Biophysical and Ecological Overview of the ƛ̓ušiiʔaaʔaq (Swiftsure Bank) Area

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Science Branch, Pacific Region
Institute of Ocean Sciences
Sidney, British Columbia
V8L 5T5

2025

Canadian Technical Report of
Fisheries and Aquatic Sciences 3735

Fisheries and Oceans Canada Pêches et Océans Canada
Ditidaht First Nations
huu-ay-aht
Yuutu?it?ath
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This Biophysical and Ecological Overview was co-authored and co-produced with the Ditidaht First Nation, Huu-ay-aht First Nations and the other four First Nations of the Maa-nulth Treaty Society.

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Canadian Technical Report of
Fisheries and Aquatic Sciences 3735

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by

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Cat. No. Fs97-6/3735E-PDF ISBN 978-0-660-79704-5 ISSN 1488-5379

https://doi.org/10.60825/6w6a-8t10

Correct citation for this publication:

Bannar-Martin, K.H., Yakimishyn, J., Proudfoot, P., Booker, H., Vos, A., Wright, M., Boldt, J., Burke, L., Douglas, K., Favaro, C., Fu, C., Gartner, H., Hall, A., Hilborn, A., Keppel, E., Lam, V., Li, Z., Lok, E., Neary, K., Nordstrom, C., Ogilvie, M., Ross, T., Sastri, A., Spaven, L., Zharikov, Y., and Robb, C.K. 2025. Biophysical and Ecological Overview of the **ƛ̓ušiiʔaaʔaq** (Swiftsure Bank) Area. Can. Tech. Rep. Fish. Aquat. Sci. 3735: xxiii + 459 p. https://doi.org/10.60825/6w6a-8t10

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ACRONYMS

AIS	Automatic Identification System
ASP	Aerial Surveillance Program
BC	British Columbia
BCCM	British Columbia Continental Margin Model
BCCSN	BC Cetacean Sightings Network
BCMCA	British Columbia Marine Conservation Analysis
CCG	Canadian Coast Guard
Chl-a	Chlorophyll-a pigment concentration
CHS	Canadian Hydrographic Service
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch per unit effort
CTD	Conductivity-temperature-depth
DFN	Ditidaht First Nation
DFO	Fisheries and Oceans Canada
EBSA	Ecologically and Biologically Significant Area
ECCC	Environment and Climate Change Canada
ECHO	Enhancing Cetacean Habitat and Observation
EEZ	Exclusive Economic Zone
EGC	European Green Crab
FMA	Fisheries Management Area
FSC	Food, Social, and Ceremonial
GAM	General Additive Model
GBIF	Global Biodiversity Information Facility
GMU	Groundfish Management Unit
HAB	Harmful Algal Bloom
IPHC	International Pacific Halibut Commission
iREC	DFO's Internet Recreational Effort and Catch database
LRP	Limit Reference Point
MPA	Marine Protected Area
NEP36-CanOE	Northeastern Pacific Canadian Ocean Ecosystem Model
NOAA	National Oceanic and Atmospheric Administration
NRCan	Natural Resources Canada
NRKW	Northern Resident Killer Whale
OMZ	Oxygen Minimum Zone
PCFG	Pacific Coast Feeding Group (Grey Whales)
PFMA	Pacific Fishery Management Areas
PMECS	Pacific Marine Ecological Classification System
PNCIMA	Pacific North Coast Integrated Management Area
PRNPR	Pacific Rim National Park Reserve
RCP	Representative Concentration Pathway
RCA	Rockfish Conservation Area
SARA	Species at Risk Act
SDM	Species Distribution Model
SoG	Strait of Georgia
SPM	Suspended Particulate Matter
SRKW	Southern Resident Killer Whale
SSB	Southern Shelf Bioregion
SST	Sea Surface Temperature
TRP	Target Reference Point
USR	Upper Stock Reference
UV	Ultraviolet light
VME	Vulnerable Marine Ecosystem
WCT	West Coast Trail
WCVI	West Coast of Vancouver Island

ABSTRACT

Bannar-Martin, K.H., Yakimishyn, J., Proudfoot, P., Booker, H., Vos, A., Wright, M., Boldt, J., Burke, L., Douglas, K., Favaro, C., Fu, C., Gartner, H., Hall, A., Hilborn, A., Keppel, E., Lam, V., Li, Z., Lok, E., Neary, K., Nordstrom, C., Ogilvie, M., Ross, T., Sastri, A., Spaven, L., Zharikov, Y., and Robb, C.K. 2025. Biophysical and Ecological Overview of the **ƛ̓ušiiʔaaʔaq** (Swiftsure Bank) Area. Can. Tech. Rep. Fish. Aquat. Sci. 3735: xxiii + 459 p. https://doi.org/10.60825/6w6a-8t10

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is located off the southwest coast of Vancouver Island, British Columbia. First Nations have had a relationship with **ƛ̓ušiiʔaaʔaq** for millennia, including Ditidaht First Nation, Pacheedaht First Nation, Huu-ay-aht First Nations and the other four First Nations of the Maa-nulth Treaty Society, as well as the Makah Tribe. **ƛ̓ušiiʔaaʔaq** is a dynamic marine region characterized by complex interactions between oceanographic, geological, and ecological processes. The area is influenced by the convergence of the North American and Juan de Fuca tectonic plates, resulting in a diverse range of geomorphologies. The Juan de Fuca Eddy, a prominent oceanographic feature, enhances biological productivity by concentrating nutrients and supporting a rich assemblage of marine species. This area also encompasses estuaries and an anoxic fjord (Nitinaht Lake), which provide crucial habitat for numerous fish, invertebrate, and bird species, contributing to the ecological significance of the region. **ƛ̓ušiiʔaaʔaq** provides important habitat to a variety of species and is designated as critical habitat for Southern Resident Killer Whales (SRKW) and overlaps Ecologically and Biologically Significant Areas. It is an area of high productivity and supports a wide array of human uses. Recognizing the ecological, cultural, and economic importance of this area, various conservation and management measures have been implemented, including Rockfish Conservation Areas, Pacific Rim National Park Reserve, and protection zones for SRKW. First Nations' relationships with the marine environment have been, and continue to be, key to the stewardship of **ƛ̓ušiiʔaaʔaq**, which provides important resources and is part of the local governance, trading and sharing economies, culture, and the retention of Indigenous language. This biophysical and ecological overview provides a comprehensive summary of the current state of knowledge for the area regarding its oceanography, ecological uniqueness and importance, taxonomic diversity, human activities, and sensitivity to climate change and highlights opportunities for collaborative research to address knowledge gaps.

RÉSUMÉ

Bannar-Martin, K.H., Yakimishyn, J., Proudfoot, P., Booker, H., Vos, A., Wright, M., Boldt, J., Burke, L., Douglas, K., Favaro, C., Fu, C., Gartner, H., Hall, A., Hilborn, A., Keppel, E., Lam, V., Li, Z., Lok, E., Neary, K., Nordstrom, C., Ogilvie, M., Ross, T., Sastri, A., Spaven, L., Zharikov, Y., and Robb, C.K. 2025. Biophysical and Ecological Overview of the **ƛ̓ušiiʔaaʔaq** (Swiftsure Bank) Area. Can. Tech. Rep. Fish. Aquat. Sci. 3735: xxiii + 459 p. https://doi.org/10.60825/6w6a-8t10

La région de **ƛ̓ušiiʔaaʔaq** (banc Swiftsure) se trouve au large de la côte sud-ouest de l'île de Vancouver, en Colombie-Britannique. Une relation existe depuis des millénaires entre elle et les Premières Nations, notamment la Première Nation des Ditidaht, la Première Nation des Pacheedaht, les Premières Nations Huu-ay-aht et les quatre autres Premières Nations de la Société du traité des Premières Nations Maa-nulth ainsi que la tribu Makah. Il s'agit d'une région marine dynamique caractérisée par des interactions complexes entre les processus océanographiques, géologiques et écologiques. Elle est influencée par la convergence des plaques tectoniques nord-américaine et Juan de Fuca, qui donne lieu à une géomorphologie variée. Le tourbillon Juan de Fuca, une caractéristique océanographique importante, améliore la productivité biologique en concentrant les nutriments et en soutenant un riche assemblage d'espèces marines. Il y a également des estuaires et un fjord anoxique (lac Nitinat) qui fournissent un habitat essentiel à de nombreuses espèces de poissons, d'invertébrés et d'oiseaux et qui contribuent ainsi à l'importance écologique de la région. **ƛ̓ušiiʔaaʔaq** offre un habitat important pour diverses espèces (il s'agit notamment de l'habitat essentiel désigné de l'épaulard résident du sud) et chevauche des zones d'importance écologique et biologique. Il s'agit d'une région à productivité élevée qui soutient un large éventail d'utilisations humaines. Compte tenu de l'importance écologique, culturelle et économique de cette région, diverses mesures de conservation et de gestion y ont été mises en œuvre, notamment les aires de conservation des sébastes, la réserve de parc national Pacific Rim et les aires de protection pour l'épaulard résident du sud. Les relations qu'entretiennent les Premières Nations avec le milieu marin ont été et continuent d'être essentielles à l'intendance de **ƛ̓ušiiʔaaʔaq**, qui leur fournit des ressources importantes, qui fait partie de leur gouvernance locale, de leurs économies fondées sur le commerce et le partage et de leur culture et qui contribue à la préservation des langues autochtones. Cet aperçu biophysique et écologique présente un résumé complet de l'état actuel des connaissances sur la région en ce qui concerne son océanographie, son caractère unique et son importance sur le plan écologique, sa diversité taxonomique, les activités humaines qui y sont pratiquées et sa sensibilité aux changements climatiques; de plus, il met en évidence les possibilités de recherche collaborative pour combler les lacunes dans les connaissances.

1 PREFACE

1.1 Use of Nuu-chah-nulth and Indigenous Knowledge

ƛ̓ušiiʔaaʔaq/Swiftsure Bank is shallow area off the West Coast of Vancouver Island, British Columbia (Figure 1) encompassing the highly productive Juan de Fuca Eddy. **ƛ̓ušiiʔaaʔaq** is a word borrowed from the Makah language, meaning shallow and we use the Indigenous name of **ƛ̓ušiiʔaaʔaq**[1] for Swiftsure Bank[2] throughout the body of this report. In addition, this document contains names of principles, places and species in the Nuu-chah-nulth language from the Wakashan language family, highlighted in **bold text**, and in English (terms are separated by a forward slash).[3] Nuu-chah-nulth speakers live along the west coast of Vancouver Island between Cape Cook and Pachena Point; speakers of Ditidaht live along the coast (including the area up the Nitinaht drainage and Cowichan Lake) between Pachena Point and Sheringham Point; and Makah speakers live along the Olympic Peninsula in Washington State, between the Hoko River and Cape Alava. Several dialects exist within this language family and distinct dialects are used by the First Nations that have a history with and present relationship with **ƛ̓ušiiʔaaʔaq**. Due to the number of dialects, for the purposes of this report the author group has chosen to use Nuu-chah-nulth words compiled from a variety of resources. Nuu-chah-nulth words referenced in this report and their source are listed in Appendix A. The lack of a Nuu-chah-nulth word should not be interpreted to mean that the word does not exist. Similarly, the use of English equivalents for Nuu-chah-nulth terms should not be taken as direct translations as, in many cases, the associated English term is only a rough approximation since the English language does not have equivalent terms. Incorporation of Nuu-chah-nulth and any other traditional languages in this document is reflective of a single point in time as language work is ongoing and flexible to change.

Indigenous knowledge presented in this report should not be considered complete and only represents a limited extent of knowledge that has been anecdotally shared, reported, or published with permission from knowledge holders. It is important to recognize that this report in no way represents the totality of knowledge regarding the marine environment from the Ditidaht First Nation, Pacheedaht First Nation, Huu-ay-aht First Nations, and the other four First Nations of the Maa-nulth Treaty Society.

[1] Note the first time **ƛ̓ušiiʔaaʔaq** is used in a paragraph it will be presented as **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, after that only **ƛ̓ušiiʔaaʔaq** will be used in the same paragraph. Note that alternative spellings of this name also exist, including **ƛ̓ušuwʔaa**.

[2] also known as **ʔ'uöu:ʔa:**, or Pacheedaht Bank (Pacheedaht Heritage Project et al. 2019)

[3] Note the first time the Nuu-chah-nulth term is used in a paragraph the equivalent English term will be provided, after that only the Nuu-chah-nulth term will be used in the same paragraph.

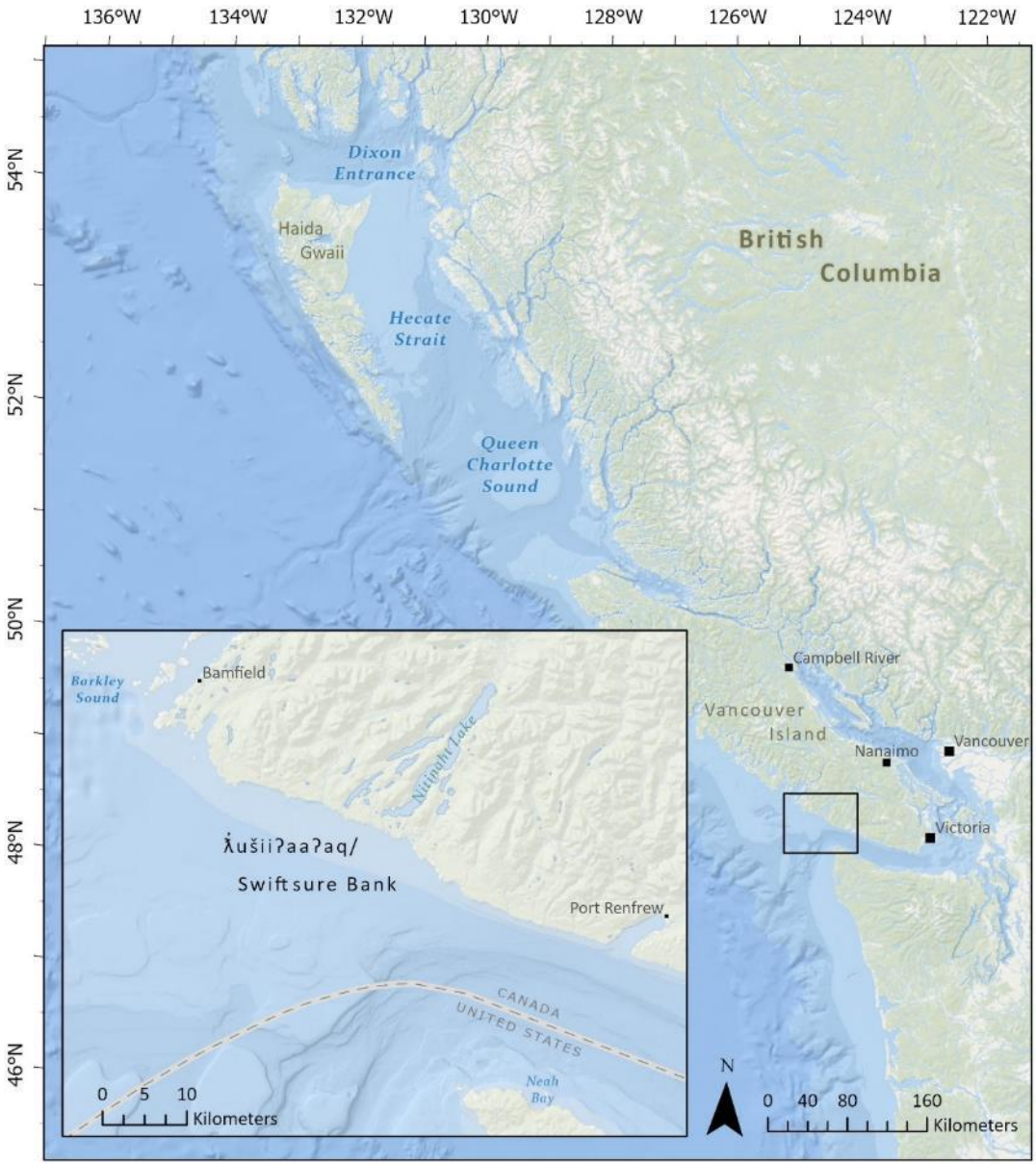


*Figure 1. The **ʔušiiʔaaʔaq**/Swiftsure Bank Area. The broad scale map shows the location of the **ʔušiiʔaaʔaq** area in relation to British Columbia's coastline. The inset map shows the **ʔušiiʔaaʔaq** area map extent we have chosen to use throughout this report. This map is repeated in the following Regional Context section and more information is provided as to the biogeographic setting of the area.*

1.2 First Nations Relationships with ʔušiiʔaaʔaq/Swiftsure Bank

First Nations have had a relationship with **ʔušiiʔaaʔaq**/Swiftsure Bank[4] for millennia. **ʔušiiʔaaʔaq** is a key marine resource and transport route for several First Nations creating opportunities for cultural exchange, trade, social and familial bonds, and creating and

[4] Please see FirstVoices for audio file of the pronunciation for ʔušiiʔaaʔaq.

maintaining a way of life. These First Nations groups include the Ditidaht First Nation, Pacheedaht First Nation, Huu-ay-aht First Nations and the other four First Nations of the Maa-nulth Treaty Society, as well as the Makah Tribe. We provide introductions to these Nations' relationships with the **ƛ̓ušiiʔaaʔaq** area in the following sections. These sections are authored by different First Nation representatives in their own words, consequently the voice changes in each section. These relationships predate colonialism and are critical to informing the history of the **ƛ̓ušiiʔaaʔaq** area, identifying its conservation importance to the multiple groups that rely upon it, and creating opportunities for co-management and stewardship.

1.2.1 Ditidaht First Nation

The Ditidaht First Nation (Ditidaht) are, and have been since time immemorial, an organized society residing in their Traditional Territory on the west coast of Vancouver Island that maintain an active and spiritual connection to their landscape. The Ditidaht were traditionally renowned warriors, whalers, fishermen, and canoe builders. The Ditidaht people have a traditional system of laws governing all forms of social and economic relations and their rights and title to their lands and its resources have never been ceded or surrendered.

The Ditidaht people speak the Ditidaht dialect of the South Wakashan sub-group of the Wakashan language, which consists of three closely related languages (Ditidaht, Makah, and Nuu-chah-nulth). The Ditidaht language and Makah language are more closely related to each other than they are to the other Nuu-chah-nulth dialects. Ditidaht is culturally and linguistically a member of the Nuu-chah-nulth group of First Nations and has close historical ties to the Pacheedaht First Nation.

Ditidaht's traditional territory is large and diverse. It takes in the lands and waters stretching along the southwest coast of Vancouver Island between **buułqawʔaa**/Bonilla Point on the east and **čuʔdaqsuus**/Pachena Point on the west, extending offshore as far as the Vancouver Island mountains are visible by canoe, and extending inland to include Nitinaht Lake, the Nitinaht River and its tributaries, and all other watersheds draining seaward between **buułqawʔaa** and **čuʔdaqsuus**. The Pacheedaht First Nation, with whom Ditidaht shares close kinship, cultural, and linguistic ties, are located to the east. The Huu-ay-aht are the neighbouring First Nation to the west. Ditidaht inland territory on Vancouver Island further extends along **ʕaʔkʷ̓aq cuubaʕsaʔtx̣'** (Lake Cowichan) and its tributary river systems, reaching down the Cowichan River to the easternmost boundary at Skutz Falls.

The Ditidaht's principal village was located at Wyah, at the entrance of Nitinaht Lake (O'Donnell 1989a; Figure 2). Most of the reserves in the watershed were situated at the sites of villages used as fishing/harvest stations for whales, Pacific Halibut (*Hippoglossus stenolepis*), and seals (i.e., Tsuquanah, Wyah, Claoose), salmon (i.e., Claoose, Homitan, Doobah, Ilclo, Opatseeah, Wokitsas, Saouk), or for their proximity to western red cedar suitable for canoe construction (i.e., Oyees, Doobah) (O'Donnell 1989; Ditidaht First Nation 2017a).

The Ditidaht rely on both freshwater and marine fisheries in their Traditional Territory for not only livelihood, but for a sense of place and identity (i.e., "home"). There are a number of important river systems within Ditidaht territory including the **ʔiixʷatiʔs** (Carmanah), **čaaxʷiyt** (Cheewaht), **ƛ̓adiiwaʔ** (Klanawa), and **ixwaatʔaa** (Darling) rivers, as well as tributaries to Nitinaht Lake, which the Nation has relied on for salmon, cedar, medicinal plants, and other cultural resources. Traditionally they used weirs, usually made of western redcedar, and stone traps, to selectively harvest salmon from the Nitinaht River and other tributaries to Nitinaht Lake

(O'Donnell 1989; Ditidaht First Nation 2017a). For instance, weirs were built at Wokitsas, Chuchummisapo, and Saouk (Figure 2; O'Donnell 1989).

Ditidaht's Territory also includes Nitinaht Lake, a tidal inlet connected to the Pacific by a slim passage known as "the Narrows". The Narrows, which measures 2.5 m in depth at low tide, limits the exchange of water between the lake and the ocean. Waters within Nitinaht Lake are grouped into two distinct bodies: a weakly stratified bottom layer containing seawater, and a strongly stratified surface layer containing brackish water. Nitinaht Lake supports a number of important species to the Ditidaht people, including Pacific salmon, Dungeness Crab (*Metacarcinus magister*), forage fish, rockfish, and other invertebrate and algal species (i.e., eelgrass).

The marine portion of the Ditidaht's Traditional Territory extends directly offshore to the 200-mile limit of the economic zone claimed by most nations. As well as the offshore Traditional Territory, their offshore fishing and resource use area extends in a south-westerly direction from Cape Beale. This includes several rich offshore fishing banks including **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. **ƛ̓ušiiʔaaʔaq** remains a vital historical and contemporary fishing ground for the Nation, providing their people with Pacific Halibut (*Hippoglossus stenolepis*), Lingcod (*Ophiodon elongatus),* Yelloweye Rockfish (*Sebastes ruberrimus*), octopus, Chinook Salmon *(Oncorhynchus tshawytsc̓ha*), and Coho Salmon *(Oncorhynchus kisutch)*. Intertribal trade was also known to occur at **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Ditidaht First Nation Traditional Marine Use and Occupancy Study Team and Traditions Consulting Services Inc. 2014).



Figure 2. Ditidaht traditional place names, locations and areas of cultural importance located on the outer coast of ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank. Details for each of these locations are provided in Appendix B.*

1.2.2 Pacheedaht First Nation

The name “Pacheedaht” translates into English as “People of the Sea Foam.” Pacheedaht Territory (Figure 3) is located on the southwest coast of Vancouver Island, generally bounded on the east near Sheringham Point, on the west at Bonilla Point; and extending inland to include the drainages of the rivers and streams on Vancouver Island between those two locations. The Pacheedaht have Aboriginal title, as well as Aboriginal fishing and hereditary harvesting rights at **ƛ̓ušuwʔaa**[5] (“Shallow Place”), or Swiftsure Bank, and at other fishing banks in their territory (Figure 3).

[5] There are several other linguistic renderings of the Indigenous name for Swiftsure Bank, including **ƛučiiʔaaʔaq. ƛ̓ušiiʔaaʔaq** is used throughout the body of this report.

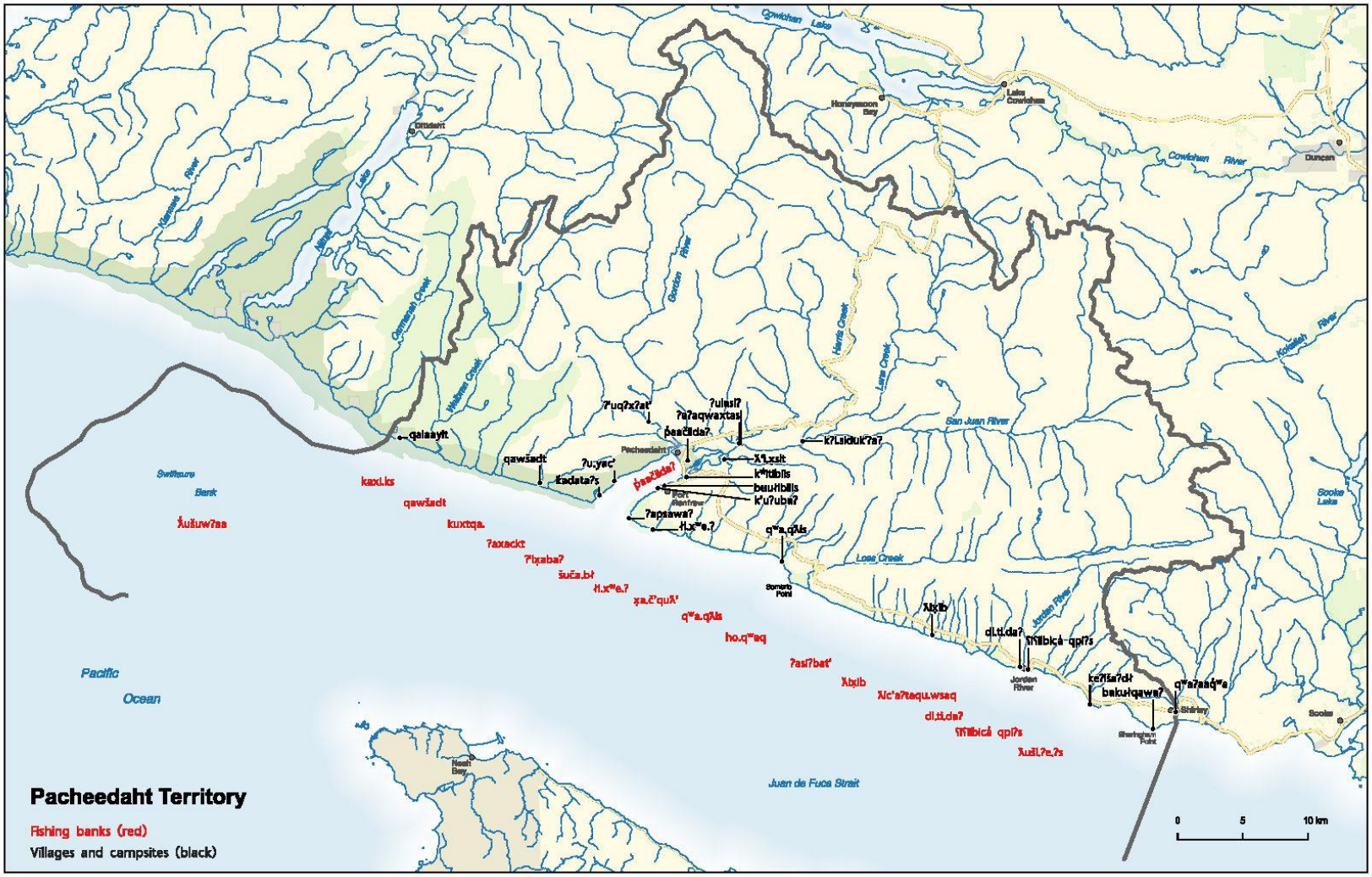


Figure 3. Pacheedaht Territory (grey line) with names of Villages and Campsites (black lettering), as well as Fishing Banks (red lettering). The placement of the names of the Fishing Banks do not correspond with actual locations in order to prevent unwanted harvesting.

Traditional accounts which relate Pacheedaht history confirm the ancient and strong connections Pacheedaht people have with their territory and resources. The earliest such account of Pacheedaht history, one that is shared with the Ditidaht, took place along and across the Strait of Juan de Fuca, and on both sides of **ƛ̓ušuwʔaa/**Swiftsure Bank. Essentially, **ƛ̓ušuwʔaa** is a resource area of paramount significance to Pacheedaht's traditional marine and cultural history, and remains important for Pacheedaht people today. There are also several historical, written records which provide evidence about the once-abundant resource area at **ƛ̓ušuwʔaa**, traditionally managed by the Pacheedaht and their allies, to the exclusion of others.

Pacheedaht people are related by kinship, language, and culture to several other First Nations on Vancouver Island, but their closest relations are with the Ditidaht to the northwest, and with the Makah across the Strait of Juan de Fuca in Washington State. The Pacheedaht's western boundary is the same as the eastern boundary of the Ditidaht First Nation. Pacheedaht share Aboriginal fishing and harvesting rights at **ƛ̓ušuwʔaa**/Swiftsure Bank with the Ditidaht First Nation; members of other First Nations also fish at **ƛ̓ušuwʔaa**, but only under approved hereditary Pacheedaht Fisheries protocol.

Pacheedaht traditional laws and government are based on the rights of the **čaačaabaƛ̓**/chiefs who were the only ones who could own rights over land, territory (**disiḇaʔk** or **tupaat**) and resources. The chiefs owned the rights to village sites; fishing locations, such as **ƛ̓ušuwʔaa/**Swiftsure Bank; locations to land canoes; build houses – as well as rights to songs, dances and much more. There were also many other ranked positions of authority and control, including **witwaak/**Warrior, **kixƛaaqa**/Beachkeeper and **čačaału/**Streamkeeper who monitored and enforced traditional laws over access to territory and resources. Failure to observe such laws, or trespass, could result in banishment, punishment or even death.

Throughout the vast majority of their long history, Pacheedaht ancestors enjoyed unrestricted access to the wide variety of resources in the ocean, rivers, and lands in their territory. In traditional times, the Pacheedaht engaged in a strategic seasonal round, using the village and camp sites as bases to harvest Pacific Halibut, salmon and other fish (Figure 3); gather intertidal resources; hunt for land and sea mammals; harvest cedar and other forestry resources; and to gather medicinal and other plants, berries, and other resources as they became seasonally or readily available, were of particular quality or abundance, or were easiest and best to obtain.

The Pacheedaht gained a wealth of knowledge about their territory over centuries of direct personal observations and practice. Pacheedaht livelihood and economy was based largely on marine resources, and they traded extensively in marine resources with other First Nations and, later, with white explorers and traders. The Pacheedaht have relied heavily, at all times, on the resources available at **ƛ̓ušuwʔaa/**Swiftsure Bank for domestic use and for trade. Commercial and non-Indigenous fisheries, as well as hunting of marine mammals, resulted in the severe depletion of many resources, particularly at **ƛ̓ušuwʔaa**, by the early 1900s. Prior to depletion, the Pacheedaht harvested a variety of resources at or near **ƛ̓ušuwʔaa** including Pacific Halibut, groundfish, fur seals, salmon, North Pacific Spiny Dogfish (*Squalus suckleyi*), and various species of whales. The Pacheedaht continue to apply their traditional management of resources, to the extent possible, through their Fisheries and hereditary protocols, and record keeping.

ƛ̓ušuwʔaa/Swiftsure Bank is an extremely important resource area in Pacheedaht's traditional marine history, and remains important for Pacheedaht people today as a source of traditional food that is a foundation of their diet and culture. **ƛ̓ušuwʔaa** has been identified by Pacheedaht

as one of its Critical Areas for a variety of purposes. **ƛ̓ušuwʔaa** has historically supported a rich and varied marine life, and remains a preferred harvesting location for the Pacheedaht. **ƛ̓ušuwʔaa** is located approximately 17 km. southwest of the Pacheedaht's traditional fishing village of **qalaayit** (Figure 3), which was established as Cullite IR No. 3 as it is the best shore site in Pacheedaht territory to access the resources at **ƛ̓ušuwʔaa**.

1.2.3 First Nations of the Maa-nulth Treaty Society

Five First Nations are signatories to the first modern-day Treaty on Vancouver Island, the Maa-nulth Treaty: Huu-ay-aht First Nations, Ka:'yu:'k't'h'/Che:k'tles7et'h' First Nations, Toquaht Nation, Uchucklesaht Tribe, and the Yuułuʔiłʔatḥ Government. The treaty came into effect on April 1, 2011, when the five Maa-nulth First Nations' laws came into effect, marking a new era of ownership and self-government. The Maa-nulth are located on the west coast of Vancouver Island with territories within Barkley Sound, Kyuquot Sound, and Chekleset Bay. The Maa-nulth are **nuučaaʕuł** (Nuu-chah-nulth) peoples and Maa-nulth means "villages along the coast" in the Nuu-chah-nulth language. Our **nuučaaʕuł** identity, who we are and what we value, is founded in our enduring connection to our **ḥaḥuuli** – our lands and seas. Our ancestors' teachings say we are connected spiritually to all creatures, plants and birds with whom we share life. This is reflected in our **nuučaaʕuł** principle of **hišukiš ċawaak** (everything is one). The Creator placed us where we belong, here, as stewards of our territories, countless generations ago. This is reflected in our **nuučaaʕuł** principle of **ʔuuʔałuk** (taking care of). Our wisdom says we were created together and equal with all other creatures. This is reflected in our **nuučaaʕuł** principle of **ʔiisaak** (utmost respect). These principles and our responsibilities to all life forms, form the foundation of who we are as Indigenous peoples.

For countless generations, by virtue of our location on the west coast of Vancouver Island, the Maa-nulth Nations have a natural bond with the ocean and its resources. We have always been connected to the sea culturally, economically, and spiritually, and fish and marine resources have been central to the health and well-being of our people.

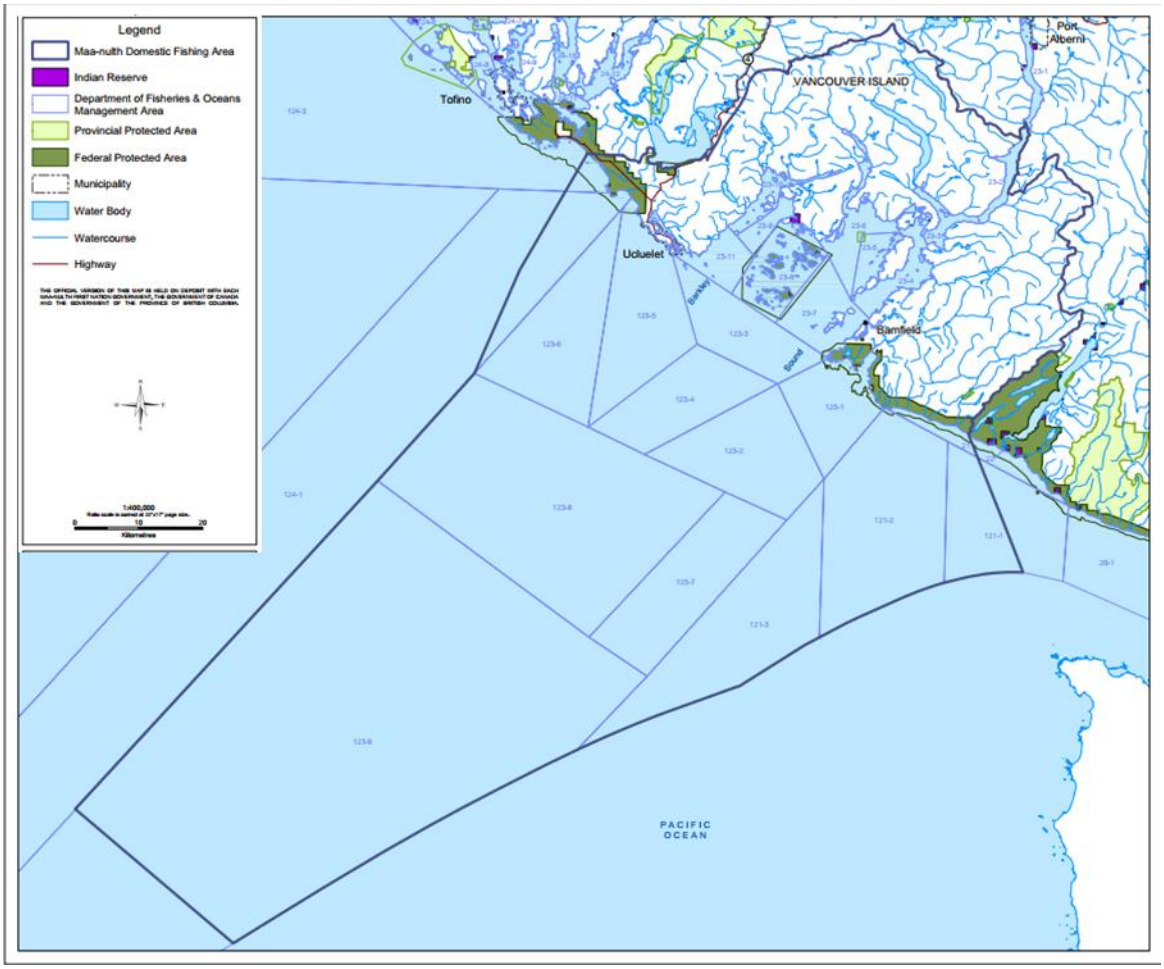


Figure 4. Southern Maa-nulth Domestic Fishing Area (MDFA) Barkley Sound.

1.2.4 Huu-ay-aht First Nations

Huu-ay-aht First Nations is a self-governing, modern treaty Nation whose lands are located in the Barkley Sound region on the West Coast of Vancouver Island, at the entrance to Alberni Inlet. The lands and waters making up our traditional territories (**ḥahuułi**, pronounced “ha-houlthee”) have been occupied by us since time immemorial. Today, Huu-ay-aht citizens number close to 900 and primarily reside around the village of Anacla, the Nation’s principal community close to Bamfield, as well as in Port Alberni, the closest population centre. The balance of our citizens live across Vancouver Island, in the Vancouver area, and beyond.

Huu-ay-aht First Nations is a member of the Nuu-chah-nulth Tribal Council and one of the five First Nations signatories to the Maa-nulth Final Agreement, the first modern-day treaty to be concluded on Vancouver Island. Today, our Nation operates under a “made in Huu-ay-aht” Constitution, which supports the laws and policies that establish how the Huu-ay-aht government makes decisions on behalf of its citizens. As a result of the treaty, Huu-ay-aht First Nations has full ownership and jurisdiction over more than 8,200 hectares of land within our territories and continues to have rights throughout our **ḥahuułi**.

With full control over these undisputed lands owned in fee simple, our Nation is able to govern the lands under our own laws. Maintaining their historic role as caretakers of the lands, waters, and resources of their **ḥahuułi**, the Huu-ay-aht **Ḥaẃiiḥ** work closely with Elected Council to ensure that all development considerations are informed and guided by the long-held principles of **ʔiisaak** (respect), **ʔuuʔałuk** (taking care of), and **hišuk ma c̓awak** (everything is connected). Furthermore, Huu-ay-aht citizens themselves contribute to the governance of the Nation through regular People's Assemblies, which employ a "direct democracy" model.

Building on a rich history, Huu-ay-aht First Nations is working to build a bright future for generations to come.

1.2.5 Makah Tribe

The Makah Tribe, located in the northwestern United States within the Olympic Peninsula (Figure 5), has a deep and enduring relationship with the ocean, which is central to their cultural identity (Wadewitz 2017, Reid 2015). As a tribe on the Northwest Coast the Makah and Nuu-chah-nulth (Nootka) people speak closely related languages and have strong cultural ties. Historically the Makah have accessed **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank.

For thousands of years, the ocean has provided the Makah people with spiritual and physical sustenance in their ancestral home on the Olympic Coast.

> *"We're a natural resource tribe–that's our wealth.*
> *We are the ocean, and the ocean is us."*
> Chad Bowechop, Makah Tribal Councilman

The 1855 Treaty of Neah Bay reserves the Makah's rights to hunt, fish, gather, whale, and seal within their usual and accustomed fishing area (Figure 5). Nearly all Makah households rely on fishing, shellfish, and hunting resources for a portion of their diet. Makah treaty fisheries include, but are not limited to, Pacific Halibut, salmon, groundfish, flatfish, whiting, Dungeness Crab, and others. Moreover, these valuable fisheries support over half of the local economy and the nutritional and financial security of most of the community.

Despite the political American and Canadian border and accompanying laws and regulations, the strong relationship between the Makah and Pacheedaht have continued to the present time. The Pacheedaht and Makah nations are closely allied by marriage, custom, traditions and language (Pacheedaht Heritage Project et al. 2019).

Huu-ay-aht First Nations and Makah have strong histories of marriage and partnership. Oral history from both nations points to intentional relationships for trade, marriage, and allyship. The totems erected at Huu-ay-aht First Nations traditional village of **kiixi?n** faces south toward Makah to represent this strong relationship (Oral History provided by Robert Dennis Sr).

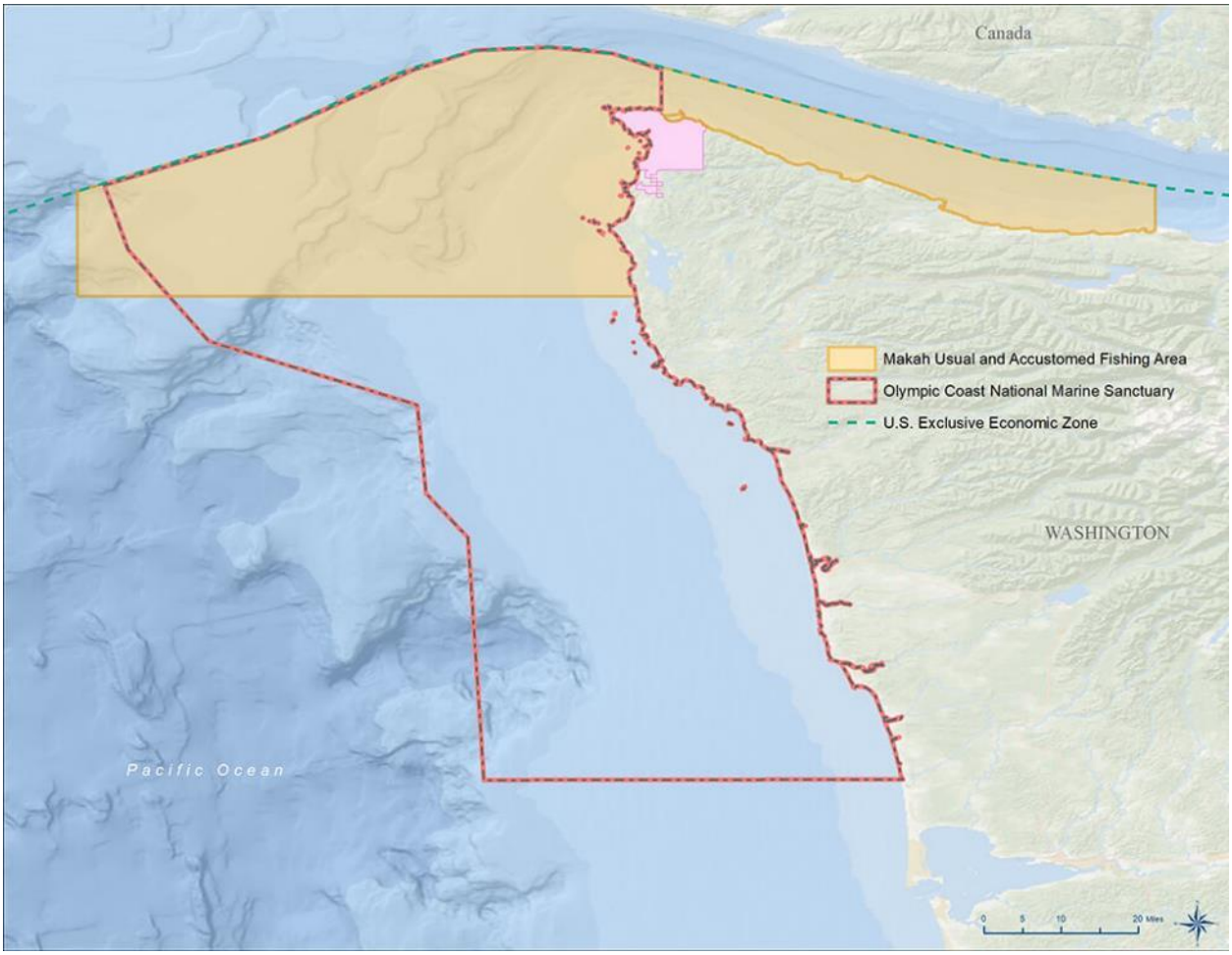


Figure 5. Makah Tribe's Usual and Accustomed Fishing Area. The Makah Indian Reservation, on the northwest tip of Washington state, is shaded in pink (NOAA).

1.3 Report Organization and Content Considerations

This biophysical and ecological overview provides a comprehensive summary of the current state of knowledge for the area regarding its oceanography, ecological uniqueness and importance, taxonomic diversity, human activities, and sensitivity to climate change and highlights opportunities for collaborative research to address knowledge gaps. The report's objectives are to:

1. Evaluate, describe and map, where possible, the key biophysical and ecological features of the study area, including:
   - predominant and/or unique physical and biological oceanographic characteristics;
   - predominant, unique, ecologically[6] important, and/or sensitive habitat features; and
   - ecologically[2] significant species; and species of conservation concern

[6] 'ecologically' includes both Indigenous and western knowledge.

2. Where appropriate, identify relevance of the study area to the life histories of species of interest, species distribution and abundance (and status and trends where available), and the local abiotic and biotic factors influencing these.
3. Identify and describe for species and habitats of interest: known sensitivities and, where possible, the potential recoverability of species and resilience of habitats of interest, including responses to anthropogenic disturbance and climate change.
4. Identify key uncertainties and knowledge gaps as it pertains to the current understanding of the existing environment and species of interest within the study area, and recommend research activities to address these gaps, where possible.

Following these objectives, this biophysical report includes six sections focusing on the **ƛ̓ušiʔaa̓ʔaq**/Swiftsure Bank Area. The first describes the regional context for the area, the second **ƛ̓ušiʔaaʔaq**'s oceanographic setting, focusing on the physical and geological structure. The third section details current and anticipated climate change impacts and the effects on specific habitats and taxonomic groups. The fourth section details Indigenous uses and human activities in the region, including potential impacts to key physical and biological features. The fifth section describes the ecological setting and cultural relationships, focusing on unique or important ecosystems, biodiversity patterns, and species and habitats identified for their ecological importance. Finally, the sixth section summarizes the ecological significance of **ƛ̓ušiʔaaʔaq**. Information gaps and data limitations, where applicable, are highlighted throughout and summarized in the final section of the report. Maps of the features within the **ƛ̓ušiʔaaʔaq** Area are included throughout. Some maps show the general **ƛ̓ušiʔaaʔaq** Area while some also include the boundary of the Juan de Fuca Eddy EBSA, which was used in some cases to help compile relevant spatial information for the area.

This report is a collective effort by a large group of knowledge holders with expertise spanning the different topics covered. In addition to the author list, the following contributors and reviewers (including workshop participants) provided text or data to inform the report (Table 1). A workshop was held to review the draft report at the Pacific Biological Station in Nanaimo, BC on December 6, 2024. Experts who reviewed report sections in advance of the workshop, as well as the workshop participants are listed in Appendix C.

Table 1. Name and affiliation of report content contributors. The listed contributors provided datasets, figures or expert reviews on specific section(s) of the report. DFO = Fisheries and Oceans Canada. NRCan = Natural Resources Canada. ECCC = Environment and Climate Change Canada.

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Miranda Smith	MC Wright and Associates Ltd.	Ditidaht knowledge
Cynthia Bluteau	DFO, Ocean Sciences Division	Oceanography
Anna Bartnik	NRCan, Geological Survey of Canada	Geology
Lily Burke	DFO, Marine Spatial Ecology and Analysis	Vessel Traffic and Fisheries and Subsistence Activities

Name	Affiliation	Report Section
Josephine Iacarella	DFO, Freshwater Ecosystems	Vessel Traffic and Fisheries and Subsistence Activities
Danielle Perron	DFO, Policy & Economics	Commercial Fisheries
Kevin Yang	DFO, Oceans Program	Commercial Fisheries
Julia Brewer	DFO, Policy & Economics	Recreational Fisheries
Selina Agbayani	DFO, Ecosystems Stressors Program	Cumulative Effects
Cathryn Murray	DFO, Ecosystems Stressors Program	Cumulative Effects
Craig Schweitzer	DFO, Ecosystems Stressors Program	Cumulative Effects
John Cristiani	DFO, Marine Spatial Ecology and Analysis	Estuaries
Tanya Schley	DFO, Ocean Sciences Division	Phytoplankton
Cameron Freshwater	DFO, Regional Ecosystem Effects on Fish and Fisheries	Salmon
Sebastian Pardo	DFO, Coastal and Oceanic Ecosystems	Salmon
Kelsey Flynn	DFO, Coastal and Oceanic Ecosystems	Salmon
Jackie King	DFO, Coastal and Oceanic Ecosystems	Salmon and Cartilaginous Fishes
Caroline Fox	ECCC, Canadian Wildlife Service	Marine Birds
Shanti Davis	ECCC, Canadian Wildlife Service	Marine Birds
Sheena Majewski	DFO, Aquatic Ecosystems and Marine Mammals	Pinnipeds
Maya Buckner	DFO, Marine Spatial Ecology and Analysis	Map creation
Anna Podhorodeski	DFO, Marine Spatial Ecology and Analysis	Map creation
hinatinyis	Huu-ay-aht First Nations, Language Coordinator	Nuu-chah-nulth Language Appendix

Biophysical overview reports in the Pacific Region share many components, topics, methodologies, and authors in common, consequently much of the language used can be the same. Within this report we have reproduced text from previous biophysical and ecological overview reports where appropriate to maintain consistency in language and its meaning. With permission from the primary authors, certain overlapping sections may have duplicate or similar descriptions, data, and figures as three previously written biophysical reports in the Pacific Region (see Bannar-Martin et al. in review, in press; Liu et al. in press).

2 REGIONAL CONTEXT

2.1 California Current Ecosystem and Columbian Pacific

Ecologically and oceanographically, the Southern Shelf Bioregion is connected to the area south of Canada's exclusive economic zone (EEZ) by the California Current System. The Northern California Current Ecosystem extends from the Canada-United States border (EEZ) line on the figures throughout this document) to Point Conception, California, and out to the 1,200 m isobath (Brand et al. 2007). Furthermore, both regions share connections with the continental shelf within the Columbian Pacific Marine Ecoregion (Wilkinson 2009). The Columbian Pacific Marine Ecoregion, home to both the Columbia and Fraser Rivers, has high runoff with significant amounts of nutrients that stimulate growth of phytoplankton, algae, and other marine life. The ecoregion stretches along the Pacific coast from Cape Mendocino, California in the south, to the Strait of Juan de Fuca, the Strait of Georgia, Puget Sound, and north on the seaward side of Vancouver Island, to the western tip of the Brooks Peninsula. We include descriptions of the California Current Ecosystem and the Columbian Pacific Marine Ecoregion because, ecologically, our marine environment is not shaped by political borders and local biodiversity is linked to areas south of these boundaries by the continuous connection of the continental shelf and the ocean currents that flow through the region. However, the majority of data that we describe in this report lies within Canadian waters, as does the map extent we are calling the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

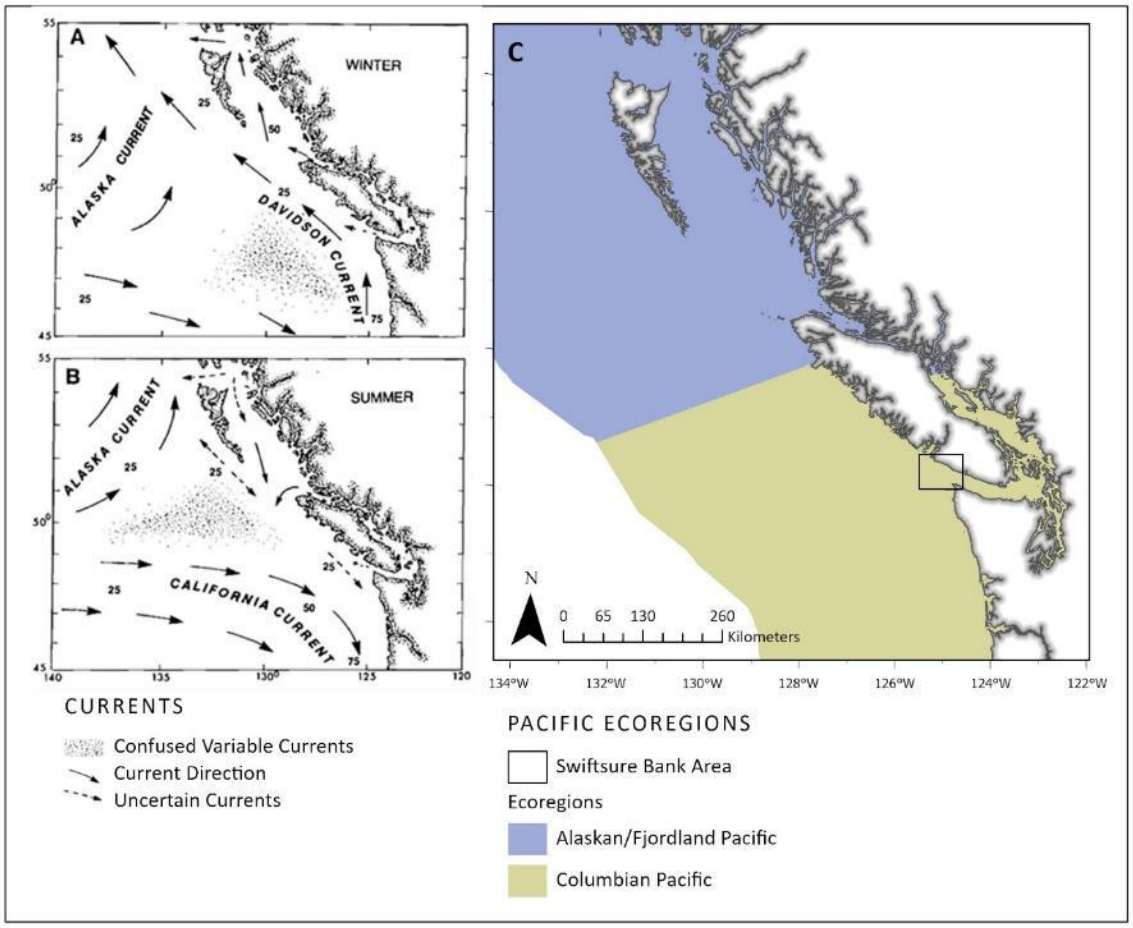


*Figure 6. Large scale ocean currents connect the marine waters of British Columbia with those in the United States. To the south the California Current creates surface circulation off of British Columbia and north Washington coast in (A) winter and (B) summer. Broken arrows indicate uncertain currents. Numbers give speeds (cm/s) (Figure 13.9 from (Thomson 1981)). (C) regional panel showing Pacific ecoregions[7] with the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area depicted as a black rectangle.*

The main currents shaping this region and both ecosystem designations (California Current Ecosystem and Columbian Pacific Marine Ecoregion), are the California Current and California Undercurrent (also detailed in the Oceanography and Physical Setting section). The California Current pushes cold nutrient-rich water at the surface southward, while the California Undercurrent is a consistent, deep northward flowing current (between 100-400 m depth) bringing warm, salty water from the Equatorial Pacific to the tip of Vancouver Island. The Davidson Current also brings warmer, saltier, less oxygenated waters north year-round, but is located closer to the coastline, ends at approximately 48 degrees North, and surfaces typically only in the winter months (Thomson 1981).These currents connect Canada and the United States along the western coast and drive ecosystem variability, including the seasonality of nutrients and organisms. Concentrated areas of upwelling are created by the latitudinal variation in continental shelf width and large geographic features along the coast. Heavier northern flows of fresh water input introduce latitudinally varied levels of nutrients into the system. Habitat-forming marine flora such as kelp and seagrass are limited by these conditions and live

[7] https://www.cec.org/north-american-environmental-atlas/marine-ecoregions/

scattered along the coast. Changes in climate patterns can alter the ecosystem for years, with El Niño patterns altering the climate for several years, and the longer scale Pacific Decadal Oscillation influencing the ecosystem for decades. This can lead to community shifts and major changes in the biomass of pelagic fish and crustaceans (e.g., Field and Francis 2002; McGowan et al. 2003).

The Columbian Pacific is characterized by a moderately narrow continental shelf and steep continental slope. The seafloor of the Juan de Fuca plate, north of the Mendocino escarpment that runs west from Cape Mendocino, is shallower than the seafloor of the Pacific plate to the south. Underwater canyons at the edge of the continental shelf, such as Astoria Canyon, Barkley Canyon (Allen et al. 2001), Clayoquot Canyon, and Juan de Fuca Canyon, have unique habitats and set up their own upwelling conditions that concentrate nutrients into areas of high topographic relief, thus driving high levels of biologic productivity (Howatt et al. 2022). The coast includes extensive tracts of forests, dunes, estuarine areas, and rocky shorelines with spectacular coastal headlands and tidal pools, and off Vancouver Island, many islands, large bays and sounds, as well as fjords and inlets. The region has higher runoff than those to the south, especially from the Columbia and Fraser Rivers. The Strait of Juan de Fuca has an estuarine circulation, with outflowing surface waters and deep, inflowing oceanic water.

The California Current Ecosystem and Columbian Pacific Region have a temperate fauna and flora. The seasonal upwelling of the region contributes to moderately high productivity. The Strait of Georgia and Puget Sound, collectively often referred to as the Salish Sea, contain the largest and most important estuaries of the region, forming unique coastal environments. The numerous rocks, bays and islands provide valuable habitat for many seabirds, such as the common murre, as well as marine mammals, including Steller and California Sea Lions. Submerged rocky reefs are also scattered along the coast. These areas and their associated kelp beds (especially Bull Kelp (*Nereocystis luetkeana*)) provide valuable habitat for a wide variety of marine species. The region is also host to Grey, Blue, Minke, and Humpback whales. Some other common species of the region include Harbour Seals *(Phoca vitulina)*, scoters, rockfish, Pacific Herring *(Clupea pallasii)* and all species of northeast Pacific salmon. Species inhabiting the Northern California Current Ecosystem have evolved within a dynamic environment. Rockfish have developed a long-living, late-maturing, live-bearing strategy that takes advantage of periodic recruitment opportunities related to annual climatic variability (Love et al. 2002). Metapopulations of anadromous salmon, including Coho and Chinook Salmon, cope with spatially and temporally variable freshwater and ocean conditions. Additionally, the long-term, slow changes in the abundance and distribution of pelagic forage fish species and crustaceans in this ecosystem is related to both biological interactions and climate regime shifts of the system (MacCall 1996). Not all species stay within the Northern California Current Ecosystem, and the extent to which it shapes their evolution and present-day populations will be taxonomically specific. Several groups of species migrate outside of the region, including small planktivores, salmon, tuna, hake, migratory birds, pinnipeds, and cetaceans. Pacific Hake *(Merluccius productus)*, sardines, tuna, Sooty Shearwater (*Ardenna grisea*), and a variety of mammals typically migrate south through the system in the fall into warmer waters to reproduce and travel north in the spring to colder waters to feed. The associated increase in predation significantly impacts prey biomass and ecosystem dynamics (Chelton et al. 1982; Carretta et al. 2002; Field and Francis 2002).

2.2 ƛ̓ušiiʔaaʔaq/Swiftsure Bank Area

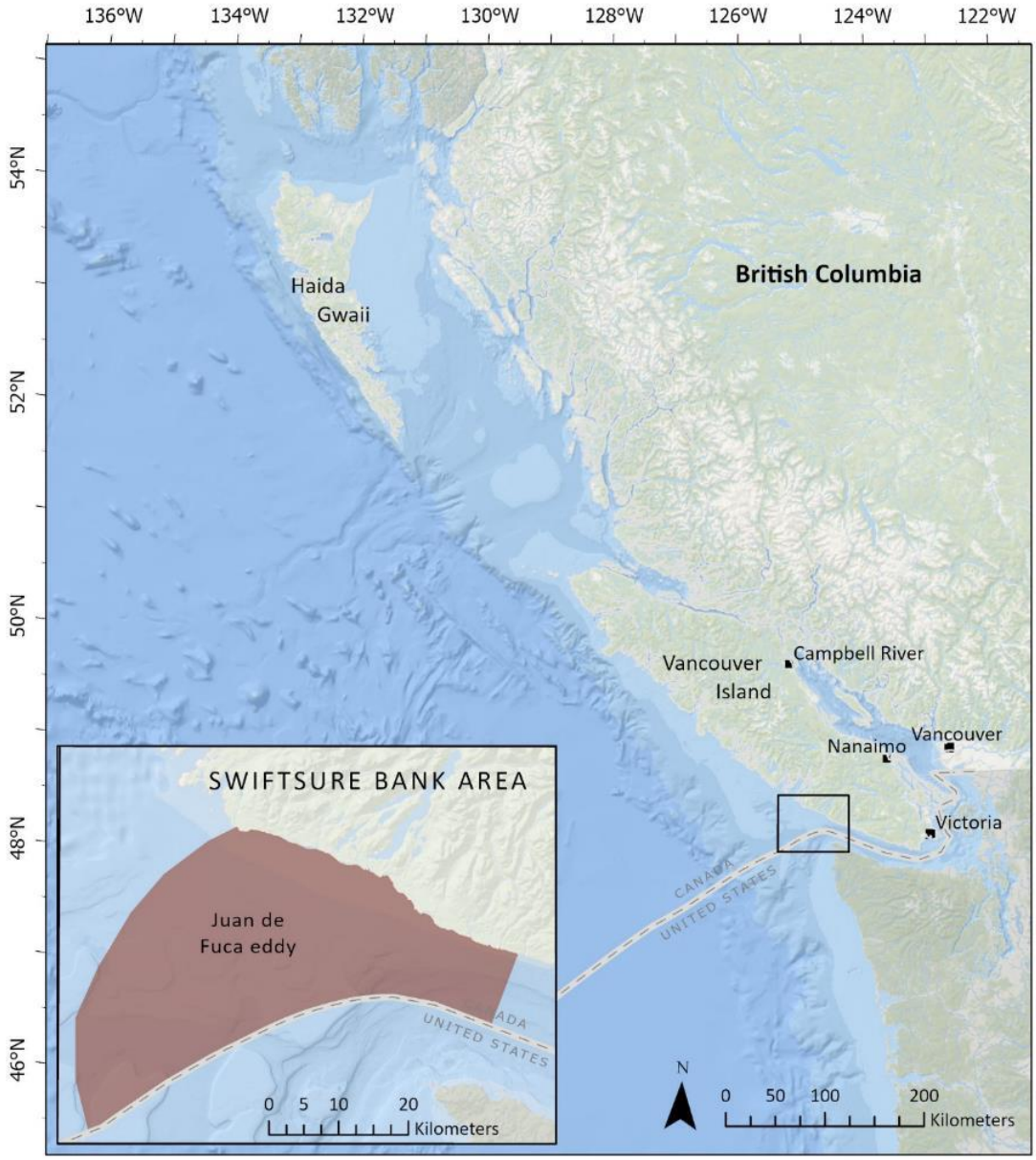


*Figure 7. The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. The broader scale map shows the location of the **ƛ̓ušiiʔaaʔaq** Area in relation to British Columbia's coastline. The finer scale inset map shows the **ƛ̓ušiiʔaaʔaq** Area map extent used throughout this report, and the reddish polygon is the Juan de Fuca Eddy Ecologically and Biologically Significant Area boundary[8] that was used for some spatial overlays detailed in the report. This polygon was also the subject of the request for Science Advice that led to this report.*

[8] https://open.canada.ca/data/en/dataset/d2d6057f-d7c4-45d9-9fd9-0a58370577e0

ƛ̓ušiiʔaaʔaq/Swiftsure Bank is located on the continental shelf off British Columbia. 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. 2023a). Throughout this report we have chosen a rectangular map extent that includes **ƛ̓ušiiʔaaʔaq** and a surrounding region (Figure 7) in order to communicate the ecological importance of the area without placing too much visual importance on boundaries prior to any codesigned and comanaged plans being established by the First Nations and relevant government agencies. However, due to some of the data analysis needs within the report, where a boundary was required, the boundaries of the **ƛ̓ušiiʔaaʔaq** area were chosen to echo the Juan de Fuca Eddy EBSA (Figure 7), a feature characterized by high primary productivity and high biomass (Jamieson and Levesque 2014; Levesque and Jamieson 2015). The Juan de Fuca Eddy is a counter-clockwise gyre off the Strait of Juan de Fuca, and influences the circulation, nutrients, and phytoplankton production in the northern California Current System (MacFadyen et al. 2008). The eddy forms in the summer at the southwest side of Vancouver Island near the mouth of the Juan de Fuca Strait. Due to its unique combination of topography and physical oceanography, it is regionally rare and stationary. The boundary for the eddy within Canadian waters (hereafter being referred to as **ƛ̓ušiiʔaaʔaq** with relation to this report) was determined from satellite images of water temperature and phytoplankton biomass (Jamieson and Levesque 2014; Levesque and Jamieson 2015).

Marine ecological classification systems are used to classify oceanic regions of British Columbia and place species and habitats at varying spatial scales. The classifications help provide an overview of the ecological setting of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Marine ecosections (Figure 8) are one level of the hierarchical BC Marine Ecological Classification System developed by the Province of BC according to physical, oceanographic, and biological characteristics at a scale of 1:250,000 (Ministry of Sustainable Resource Management (MSRM), Decision Support Services Branch 2002). Upper ocean sub-regions were defined by Parks Canada Agency (PCA) and BC Marine Conservation Analysis (hereafter BCMCA) to delineate areas with recurring physical oceanographic processes according to expert knowledge, primary literature, satellite imagery, and oceanographic modelling (BCMCA Project Team 2011). **ƛ̓ušiiʔaaʔaq** overlaps with three upper ocean subregions: Juan de Fuca Strait, Juan de Fuca Eddy, and the Vancouver Island Inner Shelf. It is also in close proximity to Low Flow Nearshore habitat (Figure 9). **ƛ̓ušiiʔaaʔaq** further overlaps with the Juan de Fuca Strait and Vancouver Island Shelf ecosections.

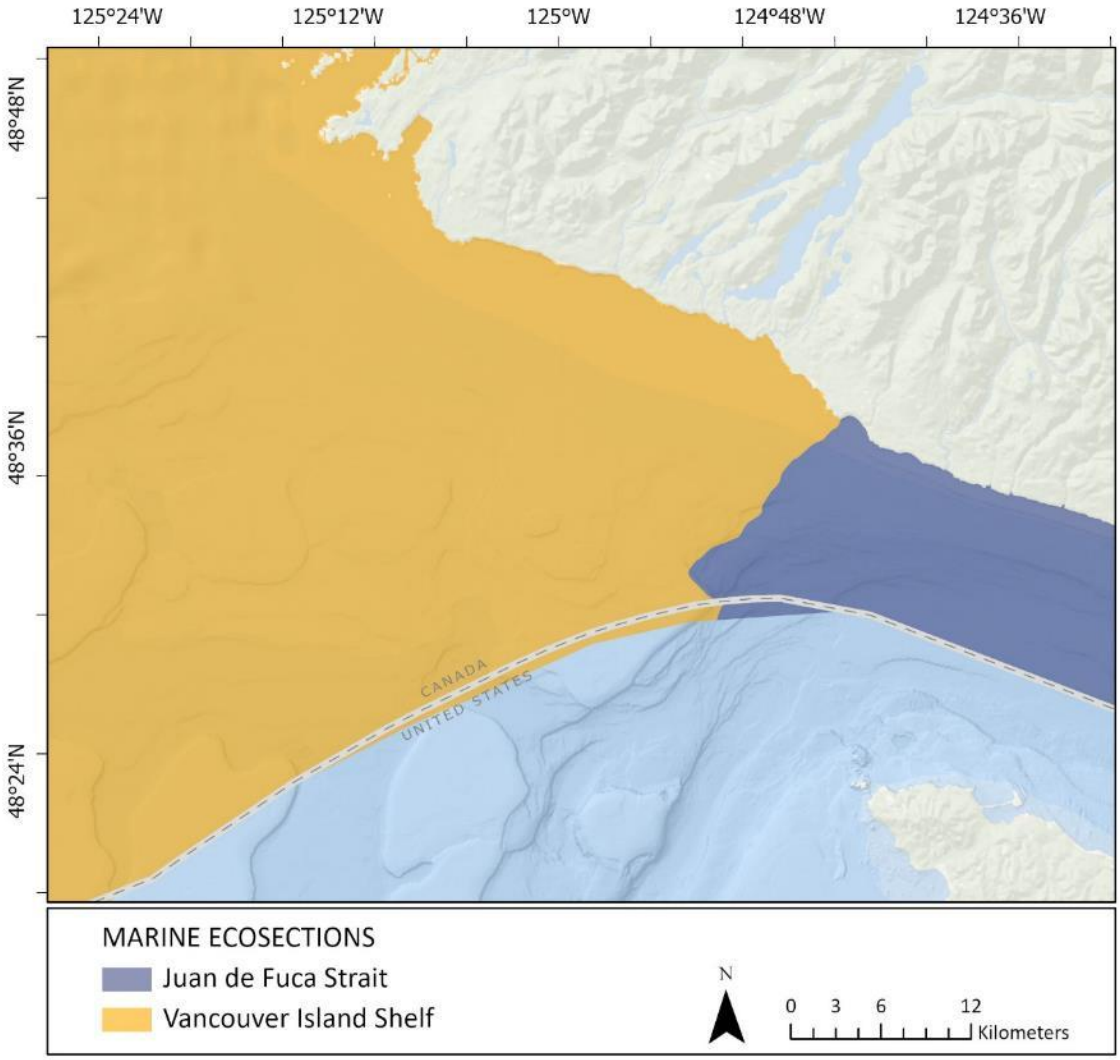


Figure 8. The ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area overlapping with the "Ecosection" boundaries classified by Province of BC*[9]*.*

[9] https://bcmca.ca/data/eco_physical_ecosections/

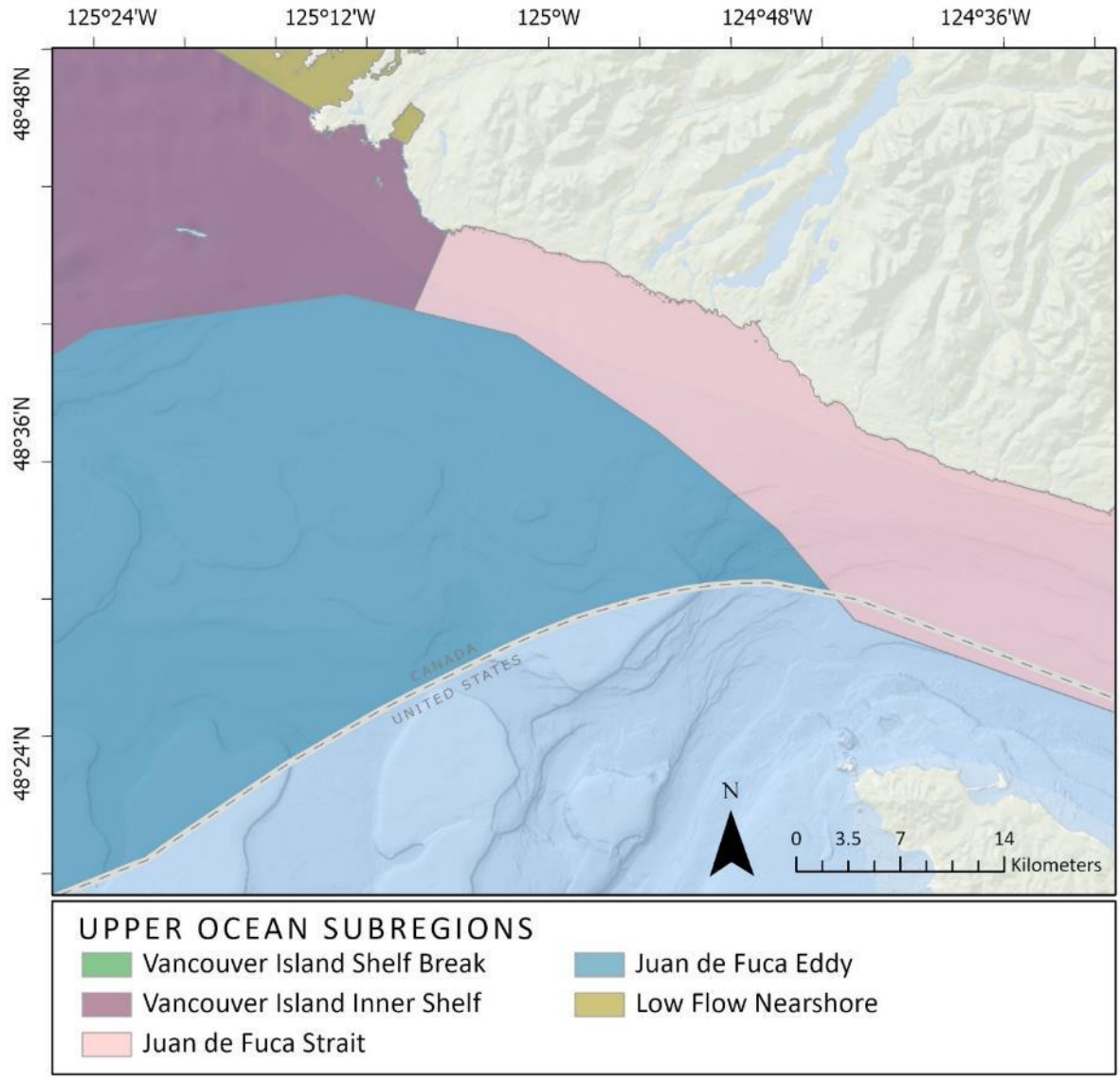


*Figure 9. The **ʎušiiʔaaʔaq**/Swiftsure Bank Area overlapping with the "Upper ocean subregions"*[10]

2.3 History of Marine Planning in the Southern Shelf Bioregion and ʎušiiʔaaʔaq/Swiftsure Bank Area

The **ʎušiiʔaaʔaq**/Swiftsure Bank Area is located along the west coast of Vancouver Island within the Southern Shelf Bioregion (SSB) (Figure 10), which is one of four marine bioregions in the Pacific Region of Canada (British Columbia). The bioregions were delineated based on bathymetric and oceanographic similarities (DFO 2009a) and the SSB extends from the northwest coast of Vancouver Island at Brooks Peninsula down to the southeastern tip near Victoria and out west to the 200 m contour at the base of the continental slope. The southern border of the SSB follows the boundary of the Canadian Exclusive Economic Zone, although the

[10] https://bcmca.ca/data/eco_physical_oceanographicregions/

ecoregion itself extends into United States waters (O'Boyle 2010). Geologically, the Strait of Juan de Fuca is a transition zone between the Strait of Georgia and the Southern Shelf bioregions. The northern boundary at Brooks Peninsula represents the northern distribution limit of many southern marine species (O'Boyle 2010).

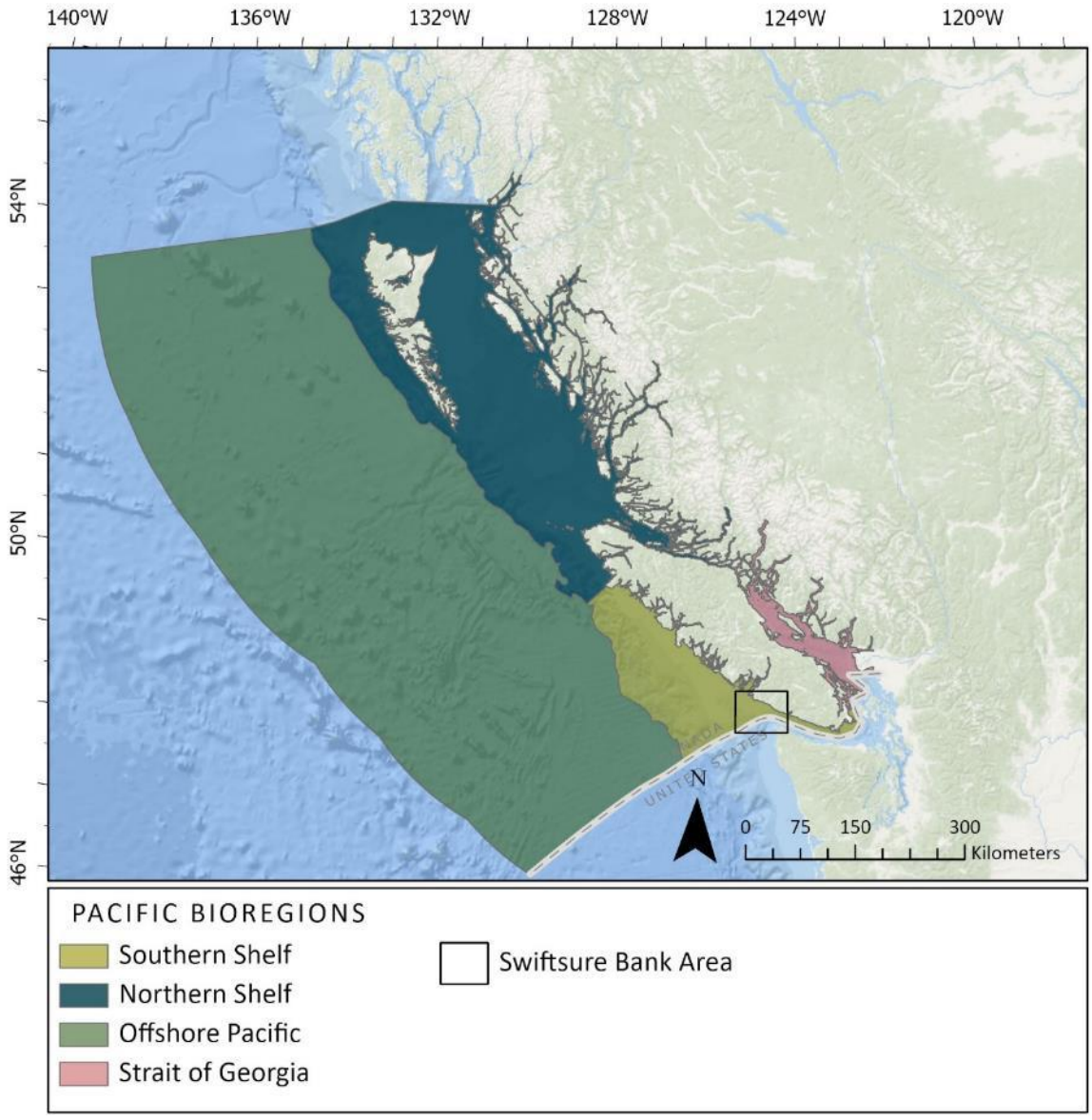


*Figure 10. The Pacific Region Bioregions[11]. The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area indicated by the bounding rectangle is located within the Southern Shelf Bioregion. The northern, southern and westernmost edges of the bioregions displayed are also the marine limits of the Exclusive Economic Zone (EEZ) boundary of Canada in the Pacific Region.*

Marine planning processes in the SSB have arisen from the collaboration of many groups, including First Nations, federal and provincial government agencies, marine stakeholders, and environmental stewardship groups. Recent marine spatial planning (MSP) efforts in the

[11] https://open.canada.ca/data/en/dataset/23eb8b56-dac8-4efc-be7c-b8fa11ba62e9

Southern Shelf and Strait of Georgia bioregions have brought together Indigenous governments and federal and provincial government agencies to gather information that could inform future planning. In neighbouring Barkley Sound, West Coast Aquatic coordinated the development of the Marine Ecosystem Reference Guide[12], a tool to support decision-making that is ecosystem-based and inclusive of multiple knowledge systems (Indigenous, local, and scientific). Several symposia have also been held in the recent past to bring together people with interest in research, stewardship, and conservation of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, including the coastal waters off northern Olympic Peninsula in Washington State. Participants and organizers from Tribes and First Nations, Canadian and US government agencies, Washington State and British Columbia governments, conservation organizations, and research institutions met to share scientific information on the marine ecosystems in the area, highlight cross-border linkages and foster collaboration, and raise awareness of the values of the area, including First Nations and Tribal traditional values (Dovetail Consulting Inc. 2004, 2006).

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area also occurs within the Vancouver Island Shelf marine region of the Parks Canada National Marine Conservation Areas Systems Plan (Figure 11). Parks Canada is beginning to engage First Nations along the west coast of Vancouver Island to determine which First Nations are interested in partnering on a feasibility assessment for a National Marine Conservation Area Reserve in the Vancouver Island Shelf Marine representative region. Local First Nations with territories overlapping the **ƛ̓ušiiʔaaʔaq** area, including Ditidaht First Nation, Pacheedaht First Nation, Huu-ay-aht First Nations and the other four First Nations of the Maa-nulth Treaty Society, implement fisheries management and environmental stewardship measures to protect marine resources. Federal, provincial, and First Nation government agencies are also involved in marine planning and management within the SSB and for protected areas within and in proximity to **ƛ̓ušiiʔaaʔaq**. Some examples of the marine planning tools that have been implemented or discussed are detailed below, and include fisheries closures, protected areas, and traffic slowdowns.

[12] https://www.communityconservation.net/marine-ecosystem-reference-guide-merg/

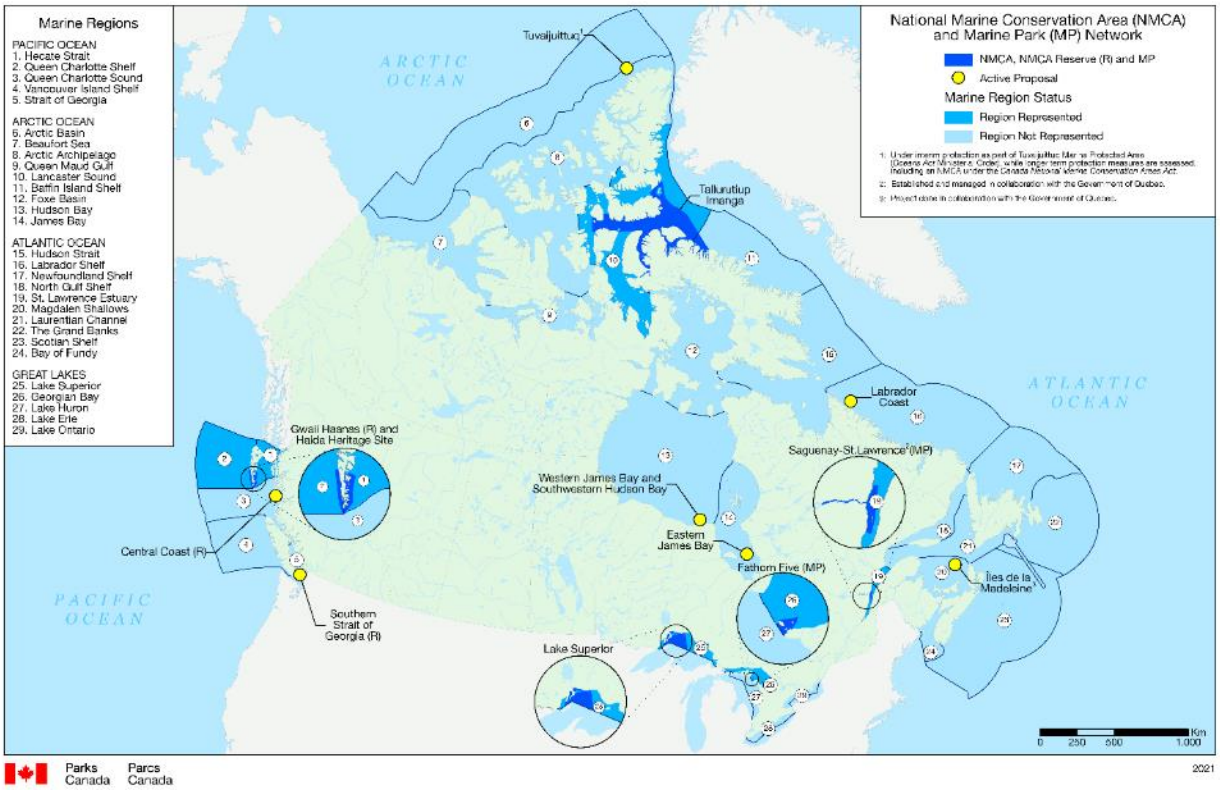


Figure 11. Parks Canada National Marine Conservation Areas System Plan. Map provided by Parks Canada.

2.3.1 Existing marine and terrestrial protected areas

Pacific Rim National Park Reserve (PRNPR) lies within a portion of nine First Nations' traditional territories and/or Treaty Settlement Lands. PRNPR extends along the west coast of Vancouver Island from Tofino in the north to Port Renfrew in the south. The National Park Reserve is comprised of both terrestrial and marine areas and consists of three non-contiguous units: the Long Beach Unit (LBU) in the north, the Broken Group Islands Unit (BGI) in the center, and the West Coast Trail Unit (WCT) in the south (Figure 12). A portion of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area occurs within the marine component of the WCT unit, where park reserve boundaries extend from land to the 20-metre isobath (Figure 12). Note that the entire Tsusiat River watershed (including Tsusiat Lake) lies within the PRNPR, and remains an untouched watershed in this region.

Parks Canada, Tla-o-qui-aht, Yuułuʔiłʔatḥ, Toquaht, Tseshaht, Uchucklesaht, Hupacasath, Huu-ay-aht, Ditidaht, and Pacheedaht have begun a partnership approach to co-develop an updated management plan for PRNPR. The updated management plan will be developed through a unit-based partnership approach for each of the park reserve's three units. The management plan will provide strategic guidance for a 10-year period, outlining a vision for the park reserve and key strategies, objectives, and targets for each of the three units of the park reserve. Management planning is an opportunity for continuing respectful dialogue and is an important step in continuing to build relationships between Parks Canada and First Nations.

Carmanah Walbran Park is a terrestrial provincial park located inside traditional Ditidaht First Nation ancestral territory adjacent to the West Coast Trail (Figure 12). The park comprises the entire drainage of Carmanah Creek and most of the lower Walbran River drainage, both of which empty into the Pacific Ocean. Carmanah is named after the Anglicized Ditidaht word kwaabaaduw7aa7tx, meaning "as far up as a canoe can go" (Ditidaht First Nation website).

Another form of conservation area within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area are Rockfish Conservation Areas (RCAs). RCAs are long-term fishing closures that were established by DFO from 2004 to 2006 to address declining rockfish populations (Yamanaka and Logan 2010). Certain bottom-contact fisheries are prohibited in RCAs (e.g., commercial and recreational hook and line and commercial groundfish bottom trawl fisheries), though other fisheries, such as commercial groundfish mid-water trawls, are permitted (See Table 2 in Haggarty (2014)). **ƛ̓ušiiʔaaʔaq** directly overlaps with three RCAs (Pachena Point, Dare Point, and Carmanah), protecting rockfish and associated biodiversity, and shaping the fishery footprint within the area (Figure 12).

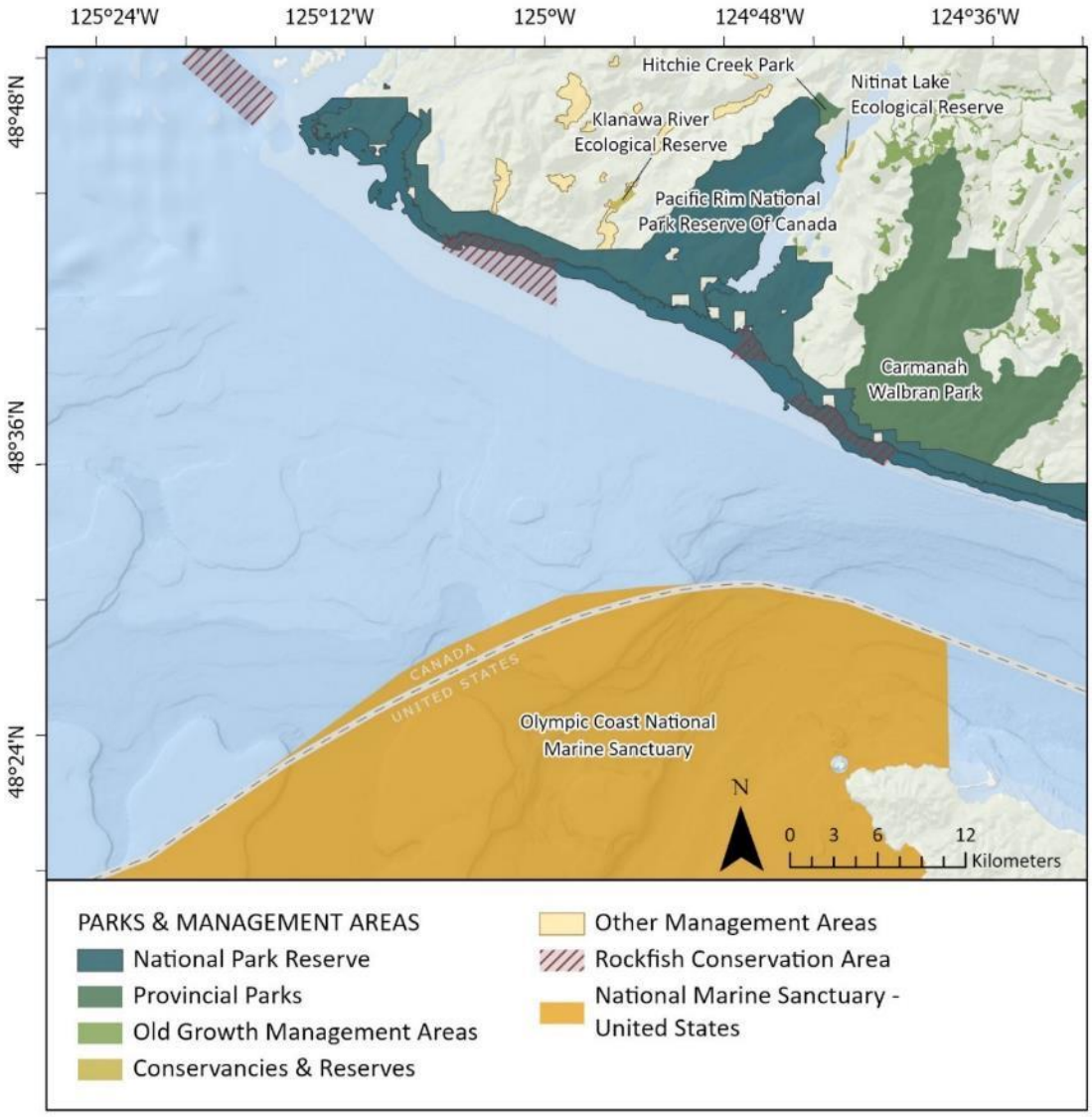


Figure 12. Nearby and overlapping important spatial management measures in the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area as of 2021 for Canada and 2023 for the United States. Data from the Canadian Protected and Conserved Areas Database (CPCAD)[13] managed by Environment and Climate Change Canada (ECCC) and the MPA Inventory Data[14] managed by the National Marine Protected Areas Center.*

2.3.2 Marine spill response planning

Marine spill response planning is another example of coordinated marine planning off the west coast of Vancouver Island. The West Coast Vancouver Island Integrated Response Plan for Marine Pollution Incidents is a framework to guide an operational, integrated and cooperative response to marine pollution incidents in the waters off the west coast of Vancouver Island, that is collaboratively developed with CCG, ECCC, DFO, Province of BC, and partner First Nations,

[13] https://open.canada.ca/data/en/dataset/6c343726-1e92-451a-876a-76e17d398a1c

[14] https://marineprotectedareas.noaa.gov/dataanalysis/mpainventory/#:~:text=NOAA's%20Marine%20Protected%20Areas%20Inventory,state%20and%20federal%20MPA%20programs.

including the Huu-ay-aht First Nation. It targets risks associated with when a pollutant enters, or has the potential to enter, Canadian waters, regardless of source. Through this coordinated effort, the plan's goal is to promote a consistent and predictable response to a marine pollution incident to minimize adverse effects to the health of the people, cultures, communities, and ecological and socio-economic resources within the area covered by the plan and affected by a marine pollution incident.

In addition, the Ditidaht First Nation is working with Western Canada Marine Response Corporation (WCMRC) as an independent contractor that is available to assist WCMRC by providing logistical support and local knowledge relevant to the provision of a Marine Spill Response in the area. The Nation has received relevant spill response training and acquired additional equipment necessary to facilitate spill responses and spill response planning. In addition, sensitive and vulnerable shorelines and habitats to the potential impacts from spills have been identified, as have appropriate staging areas for spill response equipment to protect these shorelines.

2.3.3 Vessel traffic and fisheries management

International shipping lanes for commercial vessel traffic were updated in 2005 (Pacheedaht Heritage Project et al. 2015) and transit the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, overlapping areas utilized by endangered Southern Resident Killer Whales (SRKW) and areas important for traditional, commercial, and recreational fisheries. To protect endangered SRKW, Transport Canada, DFO, Parks Canada, and Environment and Climate Change Canada (ECCC) have worked with Indigenous partners and stakeholders to develop long-term measures to address acoustic and physical disturbance of the whales, contaminants, and reduced prey availability and accessibility. Since 2018, Indigenous groups, technical working groups, Indigenous and Multi-Stakeholder Advisory Groups, and stakeholder groups have provided recommendations to DFO on measures to support SRKW recovery[15] (DFO 2024a). Measures in place in 2024 in the **ƛ̓ušiiʔaaʔaq** Area include seasonal mandatory speed-restricted zones near **ƛ̓ušiiʔaaʔaq** and a mandatory 400-metre vessel approach distance for all killer whales was put in place, and remains in effect until May 31, 2025, in Southern BC coastal waters between Campbell River and Ucluelet. In addition, voluntary vessel slowdown areas for commercial ships have been coordinated by the Vancouver Fraser Port Authority-led Enhancing Cetacean Habitat and Observation (ECHO) Program[16]. The voluntary slowdown area between Trestle Creek and Carmanah Point was co-developed with Pacheedaht First Nation (see Vessel traffic and vessel types).

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area overlaps with four Pacific Management Fishery Areas (PFMAs): 20, 21, 121, and 123 (Figure 13). Within these areas, catch quotas can be implemented for different fisheries that shape the use of the **ƛ̓ušiiʔaaʔaq** Area and fishery closures can be implemented for different classes of commercial, recreational, and aboriginal fisheries by DFO. The closures can be long-term or seasonal and can impact individual or multiple fisheries. Closures may be implemented for several reasons including, but not limited to, species conservation, safety concerns, contamination, or seasonality of the resource. Closures for commercial and recreational groundfish hook and line fishing are present in areas 121-1 and 121-2 (Figure 13) (DFO 2024a). There are also closures in the **ƛ̓ušiiʔaaʔaq** Area for

[15]Summary of input provided on management measures to address key threats to Southern Resident Killer Whales: https://www.pac.dfo-mpo.gc.ca/consultation/fm-gp/srkw-eprs/index-eng.html

[16] Swiftsure Bank Voluntary Slowdown: https://nis.ccg-gcc.gc.ca/public/rest/messages/en/message/160164

recreational and commercial salmon fishing from July 15-October 31, 2024 as part of efforts to increase the availability of Chinook Salmon, a main prey for SRKW that have been shown to forage in the **ƛ̓ušiiʔaaʔaq** Area (DFO 2024b).

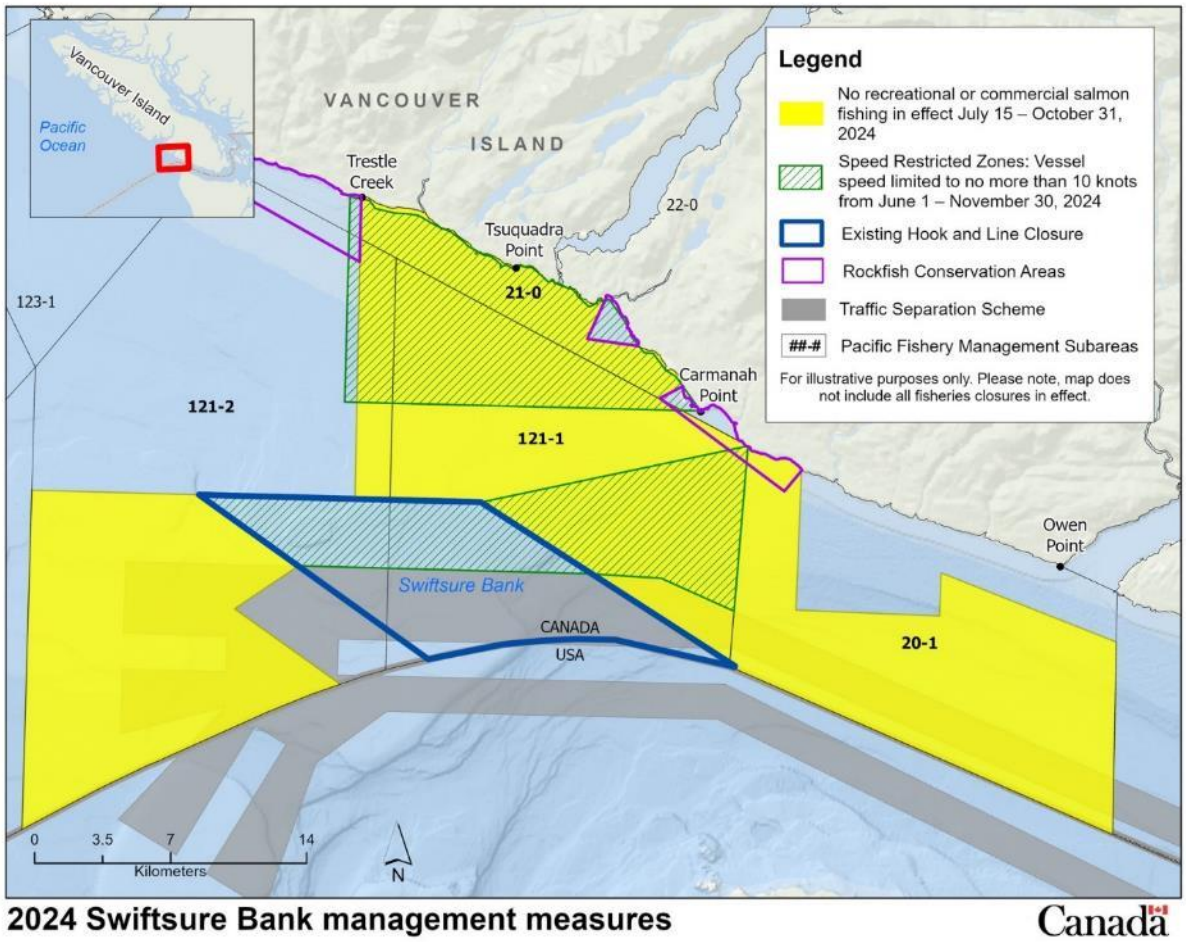


*Figure 13. **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank recreational and commercial fishery management measures for 2023. Jun 1 to Nov 30: Vessel speed limited to no more than 10 knots (with some exceptions) in the Speed Restricted Zones located in portions of Subareas 21-0, 121-1, 121-2. July 15 to until Oct 31: No recreational or commercial fishing for salmon in portions of Subareas 20-1, 21-0, 121-1, 121-2. Figure from Fisheries and Oceans Canada, Pacific Region (online): Map of management measures in **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank to support Southern Resident Killer Whale recovery*[17]

3 OCEANOGRAPHY AND PHYSICAL SETTING

The open ocean of the Northeast Pacific forms the western boundary of BC's coastal waters. The water over the upper continental slope is the source of the bottom water in the deep troughs and inlets along the BC coast, while the large wind patterns and freshwater inputs from the coast play a major role in the currents and water exchanges. The oceanography of the

[17] https://www.pac.dfo-mpo.gc.ca/fm-gp/mammals-mammiferes/whales-baleines/docs/srkw-measures-mesures-ers/2024-srkw-ers-swiftsure-eng.html

Northeast Pacific and the **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area is described here, with some repetition from previous biophysical reviews of the offshore Haida Gwaii (Bannar-Martin et al. in press), Caamaño Sound and Douglas Fjord System (Liu et al. in press), and Kitkatla Inlet Network Zones (Bannar-Martin et al. in review) on the North Coast of BC. The repetitions are mostly within the section about the large-scale forcings along the BC coastline, with some figures adapted from available data sources and literature for the **ƛ̓ušiiʔaaʔaq** Area.

3.1 Northeast Pacific

3.1.1 Large-scale circulation, currents and climate

BC is at the eastern end of the large-scale circulation pattern of the North Pacific Ocean, where both the subpolar gyre and subtropical gyre transport water from west to east via the Subarctic Current and the North Pacific Current, respectively (Figure 14). These currents are products of two large-scale atmospheric systems: the Aleutian Low in the Gulf of Alaska and the subtropical North Pacific High further south in the northeast Pacific. The resulting gyres generate two persistent currents. One is the Subarctic Current, which turns north and becomes the Alaska Current. The other one is the North Pacific Current, which turns south and becomes the California Current. These large-scale currents do not directly impinge on the continental shelf of BC, but they brought tsunami debris, including wreckage of buildings, cars, and boats, across the Pacific for several years after the 2011 Fukushima tsunami. 1.5 million tonnes of debris was left in the Pacific Oceans and has made its way to the Northeast Pacific coast since 2012, although the source of the marine debris is hard to attribute (DFO 2013a).

The atmospheric systems that generate the large-scale currents also impact the prevailing nearshore wind patterns and, thus, currents. The divergence, or bifurcation, in the currents coming across the North Pacific, leads to the oceanic region offshore of the BC shelf being a region with ‘Variable Currents” (Figure 14). In summer, the Aleutian Low weakens, causing the bifurcation region to shift northward, significantly impacting the winds and currents along BC’s southern coast.

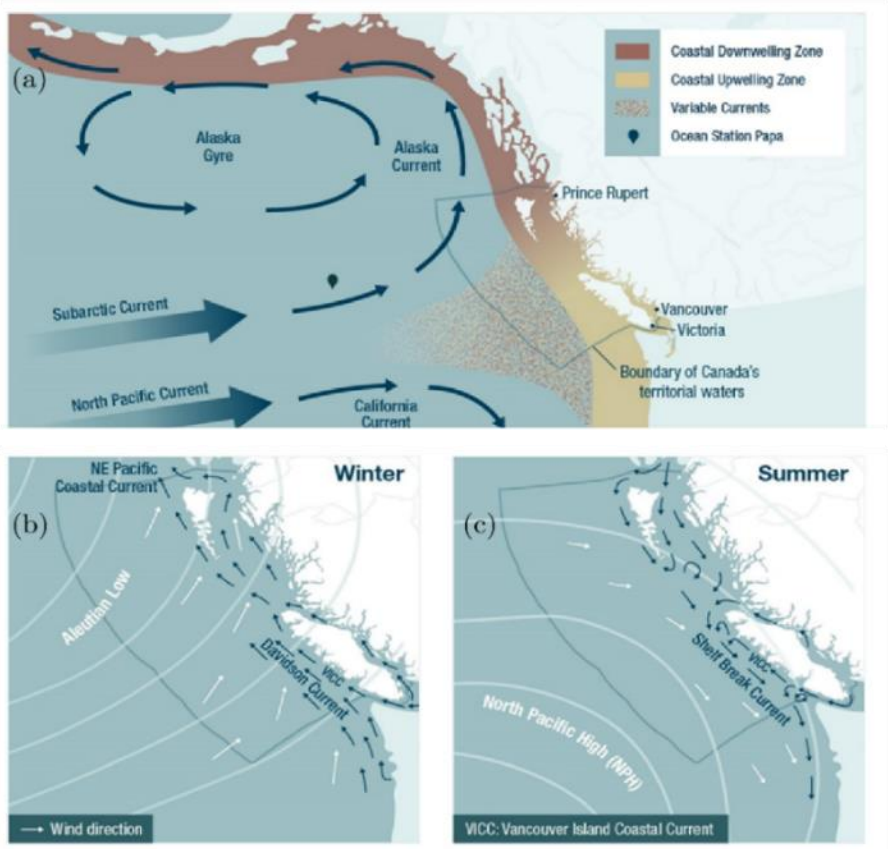


Figure 14. The Northeast Pacific regional current systems (used with permission; (DFO 2021a)). (a) Large scale current systems in Canada's Northeast; (b) Winter season currents and wind direction within Canada's territorial waters; (c) Summer season current and wind direction within Canada's territorial waters. The grey bounding box denotes Canada's territorial waters. The dark blue arrows represent the current direction, and the white arrows represent the wind direction.

The seasonal variability in the Northeast Pacific is driven primarily by changes in large-scale atmospheric weather patterns. The Aleutian Low dominates winter, whereas the North Pacific High dominates summer (Thomson 1981). These seasonal changes result in different mean wind patterns (Figure 15). In the winter, the wind generally blows towards the northeast (or north) along the coast. But in the summer, winds along the BC south coast are usually from the northwest, while mean winds along the North Coast are weaker and generally from the west. With northwesterly summer wind, the southern region typically corresponds to the 'Coastal Upwelling Zone' (Figure 14a). These changes in wind patterns are accompanied by shifts in currents along the southern BC coast. The northward-flowing Davidson Current observed in fall and winter (Hickey 1979) is replaced in summer by the Shelf Break current on the inner slope (Figure 14a,b). Further inshore, Vancouver Island Coastal Current flows north year-round since it's driven by freshwater flowing out of Juan de Fuca Strait and the west coast of Vancouver Island (Thomson et al. 1989).

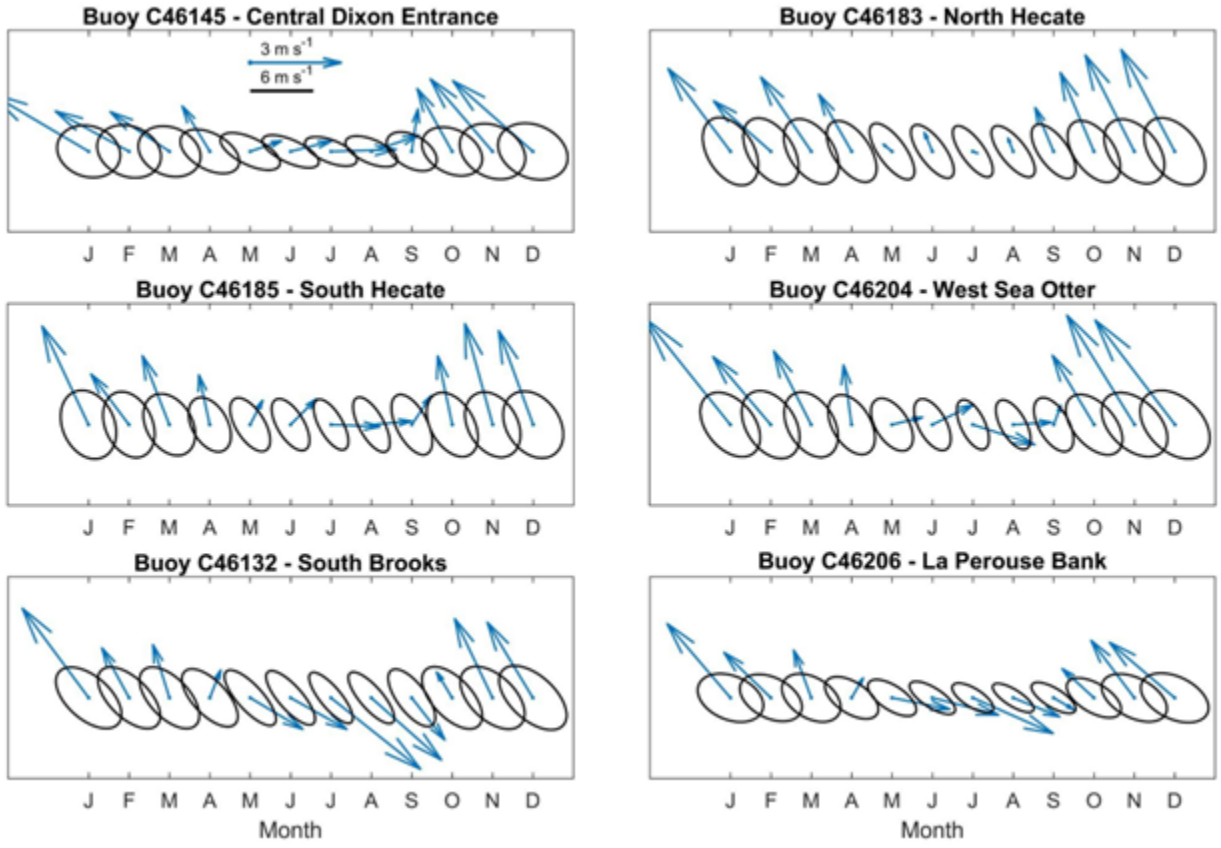


Figure 15. The monthly mean wind vectors and the standard deviation ellipses at marine weather buoys along the BC coast. The panels are organized from Dixon Entrance in the upper left to the southern Vancouver Island Shelf in the lower right. Reproduced from Bannar-Martin et al. (in press).

Atmosphere-ocean coupling variations in the tropical Pacific cause the El Niño Southern Oscillation (ENSO). ENSO plays an important role in the Northeast Pacific on time scales of about 2 to 7 years. The ENSO index has been negative (La Niña) since 2020 and recently changed signs in 2023 to positive. During the warm ENSO phase (El Niño), the Aleutian Low strengthens and moves southwards, while storm tracks extend east (Jiménez-Esteve and Domeisen 2019). The overall impact on the BC coast is warming surface waters during late winter (Crawford and Irvine 2011). The opposite occurs during the La Niña years. The Aleutian Low weakens and moves northwards, making surface waters colder. Another index is the Pacific Decadal Oscillation Index (PDO;(Newman et al. 2016). The index amalgamates the effects of many physical processes and partly describes the Northeast Pacific climate on a decadal time scale. This index is the leading mode of monthly sea surface temperature variability in the North Pacific (20--70ºN, (Newman et al. 2016) and is primarily dictated by the Aleutian Low variations. A positive PDO is associated with anomalously warm waters along the North American coast (eastern North Pacific) and below-average temperatures in the western Pacific Ocean. The opposite occurs during years of negative PDO. The PDO has been negative since 2020 but was positive during 2013-2016, known as the “blob” years (see Water properties and exchanges), bringing anomalously warm waters to the BC coast.

3.1.2 Water properties and exchanges

Along the continental slope of BC and Alaska, eddies dominate the open ocean circulation (Thomson and Gower 1998; Crawford et al. 2002; Ladd et al. 2009). The water properties (temperature, salinity, dissolved oxygen, nutrients) between the continental shelf and the deep ocean gyres result from a complicated mixture of water from the shelf, the California Undercurrent, and the subtropical and subpolar gyres represented by the Subarctic Current and the North Pacific Current, respectively (Whitney et al. 2005). Water properties along the continental slope do not just reflect the properties in the gyres. For example, Crawford and Peña (2016) showed that oxygen concentrations between about 200 – 400 m over the upper slope were closely related to those measured off California rather than those observed offshore at Ocean Station Papa (Figure 14; hereafter "Station P") in the subpolar gyre. This connection is enabled by 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). On the west coast of Vancouver Island, this current is weakest in spring, strengthens during subsequent seasons until merging with the poleward flowing Davidson Current in winter. About 30-40% of the water between 100 and 400 m depth is Pacific Equatorial Water (Thomson and Krassovski 2010) ,Over several decades of measurements, (Crawford and Peña 2016) showed that dissolved oxygen was low in the 1950s and higher in the 1970-80s before declining until 2012, when their analysis ended. Since then, oxygen levels have increased (Cummins and Ross 2020).

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

At the BC coast, sea surface temperature (SST) varies among seasons because of the changes in air temperatures, solar radiation, and local winds (Figure 16). In winter, the SST ranges from 8-9^{o}C on the west coast of Vancouver Island, temperatures are warmer offshore (Figure 16; see also Figure 12 of Jackson et al. 2015). Around Vancouver Island, the coldest temperatures are along its eastern coast with values of 6-7 ^{o}C. In Juan de Fuca Strait, the winter SST values lie in between those on either coast of Vancouver Island (Figure 16). In summer, the SST ranges from 13-14°C on the west coast of Vancouver Island, with cooler water (10-11°C) in some coastal regions with upwelling-favourable winds and in Juan de Fuca Strait. During the 2013-2014 winter, anomalously warm SSTs were observed throughout the NE Pacific and persisted into late 2016 (Bond et al. 2015; Hobday et al. 2018). The persistent warm temperatures were associated with an unprecedented extended marine heatwave (e.g. Freeland and Ross (2019); Bond et al. (2015)), referred to as "the Blob," which manifested as an extended temperature anomaly exceeding 3°C in the upper 200 meters of the water column and disrupted Pacific ecosystems (Bond et al. 2015; Suryan et al. 2021). A record high sea level pressure system in the NE Pacific is attributed to causing the marine heatwave, which preceded the onset of the warm phase of the El Niño Southern Oscillation.

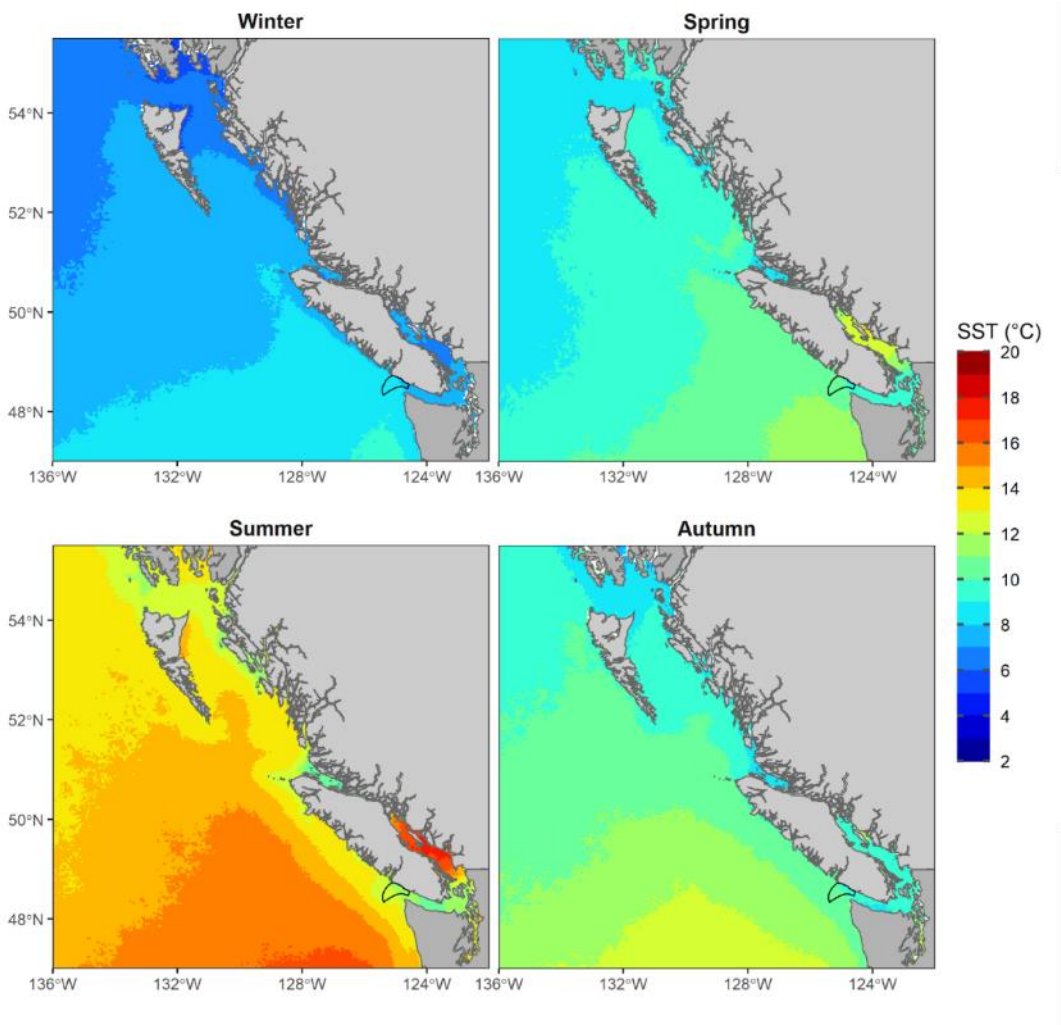


Figure 16. Sea surface temperature averaged by season over 1991-2020 (winter: Jan to Mar, spring: Apr to Jun, summer: Jul to Sep, autumn: Oct to Dec). The black line indicates the ***ƛučii?aa?aq****/Swiftsure Bank Juan de Fuca Eddy EBSA. These maps were calculated from night-time AVHRR SST at 4 km spatial resolution[18], with colours shown in 1°C intervals.*

Suspended particulate matter (SPM) and coloured-dissolved organic matter (CDOM) also vary seasonally and are higher near significant freshwater sources along the BC and Alaska coast. Of these sources, which include the Fraser, Skeena, Nass and Stikine Rivers, the Fraser River discharges the highest concentration of SPM to the surface ocean, as measured by remote sensing, during spring freshet (Giannini et al. 2021). The SPM discharge through summer and autumn is comparable to other larger rivers. Further, high CDOM absorption has been observed from spring through summer (> 4 m^{-1}) at the outlet of the Fraser River in the Strait of Georgia, declining to < 2 m^{-1} in autumn (see Figure 11 in Giannini et al. 2021). However, the elevated SPM and CDOM quickly drop when entering Juan de Fuca Strait, before increasing again in the surface waters on the west coasts of Vancouver Island and Washington State.

[18] https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:AVHRR_Pathfinder-NCEI-L3C-v5.3

Remote sensing studies along the BC coast, and the wider west coast of North America, have provided estimates of satellite sea surface temperature (SST), phytoplankton bloom phenology based on Chlorophyll-a concentration (a proxy for phytoplankton biomass), and other parameters of the surface ocean. Numerous studies have used such imagery in the vicinity of the **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area to demonstrate features of the Juan de Fuca eddy. Eddy features visible in surface waters include SST fronts and areas of colder surface water at its center (Foreman et al. 2008), and cyclonic phytoplankton bloom features (Klymak et al. 2023). Sackmann and Perry (2006) showed lower blue-absorbing materials (e.g., phytoplankton and CDOM) in the Juan de Fuca Strait relative to the eddy. Similarly, they showed that the eddy has differing constituents in the water column relative to the shelf waters at the mouth of the Strait, with non-absorbing particles throughout the water column over the shelf. Details are described further in the relevant sections: Sea surface temperature (SST); Light availability and optical conditions; Phytoplankton section.

3.2 ƛ̓ušiiʔaaʔaq/Swiftsure Bank Regional Conditions

3.2.1 Bathymetry

Bathymetry, defined as seafloor elevation data where depth below sea-level is represented in positive terms, is available in varying resolutions to collectively cover the **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area boundary. Within the extents of the Juan de Fuca Eddy EBSA polygon, the upper extent of elevation within the boundary is 44 m above sea level and encompasses some terrestrial area. Marine bathymetry ranges from 0 to 262 m below sea level and the total mean elevation/bathymetry for the boundary has a depth of 106 m below sea level (Figure 17). All elevation and bathymetry references are relative to vertical chart datum (Lower Low Water Large Tide (LLWLT)). Figure 18 and Table 2 show the available input data sources within the boundary.

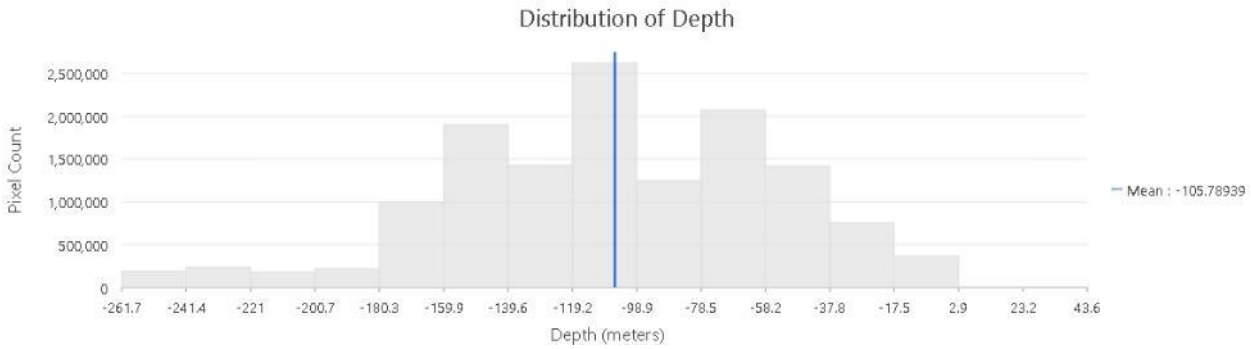


*Figure 17. The density plot of depth values within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank boundary. The mean depth is indicated as a solid blue line. Bathymetry data source: Kung et al. (2023)*

*Table 2. Bathymetry data sources available within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank boundary*

Source/Title	Date	Data Type	Resolution	Horizontal Datum	Vertical Datum	Multibeam Sonar/Ship
CHS and NRCan Multibeam Echo Sounder Bathymetry (new)	2023	Gridded Bathymetry	1 m	EPSG 4326	Chart Datum (Lowest Low Tide (LLWLT))	Kongsberg EM 710/ CCGS Vector
GEOMAR Helmholtz Centre for Ocean Research, Kiel, Expedition SO294 Bathymetry	2022	Gridded Bathymetry	2.5 m	EPSG 4326	Tidal stations at Port Renfrew and Bamfield	Kongsberg EM710/ RV Sonne
CHS and NRCan Multibeam Echo Sounder Bathymetry Holdings (older). Includes both those collected by CHS and those provided by academia.	2002-2006	Gridded Bathymetry	5-50 m	EPSG 4326	Chart Datum (Lowest Low Tide (LLWLT))	Variable
DFO/Seamless BC Coastal Elevation Model	2019	Gridded bathymetry and topography	20 m	EPSG 4326	Chart Datum (LLWLT)	N/A
NRCan West Coast Regional Bathymetry	1999	Gridded bathymetry from chart contours	75 m	EPSG 4269	Chart Datum (LLWLT)	N/A

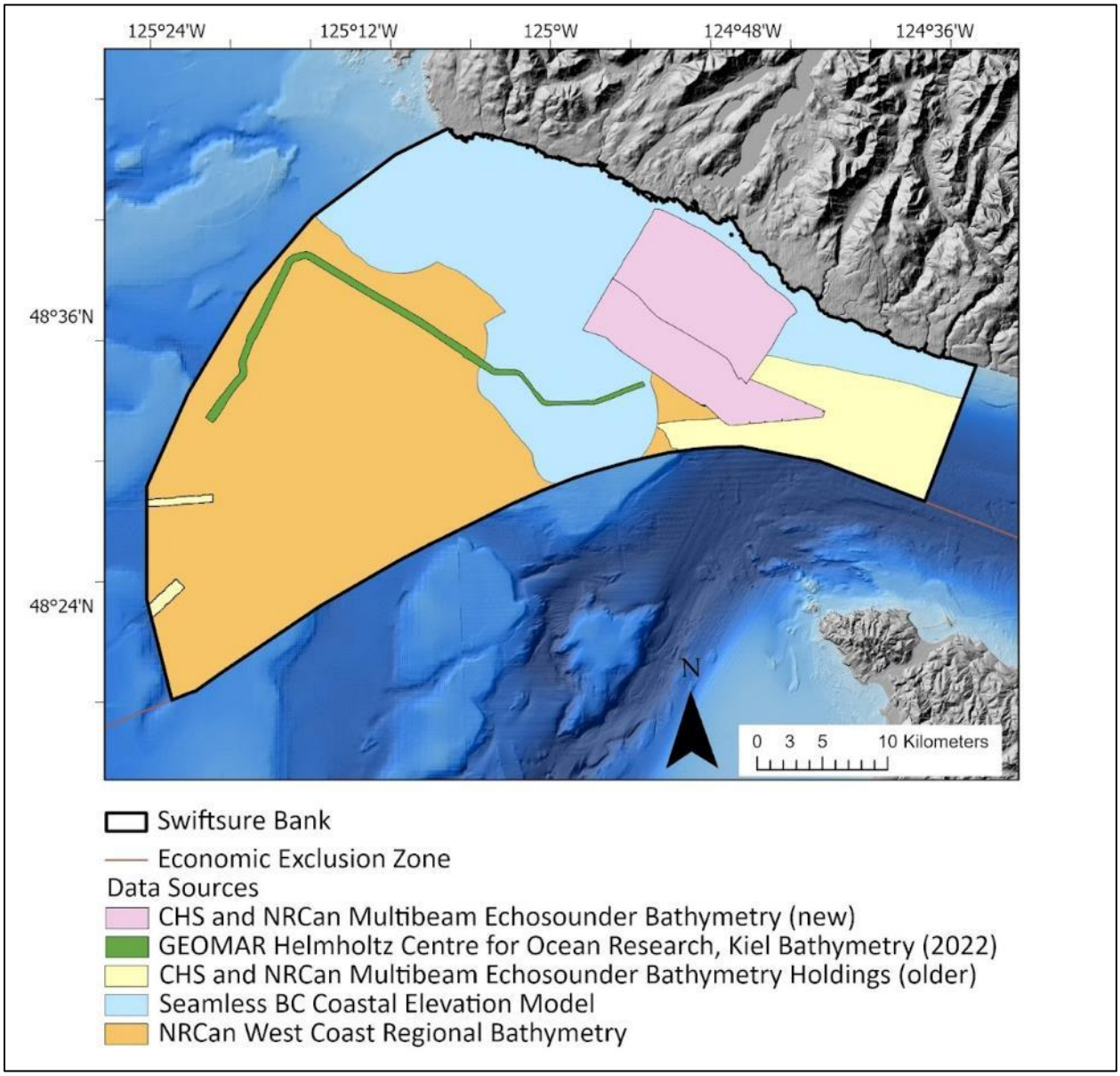


*Figure 18. Available sources for **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank bathymetry datasets overlaid on the West Coast Digital Elevation Model (Kung et al. 2023). CHS and NRCan Multibeam Echosounder Bathymetry holdings include results of survey 2006010PGC and the CHS and NRCan Multibeam Echosounder Bathymetry include results of survey 2023004PGC. Refer to Table 2 for details of each data source.*

The best-known high-resolution data available for this area were collected in 2023 by the Canadian Hydrographic Service (CHS) and Natural Resources Canada (NRCan) (Li and Kung 2024). In 2022, the GEOMAR Centre for Ocean Research, Kiel, collected data along a single transect while mapping potential cold seeps (Riedel 2022). The data were evaluated in Kehew et al. (2023). Other multibeam bathymetry data collected or held by CHS and NRCan are included at 5 m to 50 m resolution. The combined multibeam echosounder bathymetry data cover a total area of 330 sq km (24% of the EBSA polygon boundary). Figure 19 shows these data combined with the lower resolution available data as an output grid at 10 m.

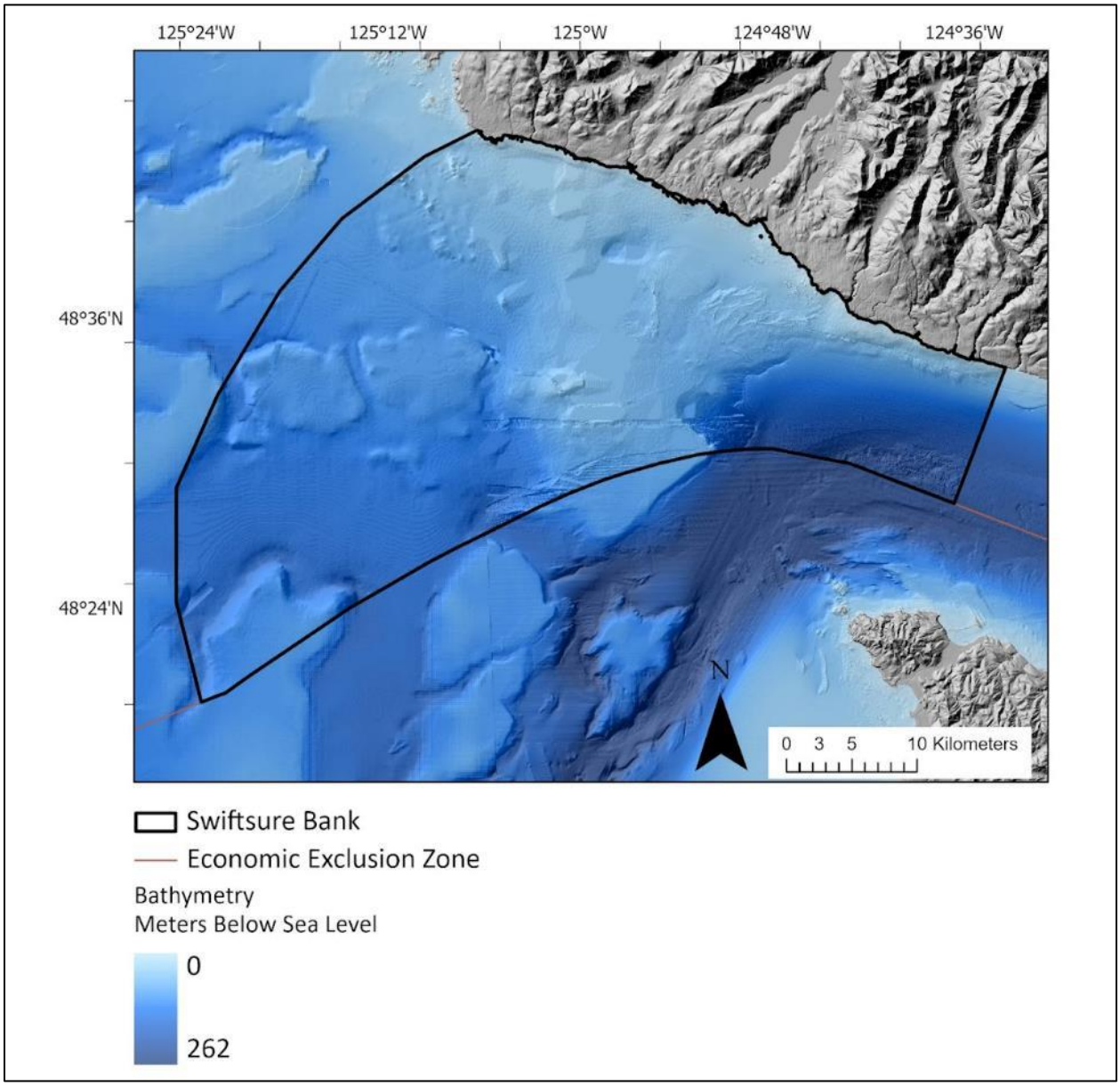


Figure 19. The region's topography and bathymetry showing ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank, Juan de Fuca Strait, and surrounding Vancouver Island and Olympic Peninsula. This map combines the available highest resolution data for the* ***ƛ̓ušiiʔaaʔaq*** *boundary into a merged grid with the Kung et al. (2023) West Coast Digital Elevation Model.*

The areas between high resolution data are filled with the NRCan West Coast Digital Elevation Model (DEM) (Kung et al. 2023) which uses the Davies et al. (2019) BC Coastal Seamless Elevation model using field sheet data to fill in data-sparse intertidal areas as well as a regional digital elevation model from NRCan derived from chart contour data.

