Tsaan Kwaay** *Learmonth Bank* and **Kadlee** *Celestial Reef* are the most prominent marine features in **Síigee** *Dixon Entrance* and are the largest rock outcrops. • **Née Kún** *Rose Spit* is a shallow 20-m sill at the south. An anti-clockwise rotating eddy, occupies the eastern end of **Síigee** *Dixon Entrance* near **Kadlee** *Celestial Reef* throughout the year • Winter SST is typically 6-7°C; this and **Tsaan Kwaay** (Zone 501) have coldest winter SST • Upwelling-favourable winds less frequent compared to further south along BC coast during summer • With **Gangxid Kun Sgaagiidaay** (Zone 505), has highest oxygen in	• Shelf large-scale Biophysical Unit • Species assemblages associated with **Kadlee** *Celestial Reef* and shelf • Corals and sponges, **K'ats** *rockfish* (Shortspine Thornyhead, **K'aalts'adaa** *Rougheye/Blackspotted*, Darkblotched), groundfish (Dover Sole, Rex Sole, **Kyaa.n** *Pacific Cod*, **Skíl** *Sablefish*, **Xaguu** *Pacific Halibut*), Big Skate, whales (**SGáan** *Northern Resident Killer Whales*, Blue, **Kún** *Fin*), **Xediit** *marine birds* (storm petrel, shearwaters and fulmars, small alcids)	• Hosts all 9 commercial fishing licenses • Recreational groundfish fishery • Highest vessel activity • Has high cultural and historical value, including important Haida spiritual relationship to area and an area that provides cultural use and food security, including **Xaguu** *Pacific Halibut*, and various **K'ats** *rockfish* (Shortspine Thornyhead, **K'aalts'adaa** *Rougheye/Blackspotted*, Darkblotched) • Activities of Concern: Commercial harvest (bottom longline/demersal hook and line; invertebrate trap; sablefish trap; gill nets; pelagic and mid-water trawl; purse seine; trolling for salmon, trolling for tuna), Recreational harverst (jigging;	• Projected sea surface temperature changes > 2°C • Projected sea bottom temperature changes > 1°C • High projected groundfish species richness gains • E-CPs: *Dixon Entrance* Ecosection; Dixon Entrance Coastal Flow Region; Corals and sponges • C-CP: **Kadlee** *Celestial Reef* (High importance)

Zone (area (km²))	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	upper 100 m given its connections with the coast • Highest satellite-measured surface Chl-a throughout the year, similar to **Tsaan Kwaay** (Zone 501), and highest variability in timing of annual maximum		invertebrate trap; trolling by rod and reel), Industrial projects* (oil and gas activities; mining; dumping), Boating and shore use/intertidal exploration, Boating	

8.1. KNOWLEDGE GAPS AND UNCERTAINTIES

The seven sites of the OHGNZ do not occur in isolation and do not present the totality of ecological variation or habitats or species of interest within **X̲aadáa Gwáay X̲aaydaG̲a Gwaay.yaay** *Haida Gwaii*'s marine waters or the Northern Shelf Bioregion. Additionally, with increased research and surveys in the area it is expected that additional underwater features will be discovered of ecological and conservation importance.

Detailed sources of uncertainty for the OHGNZ include:

- The species inventory for the zones is likely to grow as further biological surveys discover additional species occurring in these zones, including those of conservation interest. Research surveys are increasing in the area, but the offshore region is largely underrepresented in visual surveys and oceanographic sampling.
- Taxonomic diversity outlined in this report is largely limited to fish, mammal, reptile, and bird species. Our knowledge of invertebrate and plant populations is incomplete due to a lack of survey data. Data that is available is locally-specific to particular features, such as **Tsaan K̲waay** *Learmonth Bank* and **K̲adlee** *Celestial Reef* and the recently surveyed seamount SAUP 5494.
- All zones have data gaps. In particular, Gwaii Haanas Extension (Zone 504) has had less survey effort to date because of its depth and relative remoteness, consequently our knowledge of its benthic terrainand biodiversity is limited, and model results are limited to the smallest portion of its extent. Despite this data paucity, it has high spatial coverage for both species and habitat E-CP features, highlighting its importance and a knowledge gap that requires further research to increase our understanding the ecology of deeper offshore zones.
- Most multibeam mapping is limited to a depth of 1,700 m and as such large portions of the offshore continental slope zones are unmapped.
- High resolution multibeam data may reveal additional important bathymetric features that are harder or impossible to detect with lower resolution data, including cold seeps (an EBSA), mud volcanoes, seamounts (an EBSA) and other habitats of biological and ecological significance.
- Both recreational fishing and **Tsíi.n Chiina** *salmon* catch data are summarized and provided at the broad spatial scale of Pacific Fishery Management Areas and cannot be used to accurately understand fishing impacts at finer scales, such as the OHGNZ, or to analyze the distribution of fishing effort by habitat type or bathymetric depth.
- Climate change scenarios are alternative projections of how the future might unfold and the possibility that any single scenario will occur as described is highly uncertain.
- Summaries of two different climate change scenarios (Representative Concentration Pathways (RCP) 4.5 and RCP 8.5), under two different climate models (British Columbia Continental Margin Model and the Northeastern Pacific Canadian Ocean Ecosystem Model) were provided. At the relatively short time scales of the forecasts, the projected differences for marine environmental variables (temperature, aragonite, oxygen) or groundfish species distribution changes between the RCP 4.5 and 8.5 scenarios are small.
- The zones within the OHGNZ are in an impacted state, (i.e., subject to anthropogenic disturbance), and scientific observations and data were recorded within a small window of time. Consequently, there is implicit uncertainty in the data presented, given that (1) natural variation, (2) recovery from anthropogenic disturbances with protection, and (3) exposure to

a projected warming environment, may result in redistributions of species and changes to their habitats.

For science advice and recommendations for areas of further research related to these knowledge gaps and uncertainties, and related to the boundaries for each zone, please see the Science Advisory Report associated with this research document (DFO 2024). Many components required to implement effective management and zone- and network-level monitoring plans are unknowable at this time. Baseline monitoring and research to fill these knowledge gaps could be prioritized (in order of relative importance: high resolution mapping of the seafloor and water column, oceanographic sampling, visual surveys, and other research). This report is coauthored by the Council of the Haida Nation and Fisheries and Oceans Canada as part of the co-management of protected areas within Haida marine waters, as knowledge sharing and co-creation are integral components of lasting conservation work.

The OHGNZ encompass a range of depths, geologic features and large-scale oceanographic currents and eddies that have resulted in important habitat for an array of taxonomic groups of ecological and conservation importance. The natural productivity of the area, series of mud volcanoes, cold seeps and rocky outcrops attracts aggregations of marine mammals, marine birds, and biodiverse fish and invertebrate communities. Additionally this area has high ecological value to features outside of the zones and to the Haida. Further research and protective measures would help conserve the unique ecological assemblages, the health of the marine environment, and the livelihood of the people that depend on its resources. This area's long history of cultural and ecological importance to the Haida supports prioritizing the these Network Zones for conservation.

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APPENDIX A. TERMS USED

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

Barotropic – pressure is constant on surfaces of constant density.

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).

Northern Shelf Bioregion (NSB) – The Northern Shelf Bioregion covers 102,000 km^2 and is one of four bioregions located in the Pacific Region. Bioregions are identified based on oceanographic and bathymetric similarities, important characteristics the 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.