Bathymetry data are available from the CHS directly and 10 m resolution data will be included in a future update of the publicly available NONNA10 dataset.[19] There are multiple transit passes at higher speeds available through the Global Multi-resolution Topography (GMRT) compilation (Ryan et al. 2009) but these have not been included in , Figure 17, Figure 18, or Figure 19 because artefacts from the speed of the vessel limits the usability of the data.

The acquisition of high-resolution multibeam echosounder data for additional areas within the **ʎušiiʔaaʔaq/**Swiftsure Bank Area would help better inform the geological setting here and is an identified gap in available data for assessment.

3.2.2 Geological setting

The **ʎušiiʔaaʔaq/**Swiftsure Bank Area boundary is situated adjacent to the western entrance of the Juan de Fuca Strait, with Vancouver Island to the northeast and the Olympic Peninsula to the southeast. Situated within the convergence zone of the North American and Juan de Fuca Plates, this area has undergone substantial tectonic modifications, including uplift, subsidence, and faulting (Yorath 1980; Clague 1983; Booth 1994; James et al. 2000, 2005, 2009; Clague and James 2002; Dallimore et al. 2008; Johns et al. 2012). The outer coast and inlets of Vancouver Island are highly vulnerable to large tsunamis caused by subduction earthquakes beneath the Pacific Ocean (Clague et al. 2000). Residing in the Carmanah and Prometheus sub-basins of the larger Tofino Basin (Johns et al. 2012), the **ʎušiiʔaaʔaq** Area is characterized by complex morphological geological features. Moreover, the extensive effects of glaciation during the Quaternary period have resulted in very rugged and undulating topography over much of the shelf. This section focuses on surficial geology based on survey data collected in recent years, as illustrated by the following data analysis.

3.2.2.1 Data, Materials and Methods

High-resolution bathymetry and acoustic backscatter intensity of the seafloor were assessed, along with sub-bottom profiles, and grab samples to interpret the seabed geomorphology. The mapping of surficial geology followed the approach of Shaw (2012) and Shaw et al. (2014) in which the seafloor is mapped and characterized into units with a distinct combination of morphology, texture, and biota (Table 3).

[19] Canadian Hydrographic Service Non-Navigational (NONNA) Bathymetric Data - Open Government Portal (canada.ca)

*Table 3. Surficial geology types and their geomorphological patterns and distribution in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank area.*

Units	Backscatter intensity	Surface slope gradient	Acoustic reflection	Lithology	Chronology	Distribution	Interpretation
Bedrock	High, irregular	Steep and irregular high relief; faulted and fractured	Chaotic structure and parabolic diffraction; hard and dark surface; steep and continuous dome-shape outline	Sedimentary rock	Paleogene	Bedrock substrate is occasionally observed along the northern area off and near shorelines.	Bottom of the stratigraphic sequence under the moraine, glaciomarine, or postglacial mud, typically Tertiary sedimentary rocks
Glacial diamicton (Moraine)	High, continuous - irregular	Even high relief	Hard and dark surface; no chirp acoustic penetration; even and flat outline	Poorly sorted gravel or muddy gravel	Late Pleistocene	In the west, and a moraine across the north half of Juan de Fuca strait off Washington State.	Formed at ice front margins during short-time halts in the Late Wisconsinan recession of grounded ice.
Glaciomarine	High-moderate, continuous	Flat, gradient<5°	Draped, parallel, continuous, coherent reflection; transparent intervals; hard and dark surface	Gray silty clay and clayey silt with poorly sorted gravel (IRD)	Late Pleistocene	Southeast area in Juan de Fuca Strait; slope of diamictons and the moraine	Formed from glacial meltwater plumes with ice-drafted debris; large sediment supply provided by floated icebergs; the top was eroded by currents forming an erosive contact with the overlying postglacial sand or mud, or an eroded sea floor with lags of sand and gravel.

Units	Backscatter intensity	Surface slope gradient	Acoustic reflection	Lithology	Chronology	Distribution	Interpretation
Lags of sandy gravel	High	Flat, and low gradient, rough surface	Transparent intervals, chaotic structure, occasionally found 1-2 weak internal parallel layers.	Boulder-granule gravel, sand gravel	Late Pleistocene-Holocene	In the middle high-relief area	Remnants of reworked glacial deposits, usually on the top of the glacial diamicton and glacial marine
Postglacial mud	Low, continuous	Flat	Draped, parallel, continuous, coherent, semi-transparent and weak-moderate internal reflections; soft and light surface; gas masking	Olive or greenish grey silty clay or clayey silt, abundant organisms	Holocene	Thick postglacial mud with rich gas is distributed in the depressions and channels of incised shelf in the west.	Postglacial mud/sandy mud from suspended sediments or terrestrial supply carried by currents, and commonly deposited in low-energy areas.
Postglacial sand	Low, even, continuous	Flat	Acoustically reflective and scattering surface; no internal structure; evenly hard and dark surface	Well-sorted sand	Holocene	Northeast of **ƛučii?aa?aq**/Swiftsure area in Juan du Fuca Strait, occasionally found on banks, and terraces.	Sand mainly from reworked deposits and deformed by currents and waves.
Bedforms Sandy	Low	Flat	Bright reflection; no structure; irregular, rugged, or wave-shaped	Well-sorted sand	Modern	North area along the coast	Formed and mobilized by tidal currents or waves.

Units		Backscatter intensity	Surface slope gradient	Acoustic reflection	Lithology	Chronology	Distribution	Interpretation
				hard and dark surface				
	Gravelly	High			Poorly sorted, sub-round or sub-angular gravel			
Gas masking		Low	Flat	Diffuse dome with a noticeable reflective upper boundary	/	/	Commonly in thick postglacial mud and sand filled troughs	West incised shelf, and the thick sand in Juan du Fuca Strait.
Mass transport deposits		High	Deposit scars, eroded surface, linear features	Irregular and dark acoustic surface; bright and incoherent reflection; no structure or chaotic structure	Poorly sorted, muddy gravel	Late Pleistocene	Near the southeast corner of the middle high-relief diamicton	Formed from melted water flow or currents
Channels		Low-moderate	Elongated and trench-like depressions, bounded by banks	/	Sand, mud	Holocene	The west incised shelf, the northern Juan de Fuca strait	Formed by melted water flow and tidal currents
Gullies		Low-high	Elongated depressions smaller, narrower than channels	/	/	/	On the slope of the northeast	Melted water flow, currents
Ridges		High	Narrow, elongated, high-relief, gradient>5°	Irregular and dark surface; no chirp acoustic penetration	Lags of sand, gravel	Late Pleistocene	On the middle high-relief diamicton	Partially reformed surface of glacial moraine

Units	Backscatter intensity	Surface slope gradient	Acoustic reflection	Lithology	Chronology	Distribution	Interpretation
Linear features	/	Linear or near linear elongated structure	Shallow incised surface	/	Late Pleistocene	On the east slope of the moraine	Ice-ploughed scours by icebergs

Multibeam echosounder data and backscatter intensity were obtained by the Canadian Hydrographic Survey (CHS) and Geological Survey of Canada (GSC) during expeditions 2006010PGC and 2023004PGC (Figure 18, Figure 21), using a Kongsberg-Simrad EM 710 Multibeam Echo Sounder System at sonar frequencies of 70–100 kHz for water depths deeper than 50 m. Footprints of the data are shown in Figure 18 with the 2006 data in yellow and the 2023 data in pink. The output data were gridded with a resolution of 5 m and 1 m respectively. For areas not covered by multibeam surveys, bathymetric data were derived from Canada west coast topo-bathymetric digital elevation model (Kung et al. 2023), which compiles the best data available and is grided at a resolution of 10 m.

Sub-bottom acoustic lines collected by the GSC in expeditions 2006010PGC, 2007005PGC, 2023003PGC, 2023004PGC, and 2023005PGC are used. The surveys were conducted using a Knudsen Chirp 3.5-kHz echo sounder. Navigation was done at a speed of 4–5 knots, usually with closely spaced parallel lines. Echoes were recorded on a wide bed electrostatic plotter and annotated with information on course changes and GPS fixes for older data. Software applications EchoControlServer and EchoControlClient were used to acquire the newer data and generate profiles. Tools created by R.C. Courtney (Courtney 2013), including software Combine_Segy, SegyJP2, and SegyJP2Viewer, were used for data analysis and profile interpretation.

The grab samples collected during expedition 2023004PGC by the Geological Survey of Canada and the compilation of grainsize from multiple expeditions (Enkin in prep.) are used for the validation of geomorphic assignments.

3.2.3 Surficial geology units and their distributions

Based on bathymetric patterns, backscatter intensity, surface sediment texture, and acoustic reflections of sub-bottom profiles, there are 12 primary seabed geomorphic types. They are bedrock, diamictons/moraine (ice contact deposits), glaciomarine sediment, postglacial mud, sand and gravel lags. There are also regions with: bedforms, gas masking, channels, gullies, massive transport deposits (MTDs), along with prominent ridges and linear features (Table 3). Without high-resolution survey data, we have not determined the details on portions of the transgressed and eroded diamicton surface, and we simply label them as “Glacial diamicton” without providing details on the map (Figure 20).

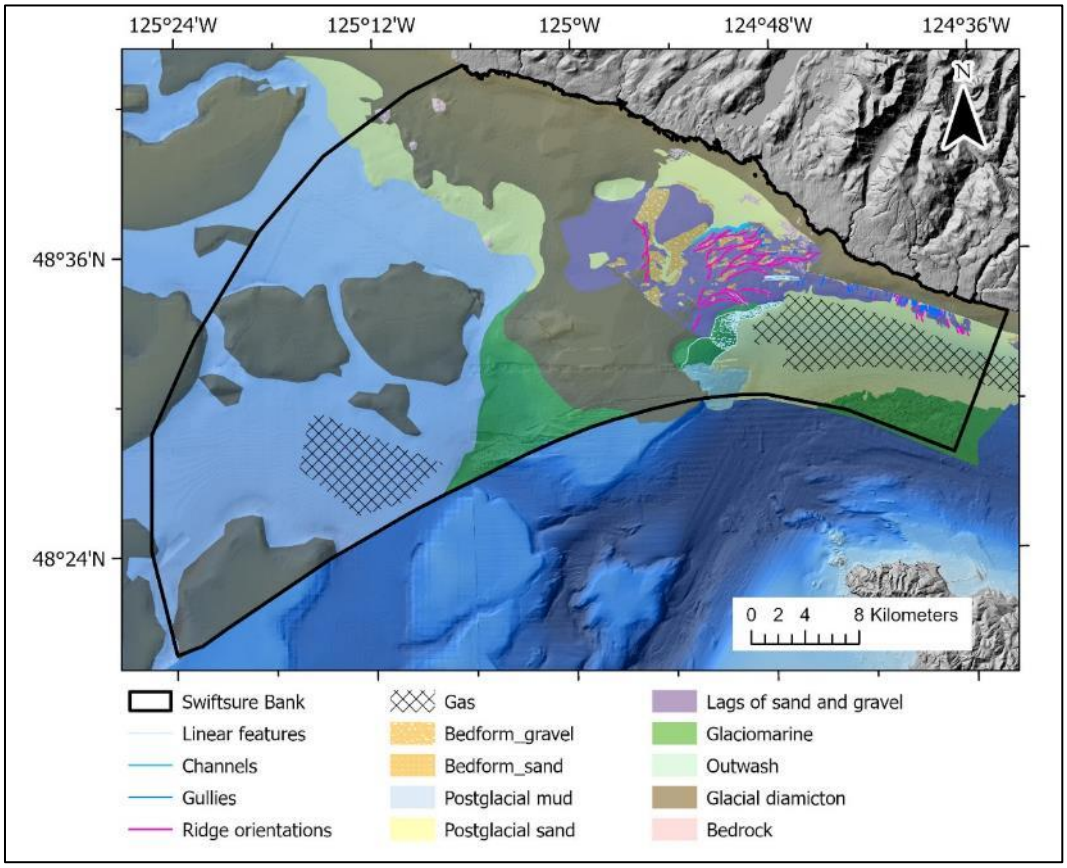


*Figure 20. Seabed morphology types of the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Boundary area and their distribution. The diamicton surface has been covered by reworked sand or gravel in the postglacial period. Details are limited without high-resolution survey data. Map provided by Natural Resources Canada.*

Bedrock

The bedrock of the **ʎ̓ušiiʔaaʔaq/**Swiftsure Bank Area consists of Paleogene sedimentary rock, dominantly characterized by Eocene-Oligocene rock (Cameron 1980; Muller 1981; Johns et al. 2012; Cui et al. 2017). In Chirp profiles, bedrock cannot be penetrated, displaying a highly reflective upper surface which is irregularly shaped and characterized by an upper envelope of parabolic diffractions. The bedrock unit supports steep slopes and high backscatter intensity. The acoustic backscatter signature shows the surficial irregularities well with high intensity and strong spatial variability over small areas. Irregular outcrops are sparsely exposed at the sea floor, mainly along the north edge of the map area along the west coast of Vancouver Island (Figure 20).

Glacial diamictons/Moraines

Glacial diamictons are ice-grounded moraines with high relief and broad gentle slopes across much of the **ʎ̓ušiiʔaaʔaq/**Swiftsure Bank Area. Moraines are landforms formed by the unstratified and unsorted deposits of sediment that result from the direct action of, or direct contact with glacial ice. They are categorized into different types based on their position with respect to a glacier. For example, terminal moraines are created at the front margin of grounded

ice at its furthest extent, while recessional moraines form during halts in the recession of grounded ice. In the **ƛ̓ušiiʔaaʔaq** Area, moraines display a poorly sorted mixture of gravel, sand, silt and clay, or sandy-muddy bouldery gravel at the seabed. They have an irregular morphology with high backscatter and high relief. In Chirp profiles, they appear as chaotic and acoustically incoherent internal reflection, folded and dipping reflectors of short lateral extent, or no recognizable internal structure. Their outline in plain view is relatively smooth, but their profile tends to have steep edges, especially along present or former coastlines or along channels. Several moraines are found at high-relief locations in the west and middle **ƛ̓ušiiʔaaʔaq** areas (Figure 20).

Glaciomarine sediment

Glaciomarine sediment consists of finely laminated grey silty clay or clayey silt with poorly sorted angular gravel. It typically features an eroded lag surface on the seafloor or an eroded contact with onlap by the overlying postglacial sediment. On the seafloor surface, lags of sandy or muddy gravel typically overlie glaciomarine stratified and draped gravelly mud. Glaciomarine sediment commonly displays continuous and relatively strong backscatter intensity, although slightly weaker backscatter may be observed in areas surrounded by harder substrates such as moraine or bedrock. Glaciomarine sediment was likely deposited during floating ice shelf conditions with some combination of hemipelagic settling through the water column and some seabed-tractive components. Glaciomarine units exposed at the seafloor are limited to the southeast **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area off Washington state in Juan de Fuca Strait and the moraine slope and they tend to be armoured with winnowed lags of sand and gravels (Figure 20).

Lags of sandy gravel

Lags of sandy gravel in this report are separated from those on the eroded surface of identified glaciomarine deposits. They particularly refer to poorly sorted gravel layers ranging from boulder to granule sizes, situated on diamicton on the middle area. They are very common on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. They can be interpreted as the remains on the surface after finer materials had been eroded or washed away by strong currents or waves present at a lower sea level stage or during peak storm shelf conditions. But some of these lags have undergone transport and accumulation away from their original sources to form postglacial gravel units.

Postglacial mud

Postglacial mud is composed of slightly sandy silt or silty clay, and it exhibits low backscatter intensity. In sub-bottom profiles, it appears as acoustically semi-transparent, continuous, and weak or moderate stratified internal reflections. The postglacial mud substrate is mainly found in the troughs and the depressions in the western **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area (Figure 20) and shows a typical mounded profile of a sediment drift, with downlap at its margins.

Postglacial sand

Postglacial sand consists of sand with various degrees of sorting and grain sizes from muddy sand to gravelly sand. The backscatter intensity is low. The surface is relatively smooth and flat compared to other nearby units. In Chirp profiles, it exhibits an acoustically intense reflective and scattering surface, without internal reflections or internal structure. Postglacial sand can be distinguished from lags of glaciomarine sediment by lower backscatter, and from postglacial

mud by having a hard or strong reflective surface that is non-stratified. Substrate of postglacial sand is mainly found at the eastern **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank boundary area in Juan de Fuca strait, and on high-relief banks, terraces, and the northern slope (Figure 20).

Bedforms

Bedforms on the seafloor are usually active sediment bodies formed and mobilized by various hydrodynamic forces. In the **ƛ̓ušiiʔaaʔaq̓/**Swiftsure Bank Area, they are primarily composed of sand, gravelly sand, and boulder-granule gravel that has been reworked from previous deposits by currents or waves. The sandy bedforms have a weak backscatter intensity, similar to postglacial sand. The gravel bedforms have a strong backscatter intensity. In sub-bottom profiles, bedforms are characterized by wave outlines or an irregular series of surface reflection outlines. On the bathymetric map, they appear as linear to sinuous low-relief dunes. In some localities, these manifest as bifurcate ribbons, suggesting complex current regimes, or they have washed-out tops indicating erosion occurred after they were active. Bedforms are predominantly found on the middle high-relief area and the slope (Figure 20).

Gas masking

Gas masking is used to describe the acoustic effects of gas filling pore spaces within a stratigraphic unit (Hart and Hamilton 1993) the acoustic vibrations are absorbed rather than transmitted to deeper levels. Gas masking often appears as a diffuse dome with a noticeable diffuse, dark upper boundary in an otherwise acoustically transparent mud or sand unit. Gas masking can also enhance particular horizontal layers. In other locations gas can manifest as a diapir or a depression with abrupt vertical edges that terminate lateral reflectors. Gassy areas, as identified by gas masking on seismic profiles, are mainly distributed in the eastern sandy area and the western muddy depression area (Figure 20).

Mass transport deposits (MTDs)

A MTD refers to sedimentary deposits that result from the movement and deposition of a large volume of sediment by rapid geological processes such as submarine mass wasting, turbidity currents, or subaerial debris flows. The deposits are characterized by a mixture of various grain sizes, ranging from fine silt to coarse sand and even larger particles like pebbles and boulders. In the **ƛ̓ušiiʔaaʔaq̓/**Swiftsure Bank Area, the surfaces have deposition scars with gradients larger than 5°. The Chirp profile shows an irregular and dark intensely reflective surface. The acoustic reflection is incoherent and chaotic, or no underlying structure can be observed. MTDs are found near the southeast corner of the high-relief area (Figure 20).

Ridges

Ridges are defined as narrow, elongated, and elevated or elevated-like features on the sea floor. Their slope gradient is larger than 5°. Ridges exhibit strong backscatter intensity, and their surfaces are typically rough and uneven. Acoustically, they display an irregular and dark reflective surface, with no chirp acoustic penetration to reveal the structure below the surface. They are found on the middle high-relief area and possibly formed by the erosion of glacial diamicton. On the north slope of Juan de Fuca Strait, a series of postglacial sand ridges are distributed in parallel, formed by currents or waves (Figure 20).

Channels

Channels here refer to elongated and trench-like depressions that are delimited by obvious banks, and exhibit tributaries and meandering patterns. Bathymetric data reveal drowned channel systems on the northern high-relief, with tidal scours along the north bank and relatively straight south bank (**Figure 20**).

Gullies

Gullies are smaller, narrower depressions compared to channels. They could be within or adjacent to channels. Gullies in the **ƛ̓ušiiʔaaʔaq̓/**Swiftsure Bank Area mainly occur along the northeast (**Figure 20**), where high-resolution multibeam data were collected. In areas without multibeam data, there is insufficient resolution available to identify gullies, though they may be present. The gullies are less than 2.5 m deep and align parallel to sand ridges in a repetitive parallel sequence, oriented either perpendicular to or at an angle to the coastline. They are likely formed by the flow of tidal or geostrophic currents following intense storms.

Linear features

Linear features refer to straight or slightly curved elongated structures on the seafloor, exhibiting a linear or nearly linear pattern. The shorter linear features are notably located on the east slope of the middle high-relief area below 90 m water depth. The longer and straight lines are observed further northward, on a slope between 70 m and 60 m water depth, with a west-east orientation (Figure 20).

3.2.3.1 Surficial geology zones

The **ƛ̓ušiiʔaaʔaq̓/**Swiftsure Bank Area exhibits complex geomorphological features due to tectonic modification located within the zone of convergence of the North American and Juan de Fuca Plate. The seafloor morphology is also notably influenced by extensive glaciation effects and sea-level changes during glacial and postglacial periods. The surficial geology within the boundaries of the Juan de Fuca Eddy EBSA is generally characterized by three main geomorphological zones: I. An incised shelf in the west, II. Terraces and Moraine in the north and the middle regions, and III. A glacial trough in the east (Figure 21).

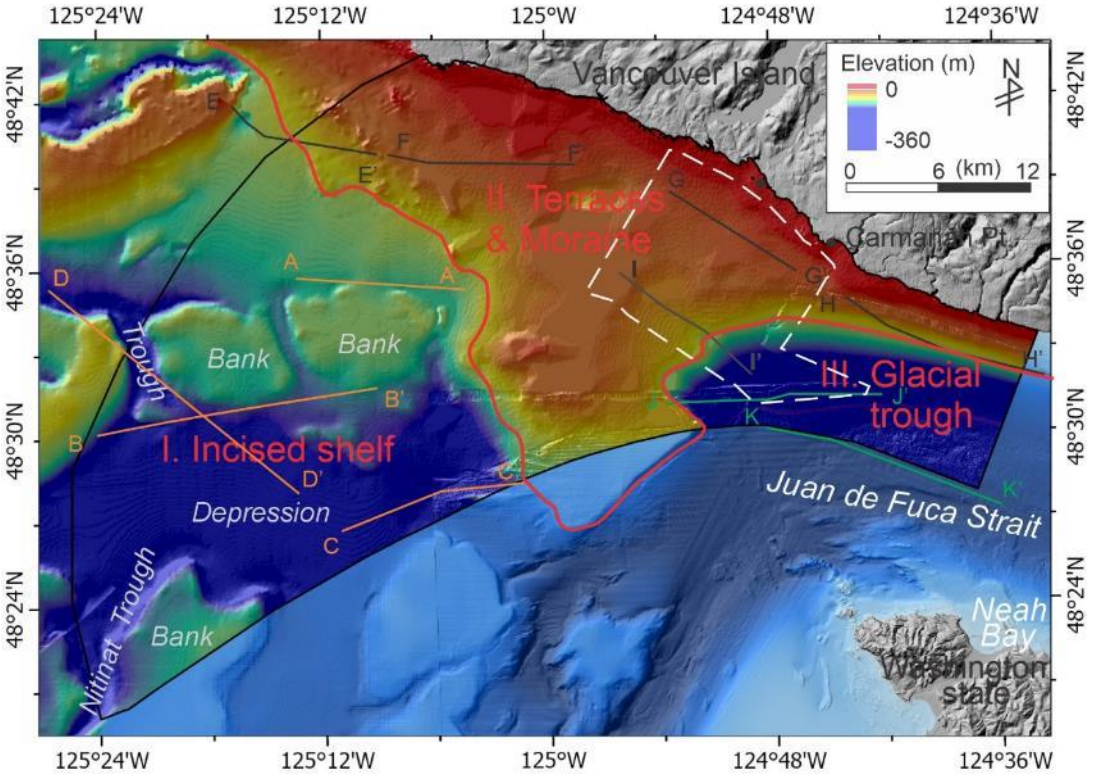


*Figure 21. Bathymetric map showing three basic geomorphologic zones of the **ʔuʔiiʔaaʔaq**/Swiftsure Bank Area: I. Incised Shelf in the west, II. Terraces and Moraine in the middle and the north, and III. Glacial Trough in the east. The black fine line is the **ʔuʔiiʔaaʔaq** area boundary. The red thick line is the boundary of surficial geology zones. Orange, black, and green lines with letters A-A' etc. show the locations of selected sub-bottom profiles in zones I-III, respectively. The inset white-dash-lined block is the newest survey area in Expedition 2023004PGC, as shown in Figure 1.2.2.5 for details. Map provided by Natural Resources Canada.*

Zone I-incised Shelf

The incised shelf has a rugged and undulating seafloor with multiple banks, depressions, and deep troughs (Figure 21). These troughs are bounded by high banks. Herzer and Bornhold (1982) interpreted this geomorphology as a result of ice incision when the grounded ice extended across the shelf during glaciation, leading to a series of troughs and moraines. However, meltwater flow during glacier outburst floods could be another possible contributing factor. Postglacial mud typically covers the seafloor of the channels and depressions as broad, gentle, convex, upward drifts (Figure 22). High-relief banks are typically underlain by diamictons containing poorly sorted muddy gravel, and the gravel deposits, ranging from boulder to granule size, indicate deposition from ice. All younger substrates onlap to these large features with poor acoustic penetration. The diamictons could be interpreted as moraines (profile D-D’ in Figure 22). Nevertheless, their irregular surfaces have been eroded, smoothed and somewhat levelled-off during the postglacial transgressive period (Shaw et al. 2024).

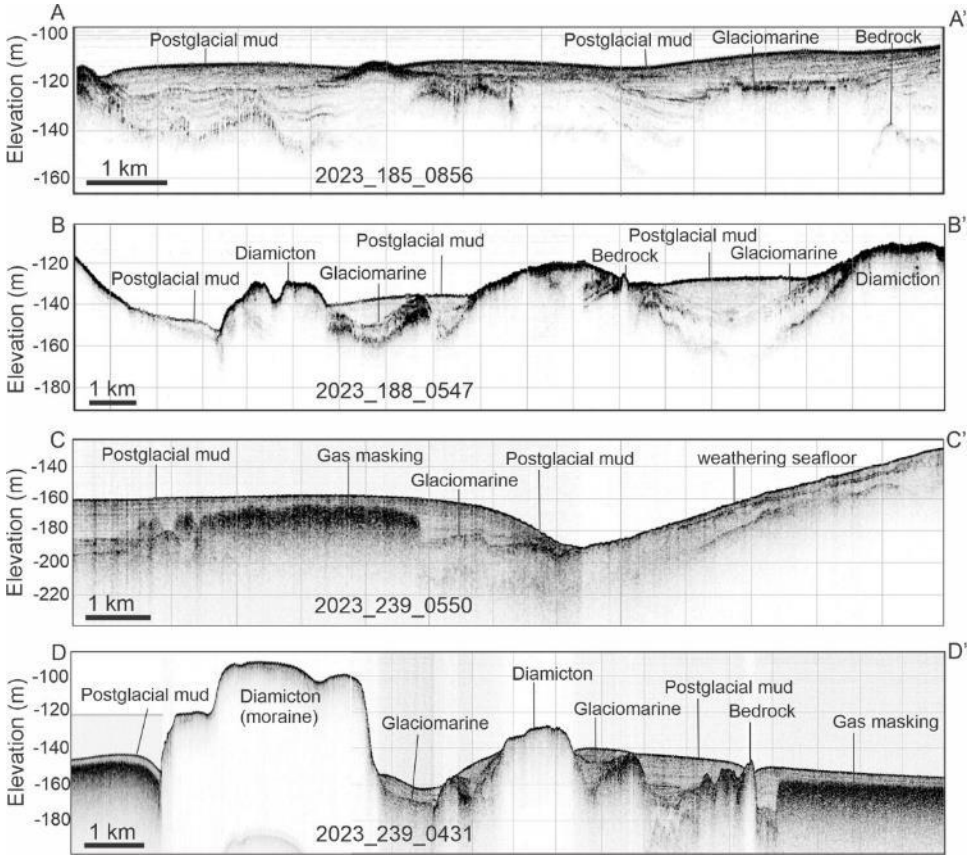


Figure 22. Sub-bottom lines showing the basic stratigraphic units in the zone of incised shelf: bedrocks, diamictons, glaciomarine sediment, and postglacial mud. Weathered seafloor is typically covered by lags of glaciomarine sediment. The locations of the profiles are marked with orange lines in Figure 1.2.2.2. Figure provided by Natural Resources Canada.

Zone II-Terraces and Moraine

The zone of terraces and moraine is situated between zone I and III, extending across the middle area and along the north coast (Figure 21). The water depth is shallower than 100 m on the slope and less than 80 m on the terraces. Substrates in this zone include sand, gravel and bedrock. Chirp 3.5 kHz profiles exhibit limited acoustic penetrative depth into sediment in general, except the slope area, where reflections of glaciomarine and postglacial sand are observable (Figure 23). The diamicton ridge across the northwestern end of Juan de Fuca Strait off between Washington State and Vancouver Island likely represents a terminal moraine formed at the western edge of the Juan de Fuca lobe. Shallower and more easterly portions of this moraine complex likely formed during the final Wisconsinan ice retreat back onto Vancouver Island. However, in the postglacial period, the top of the moraine underwent deformation and leveling due to the changes in sea level, currents, hydrodynamic forces, and sediment sources (Shaw et al. 2024). Diverse surficial geology units have been formed in the high-relief zone. A portion of **ʎušiiʔaaʔaq**/Swiftsure Bank, surveyed in expedition 2023004PGC, highlights some of the geomorphic details.

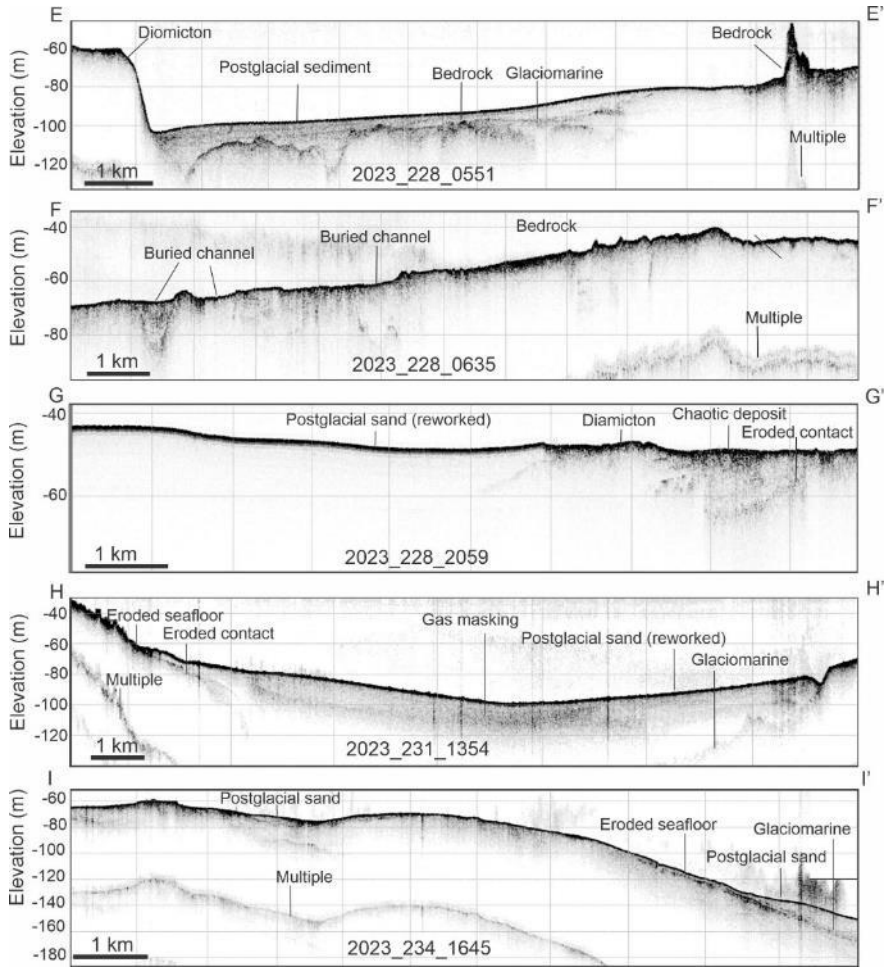


Figure 23. Sub-bottom lines showing the basic stratigraphic units in the zone of Terraces and Moraine (F-F' and G-G') and their boundaries with zones I (E-E') and III (H-H' and I-I'). The locations of the profiles are marked with orange lines in Figure 1.2.2.2. Figure provided by Natural Resources Canada.

The multibeam survey of the **ƛ̓ušiiʔaaʔaq̓/**Swiftsure Bank Area during expedition 2023004PGC covers approximately 159 km^2 (Figure 21, Figure 24). The seafloor is characterized by high-relief gravelly sand or gravel ridges, mounds, channels, and bedforms in low-relief areas among the ridges (Figure 24; Li and Kung 2024). Additionally, linear features are observed on the east slope, where lags of glaciomarine sediment form the substrate. The orientations of gravel or sand ridges are diverse but are predominately either curved to the west, south, or southeast, separated by a mound and a low-relief channel. Gravelly sediment is mainly distributed on the high-relief areas and slope, while postglacial reworked sand is predominantly in the low-relief areas. Gravel-dominated bedforms, such as ribbons, are observed in the west surveyed area, while sand-dominated bedforms are mainly distributed along the channels and in the northern slope (Figure 24).

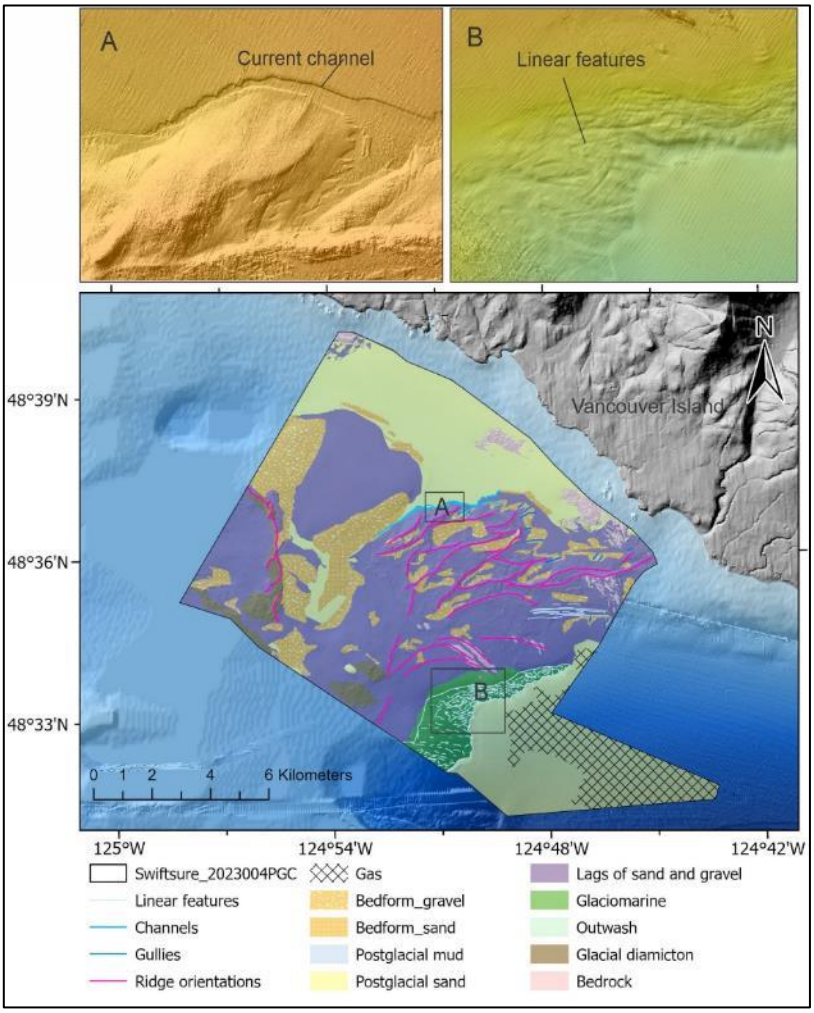


Figure 24. Seabed geomorphology of an example area from ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank and its adjacent area. A. Current Channel; B. Linear features on the slope (Insets A and B from Li and Kung 2024). Map provided by Natural Resources Canada.*

Zone III-Glacial Trough

This zone is located in the eastern part of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, identified as a glacial trough system (the main mega-fjord channel of the Juan de Fuca Strait). Grounded piedmount ice from the Juan de Fuca lobe of the Cordilleran Ice Sheet (e.g., Clague and James 2002; Dyke et al. 2003) during the last glacial period, formed this deep trough (Shaw et al. 2024). Postglacial sand typically overlies glaciomarine sediment in the north of the trough, whereas lags of glaciomarine sediment characterize the eroded seafloor in the south (profiles J-J’ and K-K’ in Figure 25). Chaotic reflection (profile J-J’ in Figure 1.2.2.6) and deposition scars seen in the bathymetry (Figure 21) at the boundary of Zone II and Zone III indicate a MTD underlying the glaciomarine sediment. The surface was eroded. It could be interpreted as an outwash formed by melted water flow.

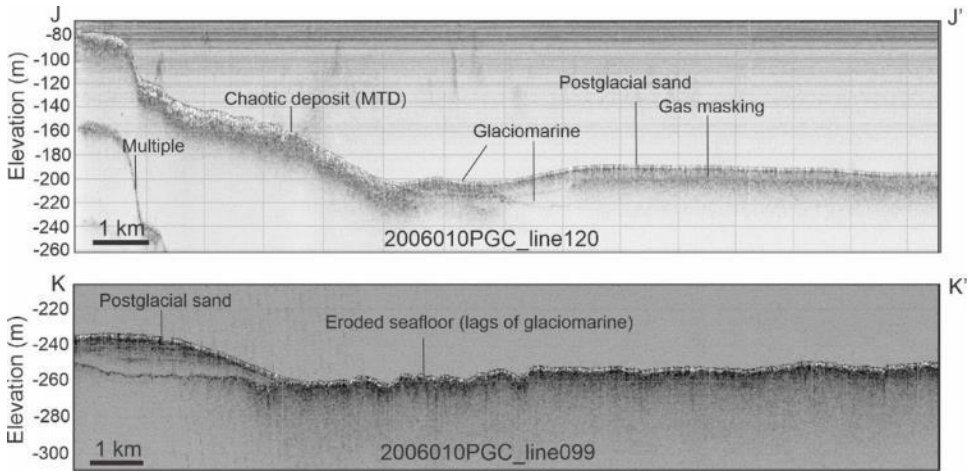


Figure 25. Sub-bottom lines showing the basic stratigraphic units in the zone of glacial trough: glaciomarine sediment and postglacial mud. A massive transport deposit could be an outwash. the locations of the profiles are marked with green lines in Figure 1.2.2.2. Figure provided by Natural Resources Canada.

3.2.4 Sediments and benthic floor

The sediment composition on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (specifically within the Juan de Fuca Eddy EBSA boundary) is assessed relative to the surficial geology where bedrock substrate makes up 0.4% of the boundary area and sedimented areas make up the remaining 99.6%. Exposed bedrock is likely underestimated with only 24% of the area having multibeam bathymetry with high enough resolution data for delineation. Sub-bottom data also exists along some transects but not with complete coverage. Sediment covered areas are evaluated for composition based on grain size measurements for 99 samples collected between 1960 and 1975 (Enkin in prep.). The samples are divided into classes separated by DFO's geomorphic units for contextual relative highs and lows (Figure 1.2.3.1). The Pacific Marine Ecological Classification System (PMECS, Rubidge et al. 2016) is another hierarchical classification system that further delineates the Pacific Ocean into finer subunits. At the scale of 100s of kms, geomorphic units characterize areas with similar geomorphology and assumed similarities in biota. Five geomorphic units characterize **ƛ̓ušiiʔaaʔaq**: Crest, Gentle slope, Lesser depression, Lesser rise, and Trough bottom (**Figure 26**). The lesser rise geomorphic unit covers the greatest percent of **ƛ̓ušiiʔaaʔaq**. Photo imagery collected in 2022 with a drop camera during NRCan expedition 2022002PGC provides some ground-truth information.

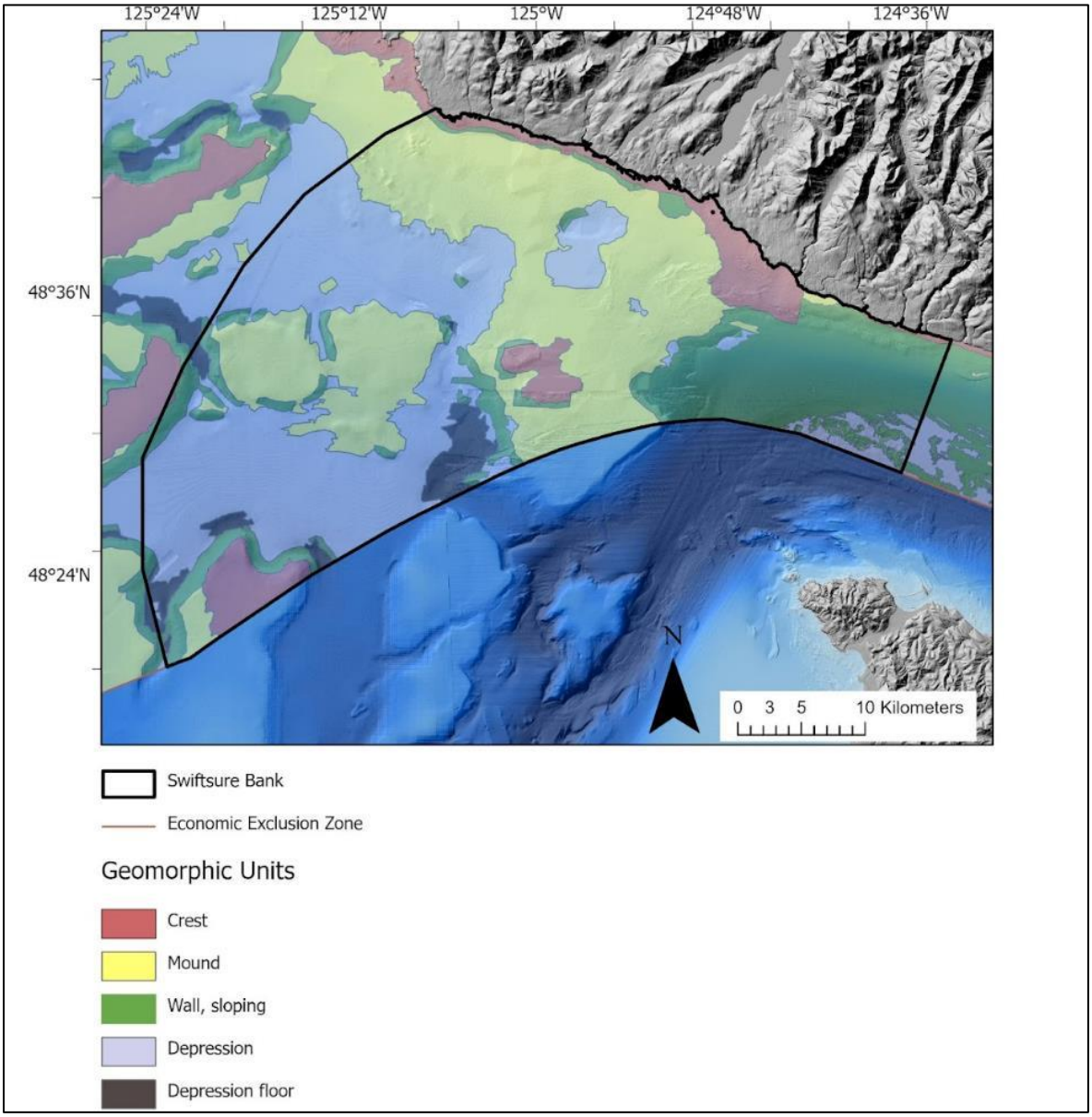


Figure 26. Geomorphology units provided by Fisheries and Oceans Canada (Proudfoot and Robb 2022) showing relative highs and lows as crests, mounds, sloping walls, depressions and depression floor, respectively.

The grain size map (Figure 27), ternary diagram (Figure 28), and depth plotted with mean grain size (Figure 29), all show finer grained sediments in sheltered depressions. Coarser gravel is found on mounds and crests where finer particles are likely transported away in these higher-energy hydrodynamic environments. There are some variations to this as expected: tractive bedforms such as sand and gravel waves create their local dynamics and allow ongoing or intermittent transport and redeposition. Also, an active tidal channel such as the Juan de Fuca Strait transports coarser materials downhill and redistributes sediment in its own system tract. Sea level change has influenced sedimentary processes here and that is evident in the photo imagery where coarse material is seen draped by mud (Figure 30).

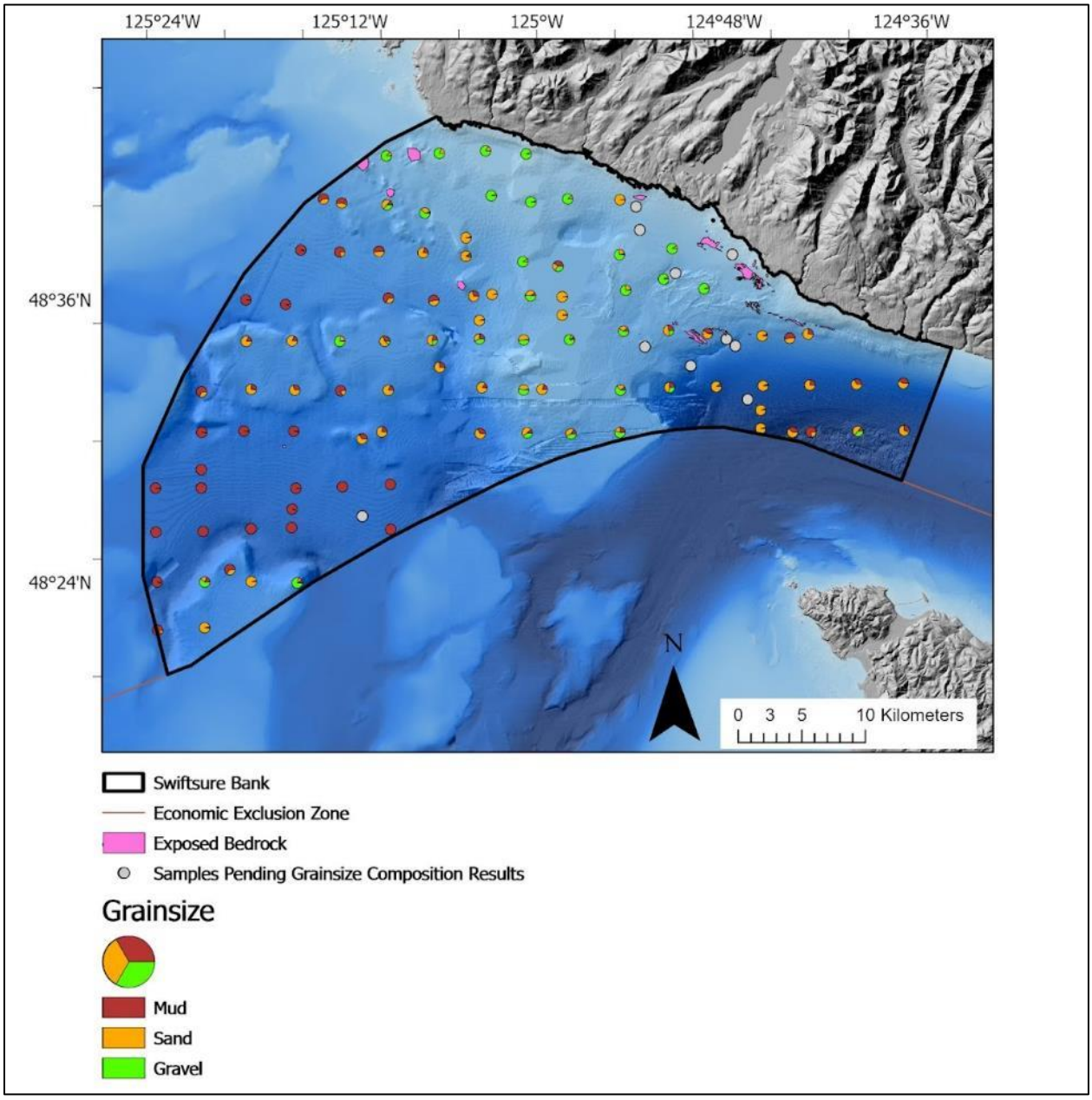


Figure 27. Sediment sample locations with grainsize distribution noted as pie charts. %Gravel, %sand, and %mud are shown in green, orange, and red respectively. Samples collected in 2023 denoted in grey are currently at a laboratory pending results. Data source for samples: Enkin (in prep).

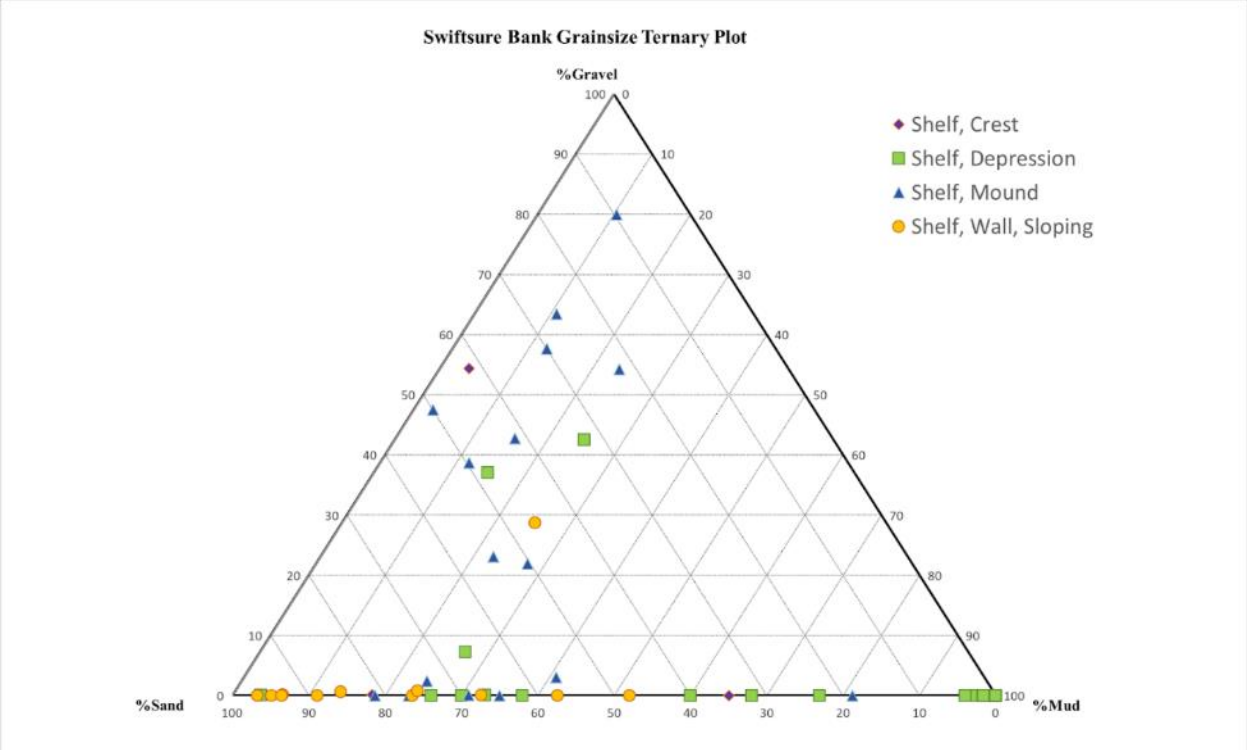


Figure 28. Ternary diagram of the 99 sediment samples shown in Figure 1.2.3.2. Data source for samples: Enkin (in prep.).

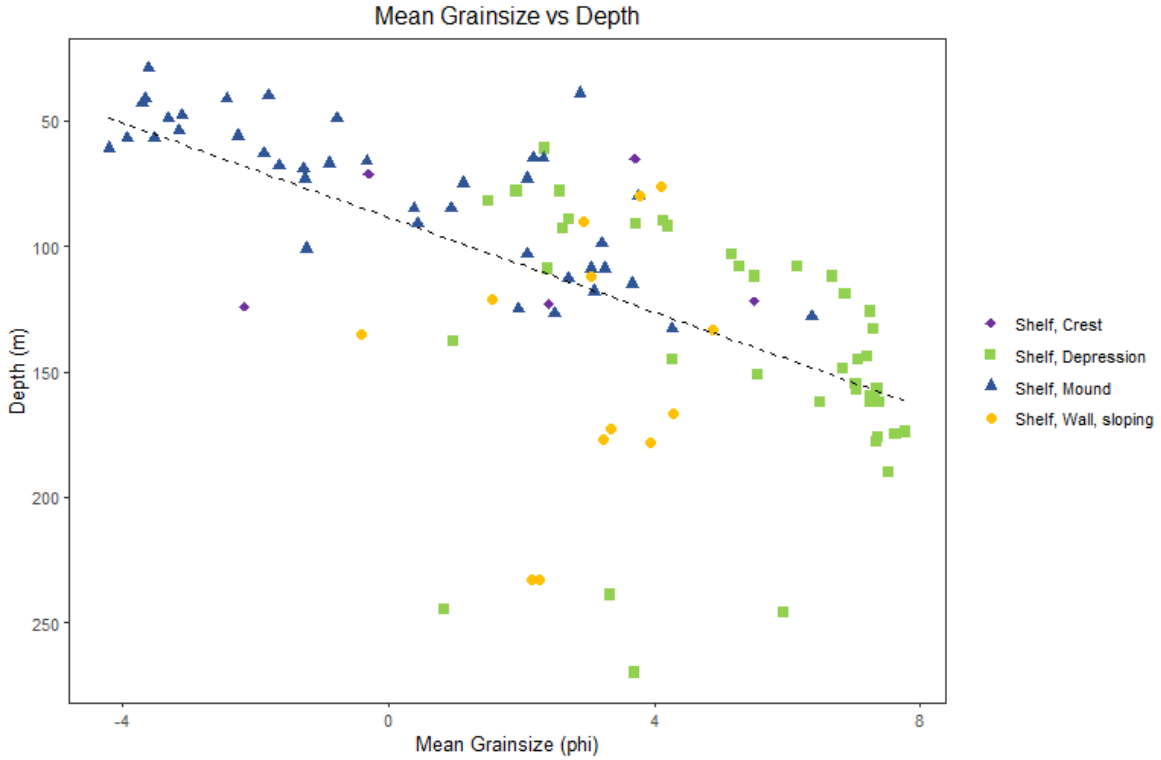


Figure 29. Mean grain size (phi) plotted against depth (m). Data source for samples: Enkin (in prep.).

Mean grain size plotted against water depth returns a linear trend with grain size trending towards higher mean phi (finer grain material) with increasing depth. Most of the outliers of this trend are located in the Juan de Fuca Strait where sediment transport from tides and currents moves different grain sizes to different depths.

For dominantly coarse-grained sandy samples with only a small mud fraction in 1960-1975, silt and clay were not differentiated. 10 samples collected in 2023 (Li and Kung 2024) are currently at the lab for analysis and may contribute to greater certainty on texture trends at the finer scale.

Seabed photos taken at two sites in 2022 on the banks during NRCan expedition 2022002PGC confirmed coarser grain sizes. Gravel was observed on local highs (Figure 30). These boulders appeared to be a lag on glacial diamicton with a light grey colour and some cavities. Physical sample collection and an analysis of the rock properties would help determine their source. Photos taken on the Bank at site 56 (water depths of 100 m-111 m) confirmed sandy-mud compositions, coarser than the measured grain size in the surrounding depressions (Figure 31).

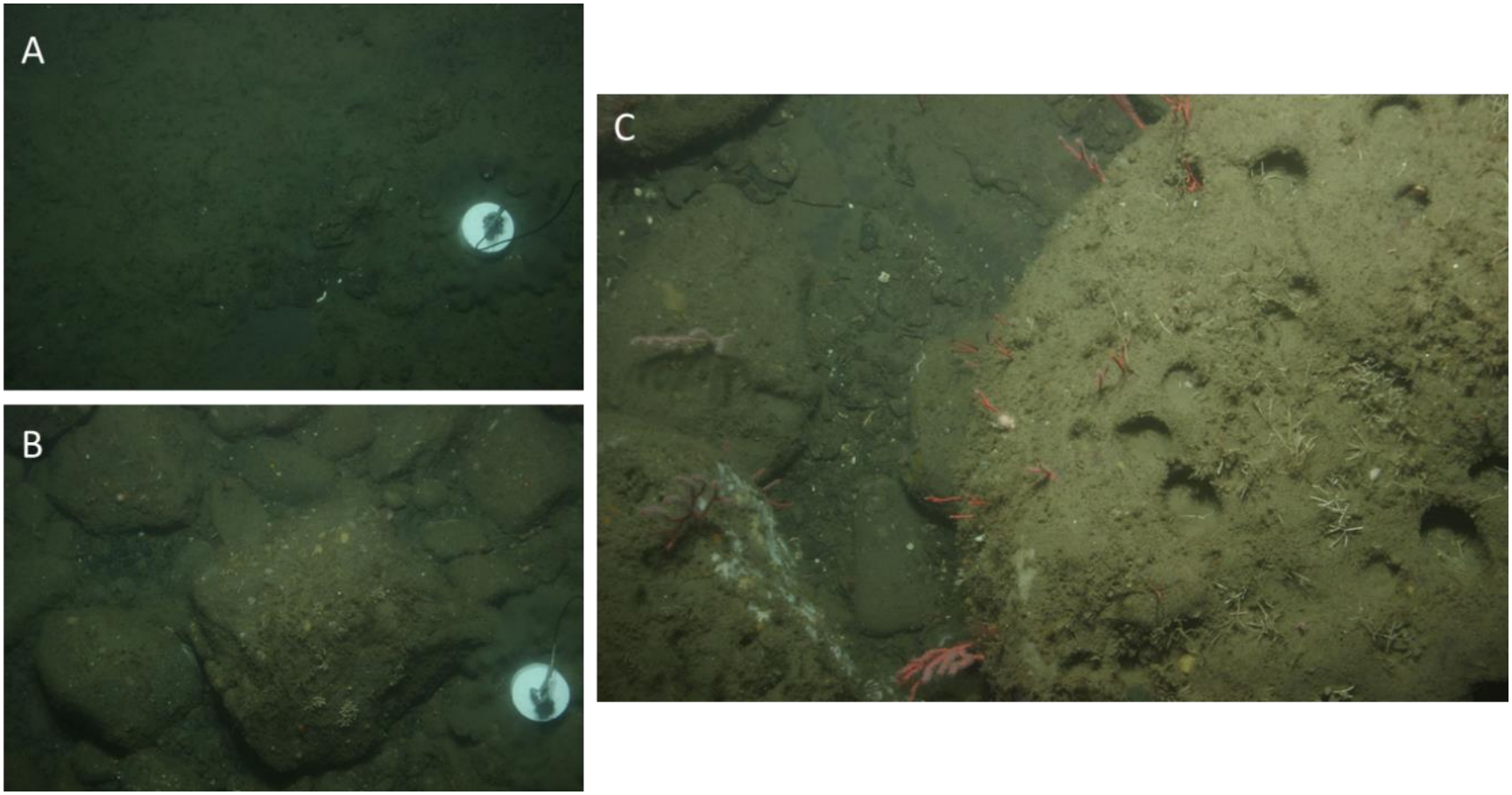


Figure 30. Three images of the seabed (A, B and C) taken at stations 54-55 during NRCan expedition 2022002PGC showing coarse gravel. Depth ranges from 77 m to 84 m below sea level. The white object measures 10 cm in diameter. The map in Figure 32 shows the location of the transect.

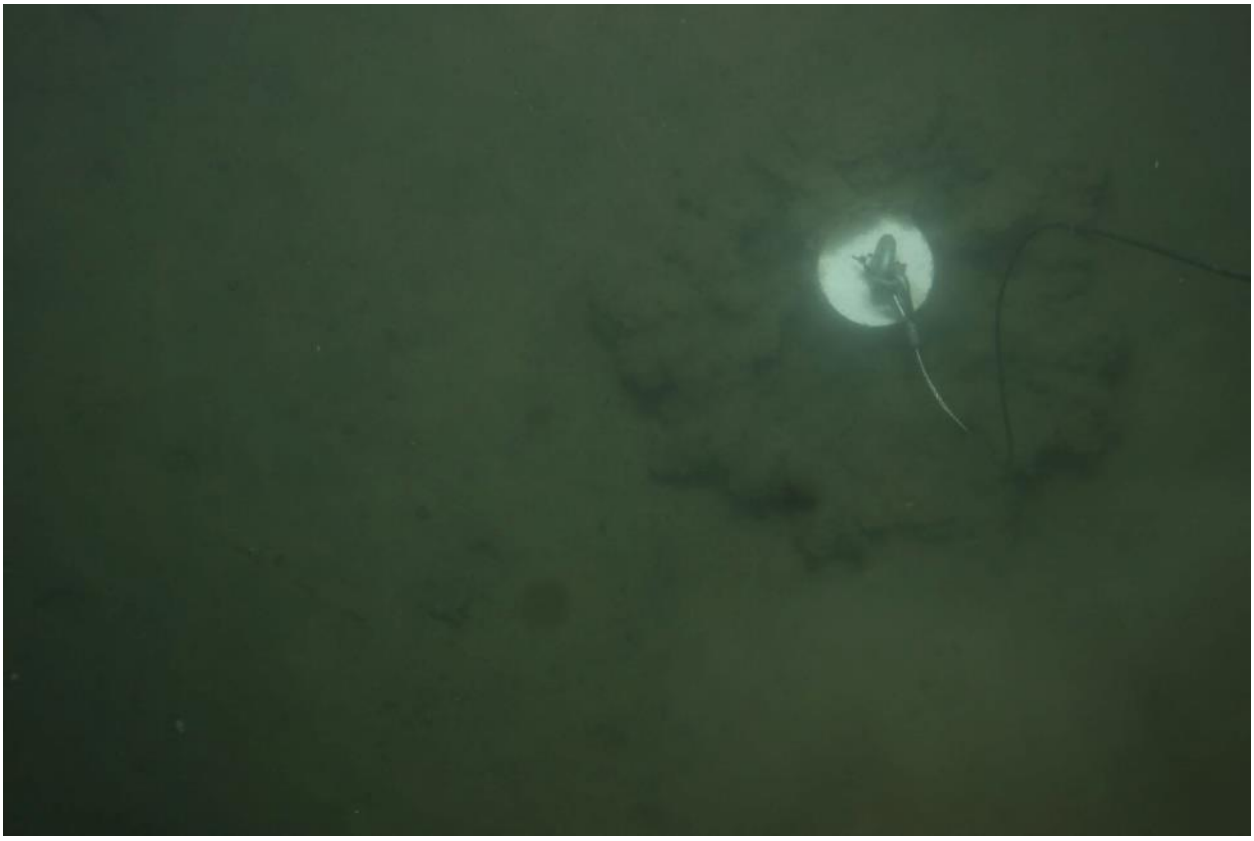


Figure 31. Image of the seabed taken at station 56 during NRCan expedition 2022002PGC on a bank with depth ranging between 100 m to 111 m. The substrate is finer than that seen at Stations 54-55. The white object measures 10 cm in diameter. The map in Figure 32 shows the location of the transect.

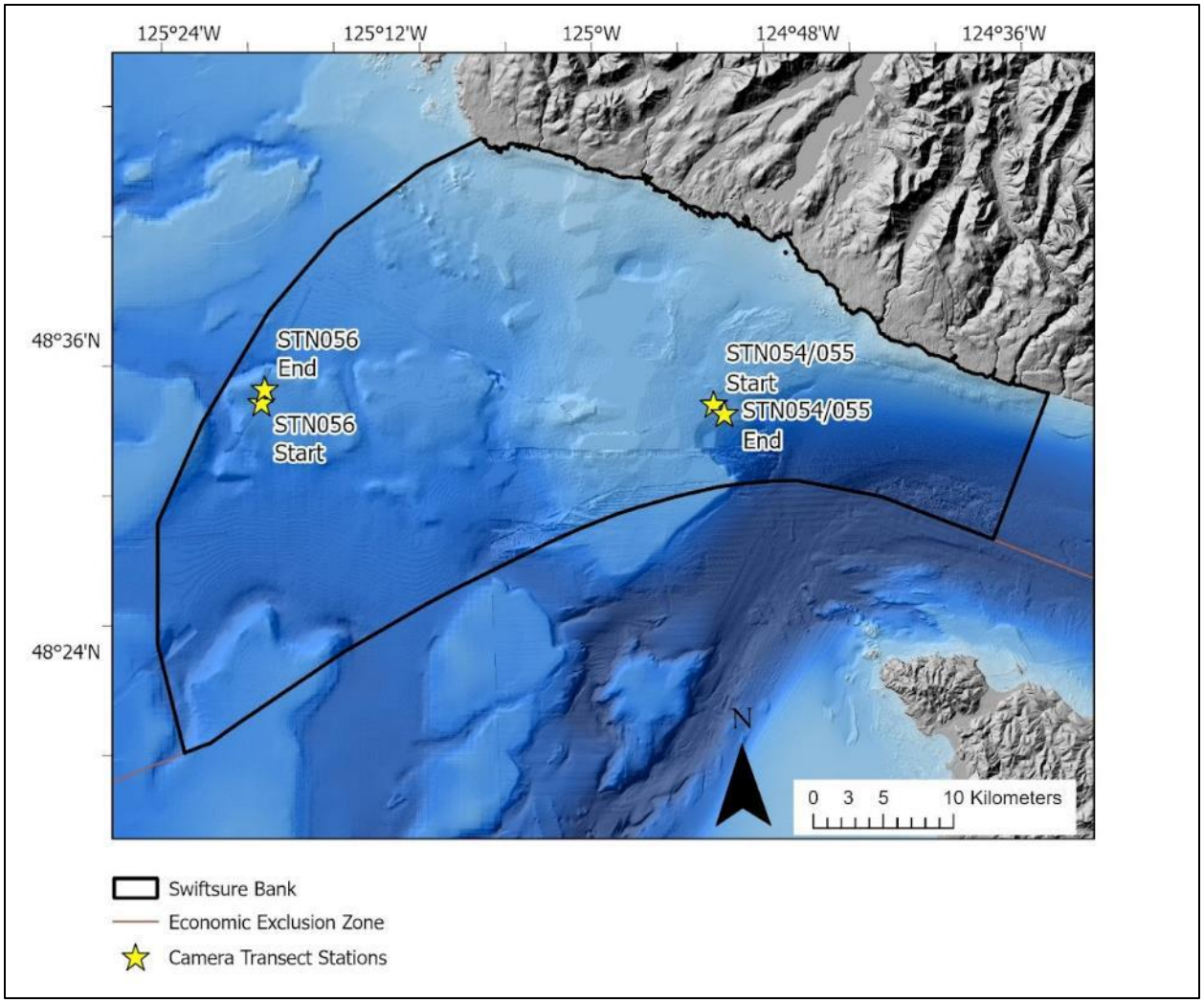


Figure 32. Locations of camera drop transects and photo imagery from NRCan expedition 2022002PGC shown in Figure 30 and Figure 31.

In nearshore and intertidal areas of **ʎ̓ušiiʔaaʔaq̓**/Swiftsure Bank, continuous high resolution sediment and substrate data and maps (e.g., interpreted multibeam) are generally lacking. This is in part due the dynamic, highly variable and poorly accessible nature of the nearshore area – termed the “white strip” (Gregr et al. 2013). While several substrate models have been developed for nearshore areas of British Columbia (see Gregr et al. 2013, 2021) ground-truthed and interpreted nearshore multibeam bathymetry and backscatter data would provide valuable information for understanding ecological and oceanographic processes in these important areas. For example, nearshore species distribution models such as those for Pacific Sand Lance (Robinson et al. 2021; Huard et al. 2022), Geoduck (Nephin et al. 2020), Eelgrass (Park et al. 2023) that utilize seafloor substrate data would benefit greatly from high resolution, ground-truthed substrate maps.

3.2.5 Freshwater inputs

Most precipitation near **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank falls as rainfall during fall and winter. Monthly precipitation exceeds 400 mm from November to January, with average air temperatures above 5°C (Figure 33). Water exchanges on **ƛ̓ušiiʔaaʔaq** are impacted by the freshwater runoff created from the melting snow of neighbouring mountain ranges that drain into the Fraser and Columbia Rivers' watersheds (Giddings and MacCready 2017). These two watersheds are vast, draining over 235,000 and 685,000 km^2 (Morrison et al. 2012), with peak monthly discharges exceeding 7500 m^{3}s^{-1} in spring (Figure 34). Although further away, the Columbia River discharges about 6750 m^{3}s^{-1} of water from November through March when the prevailing winds and surface currents blow towards the north (Figure 14). During these months, the Fraser River's flows drop significantly to below 1800 m^{3}s^{-1} owing to its colder climate and higher snowfall.

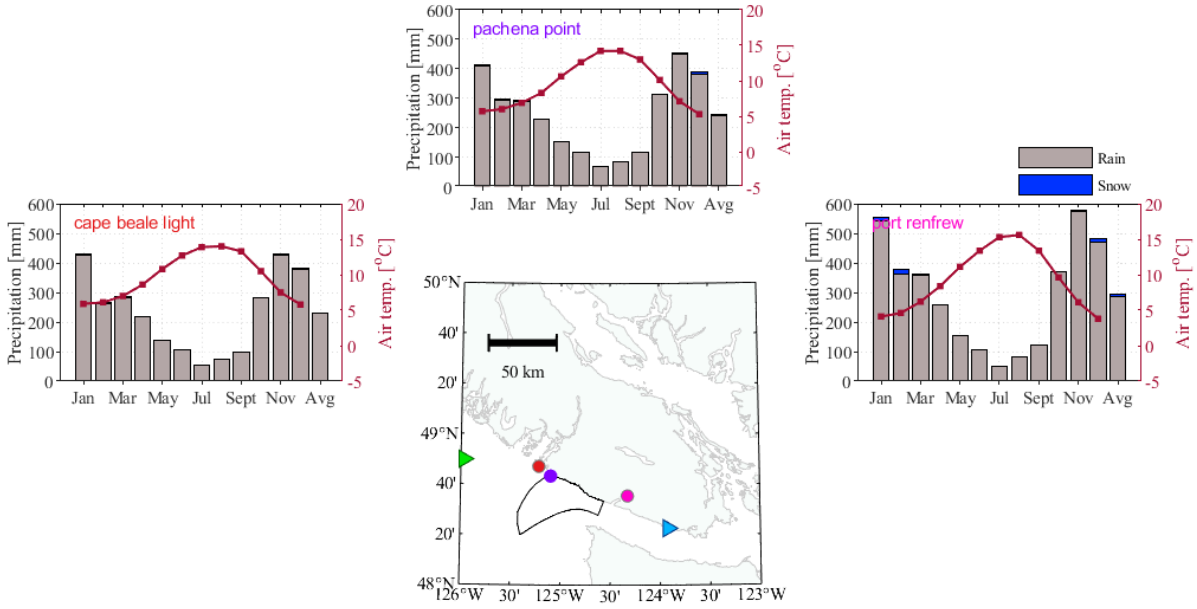


*Figure 33. Monthly average precipitation and air temperatures from ECCC's climatic normals (1981-2010) of land-based meteorological stations[20] near **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Juan de Fuca Eddy EBSA polygon shown in black) are delineated as circles on the map. Snowfall is presented as equivalent water, i.e., 10 cm snow = 10 mm water. Triangles in the map denote the location of additional wind measurements. The red circle indicates the location of Cape Beale, purple circle the location of Pachena Point, and pink circle the location of Port Renfrew. The green triangle indicates the location of La Perouse Bank, the blue triangle the location of Sheringham Point.*

Other smaller watersheds that provide freshwater to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area are those along the Washington Coast, Juan de Fuca Strait and those draining into Haro Strait and Puget Sound. For watersheds along the coast, runoff tracks local rainfall and peaks in late fall and early winter (Figure 34, Washington Coast and Juan de Fuca). Most other watersheds include a mixture of snow and rainfall-dominated catchments (Table 1 of Morrison et al. 2012), with relatively high discharges during winter and spring. Except for the Fraser River, the

[20] https://climate.weather.gc.ca/

minimum flows occur during late summer owing to reduced rainfall and the melted snowpack (Figure 34). During the spring freshet, which peaks in June, about 80% of the runoff leaving Juan de Fuca Strait comes from the Fraser River. During late winter, the Fraser River contributes about 40% of the 3500 m^3s^{-1} of freshwater entering Juan de Fuca Strait. The watersheds bordering the **ʔ̓ušiiʔaaʔaq** Area are within the eastern limit of West Vancouver Island's watershed (Figure 1 (Morrison et al. 2012). This watershed is rainfall-dominated with peak flows of 2500 m^3/s during winter (Figure 34), thus much less than the total runoff entering Juan de Fuca Strait from the Skagit and Fraser River watersheds.

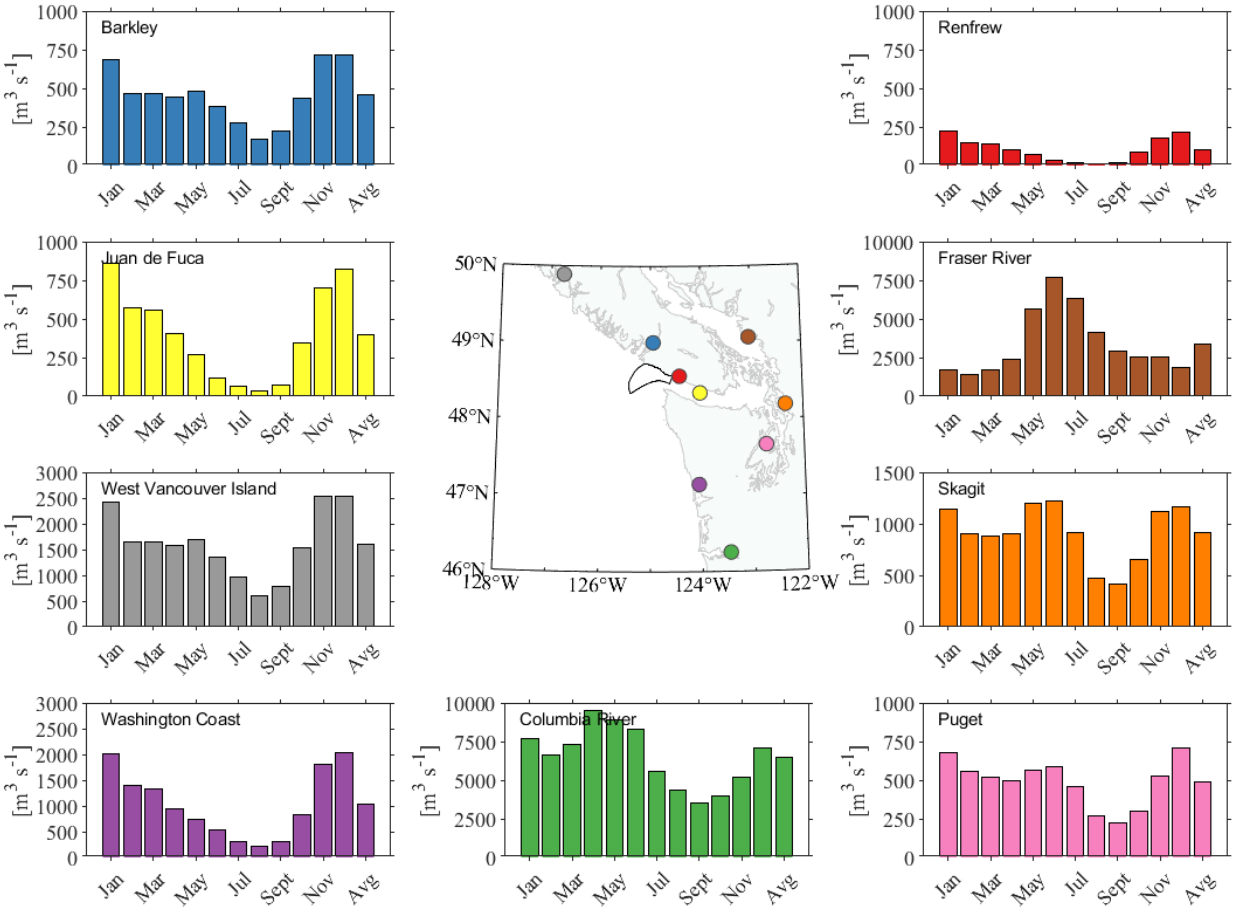


Figure 34. Summary of estimated climatological monthly mean freshwater runoff from regional catchments based on reconstructed flows by Morrison et al. (2012) for the period spanning from 1970 to 2009. The extent of the ***ʔ̓ušiiʔaaʔaq****/Swiftsure Bank (Juan de Fuca Eddy EBSA) is delineated in black. Coloured bars in the plots outside the map correspond to the locations of the same coloured circles in the map. Note the differing scale between the different panels. Barkley and Renfrew are part of the Juan De Fuca and West Vancouver Island catchments.*

3.2.6 Winds and surface waves

3.2.6.1 Winds

The wind patterns impact the physical dynamics in the region. When the winds blow towards the northeast, surface water is pushed onshore, resulting in downward transport near the coast. During winter, these downwelling-favorable winds are prevalent along the BC coast ('coastal downwelling Zone' in Figure 14). Northwest of **ƛ̓ušiiʔaaʔaq**/Swiftsure, on La Perouse Bank, these downwelling-favorable winds blow from the southeast (Figure 35). East of **ƛ̓ušiiʔaaʔaq**, in Juan de Fuca Strait, the winter winds are much weaker and blow along the strait's central axis. During summer, the winds are generally from the northwest, leading to upwelling along BC's southern coast ('coastal upwelling Zone' in Figure 14). Upwelling is the process by which winds from the northwest push the surface water offshore, which causes the underlying water to move upwards near the coast and at the shelf break. Upwelling winds are more prevalent during summer because the Aleutian Low weakens and the North Pacific High strengthens. East of **ƛ̓ušiiʔaaʔaq** within Juan de Fuca Strait, summer winds blow in the same direction as on La Perouse Bank but are stronger (Figure 35). Northwest of **ƛ̓ušiiʔaaʔaq**, on La Perouse Bank, summer winds blow generally along the coast from the northwest and are upwelling-favourable.

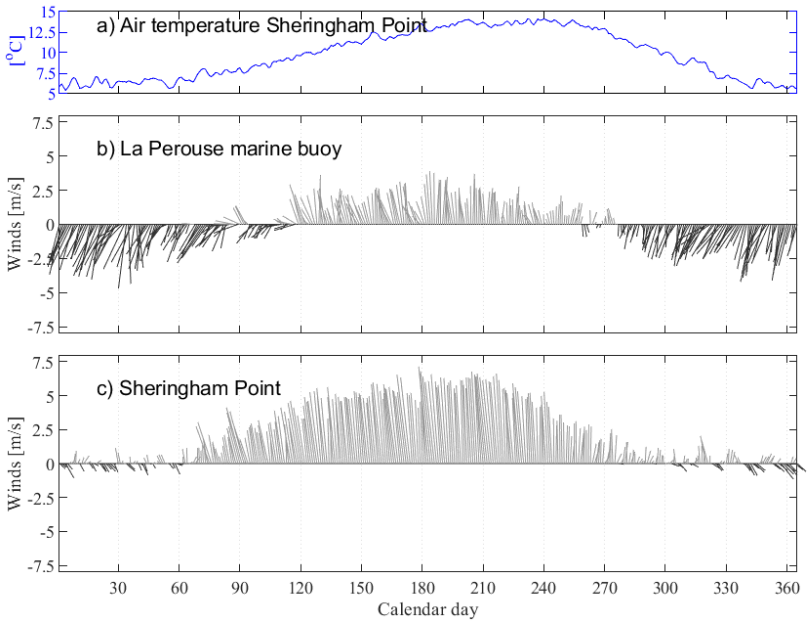


Figure 35. (a) Average daily air temperature at Sheringham Point (ECCC station #1017254, 1994-2018)[21]. Average daily wind speeds from all records measured at (b) La Perouse marine weather buoy (#46206, 1988-2023) and (c) Sheringham Point (ECCC station #1017254, 1994-2018). The lines' length indicates the speeds in the direction that they are pointing. The velocities were rotated by 65° such that upward pointing arrows are winds blowing towards WNW, i.e., along the coast and upwelling-favourable at La Perouse Bank. At Sheringham Point, upward arrows are blowing out of Juan de Fuca Strait towards the ocean. See Figure 33 for the stations' location.

[21] https://climate.weather.gc.ca/

3.2.6.2 Waves

The marine meteorological buoy on La Perouse Bank, northwest of **ẃušiiʔaaʔaq**/Swiftsure Bank, also provides wave heights and periods (Figure 36). The seasonal reduction in storm activity during summer results in smaller wave heights associated with the swell and more wind-generated waves. Swells typically have periods longer than 10 seconds and are generated from distant storm systems. Wind-generated “seas”, or “chop”, have shorter periods than swell. Their wave heights depend on fetch, wind speeds, and wind duration. The median wave height is 2.6 m, with waves exceeding 2.6 m about 5% of the time. During winter, there are some wind-generated waves, but typically, the wave periods are within the storm-generated band and are larger (Figure 36). The wave heights are thus much larger during winter storms than in summer despite the stronger summer winds (Figure 35).

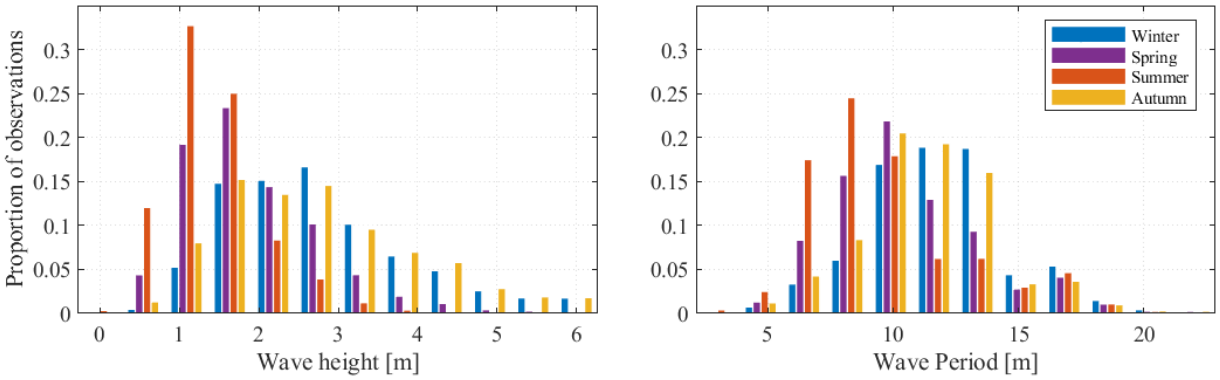


Figure 36. Wave heights and periods statistics from the hourly measurements collected at ECCC’s La Perouse marine weather buoy (#46206) between 1988 and 2023[22]*.* See *Figure 33* for *the stations’ location.*

Surface waves evolve as they move into shallower water: they become steeper as they shoal until they dissipate through breaking and bottom friction processes. The nearshore areas of **ẃušiiʔaaʔaq**/Swiftsure Bank are shallow, but not all are impacted in the same way by surface waves. The intensity of wave action impacts the presence of biota along shorelines, which can be seen from aerial surveys (Cook et al. 2017). These surveys and the known wave fetch can be used to categorize beaches' biological wave exposure (Coastal and Ocean Resources 2020), which is illustrated in Figure 37. Within **ẃušiiʔaaʔaq**, the coastline is considered exposed to wave impacts even at its western edge in Juan de Fuca Strait. Cape Flattery in the United States does shelter the coastline from the swells generated from offshore pressure systems and the wind blowing predominantly along the **ẃušiiʔaaʔaq** coastline (Figure 35). The biological wave exposure just west of **ẃušiiʔaaʔaq** is more variable owing to the orientation of Barkley Sound and the groups of islands in the Sound (Figure 37). No such sheltering occurs inside the boundaries of the **ẃušiiʔaaʔaq** Juan de Fuca Eddy EBSA.

[22] https://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/waves-vagues/data-donnees/index-eng.asp

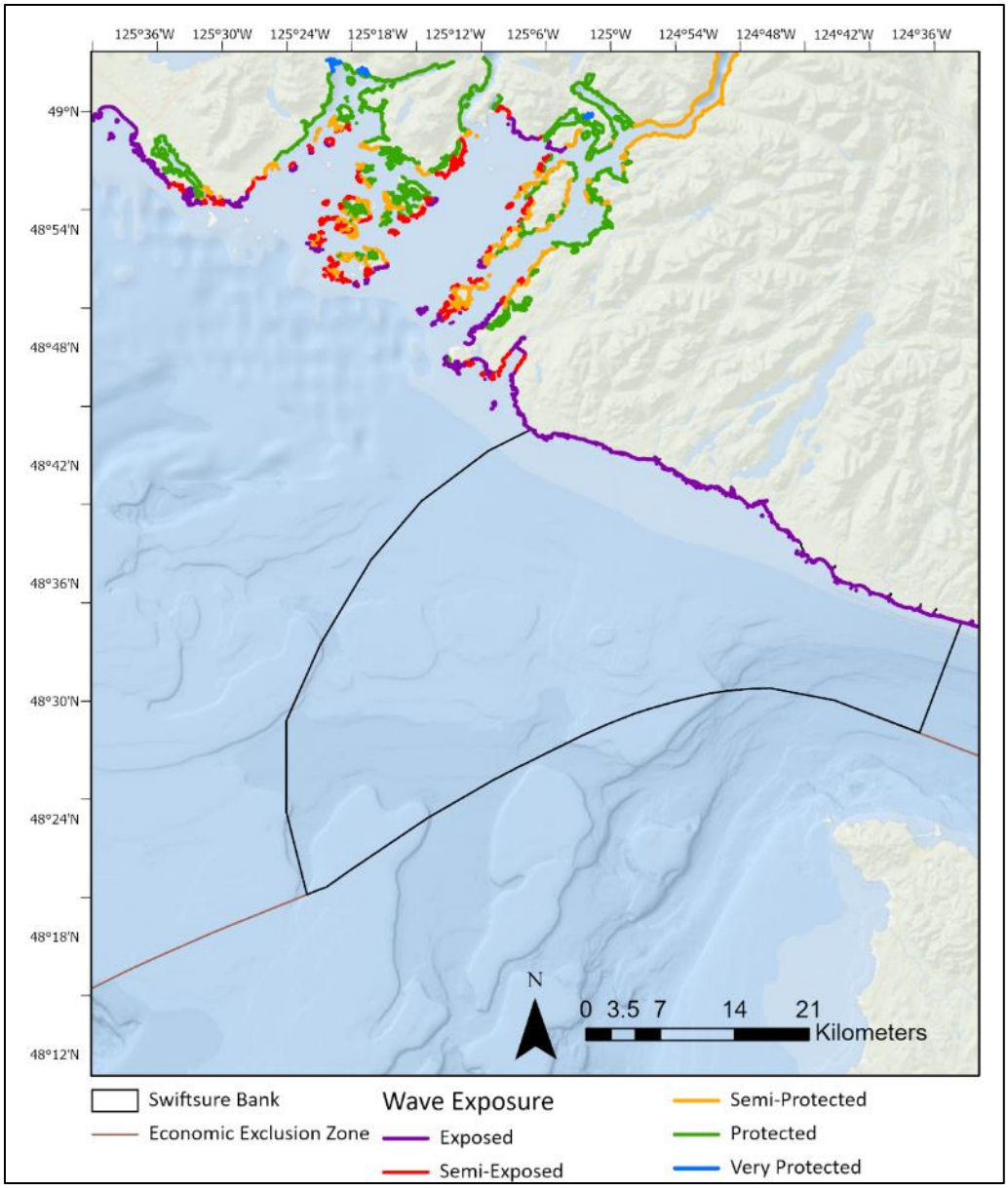


Figure 37. Biological wave exposure of the Southern BC coastline (Cook et al. 2017; Coastal and Ocean Resources 2020).

3.2.7 Currents and tides

3.2.7.1 Estuarine circulation

The water properties in the **Ẃušiiʔaaʔaq**/Swiftsure Bank area are tightly connected with those in Juan de Fuca Strait and the California Undercurrent. In the adjacent Juan de Fuca Strait, which is the primary connection between all the rivers of the Salish Sea and the Pacific Ocean, there is an estuarine circulation throughout the year. Most estuaries can be described as two-layer

systems with relatively fresh surface water outflowing towards the ocean, with a deep inflow moving in the opposite direction. The depth-averaged net flow is directed out to sea and equal to the freshwater input. The surface waters become increasingly more saline as they move downstream through the system via the entrainment of deeper water below. In contrast, bottom waters become fresher as they move upstream because of mixing and exchanges with the surface layer above. The depth-averaged salt content increases towards the sea.

In Juan de Fuca Strait, this classical picture of estuarine circulation is modulated by tidal mixing, seasonal changes in freshwater discharge, and strong wind events. Due to the strong connection between the strength of the estuarine flow and salinity, tidal mixing in narrow channels landward of Juan de Fuca leads to fortnightly variations in not only the strength of the estuarine currents (Masson and Cummins 2000) but the salinities (Li et al. 1999) and the freshwater export to the continental shelf (Masson and Cummins 2000). While the estuarine flow is present in all seasons, its strength depends on the freshwater discharge (Ott and Garrett 1998; Li et al. 1999). Additionally, due to the width of the Strait and the rotation of the Earth, the inflow (bottom) layer is thicker on the north side of the Strait and the outflow (upper) layer is thicker on the southern side (Ott and Garrett 1998; Martin and MacCready 2011). At times the estuarine flow is overwhelmed by transient flows, which dominate roughly 10% of the time in summer and 45% of the time in winter (Thomson et al. 2007). These transient flows are reversals of the estuarine circulation generated during poleward wind events along the outer coast and give rise to a fresh, surface-intensified inflow along the southern boundary of the strait (i.e., south of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank). Strong winds (e.g., storms) and atmospheric cooling may further erode the stratification between the relatively fresh surface layer and deep water below, enabling vertical exchanges across layers.

These exchanges are not limited to heat and salt but include vertical transfers of nutrients and dissolved oxygen across the layers. In many stratified ocean environments, the deepest waters have relatively low oxygen and are nutrient-rich. This distribution results from the sinking of dead organisms. Their biogeochemical breakdown consumes oxygen while providing sources of nutrients such as nitrate, phosphate, and silicate. In contrast, the surface-most layers are relatively oxygen-rich because of their direct contact with the atmosphere. The well-lit surface waters are relatively nutrient-poor, especially during summer, as plankton consumes nutrients. However, rivers and creeks may provide land-based nutrients in the surface layer. When this nutrient supply is low, the estuarine circulation can replenish some of the lost dissolved oxygen in deeper layers while transporting nutrients toward the surface.

The Juan de Fuca Eddy (Tully 1941), located off the coast of Vancouver Island, significantly impacts the current systems on the British Columbia continental shelf (MacFadyen et al. 2008), particularly around **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. It is formed when upwelling currents separate from the coastline and interact with the local topography, which can occur under both steady and variable wind-forcing conditions (MacFadyen and Hickey 2010; Klymak et al. 2023). This eddy is topographically controlled, with its formation linked to the bathymetric features off southern Vancouver Island (Freeland and Denman 1982). In models, some form of eddy near **ƛ̓ušiiʔaaʔaq** has been generated both purely by tides interacting with topography (Foreman and Walters 1990), with tides and estuarine flow (no winds; Foreman et al. 2008) and with tides absent (only winds and estuarine flow; Foreman et al. 2008); thus, it appears that all three forcings are important in its formation and the variability of its strength and location (MacFadyen et al. 2008). The Juan de Fuca Eddy influences local circulation patterns, nutrient levels, and

phytoplankton production, affecting the broader marine ecosystem (MacFadyen et al. 2008). The Eddy is primarily observed in late spring and early summer, but the region also experiences non-tidal currents throughout the year (Tully 1941; Foreman et al. 2008).

3.2.7.2 Tidal forcing

Like most of the BC coast, tides on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank are classified as mixed with larger amplitudes associated with the semidiurnal (twice/day) constituents than the diurnal (once/day) ones (Foreman and Walters 1990). The tidal range increases from 1 to 3 m over the 14-day spring and neap tidal cycles. The main semidiurnal constituents are M2 and S2, and the main diurnal constituents are K1 and O1. The main semidiurnal constituent (M2) increases westwards through Juan de Fuca Strait and along the southwest of Vancouver Island, while the main diurnal constituent (K1) decreases westwards. The M2 semidiurnal amplitude increases from 80 cm to 90 cm. In comparison, the weaker K1 amplitude decreases from 45 to 40 cm from the entrance of Juan de Fuca Strait to the western edge of **ƛ̓ušiiʔaaʔaq** (Figure 4 of Foreman and Walters 1990). The diurnal (K1+O1) tidal amplitudes are about 0.6 of the semidiurnal constituents (M2+S2), but the diurnal currents are stronger by a factor of two to four (Crawford and Thomson 1982).

3.2.7.3 Surface drifter observations

Drifter studies indicate that the surface waters in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank generally come from the Strait of Juan de Fuca year-round (Figure 38 and Figure 6 from (Pawlowicz et al. 2019). This is as and Winter, the surface waters from **ƛ̓ušiiʔaaʔaq** ultimately move north along the west coast of Vancouver Island, following the winter-season Davidson Current, while in the Summer they move south along the west coast of Washington and Oregon. In Spring some drifters moved north and others moved south. In all seasons (except Winter when there are few drifter tracks) there is evidence of many drifters circling in the Juan de Fuca eddy before traveling out of the **ƛ̓ušiiʔaaʔaq** region.

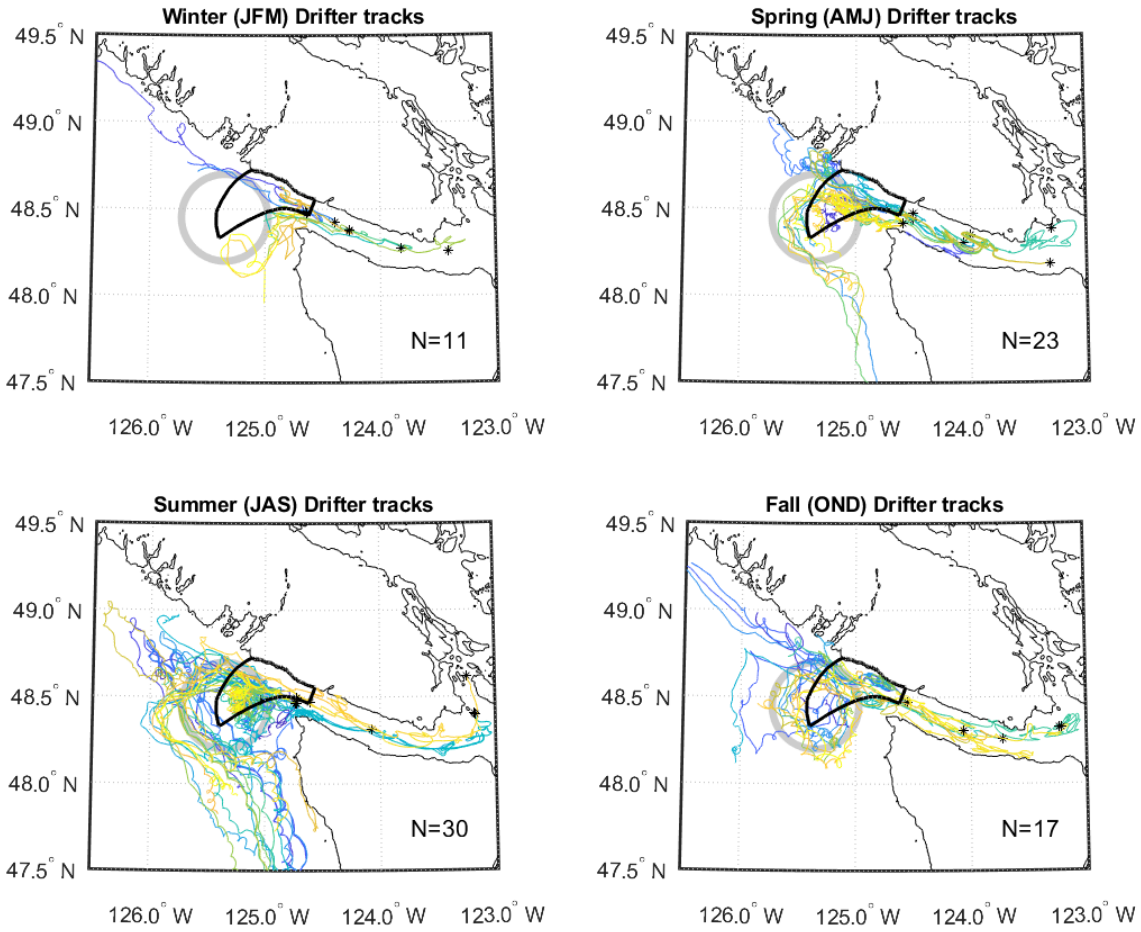


Figure 38. Surface drifter tracks during different seasons (Page et al. 2019; Hourston et al. 2021). Each colour represents a single track and its start (in that season) is marked with an asterisk. Most drifters only last one season such that there are a total of 81 seasonal tracks from 75 drifters. The bulk of the drifter data is from 2016 and 2017, but also includes tracks from 2015, 2018 and 2021. The boundary of the Juan de Fuca Eddy EBSA in the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area is shown in black and the approximate location of the Eddy is shown by the thick grey circles.*

3.2.7.4 Subsurface velocity observations

Repeated occupation of a mooring site within Juan de Fuca Eddy EBSA polygon provides information about the flow direction of subsurface waters entering/exiting the **ʎušiiʔaaʔaq**/Swiftsure Bank Area (Figure 39). The currents are roughly an equal mixture of tides – which, when fitted using the t_tide package (Pawlowicz et al. 2002), are dominated by semi-diurnal (M2; 12.42 h) and diurnal (K1; 23.93 h) periods – and estuarine flow through Juan de Fuca Strait. Near the surface the estuarine flow is towards the WNW, with peak flow rate of about 0.5 m/s. This is similar in amplitude to the tides (~0.4 m/s). The total (combined) surface current is often ~1 m/s and at times as high as 1.5 m/s to WNW. Closer to the bottom, at 150 m depth, the estuarine flow is ESE, with peak flow rate of about 0.3 m/s. This is now less than the tides (~0.4 m/s, similar to near surface). Thus, the flow reverses every tide at depth, but sometimes doesn't reverse near the surface.

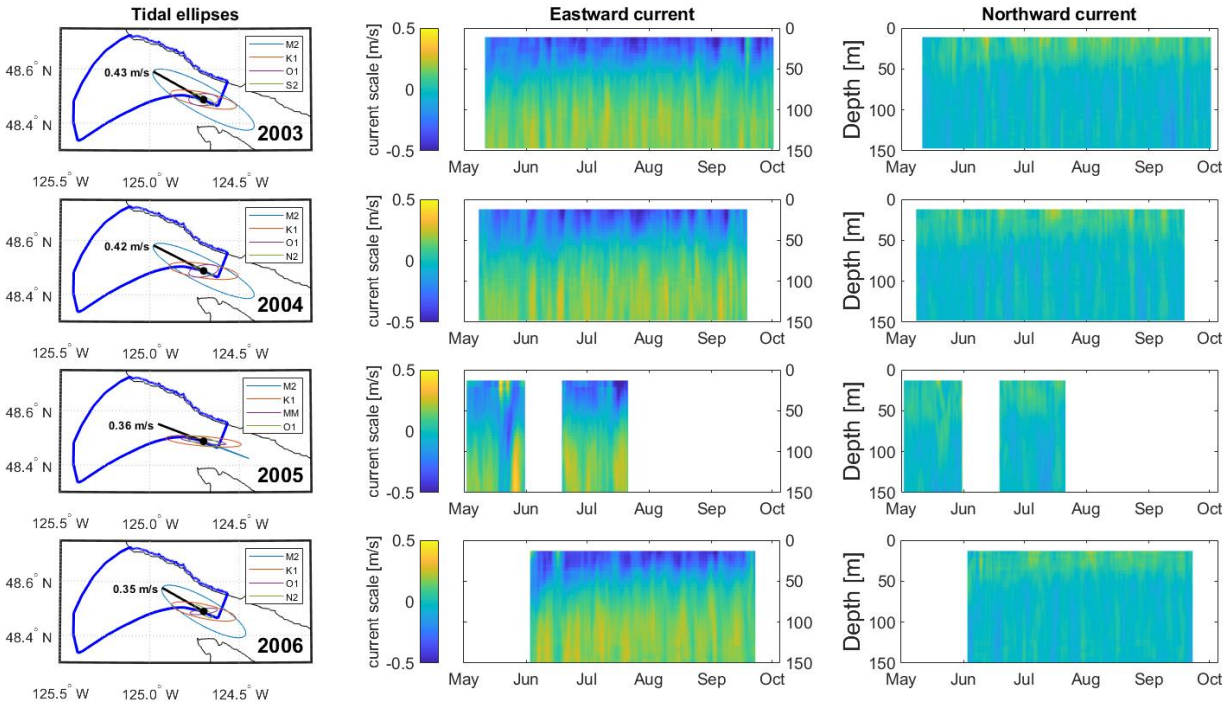


Figure 39. Subsurface currents from four ADCP mooring deployments (indicated by black dots in left hand panels) from Station EH1[23] inside the Áušiiʔaaʔaq/Swiftsure Bank Area, with the Juan de Fuca Eddy EBSA polygon delineated in blue on the maps. The left hand panel shows the tidal ellipses for the dominant tidal periods (indicated in the legend; M2 12.42 h, K1 23.93 h, O1 25.82 h, S2 12 h; N2 12.66 h; MM 27.55 d) and the black line indicates the amplitude of the M2 tide in the near surface ADCP bin (6-10 m depth). The middle panels show the full-depth eastward currents with the tides removed. The right-hand panels show the full-depth northward currents with the tides removed.

3.2.8 Surface water properties

3.2.8.1 Sea surface temperature (SST)

The longest time series of sea surface temperature (SST) in the region are from daily monitoring at twelve lightstations along the BC coast. The **Áušiiʔaaʔaq**/Swiftsure Bank Area is located between the Amphitrite Point and Race Rocks lightstations, located near Ucluelet and islands offshore of Metchosin, BC, respectively. Data records extend back to 1934 for Amphitrite Point, and to 1921 for Race Rocks. Statistically significant increases in SST have been observed at these lightstations, as well as lightstations coast-wide (discussed further in the Climate Change section; see the B.C. Lightstation Sea-Surface Temperature github page[24] for up-to-date data and trends). Further, the La Perouse Bank marine weather buoy (WMO ID 46206) is located to the northwest of the **Áušiiʔaaʔaq**, and collects hourly ocean surface temperature and other

[23] https://dmapps.waterproperties.ca/en/mooring/

[24]Data collected in the BC Shore Station Oceanographic Program can be visualized here: https://ios-osd-dpg.github.io/bc_lightstation_sst/

meteorological and oceanographic variables (see Figure 35). The Neah Bay buoy (WMO ID 46087), maintained by NOAA, collects similar information and is located along the south-eastern boundary of the **ʎušiiʔaaʔaq** on the USA marine border[25]. Hourly 360-degree photographs are also posted publicly from this buoy. The water intakes for these buoys are located at 2 m depth.

The long-term temperature data at these locations show similar, small (< 6°C) temperature ranges over the course of the year. These two lightstations have the warmest winter SST climatologies compared to the other lightstations in the monitoring program. Similarly, La Perouse Bank has the warmest winter temperature among the buoys maintained by ECCC and DFO along the BC coast (see 1991-2020 buoy climatology figure[26], and lightstation climatologies[27]). SST at La Perouse Bank is very similar to SST measured at the Amphitrite Point lightstation, ranging from ~8.5°C during January and February to ~14°C during peak temperatures in July and August. The temperature range is even smaller at Race Rocks, with a minimum of ~8°C to a maximum of ~12°C annually. Neah Bay water temperatures, while records begin later in 2004, show the same seasonal temperature range as Race Rocks.

Moderate-resolution (1 km) satellite data were used to supplement these observations, retrieving SST statistics within the **ʎušiiʔaaʔaq**/Swiftsure Bank Area based on the boundaries of the Juan de Fuca Eddy EBSA polygon. Satellite-measured SST has the advantage of greater spatial coverage compared to discrete station or buoy measurements, though typically has lower temporal resolution. Numerous studies have analyzed moderate-resolution (e.g., 300 m to 4 km per pixel) remotely sensed SST in the BC Exclusive Economic Zone (e.g., Jackson et al. 2015; Devred et al. 2021). Devred et al. (2021) compared concurrent satellite and buoy SST measurements, demonstrated a good agreement between these two sources, and emphasized the effectiveness of satellite SST for monitoring areas where no in-water measurements currently exist. Night-time SST from the MODerate Resolution Imaging Spectroradiometer (MODISA) assembled into a weekly climatology (2003-2023, Figure 40A) demonstrated that, within the **ʎušiiʔaaʔaq** Area, temperatures ranged from a minimum of ~8°C in January and February, to a maximum of 13°C in late July, with a consistent standard deviation of approximately ± 1°C. Further, weekly time series of MODISA SST over 2003 to 2023 (Figure 40B) emphasize seasonality differences between years. Notable events include winter SSTs that were at least 1°C higher compared to climatological values during the “Blob” years in 2015 and 2016.

[25] https://www.ndbc.noaa.gov/station_page.php?station=46087

[26] Regularly updated buoy SST plots for the Pacific EEZ can be found here: https://github.com/IOS-OSD-DPG/Pacific_SST_Monitoring

[27] Data collected in the BC Shore Station Oceanographic Program can be visualized here: https://ios-osd-dpg.github.io/bc_lightstation_sst/

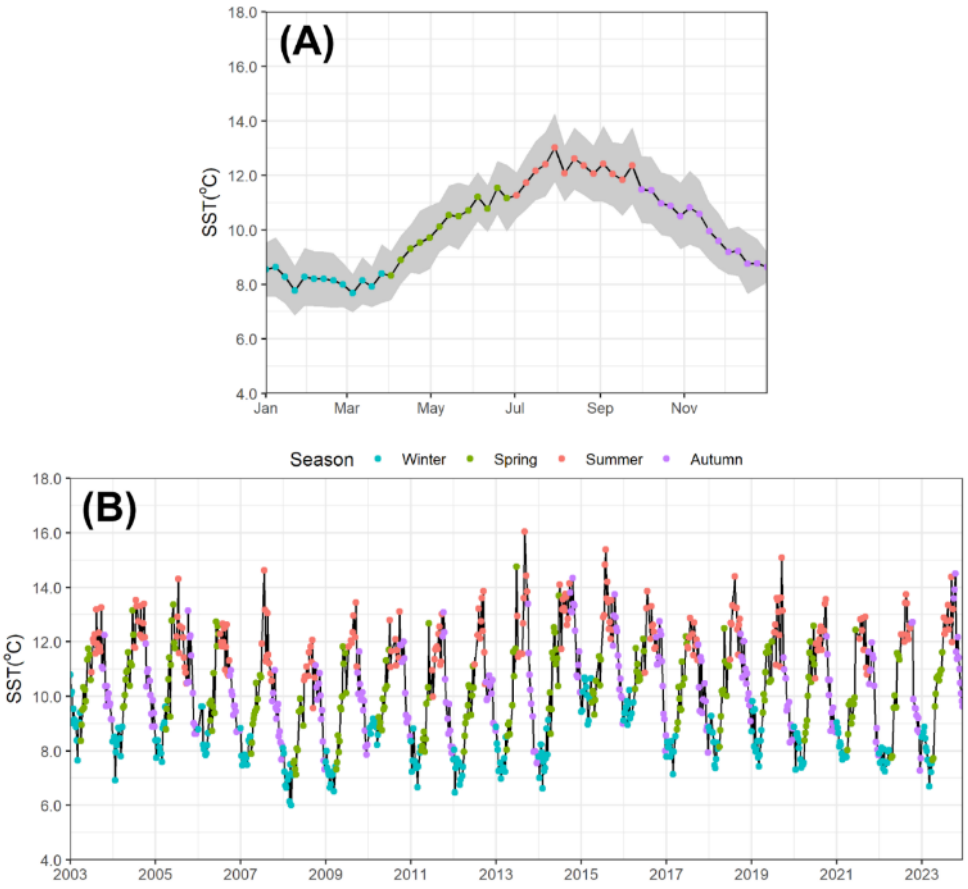


Figure 40. AH2. (A) Weekly mean MODISA night-time SST climatology of the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area, with shaded +/- 1 standard deviation, 2003-2023. (B) Weekly time series of satellite SST for the* ***ƛ̓ušiiʔaaʔaq*** *Area, coloured by season.*[28]

Spatially, the starkest gradients of SST are observed during January and during the summer months (Figure 41). During January, offshore waters that are warmer (9°C) compared to the coast and Strait of Juan de Fuca (7°C) impinge on the southwest corner of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Throughout the area, SSTs are more uniform to early spring, with cooler waters closer to shore. In April a more east-west temperature gradient develops, with cooler waters extending westward out of the Strait of Juan de Fuca intersecting the eastern half of the **ƛ̓ušiiʔaaʔaq** Area, a pattern that persists until autumn.

[28] Regularly updated buoy SST plots for the Pacific EEZ can be found here: https://github.com/IOS-OSD-DPG/Pacific_SST_Monitoring and data collected in the BC Shore Station Oceanographic Program can be visualized here: https://ios-osd-dpg.github.io/bc_lightstation_sst/

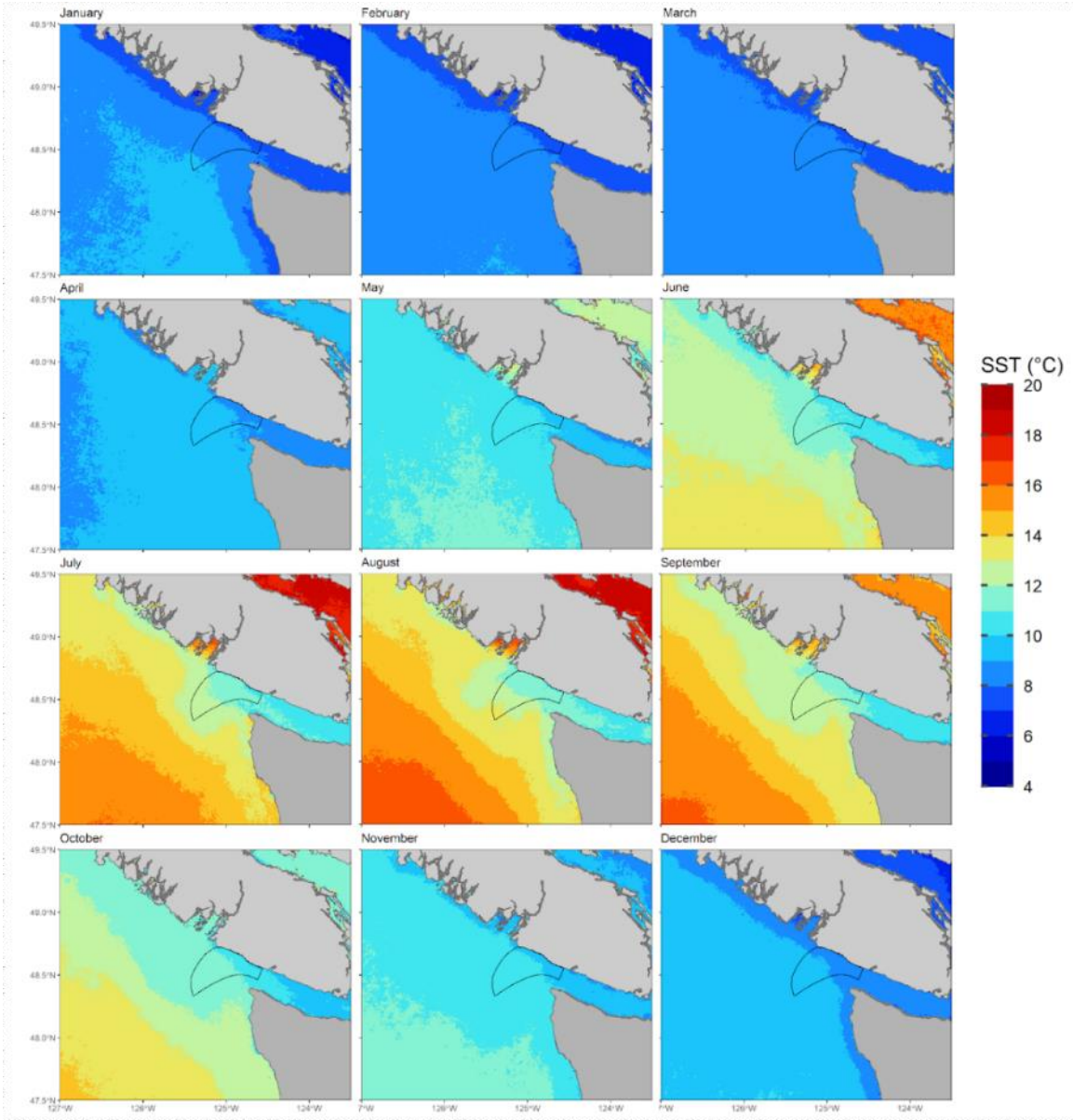


Figure 41. Monthly MODISA night-time SST composites, spanning 2003-2023[29]. The boundaries of the Juan de Fuca Eddy EBSA in the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area are indicated in black.*

Finally, as seen in higher resolution satellite SST imagery acquired from the Thermal InfraRed Sensor (TIRS) on the Landsat-8 satellite, smaller-scale gradients and surface features are present in the **ʎušiiʔaaʔaq**/Swiftsure Bank Area (Figure 42A,B). Mixing and freshwater inputs

[29] NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua SST Data; NASA OB.DAAC, Greenbelt, MD, USA. https://oceandata.sci.gsfc.nasa.gov/directdataaccess/Level-2/Aqua-MODIS/

can be seen contributing to SST variations. During summer, cooler surface features are visible west of Cape Flattery (e.g., upwelling as described in Foreman et al. 2008), while Barkley Sound and Nitinaht Lake are much warmer compared to the more exposed coastal areas (see Nitinaht lake section). On warm days with slack or ebbing tide, warmer waters of Nitinaht Lake can be seen entering into the **ʔušiiʔaaʔaq** Area through Nitinaht Narrows. Tidal motion also facilitates exchange of materials that can be seen in satellite imagery, including SPM and phytoplankton. Figure 42C is an example of showing a coccolithophore bloom in Nitinaht Lake transported out of the channel in summer 2023 (see Phytoplankton section).

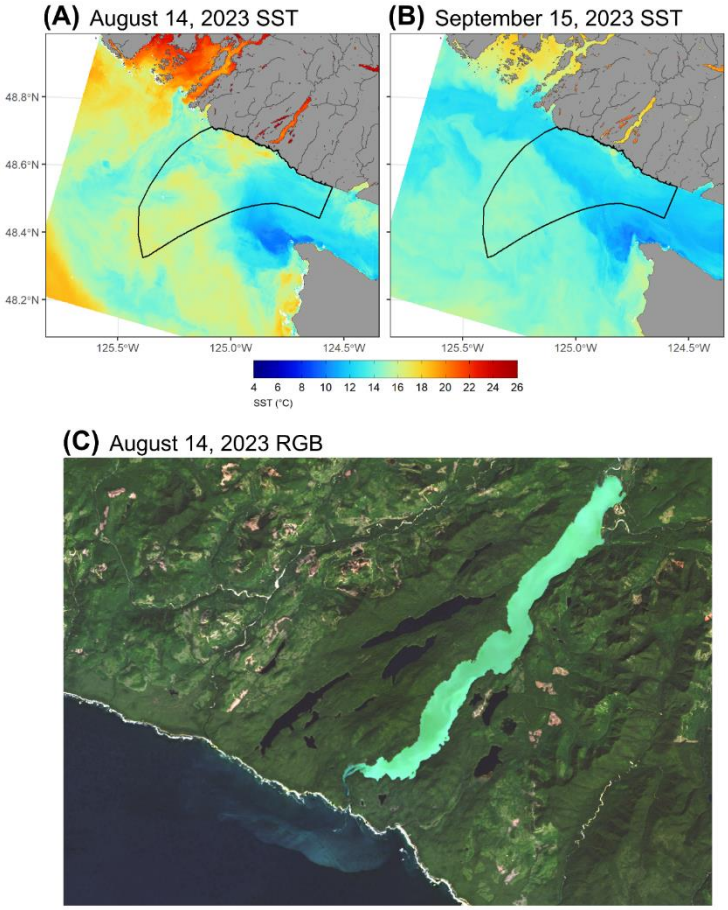


*Figure 42. Landsat-8 SST images from summer of 2023 (A-B)[30], showing temperature gradients throughout the area, and warm water entering the **ʔušiiʔaaʔaq**/Swiftsure Bank Area through Nitinaht Narrows. All images were acquired at approximately noon local time. The corresponding tides were slack (at peak), and rising tide nearing peak, respectively. (C) A true-colour image[31] from August 14th, 2023, same time as (A), showing an extensive coccolithophore bloom exchanging with open-ocean waters through Nitinaht Narrows.*

[30] USGS EarthExplorer. Level-2 SST data: Earth Resources Observation and Science (EROS) Center. (2020). Landsat 8-9 Operational Land Imager / Thermal Infrared Sensor Level-2, Collection 2 [dataset]. U.S. Geological Survey. https://doi.org/10.5066/P9OGBGM6

[31] Earth Resources Observation and Science (EROS) Center. (2020). Landsat 8-9 Operational Land Imager / Thermal Infrared Sensor Level-1, Collection 2 [dataset]. U.S. Geological Survey. https://doi.org/10.5066/P975CC9B

3.2.8.2 Light availability and optical conditions

Numerous factors impact the optical conditions of surface waters in coastal regions, which are typically loosely referred to as “Case-2” waters. “Case-2” broadly defines waters with high primary productivity with terrestrial inputs of coloured-dissolved organic matter (CDOM) and suspended particulate matter (SPM) (Morel and Prieur 1977), which includes much of the world’s coastal ocean as well as waters within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. At present, there are few existing public observations of optical parameters in the **ƛ̓ušiiʔaaʔaq** Area, though photosynthetically available radiation (PAR) data does exist in the Water Properties database maintained by DFO[32].

Concentrations of suspended particulate matter (SPM) in surface waters include particles of terrestrial origin, resuspended material, and phytoplankton cells. SPM can reduce light available in the water column, and provide food for zooplankton. Johannessen et al. (2006) examined the distribution and movement of suspended particles in the Juan de Fuca Strait to the east of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Juan de Fuca Strait was clear in the summer, while the **ƛ̓ušiiʔaaʔaq** Area was typically quite turbid during the winter. Additionally, satellite imagery from winter showed high surface concentrations of particles and suspended matter from northward transport of turbid coastal Washington surface waters (see Figure 6 of Johannessen et al. 2006). Beam attenuation coefficients measured in the eastern waters of the **ƛ̓ušiiʔaaʔaq** Area showed that attenuation at the surface of the ocean is typically elevated (e.g. > 1 m^{-1}) year-round and is more turbid relative to the Juan de Fuca Strait. This can indicate multiple processes at play, including increased mixing and resuspension during the winter, with higher attenuation during the spring and summer from phytoplankton blooms.

Further events that impact light availability through the water column in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area include phytoplankton blooms, particularly of coccolithophore species, which have highly reflective coccoliths (calcium carbonate plates) and can significantly reduce light penetration into the water column (Vance et al. 1998). Further information is provided in the Phytoplankton section.

3.2.8.3 Subsurface water properties

Since the 1970’s, the water properties in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank have been relatively well observed in the Spring and Summer, most recently by the La Perouse monitoring program conducted by DFO. Many of these observations have been analyzed and published, leading to our current understanding of the dynamics of shelf circulation near the mouth of Juan de Fuca and the dynamics of the Juan de Fuca Eddy (Freeland and Denman 1982; Hickey et al. 1991; MacFadyen et al. 2008; Klymak et al. 2023). Although not included in this analysis, there are even a few water property observations reaching back to the 1930’s, which led to the first solid evidence for the Juan de Fuca Eddy (Tully 1941).

Here we use the data from the last 50 years of observations to create climatologies of water properties along the La Perouse (LB) monitoring line that transects both the western side of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (based on the Juan de Fuca Eddy EBSA) and the typical location of the Juan de Fuca Eddy (as illustrated in the upper left corner of each of Figure 43, Figure 44 and Figure 45). First, all available profiles of water property data from samples taken

[32] https://www.waterproperties.ca/mainlogin.php?refer=/

along line LB were collected from the water properties database[33]. Then, climatologies were constructed by first averaging all profiles collected in a calendar month within 2 kms of an LB line station location (see Ross et al. (2020) for further methodological details) and then averaging across all Aprils, Mays and Junes at each station to create a representative Spring climatology and across all Julys, Augusts and Septembers to represent a Summer climatology. The resulting climatologies are show in Figure 43 (temperature, salinity and oxygen), Figure 44 (nutrients; nitrate plus nitrite, silicate and phosphate) and Figure 45 (photosynthetic active radiation, transmissivity and density).

Although there is known to be interannual variability in the location of the Juan de Fuca Eddy (e.g. MacFadyen et al. 2008), it can still be plainly seen in the climatological sections (Figure 42 - Figure 45). Note the summertime doming around 30-40 kms from shore of the deep lines of constant temperature, salinity, oxygen and density. In the vicinity of the Eddy, the water below about 20 m depth is denser, saltier, cooler and has less oxygen than during the spring (Figure 43 and Figure 45). These waters are also relatively nutrient rich (Figure 44). In the spring, the water is notably clearer in a band away from the coast but northeast of the typical Eddy location (1530 kms from shore in Figure 45).

[33] https://www.waterproperties.ca/mainlogin.php?refer=/

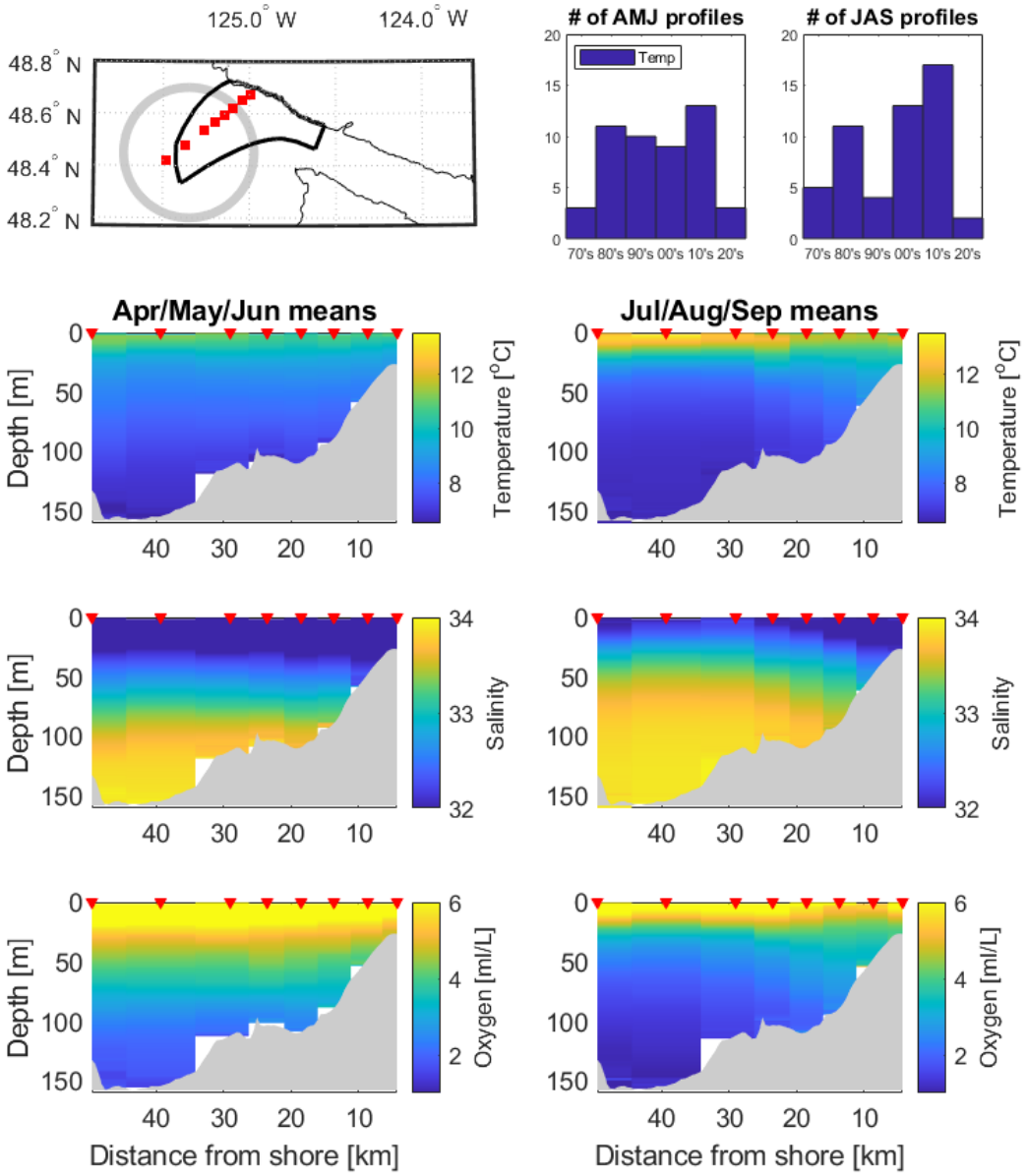


Figure 43. Section plots showing the spatial and seasonal variations of temperature, salinity and oxygen measured along the historical (La Perouse) LB monitoring line[34]. The location of the LB line within the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area (based on the Juan de Fuca Eddy EBSA delineated in black) is shown in the upper left hand panel. The grey circle on this map is the approximate location of the Eddy. In the upper right hand corner the two histograms show the number of temperature profiles that went into each seasonal average. The left hand column shows the average water property data for profiles collected in Spring (April, May and June). The right hand column shows the average water property data for profiles collected in Summer (July, August and September). There are far fewer data in other seasons, such that it was difficult to construct a climatology.*

[34] https://www.waterproperties.ca/mainlogin.php?refer=/

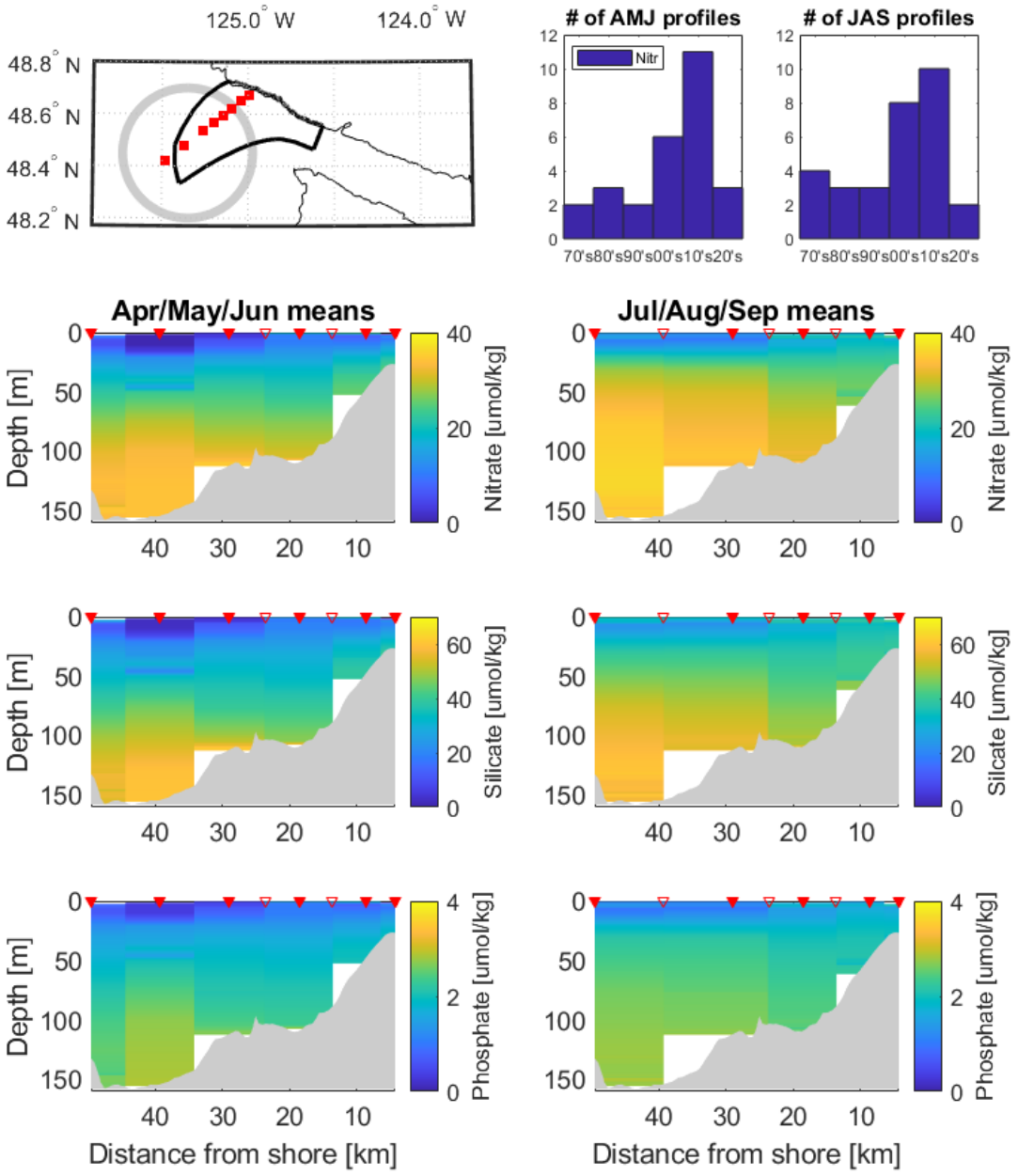


Figure 44. Section plots showing the spatial and seasonal variations of nitrate (plus nitrite), silicate and phosphate measured along the historical (La Perouse) LB monitoring line[35]. Similar to Figure 43 the upper left hand panel locates the observations within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area (based on the Juan de Fuca Eddy EBSA delineated in black). In the upper right hand corner the two histograms show the number of nitrate profiles that went into each seasonal average. The left hand column shows the average water property data for profiles collected in Spring (April, May and June). The right hand column shows the average water property data for profiles collected in Summer (July, August and September).*

[35] https://www.waterproperties.ca/mainlogin.php?refer=/

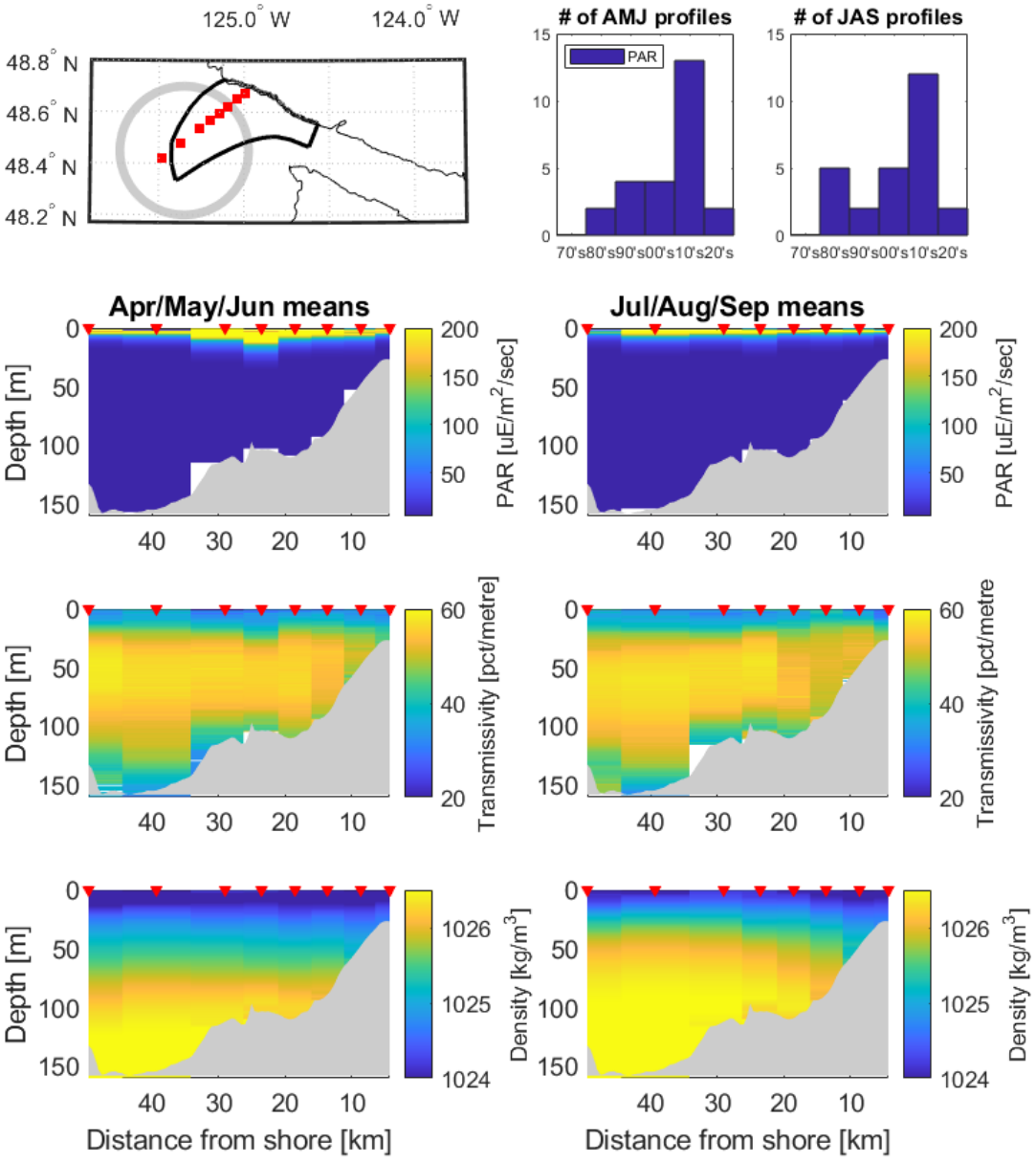


Figure 45. Section plots showing the spatial and seasonal variations of photosynthetic active radiation (PAR), transmissivity and density measured along the historical (La Perouse) LB monitoring line[36]. Similar to Figure 43 the upper left hand panel locates the observations within the ***ƛ̓ušii?aa?aq̓****/Swiftsure Bank Area (based on the Juan de Fuca Eddy EBSA delineated in black). In the upper right hand corner the two histograms show the number of PAR profiles that went into each seasonal average. The left hand column shows the average water property data for profiles collected in Spring (April, May and June). The right hand column shows the average water property data for profiles collected in Summer (July, August and September).*

[36] https://www.waterproperties.ca/mainlogin.php?refer=/

3.3 Data and Knowledge Gaps

Water properties

Water properties measurements have been more frequent on the south coast than along BC's north coast. Deployments of moored instruments collected data sporadically on currents, temperature, and salinity in the 1980s and 1990s. More recently, the DFO Ocean Acoustics team deployed hydrophone moorings in 2018 to record the soundscape in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, which will continue until at least March 2027 (end of current funding). This mooring is serviced three times a year (approximately every 4 to 5 months) to maintain continuous broadband (wide frequency range) recordings. The hydrophone is positioned approximately 2 m off the ocean floor, with other sensors attached to the mooring frame. Near-bottom oceanographic observations of temperature, salinity, dissolved oxygen, turbidity, and point velocities are made alongside the acoustic recordings. This mooring provides the bulk of winter measurements taken in the area, except for conductivity, temperature, and density (CTD) profile taken while servicing the mooring, and some historical ship-based surveys that have provided limited observations of winter conditions (Figure 46).

Current DFO programs that regularly collect ship-based measurements during the warmer months (April – September; bracketing the seasonal upwelling period) include the La Perouse (LB monitoring line, see Figure 43) and the Salish Sea Biophysical Survey on the western and eastern end of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (DFO 2021b). The La Perouse program measures water properties using electronic sensors and water collection from a CTD-rosette. This survey also includes zooplankton sampling using vertical net tows on the continental shelf, slope, and along the shelf break. The Salish Sea Biophysical survey program measures water properties at the eastern entrance of **ƛ̓ušiiʔaaʔaq**, and collect zooplankton tow samples much further east into the Strait of Juan De Fuca.

The lack of winter data is not necessarily problematic for understanding the physical processes that govern ocean conditions in the area. Instead, it represents mainly the challenge of monitoring the area in the future. For the last 7 years, winter upwelling of cold hypoxic water has been documented along the west coast of Vancouver Island from moored instruments north of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Hourston et al. 2021; Boldt et al. 2024; Hannah et al. 2024). It's unclear whether the winter upwelling is as intense over **ƛ̓ušiiʔaaʔaq**, or how the upwelled water further north might interact with the eddy and estuarine flow at the Juan de Fuca Strait entrance. Overall, there may be regime shifts in the region's major physical processes responsible for water exchanges at the entrance of Juan de Fuca Strait. Notably, the shifts in magnitude and timing of peak freshwater inputs relative to changes in offshore wind regimes alter the deep exchanges over **ƛ̓ušiiʔaaʔaq**.

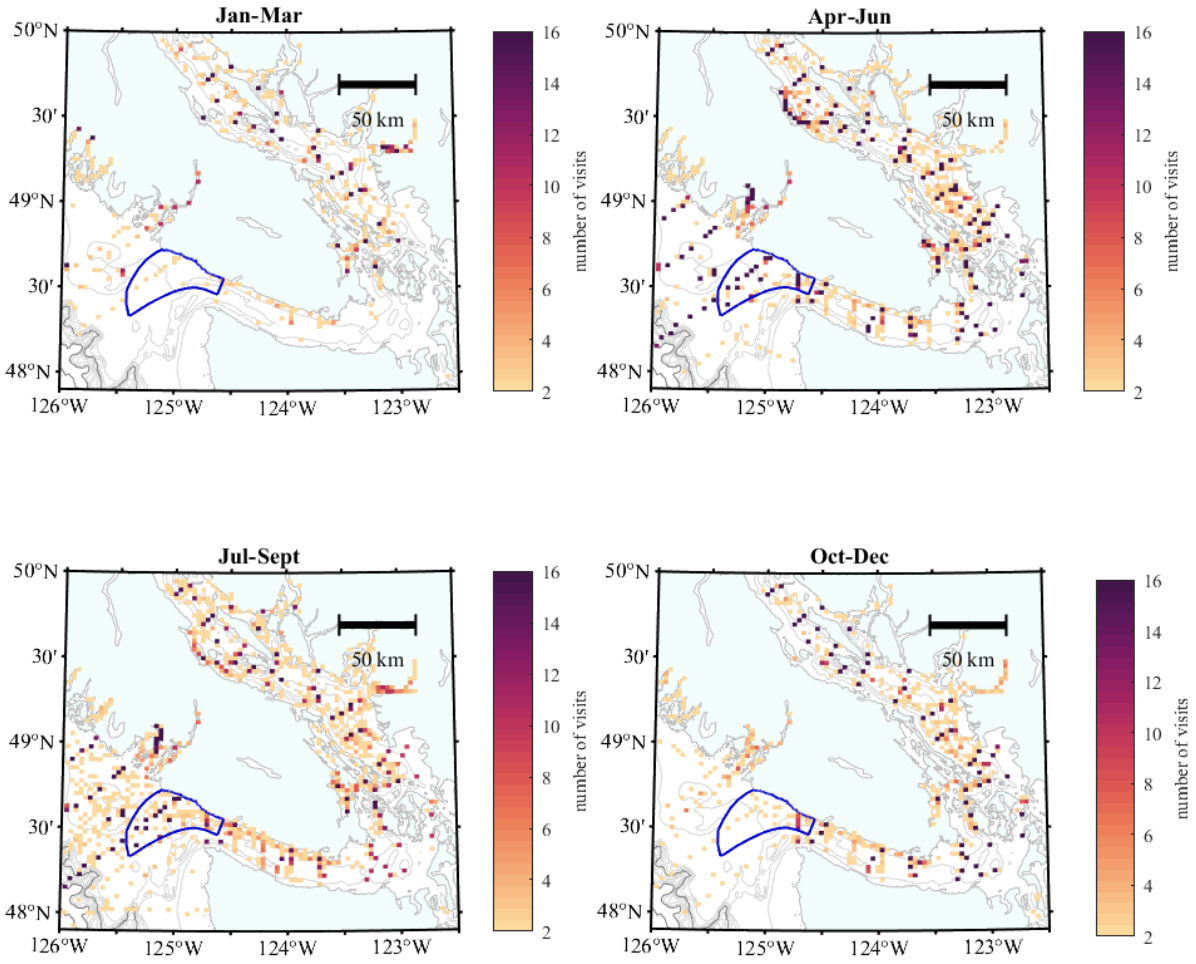


Figure 46. Spatial distribution of DFO's ship-based vertical profile measurements for each season around the southern half of Vancouver Island[37]. The conductivity-temperature-depth (CTD) profiler typically measured fluorescence since the late 1990s and dissolved oxygen since 2009. The extent of the ***ʎušiiʔaaʔaq****/Swiftsure Bank Juan de Fuca Eddy EBSA is delineated in light blue. The colors represent the number of distinct casts from July 1965 to July 2023 for areas visited more than once. Visits within* ***ʎušiiʔaaʔaq*** *proposed boundaries began in January 1978.*

Satellite imagery

Satellite data can significantly improve spatial and temporal monitoring of surface water properties, particularly for remote areas where physical sampling is challenging. Data availability and spatio-temporal resolution of satellite imagery have implications for which marine variables can be described. While satellite SST is well studied for larger areas of the BC, Alaska, and Washington continental shelf, ocean colour satellite studies (including optical properties of constituents in the water column) remain an area where further study is needed, paired with collection of *in situ* samples that can be used to validate satellite algorithms. Several studies have validated satellite parameters in coastal BC waters, although the majority focus on Chl-a

[37] https://www.waterproperties.ca/

or optical variables in the Strait of Georgia (e.g., Komick et al. 2009; Carswell et al. 2017; Clay et al. 2019; Pramlall et al. 2023). Giannini et al. (2021) additionally validated suspended particulate matter (SPM) and colour dissolved organic matter (CDOM) in BC coastal waters.

The ocean surface is obstructed by cloud cover a great deal of the time, and conditions such as low sun angles or sun glint cause data losses for satellite datasets, although these typically have a lesser impact when acquiring SST at night). Combined data losses typically impact the spatio-temporal coverage most during winter. However, the cloud coverage of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is notable (Figure 47), as it appears to be higher compared to other areas of the BC coast. During winter and spring, spatial coverage of satellite SST data is generally consistent throughout the wider Southern Shelf Bioregion and Strait of Georgia. However, during summer, nightly satellite images from 2003-2020 showed that surface waters of the **ƛ̓ušiiʔaaʔaq** Area are imaged much less frequently, with lowest observations in a band extending northward along the Washington coast towards Barkley Sound, and in the western half of Juan de Fuca Strait. The difference in data availability throughout the area is most notable in August and September, with waters further offshore having data on ~25% of nights, the Strait of Georgia exceeding 30%, while the **ƛ̓ušiiʔaaʔaq** Area is clear for satellite imaging less than 10% of the time. By October, observations are more consistent between regions, with SST measurements of the ocean surface captured 20-25% of the time throughout the area.

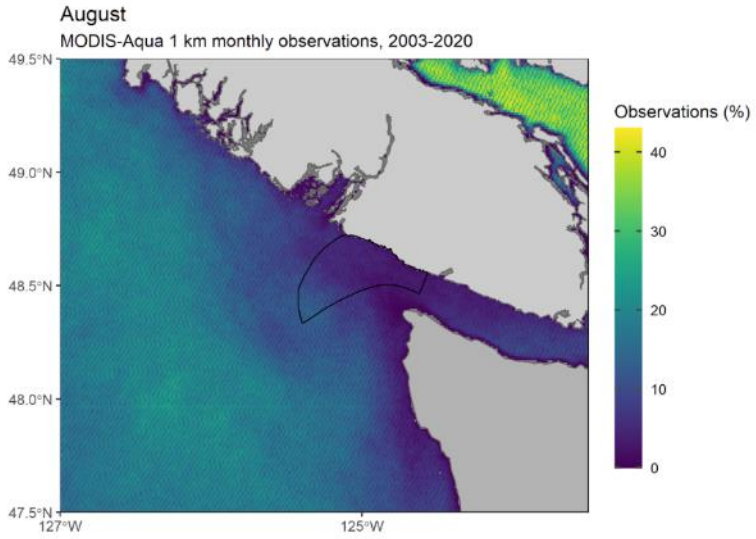


*Figure 47. MODISA SST observed in August (2003 to 2020)[38], showing the percent of nights with SST observed at each pixel. The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is obscured for much of the time from June to September. Areas of low coverage adjacent to the coastline are also evident, as pixels are usually discarded due to land contamination.*

Nearshore Sediments, Benthic Floor and Oceanography

[38] NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua SST Data; NASA OB.DAAC, Greenbelt, MD, USA. https://oceandata.sci.gsfc.nasa.gov/directdataaccess/Level-2/Aqua-MODIS/

There is a lack of high resolution substrate and bathymetric data in the intertidal zone and nearshore environments, sometimes referred to as the ‘white stripe’ that are inaccessible to monitoring equipment such as multibeam and sidescan sonar. The data gap limits our ability to understand and quantify important nearshore ecological processes that would enhance our understanding of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. A similar lack of high resolution oceanographic data (e.g., salinity, temperature, circulation) in the ‘white strip’ limits our ability to understand nearshore oceanographic processes that could inform species distributions, spill response planning and invasive species management, among others. Further, understanding seasonal and interannual sediment dynamics, and how this influences the nearshore habitats (e.g., Pacific Sand Lance burying habitat, eelgrass, infaunal bivalve habitat) would be beneficial and requires both high resolution nearshore seafloor substrate and oceanographic data.

4 CLIMATE CHANGE

Climate change is altering the ocean's physio-chemical properties as global temperatures and atmospheric carbon dioxide increase. These changes in seawater temperature, chemistry, and oxygen will have notable consequences for marine life, impacting their distribution, fitness and survival, and phenology (Cheung et al. 2009; Poloczanska et al. 2016). Warming and freshening trends have been observed at numerous lighthouse stations along the BC coast, where water samples have been collected daily for decades (Cummins and Masson 2014), as well as by Indigenous land users. The long-term warming rate of stations with data beginning in 1921 (Race Rocks) and 1934 (Amphitrite Point) extending to 2012 are 1.39 and 0.71˚C per century, respectively, in comparison to a coastwide value of 0.96˚C per century (Donnet et al. 2023). Like many other coastal regions in the world, BC’s coastal seawater is warming more rapidly than the global average warming rate of sea surface temperature (Amos et al. 2015). Additionally, a warming trend is projected into 2070 by two different regionally downscaled climate change models (Peña et al. 2019; Holdsworth et al. 2021) detailed below. Alongside increases in mean seawater temperature, climate change is causing an increased frequency and intensity of extreme heat events, including aerial and marine heatwaves (Oliver et al. 2021). These events can cause mass mortality events across intertidal and marine systems (Raymond et al. 2022). As air and water temperatures rise, the dissolved oxygen content of the ocean declines and oxygen demand from organisms increases. In addition, rising atmospheric carbon dioxide levels increase the seawater acidity as carbon dioxide is absorbed, lowering the pH. Finally, climate change is leading to rising sea levels, which can disrupt shoreline biophysical processes and lead to reduced habitat and altered ecosystem function.

Research on the impact of climate change on oceanic conditions in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, particularly in Barkley Sound, has highlighted the impact of climate change on oceanic conditions. Foreman (2014) projected an increase in sea surface temperatures and a decrease in salinities, with implications for the region's estuarine flow and coastal currents. Below, projected climate change events within the **ƛ̓ušiiʔaaʔaq** Area are presented. This includes a discussion of future changes to ocean environmental variables and a short literature review of inland and nearshore changes, including freshwater inputs. The studies reviewed underscore the complex and dynamic nature of the marine environment in the region, and the need for further research to understand and mitigate the impacts of climate change.

Marine species generally shift their ranges in response to environmental change, tracking favourable conditions (e.g., deeper, colder waters, where their physiological tolerances and dispersal abilities allow); however, low oxygen will limit how deep they can shift (Magris et al. 2016; Lenoir 2021; Thompson et al. 2023b). Further details on projected changes in groundfish distributions due to climate change can be found in Section 6.2.4.3. Shifts in distribution, abundance, and survival of marine fish and invertebrate species associated with climate change are anticipated to bring changes, both positive and negative, to commercial and recreational fisheries. As summarized in a recent presentation (B. Connors, DFO, pers. comm.), these changes may include changes in harvesting areas (ISCT 2023), increased bycatch (Sabal et al. 2023), shifts in catch potential (Weatherdon et al. 2016), and increased fisheries collapses (Litzow et al. 2023).

Addressing the potential impacts of climate change on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank is in keeping with the three Nuu-chah-nulth sacred principles - **Hišuk ma c̓awak** (everything is one and connected), **ʔiisaak** (greater respect) and **ʔuuʔałuk** (taking care of present and future generations and the resources provided by the land and the natural world).

"The environment will always be there for us as long as we take care of it…
[w]e have to maintain a balance of what we take from the environment
and what we put back."
Harry Brossault, a WitWak guardian of Huu-ay-aht

4.1 Projected changes to ocean environmental variables

Projected future seasonal environmental conditions for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area were calculated using four models, which differed in their input variables: a Canada-wide sea level change model based on increases in the volume of water in the oceans under a Representative Concentration Pathways (RCP) emissions scenario (RCP 8.5) and the vertical motion of the Canadian coastline (CanCoast 2.0[39]; Manson et al. 2019); a Canada-wide significant wave height model that included the effect of sea ice projected for 2090-2099, which is an ensemble model of five projections of climate variables under a RCP 8.5 emissions scenario (Manson et al. 2019); and two regional ocean models that downscale the global climate model projection under two RCP emissions scenarios (RCP 4.5 and RCP 8.5) while considering the complex bathymetry and ocean currents in this region. The first regional ocean model is the Northeastern Pacific Canadian Ocean Ecosystem Model (NEP36-CanOE; Holdsworth et al. 2021), which provides a historical baseline for 1986-2005 and a future projection for 2046-2065. The second is the BC Continental Margin Model (BCCM; Peña et al. 2019), which provides a historical baseline for 1981-2010 and a future projection for 2041-2070. Model outputs include potential temperature and aragonite saturation state for **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank's benthic and sea surface layers and dissolved oxygen for the benthic layer (*sensu* Friesen et al. 2021). We only report model outputs for the noncoastal regions of the **ƛ̓ušiiʔaaʔaq** Juan de Fuca Eddy EBSA (Figure 48) due to the uncertainty involved with the models in nearshore areas because they do not account well for bathymetry, narrow channels between islands, and varying water flow. RCP 4.5 is a moderate scenario in which emissions peak around 2040 and decline. RCP 8.5 is the highest baseline emissions

[39] https://ostrnrcan-dostrncan.canada.ca/entities/publication/caff0f1b-6adb-4470-be2c-d4461cf29793

scenario in which emissions continue to rise throughout the twenty-first century. A subsequent analysis of these four models was run for the **ʎušiiʔaaʔaq** Juan de Fuca Eddy EBSA and is detailed below.

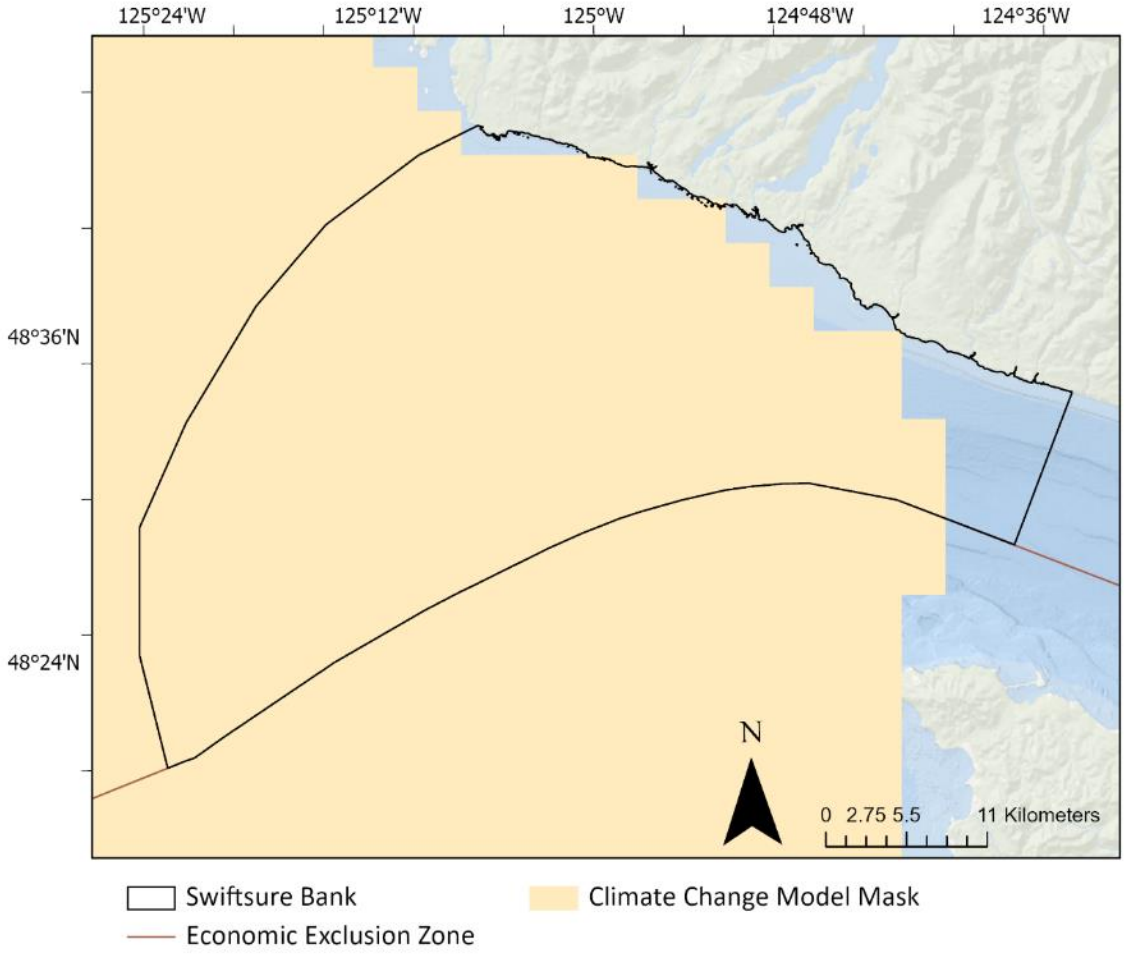


Figure 48. BCCM (Peña et al. 2019) and NEP36-CanOE (Holdsworth et al. 2021) mask extent (shown in yellow) highlights where model outputs are reported. Black line delineates boundary of Juan de Fuca Eddy EBSA.

4.1.1 Sea level rise and wave height

Sea level rise threatens intertidal areas and associated estuaries worldwide (Elmilady et al. 2019). The current global rate of sea level rise is the highest in 200 years and is expected to increase by another 0.2 to ~ 2.0 m by 2100 (Elmilady et al. 2019). These rates are expected to cause permanent submersion and alteration of intertidal ecosystems and increased salinity in salt marshes (Thorne et al. 2012; Elmilady et al. 2019). Other impacts include the conversion of wetland habitat types (e.g., palustrine wetlands to estuarine wetlands, unconsolidated shore, or open water; (Thorne et al. 2012; Elmilady et al. 2019; Gittman et al. 2019), shoreline erosion (Thorne et al. 2012), coastal squeeze in regions with coastal development or hard shorelines,

and increased inundation and flooding (Thorne et al. 2012). Within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, sea level rises of between 0.525 and 0.625 m are projected for 2099 compared to the base year of 2006 throughout the coastline (Figure 49**A**). The CanCoast dataset also includes a Coastal Sensitivity Index, a relative measure based on the coastal area's geomorphic conditions (coastal materials, slope, presence of ground ice) and potential climate forcings (sea-level change, wave height change including the effects of changing sea ice). In comparison to other places in the Pacific Region and the rest of coastal Canada, the range of sea level rise increases projected for the **ƛ̓ušiiʔaaʔaq** Area have a Coastal Sensitivity Index of 4 (with 5 being the highest sensitivity) (Manson et al. 2019).

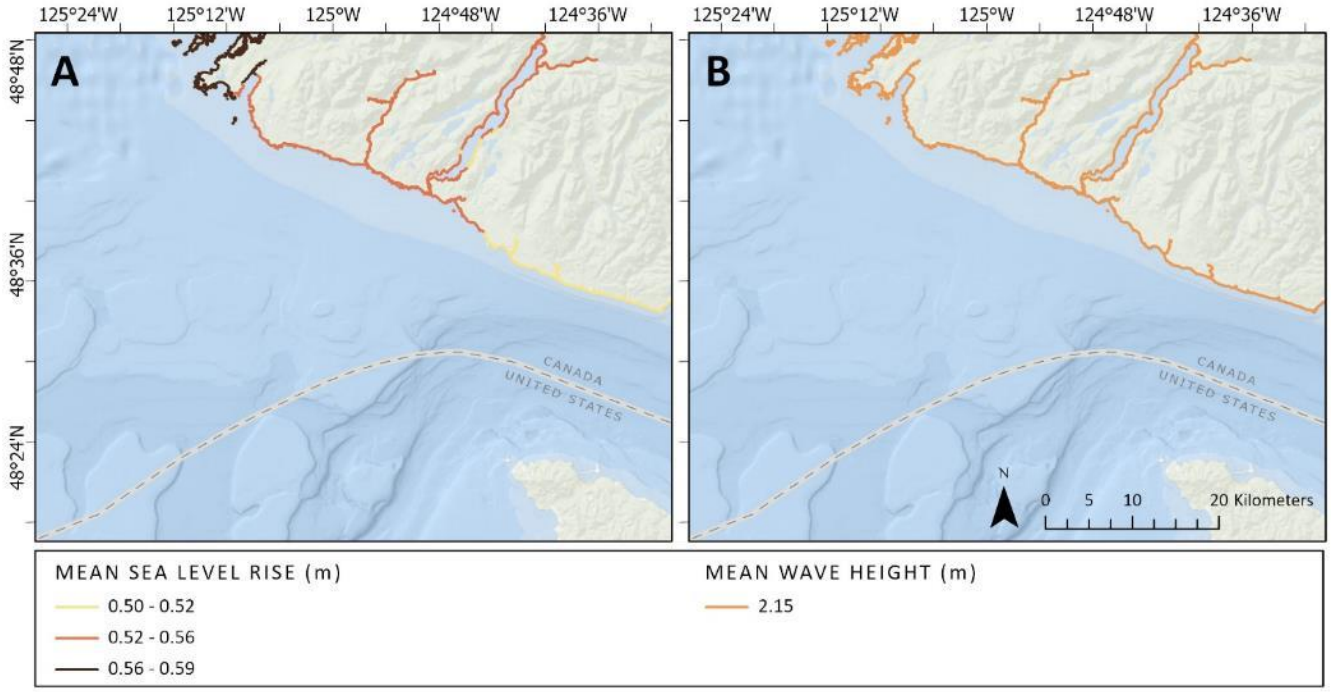


*Figure 49. (A) Sea level rise, in meters, between 2006 and 2099, for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. The sea-level change used here combines a global sea-level change model (RCP 8.5) and a model of vertical land motion for Canada (CanCoast 2.0[40]; Manson et al. 2019). (B) Decadal mean significant wave height, in meters, projected for 2090 to 2099 based on an RCP 8.5 high-emission scenario from CanCoast 2.0.*

Sea level rise poses significant risks to estuarine environments and coastal communities in BC, including impacts to infrastructure, freshwater availability, estuarine hydrodynamics, eutrophication, and expansion of invasive plants (reviewed in Robb et al. in press). Sea level rise affects estuarine hydrodynamics, including tidal wave amplification, dampening, and reflection (Khojasteh et al. 2021). Species responses to sea level rise are variable; it threatens vegetation in inundated areas and vertebrate communities (birds) where their prey populations are impacted by changes in salinity, sedimentation, and available habitat. Furthermore, eelgrass populations are affected by reductions in irradiance with sea level rise during El Niño events (reviewed in Robb et al. in press). While the projected sea level rise for the coast of the

[40] https://open.canada.ca/data/en/dataset/73714ed4-a795-a7ae-7e93-36100ce7c242

ƛ̓ušiiʔaaʔaq/Swiftsure Bank Area has a lower coastal sensitivity index, the effects of sea level rise on inland estuarine and marshland areas should be considered separately and carefully as changes to those ecosystem dynamics could have cascading impacts on the study area. For example, changes in tidal inundations and access to important salmon-bearing rivers may have negative impacts on salmon populations through the loss of significant estuarine holding and rearing habitat (i.e., the expansive Cheewaht River estuary), and changes in salinity, sedimentation, and available freshwater spawning habitat (i.e., the Nitinaht River).

Wave height is a potentially changing environmental variable with climate change. Warming ocean temperatures and extreme wind speeds increase wave energy and can result in increased coastal erosion, flooding and habitat modification (Reguero et al. 2019). Globally, wave power has increased by 0.4% per year since 1948 (Reguero et al. 2019). The highest projected mean decadal coastal wave heights in Canada are in the Pacific Region and the Eastern Maritime provinces (Figure 5 in Reguero et al. 2019). Within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, projected wave heights for 2090-2099 are between 2.090 and 2.287 m (mean 2.15 m; Figure 49**B**) in comparison to the higher range documented in 1996-2005 of 2.159 to 2.372 m. The Coastal Sensitivity Index for wave height in this area ranges from 4 to 5 (with 5 being the highest). Note that additional coastal features, including the slope of the coast, tidal ranges, and coastal materials, will influence the degree to which wave action will affect these coastal regions (Manson et al. 2019).

Changes in both sea level rise and wave height will also impact middens and First Nation cultural sites within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and along the west coast of Vancouver Island. Combined with potential increases in storm frequency and wave action, these exposed coastlines are vulnerable to continued negative pressures.

4.1.2 Ocean temperature

Ocean temperatures are warming and the frequency and severity of extreme heat events (e.g., marine heatwaves) is increasing (Oliver et al. 2021). Temperature affects the physiology of many marine organisms (Huey et al. 2012) that are already living close to their thermal tolerances (Pinsky et al. 2019) and warming associated with climate change has negative impacts on marine organism health and survival (Harvey et al. 2013). Consequently, marine organisms will have to acclimate, genetically adapt, or adjust their geographic distributions to match their physiological tolerances and habitat requirements to rising water temperatures (Schiffer et al. 2014). Increasingly, range shifts are being observed across multiple marine taxa, including marine birds (Poloczanska et al. 2016), 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 interactive effects of temperature, hypoxia, hypercapnia, and other climate-related properties can lead to unexpected ecosystem shifts and varied impacts on the abundance and distribution of marine taxa (Côté et al. 2016; Kroeker et al. 2017). For example, a meta-analysis of climate change studies (Hu et al. 2022) suggests that higher trophic level marine species have a higher tolerance for ocean acidification but greater sensitivity to increasing ocean temperatures. Furthermore, marine herbivores are the most vulnerable to acidification and warming (Hu et al. 2022). Overall, species vulnerability depends upon both organismal traits (e.g., calcification, developmental strategy, life-stage, and mobility), and environmental context (e.g., how quickly local environments are changing and in what

ways). Refer to section 6.2.4.3 for a discussion on climate change impacts to groundfish species.

Two climate models have been used within the Pacific Region to investigate projected changes to oceanic physical variables under two different climate change scenarios (BCCM: Peña et al. 2019, and NEP36-CanOE: (Holdsworth et al. 2021). Projections from the BCCM regional ocean model (Peña et al. 2019) predict mean seawater temperatures to increase by at least 0.71°C before 2070 in the benthic layer and 1.38°C in the surface layer for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area under the RCP 4.5 emissions scenario (Figure 50). The NEP36-CANOE (Holdsworth et al. 2021) projections are for higher seawater warming, with maximum increases in mean seawater temperatures of 1.96°C before 2065 in the benthic layer and 2.41°C in the surface layer for the **ƛ̓ušiiʔaaʔaq** Area across seasons (Figure 50). The RCP 4.5 scenario is more conservative than the RCP 8.5 scenario, so the bottom and surface layers have lower projected warming. Temperature change values are higher than threshold values in the Fall and Summer under NEP36. Despite these differences, both models show a warming trend in the **ƛ̓ušiiʔaaʔaq** Area across seasons and deep and shallow depths (Figure 50).

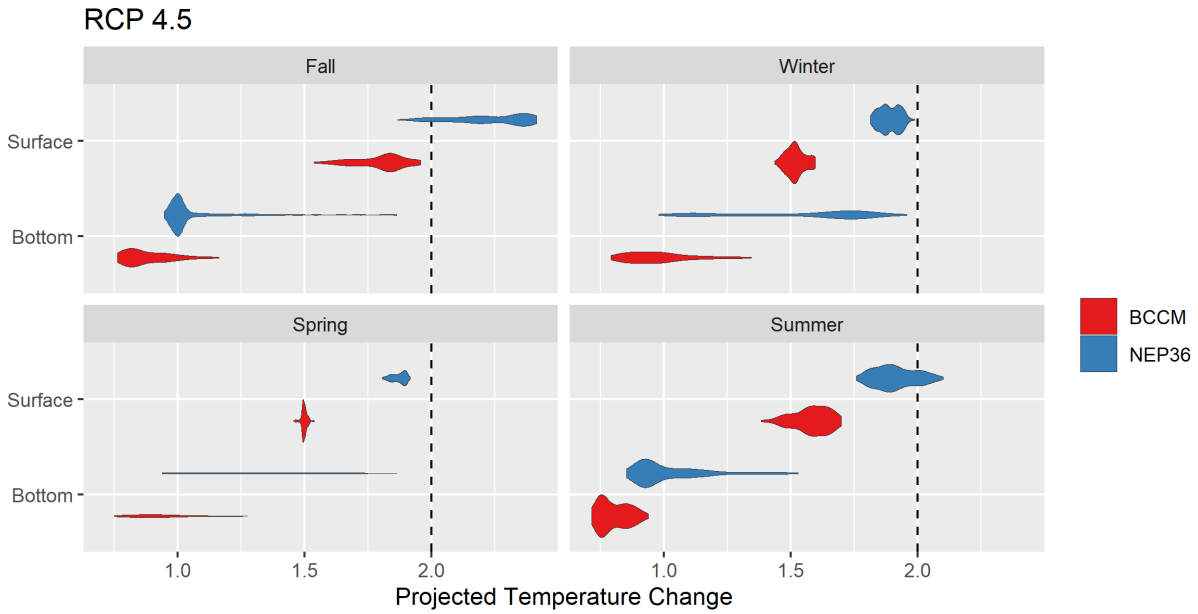


*Figure 50. Violin plots of projected temperature changes (˚C) within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The projected future period is 2041-2070 for BCCM and 2046-2065 for NEP36-CanOE under the RCP 4.5 emissions scenario (see Appendix D for RCP 8.5) in comparison to the historical period of 1981-2010 for BCCM and 1986-2005 for NEP36-CanOE. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows changes in temperature > 2˚C, a potential critical threshold value for biological functioning of marine life.*

4.1.3 Ocean acidification and aragonite

Ocean acidification is the chemical process where carbon dioxide enters the marine environment and forms carbonic acid and hydrogen ions, leading to increased seawater acidity (pH declines) and a reduction in the availability of carbonate ions (Fabry et al. 2008). Aragonite, a biogenic form of calcium carbonate, is widely used by marine organisms with calcium carbonate structures to create their shells and skeletons. A decrease in carbonate ions and increase in hydrogen ions decreases these organisms' ability to form and maintain hard carbonate structures, particularly for larvae and juveniles (Fabry et al. 2008; Przeslawski et al. 2015). Consequently, aragonite serves both as a measure of ocean acidification (in relation to carbon dioxide levels) and as a measure of available carbonate ions to organisms such as corals, bivalves, and some plankton. Corals and other calcifiers are more likely to have their shells and other carbonate structures dissolve when aragonite levels drop below one (undersaturation; Miller et al. 2009). Species that belong to this at-risk group and which occur in the **ǰušiiʔaaʔaq**/Swiftsure Bank Area include corals, scallops, urchins, Geoduck (Panopea generosa), California Mussel (Mytilus californianus), clams from Pandora and Macoma genera, and sea cucumbers (see Invertebrates). Projected values for aragonite in the benthic and surface layers of **ǰušiiʔaaʔaq** fall before the threshold of Ωa < 1 only in the benthic layer and in all seasons under the BCCM model, and only in Fall and Summer under the NEP36 model (Figure 51). Values fall as low as 0.63, with implications for the carbonate structures of **ǰušiiʔaaʔaq** invertebrate populations. Saturation states also change with latitude, and are typically highest in the tropics. This is due to the solubility properties of calcium carbonate, being less soluble in lower-pressure and higher-temperature waters (Fabry et al. 2008). The impact of a particular aragonite saturation state may also vary by species (Miller et al. 2009; Ross et al 2020). Currently, signals for ocean acidification (including increased hydrogen ion concentrations and reduced aragonite saturation states) are greater on average along BC's coast than the global average (Evans et al. 2022).

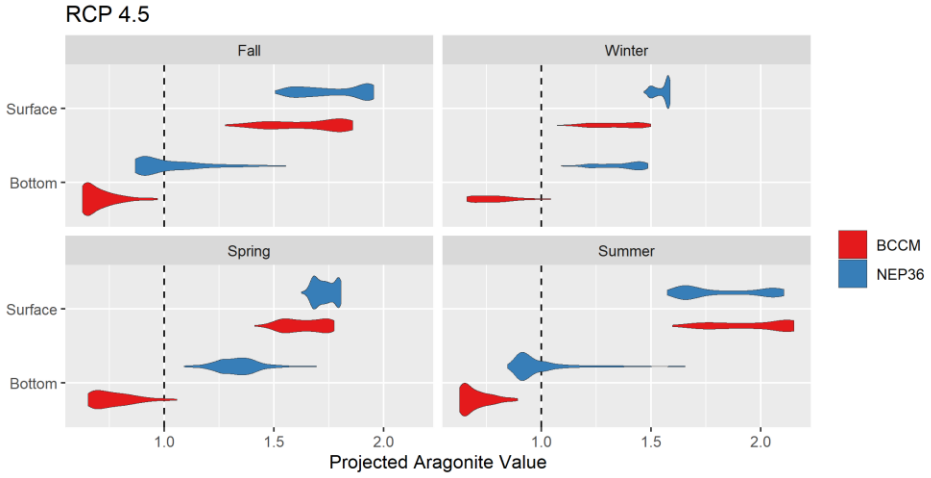


*Figure 51. Violin plots of projected seasonal aragonite saturation states within the **ǰušiiʔaaʔaq**/Swiftsure Bank Area using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The projected future period is 2041-2070 for BCCM and 2046-2065 for NEP36-CanOE under the RCP 4.5 emissions scenario (see Appendix D for RCP 8.5). Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows Ωa < 1, a potential critical threshold value for biological functioning of marine life.*

4.1.4 Oceanic oxygen conditions and hypoxia

Most water-breathing animals have a specific oxygen level required to meet aerobic requirements (Seibel 2011). Below this level, impairment of physiological processes (e.g., cell growth) may occur. Hypoxia effects differ among species, as their physiological threshold varies greatly (Rabalais et al. 2010) and can differ between areas (e.g., crustaceans in different areas have different tolerances). However, the upper threshold of hypoxic conditions for marine life ranges from 62.5–157 µmol/L, depending on the taxa used for defining the threshold (Gobler and Baumann 2016). For this report we use the upper value of 157 µmol/L to describe hypoxic bottom waters, although lower oxygen levels may still impact marine life, with the response to low oxygen levels varying between species (Rabalais et al. 2010; Ross et al 2020). Model coverage is limited to the outer areas of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank for ocean oxygen concentrations. Hypoxic bottom waters < 157 µmol/L are not observed in the historical period, nor are they projected to occur in future periods (Figure 52). **ƛ̓ušiiʔaaʔaq** is located on the continental shelf within a narrow bathymetric depth range of 0 to 262 m, with mean depths of 105 m (see Bathymetry). The benthic oxygen concentrations do not drop below the lower limit of the threshold range (62.5 µmol/L) but do drop below the upper limit of 157 µmol/L. The minimum oxygen concentration projected is 103.6 µmol/L under RCP 4.5 and 104.1 µmol/L under RCP 8.5. While depth-related oxygen loss between 300 and 1000 m is projected to impact marine species negatively, causing some species to shift to shallower depths, including into the depth range present in **ƛ̓ušiiʔaaʔaq**, model selection influences the projected oxygen changes, and considerable uncertainty exists for this region (Thompson et al. 2023b).

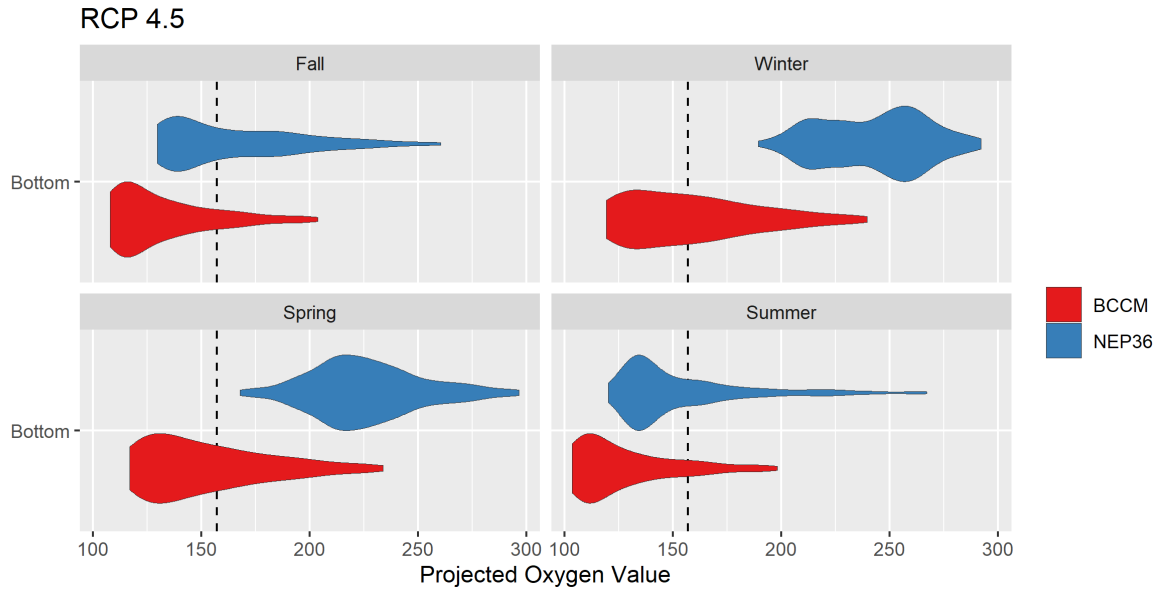


*Figure 52. Violin plots of projected seasonal sea bottom dissolved oxygen (µmol/L) within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The projected future period is 2041-2070 for BCCM and 2046-2065 for NEP36-CanOE under the RCP 4.5 emissions scenario (see Appendix D for RCP 8.5). Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows dissolved oxygen < 157 µmol/L, a potential critical threshold value for biological functioning of marine life.*

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; Ross et al. 2020). Species redistributions have cascading ecological effects, including forming new ecological communities and altering food webs (Doney et al. 2012). Within benthic marine communities, severe hypoxia on continental shelves and in coastal zones can result in an expansion of microbial mats, the emergence of infauna, species migration, and species attrition in extreme events (Levin et al. 2009). Mobile fish species can often avoid the deleterious effects of hypoxia through migration. However, migration to shallower and more oxygenated water is energetically expensive and can make them vulnerable to fishing or predators (Stramma et al. 2012; Gilly et al. 2013). Furthermore, hypoxic conditions are conditional on a variety of factors including sedimentation, water flow/mixing, and depth (Gobler and Baumann 2016; Jørgensen et al. 2022), and ecological thresholds vary by species (Thompson et al. 2023b). We discuss potential changes to oxygen levels within the nearshore areas below.

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

4.2 Climate change impacts on coastal nearshore and intertidal areas

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is characterized by a shallow shelf and includes a stretch of open and exposed coastline with seven estuaries and areas of freshwater exchange. The aforementioned climate change models do not do a good job of projecting changes in marine physical characteristics in nearshore areas, consequently a brief literature review of expectations for the area and for similar habitat types is provided here.

Alongside ocean warming, shallow and intertidal ecosystems are also directly affected by increases in air temperature caused by climate change. Increased air temperatures, particularly during summer months and aerial heatwaves, can heighten local seawater temperatures and expose ecologically and culturally important intertidal organisms to alternating aerial and aquatic thermal stress during low tide series (Harley et al. 2006; Raymond et al. 2022). Marine heatwaves, such as “the Blob” (2014-2016), have been shown to have minimal effects on fish assemblages in eelgrass meadows in BC (Robinson et al. 2022) but were associated with die-offs of several marine bird species, including the Marbled Murrelet (Drever et al. 2021). However, the lingering warm conditions from these heatwaves can have substantial impacts on coastal ecosystems, with warm conditions persisting below the surface mixed layer (Jackson et al. 2018). From June 26 to 28, 2021, an unprecedented atmospheric heatwave coincided with the lowest low tides of the year within coastal intertidal systems of the Salish Sea. The heatwave resulted in extensive mortality reports of marine organisms, including barnacles, mussels, clams, and oysters, on intertidal beaches throughout the Pacific Northwest, with far-reaching and potentially multiyear effects on nearshore ecology, cultural connections, and fisheries (Raymond et al. 2022). Nearshore canopy-forming kelp declined following the 2014-2016 marine heat wave, but within the coastal area of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, persistent canopy kelp was observed after the marine heat wave and was related to local factors such as cooler temperatures and higher current speed (Starko et al. 2024). A mid-intertidal kelp found in areas of high wave exposure, Sea Palm (*Postelsia palmaeformis),* is particularly vulnerable to climate change and marine heat waves with major declines observed during periods of elevated sea water temperatures in California (MARINe). However, its population response in the northern limit of its range is understudied, presenting a research gap (Csordas et al. 2024).

However, recent survey work (2021 and 2022) shows long-term stability of *P. palmaeformis* due to its ability to thermal buffer near its northern range edge and from its habitat of wave-exposed coastlines, which may mitigate the impact of heatwaves (Csordas et al. 2024).

Deeper inlets are typically vulnerable to reductions in oxygen, with the deeper hypoxic basins having a delicate water chemistry that is already near tipping points for resident species' ecological tolerances (Okey et al. 2012). Anoxic fjords, such as Nitinaht Lake, are unique ecosystems that are significantly influenced by climate change. In Scandinavian fjords, similar to those in British Columbia, climate change has led to increased freshwater runoff, which strengthens water stratification and results in more stagnant deep water. This stagnation is a primary cause of periodic anoxic conditions and the formation of laminated sediments (Gustafsson and Nordberg 2002). Furthermore, anoxic fjords are significant sources of methane emissions, and ongoing deoxygenation and global change will likely enhance methane emissions from fjords globally (Bonaglia et al. 2022).

Salinity levels are anticipated to undergo changes due to variations in freshwater input from rivers, precipitation patterns, evaporation rates, and ocean currents. Furthermore, land use alterations and freshwater extraction can impact marine salinity along both the East and West coasts of Vancouver Island. Monitoring sites to the north of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area revealed a decrease of 0.64 PSU in west coast salinity over an 82-year period (Iwabuchi and Gosselin 2020). Iwabuchi (2019) also discovered varying responses among four intertidal invertebrate species (Frilled Dogwinkle (*Nucella lamellosa),* sea snail species *Littorina sitkana* and *L. scutulata,* and Acorn Barnacle *(Balanus glandula))* to changing environmental conditions, such as rising marine temperatures and shifting salinity levels, potentially resulting in alterations in species abundance, distribution, and overall community assemblages. Sea surface salinity is at its lowest from November to February on the west coast. Over the period from 1935 to 2016, two-month average sea surface salinity decreased by 0.64 PSU, indicating a marine freshening at a rate of -0.79 PSU per century, while no significant change over time was observed for the east coast monitoring sites (Iwabuchi and Gosselin 2019). The lower variability and higher salinity experienced along the west coast are associated with increased oceanic mixing resulting from spring upwelling winds (Pickard and McLeod 1953). Additionally, considerably smaller drainage basins on the west coast, collecting rainfall and transferring it to the ocean, contribute to this pattern, in contrast to the Strait of Georgia (Cummins and Masson 2014). Furthermore, differences in cloud cover can impact the effect of climate warming on each coast, with up to 70% cloud cover in July and fog persisting for an average of 15 days in August on the west coast (Thomson 1981). Such atmospheric conditions may lower SST by limiting the amount of solar energy available to heat the west coast's surface waters (Tully and Dodimead 1957).

Globally, harmful algae blooms have been predicted to increase in occurrence and toxicity with the impacts of climate change (e.g., IPCC 2022) (see Pollutants and Phytoplankton sections in this report for more information), though some studies argue that observed increases may be inconclusive, with bias introduced by more recently expanded widespread monitoring efforts (Hallegraeff et al. 2021).

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area includes nearshore marine habitats, coastline and intertidal pools. A study in nearby Bamfield (to the north of **ƛ̓ušiiʔaaʔaq**) showed that fish communities in high-intertidal pools were resilient between historical and modern sampling periods, which resisted invasion. However, some changes in community composition were found in the lower shore sampling sites. The authors concluded that these tide pool fish

communities may reach a threshold with ongoing ocean warming and therefore continued monitoring is required (Green et al. 2021). The resilient physiologies of today's tidepool inhabitants might make them one of the last groups to experience the changes seen in other marine ecosystems. However, since the final sampling year in the study was 2016, any delayed effects from the marine heatwave may have developed since the study's conclusion and been compounded with ongoing ocean warming in the area (Green et al. 2021).

The BC coast has historically experienced major tsunamis, both seismic- and landslide-generated (Clague et al. 2000) and the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is located in a high tsunami run-up zone (Figure 53). Most past tsunamis have not caused significant damage to infrastructure (Clague et al. 2003) but may impact the coastal environment through the deposition of debris. Climate change and associated rising sea levels may also increase the threat of tsunamis to coastal areas (Cunneen 2022). Increased risk of submarine and aerial landslides increases the risk of local tsunamis while iceberg calving and breakups in northern areas and wandering icebergs can trigger submarine landslides and tsunamis thousands of kilometres from their source. Increased earthquakes and volcanic activity further increase the risk of tsunamis. A modeling assessment of tsunami risk to Northwest Vancouver Island from coseismic sources in Cascadia and Alaska subduction zones suggest that sea level rise does not significantly influence the tsunami wave amplitude at offshore locations, but the propagation of these waves overland will lead to greater extents of flooding as a result of sea level rise (Kouhi et al. 2022).

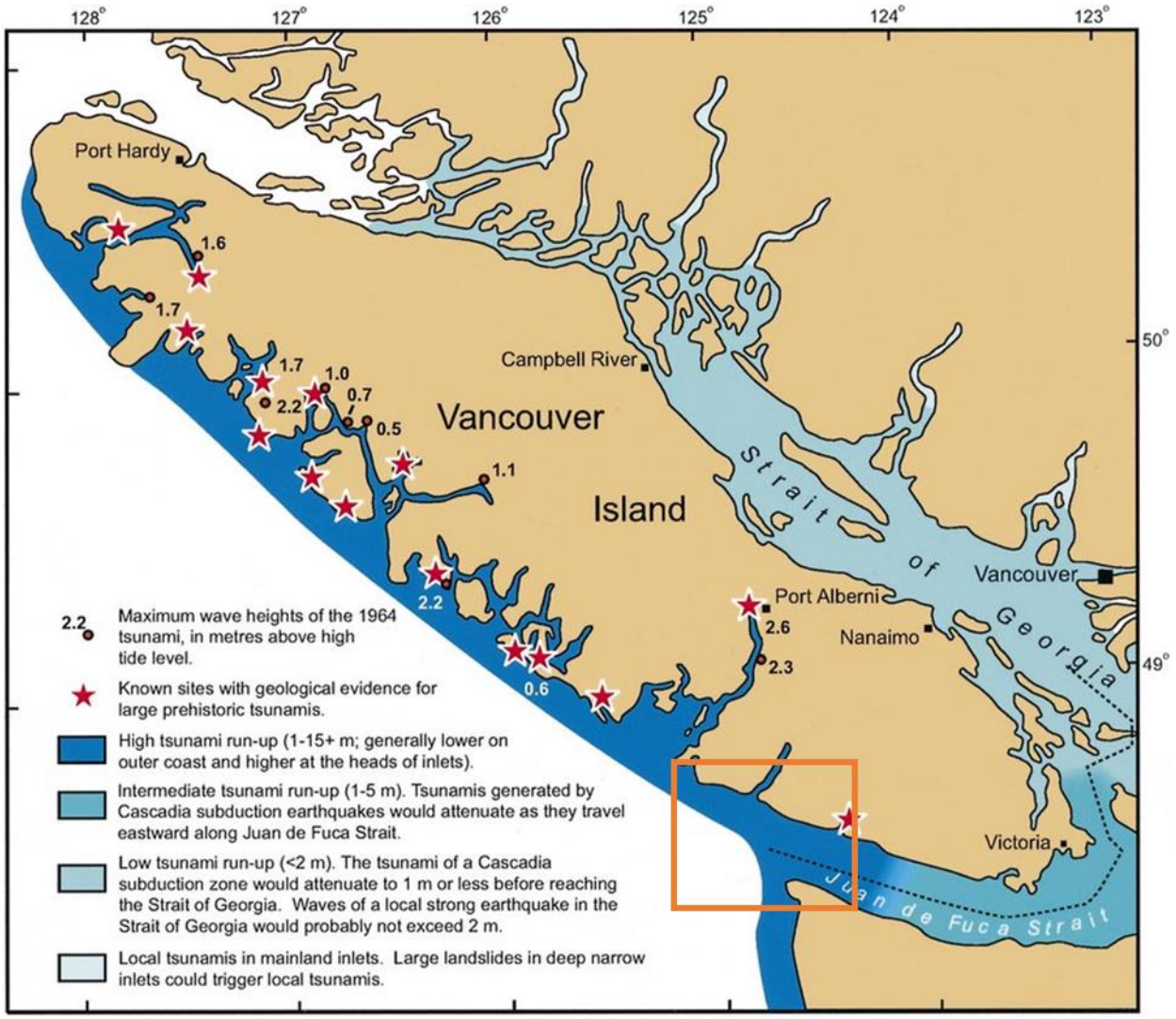


*Figure 53. Generalized tsunami hazard map for south-coastal British Columbia based on the distribution of tsunami deposits and numerical modelling of wave heights. The map shows four generalized hazard zones, as well as sites with evidence for large prehistoric tsunamis and maximum wave heights of the 1964 Alaska tsunami. The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area indicated by orange rectangle extent. Map modified from Clague et al. (2000).*

The watersheds along the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area are vulnerable to extreme rain events that result in landslides due to steep terrain of many of the headwaters and historic and recent logging in these watersheds. Together Ditidaht First Nation and Parks Canada restored over 11,000 m² of habitat in 2020-21 the **čaaxwiyt**/Cheewaht Lake watershed (Zharikov 2023). In October 2024, a storm event brought 396 mm of rain in 24 hours, completely infilled the S2 and S3 streams in the **čaaxwiyt**/Cheewaht Lake watershed a previously restored stream in 2020-21 (Figure 54, Figure 55). An additional survey conducted by the Ditidaht First Nation, in the **Tl'aadiiwa** (Ditidaht First Nation)/**ƛ̓aaniʷaʔa** (Huu-ay-aht First Nations)/Klanawa River system in late October, also recorded a significant landslide event in the east fork headwaters. The landslide covered 2 km in length and washed out 538 m of road and estimated 400,000 m³ of sediment was displaced into the headwaters.

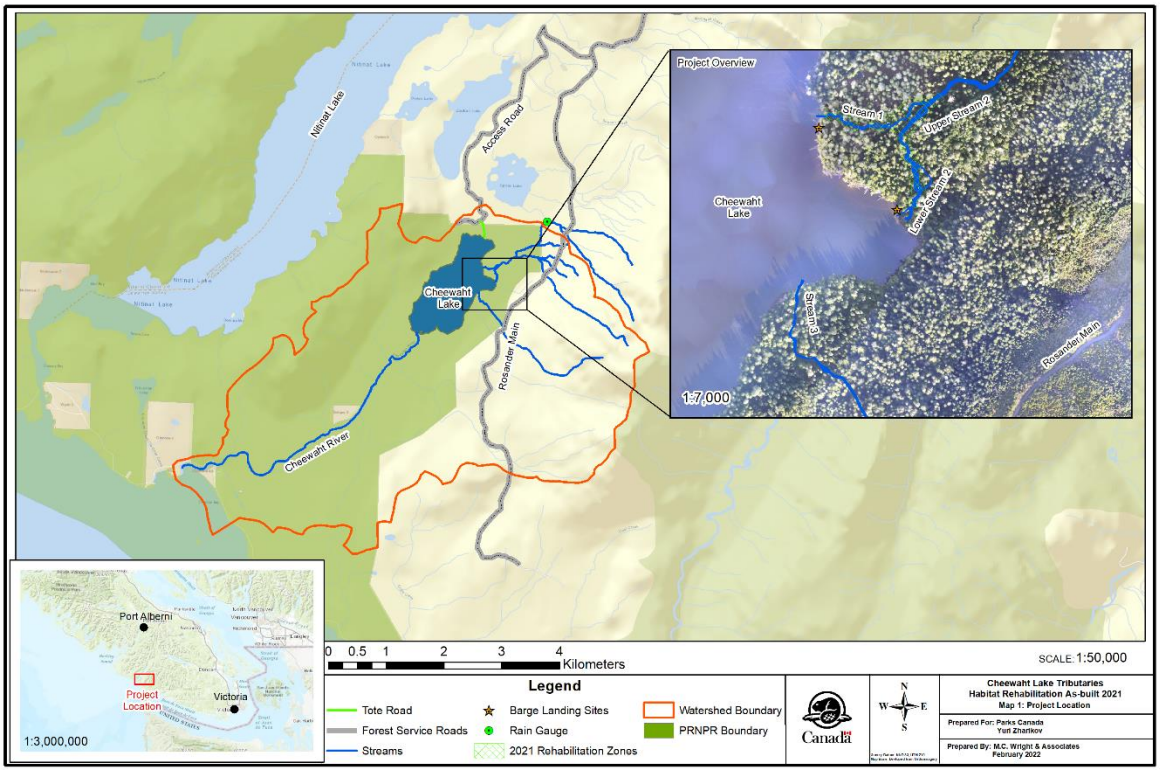


Figure 54. Cheewaht Lake tributaries and rain gauge. Map provided by Parks Canada.



*Figure 55. Restoration efforts and impacts of extreme rainfall in October 2024 in stream 3 within the **čaaxwiyt**/Cheewaht Lake watershed. Clockwise from top left: pre 2021 restoration (credit: Y. Zharikov, Parks Canada); post 2021 restoration (credit: Y. Zharikov, Parks Canada); post October 2024 storm event (credit: I. Cruickshank, Parks Canada).*

4.3 Data and Knowledge Gaps

Climate change is complex, and understanding the full range of effects it can have on marine and terrestrial systems and their interface requires long-term and locally-relevant research and data. The specific impacts of climate change on nearshore areas require further research, as current oceanographic models are not accurate for these regions due to the broad spatial scale of the model outputs and the complexity of nearshore habitats. Further, the potentially synergistic effects of multiple climate-related stressors, such as temperature, hypoxia, and ocean acidification, on marine ecosystems need investigation. Continued monitoring of key environmental parameters, such SST, dissolved oxygen, and aragonite saturation state is essential.

The degree to which climate change affects systems may be species and ecosystem-specific. Detailed studies are needed to assess the vulnerability and resilience of key species to climate change, including their thermal tolerances, dispersal abilities, and responses to altered food webs. How the confluence of these changes impacts species distributions and range shifts will have impacts on ecological relationships, culture, and local economies. Climate change is expected to have a particularly significant impact on the shallow shelf and exposed coastline of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. The degree to which unpredictable weather patterns will contribute to extreme weather events, including flooding, tsunamis, and heat waves, all needs to be better understood. A multi-faceted research approach, including First Nations, is needed to address these knowledge gaps, including enhanced monitoring programs and vulnerability assessments.

5 HUMAN USES OF AREA

This section summarizes human uses (i.e., Indigenous, social, recreational, research and commercial) within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

5.1 First Nations Activities

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area includes many sites used in maintenance and enhancement of spirituality, customs, governance, territories, and sharing of resources and trade for the First Nations that utilize the area, including the Ditidaht First Nation, Pacheedaht First Nation, Huu-ay-aht First Nations and the other four First Nations of the Maa-nulth Treaty Society**,** and the Makah Tribe. Food, social, and ceremonial fisheries provide marine food resources that support the nutrition, culture, and wellbeing of local communities.

The Huu-ay-aht First Nations have had a long history with **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Huu-ay-aht First Nations utilized the **ƛ̓ušiiʔaaʔaq** Area for fishing salmon, rockfish, and Pacific Halibut. Traditional use studies point to traditional sites that carried food fish/ ceremonial significance to the fishers of the Huu-ay-aht First Nations.

“In the past, our ancestors drew all they required from nature’s abundant bounty. Offshore, the ocean supplied halibut, cod, snapper, herring and other fish, as well as seals, sea lions, and whales. When the tide was low, mussels, clams, chitons, urchins and more would be collected and eaten. On land, many plant foods, including a wide variety of berries would ripen and be gathered. From the summer through late fall, five species of Pacific salmon returned to their spawning rivers, where our people went to the rivers to catch, smoke and dry the fish in

preparation for the coming winter. Throughout the year, land mammals, including elk, deer and bear, were hunted for their meat and fur. We lived in close harmony with nature and drew all we required for living from what nature provided. Today, we continue to believe in a close relationship between the spiritual and natural worlds."

(https://huuayaht.org/services/language-culture/culture-history/)

For countless generations, by virtue of their location on the west coast of Vancouver Island, the Maa-nulth Nations have a natural bond with the ocean and its resources. They have always been connected to the sea culturally, economically and spiritually and fish and marine resources have been central to the health and well-being of the people. As has always been the Maa-nulth practice since time immemorial, any harvest of marine and coastal resources is exercised in accordance with the **nuučaaʕuł** principles.

A meta-analysis of archaeological fisheries data from coastal BC and adjacent regions estimated the most regularly occurring fish taxa across the coast, finding that Pacific Herring and salmonids are the most ubiquitous, occurring in 95-96% of all examined sites, of which several were in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, or in proximity (McKechnie and Moss 2016). Less ubiquitous but common species for WCVI included rockfishes, greenlings, northern anchovy and Lingcod. Pacific Herring showed a hyper abundance in WCVI sites and were consistent over time. Pacific Herring was also ranked above salmonids for WCVI sites. Methods to catch salmonids and Pacific Herring varied: salmonids would have been caught with gill, seine, and reef nets, harpooned, speared, taken with leisters and caught on hook and line; Pacific Herring were caught with basketry traps and nets and raked into canoes (listed in McKechnie and Moss 2016). Surfperches are also mentioned as being caught in baited basket traps by the Nuu-chah-nulth on WCVI (Drucker 1951 cited in McKechnie and Moss 2016).

5.2 Fisheries and Subsistence Activities

Commercial, recreational and traditional fishing (described above) occur throughout **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank but data for traditional fishing are not provided within this report. **ƛ̓ušiiʔaaʔaq** spans four Pacific Fishery Management Areas (PFMA) regions (20, 21, 121, and 123)(Figure 13).

The Maa-nulth have allocations of both domestic and commercial fisheries as defined by the Maa-nulth Treaty. Domestic allocations include salmon, Pacific Halibut, rockfish, groundfish, Sablefish (*Anoplopoma fimbria*), and shellfish. Licenses for commercial allocation are issued in accordance with the *Maa-Nulth First Nations Final Agreement*. The allocations in the Harvest Agreement do not affirm Indigenous or Treaty rights. These licenses are fished in a manner that is comparable to the general commercial fishery (DFO 2024c).

The Ditidaht First Nation members are allowed to food fish within the Dare Point and Carmanah Point RCAs (Ditidaht First Nation 2017a).

5.2.1 Commercial Fishing

Currently, the waters in and around the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area support diverse commercial fisheries using different gear types for groundfish, shellfish, and salmon (Table 4, Figure 56). The main datasets used to inform the commercial fishery analyses are from validated logbooks. In the analysis, the main datasets are composed of individual fishing events

(specific locations are described spatially as points, fishing on a set line or trawl/troll path as lines, or areas as polygons) or the most granular data available for fisheries. Based on discussions with fishery advisory boards, multi-year baselines are selected to smooth out harvest cycles and some to reflect changes in fishery behavior (e.g., reaction of groundfish fishers to quota choke species, species with limited quota that co-occur with other targeted species). Year ranges are the result of the most current and available processed spatial logbooks, and engagement with various fishery advisory boards, fishing industry bilateral discussions, and advice from resource managers. Details on these analyses and fishery-specific year spans are provided in Appendix E. The datasets presented in this section may differ slightly from those data used in cumulative impact assessments for the BC coast (see Cumulative Impacts section). DFO is continuing to discuss the spatial representation of commercial fishing with advisory board members, which may result in updated spatial datasets and potential use of a different year span to describe commercial fishing activity within this area in the future.

*Table 4. Presence of different types of commercial fishing in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Juan de Fuca Eddy EBSA with the data year range provided in parentheses. Data for groundfish comes from validated and spatialized logbook records. 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 period.*

Gears	**Fishery**	**Year Range *****	**ƛučiiʔaaʔaq/ Swiftsure Bank (P/A)**
Trawl	Groundfish (bottom trawl and mid-water trawl)	5 years (2017 – 2021)	P
	Shrimp*	10 years (2012 – 2021)	P (with landing data in one year (2012))
Hook and line	Pacific Halibut	5 years (2017 – 2021)	P
	Lingcod		P
	Rockfish		P
	Sablefish		P
Gillnet**	Chinook Salmon	10 years (2012 – 2021)	P
	Chum Salmon		P
	Coho Salmon		P
	Pink Salmon		P
	Sockeye Salmon		A
Seine**	Chinook Salmon	10 years (2012 – 2021)	A
	Chum Salmon		P
	Coho Salmon		A
	Pink Salmon		A
	Sockeye Salmon		A
Troll**	Chinook Salmon	10 years (2012 – 2021)	P
	Chum Salmon		P
	Coho Salmon		P
	Pink Salmon		P
	Sockeye Salmon		P
Dive fisheries	Sea Cucumber	9 years (2013 – 2021)	A
	Red Sea Urchin		A
	Geoduck		A

Gears	Fishery	Year Range ***	ƛučii?aa?aq/ Swiftsure Bank (P/A)
Invertebrate trap	Prawn	10 years (2012 – 2021)	P (only in 2013)
	Crab	10 years (2012 – 2021)	P
Hook and line	Pacific tuna	10 years (2012 – 2021)	P

** Shrimp species include Humpback shrimp, Pink shrimp, and Sidestripe shrimp*
***Note that the commercial salmon data does not have fine-scale spatial resolution, as data is spatialized at the Pacific Fisheries Management Area Subarea level, which represent large areas.*
**** The reasons for selecting the specific time span for each fishery are listed in Table F1.*

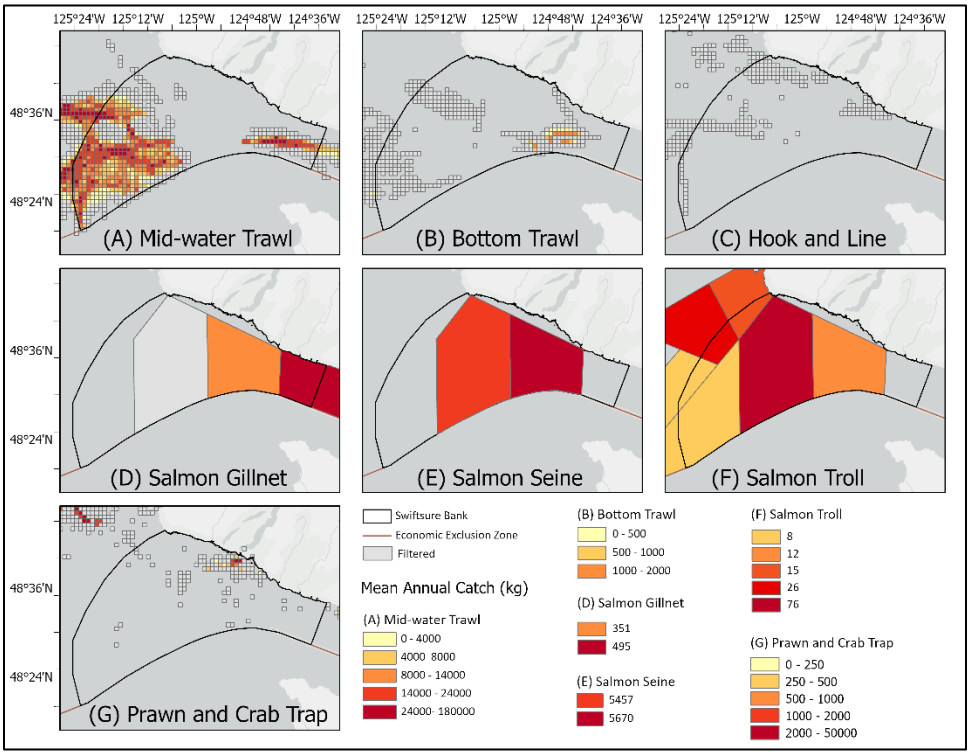


Figure 56. Commercial fishing footprints, derived from logbooks for A) Mid-water Trawl (2017-2021), B) Bottom Trawl (2017-2021), C) Hook and Line (2017-2021), which includes Pacific Halibut, rockfish, Lingcod, and Sablefish D) Salmon Gillnet (2012-2021), E) Salmon Seine (2012-2021), F) Salmon Troll (2012-2021), and G) Prawn and Crab Trap (2012-2021) in and around ***ƛušiiʔaaʔaq****/Swiftsure Bank, based on the Juan de Fuca Eddy EBSA polygon. Catch data is aggregated to 1x1km^2 grid cells (A-C, G in order to maintain privacy for commercial fishers. Grid cells that do not meet a minimum of 5 vessels per 1x1km^2 cell (i.e. Rule of Five) are displayed as 'filtered' to protect confidential information.) Commercial salmon harvests are recorded and displayed at the PFMA and/or sub-area level ((D) – (F)) and also meet the Rule of Five. Table 5 (below) shows the landed harvest of all fishing events, even those in filtered cells.*

Groundfish is the predominant fishery, with salmon and shellfish fisheries making up a small portion of the overall landings and fishing effort in the area. The major fishing gear used in the area is midwater trawl followed by bottom trawl, longline, hook and line, purse seine, troll, trap, and other gear types. Among all the commercial fisheries, groundfish midwater trawl fishery constitutes about 88% of total annual landings (in terms of kg) in the **ƛušiiʔaaʔaq**/Swiftsure Bank Area. The fishery harvested an annual average of 6.8 million kg from 2017-2021 (Table 5), with Pacific Hake the major target species. Although Pacific Hake is a migratory species and its

harvest has inter-annual variation, it was harvested in all five years accounting for 63% to 96% of all groundfish harvest from 2017 to 2021. The next two most prominent fisheries, by volume, in this area are chum salmon by seine (6.1%) and chum salmon by gillnet (2.9%) fisheries. Crab by trap is the major target species and gear for the shellfish fishery in this area.

Table 5. Total harvest (kg) and annual average harvest (kg) as reported in commercial fishing logbooks spatialized DFO Official Logbooks (MPA Network BC Northern Shelf Initiative 2023 for methods). Rounded to nearest kg.

Gears	Fishery/species	Total landing in ƛ̓ušiiʔaaʔaq/Swiftsure Bank (KG)	Annual average landing in ƛ̓ušiiʔaaʔaq/Swiftsure Bank (KG/year)
Trawl	Groundfish bottom trawl *	863,750	172,750
	Groundfish midwater trawl *	33,915,676	6,783,135
	Shrimp ***	NA	NA
Hook and line	Pacific Halibut *	15,239	3,048
	Lingcod *	NA	NA
	Rockfish *	NA	NA
	Sablefish*	NA	NA
Gillnet**	Chinook Salmon **	NA	NA
	Chum Salmon **	1,335,237	222,539
	Coho Salmon **	NA	NA
	Pink Salmon **	NA	NA
Seine**	Chum Salmon **	1,395,299	465,100
Troll**	Chinook Salmon **	17,331	1,733
	Chum Salmon **	NA[ł]	NA[ł]
	Coho Salmon **	1,774	296
	Pink Salmon **	NA[ł]	NA[ł]
	Sockeye Salmon **	133	4
Invertebrate Trap	Prawn trap ***	NA	NA
	Crab trap ***	293,769	29,377
Hook and line	Pacific tuna***	NA	NA

**Groundfish data span 2017-2021.*
Salmon data span 2012-2021; note that due to the low spatial resolution of the salmon logbook data, estimates of harvest and vessel counts for seine fisheries are associated with a higher degree of uncertainty than estimates for other fisheries. This measure of landed kg is applied to sub area % of the* ***ƛ̓ušiiʔaaʔaq*/Swiftsure Bank polygon within the PFMA. "NA[ł]" represents small slivers of overlap between the* ***ƛ̓ušiiʔaaʔaq*** *polygon and a sub-area can result in small estimates of volume associated with 5 or more vessels, as seen for chum and pink caught by troll."*
****Shellfish and Pacific tuna data span 2012-2021.*

"NA" Indicates that there are fewer than five vessels reporting for that fishery/species & year span within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area*

Commercial fishing no longer occurs on Nitinaht Lake, though the watershed stocks support a large recreational fishery, an offshore commercial fishery, and a Ditidaht food fishery (McNaught 1972; Pawlowicz et al. 2007).

5.2.2 Recreational Fishing

Recreational fisheries occur throughout **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Three data sources provided information about recreational fishing activities in the area: the DFO's Internet Recreational Effort and Catch (iREC) database, DFO's recreational mapping survey in BC (DFO and Sport Fishing Institute of BC 2018), and recreational fishing data collected during marine mammal surveys by Parks Canada. These sources focus on different aspects of fishing activity, with iREC showing catch and effort by PFMA. A survey conducted by Sport Fishing Institute on behalf of DFO (DFO and Sport Fishing Institute of BC 2018) identified areas of importance for the recreational fishing sector for the use in marine spatial planning initiatives. The resultant data from this survey shows recreational fishing areas, along with importance of the area attributed by survey respondents, for shellfish, groundfish and salmon throughout the coast of BC including the **ƛ̓ušiiʔaaʔaq** Area (Figure 57). The data from this survey, however, is not based on a representative sample, and the areas of recreational fishing depend on the knowledge of the interviewees. Crab fishing spots occur coastally in the northeastern part of the **ƛ̓ušiiʔaaʔaq** Area between Clo-oose Bay and the mouth of Klanawa River (Figure 57A). The major fishing locations of groundfish are in subarea 121-1, 121-2, 123-1 and 21 with the fishing spots of Lingcod mainly along the coast in subarea 21 (Figure 36B). For salmon species, their major recreational fishing spots are in part of subarea 21, 121-1, 121-2, 20-1 and 123-1 in **ƛ̓ušiiʔaaʔaq** Area (Figure 57C).

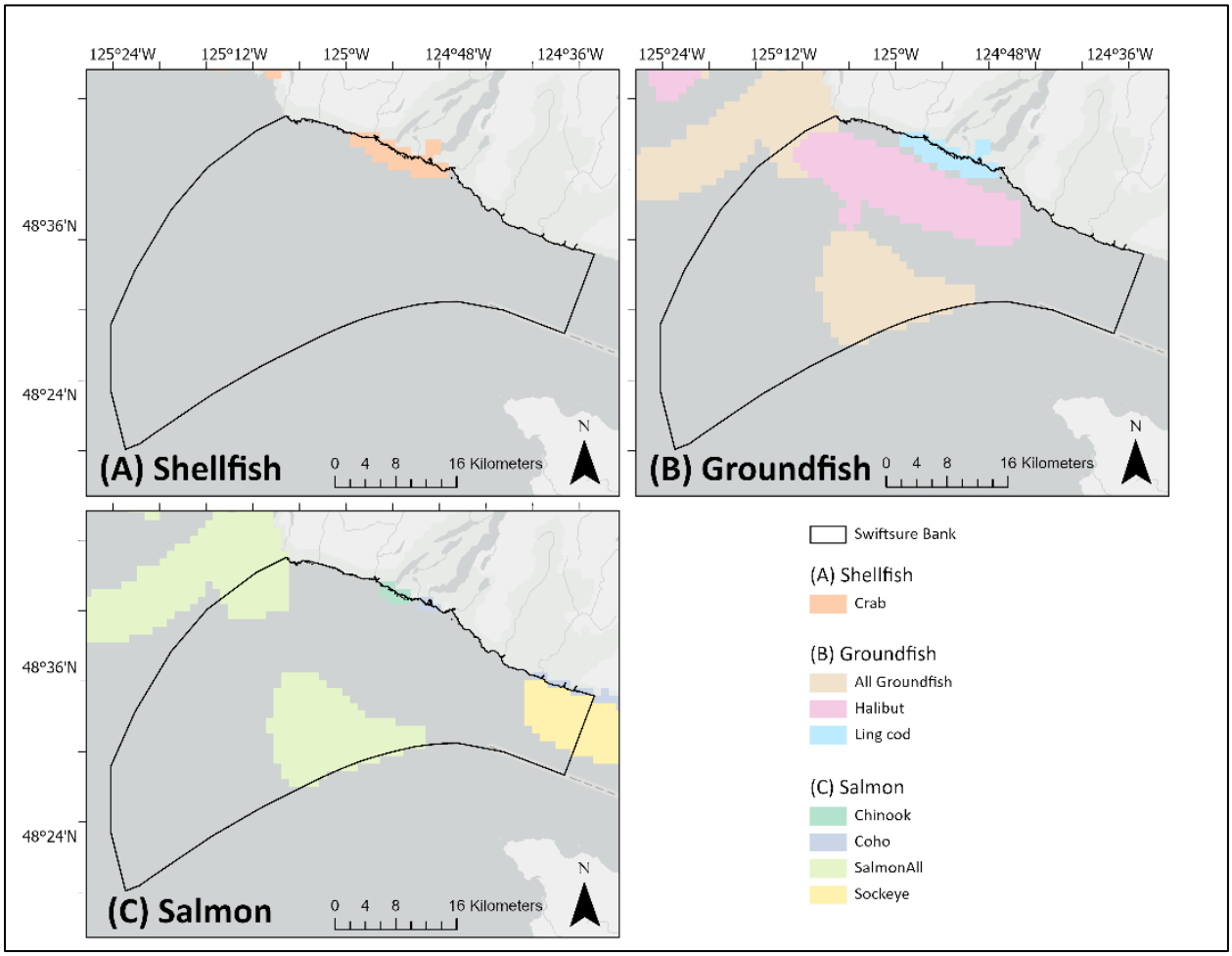


Figure 57. Overlap of areas where recreational (sport) fishing for (A) crab, and (B) Pacific Halibut, Lingcod and all other groundfish and (C) salmon and other anadromous fish occurs within the ***ʎ̓ušiiʔaaʔaq****/Swiftsure Bank Area, delineated using the Juan de Fuca Eddy EBSA polygon. The data is obtained from the product of a collaborative mapping survey in which a group of individuals with knowledge on recreational fishing sector in BC were interviewed in 2017 (DFO and Sport Fishing Institute of BC 2018).*

DFO's Internet Recreational Effort and Catch[41] (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 obtained from iREC included angling from a boat, angling from the shore, beach digging, dive-based, shellfish trapping from the boat, and shellfish trapping from shore/dock (Figure 58**,** Table 6). Recreational fishing days, defined as one day trip by one adult licensee using one fishing method in one PFMA, were documented between April 2020 and March 2023 within the four PFMAs overlapping **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank (Figure 58). However, specific fishing locations within the PFMAs are not known. PFMA 121 and 21 have the highest spatial coverage with the **ʎ̓ušiiʔaaʔaq** Area, totaling 20,722 fisher days between 2020 and 2023. If days are expressed by the proportion of spatial coverage within the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank polygon (Table 6), PFMA 20 (West) is a more popular recreational

[41] iREC: https://www.pac.dfo-mpo.gc.ca/fm-gp/rec/report-declarez-eng.html

fishing region compared to the other three PFMAs (21, 121, and 123) which overlapped with **ƛ̓ušiiʔaaʔaq**.

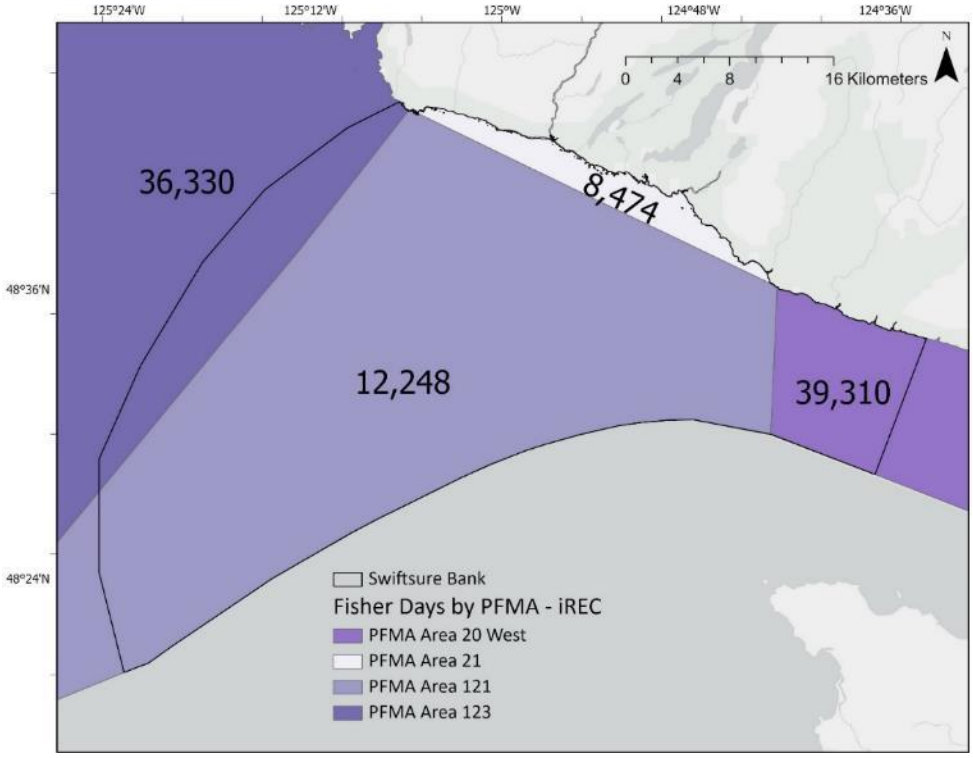


*Figure 58. iREC Fishing effort estimates by 'Fisher Days' in each Pacific Fishery Management Area (PFMA) that overlapped with **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Fishing estimates (total fisher days) are labelled over each PFMA, although precise fishing locations within the PFMAs are unknown. One fisher day is defined as one day trip by one adult licensee using one fishing method in one PFMA. In cases where an individual fished using multiple methods or in multiple areas, one fisher day was counted for each method and each PFMA. Fishing events were calculated from data collected between April 2020 to March 2023 for all areas. Black line delineates boundary of Juan de Fuca Eddy EBSA.*

*Table 6. Total fishing effort reported by license from iREC. iREC fishing effort estimates for the period between April 2021 and March 2023. Fisher days are the total number of licensee days reported by licensees. The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area overlaps four Pacific Fishery Management Areas (PFMAs), and each fishing estimate is for the entire shaded region (i.e., entire PFMA), however, it is understood that these fishing activities do not occur throughout each shaded area due to the limitations of recreational fishing boats and fish distributions. Licensee days = 1 day trip by one licensee to fish via one method in one area and are not mutually exclusive (i.e. the same licensee can participate in more than one method in the same day, or in multiple areas in one day).*

	PFMA 21		PFMA 121		PFMA 123		PFMA 20 (West)	
Licensees	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Angling from boat	3,329	2,283	3,678	4,961	12,982	11,350	10,309	9,243
Angling from shore	36	15	0	2	113	234	476	1,028
Beach digging or hand picking	2	60	0	0	6	4	187	82
Dive-based or other	11	0	5	2	122	49	191	53

	PFMA 21		PFMA 121		PFMA 123		PFMA 20 (West)	
Shellfish trapping from boat	321	40	211	137	119	71	2,090	1,421
Shellfish trapping from shore or dock	151	21	0	9	926	26	313	311
Total Fishing Days	3,850	2,418	3,894	5,111	14,267	11,734	13,565	12,138

The number of recreational fishing boats are also opportunistically collected during dedicated marine mammal surveys from 2019 onwards in Pacific Rim National Park Reserve by Parks Canada (Figure 59). Recreational fishing vessels had higher densities observed in the southern portion of the West Coast Trail Unit, with an additional area in the north off Tsuisiat.

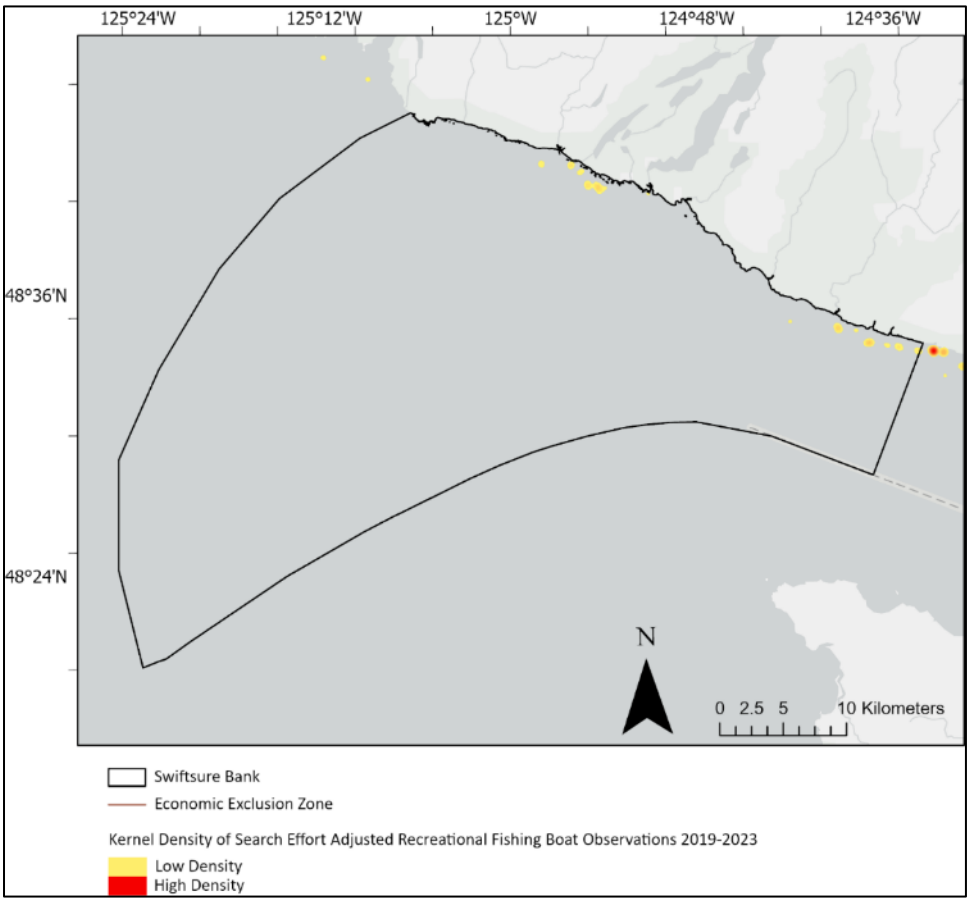


Figure 59. Recreational fishing vessel survey adjusted densities along West Coast Trail Unit of Pacific Rim National Park Reserve from 2019 to 2023. The black line delineates the boundary of the Juan de Fuca Eddy EBSA. Data from Parks Canada.

5.2.3 Fisheries management measures

Since 2019, the Government of Canada has implemented annual management measures in the **ʎušiiʔaaʔaq**/Swiftsure Bank Area to protect and support the recovery of the Southern Resident Killer Whale (SRKW) population by increasing prey availability, particularly Chinook Salmon,

and minimizing physical and acoustic disturbance from vessels in this important foraging area for the species. Since 2020, DFO has implemented fishing closures for commercial and recreational salmon fishing in the **ƛ̓ušiiʔaaʔaq** Area, at specific times of the year. These SRKW management measures have been reviewed and adjusted annually based on new scientific research, lessons learned from previous years and feedback from First Nations, stakeholders and the public[42].

In addition to the fisheries closures related to SRKW, the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area also has a year-round hook and line finfish closure, as well as three long-term fisheries closures to protect inshore rockfish populations, known as rockfish conservation areas (RCAs) at Dare Point, Carmanah, and Pachena Point. RCAs were designed to help alleviate inshore rockfish population decline by restricting multiple bottom-contact commercial and recreational fisheries within their boundaries (Yamanaka and Logan 2010). As such only the following fisheries are allowed to occur in these areas: (1) Commercial fishing of invertebrates by hand picking or dive; crab by trap; prawn by trap; scallops by trawl; salmon by seine or gillnet; Pacific Herring by gillnet, seine and spawn-on-kelp; sardine by gillnet, seine, and trap; smelt by gillnet; euphausiid (krill) by mid-water trawl; and groundfish by mid-water trawl; and (2) Recreational fishing of invertebrates by hand picking or dive; crab by trap; shrimp/prawn by trap; and smelt by gillnet.

Shellfish harvest closures are enacted by DFO to prevent eating contaminated shellfish, which can cause serious illness or be fatal. Additionally, shellfish must not be harvested within 125 metres (410 feet) of a wharf, marina, finfish aquaculture operation, or floating house. The shellfish closures in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area are predominantly for biotoxin contamination of all bivalve species (Figure 60) that prohibit some or all shellfish harvest, with additional seasonal closures possible. More information on these closures can be found at the Fisheries and Oceans Canada Shellfish Harvesting Map and the BC Centre for Disease Control Shellfish Harvesting Status Map.

[42] Management measures to protect Southern Resident Killer Whales | Pacific Region | Fisheries and Oceans Canada (dfo-mpo.gc.ca)

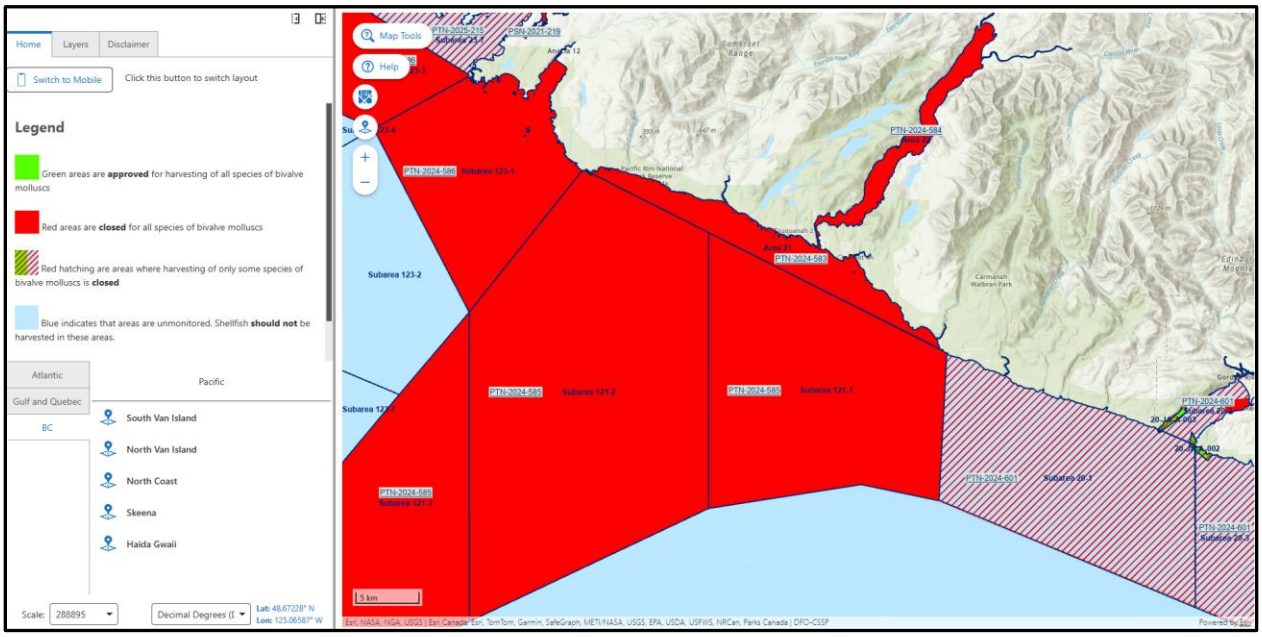


*Figure 60. [Interactive DFO bivalve shellfish safety harvesting map] showing closures of Canadian harvesting areas for bivalve shellfish (mussels, oysters, clams and scallops) in the **ʎušiiʔaaʔaq**/Swiftsure Bank Area, as of April 30, 2025.*

5.3 Human coastal and nearshore activities

5.3.1 Forestry cutblocks, log storage, and log tenures

Forestry activities have a long history in BC's coastal regions and watersheds. Forestry cutblocks, access roads, and associated log handling and storage activities result in pollution, sedimentation, habitat modification, and nutrient flushing (Hodgson et al. 2020; Shah et al. 2022). Logging activities are variable in their ecological impact, as they can be seasonal, have terrestrial and marine components, and may still influence downstream habitat after the logging activities have ceased (Shah et al. 2022). Within the **ʎušiiʔaaʔaq**/Swiftsure Bank Area, no marine log handling tenures (including log booms, log dumps, log sorting, and log storage) are currently documented. There are numerous forestry cutblocks in proximity to the coastal edge of the polygon (Figure 61) that have been logged at various times over the past decades (Figure 62, Figure 63). Note that prior to the construction of roads connecting these remote coastal areas to major log sorts elsewhere on Vancouver Island, much of the wood harvested in these areas would have been handled by water-based methods, such as log dumps and log booms towed by tugboat. Each of these methods is known to have impacts to aquatic habitats through the deposition of wood waste and mechanical scour on the sea floor (Gerwing et al. 2018).

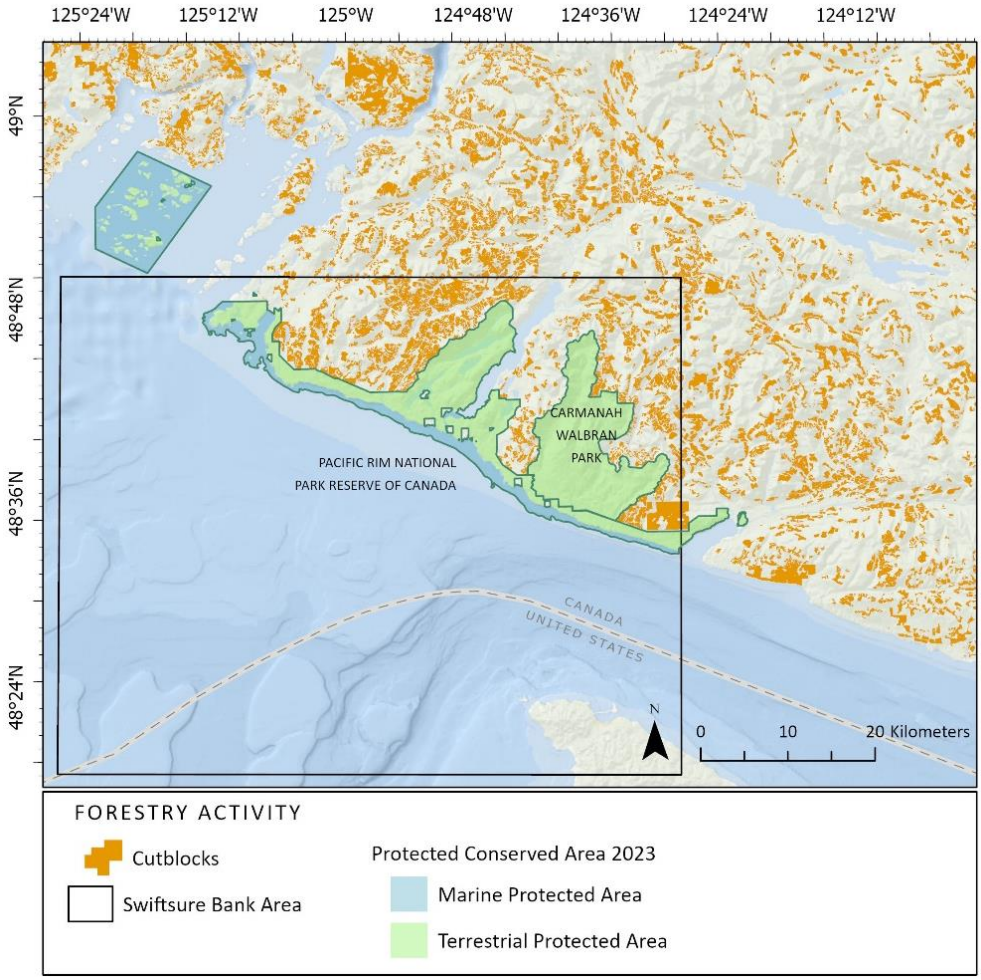


Figure 61. Forestry cutblocks (orange shaded areas) in close proximity to ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank. Data on forestry cutblocks comes from the Province of BC - Forest Analysis and Inventory[43] current until 2021. There are currently no tenures for log handling and storage within the* ***ƛ̓ušiiʔaaʔaq*** *Area.*

[43] https://catalogue.data.gov.bc.ca/dataset/b1b647a6-f271-42e0-9cd0-89ec24bce9f7

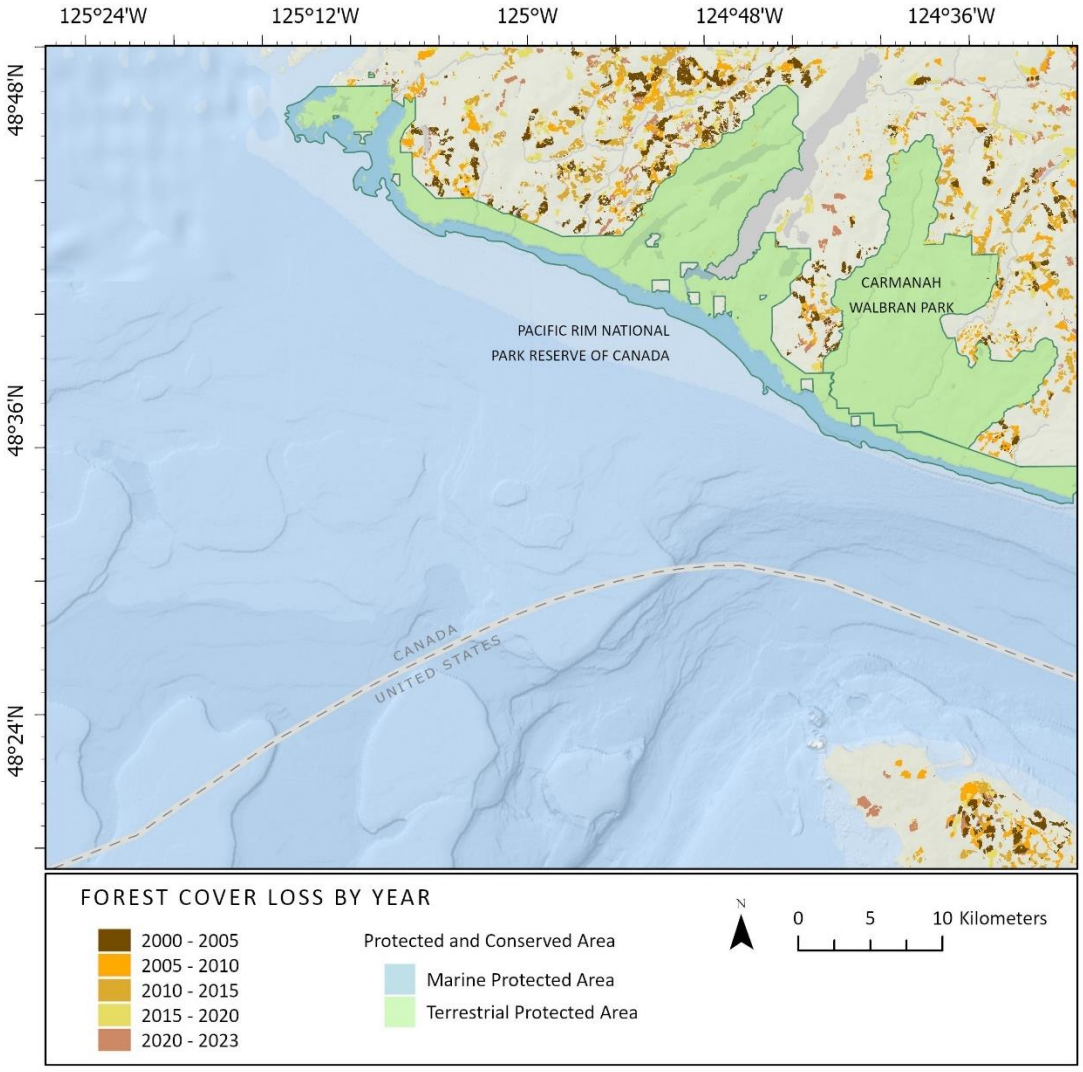


Figure 62. Loss of forest cover by year from 2000-2023 within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area. Data from Global Forest Change[44].*

[44] Global Forest Change – Global Land Analysis & Discovery https://glad.earthengine.app/view/global-forest-change#bl=off;old=off;dl=1;lon=-136.58050990770454;lat=55.19396976365901;zoom=4;

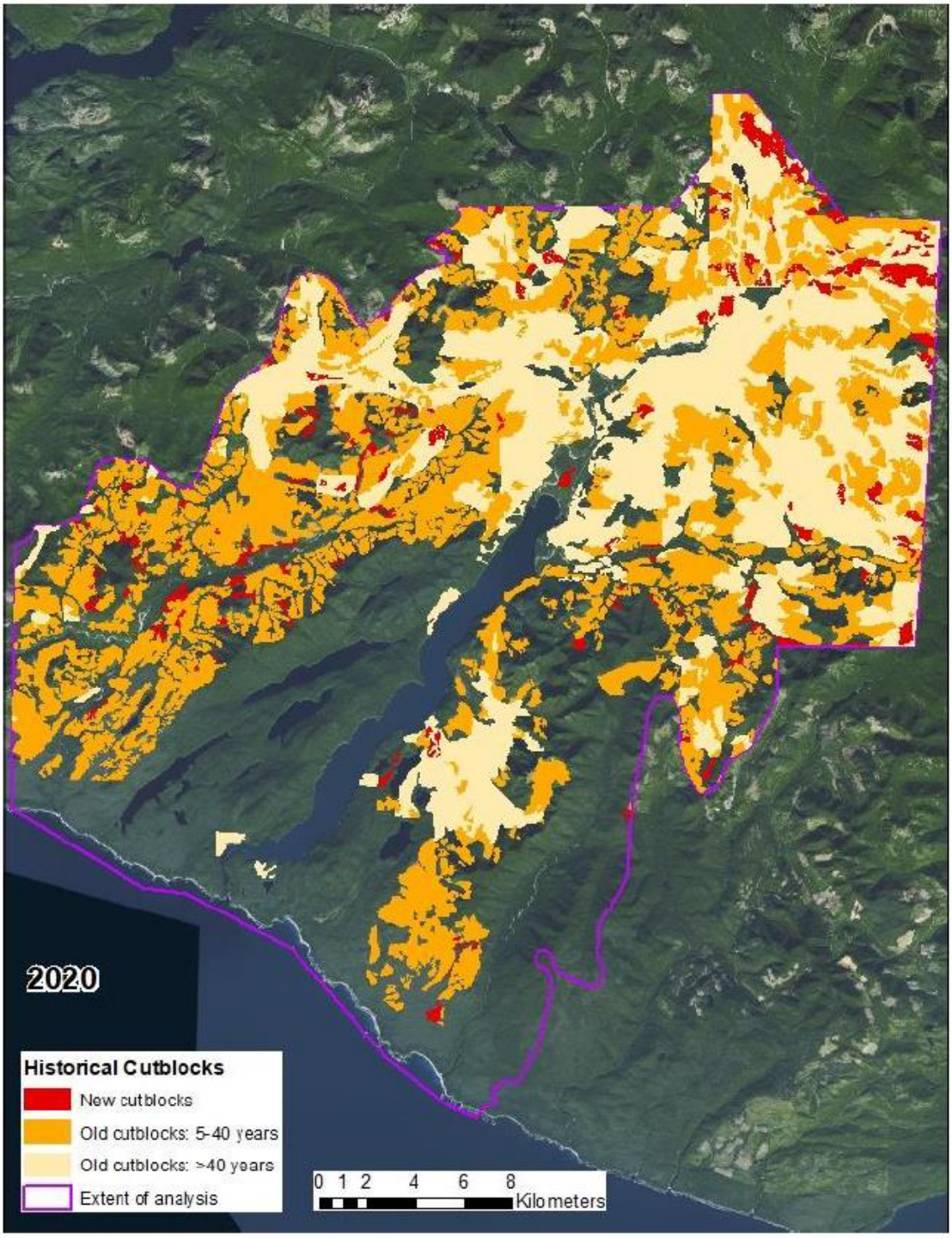


Figure 63. Historical cutblocks within Ditidaht First Nation territory to 2020. Map provided by Ditidaht First Nation.

Despite the lack of current log handling tenures in the **ʔušiiʔaaʔaq**/Swiftsure Bank Area, benthic debris from past logging (i.e., 1940s – 1980s) persists. Historically, preferred log handling and storage sites were situated in areas with lower salinity (such as estuarine environments) in order to prevent shipworms (*Teredo navalis*) from boring into and

compromising the logs. Bark shed from logs being stored in these zones in most cases has resulted in a ubiquitous layer of fine, coarse, and large woody debris being deposited on the seafloor, which has both smothered benthic habitats, and resulted in a persistent degradation of water quality through the leachate from submerged wood waste. Even with no further wood waste inputs at a site, these cumulative impacts are likely to last for decades or even centuries (Picard et al. 2003).

The forestry industry is the main industry operating within the Nitinaht River watershed, with both tree farm licenses and clearcutting operating in the area. Areas within Nitinaht Lake such as the Doobah Creek estuary have been heavily impacted from historical log dumping and storage, and recent ROV survey data has identified a significant fiber mat fronting and adjacent to the Doobah Creek estuary (MC Wright in-field observations). This fiber mat is likely impacting salmon and other important species rearing in Nitinaht Lake, particularly those relying on the nearshore habitats near Doobah Creek. Other areas impacted by logging include the Nitinaht Narrows, where booms were transported from the lake out to the Pacific Ocean. The transport of logs through this shallow and narrow zone likely impacted habitats through physical scour; in addition, a rock was blasted out of the narrows in 1933 to allow for easier passage of boats supporting log transport (O'Donnell 1989).

5.3.2 Mining

Mineral and placer titles exist within the terrestrial portion of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and beyond (Figure 64). Only mineral tenures are held within the terrestrial and watershed areas of **ƛ̓ušiiʔaaʔaq**. Active mines are not reported in the area. Mineral extraction activities in the area, if the tenures were used, could have negative environmental, cultural, social and economic impacts (BC Mining Law Reform – Mineral Tenure), including water contamination, soil degradation, and negative effects on fish habitats. Indigenous engagement and negotiated agreements in mining projects can help address environmental and social concerns, leading to more sustainable resource development (Fidler 2010), if it were to be considered in the area.

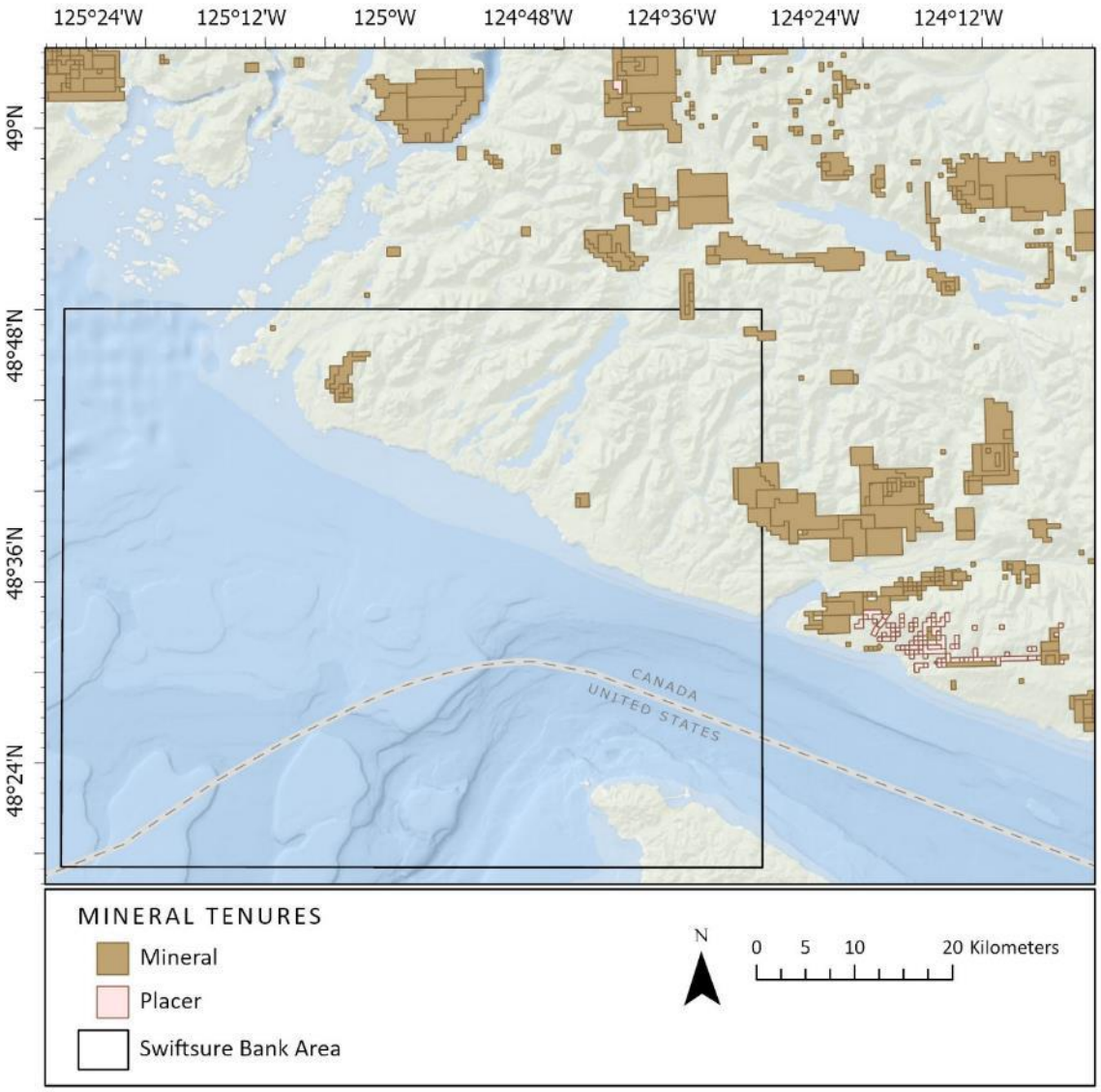


*Figure 64. Current Land Act Mining Tenures (MTA) within the **ʔ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Possible tenure types are coal, mineral or placer. Data available from the British Columbia Data Catalogue[45].*

5.3.3 Underwater development

Provincial utility tenures are distributed throughout BC's coastal waters for underwater developments to connect remote communities to power grids and other services. It is important to note these structures as they could impact local biodiversity. For example, underwater submarine cables can result in magnetic field alteration, though the extent of potential impacts (e.g., on juvenile salmon in estuaries (Hodgson et al. 2020)) is unclear. Underwater development can also contribute to benthic habitat modification, habitat disturbance, and pollution. Underwater development within the **ʔ̓ušiiʔaaʔaq**/Swiftsure Bank Area includes a

[45] https://catalogue.data.gov.bc.ca/dataset/mta-mineral-placer-and-coal-tenure-spatial-view/resource/2e6f14c5-c82a-43c5-9889-3b2d05c5b123

submarine cable for research following the border with the United States, and submarine features in proximity to **ƛ̓ušiiʔaaʔaq** in Barkley Sound (Figure 65). Further, there is a section of the sub-sea Connected Coast internet project, in the proposal phase that goes through the **ƛ̓ušiiʔaaʔaq** Area (Connected Coast).

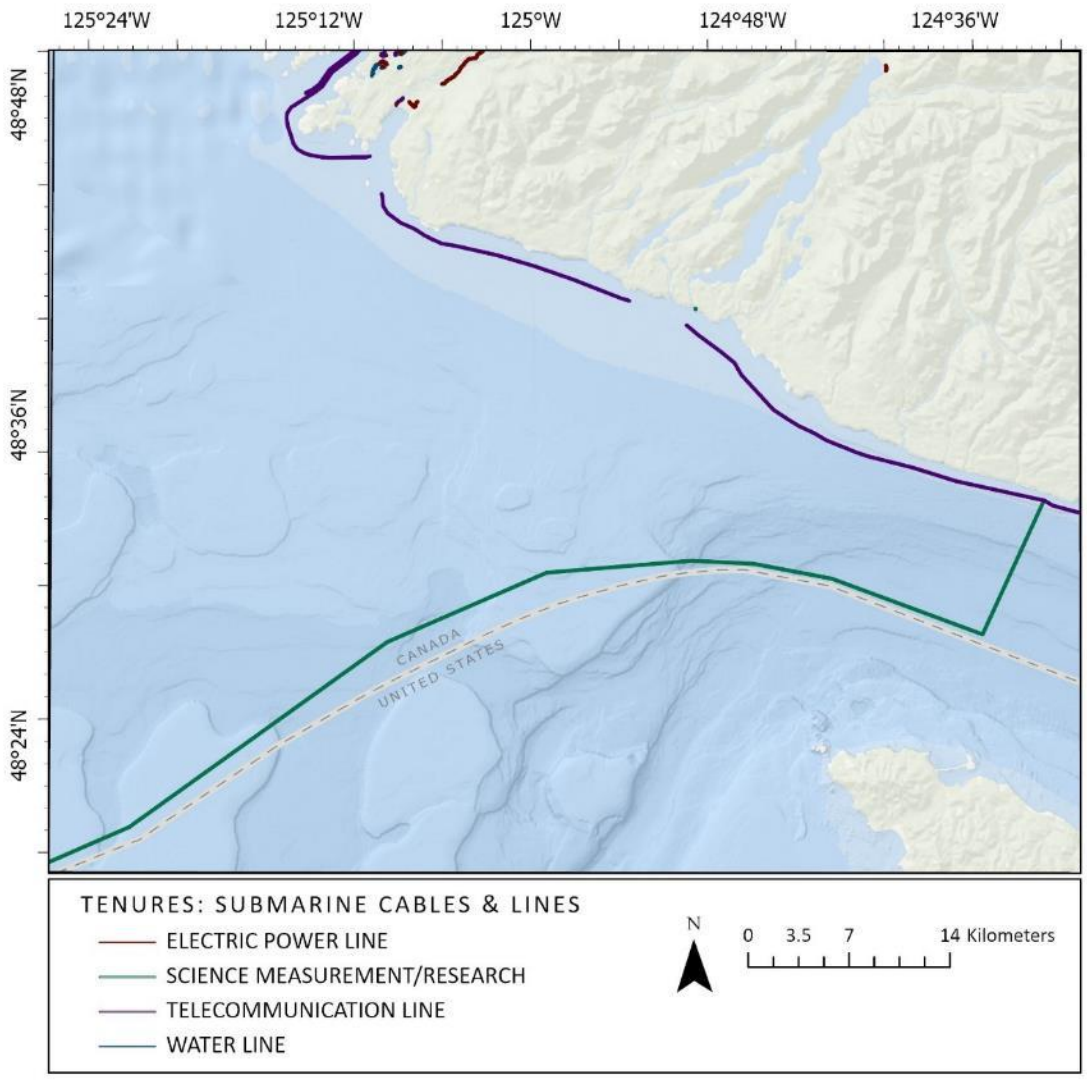


*Figure 65. Provincial tenure data for submarine cables and lines at **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Data are from the British Columbia Data Catalogue[46] current up to December 2022. One line exists within the boundaries of **ƛ̓ušiiʔaaʔaq** for the purpose of scientific measurement and research. Tenures for utilities, such as telecommunication, electric power, sewer, and water lines exist outside of **ƛ̓ušiiʔaaʔaq** in Barkley Sound and Port San Juan. Black line delineates boundary of Juan de Fuca Eddy EBSA.*

[46] https://catalogue.data.gov.bc.ca/dataset/tantalis-crown-tenures

5.3.4 Ocean Energy

Natural energy resources in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, such as areas with high winds, and waves, can be potentially used for renewable energy development (BCMCA Project Team 2011). Mean wind energy in the **ƛ̓ušiiʔaaʔaq** Area is comparatively low to the rest of the BC coast (Figure 66). By comparison, wave energy potential is moderate to high in the northeastern portion of the **ƛ̓ušiiʔaaʔaq** Area (Figure 67). There are currently no wind or wave energy production sites in effect in the area and any future development of these resources would need to done through due process with an engagement and consultation plan with First Nations with relationships to the area.

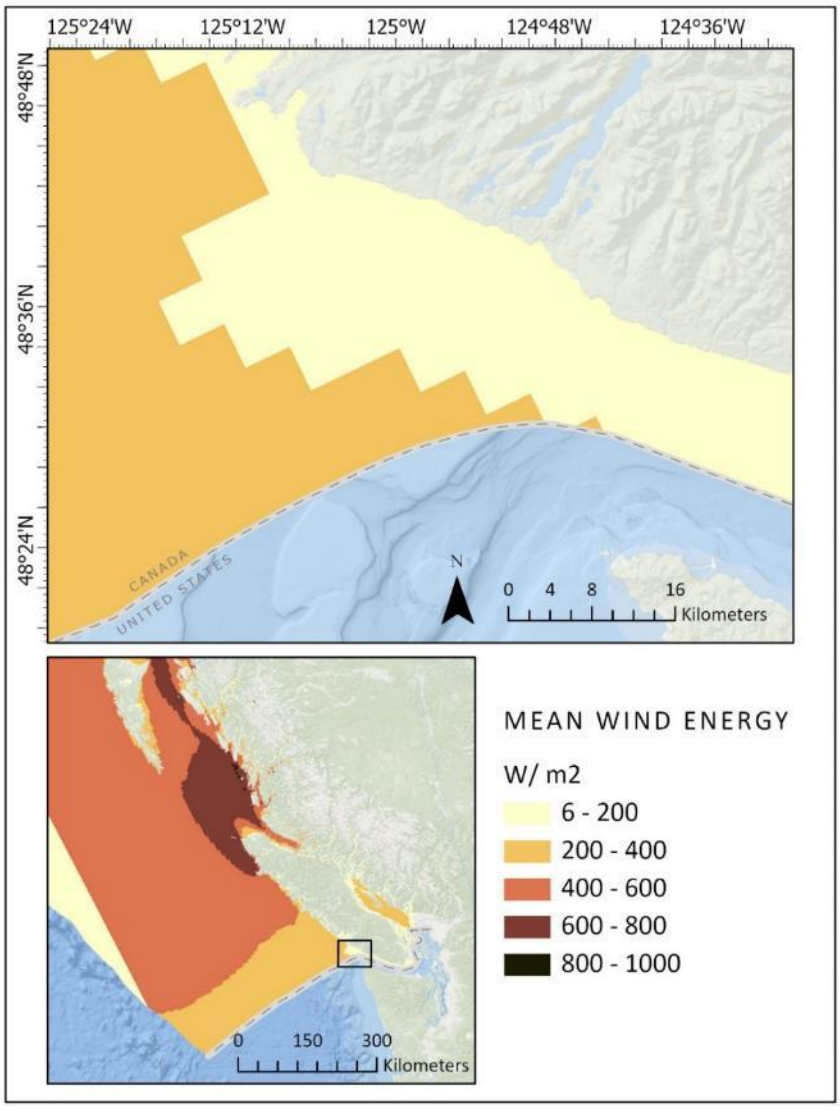


Figure 66. Mean wind energy in watts per meter squared (W/m^2) and power tenure locations in the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area from BCMCA Project Team (2011).*

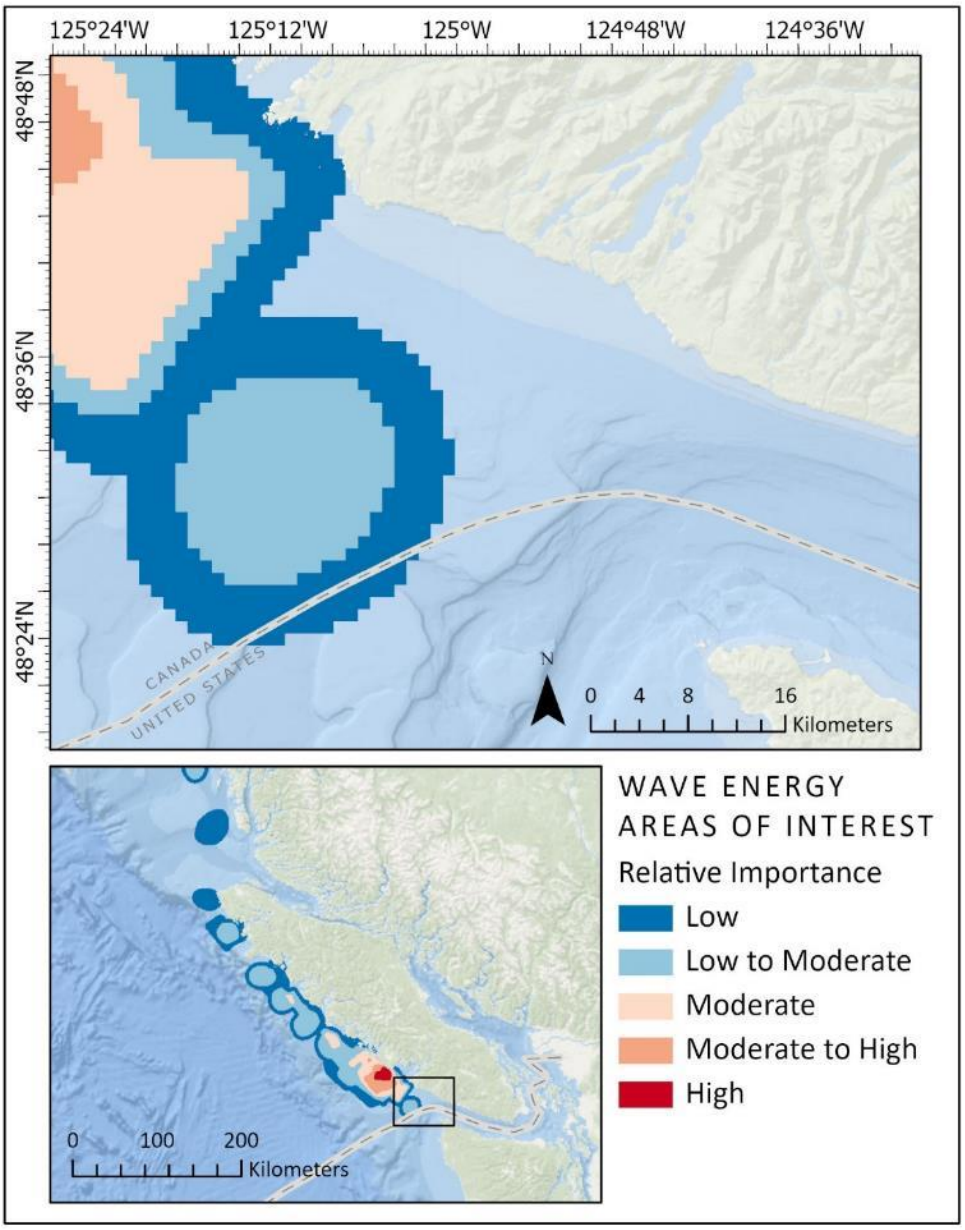


*Figure 67. Wave Energy Areas of Interest in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank and surrounding area from BCMCA Project Team (2011).*

Non-renewable energy resources in the SSB include petroleum and offshore oil and gas. The provincial and federal government issued tenures to various companies in the 1960s. Federal and provincial moratoriums were imposed in 1972 and 1989 respectively, which halted the issuance of permits for oil and gas exploration in BC. One company, Shell, has historically held federal tenures that partially overlapped with **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank but, has recently relinquished their licenses to the Federal Government (Jaremko 2018).

5.3.5 Tourism and recreation

There are no year-round anchorages in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Figure 68). Some areas are used seasonally by First Nations and Parks Canada, but local knowledge is needed to anchor, as conditions are not always safe for anchoring. Vessels circumnavigating Vancouver Island either anchor at the Port of San Juan or in Barkley Sound.

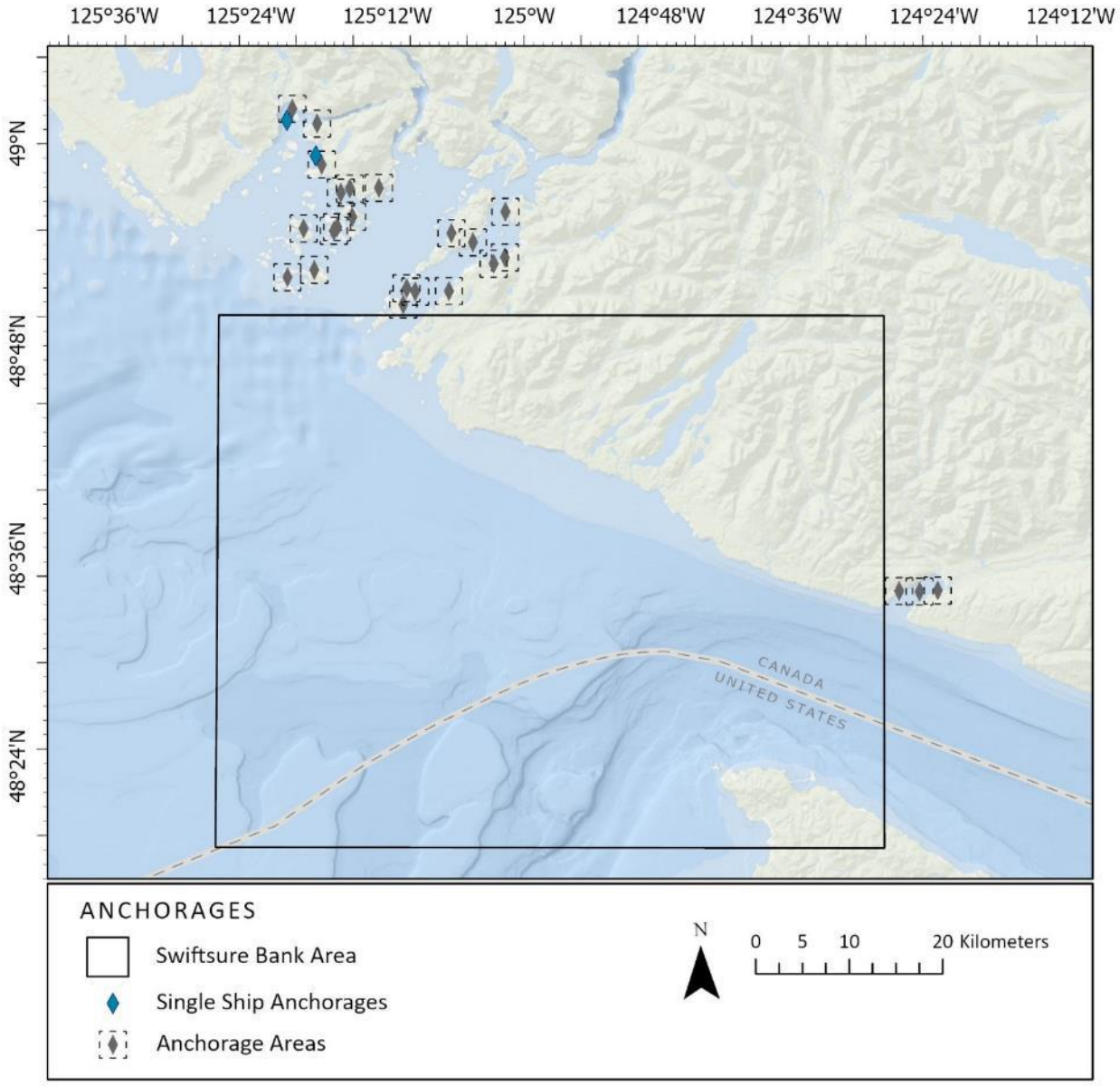


*Figure 68. Anchorage areas and single ship anchorages in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Data are from the Open Government Portal*[47].