APPENDIX B. ACRONYMS

AIS	Automatic Identification System
AOI	Area of Interest
ASP	Aerial Surveillance Program
AVHRR	Advanced Very High Resolution Radiometer satellite instrument
BC	British Columbia
Chl-a	Chlorophyll-a
CHN	Council of the Haida Nation
CITES	Convention on International Trade of Endangered Species of Wild Fauna and Flora
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CP	Conservation Priority
C-CP	Cultural Conservation Priority
CPUE	Catch per unit effort
DFO	Fisheries and Oceans Canada
E-CP	Ecological Conservation Priority
EBSA	Ecologically and Biologically Significant Area
ENSO	El Niño Southern Oscillation
ESS	Ecologically Significant Species
HHS	Haida Heritage Site
HMTK	Haida Marine Traditional Knowledge
IUCN	International Union for the Conservation of Nature
MaPP	Marine Plan Partnership
MODIS-Aqua	MODerate Resolution Imaging Spectroradiometer on Aqua satellite
MPATT	Marine Protected Area Technical Team
MPA	Marine Protected Area (please note that 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)
NCODE	North Coastal Ocean Dynamics Experiment
NEPDEP	Northeast Pacific Deep-sea Exploration Project
NMCAR	National Marine Conservation Area Reserve
NSB	Northern Shelf Bioregion
OHGNZ	Offshore Haida Gwaii Network Zones
OMZ	Oxygen Minimum Zone
PDO	Pacific Decadal Oscillation

PFMA	Pacific Fishery Management Areas
PMECS	Pacific Marine Ecological Classification System
PMZ	Protection Management Zone
PNCIMA	Pacific North Coast Integrated Management Area
QCF	Queen Charlotte Fault
RCP	Representative Concentration Pathway
SARA	*Species At Risk Act*
SD	Species Density
SK-B	**SGáan Kínghlas**-Bowie
SST	Sea Surface Temperature
VME	Vulnerable Marine Ecosystem
VCI	Vulnerable Composite Index
VPZ	Voluntary Protection Zone

APPENDIX C. HAIDA NAMES

Online Pronunciation guides:

Xaad Kíl

Xaayda Kil

Haida language used in this document, or that is relevant to the area:

Place Names, Zone Names & Features

X̱aad kíl	X̱aayda kil	*English*
X̱aadáa Gwáay	X̱aaydaG̱a Gwaay.yaay	*Haida Gwaii*
Duu Gúusd	Daawxuusda	*The west coast*
Síigee	-	*Dixon Entrance*
Ḵadlee	-	*Celestial Reef (and Zone)*
Tsaan Ḵwaay	-	*Learmonth Bank (and Zone)*
Nasduu Gwaayee	-	*Hippa Island*
Ḵ'íis Gwáay	-	*Langara Island*
G̱adsguusd	-	*McIntyre Bay (North Beach)*
Née Kún	-	*Rose Spit*
Ja.a Xwii Xyaang	-	*Dogfish Bank*
Sasga Ḵ'ádgwii	-	*Offshore Continental Slope North*
-	Tang.g̱wan	*Pacific Ocean*
-	Ḵandaliig̱wii	*Hecate Strait*
-	Ginda Kun Sg̱aagiidaay	*Offshore Continental Slope South*
-	Ginda Kun	*Kindakun Point*
-	Gwaaygiids	*Marble Island*
-	Ḵaysuun Ḵaahlii	*Englefield Bay*
-	G̱wiig̱u G̱awg̱a Sg̱aagiidaay	*Gwaii Haanas Extension North*

Xaad kíl	Xaayda kil	***English***
-	Gawgaay.yaa Sgaagiidaay	*Gwaii Haanas Extension South*
-	Gangxid Kun Sgaagiidaay	*Cape St. James Zone*
-	Gangxid Kun	*Cape St. James*
Chaan tlat'a.awée	-	*Seamount*

Species

Xaad kíl	Xaayda kil	***English***
Tsíi.n	Chiina	*Fish (or multiple species of salmon)*
SGwáagaan	Sgwaagan	*Sockeye Salmon*
T'áaw'un	Taagun	*Chinook/Spring Salmon*
Táayii	Taay.yii	*Coho Salmon*
Ts'at'áan	Ts'iit'an	*Pink Salmon*
Sk'aga	Sk'aagii	*Chum Salmon*
Tayáng	Taay.ying.nga	*Steelhead*
Tak'áal	Taatl'ad	*Trout*
Xaguu	Xaaguu	*Pacific Halibut*
Ts'alj	-	*Dried Halibut*
Skíl	Skil	*Sablefish (Black Cod)*
Skáaynang	Skaynang	*Lingcod*
T'ál	T'aal	*Flounder*
'íináang	iinang	*Herring*
K'áaw	K'aaw	*Herring roe on kelp*
K'aad	K'aaxada	*Dogfish*
Sáaw	Saaw	*Eulachon*

X̲aad kíl	X̲aayda kil	***English***
-	Taw	*Eulachon Grease*
Kyaa.n	SG̲aahlan	*Pacific Cod*
Sgagwíid	Kaaun	*Ratfish – General*
Ts'íit'aa	Ts'iiG̲a	*Skate – General*
K̲'ats	Sgaadang.nga	*Rockfish – General*
SG̲an	SG̲an	*Yelloweye Rockfish*
K'aalts'adaa	-	*Rougheye/Blackspotted Rockfish*
-	Kaa	*Canary Rockfish*
-	Xaadxadey	*Copper Rockfish*
Núu	Naw	*Octopus*
Daga 'íiwaans	G̲uudagiiG̲ayd	*Prawn*
Gúudangee	Guuding.ngaay	*Red Sea Urchin*
K̲'amaahl	K̲'aamahl	*Razor Clam*
SK̲áw tl'áahjuu	SK̲aaawal	*Geoduck*
K̲'ust'áan	K̲'uust'an	*Dungeness Crab*
Huuga	Huuga	*Tanner Crab (Spider crab)*
'Waahúu	Siiga	*Leatherback Sea Turtle*
K̲áay	K̲ay	*Steller Sea Lion*
SK̲ál	SK̲ul	*Harbour Porpoise*
K̲'áang	K̲'aang	*Dall's Porpoise*
SG̲áan	SG̲aana	*Orca/Killer Whale*
Kún	Kun	*Grey Whale*
Sgagúud	SG̲ap	*Humpback Whale*
Kún	Kun Xyapxyandal	*Fin Whale*

Xaad kíl	Xaayda kil	***English***
-	Kun K’uuan	*Minke Whale*
Kún kaj Gajaaw	Kun kaajii Gaajaawuu	*Sperm Whale*
K’aad aw	K’aaxada awga	*Shark*
Xedíit	Siigaay xidid	*Marine Bird – General*
Xedíit káw	Siigaay xidid kaw	*Seabird egg*
Sk'áay	Sk’aay	*Albatross*
Hajaa	Haaja	*Cassin’s Auklet*
SGidaanáa	Sgin xaana	*Ancient Murrelet*
Kwa.anaa	Kuuxaana	*Tufted Puffin*
Gúud	Guud	*Eagle*

APPENDIX D. OFFSHORE HAIDA GWAII NETWORK ZONE BOUNDARIES

See the [MPA Network website] and MPA Network BC Northern Shelf Initiative (2023) for more details.

G̲angx̲id Kun Sg̲aagiidaay *Cape St. James* (Zone 505)

The boundary for this zone extends an existing area of strict protection within the Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site out to the base of the continental slope. **G̲angx̲id Kun Sg̲aagiidaay** is one of three representational 'bands' seeking to protect high habitat heterogeneity across the slope habitat and range of depths from the toe of the slope to the nearshore, building from existing highly protected areas closer to shore. The boundaries differ significantly from those of the Protection Management Zones in the Haida Gwaii Marine Plan (MaPP 2015), reflecting adjustments made in response to stakeholder feedback provided through the MPAn Process. The zone captures a portion of a significant Marxan 'hotspot', an indication of a location that either contains conservation features that are spatially limited in their distribution or a number of conservation features that can be efficiently captured together in one area, or a combination of both. The zone contributes towards meeting network regional scale representational targets for a number of E-CPs, as well as sub-regional replication targets for a range of habitats and areas, including multiple EBSAs. The zone also contributes to representation of Haida cultural conservation priorities.

Gwaii Haanas Extension (Zone 504)

The boundary for this zone extends an existing area of high protection within the Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site out to the edge of the continental slope. It is one of three representational 'bands' seeking to protect high habitat heterogeneity across the slope habitat and range of depths from the toe of the slope to the nearshore, building from existing highly protected areas closer to shore. The boundaries differ significantly from those in the MaPP plan for the area, now aligning with the new strict protection zone presented in the **Gina 'Waadlux̲an KilG̲uhlG̲a** Land-Sea-People Management Plan, completed in 2018. The zone contributes towards meeting sub-regional replication targets for a range of habitats and areas, including the Continental Slope Ecosection, the West Coast Queen Charlotte Islands Upwelling Region – Upper Ocean Subregion and the Shelf Break EBSA.