[47] https://open.canada.ca/data/en/dataset/622a7f72-4a00-4f9e-b04f-af6551c77db3

The West Coast Trail (WCT, Figure 69) is a well-known multi-day backpacking trail that crosses the traditional territories and ancestral lands of the Huu-ay-aht, Ditidaht, and Pacheedaht First Nations. Parks Canada co-manages the WCT with the First Nations whose traditional territories the trail intersects. Each of these three Nations have a WCT Guardian team which assists Parks Canada with trail maintenance, hiker safety, and protecting their land for generations to come. The Huu-ay-aht First Nations operate a West Coast Trail Guardian Program which serves the hikers on the Pacific Rim Nation Park Trail. This is a collaboration and partnership between HFN and Parks Canada which aim to employ Huu-ay-aht First Nations' citizens and enrich hikers' experiences with added cultural information. The backcountry trail extends along 75 km of the coastline between the communities of Bamfield in the north and Port Renfrew in the south. Annual visitation to the WCT is approximately 7,000 users a year. The trail is open and reservable from May 1 to September 30 each year and requires a valid WCT Backcountry Use Permit as well as a valid National Park entry Pass for the Pacific Rim National Park Reserve (PRNPR). Motorized and non-motorized vessels, including kayaks, paddleboards or canoes, are not permitted to land anywhere within the WCT unit of PRNPR.[48]

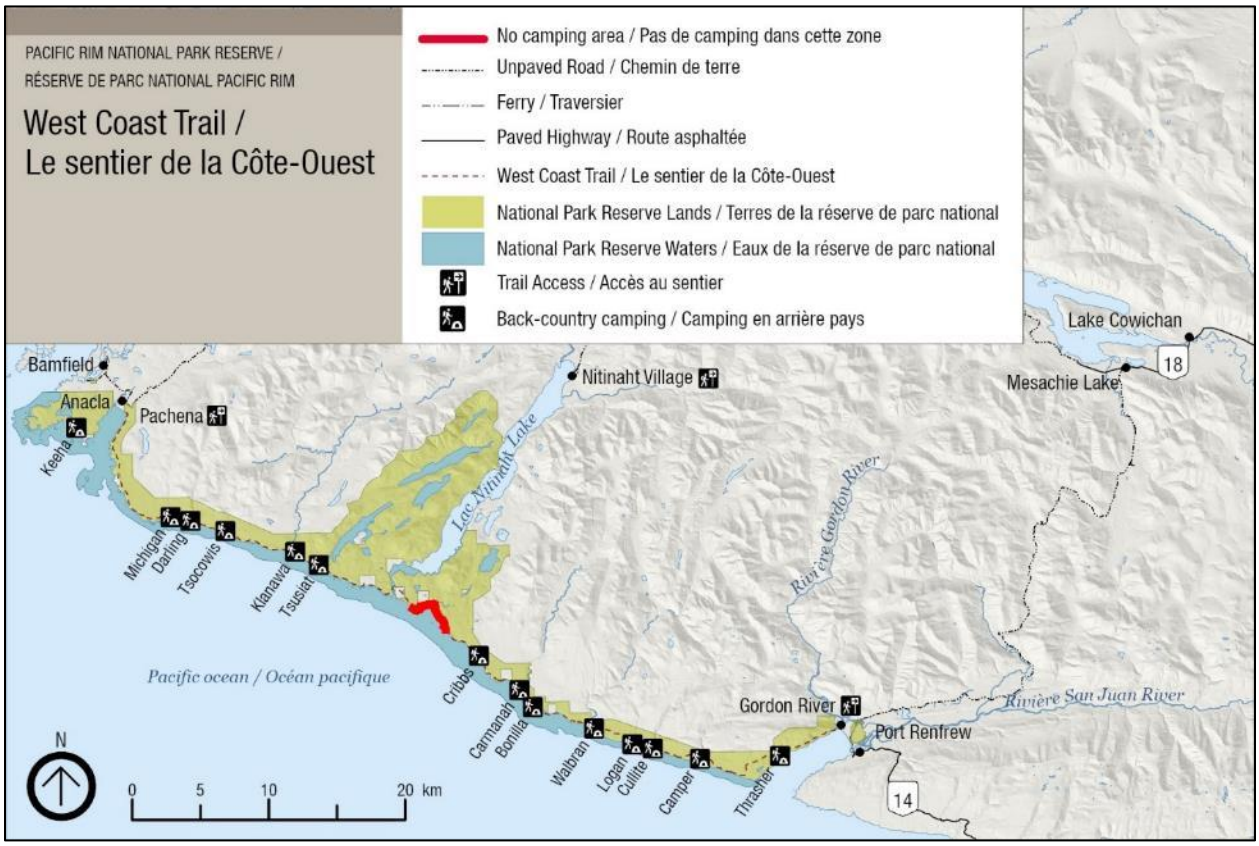


Figure 69. Tourism areas within the West Coast Trail and Pacific Rim National Park Reserve areas that overlap with ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank. Map provided by Parks Canada.*

Within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, there are limited tourism activities related to whale watching. A model of commercial whale watching activities in British Columbia was developed in 2023 based on AIS vessel data for 2019-2021[49] (Figure 70). There are no current business

[48] West Coast Trail: Hike of a lifetime - Pacific Rim National Park Reserve (canada.ca)

licenses for wildlife viewing within the marine area of the WCT unit of the National Park Reserve.

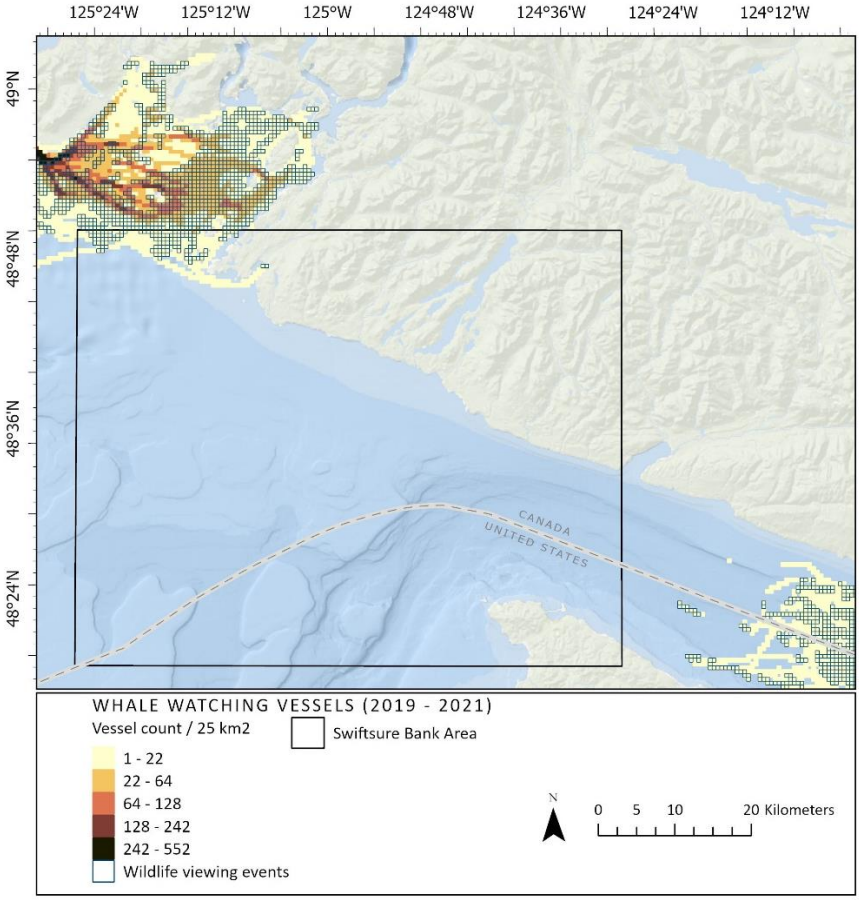


*Figure 70. Commercial whale watching vessel counts and wildlife viewing events, 2019 to 2021 June through September, around the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Serra Sogas et al. 2022). Whale watching vessel traffic derived from vessel Automatic Identification System (AIS) and presented on a 25 kilometer grid. Data available from the Open Government Portal[49].*

In addition to the National Park Reserve Lands, the Nitinaht Lake area supports recreation and tourism assets such as access to windsurfing, the Nitinaht campground and cabins (run by the Ditidaht First Nation), Carmanah Walbran Provincial Park, the Nitinaht Triangle route, old growth forests, freshwater fishing, and other wilderness experiences. Recent studies by the Ditidaht First Nation have identified the potential to expand the existing recreational and tourism opportunities through the provision of additional infrastructure (i.e., campgrounds, upgraded trail networks, rustic lodges, guiding services, etc.). Visitation to this area peaks in June, July, and August; however, recreational opportunities exist and do occur year-round.

[49] https://open.canada.ca/data/en/dataset/8a80c6f7-86a7-49e8-97c2-5229068e64cd?_gl=1*vcyozp*_ga*MTk1NzA1MDQyMy4xNzEwNTQ0MTM0*_ga_S9JG8CZVYZ*MTczNzI0MDEyMi42NC4xLjE3MzcyNDAxMjguNTQuMC4w

5.4 Vessel traffic and vessel types

Since 2019, the Government of Canada has implemented annual management measures in the **ʎušiiʔaaʔaq**/Swiftsure Bank Area to protect and support the recovery of the SRKW population.[50] From 2019 to 2021, an Interim Sanctuary Zone was implemented under the *Canada Shipping Act*. All vessels were prohibited from entering the designated sanctuary zone at certain times of the year, with some exemptions. Transport Canada and Pacheedaht First Nation subsequently co-developed two Speed Restricted Zones at **ʎušiiʔaaʔaq** in 2022, replacing the Interim Sanctuary Zone, to limit vessels to travel at no more than 10 knots to cover a larger portion of key foraging areas for SRKW. Since 2020, the Vancouver Fraser Port Authority's Enhancing Cetacean Habitat and Observation (ECHO) Program has coordinated a voluntary ship slowdown for commercial vessels at **ʎušiiʔaaʔaq** outbound shipping lanes, and since 2022 the inbound shipping lanes, as well as a recent voluntary lateral displacement in the Strait of Juan de Fuca for tugboats, requesting them to alter their transit route to be more southernly and further away from the Canadian coast, to help reduce underwater noise in possible SRKW foraging areas[51] (Figure 71).

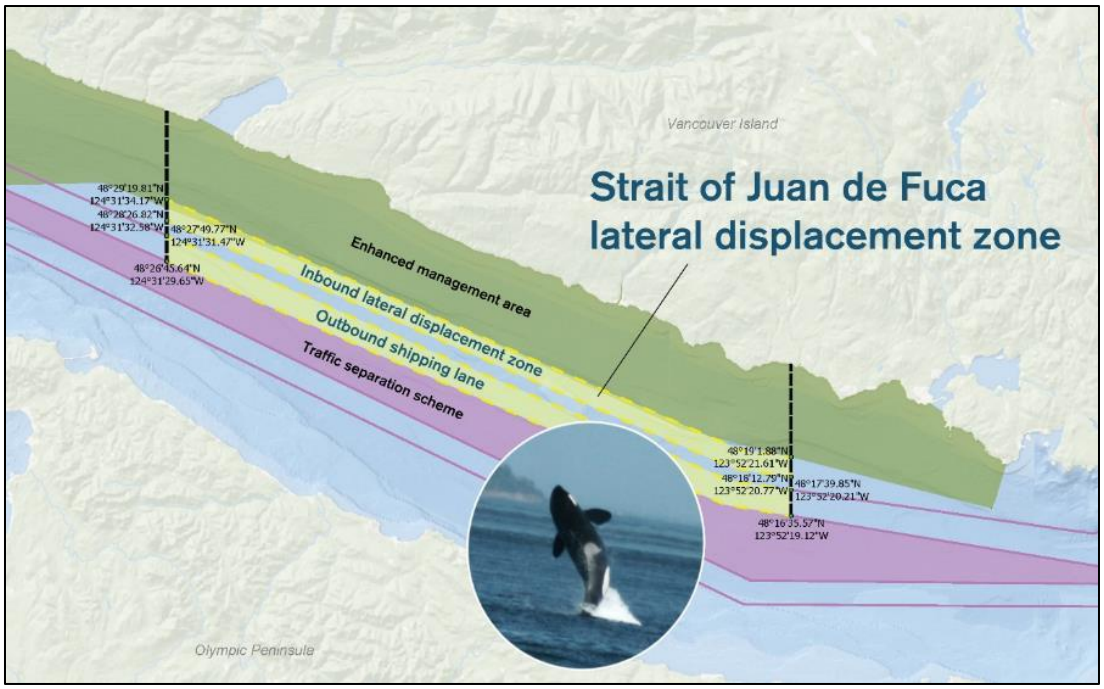


*Figure 71. **Strait of Juan de Fuca voluntary lateral displacement zone and parameters** for 2024 overlapping with the **ʎušiiʔaaʔaq**/Swiftsure Bank Area. Map from Vancouver Fraser Port Authority.*

Harmful effects from vessel traffic include ship strikes with marine animals, underwater noise pollution, the release of pollutants (e.g., airborne or oil, discharge such as sewage, greywater and scrubber washwater, marine debris, see Pollutants), disruptions to fishing gear and seaweed harvest due to increased wake on intertidal beds (Satterfield et al. 2012), and the introduction of nonindigenous or invasive species. Ship strikes are particularly harmful to larger animals, such as marine mammals (Nichol et al. 2017). Underwater noise pollution from vessels

[50] For more information regarding the suite of SRKW management measures, please visit https://www.canada.ca/southern-resident-killer-whales

[51] 2024 Strait of Juan de Fuca lateral displacement - Fact sheet (portvancouver.com)

can disturb the regular behaviours of animals that depend on acoustics for communication and foraging (Wright et al. 2007a; Weilgart 2007). Cetaceans and pinnipeds in particular, are susceptible to the harmful byproducts of increased marine traffic (Kucey 2005; Johnson and Acevedo-Gutiérrez 2007), especially when large vessels travel fast in areas where they aggregate. Examples of measures that can help mitigate collision risk for cetaceans, not all of which have been used in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, include limiting speeds to less than 10 knots while in the area and limiting large vessel traffic (> 180 m) during nighttime (to avoid behaviours when whales are in shallow waters) and seasons when whales are most active in the area (Keen et al. 2023). For more ship-strike information, please refer to (Liu et al. in press) and Keen et al. (2023). Finally, ships can also be a prominent method of introduction and connection for non-indigenous or invasive species to be transported into and between marine conservation areas (Iacarella et al. 2020a). It was noted that vessel biofouling regulations were needed in addition to plans on invasive species monitoring and prevention for marine conservation areas and marine conservation area networks (Iacarella et al. 2020a).

Vessel traffic density and type

Many ships have Automatic Identification System (AIS) transponders that provide information such as the vessel's identity, position, and activity to other AIS devices and satellite and terrestrial-based antennas. In Canada, large vessels are required to carry AIS (≥ 300 tons on an international voyage or ≥ 500 tons on a domestic voyage), vessels ≥ 150 tons carrying more than 12 passengers on an international voyage, vessels voyaging outside of sheltered waters certified to carry more than 12 passengers or vessels that are ≥ 8 m in length and carrying passengers (Navigational Safety Regulations (Automatic Identification Systems): SOR/2019-100). Smaller commercial fishing and recreational vessels are not required to have AIS. Therefore, an absence of AIS data does not indicate an absence of vessels, and there can be significant vessel omissions in Canada's AIS data (Iacarella et al. 2023). For example, only 30% of vessels detected in a C&P flyover over the Salish Sea in BC transmitted AIS (Serra-Sogas et al. 2021). AIS data provided by Transport Canada from Terrestrial AIS via Canadian Coast Guard and Satellite AIS via Maerospace (MPATT vessel traffic density grids 2015-2019 metadata) were used to summarize total vessel counts and vessel types within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank in 2019 per 1 square kilometer.

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is heavily utilized by vessels, not including the separation scheme that shows areas of no vessel use. The densest vessel traffic is observed in on the edges of the separation scheme and along the coast, into the Strait of Juan de Fuca and out in the deeper regions of the continental shelf (Figure 72).

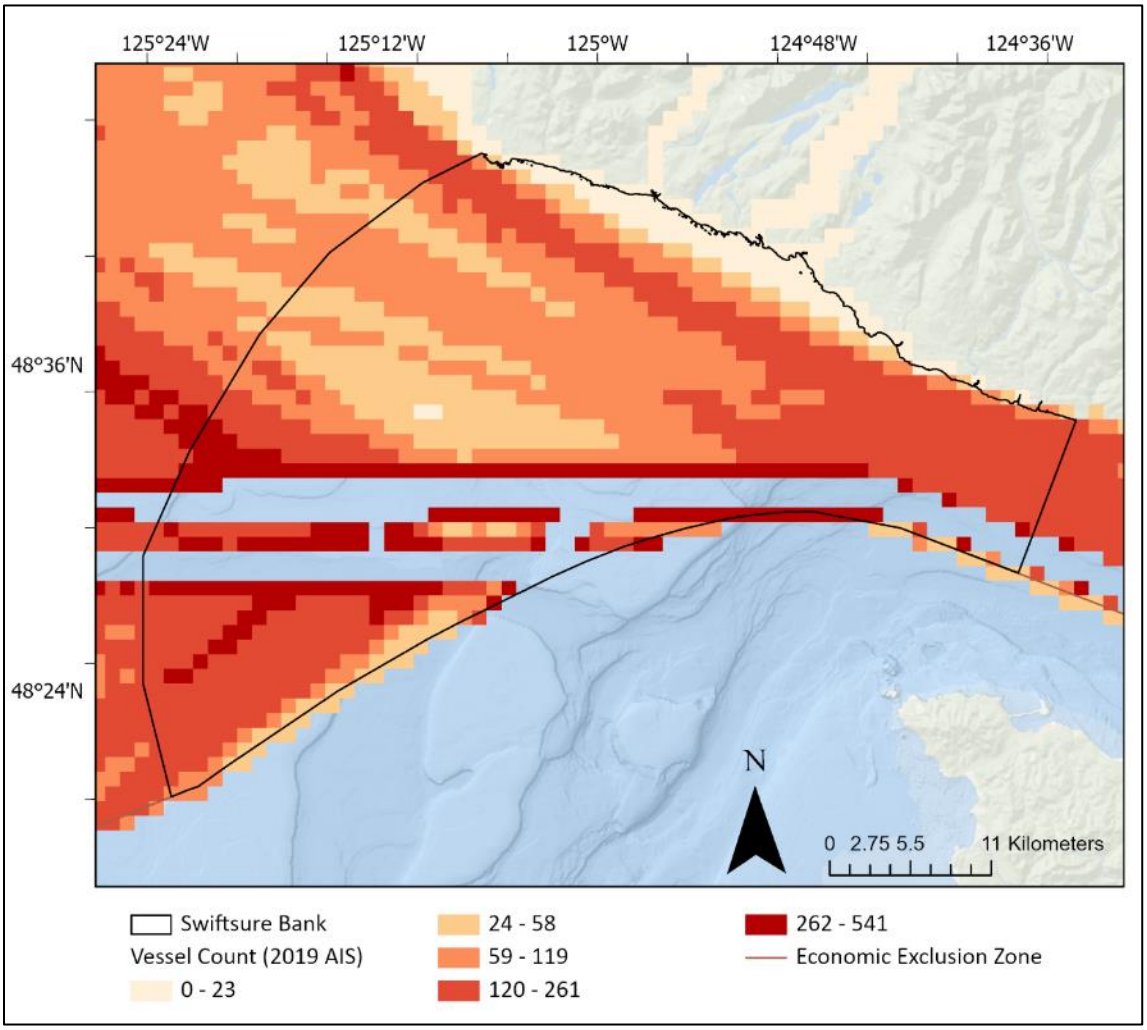


Figure 72. Total annual estimated vessel traffic in 2019 in the ***ʎ̓ušiiʔaaʔaq****/Swiftsure Bank Area (black polygon delineates boundary of Juan de Fuca Eddy EBSA) of the Southern Shelf Bioregion, British Columbia. Vessel traffic counts are the total number of vessels per 1 km² grid cell based on AIS data.*

Additionally, DFO's Conservation & Protection runs the Aerial Surveillance Program (ASP) to enforce fisheries closures regulated by DFO. The ASP provides observations of fishing vessels through transmissions received by AIS, radar detection, and visual observations (Burke et al. 2022). These flyovers fill in gaps from AIS, since flyovers can detect vessels with or without AIS transponder units on board. C&P flyovers cover the entire BC coast, albeit in a non-continuous time span, and collect information on vessel's identity and position along with detailed information on vessel activity and type, including fishing gear types (Iacarella et al. 2020b, 2023; Burke et al. 2022). C&P flyover data within the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area were compiled from the C&P flyovers database for 2019 and 2020 and were used to summarize vessel counts and vessel types along with fishing gear type.

Most vessels detected in **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank on C&P flyovers from 2012 to 2020 were cargo or fishing vessels (Figure 73), and most of the fishing vessels were recreational (Figure 74)

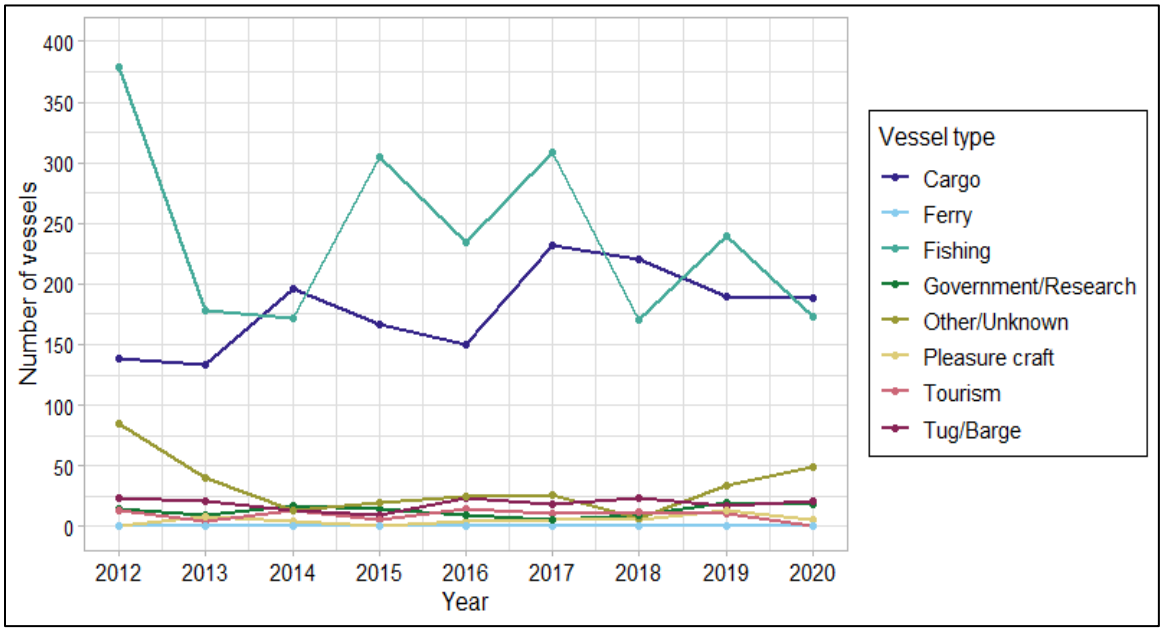


*Figure 73. Vessel types detected in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area from 2012 to 2020. Data comes from the Conservation & Protection Aerial Surveillance Program flyovers per year (Burke et al. 2022; Iacarella et al. 2023).*

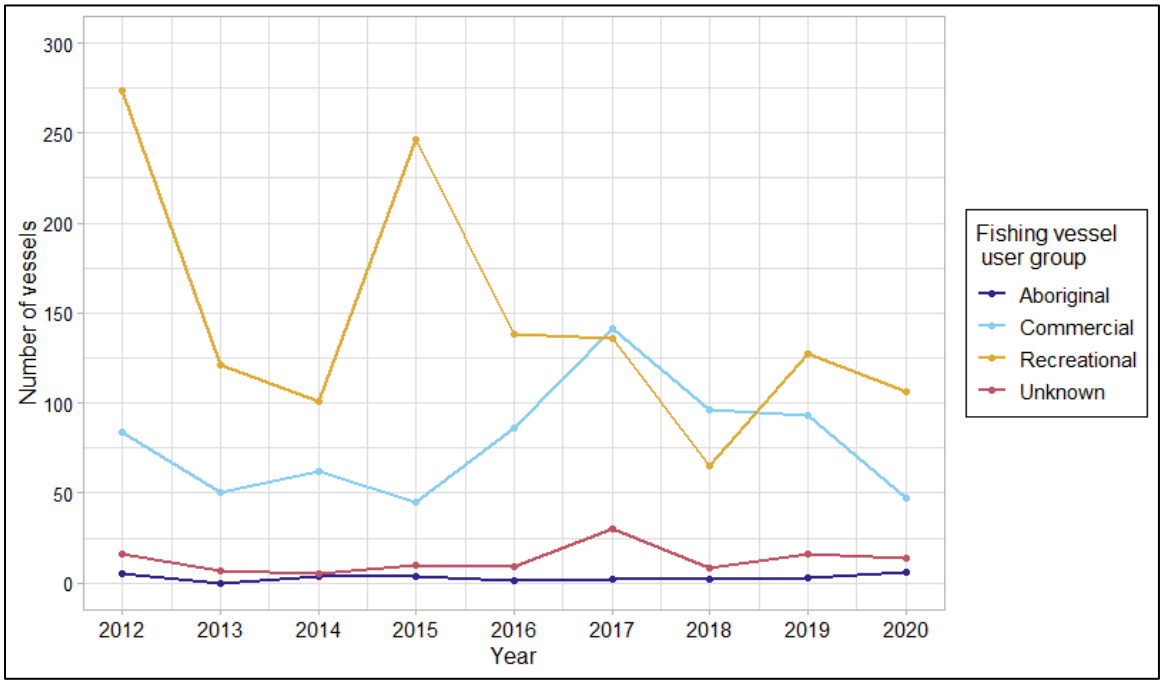


*Figure 74. Fishing vessel user groups detected in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area from 2012 to 2020. Data comes from the Conservation & Protection Aerial Surveillance Program flyovers per year (Burke et al. 2022; Iacarella et al. 2023).*

Parks Canada staff conduct bird surveys following line transects along the West Coast Trail Unit of Pacific Rim National Park Reserve between Cape Beale and Port Renfrew and also document recreational vessels. Five to seven surveys are conducted annually along a permanent 68.9 km transect approximately every fortnight between the months of May and

August using a power boat (a Rigid Hull Inflatable Boat) moving at ~ 10 knots. The transect was broken up into 25 legs of unequal length separated by prominent landmarks. The boat, typically crewed by a driver and 1-2 observers, followed a fixed route along the 20-m depth contour and staying for the most part within ~ 1 km of shore. During a survey, all actively fishing and/or transiting recreational vessels were counted within ~ 400 m of the research vessel on both sides, recording the time of observation, their state (fishing or transiting) and survey leg. The great majority of the vessels observed were sports fishing boats, although occasionally other types of vessels, such as sailboats, were present and counted. The transect legs were used as the unit of data aggregation. For the purpose of this report, we used the data collected between 2005 and 2023. Additional details about the study area and some aspects of the methodology can be found in Bellefleur et al. (2009).

The highest density of recreational vessels observed during Parks Canada surveys was towards the southern end of the West Coast Trail Unit between the Walbran Creek and Owen Point, followed by the area off the Tsusiaht Falls. Lower levels of recreational boat activity were observed elsewhere along the Trail (Figure 75). The overall recreational boat activity along the West Coast Trail Unit over the past 18 years has been relatively stable with a slight tendency to decline (Figure 76). Within a season, boat activity tends to increase sharply from May to August.

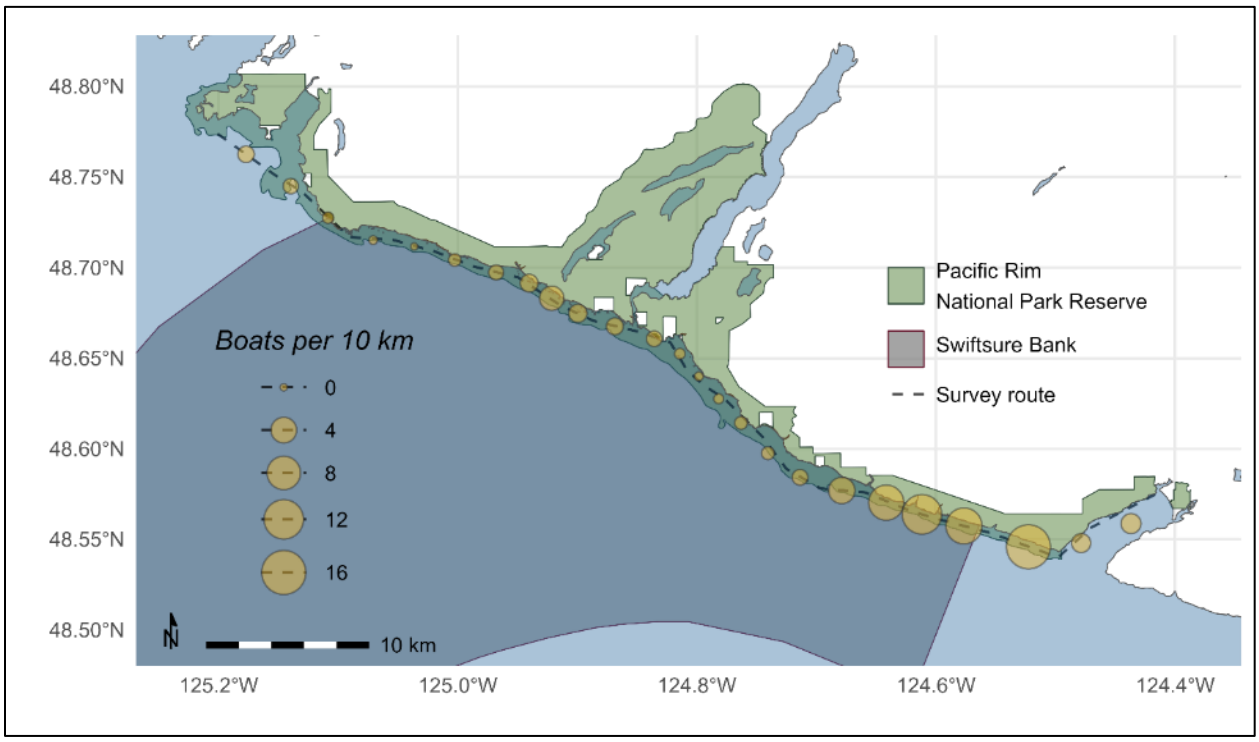


Figure 75. Recreational vessel density along the West Coast Trail Unit of Pacific Rim National Park Reserve. Counts of recreational vessels are expressed as density per 10 km (individual legs had different lengths), averaging the density per survey leg over the entire time series and plotting the values along the survey route (Fig. 1). Dark blue area delineates the Juan de Fuca Eddy EBSA. Map provided by Parks Canada.

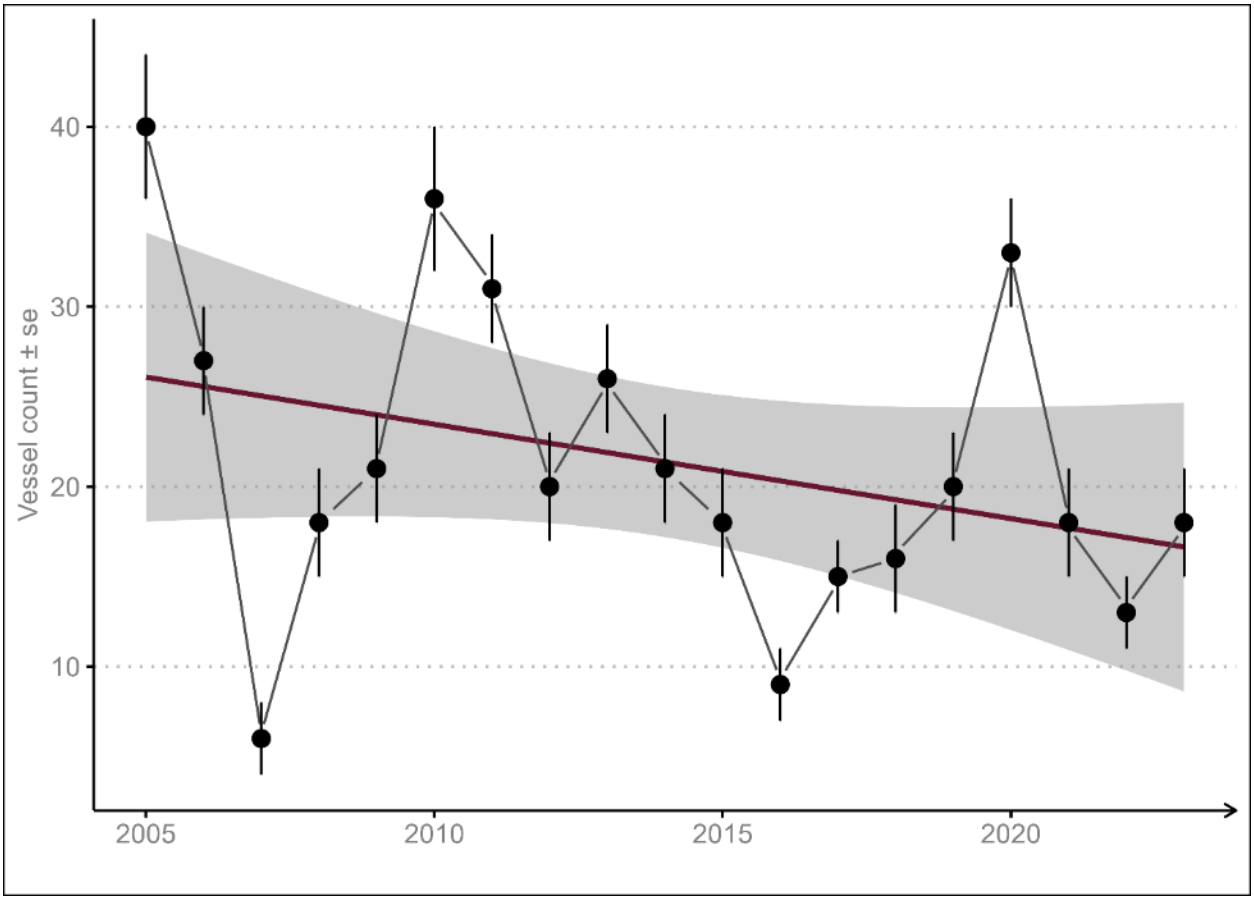


Figure 76. Annual pattern in the mean estimated count of recreational vessels (± standard error) per full length of the West Coast Trail survey (68.9 km), Pacific Rim National Park Reserve. Dark red line indicates the overall trend in the data estimated using a generalized estimating model (R package rtrim, Bogaart et al. 2021).

Sunken vessels and wrecks

In addition to the high rates of contemporary vessel traffic in the area, this area of the west coast of Vancouver Island is also part of the "Graveyard of the Pacific" (Figure 77), a loosely defined area stretching along the west coast of Vancouver Island and Oregon with high numbers of sunken ships and wrecks. The West Coast Trail[52] in the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area originated as a lifesaving trail, used to rescue people from shipwrecks along the west coast of Vancouver Island. The unpredictable weather conditions (storms and fog) and dangerous coastal rocky shorelines (shifting sandbars, tidal rips, rocky reefs) have led to thousands of wrecks along its length. The most dangerous points along the trail are Pachena and Carmanah Points. Satellite navigation and improved search and rescue methods have reduced the danger of shipwrecks (French 1999). Four manned lighthouses now operate in the area, providing navigational support and weather observations, including Cape Beale Lighthouse, Pachena Point Lighthouse, Carmanah Point Lighthouse and Cape Flattery Lighthouse (Figure 77). However, Pachena Point and Carmanah Point Lighthouse will no longer be manned as of winter 2024 due to safety concerns. Further, with increasing storm frequency

[52] West Coast Trail: Hike of a lifetime - Pacific Rim National Park Reserve (canada.ca)

and unpredictable weather due to climate change the potential risk for vessel damage and wrecks could increase, despite improvements to navigational technology or weather warning systems.

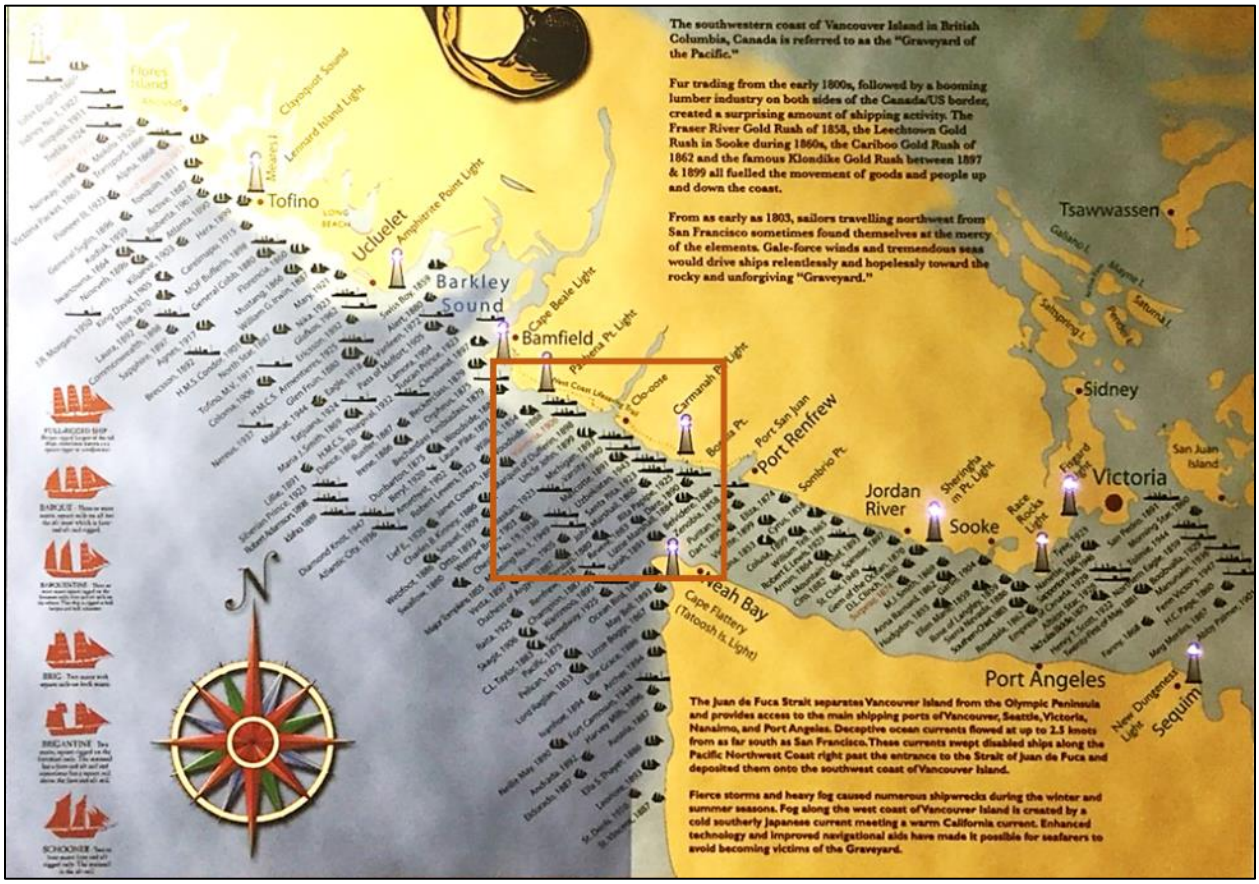


Figure 77. Graveyard of the Pacific – modified map of sunken ship locations on the West Coast of Vancouver Island (https://hikewct.com/index.php/shipwrecks). The orange square shows the approximate location of the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area described in this report. The lighthouse images on the map show the location of manned lighthouses in the area, including Cape Beale, Pachena Point, Carmanah Point, and Cape Flattery). This area runs along a treacherous stretch of the Graveyard of the Pacific, a loosely defined stretch of the Pacific Northwest Coast with a history of hundreds to thousands of wrecks.*

5.5 Pollutants

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

The West Coast Vancouver Island Integrated Response Plan for Marine Pollution Incidents referred to in the Marine spill response planning section of this report targets risks associated with when a pollutant enters, or has the potential to enter, Canadian waters, regardless of source. A pollutant in this context is formally defined as: (a) a substance that, if added to any waters, would degrade or alter or form part of a process of degradation or alteration of the quality of the waters to an extent that is detrimental to their use by humans or by an animal or a plant that is useful to humans; and (b) any water that contains a substance in such a quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state, that it would, if added to any waters, degrade or alter or form part of a process of degradation or alteration of the quality of the waters to an extent that is detrimental to their use by humans or by an animal or a plant that is useful to humans. It includes oil and any substance or class of substances that is prescribed for the purpose of Part 8 of the *Canada Shipping Act* (2021) to be a pollutant.

The Ditidaht First Nation is currently working with Canadian Coast Guard (CCG) and Western Canada Marine Response Corporation (WCMRC) to develop spill response capacity within their traditional territory. This has included the selection of spill response storage sites, collaborative planning with the Nitinaht Hatchery, CCG, and WCMRC, baseline habitat assessments as a tool for spill response monitoring, acquiring necessary spill response equipment, identifying priority protection zones for potential spills, and developing a spill response plan.

Maa-nulth Nations are pursuing opportunities to work collaboratively with the WCMRC and participating on the Marine Shipping Subcommittee (subcommittee of the Indigenous Advisory Monitoring Committee) to develop spill response capacity within their traditional territories. The Maa-nulth Nations are also collaborating with researchers to understand how contaminants may spread within the Maa-nulth Treaty Domestic Fishing Area in the event of a disaster and the potential impacts to species and ecosystems.

With increased ship traffic comes increased concern for potential cargo ship spills and increased ship discharges of pollutants. Furthermore, climate change impacts on wave height and storm frequency could increase the odds of pollutants entering the marine environment from vessel traffic in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

A recent study by JASCO Applied Sciences (MacGillivray et al. 2024) that utilized an advanced soundscape model to explore how underwater noise from various marine sectors impacts Southern Resident Killer Whale (SRKW) habitat based on data from 2022. The study describes the noise impacts from 15 vessel types, as well as ambient noise for the Salish Sea and **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank and compares the months of January and July 2022 to investigate seasonal variability. The study found that, on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, broadband noise (the frequency band used to evaluate behavioral and physiological impacts to SRKW) was dominated by commercial cargo vessels in January, with a large additional contribution from fishing vessels in July. The higher frequency SRKW communication and echolocation bands were dominated by small fishing vessels (which tend to have noise emissions concentrated at higher frequencies), particularly in July. The noise contributions of smaller vessels had high seasonal variability with more spatially diffuse noise contributions compared to large commercial vessels. The study also noted that the percentage of non-AIS vessels is still poorly understood on **ƛ̓ušiiʔaaʔaq** because the area was not covered by the aerial survey data that were used to derive non-AIS vessel noise contributions.

MacGillivary et al. (2024) notes that a data gap exists for non-AIS vessel detections in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, and suggests that additional aerial survey data, and exploring alternative methods for assessing non -AIS vessel traffic would increase confidence in noise contribution estimates from these vessels in the area. The authors also note that additional research is needed to understand the large contribution of fishing vessels and potentially fishing sonars to the underwater soundscape at **ƛučiiʔaaʔaq**, particularly in the context of overlapping SRKW presence and fishing activities. The methods used in this study to investigate the overlap of vessel noise on acoustic sensitivity of SRKW could also be applied to fishes and invertebrates (if noise sensitivity data are available) and the authors note that more research is necessary to understand the potential impacts of noise on marine life (particularly those that are important for SRKW survival).

Marine Debris

Marine debris, or litter, is synthetic materials found in the marine environment with anthropogenic origins that may negatively affect local ecosystems. Research quantifying marine macro-debris from archived shoreline aerial photographs taken over Vancouver Island and in-situ surveys showed some areas of significant debris on beaches with a variety of visible debris types, not including logs, in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Figure 1 in Kataoka and Murray 2018). Clo-oose Beach had a significantly higher percentage of debris coverage (14%) compared to Cheewaht Beach (4%). Ocean currents and wind patterns were attributed with concentrating debris at specific locations. Lost, abandoned, or discarded fishing gear (also called ghost gear) harms marine life and habitats, sheds microplastics, and presents hazardous obstacles for marine species and divers (Huntington 2019). Threats to marine mammals and fishes include ingestion and entanglement from ghost gear and other marine debris. The proliferation of microplastics (< 5 mm) in the marine environment is an emerging global concern (Worm et al. 2017). The effects of microplastic bioaccumulation across the food web is a concern across the coast (Alava 2022), especially for First Nations and coastal communities that depend on marine resources for subsistence and harvest (Provencher et al. 2023). Huu-ay-aht First Nations have been active beach keepers for the past 20 years on the beach within their territory and the beach of the West Coast Trail. Research by Covernton et al. (2022) found that larger microplastics (> 100 µm) were not accumulating up BC's marine food web. However, they acknowledged that research on smaller microplastics is lacking for risk assessments. Williams et al. (2011) modelled the distribution of marine debris and its overlap with marine mammal species in BC waters. In the study, styrofoam, plastic bags, and plastic bottles were the most common observed debris throughout the coast, however survey overlap with the **ƛ̓ušiiʔaaʔaq** Area was low and the predicted marine debris density in the southern portion was in the lower end of the range (Figure 2 in Williams et al. 2011). An example of extreme marine debris is when the Zim Kingston lost 109 containers at sea off the west coast of Vancouver Island in 2021. A recent expedition (PAC2023-034) surveyed the primary region of lost containers just outside of the **ƛ̓ušiiʔaaʔaq** Area (Figure 78; Clyde et al. 2025). Debris scattered outside of the containers included (but was not limited to) brake rotors, plastic packaging, work boots, plastic ribbon, couches, wicker furniture, black hose, and playing cards. DFO Fishery Notices have since been issued listing the known location of underwater obstacles and the area has been added as navigational seabed hazards on CHS charts. This marine debris fall begins just 18 km from the edge of the Swiftsure Polygon and comprises only 28% of the 109 lost containers from the incident.

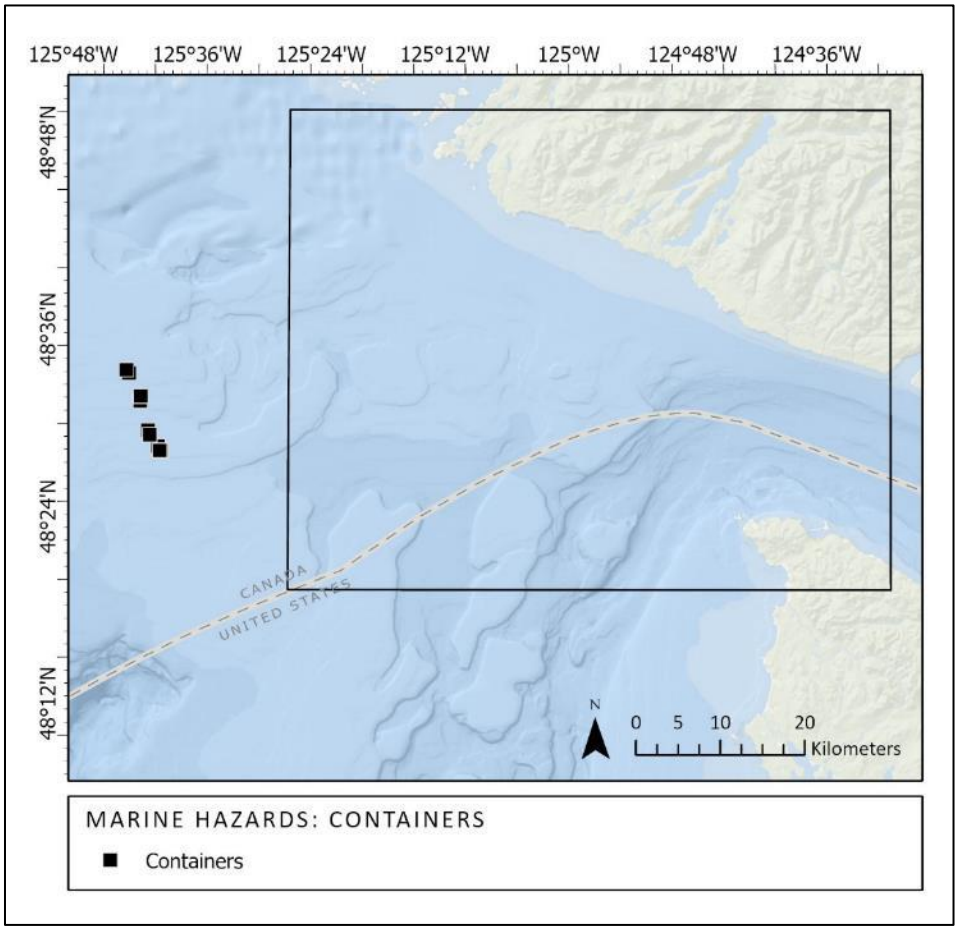


Figure 78. Location of marine hazards documented from the Zim Kingston in the vicinity of the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area.*

Noise

Underwater noise pollution from marine transportation is a growing concern which can interfere with and impair animal behaviours. Ship propellers generate most of this pollution, and noise disturbance is often correlated with vessel speed. This pollution threatens marine mammals such as whales and dolphins that rely on acoustic signals for communication, foraging, and navigation (see Marine mammals and reptiles). Other sources of underwater noise that could negatively impact marine animals, such as Killer Whales, include military and commercial sonars, seismic survey air guns, tidal turbines, underwater explosions, acoustic devices used for pinniped deterrence, and pile-driving operations (Ford et al. 2013b).

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area has been an area of increased research activity, particularly around noise pollution, due to it being a critical feeding area for SRKW, which have demonstrated sensitivities to noise pollution. A 2019 evaluation of an interim sanctuary zone (ISZ) intended to exclude vessels at **ƛ̓ušiiʔaaʔaq** showed that there was poor compliance but an up to a 1.1 dB reduction in broad-band (10-100,000 Hz) noise was observed at a mooring just south of the ISZ, under the shipping lane (Vagle 2020). Reduced underwater noise levels (~2dB reduction in band averaged sound pressure level (SPL)) were indicated during the summer and fall ISZ timeframe, except in the large-vessel-dominated 100-1000 Hz band. Most

of the observed decrease was attributed to changes in the traffic pattern of deep-sea vessels. This trend was similar to patterns observed in 2018, when no sanctuary zone was in place, and may relate to reduced ship traffic during this period (Vagle 2020). A second mooring has since been placed at **ƛ̓ušiiʔaaʔaq** within the ISZ (Vagle 2020).

Greywater and Washwater

Greywater is generated from human usage onboard vessels, such as sinks and laundry, but excludes sewage. According to the *Canada Shipping Act* (2021), dumping untreated sewage from recreational boats is banned within three nautical miles of the shore for all vessels, while treated sewage cannot be discharged within one nautical mile of the shore. Recent environmental regulations also require that cruise ships discharge treated sewage and greywater at least three nautical miles from shore (Transport Canada 2022). However, exemptions exist, and dumping within this distance does occur. In contrast, small commercial and recreational boats can dispose of untreated greywater in marine environments. The BC coast is the largest cruise region in Canada, and modern cruise ships carry over 2,000 people, which can produce a substantial amount of discharge. Sewage discharge threatens commercial and recreational shellfish beds and affects water quality, particularly in areas with low tidal exchange (Campos and Lees 2014) In a recent study quantifying the threat of ship waste in Canada's MPAs, cruise ships were found to account for 69.6% of greywater, 66% of scrubber washwater (described below), 60.8% of sewage, and 29.4% of the bilge water generated annually in Canadian Waters despite representing only 2% of vessels (Davin et al. 2022).

"Scrubbers" on larger vessels are systems that aid in cleaning engine exhaust after burning heavy fuel oils to prevent atmospheric pollution. The scrubbing process creates washwater that contains acidic compounds, such as sulfur and nitrogen oxides, heavy metals, and polycyclic aromatic hydro carbons (PAHs) that is subsequently discharged into the ocean, often with little to no filtration. This can contribute to ocean acidification and the leaching of metals from corroding discharge lines (Stips et al. 2016; Teuchies et al. 2020; Davin et al. 2022). An assessment on scrubber washwaters by Clear Seas Centre for Responsible Marine Shipping (2022) supported limiting and restricting discharge in coastal and inlet waters. Within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area high levels of scrubber washwater releases are associated with the heavy vessel traffic area along the EEZ and into the Strait of Georgia (Figure 79).

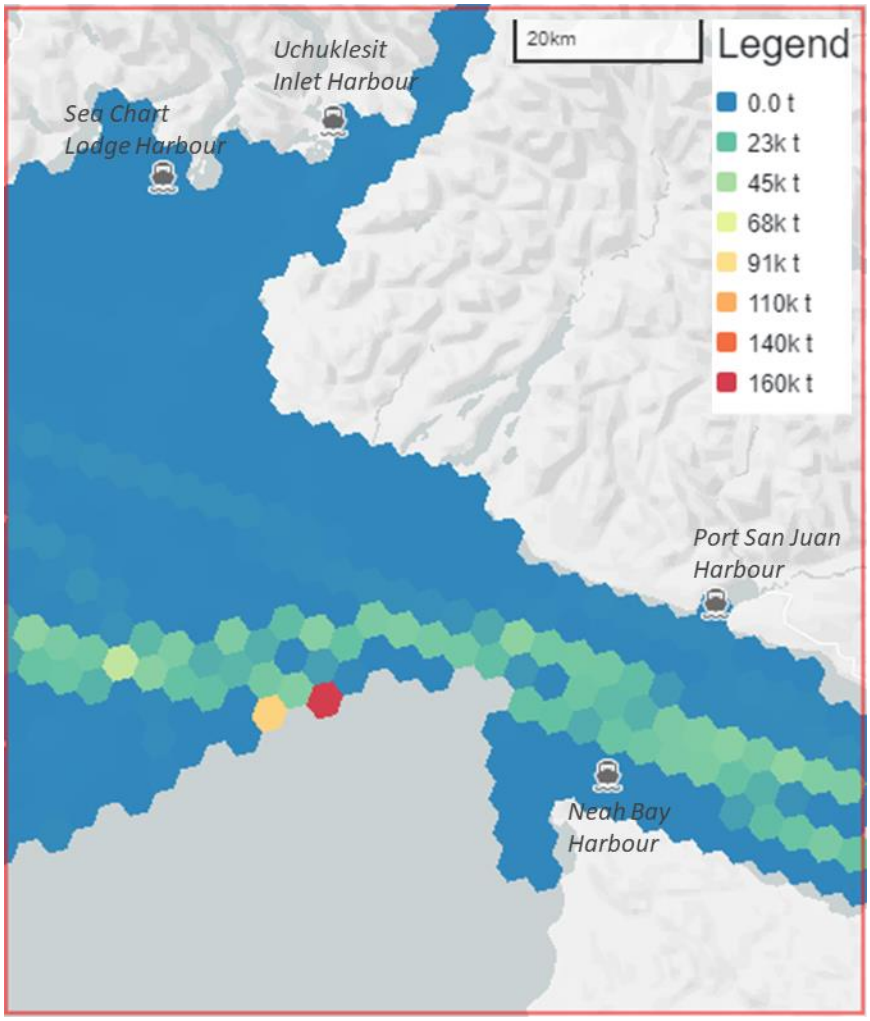


Figure 79. Scrubber washwater releases from ships travelling off the bank to/from port in the ***ʎušiiʔaaʔaq̓****/Swiftsure Bank Area during 2020, with harbour locations in proximity. Data comes from Marine Emissions Inventory Tool[53]. Note that for each hexagon in the hex grid, additional air emission pollutant and washwater pollutant data are available.*

Wastewater

Canadian Nuclear Laboratories is conducting a field-based research program to establish baseline levels of tritium prior to the arrival of the tritium-containing, treated wastewaters from the Fukushima Daiichi nuclear power plant. Tritium is a radioactive isotope of hydrogen that can be found in water and food (Facts about tritium (nuclearsafety.gc.ca)). This program includes the collection of waters along DFO's Line-P research cruise, coastal waters, and fish and shellfish with a focus on important community food sources. This research occurs within close proximity to the **ʎušiiʔaaʔaq̓**/Swiftsure Bank Area. Water and biota samples will be analyzed for tritium and gamma emitters. The research is funded by Atomic Energy of Canada's Federal

[53] https://www.canada.ca/en/environment-climate-change/services/managing-pollution/marine-emissions-inventory-tool.html

Nuclear Science and Technology work program. External publication of results is scheduled for summer 2026 (E. Priebe, Canadian Nuclear Laboratories, pers. comm.).

Biotoxins

As mentioned in the Commercial Fishing section, shellfish harvesting closures exist for most of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, predominantly due to the risk of biotoxin contamination. The consumption of contaminated shellfish can lead to various poisoning syndromes, including Paralytic Shellfish Poisoning (PSP), Amnesic Shellfish Poisoning (ASP), and Diarrhetic Shellfish Poisoning (DSP) (Visciano et al. 2016). These syndromes are caused by toxins primarily produced by harmful algal blooms (HABs) that accumulate in shellfish tissues (Ben-Gigirey et al. 2021). Within marine ecosystems, harmful algal toxins can be transmitted through the food web from zooplankton to higher trophic levels (fish, marine invertebrates, marine birds, marine mammals, and people)(reviewed in Ben-Gigirey et al. 2021). Furthermore, the economic implications of shellfish biotoxin contamination are significant, as closures of harvesting areas can disrupt local fisheries (BC Centre for Disease Control and First Nations Health Authority 2017). The accumulation of these biotoxins in shellfish is influenced by the species of shellfish, environmental conditions (including climate change and eutrophication), and the presence of specific toxic algae (Visciano et al. 2016). In British Columbia, environmental monitoring programs have been established to track phytoplankton levels and biotoxin concentrations in shellfish (Taylor et al. 2013). A notable outbreak of DSP was reported in 2011 in BC, which was associated with the consumption of contaminated mussels from the Strait of Georgia (Taylor et al. 2013). Continuous monitoring and research are essential to understand the dynamics of biotoxin accumulation in shellfish and to develop effective management strategies to safeguard public health and wellbeing and the local economy. Further research is required to understand the known and potential risks associated with biotoxins and their environmental levels, particularly for coastal Indigenous populations that routinely consume a greater diversity of seafood species (Lee et al. 2024). Details regarding the harmful algal species that have already been observed in the Swiftsure Bank area are detailed in the Plankton section.

Contaminated Sites

Contaminated sites are documented federally and provincially[54]. Federally they are classified as Suspected, Active, and Closed. Within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, several active contaminated sites exist (Figure 80). While these sites are terrestrially located, the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank polygon is coastal with a large terrestrial-marine interface and contamination that occurs within proximity of the area could pose concern for the health and wellbeing of the marine environment and coastal communities. These sites have associated contamination estimates that include the contaminant and medium type (DFRP/FSCI Map Navigator). Three sites are further indicated in Figure 80 by their site numbers for which we provide more detail here as they are within the zone of interest for **ƛ̓ušiiʔaaʔaq**:

- Site 17810001 (Pachena Point) is an active contamination site of high priority for action with soil contamination of petroleum hydrocarbons, and metal, metalloid, and organometallic pollutants. Remediation / risk management is completed and confirmatory sampling is underway (https://www.tbs-sct.gc.ca/fcsi-rscf/fsi-isf/17810001-eng.aspx).

[54] https://map-carte.tbs-sct.gc.ca/map-carte/fcsi-rscf/map-carte.aspx?Language=EN&backto=www.tbs-sct.gc.ca/fcsi-rscf/home-accueil-eng.aspx

- Site 17533001 (Carmanah Point) is an active contamination site of high priority for action with soil contamination of petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and metal, metalloid, and organometallic pollutants. Remediation / risk management is completed and confirmatory sampling is underway (Site 17533001 - Carmanah Point (tbs-sct.gc.ca)).
- Site 00006415 (662 - Ditidaht - 06899 - MALACHAN 11 – 7000128398) is located in the Nitinaht Lake area. The site is active and has a medium priority for action status. The site has suspected soil and water contamination of petroleum hydrocarbons, benzene, toluene, ethylbenzene, and xylene, polycyclic aromatic hydrocarbons and metal, metalloid, and organometallic pollutants. Initial testing has been completed and detailed testing is underway (Site 00006415 - 662 - Ditidaht - 06899 - MALACHAN 11 - 7000128398 (tbs-sct.gc.ca)).

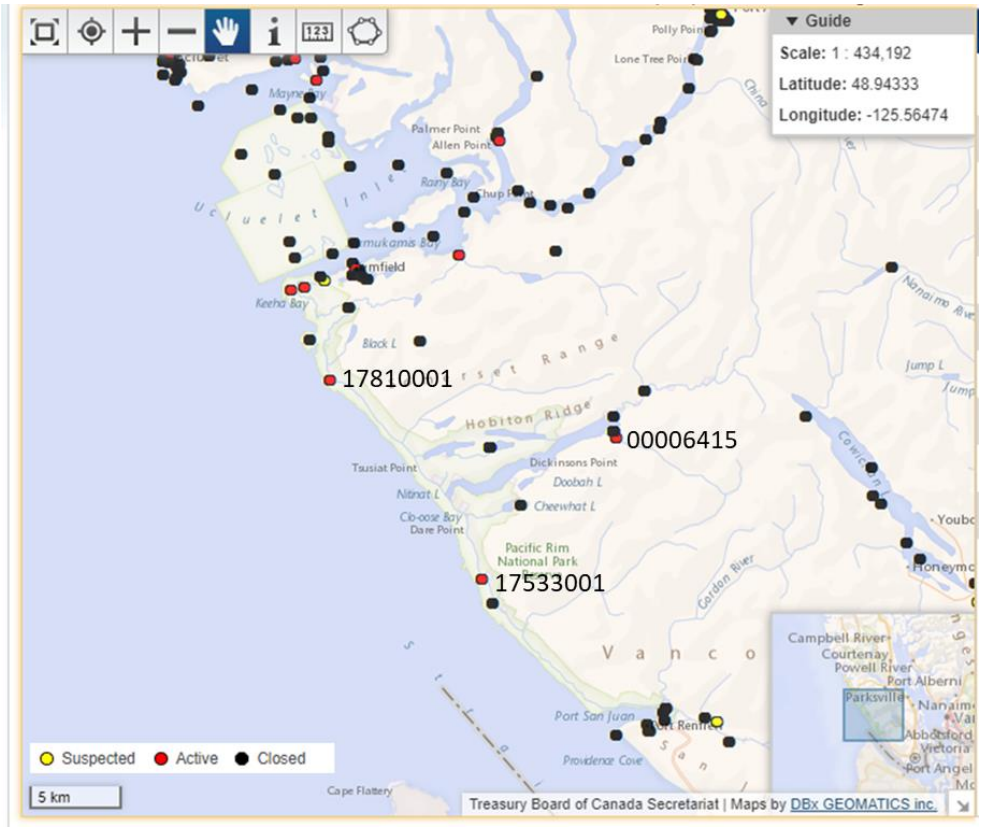


Figure 80. Federal contaminated sites as of March 21, 2024. Three active sites within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area of interest (including Nitinaht Lake) are indicated with their site numbers. Data and map from the Treasury Board of Canada Secretariat*[55]*.*

5.6 Aquatic Invasive and Non-Indigenous Species

Invasive species are non-native organisms that, when introduced to a new environment, can outcompete native species, disrupt ecosystems, and alter local biodiversity, with significant ecological and economic consequences. The presence and impact of invasive species can vary

[55] https://map-carte.tbs-sct.gc.ca/map-carte/fcsi-rscf/map-carte.aspx?Language=EN&backto=www.tbs-sct.gc.ca/fcsi-rscf/home-accueil-eng.aspx

over time, and ongoing monitoring is crucial. An invasive species with documented occurrences and of concern in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is the European Green Crab (*Carcinus maenas*), which is detailed below.

The European Green Crab has established itself in the Pacific Northwest, including the west coast of Vancouver Island, and has recently entered the inner Salish Sea (Yamada and Gillespie 2008; Yamada et al. 2017). This invasion is likely due to the transport of crab larvae from established source populations in California, and the species has shown the ability to persist and locally recruit in the region (Yamada 2008). This invasive species poses a threat to local ecosystems and fisheries, particularly in the Strait of Georgia/Puget Sound and coastal estuaries (Jamieson et al. 1998). European Green Crab was first detected in Sooke Basin in 2012, and in US waters of the Salish Sea in 2016 (DFO 2022a). The recent range expansion of the green crab in Washington State, including the San Juan Islands and Padilla Bay, highlights the need for ongoing monitoring and control efforts in the Salish Sea (Grason et al. 2018). It is a versatile predator that can negatively impact bivalve and crab fisheries (Jamieson 1998). Furthermore, the green crab's habitat alteration can lead to the loss of eelgrass, a key component of coastal ecosystems (Howard et al. 2019), and impact their associated biodiversity including fish communities (Matheson et al. 2016). However, the potential distribution of the green crab in the northeastern Pacific may be limited, and its impacts attenuated through predation by, and competition with, native crab species (Jensen et al. 2007).

European Green Crab has been observed in neighbouring Barkley and Clayoquot Sounds, Port Renfrew, the Pacific Rim National Park Reserve, and within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area in Nitinaht Lake in 2022 and 2023 (Figure 81; DFO unpublished data; N. Nolet, DFO, pers. comm.). It is likely that the rocky and exposed coastline which makes up the majority of the coastline of the **ƛ̓ušiiʔaaʔaq** is not suitable for European Green Crab, which are typically found in more sheltered, soft-sediment areas (Gillespie et al. 2015) protected from oceanic swell in the Pacific (Jamieson 1998).

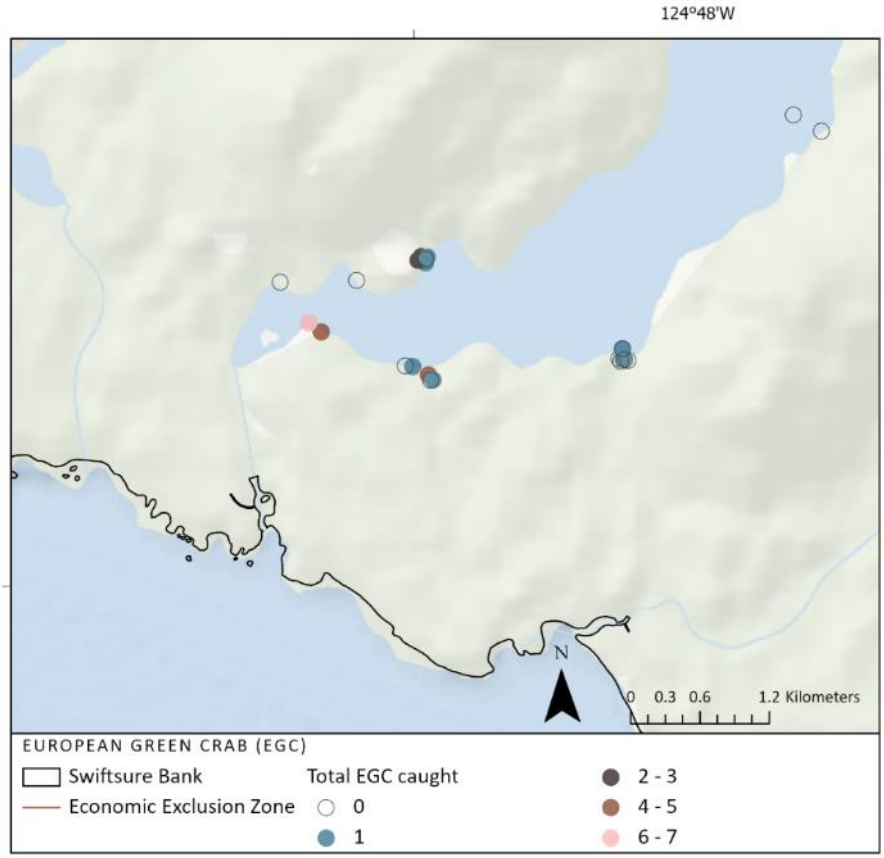


Figure 81. European Green Crab sampling locations and number of individual crabs caught in Nitinaht Lake. The first EGC occurrence in Nitinaht Lake was reported to AIS management in 2022. Current EGC trapping is confined to the entrance of Nitinaht Lake, where the initial detection was reported.

Ongoing surveys are performed in the **ʕ́ušiiʔaaʔaq**/Swiftsure Bank Area by Parks Canada, DFO, and Ditidaht First Nation to track changes in population size and impacts on eelgrass ecosystems. The Ditidaht First Nation green crab monitoring program in Nitinaht Lake is being expanded to include the Cheewaht estuary. Evaluation of European Green Crab removal methods showed areas and months when green crab catch was higher. This information will be used in future efforts to control the spread of the invasive species. Huu-ay-aht First Nations have been assessing and removing European Green Crab from their territory for the past two years as part of the Marine Monitoring Program.

Continued monitoring of green crab densities will contribute to our understanding of how these populations change overtime and allow us to make informed management actions. Additional monitoring of eelgrass meadows will also ensure early detection of habitat loss and trigger additional management actions.

DFO's Aquatic Invasive Species (AIS) settlement plate program conducts annual monitoring of biofouling invertebrate communities at locations throughout coastal British Columbia. The nearest settlement plate sampling location to the **ʕ́ušiiʔaaʔaq**/Swiftsure Bank Area is on Keith

Island in Barkley Sound. This site was most recently sampled in 2021 and two AIS were detected (*Amphibalanus improvisus* and *Schizoporella japonica*)[56].

Other non-indigenous species considered beneficial are also potentially found within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank area – however the extent of these species is not well known from current observations. The Pacific Oyster (*Crassostrea gigas*) is a non-indigenous species introduced to British Columbia for the purpose of aquaculture production on tenured aquacultural sites, and expansion to untenured wild beaches subsequently occurred. In addition to aquaculture operations, the current commercial fishery occurs primarily along mid portions of the east and west sides of Vancouver Island (DFO 2024d). Another non-indigenous species that supports commercial, recreational and First Nations' food social and ceremonial (FSC) fisheries and aquaculture operations is the Manila Clam (*Venerupis philippinarum*), a species accidentally introduced from Japan in the 1930s with the introduction of Pacific Oyster seed. However, it is unlikely that the rocky and exposed nature of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank supports Manila Clams, which are typically found in the upper half of the intertidal zone in mixed substrates of mud, clam and gravel.

5.7 Cumulative Impacts

Ongoing cumulative impact mapping at DFO estimates the impact of anthropogenic activities and stressors to aid ecosystem-based management and spatial planning (Murray et al. 2024). Spatial data[57] on the location and intensity of marine, coastal, and land-based human activities and climate change stressors were compiled and updated in 2023 from Murray and co-authors (Clarke Murray et al. 2015; Murray et al. 2024). The updated analysis included 54 human activities including SST as a climate change variable. They found that the highest cumulative impacts affecting the Pacific region's marine environment occur in coastal areas, and along the continental shelf break. However, the highest sum impact score coastwide was from sea surface temperature change, primarily because the impact extends throughout the entire study area.

Cumulative impact scores are shown in Figure 82 and were last updated on October 13, 2023, with details on datasets, including sources, date ranges, and processing steps available through the Open Government Portal[57]. In total, 31 activities and stressors had spatial area coverage in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank identified through the latest cumulative impact assessment (Table 7). Land-based activities occurring in major watersheds, such as forestry cutblocks and mines were modeled to affect the marine ecosystem via freshwater runoff. Impacts from marine and land-based activities occurring along the coast were modeled using a kernel density analysis. Data compiled for commercial and recreational fisheries may differ from those displayed in the fisheries and subsistence activities section. Note that the data presented in Table 7 are current from 2011 to October 2021, depending on the data layer. Warming sea surface temperatures and vessel activity impacted the entirety of the **ƛ̓ušiiʔaaʔaq** Area. Land-based activities also influenced Swiftsure's marine environment through ports, cities, and a variety of associated

[56] Howard B, Therriault T (2023). AIS Settlement Plate Program: Ongoing monitoring of invasive biofouling species on the Pacific coast of Canada. Version 1.5. Fisheries and Oceans Canada. Sampling event dataset. https://ipt.iobis.org/obiscanada/resource?r=pacificais-foulingspecies&v=1.5

[57] Selina Agbayani, Craig Schweitzer, and Cathryn Clarke Murray. 2024. Cumulative impacts from anthropogenic activities and stressors on marine ecosystems in Pacific Canada. Ecosystem Stressors Program, Ocean Sciences Division, Fisheries and Oceans Canada, Sidney, B.C. Available at: https://open.canada.ca/data/en/dataset/8a08603a-a60c-4ca5-aab8-614ed14bc68f

activities. Cumulative impact scores range from 3.1 to 90 and the highest scores were found on the coast near Nitinaht Lake (**Figure 82**). Climate change was projected to affect every square kilometer of British Columbia's marine waters, leading to potential cumulative impacts in various depth classes and habitats (Agbayani et al. 2024). The cumulative impact scores calculated for **ƛ̓ušiiʔaaʔaq** were comparable to other nearshore regions of similar population density and activity levels along the BC coast, and were in the low to medium-high range of the impact scores coastwide (Figure 82; Agbayani et al. 2024).

*Table 7. Human activities and climate change stressors with documented impact scores in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, based on the data compiled for cumulative impact assessments by Agbayani et al. (2024)[58]. Activities are shown in order of increasing proportion of impact area. Note that coastal and land-based activities do not occur within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, but their marine impacts do.*

	Human Activity (Date Range of Dataset)	**Proportion of ƛučiiʔaaʔaq**/Swiftsure Bank
Climate Change		
	Sea Surface Temperature	1.00
Coastal		
	Ports (2023)	0.33
	Agriculture (2020)	0.11
	Cities (2020)	0.64
	Cutblocks (2020)	0.13
	Industrial (2022)	0.11
	Mines (1874-2019)	0.11
	Roads (2022)	0.14
	Sewage (2020)	0.11
Fishing		
	Commercial: Sablefish Trap (2007-2016)	< 0.01
	Commercial: Shrimp Trawl (2007-2016)	< 0.01
	Commercial: Prawn Trap (2007-2016)	< 0.01
	Commercial: Salmon Troll (2019)	0.02
	Commercial: Lingcod Hook and Line (2007-2016)	0.03
	Commercial: Crab Trap (2006-2016)	0.05
	Commercial: Tuna Jig/Hook and Line (2006-2016)	0.11
	Commercial: Rockfish Hook and Line (2007-2016)	0.12
	Commercial: Groundfish Bottom Trawl (2012-2016)	0.22
	Commercial: Groundfish Midwater Trawl (2012-2016)	0.26
	Commercial: Halibut Hook and Line (2007-2016)	0.33
	Commercial: Salmon Gillnet (2009-2018)	0.67
	Commercial: Salmon Seine (2009-2018)	0.67
	Commercial: Fishing Vessels (2019)	1.00

[58] Supplementary details and technical information on the human activity input datasets used in Agabayani et al. (2024) can be found at: 1-s2.0-S0301479724030913-mmc1.pdf

	Human Activity (Date Range of Dataset)	Proportion of ƛučii?aa?aq/Swiftsure Bank
	Sportfish: Shellfish (2017)	0.02
	Sportfish: Salmon (2017)	0.21
	Sportfish: Groundfish (2017)	0.31
Marine		
	Recreational Boat Routes (2015-2021)	0.68
	Shipping (2019)	0.98
Total Count of Activities		31

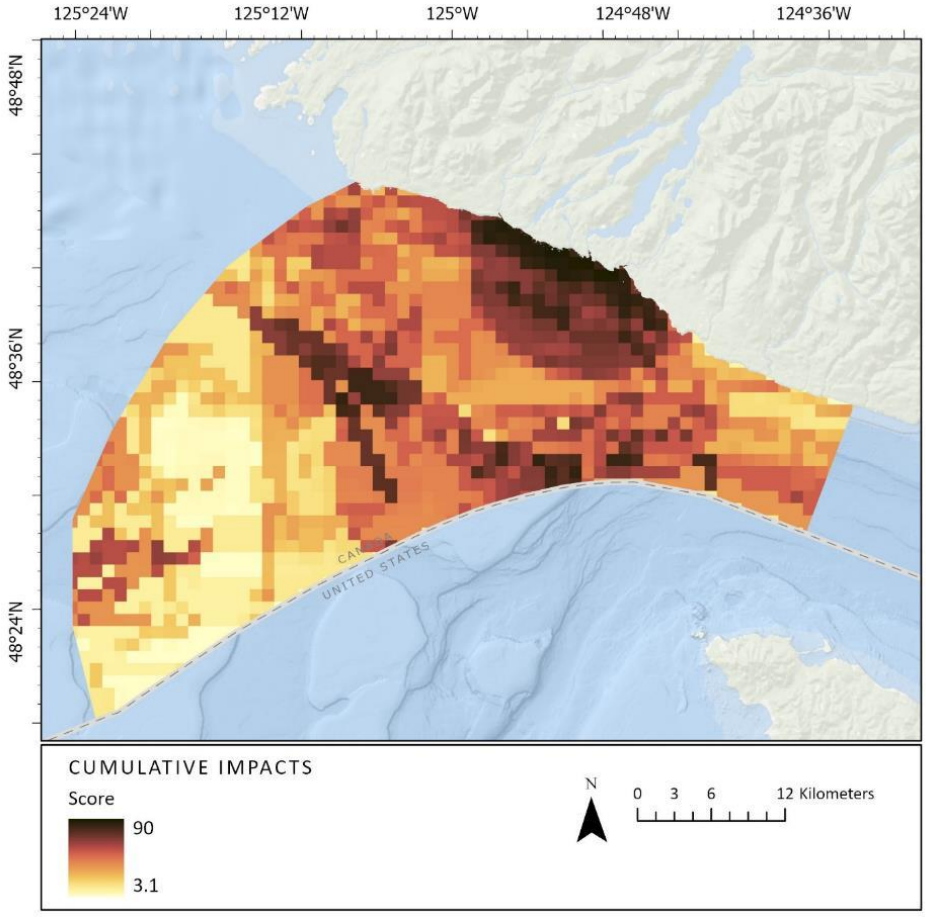


*Figure 82. Cumulative impact scores for all combined current activities and stressors in the Juan de Fuca Eddy EBSA polygon within the **ƛ́ušiiʔaaʔaq**/Swiftsure Bank Area (see Table 7 for activities and stressors included). 31 activities are present in area with cumulative impact scores ranging from 5.30 to 89.64, and a mean of 24.59. Data from Open Government Portal[59].*

[59] Selina Agbayani, Craig Schweitzer, and Cathryn Clarke Murray. 2024. Cumulative impacts from anthropogenic activities and stressors on marine ecosystems in Pacific Canada. Ecosystem Stressors Program, Ocean Sciences Division, Fisheries and Oceans Canada, Sidney, B.C. Available at: https://open.canada.ca/data/en/dataset/8a08603a-a60c-4ca5-aab8-614ed14bc68f

5.8 Data and Knowledge Gaps

Human uses span a large number of potential activities, for which there are varying levels of data and spatial resolution. Integrating local human use datasets spatially would improve understanding of the cumulative impacts of multiple activities on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Further, incorporation of Indigenous local knowledge is key to understanding the long-term impacts of human activities on the ecosystem. However, there is a need for more systematic integration of traditional ecological knowledge into research, data collection and comanagement. Particular data gaps are highlighted in the subsections below.

Fisheries and Subsistence Activities

Fisheries data for recreational and salmon logbooks exists at a coarse spatial resolution, making it difficult to accurately estimate harvest and vessel counts within the specific boundaries of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Similarly, recreational fishing data is often aggregated at the Pacific Fisheries Management Area Subarea level, which encompasses large areas and may not accurately reflect fishing effort and removals within the **ƛ̓ušiiʔaaʔaq** Area.

Estimation of vessel activity comes from multiple sources, and none on their own are sufficient to quantify the amount of vessel activity in the area. For example, reliance solely on AIS data for understanding vessel traffic patterns can lead to significant underestimations. Smaller commercial fishing vessels and recreational vessels are not required to use AIS, creating potential gaps in understanding the full extent of vessel presence and activity.

Human coastal and nearshore activities

The range of human coastal and nearshore activities described in this report may not fully encompass all types and sources of activity in the area. Some datasets are older or hint at potential development in the area. And for some activities the full scope of potential impacts is not described or understood. For example, the effects of mineral extraction activities or underwater development in the area warrants more research on local ecosystems and biodiversity. Submarine cables, in particular, can alter magnetic fields, but the extent of these impacts on marine species, such as juvenile salmon in estuaries, is unclear.

Further, the spatial and temporal scale of recreational fishing and boating in the area is not fully quantified. There is limited data on the specific impacts of recreational vessel traffic on marine wildlife, including noise disturbance, potential collisions, and habitat degradation.

6 ECOLOGICAL SETTING

This section describes the unique ecosystems and taxonomic diversity present within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. This description includes the marine area within **ƛ̓ušiiʔaaʔaq** and the surrounding marine area to consider ecological linkages and connectivity. Where noted, the Juan de Fuca Eddy EBSA polygon was used to help extract relevant spatial data for the area.

Importantly, this section also summarizes the ecological Vulnerabilities and Recoverability of relevant ecosystem features and all taxonomic groups and species of interest to inform downstream decision-making processes and risk assessments. Currently, there is no formal framework for evaluating and describing Vulnerabilities and Recoverability of habitat features or

taxonomic groups in the context of marine planning in the Pacific Region. This report's scope is set using definitions of ecological sensitivities, resiliency, stressors, and recoverability informed by other reports and is presented below (Bannar-Martin et al. in review, in press; Liu et al. in press) and guide the ecological summary writing for this report.

Sensitivities are the traits of a habitat or species that make them more vulnerable when interacting with a stressor (O et al. 2015). **Stressors** include naturally occurring physical or environmental disturbances or anthropogenic disturbances such as the effects of climate change (see Climate Change) and other human activities (see Human Uses of Area) that may negatively impact habitats or species (O et al. 2015). These stressors may affect the sensitivity of a species or habitat directly or indirectly through the food web or other ecosystem interactions. For example, a species might be sensitive to a stressor like overexploitation if it is susceptible to decline and slow recovery. Furthermore, a local population might be more sensitive than other regional populations if their prey is depleted or their abundance is already low from previous disturbances. **Resilience**, on the other hand, is the ability, or flexibility, of a habitat or species to return to pre-impact conditions and functions after exposure to a stressor (O et al. 2015). For example, a species with life history traits such as fast growth or high fecundity may be more resilient after a population decline than those with slow growth and/or low fecundity. In addition, a habitat or species could be described as resilient to a specific stressor if an interaction shows no adverse effects or trends. **Recoverability** is another aspect of resilience referring to the ability of a species or population to return to preexisting states once the stressor has been removed (O et al. 2015). This includes details of restoration efforts and trends over time (Hunter et al. 2014). Recoverability is included in the description of resilience when this information is available.

In the following sections, particular subsections are provided to help guide the reader. "Data Sources" is provided as a subsection when multiple data sources have been collated to generate information for a particular ecosystem of suite or species and their methods and/or limitations are important to highlight. In some cases, the data sources are described with their accompanying analysis to improve readability. "Sensitivities" is provided as a subsection to provide a list of sensitivities for the ecosystem or taxonomic grouping in question. Where possible, information on their resilience and/or recoverability is also provided. "Data and Knowledge Gaps" are provided at the end of each section to list relevant data gaps and knowledge gaps for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, and research opportunities for each data gap are provided where possible. A summary of major knowledge gaps is provided again at the end of the document in section 7.2. Note that not all sections will have the same subsections, as these depend on information availability and readability.

6.1 Important ecosystems

Recognizing important ecological features and habitats and their associated biological assemblages across spatial scales is essential for informing marine planning processes and any related monitoring and management decisions. Previous work has identified and categorized important features, habitats, and ecosystems in the SSB including the designation of Ecologically and Biologically Significant Areas (EBSAs). This report section is used to describe unique features and important ecosystems that occur in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank.

6.1.1 Ecologically and Biologically Significant Areas (EBSAs)

EBSAs are areas with relatively high ecological and biological significance that warrant increased management and protection (DFO 2004; Convention on Biological Diversity (CBD) 2008). EBSAs are identified using eight criteria that contrast to the locations outside of the area of interest. These criteria are uniqueness, special importance for life-history stages, importance for threatened, endangered, or declining species, vulnerability, productivity, biodiversity, naturalness, and aggregation (DFO 2004; Ban et al. 2016; Rubidge et al. 2020). Four EBSAs overlap with the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (first described and proposed in DFO 2013b, 2018a)): the Continental Shelf off Barkley Sound, the Juan de Fuca Eddy (used in some areas of the report to help extract spatial data relevant to the **ƛ̓ušiiʔaaʔaq** Area), the Juan de Fuca Strait, and cold seeps (Figure 83). These four EBSAs are described in more detail below.

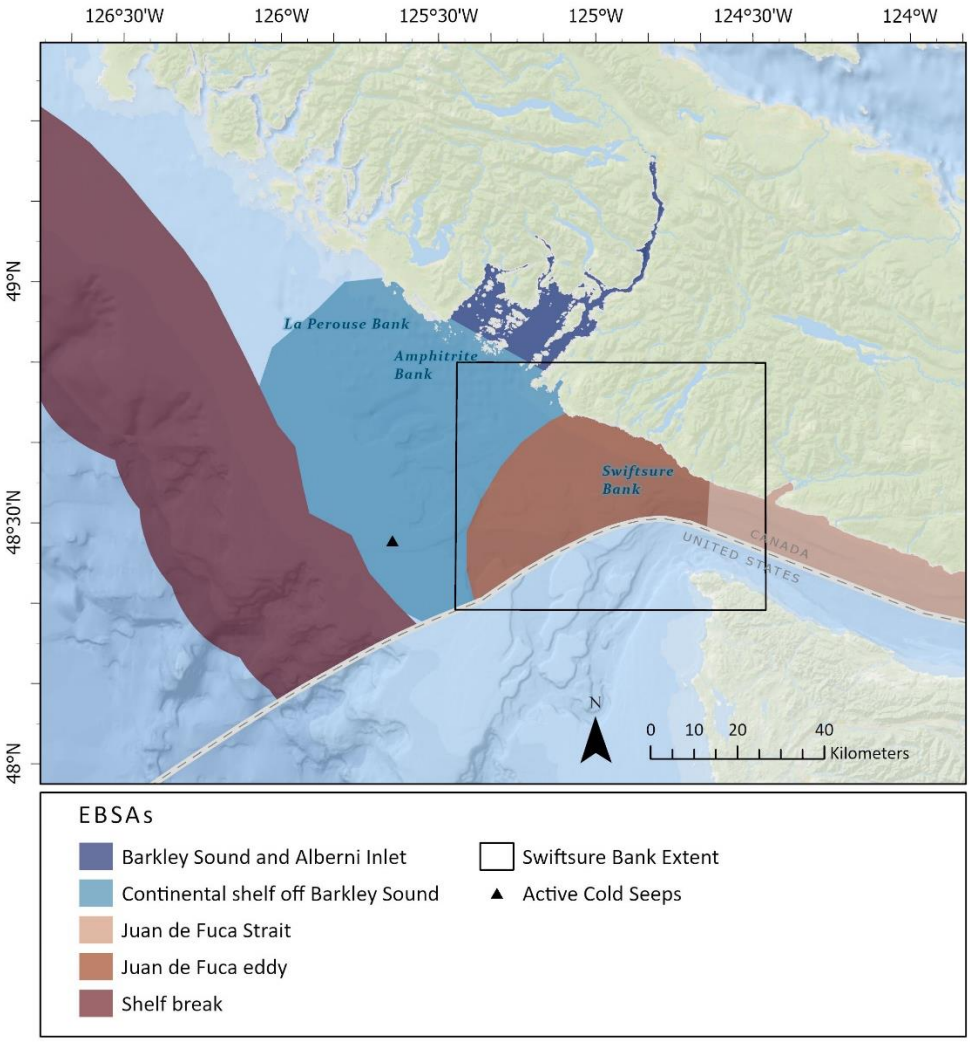


*Figure 83. Ecologically and Biologically Significant Areas (EBSAs) overlapping, or in proximity, to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (DFO 2013b, 2018a).*

6.1.1.1 Continental Shelf off Barkley Sound EBSA

The Continental Shelf off Barkley Sound EBSA includes the edges of the banks and basins across from Barkley Sound inshore of La Perouse Bank, **ƛ̓ušiiʔaaʔaq**/Swiftsure, Amphitrite, and Finger Banks. This is a highly productive area, where aggregations of nutrients and zooplankton contribute to upward trophic transfer (Jamieson and Levesque 2014). The EBSA overlaps with 29 species-specific Important Areas for marine pelagic birds, cetaceans and pinnipeds, several fish species (anadromous fish, pelagic species, elasmobranchs, flatfish, roundfish), invertebrates and Leatherback Sea Turtle (*Dermochelys coriacea*) (Jamieson and Levesque 2014).

6.1.1.2 Juan de Fuca Eddy EBSA

The Juan de Fuca Eddy has been described oceanographically in earlier sections (Oceanography and Physical Setting); however, its designation as an EBSA is detailed here. While the Juan de Fuca Eddy polygon falls entirely within Canada's Economic Exclusion Zone, the Juan de Fuca Eddy ecologically extends into U.S. territorial waters (DFO 2013b). The area is a coastal retention area within the California Current (Dunn et al. 2011). The Juan de Fuca Eddy is an area of high productivity and qualified as an EBSA due to the high number of biologically important areas that overlap with the feature (Table 8). In the Jamieson and Levesque (2014) analysis of EBSAs, the Juan de Fuca Eddy feature had one of the highest counts of related Important Areas (IAs). IAs were identified by regional scientific experts in Phase I of the process to establish EBSAs in the Pacific North Coast Integrated Management Area (PNCIMA; Clarke and Jamieson 2006a), and subsequently in West Coast of Vancouver Island (Jamieson and Levesque 2014) and the Strait of Georgia (Levesque and Jamieson 2015).). In the Jamieson and Levesque (2014) analysis of EBSAs, the Juan de Fuca Eddy feature had one of the highest counts of related Important Areas (IAs). IAs were identified by regional scientific experts in Phase I of the process to establish EBSAs in the Pacific North Coast Integrated Management Area (PNCIMA)(Clarke and Jamieson 2006a), and subsequently in West Coast of Vancouver Island (Jamieson and Levesque 2014) and the Strait of Georgia (Levesque and Jamieson 2015).

Table 8. Biological significance of the Juan de Fuca Eddy EBSA, reproduced from Table 4 of Jamieson and Levesque 2014, with additions from co-authors of this report.

Species Group	Species Important Areas Overlapping in EBSA	Why Important Area important under EBSA criteria	Proportion of Important Area(s) captured in EBSA (%)
Marine Birds	Pelagic species	Foraging area	11
Cetaceans	Southern Resident Killer Whale	Swiftsure Bank	32
	Humpback Whale	Area of concentration; consistently utilized foraging area	16
	Harbour Porpoise	High sightings area in Juan de Fuca Strait	6
	Grey Whale	Migration and Foraging area	3
Pinnipeds	Harbour Seal	Resident	54
	Steller Sea Lion	Foraging area around four haulouts	60
		Forage area around two haulout sites	
		Carmanah Point	53

Species Group	Species Important Areas Overlapping in EBSA	Why Important Area important under EBSA criteria	Proportion of Important Area(s) captured in EBSA (%)
		Pachena Point	63
	Northern Fur Seal	High concentration	13
Anadromous Fish	Juvenile Pacific Salmon*	Migration and Foraging area	8
	Green Sturgeon	Migration route	6
	Eulachon*	Older juvenile offshore feeding area	13
Pelagic Fish	Sardine	Migration and foraging area	9
	Pacific Sand Lance	Potential spawning and burrowing habitat (to 100 m)	40
		Confirmed habitat for Pacific Sand Lance	64
Elasmobranch	Basking Shark	Historical area of concentration	3
	Big Skate	Distribution	7
	Longnose Skate	Distribution	8
	Sandpaper Skate	Distribution	7
Roundfish	Pacific Hake	La Perouse Bank – foraging and Migratory Corridor, 80-500m	13
		Aggregation	5
	Pacific Herring*	Feeding area (Large aggregations of pre-recruit and adult)	39
Flatfish	Arrowtooth Flounder	Distribution	4
	Dover Sole	Summer Important Area and a smaller portion (~8%) of the winter Important Area	40
	English Sole	Distribution	100
	Flathead Sole	Distribution	5
	Petrale Sole	Summer Important Area and 18% of winter Important Area	100
	Rex Sole	Distribution	4
	Rock Sole	Distribution	8
	Sand Sole	Distribution	38
Invertebrates	Shrimp	*Pandalopsis dispar, Pandalus jordani*	23, 35
Turtle	Leatherback	Foraging	5

*described in detail in the Pelagic fishes section of this report

6.1.1.3 Juan de Fuca Strait EBSA

The Juan de Fuca Strait EBSA is found southeast of the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area and is a geographic bottleneck for various fish species, including salmonids and Pacific Herring, moving between the Strait of Georgia and the outer continental shelf and offshore Pacific waters (Jamieson and Levesque 2014). The area overlaps with 14 Important Areas for cetaceans, pinnipeds, anadromous and pelagic fish, elasmobranchs, flatfish, roundfish, and invertebrates (Jamieson and Levesque 2014).

6.1.1.4 Cold Seeps EBSAs

Cold seeps are benthic marine features where fluids enriched with reduced compounds (e.g., methane or hydrogen sulphide) 'bubble' out of the seafloor. They form along continental shelves and are fed from hydrocarbon reservoirs beneath the seafloor (DFO 2018a). TheseCold seeps are benthic marine features where fluids enriched with reduced compounds (e.g., methane or hydrogen sulphide) 'bubble' out of the seafloor. They form along continental shelves and are fed from hydrocarbon reservoirs beneath the seafloor (DFO 2018a). These features can become productive chemosynthetic (origin of word: 'chemical' 'formation') ecosystems where bacteria turn the reduced chemicals into carbon for a unique food web. In comparison, most food webs on Earth start with photosynthesis (using the sun's energy to produce carbon). These cold seep chemosynthetic communities create biological hotspots of productivity, contribute to regional biodiversity through their high levels of endemism, and have cascading effects on the ocean communities around them (Le Bris et al. 2016; Levin et al. 2016). In the Pacific Region, the biological components of cold seep ecosystems are generally characterized by bacteria and by two types of endemic megafauna, tubeworms and bivalves (summarized in DFO 2018a and references therein). Cold seeps can also create important habitat heterogeneity in the deep sea through biogenetic habitat (e.g., large clumps of tubeworms) and when carbonate rock is formed from the bacterial activity (summarized in DFO 2018a; Le Bris et al. 2016; Levin et al. 2016). In the Pacific Region, the biological components of cold seep ecosystems are generally characterized by bacteria and by two types of endemic megafauna, tubeworms and bivalves (summarized in DFO 2018a and references therein). Cold seeps can also create important habitat heterogeneity in the deep sea through biogenetic habitat (e.g., large clumps of tubeworms) and when carbonate rock is formed from the bacterial activity (summarized in DFO 2018a).

Cold seep habitats were formally assessed as EBSAs in Canada in 2018 (DFO 2018a). The assessment indicated that all known seeps in BC waters had been recent discoveries (past 25 years, with majority in most recent years) indicating the likelihood that more cold seep locations were possible. Since the EBSA assessment in 2018, the Deep-Sea Ecology Program at DFO has been working to better understand these ecosystems in the Pacific to provide scientific advice for their conservation and management. Through working collaboratively with Natural Resources Canada and GEOMAR, DFO colleagues, as well as conducting Northeast Pacific Deep-sea Exploration Project (NEPDEP; a collaboration between the DFO Deep-Sea Ecology Program, coastal First Nations, Ocean Networks Canada, and academia) expeditions, the Deep-Sea Ecology Program is preparing publications summarizing recent findings[60]. In this biophysical overview, we summarize the updated findings for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

Cold seeps are typically distributed between 200-1500 m depth and can be quite variable in magnitude, intensity, chemical composition, and location over short to long timescales (DFO 2018a). **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank is a relatively shallow and dynamic environment (see Oceanography and Physical Setting) where seep activity would be influenced by both subterranean and water column properties (e.g., tides). Cold seeps can be located by surveying using ship-based echosounders to detect gas plumes in the water column (also known as bubble streams or flares) and specific bathymetric features on the seafloor (e.g., mounds, rocks, pockmarks). Confirming the presence of a cold seep and any potential associated structures or communities requires a direct visual observation or physical sample. For the **ƛ̓ušiiʔaaʔaq** Area,

[60] Du Preez, C. et al. In prep. Biophysical and Ecological Overview of the West Coast Vancouver Island Cold Seeps.

217 cold seep bubble streams have been detected through echolocation (Figure 84) within the boundaries of the Juan de Fuca Eddy EBSA polygon. It is very likely that more bubble steams exist within the polygon as the spatial distribution of documented bubble streams is a function of survey effort as vessels transit through the area as opposed to dedicated survey design. In Figure 84, we've also included cold seeps outside the Eddy area to demonstrate the broad distribution of cold seeps along our continental shelf. The nearest visual confirmation of a benthic cold seep ecosystem is 20 km west of the Eddy polygon. To date, there has been no confirmation within the Eddy polygon.

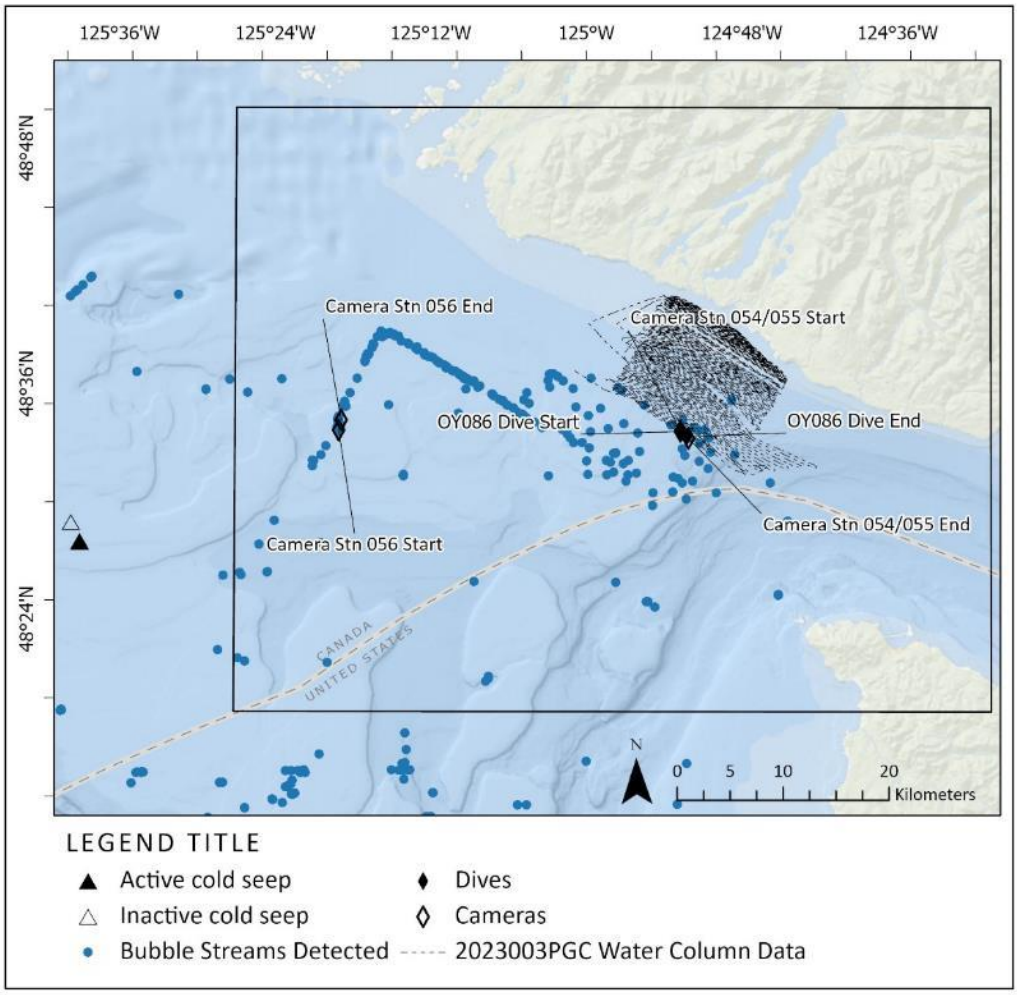


Figure 84. Map of observed bubble streams and data yet to be assessed within and in proximity to the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area. Points were observed on various transits identified in Riedel et al. (2018), on the 2022002PGC Natural Resources Canada expedition and on the SO294 RV Sonne Geomar Helmoltz Centre for Ocean Research expedition (Riedel 2022; Kehew et al. 2023). The lines represent data yet to be assessed, collected in 2023 (Li and Kung 2024). The internal black rectangle outline indicates the* ***ƛ̓ušiiʔaaʔaq*** *Area bounding rectangle. The dotted line indicates the Economic Exclusion Line separating Canada and the United States of America.*

Scientists attempted to visually confirm cold seeps on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank during a 2022 expedition (2022002PGC) where a sounder survey looking for bubble streams was paired with three camera stations to hopefully confirm the cold seep activity with visual imagery (Stn

054/055 and Stn056 in Figure 84; unpublished imagery courtesy of Cooper Stacey). Seeps are observed acoustically as bubbles originating at the seafloor and forming a bulbous or vertical channel up into the water column. They appear as high intensity signals compared to the surrounding water column when observed in echosounder data due to the sound being scattered by the gas bubbles. Acoustic data from 20 expeditions occurring between 2003 and 2022 have been evaluated in Riedel et al. (2018) and Kehew et al. (2023), including a dedicated transect survey for cold seep evaluation in 2022. The imagery collected at the camera stations did not provide any evidence of cold seep habitat. During a 2022 NEPDEP expedition, scientists attempted to visually document cold seep sites on **ƛ̓ušiiʔaaʔaq** (Dive in Figure 84). Unfortunately, conditions prevented the submersible from reaching all target sites and the dive had to be called off early. The data are unpublished but the imagery is viewable on Seatube[61]. The imagery did not reveal any cold seep activity (e.g., no bubbles, bacteria, carbonate rock, or chemosynthetic animals). Timing plays into the visual detection of bubbles. The fact that both surveys did not provide visual confirmation of a seep associated benthic ecosystem suggests seepage may not translate into an ecological response. This could be attributed to the shallow, rocky, and dynamic nature of **ƛ̓ušiiʔaaʔaq**. Seep sites are naturally variable in space and time, and at these shallow depths, seepage may be shifting continuously (e.g., based on the tide), preventing the build-up of bacteria, communities, and carbonate structures that require long time periods (even centimeters of thick carbonate would take hundreds of years; Luff et al. 2004). Additionally, cold seep habitats are extremely vulnerable to bottom contact fishing (see Fisheries and Subsistence Activities).

A NEPDEP expedition in 2023 visually surveyed a site of relatively comparable depth and substrate to that of the **ƛ̓ušiiʔaaʔaq**/Swiftsure cold seep area, off of **Mʔuqʷin /**Brooks Peninsula (i.e., ~60 m depth over boulders and bedrock). During the towed camera dive the transect was characterized by evidence of seepage and chemosynthetic activity including bacteria and visual confirmation of bubbles, possible carbonate rock and a clump of tubeworms. However, again, there was evidence of the shallow and dynamic nature of the area interplaying with the seep activity. On the soft sediment, bacteria were distributed in thin cascading lines (as opposed to thick mats), limited carbonate, bubbles were observed coming out in multiple places including near bedrock and boulder substrate, and there was only one small clump of tubeworms seen. Of note, in and around the seep site were many culturally and commercially important species including sea cucumbers, Lingcod, Pacific Halibut, and many rockfish species (including Quillback and Yelloweye Rockfish). The data from this dive is unpublished but viewable on Seatube[62]. It is possible that the bubble streams detected in **ƛ̓ušiiʔaaʔaq** Juan de Fuca Eddy EBSA polygon, although numerous, are similarly dynamic and ephemeral with relatively low associated chemosynthetic activity on the seafloor.

Amongst the observations made in 2022, 44 occurrences overlap with at least one previous observation within the surrounding sonar footprint (Riedel et al. 2018; Kehew et al. 2023), suggesting that at least some of these features are persistent in a single location rather than intermittent or more ephemeral. However, there are limited repeat data available to quantify the level of persistence for the boundary area or the location of seeps across the whole boundary.

[61] under Expeditions> Fisheries and Oceans Canada> 2022> DFO Expedition 2022-06 (Jun 2022)> OY086 – 2022-Jun-26 20:02:00 – Swiftsure Bank

[62] under Expeditions> Fisheries and Oceans Canada> 2023> DFO Expedition 2023-07 (Jul 2023)> B102 – 2023-Jul-21

6.1.2 Estuaries and salt marshes

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

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

Estuaries were previously identified as EBSAs due to positive fitness and aggregation importance for salmon smolts (Clarke and Jamieson 2006b). Marine survival rates were found to be reduced for juvenile salmon populations that transit through disturbed estuaries compared to pristine estuaries (Magnusson and Hilborn 2003). Chalifour et al. (2021) examined the effects of estuary residency in the Fraser River during juvenile Chinook Salmon migration and found consistent daily growth rates despite variable entry and residency dates. Their results suggest that estuary habitats, even highly modified ones such as those in the Fraser River, are critical for early marine growth before seaward migrations. Juvenile Dungeness Crabs were found to have higher growth rates in estuaries than in habitats outside of estuaries (Gunderson et al. 1990). The known use of estuaries by various marine species has been documented in Rubidge et al. (2020) and Robb et al. (2025).due to positive fitness and aggregation importance for salmon smolts (Clarke and Jamieson 2006b). Marine survival rates were found to be reduced for juvenile salmon populations that transit through disturbed estuaries compared to pristine estuaries (Magnusson and Hilborn 2003). Chalifour et al. (2021) examined the effects of estuary residency in the Fraser River during juvenile Chinook Salmon migration and found consistent daily growth rates despite variable entry and residency dates. Their results suggest that estuary habitats, even highly modified ones such as those in the Fraser River, are critical for early marine growth before seaward migrations. Juvenile Dungeness Crabs were found to have higher growth rates in estuaries than in habitats outside of estuaries (Gunderson et al. 1990). The known use of estuaries by various marine species has been documented in Rubidge et al. (2020) and Robb et al. (2025).

Estuaries across the Pacific coast have been identified and categorized based on their importance to waterbirds by the Pacific Estuary Conservation Program (PECP, Ryder et al. 2007) and since updated by the Pacific Birds Habitat Joint Venture (Pacific Birds Habitat Joint Venture Technical Team 2021), with rankings from 1 (most important) to 5 (least important). (PECP, Ryder et al. 2007) and since updated by the Pacific Birds Habitat Joint Venture (Pacific Birds Habitat Joint Venture Technical Team 2021), with rankings from 1 (most important) to 5 (least important). The ranking system assessed estuaries based on the cumulative score on five biophysical variables: estuary size, species rarity, waterbird density, herring spawn, and fish

escapement. Using the same spatial data, the biomass and richness of Pacific salmon that transit through BC's estuaries has also been recently assessed (DFO 2023a).

Seven estuaries exist in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Table 9**,** Figure 85).

*Table 9. The name, estuary area (km^2), watershed area (km^2), and Importance class (1 = highest) of estuaries located in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank . Estuary data is from Pacific Birds Habitat Joint Venture Technical Team (2021). Watershed area from Robb et al. (2025).*

Estuary Name	Estuary Area (km^2)	Watershed Area (km^2)	Importance class
Camper Creek	0.04	32.76	5
Carmanah Creek	0.11	67.60	5
Cheewaht River	0.32	27.47	4
Cullite Creek	0.08	15.90	4
Klanawa River	0.05	243.63	4
Logan Creek	0.11	18.17	4
Nitinaht River	0.04	805.28	4
Pachena River	0.47	48.88	3
Walbran Creek	0.13	128.76	4

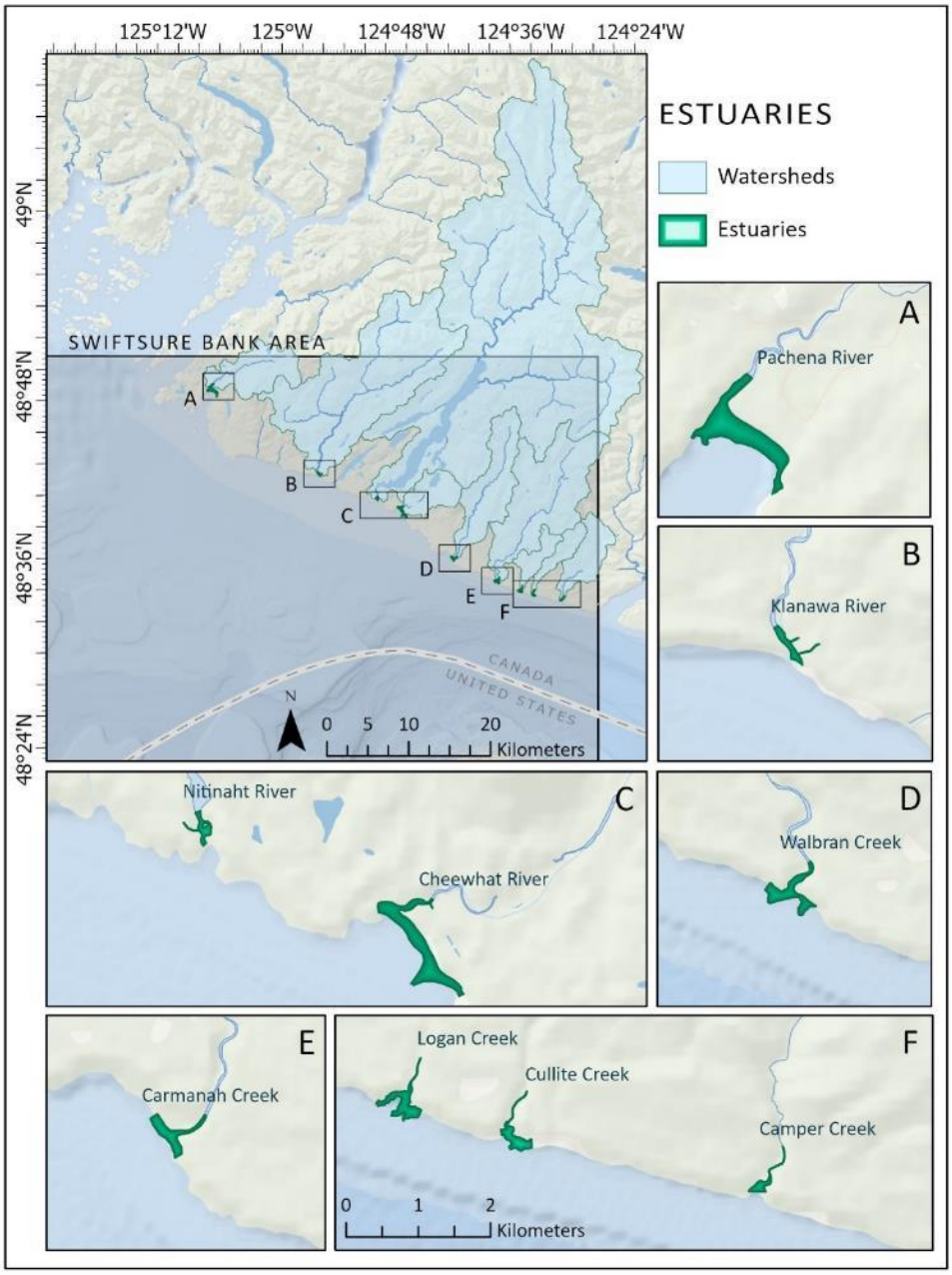


*Figure 85. Estuaries and watersheds in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Data are from Pacific Birds Habitat Joint Venture Technical Team (2021).*

Salt marshes are coastal wetland habitats found within estuaries, which contain grasslands exposed at low tide and covered at high tide. These habitats require a constant supply of sediments to remain intact because of their location in a highly variable environment. Salt marshes contribute to ecosystem functions by preventing flooding and erosion of shorelines and providing water filtering and nutrient cycling. Thus, salt marsh habitats provide essential shelter, refuge, and food resources for many species, including juvenile fish and marine birds. Salt marshes were also found to be efficient carbon sinks for carbon sequestration relative to their area (Chmura 2013; Gailis et al. 2021). Despite the vast extent of salt marshes on BC's coast (area of 635 km2-; see Table 1 in Rabinowitz and Andrews 2022), these habitats have not been

evaluated as EBSAs in the Pacific Region and are instead categorized within the estuary EBSA (Rubidge et al. 2020).

Saltmarsh habitats have been delineated through the ShoreZone mapping system, which uses aerial imaging surveys to identify and categorize biological and geomorphic attributes of the BC coastline (Cook et al. 2017). Biobands are spatial attributes of the ShoreZone dataset, generally describing each shoreline unit's dominant biological species or assemblage across the subtidal, lower intertidal, upper intertidal, and supratidal zones. Additional spatial attributes describe shoreline morphology, exposure, and substrate. Biobands relevant to estuaries and saltmarshes within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area include saltmarsh, eelgrass, and canopy kelp. Biobands are classified as either patchy (visible in <50% of each shoreline unit surveyed) or continuous (visible in >50% of the unit). Updated imagery was collected for Nitinaht Lake in 2007 and the outer coastline in 2021. Saltmarsh biobands that overlap with the **ƛ̓ušiiʔaaʔaq** Area are shown in Figure 86.

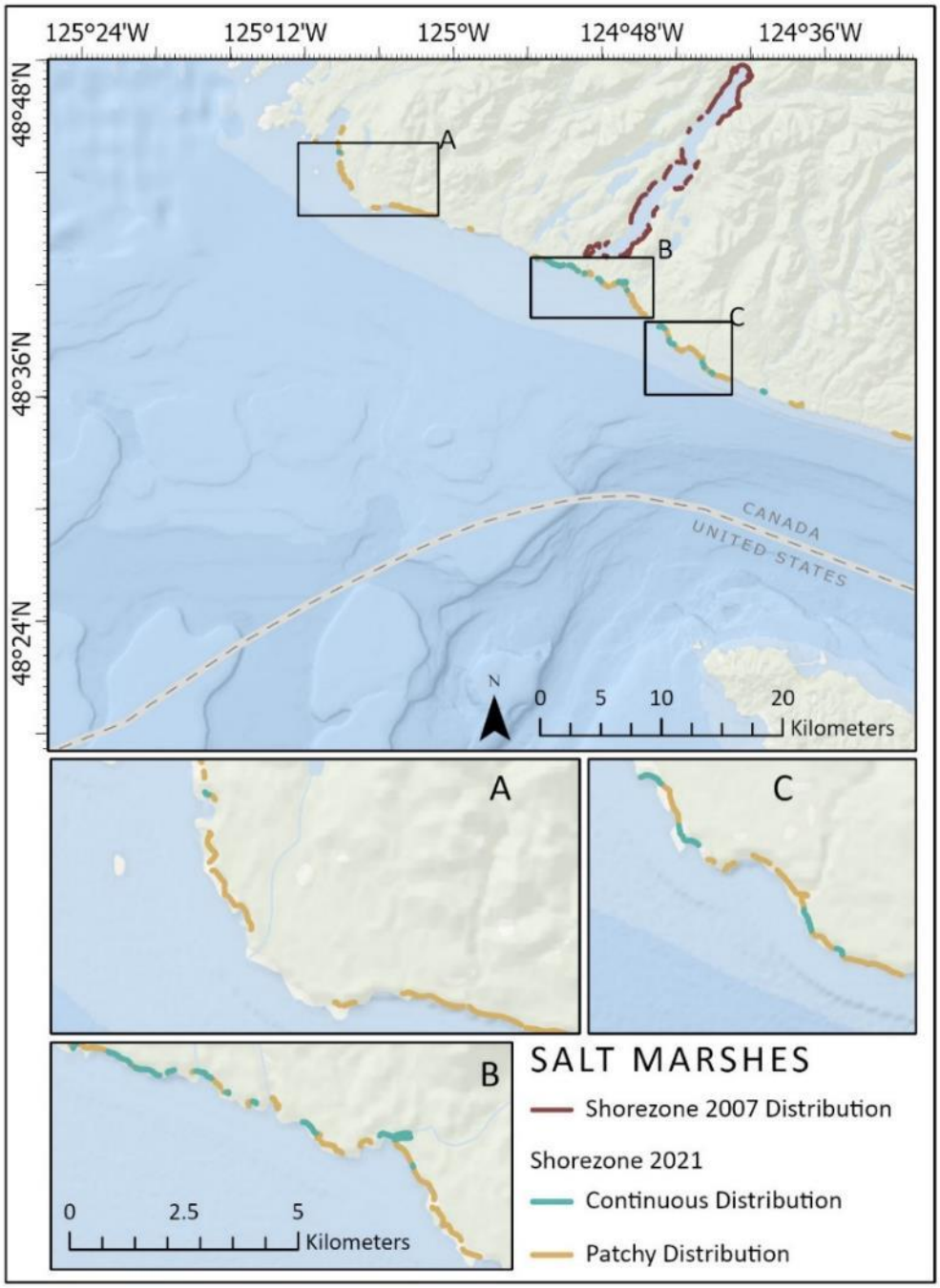


Figure 86. Salt marsh shorezone biobands present in the ***ƛ̓ušiiʔaaʔaq****Swiftsure Bank Area, with green lines representing continuous areas of salt marsh (comprising more than 50% of the shoreline unit) and orange lines representing patchy habitats. Outer coastline shorezone biobands were last updated in 2021, purple biobands shown in Nitinaht Lake are sourced from 2007 shorezone data*[63]*.*

[63] https://www.shorezone.org/downloadzone/

Since estuaries and salt marsh habitats are associated with high biodiversity, humans have cultivated these ecosystems for habitation, food, and utility. Uses within estuaries include fishing, hunting, trapping, harvesting, wildlife viewing, canoeing and kayaking.

6.1.3 Freshwater ecosystems

This report focuses on marine ecosystems and species, however several freshwater ecosystems and their associated riparian habitats and tributaries are within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area extent (Figure 87). We describe further two that have been highlighted by coauthors for the ecological importance and importance to local First Nations: Nitinaht Lake and Cheewaht Lake. We have not included comprehensive species lists for these systems; however, resources that indicate the biodiversity of these ecosystems are available in the literature (e.g., Mudry and Green 1976) and have been provided by the Ditidaht Nation (Appendix G).

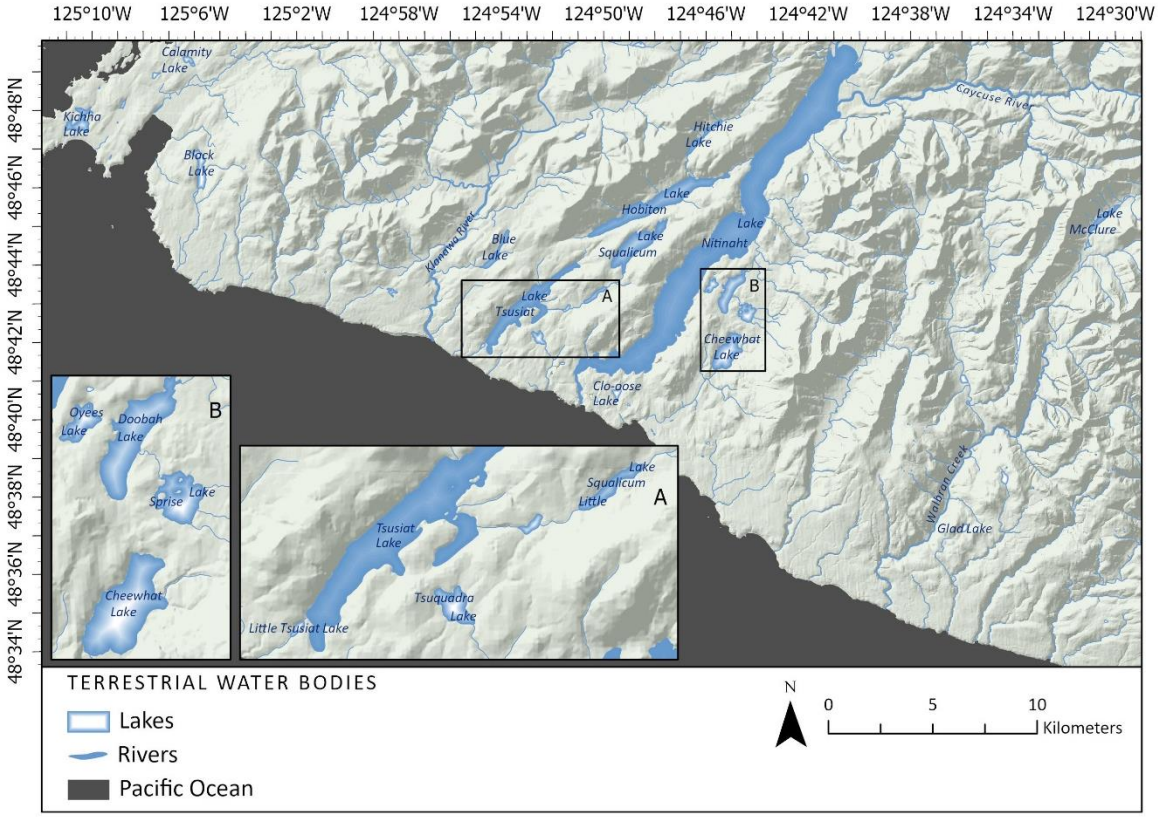


*Figure 87. Freshwater ecosystems within the **ƛučii?aa?aq**/Swiftsure Bank Area.*

6.1.3.1 Nitinaht lake

Nitinaht Lake (also spelled Nitinat in other sources, Figure 88, Figure 89), feeding Nitinaht Estuary, is a permanently anoxic seawater fjord. It is connected to the open ocean through a 3 km long, narrow and shallow (2-5 m at low tide) linking channel (Nitinaht Narrows), which limits the exchange of water and is separated by a narrow sill (Lamont 2005; Pawlowicz et al. 2007). The lake is dynamic, with a deep-water renewal time of about 5 years, and experiences significant spatial and temporal variability (Pawlowicz et al. 2007). It is approximately 20 km in

length and averages about 1.2 km in width with a surface area of 27.6 km^2. It is 203 m at its deepest. The upper 20-30 meters of the lake are oxygenated, with marked changes in salinity (Northcote et al. 1964), below this level are high levels of hydrogen sulfide. Weather conditions cause the lake to “turn over” periodically, which is deadly to the species that ordinarily thrive in the oxygenated top layer of the lake. The lake's anoxic seawater is renewed by oxygenation from surface mixing in winter and by upwelling of anoxic water and horizontal inflow of subducted ocean water in summer (Pawlowicz et al. 2007). The lake's sediment deposition and turbidite frequency are influenced by climatic changes (Knudson and Hendy 2009). Four major tributaries feed Nitinaht Lake: Nitinaht River, Caycuse River, Hobiton and Doobah Creeks (O’Donnell 1989). Flows are typically low during summer months and high during winter months (Lamont 2005). The tributary system is highly impacted by precipitation, partially a result of extensive logging in the area, and tidal fluctuations in the lake affect water levels in Hobiton Creek, and potentially in other tributaries within its floodplain.

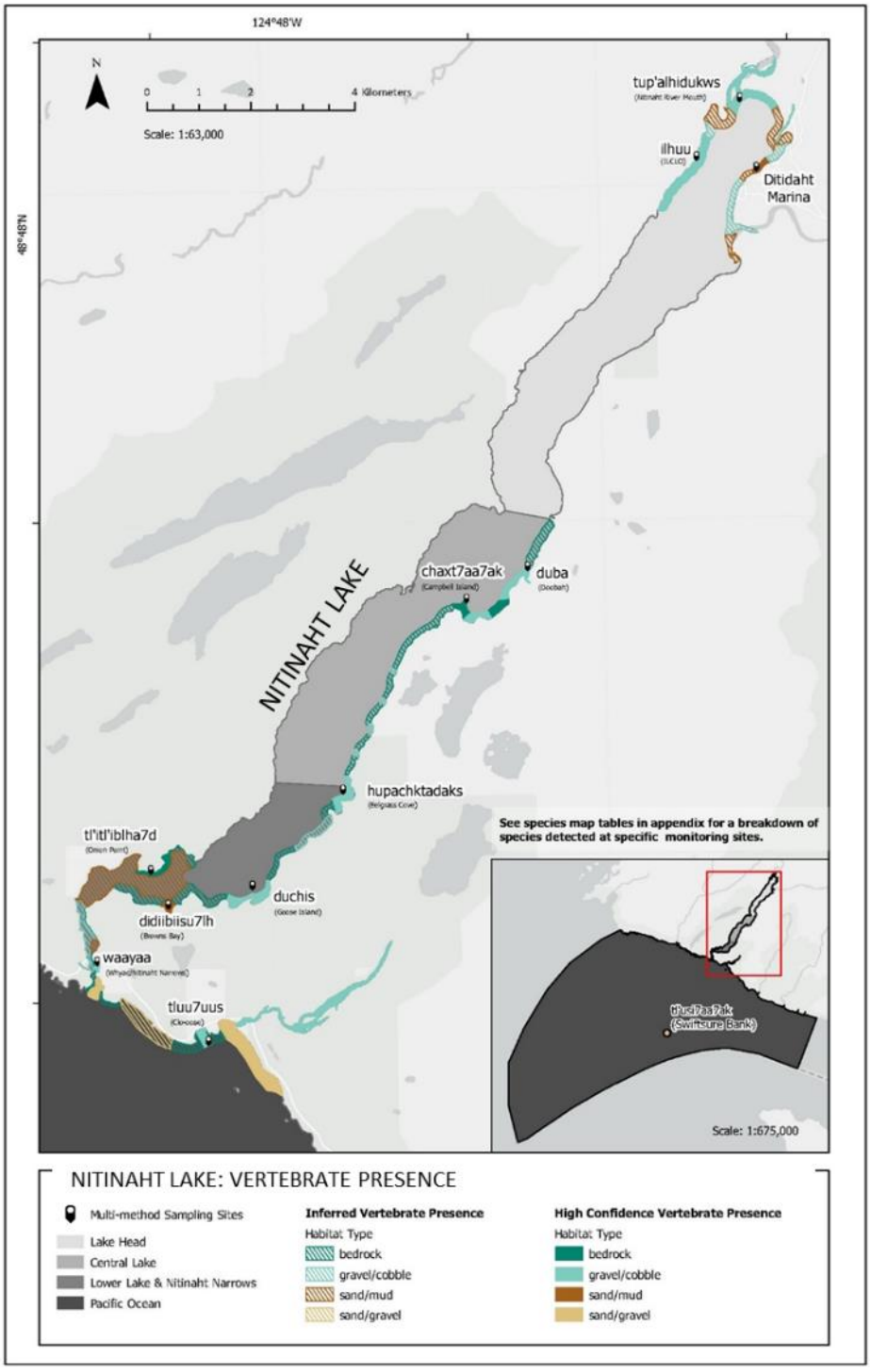


*Figure 88. Nitinaht Lake location within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Habitat types observed and inferred within Nitihaht Narrows and Nitinaht Lake from multi-method sampling completed by the Ditidaht First Nation and MC Wright and Associates. Associated vertebrate communities are reported in Appendix G.*

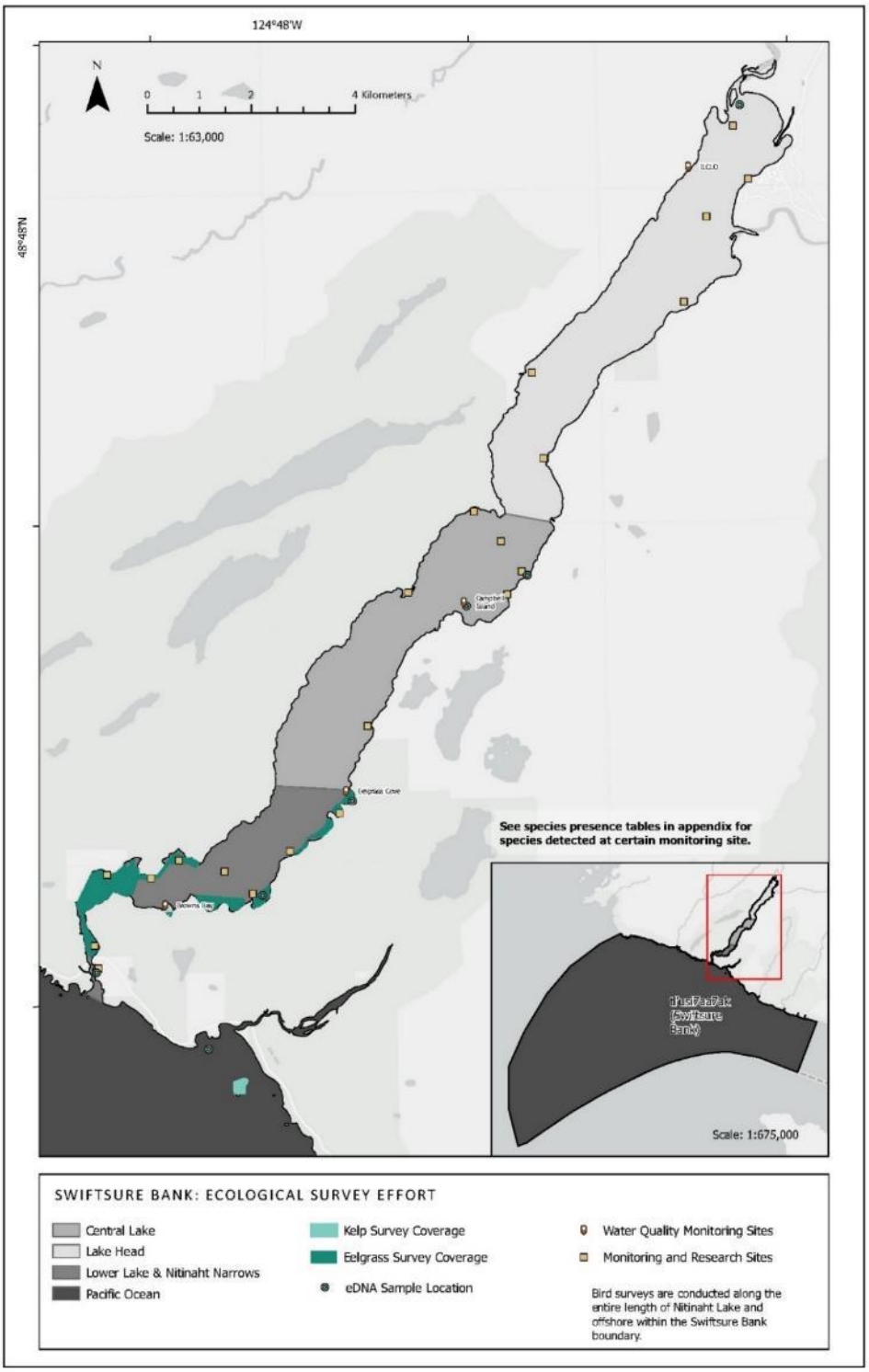


Figure 89. Survey effort in Nitinaht Narrows and Nitinaht Lake by the Ditidaht First Nation and kelp and eelgrass habitat coverage.

Nitinaht Lake is home to a diverse range of marine species. It has a large salmon hatchery, rearing over 40 million fry annually (Lamont 2005). The lake's physical and chemical characteristics, including its anoxic nature and the accumulation of ammonia, carbonates, phosphates, silicates, and sulfides, have significant ecological implications (Northcote et al. 1964; Richards et al. 1965). These conditions support a dynamic microbial regime, with high phytoplankton levels near the surface and a peak in biological activity near the anoxic boundary (Pawlowicz et al. 2007). Furthermore, Hanke and Roias (2012) identified the presence of the marine eels *Venefica ocella* and *V. tentaculata*, which are the first records of this family in the area. Northcote (1964) noted that the biota in the lake consists of marine, brackish, or euryhaline forms. Local observations of marine fish, including Sablefish, have also been recorded (M. Wright, MC Wright and Associates Ltd., pers. comm.).

The Nitinaht River watershed falls within three Biogeoclimatic Zones, and is mostly characterized by the Coast Western Hemlock biogeoclimatic zone.

The Ditidaht continue to utilize a wide range of plants and traditional materials within the watershed (Ditidaht First Nation 2017b). The Nitinaht River Hatchery was built in 1980 to help sustain salmon populations for local commercial, recreational and Ditidaht First Nation Fisheries. In 2015 it reared and released 3,599,845 Chinooks, 17,767,521 Chum and 122,935 Coho. Approximately 5% of salmon fry released survive and return to spawn.

6.1.3.2 Cheewaht Lake

Cheewaht Lake (Figure 90) is a low-elevation lake that became isolated from the Pacific Ocean over the last 1200 years (Holtham 2003). It lies within the traditional territory of the Ditidaht First Nation and is a place of cultural and ecological significance. At present, the lake and the western and southern portions of its watershed fall within the West Coast Trail Unit of Pacific Rim National Park Reserve (PRNPR). The lake is oligotrophic and receives high precipitation input, and was documented as slightly acidic as of 2000 (Holtham 2003). It has one main basin, with a surface area of 1.52 km^2, a maximum depth of 20.2 m (Mudry and Green 1976) and a mean depth of 9 m. There are five small tributaries that feed the lake (McHugh and King 2018). The watershed area is 8.0 km^2 (Holtham 2003). The Cheewaht marsh is extensive and biodiverse, and the Cheewaht River valley is surrounded by beach plain habitat (low-lying flat or gently undulating land) (Cordes et al. 1974). Cheewaht River is a slow-moving river that forms a marshy flat which is inundated during very high tides and winter storms where it reaches sea level (Cordes et al. 1974). The Ditidaht First Nation has used the lake as an important source of Pacific salmon (particularly **miʔaat**/Sockeye), and its nearby forests for cedar harvesting and canoe constructions (MC Wright and Associates Ltd 2002). Lake-type Sockeye Salmon *(Oncorhynchus nerka*) have been found to be genetically heterogenous in geographically neighbouring samples, including those taken from Cheewaht Lake (Gustafson and Winans 1999).

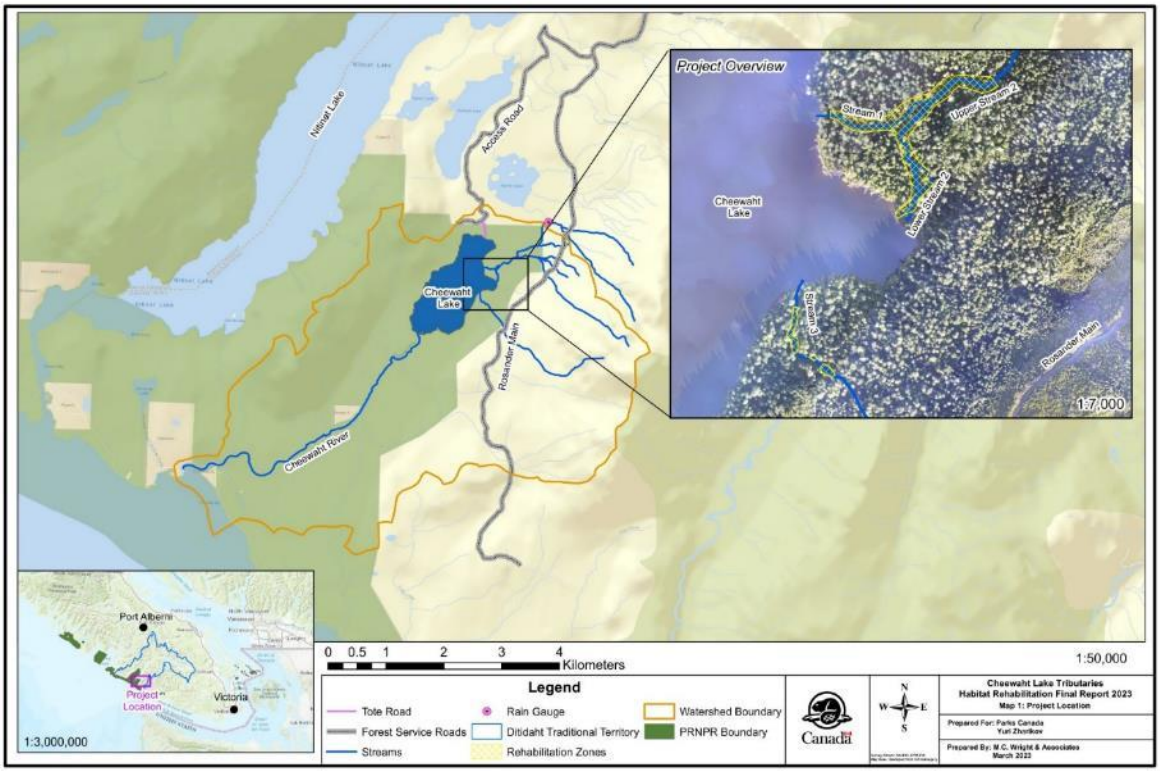


Figure 90. Cheewaht watershed on the west coast of Vancouver Island, with details of Cheewaht Lake and the immediate restoration area (insert).

Cheewaht Lake's watershed was the site of clearcut logging from 1984 to 1992, which drastically altered the riparian forest, changed stream morphology, and contributed to flooding, debris jams, erosion, and landslides (Wright et al. 1993; MC Wright and Associates Ltd 2002). Logging activities and subsequent bank failures upslope from PRNPR have degraded spawning and rearing salmon habitat in the park reserve itself. Fish abundance studies in the Cheewaht watershed began in 1985, and have documented a steady decline of salmon runs and habitat from 1989 onwards. The Ditidaht community began to limit harvesting of Cheewaht salmon to protect future salmon runs (Ditidaht First Nation and Parks Canada - Restoration of Cheewaht Lake salmon stream - Canada.ca), and all known Cheewaht Lake spawning areas have protection under the *Canada National Park Act*.

Restoration of the Cheewaht Lake watershed is currently ongoing through the collaboration of multiple interest groups through the establishment of the Cheewaht Restoration Working Group, including Ditidaht First Nation, Nuu-chah-nulth Tribal Council/Uu-a-thluk, Parks Canada, Fisheries and Oceans Canada and the Nitinaht Hatchery, BC Ministry of Forests, BC Timber Sales, Western Forest Products, Teal-Jones Group, MC Wright and Associates, and West Coast Aquatic. Current work in the area includes detailed habitat mapping and spawning surveys, as well as geotechnical and hydrological assessments. In 2009, as a result of this working group, sediment catchment basins were constructed outside of Pacific Rim National Park Reserve's boundary to reduce the transport of sediment to downstream fish habitat. A restriction on commercial fishing was also developed by DFO at the mouth of the Cheewaht River to protect salmon stocks. In 2018, Parks Canada committed to working with Ditidaht First Nation to restore 1 km of important Sockeye and Coho habitat in three separate streams of the

Cheewaht Lake watershed. Through Parks Canada restoration funds MC Wright and Associates, who have worked with Ditidaht First Nation on the Cheewaht Lake watershed for the past 35 years, designed a restoration approach to re-establishing the stream channels to follow their historic routes, using natural materials found on site to stabilize the stream banks, and lowering the streambed elevation to pre-logging conditions. More than 3,000 cubic metres of sediment were removed from the streams. Additionally, disturbed areas beyond the top of the stream banks were revegetated with native plant species to stabilize these areas during storm events. In October 2020, adult Sockeye and Coho began returning to the watershed, spawning in all three of the restored streams, as well as an additional 100 metres of habitat that had not been accessible for over two decades. Once the streams were cleared of log and sediment jams and channels re-established, spawning Sockeye re-occupied the entire anadromous zone of the Cheewaht tributaries within two seasons of work completion (Zharikov 2023; Figure 91).

Link to Ditidaht restoration video: https://vimeo.com/832661741

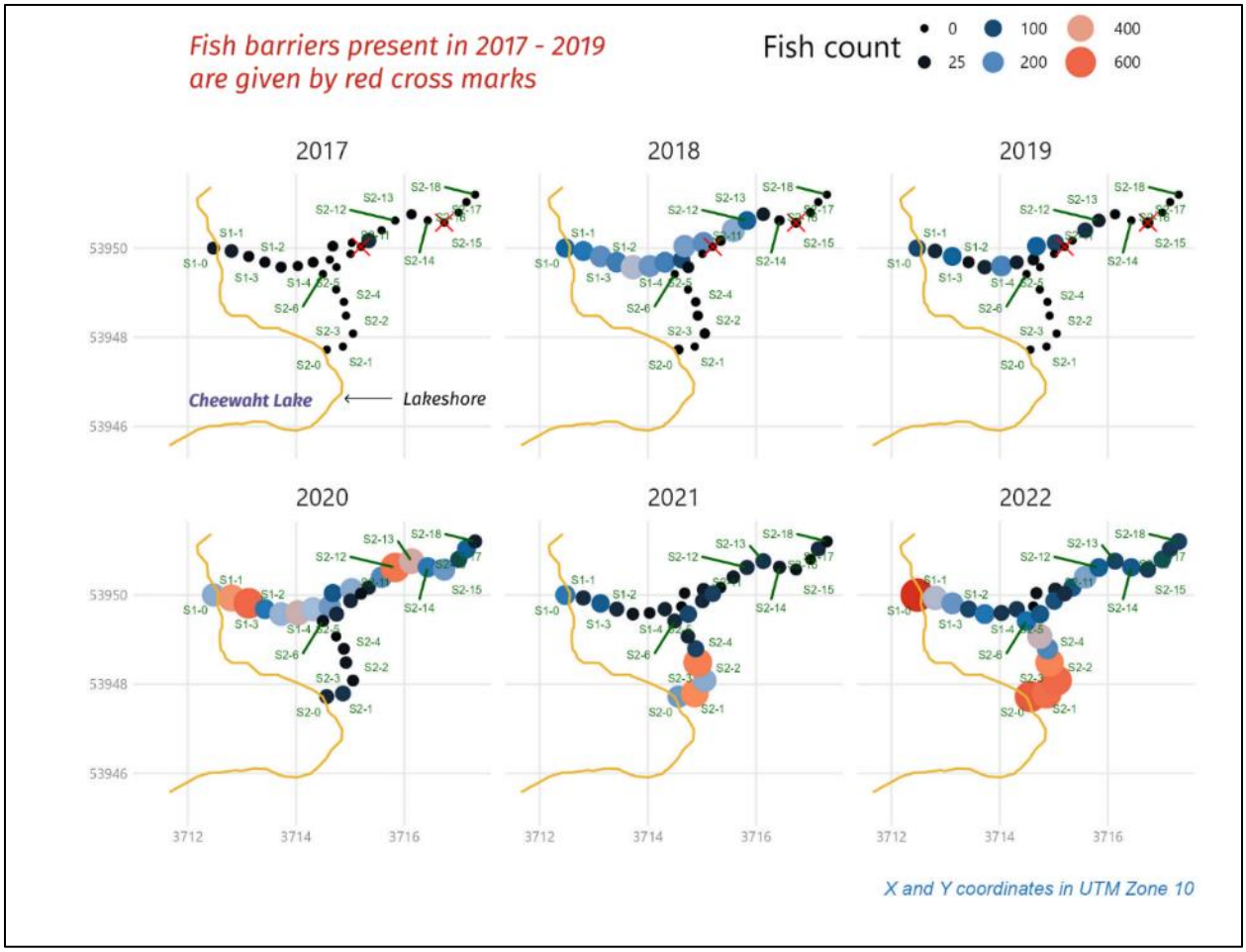


Figure 91. Annual change in the cumulative count of spawning Sockeye per stream segment in Cheewaht tributaries S1 and S2 (Zharikov 2023).

6.1.4 Sensitivities and Recoverability

Ecologically and Biologically Significant Areas

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

Cold seeps host fragile, long-lived species that struggle to recover from disturbances. Mature seep tubeworms grow slowly (centimetres per year) and can live over 300 years (Fisher et al. 1997; Cordes et al. 2009). Carbonates formed by microbial activity create complex habitats, but disruptions (e.g., from bottom trawling) can harm associated species like anemones, corals, and sponges (Bowden et al. 2013). Cold seeps are vulnerable to degradation from human activities, including direct impacts from bottom trawling (predominantly) and cabled infrastructure, as well as indirect effects from changes in ocean oxygen levels, potential oil spills, and other deep-sea pollution (Ramirez-Llodra et al. 2010). Recovery from human impacts is poorly understood but it may take decades or even centuries (Bowden et al. 2013; Levin et al. 2016). Fishing has already affected some Canadian Pacific cold seeps; in Barkley Canyon, trawling damaged methane hydrate and seafloor infrastructure (Spence et al. 2001; DFO 2018a), and ripped nets have been found around seep chimneys in Hecate Strait (Barrie et al. 2011). Observations of tubeworms at Clayoquot Slope suggest long lived populations with low recruitment rates (Breen 2002) can make recovery difficult. Additionally, the distribution of cold seeps and the recovery of populations may be influenced by larval dispersal distances and metapopulation connectivity, which remain largely unknown for most cold-seep species (DFO 2018a).

Estuaries and salt marshes

Estuarine habitats such as salt marshes are considered one of the most threatened ecosystems in the world and share sensitivities to natural and anthropogenic disturbances. Coastal erosion disrupted sediment transport, sea-level rise, and natural stochastic events such as storm surges can threaten the structure and function of estuaries. These effects may intensify with climate change (Gedan et al. 2011). Similarly, increased human activity and density can disturb estuaries through agriculture, freshwater diversion, pollution, oil spills, habitat alteration, the introduction of invasive species (Meyerson et al. 2009), and historical logging activities (Hodgson et al. 2020). Salt marsh habitats were ranked the highest vulnerability to oil spills (Jeffery et al. 2023). Studies examining the effects of the Deepwater Horizon oil spill on salt marsh areas found heavy erosion in oiled areas, heavily reduced above-ground plant cover, and a recovery time of over a decade (Zengel et al. 2022).

A recent coastwide classification of estuaries based on anthropogenic activities (DFO 2023a) identified anthropogenic activities and associated stressors relevant to estuary habitats through a literature review to guide the compilation of spatial datasets. The spatial datasets were then used to enumerate the type of activities each estuary along the BC coast is exposed to and to cluster estuaries that share similar activity types and levels of use. We present here the first part

of this analysis - the number and type of activities in each estuary and its associated watershed. There were 29 possible marine activities and 12 possible terrestrial activities analyzed. The seven estuaries within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank had between 7-12 relevant marine and terrestrial activities, with the highest for Walbran Creek and Nitinaht River estuaries (Table 10). Common activities among all estuaries were debris/litter, recreational boating, marine shipping, recreational fishing for salmon and groundfish, and general development activities within the watershed. Note that a count of activities is not a measure of the relative impact of each activity on the estuary, and this is not an exhaustive list of potential stressors on estuaries. However, knowledge of activity locations, associated stressors, and potential impacts to estuarine habitats can help identify estuaries that face similar concerns, such as those in **ƛ̓ušiiʔaaʔaq**, potential mitigation options, and the partners and stakeholders needed for successful management (DFO 2023a).

Table 10. Estuaries and associated activities within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area. Activities and activity count is from analysis presented in Robb et al. (2025). See Figure 85* for *estuary locations.*

Estuary Name	Carmanah Creek	Cheewaht River	Cullite Creek	Klanawa River	Logan Creek	Nitinaht River	Walbran Creek
Marine activities							
Commercial fishing - hook and line	0	0	0	0	X	0	X
Commercial fishing - salmon gillnetting	X	0	X	0	X	0	X
Commercial fishing - salmon seine	X	0	X	0	X	0	X
Recreational fishing - anadromous	X	X	X	X	X	X	X
Recreational fishing - groundfish	X	X	X	X	X	X	X
Recreational boating	X	X	X	X	X	X	X
Shipping	X	X	X	X	X	X	X
Terrestrial Activities							
Agriculture	0	0	0	X	0	X	X
Forestry cutblocks	X	X	X	X	0	X	X
Burned areas	0	0	0	X	0	X	X
Debris/litter	X	X	X	X	X	X	X
Mining	0	0	0	0	0	X	0
General development	X	X	X	X	X	X	X
Freshwater obstructions	0	0	0	0	0	X	0
Marine activity count	6	4	6	4	7	4	7
Terrestrial activity count	3	3	3	5	2	7	5
Total activity count	9	7	9	9	9	11	12

The dynamic properties of estuaries and salt marshes make these habitats naturally resilient and capable of rebounding from certain stressors (Gedan et al. 2011). In addition, salt marsh plant species can quickly grow and tolerate soils that are anoxic, saline, or contain metal contaminants (Weis and Weis 2004). The Nature Trust of BC launched a five-year assessment, monitoring and research project to look at resilience to climate change for 15 estuaries on Vancouver Island, Haida Gwaii and the Central Coast[64]. This assessment project will use the Marsh Resilience to Sea-Level Rise (MARS) monitoring tool and approach[65]. The Ditidaht Stewardship program have also started work to assess the resiliency of estuarine habitats to climate change, using the MARS approach.

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

Freshwater Ecosystems

Freshwater ecosystems, including Nitinaht and Cheewaht lake in the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area are sensitive to external stressors. Nitinaht Lake, an anoxic fjord, is a unique and sensitive ecosystem. Anoxic fjords are particularly susceptible to environmental changes, which can significantly impact their biogeochemical cycles, sediment composition, and overall ecosystem health. Climate change affects rainfall and river discharge into fjords, impacting the thickness and extent of low-salinity layers and deep-water renewal rates, which in turn affect bottom water oxygen concentrations (Bianchi et al. 2020). Work on Norwegian anoxic fjords has shown them to be critical indicators of past and present ecological shifts due to their ability to preserve detailed sedimentary records (Bianchi et al. 2020). Anoxic fjords in British Columbia, including Clayoquot Sound, serve as natural laboratories for studying the impacts of hypoxia on marine ecosystems, particularly microbial communities and nutrient cycling. Historical data confirm the persistence of hypoxic conditions in Clayoquot Sound, suggesting that long-term studies are necessary to predict the impacts of hypoxia and deoxygenation on marine life, particularly Pacific salmon, as the climate changes (Rosen et al. 2022). Additionally, summer streamflow droughts on Vancouver Island are becoming more severe due to climate warming. Historical data from tree-ring width analysis indicate that recent droughts are not anomalous compared to the past 477 years, suggesting that future droughts could be more severe due to compounded effects of climate change and land use changes (Coulthard and Smith 2016). An analysis of more recent data, including recent drought years, is a necessary next step is understanding how anomalous and severe weather patterns are compounding with local land use changes.

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

[65] https://coast.noaa.gov/digitalcoast/data/marshresilience.html

European Green Crab (*Carcinus maenas*) is an invasive invertebrate species of much concern. Several trapping stations in Nitinaht Lake, sampling done in collaboration between DFO and the Ditihaht First Nation, have caught European Green Crabs (see Invasive Species section).

6.1.5 Data and Knowledge Gaps

Ecologically and Biologically Significant Areas

While four EBSAs overlap with the **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area (Continental Shelf off Barkley Sound, Juan de Fuca Eddy, Juan de Fuca Strait, and cold seeps), there are a lack of comprehensive vulnerability assessments for these areas. The Continental Shelf off Barkley Sound, the Juan de Fuca Eddy, and Juan de Fuca Strait EBSAs have further not been evaluated using the EBSA ranking system for "Vulnerability, fragility, sensitivity, or slow recovery".

Cold Seeps

There are limited repeat data of cold seep activity available to quantify the level of persistence for the boundary area or the location of seeps across **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Limited visual imagery in the form of photos or videos are available for these sites. A drop camera that takes still photo images at intervals across a transect was used in 2022 in an attempt to collect ground-truth information at two stations, but photos of bubbles in the water column have yet to be obtained (C. Stacey, NRCan (Chief Scientist 2022002PGC), pers. comm.). More photographs or video that capture bubbles would help confirm these sites as cold seeps.Further echosounder data collected in the **ƛ̓ušiiʔaaʔaq** Area would contribute to a more comprehensive understanding of the presence and persistence of potential cold seeps in this area. ROV surveys or other forms of seabed imagery would help to determine the characteristic of these sites and the presence of any vent structures and venting of gas.

Estuaries and Salt marshes

There is a need for repeat surveys of nearshore habitats, including salt marshes and eelgrass beds, to monitor their health and extent, particularly in the context of climate change and sea-level rise. The most recent Shorezone mapping for the outer coastline and estuaries was completed in 2021, while mapping for Nitinaht Lake dates back to 2007. Updated mapping and repeat surveys could help assess current habitat extents as well as changes over time. Further, the current Shorezone mapping primarily focuses on delineating habitat boundaries. Incorporating additional survey methods to collect data on habitat condition (e.g., sediment quality, vegetation health) would enhance understanding of these vulnerable ecosystems

Freshwater ecosystems

Several freshwater ecosystems exist within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (e.g., Nitinaht Lake, Cheewaht Lake), and there is ongoing need for research assessing the specific impacts of climate change and other stressors on these systems and their biodiversity.

The unique characteristics of Nitinaht Lake as an anoxic fjord make it particularly vulnerable to environmental changes. Research is needed to understand how factors like increased freshwater runoff, stratification, and deoxygenation impact the lake's biogeochemical cycles and ecosystem health. Shorezone mapping was last completed for Nitinaht Lake in 2007 and could

be updated to help assess current habitat extents to complement ongoing survey work by the Ditidaht Nation.

Further, there is need for assessments of salmon populations in watersheds adjacent to Nitinaht and Cheewaht Rivers to better understand the status and trends of salmon in the broader **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

6.2 Taxonomic diversity

Taxonomic diversity describes a broad group of marine organisms of ecological, cultural, or commercial importance in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and specific taxonomic groups are highlighted throughout this report. These taxonomic groups include Plankton, Macroalgae and Plants, Invertebrates, Fishes, Marine Birds, and Marine Mammals and Reptiles. Here, each feature's ecological importance, occurrence and trends, and/or cultural usage are described within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank and nearby area when available. Recent patterns of occurrences in the area are presented where available. Finally, a summary of Sensitivities and Recoverability is reported and Data and Knowledge Gaps are highlighted.

6.2.1 Macroalgae and plants

6.2.1.1 Canopy-forming kelps

Kelp is the common name for marine brown algae belonging to the order Laminariales, which is found mainly in lower intertidal to subtidal zones with rocky or mixed substrates in temperate ecosystems. Kelp forests are among the world's most productive habitats (Mann 1982), and their complex structures serve as valuable habitats for coastal marine organisms. Canopy-forming kelp is consumed by an abundance of lower trophic detritivores and grazers, which attract and feed higher trophic level organisms. In addition, the vast heterogeneous structures of kelp forests serve as a substrate for microorganisms and small invertebrates, provide protection against predators, and offer ideal conditions for juvenile spawning and rearing (summarized in Rubidge et al. 2020). Kelp habitats are associated with higher species diversity, species density, and higher life stage density of species. A multiyear zooplankton drop net and snorkel survey by Shaffer et al. (2020) compared the differences between kelp forest and open-water habitats in Washington state. They detected more presence and biomass of zooplankton, juvenile salmon (Chinook and Coho), and forage fishes (Pacific Herring, Surf Smelt, and Pacific Sand Lance) in kelp forests. Many other species, including invertebrates, salmon, rockfish, Killer Whales, and Sea Otters, depend on kelp forest ecosystems for crucial life history functions such as feeding, spawning, and rearing (Rubidge et al. 2020).

In addition to their function as marine ecosystem engineers, kelp forests provide valued ecosystem services. They absorb excess nutrients and ameliorate localized impacts of ocean acidification and hypoxia (Hirsh et al. 2020; Umanzor and Stephens 2022). The high productivity of kelp forests suggests that they could play a substantial role in climate change mitigation by sequestering carbon dioxide from the atmosphere. However, there is still considerable uncertainty regarding the flux of kelp-derived carbon in the marine environment and its fate in the global carbon cycle (Krause-Jensen and Duarte 2016).

In **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, Bull Kelp, a canopy-forming kelp is found distributed relatively evenly along the coastline (Figure 92) and a recent analysis found that Bull Kelp distribution was stable between 2007 and 2021 (Starko et al. 2024). The distribution of canopy-forming kelp

based on the ShoreZone Bull Kelp bioband lines and the BC Marine Conservation Analysis (BCMCA) general kelp (species not identified) bed polygons are shown in Figure 92. Imagery mapping for Shorezone in **ƛ̓ušiiʔaaʔaq** was conducted in 2021 and polygons delineating Bull Kelp beds as sensitive habitat were developed using the Shorezone bioband data together with the best available satellite imagery for the area (SeaChange Marine Conservation Society 2023). Historical kelp distribution has also been mapped from British Admiralty charts **(**Figure 93; Costa et al. 2020). The Hakai Institute is developing canopy kelp polygons for the using remotely sensed imagery that may be useful for future work in **ƛ̓ušiiʔaaʔaq**.

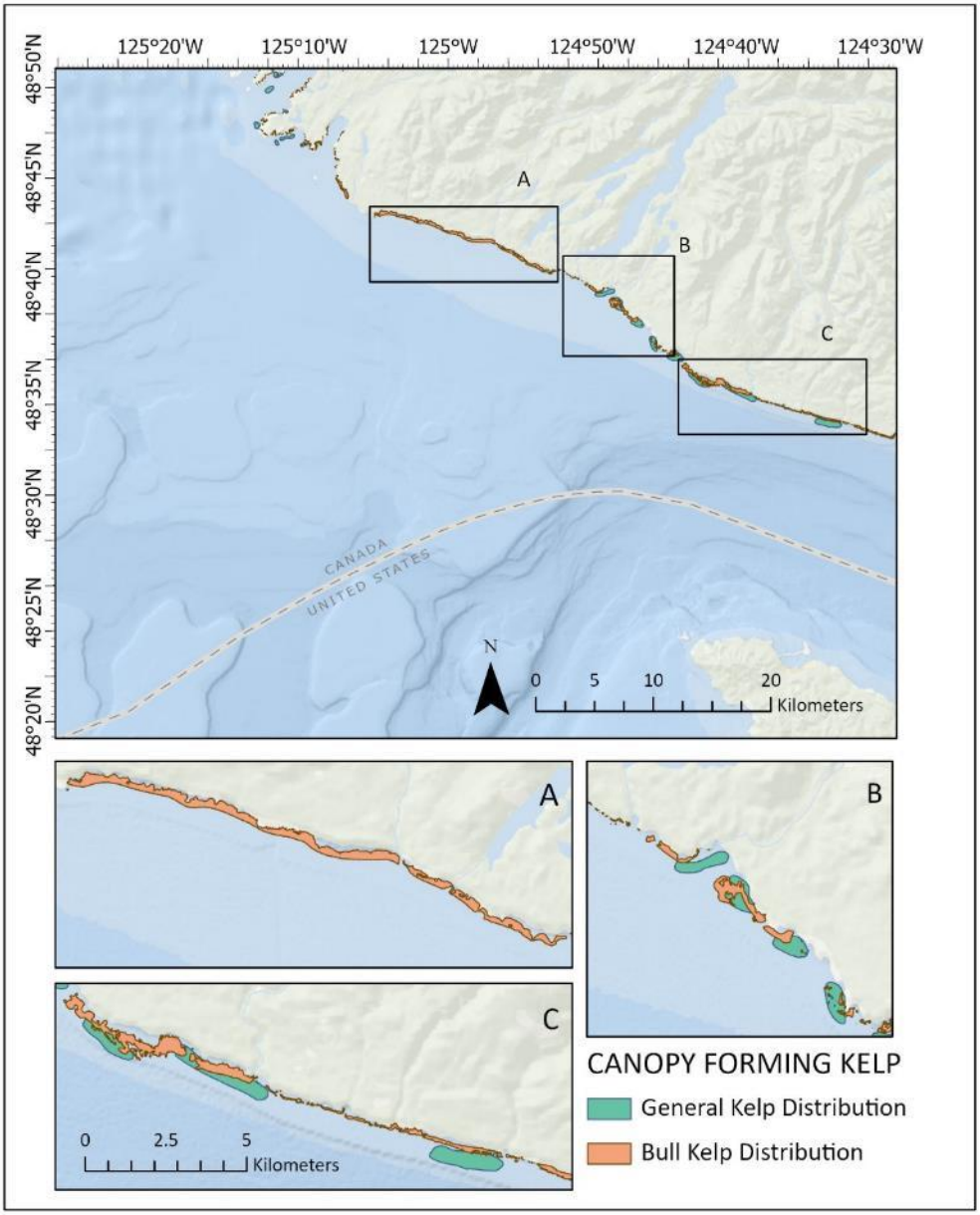


*Figure 92. Canopy-forming kelp beds based on Shorezone sensitive habitat polygon data for Bull Kelp and general kelp (no species identified) polygon data from the BCMCA (BCMCA Project Team 2011) within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Bull Kelp data are shown in orange and general kelp in green.*

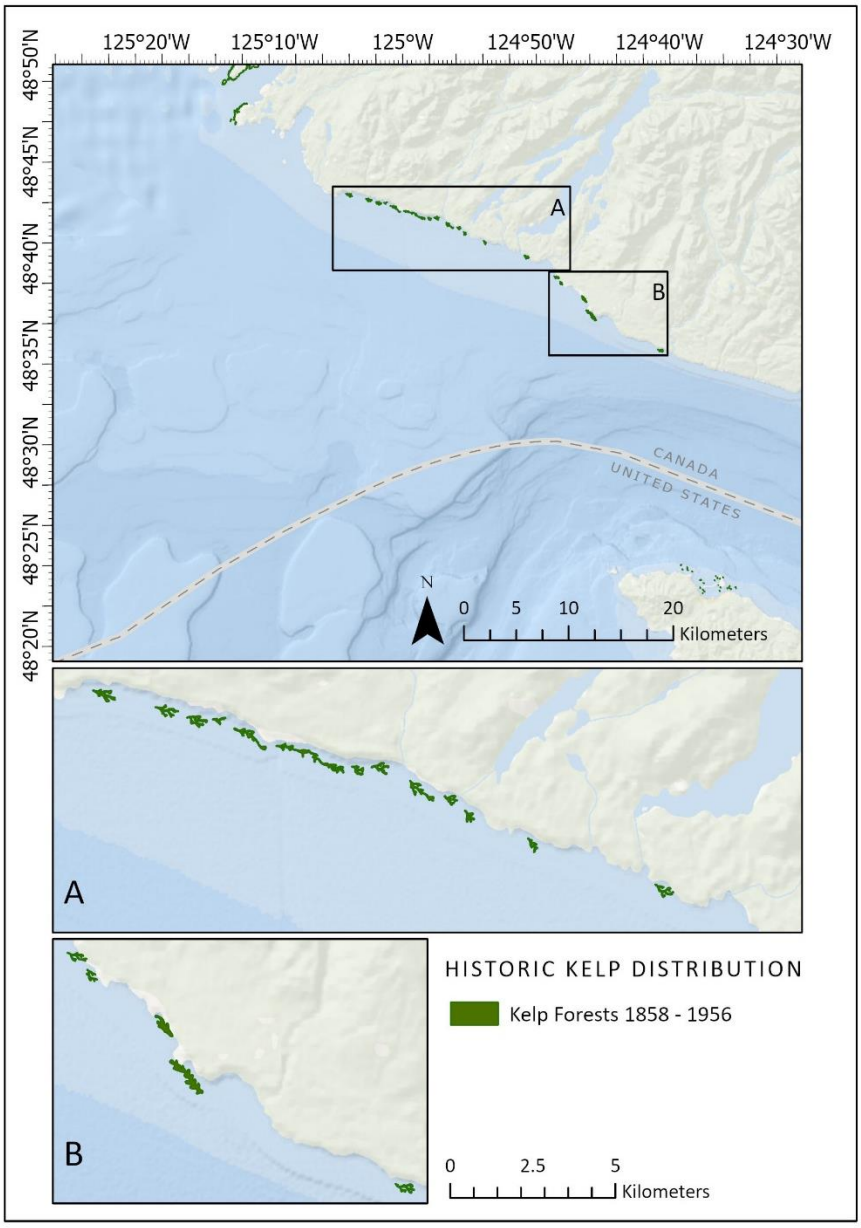


Figure 93. Historical kelp forest distribution from British Admiralty charts within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area (Costa et al. 2020).*

Several general caveats for the bioband datasets exist. Data gaps may indicate a lack of surveillance in certain areas and not necessarily an absence of kelp. Multiple surveillance methods were used to compile these datasets, so direct comparisons between the data may be difficult. Much of the data represents the surface distribution of kelp; therefore, there is not much information about sub-surface distribution. In addition, kelp distributions are dynamic, meaning the presence of kelp forests and beds may change over time. Huu-ay-aht have observed a loss of kelp coverage, a key habitat and have developed several partnerships with kelp companies and the Bamfield Marine Science Center to form a kelp rescue initiative. There are currently no

monitoring sites with the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Juan de Fuca Eddy EBSA polygon, but there is some monitoring in the surrounding area, particularly in Barkley Sound.

The high productivity of kelp forest ecosystems has led to many traditional and contemporary human uses in the Pacific Northwest. Kelp is harvested for cultural and commercial purposes, and preserving kelp forests leads to higher productivity of culturally and economically important species such as Chinook and Coho Salmon (Shaffer 2004; Daly et al. 2009). Bull Kelp has been described as "the most valued marine plant material in traditional Northwest Coast technology" among its many uses in ceremonial, domestic, and substance practices (Turner 2003; Calloway et al. 2020). Kelp forests are also vital habitats for the proliferation and recovery of culturally important and endangered species of concern, such as Northern Abalone (Sloan and Breen 1988; COSEWIC 2009a; DFO 2012a) and rockfish (Markel and Shurin 2015; Tolimieri et al. 2023). Managing and preserving kelp forest ecosystems ensures the connection for many important cultural and ecological practices.

6.2.1.2 Other marine macroalgae

Marine macroalgae, also commonly known as seaweed, are categorized into three broad groups consisting of red, green, and brown algae (which includes the canopy-forming kelps described above). There are at least 615 described native species along the coast of BC. The functions of algae in the marine environment are similar to those of plants in the terrestrial ecosystem, including photosynthesis as primary producers at the base of the marine food web, forming habitats, regulating environmental conditions, and providing structural support against erosion and shelter against predators and disturbances. A project to create species distribution models for multiple algae species is currently underway by DFO (Davies et al. 2018; Nephin et al. 2020).

Other kelp genera, such as *Laminaria*, *Alaria*, and *Pterygophora*, make up understory kelp that likely provides similar ecosystem engineering functions to canopy-forming species Bull Kelp and Giant Kelp (*Macrocystis pyrifera*) (Springer 2010, summarized in Rubidge et al. 2020). In other temperate waters, species of the genus *Laminaria* and *Saccharina* form dense beds in areas where they are the dominant kelp species (e.g., Arctic and North Atlantic Oceans) and provide complex habitats and feeding grounds for coastal biodiversity (Schoenrock et al. 2020; Kvile et al. 2022). Field manipulation studies that removed understory kelp species saw changes in abiotic conditions and some species assemblages (e.g., Kennelly 1989; Flukes et al. 2014). Additionally, Clark et al. (2004) noted that the responses of benthic algal communities to experimental removal of kelp forest canopy and understory *Pterygophora californica* varied depending on whether the dominant kelp canopies were removed individually or together. These studies highlight the role of both canopy-forming and understory kelps in contributing to benthic community composition and dynamics. Alternatively, a study by Hüne et al. (2021) measured fish species diversity and abundance in areas with Giant Kelp and co-existing understory kelp (*Lessonia spp.*) in Southern Chile. The study found a negative correlation in regions of denser *Lessonia spp.* and discussed that Giant Kelp fronds may provide more food and shelter for fishes than understory kelp.

Corraline red algae (Order *Corallinales* and *Sporolithales*) have been described as habitat and reef-forming species due to their quick colonization of bare rock and ability to form complex structures with a high composition of calcium carbonate (Kelaher et al. 2001). Their presence has increased settlement and growth in many invertebrate larvae (e.g., Steller and Cáceres-Martínez 2009; Fisher and Martone 2014). Notably, crustose coralline algae may play a role in

settlement cues for Northern Abalone, and adults were shown to prefer habitats with increased kelp and coralline algae cover (Rogers-Bennett et al. 2011). Abundant species of algae such as Rockweed (*Fucus sp.*) and Sea Lettuce (*Ulva sp.*) can dominate rocky shorelines or beach wracks, contributing to marine and terrestrial nutrient transfer (Orr et al. 2005; Fox et al. 2015). Rockweed can form dense canopies, which can increase invertebrate diversity and abundance by providing refuge, whereas their removal can change those community assemblages (Jenkins et al. 2004; Martins et al. 2019). Sea Lettuce provided habitat for fish and decapods (Sogard and Able 1991) and protection for larval crabs compared to unvegetated areas (Wilson et al. 1989).

Understory kelp species, including *Laminaria setchelli, Lessoniopsis littoralis, Laminaria longipes, Laminaria yeozensis, Saccharina latissimi, Sargassum muticum, and Cystoseira species*, have been mapped through the Shorezone mapping system and are found distributed along the coast of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank and into Nitinaht Narrows and Nitinaht Lake (Figure 94; also see Nitinaht lake). A coastwide species distribution model for *Pterygophora californica* also shows a high probability of occurrence in the **ƛ̓ušiiʔaaʔaq** Area (Figure 95, Park et al. (2023)).

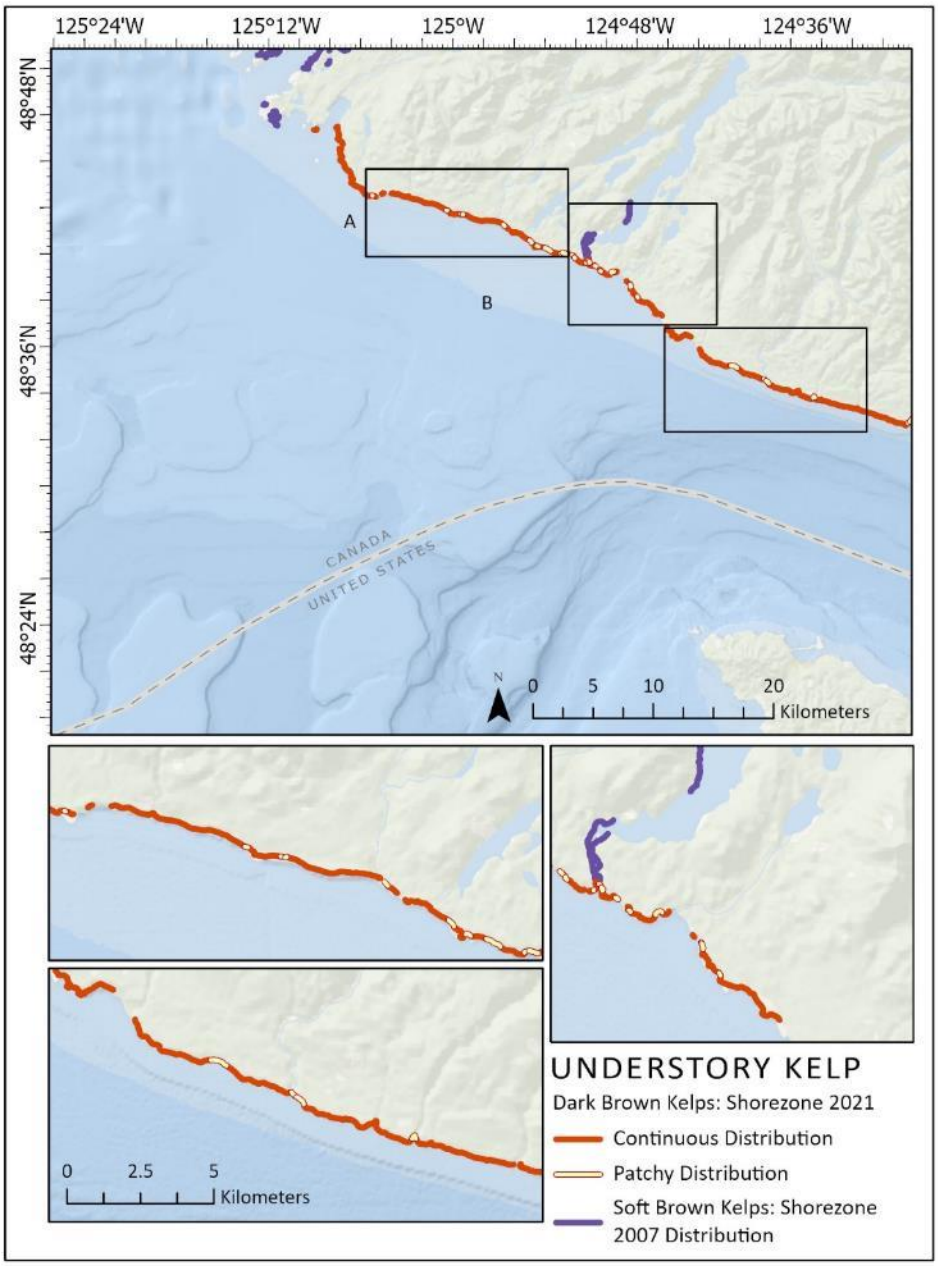


Figure 94. Shorezone biobands[66] representing distribution of understory kelp in the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area. Dark brown kelps, indicator species including Laminaria setchelli, Lessoniopsis littoralis, Laminaria longipes, and Laminaria yeozensis, Biobands, last updated in 2021, are shown in red for areas of continuous distribution and in yellow for patchy areas. In Nitinaht lake soft brown kelp biobands, indicator species including Saccharina latissimi, Cystoseira sp., and Sargassum muticum, were last updated in 2007 and are shown in purple.*

[66] https://www.shorezone.org/downloadzone/

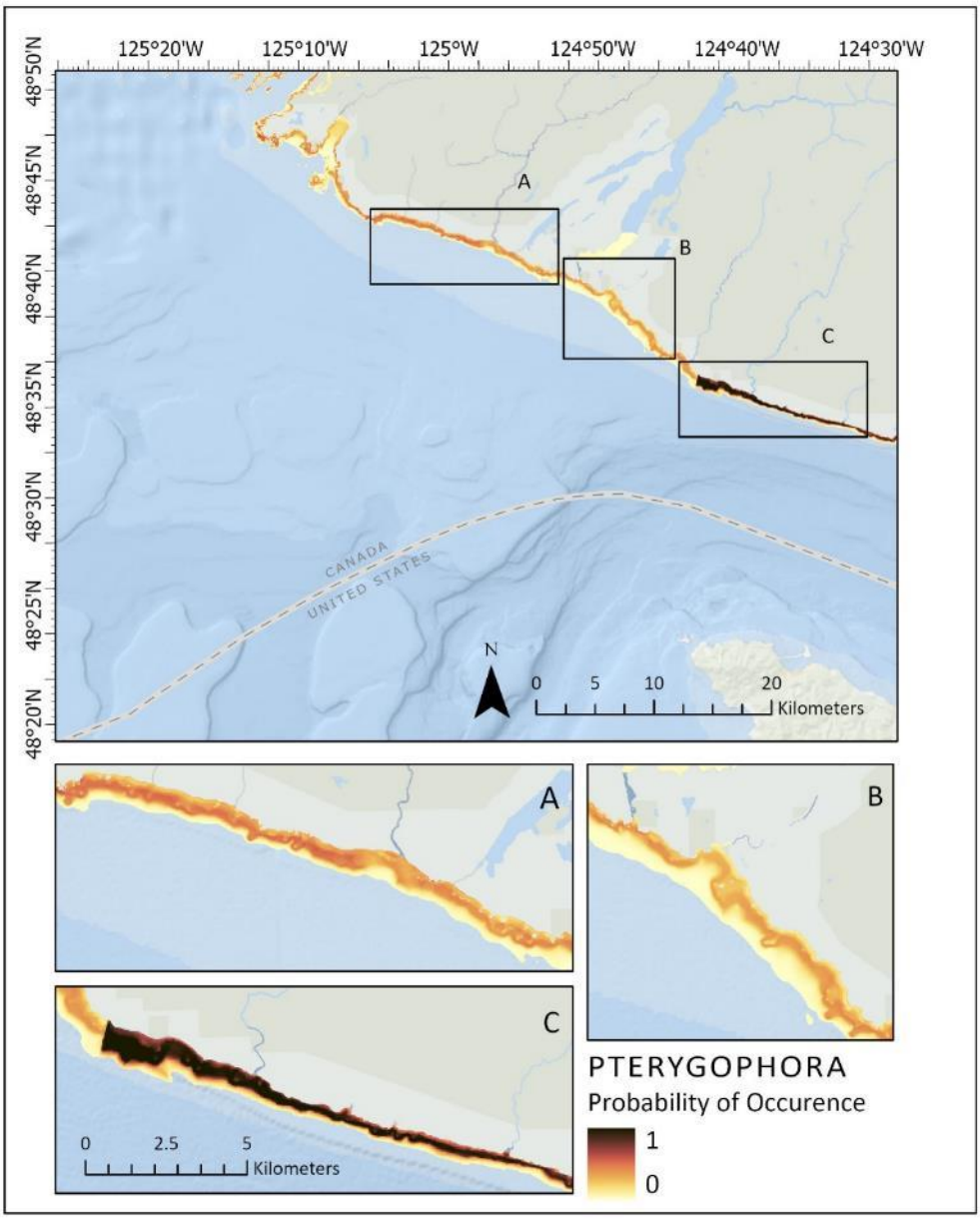


*Figure 95. Pterygophora species distribution model, **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Park et al. 2023).*

Certain algae species have important uses for humans. The red algae, *Pyropia abbottiae*, for example, grows on intertidal rocks and is commonly harvested, dried, and used as snacks and meals by many coastal First Nations (Turner 2003; Marsden 2012). Red algae has names across 16 language groups in five language families across the Pacific Coast of Canada and Alaska, indicating this seaweed's widespread usage and importance (Turner, 2003). Other seaweeds traditionally or contemporarily eaten or have food-related uses by nearby coastal First Nations include Rockweed, Sea lettuce, and Pacific Dulse (*Palmaria mollis*) (Kuhnlein and Turner 1991).

6.2.1.3 Eelgrass and surfgrass

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

Two eelgrass species are found in BC: the native Common Eelgrass (*Zostera marina)* and the introduced Dwarf Eelgrass (*Zostera japonica)*. The non-native Dwarf Eelgrass would likely form mixed-species meadows with Common Eelgrass if the spread of non-native Dwarf Eelgrass continues (Rubidge et al. 2020). Eelgrass habitats have strong support for EBSA designation (Rubidge et al. 2020). Eelgrass meadows serve many important functions for various life stages for many species. For example, these habitats are essential nursery grounds for many ecologically, culturally, and economically important species such as salmon (all species), Lingcod, Pacific Herring, Dungeness Crabs (Moore et al. 2015; Sharpe et al. 2021), and various waterfowl. Both commercial and small-scale fisheries benefit from eelgrass meadows as these habitats provide protection and supply food for many juvenile fish and invertebrates (Carr-Harris et al. 2015; Moore et al. 2015; Unsworth et al. 2019). The rhizomes and stems of eelgrass meadows grow throughout and stabilize sediments, which prevents coastal erosion. Furthermore, eelgrass meadows oxygenate surrounding waters (Rasmusson et al. 2017), contribute directly and indirectly to nutrient cycling and transfer, and accumulate carbon in the marine environment (Greiner et al. 2013), among multiple other beneficial ecosystem services (Cole and Moksnes 2016).

The Parks Canada Coastal Health Eelgrass Assessment Monitoring program, was developed in 2002 and implemented across all coastal British Columbia National Park Reserves since 2004 (Robinson et al. 2011; Robinson and Yakimishyn 2013). Eelgrass meadow fish diversity, environmental and eelgrass parameters are collected on annual basis and reported on as part of PRNPR's Ecological Integrity Monitoring program. Recent aerial mapping of eelgrass meadows within the park reserve have been done in collaboration with Hakai Institute and First Nation partners using Unmanned Aerial Systems (UAS, aka drones) (Nahirnick et al. 2019). Within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, Parks Canada works collaboratively with the Ditidaht First Nation to support their eelgrass monitoring and research work in the Nitinaht Lake area.

While there are no eelgrass data within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, eelgrass has been mapped within Nitinaht Lake and neighbouring Barkley Sound. The Shorezone Bioband data (Figure 96) include eelgrass information mapped in Nitinaht Lake in 2007, from which sensitive habitat polygons for eelgrass have been developed (SeaChange Marine Conservation

Society 2023). Polygons representing eelgrass beds have also been compiled from a variety of sources across the BC coast by the BCMCA (BCMCA Project Team 2011) and include polygons mapped within neighbouring Barkley Sound.

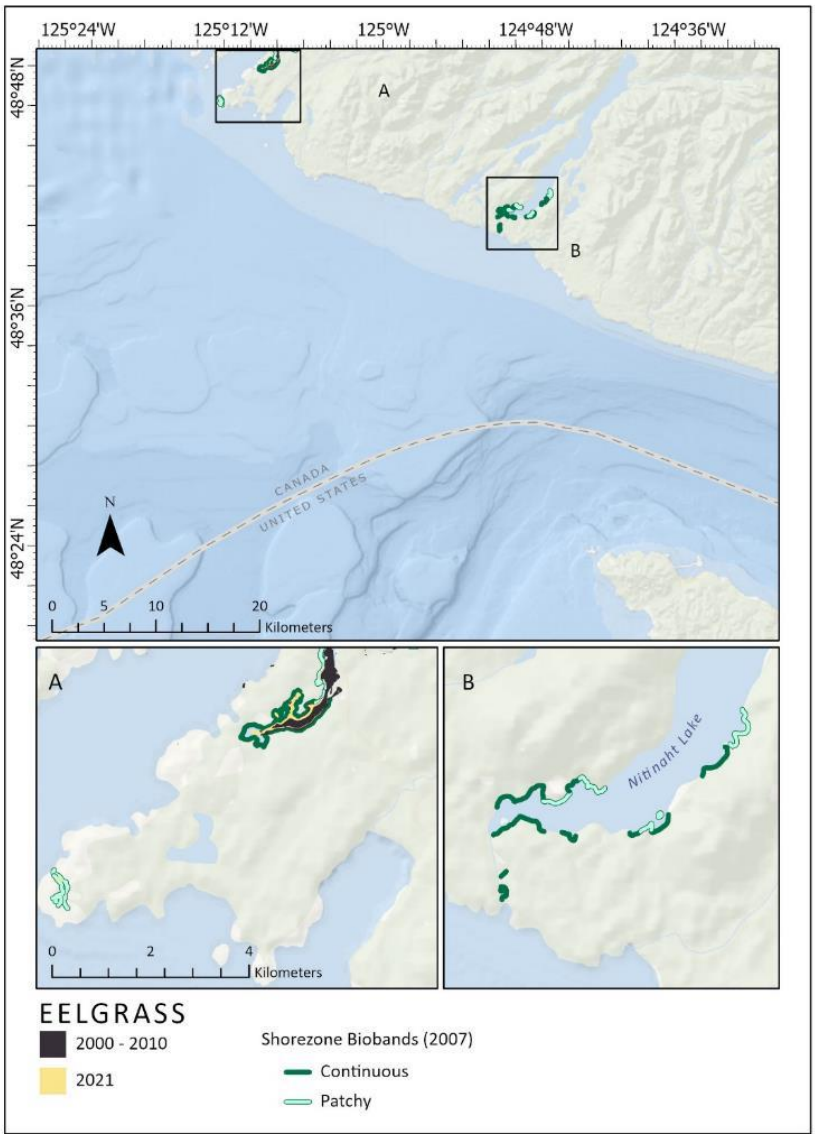


Figure 96. Historic distribution of eelgrass (BCMCA Project Team 2011) and Shorezone Bioband data for Eelgrass species distribution (Zostera spp.)[67] *in* ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank and surrounding area, including Barkley Sound (inset A) and Nitinaht Lake (inset B). Additional data (not shown) are available from the sites within the Pacific Rim National Park Reserve.*

Surfgrass, also known as *Phyllospadix*, is a genus of marine plants that belong to the family Zosteraceae. It typically grows in intertidal areas, forming dense patches along rocky shores and sandy beaches. It is characterized by long, ribbon-like leaves and small, inconspicuous flowers. It plays an important role in stabilizing sediments and providing habitat for a variety of marine organisms, including invertebrates and small fish. Surfgrasses typically use rock as

[67] https://www.shorezone.org/downloadzone/

substrate (Balestri et al. 2015); however, they have also been observed anchored in soft sediment along the Pacific Northwest coast, and additionally differ from other seagrasses in preferring habitat with higher wave exposure (Stephens et al. 2019). In the Pacific Northwest, surfgrasses and eelgrasses can dominate shallow seascapes, and often grow intermixed instead of forming distinct bands (Stephens et al. 2019). Surfgrass biobands mapped through the Shorezone system occur along the length of the exposed coastline of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, in both continuous and patchy distributions (Figure 97).

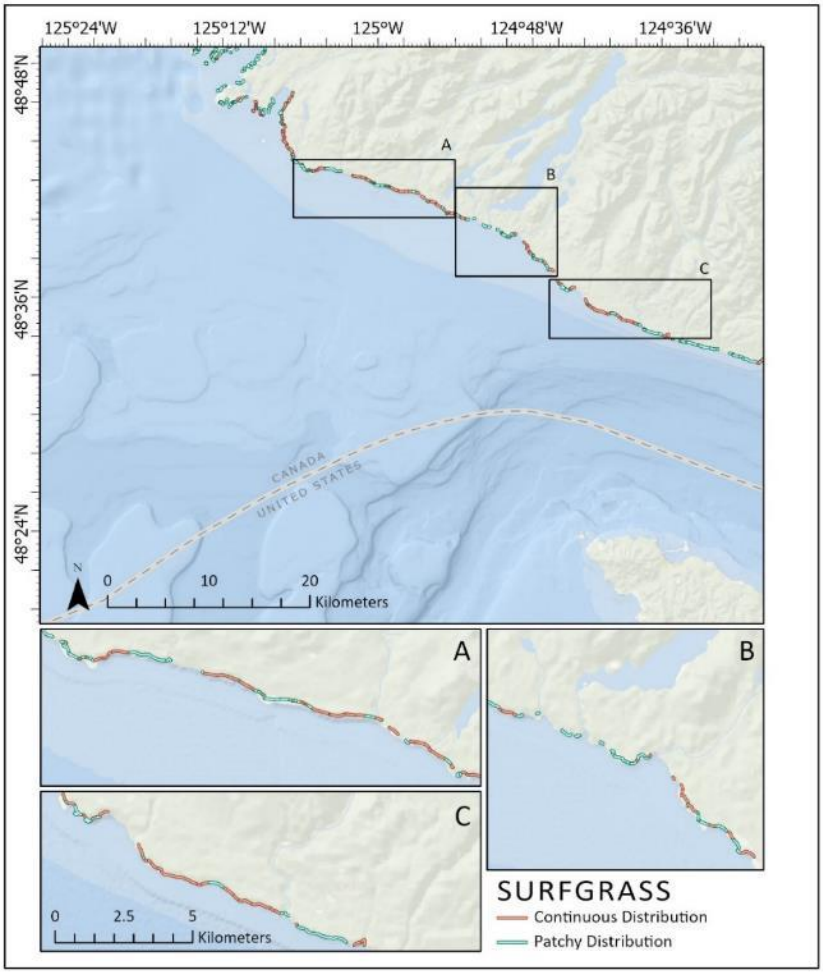


*Figure 97. Surfgrass distribution from Shorezone bioband data[68] in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank and surrounding area.*

6.2.1.4 Sensitivities and Recoverability

Canopy-forming kelps

Kelps are sensitive to multiple and potentially interacting stressors related to climate change and other human activities, including rising seawater temperatures and associated changes in

[68] https://www.shorezone.org/downloadzone/

nutrient availability, changing salinity regimes, increased herbivory, and decreasing water clarity and substrate availability due to land-use practices (Harley et al. 2012; Smale 2019).

Cool (≤12°C for Bull Kelp, ≤15°C for Giant Kelp), high salinity (≥28‰), low turbidity waters rich in nutrients (nitrogen, phosphorus) provide the optimal conditions for kelp recruitment and growth (Druehl 1978; Rogers-Bennett and Catton 2019). General warming trends and anomalous warming events (marine heatwaves) associated with climate change can threaten kelp persistence because growth and recruitment are reduced at warmer temperatures (Buschmann et al. 2004; Krumhansl et al. 2017; Hollarsmith et al. 2020).

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

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

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

Regionally coordinated monitoring of canopy-forming kelp forests in the Northern Shelf Bioregion (NSB)[69] has revealed considerable annual variation in kelp abundance and that trends in kelp forest extent vary sub-regionally, highlighting the need for local-scale, long-term monitoring to detect trends and identify drivers of change. Additionally, a recent BC coast-wide study found variable patterns of change in BC's canopy-forming kelp forests over decadal periods related to thermal microclimate, currents and wave exposure, and food chain length (Starko et al. 2024).

Local to regional scale environmental and biological conditions play an important role in determining the resilience of kelp forests to disturbance events. In BC, fine-scale (a few to 10s of km) variations in seawater temperature of ~1-3°C drive the recovery of Giant Kelp from harvest (Krumhansl et al. 2017) and the resistance of Giant Kelp and Bull Kelp to marine heatwaves (Starko et al. 2022). Cooler microclimates promote faster rates of biomass recovery following harvest and act as thermal refugia during anomalous warming events. Wind and tidal-

[69] Regional Kelp Monitoring on the North Pacific Coast

driven mixing can promote favourable conditions for kelp persistence by providing cooler, nutrient-rich water, potentially providing refugia for regional kelp diversity (Berry et al. 2021).

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

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

Eelgrass and surfgrass

Globally, seagrass ecosystems have declined by an estimated average rate of 1.7% per year (Dunic et al. 2021). Temperate eelgrass meadows are sensitive and vulnerable to changes in the ecosystem such as increased temperature, decreased salinity, lower light conditions, wasting diseases, and increased herbivory (Orth et al. 2006; Salo et al. 2014). Both eelgrass and surfgrass meadows face pressures from pollution related to human development and activities such as oil spills, run-off and increased nutrient output from agriculture, aquaculture, sewage, and vessel discharge (reviewed in Rubidge et al. 2020). Although the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area is relatively sparsely populated in comparison to other areas on Vancouver Island, marine vessel traffic is common, which could impact local seagrass ecosystems (see Vessel traffic and vessel types).

Invasive species, such as European Green Crab (see Invasive Species section; Garbary et al. 2014; Matheson et al. 2016) and introduced Pacific oysters (Kelly and Volpe 2007), are known to impact eelgrass health by altering fish communities and water properties respectively. European green crab invasions have resulted in a loss of eelgrass meadows. The invasive crab burrows into the muddy ocean floor as it forages for food, uprooting eelgrass plants. Green crab populations spread and grow quickly as the species can thrive in a wide variety of temperatures and salinity levels. In BC, high densities of green crabs can also directly contribute to declines in

eelgrass shoot density by shredding eelgrass blades and consuming both blades and rhizomes (Howard et al. 2019).

The disturbance mechanism of European Green Crab differs from that exerted by Sea Otters digging in eelgrass meadows, which can promote eelgrass genetic diversity (Foster et al. 2021); however, only incidental observations of Sea Otters exist within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (see Sea Otters).

Physical disturbances relating to human activities, such as frequent trampling, boating, logging, coastal construction, and coastline alterations, impact eelgrass negatively. Recreational boating activity is common in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, which could affect eelgrass and seagrass distributions through boating, anchoring, and beachcombing activities (see HUMAN USES OF AREA). Natural disturbances such as winter storms can also alter and uproot eelgrass. In contrast, dense and undisturbed surfgrass meadows are more resilient to these disturbances because they naturally prefer wave-exposed habitats (Turner and Lucas 1985). Surfgrasses are, however, affected by desiccation and heat stress during low tides (Raimondi et al. 1999). Naturally occurring disturbances, such as storms and heatwaves, occurring with increased frequency and intensity exacerbated by climate change may be a cause of concern for the health and persistence of eelgrass and surfgrass meadows, particularly when interacting with other stressors mentioned above (Orth et al. 2006).

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

Transplanted eelgrass in suitable habitats or partially damaged meadows are more effective than restoring meadows that have been completely lost. Notably, partially restored eelgrass ecosystems have been shown to increase the presence of certain juvenile fish species (such as Pink Salmon) in areas of human disturbance (Hass et al. 2002). Resilience and recovery of many fish and invertebrate populations of conservation concern depend on healthy eelgrass communities (Orth et al. 2006; Unsworth et al. 2019; Knutsen et al. 2022).

Conservation of eelgrass meadow ecosystems in BC is aided by long-term monitoring efforts, up-to-date spatial data collecting, consistent funding, and environments with low disturbance (Wright 2002, 2005). Community-based conservation is encouraged by national policies (United Nations Environment Programme 2020). The Ditidaht First Nation have been and continue to monitor eelgrass and under story kelp in Nitinaht Lake and Canopy Kelp on the outer coast near Clo-oose and the Cheewaht River.

A total of 74 fish species, comprised of 305,152 individuals, were caught and released from 2004 to 2018 in the Pacific Rim National Park Reserve eelgrass monitoring program. Overall, eelgrass fish assemblages are persistent and stable over the study period (Robinson and Yakimishyn 2013). The aerial extent of 22 eelgrass meadows in the national park reserve were assessed in 2016 and 2017 and these surveys will continue to assess future changes in meadow extent.

6.2.1.5 Data and Knowledge Gaps

Canopy-forming kelp

Information on canopy-forming kelp persistence and drivers of change in BC is limited to geographically constrained case studies. More work is needed across larger spatial and temporal scales to understand how underlying environmental conditions and stressors at local to regional scales affect the resilience of canopy-forming kelp to global climate change (Hollarsmith et al. 2022). Updated species-specific information on the occurrence and abundance of canopy-forming kelp is lacking for much of the BC coast. Canopy-forming kelp forests exhibit high levels of natural variability both seasonally and interannually, especially the annual Bull Kelp. Consequently, detecting long-term trends of changes in canopy-forming kelp density and extent requires dedicated annual surveys over multiple years supported by local and traditional ecological knowledge.

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

Other marine macroalgae

Many macroalgae research surveys focus on Bull Kelp and Giant Kelp distribution due to their visible canopy at the ocean surface. Surveys that record coastal macroalgae diversity tend to concentrate in in Barkley Sound on the WCVI, however in recent years fewer studies have been conducted in the Strait of Georgia/north Salish Sea (see Levings and Stewart 2020 for details).

The population response of the mid-intertidal kelp *Postelsia palmaeformis* in the northern limit of its range is understudied, presenting a research gap (Csordas et al. 2024). However, recent survey work (2021 and 2022) shows long-term stability of *P. palmaeformis* due to its ability to thermal buffer near its northern range edge and from its habitat of wave-exposed coastlines, which may mitigate the impact of heatwaves.

Eelgrass and surfgrass

Monitoring and mapping of eelgrass beds will continue annually in Nitinaht Lake and on the outer coast within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Although significant work has been done within Nitinaht Lake by the Ditidaht Stewardship Program and Parks Canada, more work is

required to identify and map other areas that have not been included in the maps compiled by the DFN Stewardship Team. Ground truthing of polygons created from drone surveys will be ongoing and the DFN will update maps as information is completed.

Further research on surfgrass in BC is needed to understand its habitat requirements, environmental tolerance, and importance to other species of conservation priority. Local knowledge, spatial imagery, and monitoring programs can supplement species distribution models and occurrence information. Maps of eelgrass distributions are continuing to be updated and the National Eelgrass Task Force was created to produce dynamic maps of eelgrass distribution throughout Canada that have incorporated historical eelgrass datasets from BC (Gomez et al. 2021; Guijarro-Sabaniel et al. 2024).

6.2.2 Plankton

Plankton, including phytoplankton (marine plants) and zooplankton, play a vital ecological role in British Columbia's marine environment, influencing nutrient dynamics and supporting the marine food web. Understanding the dynamics of plankton communities in this region is essential for assessing the overall health and productivity of British Columbia's marine ecosystems. Plankton contribute to biodiversity and are an important food source for various organisms, including fish, mammals, and marine birds. Changes in plankton populations can signal shifts in oceanographic conditions, nutrient availability, and climate, providing valuable information for long-term monitoring. The presence of the shallow bank in the path of the constant ebb and flow of tides at the entrance to Juan de Fuca condenses the stratified ocean environment that normally distributes in a water column of 200-300 m, and forces the biomass up and onto **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, creating a large pool of colder surface water and an area of high productivity (Burger 2003). The following subsections summarize what is currently known about the phytoplankton and zooplankton communities found within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

6.2.2.1 Phytoplankton

Phytoplankton are the basis of the marine food web. In addition to consuming carbon dioxide during photosynthesis and producing oxygen, phytoplankton provide a critical resource base, supporting marine life and maintaining the ecosystem's overall health. Phytoplankton in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and its surroundings have been generally well-studied, due to the presence of the Juan de Fuca Eddy. High concentrations of phytoplankton biomass and domoic acid (a toxin produced by some marine diatom species in the *Pseudo-nitzschia* genus) have been observed frequently in the area of the Eddy, particularly the margins (Trainer et al. 2002; Marchetti et al. 2004; see Figure 2 of Foreman et al. 2008; MacFadyen et al. 2008), leading to it often being referred to as a phytoplankton and toxicity “hot spot” (Trainer et al. 2009).

Phytoplankton biomass typically remains high in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area throughout the year (Sackmann et al. 2004; Sackmann and Perry 2006; DFO 2013b). Elevated phytoplankton biomass near the surface has been linked to multiple processes, including vertical mixing of nutrients into the euphotic zone (Mackas et al. 1980; Denman et al. 1981). MacFayden et al. (2008) showed large inputs of nutrients from the combination of California Undercurrent waters in the Juan de Fuca Eddy, and advection of water exiting the Juan de Fuca Strait, though outflowing Juan de Fuca waters were shown to be generally low in phytoplankton biomass while high in nutrients (Marchetti et al. 2004). The persistent supply of nutrients has

been attributed as a driving factor behind the toxic blooms observed originating in the Juan de Fuca Eddy (MacFadyen et al. 2008).

Further data describing the phytoplankton present in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank come from three sources: Chlorophyll-a (Chl-a) calculated from satellite remote sensing, Chl-a from water samples analyzed to retrieve concentration from pigment fluorescence or high-performance liquid chromatography (HPLC), and phytoplankton taxonomy from preserved water samples. Chl-a fluorescence acquired during vertical casts in the water column, available in the DFO Water Properties database, were not included here. The phytoplankton patterns associated with each data source and corresponding published works are described separately below.

6.2.2.1.1 Chlorophyll-a and satellite imagery

Remotely sensed Chlorophyll-a concentration (Chl-a), a parameter measured from optical satellite sensors, is a proxy for surface phytoplankton biomass used to monitor phytoplankton bloom phenology and events, and, in many models, to estimate primary productivity (Platt and Sathyendranath 1988). Remote sensing studies along the BC coast have provided moderate-resolution (300 m to 4 km per pixel) estimates of Chl-a. In northern BC waters, surface Chl-a is higher in north Hecate Strait and Dixon Entrance than on the west coast of Haida Gwaii and central Hecate Strait (Jackson et al. 2015). In southern BC, along the west coast of Vancouver Island and Juan de Fuca Strait, spring Chl-a peaks earlier than in the north, while the magnitude of the late summer bloom is higher than the spring bloom (Figure 7 of Jackson et al. 2015). The Strait of Georgia exhibits the highest Chl-a along the BC coast. Studies using satellite Chl-a have shown moderate to high surface biomass (> 1 to above 10 mg m^{-3}) from late April to September at the entrance to the Juan de Fuca Strait, with Chl-a generally much lower in the Strait itself (Jackson et al. 2015; Giannini et al. 2021; Marchese et al. 2022). Generally, Chl-a is also much higher on the Vancouver Island slope compared to the Washington slope further south (Sackmann et al. 2004).

Jackson et al. (2015) described phytoplankton bloom regimes along the BC coast, defined with satellite SST and Chl-a. There is an annual spring bloom typically beginning in March, with a stronger bloom again later in fall in the larger region surrounding the **ƛučii?aa?aq**/Swiftsure Bank Area. Updated satellite Chl-a weekly climatology (2003-2023 from MODISA) are presented in Figure 87, including statistics within the boundaries of the proposed **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Surface phytoplankton biomass typically peaks in late April during a spring bloom, with a slow decline as summer and autumn progress, and a slight increase in some years later in September (Figure 98A). There is a large variation in bloom magnitudes and timing among years, with spring bloom onset beginning in early April in some years, toward the end of May in others (Figure 98B). Most years reach a high concentration of phytoplankton biomass, exceeding 10 mg m^{-3} for a short period of time, though a few years in recent decades (2005, 2010 and 2012) remained consistently low in comparison (< 5 mg m^{-3}). On the other hand, 2015, 2018, and 2019 exceeded 15 mg m^{-3} during the spring bloom.

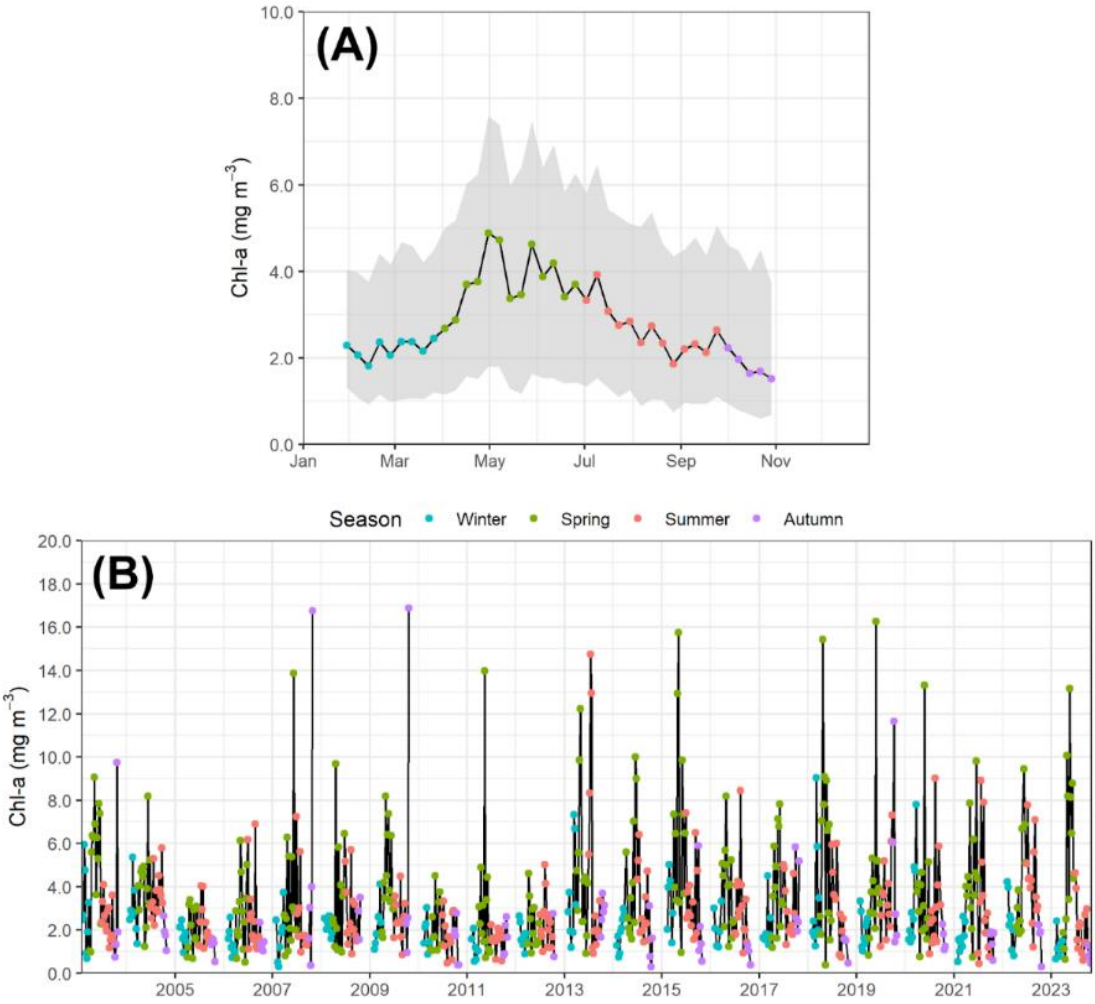


Figure 98. (A) Weekly geometric mean climatology (2003-2023) of MODISA Chl-a[70], with shaded 1 geometric standard deviation, and (B) weekly time series of Chl-a for the ***Ḵušiiʔaaʔaq****/Swiftsure Bank Area. Satellite data is at 1 km resolution and points are coloured by season. Geometric mean and standard deviation are used to account for the log-normal distribution of Chl-a. November, December and January were excluded due to the low sun angle preventing acquisition of sufficient quality data.*

As shown in monthly Chl-a climatology maps (Figure 99), areas of high phytoplankton biomass can be seen shifting gradually westward as the year progresses, leading to bloom timing differences depending on the spatial area that is summarized. The spatial surface patterns showed in the climatology agree with other studies; Edwards and Hickey (2005) showed strong Chl-a in the area of the Juan de Fuca Eddy in spring, but higher at the offshore edge later in spring and into summer. MacFayden et al. (2008) also showed elevated Chl-a on the western edge of the Juan de Fuca Eddy later in summer (September), with very little to none in the Eddy centre. Generally, biomass is observed to be higher on shelf compared to deeper, open-ocean waters (Harris et al. 2009).

[70] NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua Ocean Colour Data; NASA OB.DAAC, Greenbelt, MD, USA. doi: 10.5067/AQUA/MODIS/L2/OC/2022

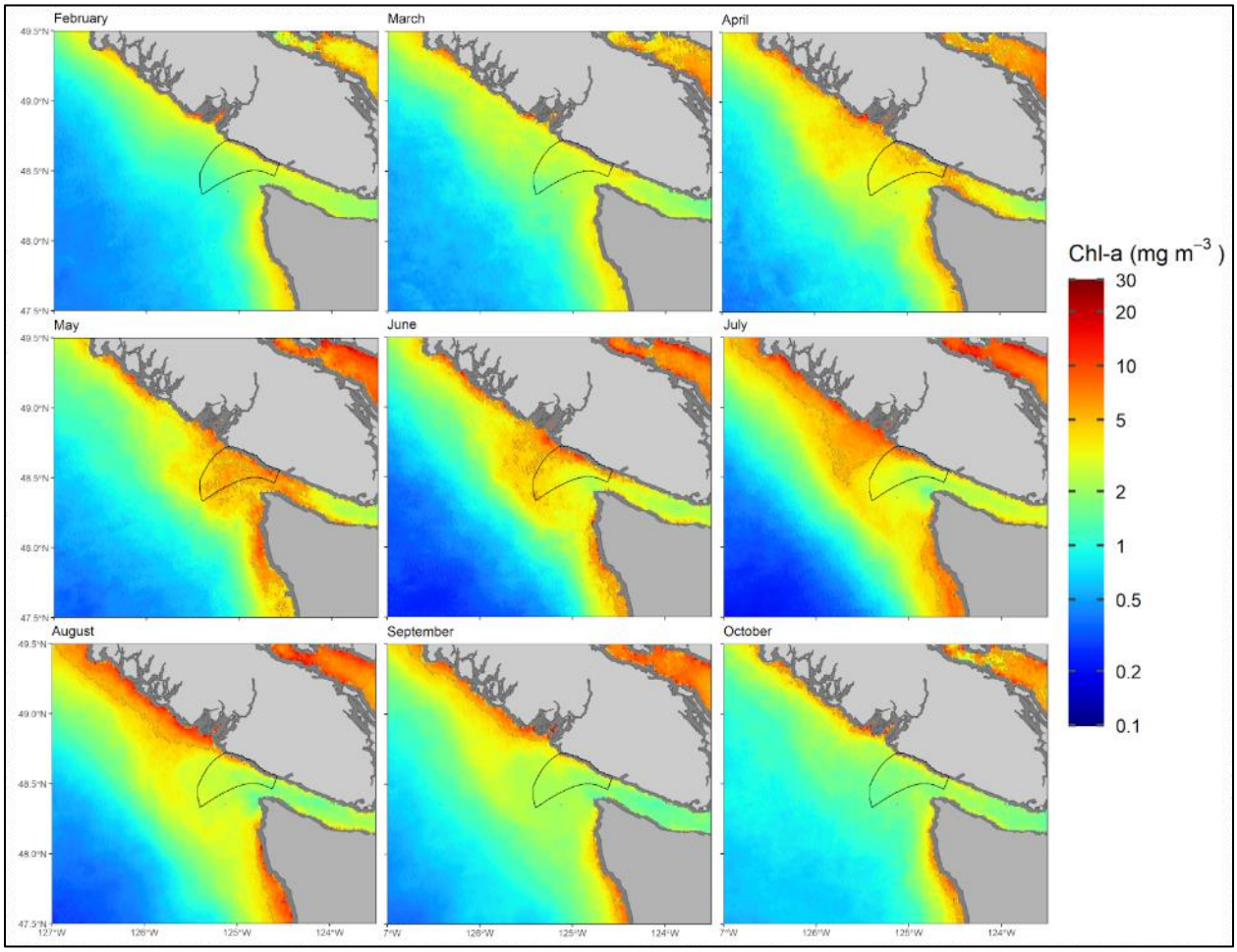


Figure 99. Monthly Chl-a composites (2003-2020) from MODISA, calculated from blue and green wavelengths using an empirical band-ratio method which has been validated in the Pacific region in prior studies with Chl-a from High-Performance Liquid Chromatography (HPLC; e.g., Carswell et al. 2017; Clay et al. 2019). January, November and December were removed due to the loss of data from low sun angle. The Juan de Fuca Eddy EBSA within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area is indicated with a black line, areas of "no data" with dark grey, and a 5 mg m^{-3} Chl-a contour in light grey.*

Exchanges of phytoplankton occur between the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and Nitinaht Lake. Previous work has found only marine and brackish phytoplankton species occur in Nitinaht Lake, which has a salinity similar to the ocean at depth, whereas the surface layer is shaped by precipitation and runoff from Nitinaht River (Northcote et al. 1964; Lamont 2005). Similarly, zooplankton observed in the lake were entirely marine species except near the inflow of the Nitinaht River on the northeast side of the lake. Satellite imagery emphasizes the exchanges between marine and lake waters with the **ƛ̓ušiiʔaaʔaq** Area, as coccolithophore blooms in the lake (which have a very bright spectral signature due to the presence of calcium carbonate plates) can be seen exiting into the **ƛ̓ušiiʔaaʔaq** Area during blooms; similarly, much warmer surface waters in summer are visible discharging into the **ƛ̓ušiiʔaaʔaq** Area (Figure 42 in Oceanography and Physical Setting).

6.2.2.1.2 Phytoplankton taxonomy

Descriptions of phytoplankton species near the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area often have a focus on harmful algae blooms (HABs), as the Juan de Fuca eddy is considered a "hot spot" for toxic species. Domoic acid (DA), produced by diatoms in the *Pseudo-nitzschia* genus, is a neurotoxin that causes Amnesic Shellfish Poisoning and can accumulate in shellfish and fish. As a result, these blooms pose threats to upper trophic levels including humans. Trainer et al. (2002, 2009) analyzed high DA concentrations sampled in the Juan de Fuca eddy in early summer of 1997, 1998, and in September 2004, corresponding to large blooms of *Pseudo-nitzschia* species (including *P. pseudodelicatissima, P. cuspidata, P. multiseries* and *P. australis*, which are associated with more toxic blooms, though over 10 species have been identified in this area). Transport of these HABs from the Juan de Fuca eddy is an ongoing area of research, considering the negative effects to shellfish-consuming species and the harvesting industry. In Trainer et al. (2002), DA sampling measured high concentrations within the Juan de Fuca eddy in summer 1998; weeks later, high counts of *Pseudo-nitzschia pseudodelicatissima* were measured along Washington beaches, followed by record-high DA toxin levels in Razor Clams, demonstrating spread of the plankton and toxin over large distances to coastal areas.

As discussed in oceanographic data reports and articles, observations of large phytoplankton blooms, though not always toxic, date back decades in this area (e.g., novel widespread "red tide" of *Gonyaulax spinifera* in August 1990, Ware and Thomson 1991). Detailed analysis by Harris et al. (2009) documented community composition shifts in the area corresponding to the strong ENSO events of 1997 into 1998 (see pages 162-163 of Harris 2001 for a full species list), with further HAB analysis during this time period in Trainer et al. (2002). The composition shift of Harris et al. (2009) showed higher abundances of upwelling-associated species in 1997, shifting to more toxic species in 1998. Specifically, they detailed *Prymnesiophyte* (in particular coccolithophore) and nanoplankton abundance in 1997, with higher abundance of diatoms (particularly *Pseudo-nitzschia spp.* and *Chaetoceros spp.*) in 1998 in comparison, followed by photosynthetic dinoflagellates later in the year. *Myrionecta rubra*, a ciliate species that is associated with blooms in upwelling regions, was observed in 1997. However, this species was not found in the samples described from the Pacific Marine Database[71] in other years.

Phytoplankton samples are collected at least 1-2 times per year in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area on regular DFO sampling cruises, from which a selection of stations in the Pacific Marine Database[19] (which provides species concentrations in cells/mL; see Taxonomic Diversity table (Appendix F) for full species list) are described below, in addition to currently published information. The samples are acquired typically much deeper in the water column (e.g., no shallower than 45 m depth) compared to the phytoplankton biomass estimates retrieved by ocean colour satellite. The majority of samples in the database were collected in April, May June, August and September, with very few collected during late autumn and winter.

A selection of DFO sampling stations near the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area are shown in Figure 100. Notably, the first station of the Line P program (station P1) is located to the west of the **ƛ̓ušiiʔaaʔaq** Area boundary, with further stations extending in a line to the northwest. The "LB" line, sampled on the La Perouse and West Coast Vancouver Island surveys, also transits the **ƛ̓ušiiʔaaʔaq** Area, with the first station (LB01) located near the coastline at the outlet of Tsusiat Lake, between the Klanawa River and Nitinaht Lake. Of this line, station LB02 is

[71] Pacific Marine Database for Phytoplankton at the Institute of Ocean Sciences, DFO.

sampled most frequently at an average depth of 54 metres. Other notable stations include stations 75 and 102, typically sampled during Strait of Georgia / Juan de Fuca, and Salish Sea Biophysical water properties surveys, station C2 (from the La Perouse cruise), and station VI04. Stations 102 and LB02 have the greatest number of phytoplankton taxonomy samples currently in the Pacific Marine Database[19].

Table 11 summarizes the samples included in this report with species observed in the Taxonomic Diversity Table (Appendix F). Coccolithophore cell counts, which are preserved differently than most of the samples used for phytoplankton taxonomy, are also available from 2004-2022. Coccolithophore samples from cruises corresponding to taxonomic analysis are indicated in Table 11.

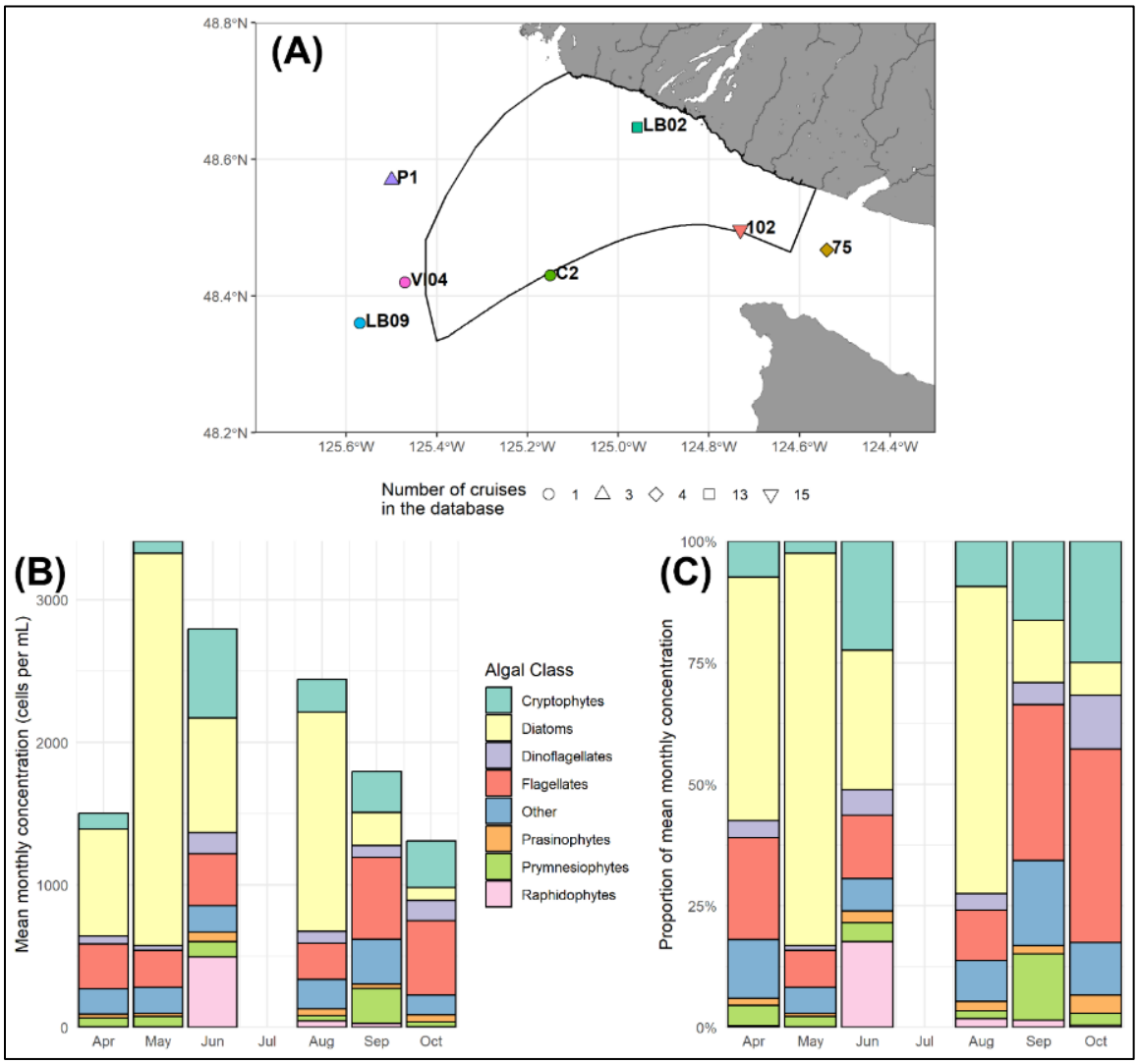


Figure 100. (A) Stations where phytoplankton data were summarized for this report, from the Pacific Marine Phytoplankton database at DFO[71]. The shape indicates number of individual cruises with data in the database since 2008. Mean (B) and relative (C) concentration by algal class at all stations from samples in Table 11, excluding February, July and November as they each have one sample in the database.

Most of the coccolithophore samples were from cruises during spring and summer (April to September), with the majority from station LB02. Notably high concentrations of coccolithophore species were captured at station LB02 in May, 2018 (198 cells/mL) and May 2022 (115 cells/mL), and summer events were captured in early September 2016 (761 cells/mL) and August, 2020 (122 cells/mL).

Table 11. Number of cruises with phytoplankton taxonomy in the Pacific Marine Phytoplankton database at DFO[71]. Bold and underlined indicates that corresponding coccolithophore counts are available. A star indicates only one of the cruises has coccolithophore data.

	2008	2011	2013	2015	2016	2017	2018	2019	2020	2021	2022
Feb								1			
April		**1**		1				1		1	1
May			1	**1**		**1**	**1**			**1**	**1**
June	**1**	**1**		1	1		1	**2***	**2***	1	1
July				1							
August						1		**1**	**1**		**1**
September						**1**	**3***			**1**	
October								1	1	1	
November							1				

Of the algal classes of the samples from stations in Figure 100, the highest number of observed species as well as concentrations were diatoms, with the majority being centric species. Centric diatom *Chaetoceros spp.* were often biologically dominant in the samples, as well as *Ditylum brightwellii.* The concentration of diatoms observed reached a peak annually in May, with a second peak in August. Flagellate phytoplankton had the second-highest concentrations, with heterotrophic (non-photosynthetic) species approximately twice as abundant relative to autotrophic (photosynthetic) flagellates. The concentration throughout the year was relatively consistent and highest in August. Cryptophyte species were third most abundant, particularly during June. Dinoflagellates had generally a low contribution to the concentration of cells observed, with highest proportion later in the year. Photosynthetic dinoflagellates had higher concentrations relative to non-photosynthetic species, similarly observed in Harris et al. (2009), where it was noted that non-photosynthetic dinoflagellates had a higher proportion off the shelf.

Years of note from the sample dataset and literature of the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area and surroundings include 2015, 2018, and 2021. In 2015, widespread *Pseudo-nitzschia* blooms along the west coast corresponded with anomalously warm SSTs (see McCabe et al. 2016). Widespread impacts along the Alaska, BC, and Washington coasts included recurring shellfish harvest closures and deaths of marine mammals and seabirds. *Pseudo-nitzschia spp.* were

similarly captured in DFO sampling, as well as high concentrations of diatoms *Skeletonema costatum/marinoi* in April (990 cells/mL) and *Chaetoceros debilis* in May (5400 cells/mL). Relatively high concentrations of Prymnesiophyte *Corymbellus aureus* (557 cells/mL), as well as *Phaeocystis cf. globosa* (286 cells/mL), which may form gigantic colonies and cause fish mortalities (see Schoemann et al. 2005), were also observed during June sampling.

A large bloom of *Heterosigma/chattonella* (2818 cells/mL), which may harm fish at high concentrations, was captured in June, 2018. The potentially harmful Dictyochophyte *Apedinella spinifera* (63 cells/mL) was also detected. This followed a particularly large spring bloom of *Chaetoceros socialis* (3068 cells/mL) sampled the previous month in May. *Phaeocystis cf. globosa* (953 cells/mL) was again observed at high concentration later in the summer during August.

Another studied event occurred in 2021 near the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, where a strong bloom was followed by a hypoxic event (Franco et al. 2023). Samples from the area consisted mainly of *Chaetoceros spp.* and non-photosynthetic choanoflagellates and flagellate species.

Finally, other notable harmful species were observed in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area through these sampling efforts; *Alexandrium spp.*, a toxic dinoflagellate that may cause Paralytic Shellfish Poisoning, was observed at concentrations > 25 cells/mL in 2018 and 2020. *Dinophysis acuminata*, another toxin-producing species that can cause Diarrhetic Shellfish Poisoning, was observed in 2015, 2018 and 2019, though at low cell counts (< 3 cells / mL). Red-tide forming *Heterosigma akashiwo* was also sampled during two cruises, in June 2011 (4 cells/mL) and August 2020 (83 cells/mL).

6.2.2.2 Zooplankton

DFO's Pacific Plankton Ecology program has routinely and continuously monitored zooplankton abundance, biomass, and composition along the west coast of Vancouver Island (WCVI) for several decades. The longest continuous WCVI zooplankton time series started in the La Perouse region (1979-present) of the southern shelf with survey stations within or immediately outside of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Figure 101). La Perouse monitoring currently takes place twice a year during late spring/early summer and late summer/early fall surveys. The timing of these surveys covers most of the annual zooplankton production cycle and brackets the annual upwelling period (Mackas 1992; Bertram et al. 2001). Additional sampling outside of this period is covered by other DFO oceanographic and fisheries monitoring in the region.

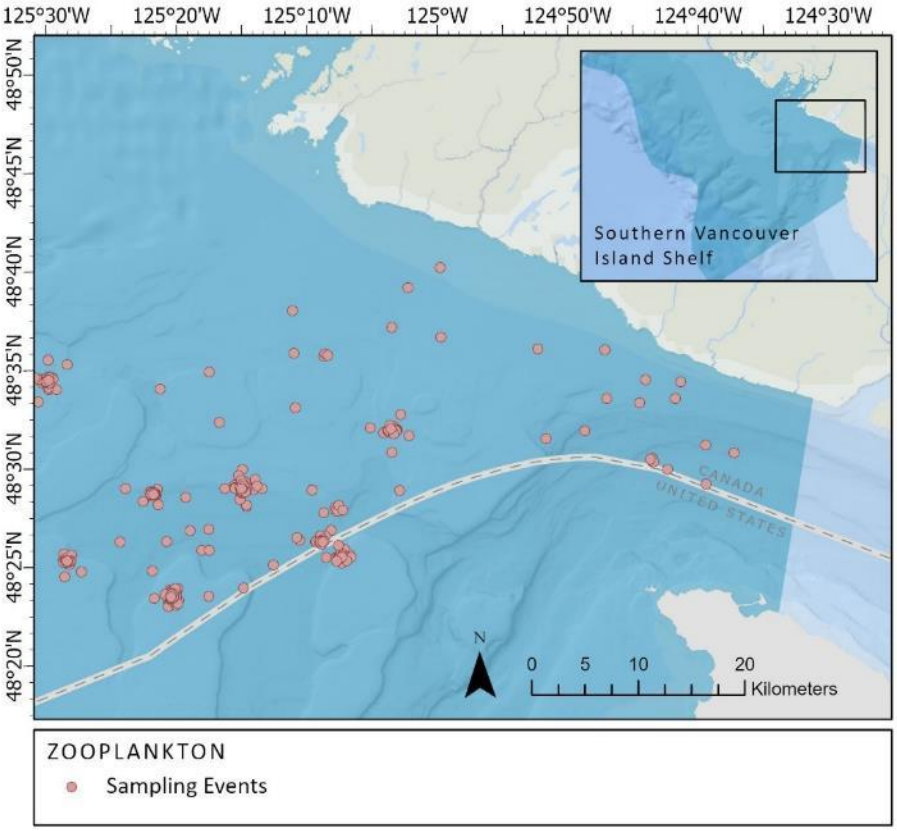


*Figure 101. Map of zooplankton sampling events (symbols; 1985-2022) within and in the vicinity of the Juan de Fuca Eddy EBSA (black line) in the **ʎušiiʔaaʔaq**/Swiftsure Bank Area. Inset places the Juan de Fuca Eddy EBSA (dashed line) in the broader context of the southern Vancouver Island (SVI) shelf/slope zooplankton bioregion (blue line) The SVI bioregion includes sampling events used to calculate annual biomass anomalies for zooplankton indicator groups. Data source: Plankton Ecology Program, Institute of Ocean Sciences, DFO.*

An archival database of sampling events and associated taxonomic enumeration for all zooplankton samples collected by DFO and contributing non-government survey programs within coastal BC is maintained by Plankton Ecology at the Institute of Ocean Sciences (IOS). A total of 710 events (1985-2022) were identified within and in the immediate vicinity of the **ʎušiiʔaaʔaq**/Swiftsure Bank Area (Figure 101). Figure 102 illustrates the sampling frequency of these selected events by both month and year. Sampling events retained for this analysis include all vertical or oblique plankton net (50-60 cm mouth diameter, 236-250 μm mesh) tows from 10 m above the bottom to the surface. A daytime correction factor was applied to late-stage juvenile and adult euphausiids (Mackas et al. 2013). Within-group biomass for **ʎušiiʔaaʔaq** was averaged within each survey and within seasons across years to construct a composite seasonal cycle without correcting for varying sampling effort (Figure 103).

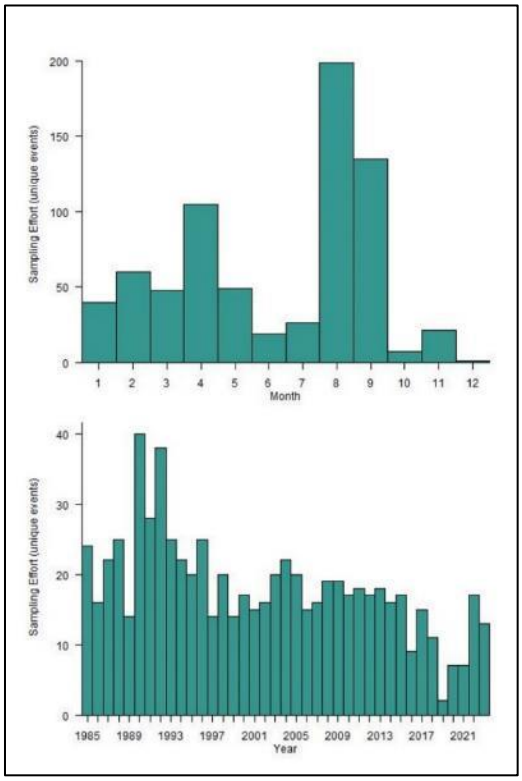


*Figure 102. Number of sampling events (mapped in **Figure 101**) within and in the vicinity of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area by month (upper plot); and year (1985-2022)(lower plot).Data source: Plankton Ecology Program, Institute of Ocean Sciences, DFO.*

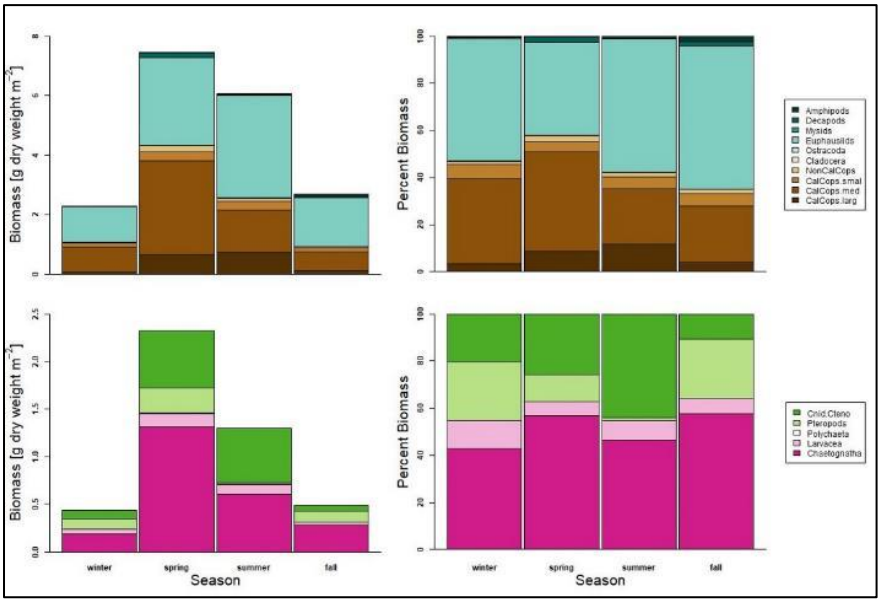


*Figure 103. Seasonally averaged biomass (g dry weight m^{-2}; upper left) and relative biomass (%, upper right) of major crustacean and non-crustacean (lower left and lower right) zooplankton groups sampled within and in the vicinity of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area 1985-2022. Data source: Plankton Ecology Program, Institute of Ocean Sciences, DFO.*

Overall, zooplankton biomass is dominated (43%; Figure 103) by euphausiids and followed by medium-sized calanoid copepods (26%; Figure 103) across all seasons. The mean seasonal biomass for total zooplankton is lowest in winter and fall (Figure 103), 2.7 and 3.2 g dry weight m^{-2}), respectively. On average, biomass in the fall is dominated by euphausiids (1.6 g dry weight m^{-2}), medium-sized calanoid copepods (0.6 g dry weight m-2), chaetognaths (0.3 g dry weight m^{-2}), and small calanoid copepods and pteropods (0.3 g dry weight m^{-2}) The winter (February and March) biomass of euphausiids (1.2 g dry weight m^{-2}) consists mostly of adults and is reduced relative to the fall (October) and medium calanoid copepod biomass is also relatively high (30%). The mean annual biomass maximum (9.8 g dry weight m^{-2}) in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area occurs in the spring (April, May and June) and is dominated (62%) by crustacean zooplankton important in the diets of forage fish and early marine juvenile salmon; medium-sized calanoid copepods and euphausiids (Tanasichuk et al. 1991; Robinson 2000; Hertz et al. 2015). Soft-bodied zooplankton groups, chaetognaths, pteropods, cnidarians and ctenophores are also seasonally important making up a further 22% of the total zooplankton biomass. Large calanoid copepods are more biomass-dominant over the deep outer WCVI shelf and slope (Mackas et al. 2001). The biomass of large copepods within the relatively shallow **ƛ̓ušiiʔaaʔaq** reaches its seasonal maximum during the spring and summer (0.6 and 0.7 g dry weight m^{-2}) but only contributes ~8% of the total biomass during both seasons.

The seasonal cycle of euphausiid production, species-specific spatial patterns, and aggregation behaviour in Barkley Sound and nearby inner shelf (close proximity to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area) and outer shelf/shelf break area was reviewed and studied in detail by Tanasichuk (2002) and Mackas et al. (1997). Both *Euphausia pacifica* and *Thysannoessa spinifera* tend to dominate abundance in these studies and the DFO data set discussed here. Euphausiids are second to medium-sized calanoid copepods in terms of relative biomass during the spring, representing 30% of the total biomass. Whereas, euphausiids dominate total biomass during summer, fall, and winter representing, 47, 51, and 43% of the total zooplankton biomass, respectively. Winter biomass is relatively low (1.2 g dry weight m^{-2}), consisting mostly of adults from the previous season with some production of eggs/early larvae. Most of the spring biomass (2.9 g dry weight m^{-2}) is split among eggs, developing larval and juvenile stages. By summer most of the biomass (3.1 g dry weight m^{-2}) is dominated by developing juveniles and early adults. The biomass of medium calanoid copepods is second to euphausiids in the winter (0.82 mg dry weight m^{-2}), summer (1.4 g dry weight m^{-2}) and fall (0.6 g dry weight m^{-2}). The calanoid copepods *Calanus marshallae* and *Pseudocalanus* spp., dominate the annual biomass and production of this group during the spring and summer, especially during climate-normal or cool years. The biomass of chaetognaths follows euphausiids and medium calanoid copepods for all seasons. Other soft-bodied zooplankton groups, pteropods, ctenophores and cnidarians represent a combined 5.7 to 10% of the total zooplankton biomass across seasons.

Groupings of zooplankton based primarily on shared geographic affinity have been used as climate-ocean-food web indicators along Canada's outer west coast (Mackas et al. 2004). The biomass anomalies for these groupings are presented for the broader region (Figure 101 inset) which includes the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and is defined by similarity of zooplankton community composition and bathymetry (see Mackas et al. 2004). Galbraith and Young (2021) provide a detailed accounting of species composition within indicator groupings and how annual biomass anomalies are calculated. Briefly, biomass averages are first calculated on a seasonal basis by averaging within survey and then within season. Season-specific biomass for each year is then referenced against a long-term seasonal average (1990-2019) to estimate seasonal biomass anomalies. These seasonal anomalies are then averaged within a year to estimate the

annual biomass anomaly. The biomass anomaly time series represented in Figure 104 are log_{10} scale with values of 1 equivalent to a 10-fold greater biomass than the climatological average. Similarly, a value of -1 represents 1/10th of the climatological average. Biomass anomaly time series for three groupings: boreal copepods, indicative of 'cool' conditions; southern copepods, indicative of 'warm' conditions; and northern euphausiids (dominated by *E. pacifica* and *T. spinifera* within the **ƛušiiʔaaʔaq** Area) are presented in Figure 104. Annual sea surface temperature anomalies for the Amphitrite Lighthouse long-term time series are also (https://open.canada.ca/data/en/dataset/719955f2-bf8e-44f7-bc26-6bd623e82884) are also included as an environmental reference.

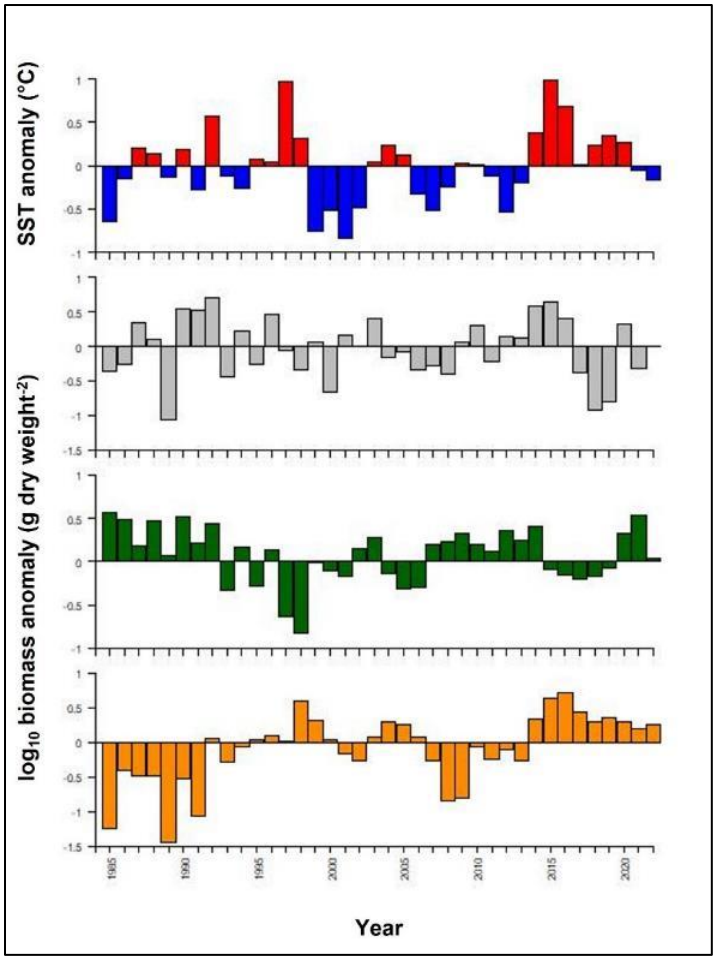


Figure 104. Annual anomalies of: a) Sea surface temperature measured at Amphitrite Lighthouse[72]; b) log_{10} biomass of northern euphausiids (grey;primarily E. pacifica and T. spinifera); c) log_{10} biomass of boreal copepods; and d) log_{10} biomass of copepods with southern geographic affinity. The climatology period for each time series is 1990-2019. Data source for b), c) and d): Plankton Ecology Program, Institute of Ocean Sciences, DFO.

The biomass anomaly time series for boreal and southern copepod groups are characterized by moderate (negative) and strong (positive) correlation with the SST anomaly time series (which is itself correlated with the Pacific Decadal Oscillation index). These two groups vary in phase but

[72] https://open.canada.ca/data/en/dataset/719955f2-bf8e-44f7-bc26-6bd623e82884

with opposite sign and include species common to the medium calanoid copepod grouping (Figure 103). Positive annual euphausiid biomass anomalies tend to be associated with warm SST anomalies, but not in a predictive manner. All groups are present on the southern Vancouver Island shelf and present across all sampled years in the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area. Boreal copepod biomass anomalies during the 1985-1996 time period are mostly positive and vary with local SST anomalies. Southern copepods also reflect the pattern during this mostly 'cool' phase with mostly negative biomass anomalies. The 1997-1998 El Nino event was reflected in a strong positive and negative response by southern and boreal copepods, respectively. The return to cool conditions in 1999 is notable for the large positive shift of boreal copepod biomass. More recently, the large 2014-2015 marine heatwave (Bond et al. 2015) exerted a strong influence on marine food webs along much of the North American coast. Superimposed upon and immediately following this event was a strong El Nino extending into 2016. This period is characterized by strong negative/positive biomass anomalies for boreal/southern copepod and positive biomass anomalies for euphausiids. This temporal pattern of copepod biomass anomalies continued through another marine heatwave in 2019 and into late 2021 with the transition to cool La Nina conditions. Note, however, that the biomass anomalies for southern copepods have declined since the transition to cooler conditions but remain positive.

6.2.2.3 Sensitivities and Recoverability

Plankton populations in BC, like in other regions, are sensitive to a range of anthropogenic stressors. Freshwater-associated bulk turbidity, a common result of human activities, can negatively impact the plankton ecosystem, leading to delayed spring blooms and decreased production rates (e.g., Le Fouest et al. 2010). Similarly, eutrophication and climatic change, often driven by human activities, can disturb pelagic communities, including plankton (e.g., Tett 1992). UVB radiation, which can be exacerbated by the erosion of the stratospheric ozone layer due to human activities, can also significantly affect plankton community production (Regaudie-de-Gioux et al. 2014). Studies on the impact of ultraviolet radiation (UV) on marine organisms have mostly focused on plankton in marine ecosystems, showing that increased levels of UV affect photosynthetic activity, growth, and metabolic rates, impair nitrogen assimilation, inhibit the motility and orientation of freely motile organisms, and bleach photopigments (El-Sayed et al. 1996).

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

Fish predation also affects plankton populations. A modeling study off La Perouse Bank on the West Coast of Vancouver Island highlighted how zooplankton production (specifically euphausiids) can be influenced by the migratory characteristics of pelagic fishes such as Pacific Hake. They found a combination of high adult euphausiid growth and oceanographic mechanisms that import and accumulate euphausiids in the Juan de Fuca Eddy region is needed to satisfy the relatively high upper trophic level demand for euphausiids. Furthermore, the high production potential of plankton is a major reason why the continental shelf off southern Vancouver Island has been the most productive fishing region along the west coast of Canada (Robinson and Ware 1994).

Furthermore, ocean warming influences vertical mixing and stratification patterns, altering nutrient cycles, plankton production, and aquatic food webs. Climate warming can lead to fluctuations in plankton production and changes to community composition. Zooplankton play a crucial role in aquatic food webs and global biogeochemical cycles, serving as food sources for economically valuable fishes and driving carbon and nutrient cycles. Changes in temperature can influence zooplankton productivity, with higher temperatures potentially leading to increased productivity. Moreover, ocean acidification, driven by increased carbon dioxide absorption, poses additional challenges to marine ecosystems, particularly affecting calcifying organisms such as corals, mollusks, and some plankton species. Species composition of phytoplankton and pteropods abundance may also shift as a result of ocean acidification, affecting the food web and impacting species dependent on them as a food source (e.g. Pink Salmon, rockfish, and flatfish) (Haigh et al. 2015). The alteration of ocean chemistry can disrupt shell formation in marine organisms, affecting their growth, survival, and overall ecological function. Additionally, changes in pH levels may impact the behavior, physiology, and distribution of marine species, potentially leading to shifts in community structure and species composition. Consequently, the combined effects of ocean warming and acidification exacerbate the vulnerabilities of marine ecosystems. Continuous monitoring of plankton populations through surveillance programs is essential to understand future changes in marine ecosystems and serve as ecological indicators of climate change impacts (Azani et al. 2021).

6.2.2.4 Data and knowledge gaps

The satellite Chl-a data described in this report represent surface waters, so features including deep chlorophyll maxima are missed. Further, optically complex waters and atmospheric correction difficulties when processing satellite data add uncertainties (Mélin et al. 2007). This area has low temporal coverage of satellite data compared to other coastal areas of BC, so further work examining the available in-water measurements is needed. Existing CTD fluorescence data in the DFO database should be summarized to assist with defining phytoplankton seasonality throughout the water column. Opportunities for further monitoring in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area using remote sensing lie in incorporating other sources of satellite data. For example, the Sentinel-3 satellites (350 m resolution) and Sentinel-2 satellites (10 m resolution) offer higher spatial resolution that can distinguish smaller-scale spatial features and blooms (e.g., Detoni et al. 2023), with the OLCI instrument on Sentinel-3 having more spectral bands for identifying phytoplankton groups. Further, while the instrument on Sentinel-2 has fewer spectral bands, it has an additional red band that can help monitor Harmful Algae Blooms (Rodríguez-Benito et al. 2020; Gernez et al. 2023; Detoni et al. 2023).

While more phytoplankton and zooplankton sample data exist in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area relative to more remote areas of the BC coast, regular sampling throughout the year (e.g., quarterly) at consistent depths in the water column is needed in order to monitor changes to the seasonal cycles of species composition.

Continued phytoplankton taxonomy sampling at station 102 and LB02 is very valuable, as these stations have regular or semi-regular phytoplankton sampling, now in the Pacific Marine Phytoplankton database kept at IOS[19], dating back over a decade, though with a distinct under-sampling during winter. Similarly, collecting data for taxonomy and Chl-a at multiple depths could be a valuable addition for examining species distribution in the water column. There are also a number of opportunities to increase phytoplankton sampling during existing oceanographic cruises. For example, phytoplankton samples along Line P are typically collected at stations P4 and P26; Station P1 could be included in the future as it is located very close to

the Juan de Fuca Eddy EBSA boundary. Regular sampling in this area may further assist programs for monitoring harmful algae species, given the blooms observed in this area.

As above, the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and vicinity are well represented in the archived IOS zooplankton database. Sampling has occurred with seasonal sampling throughout the time series. However, the frequency of sampling during winter and fall has dropped during the last twenty years (Figure 100, Figure 101). A new March survey has been added to the La Perouse monitoring program (starting in 2025) in order to balance annual sampling effort. Positive annual biomass anomalies for southern copepods have persisted since the start of recurring marine heatwaves beginning in 2014. This particular grouping includes species indicative of southern and offshore origin. Current time series analysis is exploring compositional shifts within historical groupings and the possibility that some species are now less transitory and more resident along the southern Vancouver Island shelf. Data regarding copepod distribution in nearshore habitats is also limited, but provides critical food resource for Pacific Sand Lance (*Ammodytes hexapterus*), and other forage fish in the area, with strong ecological linkages to marine bird and mammal populations. Additional plankton sampling in nearshore areas of the west coast of Vancouver Island is needed to better understand the food chain dynamics in these ecosystems.

6.2.3 Invertebrates

Invertebrates are prolific and abundant organisms found in every marine ecosystem. Broad groups of marine invertebrates relevant to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area are separated by taxonomic grouping and described in the following sections: Corals and Sponges, Molluscs, Crustaceans, and Echinoderms. Of the invertebrate species listed in this section, two have been identified as species contributing to the biological significance of the Juan de Fuca Eddy EBSA (Shrimp: *Pandalopsis dispar, Pandalus Jordani*; Table 8) (Jamieson and Levesque 2014).

Data sources

The occurrence records used in the subsequent invertebrate sections have been extracted from several sources: DFO Hard Bottom Longline Research Survey (2006-2021), DFO Groundfish Synoptic Bottom Trawl Survey (WCVI; 2005-2021), DFO Small Mesh Multispecies Bottom Trawl Survey, DFO Integrated Pelagic Ecosystem Survey (King et al. 2019), International Pacific Halibut Commission (IPHC) Fishery Independent Setline Survey, Commercial Shellfish Harvest Fishery Logs (1990-2023), the Global Biodiversity Information Facility (GBIF), and iNaturalist open databases, personal communications, and local knowledge. Occurrences of species from DFO surveys and Commercial Harvest fishery logs are shown as 1 km by 1 km grids and are pulled from multiple survey datasets unless specified differently. Because species occurrences were collated from multiple databases with different protocols, target species, and survey methods, survey areas where there were no detections are currently not shown in the gridded figures. All of the datasets were overlaid with the Juan de Fuca Eddy EBSA polygon to generate summaries of the species observed within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

Data from the following DFO surveys were also investigated as potential data sources but found to not overlap with the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, as represented by the Juan de Fuca Eddy EBSA polygon: DFO Shellfish Research Surveys (sea urchin, sea cucumber, geoduck and multispecies dive surveys), Benthic Habitat Mapping dive surveys, and other DFO groundfish and pelagic research surveys (e.g., the Joint Canada/US Hake Acoustic Survey, Sablefish Research and Assessment Trap Survey, Prawn Trap Survey, etc.). In addition to occurrence

data, available species distribution models (SDMs) were used to map the predicted distributions of Geoduck, Green Sea Urchin, Red Sea Urchin, Purple Sea Urchin, Giant Red Sea Cucumber (Park et al. 2023), and Dungeness Crab (Nephin et al. 2023) in the **ƛ̓ušiiʔaaʔaq** Area. All SDMs except the Dungeness Crab model cover nearshore areas only and do not extend beyond 25 m depth.

6.2.3.1 Cold water corals and sponges

Cold-water corals (Phylum Cnidaria, Class Anthozoa) and sponges (Phylum Porifera) are sessile long-living invertebrates that are found throughout the Northeast Pacific that can form reef communities or aggregating groups (also called “gardens”). These animals provide complex three-dimensional biogenic habitats for many species and provide ecosystem services such as nutrient and water column transport and cycling, boosting primary productivity and facilitating key life stages of many species (Henry and Roberts 2007; Cathalot et al. 2015; Rix et al. 2016). Therefore, areas with an abundance of coral and sponge habitats are often linked to high invertebrate and demersal fish biodiversity (Marliave et al. 2009; Chu and Leys 2010). For example, sea pens (order Pennatulacea) provide nursery habitats for rockfish larvae (Baillon 2012), and stony corals (order Scleractinia) provide spawning habitats for juvenile sharks (Henry et al. 2013). This includes coral structures that provide habitats to a plethora of benthic invertebrate species (Henry and Roberts 2007). BC is home to over 80 species of cold-water corals and over 250 species of sponges (Gardner 2009). Many corals and sponges distributed throughout the Northeast Pacific are typically found in depths on the continental slope characterized by areas of severely low dissolved oxygen levels (Chu et al. 2019). However, many species can also be found in shallow and intertidal zones (ICES 2009).

Cold-water coral and sponge communities have been identified as vulnerable marine ecosystems (VMEs) by the Fisheries and Agriculture Organization of the United Nations due to their vulnerability to adverse impacts from fishing activities and habitat disturbances (FAO 2009). With this knowledge, Chu et al. (2019) created a VME composite map for the Pacific Northwest using 30 environmental data layers indicating habitat suitability and potential distribution of the six habitat-forming sponge and coral groups. A vulnerable composite index (VCI) value of 6 indicates cells with suitable habitats for all cold-water sponge and coral groups used in the analysis (Figure 105). Coral and sponge group observations throughout BC were compiled[73] from DFO and external databases through different survey methods and gear types, including dive, ROV, traps, longline, and bottom trawls (Figure 105B).

The VME composite map shows moderate to high habitat suitability (VCI values of 3-5) for cold-water coral and sponge groups in a small region at the entrance to Juan de Fuca Strait (Figure 105A**)** and moderate to low suitability (VCI score of 1-2) throughout the rest of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. These moderate and low suitability values indicate that the area is suitable for a limited number of species groups. Occurrences of sea pens (Order Pennatulacea) are fairly widespread in these areas (85 occurrences within the **ƛ̓ušiiʔaaʔaq** Area), suggesting that the area is comprised of the soft-sediment habitats required by this species group (Lamb and Hanby 2005). Aside from sea pens (Figure 105C), occurrences of corals and sponges are fairly sparse within **ƛ̓ušiiʔaaʔaq** (Figure 105B). There were 2 occurrences of stony corals (Order Scleractinia), 7 occurrences of glass sponges (Class Hexactinellida) and 4 occurrences of demosponges (Class Demospongiae).

[73] https://gitlab.com/dfo-msea/corals-sponges-dataset

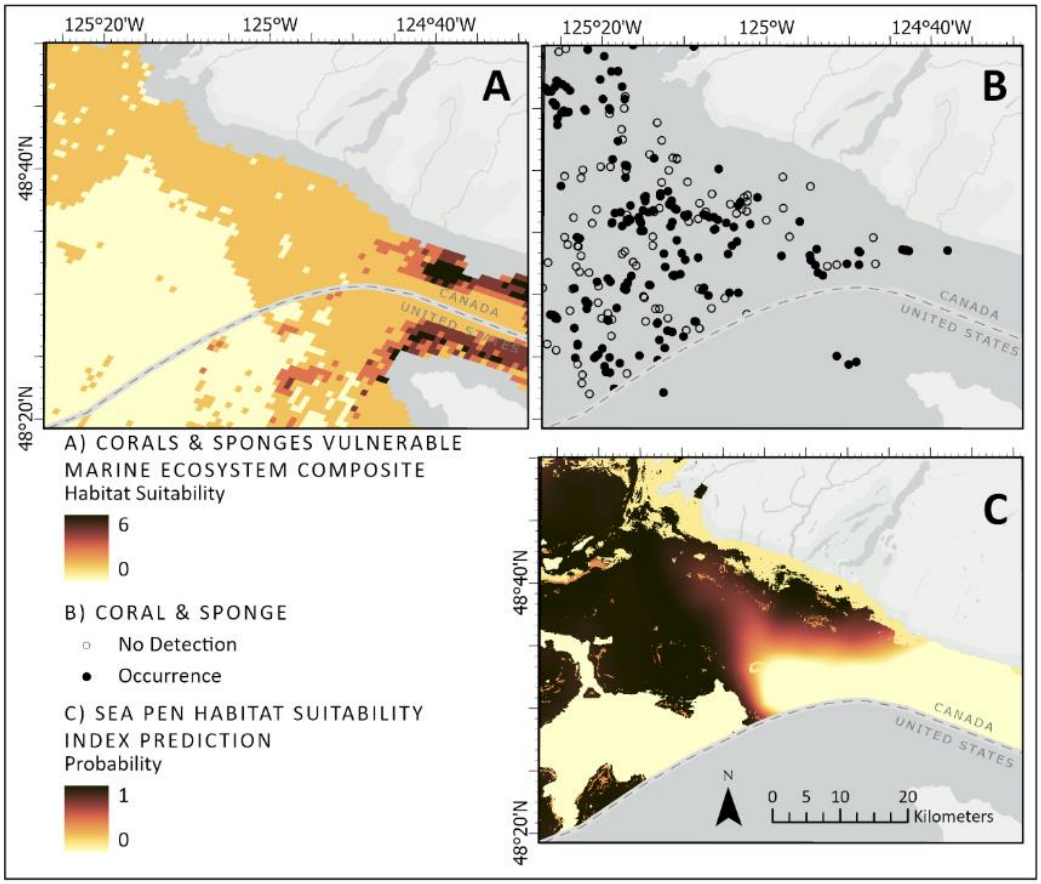


Figure 105. A) Vulnerable Marine Ecosystem (VME) composite index of habitat suitability for cold-water coral and sponge groups, from Chu et al. (2019). Values range from 0 to 6, indicating the number of cold-water coral/sponge groups for which each raster is a suitable habitat; i.e., 6 is suitable for all coral and sponge groups, and 0 is no suitable habitat. B) Sponge and coral occurrence in the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area. Black dots indicate point occurrences, although this figure does not differentiate between groups. Data source: Presence/Absence Observations of Coral and Sponge Groups*[74] *C) Predictions of Orange Sea Pen distribution from the Sea Pen Habitat Suitability Index Prediction Model (Nephin et al. 2020).*

However, imagery, and limited collections, gathered on the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area in a 2022 survey (2022002PGC, see Cold Seeps EBSAs) did confirm the presence of sponge and coral. At Dive OY086 and camera station 054/055 (see Figure 106 for selection), lots of small encrusting sponges (Porifera), finger-like demosponges (Demospongiae), Velvety Red Sponge (*Ophlitaspongia pennata*), Plate Sponge (*Poecillastra tenuilaminaris)*, *Polymastia* sp., Moon Sponge (*Latrunculia* cf. a*ustini)*, *Auletta* sp., boot sponges (Rossellidae), and Cloud Sponge (*Aphrocallistes vastus*) were found. In the Cnidaria, hydroids (Hydrozoa), many small anemones (Actiniaria), Crimson Anemone (*Cribrinopsis fernaldi*), Orange Seapen (*Ptilosarcus gurneyi),* cup corals (Scleractinia), and lots of Red Gorgonian (*Swiftia sp.)* were observed. At Station 056 there were also a few sea whips that were not identifiable to species.