Ginda Kun Sg̲aagiidaay *Offshore Continental Slope South* (Zone 503)

The boundary for this zone captures the western portion of a large bathymetric feature located in the eastern part and extends westward to the base of the continental slope. The boundary, which aligns with the Protection Management Zone presented in the Haida Gwaii Marine Plan (MaPP 2015), reflects an effort to protect a portion of the bathymetric feature and associated species assemblages, while maintaining commercial access in the east. The eastern portion of this zone captures a Marxan 'hotspot', an indication of a location that either contains conservation features that are spatially limited in their distribution or a number of conservation features that can be efficiently captured together in one area, or a combination of both. The zone contributes towards meeting network regional scale representational targets for a number of E-CPs, including a variety of cold-water corals and sponges, as well as supporting sub-regional replication targets for a range of habitats and areas. The zone also contributes to representation of Haida cultural conservation priorities.

Sasga K̲'ádgwii *Offshore Continental Slope North* (Zone 502)

The boundary for this zone extends westward from the existing Frederick Island Rockfish Conservation Area out to the toe of the continental slope. It is one of three representational 'bands' seeking to protect high habitat heterogeneity across the slope habitat and range of depths from the toe of the slope to the nearshore, including capturing the peak and portion of the only known seamount in the NSB, building from existing highly protected areas closer to shore. The boundaries are similar to those of the Protection Management Zones in the Haida Gwaii Marine Plan (MaPP 2015), with a reduction in extent to the north and south in an effort to enable continued access for various commercial fisheries active in the area and reduce potential socio-economic impacts. The zone captures a portion of a significant Marxan 'hotspot' that runs along the continental slope, an indication of a location that either contains conservation features that are spatially limited in their distribution or a number of conservation features that can be efficiently captured together in one area, or a combination of both. The zone contributes towards meeting network regional scale representational targets for a number of E-CPs, including cold-water corals and sponges and a variety of groundfishes and rockfishes species. This particular area also supports sub-regional replication targets for a range of habitats and areas including Shelf Break and Seamount EBSAs. The zone also contributes to representation of Haida cultural conservation priorities.

Offshore Northwest Dixon (Zone 506)

The boundary for this zone was delineated for its high conservation value indicated from optimization software used in the network site selection process (Marxan software – see the MPA Network website for more details), its importance to multiple species – notably slope rockfish species, and overlap with both fish and invertebrate biomass hotspots. This is also the only zone in the OHGNZ that doesn't have at least a partial overlap with an area identified in the MaPP process (MaPP 2015).

Tsaan Kwaay Offshore Learmonth Bank (Zone 501)

The delineated boundaries of this zone differ from those of the Protection Management Zones in the Haida Gwaii Marine Plan (MaPP 2015), with reductions on all sides, but most significantly to the northwest. The intent with the modified boundaries was to capture a significant amount of the benthic feature and identified EBSA along with the associated species assemblages, while leaving commercial fishing opportunities in the northern area, a portion of which extends into the disputed international boundary area with United States. This zone captures a Marxan 'hotspot', an indication of a location that either contains conservation features that are spatially limited in their distribution or a number of conservation features that can be efficiently captured together in one area, or a combination of both. The zone contributes towards meeting network regional scale representational targets for a number of E-CPs, including a variety of groundfish and rockfish species. This particular area also supports sub-regional replication targets for a range of habitats and areas including the Dixon Entrance Ecosection and the Dixon Entrance Coastal Flow Region – Upper Ocean Subregion, and being the only zone that captures the Learmonth Bank EBSA. The zone also contributes to representation of Haida cultural conservation priorities.

Kadlee Offshore Celestial Reef (Zone 500)

The boundary for this zone was delineated to capture the southern portion of **Kadlee** *Celestial Reef*. The boundaries differ from those of the Protection Management Zones in the Haida Gwaii Marine Plan (MaPP 2015). The intent is to capture a significant amount of the benthic feature and associated species assemblages, while leaving commercial fishing opportunities in the surrounding area, including the northern portion of the reef itself which extends into the disputed international boundary area with United States. The zone captures a portion of a significant Marxan 'hotspot', an indication of a location that either contains conservation features that are spatially limited in their distribution or a number of conservation features that can be efficiently captured together in one area, or a combination of both. The zone contributes towards meeting network regional scale representational targets for a number of E-CPs, including a variety of groundfish and rockfish species. This particular area also supports sub-regional replication targets for a range of habitats and areas including invertebrate biomass and diversity hotspots and the Dixon Entrance Ecosection and the Dixon Entrance Coastal Flow Region – Upper Ocean Subregion. The zone also contributes to representation of Haida cultural conservation priorities.

APPENDIX E. RESEARCH SURVEY LOCATIONS

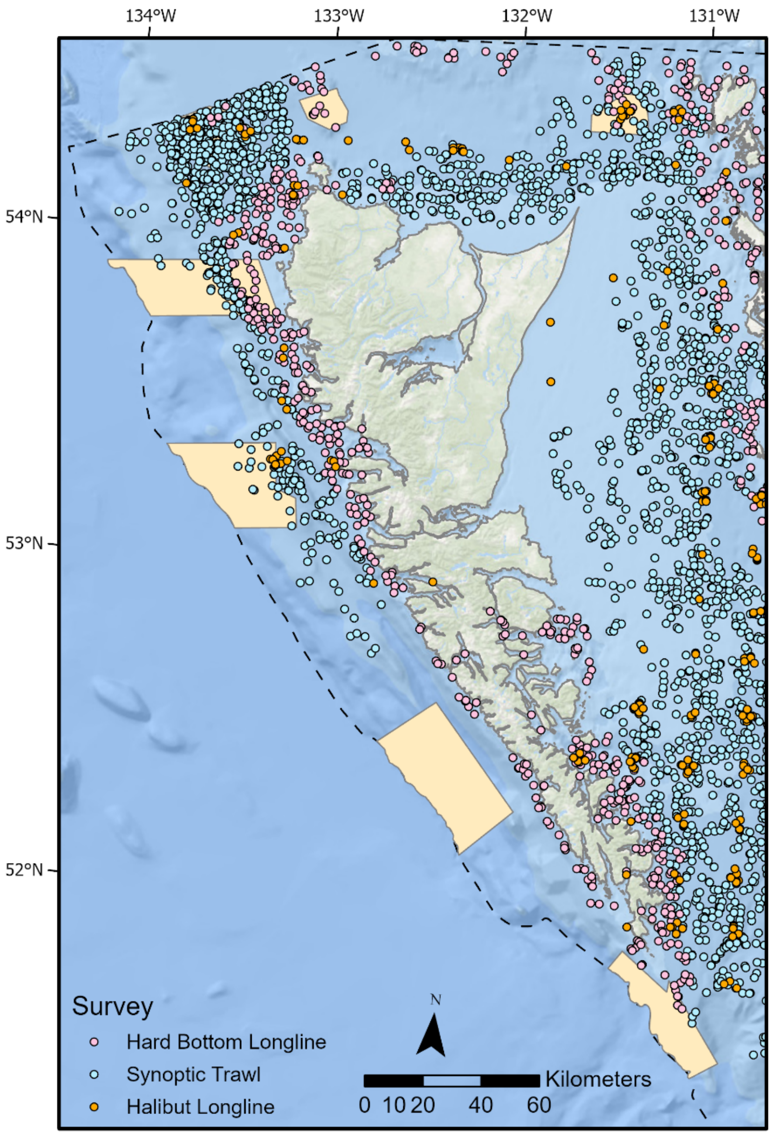

Figure E.1. Sampling extent of surveys for the Offshore Haida Gwaii Network Zones. Map shows the sampling points for the Hard Bottom Longline, Halibut Longline, and Synoptic Trawl Surveys. Fisheries-independent scientific surveys conducted within Canadian Pacific Waters: the Fisheries and Oceans Canada (DFO) Groundfish Synoptic Bottom Trawl Surveys (Sinclair et al. 2003; Anderson et al. 2019), the DFO Groundfish Hard bottom Longline Surveys (Lochead and Yamanaka 2006, Lochead and Yamanaka 2007, Doherty et al. 2019), and the International Pacific Halibut Commission Fisheries Independent Setline Survey (Stewart and Hicks 2022).

APPENDIX F. CONSERVATION STATUS AND OCCURRENCE OF SPECIES INCLUDED IN REPORT

Table F.1. Taxa observed in or modelled to inhabit the Offshore Haida Gwaii Network Zones and documented in this report. Conservation status of taxa are provided where applicable, including the CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora) Appendix II, the IUCN (International Union for the Conservation of Nature) Red List, Species at Risk Act (SARA) Schedule 1, and the COSEWIC (Committee on the Status of Wildlife in Canada; COSEWIC 2015) Assessment. The Conservation Priority (Cons. Priority) of each taxa in the Northern Shelf Bioregion, as assessed by Gale et al. 2019, is provided where possible where 'Y' denotes the species is a conservation priority, 'N' denotes it is not. For Class Aves a CP score of 1 or 2 gets a Y (Gale et al. 2019). A dash indicates the species is not listed or assessed. If the species has been observed in a zone it is denoted by an 'X' (observations through DFO surveys, Haida Marine Traditional Knowledge, and GBIF records). Abbreviations for the conservation statuses are provided at the end of the table.

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Demospongiae	Demosponges	Demospongiae	-	-	-	-	Y	X	-	X	X	X	X	X
Hexactinellida	Glass sponges	Hexactinellida	-	-	-	-	Y	X	X	X	X	X	X	X
Hexacorallia	Black Corals	Antipatharia	App. II	-	-	-	Y	X	-	X	X	X	X	X
Hexacorallia	Hard or Stony Corals	Scleractinia	App. II		-	-	Y	X	-	X	X	X	X	X
Octocorallia	Sea Pens	Pennatulacea	-	-	-	-	Y	X	-	X	X	X	X	X
Octocorallia	Gorgonian and Soft Corals	Alcyonacea	-	-	-	-	Y	X	X	X	X	X	X	X
Asteroidea	Sunflower Sea Star	*Pycnopodia helianthoides*	-	CR	-	-	Y	X	-	-	X	X	-	X
Cephalopoda	Giant Pacific Octopus	*Enteroctopus dofleini*	-	LC	-	-	Y	-	-	X	-	-	-	-
Cephalopoda	Opal Squid	*Doryteuthis opalescens*	-	LC	-	-	Y	-	-	X	-	-	-	-
Malacostraca	Deepwater Grooved Tanner Crab	*Chionoecetes tanneri*	-	-	-	-	Y	X	X	X	X	X	-	-
Malacostraca	Dungeness Crab	*Metacarcinus magister*	-	-	-	-	Y	-	-	-	-	-	-	X

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Malacostraca	Sidestripe Shrimp	*Pandalopsis dispar*	-	-	-	-	Y	-	-	-	X	X	-	X
Malacostraca	Smooth Pink Shrimp	*Pandalus jordani*	-	-	-	-	Y	-	-	-	X	X	-	X
Malacostraca	Spiny/Northern Pink Shrimp	*Pandalus borealis*	-	-	-	-	Y	-	-	X	X	X	-	X
Malacostraca	Spot Prawn	*Pandalus platyceros*	-	-	-	-	Y	-	-	-	X	X	-	X
Actinopterygii	Arrowtooth	*Atheresthes stomias*	-	-	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Butter Sole	*Isopsetta isolepis*	-	LC	-	-	N	-	-	-	-	-	-	X
Actinopterygii	Curlfin Sole	*Pleuronichthys decurrens*	-	LC	-	-	-	X	-	-	-	-	-	-
Actinopterygii	Darkfin Sculpin	*Malacocottus zonurus*	-	-	-	-	-	X	-	X	X	X	X	X
Actinopterygii	Dover Sole	*Microstomus pacificus*	-	DD	-	-	Y	X	X	X	X	X	-	X
Actinopterygii	English Sole	*Parophrys vetulus*	-	LC	-	-	N	-	-	-	X	-	-	X
Actinopterygii	Flathead Sole	*Hippoglossoides elassodon*	-	LC	-	-	N	-	-	-	X	-	-	X
Actinopterygii	Pacific Halibut	*Hippoglossus stenolepis*	-	LC	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Petrale Sole	*Eopsetta jordani*	-	LC	-	-	Y	-	-	X	X	X	X	X
Actinopterygii	Rex Sole	*Glyptocephalus zachirus*	-	LC	-	-	Y	X	-	X	X	X	X	X
Actinopterygii	Rock sole	*Lepidopsetta bilineata*	-	LC	-	-	Y	X	-	-	X	-	X	X
Actinopterygii	Slender Sole	*Lyopsetta exilis*	-	LC	-	-	-	-	-	X	X	X	-	X
Actinopterygii	Eulachon	*Thaleichthys pacificus*	-	LC	-	E	Y	-	-	-	-	-	-	X
Actinopterygii	Pacific Herring	*Clupea pallasii*	-	DD	-	-	Y	-	-	-	X	-	-	X

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Actinopterygii	Northern Lampfish	*Stenobrachius leucopsarus*	-	LC	-	-	Y	-	-	X	X	X	-	-
Actinopterygii	Kelp Greenling	*Hexagrammos decagrammus*	-	LC	-	-	N	-	-	-	X	-	X	X
Actinopterygii	Lingcod	*Ophiodon elongatus*	-	-	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Sablefish	*Anoplopoma fimbria*	-	-	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Chinook Salmon	*Oncorhynchus tshawytscha*	-	-	-	E	Y	-	X	X	X	X	X	X
Actinopterygii	Chum Salmon	*Oncorhynchus keta*	-	-	-	-	Y	-	-	-	X	X	X	X
Actinopterygii	Coho Salmon	*Oncorhynchus kisutch*	-	-	-	T	Y	-	-	X	X	X	X	X
Actinopterygii	Pink Salmon	*Oncorhynchus gorbusha*	-	-	-	-	Y	-	-	-	X	X	X	X
Actinopterygii	Sockeye Salmon	*Oncorhynchus nerka*	-	LC	-	E	Y	-	-	-	X	X	X	X
Actinopterygii	Bocaccio	*Sebastes paucispinis*	-	CR (A1abd+2)	-	E	Y	X	X	X	X	X	-	-
Actinopterygii	Canary Rockfish	*Sebastes pinniger*	-	-	-	T	Y	X	X	-	X	X	X	X
Actinopterygii	China Rockfish	*Sebastes nebulosus*	-	-	-	-	Y	X	X	-	X		X	X
Actinopterygii	Copper Rockfish	*Sebastes caurinus*	-	-	-	-	Y	-	-	-	X	X	-	X
Actinopterygii	Darkblotched Rockfish	*Sebastes crameri*	-	-	-	SC	Y	X	-	X	X	X	X	X
Actinopterygii	Dusky Rockfish	*Sebastes ciliatus*	-	-	-	-	N	-	-	-	X	-	-	-
Actinopterygii	Greenstriped Rockfish	*Sebastes elongatus*	-	-	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Harlequin Rockfish	*Sebastes variegatus*	-	-	-	-	-	X	-	X	X	X	X	-