[74] https://gitlab.com/dfo-msea/corals-sponges-dataset

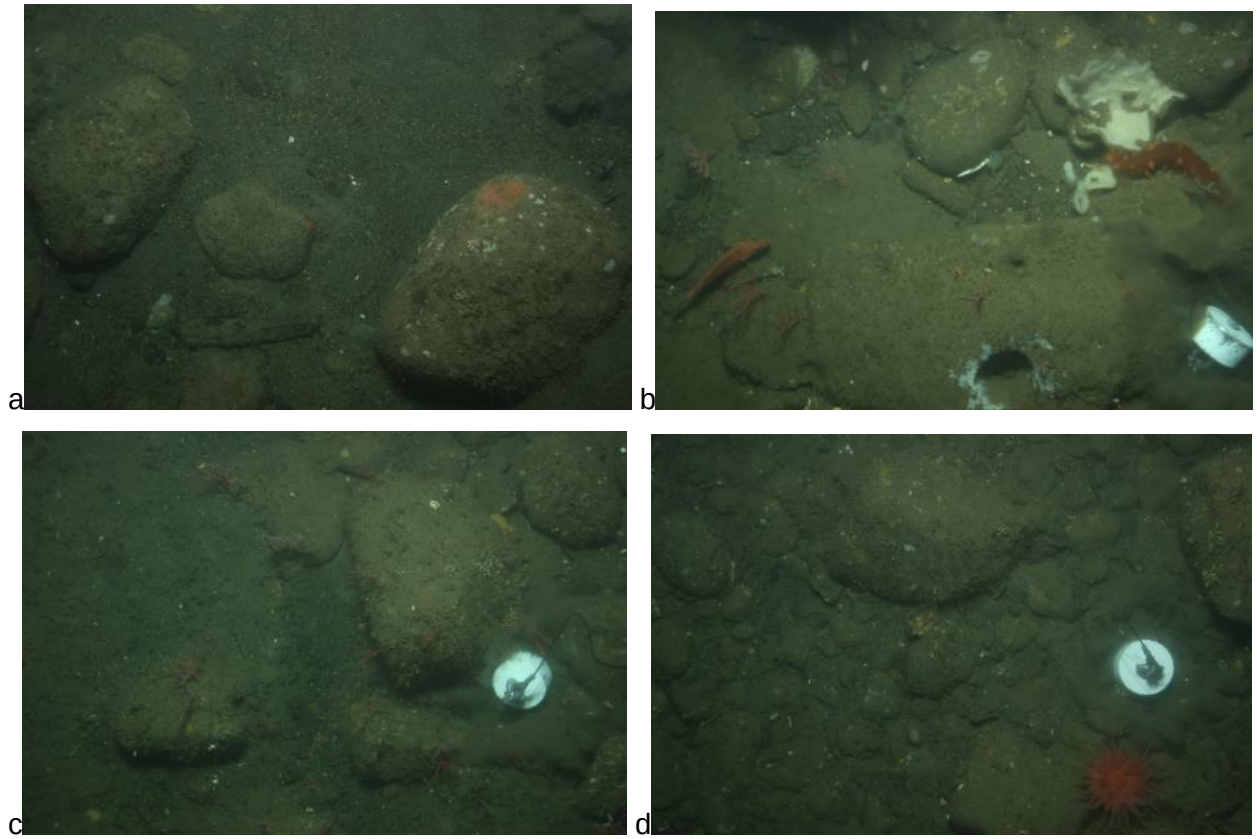


Figure 106. Imagery of benthic diversity (including sponge and corals) collected during 2022002PGC survey of ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank from Station 55/54* ***a)*** *Velvety Red Sponge (Ophlitaspongia pennata) encrusting boulder* ***b)*** *Yelloweye Rockfish (Sebastes ruberrimus), Red Gorgonian (Swiftia spp.), encrusting sponges (Porifera), serupulid worms (Serpulidae), Leopard Dorid (Diaulula sandiegensis), Cloud Sponge (Aphrocallistes vastus), Plate Sponge (Poecillastra tenuilaminaris), Giant Red Cucumber (Apostichopus californicus)* ***c)*** *lots of small Red Gorgonian (Swiftia sp.) and bryozoans* ***d)*** *Crimson Anemone (Cribrinopsis fernaldi) and encrusting fauna including hydroids and little orange cup corals (Scleractinia).*

6.2.3.2 Infauna and epibenthic bivalves

Class Bivalvia (hereafter bivalves) are a group of freshwater and marine molluscs that have their bodies encased in two hinged shells. Infauna species such as clams and cockles spend most of their lives buried in benthic substrates such as sand and mud. Epibenthic species, such as scallops, mussels, and oysters, instead settle on top of hard benthic substrates. These species provide important roles in the coastal ecosystem, such as benthic-pelagic coupling, nutrient cycling, and water filtration. Bivalves can accumulate and retain biotoxins from algal blooms through filter feeding, which can cause harmful effects to humans and animals when consumed during these events. Certain epibenthic bivalves, such as mussels and oysters, aggregate and form hard, complex biogenic habitats that can influence species abundance and diversity in intertidal and subtidal environments (Commito et al. 2008; Richardson et al. 2022). Spawning bivalves typically release gametes into the water column, and pelagic larvae will settle and become sedentary. Clams and cockles settle on soft sediment substrates, whereas mussels, oysters, and scallops can form beds or aggregations on rocky and/or mixed substrates. Bivalves are found in the diet of many macrofauna, including marine birds (Cox et al. 2020), Sea Otters (Ford 2014), Giant Pacific Octopus (Enteroctopus dofleini) (Scheel and Anderson 2012), Dover and Rock Soles (Buckley et al. 1999), and Dungeness Crabs (Behrens Yamada and G. Boulding 1998). Bivalves and their marine-derived nutrients were found to subsidize terrestrial environments after being transported on land by predators and people (Trant et al. 2016; Cox et al. 2020), and bears, raccoons, and mink are known predators of intertidal invertebrate prey (Suraci et al. 2017). Commercial, recreational, and First Nations fisheries exist for both infauna and epibenthic bivalves. Harvest for the Butter Clam (Saxidomus gigantea), Littleneck Clam (Leukoma staminea), and Cockle (Clinocardium nuttalli) is conducted by hand digging during low tide cycles. The Pink Scallop (Chlamys rubida) and Spiny Scallop (Chlamys hastata) are generally harvested using commercial trawl gear in Southern BC and are otherwise harvested by hand picking and diving (DFO 2023b). The only bivalve species that occur in the DFO research and fisheries log data for the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank are scallops (spiny and pink scallop (Chalmys spp.) and Weathervane Scallop (Patinopecten caurinus)) (*

Figure 107A). Geoduck occurrence probability is predicted to be high in subtidal areas near the Nitinaht River estuary, and moderate throughout the nearshore area in the ***ƛ̓ušiiʔaaʔaq*** *Area (*

Figure 107B; Park et al. (2023)). Records from GBIF indicate that several bivalve species, including California mussel (*Mytilus californianus*), clams from the *Pandora* and *Macoma* genera, and other small clam species (refer to Appendix F for full species list) utilize the **ƛ̓ušiiʔaaʔaq** Area. Razor Clam (*Siliqua patula*) records from GBIF and iNaturalist indicate presence in Pachena Bay and Port Renfrew, although it is likely that these species utilize other soft sediment areas in the region. Imagery gathered on **ƛ̓ušiiʔaaʔaq** during a 2022 survey (2022002PGC, see Cold Seeps EBSAs) did confirm the presence of a few bivalves with Dive OY086 and camera station 054/055 (Figure 84) showing lots of shellhash, some empty intact shells, False Jingleshell (*Pododesmus macrochisma*), Swimming Scallops (*Chlamys* sp.), and Rock Scallop (*Crassodoma gigantea*). However, the limited number of infauna and epifauna bivalve records highlights the need for additional surveys (e.g., dive and intertidal surveys) in the **ƛ̓ušiiʔaaʔaq** to understand the extent to which these species utilize the area.

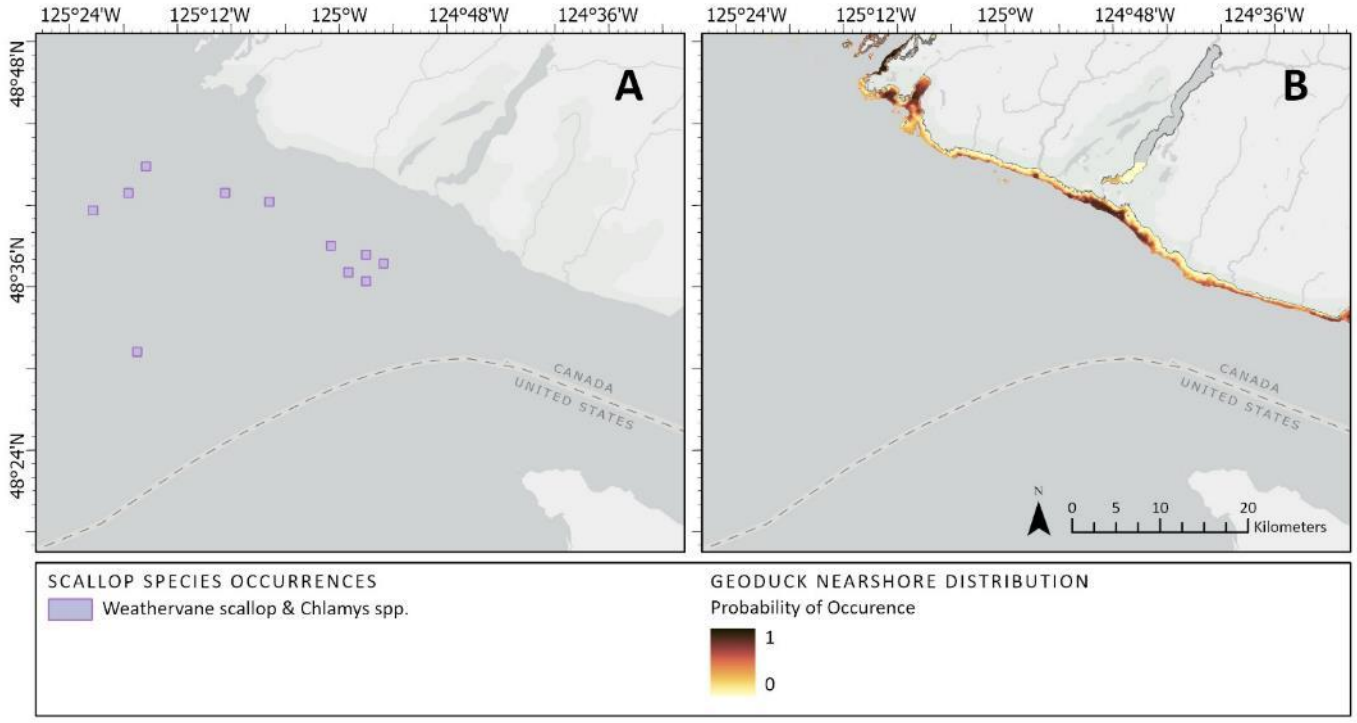


Figure 107. A) Occurrences of scallop (Chalmys spp (spiny and pink scallop) and Weathervane scallop) within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area represented by 1 km x 1 km grids. Occurrence data are from DFO Research and Commercial Shellfish Harvest Fishery Logs (1990-2023). B) Probability of occurrence of Geoducks from the Nearshore Distribution Model (Park et al. 2023).*

6.2.3.3 Marine snails, sea slugs and chitons

Marine snails (Class Gastropoda) and chitons (Class Polyplacophora) have a variety of feeding behaviours. However, many species are foragers and grazers, such as the Red Turban Snail (*Pomaulax gibberosus*), which feeds and seeks shelter on Giant Kelp (Harbo 2011). Many species of snails will graze on green algae, coralline algae, encrusting sponges, and a variety of kelps (O'Clair and O'Clair 1998; Pellegrin et al. 2007; Harbo 2011). The Lewis' Moonsnail (*Neverita lewisii*), on the other hand, mainly predates on infaunal bivalves, such as Butter, Littleneck, and Pacific Gaper clams (Harbo 2011). In turn, marine snails and chitons are predated upon by a variety of other invertebrates such as urchins, sea stars, octopus, and vertebrates such as marine birds (O'Clair and O'Clair 1998), rockfish (Love et al. 2002), and Sea Otters (Pauly et al. 1998; Ford 2014). As benthic slow-moving creatures, most snails and chitons prefer rocky and hard substrates, with semi-exposed coastlines. The Lewis' Moonsnail is often found in areas of finer substrates such as mud or sand (Harbo 2011).

Northern Abalone (*Haliotis kamtschatkana*) is an ecologically and culturally important and highly vulnerable species (COSEWIC 2009a). Currently there is no DFO occurrence data for Northern Abalone in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank area. Nearby Barkley Sound has been identified as one of the four critical habitats for survival and recovery efforts (DFO 2012a). Diet preferences for adult Northern Abalone include Bull Kelp and Giant Kelp as well as diatoms, algae, and kelps (Sloan and Breen 1988; Neuman et al. 2018). Population genetics of Northern Abalone

using microsatellites indicated low regional differentiation throughout 16 coastal BC populations (including those in Barkley and Clayoquot Sounds) but higher variation within samples from all populations (Withler et al. 2001). Northern Abalone in BC likely had unimpeded gene flow and dispersal in historical populations and low inbreeding, representing one significant evolutionary unit (Withler et al. 2001). Spawning occurs more often at night and during the spring and summer (Sloan and Breen 1988). Northern Abalone densities and average shell lengths have decreased considerably from 1978 to 2007 (DFO 2008).

Limited DFO occurrence data for marine snail and chiton species data are available for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Figure 108 shows the locations of Moonsnail occurrences from DFO surveys. Observations from the GBIF database show the presence of Giant Gumboot Chiton (*Cryptochiton stelleri*), three species of nudibranch and limited observations of other gastropod and chiton species (Appendix F). Imagery gathered on **ƛ̓ušiiʔaaʔaq** during a 2022 survey (2022002PGC, see Cold Seeps EBSAs) at Dive OY086 and camera station 054/055 showed *Mopalia* sp*.,* lots of small snails (including Columbellidae and Calliostomatidae), Top Snail (*Callistoma* sp.), Smooth Velvet Snail (*Velutina prolongata*), Hairy Triton (*Fusitriton oregonensis*), limpets, Leopard Dorid (*Diaulula sandiegensis*), and the Opalescent Nudibranch (*Hermissenda crassicornis*). It is likely that the **ƛ̓ušiiʔaaʔaq** Area supports other species of marine snails and chitons given the rocky and exposed/semi exposed coastline, and additional surveys are required to characterize habitat use within **ƛ̓ušiiʔaaʔaq** by marine snails and chitons.

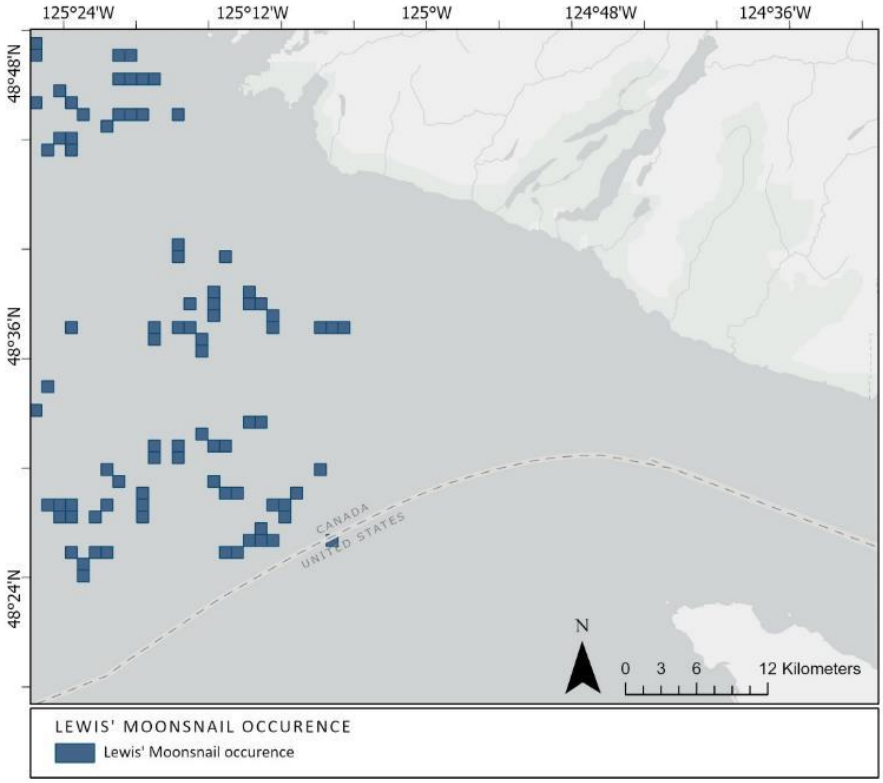


Figure 108. Occurrence represented by 1 km x 1 km grids of Lewis' Moonsnail in ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area. Occurrence data are from DFO Research and Commercial Shellfish Harvest Fishery Logs (1990-2023)*

6.2.3.4 Cephalopods

Class Cephalopoda (hereafter, cephalopods) includes octopus and squids. The Giant Pacific Octopus and Opal Squid are abundant throughout BC's coasts. There are no current fisheries for Opal Squid and Giant Pacific Octopus in BC, although Opal Squid were fished for bait in the 2000s (Wade and Curtis 2015). The Giant Pacific Octopus (*Enteroctopus dofleini*), the largest octopus species in the world, is an upper-level predator that resides in rocky crevices and oxygen-rich cold waters. Their diet consists mainly of crustaceans (crabs), bivalves, other cephalopods, and sometimes fish and fish eggs (Gillespie et al. 1998; Scheel and Anderson 2012). In turn, they are prey for Lingcod, Rockfish, Pacific Sleeper Shark, and Pinnipeds (Love et al. 2002; Love 2011; Ford 2014). Opal Squid (*Dorytheuthis opalescens*) are important forage prey in the diets of at least 51 species, including marine mammals, sea lions, fish, and birds (Walthers and Gillespie 2002; Enticknap et al. 2011). Information about the distribution and movements of pelagic Opal Squid in BC are limited, although they are known to aggregate for mass spawning inshore (Walthers and Gillespie 2002). Opal squid was identified as an ecological conservation priority in previous planning initiatives in British Columbia (Gale et al. 2019) due to their low reproductive output, unpredictable recruitment, and strong aggregating behaviour. Giant Pacific Octopus was identified as a conservation prior through the same process due to their unpredictable recruitment and low reproductive output. Occurrence data for the Pacific Bobtail Squid (*Rossia pacifica*), another commonly encountered cephalopod within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, is available in DFO survey data. Figure 109 shows the locations of Giant Pacific Octopus, Opal Squid and Pacific Bobtail Squid in the DFO data collected within **ƛ̓ušiiʔaaʔaq**.

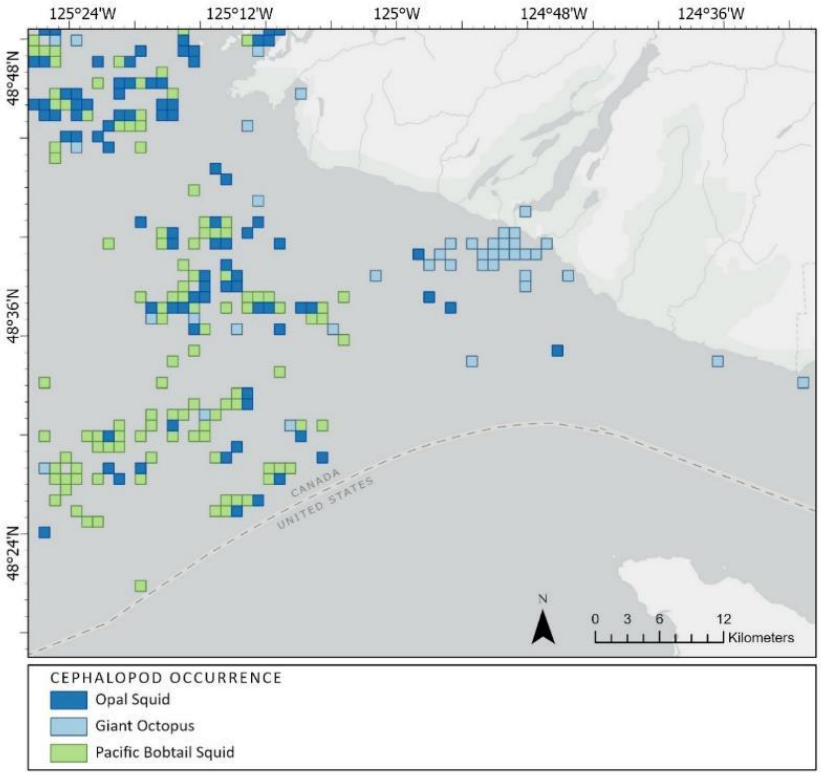


*Figure 109. Occurrences of Opal Squid (dark blue), Giant Pacific Octopus (light blue) and Pacific Bobtail Squid (green) in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area represented by 1 km x 1 km grids.*

6.2.3.5 Crustaceans

The Subphylum Crustacea (hereafter crustaceans) includes a diversity of species, such as barnacles, crab, prawns, and shrimps that are characterized by their segmented bodies and a hard exterior (exoskeleton). Over 90 prawns and 35 crab species are found in BC (DFO 2024e). For detailed summaries of Dungeness Crab and Spot Prawn (*Pandalus platyceros*) in BC, please refer to Hunter and Wade (2015).

Crabs

Crabs are important prey for many species, including fish (flatfish, rockfish, Pacific Hake, and skates), Sea Otters, and octopus (Pearcy and Hancock 1978; Buckley and Livingston 1997; Love et al. 2002; Brown et al. 2012). Dungeness Crab (*Metacarcinus magister*) and Red Rock Crab (*Cancer productus*) are prolific species throughout coastal BC and are targets for commercial, recreational, and First Nations fisheries. Dungeness Crabs make up the largest proportion of catch for the commercial shellfish fishery in BC and 99.9% of the crab fishery (DFO 2024f). Stock assessments of Dungeness Crabs are conducted using commercial crab-trapping gear. Less information is available for crabs that do not have ongoing fisheries, such as the Puget Sound King Crab (*Lopholithodes mandtii*) and Inshore Tanner Crab (*Chionoecetes bairdi*). Both crabs are found in shallow to subtidal waters, up to 137 m for Puget Sound King Crabs and 10 - 475 m for Tanner crabs (Jensen 1995; Fong 2005). Established populations of invasive European Green Crab are located in Sooke Basin to the south of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, and in Barkley and Clayoquot Sounds to the north (Gillespie et al. 2015; see section 5.6 – Aquatic Invasive and Non-Indigenous Species).

Dungeness Crab larvae, a form of pelagic zooplankton, make up an important part of the diet of several animals, including Pacific salmon, flatfish, and Grey Whales (Pearcy and Hancock 1978; Quinn 2005; Ford 2014). Crab larvae are dispersed throughout May to September before settling on suitable bottom habitats and favour intertidal areas with large estuaries and freshwater input (Armstrong et al. 2003; Curtis and McGaw 2008). Juvenile crabs prefer these shallow coastal and estuarine areas and habitats with protective structures such as eelgrass, macroalgae, woody debris, and bivalve shells (Thayer and Phillips 1977; Dinnel et al. 1987). After reaching a carapace width of 30 mm, juveniles migrate to subtidal waters and sandy and silty substrates in search of prey such as small fish, molluscs, shrimps, bivalves, and other crabs (Stevens et al. 1984; Pauly et al. 1998; DFO 2024f).

There are two records of Inshore Tanner Crabs and one occurrence of Puget Sound King Crab within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, as represented by the Juan de Fuca Eddy EBSA polygon. While Red Rock Crabs are common in the shallow subtidal, no occurrences are reported in the DFO data in the nearshore area of **ƛ̓ušiiʔaaʔaq**. A single occurrence of Red Rock Crab from iNaturalist is located within **ƛ̓ušiiʔaaʔaq** at the mouth of Bonilla Creek. Dungeness Crab data within **ƛ̓ušiiʔaaʔaq** are concentrated in the region where Nitinaht Narrows reaches the ocean. (Figure 110**A**). A Dungeness Crab species distribution model (Nephin et al. 2023) predicts moderate to low probability of occurrence in **ƛ̓ušiiʔaaʔaq**, with the highest probability of occurrence estimated in the nearshore region between Nitinaht Narrows and Port Renfrew (Figure 110).

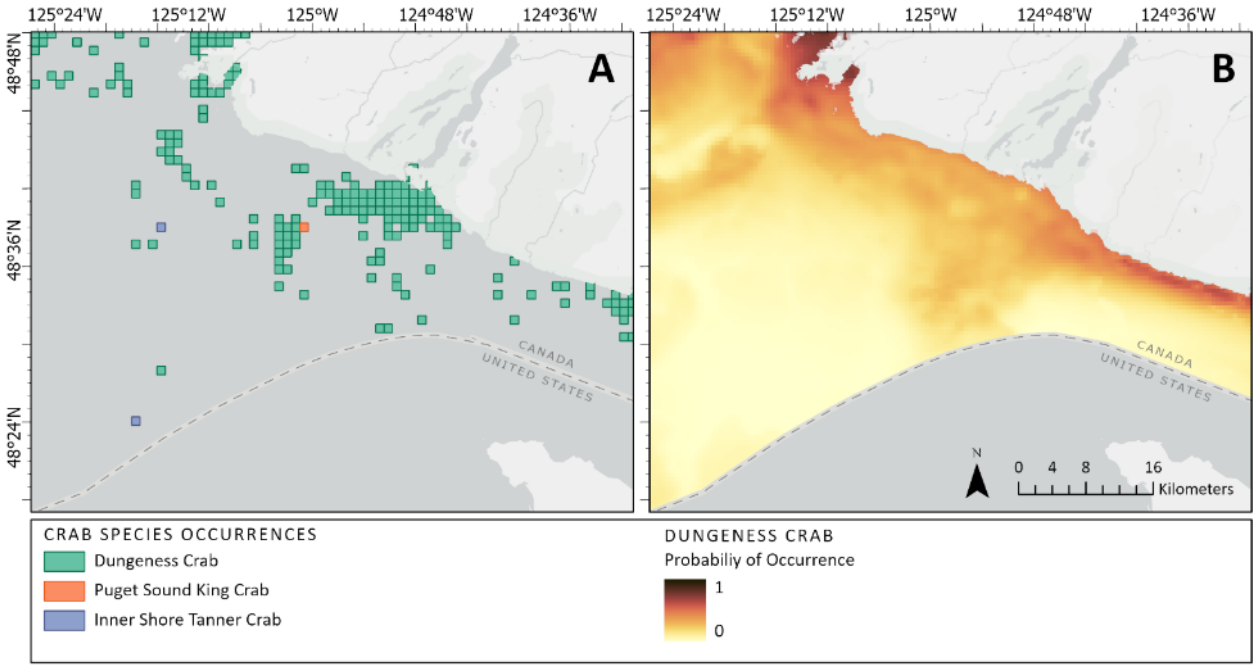


*Figure 110. Map panel A) shows the occurrence of three crab species in the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area from various DFO surveys, represented by 1 km x 1 km grids. Occurrence data are from DFO Research and Commercial Shellfish Harvest Fishery Logs (1990-2023). Map panel B) displays the Dungeness Crab probability of occurrence model (Park et al. 2023).*

Barnacles

Gooseneck Barnacles (*Pollicipes polymerus*) grow on rocky exposed coastlines in high-energy environments and are harvested using hand tools (Lauzier 1999). There is a lack of Gooseneck Barnacle occurrence information from DFO databases because existing surveys do not record their presence. Eleven occurrences of Gooseneck Barnacles are reported in the GBIF database for the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area. It is likely that this area supports higher occurrences of Gooseneck Barnacles than the available data suggest given the rocky and exposed coastline within **ʎ̓ušiiʔaaʔaq**. Gooseneck Barnacles are additionally harvested by the Ditidaht First Nation.

Shrimps and Prawns

Shrimp (Family Pandalidae; hereafter Pandalids) are opportunistic feeders, foraging for detritus, including other crustaceans, sponges, polychaete worms, and krill (Butler 1980). As forage species, they facilitate nutrient transfer for higher trophic species, including flatfish, rockfish, Pacific Hake, and skates (Pearcy and Hancock 1978; Buckley and Livingston 1997; Love et al. 2002; Yang et al. 2006; Brown et al. 2012). During the day, shrimp are found on benthic sand and muddy substrates and swim through the water column at night to feed on pelagic zooplankton (DFO 2023c). Spot Prawns are BC's largest pandalid species and prefer rocky or hard bottoms. All Pandalid shrimp start their lives as males, mature around 18-24 months, and eventually change sexes to females around three years (Butler 1980; DFO 2023c). Breeding occurs during the fall, and eggs hatch in the late winter, followed by a 3-4 month pelagic larval stage into the summer (Butler 1980; DFO 2023c). Two species of shrimp (*Pandalopsis dispar, Pandalus jordani*; Table 8), have Important Areas overlapping with the **ʎ̓ušiiʔaaʔaq**/Swiftsure

Bank as represented by the Juan de Fuca Eddy EBSA and contributing to its biological importance (Jamieson and Levesque 2014). The reasoning for the Important Areas is not provided, and the Juan de Fuca Eddy EBSA overlaps with 23-35% of their surface area.

Shrimp fisheries in BC use trawl nets and traps for harvest, whereas prawns are only harvested by trap. The most common targets for trawl are Northern Pink Shrimp (*Pandalus borealis*) and Smooth Pink Shrimp (*Pandalus jordani*) while over 97% of the trap gear fishery catches Spot Prawns (Figure 111; DFO 2023b).

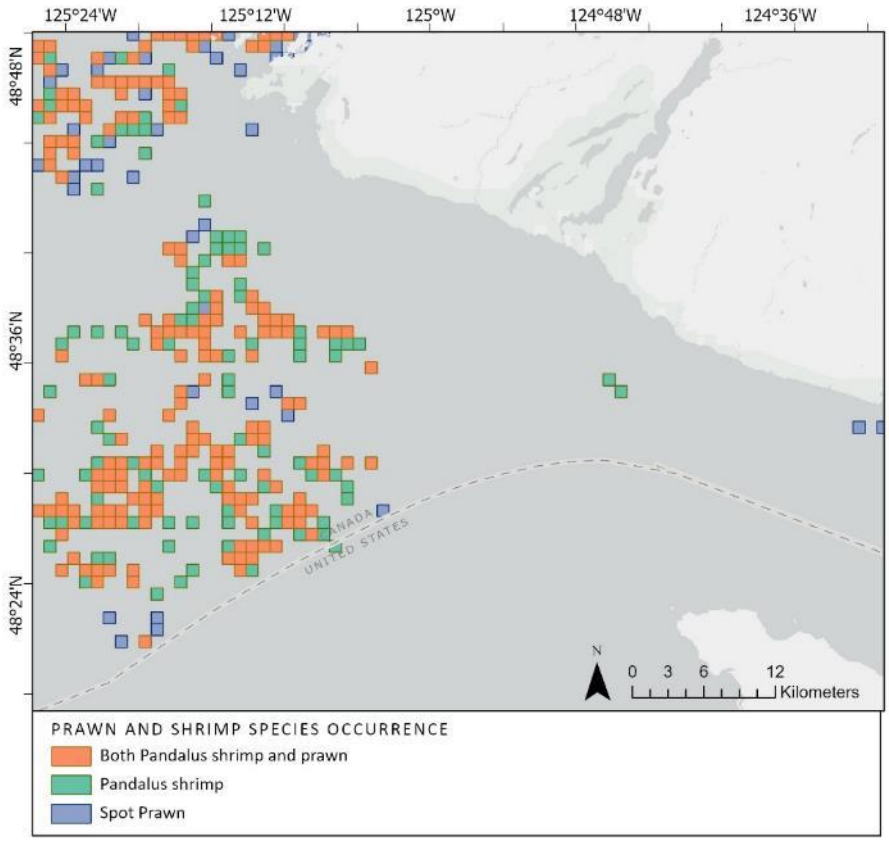


Figure 111. Occurrences of seven species of Pandalid shrimp, including the Spot Prawn (Pandalus platyceros), are available in DFO survey data for the Juan de Fuca Eddy EBSA polygon within the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area. These species include: Northern Shrimp (Pandalus borealis), Sidestripe Shrimp (Pandalopsis dispar), Coonstripe Shrimp (Pandalus danae), Smooth Pink Shrimp (Pandalus jordani), Spot Prawn (Pandalus platyceros), Pandalus tridens and Pandalus stenolepis. Smooth Pink Shrimp and Spot Prawn are the most common Pandalid species in the DFO data for* ***ʎušiiʔaaʔaq****. Occurrences of Spot Prawn (Pandalus platyceros) represented in blue, the other six shrimp (Family Pandalidae) species in green, and occurrences of all species shown in orange in ʎučii?aa?aq/Swiftsure Bank represented by 1 km x 1 km grids. Occurrence data are from DFO Research and Commercial Shellfish Harvest Fishery Logs (1990-2023).*

6.2.3.6 Echinoderms

Phylum Echinodermata (hereafter echinoderms) consists of prolific, slow-moving epibenthic or benthic invertebrates, which include sea cucumbers (Class Holothuroidea), sea stars (Class Asteroidea), urchins, and sand dollars (Class Echinoidea). Echinoderms occupy a diversity of

ecological niches and serve many different ecosystem functions, with consequences for species distributions and diversity. If unchecked by predators, for example, sea urchins can overgraze algae and kelp beds, destroying important habitats and leading to barren patches stretching kilometres across coastlines (Filbee-Dexter and Scheibling 2014). Voracious keystone predators such as Ochre Sea Star (*Pisaster ochraceus*) and Sunflower Sea Star (*Pycnopodia helianthoides*) help mediate invertebrate diversity by preying upon urchins in the intertidal and subtidal, respectively (Schultz et al. 2016). The excreted waste of detritivores, such as sea cucumbers, redistributes sediment loads, provides inorganic nitrogen and phosphorus for nutrient cycling, and increases benthic communities' productivity (Hughes et al. 2016). Echinoderms are prey to various species, including sea otters, octopuses, fishes, and marine birds (Gale et al. 2019).

Giant Red Sea Cucumber (*Apostichopus californicus)*, Green Sea Urchin (*Strongylocentrotus droebachiensis*), and Sunflower Sea Star (*Pycnopodia helianthoides*) have occurrence data within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank from DFO survey and shellfish fishery log data and are mapped (Figure 112). Species distribution models (Park et al. 2023) predict moderate to high occurrence probability for Green Sea Urchin (Figure 112C) and Red Sea Urchin (Figure 112D) throughout the majority of the nearshore area in **ƛ̓ušiiʔaaʔaq**, aside from the eastern most region. The Purple Sea Urchin SDM (Park et al. 2023) estimates moderate occurrence probability throughout nearshore areas in **ƛ̓ušiiʔaaʔaq**, including the easternmost areas that have low occurrence probabilities for Green and Red Sea Urchins. The Giant Red Sea Cucumber SDM (Park et al. 2023) predicts moderate to low occurrence throughout nearshore areas in **ƛ̓ušiiʔaaʔaq**. (Figure 112B). Other sea star (Class Asteroidea) and Sea Urchin (Class Echinoidea) species that are present in the DFO data in moderate numbers (>75 records) include: the Sand Star (*Luidia foliolata*), Spiny Red Star (*Hippasteria spinosa*), Velcro Star (*Stylasterias forreri)* and Orange-pink Sea Urchin (*Strongylocentrotus fragilis)*. However, DFO occurrence data is relatively sparse in **ƛ̓ušiiʔaaʔaq**, particularly in nearshore regions and it is likely that the **ƛ̓ušiiʔaaʔaq** supports other echinoderm species given the rocky and exposed/semi exposed coastline. Observations from the GBIF database show the presence of Ochre Sea Star (*Pisaster ochraceus*), Purple Sea Urchin (*Strongylocentrotus purpuratus*), Red Sea Urchin (*Mesocentrotus franciscanus*) and several sea star, sea cucumber, brittle star, and sea urchin species. Imagery gathered on **ƛ̓ušiiʔaaʔaq** during a 2022 survey (2022002PGC, see Cold Seeps EBSAs) at Dive OY086 and camera station 054/055 showed Giant Red Cucumber (*Apostichopus californicus*), Giant Orange Cucumber (*Apostichopus leukothele*), lots of brittle stars (Class Ophiuroidea), Basket Star (G*orgonocephalus eucnemis*), a few unidentified seastars, Vermillion Star (*Mediaster aequalis*), Velcro Star (*Stylasterias forreri*), Morning Sun Stars (*Solaster dawsoni*), Rose Star (*Crossaster papposus*), Blood Star (*Henricia* sp.), and the Pale Urchin (*Strongylocentrotus pallidus*). Purple Sea Urchin occur along the entire coastal area of **ƛ̓ušiiʔaaʔaq** in the low intertidal to shallow subtidal region along rocky shelves (J. Yakimishyn, PCA, pers. comm.). Refer to Appendix F for a full species list.

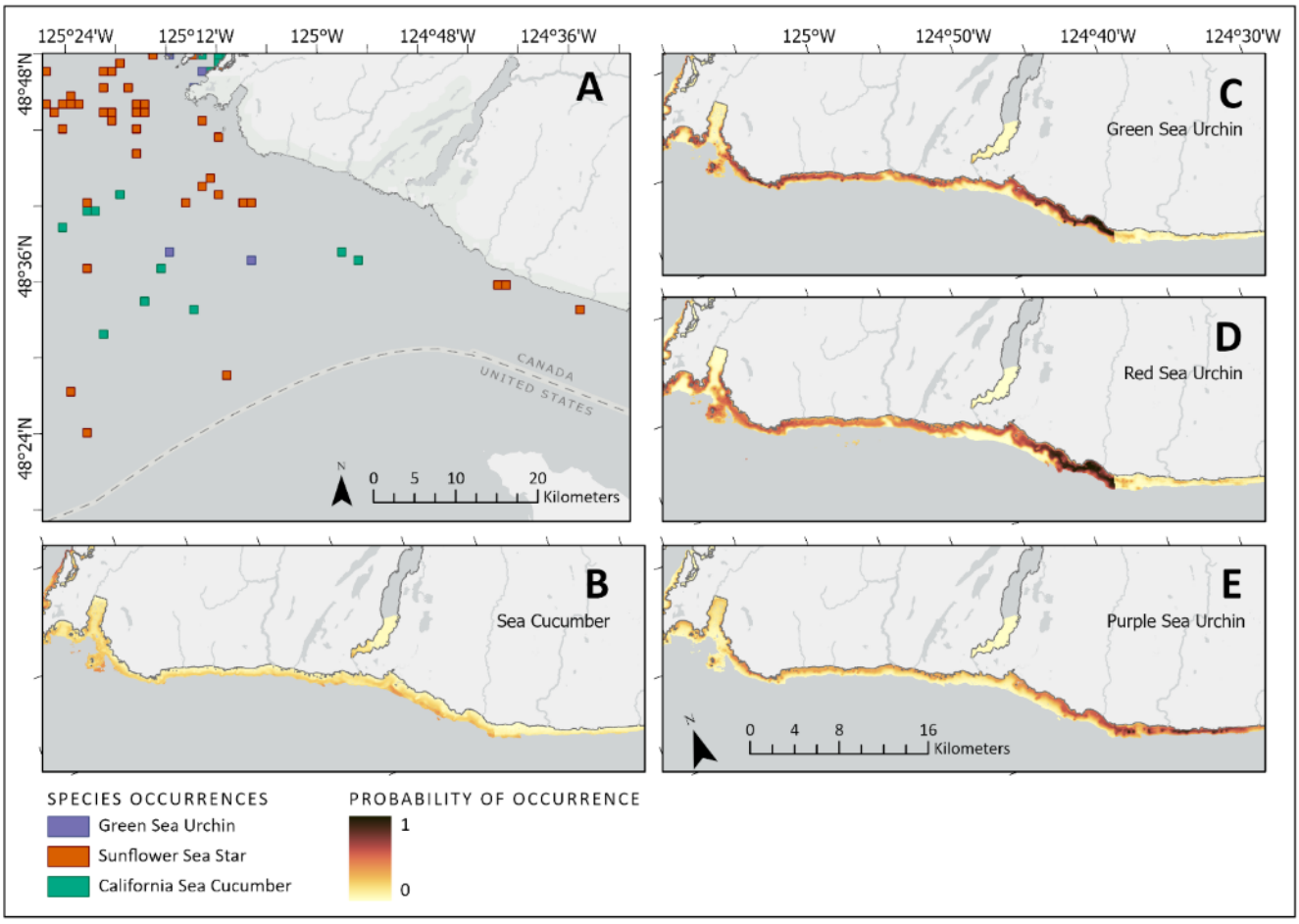


*Figure 112. A) Occurrences of three Echinoderm species represented by 1 km x 1 km grids: Green Urchin, Sunflower Sea Star, and Giant Sea Cucumber in the **X̱ušiiʔaaʔaq**/Swiftsure Bank Area. Occurrence data are from DFO Research and Commercial Shellfish Harvest Fishery Logs (1990-2023). Panels B to E: probability of occurrence of B) Sea Cucumber, C) Green Sea Urchin, D) Red Sea Urchin, and E) Purple Sea Star from nearshore distribution models (Park et al. 2023).*

6.2.3.7 Cnidarians

The Phylum Cnidaria consists of animals with two life-history phases: swimming medusa and sessile polyps. Cnidarians in the medusa stage are encountered in DFO surface trawl surveys that employ a fine mesh codend liner (Figure 113). Since 2017, summer and fall surveys have enumerated cnidarian catches to the lowest taxonomic level possible. True jellyfish (Class Scyphozoa), i.e., cnidarians with oral arms, have been encountered within the **X̱ušiiʔaaʔaq**/Swiftsure Bank Area (Figure 113), including the Pacific Sea Nettle (*Chrysaora fuscescens*) and Fried Egg Jellyfish (*Phacellophora camtschatica*). Species in Class Hydrozoa encountered within the **X̱ušiiʔaaʔaq** Area (Figure 113) include the Water Jelly (*Aequorea sp.*) and colonial Siphonophores. It is important to note that these same surveys encounter additional cnidarians, such as Moon Jellyfish (*Aurelia labiata*) and Lion's Mane Jellyfish (*Cyanea capillata*), throughout waters of the WCVI, suggesting that they are also likely present in the **X̱ušiiʔaaʔaq** Area.

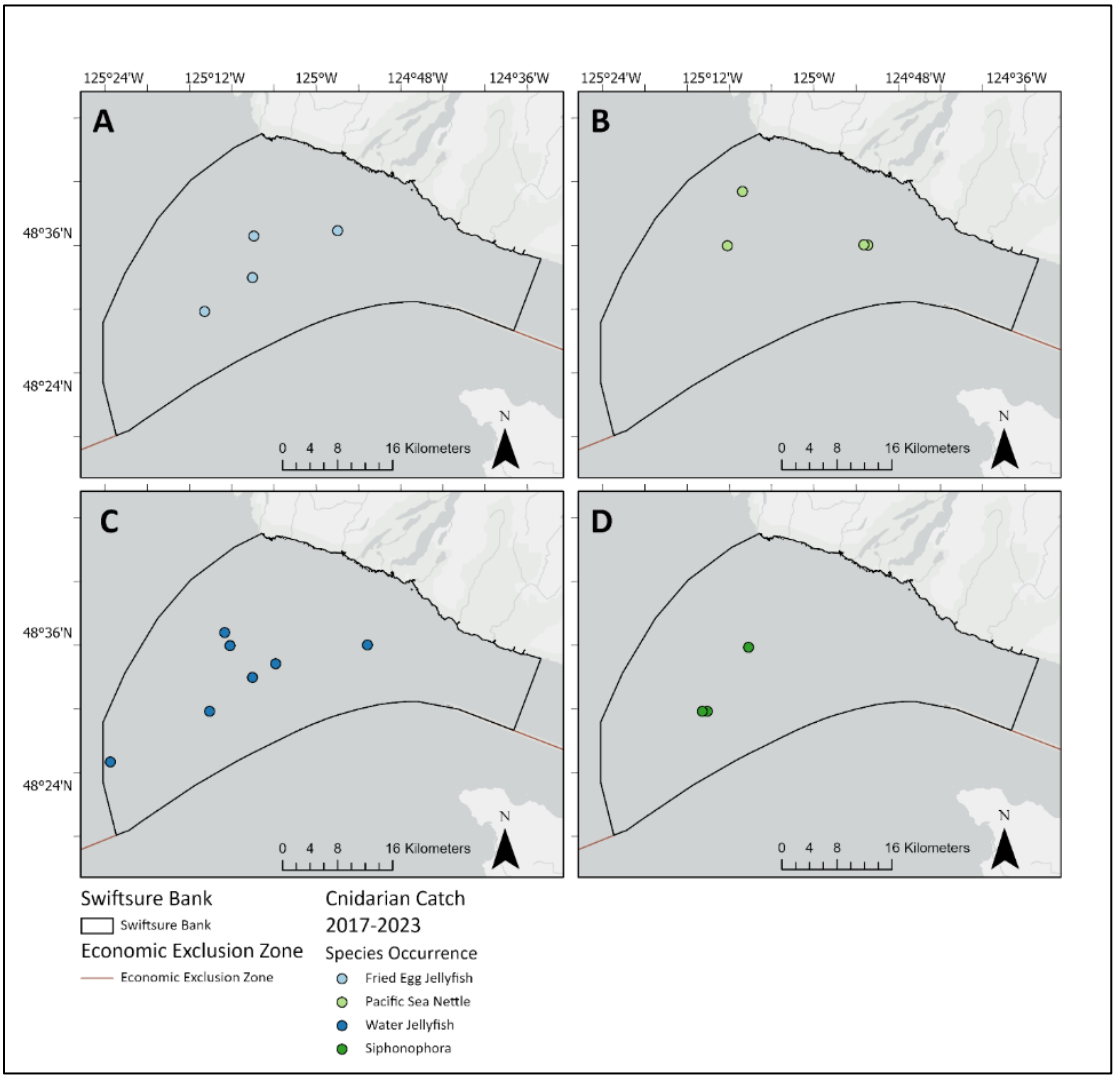


*Figure 113. Occurrence of jellyfish in DFO surface trawl surveys (2017-2023) conducted in July and October in the **ʎušiiʔaaʔaq**/Swiftsure Bank Area.*

6.2.3.8 Sensitivities and Recoverability

Marine invertebrates have different levels of sensitivity and resilience corresponding to their diverse life histories and unique forms. Natural and anthropogenic stressors affecting invertebrates include fishery activities, predation, disease, and various effects of climate change (e.g. ocean acidification). Generally, species with high reproductive output, larval settlement and recruitment rates, and a high population abundance are more resilient to compounding stressors. Recruitment in invertebrate populations is difficult to predict due to a variety of factors including the broad geographic scale of spawning (as many species are broadcast spawners), high larval and juvenile mortality rates, predation, disease, environmental variables, and oceanographic conditions (Hunter and Wade 2015).

Climate change, including ocean acidification and global sea surface temperature increases, poses many challenges to marine organisms. Increased ocean acidification can directly affect the growth, survival, and development of invertebrates with hard structures, such as certain

corals and sponges, bivalves, snails, and crustaceans (Talmage and Gobler 2010). Rising sea levels and changing freshwater discharge may affect the health and accessibility of important habitats for invertebrates, such as estuaries, eelgrass, and kelp beds (Bornhold and Thomson 2013). For example, crustaceans such as Dungeness Crabs and Spot Prawns are likely impacted through all stages of their life history by changes in sea surface temperature, ocean acidification, ocean current change, nutrient availability, and dissolved oxygen (Hunter and Wade 2015).

Cold water corals and sponges

Cold-water corals and sponges are fragile, long-lived, slow-growing, biogenic structures that are vulnerable to anthropogenic stressors (summarized in Du Preez and Norgard 2022). Cold-water coral and sponge communities are vulnerable to physical habitat disturbances such as bottom-contact fishing gear (Campbell and Simms 2009; Ragnarsson et al. 2016) . Bottom trawling can dislodge sessile animals and stir up sediments in the water column, impairing the ability to filter or suspension feed (Ragnarsson et al. 2016). The effects of marine debris, including lost and sunken fishing gear, can entangle and cause long-term damage to biogenic structures and habitats (Baco et al. 2019; Du Preez et al. 2020; Appah et al. 2022). Furthermore, oil spills can also pose a risk of delayed health effects, such as a higher branch rate loss for corals (Girard and Fisher 2018) and decreased larval settlement rates (Luter et al. 2019). Cold-water coral and sponge biomass recovery after habitat disturbance has been shown to take decades due to the slow growth and settlement of many species and their long lifespans (Rooper et al. 2011; Baco et al. 2019). Management and regulatory measures, such as spatial closures, can be effective tools to reduce habitat disturbances and preserve cold-water sponge and coral communities (summarized in Appendix C of Pacific Region Cold-water Coral and Sponge Conservation Strategy; DFO 2010). This has been demonstrated after the implementation of the Groundfish Trawl Habitat Agreement (Wallace et al. 2015), where bottom-trawling fleets were shown to be avoiding areas of high coral and sponge densities compared to years before the agreement (Gale et al. 2022).

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

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

Molluscs

Infauna, epibenthic bivalves, marine snails, and chitons mostly exhibit limited movement and aggregating behaviours. These traits make these groups of molluscs more sensitive to the local effects of pollution, such as oil spills and intense harvesting. On a broader scale, ocean acidification reduces the ability of calcifiers (i.e., bivalves and marine snails) to build their shells, and causes the dissolution of existing shell material (Miller et al. 2009; Haigh et al. 2015 and references therein). Additionally, while intertidal molluscs are able to withstand reasonable daily fluctuations in temperature, salinity and exposure caused by tidal cycles, when extreme temperatures coincide with low tides, the combination of temperature, UV, and salinity-related stress can lead to high species mortality (Hesketh and Harley 2023), especially as the frequency, duration, and intensity of these extreme weather events are expected to increase with climate change (White et al. 2023). Refer to the Climate Change section for a more detailed discussion on the impact of climate change on oceanographic conditions in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

Crustaceans

The abundance of crustaceans depends on the survival and recruitment of larval and juvenile life stages, as mortality rates in adults are greatly reduced. These pelagic and planktonic stages are influenced by a variety of conditions, including climate-related effects (e.g., currents, ocean acidification) and biotic interactions (e.g., predation) (Brand et al. 2007). Recruitment and stock declines in offshore pandalid shrimps have been associated with warmer-than-usual oceanic conditions in the Pacific (Anderson 2000) and the Atlantic (Richards and Hunter 2021) oceans. Water temperatures can influence larval, juvenile, and adult development, growth, survival, and reproductive capacities in shrimp and prawns (Koeller 2006; Lowry 2007). A mismatch in egg hatch and phytoplankton bloom timing from changing sea surface temperatures can lead to decreased recruitment in a given year (Hunter and Wade 2015). Spot prawn fecundity is lower than other Pandalid species (see table 2-2 in King 1997; Lowry 2007; Hunter and Wade 2015).

Crustaceans rely on an exoskeleton shell for protection, which molts as they grow. Ocean acidification can impair the development of calcareous structures (Feely et al. 2004). Decreased pH conditions impaired Dungeness Crab development, growth, and survival in both larvae and adults (Bednaršek et al. 2020; Berger et al. 2021). Low oxygen severely impacted adult life stages specifically, which can affect population numbers (Berger et al. 2021). A study on the coast of Oregon showed higher Dungeness Crab mortality or migration away from areas with longer durations of hypoxic conditions (Chan et al. 2008). The health of habitats associated with juvenile development and protection should be considered when accounting for overall population survival and abundance. Notably, Dungeness Crab aggregate in estuaries (Gunderson et al. 1990; Rasmuson 2013), and Spot Prawn are commonly found on complex substrates such as sponge and coral reefs and beds, areas with high rugosity, and drift macroalgae (Butler 1980; Lowry 2007; Britton-Simmons et al. 2012).

Echinoderms

Many echinoderms are shown to have a boom-and-bust population dynamic characterized by an explosion of abundance followed by a sharp decline. This cycle may be explained by the natural prey-predator population dynamic or exacerbated by anthropogenic activity such as intense harvesting (Uthicke et al. 2009; Schultz et al. 2016) and/or the spread of disease. In coastal BC, urchin populations are highly correlated with rates of Sea Otter predation rather

than harvesting. Disease can make local populations more susceptible to other stressors. The most prevalent example is the recent coastwide decline of sea star populations from sea star wasting disease (Miner et al. 2018). Laboratory experiments comparing temperature treatments with the onset of disease and death of adult sea star showed faster mortality rates with increased temperatures (Eisenlord et al. 2016; Kohl et al. 2016). Intertidal surveys of sea star health and temperature loggers from San Juan Island to Puget Sound and the west coast of Washington state showed high-temperature anomalies correlated with mass sea star die-offs in the summer of 2014 in the Pacific Northwest (Eisenlord et al. 2016). These results may suggest that frequent ocean warming events can lead to further population declines (Eisenlord et al. 2016). As sea stars are apex invertebrate predators, their distribution and abundance changes may lead to cascading effects on prey abundance and assemblages in localized habitats and ecosystems (Galloway et al. 2023; Paine 1966; Konar 2019).

6.2.3.9 Data and Knowledge Gaps

Data from stock assessment surveys conducted by DFO are extremely limited for many of the invertebrate taxonomic groups, including marine snails and chitons, barnacle species like Gooseneck Barnacle, and many echinoderms. Bivalve occurrence data collected by DFO is limited for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, particularly in nearshore areas within the boundaries of PRNPR that are closed to commercial shellfish harvesting. Additional ground truthing (i.e., direct observation, survey, and measurement) within the **ƛ̓ušiiʔaaʔaq** and surrounding area is needed to describe the presence and distribution of bivalve species, several of which (e.g., mussels) are relatively common and widespread and likely occur within **ƛ̓ušiiʔaaʔaq**. Further observations would also facilitate the development of species distribution models, such as those for Geoduck and several urchin species, to help identify likely areas of occurrence for invertebrate species.

6.2.4 Fishes

Fish are a diverse taxonomic group that form an important part of the biodiversity of West Coast Vancouver Island and the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, 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 **ƛ̓ušiiʔaaʔaq** 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, salmonids, and other). Cartilaginous fishes have been separated into demersal fishes (sharks, skates, and ratfish) and pelagic sharks. At least 78 species of fish occur in **ƛ̓ušiiʔaaʔaq** (Appendix F); too many to describe in detail here. Of those 75 species, 19 have been identified as species contributing to the biological significance of the Juan de Fuca Eddy EBSA (Table 8), which **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank overlaps with in its entirety (Jamieson and Levesque 2014). We provide detailed information for these species, and others as suggested as additionally culturally or ecologically important by co-authors of this report in the relevant sections below.

Data sources

Fish species occurrence data for this section as a whole are retrieved from several sources: 1) observation data from DFO or external research surveys or commercial fisheries, 2) published literature and reports, 3) direct observations from the Global Biodiversity Information Facility

(GBIF), and/or 4) personal communications and local knowledge, including Traditional Ecological Knowledge.

DFO conducts a suite of randomized fish surveys using bottom trawl, longline hook, and longline trap gear that, in aggregate, cover Canada's Pacific Coast (Anderson et al. 2019). The distribution of surveys relevant to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area are shown in Figure 114, and illustrate where geographic survey coverage is missing. Synoptic trawl surveys on the West Coast of Vancouver Island (WCVI; Areas 3C and 3D) are conducted in even numbered years. In addition, four biennial Hard Bottom Longline (HBLL) surveys are conducted, two in "inside" waters (east of Vancouver Island; Area 4B) and two in "outside" waters (everywhere else), including WCVI. Multispecies small mesh bottom trawl surveys occur annually and monitor trends and document all species encountered. A coast-wide longline trap survey targeting Sablefish is also conducted every year along the continental slope, though do not overlap the **ƛ̓ušiiʔaaʔaq** Area. Lastly, DFO collects biological information from the International Pacific Halibut Commission (IPHC) Fisheries Independent Setline Survey. In 2022, the HBLL outside south, HBLL inside south, synoptic WCVI, multispecies small mesh bottom trawl, IPHC and Sablefish trap surveys were conducted. Where possible, we summarize some of those stock trends for WCVI in the sections below and report on observations within the **ƛ̓ušiiʔaaʔaq** Area based on the overlap of data with the Juan de Fuca Eddy EBSA polygon.

Within the groundfish section (Section 6.2.4.1.1), the following terms associated with fisheries stock assessments are used to highlight the stock status of the groundfish species. DFO's precautionary approach as part of the sustainable fisheries framework (DFO 2009b) classifies fish stocks into three zones: healthy, cautious, and critical. The Limit Reference Point (LRP) represents the boundary between the cautious and critical zones and is "the stock status below which serious harm is occurring to the stock" and a rebuilding plan is required (DFO 2009b). The Upper Stock Reference (USR) is the boundary between the healthy and cautious zones, below which removals must be managed to avoid the stock status being reduced to the LRP (DFO 2009b). The Target Reference Point (TRP) is a milestone for rebuilding stocks and can be determined by productivity estimates (DFO 2009b). The USR may be the same as the TPR for some stocks. Stocks are considered in the critical zone if the biomass of the stock is less than or equal to the biomass that will generate the maximum sustainable yield (B_{MSY}). If the biomass if greater than 40% B_{MSY} but less than or equal to 80% B_{MSY}, the stock status falls in the cautious zone, and if greater than 80% B_{MSY}, the stock falls in the healthy zone.

Population snapshots and fishing trends, growth and maturity patterns, as well as data availability, for 116 groundfish species in British Columbia, up to 2022, is available in Anderson et al. (2024).

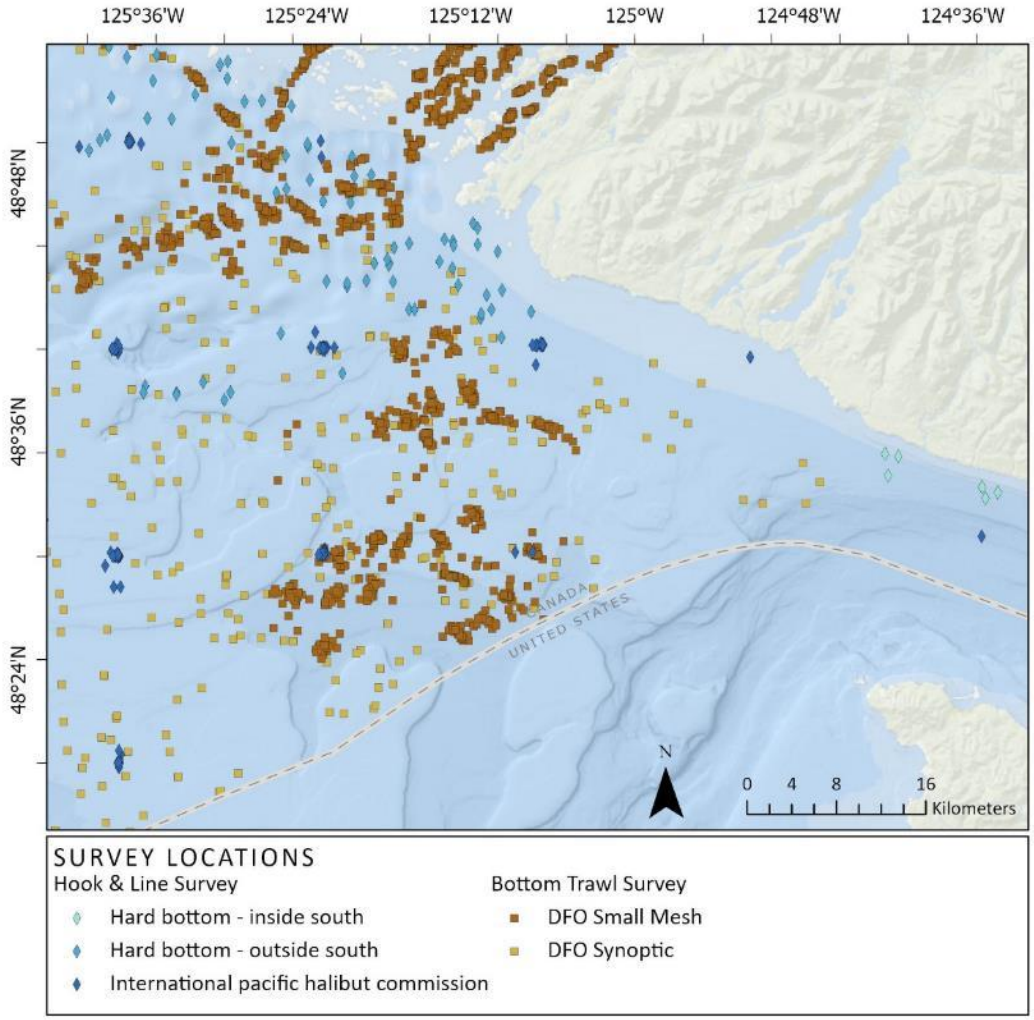


*Figure 114. Sampling extent of surveys for the **ǰušiiʔaaʔaq**/Swiftsure Bank Area. Fisheries-independent scientific surveys conducted within Canadian Pacific Waters: the Fisheries and Oceans Canada (DFO) Groundfish Synoptic Bottom Trawl Surveys (Sinclair et al. 2003; Anderson et al. 2019), the DFO Groundfish Hard bottom Longline Surveys (Lochead and Yamanaka 2006, 2007; Doherty et al. 2019), and the International Pacific Halibut Commission Fisheries Independent Setline Survey (Stewart and Hicks 2022).*

6.2.4.1 Bony Fishes

Bony fishes (Superclass Osteichthyes) have skeletons primarily composed of bone tissue, and make up the majority of extant fish species. The superclass is diverse, consisting of seven classes, including the specious Actinopterygii (ray-finned fish). Within **ǰušiiʔaaʔaq**/Swiftsure Bank at least 60 species of Actinopterygiians occur (Appendix F). We separate out the bony fishes into two groupings in the following section based on similarities in habitat use: groundfish and pelagic fishes.

6.2.4.1.1 Groundfish

Groundfish comprise benthic and/or demersal free-swimming species living in or near the benthic layer of the marine environment. They are typically found on or near the continental shelf, slope, or around seamounts. They have been grouped below into four groups by ecological similarity: rockfish, flatfish, roundfish, and other groundfish. Groundfish tend to associate with key oceanographic habitats off the West Coast of Vancouver Island, which are primarily determined by depth, surface chlorophyll concentration, bottom salinity, and temperature (Juan-Jordá et al. 2009). As with most other rockfish and groundfish in the California Current ecosystem, recruitment or cohort strength appears to be highly variable. Oceanographic and ecosystem factors are widely recognized to be key drivers of recruitment variability for most species of groundfish, as well as most elements of California Current ecosystem food webs (Monk et al. 2024).

Thompson et al. (2023a) developed a groundfish distribution model to inform the probability of occurrence of 57 groundfish species in the Canadian Pacific, which we overlapped with the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, using the Juan de Fuca Eddy EBSA polygon. Despite the term groundfish being used, non-groundfish species such as Pacific Herring and sharks are included in the model. The model integrated data from three fisheries-independent scientific surveys: the DFO Groundfish Synoptic Bottom Trawl Surveys (Sinclair et al. 2003; Anderson et al. 2019), the DFO Groundfish Hard Bottom Longline Surveys (Lochead and Yamanaka 2006, 2007; Doherty et al. 2019), and the International Pacific Halibut Commission (IPHC) Fisheries Independent Setline Survey (Stewart and Hicks 2022). Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used in this distribution model to produce predicted species densities per grid cell for each groundfish species. Groundfish species density was calculated as the sum of the estimated occurrence probabilities from the presence-absence model for each groundfish species per unit area (Thompson et al. 2023a; Figure 115). Within the **ƛ̓ušiiʔaaʔaq**, groundfish species density or species richness is modelled to be highest in the western portion of the polygon, an area of higher bathymetric variation then near the coast and towards the Strait of Juan de Fuca. Outside of **ƛ̓ušiiʔaaʔaq**, Barkley Sound and the offshore regions of the map are predicted to have higher groundfish species richness, reaching a maximum species richness of over 25, from a potential pool of 45 modeled species in the area (Appendix F). We provide species density maps by taxonomic grouping within the text in support of modeled groundfish species. Species-level density maps for featured species in the text are provided in Appendix H.

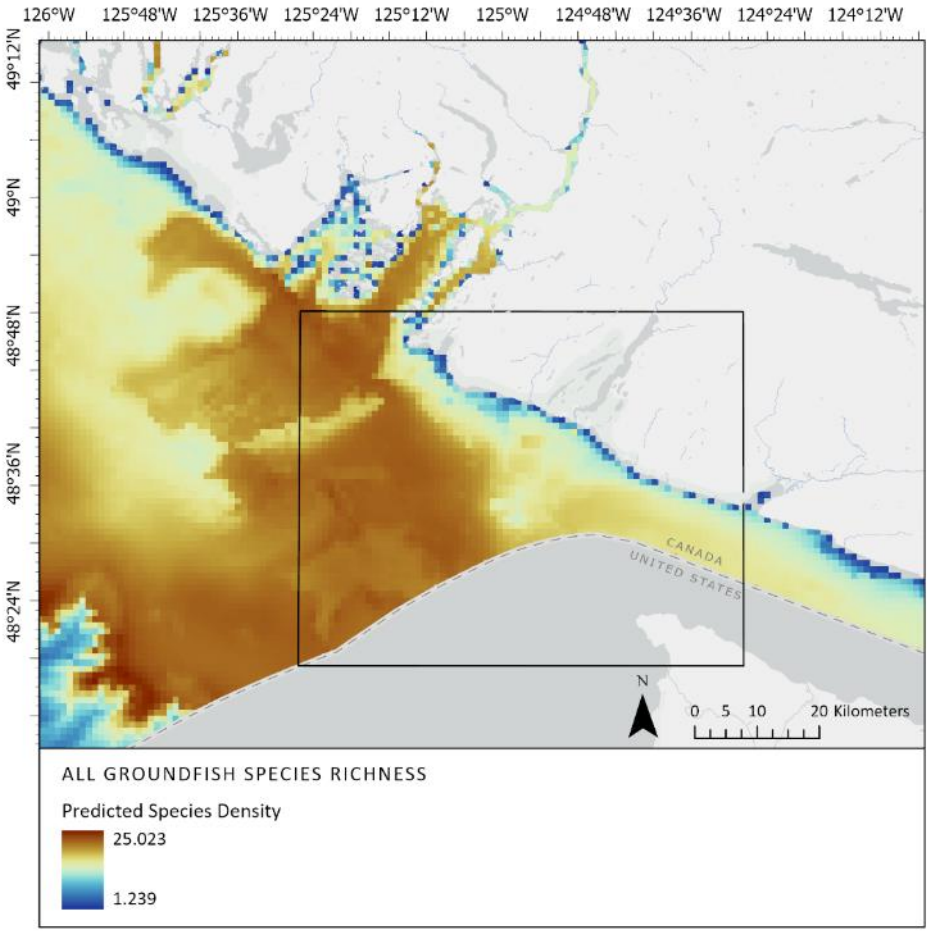


*Figure 115. Estimated variation in species density values per grid cell (Species Richness) for all 45 groundfish species modeled for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area by Thompson et al. (2023a). Note this species list is not exhaustive and groundfish species richness per grid cell may actually be higher. See Appendix H for full list.*

6.2.4.1.1.1 Rockfish

Rockfish (*Sebastes* and *Sebastolobus spp.*) are ecologically, commercially, and culturally valued fishes on the West Coast of North America with a diversity of life histories and behaviours. There are at least 65 species described, ranging from Alaska to the Baja peninsula in California, and 30-36 species are found throughout the BC coast (Love et al. 2002), and at least 19 species occur in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Appendix F). Rockfish are classified into three groups for broad management purposes in Canada. Inshore rockfish describes nearshore species found between 0 to 200 meters deep (Yamanaka and Logan 2010). Whereas shelf and slope rockfish include species found deeper in the continental shelf and the continental shelf and slope, respectively, species lists for these categorizations may be outdated and vague for current classifications (Schnute et al. 1999; Stanley 1999). Two distinct units of rockfish populations in coastal BC are further categorized into inside waters (from Vancouver Island to the Vancouver mainland) and outside waters (the rest of the BC coast, including the **ƛ̓ušiiʔaaʔaq**). Similarly, there are the Outside and Inside commercial rockfish sectors; Hook-and-line and trawl gear are used for commercial rockfish catch (DFO 2024c).

Rockfish range in maximum lifespans from 22 years (Puget Sound Rockfish (*Sebastes emphaeus*)) to 205 years (Rougheye-Blackspotted complex) (Leaman 1991; Love et al. 2002). Trophic levels for various species range from planktivores (Pacific Ocean Perch) to piscivores (Quillback Rockfish) (Love et al. 2002; Olson et al. 2020). Rockfish are viviparious, and yearly fecundity in species can range from thousands of larvae (Puget Sound Rockfish) to nearly three million (Yelloweye Rockfish) (Love et al. 2002). Their distributions can differ by habitat type (e.g. rock type and biocover; Haggarty et al. 2016) and depth from the intertidal zones to greater than 1,500 meters (Love et al. 2002). Rockfish with long lifespans, slow growth and maturity can make those species vulnerable to the effects of overfishing and population collapse (Cheung et al. 2005; Haggarty et al. 2016; Gale et al. 2019). Juvenile rockfish are prey to many ecologically important species (Gale et al. 2019).

Rockfish have been a stable part of coastal First Nation diets for millennia and have important cultural significance for community relations and other usages (McKechnie and Moss 2016). Archaeological work on midden deposits in prehistoric village sites in nearby Barkley Sound, show evidence of consistent and long-term use of marine resources, including several *Sebastes* spp. and other fish species and mammals (McKechnie 2007; Rodrigues et al. 2018). A meta-analysis of four decades of archaeological fisheries research in the region shows that rockfish are found in more than 60% of archaeological sites along the Northwest Coast, making them the fifth most frequently identified fish taxa in sites from Oregon to southeast Alaska (McKechnie and Moss 2016). They are especially prevalent at archaeological sites along the exposed outer coast, where rocky reef habitats with significant relief are common (McKechnie and Moss 2016).

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is exposed and while generally shallow, does have rocky areas with gullies, ridges, and bathymetric variation (see OCEANOGRAPHY AND PHYSICAL SETTING) providing habitat for a variety of rockfish species. Additional rockfish habitats can include rocky reefs, kelp forests, and eelgrass beds. Within the **ƛ̓ušiiʔaaʔaq** predicted species occurrence for 16 total species of rockfish show the most species rich area to be in the southwestern portion of the extent closes to the edge of the continental shelf (Figure 116).

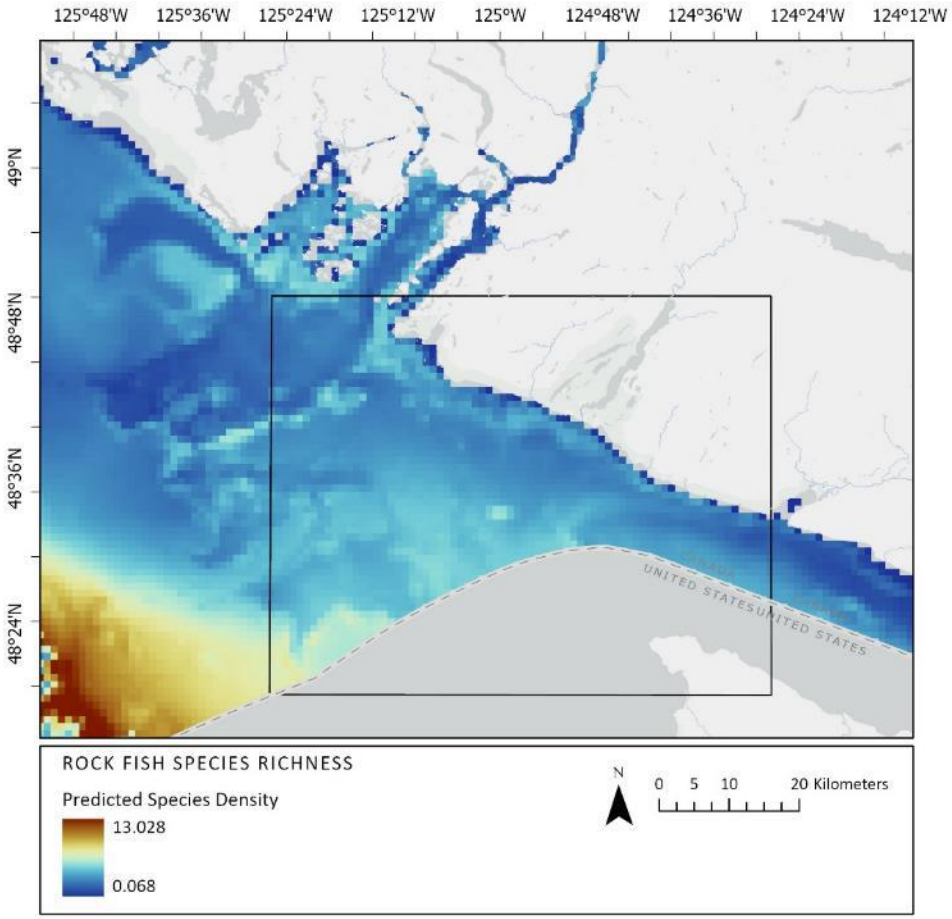


Figure 116. Summed predicted species density values per grid cell (Species Richness) for rockfish species, including 16 species modeled in the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area (black rectangle inset) using the Thompson et al. (2023a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 57 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used.*

Imagery gathered on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank during a 2022 survey (2022002PGC, see Cold Seeps EBSAs) did confirm the presence of several species with Dive OY086 and camera station 054/055 catching imagery of schools of rockfish, with individual rockfish species including Yelloweye (*Sebastes ruberrimus)*, Yellowtail (*Sebastes flavidus*), Sharpchin (*Sebastes zacentrus)*, and Canary (*Sebastes pinniger)* rockfish. At camera station 056, Sablefish (*Anoplopoma fimbria*) was also observed. Further, large schools of Black Rockfish (*Sebastes melanops*) are often observed in nearshore Bull Kelp in summer months along the entire coastline of the **ƛ̓ušiiʔaaʔaq** (J. Yakimishyn, PCA, pers. comm.).

Widely occurring and important cultural rockfish species in the area include Canary Rockfish, China Rockfish (*Sebastes nebulosus*), Copper Rockfish, Quillback Rockfish (*Sebastes maliger)*, Pacific Ocean Perch (*Sebastes alutus*), Rougheye/Blackspotted Rockfish complex, Yelloweye Rockfish, and Yellowtail Rockfish, for which more information is provided below. None of the rockfish species are listed as being of biological importance to the Juan de Fuca Eddy EBSA

(Jamieson and Levesque 2014). Support maps for these featured species are available in Appendix H. For the full rockfish occurrence list please see Appendix F.

Canary Rockfish

Canary Rockfish (*Sebastes pinniger*) is a commercially important species, found patchily in the Juan de Fuca Eddy EBSA area of the **ʎušiiʔaaʔaq**/Swiftsure Bank Area, and along the deeper western edge of the extent rectangle and into Barkley Sound. This species is also found in nearby archaeological samples from shellfish middens of Indigenous coastal villages (Rodrigues et al. 2018). The species ranges from the Gulf of Alaska southward to northern Baja peninsula in California, with the highest concentration on the west coast of Vancouver Island (area 3CD), particularly in the northern part (3D) (DFO 2023d).

COSEWIC assessed the species as 'Threatened' in 2007, and in 2009 the stock was described as being in the Healthy zone by DFO. The 2022 stock assessment put the current (beginning 2023) Canary Rockfish population in the Healthy zone, predicting it will stay in there over the next 10 years at catch levels up to 2000 t/y) (Table 12; DFO 2023c). Adults and sub-adults primarily eat krill and small fishes (Love et al. 2002). Pacific Herring and Pacific Sand Lance are probably important prey in BC waters, but no diet studies have been conducted. A genetic assessment for Canary Rockfish has not been done in BC but work in Washington State, to which DFO contributed samples, may provide some insight into regional diversity as the assessment showed that Canary Rockfish in Puget Sound were not genetically different from those on the outer Washington coast (Andrews et al. 2019).

Table 12. Stock status information for Canary Rockfish (Sebastes pinniger) from 2023 Stock Assessment (DFO 2023d). LRP = limit reference point; USR = upper stock reference; B_{2023} = Spawning biomass at the start of 2023; B_{msy} = Maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2023	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$	B_{2023}/B_{MSY} = 3.04	Healthy Zone	Not required	Threatened (2007)	N

Copper Rockfish/China Rockfish

Copper Rockfish (*Sebastes caurinus*) and China Rockfish (*Sebastes nebulosus*) are inshore benthic species both found along the nearshore regions of **ʎušiiʔaaʔaq**/Swiftsure Bank Area. Both species are also found in nearby archaeological samples from shellfish middens of Indigenous coastal villages (Rodrigues et al. 2018). Copper rockfish in Canadian waters are managed as a part of a species complex termed "Inshore Rockfish". Inshore Rockfish are a group of *Sebastes* species that are caught by hook and line gear in subsistence, recreational, and commercial fisheries. The species included in this management group are Yelloweye, Quillback, Copper, China, Black, and Tiger Rockfishes. The abundance of some species of rockfish within the Inshore Complex is currently unknown; and Copper and China rockfish stocks have not been assessed by DFO (Table 13).

Table 13. Copper Rockfish (Sebastes caurinus) and China Rockfish (Sebastes nebulosus) stock status information is not available. COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status	Rebuilding Plan	COSEWIC	SARA
n/a	n/a	n/a	n/a	n/a	n/a

n/a = not available

Copper rockfish are a demersal species found primarily in nearshore environments, ranging from northern Baja peninsula in Mexico to the Gulf of Alaska. They inhabit depths from the sub-tidal zone as juveniles to approximately 180 meters (Love et al. 2002). Typically, Copper Rockfish are encountered in waters shallower than 100 meters, where they thrive in nearshore kelp forests and complex low-relief rocky habitats (Love 1996). Adults exhibit high site fidelity and are not known to undertake long-distance movements. They are considered relatively long-lived, living for at least 50 years (Love 1996). Based on life history traits and vulnerability to external stressors, this species has been classified as one of the most vulnerable among West Coast groundfish stocks (Cope et al. 2011). As opportunistic carnivores, copper rockfish primarily feed on crustaceans, mollusks, and fish (Lea et al. 1999; Bizzarro et al. 2017). Juveniles are preyed upon by Harbour Seals and Lingcod.

Currently, genetic studies provide limited evidence of significant stock structure among Copper Rockfish along the West Coast. Buonaccorsi et al. (2002) investigated genetic variation using six microsatellite DNA loci in samples from British Columbia to southern California. They found notable population subdivision between Puget Sound and coastal samples, supporting the isolation-by-distance model. Additionally, a study of Copper Rockfish in five sounds along the west coast of Vancouver Island, including Barkley Sound, examined genetic diversity and phenotypic variation between the outer coast and inlet heads (Dick et al. 2014). Copper Rockfish from the head of the inlet in Barkley Sound were genetically distinct from those at the outer coast site. This finding corresponds with a broader pattern of significant genetic differentiation between paired coastal and head of inlet sites across all five sounds, indicating limited gene flow between these habitats. The study also revealed that the head of inlet population had low genetic diversity, which aligns with the general trend of reduced genetic diversity in head of inlet populations compared to those found along the coast.

China Rockfish (*Sebastes nebulosus*) is a medium-sized, commercially and recreationally prized deeper-dwelling nearshore rockfish ranging from southern California, north to the Gulf of Alaska (Love et al. 2002). Core abundance is found from northern California to southern British Columbia, Canada. There is limited information available on either stock structure or life history. No genetic research has been conducted for China Rockfish, and no published research indicates separate stocks along the West Coast (Dick et al. 2016). China Rockfish are among the longer-lived rockfish, living to at least 79 years. They consume a diet of benthic organisms (brittle stars, crabs and shrimps) (Love et al. 2002). Both juvenile and adult China Rockfish tend to be solitary and exhibit high site fidelity within rocky habitats.

Pacific Ocean Perch

Pacific Ocean Perch (*Sebastes alutus*) is a long-lived commercially important species found in the Southeast of **ƛušiiʔaaʔaq**/Swiftsure Bank into the Strait of Georgia, and in the Southwest corner along the EEZ line. They are found along the west coast of North America from California to the Bering Sea at depths ranging from 40-600 m along sloping areas and canyon walls in

association with other rockfish species. They have a higher probability of occurrence along the edge of the continental shelf on the slope. They last had their West Coast Vancouver Island population (stock) assessed in 2023. **ƛ̓ušiiʔaaʔaq** is within Groundfish Management Unit (GMU) area 3C but trends are reported for the combination of areas 3C and D, as an independent stock, covering all of west coast Vancouver Island (DFO 2024g). This stock (and others in the Pacific Region) were assessed to be in the Healthy zone and trending upward, however stock status for 3CD has greater uncertainty than for the other two stocks in BC (Table 14).

Table 14. Stock status information for Pacific Ocean Perch (Sebastes alutus) from 2024 Stock Assessment (DFO 2024g). LRP = limit reference point; USR = upper stock reference; B_{2023} = Spawning biomass at the start of 2023; B_{msy} = Maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2024	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$	5ABC: B_{2024}/B_{MSY} = 1.99 3CD: B_{2024}/B_{MSY} = 2.81 5DE: B_{2024}/B_{MSY} = 2.88	Healthy Zone	Not required	N	N

Quillback Rockfish

Quillback Rockfish (*Sebastes maliger*) are found throughout the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and into Barkley Sound. It is part of an inshore rockfish complex, occurring mostly between 14 and 143m in depth in rocky habitats. The species is commonly found coastwide in BC and ranges from the Gulf of Alaska to Southern California (Huynh et al. 2024). It is a long-lived species, up to 95 years. The species is commercially and recreationally prized and is of value to Indigenous fisheries coastwide. Its shallow distribution means it has been fished for many decades (COSEWIC 2009b). Quillback Rockfish bones and eDNA are found in nearby archaeological samples from shellfish middens of Indigenous coastal villages (Rodrigues et al. 2018).

The population off the West Coast of Vancouver Island – overlapping with the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, is considered to be part of the outside management unit. Quillback Rockfish were designated as Threatened by COSEWIC in 2009. The status of the Quillback Rockfish outside stock was recently evaluated with regards to a Limit Reference Point (LRP) and Upper Stock Reference (USR) of 0.4 BMSY and 0.8 BMSY, respectively. The 2021 spawning biomass was estimated to be 189% of BMSY (standard deviation (SD) = 13%), and above both the LRP and USR with a 99% probability – the stock is in the healthy zone with a high degree of probability (Table 15; DFO 2023d). Recently the population declines were estimated for the inside stock, found in GMU 4B which includes the Strait of Juan de Fuca to the southern extents of **ƛ̓ušiiʔaaʔaq**, though the stock was estimated to be above the LRP (Huynh et al. 2024).

Table 15. Stock status information for Outside Quillback Rockfish (Sebastes maliger) from 2023 Application of the Management Procedure Framework (DFO 2023e). LRP = limit reference point; USR = upper stock reference; TRP = target reference point; B_{2021} = Spawning biomass at the start of 2021; B_{msy} = Maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2023 (Outside)	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$ TRP = B_{MSY}	B_{2021}/B_{MSY} = 1.93	Healthy Zone	Not required	Threatened (2009)	N

Rougheye/Blackspotted Rockfish complex

The Rougheye/Blackspotted Rockfish complex (*Sebastes aleutianus/S. melanostictus*) are a commercially valuable sympatric species complex found patchily in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area along the southeastern edge into the Strait of Georgia, in the southwestern edge and the rocky areas towards the northwestern corner of the area. The species occur on seafloor areas with soft substrates and boulders and sloped areas of at least 20 degrees. The species complex is among the longest-lived fish on earth (DFO 2012b). The complex is found in the Pacific Ocean, spanning from the northwestern Pacific to British Columbia and southern California. However, the distribution and abundance of these two species in Canadian waters are unknown. The complex is listed by SARA as 'special concern' in part because of the complex's recent identification (used to be thought to be just Rougheye Rockfish) and its biology (long life and low fecundity) that makes it particularly susceptible to fishing (DFO 2012b). The species co-occur with other commercially targeted species, including Pacific Ocean Perch. They consume shrimp and other fish species, identified from studies in Alaska, and are predated on by Pacific Halibut, Pacific Cod, and Sablefish. Further information on their biology, sensitivities and research needs are provided by Fisheries and Oceans Canada (2012b), however the information is not regionally specific.

A 2020 coastwide stock assessment of the complex showed that the southern stock of the complex is comprised mostly of Rougheye Rockfish, including the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Members of the southern stock can live as long as 25 years (DFO 2020). The southern stock has been on the decline since 1935 and the current catch strategy was determined to not be sustainable over the long term (Table 16; DFO 2020). Therefore, following the 2020 stock assessment, management was updated to incorporate two separate stock areas (northern and southern stocks) and the total allowable catch (TAC) was decreased (DFO 2024a).

Table 16. Stock status information for Rougheye/Blackspotted Rockfish Complex (Sebastes aleutianus/S. melanostictus) from 2020 Stock Assessment (Starr and Haigh 2020). LRP = limit reference point; USR = upper stock reference; B_{2020} = Spawning biomass at the start of 2020; B_{msy} = Maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2020	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$	North: B_{2021}/B_{MSY} = 2.21 South: B_{2021}/B_{MSY} = 1.07	Healthy Zone	Not required	Special Concern (2007)	Special Concern (2009)

Yelloweye Rockfish

Yelloweye Rockfish (*Sebastes ruberrimus*) are found throughout the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and into Barkley Sound. Yelloweye Rockfish is a widely distributed species along the Pacific coast from the Aleutian Islands in Alaska to northern Baja peninsula in California. They occur in high-relief rock habitats at depths between 15 and 549 metres, but adults are commonly found at depths between 91 and 180 metres (Eschmeyer and Herald 1983; Kramer and O'Connell 1995; Love et al. 2002). In BC, Yelloweye Rockfish exhibit a demersal existence over hard, complex substrates such as rock reefs and boulder fields. Observations from submersibles in BC show juvenile Yelloweye Rockfish occur at depths from 30 to 168 metres, generally shallower than the adults which range from 30 to 232 metres (Yamanaka et al. 2006). In some areas, juveniles were observed coexisting with adults in the same steep rock reef habitat. Both juveniles and adults commonly associate with corals and sponges that also occur in these rock habitats. The species is long-lived, with a documented maximum age of 121 years in BC. Their life history is not well known (Yamanaka et al. 2018). They appear to be largely sedentary, demersal and show some site fidelity.

Yelloweye Rockfish are aggressive piscivores that prey on various species, including rockfishes, Pacific Herring (*Clupea pallasi)*, juvenile cod (*Gadidae*), Pacific Sand Lance (*Ammodytes hexapterus*), flatfishes (*Pleuronectiformes*), opal squid (*Loligo opalescens*), shrimps (*Caridea* spp., *Pandalus* spp.), and crabs (*Acantholithodes hispidus*, *Cancer oregonensis*) (Steiner 1978; Rosenthal et al. 1988; Love et al. 2002). Due to their piscivorous diet, longevity, size, and sedentary nature, Yelloweye Rockfish likely play a significant role in the rock reef ecosystem. Additionally, they are preyed upon by Sperm Whales (*Physeter macrocephalus*), Killer Whales (*Orcinus orca*), Harbour Seals (*Phoca vitulina*), and Steller Sea Lions (*Eumetopias jubatus*) (Olesiuk et al. 1990; Ford and Ellis 2006; Lance et al. 2012; Ford 2014). Juvenile Yelloweye Rockfish are vulnerable to predation from Chinook Salmon (*Oncorhynchus tshawytscha*), other rockfishes, Lingcod (*Ophiodon elongatus*), and marine birds (Mills et al. 2007). This species is also found in nearby archaeological samples from shellfish middens of Indigenous coastal villages (Rodrigues et al. 2018) and is an important Indigenous food resource (Yamanaka et al. 2018).

A Yelloweye Rockfish stock status report was prepared for the Committee on the Status of Wildlife in Canada (COSEWIC) in 2006 (Yamanaka et al. 2006). Research on the genetic population structure identified two distinct populations of Yelloweye Rockfish in British Columbia, which COSEWIC classifies as two designatable units known as "Inside" and "Outside" (Yamanaka et al. 2000, 2006; COSEWIC 2008; Siegle et al. 2013, 2013). The Outside population is broadly distributed, extending from fishing areas near Sitka in Southeast Alaska, westward to SGaan-Kinghlas-Bowie Seamount, and as far south as Washington State and northern Oregon. The Outside population of Yelloweye Rockfish was designated as Threatened in December of 2020 by COSEWIC (COSEWIC 2020). The Outside population is assessed as a northern and southern stock. A 2023 assessment of the Outside population of Yelloweye Rockfish (DFO 2023f) suggested the population is in the Healthy zone, with an 87% probability of being above the upper stock reference point (Table 17). The southern stock is also estimated above its upper stock reference point with an 80% probability and in the Healthy zone (DFO 2023f).

Table 17. Stock status information for Yelloweye Rockfish (Sebastes ruberrimus) from 2023 Management Procedures Update and Catch Advice (DFO 2023f). LRP = limit reference point; USR = upper stock reference; TRP = target reference point; B_{2018} = Spawning biomass at the start of 2018; B_{msy} = Maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2023 (Outside)	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$ TRP = B_{MSY}	North: B_{2018}/B_{MSY} = 1.15 South: B_{2018}/B_{MSY} = 1.16 CW: B_{2018}/B_{MSY} = 1.17	Healthy Zone	Not required	Threatened (2020)	Special Concern (2011)

Yellowtail Rockfish

Yellowtail Rockfish (*Sebastes flavidus*) are a commercially important species found in the deeper southern and western portions of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. This species is also commonly found in nearby archaeological samples from shellfish middens of Indigenous coastal villages near **ƛ̓ušiiʔaaʔaq** (Rodrigues et al. 2018). They are found throughout the water column at depths between 0 and 550 m. Adults are semi-pelagic or pelagic and spend time near steep slopes and above rocky reefs, commonly on the ocean floor of the continental shelf. In managed area 3CD (the west coast of Vancouver Island, including **ƛ̓ušiiʔaaʔaq**) the species is typically caught between 102 and 247 m (DFO 2015). Adult Yellowtail Rockfish feed on shellfish, such as shrimp, and small forage fish, such as anchovies, and are widely distributed across the coast from Alaska to the Baja peninsula in California and Mexico. The species is unique for being able to rapidly release gas from their swim bladders. Consequently, when caught at depth the Yellowtail Rockfish can avoid barotrauma that kills most other rockfish species.

Although there is no biological evidence for stock structure within BC waters, YTR is currently managed in two areas: a “boundary” management area that includes GMU area 3C (overlapping with **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank) and a “coastal” management area that includes areas 3D and 5A-E (DFO 2015). The 2015 stock assessment determined the coastwide stock was in the Healthy zone (Table 18; DFO 2015). Their stock assessment is being updated currently.

Table 18. Stock status information for Yellowtail Rockfish (Sebastes flavidus) from 2015 Stock Assessment (DFO 2015). LRP = limit reference point; USR = upper stock reference; B_{2015} = Spawning biomass at the start of 2015; B_{msy} = Maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2015	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$	B_{2015}/B_{MSY} = 2.20	Healthy Zone	Not required	N	N

6.2.4.1.1.2 Flatfish

Flatfish (Order *Pleuronectiformes*) are a group of benthic fish that live on continental shelf habitats, generally in sandy and mud flat bottoms. At least 13 species of flatfish occur in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Figure 117, Appendix F) and include the populace Pacific Halibut, several sole species, and two flounder species. Eight species of flatfish have been previously

identified as being of biological importance to the Juan de Fuca Eddy EBSA (Table 8; (Jamieson and Levesque 2014)). Imagery gathered on **ƛ̓ušiiʔaaʔaq** during a 2022 survey (2022002PGC, see Cold Seeps EBSAs section) did confirm the presence of several species with Dive OY086 and camera stations 054/055, 056 observing the Starry Flounder (*Platichthys stellatus*), and Dover Sole (*Microstomus pacificus*). Sand sole (*Psettichthys melanostictus*) has been observed coastal areas near Cheewaht (J. Yakimishyn, PCA, pers. comm.). More information on Pacific Halibut, a key resource fish and ecologically important species, and several sole species and Arrowtooth Flounder, which all contribute to the biological significance of the Juan de Fuca Eddy EBSA, is provided below.

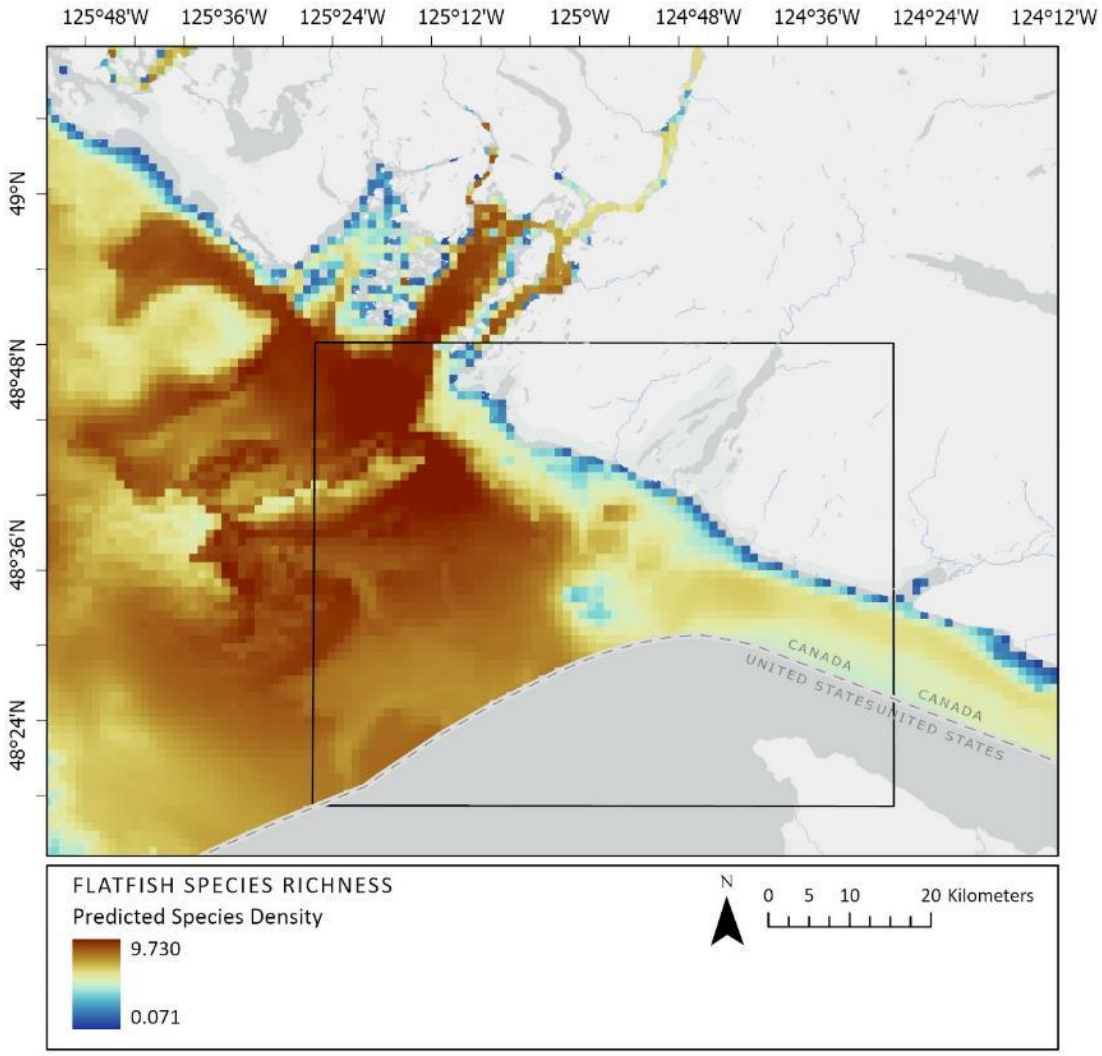


Figure 117. Summed predicted species density values per grid cell (Species Richness) for flatfish species, including 12 species modeled in ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank using the Thompson et al. (2023a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 57 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used.*

Pacific Halibut

Pacific Halibut (*Hippoglossus stenolepis*) is a significant species for First Nations and coastal communities for cultural use and food security. Adult Pacific Halibut have a high trophic position, a wide variety of diets, and juveniles are important prey for larger animals (Best and St-Pierre 1986; Ford 2014). Pacific Halibut is found throughout the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area. For a detailed species profile on Pacific Halibut please refer to Hunter and Wade (2015).

The largest of all flatfish species in BC, many adult Pacific Halibut reside in demersal waters up to 1500 m in the outer continental shelf and slope. Pacific Halibut will use the inner continental shelves and inlets as nurseries and migrate into deeper waters as early as two years old. Spawning season occurs from November to March. Recruitment of juvenile Pacific Halibut has been shown to be variable in historical records, and this variability is thought to follow oceanic productivity cycles in the North Pacific (Clark et al. 1999). Larval Pacific Halibut feed on zooplankton, whereas juveniles feed on invertebrates and other small fish. During these stages, they are vulnerable to predation by other fishes, whereas adults will only be targeted by marine mammals and sharks.

Pacific Halibut is one of the seven major commercial groundfish fisheries in BC (see Commercial Fishing section), and Pacific stocks are assessed annually by the International Pacific Halibut Commission. Most Pacific Halibut stocks in the Pacific region showed population decline and a decrease in size at catch from the 1990s to 2012, with a smaller decline from 2017 onwards. Still, the stock for BC (IPHC Regulatory Area 2B) is assessed as healthy, and stocks are assumed to repopulate in upcoming years when the 2012-age cohort matures (Table 19; Stewart and Hicks 2022). Thompson et al. (2023a) examined changes in Pacific Halibut distribution according to future climate scenarios, specifically temperature and dissolved oxygen concentration changes. Their results suggested a decrease in BC Pacific Halibut populations as a response to decreased dissolved oxygen concentration in shallow coastal waters, similar to habitats in the shallower coastal portions of the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area. Protection of areas with larger bathymetric variation can allow for species to move to deeper regions with more favourable oxygen concentrations, if their physiology and habitat requirements allow.

Table 19. Stock status information for Pacific Halibut (Hippoglossus stenolepis) from 2024 Stock Assessment (Hicks et al. 2024; Stewart and Hicks 2025). LRP = limit reference point; USR = upper stock reference; TRP = target reference point; B_0 =mean equilibrium unfished biomass (average biomass level before any fishing had occurred ; B_{2023} = Spawning biomass at the start of 2023; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2024	LRP= $0.2B_0$ USR = $0.3B_0$ TRP = $0.36B_0$	$B_{2024}/B_0 = 0.38B_0$	Healthy Zone	Not required	N	N

Arrowtooth Flounder

Arrowtooth Flounder (*Atheresthes stomias*) has been identified as contributing to the biological importance of the Juan de Fuca Eddy EBSA (Jamieson and Levesque 2014). Arrowtooth Flounder are prey generalists (Fargo et al. 1981; Yang 1993; Doyle et al. 2018)). The species is predated on by Pacific Cod, Pacific Halibut, and Steller Sea Lions, adult Arrowtooth Flounder

when juveniles, and pollock (Spies et al. 2019). Migration patterns are not well known but larger fish may migrate to deeper water in winter and to shallower water in summer (Rickey 1995; Fargo and Starr 2001). Spawning and hatching occur in deeper waters (> 350 m) along the continental shelf break in fall and winter (Rickey 1995; Blood et al. 2007). Arrowtooth Flounder are found throughout the majority of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, not including the nearshore shallow areas. The stock is currently considered to be in the cautious zone relative to the Limit Reference Point (Table 20), and has had a low and declining recruitment from 2010-2019 coast-wide (DFO 2023g). A single stock has been identified along the BC coast based on a lack of observable differences in mean weight, length, or growth. Commercial catches are highest on the edge of the continental shelf, as well as along the edges of the main gullies in Queen Charlotte Sound and the eastern portion of Dixon Entrance.

Table 20. Stock status information for Arrowtooth Flounder (Atheresthes stomias) from 2023 Stock Assessment (DFO 2023g). LRP = limit reference point; USR = upper stock reference; B_{2022} = Spawning biomass at the start of 2023; B_0 = unfished spawning biomass (males plus females) at the mean recruitment level; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2023	LRP= $0.2B_0$ USR = $0.4B_0$	B_{2022}/B_0 = 0.37	Cautious Zone	Not required	N	N

Sole

Seven sole species have been identified as contributing to the biological importance of the Juan de Fuca Eddy EBSA (Jamieson and Levesque 2014): Dover Sole (*Solea solea*), English Sole (*Parophrys vetulus*), Flathead Sole (*Hippoglossoides elassodon*), Petrale Sole (*Eopsetta jordani*), Rex Sole (*Glyptocephalus zachirus*), Rock Sole (*Lepidopsetta bilineata*), and Sand Sole (*Pegusa lascari*). English Sole, Flathead Sole, Rex Sole, Rock Sole and Sand Sole all have important distribution areas in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, with varying spatial coverages ranging from 4 to 100% of the Juan de Fuca Eddy EBSA (Table 4 in Jamieson and Levesque 2014). **ƛ̓ušiiʔaaʔaq** is an important area for a smaller portion of the Juan de Fuca Eddy EBSA spatial area for Dove Sole and Petrale Sole (Jamieson and Levesque 2014).

Population trends of flatfish species are limited generally and for the West Coast of Vancouver Island. The Rex sole has no official stock assessments in BC. The stock assessments for Dover Sole (DFO 1999), and Petrale Sole (Starr 2009) are currently outdated or have high data uncertainty. However, an updated stock assessment for Dover Sole is underway and a stock assessment for Petrale Sole completed in 2024 is pending publication and placed that species in the Healthy zone (T. Williams, Pacific Fisheries Management Inc., pers. comm.). Ongoing data collection in support of flatfish research, inclusive of Arrowtooth Flounder, Petrale Sole, Southern Rock Sole, Dover Sole, and English Sole occurs through surveys and commercial sampling, with a gap in 2020 due to the suspension of the At Sea Observer program due to COVID-19 (Cornthwaite and Williams 2022). More information regarding the biology and regional distribution of sole species in the area would address this data gap. Furthermore, sole species, including English sole, are important food resources for upper trophic level carnivores (e.g., Steller Sea Lions; Liu et al. in press).

6.2.4.1.1.3 Roundfish

At least four species of roundfish occur in **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank, including Pacific Cod (*Gadus macrocephalus*), Pacific Hake (*Merluccius productus*), Pacific Tomcod (*Microgadus proximus*), and Walleye Pollock (*Gadus chalcogrammus*) (Appendix F, **Figure 118**). Pacific Hake has an Important Area overlapping 13% of the Juan de Fuca Eddy EBSA (Jamieson and Levesque 2014).

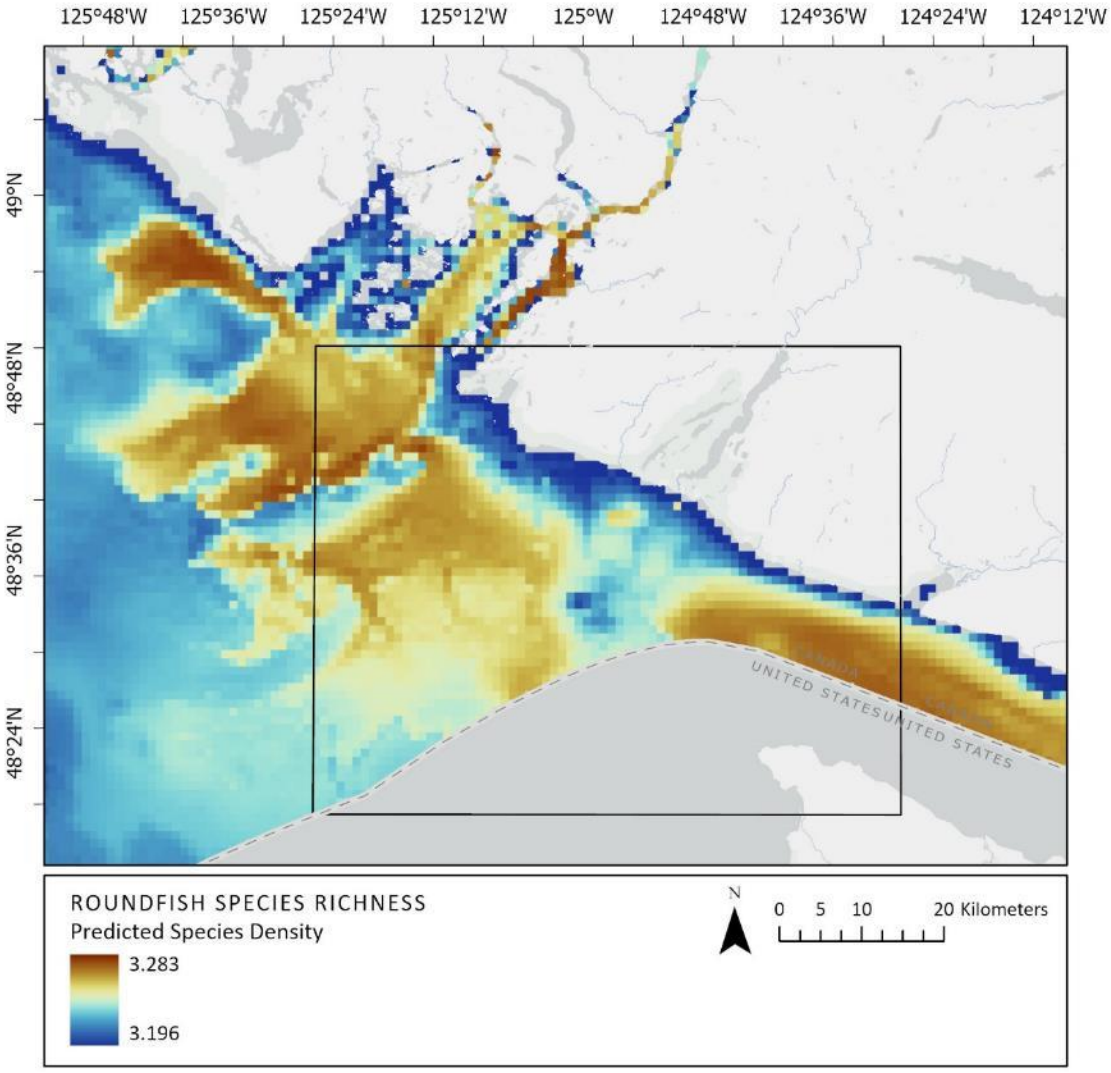


*Figure 118. Summed predicted species density values per grid cell (Species Richness) for four Roundfish species modeled (Walleye Pollock, Pacific Hake, Pacific Cod and Pacific Tomcod) in **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank using the Thompson et al. (2023a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 57 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used.*

Walleye Pollock

Walleye Pollock (*Theragra chalcogramma*) undergo diurnal (daily) vertical migrations through the water column. Although nearshore survey sampling is limited, Walleye Pollock are found throughout **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Their prey species include crustaceans, Pacific Hake, squid, Pacific Sand Lance, and Pacific Herring (Gale et al. 2019). They are prey species for a variety of taxonomic groups including marine mammals, sea birds, and fish. Due to their importance as a food resource, Walleye Pollock population dynamics have been implicated to affect other key ecological groups such as marine birds and marine mammals (e.g., Springer 1992; Rosen and Trites 2000; Fritz and Hinckley 2005). Stock status for the BC South stock, which includes **ƛ̓ušiiʔaaʔaq**, in 2017 was predicted to decline over the following 1 to 2 years (Table 21; Starr and Haigh 2021). 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.

Table 21. Stock status information for Walleye Pollock (Theragra chalcogramma) from 2018 Stock Assessment (DFO 2018b). LRP = limit reference point; USR = upper stock reference; B_{min} = minimum spawning biomass from which the stock subsequently recovered to the average spawning biomass from 1967 – 2016; B_{2017} = Spawning biomass at the start of 2017; B_{avg} = proxy for B_{MSY} (maximum sustainable yield); COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2017 (BC South*)	LRP = B_{MIN} USR = 2*B_{MIN}	B_{2017}/B_{avg} = 0.90	Healthy Zone	Not required	N	N

*BC South refers to four outside Pacific Marine Fisheries Commission (PMFC) major areas (3C, 3D, 5A, 5B plus minor areas 12 and 20).

Pacific Hake

Pacific Hake (*Merluccius productus*) is the most abundant commercial stock in the California Current system (Edwards et al. 2022). Pacific Hake use La Perouse Bank as a foraging and migration corridor and **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank as an area for aggregation and contribute to the biological significance of the Juan de Fuca Eddy EBSA (Jamieson and Levesque 2014). Pacific Hake are highly migratory (Gale et al. 2019). Spawning occurs during the winter season in coastal areas and aggregations are found in the mid-water continental shelf and slope. The highest densities are located in bottom depths of 200-300 m. Juveniles are found in nearshore waters whereas older individuals are found in deeper waters. During El Nino (warmer) events, a larger proportion of stock migrates into BC waters, whereas a smaller population is found during La Nina (cooler) years. There are at least 60 known predator species of Pacific Hake (Coad 1995; Love 2011). Of note, studies have examined the decreased abundance of Pacific Hake in relation to the increased abundance of their predator, Humboldt Squid (*Dosidicus gigas*) (Stewart et al. 2014; Taylor et al. 2015). This population is modelled as a single stock throughout the West Coast of Canada and the United States. Coastwide stock assessments for both countries were found in the healthy zone with respect to upper stock reference metrics set by DFO (Johnson et al. 2025). The highly variable recruitment rate of Pacific Hake and the fluctuations in population biomass were sources of high uncertainty for population modelling (Johnson et al. 2025). For a detailed species profile on Pacific Hake please refer to Hunter and Wade (2015).

Table 22. Stock status information for Pacific Hake (Merluccius productus) from 2024 Stock Assessment (Johnson et al. 2025). LRP = limit reference point; USR = upper stock reference; B_{2024} = Spawning biomass at the start of 2024; B_{msy} = Biomass for maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2025	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$	B_{2024}/B_{MSY} = 2.66	Healthy Zone	Not required	N	N

Pacific Cod

Pacific Cod (*Gadus macrocephalus*) is a fast-growing, relatively short-lived (~10–13 years), member of the family Gadidae. It is distributed throughout the North Pacific Ocean, and throughout the waters of BC, typically in depth ranges up to 200 m and have spatially limited migrations. Their diets include marine invertebrates (crabs and shrimps), Pacific Sand Lance, and Pacific Herring (Westrheim 1996). Variation in Pacific Cod predation may affect Pacific Herring abundance and recruitment (Walters et al. 1986). In turn, they are eaten by Pacific Halibut, North Pacific Spiny Dogfish, and pinnipeds (Westrheim 1996). Although nearshore survey sampling is limited, Pacific Cod are commonly found throughout **ʎ̓ušiiʔaaʔaq̓**/Swiftsure Bank.

The most recent assessment and stock status update placed Pacific Cod stocks on the West Coast of Vancouver Island (area 3CD) in the Cautious Zone (Forrest et al. 2020; DFO 2024h). Genetic population differentiation was uncertain for BC stocks (Forrest et al. 2015). A stock update for 2023 (DFO 2024h) continues to model the 3CD stock in the Cautious Zone (Table 23). Current fishing mortality, while estimated to be low, is increasing slightly. Pacific Cod populations, particularly in Alaska, have experienced significant declines since the marine heatwave of 2015 and 2016 (e.g., Laurel and Rogers 2020; Barbeaux et al. 2020). However, survey indices of abundance in other regions of BC (Hecate Strait, Queen Charlotte Sound, and the West Coast of Haida Gwaii) have not suggested similar declines (DFO 2024h). A comprehensive analysis of the factors contributing to the current decline of the Area 3CD Pacific Cod stock has not yet been conducted, and is a major data gap. This decline may be linked to climate change impacts on egg, larval, and juvenile stages (Abookire et al. 2022; Laurel et al. 2023) or adult stages (Barbeaux et al. 2020), as well as fish movement, fishing pressure, or other variables (DFO 2024h).

Table 23. Stock status information for Pacific Cod (Gadus macrocephalus) from 2023 Stock Assessment (DFO 2024h). LRP = limit reference point; USR = upper stock reference; B_{2023} = Spawning biomass at the start of 2023; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2024 (WCVI*)	LRP= B_{1986} USR = Mean Biomass Estimate 1956-2004	B_{2023}/LRP = 1.16 B_{2023}/USR = 0.36	Cautious Zone	Not required	N	N

*West Coast Vancouver Island stock refers to two outside Pacific Marine Fisheries Commission (PMFC) major areas (3C and 3D).

6.2.4.1.1.4 Other Groundfish

In addition to the rockfish, flatfish and roundfish, other groundfish species live and feed on or near the bottom of the Pacific Ocean, utilizing mud, sand, or gravel habitats. Thirteen species included in this group occur in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Appendix F). Those modeled by Thompson et al. (2023b) that have modeled distributions in **ƛ̓ušiiʔaaʔaq** (**Figure 119**) include: Lingcod (*Ophiodon elongatus*), Sablefish (*Anoplopoma fimbria*), Blackbelly Eelpout (*Lycodes pacificus*), Cabezon (*Scorpaenichthys marmoratus*), and Threadfin Sculpin (*Icelinus filamentosus*). Highest predicted species density for this grouping is in the deeper regions of the **ƛ̓ušiiʔaaʔaq** Area, with at least three of these species occurring. More information on the commercially important Lingcod and Sablefish are provided below.

Imagery gathered on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank during a 2022 survey (2022002PGC, see Cold Seeps EBSAs) did confirm the presence of several species with Dive OY086 and camera station 054/055 catching imagery of sculpins (Suborder Scorpaenoidei), and Lingcod (*Ophiodon elongatus*).

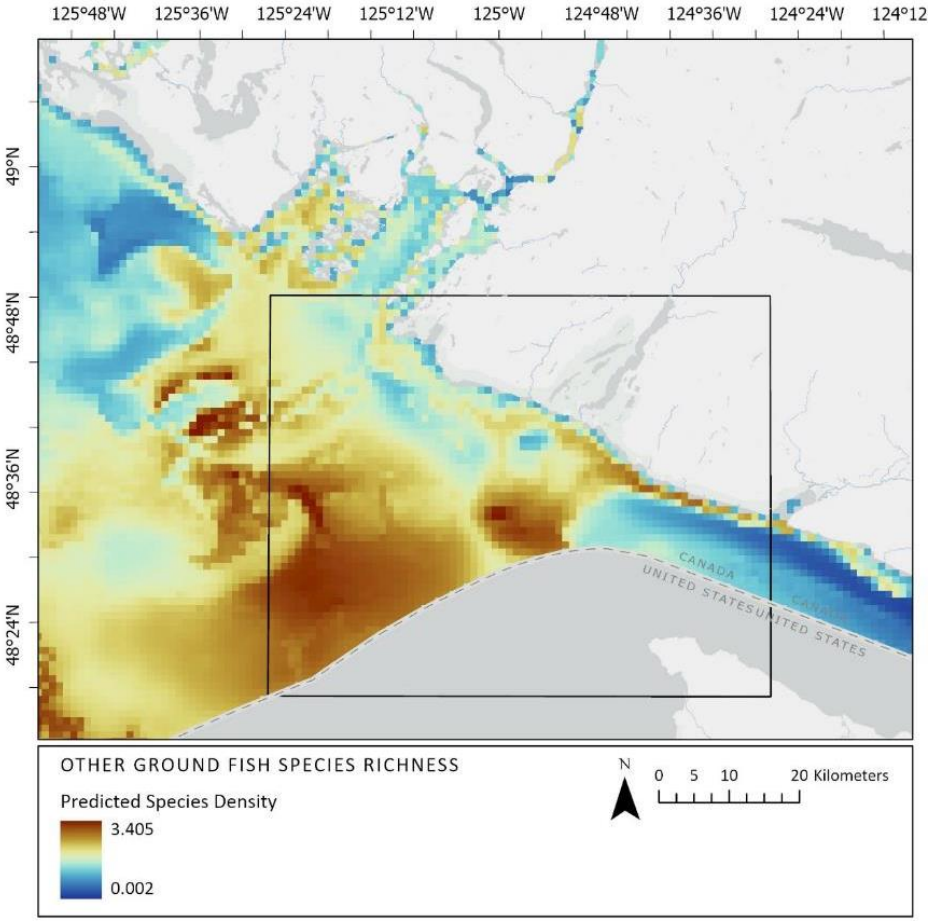


*Figure 119. Summed predicted species density values per grid cell (Species Richness) for five "Other Groundfish" species modeled (Lingcod, Sablefish, Blackbelly Eelpout, Cabezon, and Threadfin Sculpin) in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank using the Thompson et al. (2023a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 57 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used.*

Lingcod

Lingcod (*Ophiodon elongatus*) are commonly found in nearshore rocky habitats between 10 to 100 m, although their range goes to 450 m. Lingcod diet was found to be highly variable and includes many fish species (Beaudreau and Essington 2007; Pearsall and Fargo 2007), crustaceans, cephalopods, and other Lingcod (Cass et al. 1990; Beaudreau and Essington 2009). Predators include seals and sea lions (Cass et al. 1990). A unique characteristic of Lingcod is parental care for their egg masses, which are deposited in shallow (< 100 m) nearshore waters from December until March. Lingcod larvae hatch between March and April, and drift as plankton for 3 to 9 weeks before settling on flat benthic habitats as juveniles (Phillips and Barraclough 1977; Marko et al. 2007). Habitats with structural complexity, such as areas with high rugosity, eelgrass, and kelp beds, are important for juvenile and adult Lingcod (Cass et al. 1990; Petrie and Ryer 2006). Shallow areas with these features along the coast of **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank may be important habitats for Lingcod.

Tagging studies in BC have shown strong site fidelity (King and Withler 2005; Freiwald 2012). For example, Cass et al. (1990) showed a majority (95%) of fish stayed within 10 km of their tagging locations, and only a few migrated over 50 km. Juveniles tend to migrate further than adults (Cass et al. 1990; Smith et al. 1990). Male Lingcod aggregate during winter inshore spawning grounds and migrate back to nearshore areas in the summer seasons (Cass et al. 1990; Martell et al. 2000). Females spend a shorter time in spawning grounds (Cass et al. 1990).

Lingcod are commercially caught using trawl gear, which has limited presence within the nearshore areas of **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank but occurs throughout the rest of its extent. The other catch method is using hook and line gear (including handline, longline, and troll), which are present but at lower quantities (**Table 4**). Outside stocks in area 3C (overlapping with **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank) were last assessed over a decade ago as likely in the Healthy Zone, though considerable uncertainty existed in the stock status estimates (Table 24; DFO 2012c). Area 3D (North West Coast Vancouver Island) was safely assessed to be in the Healthy Zone based on an upper stock reference of at least 80% of optimal stock size at maximum sustainable yield (King et al. 2012). An updated assessment is planned for spring 2025.

Table 24. Stock status information for Lingcod (Ophiodon elongatus) from 2012 Stock Assessment (DFO 2012c). LRP = limit reference point; USR = upper stock reference; B_{2010} = Spawning biomass at the start of 2010; B_{MSY} = maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		Rebuilding Plan	COSEWIC	SARA
2011 (Area 3C*)	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$	B_{2010}/B_{MSY} = 1.11	Healthy Zone	Not required	N	N

*Stock status refers to Pacific Marine Fisheries Commission (PMFC) major area 3C.

Sablefish

Sablefish (also known as black cod; *Anoplopoma fimbria*) are one of the seven main BC commercial groundfish sectors, mainly caught by longline hook and trap gear (Lacko et al. 2021). Juvenile Sablefish feed on crustaceans, midwater fish, and, most importantly, Pacific Herring (Laidig et al. 1997; Buckley et al. 1999; Coutré et al. 2015). Adult Sablefish will feed on

demersal fish, cephalopods, and other fish species including juvenile salmon, rockfish, and Pacific Hake (Coutré et al. 2015). While adult Sablefish tend to inhabit and spawn in depths of 300-500 m in the edge of the continental shelf, Larvae and juvenile (up to 12 weeks of growth) Sablefish drift shoreward to coasts. Interestingly, SRKW have been observed foraging numerous times in **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank on Sablefish (Thornton et al. 2022b). Juvenile Sablefish remain over winter and migrate offshore to slope habitats in the late summer once they reach 400 - 600 mm (Rutecki and Varosi 1997). For a detailed species profile on Sablefish, please refer to Hunter and Wade (2015).

The BC Sablefish Research and Assessment Survey Program conducts annual surveys along the continental shelf edge in British Columbia and some inlet areas on the mainland (Figure 1 in Lacko et al. 2021). The surveys, therefore, do not overlap with the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area but do still describe population trends for the region. Sablefish population declines were seen in the past three decades, leading to reduced harvesting opportunities. The most recent revision to the Sablefish operating model estimated BC's Sablefish stock to have a high probability of being above the upper stock reference point and the target biomass of B_{MSY} in 2022 (DFO 2023h, 2024i). Genetic analyses supported one genetic population throughout its range in the Pacific Northwest from Alaska to the Baja peninsula in California (Tripp-Valdez et al. 2012).

Sablefish stock assessments for the US West Coast in 2021, including Neah Bay, show strong coastwide recruitment (Table 25; Johnson et al. 2023). Sablefish disperse to and from offshore seamounts; along the coastal waters of the U.S. West Coast, Canada, and Alaska; and across the Aleutian Islands to the Western Pacific. Further, a climate vulnerability analysis for the California Current Ecosystem (McClure et al. 2023) indicates that factors influencing Sablefish recruitment are affected by climatic and oceanic conditions. Due to Sablefish's significant climate vulnerability, it is expected that their abundance, productivity, and spatial distribution will change.

Table 25. Stock status information for Sablefish (Anoplopoma fimbria) from the 2024 Application of the Sablefish Management Procedure (DFO 2023h, 2024i). LRP = limit reference point; USR = upper stock reference; TRP = target reference point; B_{2022} = Spawning biomass at the start of 2022; B_{msy} = Maximum sustainable yield; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; SARA = Species at Risk Act.

Science Advice	Reference Points	Stock Status		COSEWIC	SARA	Rebuilding Plan
2022	LRP= $0.4B_{MSY}$ USR = $0.8B_{MSY}$ TRP = B_{MSY}	B_{2022}/B_{MSY} = 1.32	Healthy Zone	N	N	Not required

6.2.4.1.2 Pelagic fishes

Pelagic fish comprise free-swimming species that live in the water column of coastal or open ocean environments. Coastal pelagic fish thrive in the relatively shallow waters above the continental shelf, typically less than 200 meters deep (Levesque and Jamieson 2015). Conversely, oceanic fish, though occasionally found closer to shore, predominantly inhabit deep waters extending beyond the continental shelf, reaching far below the epipelagic zone, defined as upper 200 meters of the ocean. Coastal pelagic species are broadly categorized into two ecologically similar groups: forage fish and salmonids.

6.2.4.1.2.1 Forage Fishes

Forage fish are small to intermediate-sized marine fish that generally occupy low to middle trophic levels (mostly consuming zooplankton). Despite their modest size, they boast high levels of fat content and energy density, rendering them highly coveted prey for a myriad of marine predators, including fish, marine mammals, reptiles, and marine birds (e.g., Szoboszlai et al. 2015). Consequently, forage fish play pivotal roles in ecosystem structuring, with their population dynamics exerting significant influence on the diversity and overall health of coastal ecosystems at large (Guénette et al. 2014; Koehn et al. 2017). Their propensity to form dense aggregations facilitates their capture in substantial quantities, both by natural predators and human fisheries (Gale et al. 2019). Moreover, several forage fish species hold considerable commercial value, generating substantial revenues, and are deeply ingrained in cultural practices, serving as staple food sources, trade commodities, bait, and fodder for animals (e.g., Moody 2008; DFO 2025). At least seven species of forage fish occur in the **ƛušiiʔaaʔaq**/Swiftsure Bank Area (Appendix F). Four species of forage fish have been identified as species of biological importance for the Juan de Fuca Eddy EBSA: Eulachon (older juvenile offshore feeding area), Pacific Sardine (migration and foraging), Pacific Sand Lance (habitat), and Pacific Herring (feeding area) (Table 8; (Jamieson and Levesque 2014). More details on these species are provided below.

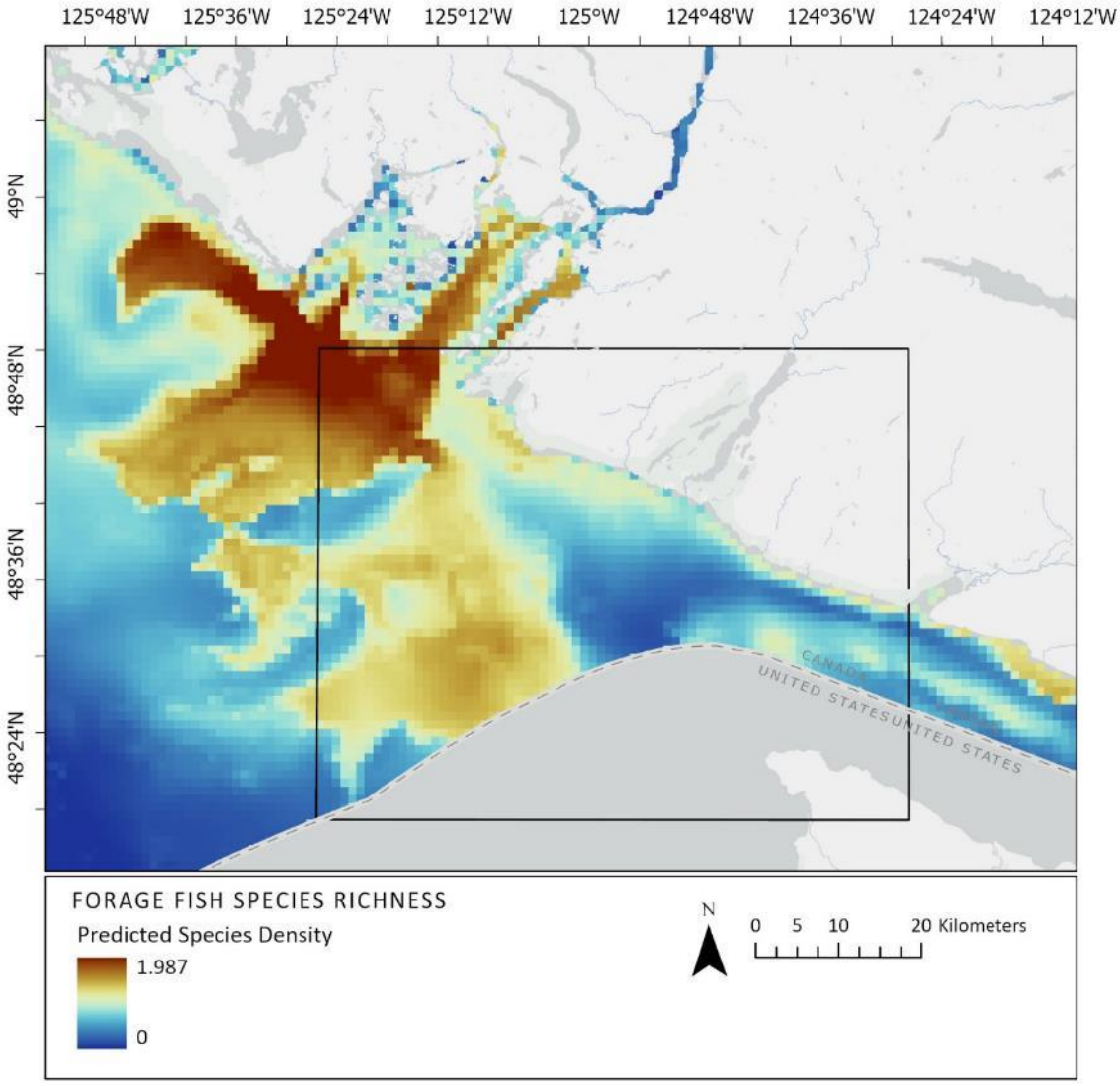


*Figure 120. Summed predicted species density values per grid cell (Species Richness) for three forage fish species (Eulachon, Kelp Greenling, Pacific Herring) modeled in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area using the Thompson et al. (2023a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 57 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used.*

Herring

Life history and distribution

In the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area, Pacific Herring contribute to the biological significance of the Juan de Fuca Eddy EBSA, using the region as a feeding area with large aggregations of pre-recruit and adult fish (Jamieson and Levesque 2014). Pacific Herring (hereafter referred to as Herring) are characterized by their small body size, schooling behavior, and short lifespan (typically less than 10 years) (Taylor 1964). Sexual maturity in Pacific Herring is reached at approximately three years, with adult Herring aged 3 and older embarking on migrations from their feeding and overwintering grounds to the same large geographical region each year for spawning during late winter and spring (Taylor 1964; Cleary et al. 2019). Spawning areas are located in nearshore habitats, restricted to inlets, sounds, bays, estuaries, and coastal waters with suitable spawning substrates and being sheltered from the surf of the ocean (Haegele and Schweigert 1985). Pacific Herring primarily deposit their eggs on marine vegetation, such as eelgrass, rockweed, kelps, and algae in intertidal and subtidal waters (Haegele and Schweigert 1985). Following their first year spent in coastal areas, Pacific Herring migrate offshore to continental shelf areas to forage during summer months.

In BC, Pacific Herring are managed individually for five major and two minor stock assessment regions, of which two are located in Southern BC, including the Strait of Georgia (SoG) and West Coast of Vancouver Island (WCVI) (Cleary et al. 2019; DFO 2022b). The primary spawning areas for the WCVI Herring stock are located within the Barkley Sound region, with no recorded occurrences in the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Figure 121). Over time, spawning areas in Barkley Sound have changed, and have been primarily confined to the northeast side the Sound since the 1980s.

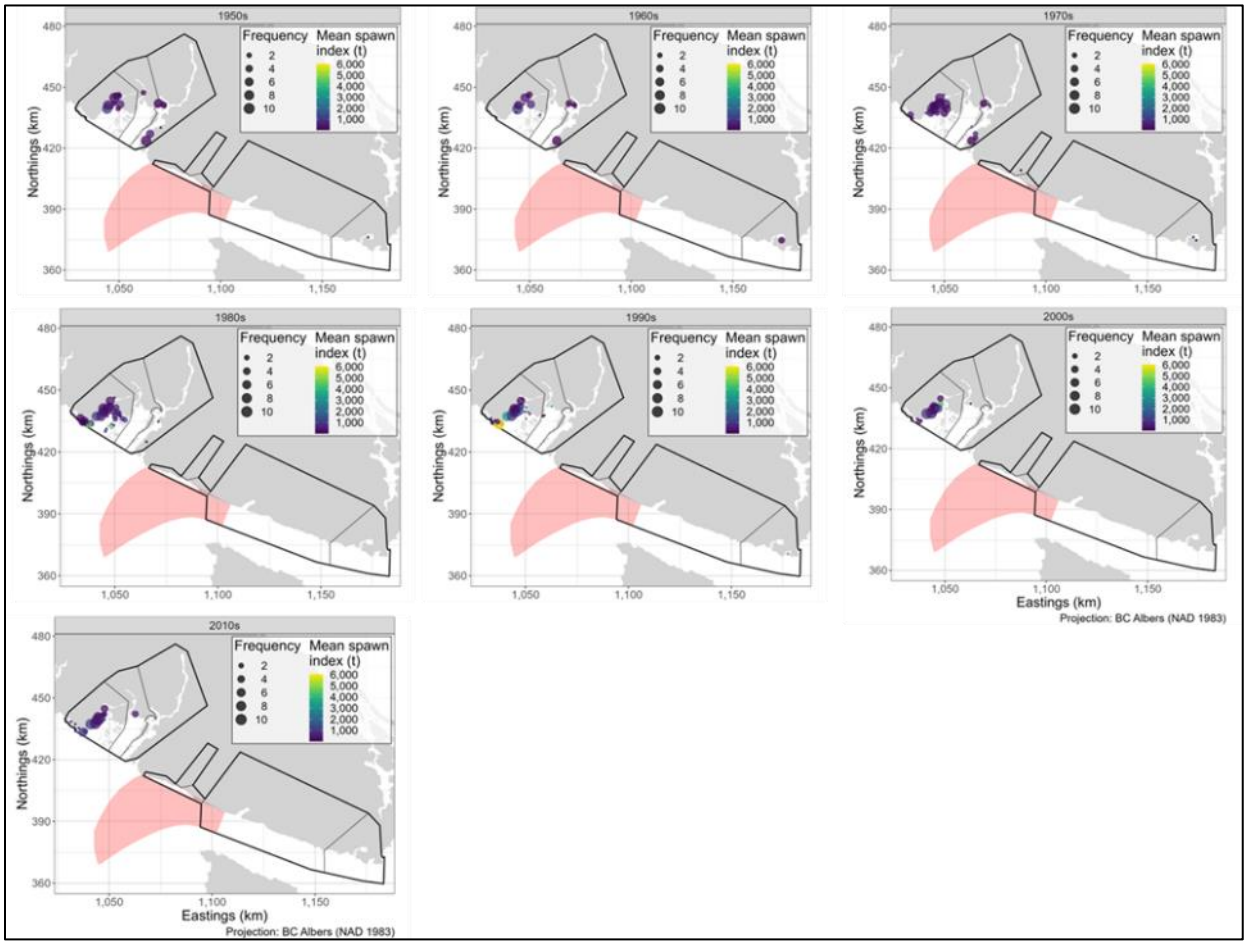


Figure 121. Spawning index and distribution off the West Coast of Vancouver Island through the 1950s to the 2010s. Source: Jaclyn Cleary, DFO.