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Actinopterygii	Pacific Ocean Perch	*Sebastes alutus*	-	-	-	-	Y	X	-	X	X	X	X	X
Actinopterygii	Pygmy Rockfish	*Sebastes wilsoni*	-	-	-	-	-	X	-	-	X	X	X	-
Actinopterygii	Quillback Rockfish	*Sebastes maliger*	-	-	-	T	Y	X	X	-	X	-	X	X
Actinopterygii	Redbanded Rockfish	*Sebastes babcocki*	-	-	-	-	N	X	-	X	X	X	X	X
Actinopterygii	Redstripe Rockfish	*Sebastes proriger*	-	-	-	-	Y	X	-	X	X	X	X	X
Actinopterygii	Rosethorn Rockfish	*Sebastes helvomaculatus*	-	-	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Sharpchin Rockfish	*Sebastes zacentrus*	-	-	-	-	N	X	-	X	X	X	X	-
Actinopterygii	Shortraker Rockfish	*Sebastes borealis*	-	-	-	-	Y	X	-	X	X	X	X	X
Actinopterygii	Silvergray Rockfish	*Sebastes brevispinis*	-	-	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Tiger Rockfish	*Sebastes nigrocinctus*	-	-	-	-	Y	X	-	-	X	-	X	X
Actinopterygii	Vermillion Rockfish	*Sebastes miniatus*	-	-	-	-	Y	X	X	-	X	-	-	-
Actinopterygii	Widow Rockfish	*Sebastes entomelas*	-	-	-	-	Y	X	-	X	X	X	X	-
Actinopterygii	Yelloweye Rockfish	*Sebastes ruberrimus*	-	-	SC	SC	Y	X	X	X	X	X	X	X
Actinopterygii	Yellowmouth Rockfish	*Sebastes reedi*	-	-	-	T	Y	X	-	X	X	X	X	-
Actinopterygii	Yellowtail Rockfish	*Sebastes flavidus*			-		Y	X	X	X	X	X	X	X
Actinopterygii	Longspine Thornyhead	*Sebastolobus altivelis*	-	-	SC	SC	Y	X	X	X	X	X	-	-
Actinopterygii	Shortspine Thornyhead	*Sebastolobus alascanus*	-	E (A2d)	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostichus*	-	-	SC	SC	Y	X	X	X	X	X	X	X
Actinopterygii	Pacific Cod	*Gadus macrocephalus*	-	-	-	-	Y	X	X	-	X	X	X	X

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Actinopterygii	Pacific Hake	*Merluccius productus*	-	LC	-	-	Y	X	X	X	X	X	X	X
Actinopterygii	Walleye Pollock	*Gadus chalcogrammus*	-	-	-	-	Y	X	-	X	X	X	X	X
Elasmobranchii	Brown Cat Shark	*Apristurus brunneus*	-	DD	-	-	N	X	-	X	X	-	-	-
Elasmobranchii	Bluntnose Sixgill Shark	*Hexanchus griseus*	-	NT	SC	SC	Y	X	-	-	X	-	-	-
Elasmobranchii	Pacific Sleeper Shark	*Somniosus pacificus*	-	NT	-	-	Y	X	-	X	X	-	X	-
Elasmobranchii	Spiny Dogfish	*Squalus suckleyi*	-	-	-	SC	Y	X	X	X	X	X	X	X
Elasmobranchii	Blue Shark	*Prionace glauca*	-	NT	-	NR	Y	X	-	X	X	X	-	X
Elasmobranchii	Salmon Shark	*Lamna ditropis*	-	LC	-	-	Y	X	-	-	X	-	-	-
Elasmobranchii	Abyssal Skate	*Bathyraja abyssicola*	-	DD	-	-	-	X	-	X	X	X	-	X
Elasmobranchii	Alaska Skate	*Bathyraja parmifera*	-	LC	-	-	-	X	-	-	X	-	X	X
Elasmobranchii	Aleutian Skate	*Bathyraja aleutica*	-	LC	-	-	-	X	-	X	X	X	-	X
Elasmobranchii	Big Skate	*Beringraja binoculata*	-	NT	-	NR	Y	X	-	X	X	X	X	X
Elasmobranchii	Longnose Skate	*Beringraja rhina*	-	LC	-	NR	Y	X	X	X	X	X	X	X
Elasmobranchii	Roughtail Skate	*Bathyraja trachura*	-	LC	-	-	Y	X	-	X	X	X	-	X
Elasmobranchii	Sandpaper Skate	*Bathyraja interrupta*	-	LC	-	NR	Y	X	X	X	X	X	X	X
Chondrichthyes	Spotted Ratfish	*Hydrolagus colliei*	-	LC	-	-	-	X	-	-	X	X	X	X
Mammalia	Blue Whale	*Balaenoptera musculus*	App. I	E	E	E	Y	X	X	X	X	X	X	X
Mammalia	Fin Whale	*Balaenoptera physalus*	App. I	V	-	SC	Y	X	X	X	X	X	X	X
Mammalia	Minke Whale	*Balaenoptera acutorostrata*	App. I & II	LC	-	NR	Y	-	-	-	X	-	X	X

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Mammalia	Sei Whale	*Balaenoptera borealis*	App. I	E	E	E	Y	X	X	X	X	X	X	-
Mammalia	Humpback Whale	*Megaptera novaeangliae*	App. I	LC	SC	SC	Y	X	X	X	X	X	X	X
Mammalia	Sperm Whale	*Physeter macrocephalus*	App. I	V	-	NR	Y	X	X	X	X	X	-	X
Mammalia	Northern Right Whale Dolphin	*Lissodelphis borealis*	App. II	LC	-	NR	Y	X	-	-	-	-	-	-
Mammalia	Pacific White Sided Dolphin	*Lagenorhynchus obliquidens*	-	-	-	-	Y	X	X	-	X	-	-	-
Mammalia	Killer Whale	*Orcinus orca*	App. II	DD	T	T	Y	X	-	-	X	-	X	X
Mammalia	Harbour Porpoise	*Phocoena phocoena*	App. II	LC	SC	SC	Y	X	-	-	-	-	-	X
Mammalia	Dall's Porpoise	*Phocoenoides dalli*	App. II	LC	-	NR	Y	X	X	X	X	-	X	X
Mammalia	Steller Sea Lion	*Eumetopias jubatus*	-	NT	SC	SC	Y	-	-	-	-	-	-	-
Mammalia	Northern Fur Seal	*Callorhinus ursinus*	-	V	-	T	Y	-	-	-	X	-	-	-
Reptilia	Leatherback Sea Turtle	*Dermochelys coriacea*	App. I	V	E	E	Y	X	X	X	X	X	X	-
Aves	Black-footed Albatross	*Phoebastria nigripes*	-	NT	-	SC	Y	X	X	X	X	X	X	X
Aves	Laysan Albatross	*Phoebastria immutabilis*	-	NT	-	-	Y	X	X	-	X	-	X	-
Aves	Fork-tailed Storm-petrel	*Hydrobates furcatus*	-	LC	-	-	Y	X	X	X	X	X	X	X
Aves	Leach's Storm-petrel	*Hydrobates leucorhous*	-	V	-	-	Y	X	X	X	X	X	X	X
Aves	Mottled Petrel	*Pterodroma inexpectata*	-	NT	-	-	-	X	X	-	-	-	-	-
Aves	Northern Fulmar	*Fulmarus glacialis*	-	LC	-	-	Y	X	X	X	X	X	X	X
Aves	Buller's Shearwater	*Ardenna bulleri*	-	V	-	-	Y	-	-	-	-	-	X	-

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Aves	Pink-Footed Shearwater	*Ardenna creatopus*	-	V	E	E	Y	X	X	X	X	-	-	X
Aves	Short-tailed Shearwater	*Ardenna tenuirostris*	-	LC	-	-	Y	X	X	-	-	-	-	X
Aves	Sooty Shearwater	*Ardenna grisea*	-	NT	-	-	Y	X	X	X	X	X	X	-
Aves	Ancient Murrelet	*Synthliboramphus antiquus*	-	LC	SC	SC	Y	-	X	X	X	X	-	X
Aves	Cassin's Auklet	*Ptychoramphus aleuticus*	-	NT	SC	SC	Y	X	X	X	X	X	X	X
Aves	Parakeet Auklet	*Aethia psittacula*	-	LC	-	-	-	X	-	-	-	-	X	-
Aves	Common Murre	*Uria aalge*	-	LC	-	-	Y	X	X	X	X	-	X	X
Aves	Marbled Murrelet	*Brachyramphus marmoratus*	-	E	T	T	Y	-	X	-	X	-	-	X
Aves	Pigeon Guillemot	*Cepphus columba*	-	LC	-	-	Y	X	X	-	X	-	-	X
Aves	Rhinoceros Auklet	*Cerorhinca monocerata*	-	LC	-	-	Y	X	X	X	X	X	X	X
Aves	Tufted Puffin	*Fratercula cirrhata*	-	LC	-	-	Y	X	X	X	X	X	X	X
Aves	Guadalupe or Scripp's Murrelet	*Synthliboramphus hypoleucus or S. scrippsi*	-	E	-	-	-	X	-	-	-	-	-	-
Aves	Pelagic Cormorant	*Urile pelagicus*	-	LC	-	-	Y	X	-	-	-	-	-	X
Aves	Black-legged Kittiwake	*Rissa tridactyla*	-	V	-	-	-	X	X	-	-	X	-	X
Aves	Bonaparte's Gull	*Chroicocephalus philadelphia*	-	-	-	-	-	X	-	-	-	-	-	-
Aves	California Gull	*Larus californicus*	-	LC	-	-	Y	-	X	-	X	X	-	X