Both the SoG and WCVI Herring stocks forage in the continental shelf areas off the WCVI during their juvenile and adult stages (Taylor 1964; Boldt et al. 2019; Cleary et al. 2019). Therefore, in the following sections, we include both the SoG and WCVI Herring stocks. DFO conducted annual night trawl surveys off the WCVI during 2006-2014 and annual integrated pelagic surveys on the Vancouver Island continental shelf during 2017-present; these surveys sample the pelagic ecosystem, including species such as Pacific Sardine (*Sardinops sagax*), Herring, and juvenile salmonids (Flostrand et al. 2015). Spatio-temporal modeling of survey data from 2006 to 2014 revealed that the typical mid-summer spatial distribution of Herring tends to concentrate on the continental shelf, characterized by waters with bottom depths less than 185 meters, including La Perouse and **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank (Figure 122; Godefroid et al. 2019). Conversely, lower abundances are generally observed along the shelf-break areas where water depth exceeds 185 meters (Godefroid et al. 2019). Spatio-temporal analyses of survey data (2006-2022) indicate that there was a general increase in the biomass of Herring in most summer foraging areas off the west coast of Vancouver Island; the highest biomass was observed in 2022 (Figure 122; (Boldt et al. 2023).

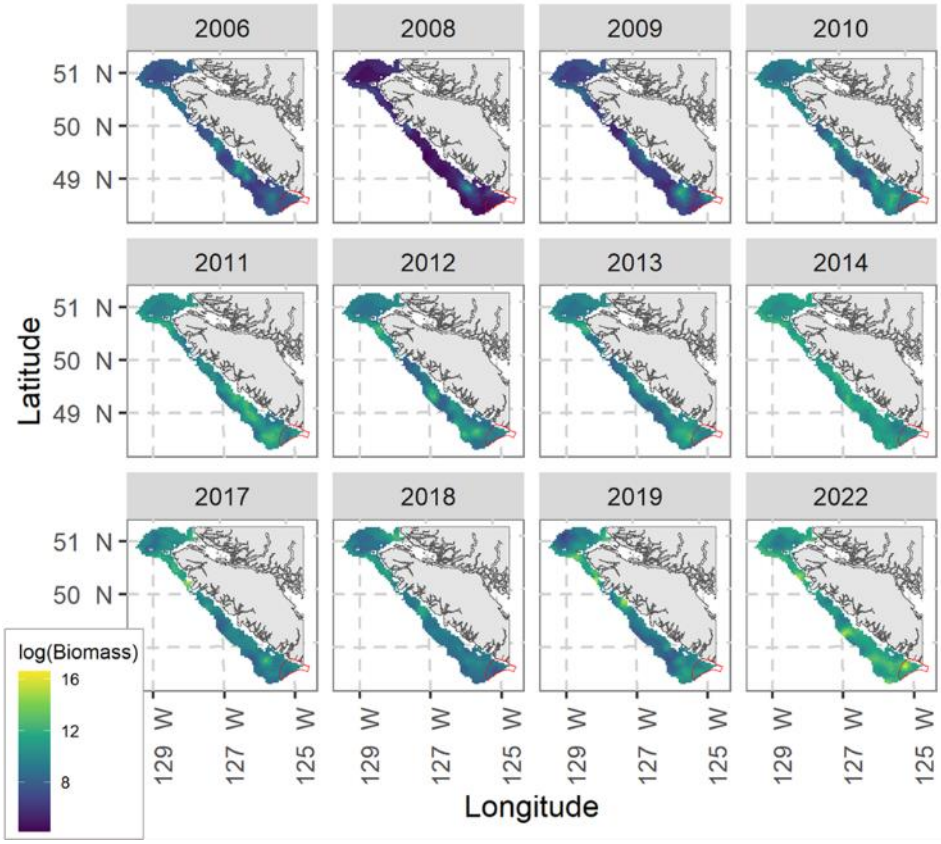


Figure 122. Pacific Herring biomass, as estimated with a spatio-temporal model, from the night pelagics (2006-2014) and Integrated Pelagic Ecosystem Science surveys (2017-2022). Adapted from Boldt et al. (2023). ***Ḵušiiʔaaʔaq****/Swiftsure Bank Area outlined in red.*

Population trend

Herring stocks have been quantitatively assessed and conservatively managed to meet management targets since the early 1980s (Haist and Stocker 1984; DFO 2022b). Despite increases in estimated natural mortality rates over the last three to five years, the spawning index of the SoG Herring stock has remained stable and high from 2011 through 2020 (Figure 123, top panel) (DFO 2022b). In contrast, the spawning index of the WCVI Herring stock has been low over the last two decades (Figure 123, bottom panel). Similarly, the total biomass trends for the SoG and WCVI Herring stocks exhibit different patterns of dynamics (Figure 124).

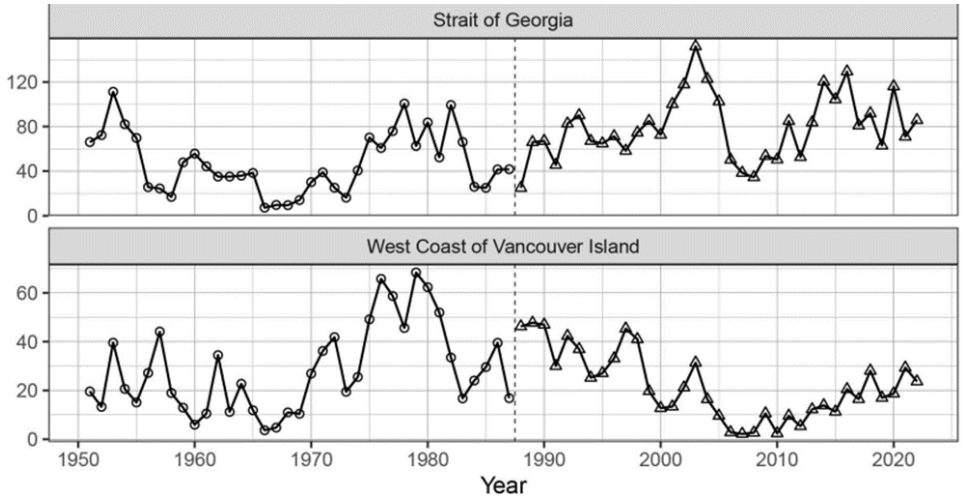


Figure 123. Spawn index in thousands of tonnes (t) for Pacific Herring from 1951 to 2022 in the Strait of Georgia and West Coast of Vancouver Island. The dashed vertical line delineates between two periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2022). Note: the 'spawn index' is not scaled by the spawn survey scaling parameter. Figure source: DFO (2022a).

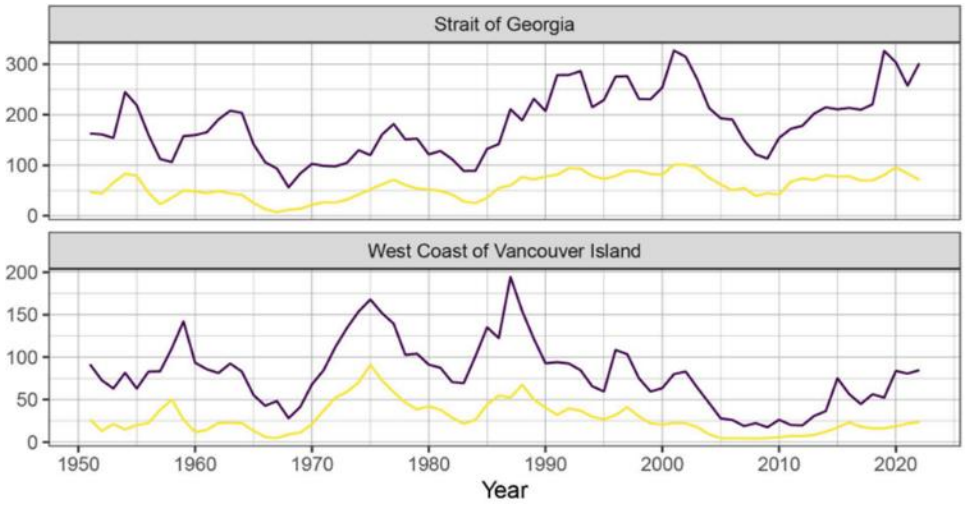


Figure 124. Total biomass (purple line) and spawning biomass (yellow line) in thousands of tonnes (t) for Pacific Herring from 1951 to 2022 in the Strait of Georgia and West Coast of Vancouver Island. Biomass is represented by median posterior estimates. Figure source: DFO (2022a)

The Huu-ay-aht practice roe on cedar bow Herring roe collection (Figure 125). To harvest Herring eggs, cedar branches are suspended near Herring spawning grounds. Female Herring deposit their eggs on these surfaces, usually in many layers. After the spawning event, the Herring eggs can be peeled off the branches for immediate consumption, or, more commonly, are preserved by air-drying. The dried eggs are then stored for later consumption at feasts, potlatches, and daily meals, or they are traded with neighbours (https://www.pacificherring.org/traditional-fishery). However, no active spawn is observed in the **ƛušiiʔaaʔaq**/Swiftsure Bank Area. Huu-ay-aht First Nations monitor their marine territory for Herring abundance and spawn every spring.



Figure 125. Roe on cedar branches, collected in Barkley sound to the north of ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank. Pictures from Huu-ay-aht First Nation's Facebook page, dated March 15, 2023.*

Data sources

Time series data of Pacific Herring commercial catch, average weight at age, proportion at age, and spawn survey indices are fundamental inputs for Herring stock assessment models (Cleary et al. 2019; DFO 2022b). Commercial catch information is gathered from landing slips or dockside monitoring, with catch data by gear type and fishing category available from 1951 onwards (Cleary et al. 2019). Average weight-at-age and proportion-at-age data by gear type/ fishery are derived from biological samples collected since 1951 from major commercial Herring fisheries (Figure 126) and through the test fishery program (Cleary et al. 2019).

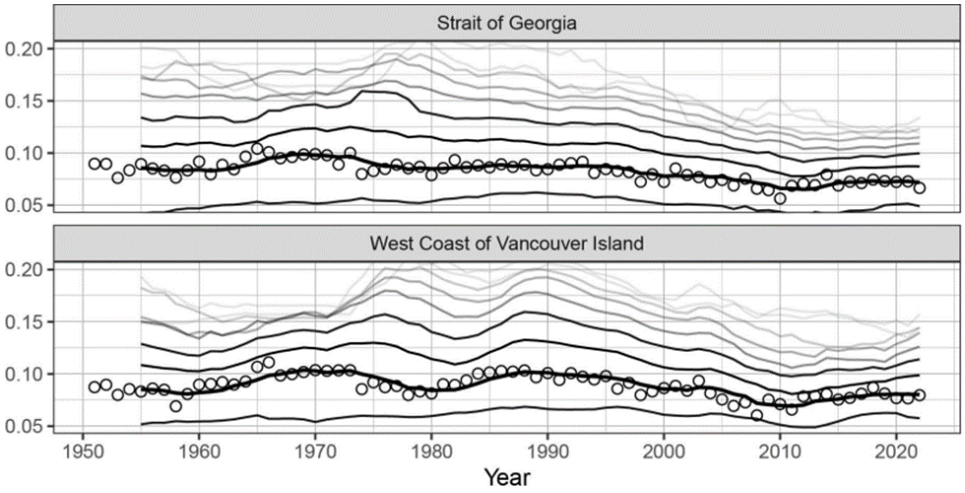


Figure 126. Mean weight-at-age for Pacific Herring in kilograms (kg) from 1951 to 2022 in the Strait of Georgia and West Coast of Vancouver Island. Lines show 5-year running means for age-2 to age-10 Herring, incrementing up from bottom line and shaded from darker to lighter, except thickest line shows age-3 Herring. Circles show mean for age-3 Herring. The age-10 class includes fish ages 10 and older. Figure source: DFO (2022b).

Spawn surveys, initiated in 1928, aim to estimate egg densities per spawning bed to back-calculate the biomass of mature spawners responsible for egg deposition (Xu et al. 2019). However, only spawn survey indices from 1951 onwards are utilized for Herring stock assessments (Cleary et al. 2019). Pre-1988 spawn surveys, known as “Surface" surveys, were conducted from the surface, either by walking along the beach at low tide or by using a drag from a skiff to estimate the shoreline length and width of spawn (Cleary et al. 2019). Subsequently, SCUBA methods (referred to as “Dive”) were introduced in 1988 and were implemented coastwide within a couple of years (Cleary et al. 2019). These methods involve measuring spawn length (parallel to shore), spawn width (perpendicular to shore), and the number of egg layers by vegetation type.

The Integrated Pelagic Ecosystem Survey (IPES; 2017-2023) and night pelagics survey (2006-2014) provide estimates of Herring biomass in summer foraging areas on the continental shelf off of the north and west coast of Vancouver Island (Flostrand et al. 2015; Boldt et al. 2023; King et al. 2023). These random, stratified, trawl surveys were conducted annually, with comprehensive biological sampling, along with physical and biological oceanographic sampling.

Eulachon

Life history and distribution

Eulachon (*Thaleichthys pacificus*) is an anadromous smelt species with a length between 16 and 25 cm that migrates from ocean environment to rivers to spawn typically between ages 2 and 5 (Gustafson et al. 2022). Following spawning, Eulachon are generally thought to perish (Hay and McCarter 2000; DFO 2023i), although spent Eulachon have been captured in the ocean (Dealy and Hodes 2019). In BC, Eulachon are known to spawn in 25 mainland rivers with typically a distinct spring freshet, and the Fraser River stands out as the primary spawning river in Southern BC (Hay and McCarter 2000; Levesque and Therriault 2011; DFO 2023i). Spawning in the Fraser River typically spans from February to May with eggs hatching within three to five

weeks under ambient temperatures, usually ranging between 3° and 10°C (DFO 2023i). Post-hatching, larvae are swiftly carried by spring freshets to estuarine or marine waters (Hay and McCarter 2000; Willson et al. 2006).

Juvenile Eulachon disperse to the continental shelf within their first year of life, yet information regarding their spatial distribution remains scarce, with only a few recorded observations in Barkley Sound (Hay and McCarter 2000; Levesque and Jamieson 2015). Eulachon at ages 1 and 2 are typically found in coastal marine areas, as indicated by bottom and mid-water research trawl surveys directed at groundfish, Pacific Herring, and shrimp, most often at depths ranging from 50 to 200 meters (Levesque and Therriault 2011; Gustafson et al. 2022, Figure 127). Eulachon occurring off of the WCVI, that are bound to spawn in the Fraser River, migrate via the Juan de Fuca Strait (Levesque and Jamieson 2015).

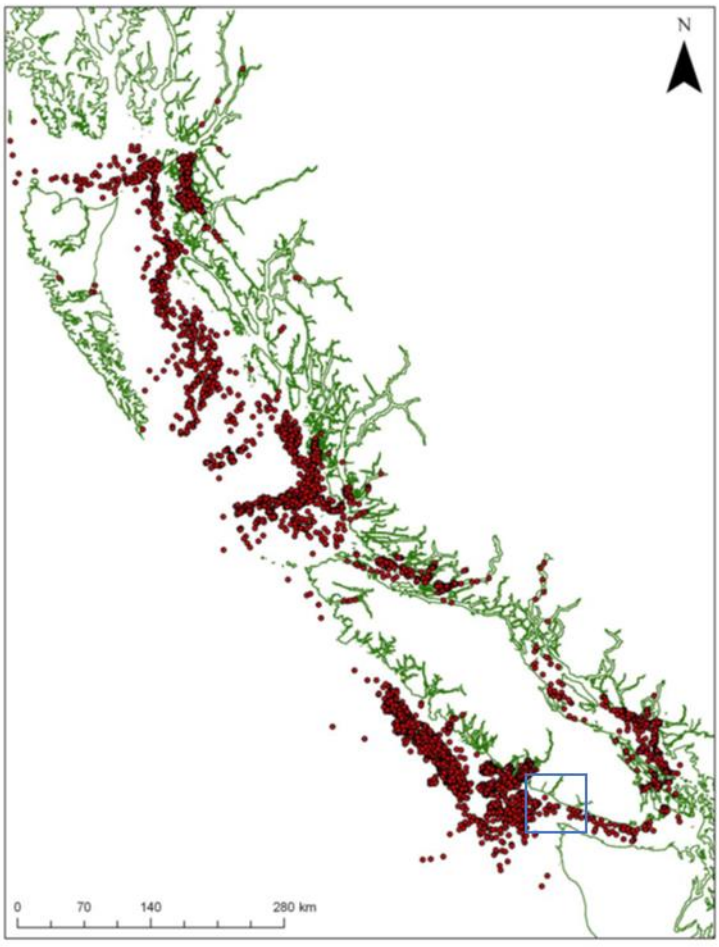


Figure 127. Catch locations of Eulachon in bottom and mid-water research trawl surveys directed at groundfish, Herring and shrimp in British Columbia. Figure source: Levesque and Therriault 2011. ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area is indicated by the blue rectangle.*

Population trend

In the Fraser River, the commercial harvest of Eulachon commenced in the 1870s (DFO 2023i). Throughout the 1980s to the mid-1990s, the commercial catch of Fraser River Eulachon

hovered around 20 tonnes annually, peaking at 63 tonnes in 1996 (DFO 2023i). However, due to declining abundance levels, the commercial fishery was closed in 1997 (DFO 2023i). Since then, the commercial fishery has remained closed, with only temporary opening occurring in 2002 and 2004. Indigenous harvest for food, social, and ceremonial (FSC) purposes has been permitted under the Sustainable Fisheries Framework policy (DFO 2023i).

This prolonged decline in spawning Eulachon populations over recent decades has been observed across numerous rivers spanning from California to Alaska (DFO 2023i). This serial decline suggests that the primary driver of Eulachon abundance may not solely be attributed to fisheries, but rather include threats from predation, and changes to riverine, freshwater, estuarine, and oceanic conditions (Hay et al. 1999; Schweigert et al. 2012; Gustafson et al. 2022).

The Fraser River Eulachon egg and larval survey index of spawning stock biomass has exhibited a notable decadal shift, characterized by relatively high levels in the late 1990s, followed by a period of extremely low spawning stock biomass from 2004 to 2011, and subsequent low/modest values between 2012 and 2021 (Figure 128; Flostrand et al. 2023).

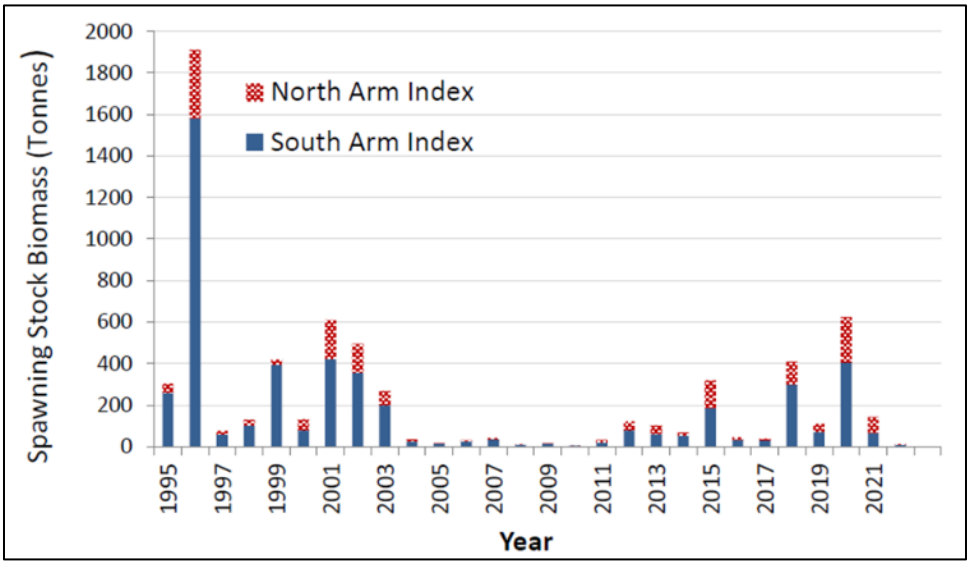


Figure 128. Estimated spawning stock biomass indices (in tonnes) of Eulachon from the South and North Arms of the Fraser River for the period of 1995 to 2022 based on annual spring-time Fraser River Eulachon egg and larval survey. Figure source: Flostrand et al. 2023.

Similarly, Eulachon catch per unit effort (CPUE) collected from the WCVI offshore small mesh multi-species survey spanning from 2000 to 2022 has mirrored this trend, indicating a period of persistently low values from 2004 to 2011, followed by a period of low and variable values (Figure 129). Although this pattern aligns with the spawning stock biomass index (refer to Figure 128), it is noteworthy that the CPUE data may not accurately reflect the Fraser River Eulachon trend due to the intermingling of this stock with that from the Columbia River in the offshore area (Schweigert et al. 2012).

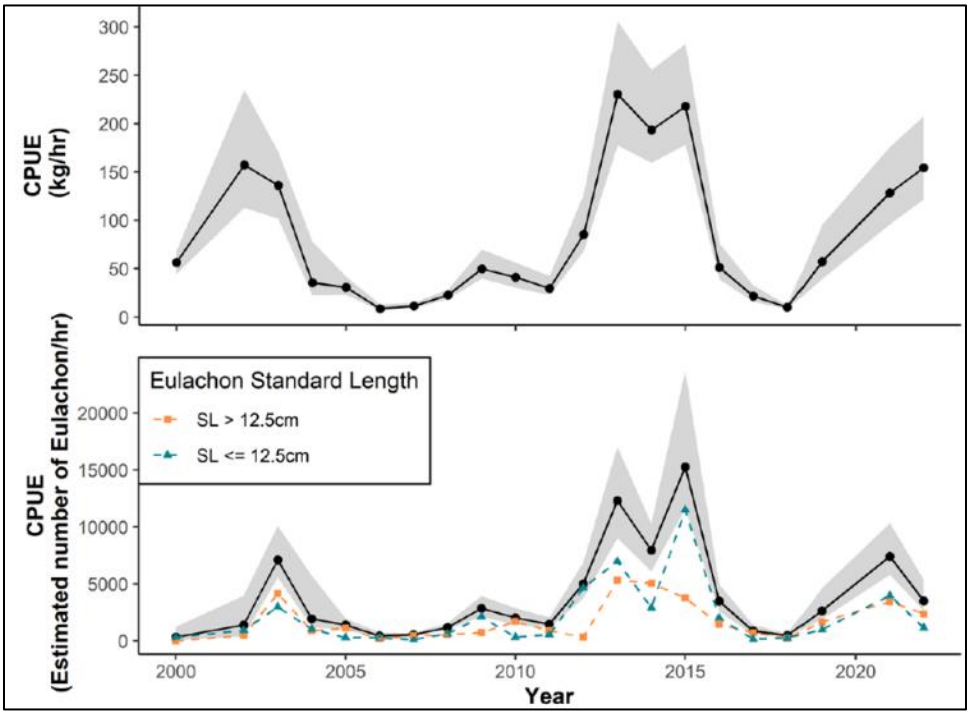


Figure 129. Top panel: Eulachon mean catch per unit effort (CPUE) in weight per trawl tow hour (kg/hour) from multispecies trawl surveys off the West Coast of Vancouver Island (2000- 2022, no survey in 2020) and 95% studentized bootstrap confidence intervals (gray envelopes); Bottom panel: CPUE in number trawl tow hour. Dashed lines represent mean CPUE for Eulachon greater than 12.5 cm standard length (orange) or less than or equal to 12.5 cm standard length (blue). Figure source: Flostrand et al. 2023.

Data sources

To generate a relative index of spawning stock biomass based on densities of Eulachon eggs and larvae, an annual 7-week core sampling program has been conducted since 1995 in the waters of the lower Fraser River (McCarter and Hay 2003). However, the spawning stock biomass index alone is insufficient for predicting returns in subsequent years due to the highly uncertain age at which Eulachon sexually mature and spawn (Langness et al. 2020).To address the lack of data associated with life history traits and seasonal trends in the marine distribution of Fraser River Eulachon, monthly bottom trawl surveys comprising 227 fishing events were conducted from October 2017 to June 2018 in three regional strata within the Juan de Fuca Strait and the SoG (Dealy and Hodes 2019). Of these, 169 tows captured Eulachon, with a total catch of 217 kg in the Juan de Fuca Strait between **ʔušiiʔaaʔaq**/Swiftsure Bank and Race Rocks, nearly ten times higher than in the other two regional strata (Dealy and Hodes 2019). Fishing event data were stored in GFBioField, the Pacific Region's at-sea data acquisition system for DFO Groundfish Surveys (Olsen 2010).

Since 2017, the Lower Fraser Fishery Alliance (LFFA) has conducted Eulachon gillnet surveys in the Fraser River (DFO 2023i). These surveys employ shorter fishing times and gillnet panels compared to the test fishery to minimize mortality impacts (DFO 2023i). The survey gathers information on Eulachon seasonal relative abundance, run timing, and biology, including fish length, weight, sex, spawning condition. Samples collected during this survey are retained for potential studies on genetics; otolith ageing, isotope analyses, and eDNA trials.

Eulachon CPUE data and fish length samples have been collected from the WCVI offshore small mesh multi-species survey, conducted annually in late April or early May since 1973 (DFO 2023i). These comprehensive data sources contribute to our understanding of Eulachon populations and aid in informed management decisions for their conservation and sustainable use.

Pacific Sand Lance

Life history and distribution

Pacific Sand Lance (*Ammodytes personatus*) is a small (<25 cm fork length), planktivorous, semi-demersal forage fish species that typically lives up to six years (Sisson and Baker 2017; Staudinger et al. 2020). Notably, Pacific Sand Lance (hereafter referred to as Sand Lance) exhibit distinct life history patterns, such as actively burrowing into sand-gravel bottom sediments for refuge and rest in both diurnal and seasonal fashions (Baker et al. 2019). They undergo a seasonal transition from pelagic foraging to winter dormancy, as well as ontogenetic shift from nearshore to deep water benthic habitats as they age. For instance, in a study where 155 Sand Lance were taken from the sand wave field in the San Juan Channel between September and November in 2012, 80% were found to have empty stomachs. This observation suggests that Sand Lance may enter a period of winter dormancy during this timeframe (Sisson and Baker 2017). Additionally, they may also follow a biennial (every 2-year) fluctuation cycle in year-class strength the number of larvae hatched in a given year (Baker et al. 2019).

Sand Lance distribution is primarily determined by the presence of coarse sand, pebble, and pea gravel sediment with minimal silt content in sand-wave fields (Selleck et al. 2015; Sisson and Baker 2017; Greene et al. 2023). In the SoG, community science surveys targeting intertidal Sand Lance spawning have identified 90 beaches where Sand Lance eggs were found, covering a mere 5.4% of the intertidal zone in the SoG (Huard et al. 2022). Furthermore, the maximum entropy model for the SoG has identified 105 km^2 of suitable subtidal burying habitat for Sand Lance, accounting for just 2.6% of the study area (Robinson et al. 2021). However, it was discovered that aside from the nearshore and shallow subtidal areas, predominant and important habitats for Sand Lance existed in deep subtidal areas of the SoG (Greene et al. 2017, 2020), thus resolving the disjunction between the prevailing abundance of Sand Lance (Selleck et al. 2015) and the limited availability of known habitats (e.g., Robinson et al. 2021).

While spawning sites are well documented along the beaches in the SoG, the shoreline in the San Juan Islands and Puget Sound (Selleck et al. 2015; Robinson et al. 2024), research endeavors aiming to delineate, map, and predict offshore benthic habitat are ongoing off the USA coast (Sisson and Baker 2017) and yet to be made for the areas off the WCVI.

Sand Lance play a pivotal role in the dynamics of predator-prey food web, serving as an essential link between planktonic production and higher trophic level predators (Zamon 2003; Guénette et al. 2014; Selleck et al. 2015; Greene et al. 2023). Across various regions off the BC coast, Sand Lance were found preying largely on copepods (Hipfner and Galbraith 2013). Another study also found that Sand Lance fed primarily on calanoid copepods, the dominant zooplankton in the water column, underscoring their opportunistic feeding habit (Sisson and Baker 2017). Sand Lance are a primary prey species for more than 100 species of fishes, marine mammals and birds (Baker et al. 2019). In particular, they contributed to half of the prey

consumed by Resident Chinook Salmon in the southern SoG between April and September (Osgood et al. 2016).

Population trend

In contrast to Herring, Sand Lance have received limited attention regarding studies on their abundance and the factors driving their dynamics across their distribution range (Staudinger et al. 2020; Suca et al. 2021). Employing a Van Veen grab sampler, which covers 0.12 m^2 of surface area per drop with a penetration depth of 22 cm, Sisson and Baker (2017) estimated that in the fall of 2012, there were approximately 100 million Sand Lance inhabiting in the sand wave field in the San Juan Channel. Furthermore, through expert surveys conducted for vulnerability assessment, Huard (2023) concluded that Sand Lance populations were experiencing a decline primarily due to climate change, pollution, and human development pressures.

Data sources

Spawning habitats of Sand Lance in BC have been surveyed through efforts by citizen science initiatives, community groups and non-profit organizations (Boldt et al. 2019). These records of spawning sites are documented in the Forage Fish Atlas (http://www.cmnbc.ca) Through these endeavors, more than 90 beaches in the Canadian Salish Sea have been identified as intertidal Sand Lance spawning habitats between 2001 and 2021, accounting for less than 6% of the intertidal zone (Huard 2023).

In nearshore shallow areas of the Salish Sea off Washington State, 15,192 records of Sand Lance have been collected from 1,630 sites from 1970 to 2009 (Selleck et al. 2015). This study found that Sand Lance were present in 78% of the shoreline year-round with higher abundance between May and August.

The absence of swim bladders, a characteristic of Sand Lance, has posed challenges in effectively monitoring their abundance and distribution using acoustic methods. To overcome this limitation, researchers have turned to alternative approaches. Directed observations conducted from a manned submersible and images captured by a stereo camera have been utilized to estimate fish abundance, distribution, habitat, and behavior of Sand Lance in the US Salish Sea (Baker et al. 2021).

6.2.4.1.2.2 Salmonids

Pacific salmon (*Oncorhynchus* spp.) are anadromous, spawning, and hatching in freshwater, but migrating to marine environments where the majority of growth occurs. Generally, juvenile Pacific salmon enter the marine environment in spring or early summer and rear in nearshore habitats for weeks to months before beginning to disperse away from their natal streams. Juvenile Pacific salmon have been identified as a group of biological importance for the Juan de Fuca Eddy EBSA for using the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area as a migration and foraging area (Jamieson and Levesque 2014). Mature Pacific salmon (i.e. those that are preparing to spawn) begin to migrate towards natal streams during the summer and fall, with the timing of spawning migrations varying among and within species. All species are zooplanktivores immediately after ocean entry, consuming a wide variety of marine invertebrates including copepods, amphipods, decapods, and euphausiids (Brodeur et al. 2007). Chinook (*O. tschawytscha*) and coho (*O. kisutch*) salmon begin to transition to piscivory shortly after ocean entry (Beauchamp and Duffy 2011; Hertz et al. 2015), ultimately foraging on Pacific Herring,

Pacific Sand Lance, Northern Anchovy, and squid (Beamish 2018). While some Chinook and Coho Salmon migrate offshore, many individuals are present along the continental shelf and in inland waters year-round (O'Neill and West 2009; Rohde et al. 2014; Freshwater et al. 2021; Beamish and Neville 2021). Conversely, Chum (*O. keta*), Pink (*O. gorbuscha*), and Sockeye (*O. nerka*) salmon remain predominantly zooplanktivorous and spend the majority of their marine life cycle in offshore habitats such as the Gulf of Alaska (Groot and Margolis 1991; Fisher et al. 2007; Tucker et al. 2009). Steelhead Trout (*O. mykiss*) are the least abundant species of Pacific salmon and migrate offshore particularly rapidly (Beamish 2018). Since they are rarely encountered by DFO marine surveys they are not discussed in detail here.

The primary salmon producing watershed proximate to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is the Nitinaht River. The Nitinaht River contains the largest number of spawners, including relatively large populations of chum and Chinook Salmon, as well as smaller populations of Coho and Sockeye Salmon. Campus, Caycuse, and Doobah Creeks have smaller populations of Chum and Coho Salmon, and the Hobiton River is an important producer of Sockeye Salmon. Outside of the Nitinaht watershed, the Klanawa River also produces moderate numbers of Chum, Coho, and Sockeye Salmon that migrate directly into the **ƛ̓ušiiʔaaʔaq**, and the Cheewaht River produce a genetically unique and culturally important population of Sockeye Salmon.

Recent Wild Salmon Policy Habitat Status assessment work in the Nitinaht and Cheewaht Rivers has been completed and has helped identify some of the limiting factors to wild salmon production. In both systems, heavy impacts from the historical industrial use of the watershed has resulted in massive amounts of sediment mobilization, habitat degradation (both instream and riparian), loss of floodplain and off-channel habitats, access limitations, and changes in hydrology, all of which were assessed as limiting the production of wild salmon in these systems. Based on the similarities of these watersheds to others in the area, it can be assumed that similar limiting factors to wild salmon exist in adjacent watersheds in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

In 2020, Nitinaht Hatchery and Huu-ay-aht First Nation implemented active management of proportion of natural influence, an index of hatchery risk and a proxy for the genetic risk posed by hatchery fish, through mark-selective fisheries, number of releases, new release strategies, limits to brood removals, 100% otolith marking, and external marking. In Canada, Pacific salmon are managed following the Wild Salmon Policy, which groups populations with similar life histories and geographic distributions into conservation units. By definition, a conservation unit is a genetically distinct group that, if extirpated, is unlikely to be recolonized in a reasonable period of time (DFO 2005). The populations that spawn proximate to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area belong to several conservation units that typically have a geographic extent larger than the Nitinaht watershed and few of which have been formally assessed (Table 26).

*Table 26. Salmon species that occur in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, along with their designated Conservation Unit and Wild Salmon Policy Status.*

Species	Conservation Unit	Wild Salmon Policy Status
Coho	Juan de Fuca-Pachena	Not Assessed
Chum	Southwest & West Vancouver Island	Not Assessed
Chinook	West Vancouver Island-South	Poor

Species	Conservation Unit	Wild Salmon Policy Status
Pink	West Vancouver Island-Odd	Not Assessed
	West Vancouver Island-Even	Not Assessed
Sockeye	Cheewaht	Poor
	Hobiton	Poor
	Nitinaht	Poor

Importantly, the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area provides habitat for a large number of Pacific salmon populations that do not spawn in local watersheds. Due to its proximity to the western edge of Juan de Fuca Strait, the **ƛ̓ušiiʔaaʔaq** Area overlaps the migration routes of Pacific salmon populations that spawn in watersheds on the east coast of Vancouver Island, Fraser River, Puget Sound, coastal Washington and Oregon, the Columbia River, and California. Broadly speaking, Sockeye Salmon likely utilize the region the least due to their relatively rapid migration northward along the continental shelf (Tucker et al. 2009; Beacham et al. 2014), but large abundances of adult Fraser River Sockeye Salmon may occur in the late summer depending on year-class strength and diversion rate (Grant et al. 2018), i.e., the proportion of an adult run returning to the Salish Sea via the northern Johnstone Strait or southern Juan de Fuca Strait. Chum and pink salmon have an intermediate pattern of residence due to a more protracted juvenile migration (Fisher et al. 2007; Freshwater et al. 2024) and will also be seasonally abundant as adults during return migrations. Conversely, anecdotal information from harvesters indicates Chinook and coho salmon are present within the **ƛ̓ušiiʔaaʔaq** region year-round (C. Freshwater, DFO, pers. comm.). Indeed, there was substantial historical fishing effort early in the year on **ƛ̓ušiiʔaaʔaq** (Healey et al. 1990), which is consistent with evidence that both Chinook and coho salmon rear in nearshore areas such as the Salish Sea (O'Neill and West 2009; Rohde et al. 2014; Freshwater et al. 2021; Beamish and Neville 2021).

Since 1998, DFO has operated midwater trawl surveys to better understand juvenile salmon ecology and monitor abundance. Originally, surveys were led by the High Seas Salmon program (e.g., Welch et al. 2003), which was reorganized into the Basin-Coastal Scale Interactions program in 2017 (e.g., King et al. 2019). Although surveys have occurred throughout British Columbia, the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank region has been particularly well sampled. Spatiotemporal models built in sdmTMB (Anderson et al. 2022) using juvenile catch data from surveys were used to quantify patterns in abundance, while accounting for variable survey effort (Figure 130 to Figure 134).

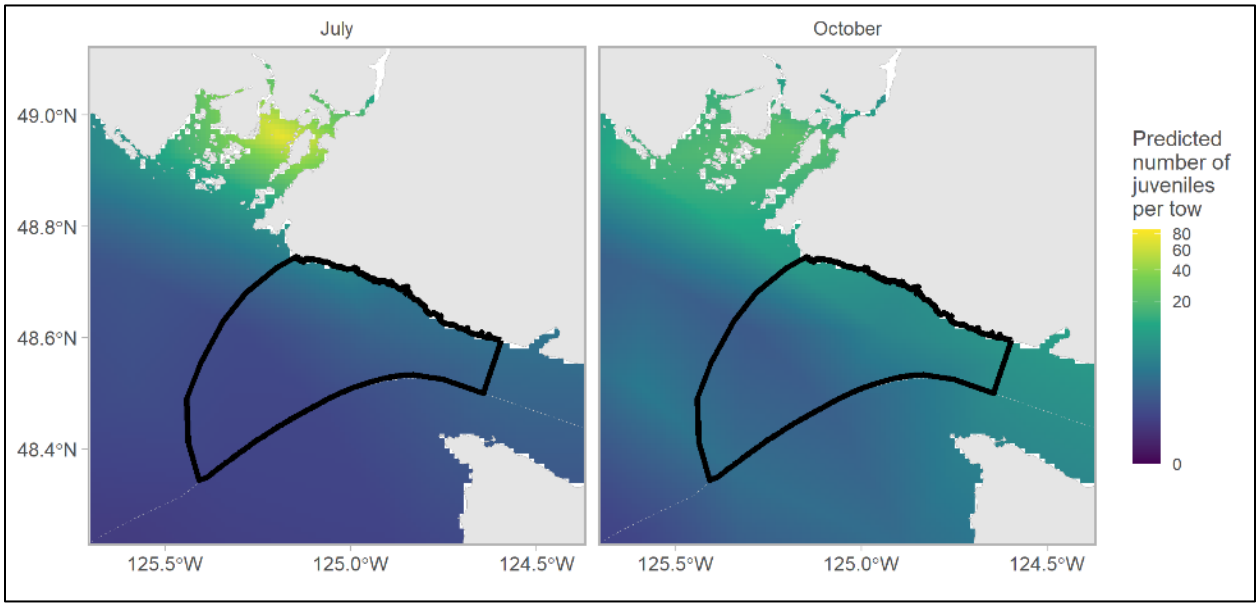


Figure 130. Predicted juvenile Chinook Salmon abundance in July and October based on spatio-temporal model fit to midwater trawl survey data (1998-2022). The Juan de Fuca Eddy EBSA polygon in the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area outlined in black. Data source: DFO, see Freshwater et al. (2024).*

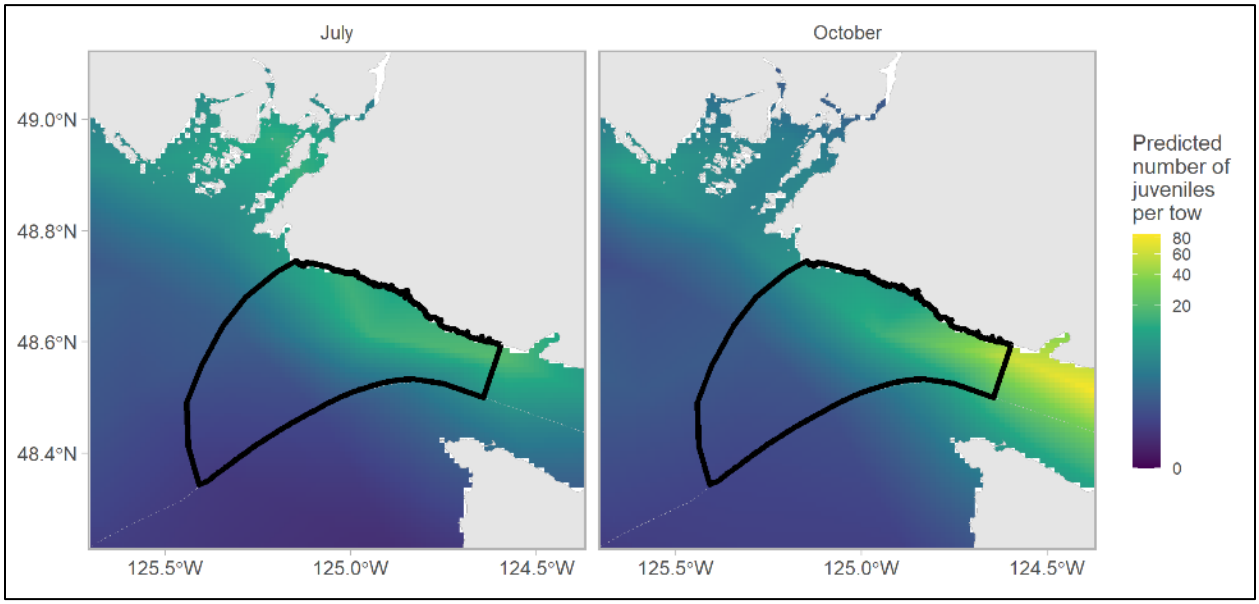


Figure 131. Predicted juvenile Chum Salmon abundance in July and October based on spatio-temporal model fit to midwater trawl survey data (1998-2022). The Juan de Fuca Eddy EBSA polygon in the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area outlined in black. Data source: DFO, see Freshwater et al. (2024).*

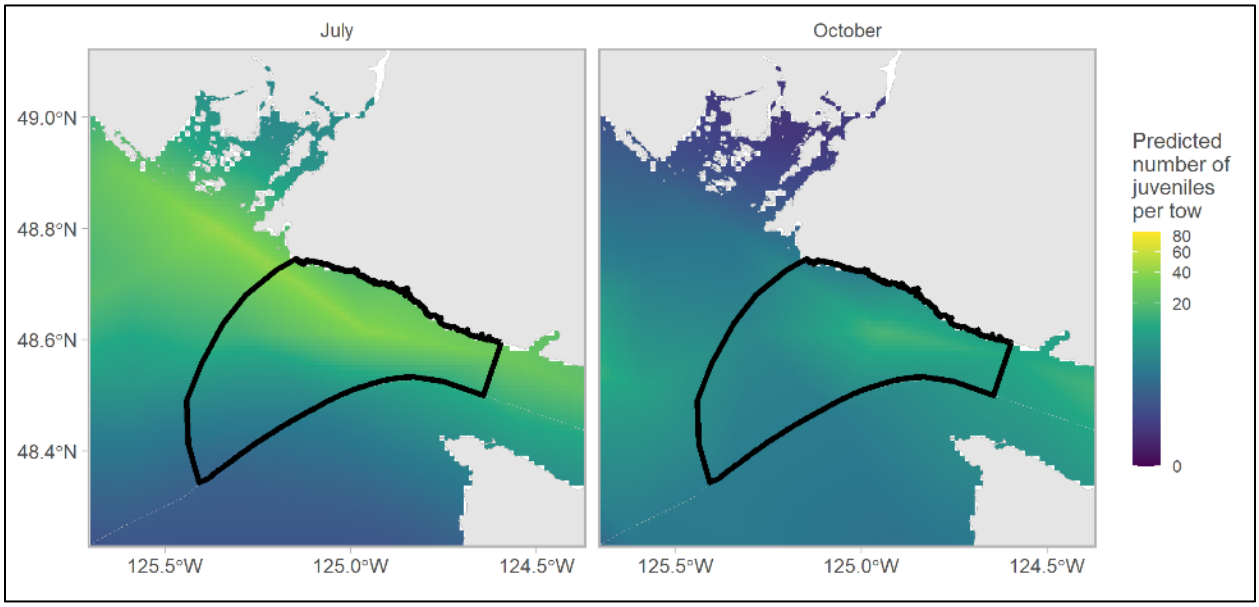


Figure 132. Predicted juvenile Coho Salmon abundance in July and October based on spatio-temporal model fit to midwater trawl survey data (1998-2022). The Juan de Fuca Eddy EBSA polygon in the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area outlined in black. Data source: DFO, see Freshwater et al. (2024).*

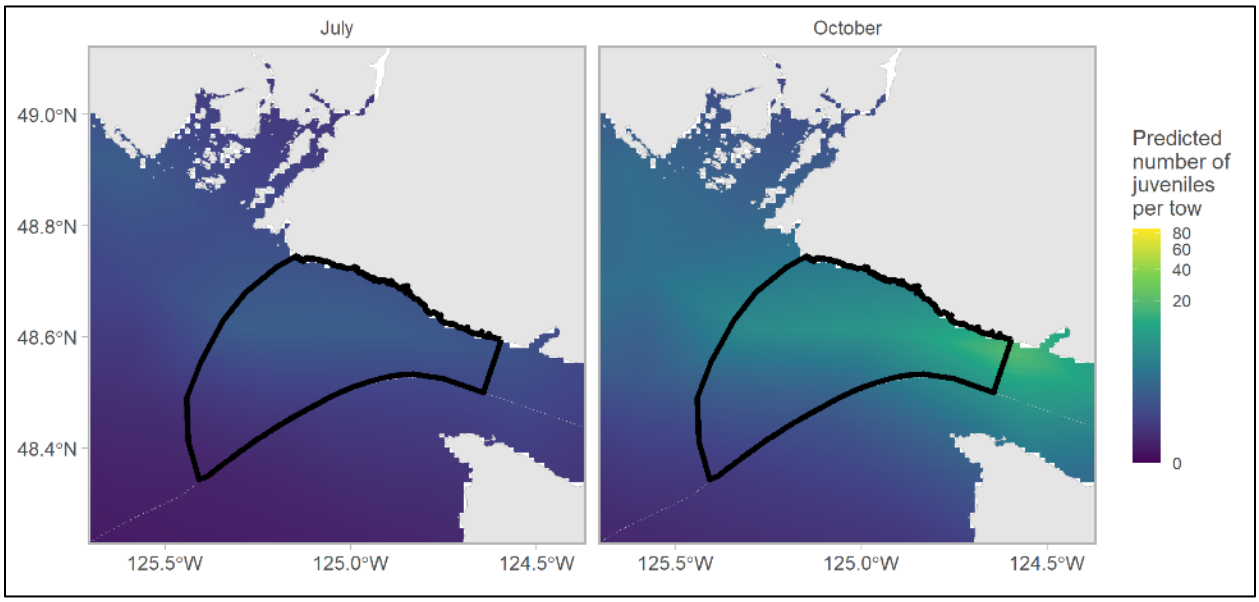


Figure 133. Predicted juvenile Pink Salmon abundance in July and October based on spatio-temporal model fit to midwater trawl survey data (1998-2022). The Juan de Fuca Eddy EBSA polygon in the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area outlined in black. Data source: DFO, see Freshwater et al. (2024).*

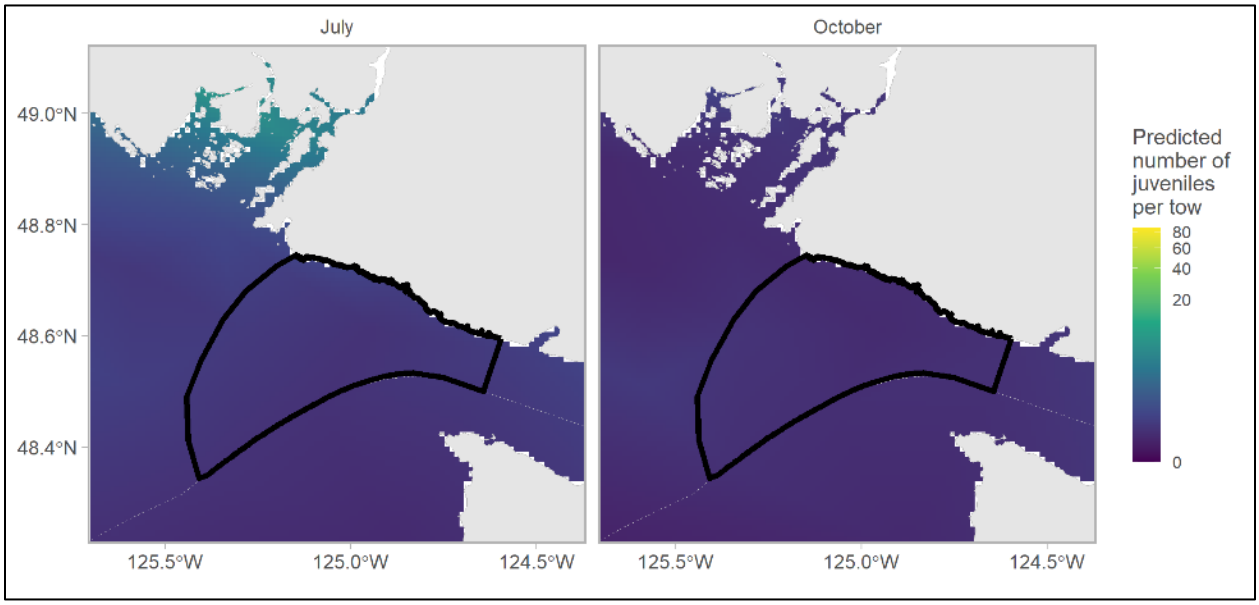


Figure 134. Predicted juvenile Sockeye Salmon abundance in July and October based on spatio-temporal model fit to midwater trawl survey data (1998-2022). The Juan de Fuca Eddy EBSA polygon in the ***Ẃušiiʔaaʔaq****/Swiftsure Bank Area outlined in black. Data source: DFO, see Freshwater et al. (2024).*

Marine distributions and migration timing often vary among stocks within Pacific salmon species. As a result, the relative abundance of populations will differ spatially and temporally. For example, DFO South Coast Stock Assessment has conducted extensive genetic sampling of Chinook Salmon recreational fisheries in the **Ẃušiiʔaaʔaq**/Swiftsure Bank Area. In offshore locations such as PFMA 121A and 121B, Columbia River and Puget Sound Chinook Salmon compose the majority of the catch (greater than 80%), particularly early in the year. Conversely, in inshore locations (less than 3 nautical miles from shore; PFMAs 121C and 21A), west coast Vancouver Island Chinook Salmon populations are the dominant stocks particularly in August and September immediately preceding spawning migrations.

6.2.4.1.2.3 Molids

Ocean sunfishes (Family Molidae) are distributed from southern Chile to the Arctic Circle, and include the largest and heaviest bony fishes worldwide. Two species are found in British Columbia: *Mola mola* and *Mola tecta* (Mowatt-Larssen et al. 2025). It's important to note that prior to 2019-2020, *Mola tecta* was not known to be present in British Columbia (and was only described as a distinct species fairly recently (Nyegaard et al. 2018). Recent investigations have found that some previously identified *Mola mola* in British Columbia are in fact *Mola* sp.[75] because they cannot be confidently identified as either *M. mola* or *M. tecta*. The Yuułuʔiłʔatḥ Government's marine stewardship program has recorded 491 individual *Mola* sp. between May 2022 and October 2024 (Crosby, Yuułuʔiłʔatḥ Government, *unpub. data*). The occurrence data are collected during aerial monitoring surveys that collect whale occurrence and abundance data within marine shipping vessel corridors and critical habitat (sanctuary areas) off the WCVI. The two flight paths conducted as part of the survey both cover crucial marine areas of **Ẃušiiʔaaʔaq/**Swiftsure Bank (Crosby 2024). Identifying the individuals to species is not possible given that high quality images are required to differentiate *Mola mola* and *Mola tecta*,

[75] Mola / Sunfish Research | MERS Marine Education & Research Society

and such images cannot be acquired from aerial imagery. *Mola* sp. are also encountered in surface trawls during DFO's Integrated Pelagic Ecosystem Survey (King et al. 2019). Between 2005 and 2024, 29 individuals have been recorded, including one *M. tecta* (2022). The majority of the records are classified as *Mola* sp. (J. King, DFO, *unpub.data*). The *Mola* sp. records from the Integrated Pelagic Ecosystem Survey are distributed throughout the WCVI, however none occur in the **ƛ̓ušiiʔaaʔaq** area.

6.2.4.2 Cartilaginous Fishes

Sharks, Skates, and Ratfish are cartilaginous fishes that belong to the Class Chondrichtyes. This group encompasses a wide range of ecological roles, from top-level pelagic predators to benthic detritivores and planktivorous filter feeders. Many cartilaginous fishes have slow growth rates, large sizes, long lifespans, and delayed sexual maturity (McFarlane and King 2020). Newborn and juvenile sharks and skates may use inlets and shallow waters for protection before migrating to deeper waters in the continental slope (McFarlane and King 2020). These characteristics make them vulnerable to exploitation and population declines. Historical harvest of sharks as a source of Vitamin A from livers and as food fisheries, along with eradication programs for species considered to be pests were common in the 20th century and led to declines in abundance (King et al. 2017; McFarlane and King 2020). Population recovery of cartilaginous fishes may be limited due to their life history, and population assessments are difficult due to limited survey data and the rarity of many species. For example, the abundance of the endangered Basking Shark (*Cetorhinus maximus*) has been drastically reduced compared to the historically widespread population in Canada's Pacific, and historical catch records have been relied on to inform modern estimates (McFarlane et al. 2009). North Pacific Spiny Dogfish (Special concern, COSEWIC 2011) are regularly by-caught by trawl and longline gear in groundfish fisheries and by recreational gear (King et al. 2017).

Shark species found in this area, or expected to be periodically found here given their migratory behaviour, include Salmon Shark (*Lamna diptropis*), Common Thresher Shark (*Alopias vulpinus*), Tope Shark (*Galeorhinus galeus*) and Blue Shark (*Prionace glauca*). Basking Sharks are also potential occurrences in the area, with a documented historical distribution and nearby occurrences (J. King, DFO, *unpub. data*). Sandpaper Skate (*Bathyraja kincaidii*), Big Skate (*Beringraja binoculata*) and Longnose Skate (*Beringraja rhina*) have been encountered in the area in groundfish fisheries and trawl surveys (McFarlane et al. 2010). The chimera, Whitespotted Ratfish (*Hydrolagus colliei*), is ubiquitous and abundant throughout the WCVI and occurs in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (McFarlane and King 2020). A total of 13 elasmobranch species have been observed in **ƛ̓ušiiʔaaʔaq** from 2010 to 2023 during DFO research surveys and commercial fishery catches (Figure 135, Appendix F). Four species of elasmobranch have also been identified as species of biological importance in the Juan de Fuca Eddy EBSA: Basking Shark (historical area of concentration), Big Skate, Longnose Skate, and Sandpaper Skate (distribution) (Table 8; Jamieson and Levesque 2014).

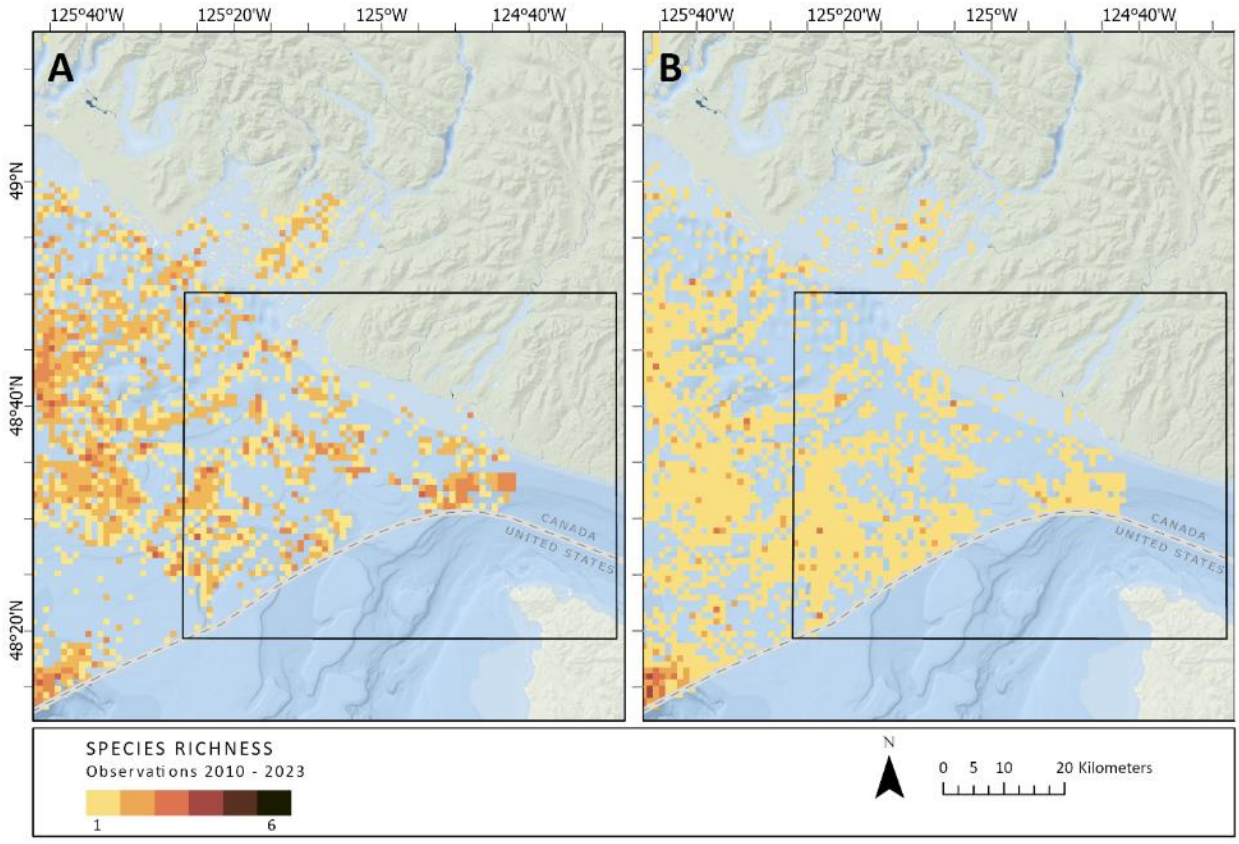


*Figure 135. Species richness of elasmobranchs in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area using DFO survey and commercial catch point occurrences from 2010 to 2023. Occurrences were gridded to a 1km grid and the number of unique species per cell were counted for a maximum species richness of 13 in the Juan de Fuca Eddy EBSA polygon. Data source: DFO survey and commercial catch point occurrences.*

6.2.4.3 Sensitivities and Recoverability

ƛ̓ušiiʔaaʔaq/Swiftsure Bank is a highly productive and biodiverse area that is also exposed to a variety of human uses that put stressors on the environment and its inhabitants. The fish communities within the **ƛ̓ušiiʔaaʔaq** ecosystem are interconnected. Changes in one species' abundance or distribution can have cascading effects on other species that rely on them for food or compete for resources. Understanding these sensitivities is crucial for effective management and conservation efforts to ensure the long-term health and sustainability of the marine ecosystem in this region.

Commercial and recreational fisheries are well established in the area and direct and indirect mortality effects on the fish species in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Sensitivities to fishing pressures depend on species' life history traits. Rockfish and cartilaginous fishes, for example, are highly vulnerable to fishing pressures and overexploitation because of their slow growth rate, slow sexual maturity, and long lifespans, which contribute to slow population recovery in the span of several decades as opposed to years. Both species groups have suffered population declines in the second half of the 20th century due to previously high levels of commercial and recreational pressures (rockfish) or extermination efforts (sharks). Rockfish and Sablefish also have higher bycatch mortality rates for the Hook & Line and Trap gear (See Table 2 in Appendix 2 of DFO 2024c) when compared to other groundfish species such as

Lingcod, North Pacific Spiny Dogfish, Pacific Halibut and skates. A Sablefish Fishing Mortality Working Group was formed in February 2021 to improve monitoring and reduce Sablefish discard mortality.

Copper Rockfish are considered one of the most vulnerable West Coast groundfish stocks due to their lifespan and susceptibility to external stressors (Cope et al. 2011). The Rougheye/Blackspotted Rockfish complex is listed as a species of "special concern" by SARA due to their recent identification, long lifespan, and low fecundity, which makes them particularly susceptible to fishing pressure (DFO 2012b). The Outside population of Yelloweye Rockfish were assessed as "Threatened" by COSEWIC in 2020 (COSEWIC 2020).

High fecundity and periodic high recruitment events provide rockfish populations with the chance of recovery. Lowered fishery catch quota and implementation of Rockfish Conservation Areas (RCAs) throughout the Pacific Region, including the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, were implemented in 2006-2007 with the intent to reduce fishery mortality for the genus (Yamanaka and Logan 2010). There are ongoing restoration plans for species of interest such as Yelloweye and Quillback rockfish. A recent study conducted by the Central Coast Indigenous Resource Alliance (CCIRA) found that rockfish relative abundance (CPUE) and body size increased, on average, at locations nearer to, or inside, seven RCAs on the Central Coast of BC, with benefits varying between RCA locations and species[76].

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

Genetic studies have shown many groundfish species exist in one breeding population in BC waters (in addition to Alaska and the west coast of the United States; e.g., Sablefish (Jasonowicz et al. 2017); Yelloweye Rockfish (Siegle et al. 2013)), perhaps due to extensive adult migrations and pelagic larval dispersal resulting in a lack of reproductive isolation. This may be helpful for rescue effects, where healthy populations in one area could replenish depleted areas. The overall health of local nearshore habitats in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (including kelp forests, eelgrass beds, and cold-water corals and sponges) can also aid in the recovery of local populations by supporting juvenile growth of species that migrate offshore and the productivity of adult Lingcod and rockfish.

Another threat to the fishes in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is from the effects of vessel traffic: ship strikes, vessel noise, and oil spills (see Human Uses of AreaHUMAN USES OF AREA). Increased development and density of marine traffic naturally will increase vulnerability for fishes and other species within the area. Vessel traffic has been covered extensively in this report, as vessel studies and traffic restrictions are tested and refined for the protection of

[76] Wilson, K.L., Frid, A., and Anderson, S.C. *In prep.* The benefits of marine spatial protections for groundfish with diverse life histories in a temperate ecosystem.

SRKW (see Vessel traffic and vessel types). In addition, larger fish species such as basking sharks are vulnerable to ship strikes as they tend to stay near the surface for basking behaviours. Research on the effects of anthropogenic noise on Pacific salmon and Pacific Herring showed heightened anti-predatory behaviour (van der Knaap et al. 2022). Oil spills on eelgrass and kelp habitats can harm the abundance of forage fishes and juvenile fishes (groundfish, salmonids). Fishes that are less mobile and rely on biogenic habitats such as adult rockfish and Lingcod may have greater sensitivities to oil spill effects (Jeffery et al. 2023).

Global and regional effects such as increased temperatures, ocean acidification, dissolved oxygen levels, and variable oceanic circulation can also cause fluctuations in prey abundances, spawning returns, and yearly recruitment rates. Warmer waters are associated with extreme recruitment events for some groundfish species (e.g., Starr and Haigh 2022). Fishes with life history events linked with environmental cues (e.g., Pacific Herring spawn and Pacific Cod) have higher sensitivities than those with consistent recruitment (e.g., Sablefish). Pacific Cod populations have experienced declines since the 2015-2016 marine heatwave. While similar declines have not been observed in other BC regions, the Area 3CD Pacific Cod stock, which includes **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, is in the Cautious Zone. The decline may be linked to climate change impacting egg, larval, and juvenile stages, adult stages, fish movement, fishing pressure, or other factors (Laurel et al. 2023). Strong correlations between zooplankton productivity and environmental conditions and timing were shown to affect populations and annual recruitment levels of fishes that rely on zooplankton prey, such as forage fishes and larval groundfish (Schweigert et al. 2013; Kimmel and Duffy-Anderson 2020). A preliminary climate change sensitivity analysis for marine species in West Coast Vancouver Island identified cartilaginous fishes and pelagic fishes (notably Pacific Herring) with the highest average risk scores, and flatfish with the lowest scores (Hunter et al. 2014). Refer to Hunter and Wade (2015) for a comprehensive summary of species profiles and climate vulnerabilities on Pacific Halibut, Pacific Hake, Sablefish, Pacific Herring, and Pacific Sardine in the waters of BC. A recent modeling effort by Thompson and colleagues (2023b) also looked at projected changes in groundfish community composition and distribution with a warming climate. We provide the projected changes in groundfish communities within **ƛ̓ušiiʔaaʔaq** under two climate change scenarios below.

Projected changes in groundfish communities

Under a no-mitigation climate scenario (RCP 8.5), groundfish species are expected to shift their distribution by as much as 1000 km by 2100 in Pacific North America due to climate change (Morley et al. 2018). Thompson and colleagues (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 depth distribution based on fisheries independent trawl surveys. For more details on the climate models used refer to the Climate Change section. They found that groundfish vary in their sensitivity to warming and dissolved oxygen (Thompson et al. 2023b). Consequently, the distribution or occurrence of some species may increase while others decrease.

Generally, warming in shallow waters is projected to cause species to shift to deeper depths, but hypoxic conditions will limit how deep they can go (Thompson et al. 2023b). The net result is that the number of species in shallow (< 100 m) and deep (> 600 m) waters is projected to decrease, but more species are expected to occur at depths. Within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, the redistribution of groundfish species due to climate change is projected to result in

species richness changes from 0.9 to 1.97 species lost per grid cell (Figure 136). The RCP 8.5 scenario in the NEP36-CanOE model projects the highest species losses (Figure 137). **ƛ̓ušiiʔaaʔaq** is a shallow area with a limited depth profile for species redistributions. The greatest projected losses of species however in **ƛ̓ušiiʔaaʔaq** are for the nearshore areas, as those species potentially redistribute into the deeper regions towards the southwest and west of the Juan de Fuca Eddy EBSA area (Figure 136).

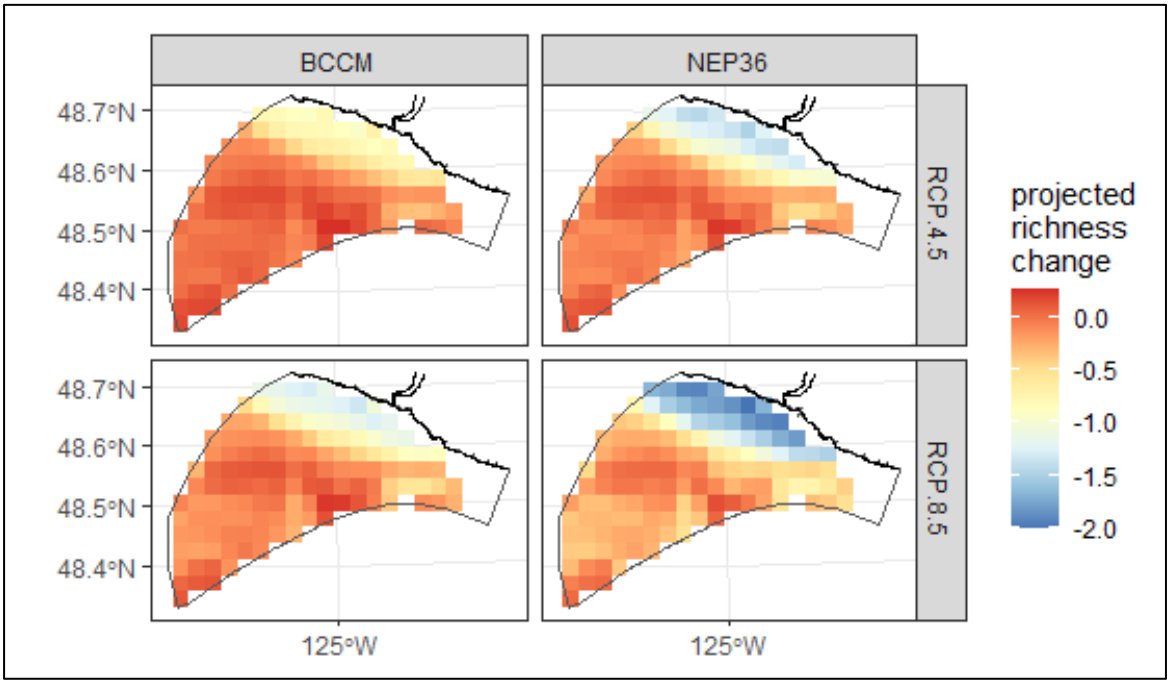


*Figure 136. Projected species richness change in the groundfish communities (total of 40 groundfish species on the Pacific coast) in the Juan de Fuca Eddy EBSA polygon in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 emissions scenario (top row) and the RCP 8.5 emissions scenario (bottom row) for both the BCCM climate model (first column) and the NEP36-CanOE climate model (second column). Note the incomplete coverage of the models in the figure indicated by a white background within the polygon. Data are from Thompson et al. (2023b).*

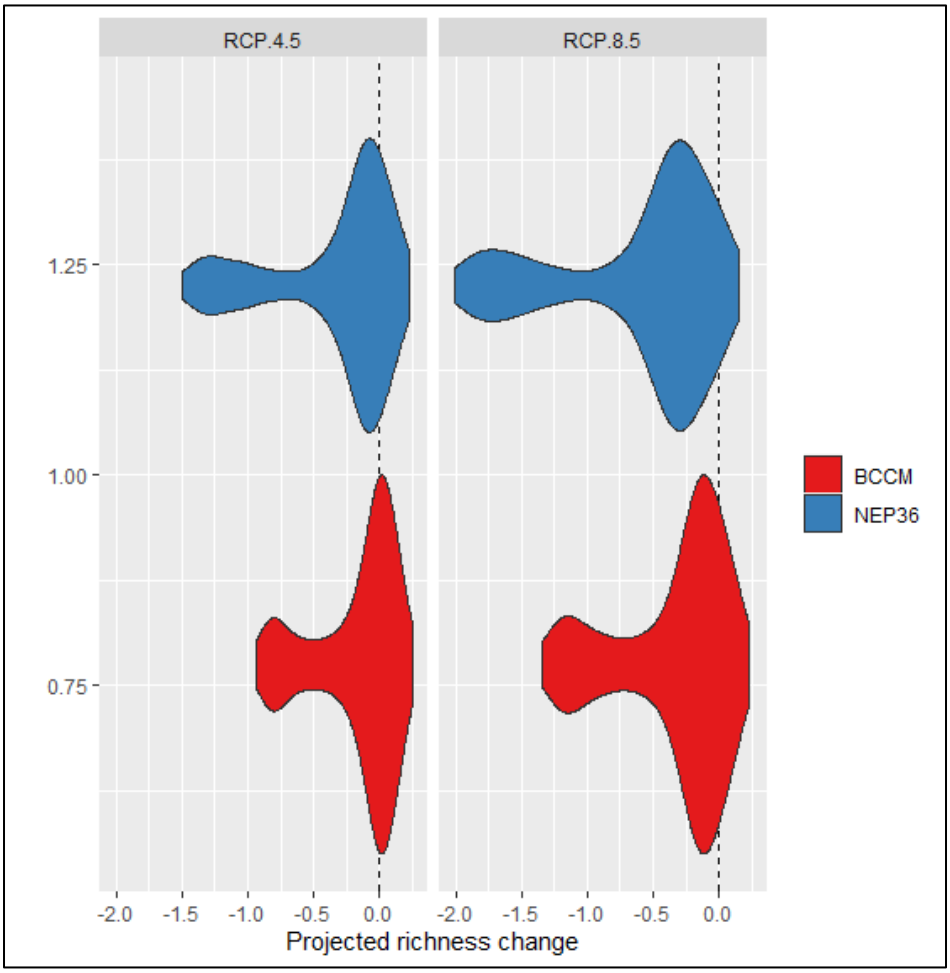


Figure 137. Distributions of projected change in occurrences across the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area for groundfish communities (total of 40 groundfish species on the Pacific coast; Thompson et al. 2023) based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 emissions scenario (left panel) and the RCP 8.5 emissions scenario (right panel) for both the BCCM climate model (in red) and the NEP36-CanOE climate model (in blue). Data are from Thompson et al. (2023b).*

Pacific Herring

The WCVI Pacific Herring stock had its last operation of commercial Herring roe fishery in 2006 and has remained closed to support ongoing rebuilding efforts since then (Cleary et al. 2019). In contrast, the SoG Pacific Herring stock has maintained levels above historical averages over the past two decades (Figure 121). The divergent dynamics observed among different Pacific Herring stocks imply that region-specific environmental forcing factors may exert more influence on Pacific Herring stocks than fishing activities alone (Schweigert et al. 2010). This is consistent with the conclusions by Hare et al. (2016), who emphasized the significance of climate change and decadal variability in fish population dynamics. Employing a machine approach to identify factors associated with Pacific Herring spawn indices, Xu et al. (2019) revealed that spawn abundances of different Pacific Herring stocks in BC were indeed influenced by distinct region-specific environmental variables.

The upwelling index emerged as the most influential environmental factor impacting age-0 Pacific Herring abundance in the SoG (Reum et al. 2011) and Herring spawn indices in the WCVI (Xu et al. 2019). The “dome-shaped” relationship between upwelling-favorable wind-stress and spawn indices suggests that weaker upwelling may curtail nutrient availability for primary production, while stronger upwelling could lead to reduced larval retention and, consequently, lower larval survival rates (Xu et al. 2019). The prevalence of upwelling-favorable wind-stress in the WCVI throughout the 2000s (Xu et al. 2019) indicates that the depressed WCVI Pacific Herring stock may have faced challenges with lower larval retention and survival rates.

In contrast, Schweigert et al. (2010) focused on biotic factors such as zooplankton indices, fish and marine mammal predation, and competing Sardine abundance, and were unable to pinpoint factors responsible for the increase in natural mortality of the WCVI Pacific Herring stock. Predation alone appears insufficient to explain the increase in Pacific Herring natural mortality, despite the species serving as a crucial food source for piscivorous fish, seabirds, and marine mammals (Schweigert et al. 2010). Fu et al. (2017) similarly concluded, through ecosystem modeling, that estimated predation mortality had not shown increasing trends for Pacific Herring stocks off the Northern BC coast over the last two decades. The rising consumption of Pacific Herring by marine mammals may have been offset by the declining consumption of Pacific Herring by decreasing predatory fish abundances (Schweigert et al. 2010; Fu et al. 2017).

Therefore, the recoverability of the Pacific Herring stocks is determined not only by a complex interplay of biotic factors, including an abundant food supply, limited competition, and a reduced predator community (Schweigert et al. 2010), but also by physical environmental factors such as upwelling-favorable wind-stress (Fu et al. 2017; Xu et al. 2019). Achieving a deeper understanding of how both biotic and abiotic factors interact to shape the dynamics of Pacific Herring stocks is crucial for implementing sustainable management practices and facilitating stock recovery efforts.

Eulachon

Applying expert knowledge and employing ten metrics for vulnerability assessment, Moyle et al. (2013) concluded that California Eulachon are “highly vulnerable” to climate change, despite lacking quantitative data on status and trends. This underscores the precarious situation faced by Eulachon populations in the face of environmental shifts and emphasizes the urgent need for conservation efforts and adaptive management strategies. The high vulnerability of Eulachon may stem from several factors, which are elaborated upon below.

The predominant prey item of Eulachon is Euphausiids (see review in Levesque and Therriault 2011; Dealy and Hodes 2019). Eulachon’s specialization in prey may render it more sensitive to environmental change, potentially making it vulnerable to displacement by generalist species (Clavel et al. 2011). The abundance of Euphausiids in Barkley Sound declined up to five-fold, following extreme El Nino (ENSO) events in 1992 and 1993 (Tanasichuk 1998).

Drawing from fisheries acoustics data collected during biennial joint US–Canada Integrated Ecosystem and Acoustic Trawl Surveys for Pacific Hake (*Merluccius productus*), Phillips et al. (2022) developed a time series of Euphausiid abundance for odd years between 2007 and 2019. Their generalized additive modeling indicated that the highest Euphausiid abundance was correlated with cooler waters, implying that the rising water temperatures off the west coasts of the United States and Canada in recent decades may have led to a reduction in Euphausiid

abundance. This decline in Euphausiids could have contributed to the ongoing declines in Eulachon populations.

Indeed, studies have documented negative correlations between warmer ocean temperatures and Eulachon abundance across various temporal and spatial scales (e.g., Hay et al. 1997; Ferriss and Zador 2021). As ocean temperatures continue to rise, there is a looming concern that future warming trends may exacerbate the decline in Eulachon abundance in BC and other regions.

Larval and juvenile Eulachon also exhibit high dietary specialization, with 73% of their diet comprising calanoid copepods and 13% cladocerans, as recorded from stomach content during 1966-68 (Osgood et al. 2016). It's been speculated that this pronounced diet specialization may have contributed to the decline and limited recovery of Fraser River Eulachon (Mackas et al. 2013).

Eulachon serve as prey for a diverse array of species, including fish, marine mammals, and birds, throughout their lifecycle, whether in spawning rivers or in oceanic environments (Levesque and Therriault 2011; Schweigert et al. 2012). The notable increases of Pacific Hake and Harbour Seals (*Phoca vitulina*) observed in Canadian waters during the early 1990s are among the prominent factors believed to have escalated Eulachon predation mortality (Levesque and Therriault 2011). The potential rise in predation mortality, coupled with the decline of their preferred prey, along with coastwide climate changes, particularly warming trends (DFO 2023i), may render Eulachon highly vulnerable, necessitating additional efforts to achieve recovery.

Pacific Sand Lance

Sand Lance in the Northwest Atlantic Ocean was assessed as "moderately vulnerable" in a vulnerability assessment to climate change (Hare et al. 2016). In the assessment, vulnerability was scored based on the species' exposure to a stressor (climate change and decadal variability) and the sensitivity of the species to the stressor (Hare et al. 2016). As prey generalists, Sand Lance exhibit a lower vulnerability to climate-induced shifts in zooplankton species composition compared to prey specialists like Eulachon. Moreover, their life history strategy, which involves diurnal and seasonal (during winter months) burrowing in sandy sediments for refuge and rest, contribute to their relatively high resilience (Huard 2023). The winter dormancy observed in Sand Lance is believed to be an adaptive strategy to cope with limited food resources during the winter months (Matta and Baker 2020), further enhancing the resilience of this species.

A comprehensive evaluation of threats affecting both Sand Lance and their unique coarse, silt-free sand habitats in the Salish Sea has been conducted through meticulously designed expert surveys and the calculation of cumulative rank score of relative vulnerability (Huard et al. 2024). This investigation identified the top three threats as sea level rise, increasing sea temperatures, and extreme weather events (refer to Table 27 for a full list of weighted vulnerability scores of threats to Pacific Sand Lance). Sand Lance, being a species highly specific to its habitat, may face habitat reduction due to rising sea level rise (Greene et al. 2017). Moreover, an elevated sediment slope has been linked to decreased overwinter survival of reproductive adults of Sand Lance (Suca et al. 2021).

Table 27. Weighted relative vulnerability scores of threats assessed to Pacific Sand Lance and their habitats in the Salish Sea. Table source: Huard et al. (2024). Threats were weighted based on expert responses to questions about the vulnerability of sand lance to each threat.

Order	Threat in Rank Order	Weighted Vulnerability Values
1	Climate change: Sea Level Rise	0.818994
2	Climate change: Sea Temp Rise	0.808459
3	Climate change: Extreme Weather	0.808459
4	Microplastics	0.808459
5	Shoreline Armouring	0.699717
6	Dredging: Sediment Removal	0.682608
7	Shipping	0.682608
8	Decrease in Sediment Input from freshwater sources	0.653483
9	Pollution: Non-Point Source	0.607396
10	Port Activities and Developments	0.605802
11	Dredging: Sediment Dumping	0.595486
12	Climate change: Ocean Acidification	0.580546
13	Increase in Sediment Inputs	0.574110
14	Pollution: Accidental Spills	0.569574
15	Aquaculture: Shellfish	0.540972
16	Riparian Vegetation Loss	0.520428
17	Pollution: Urban Waste Water	0.517685
18	Aquaculture: Salmon	0.476269
19	Beach Recreation	0.454151
20	Aquaculture: Kelp	0.360306

Rising sea temperatures have led to poor recruitment of Sand Lance (Bertram and Kaiser 1993) and the extreme weather event of marine heatwave occurring between 2014 and 2016 has stunted their body growth (Robinson et al. 2024). Shoreline armoring, a prevalent form of coastal development in the Salish Sea (Dethier et al. 2016), has reduced the unique sedimentary habitats of Sand Lance and was ranked as the fifth threat (Table 27; Huard et al. (2024)). This threat was deemed relatively more manageable compared to the top three climate-induced threats.

Although bottom fishing trawls are not a threat to Sand Lance in the Salish Sea, Sand Lance populations associated with the **ʔušiiʔaaʔaq̓**/Swiftsure Bank Area are susceptible to this threat. Bottom fishing trawls have the potential to disrupt their eggs during development periods or disturb older individuals burrowed in the sediment (Staudinger et al. 2020).

Salmonids

The predation dynamics involving marine mammals (pinnipeds and Killer Whales) and salmon populations on the west coast of Vancouver Island are complex due to various ecological and anthropogenic factors. The interplay between these predators and prey, specifically Chinook Salmon (*Oncorhynchus tshawytscha*), could be key to understanding the ecological balance in this region. Pinniped populations, including Harbour Seals (*Phoca vitulina*) and sea lions, have rebounded since the early 1970s (see Pinnipeds), coinciding with a decline in Chinook Salmon populations, which are vital food resources for critically endangered SRKW (Hanson et al. 2010; Chasco et al. 2017; Riera et al. 2019; Couture et al. 2022; see Cetaceans). Competition for salmon has intensified, raising concerns about salmon sustainability (Chasco et al. 2017; Sorel et al. 2020).

Research highlights the impact of pinniped predation on salmonids (e.g., Wright et al. 2007b; Naughton et al. 2011). Pinniped predation is concentrated in estuarine environments, complicating salmon recovery during critical migration stages (Wright et al. 2007b; Ohlberger et al. 2019). However, this research should be interpreted cautiously in its application to the west coast of Vancouver Island. Environmental factors, such as seasonal upwelling and marine ecosystem health, further influence salmon dynamics, creating feedback loops that affect the entire food web (Miller et al. 2012; Bass et al. 2023). Efforts to reduce juvenile marine mortality are critical for rebuilding Chinook Salmon populations, yet the high survival rates of the 1970s and 1980s may have applied to a limited number of coastal stocks, while many have exhibited stable or cyclical survival despite changing conditions (Freshwater et al. 2022). Although juvenile Chinook Salmon survival has been low, it has also been stable and most stocks have shown no recent decline except for sub-yearling stocks in the Strait of Georgia, which entered a low survival period in the mid-1980s (Freshwater et al. 2022), prior to the peak pinniped abundance of the 1990s. Declines in mean age-at-maturity across stock groups may influence future Chinook productivity, and evidence suggests that late-stage mortality rates from predators like Resident Killer Whales and Salmon Sharks could be higher than previously recognized. However, local diet estimates indicate that the actual proportion of salmon in pinniped diets may be lower than previously reported (S. Tucker, DFO, pers. comm.).

These predator-prey interactions pose significant challenges for fisheries management and conservation. Balancing the needs of protected marine mammals with salmon recovery necessitates integrated management strategies (Chasco et al. 2017; Sorel et al. 2020) and innovative ecosystem management approaches will be required to address these multifaceted interactions (Heredia-Azuaje et al. 2021; McDonald 2023).

Cartilaginous Fishes

Many cartilaginous fish populations have declined due to historical overfishing, bycatch in fisheries, and habitat degradation. For example, the Basking Shark population in Canada's Pacific has been drastically reduced compared to its historical abundance. Historical harvest of sharks as a source of Vitamin A from livers and as food fisheries, along with eradication programs for species considered to be pests were common in the 20th century and led to declines in abundance (King et al. 2017; McFarlane and King 2020). As noted above, many cartilaginous fishes have slow growth rates, large sizes, long lifespans, and delayed sexual maturity (McFarlane and King 2020), which may limit population recovery.

6.2.4.4 Data and Knowledge Gaps

Groundfish

Genetic assessments of coastal groundfish populations are largely absent, limiting understanding of their site fidelity, movement patterns, and population exchange. This lack of data hinders the ability to assess the extent of population mixing within the EEZ and the California Current ecosystem. The potential for hybridization along the West Coast of Vancouver Island is also poorly understood. Stock assessments for many groundfish species are outdated or characterized by uncertainty, often based on limited data or inadequate biological sampling. For example, stock assessments for Dover Sole and Petrale Sole carry high uncertainty and require updates. Additionally, more data are needed on the biology and regional distribution of sole species in the **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area to address these gaps and understand their ecological role. Lingcod stock assessments, conducted over a

decade ago, also showed significant uncertainty in estimates, indicating a need for more current evaluations.

Biological data for many groundfish species are limited, both regionally and coastwide. For instance, information on the Canary Rockfish's diet, migratory patterns, and genetics is sparse. The abundance of rockfish in the Inshore Complex, which includes Copper and China Rockfish, is unknown, and these stocks have not been assessed by DFO. Although genetic studies have provided some insight into Copper Rockfish stock structure, further research is needed to fully understand their population connectivity and the implications for management. There is a lack of data on the stock structure, life history, and genetics of China Rockfish. Estimates for Quillback Rockfish in the outside management unit are highly uncertain due to variability in trend indices and imprecise biomass estimates. The life history of Yelloweye Rockfish is poorly understood, making it difficult to assess the effectiveness of conservation measures and understand the factors contributing to their decline. The habitat preferences of rockfish species in the **ʎušiiʔaaʔaq/**Swiftsure Bank Area requires continued research, particularly regarding their preference for different types of rock and biocover. Additionally, the factors affecting rockfish recruitment and the long-term consequences of overfishing are still unclear. Given their long lifespans and slow growth, understanding the impacts of these factors on their populations is critical.

Ecosystem models – models that attempt to incorporate ecosystem components and processes into a single modelling framework (Geary et al. 2020) – are limited, both regionally and coastwide (see Fu et al. 2012; Oldford 2024 for ecosystem models for the Strait of Georgia). The ability for complex interactions, feedback loops and dependencies between ecosystem components to be incorporated into ecosystem models makes them valuable tools for understanding and managing ecosystems and marine spaces. Predicting the outcomes of complex interactions using these models can inform decision making, identify important uncertainties, and would be valuable information for better understanding ecosystem patterns and processes in the **ʎušiiʔaaʔaq/**Swiftsure Bank Area.

An additional data gap related to groundfish species as a whole is the current lack of a dedicated groundfish diet monitoring program (with the exception of Pacific Hake (DFO unpublished data; S. Gauthier, DFO, pers. comm.)). This information (i.e., predator prey interactions) would be beneficial to incorporate into ecosystem models and studies on species interactions and warrants further investigation. Information on population trends for flatfish species, particularly on the West Coast of Vancouver Island, is also limited and warrants further investigation. The effects of declining dissolved oxygen levels on Pacific Halibut populations, especially in shallow coastal areas like the **ʎušiiʔaaʔaq**/Swiftsure Bank, should be studied further, particularly in the context of climate change.

There is a significant data gap regarding the decline of the Pacific Cod stock in Area 3CD, which includes the **ʎušiiʔaaʔaq/**Swiftsure Bank Area. Research should focus on the potential impacts of climate change, fishing pressure, and other environmental factors on Pacific Cod populations in this region. Finally, given the vulnerability of Sablefish to changing oceanographic conditions, further research is essential to understand the impacts of climate change on their abundance, productivity, and distribution.

Pelagic fishes

Small pelagic fish, forage fish, are an essential part of marine trophic food webs and can also be commercially and culturally important. Their abundance is highly spatially and temporally variable, which creates difficulties for designing sampling protocols and creating population forecasts and retrospective analyses related to recruitment. Factors that affect the population abundance of forage species include environmental conditions, system productivity, and the carrying capacity of ecosystems, as well as by a variety of factors influencing survival and recruitment to the adult population. A detailed understanding of which factors affects their population dynamics is required for accurate assessments of these species and to determine their role within food webs and ecosystems (Boldt et al. 2019). Surveys and assessments of non-commercially important species are often undeveloped, and important life history attributes remain unknown. Many researchers have identified a lack of forage fish data as a limiting factor for our understanding of ecosystems and in tools such as ecosystem models. DFO Science requires forage fish time series in order to develop ecosystem models that can provide an indication of how changing environmental conditions will affect fish productivity. Fisheries management can use forage fish abundances as indices for commercially important fish productivity. This would also benefit the *Species At Risk Act* (SARA) through improvement of methods for detecting rare species, and benefit marine conservation planning, by improving our ability to identify critical foraging habitats and inform decisions to develop and define boundaries for Ecologically or Biologically Significant Areas (EBSAs) and marine conservation areas (Liu et al. in press).

Pacific Herring

Despite extensive research dedicated to Pacific Herring, understanding its recruitment process remains elusive (Boldt et al. 2022; DFO 2022b). Recruitment variability in marine fishes, believed to be the force behind the “boom–bust” fluctuations in small pelagic fish populations, is influenced by a multitude of factors, including trophodynamic and physical processes, operating across various temporal and spatial scales during the early life stages, which impact the mortality and growth of eggs, larvae, and juveniles (Hjort 1914; Houde 2008). For the SoG and WCVI Pacific Herring stocks, the specific factors driving recruitment and their impacts have yet to be understood, posing challenges in forecasting the future dynamics of these stocks (DFO 2022b). A comprehensive review of scientific literature on forage fish revealed a predominant focus on the adult stage, with less attention given to each of the early life history stages (Boldt et al. 2022). The results of this study highlighted the need for increased research on early life history stages of forage fish to identify drivers of recruitment variability.

Temporal variation in natural mortality has been incorporated into certain (e.g., Fu et al. 2004), though not all, Pacific Herring stock assessments. The overestimation of abundance resulting from the omission of natural mortality variability in stock assessment models has been considered as a potential factor contributing to the decline of many Pacific Herring stocks worldwide (Jacobsen et al. 2019; Benson et al. 2023). However, the root cause of temporal variation in natural mortality remains largely unidentified, and linkages between natural mortality variability and specific environmental or biological variables are largely unknown. Nevertheless, natural mortality variability is believed to reflect underlying changes in marine ecosystems resulting from global climate change (Pereira Campos et al. 2023).

Moreover, the absence of mechanistic models linking climate to population dynamics is a common challenge across various species (Hare et al. 2016), and Pacific Herring is no

exception. Research conducted in the Gulf of Alaska revealed that the abundance and quality of several key forage fish species, including Pacific Herring, reached historically low levels during the Pacific marine heatwave of 2014–2016 (Arimitsu et al. 2021). This marine heatwave event also affected seabirds, marine mammals, and groundfish, leading to shifts in their distribution, mass mortalities, and reproductive failures (Arimitsu et al. 2021). The impacts of this marine heatwave on the dynamics of the SoG and WCVI Pacific Herring stocks have not been thoroughly investigated.

Eulachon

Unlike BC Pacific Herring, which undergo regular stock assessments (e.g., DFO 2022b) and have biological reference points for facilitating fisheries management (Forrest et al. 2023), no such stock assessment has been conducted for Fraser River Eulachon. This is partly due to the lack of age composition data (DFO 2023i; Flostrand et al. 2023). Conservation limits for Eulachon based on ecosystem considerations are also unavailable, and there is a lack of pre-season abundance estimates to guide management decisions on river FSC harvest (DFO 2023i). Indigenous communities in the Lower Fraser Area have requested a review of allowable bycatch and encounter protocols to minimized incidental mortality of Eulachon and advocated for a reassessment of current FSC harvest levels and the development of an abundance-based approach to determine harvest levels for future years (DFO 2023i). These initiatives underscore the importance of collaborative efforts between Indigenous knowledge holders, scientists, and policymakers to promote sustainable management practices for Eulachon populations.

In contrast, year-specific age composition data were obtained for the Columbia River Eulachon population through surface reading of 735 whole otoliths, enabling the estimation of recruitment for the specific years and the identification of fisheries management reference points (Langness et al. 2020). A similar study could be conducted for the Fraser River Eulachon population to gain a comprehensive understanding of its dynamics and underlying drivers. Such research efforts are vital for informed conservation and management strategies aimed at ensuring the sustainability of Eulachon populations.

Crucial information regarding the carrying capacity, particularly within the spawning river, and the population growth rates of Eulachon remain unknown (Levesque and Therriault 2011). Additionally, key life history parameters are unavailable, hindering the estimation of recovery time and likelihood (Levesque and Therriault 2011).

Research on the relationship between Eulachon population dynamic and various environmental factors has been limited, creating a knowledge gap in our mechanistic understanding of Eulachon variability. As data on Eulachon spawning stock biomass and CPUE become increasingly available, there is an opportunity to apply advanced analytical techniques, including machine learning approaches, to elucidate relationships between multiple factors and Eulachon dynamics, similar to studies conducted for Pacific Herring (Xu et al. 2019).

Pacific Sand Lance

Sand Lance hold significant ecological importance within marine food webs; however, they are not commercially harvested, resulting in a lack of fishery-dependent data (Boldt et al. 2019). Throughout their range, critical aspects of their population status, population structure, feeding ecology, reproductive biology, life history, and distribution are largely unknown (Selleck et al. 2015; Sisson and Baker 2017; Baker et al. 2019; Staudinger et al. 2020).

Pacific Sand Lance (*Ammodytes personatus*) support marine food webs in coastal BC, yet knowledge of intertidal spawning habitat for this species is limited. Studies of winter habitat in shallow subtidal areas of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank would help fill this data gap, as there has been some detection of potential winter burrowing for Sand Lance.

Salmonids

Although recent assessments have identified limiting factors for wild salmon production in the Nitinaht and Cheewaht Rivers, similar assessments are needed for adjacent watersheds in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Additionally, many salmon Conservation Units in the **ƛ̓ušiiʔaaʔaq** Area have not been formally assessed. This suggests a lack of comprehensive information about the status and trends of these salmon populations. Although some of these gaps are being addressed by monitoring work by the Ditidaht First Nation.

The amount of salmon removals from the marine ecosystem through fisheries (commercial or recreational) and through predation (from marine mammals) is unclear. The spatial resolution of salmon logbook data is low, as is the recreational fishing data, which is spatialized at the Pacific Fisheries Management Area Subarea level. These represent large areas and may not accurately reflect salmon removals within the specific boundaries of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Furthermore, there is limited data available on how diet and prey dynamics of Harbour Seal and Pacific salmon consumption influence their population dynamics (see Sensitivities and Recoverability and Pinnipeds).

Cartilaginous fishes

Population assessments for cartilaginous fishes are often challenging due to limited survey data, the rarity of many species, and data gaps in life history information. More research is needed to understand the recovery potential of cartilaginous fish populations, considering their vulnerability to exploitation and the long-term impacts of historical harvest and eradication programs.

6.2.5 Marine birds

The productive habitats within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area support globally, nationally, and regionally important concentrations of a diverse community of marine birds during migration, breeding, and non-breeding periods. Marine birds are upper-level predators within marine food webs. Their use of habitat reflects 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) as well as other factors. Marine bird 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 2006a; Kenyon et al. 2009; Santora et al. 2018). Common marine bird prey species include zooplankton, fish and fish eggs, crustaceans, bivalves, and other invertebrates. Availability of zooplankton such as krill and copepods are important drivers for breeding phenology, productivity, and distribution of planktivorous birds that use marine habitat in the **ƛ̓ušiiʔaaʔaq** (Bertram et al. 2005, 2017a, 2017b). Zooplankton species are also prey for fish species eaten by marine birds such as Pacific Sand Lance, Pacific Saury, Pacific Herring, juvenile rockfish, and juvenile salmon (Burger et al. 1993; Hedd et al. 2006). Consequently, climate-driven variation in the distribution, abundance, and phenology of low trophic-level organisms can have cascading effects within marine food webs (Hipfner et al. 2020). Marine birds provide an integrated response to climate change because their breeding phenology, productivity, and distribution are closely linked to marine resources. Similarly, marine birds can be valuable indicators of ocean health because their breeding habitats remain static, while the availability of their food resources is dynamic in both time and distribution (Sydeman et al. 2015, 2021).

Baseline scientific data on the distribution, abundance, and species composition at sea within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is not comprehensive, primarily due to variability in survey effort and methodology, as well as hourly, daily, seasonal, and annual fluctuations in numbers that are common for many marine bird species. However, recent survey efforts are increasing the availability of current and year-round abundance and distribution data in the **ƛ̓ušiiʔaaʔaq** (C. Fox, ECCC, pers. comm.). Species occurrence data for Nitinaht Lake were provided by the Ditidaht First Nation Marine Bird Monitoring Program (Figure 138), while occurrence data in the Juan de Fuca Eddy EBSA polygon in the **ƛ̓ušiiʔaaʔaq** (Appendix F) were obtained from several sources, including the Pacific Rim National Park Reserve monitoring program, the Environment and Climate Change Canada Canadian Wildlife Service (ECCC-CWS) Pelagic Seabird Atlas Database (Kenyon et al. 2009), British Columbia Seabird Colony Database[77], and unpublished ECCC-CWS data. Data were also sourced from Global Biodiversity Information Facility[78].

[77] https://open.canada.ca/data/en/dataset/cc3c0551-1bf7-47cf-9510-f2df2de55730
[78] https://www.gbif.org/

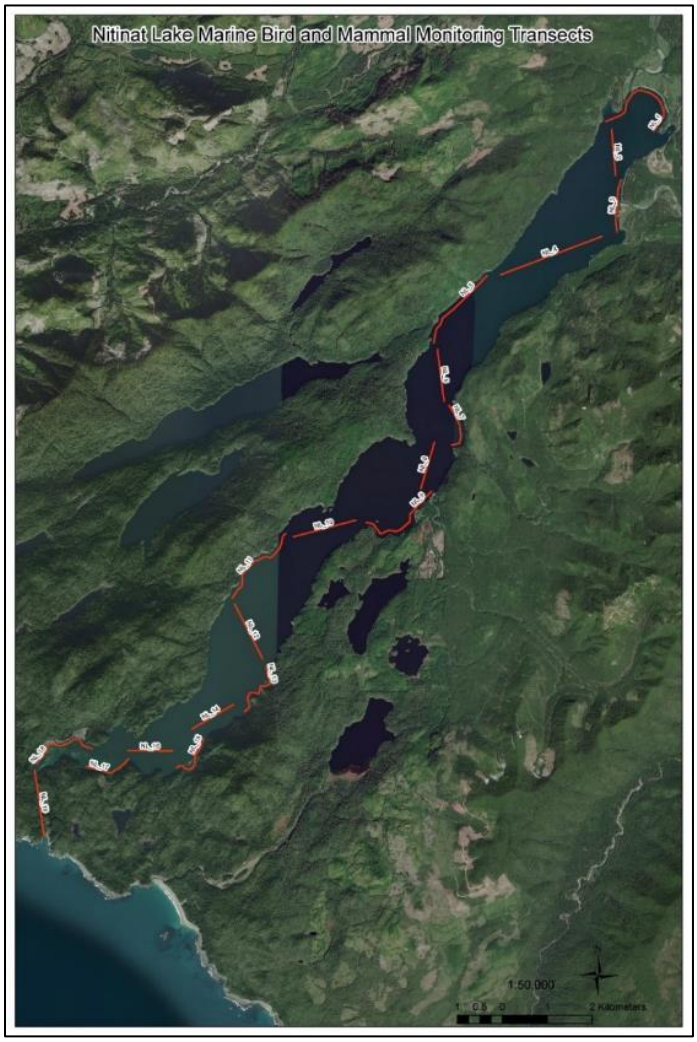


Figure 138. Nitinaht Lake marine bird and mammal monitoring transects completed by the Ditidaht First Nation and MC Wright and Associates Ltd.

The **ʔušiiʔaaʔaq**/Swiftsure Bank Area supports a diversity of species including albatrosses, auklets, cormorants, fulmars, guillemots, gulls, grebes, loons, jaegers, kittiwakes, murrelets, murres, petrels, phalaropes, shearwaters, storm-petrels, and waterfowl. At least 82 species of marine birds have been observed within the Juan de Fuca Eddy EBSA polygon for the **ʔušiiʔaaʔaq**; however, this species list is considered by experts to under-represent the species that use these habitats. Including the biodiversity observed at Nitinaht Lake, the number of total bird species documented is 90. The Juan de Fuca Eddy EBSA polygon also overlaps with the internationally recognized Amphitrite and **ʔušiiʔaaʔaq**/Swiftsure Bank Important Bird Area, which is recognized for global and nationally significant concentrations of albatross, shearwaters, and gulls (IBA Canada).

Pelagic seabirds such as albatrosses, petrels, and shearwaters travel long distances across the Pacific Ocean, with many crossing hemispheres, to use the marine habitats along the BC coast, including the continental shelf and shelf break, eddies, and other areas of importance (Kenyon et al. 2009). The productive habitats in the **ʔušiiʔaaʔaq**/Swiftsure Bank Area are known to support often high densities of marine bird species for significant proportions of their annual

cycle (Beal et al. 2021), with notable examples including albatrosses, petrels, and shearwaters. An analysis of pelagic marine bird density, conservation status and species richness resulted in a relative grid cell importance score for the pelagic population of the Pacific Region (Kenyon et al. 2009), with high values of grid cell importance reported for pelagic marine birds species throughout the **ƛ̓ušiiʔaaʔaq** (Figure 139, Figure 140).

Among the rich diversity of marine bird species that use the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area**,** two species in particular stand out for their conspicuous aggregations that seasonally occur in the region, and which are not found in similar numbers elsewhere in coastal BC. For example, from spring to fall, the **ƛ̓ušiiʔaaʔaq** and surrounding waters support high densities of Pink-footed Shearwater (*Ardenna creatopus*) (SARA Schedule 1 Endangered), which ranks among the most threatened seabird species on Canada's Pacific coast (Kenyon et al. 2009, C. Fox, pers. comm.). Sabine's Gull (*Xema sabini*), which undertake the longest migration of any gull species (Stenhouse et al. 2012), are heavily reliant on the Juan De Fuca eddy, including the **ƛ̓ušiiʔaaʔaq,** with GPS tracking of individuals on breeding grounds in the Canadian Arctic and Alaska indicating that the majority of the Pacific wintering population stage in the Juan De Fuca eddy and the northern portion of the California Current System (Davis et al. 2016; Gutowsky et al. 2021; McGuire et al. 2024).

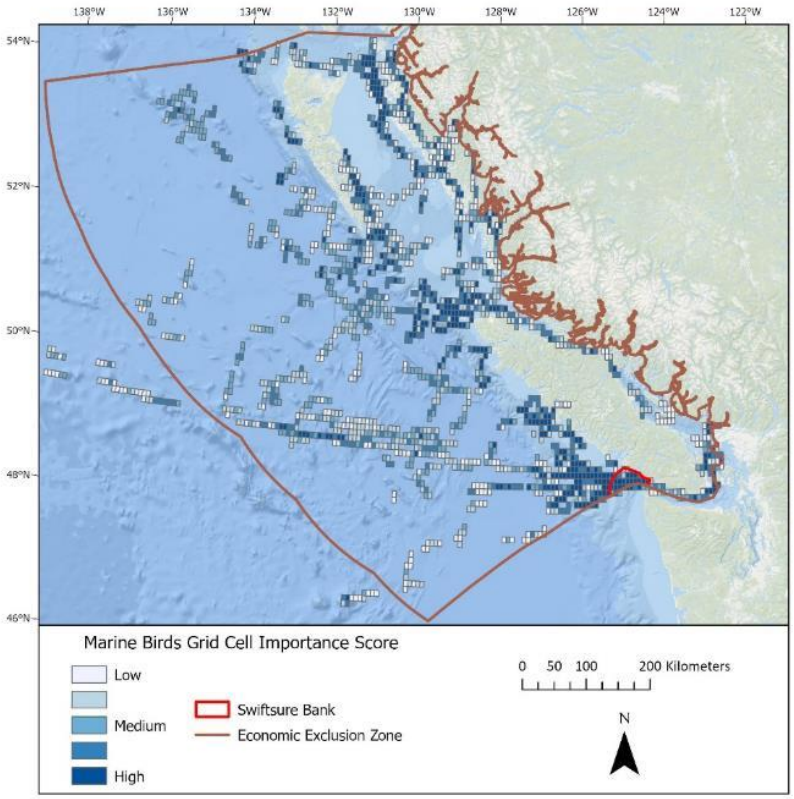


Figure 139. Relative grid cell importance for pelagic marine birds on the Pacific coast and the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area (Juan de Fuca Eddy EBSA polygon delineated in red). For each grid cell, the grid cell importance score was the sum of three standardized values (total bird density, 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 (Kenyon et al. 2009).*

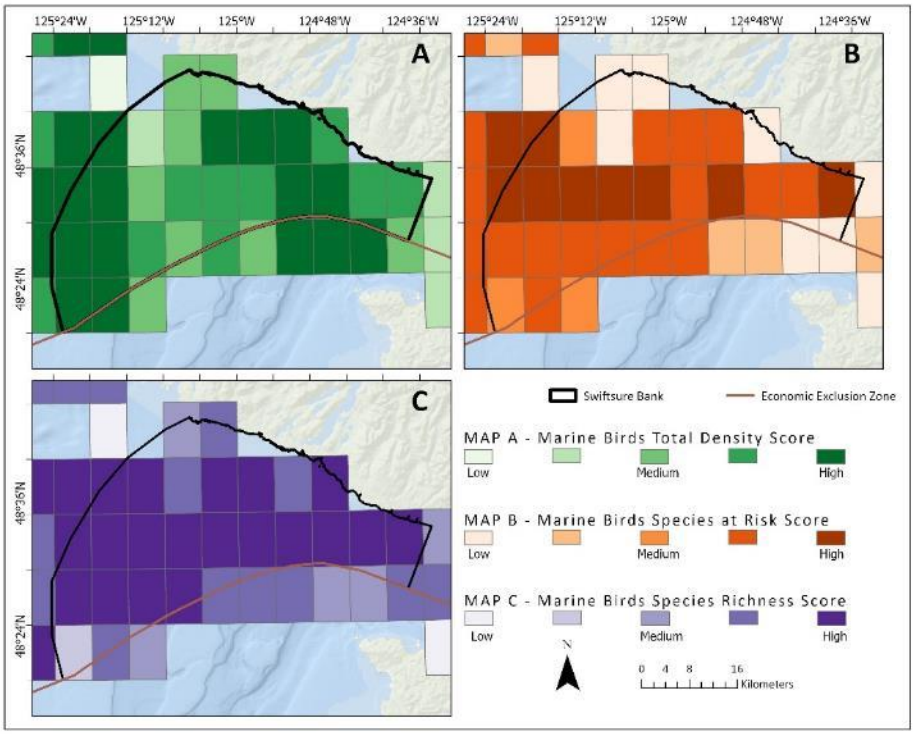


*Figure 140. Total bird density, species richness value, and species at risk score of marine birds in the Juan de Fuca Eddy EBSA polygon in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Grid shading represents five quantiles, with high being the upper 20% of the cells with the highest grid cell importance values. Data from the Atlas of Pelagic Seabirds off the West Coast of Canada and Adjacent Areas (Kenyon et al. 2009).*

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area also includes a variety of nearshore habitats and sites of ecological value for marine birds throughout their annual cycles, including nearshore waters, rocky shorelines, estuaries and salt marshes, kelp and eelgrass beds, and coastal islands (Kenyon et al. 2007). Estuaries are known to be important habitats to a diverse complex of birds for breeding and foraging, and for associations with eelgrass beds and Pacific Herring spawning habitat; ecological importance of estuaries for waterbirds has been ranked by the Pacific Estuary Conservation Program (Pacific Birds Habitat Joint Venture Technical Team 2021). Ranked estuaries in the **ƛ̓ušiiʔaaʔaq** are described in more detail in the Estuaries and salt marshes section. The protected waters of Nitinaht Lake also provide important habitat for marine birds, in particular for sea ducks and other waterfowl in the winter and early spring months, and a variety of gull species in the fall, which are monitored by the Ditidaht First Nation Marine Bird Monitoring Program.

Records of marine bird breeding colonies within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank polygon are limited to two small Pelagic Cormorant (*Phalacrocorax pelagicus)* breeding colonies, but there is a notable multi-species breeding colony located immediately north at Seabird Rocks within Pacific Rim National Park Reserve (PRNPR). It is the most significant breeding site within the park reserve and Barkley Sound area. Species observed breeding at this site include include: Black Oystercatcher (*Haematopus bachmani*), Cassin's Auklet (*Ptychoramphus aleuticus*), Leach's Storm-petrel (*Hydrobates leucorhous*), Fork-tailed Storm-petrel (*Hydrobates furcatus*), Glaucous-winged Gull (*Larus glaucescens*), Pelagic Cormorant (*Phalacrocorax pelagicus*), Pigeon Guillemot (*Cepphus columba*), Rhinoceros Auklet (*Cerorhinca monocerata*), and

historically, Tufted Puffin (*Fratercula cirrhata*) (Carter et al. 2012). In addition, there are additional significant breeding colony sites south of **ƛ̓ušiiʔaaʔaq** in Washington State.

The PRNPR monitoring program (Zharikov and Yakimishyn in Boldt et al. 2020) continues annual monitoring of demographic parameters and breeding abundance for 5 species of nesting seabirds (Pigeon Guillemot, Rhinoceros Auklet, Glaucous-winged Gull, Leach's Storm-Petrel and Fork-tailed Storm-Petrel) at the Seabird Rocks Colony through population counts and capture-mark-recapture techniques. The monitoring program also assesses trends in marine (at-sea) abundance of the seven most common and regularly encountered species of marine birds occurring in the nearshore waters of the PRNPR: Common Murre (*Uria aalge*),Glaucous-winged Gull, Marbled Murrelet (*Brachyramphus marmoratus*), Pacific Loon (*Gavia pacifica*), Pelagic Cormorant, Pigeon Guillemot, and Rhinoceros Auklet (Figure 141).

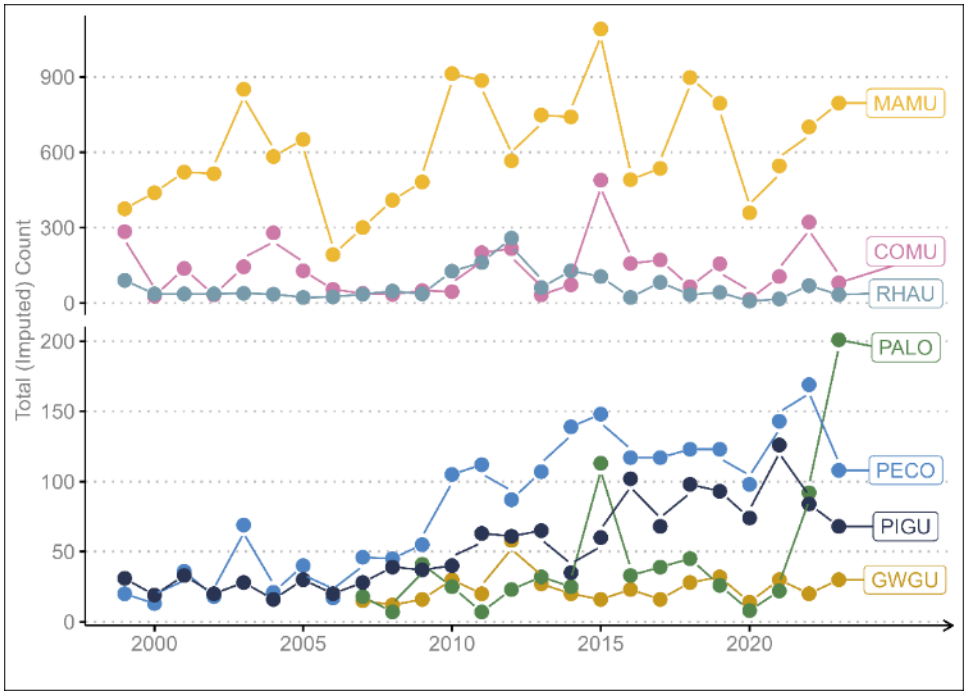


Figure 141. Annual variation in seabird abundance in Pacific Rim National Park Reserve based on at-sea counts in the Broken Group Island and West Coast Trail Units of Pacific Rim National Park Reserve. The plotted values represent the combined mean estimated transect count. The total transect length is ca. 90 km

Terrestrial habitat adjacent to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area provides Critical Habitat for breeding Marbled Murrelet (Figure 142) and highlight the importance of the connection between the ocean and coastal rainforests. These small seabirds spend most of their time at sea close to shore while nesting as solitary pairs at low densities, typically in old-growth forests within 50 km of the ocean (Environment and Climate Change Canada 2023). Proximity to nesting habitats has been identified as a key variable in predicting Marbled Murrelet marine distribution patterns during breeding in the nearshore waters of BC, and they show high forage site fidelity with spatially fixed habitat components such as streams (Ronconi 2008; Pastran et al. 2021).

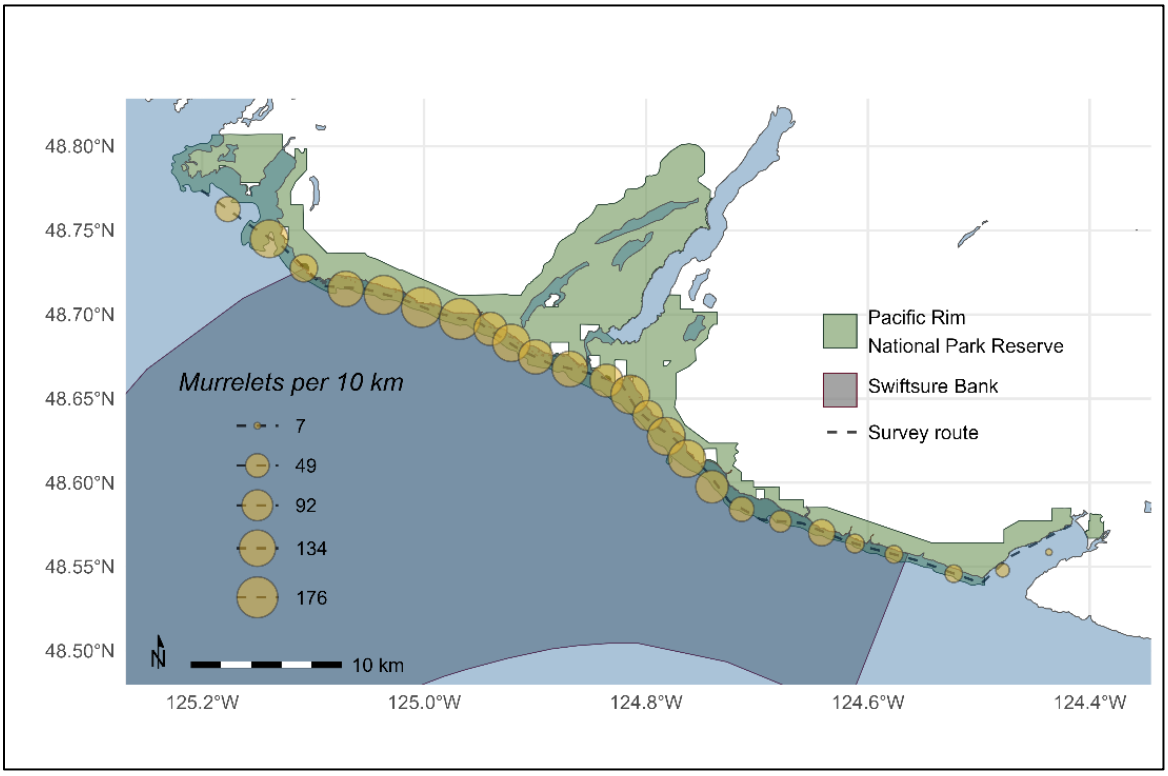


Figure 142. Spatial patterns in distribution of Marbled Murrelet along the West Coast Trail transects of PRNPR. Mean-long term (1999-2023) bird density per transect leg.

There are few records of Pacific Herring spawning within the **ʎušiiʔaaʔaq**/Swiftsure Bank polygon; however, there are numerous Pacific Herring spawn events north of the area in Barkley Sound and marine birds are known to congregate at Pacific Herring spawning sites during late winter and early spring. Both Pacific Herring adults and roe are an important food source for many bird species. The relative seasonal predictability of spawn events and the seasonal pulse of energy-rich food makes them important habitats for large numbers of both overwintering and migrating marine birds (Willson and Womble 2006).

Since 2022, the Ditidaht First Nation has been completing at-sea marine bird monitoring as part of their Marine Stewardship and Monitoring Program. The objective of this program is to document species-specific densities, distribution, and occurrence on Nitinaht Lake throughout the year. To date, a total of 39 species of birds have been observed on the lake (Table 28).

Table 28. List of species observed during at-sea marine bird monitoring on Nitinaht Lake since January of 2022.

Common Name	Scientific Name	4-letter Code
American Crow	*Corvus brachyrhynchos*	AMCR
American Robin	*Turdus migratorius*	AMRO
Bald Eagle	*Haliaeetus leucocephalus*	BAEA
Band-tailed Pigeon	*Patagioenas fasciata*	BTPI
Barrow's Goldeneye	*Bucephala islandica*	BAGO
Common Goldeneye	*Bucephala clangula*	COGO
Belted Kingfisher	*Megaceryle Alcyon*	BEKI
Blue-winged Teal	*Spatula discors*	BWTE
Brandt's Cormorant	*Urile penicillatus*	BRAC
Bufflehead	*Bucephala albeola*	BUFF
California Gull	*Larus californicus*	CAGU
Canada Goose	*Branta canadensis*	CANG
Common Loon	*Gavia immer*	COLO
Common Merganser	*Mergus merganser*	COME
Common Raven	*Corvus corax*	CORA
Double-crested Cormorant	*Nannopterum auritum*	DCCO
Great Blue Heron	*Ardea herodias*	BGHE
Green-winged Teal	*Anas crecca*	GWTE
Glaucous-winged Gull	*Larus glaucescens*	GWGU
Harbour Seal	*Phoca vitulina*	N/A
Herring Gull	*Larus argentatus*	HERG
Hooded Merganser	*Lophodytes cucullatus*	HOME
Horned Grebe	*Podiceps auritus*	HOGR
Mallard	*Anas platyrhynchos*	MALL
Marbled Murrelet	*Branchyramphus marmoratus*	MAMU
Northern Shoveler	*Spatula clypeata*	NSHO
Pelagic Cormorant	*Urile pelagicuse*	PECO
Red-throated Loon	*Gavia stellata*	RTLO
Rhinoceros Auklet	*Cerorhinca monocerata*	RHAU
Ring-billed Gull	*Larus delawarensis*	RBGU
Ring-necked Duck	*Aythya collaris*	RNDU

6.2.5.1 Sensitivities and Recoverability

Marine birds have diverse life history strategies, including use of terrestrial and marine environments. Therefore, marine birds are vulnerable to changes in multiple ecosystems, such as shifting availability of prey or forage species in their ocean feeding grounds, and habitat degradation and invasive species impacts on their nesting sites. At the Seabird Rocks breeding colony within PRNPR, Cassin's and Rhinoceros Auklets were extirpated by 2011 and populations of Leach's and Fork-tailed Storm-Petrels were possibly reduced due to predation by Northern River Otter (*Lontra canadensis*) (Carter et al. 2012). Tufted Puffins stopped nesting on the Rocks in 1998, likely due to human disturbance and predation. Expanded use of Seabird

Rocks by California sea lions (*Zalophus californianus*) since 2016 has further degraded nesting seabird habitat (S. Tyne, PCA, pers. comm.).

Ocean warming events also impact food webs and have population consequences for marine birds, with alcid species experiencing significant mortality events in recent marine heatwaves (Jones et al. 2018; Piatt et al. 2020). Marine birds are subject to other threats, including physical disturbance from human activities, impacts from chronic and accidental marine pollution, and entanglement and ingestion of marine debris and plastics. Fishing activities conducted in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area may threaten marine bird species, including albatrosses, shearwaters, auklets, murrelets, and murres (Gilman and Freifeld 2003; Bull 2007; Fox et al. 2021; Bertram et al. 2021), which are killed incidentally as bycatch in some fisheries and are often slow to recover from population declines due to their long lifespan and delayed slow reproduction. While protecting all phases of migratory species' life cycles is important, resilience to climate change and recovery from previous impacts can be supported by reducing pressure wherever possible. Marine protections can ensure populations of threatened bird species aren't further impacted by being caught as bycatch in fisheries, and can reduce pressures on forage species and forage species habitat.

6.2.5.2 Data and Knowledge Gaps

More comprehensive baseline data on marine bird distribution, abundance, and species composition is needed for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. The number of documented occurring marine bird species within the **ƛ̓ušiiʔaaʔaq** provided here is considered by experts to under-represent the number of species that use these habitats. Research should focus on conducting year-round surveys and incorporating traditional ecological knowledge to address data gaps and assess threats.

6.2.6 Marine mammals and reptiles

Marine mammals are described as four separate groups in the following sections based on their feeding ecology and taxonomy: baleen whales (Mysticetes), toothed whales (Odontocetes), pinnipeds, and Sea Otters. Baleen and toothed whales differ in their mode of feeding and diet. Baleen whales primarily feed on copepods, euphausiids, amphipods, and/or small schooling fishes (Kawamura 1980), in contrast to toothed whales that feed on fishes, cephalopods, or other marine mammals (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. Pinnipeds and Sea Otters are grouped separately due to their phylogenetic differences from cetaceans. Four marine reptiles (Leatherback, Green, Olive Ridley, and Loggerhead Sea Turtles) also occur in these waters.

6.2.6.1 Cetaceans

The region around the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area provides habitat for several cetacean species including the Humpback Whale (*Megaptera novaeangliae*), Killer Whale (*Orcinus orca*), Grey Whale (*Eschrichtius robustus*), Harbour Porpoise (*Phocoena phocoena*), and Dall's Porpoise (*Phocenoides dalli*). Other species have been sighted occasionally (Crosby 2024) or

their occurrence is only known through opportunistic sightings[79] but it is unknown how they use the area. Infrequently sighted species within the **ƛ̓ušiiʔaaʔaq** Area include the Fin Whale (*Balaenoptera physalus*), Minke Whale (*B. acutorostrata*), Pacific White-sided Dolphin (*Lagenorhynchus obliquiden*s), and Risso's Dolphin (*Grampus griseus*). Single sightings have been reported of Hubb's Beaked Whale (*Mesoplodon carlhubbsi*) in 2018, Sperm Whale (*Physeter macrocephalus*) in 2007, and North Pacific Right Whale (*Eubalaena japonica*) in 2013. Sperm whales have also been recently observed (2022-2024) during aerial surveys conducted by the Yuułuʔiłʔatḥ Government's marine stewardship program (described below).

For the Maa-nulth, many of our most important traditions describe the history we share with our relatives, the whales – the largest, most powerful, and magnificent beings of all. Our relations with the whales help define our uniqueness as **nuučaaʔnuł***.* Storied chiefs, our whaling **ḥaẃiiḥ***,* earned their greatest glory through successful whale hunts. Months of strict training and practice was demanded of each member of a whaling crew. Preparation during long, rigorous **ʔuusimč** (prayer) rituals brought the whalers the spiritual purity and physical endurance required for success. The most successful whalers prayed to the whales' spirits, urging that they offer themselves to be harpooned. Imagine the tremendous courage, skill, patience, precision and teamwork required for eight hunters in a single canoe to track, hunt and kill a whale – without mechanical aids. Once taken, each whale was towed to shore as an honoured guest, to be greeted with celebration, song and ritual. Festivities and ceremony accompanied the whale on each step of its journey. Each one was an enormous bounty to be shared with families throughout the whalers' community and traded to others. It is the sincere hope of **nuučaaʔnuł** people that our whales will return to their former abundance and be given the high position of respect they deserve.

Some of these species noted to be present in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area have been well-studied in the area in recent years. These include Humpback Whales, Killer Whales, and Grey Whales. Information about the occurrence and use of the **ƛ̓ušiiʔaaʔaq** by these species is described below. Ongoing work to examine acoustic recordings from 2018 onwards will further aid in determining species presence through time in this area. Preliminary analysis shows that Humpback and Killer Whales are acoustically present in every month of the year (data April 2018-November 2019 inclusive). For humpbacks this is consistent with observations made by MacMillian et al. (2022) for September 2020 to February 2022, but represents a greater presence of Killer Whales than was noted by visual survey for Killer Whales. Acoustic presence of Grey Whales matched their migration timing, with presence in March representative of northward migration, and presence in September-December representative of southward migrating individuals (L. Rannankari, unpublished data).

Although Fin Whales have been the focus of dedicated research efforts within the **ƛ̓ušiiʔaaʔaq**, there have been few reported sightings of this species in the area. Those recorded have occurred over La Perouse Bank, along the nearby shelf break, and within Juan de Fuca Strait. Additionally, Fin Whale sighting data collected in more recent years have yet to be processed fully, but also include nearshore Fin Whale sightings on the continental shelf north of the **ƛ̓ušiiʔaaʔaq** (B. Gisborne, pers. comm.; Whales of Clayoquot and Barkley, pers. comm.). This

[79] Data included in this report obtained from the BC Cetacean Sightings Network (BCCSN) were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

is consistent with nearshore sightings in waters around Tofino in the spring in recent years. Preliminary analysis of acoustic data show the presence of Fin Whale calls in almost every month, however the number of calls is few (L Rannankari, unpublished data). This is compared to an more northern offshore recorder at the base of the shelf break at Clayoquot Canyon where thousands of calls per month have been heard (L. Rannankari, unpublished data).

Minke Whales have similarly been reported infrequently in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area and Juan de Fuca Strait despite thousands of kilometres of survey effort. A single Minke Whale live-stranded on May 4, 2024 1 km south of Tsusiat campsite in the Pacific Rim National Park Reserve within **ƛ̓ušiiʔaaʔaq** (J. Yakimishyn, PCA, pers. comm.). They are a challenging species to study, not easily detected using the visual and acoustic methods used to study other cetaceans (C. McMillan, DFO, pers. comm.). Due to the challenging nature of studying Minke Whales, little is known about their occurrence in and use of **ƛ̓ušiiʔaaʔaq** and the surrounding area. Minke Whales occur along the entire Pacific coast of Canada and are more commonly reported in shallow, coastal waters (Ford et al. 2010a; Ford 2014). A study using photo identification data to examine seasonal movements of minke whales in the Northeast Pacific identified 44 unique individuals from distinct areas in British Columbia and Washington state waters (Towers et al. 2013). They report seasonal movements to more northern latitudes in the spring and summer, and southern latitudes in the fall and winter, and document occurrence within Juan de Fuca Strait. Further study is required to understand the distribution of Minke Whales in the **ƛ̓ušiiʔaaʔaq**.

Harbour Porpoise and Dall's Porpoise have not been well-studied on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. However, a recent paper reported seasonal abundance estimates for these species in the southern Salish Sea and on **ƛ̓ušiiʔaaʔaq**, which are included in the present paper. Surveys and acoustic research are currently underway to better understand the spatial distribution and abundance of porpoises and other cetaceans in the southern Salish Sea and on **ƛ̓ušiiʔaaʔaq**. The North Pacific Right Whale is a critically endangered species that has been sighted in the area, and thus information on recent sightings is also reported here.

Year-round abundance monitoring of large cetaceans throughout the Yuułuʔiłʔatḥ Government and Maa-nulth Nations' Southern Marine Territory have been conducted by the Yuułuʔiłʔatḥ Government's marine stewardship program since March 2022 (Crosby 2024). The aerial monitoring surveys collect whale occurrence and abundance data within marine shipping vessel corridors and critical habitat (sanctuary areas) off the WCVI. The two flight paths conducted as part of the survey both cover crucial marine areas of Swiftsure Bank (Crosby 2024). These surveys represent one of the few year-round monitoring efforts occurring offshore of the WCVI, and fills an important data gap within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. From March 2022 to December 2023, 64 monitoring flights recorded 2611 individual cetaceans, including Humpback Whales, Grey Whales, Orcas, Fin Whales, Minke Whales, Sei Whales and Sperm Whale, as well as incidental observations of other species including *Mola Mola*, Dall's and Harbour Porpoises, Fur Seals, dolphins and Blue Sharks. The three most abundant species recorded in the surveys were Grey Whales, Humpback Whales and Orcas. Figure 143 illustrates the year-round large cetacean species occurrences and Figure 144 shows the abundance of all large cetaceans (not differentiated by species) in the survey area. Species were found to occur regularly and year-round within the survey area, and in high concentrations within critical marine habitats and upwelling areas.

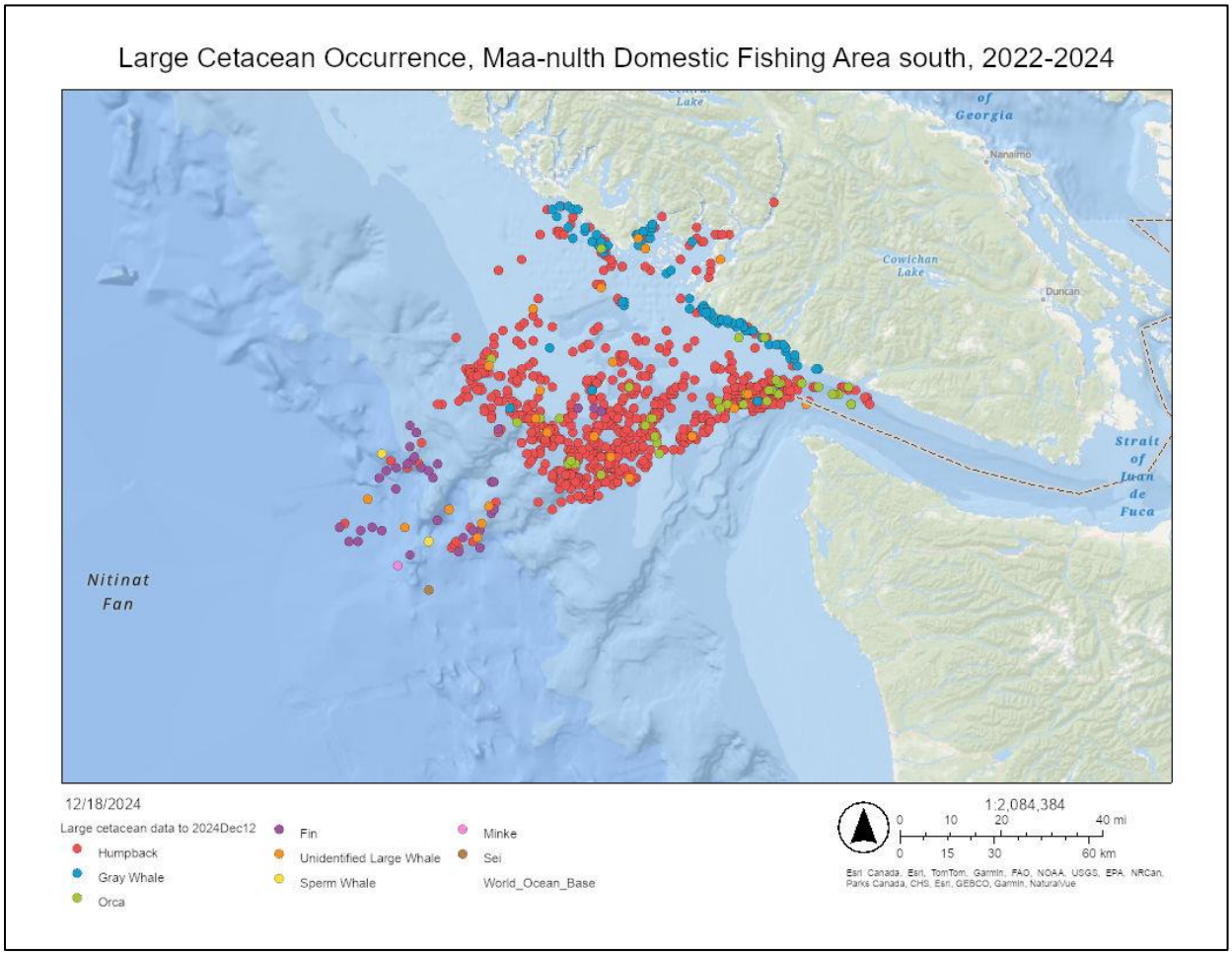


Figure 143: From Crosby (2024). Year-round large cetacean occurrence by species within the southern Maa-nulth Domestic Fishing Area from March 2022- December 2024.