Class	Common Name	Scientific Name	CITES List*	IUCN List*	SARA*	COSEWIC*	Cons. Priority**	Zone 505	Zone 504	Zone 503	Zone 502	Zone 506	Zone 501	Zone 500
Aves	Glaucous-winged Gull	*Larus glaucescens*	-	LC	-	-	-	X	X	-	X	X	X	X
Aves	Herring Gull	*Larus argentatus*	-	LC	-	-	-	X	X	-	-	-	-	X
Aves	Iceland Gull/Thayer's Gull	*Larus glaucoides*	-	LC	-	-	Y	-	X	-	-	-	-	-
Aves	Mew Gull/Short-billed Gull	*Larus brachyrhynchus*	-	-	-	-	-	-	-	-	-	-	-	X
Aves	Sabine's Gull	*Xema sabini*	-	LC	-	-	N	X	-	-	X	X	-	-
Aves	Western Gull	*Larus occidentalis*	-	LC	-	-	-	X	X	-	-	-	-	-
Aves	South Polar Skua	*Stercorarius maccormicki*	-	LC	-	-	-	X	X	X	-	-	-	X
Aves	Long-tailed Jaeger	*Stercorarius longicaudus*	-	LC	-	-	-	X	X	-	X	-	-	-
Aves	Arctic Tern	*Sterna paradisaea*	-	LC	-	-	-	X	X	X	-	-	-	-
Aves	Pacific Loon	*Gavia pacifica*	-	LC	-	-	Y	-	X	X	-	-	-	X
Aves	Snow Goose	*Anser caerulescens*	-	LC	-	-	N	-	-	-	-	-	X	-
Aves	Red-necked Phalarope	*Phalaropus lobatus*	-	LC	SC	SC	Y	X	-	X	-	-	X	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

** Additional lists regarding the conservation status of birds do exist (e.g. ANMU, CAAU, MAMU, BFAL, PFSH) but are not included in the Conservation Prioirty assessment provided (Gale et al. 2019).

APPENDIX G. VESSEL DATA GEAR CLASS DEFINITIONS

For reference to Figure 36 and Table 24; Iacarella et al. 2023a, 2023b

Convolutional neural network algorithms were used to predict whether a vessel was fishing and, together with vessel registries, what gear type it was using for 16 gear classes. Global Fishing Watch uses the below vessel class hierarchy to reflect increasing levels of confidence. More specific gear classes were applied when there was high confidence from the model predictions and vessel registries, otherwise umbrella classes were used.

Gear classes (not all are relevant to map and table):

1. Squid jigger: Squid jiggers and other vessels fishing with lights while stationary, notably lift-net vessels fishing for Pacific Saury.
2. Drifting longlines: Vessel that fishes by deploying longlines that drift, attached to buoys. These lines have shorter hooked, typically baited, lines hanging from them.
3. Pole and line: Vessel from which people fish with pole and line.
4. Trollers: Vessel that tows multiple fishing lines.
5. Fixed gear: Umbrella category including pots and traps, set longlines, and set gillnets.
6. Pots and traps: Vessel that deploys pots (small, portable traps) or traps to catch fish.
7. Set longlines: Vessel that fishes by setting longlines anchored to the seafloor. These lines have shorter hooked, typically baited, lines hanging from them.
8. Set gillnets: Vessel that fishes by setting gillnets anchored to the seafloor.
9. Trawlers: Vessel that fishes by towing a net through the water.
10. Dredge fishing: Vessel that tows a dredge the scrapes up edible bottom dwellers such as scallops or oysters.
11. Seines: Umbrella category including purse seines and other seines.
12. Purse seines: Sub-category including tuna purse seines and other purse seines.
13. Tuna purse seines: Large purse seines primarily fishing for tuna.
14. Other purse seines: Purse seiners fishing for mackerel, anchovies, etc., often smaller and operating nearer the coast than tuna purse seines.
15. Other seines: Danish seines and other seiners not using purse seines.
16. Other fishing: Fishing vessel that does not fall into one of the categories specified above.

APPENDIX H. CLIMATE CHANGE IMPACTS RCP 8.5 SCENARIO RESULTS

Table H.1. Seasonal mean sea temperature (°C; sea bottom and sea surface) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii Network Zones using BCCM (Peña et al. 2019) regional ocean model outputs. The historical time period is 1981–2010, for which mean sea temperature values are provided. The projected future time period is 2041–2070 under the RCP 8.5 emissions (no climate mitigation) scenario, for which the projected change in mean sea temperature is provided. Seasons were delineated as: spring (Spr; Mar–Apr–May), summer (Sum; Jun–Jul–Aug), fall (Sep–Oct–Nov), and winter (Win; Dec–Jan–Feb). Red shading with an asterisk (*) highlights zones with a temperature change >2°C for surface waters, and >1°C for bottom waters between the historical values and projected future values.

	Sea Bottom Temperature (˚C)								Sea Surface Temperature (˚C)							
	Historical Value (1981–2010)				Projected Future Change (2041–2070; RCP 8.5)				Historical Value (1981–2010)				Projected Future Change (2041–2070; RCP 8.5)			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	3.28	3.27	3.35	3.33	+0.22	+0.23	+0.24	+0.24	8.69	13.35	12.31	8.20	+2.20*	+2.35*	+2.30*	+2.17*
Zone 504	2.08	2.09	2.11	2.10	+0.01	+0.02	+0.02	+0.01	8.33	13.09	12.17	7.92	+2.27*	+2.47*	+2.55*	+2.17*
Zone 503	2.56	2.56	2.60	2.58	+0.10	+0.09	+0.10	+0.10	8.02	13.09	12.25	7.67	+2.34*	+2.60*	+2.67*	+2.28*
Zone 502	3.90	3.87	4.01	4.05	+0.51	+0.40	+0.42	+0.55	7.92	12.98	12.06	7.55	+2.30*	+2.65*	+2.82*	+2.28*
Zone 506	5.10	4.94	5.08	5.29	+0.82	+0.75	+0.72	+0.87	7.78	12.67	11.60	7.37	+2.34*	+2.69*	+2.89*	+2.35*
Zone 501	5.41	5.25	5.46	5.74	+0.94	+0.78	+0.78	+1.04*	7.83	12.42	11.00	7.22	+2.25*	+2.33*	+2.63*	+2.19*
Zone 500	5.85	5.77	6.05	6.22	+1.14*	+0.88	+0.89	+1.19*	8.11	12.93	10.81	7.08	+2.18*	+2.57*	+2.50*	+2.06*
Shelf	6.79	6.74	7.20	7.26	+1.41*	+0.99	+1.10*	+1.52*	8.67	13.29	11.66	8.00	+2.18*	+2.35*	+2.50*	+2.15*
Slope	2.71	2.71	2.76	2.74	+0.11	+0.11	+0.12	+0.11	8.49	13.26	12.38	8.04	+2.26*	+2.40*	+2.59*	+2.23*

Table H.2. Seasonal mean sea temperature (ºC; sea bottom and sea surface) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii Network Zones using NEP36-CanOE (Holdsworth et al. 2021) regional ocean model outputs. The historical time period is 1986–2005, for which mean sea temperature values are provided. The projected future time period is 2046–2065 under the RCP 8.5 emissions (no climate mitigation) scenario, for which the projected change in mean sea temperature is provided. Seasons were delineated as: spring (Spr; Mar–Apr–May), summer (Sum; Jun–Jul–Aug), fall (Sep–Oct–Nov), and winter (Win; Dec–Jan–Feb). Red shading with an asterisk (*) highlights zones with a temperature change of >2ºC for surface waters, and >1ºC for bottom waters between the historical and projected future values. Yellow shading with a circumflex (^) highlights zones with a temperature change of >1ºC and <2ºC for surface waters between the historical and projected future values.

	Sea Bottom Temperature (˚C)								**Sea Surface Temperature (˚C)**							
	Historical (1986–2005)				**Projected Future (2046–2065; RCP 8.5)**				**Historical (1986–2005)**				**Projected Future (2046–2065; RCP 8.5)**			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	3.23	3.15	3.18	3.27	+0.21	+0.24	+0.29	+0.24	7.89	13.78	11.85	7.66	+2.11*	+2.21*	+2.04*	+2.34*
Zone 504	2.04	2.04	2.04	2.04	+0.01	+0.01	+0.02	+0.01	7.00	13.07	11.60	7.14	+3.00*	+2.85*	+2.66*	+2.86*
Zone 503	2.89	2.86	2.90	2.94	+0.17	+0.19	+0.20	+0.16	7.00	13.86	12.00	7.00	+3.00*	+1.75^	+2.11*	+2.78*
Zone 502	4.23	4.39	4.57	4.34	+0.71	+0.62	+0.63	+0.74	7.00	13.01	11.49	6.99	+2.51*	+2.2*	+2.51*	+2.49*
Zone 506	5.92	5.17	5.64	6.00	+1.04*	+1.21*	+1.26*	+1.33*	7.00	12.67	11.00	7.00	+2.00^	+2.14*	+2.21*	+2.00^
Zone 501	5.99	5.40	5.82	6.00	+1.00*	+1.15*	+1.12*	+1.50*	7.00	12.70	11.00	7.00	+2.00^	+1.96^	+2.54*	+2.00^
Zone 500	6.00	6.02	6.17	6.40	+1.64*	+1.11*	+1.07*	+1.46*	6.35	13.00	11.00	6.00	+2.65*	+2.00^	+2.00^	+3.00*
Shelf	6.72	6.99	7.43	7.22	+1.92*	+1.36*	+1.45*	+1.98*	7.45	13.01	11.35	7.50	+2.52*	+2.04*	+2.37*	+2.28*
Slope	2.75	2.74	2.76	2.79	+0.13	+0.15	+0.16	+0.15	7.40	13.35	11.87	7.46	+2.66*	+2.18*	+2.42*	+2.39*

Table H.3. Seasonal mean aragonite saturation state (sea bottom and sea surface) within the seven zones and two large-scale biophysical unit areas of the Offshore Haida Gwaii 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 8.5 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 with an asterisk (*) highlights zones with W_A <1.

	Sea Bottom Aragonite Saturation State								**Sea Surface Aragonite Saturation State**							
	Historical Value (1981–2010)				**Projected Future Change (2041–2070; RCP 8.5)**				**Historical Value (1981–2010)**				**Projected Future Change (2041–2070; RCP 8.5)**			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	0.60*	0.60*	0.60*	0.60*	-0.05*	-0.06*	-0.06*	-0.06*	2.07	2.36	2.17	1.75	-0.51	-0.53	-0.54	-0.45
Zone 504	0.53*	0.54*	0.53*	0.53*	-0.01*	-0.02*	-0.02*	-0.02*	2.07	2.39	2.20	1.73	-0.50	-0.59	-0.53	-0.44
Zone 503	0.54*	0.54*	0.54*	0.54*	-0.03*	-0.03*	-0.03*	-0.03*	2.08	2.44	2.30	1.78	-0.51	-0.61	-0.56	-0.46
Zone 502	0.72*	0.70*	0.69*	0.72*	-0.11*	-0.11*	-0.11*	-0.11*	2.06	2.48	2.31	1.76	-0.50	-0.60	-0.56	-0.45
Zone 506	0.83*	0.83*	0.80*	0.81*	-0.17*	-0.16*	-0.16*	-0.17*	2.06	2.46	2.25	1.74	-0.48	-0.55	-0.50	-0.43
Zone 501	0.91*	0.88*	0.84*	0.90*	-0.20*	-0.18*	-0.18*	-0.20*	2.01	2.36	2.07	1.62	-0.43	-0.50	-0.44	-0.38
Zone 500	1.03	0.97*	0.94*	1.01	-0.24*	-0.23*	-0.22*	-0.23*	2.00	2.21	2.00	1.56	-0.41	-0.39	-0.40	-0.36
Shelf	1.19	1.07	1.05	1.19	-0.30*	-0.28*	-0.28*	-0.30*	2.01	2.32	2.05	1.64	-0.44	-0.48	-0.45	-0.39
Slope	0.56*	0.56*	0.56*	0.52*	-0.03*	-0.03*	-0.04*	-0.04*	2.07	2.4	2.24	1.77	-0.51	-0.57	-0.54	-0.45

Table H.4. Seasonal mean aragonite saturation state (sea bottom and sea surface) within the seven zones and two large-scale biophysical unit areas of the Offshore Haida Gwaii Network Zones using NEP36-CanOE (Holdsworth et al. 2021) regional ocean model outputs. The historical time period is 1986–2005, for which mean aragonite saturation state values are provided. The projected future period is 2046–2065 under the RCP 8.5 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 with an asterisk (*) highlights zones with W_A <1.

	Sea Bottom Aragonite Saturation State								**Sea Surface Aragonite Saturation State**							
	Historical (1986–2005)				**Projected Future (2046–2065; RCP 8.5)**				**Historical (1986–2005)**				**Projected Future (2046–2065; RCP 8.5)**			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	1.00	0.96*	0.98*	1.00	0	+0.01	+0.01	0	2.00	2.00	2.00	2.00	-1.00	0	-0.50	-1.00
Zone 504	0.94*	1.00	1.00	1.00	0	0	0	0	2.00	2.00	2.00	2.00	-1.00	0	0	-1.00
Zone 503	0.92*	0.70*	0.79*	1.00	-0.28*	0	0	0	2.00	2.00	2.00	2.00	-1.00	0	0	-1.00
Zone 502	1.17	1.00	0.85*	1.19	-0.48*	-0.16	-0.16	-0.32	2.00	2.00	2.00	2.00	-1.00	0	0	-1.00
Zone 506	1.00	1.00	1.00	1.00	0	0	0	0	2.00	2.00	2.00	2.00	-1.00	0	-0.11	-1.00
Zone 501	1.00	1.00	1.00	1.00	0	0	0	0	2.00	2.00	2.00	2.00	-1.00	0	-0.18	-1.00
Zone 500	1.08	1.00	1.00	1.15	-0.08	0	0	-0.15	2.00	2.00	2.00	2.00	-1.00	0	-0.90	-1.00
Shelf	1.60	1.26	1.35	1.71	-0.60	-0.20	-0.31	-0.71	2.00	2.00	2.00	2.00	-0.94	-0.03	-0.19	-1.00
Slope	0.94*	0.89*	0.84*	1.00	-0.14*	-0.05*	-0.03*	0.00	2.00	2.00	2.00	2.00	-0.79	0	-0.05	-1.00

Table H.5. Seasonal mean sea bottom dissolved oxygen (µmol/L) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii 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 8.5 emissions (no climate mitigation) scenario, 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). Red cells with an asterisk (*) highlight dissolved oxygen < 62.5 µmol/L.

	Sea Bottom Dissolved Oxygen (µmol/L)							
	Historical Value (1986–2005)				Projected Future Change (2046–2065; RCP 8.5)			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	42.16*	41.31*	43.56*	43.77*	+0.94*	+0.61*	+0.28*	+0.79*
Zone 504	45.31*	45.17*	44.84*	44.73*	-0.39*	-1.14*	-0.91*	-0.59*
Zone 503	38.62*	39.08*	38.79*	38.50*	-0.22*	+0.38*	+0.64*	+0.68*
Zone 502	73.36	66.80	61.06	72.16	-1.91	-0.61	-2.13*	-0.75
Zone 506	108.05	105.68	94.23	99.47	-0.44	+0.50	-1.38	+1.08
Zone 501	128.56	113.19	100.65	124.68	-3.92	-2.71	-2.91	-1.16
Zone 500	152.14	129.20	116.81	146.38	-7.13	-7.19	-5.46	-4.00
Shelf	178.88	144.13	139.53	182.51	-5.26	-7.72	-6.27	-3.17
Slope	43.84*	43.61*	43.43*	43.77*	+0.75*	+0.62*	+0.59*	+0.58*

Table H.6. Seasonal mean sea bottom dissolved oxygen (µmol/L) within the seven zones and three biophysical unit areas of the Offshore Haida Gwaii 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 time period is 2046–2065 under the RCP 8.5 emissions (no climate mitigation) scenario, 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). Red cells with an asterisk (*) highlight dissolved oxygen <62.5 µmol/L.

	Sea Bottom Dissolved Oxygen (µmol/L)							
	Historical Value (1986–2005)				Projected Future Change (2046–2065; RCP 8.5)			
Area	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**
Zone 505	57.38*	55.77*	59.05*	60.64*	-9.60*	-9.15*	-12.59*	-10.58*
Zone 504	47.86*	48.15*	48.21*	47.95*	-4.11*	-5.46*	-5.87*	-5.36*
Zone 503	48.53*	47.66*	48.92*	50.33*	-6.54*	-4.11*	-5.47*	-7.10*
Zone 502	110.40	97.97	96.83	112.84	-10.17	-10.21	-10.56	-9.38
Zone 506	164.58	133.43	138.55	183.57	-13.51	-11.64	-13.17	-6.66
Zone 501	183.68	139.51	152.76	204.84	-15.34	-15.43	-17.98	-10.08
Zone 500	254.70	191.30	188.08	244.11	-17.69	-20.21	-23.12	-14.89
Shelf	256.68	205.66	209.24	260.34	-12.68	-17.78	-20.88	-10.08
Slope	46.85*	46.37*	47.33*	47.84*	-8.05*	-7.80*	-8.76*	-8.64*

APPENDIX I. E-CP DATA SOURCES

Table I.1. Ecological Conservation Priority (E-CP) data sources for Table 32 in the report.

Spatial Feature Name	Brief Description	Date Range	Metadata link for further information	Institutional Source	Citation
Species features					
Blue Whale "Important Areas"	Blue Whale "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process	2006	Blue Whale "Important Areas"	DFO	Clarke and Jamieson 2006a
Coral CPUE (excluding sea pens) (DFO Surveys and commercial catch)	Coral (excluding sea pens) catch per unit effort (CPUE) from DFO synoptic groundfish trawl surveys and groundfish trawl fishery records, displayed as deciles of CPUE	2003–2016	Coral (excluding sea pens) catch per unit effort on the continental shelf	DFO	-
Coral presence (CCIRA Surveys)	Coral presence along nearshore areas of British Columbia's central coast. Mainly *Paragorgia pacifica* and *Calcigorgia spiculifera*, with one site containing abundant *Stylaster* sp.	2015–2017	-	Central Coast Indigenous Resource Alliance (CCIRA)	Frid et al. 2018
Darkblotched Rockfish CPUE (DFO Surveys)	Darkblotched Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE	2003–2016	-	DFO	-
Deepwater Tanner Crab CPUE (DFO Surveys)	Deepwater Tanner Crab catch per unit effort (CPUE) from research surveys (DFO Sablefish trap), displayed as deciles of CPUE	2003–2016	Deepwater Tanner Crab catch per unit effort (count/trap/hr) from DFO sablefish trap surveys	DFO	-
Fish Shelf Biomass Hotspots	Hotpots of fish biomass from DFO synoptic trawl surveys. Hotspots represent areas where groups of points (fishing events) had biomass values higher than expected compared to neighbouring points.	2003–2016	-	DFO	Rubidge et al. 2018

Spatial Feature Name	Brief Description	Date Range	Metadata link for further information	Institutional Source	Citation
Species features					
Invertebrate Shelf Biomass Hotspots	Hotpots of invertebrate biomass from DFO synoptic trawl surveys. Hotspots represent areas where groups of points (fishing events) had biomass values higher than expected compared to neighbouring points.	2003–2016	-	DFO	Rubidge et al. 2018
Leatherback Turtle "Important Areas"	Leatherback Turtle "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process	2006	Leatherback Turtle "Important Areas"	DFO	Clarke and Jamieson 2006a
Longspine Thornyhead CPUE (DFO Surveys)	Longspine Thornyhead catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE	2003–2016	Longspine Thornyhead catch per unit effort from DFO research surveys	DFO	-
Northern Right Whale Dolphin Effort-corrected Density	Effort-corrected density derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database	1975–2017	Northern Right Whale Dolphin density	DFO	-
Predicted habitat suitability for black corals (Antipatharia)	Predicted habitat suitability for black corals (Antipatharia)	1882–2008	Predicted habitat suitability for Black Corals (Antipatharia)	DFO	Finney 2010
Rosethorn Rockfish CPUE (CCIRA Surveys)	CPUE of Rosethorn Rockfish from research surveys (CCIRA), displayed as deciles of catch per unit effort	2006–2017	Rosethorn Rockfish CPUE (CCIRA Surveys)	Central Coast Indigenous Resource Alliance (CCIRA)	Frid et al. 2018
Rosethorn Rockfish CPUE (DFO, PHMA Surveys)	Rosethorn Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE	2003–2016	Rosethorn Rockfish catch per unit effort from DFO research surveys	DFO	-

Spatial Feature Name	Brief Description	Date Range	Metadata link for further information	Institutional Source	Citation
Species features					
Rougheye-Blackspotted Rockfish CPUE (DFO, PHMA Surveys)	Rougheye-Blackspotted Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE	2003–2016	Rougheye-Blackspotted Rockfish catch per unit effort from DFO research surveys	DFO	-
Roughtail Skate CPUE (DFO Surveys)	Roughtail Skate catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE	2003–2016	Roughtail Skate catch per unit effort from DFO research surveys	DFO	-
Sablefish CPUE (DFO, PHMA Surveys)	Sablefish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, DFO Sablefish trap, PHMA longline), displayed as deciles of CPUE	2003–2016	Sablefish catch per unit effort from DFO research surveys	DFO	-
Sea Pens	Predicted habitat suitability for sea pens (Pennatulacea)	1882–2008	Predicted habitat suitability for Sea Pens (Pennatulacea)	DFO	Finney 2010
Sei Whale "Important Areas"	Sei Whale "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process	2006	Sei Whale "Important Areas"	DFO	Clarke and Jamieson 2006a
Shortraker Rockfish CPUE (DFO, PHMA Surveys)	Shortraker Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE	2003–2016	Shortraker Rockfish catch per unit effort from DFO research surveys	DFO	-
Shortspine Thornyhead CPUE (DFO Surveys)	Shortspine Thornyhead catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE	2003–2016	Shortspine Thornyhead catch per unit effort from DFO research surveys	DFO	-
Soft Corals	Predicted habitat suitability for soft corals (Alyconacea)	1882–2008	Predicted habitat suitability for Soft Corals (Alcyonacea)	DFO	Finney 2010

Spatial Feature Name	Brief Description	Date Range	Metadata link for further information	Institutional Source	Citation
Species features					
Sperm Whale "Important Areas"	Effort-corrected density derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database	2006	Sperm Whale "Important Areas"	DFO	Clarke and Jamieson 2006a
Sperm Whale Effort-corrected Density	Sperm Whale "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process	1975–2017	Sperm Whale density	DFO	-
Widow Rockfish CPUE (DFO Surveys)	Widow Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE	2003–2016	Widow Rockfish catch per unit effort from DFO research surveys	DFO	-
Yellowmouth Rockfish CPUE (DFO, PHMA Surveys)	Yellowmouth Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE	2003–2016	Yellowmouth Rockfish catch per unit effort from DFO research surveys	DFO	-
Habitat features					
Areas of high rugosity	Measure of the roughness of seafloor terrain, defined as the ratio of surface area to planar area	2008	-	British Columbia Marine Conservation Analysis (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 2006b

Spatial Feature Name	Brief Description	Date Range	Metadata link for further information	Institutional Source	Citation
Species features					
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) Biophysical Units (5 classes)	Areas characterized by the bathymetric distribution of biota	2003–2013	-	DFO	Rubidge et al. 2016
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	-

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