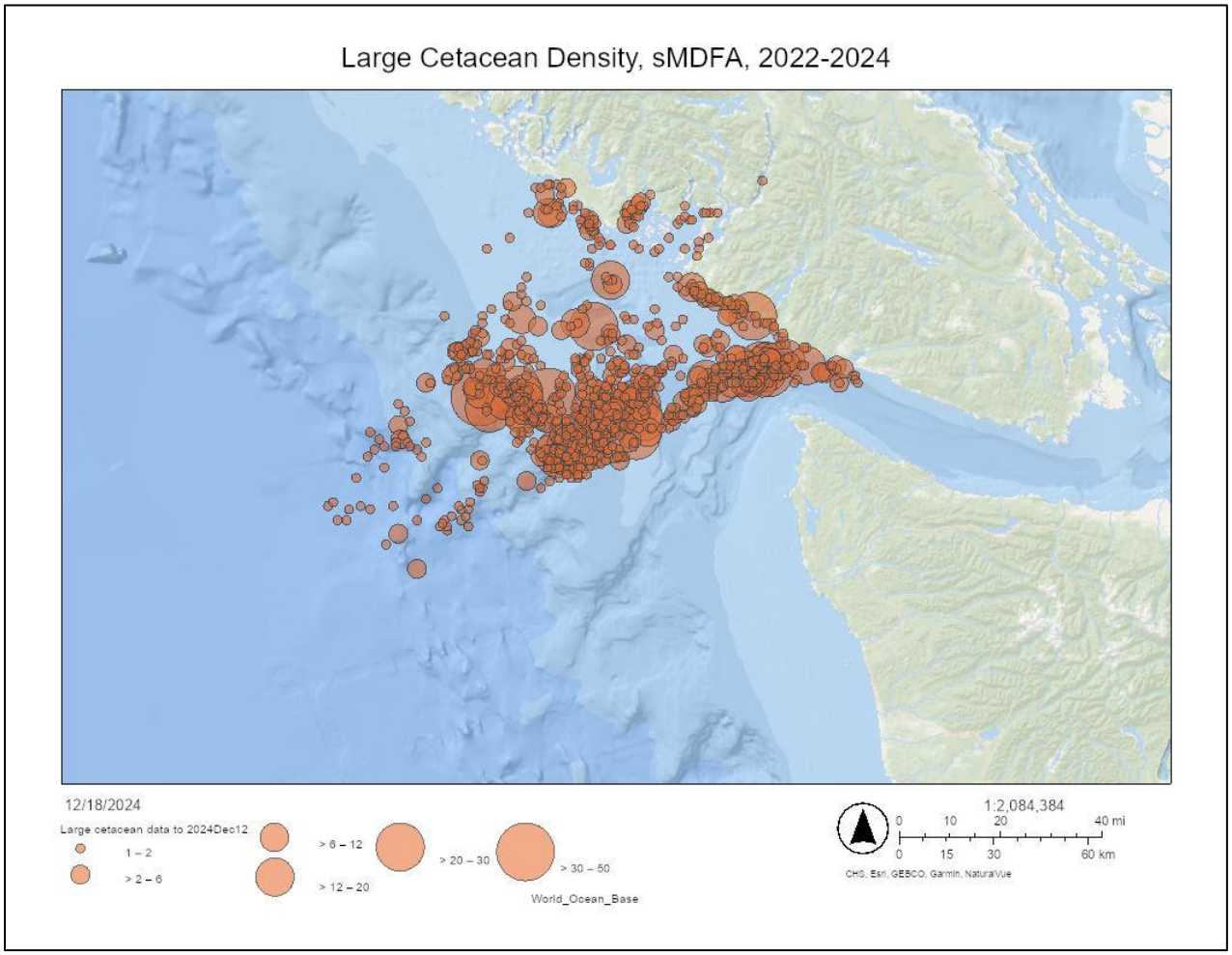


Figure 144: From Crosby (2024). Year-round large cetacean abundance (all species combined) within the southern Maa-nulth Domestic Fishing Area from March 2022-December 2024.

In 2020, the Pacheedaht First Nation developed a rigorous scientific program to collect multi-species marine mammal data. Over the past half decade, a small Pacheedaht First Nation marine mammal team, with guidance and oversight by Dr. Anna Hall and Sea View Marine Sciences, has conducted fine-scale systematic line transect surveys in central and western Juan de Fuca Strait, and **Ẃušiiʔaaʔaq/**Swiftsure Bank. SMRU Consulting Ltd. also provides scientific support for this long-term and uninterrupted research project. Prior to the Pacheedaht First Nation marine research, the central and western stretches of Juan de Fuca Strait were largely unstudied by marine mammal science, leading to significant data gaps. Over the past five years, the research team has documented a minimum of five species of cetaceans, four species of pinnipeds, and one species of mustelid occurring regularly. These include Humpback Whales (by far the most numerous in terms of both sightings and numbers of individuals), Grey Whales, Killer Whales (Southern Resident, Bigg's (i.e., transient), and undetermined ecotype), Dall's Porpoise, Harbour Porpoise, Steller Sea Lions, California Sea Lions, Elephant Seals, Harbour Seals, and Sea Otters. Inter-annual trends in occurrence have been detected and analyses including the most recent year of data (2024) are underway. Inter-annual field observation data spatial analyses (non-effort corrected) have yielded cetacean hotspots identified within the study area in the nearshore, mid-channel and offshore habitats. Some

hotspots intersect with the deep-sea vessel Traffic Separation Scheme (TSS), including at **ƛ̓ušiiʔaaʔaq**. This offshore hotspot was noted to be of significance to marine mammals due to the substantial number of Humpback Whale, Killer Whale, and to a lesser extent, Harbour Porpoise sightings. Comparison to the field effort, suggested that whilst non-effort corrected data were used, the analysis does identify important habitat for cetaceans. The importance of the region is not just limited to marine mammals, as the research team has also documented seabird and shark species in the area. These data indicate that **ƛ̓ušiiʔaaʔaq** is not only important to the marine mammals of the coastal waters of the eastern North Pacific, but also to maintaining ecosystem integrity. Whilst **ƛ̓ušiiʔaaʔaq** has high relative densities of marine mammals, many species including Humpback Whales, Killer Whales, and Dall's Porpoise have also been documented throughout the outbound deep-sea Juan de Fuca Strait TSS. Inter-annual sightings of Humpback Whales occur consistently, in and near, the TSS. These findings support the need for tangible and quantifiable conservation management actions such as the seasonal voluntary deep-sea vessel slowdown implemented by the ECHO Program. Whilst this program is centered on the conservation of endangered southern resident killer whales, the reduction in underwater noise from the slower speeds (Joy et al. 2019), also benefits the other cetaceans and marine life along the route. It is well accepted that slowing of large vessels also has the added benefit of reducing the risk of vessel strike to large whales. The Pacheedaht First Nation data set demonstrates that this type of conservation action is warranted in the TSS, particularly with the increase in humpback whale densities over the past two decades. The Pacheedaht First Nation marine mammal research is continuing in 2025, making this the longest running continuous study of marine mammals in central and western Juan de Fuca Strait. This research program is also one of the longest continuous collaborative Indigenous marine mammal studies in BC. The results of these annual research studies are available in the following reports: (Hall et al. 2021, 2022, 2023, 2024, In prep).

6.2.6.1.1 Humpback Whale

Humpback Whales (*Megaptera novaeangliae*) occur throughout coastal BC waters (Figure 145), with those in BC belonging to the North Pacific Humpback Whale population. They are found in BC waters year-round, though they are most abundant from May to October (Ford et al. 2009). Humpbacks are known to be a highly migratory species, undergoing lengthy migrations between tropical or subtropical breeding areas in the winter and feeding grounds in more northern latitudes in summer. Humpback Whales exhibit high site fidelity in BC waters, returning each year to productive feeding grounds in BC from winter breeding areas including Hawaii, Mexico, and Central America (McMillan et al. 2023).

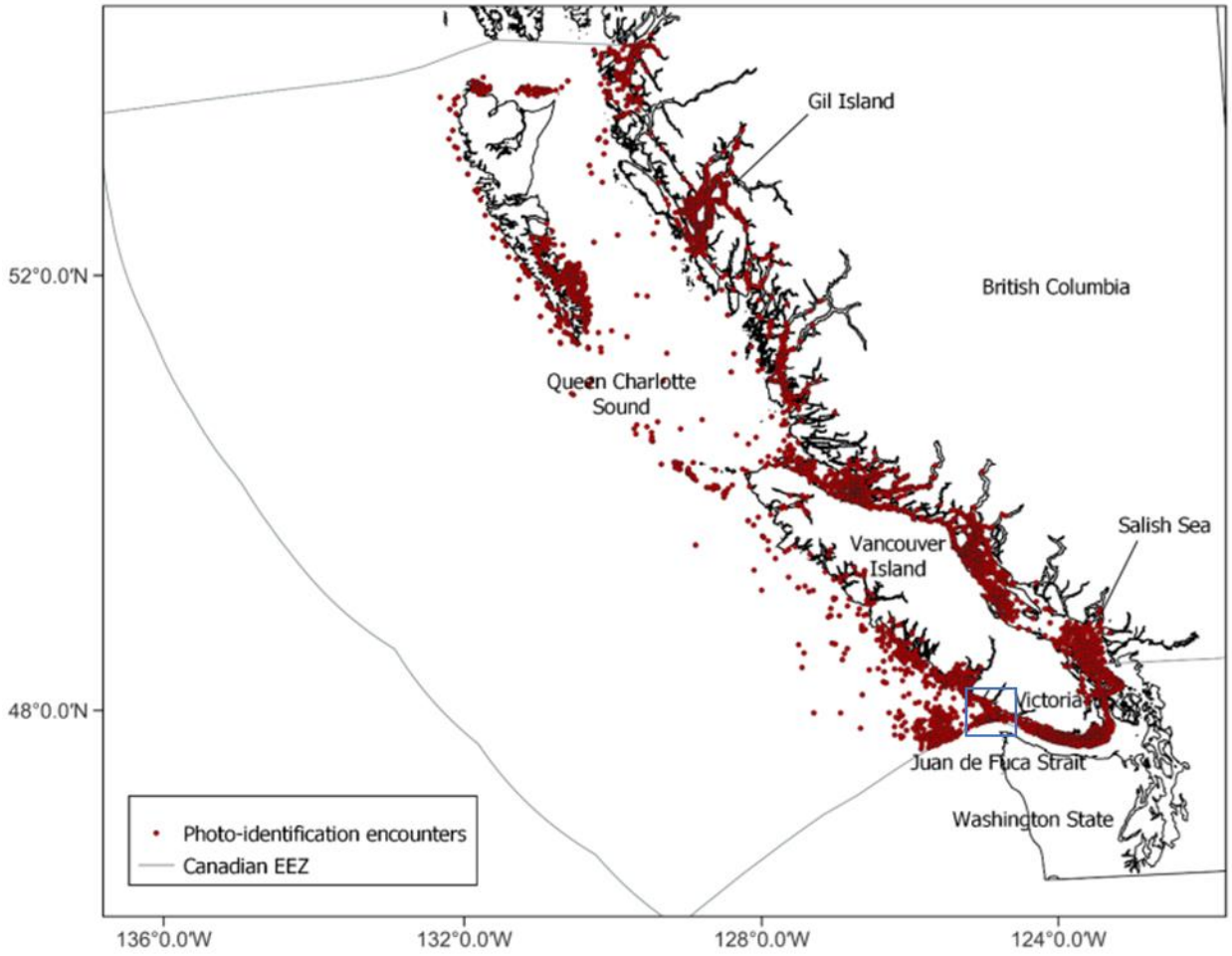


Figure 145. Locations of all Humpback Whale photographic identification encounters (35,872 encounters of 3,376 individuals) from Canadian Pacific waters between 1985 and May 2022). Blue rectangle indicates approximate location of ***ʎušiiʔaaʔaq̓****/Swiftsure Bank are described in this report. Reproduced from McMillan et al. (2023).*

In Canada, North Pacific Humpback Whales are considered a single population and are currently listed as Special Concern under Canada's *Species at Risk Act* (SARA). In neighbouring US waters, they are assessed as four distinct population segments (DPSs) based on winter breeding grounds. Under the U.S. *Endangered Species Act* (ESA), humpbacks that breed in Central American and Western Pacific waters are listed as Endangered, whales that breed in the waters off Mexico are listed as Threatened, and those that breed around the Hawaiian Islands are considered Not at Risk (NOAA 2016). Humpback Whales were heavily hunted during the commercial whaling period, though the North Pacific population has been recovering in recent decades (Nichol et al. 2002; Calambokidis et al. 2008; Wright et al. 2021b; McMillan et al. 2023). Overall, Humpback Whale abundance in coastal BC waters was estimated at 2,145 (95% CI = 1970-2331) individuals in 2006 using mark-recapture methods based on photo identification data collected from 1984 to 2006, with an estimated annual rate of increase over the study period of 4.1% per year (Rambeau 2008; Ford et al. 2009). In 2018, DFO conducted a coastwide survey to estimate spatial abundance and distribution of cetaceans in Canadian Pacific waters based on distance sampling methods. Abundance was estimated using both a design-based analysis and density surface modelling which can reduce uncertainty

in abundance by accounting for between-transect variation (Miller et al. 2013). Resulting overall humpback abundance in Canadian Pacific waters in 2018 was estimated at 7,030 (95% CI = 5,733-8,620) individuals from density surface models (Wright et al. 2021b) and 12,244 (95% CI = 8,214–18,252) based on the design-based approach (COSEWIC 2022; Doniol-Valcroze et al. 2024). Wright et al. (2021b) reported greater confidence in the design-based abundance estimate due to instability in fitting models. Note that the 2006 and 2018 estimates are not directly comparable as they are based on different data types, analytical methods and assumptions. Updated abundance estimates and annual trends for the full North Pacific Humpback Whale population were recently published using a comprehensive photo-identification dataset including encounters with from 1985 to 2022 contributed by researchers in ten different countries with jurisdiction over waters where North Pacific Humpback Whales occur (locations of photo-identifications shown in Figure 145, reproduced from McMillan et al. 2023). Abundance trends were calculated for 2002 to 2022 and showed population recovery from 16,875 (± 5,955) individuals in 2002 to a peak abundance estimate of 33,488 (± 4,455) in 2012 followed by a decline to 26,662 (± 4,192) in 2022 (Cheeseman et al. 2024). The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is known to be important for North Pacific Humpback Whales. It is currently identified as Critical Habitat for Humpbacks in the United States[80] and was previously recommended for critical habitat for humpbacks in Canada (Figure 146, Nichol et al. 2010; DFO 2013c) prior to the SARA listing changing from Threatened to Special Concern in 2017.

[80] https://www.fisheries.noaa.gov/resource/map/humpback-whale-critical-habitat-maps-and-gis-data

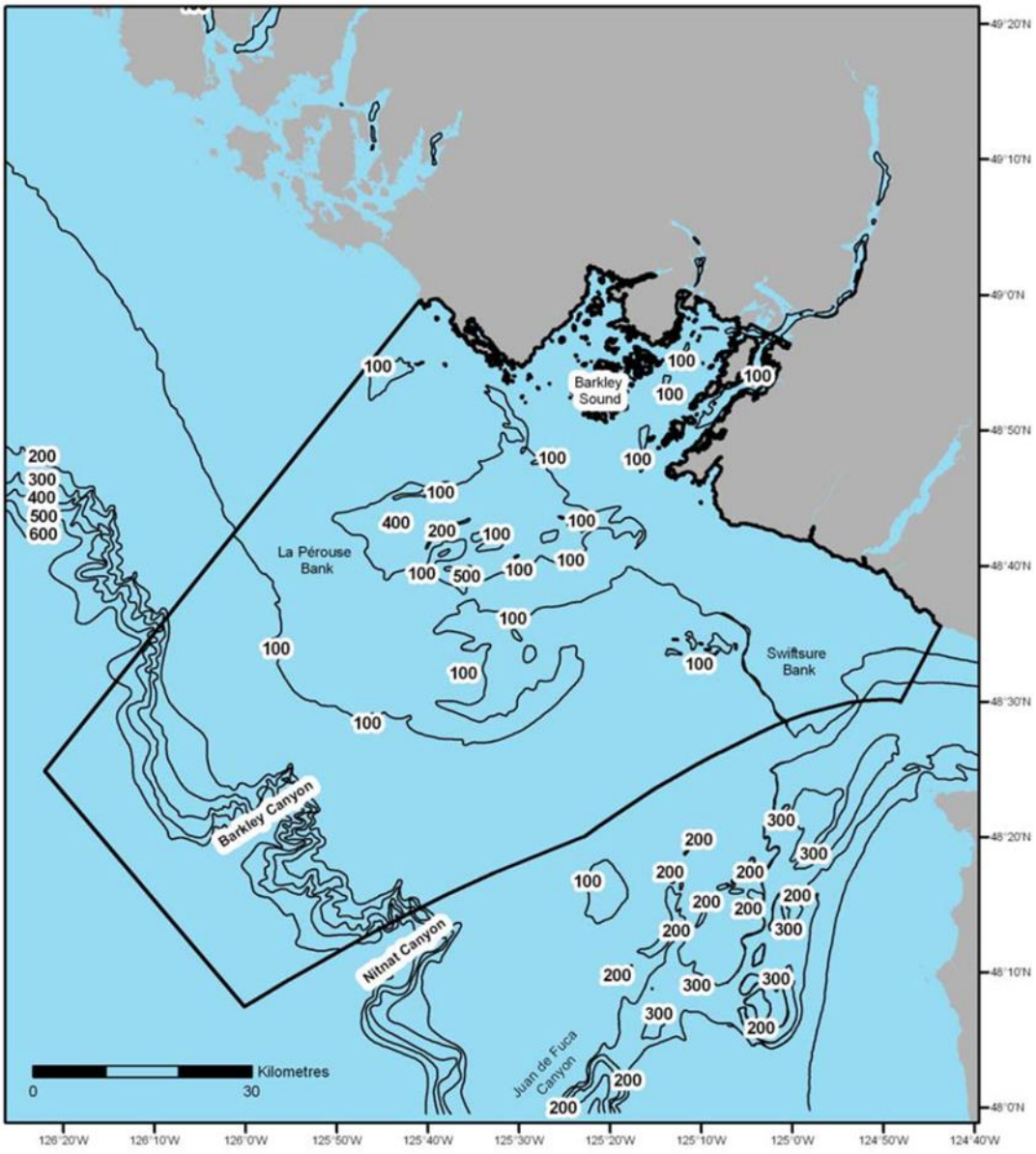


Figure 146. Southwest Vancouver Island area, one of four areas previously recommended as Critical Habitat for Humpback Whales (black-line polygon delineates area). Bathymetric contour depths are in metres. Southwest Vancouver Island area is 6,188.3 km2. Adapted from Nichol et al. (2010).

Abundance estimates for Humpback Whales specifically in the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area are not currently known. A study based on aerial surveys conducted from 2012-2015 in mostly fall and winter months demonstrated occurrence of Humpback Whales in the ƛučiiʔaaʔaq and modelled the probability of encountering large whales off southwestern Vancouver Island as part of a ship-strike risk analysis. Figure 147 displays the modelled output of probability of encountering a Humpback Whale in the study area, including on and around **ʎ̓ušiiʔaaʔaq** (Nichol et al. 2017).

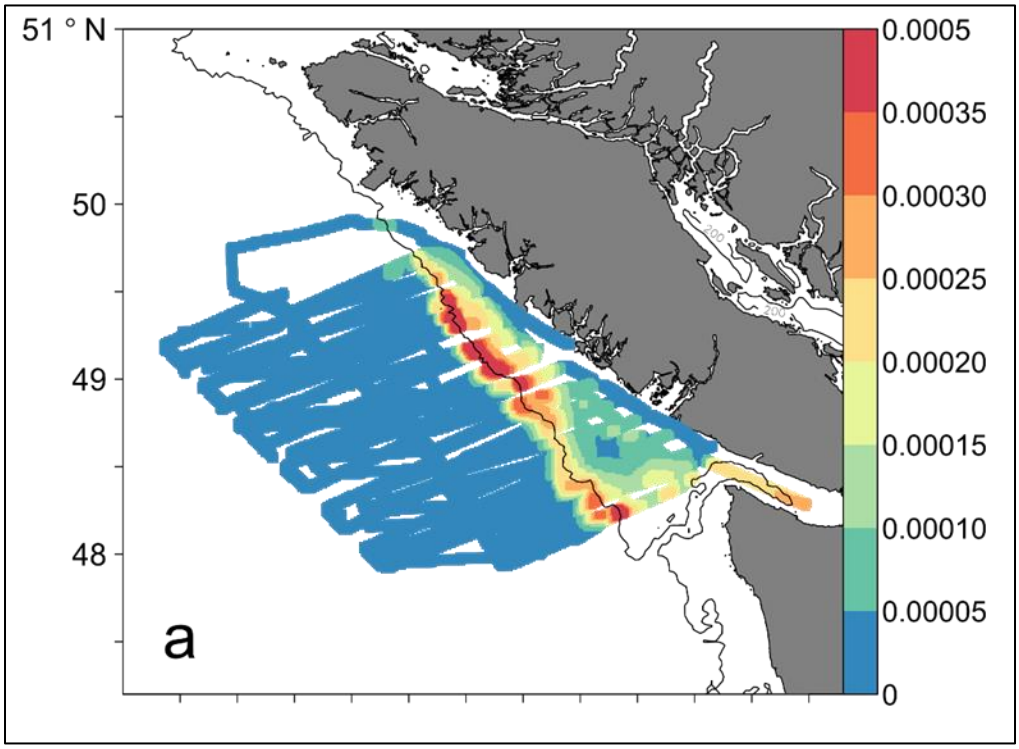


Figure 147. Aerial survey study area off the west coast of Vancouver Island, BC, Canada, divided into 1 km2 grid cells (N=23,996). Filled cells indicate those containing survey effort that was retained for analysis. Colours indicate the relative probability of encountering a Humpback Whale (calculated from GAM model estimates of whale densities). Reproduced from Nichol et al. (2017).

In the 2018 DFO coastwide survey, the study area included all Canadian Pacific waters divided into three strata – North coast, offshore, and Salish Sea – which were each surveyed once in one season (summer) and data from each stratum were modelled separately for each species (Wright et al. 2021b). Data from the offshore and Salish Sea strata each cover part of the **ƛušiiʔaaʔaq**/Swiftsure Bank Area. Figure 148 shows the modelled spatial densities for Humpback Whales in these strata (Wright et al. 2021b). Note the sharp change in modelled abundance estimates where the two strata meet. The authors report low predicted abundance in this portion of the offshore stratum over **ƛušiiʔaaʔaq**, and suggest this is likely due to either the poor sighting conditions at the time of the survey or few animals being present when the ship passed through the area (Wright et al. 2021b). Despite the low numbers of humpbacks in the **ƛušiiʔaaʔaq** during the 2018 survey, it is known to be of importance for humpbacks as it was previously recommended for designation as Critical Habitat (Figure 146) based on consistently high seasonal presence in the area (Nichol et al. 2010; DFO 2013c), which is demonstrated in photo-identification data and in the effort-corrected aerial survey data described above.

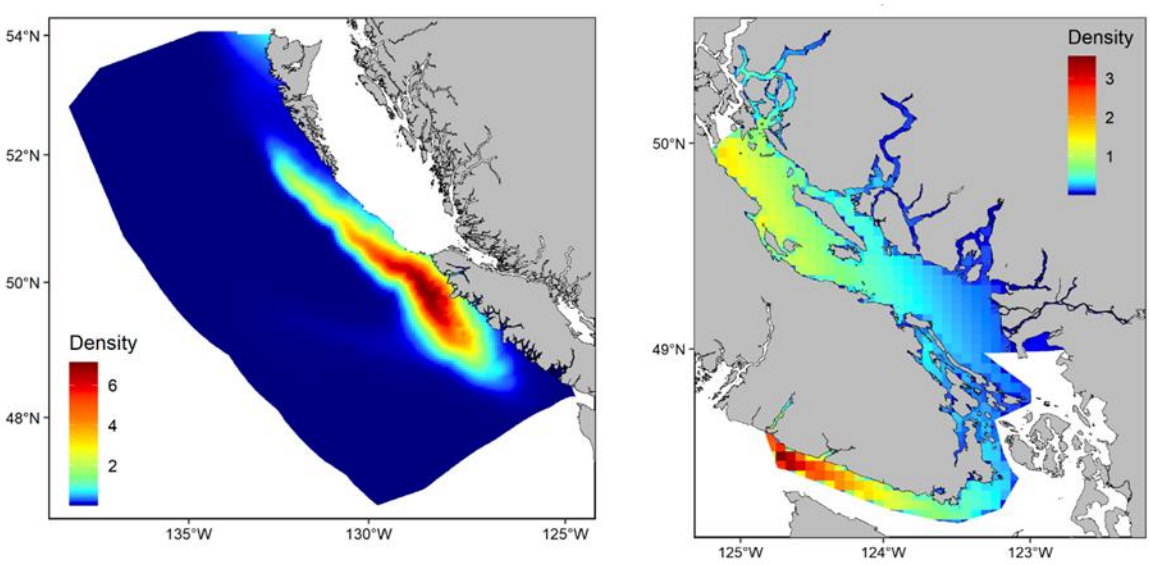


Figure 148. Estimated densities (fill colour indicates the number of individuals per 25 km$_2$ grid cell) of Humpback Whales in the offshore stratum from the 2018 DFO survey (left), with a total estimated abundance for this stratum of 4,935 Humpback Whales (95% CI = 3,865-6,303; from Wright et al. 2021) and the Salish Sea stratum (right), with a total estimated abundance for this stratum of 279 Humpback Whales (95% CI = 130-596). Adapted from Wright et al. 2021

A new DFO research program was initiated in 2020 to study cetaceans specifically in the Southern Salish Sea and over **ʎušiiʔaaʔaq**/Swiftsure Bank by season. To obtain detailed distribution and abundance estimates of cetaceans in this area, repeated seasonal boat-based surveys began in September 2020. A recent study estimated seasonal abundance and distribution of cetaceans in the study area (shown in Figure 149) using data from September 2020 to February 2022. Abundance for Humpbacks in the study area was estimated at 18 (95% CI = 9-36) humpbacks in winter (January through March), 84 (95% CI = 40-174) in spring (April through June), 96 (95% CI = 52-176) in summer (July through September) and 274 (95% CI = 160-468) in fall (October through December) (McMillan et al. 2022). The surveys are ongoing and are contributing to development of seasonal spatial species density models. Updated Humpback Whale sightings and survey effort data by season from these surveys up to November 2023 are provided in Figure 150.

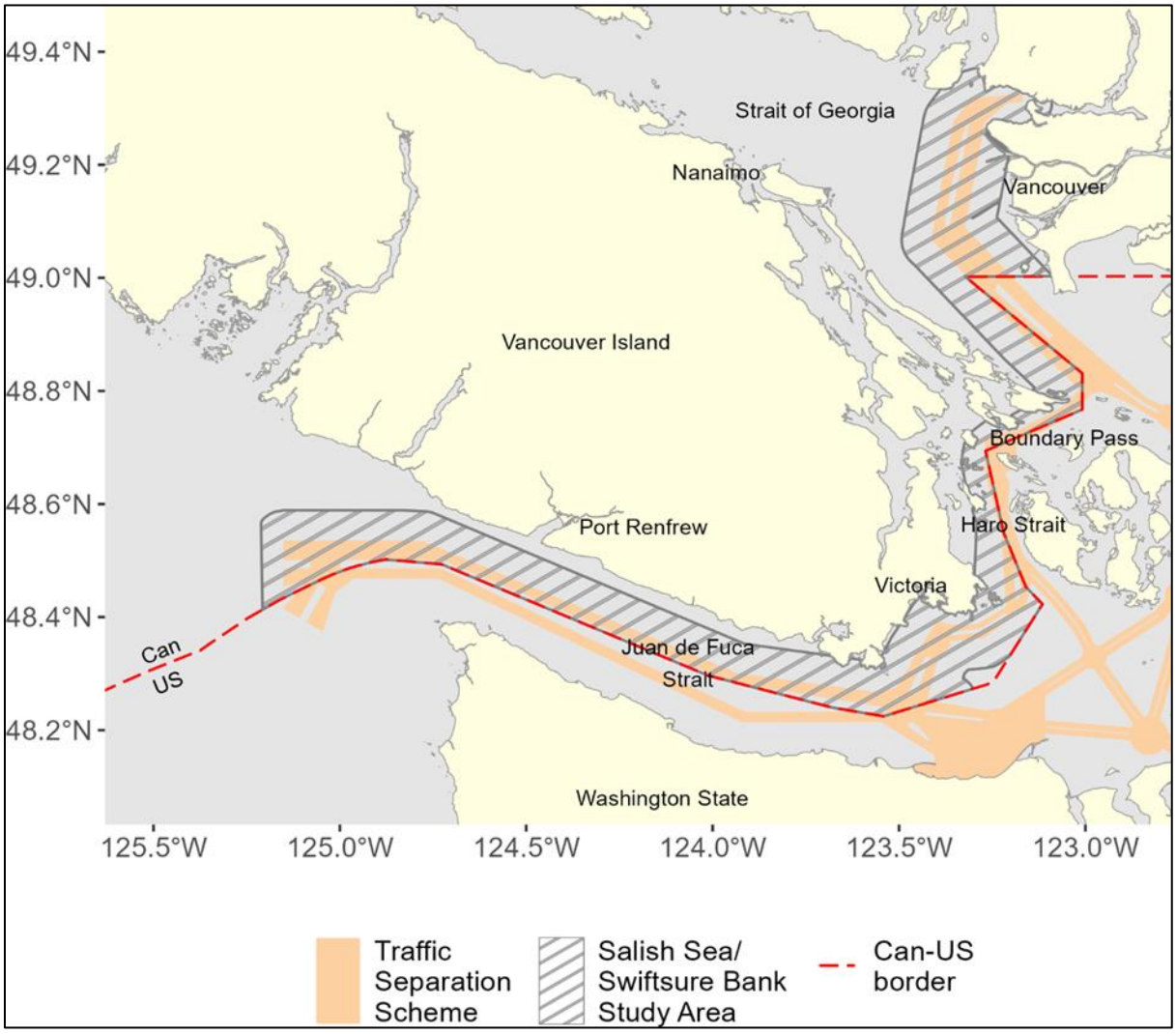


Figure 149. Map showing study area of the DFO cetacean monitoring and research program in the southern Salish Sea and ***ʎušiiʔaaʔaq****/Swiftsure Bank Area (McMillan et al. 2022).*

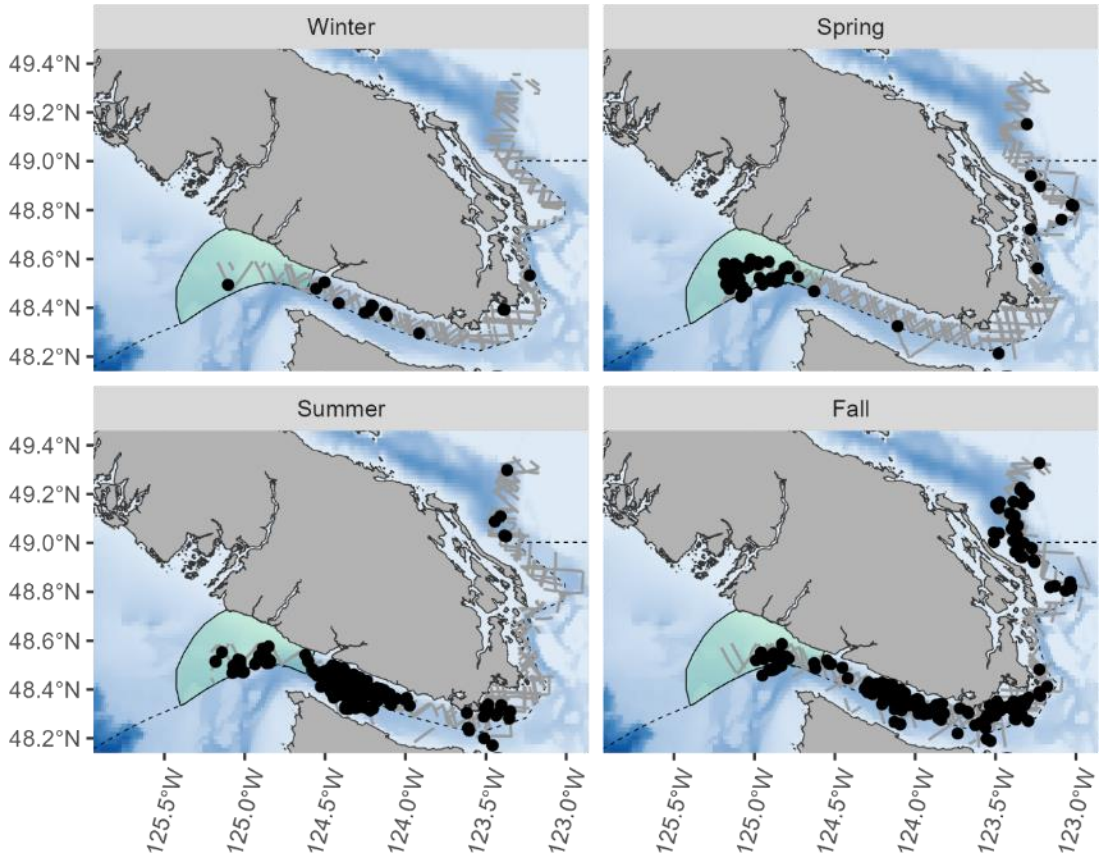


*Figure 150. Distribution of seasonal Humpback Whale sightings and survey effort near **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank (Juan de Fuca Eddy EBSA) by the DFO seasonal cetacean monitoring and research program initiated in 2020 for the Salish Sea and **ʎ̓ušiiʔaaʔaq**. Seasons are defined as follows: winter = January through March, spring = April through June, summer = July through September, fall = October through December. Data shown here were collected between August 2020 and November 2023 (see McMillan et al. 2022).*

Analysis of the large Humpback photo-identification dataset mentioned above shows a shift in humpback distribution around southern Vancouver Island, particularly in the inside waters of the southern Salish Sea (McMillan et al. 2023) compared to earlier distributions of photo-identification data (i.e., Ford et al. 2009) and surveys in the early 2000's which did not encounter any Humpbacks in that region (Williams and Thomas 2007; Best et al. 2015). Humpbacks that have been documented in the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area include portions of the North Pacific population that are particularly vulnerable to anthropogenic threats. Of the Humpbacks that migrate to Central America wintering areas, almost all matched to BC waters have been exclusively photo identified in the **ʎ̓ušiiʔaaʔaq**, and a high proportion of Humpbacks in the **ʎ̓ušiiʔaaʔaq** are those that migrate to Mexico (McMillan et al. 2023).

Humpback Whales migrate between lower latitude breeding grounds in the winter and higher latitude feeding grounds in the summer when biological productivity increases, though Humpbacks are present in BC waters, including the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area, year-round, as evidenced in visual surveys (e.g., McMillan et al. 2022) and acoustic recordings. In BC, humpback feeding areas occur primarily in coastal or shelf waters (Ford et al. 2009; Nichol et al. 2010; Ford 2014). Oceanographic processes interact with bathymetric features in the

ƛ̓ušiiʔaaʔaq to enhance nutrient availability, biological productivity, and therefore prey availability, making this a rich feeding area for Humpbacks (Nichol et al. 2010).

In the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, Humpback Whales have been observed lunge feeding. Prey samples obtained near foraging Humpbacks in 2000 and 2002 were of euphausiids of both *Thysanoessa spinifera* and *Euphausia pacifica* (DFO unpublished data; Nichol et al. 2010). Recent fecal sampling from a study on Humpback prey and foraging behaviour in southern BC identified prey from three Humpback Whales in the **ƛ̓ušiiʔaaʔaq** to include shrimp (Cumacea, *Eualus avinus*), Pacific Herring (*Clupea pallasii*), euphausiids (*T. spinifera* and *E. pacifica*), and an unknown rockfish (*Sebastes* spp.) (Reidy et al. 2022). Recent dive data from suction-cup tags deployed on Humpback Whales shows highly focused feeding activity in this region (DFO unpublished data; Reidy, R. unpublished data). A study surveying Humpback Whale foraging areas near the eastern edge of the **ƛ̓ušiiʔaaʔaq** using active acoustic prey mapping, identified extremely dense prey layers near the seafloor (Reidy et al. 2024). This finding aligns with a detailed feeding analysis of Humpback Whales tagged in the same area during the same period, where subsurface prey data and whale-borne tag recordings were collected simultaneously (Reidy, R. unpublished data). The whales consistently dove to the recorded prey depths exceeding 100 m.

6.2.6.1.2 Grey Whale

Grey Whales (*Eschrichtius robustus*) in Pacific waters belong to two populations: the Eastern North Pacific (ENP) population and the Western Pacific (WP) population. Most Grey Whales undertake seasonal migrations, spending the winter months in low-latitude breeding grounds and the summer months in temperate and Arctic feeding grounds (Rice et al. 1984). Most of the ENP population migrates along the west coast of North America between Mexico and the Bering, Chukchi and Beaufort Seas while the Western Pacific (WP) population generally migrates along the east coast of Asia between the Korean Peninsula and Russia (Rice and Wolman 1971; LeDuc et al. 2002).

Grey Whales in Canadian Pacific waters are currently considered a single population (the ENP), listed as Special Concern under SARA. However, in 2017, COSEWIC reassessed Grey Whales in Canadian Pacific waters as three distinct designatable units (DU's): the North Pacific Migratory group (NPM, Not at Risk), and the WP and Pacific Coast Feeding Group (PCFG) populations (both Endangered) (COSEWIC 2017). However, these DUs have not been legally accepted under SARA yet.

The NPM migrates along the west coast of North America as mentioned above. The PCFG exhibits maternally-directed site fidelity to specific feeding sites further south than the NPM population, primarily from northern California to northern BC (Calambokidis et al. 2002, 2017). Recent findings indicate that a small number of Grey Whales from the Western Pacific (WP) population migrate to the west coast of North America to join the ENP Grey Whales during migration and on breeding grounds in Mexico (Lang 2010; Mate et al. 2011, 2015; Weller et al. 2012; Urbán et al. 2013).

Grey Whale population abundance in the eastern North Pacific estimated from whales migrating south along California was relatively stable during the mid-1990s to 2010 period and increased from 2014 to 2015 (Gavrilchuk and Doniol-Valcroze 2021). Abundance was estimated at 26,960 in 2015/2016 (Durban et al. 2017), which likely includes members from all three DU's (NPM, PCFG, and WP), with the PCFG proportion estimated at approximately 243 individuals in 2015 (Calambokidis et al. 2017). However, a recent study reported declining abundance in the North

Pacific Grey Whale population since 2015/2016, overlapping with a multi-year Unusual Mortality Event declared in 2019, which may suggest sensitivity to climate-driven habitat changes (Stewart et al. 2023; Eguchi et al. 2024).

Grey Whale occurrence in the **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area is demonstrated by Parks Canada dedicated surveys (Figure 151 and Figure 152) and opportunistic sightings (BCCSN and off-effort DFO sightings while transiting between survey areas or transect lines) (Figure 153). Acoustic recordings add to this. Boat-based visual marine mammal surveys are conducted bi-weekly April through November each year, weather-permitting, by Parks Canada along the West Coast Trail Unit of Pacific Rim National Park Reserve between Cape Beale and Port Renfrew within the traditional territories of the with Huu-ay-aht, Ditidaht, and Pacheedaht First Nations. This area of the coast aligns with the northeast boundary of the **ƛ̓ušiiʔaaʔaq**. Density of Grey Whales sighted on these surveys from 2019 to 2023 is shown in Figure 151 and earlier surveys from 2005 to 2019 in Figure 152. The timing of these surveys targets more those whales that are part of the PCFG, rather than the ENP population that would be migrating through the area. The highest densities for Grey Whales were observed towards the western extent of the survey area in both time periods. The overall trend in counts per 100 km per year was analyzed by Parks Canada for this report using a generalized estimating model (mean 4.6 ± 3.9, $p > 0.05$) and appears to be relatively stable though variability appears to increase between 2015 and 2023 (Figure 154) (J. Yakimishyn and M. Collyer, PCA, pers. comm.). Opportunistic sightings show Grey Whale presence in the **ƛ̓ušiiʔaaʔaq** Area in all months except January, with a peak in summer from July to September (Figure 154, Figure 155). Opportunistic sightings are effort-biased towards summer months. Acoustic records suggested their presence to be greatest at times of north- and south-bound migration (L. Rannankari, unpublished data). Recent Grey Whale tag data from NOAA (Pacific Coast Feeding Group Gray Whale Movements Map) also demonstrates year-round occurrence of Grey Whales in the **ƛ̓ušiiʔaaʔaq** in 2020-2021. Current research efforts by DFO will contribute to better understanding of Grey Whale distribution in and use of the southwestern Vancouver Island area.

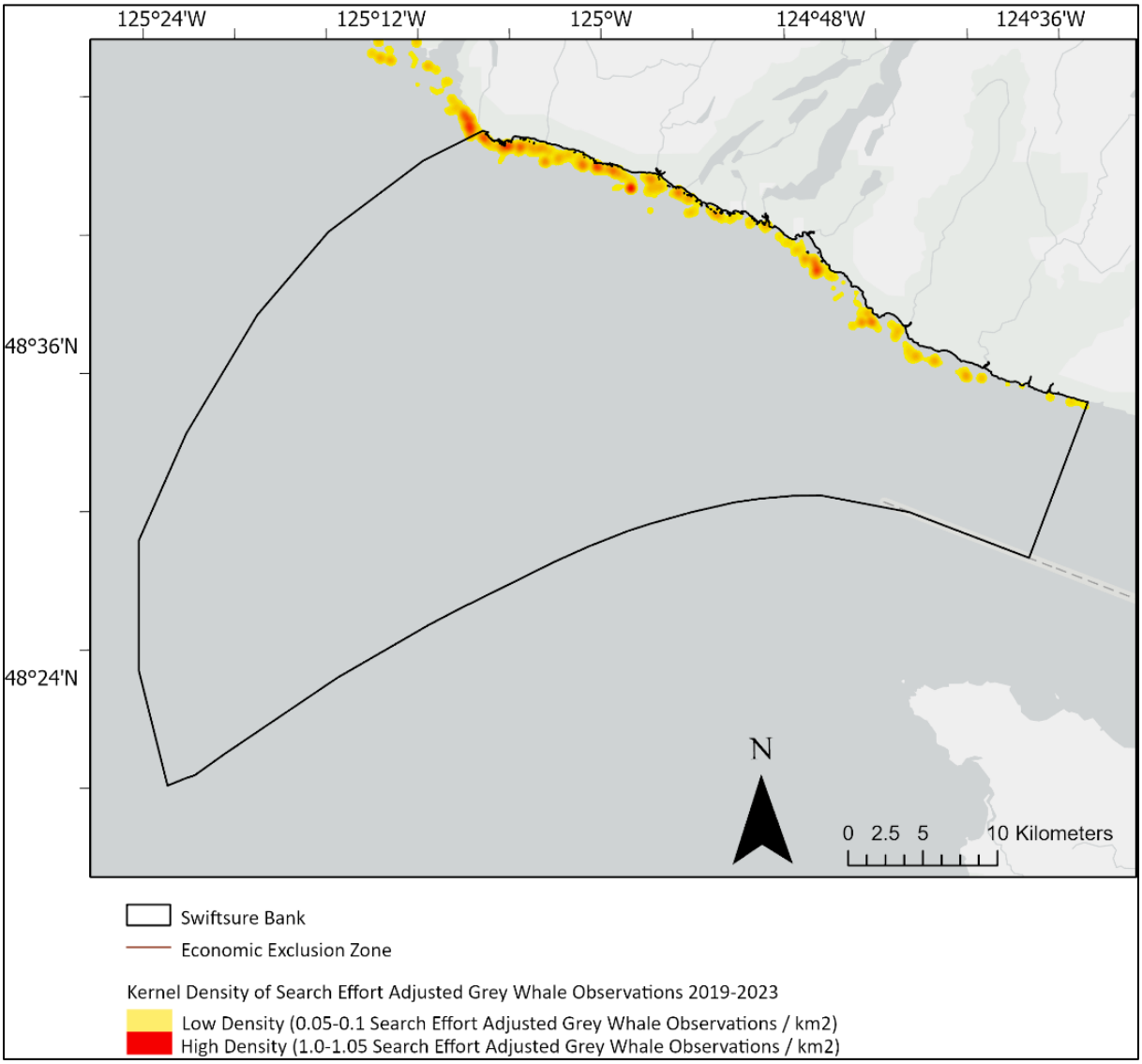


Figure 151. Grey Whale survey adjusted densities along West Coast trail Unit of Pacific Rim National Park Reserve in recent years, from 2019 to 2023. The black line delineates the Juan de Fuca Eddy EBSA boundary in the ***ʔušiiʔaaʔaq****/Swiftsure Bank Area. A survey search area was created along route from the visibility distance and observations were divided by the sum of the applicable search areas resulting in a search effort adjusted population for each observation. Fixed kernel density layers using a search radius of 500 m, a cell size of 25 m and the adjusted population were generated for each set of observations. Data from Parks Canada surveys, 2019-2023. Map provided by Parks Canada.*

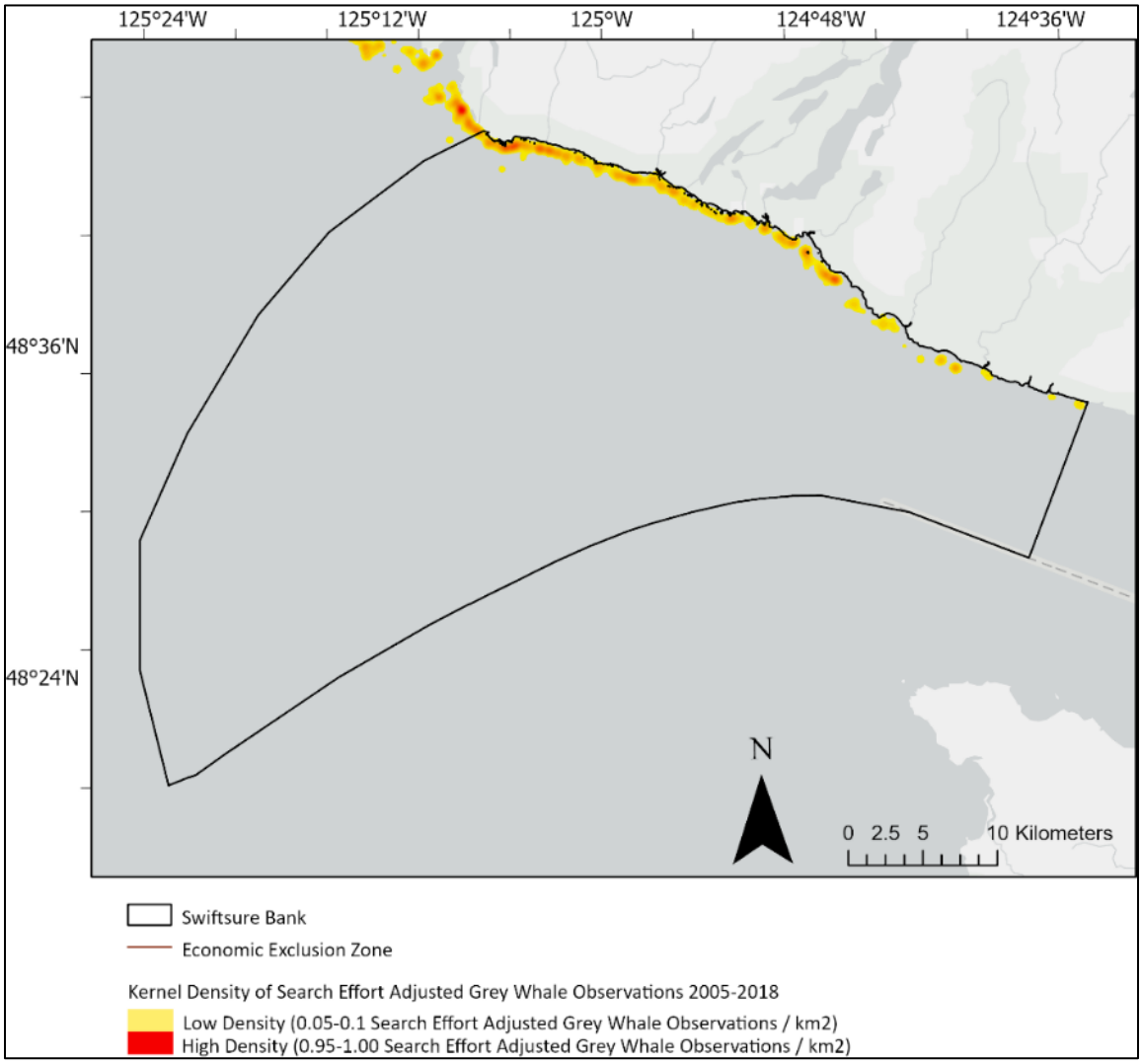


Figure 152. Grey Whale survey adjusted densities along West Coast trail Unit of Pacific Rim National Park Reserve from 2005 to 2018. The black line delineates the Juan de Fuca Eddy EBSA boundary in the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area. A survey search area was created along route from the visibility distance and observations were divided by the sum of the applicable search areas resulting in a search effort adjusted population for each observation. Fixed kernel density layers using a search radius of 500 m, a cell size of 25 m and the adjusted population were generated for each set of observations. Data from Parks Canada surveys, 2005-2018. Map provided by Parks Canada.*

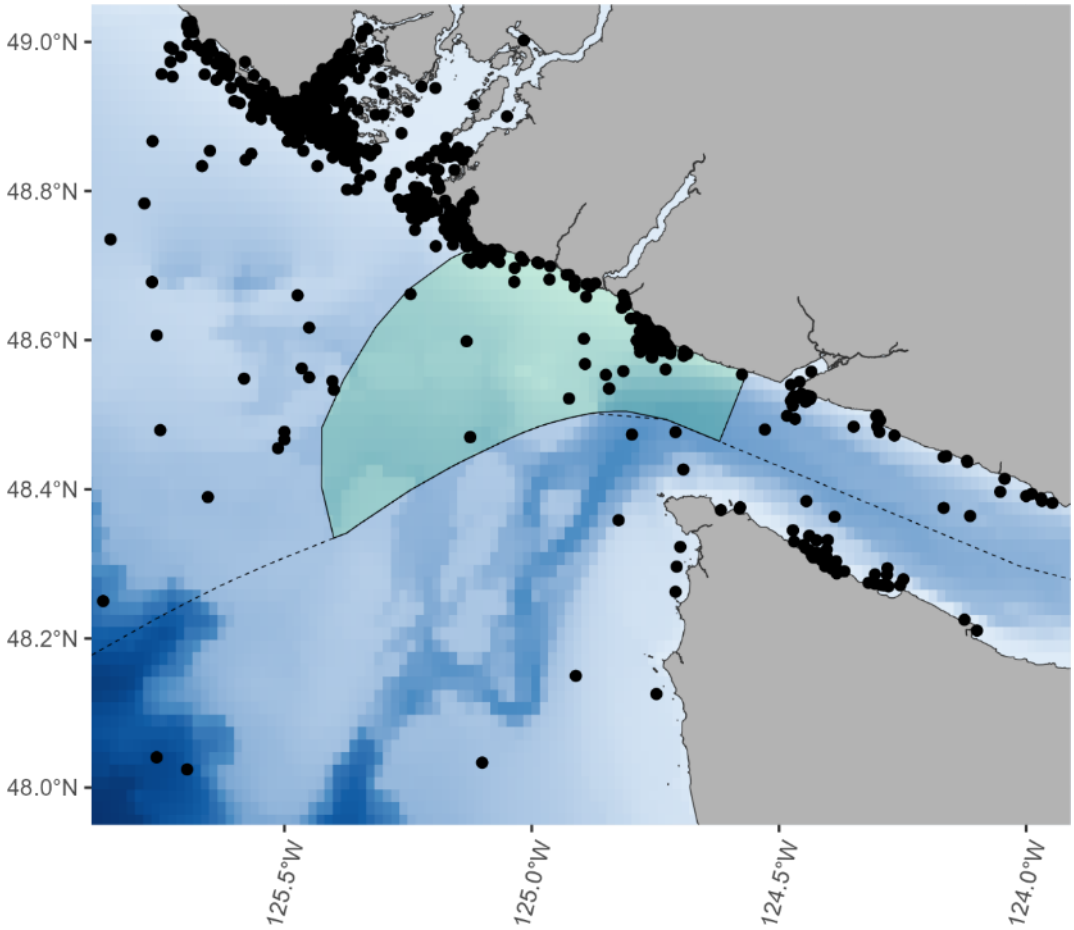


*Figure 153. Grey Whale sightings 1991 to 2023 in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (black line delineates Juan de Fuca Eddy EBSA polygon). Data sources include DFO sightings on dedicated surveys and opportunistic sightings provided by the BCCSN[81]. Sightings data supplied by the BCCSN are opportunistic and not corrected for effort.*

[81] https://ocean.org/overfishing/whales/ocean-wise-sightings-network/

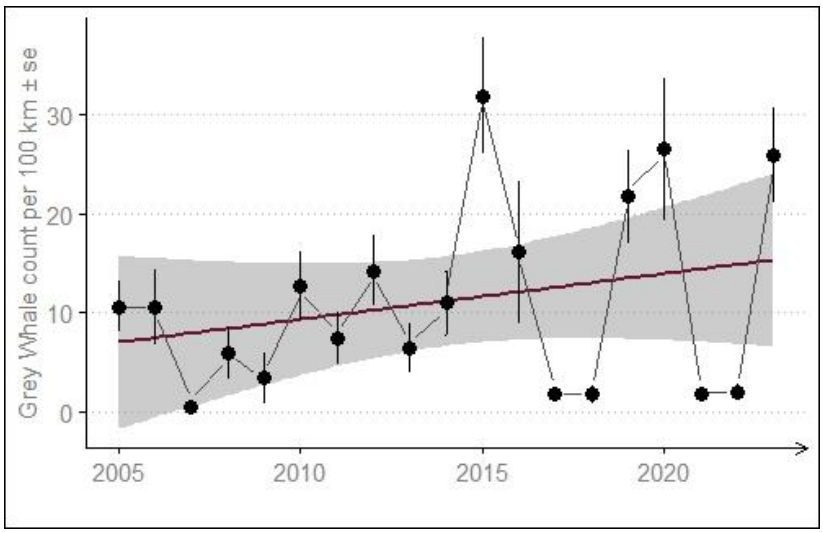


Figure 154. Grey Whale densities along West Coast trail Unit of Pacific Rim National Park Reserve in recent years, from 2005 to 2023. Data from Parks Canada surveys, 2005-2023. Map provided by Parks Canada.

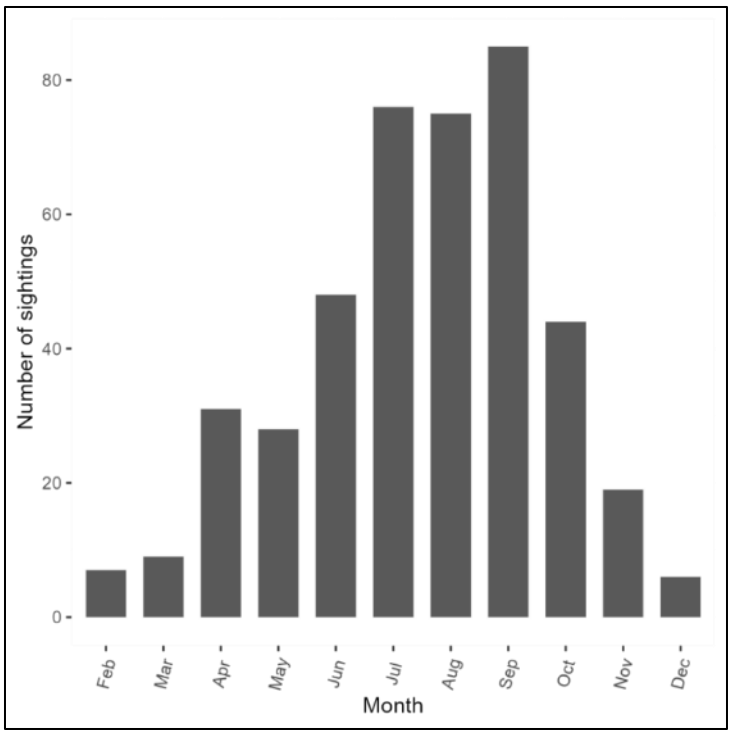


*Figure 155. Opportunistic Grey Whale encounters in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area by month, 1991 to 2023. Data sources include primarily opportunistic sightings provided by the BCCSN[82] (sightings data supplied by the BCCSN are opportunistic and not corrected for effort) with limited DFO data from off-effort sightings during dedicated surveys.*

[82] https://ocean.org/overfishing/whales/ocean-wise-sightings-network/

For the majority of Grey Whales in the northeast Pacific, BC waters are a migratory corridor between winter breeding and summer feeding grounds, with occurrence generally peaking off western Vancouver Island in December on their southern migration and in mid-to-late March on their return migration north (Ford 2014). Most appear to favor a coastal route through Canada, particularly on the northward migration (Ford et al. 2013a). Along the west coast of Vancouver Island, the northbound migratory corridor is approximately 8 km from the shore for most adults and juveniles, and within 5 km for mother and calf pairs, with occasional sightings as close as 200 to 400 m from shore (Poole 1984; Perryman et al. 1999, 2002). The southbound migratory corridor is geographically similar, with some individuals traveling up to 40 km from shore (Green et al. 1995; Shelden et al. 1999; Meyer 2017).

For PCFG whales, BC waters provide more than a migration route. PCFG animals spend the summer and autumn feeding in temperate coastal waters of the eastern Pacific from northern California to the Gulf of Alaska (Calambokidis et al. 2017) including waters off southwest Vancouver Island in and around the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Photo-identification studies have shown that PCFG whales exhibit maternally-directed site use and strong site fidelity, returning to the specific feeding areas repeated years (Calambokidis et al. 2017). Genetic work by Lang et al. (2014) also indicates that matrilineal fidelity contributes to feeding ground use. Grey Whales are bottom-feeders and feed in shallow waters close to shore on benthic and epibenthic invertebrates including amphipods, mysids, Ghost Shrimp, small clams, planktonic crab larvae, and Pacific Herring eggs and larvae (Dunham and Duffus 2001, 2002; Burnham and Duffus 2018, 2022; detailed summary of prey species in Gavrilchuk and Doniol-Valcroze 2021). Shallow, coastal waters adjacent to **ƛ̓ušiiʔaaʔaq** provide important feeding habitat for this Endangered group.

6.2.6.1.3 Killer Whale

Three distinct, non-associating ecotypes of Killer Whale (*Orcinus orca*) inhabit BC waters: Resident Killer Whales, Bigg's Killer Whales (also known as Transient Killer Whales), and Offshore Killer Whales. The ecotypes differ in terms of diet, behaviour, social structure, acoustics, morphology, and genetic characteristics (Ford 2006, 2014). All three ecotypes occur in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Despite overlapping ranges, these ecotypes do not mix and are thus socially and reproductively isolated from each other.

6.2.6.1.3.1 Resident Killer Whale

Two populations of Resident Killer Whales (Northern (NRKW) and Southern (SRKW)) are regularly found in BC waters, with a portion of a third population (Alaskan Residents) making occasional forays into northern BC waters. Though their ranges overlap, they do not mix and are genetically, acoustically, and culturally distinct (Ford 2006). NRKW range from Glacier Bay, Alaska, to Gray's Harbor, Washington State (Ford et al. 2017). As of the 2022 photo-identification census, the NRKW population is estimated at 341 individuals, and has grown at an average of 2.2% annually since first being censused in 1973 (DFO 2023j). The 2023 census estimate for NRKW was 345 whales, with average growth since 1973 of ~2.2% (Cetacean Research Program, unpublished data). SRKW range from Monterey Bay, California to Chatham Strait, southeast Alaska (Ford et al. 2017). The SRKW population consisted of 72 individuals as of November 1, 2024 (Centre for Whale Research 2024). Both populations of Resident Killer Whales are listed under SARA, NRKW as Threatened and SRKW as Endangered. **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank is identified as part of the Southwest Vancouver Island Critical Habitat (displayed in Figure 156) required for recovery of both Resident Killer Whale populations (DFO 2018c).

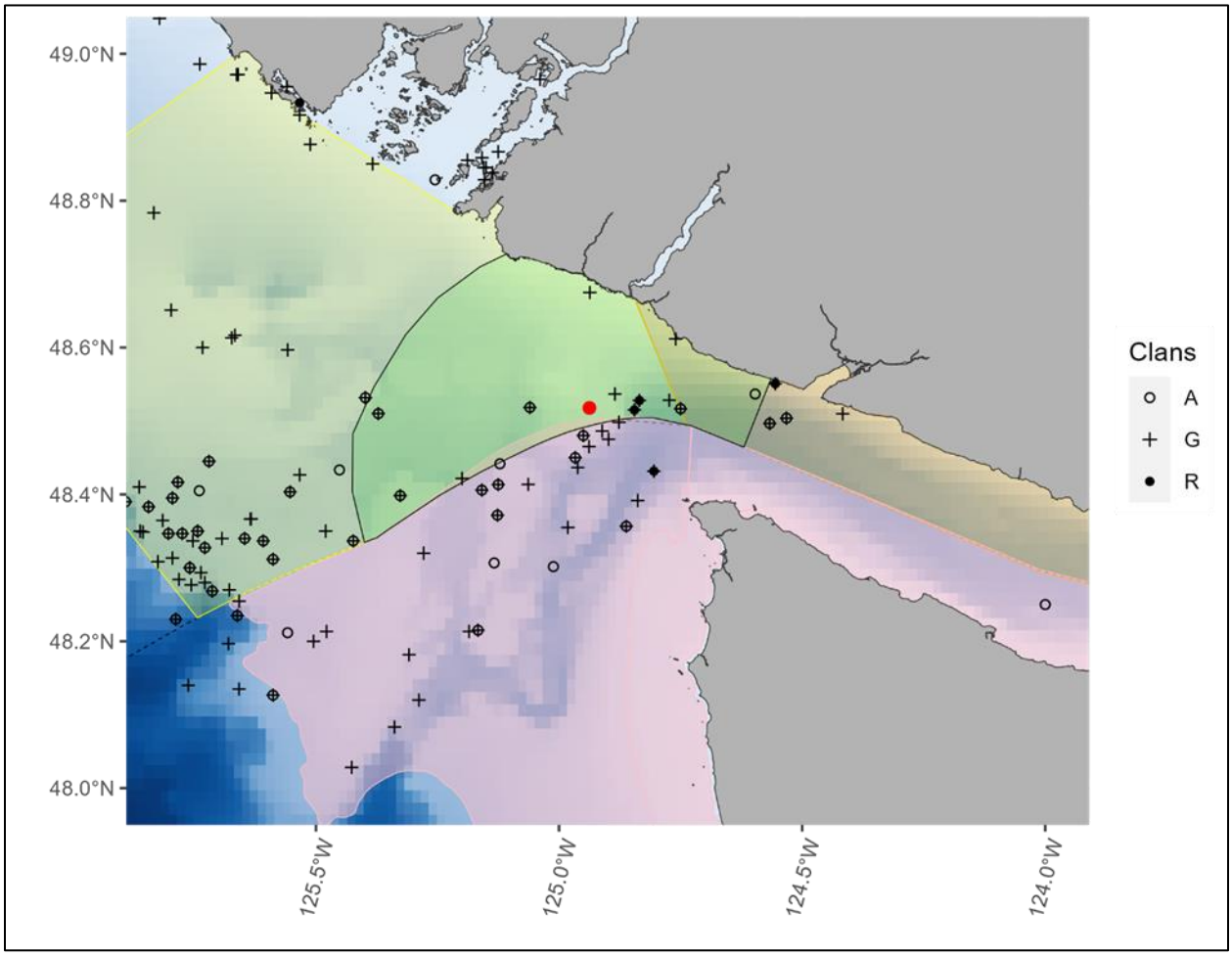


*Figure 156. Northern Resident Killer Whale boat-based encounters on and near **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank by clan (data from the DFO Cetacean Research Program, 1973-2022). RKW Critical Habitat displayed in yellow for the Canadian portion of **ƛ̓ušiiʔaaʔaq**, orange for the Canadian portion of the Salish Sea, and pink for the American portions of **ƛ̓ušiiʔaaʔaq** and the Salish Sea. The **ƛ̓ušiiʔaaʔaq** is shown in green, delineated using the boundary of the Juan de Fuca Eddy EBSA. Acoustic recorder deployment location August 2009-July 2011 is shown in red. A dedicated Swiftsure Bank recorder has been in place from early 2018, a recorder was in place for the ISZ from February 2020 to spring 2022, and shorter term recorders/click detectors were in place in 2021 and 2022.*

Occurrence of NRKW and SRKW in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area has been documented using boat-based photo-identification encounters and passive acoustic monitoring. In remote areas exposed to open ocean conditions, such as **ƛ̓ušiiʔaaʔaq**, where data collection from small boat encounters is difficult, acoustic detection techniques are able to capture year-round occurrence of Killer Whales (Ford et al. 2017). Individuals from all three NRKW clans have been photo-identified within the **ƛ̓ušiiʔaaʔaq**, with both NRKW and SRKW acoustically detected within the study area. Locations of DFO NRKW boat-based encounters near **ƛ̓ušiiʔaaʔaq** from 1973 to 2022 are shown by clan in Figure 156, with a total of 12 visual encounters recorded within the boundaries of the **ƛ̓ušiiʔaaʔaq** from 2001 to 2022 (data from Ford et al. 2010a updated to 2022). Most encounters took place between July and October, with one encounter in May.

Acoustic data from a hydrophone deployed at **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (location shown in Figure 156) were collected from August 2009 to July 2011 for a total of 680 days. Acoustic recordings of NRKW calls were detected year-round on 95 (14%) of the recorded days, predominantly (79%) in spring (February through April) and fall (September through October) though NRKW were present in all months (Figure 157) (Riera et al. 2019). Similar to the NRKW photo-identification data, acoustic recordings on **ƛ̓ušiiʔaaʔaq** primarily detected G clan (all months), with some A clan presence (mostly summer and fall) and only two recordings of R clan (August and September). Ongoing recording and acoustic analysis of the presence of calls from recordings from 2018 onwards will add much to what is known about Killer Whale presence on **ƛ̓ušiiʔaaʔaq**, including their winter habitat use and residency times.

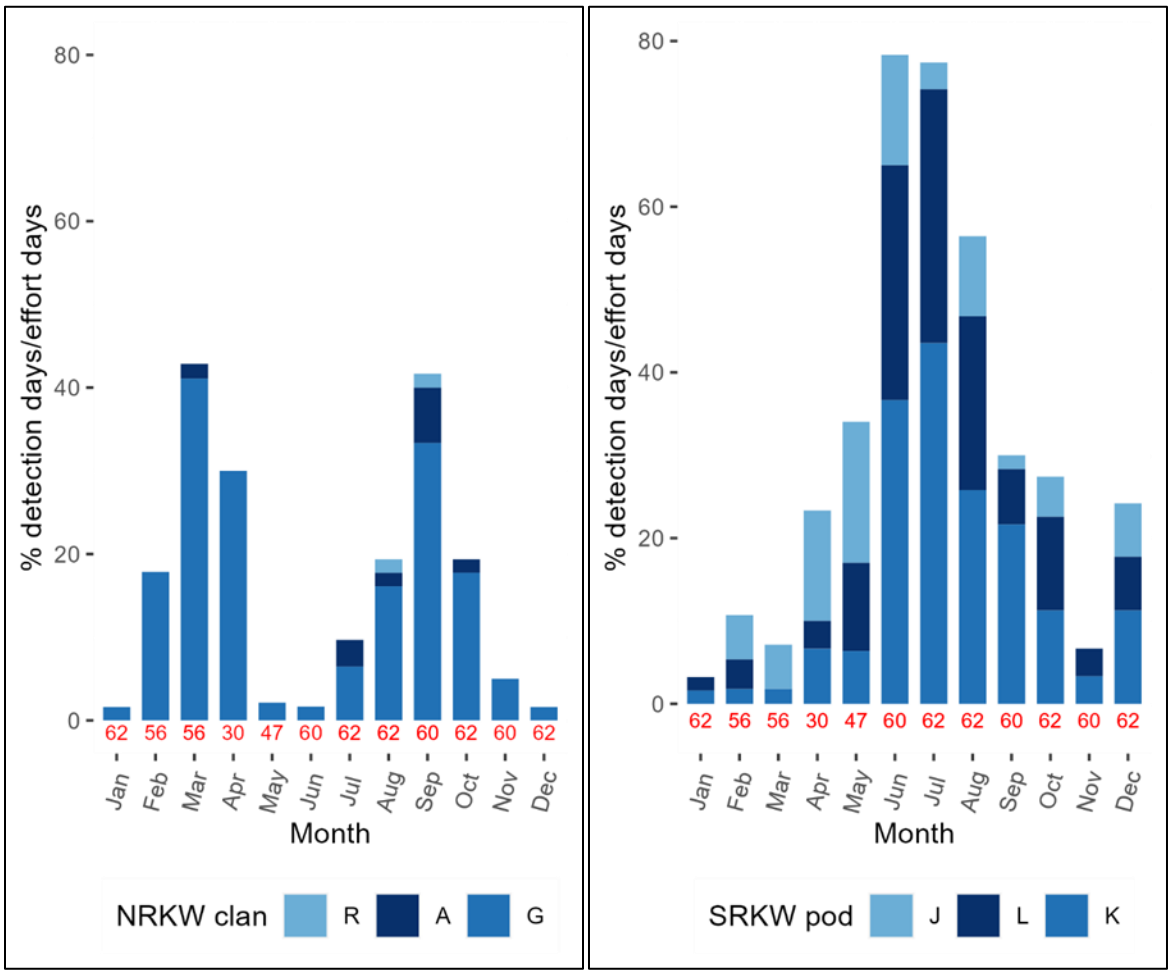


*Figure 157. Adapted from data presented in Riera et al. (2019). Proportion of days per month with NRKW (left) and SRKW (right) acoustic detection(s) at **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank during the deployment period (August 2009− July 2011). Numbers in red: days of effort. No data were available for 50 d between 26 March and 15 May 2011.*

SRKW are encountered more often than NRKW in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. A recent study combined data from whale watch operators (2009-2018) and DFO surveys (2009-2020) within RKW Critical Habitat in the Salish Sea and **ƛ̓ušiiʔaaʔaq** to model predicted SRKW occurrence for May to October (Thornton et al. 2022b). The **ƛ̓ušiiʔaaʔaq** was found to be one of the preferred habitats, and to have the largest spatial extent of high intensity SRKW

occurrence within the Salish Sea (Thornton et al. 2022b). For the **ʎušiiʔaaʔaq**, the probability of occurrence increased steadily from May to July, peaked in August, and then diminished into the fall (Figure 158; Thornton et al. 2022).

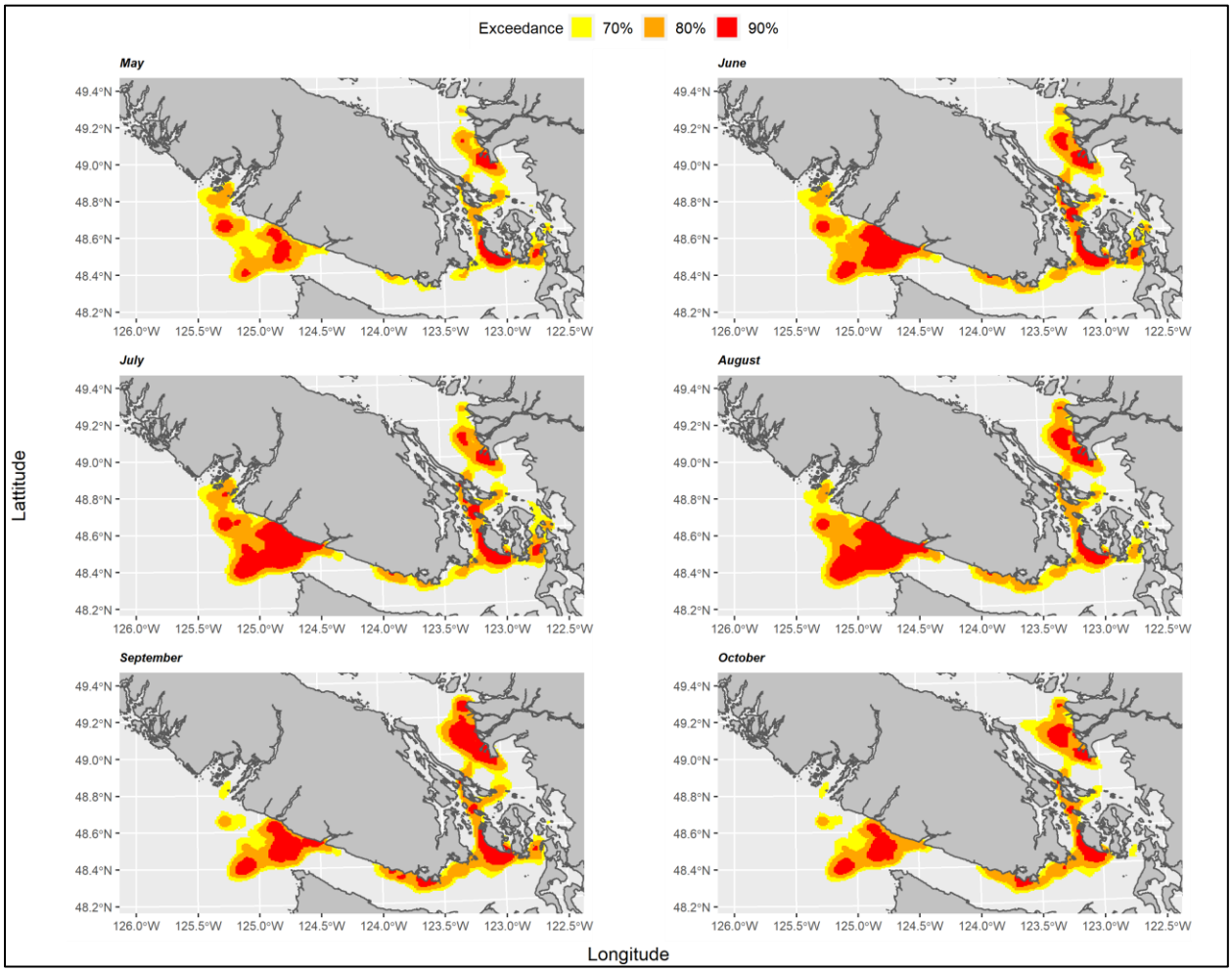


Figure 158. Predicted monthly habitat preference of SRKW when in their Critical Habitat, using data from each month for estimating preference thresholds ("exceedance"). The expected number of SRKW sightings per unit search effort within each month at a given location is referred to as the SRKW intensity of occurrence. The 90% polygon (red) represents the areas of highest SRKW intensity of occurrence values within each individual month, with diminishing intensity described by the 80% (orange) and 70% (yellow) polygons. From Thornton et al. (2022b).

Acoustic patterns follow the same trends as those of the modelled visual encounter data. SRKW calls were detected year-round on the acoustic recorder deployed on **ʎušiiʔaaʔaq**/Swiftsure Bank (location shown in Figure 156). Riera et al. (2019) reported SRKW detections on 163 (24%) of the 680 recording days (August 2009-July 2011), predominantly in summer (79%, May through September). All three SRKW pods were heard in nearly all months; J pod was not heard in January or November and L pod was not heard in March. K and L pods were heard more in the summer, while J pod was heard more in winter and spring. Acoustic analysis by Thornton et al. (2022b) examined the same **ʎušiiʔaaʔaq** acoustic data from Riera et al. (2019) with additional acoustic data from the same deployment location (shown in Figure 156) on **ʎušiiʔaaʔaq** in 2018 and 2019 looking at summer months only (May through October). SRKW

were detected on 79 of 167 (47.3%) of recording days in summer 2018 and 61 of 184 (33.2%) recording days in summer 2019.

The percentage of days with SRKW acoustic detections on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank was low in May 2018 and 2019 (3.2%), and progressively increased to a peak in August (93.8% in 2018 and 80.7% in 2019). This shift is later than that in the 2009-2011 acoustic data, when 29% and 31.3% of days in May had detections in 2010 and 2011, respectively. Peak detections occurred in June (63.3% in 2010, 56.7 in 2011) and July (45.2% 2010, 67.7% in 2011), rather than August for the earlier years. A similar study examined Killer Whale acoustic detections on nearby La Perouse Bank, which is also designated RKW Critical Habitat, with data collected from August 2015 to June 2016 and July 2017 to July 2018. Both NRKW and SRKW calls were again detected year-round (DFO, unpublished data), though more NRKW were detected than SRKW at the La Perouse Bank location.

Movement patterns of NRKW and SRKW are influenced by the availability of their preferred prey, Chinook Salmon (*Oncorhynchus tshawytscha*), and to a lesser extent chum (*O. keta*) and coho (*O. kisutch*) (Ford and Ellis 2006; Ford et al. 2017). The strong tidal mixing and upwelling around southwestern Vancouver Island promotes productive salmon habitat, and salmon migratory routes cross the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area as they funnel into Juan de Fuca Strait, providing key foraging habitat for Resident Killer Whales (Ford et al. 2017; DFO 2018c). Prey species were identified from 184 Resident Killer Whale predation events in southwestern Vancouver Island Critical Habitat between 2003 and 2013. The vast majority of these were salmonids (98%); 88% of all prey taken were Chinook Salmon, 5% were chum and 3% coho (Ford et al. 2017). Behavioural studies of SRKW from the **ƛ̓ušiiʔaaʔaq** Area were conducted in 2018-2021, where individual animals or groups were closely tracked to assess behavioural states such as travelling or foraging (Thornton et al. 2022b; Stredulinsky et al. 2023). Behavioural models showed areas of high foraging probability along the bathymetric contours around **ƛ̓ušiiʔaaʔaq** (edges of the bank), specifically near Nitinaht Narrows and the eastern and southwestern edges of **ƛ̓ušiiʔaaʔaq** (Figure 159, adapted from Stredulinsky et al. 2023; see also Thornton et al. 2022).

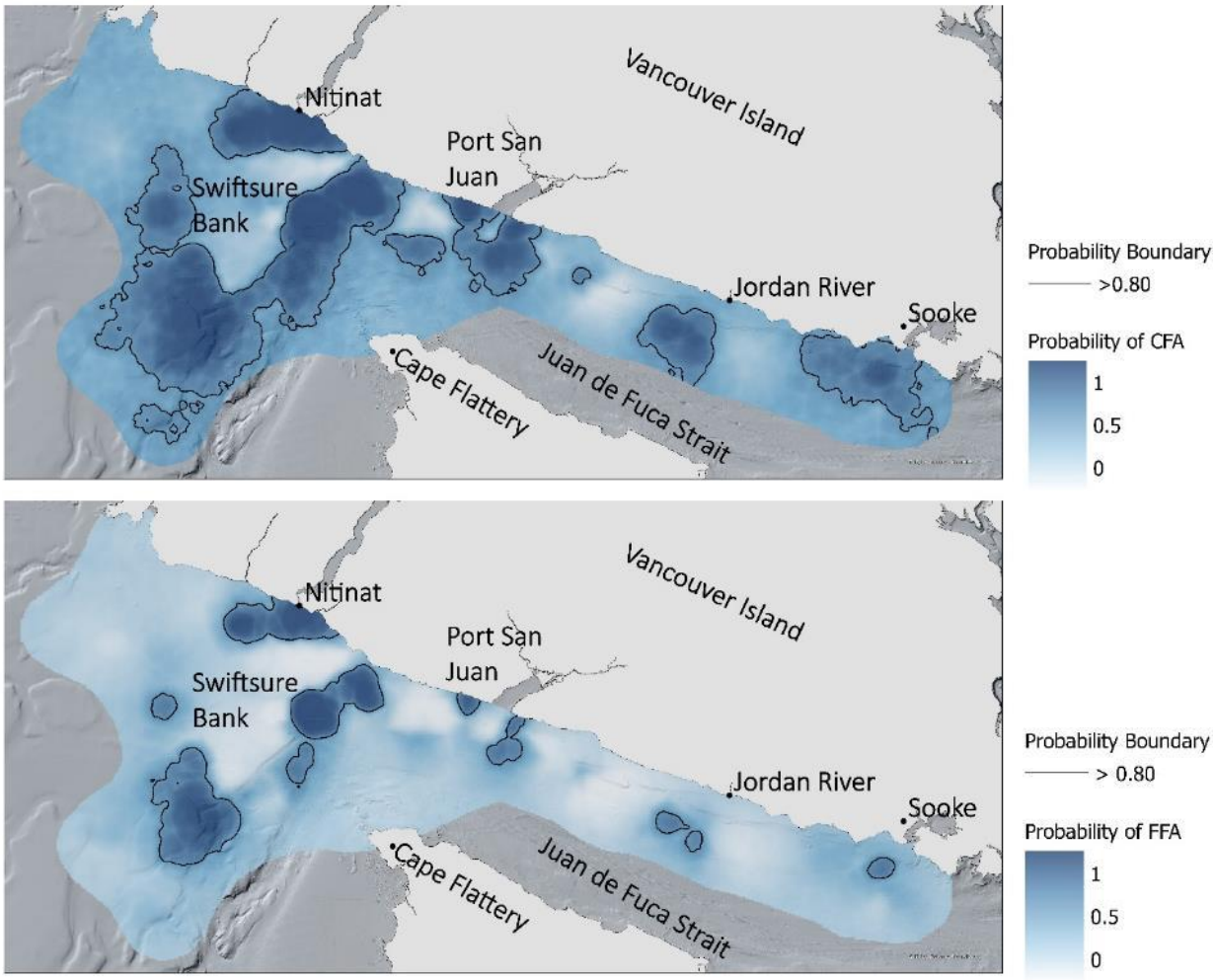


Figure 159. Common foraging areas (CFA, top) are defined as locations where the probability of foraging exceeded 0.25 and frequent foraging areas (FFA, bottom) as locations where the probability of foraging exceeded 0.50, as predicted by the top-ranked spatiotemporal models for the ***ẃušiiʔaaʔaq****/Swiftsure Bank region. The probability of the area being a CFA or FFA is indicated by the blue gradient scale. Gray areas are outside the geographic extents of the model. From Stredulinsky et al. 2023.*

Management measures have been implemented in this region in recent years, including fishery restrictions on **ẃušiiʔaaʔaq**/Swiftsure Bank, aiming at increasing the availability of salmon and reducing disturbance to SRKW in this area (Figure 13). More information can be found in fisheries management measures (Fisheries management measures) and vessel traffic (Vessel traffic and vessel types) sections. A beneficial biproduct may be less acoustic disturbance for SRKW using these areas (Burnham and Moore 2023).

6.2.6.1.3.2 Bigg's Killer Whale

Bigg's (transient) Killer Whales are found throughout the BC coast year-round, including the **ẃušiiʔaaʔaq**/Swiftsure Bank Area (Figure 160), and are relatively evenly distributed throughout their range (Ford et al. 2013b). Analyses of large-scale movement patterns indicate that Bigg's Killer Whales are highly mobile and utilize much of their known range. Many individuals show a relatively high degree of site fidelity to particular coastal regions, potentially because familiarity with foraging grounds provides an advantage (Ford et al. 2013b). Within the **ẃušiiʔaaʔaq**,

Bigg's are encountered year-round, with most of encounters reported in the summer (Figure 161), though this may reflect more research effort in those months.

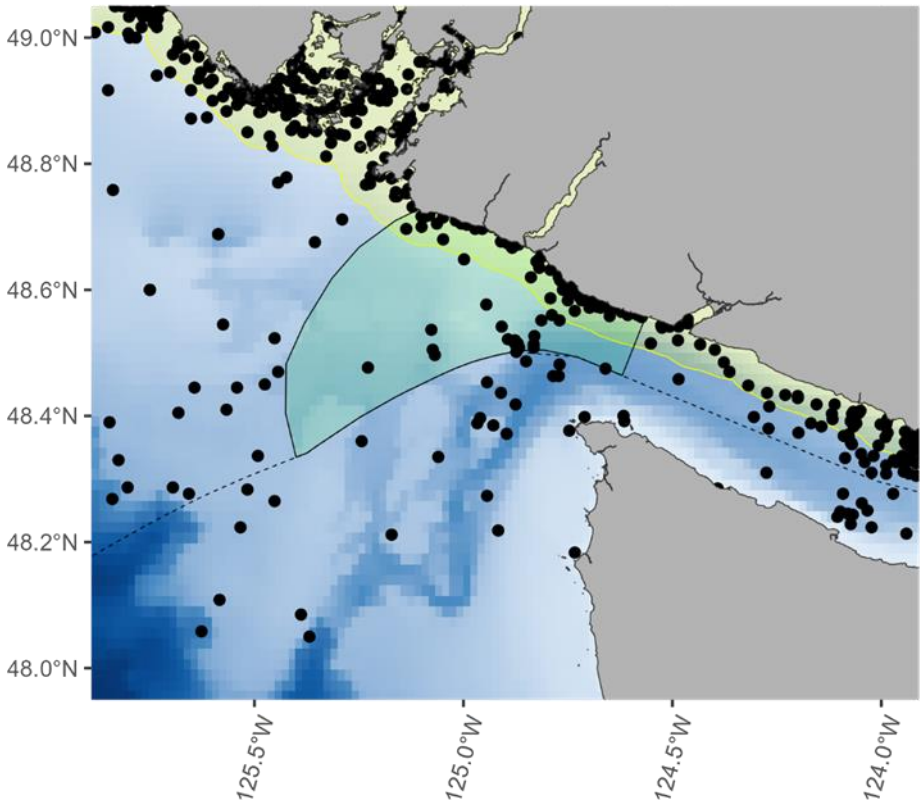


Figure 160. Map showing Bigg's Killer Whale photo-identification encounters by DFO's cetacean research program. Data are from Ford et al. (2013b), updated to 2023. The important Habitat considered necessary for meeting recovery objectives for Bigg's Killer Whales (in yellow, from Ford et al. (2013b)) is shown overlapping with the ***ʎušiiʔaaʔaq****/Swiftsure Bank Area (delineated in green based on the Juan de Fuca Eddy EBSA).*

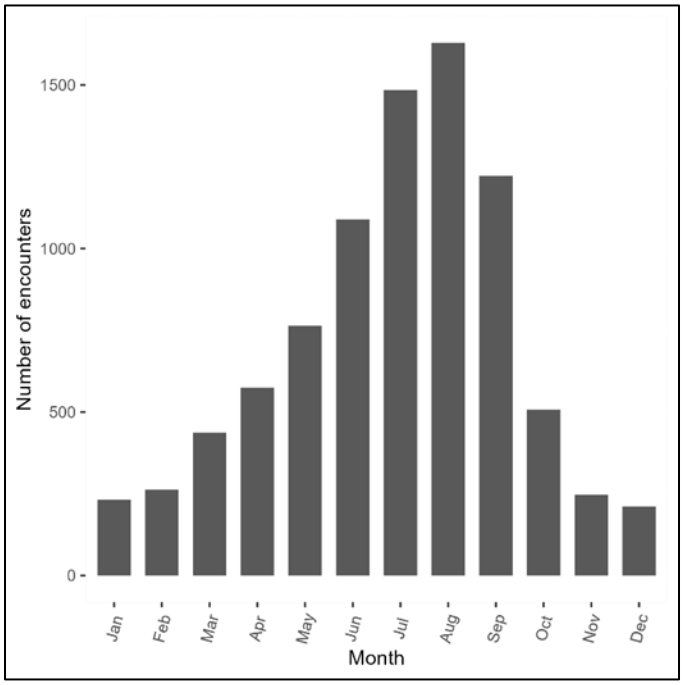


Figure 161. Bigg's Killer Whale encounters in the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area by month to 2023. Data from Ford et al. (2010a), updated to 2023.*

Bigg's Killer Whales feed almost exclusively on marine mammals, with Harbour Seals (P*hoca vitulina*) comprising more than half of predation encounters documented in BC, and other important prey species being Steller Sea Lions (*Eumetopias jubatus*), Dall's Porpoise (*Phocoenoides dalli*), and harbour Porpoise (*Phocoena phocoena*) (Ford et al. 2007, 2013b). All of these species are widely distributed within Bigg's Killer Whale range and are present in BC waters year-round. Steller Sea Lions are the most commonly taken prey in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, but there are also records of Harbour Seal, Harbour and Dall's Porpoise kills and harassment of Humpback Whales, and occasional seabird predation (Figure 162, data from Ford et al. (2013b), updated to 2023). Most of these predation events on **ƛ̓ušiiʔaaʔaq** were observed in August through October, with a few in May through July, though this likely reflects greater research effort in summer and fall than virtually none in winter and spring. The average distance from shore for observed kills throughout BC was previously calculated at 2.1 km (SE = 0.21), with 95% taking place less than 10 km from shore (Ford et al. 2007). Due to the widespread occurrence of nearshore predation events throughout BC coastal waters, Critical Habitat required for recovery Bigg's Killer Whales has been proposed as marine waters bounded by a distance of 5.56 km from the nearest shore (Figure 160). This proposed Critical Habitat has not yet been legally identified or protected under SARA.

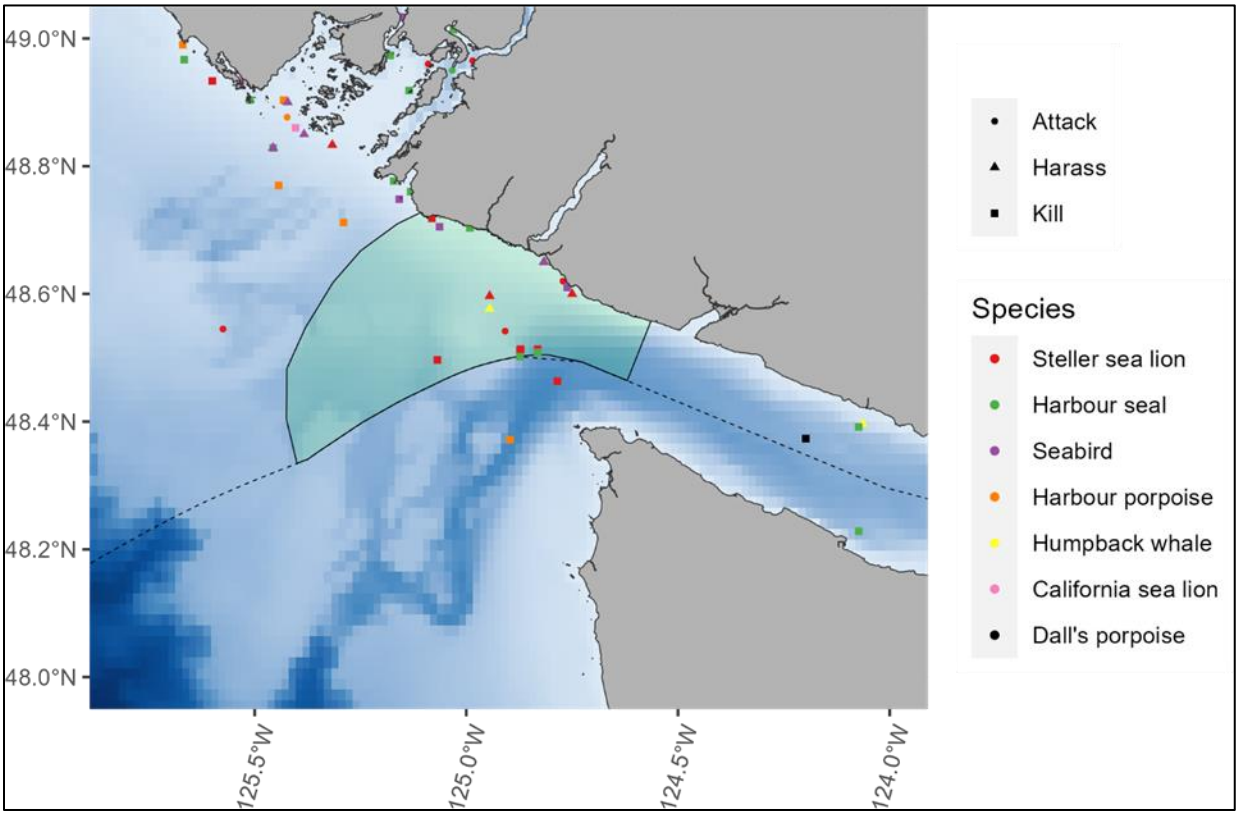


*Figure 162. Map of Bigg's Killer Whale predation events in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Most of these encounters involved predation on Steller Sea Lions. Data from Ford et al. (2013b), updated to 2023. Green polygon delineates Juan de Fuca Eddy EBSA.*

6.2.6.1.3.3 Offshore Killer Whale

Offshore Killer Whales (OKW) occur over the continental shelf from the eastern Aleutian Islands in Alaska to southern California. They are widespread in BC waters, though they are observed infrequently (accounting for only approximately 1% of >10,000 DFO Killer Whale photo-identification encounters throughout their range, see Figure 163) and are most frequently encountered in near the continental shelf edge off southwestern Vancouver Island and around Haida Gwaii (Ford et al. 2014). Range-wide population abundance for OKW was estimated to be approximately 300 individuals in 2012 using a Bayesian mark-recapture framework (Ford et al. 2014). They are currently listed as Threatened under SARA.

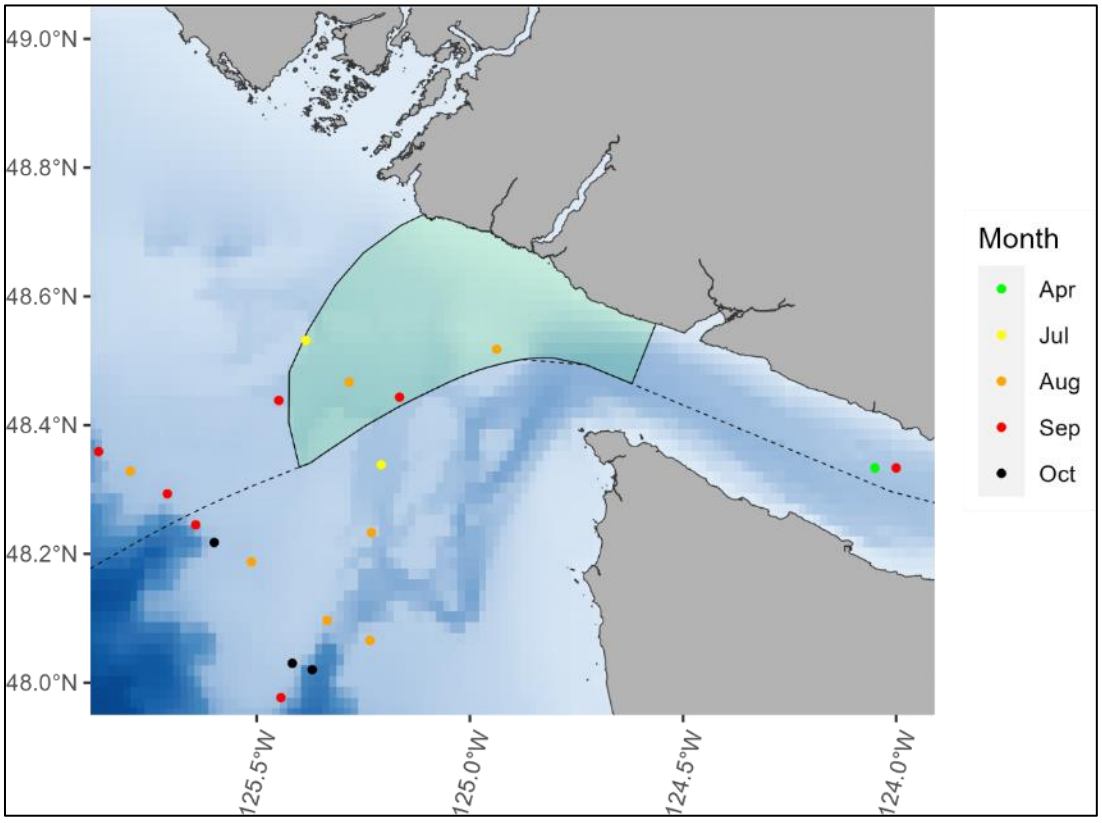


*Figure 163. Offshore Killer Whale visual encounters by month in southwest Vancouver Island from 1988 to 2023, including four in the **ʎušiiʔaaʔaq**/Swiftsure Bank Area. Data from Ford et al. (2014), updated to 2023. Green polygon delineates Juan de Fuca Eddy EBSA.*

Offshore Killer Whales generally are found at more northern latitudes of their range towards Alaska in the summer and southern latitudes towards California in the winter (Ford et al. 2014) though recent findings show variability amongst individuals (Schorr et al. 2022). They are found in BC in all months, though there are peaks in encounters in March, August and September (Figure 164). There is a seasonal bias in observer effort with more effort in summer months in BC and Alaska; OKW presence may be underrepresented in winter at more northern latitudes when conditions are less favourable and fewer boats are on the water and searching for whales (Ford et al. 2014).

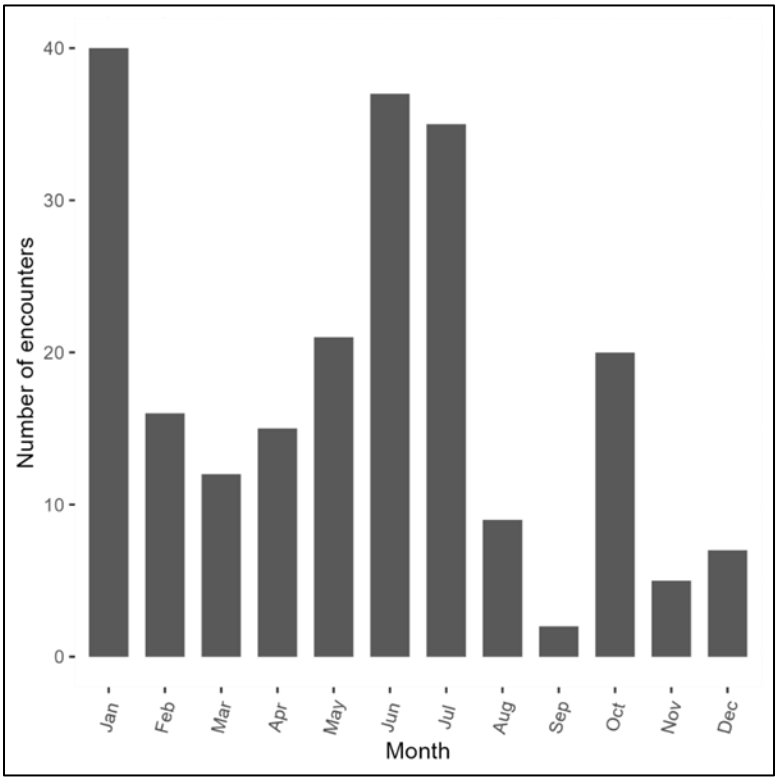


Figure 164. Offshore Killer Whale photo-identification encounters in BC by month, 1988 to 2023. Data from Ford et al. (2014), updated to 2023.

Visual records of OKW in southwest Vancouver Island are limited. Of all recorded coastal encounters (n=327 as of October 2023), there are four from within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area from 1998, 2009, 2010 and 2020 (Figure 163; data from Ford et al. (2014) updated to October 2023). All four encounters occurred in the summer (July to Sept), which may reflect more effort in those months. Analysis of Killer Whale acoustic detections at monitoring sites in BC has been used to identify presence and seasonal patterns when visual detections are limited. One OKW call was recorded at the **ƛ̓ušiiʔaaʔaq** (Figure 156) as of 2014 (Table 1 *in* Ford et al. (2014)). More recent acoustic data have been collected but not yet analyzed that may hold further OKW detections.

OKW diet predominantly consists of elasmobranchs (Pacific sleeper shark (*Somniosus pacificus*), North Pacific Spiny Dogfish, (*Squalus suckleyi*), Blue Shark (*Prionace glauca*)), with some records of consumption of Chinook Salmon and Pacific Halibut (Ford et al. 2014). While there are no documented predation events for OKW within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, Blue Shark and North Pacific Spiny Dogfish are taken by OKW around the Nitinaht, Barkley and Juan de Fuca Canyons directly to the south and west of this region in the late summer and fall (August-October) (DFO, unpublished data).

6.2.6.1.4 Other cetacean species

6.2.6.1.4.1 Fin Whale

Fin Whales (*Balaenoptera physalus velifera*) are not frequently reported in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. However, they are present along the shelf edge adjacent to this area (Figure 166**,** Nichol and Ford 2018)) and on the shelf close to shore north of

ƛ̓ušiiʔaaʔaq (Burnham et al. 2019, 2021; B. Gisborne, pers. comm.), and in the inside waters of Juan de Fuca Strait which implies they travelled through the **ƛ̓ušiiʔaaʔaq** (DFO unpublished data; Towers et al. 2018). Acoustic recordings suggest that Fin Whales are present on **ƛ̓ušiiʔaaʔaq**, but few calls are heard relative to more offshore and sub-marine canyon areas (R. Burnham, DFO, pers. comm.). Fin Whales are currently listed as Threatened under SARA. Recent research has been conducted into the distribution and status of Fin Whales on the BC coast, and they are therefore addressed here.

Fin Whales are found globally in all major seas (Ford 2014). Within the Canadian Pacific, combined efforts of dedicated surveys (Nichol et al. 2017; Nichol and Ford 2018; Wright et al. 2021b) and acoustic investigations (Pilkington et al. 2018; Burnham et al. 2021) conducted from 2002-2021 along with opportunistic sightings data (BCCSN[83]) demonstrate a range for Fin Whales throughout the BC coast. Greater concentrations of sightings occur along the continental shelf, and in Hecate Strait, Dixon Entrance, and Queen Charlotte Sound, and the majority of sightings occur beyond the continental shelf (Ford et al. 2010a; Nichol et al. 2017; Nichol and Ford 2018; Wright et al. 2021b). Ford et al. (2010a) reported that Fin Whales are found in Canadian Pacific waters during all seasons of the year. Fin Whale abundance was estimated from the 2018 DFO coast-wide boat-based survey data to be 2,893 (95% CI = 2,171-3,855) for the Canadian Pacific (Figure 165) (Wright et al. 2021b). COSEWIC estimated that Pacific Fin Whale population levels in 2005 were under 50% of what they were 60-90 years ago. No abundance estimate of Fin Whales on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank has been made at this time, but a compilation of sighting and acoustic data suggests that they are starting to recover from removals by commercial whaling (Rannakari et al. 2024).

[83] https://ocean.org/overfishing/whales/ocean-wise-sightings-network/

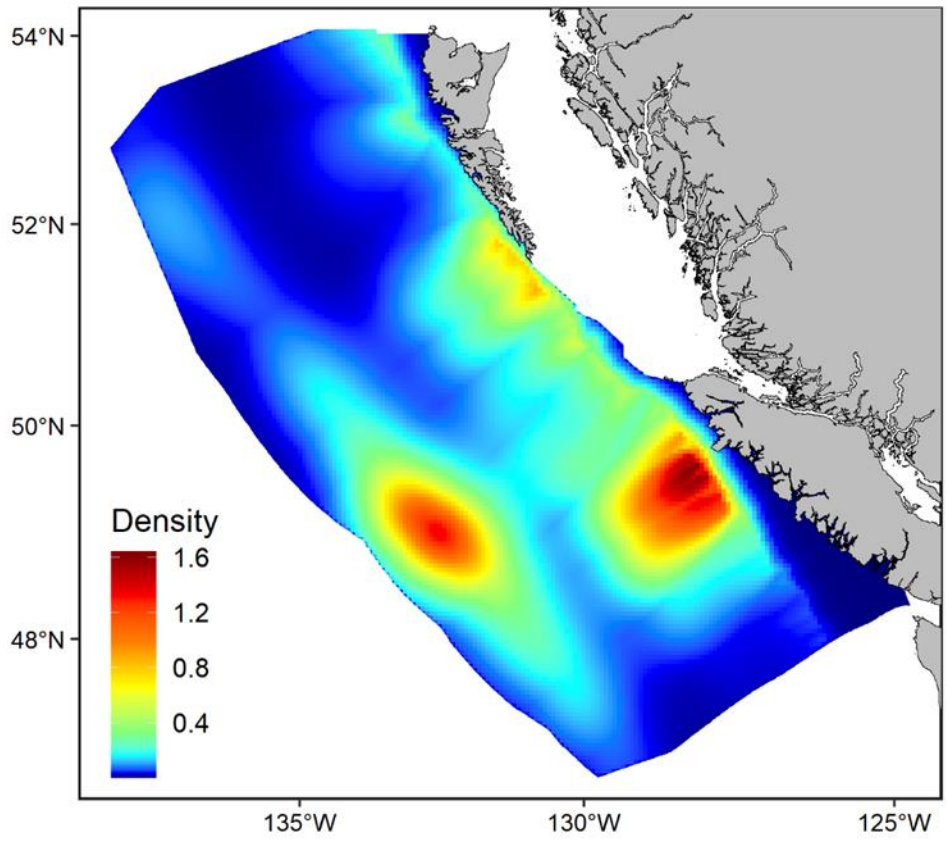


Figure 165. Estimated densities (fill colour indicates the number of individuals per 25 km2 grid cell) of Fin Whales in the offshore stratum from the DFO 2018 coast-wide survey, based on predictions from the best-fit Tweedie GAM. Total estimated abundance for this stratum is 2,732 (95% CI = 2,044-3,651) Fin Whales. Adapted from Wright et al. (2021b).

None of the recent and data-processed DFO survey efforts covering southwestern Vancouver Island reported any sightings of Fin Whales within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, though, as mentioned above, they have been sighted on the nearby shelf break and on the shelf north of **ƛ̓ušiiʔaaʔaq** (Nichol et al. 2017) and in Juan de Fuca Strait (DFO, unpublished data; Towers et al. 2018). A distribution map for Fin Whales modelled from the 2018 DFO coast-wide survey is shown in Figure 165 for the outer coast which overlaps the western portion of the **ƛ̓ušiiʔaaʔaq** Area suggesting few to no Fin Whales in that area, although this conclusion was based on only one survey in one season (Wright et al. 2021b). No Fin Whales were sighted in inside waters on which to base distribution models for the surveys' Salish Sea stratum which overlaps the eastern portion of the **ƛ̓ušiiʔaaʔaq** (Wright et al. 2021b). Aerial survey sightings of Fin Whales in 2012-2015 occurred exclusively on or beyond the continental shelf break (Figure 166, Fin Whale sightings shown in pink), and the modelled probability of encountering a Fin Whale in the survey area showed extremely low chance Fin Whale in the **ƛ̓ušiiʔaaʔaq** (Figure 167) (Nichol et al. 2017). More recent DFO survey data that has yet to be processed may hold more Fin Whale sightings, with more extensive acoustic analysis also likely to add more evidence.

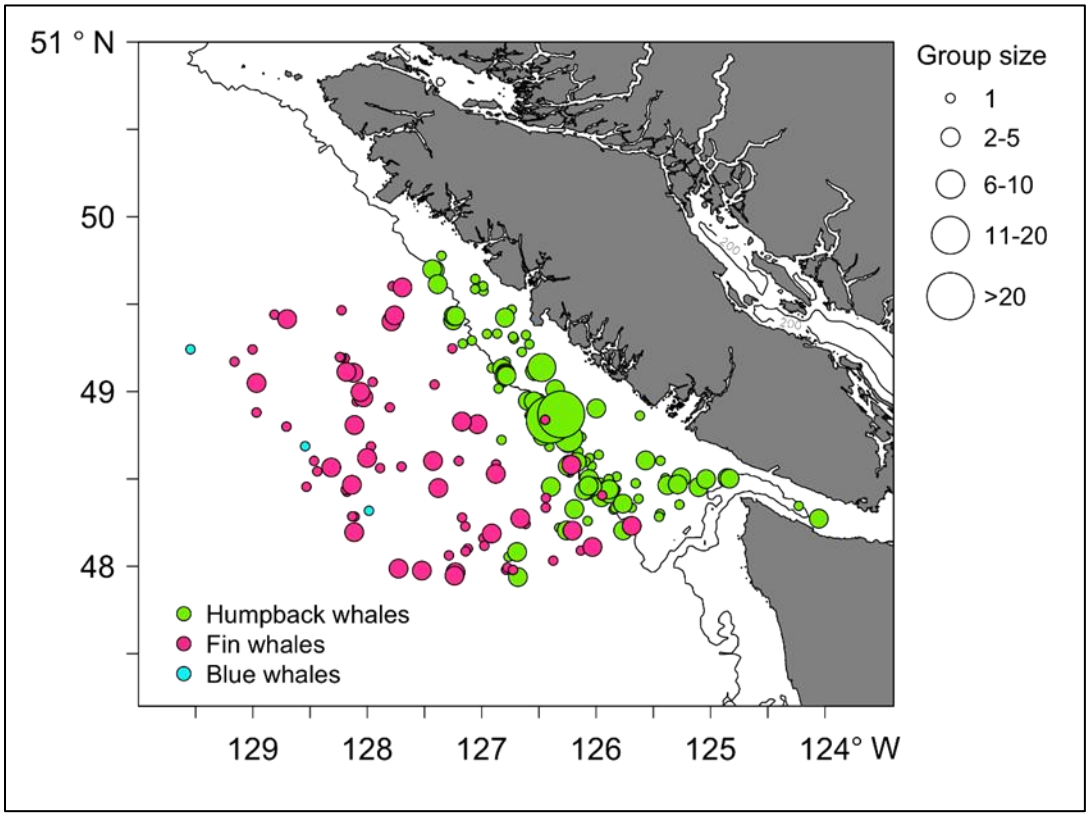


Figure 166. Locations of large whale sightings (N=237) by species and group size (range = 1-33), observed during aerial surveys off the west coast of Vancouver Island and western Juan de Fuca Strait (2012-2015). Adapted from Nichol et al. (2017).

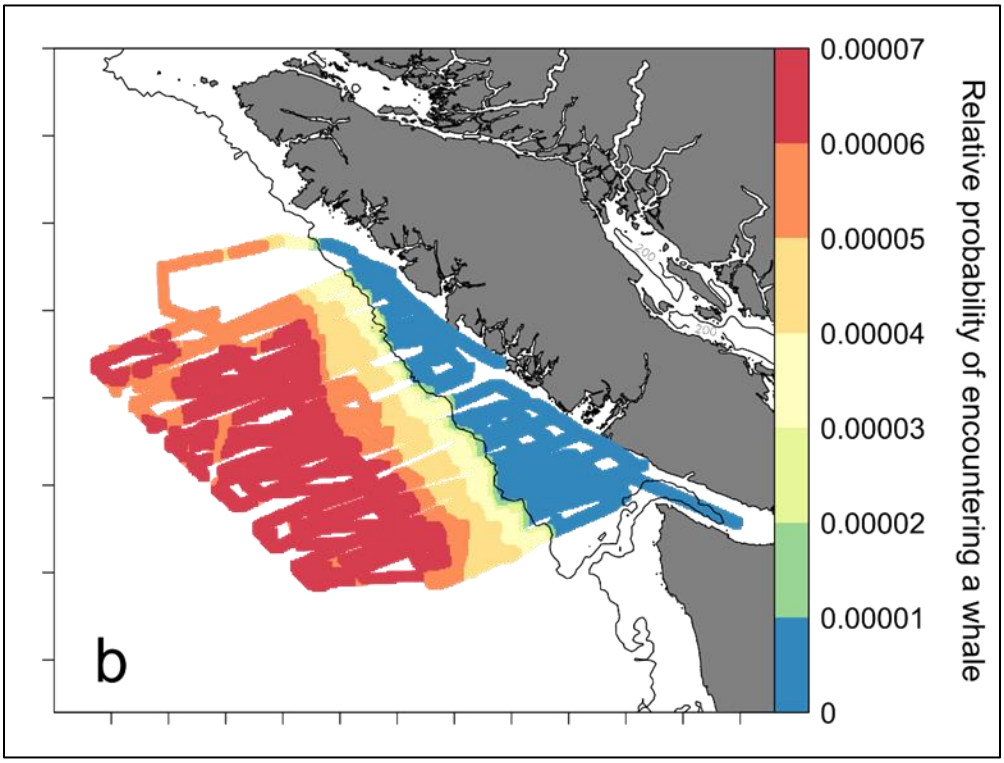


Figure 167. Aerial survey study area off the west coast of Vancouver Island, BC, Canada, divided into 1 km² grid cells (N=23,996). Filled cells indicate those containing survey effort that was retained for analysis. Colours indicate the relative probability of encountering a Fin Whale. The continental shelf break is illustrated by the 200 m bathymetric contour (black line). Adapted from Nichol et al. (2017).

Dedicated boat-based, seasonal surveys that cover **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank year-round since 2020 have reported no on-effort sightings of Fin Whales in the area, although two Fin Whales were reported in Juan de Fuca Strait (McMillan et al. 2022; DFO, unpublished data). Opportunistic sightings data from the BCCSN covering 1991 to 2023 have only three reported sightings of Fin Whales within the **ƛ̓ušiiʔaaʔaq** Area (Figure 168).

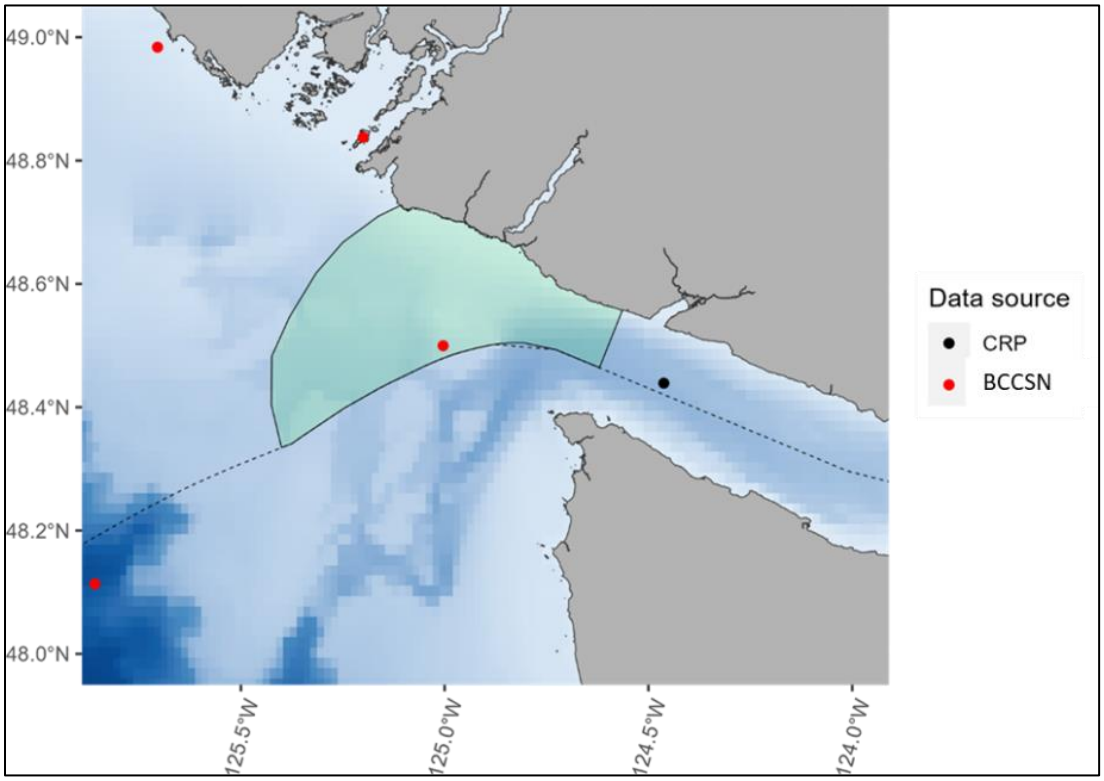


*Figure 168. Fin Whale sightings in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank and surrounding area (data from BC Cetacean Sightings Network (BCCSN)[84] opportunistic sightings 1975 to 2023 and DFO dedicated surveys 2003 to 2017). The Fin Whale sighting shown in red within the **ƛ̓ušiiʔaaʔaq** (based on the Juan de Fuca Eddy EBSA polygon) occurred in November 2013 (BCCSN). Sightings data supplied by the BCCSN are opportunistic and are not corrected for effort.*

In 2018 a report on partial habitat of special importance to the survival and recovery of Fin Whales off the northern BC coast was published. It included most of the waters of Hecate Strait, Queen Charlotte Sound, and Greater Caamaño Sound (Nichol and Ford 2018). However, only the northern part of BC was considered in this analysis and it was noted that additional areas may be required for habitat of special importance for the survival and recovery of this species.

6.2.6.1.4.2 Harbour Porpoise and Dall's Porpoise

Harbour Porpoise (*Phocoena phocoena*) and Dall's Porpoise (*Phocenoides dalli*) are known to occur in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area but are not well studied in the waters off southwestern Vancouver Island. The DFO 2018 coast-wide survey offshore and Salish Sea strata each overlap part of the **ƛ̓ušiiʔaaʔaq**. Harbour Porpoise abundance within the Salish Sea stratum of the 2018 coast-wide survey was estimated at 3,893 (95% CI = 1,991-7,611), and there were not enough sightings in the offshore stratum to estimate abundance (Wright et al. 2021b). Dall's Porpoise abundance was estimated at 580 (95% CI = 313-1,075) within the Salish Sea stratum and 17,934 (95% CI = 13,818-23,275) within the offshore stratum (Wright et al. 2021b). A spatial density map for Harbour Porpoise in the Salish Sea stratum is shown in Figure 169 and for Dall's Porpoise in the offshore and Salish Sea strata in Figure 170 and Figure 171.

[84] https://ocean.org/overfishing/whales/ocean-wise-sightings-network/

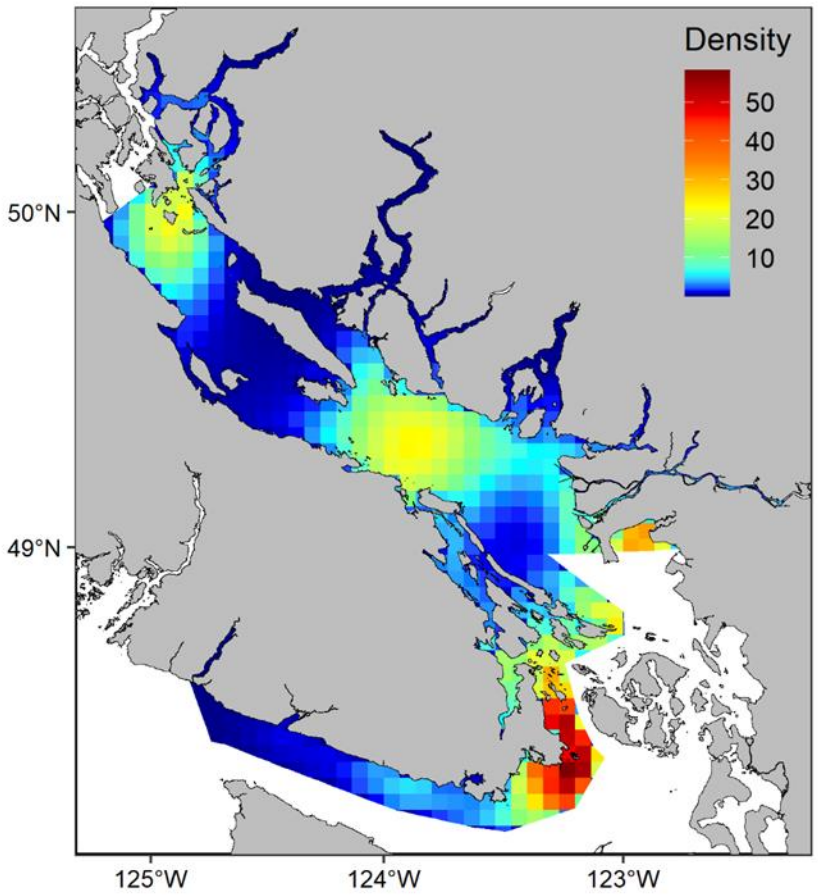


Figure 169. Estimated densities (fill colour indicates the number of individuals per 25 km^2 grid cell) of Harbour Porpoises in the Salish Sea stratum, based on predictions from the best-fit negative binomial general additive model (GAM). The only significant environmental covariates included in the GAM was a bivariate smoother of easting and northing (X and Y coordinates). Total estimated abundance for this stratum is 3,893 (95% CI = 1,991-7,611) Harbour Porpoises. From Wright et al. (2021b).

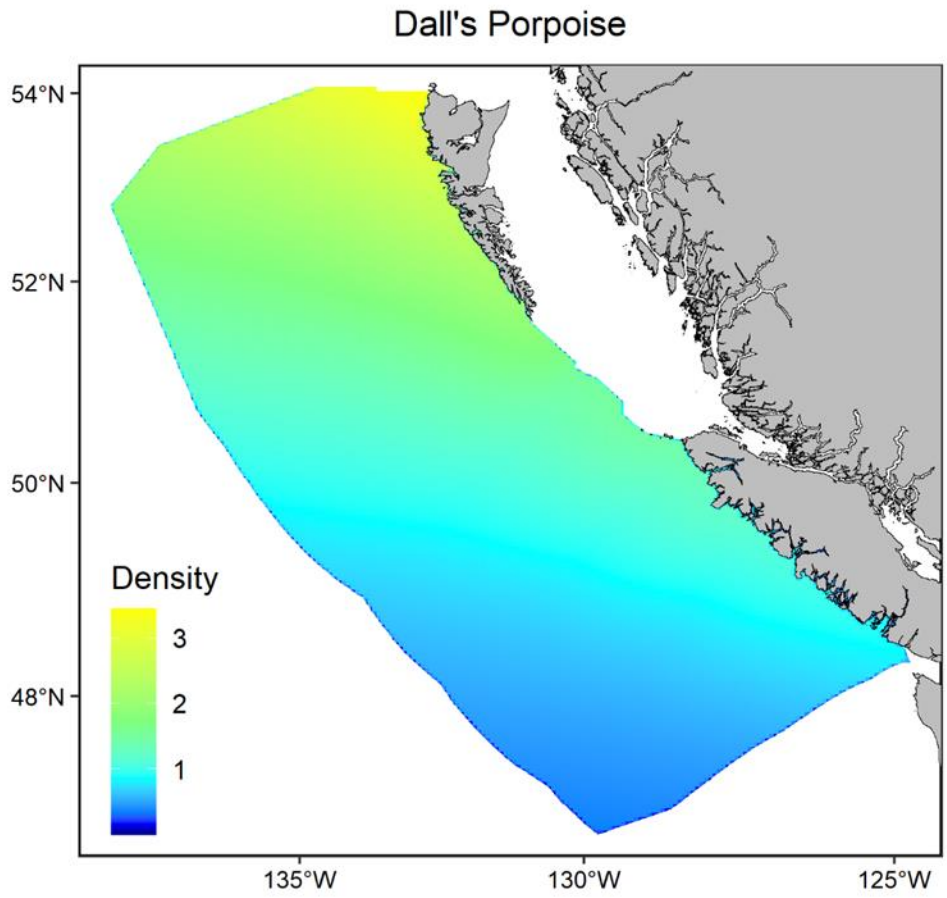


Figure 170. Estimated densities (fill colour indicates the number of individuals per 25 km^2 grid cell) of Dall's Porpoises in the offshore stratum, based on predictions from the best-fit Tweedie GAM. The environmental covariate included in the GAM was a bivariate smoother of distance from shore and northing (Y coordinates). Total estimated abundance for this stratum is 17,934 (95% CI = 13,818-23,275) Dall's Porpoises. From Wright et al. (2021b).

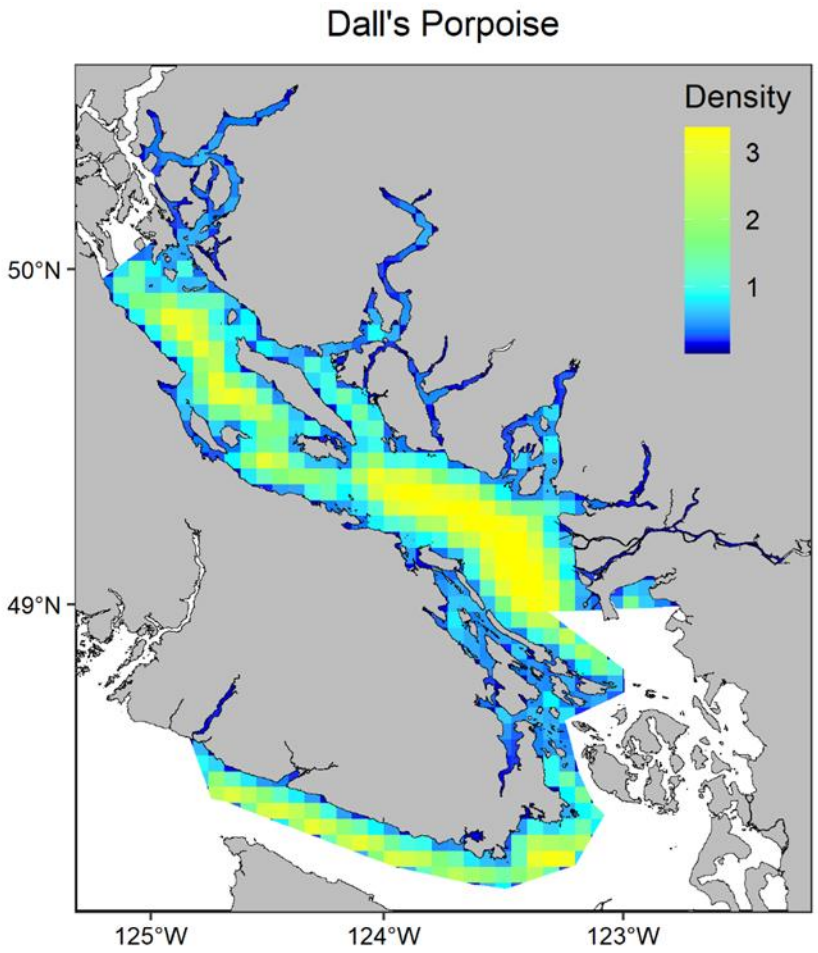


Figure 171. Estimated densities (fill colour indicates the number of individuals per 25 km^2 grid cell) of Dall's Porpoises in the Salish Sea stratum, based on predictions from the best-fit Tweedie GAM. The only significant environmental covariate included in the GAM was a smoother of distance from nearest shore (Duchon spline). Total estimated abundance for this stratum is 580 Dall's Porpoises (95% CI = 313-1,075). From Wright et al. (2021b).

The DFO research program initiated in 2020 to study cetaceans in the southern Salish Sea and over **Áušiiʔaaʔaq**/Swiftsure Bank by season recently estimated seasonal abundance for Harbour Porpoise in the study area (map of study area in Figure 149) at 584 (95% CI = 274-1242) individuals in winter (January through March), 915 (95% CI = 603-1,387) in spring (April through June), 1,089 (95% CI = 709-1,674) in summer (July through September) and 1,430 (95% CI = 986-2,073) in fall (October through December) (McMillan et al. 2022). Abundance for Dall's Porpoise was estimated at 362 (95% CI = 203-643) individuals in winter (January through March), 131(95% CI = 62-278) in spring (April through June), 89 (95% CI = 36-218) in summer (July through September) and 182 (95% CI = 80-413) in fall (October through December) (McMillan et al. 2022). Interestingly, Harbour Porpoise were lowest in abundance in winter, and increased in abundance through spring and summer to a peak in fall, while Dall's Porpoise were highest in abundance in winter, decreased through spring and summer, and begin to increase in abundance through the fall. Note, however, that these seasonal changes in abundance may differ spatially within the study area (see seasonal sightings maps in Figure 172 for Harbour Porpoise and Figure 173 for Dall's Porpoise). The surveys are ongoing and are contributing to the development of seasonal spatial density models for each species. Acoustic data are also

being collected to inform porpoise use of the **ƛ̓ušiiʔaaʔaq** (C. McMillan, DFO, pers. comm.); however, the spatial area of detection can be limited due to the high-frequency nature of their calls and echolocation signals. Updated Harbour Porpoise and Dall's Porpoise sightings and survey effort data by season from these surveys up to November 2023 are provided in Figure 172 and Figure 173, respectively.

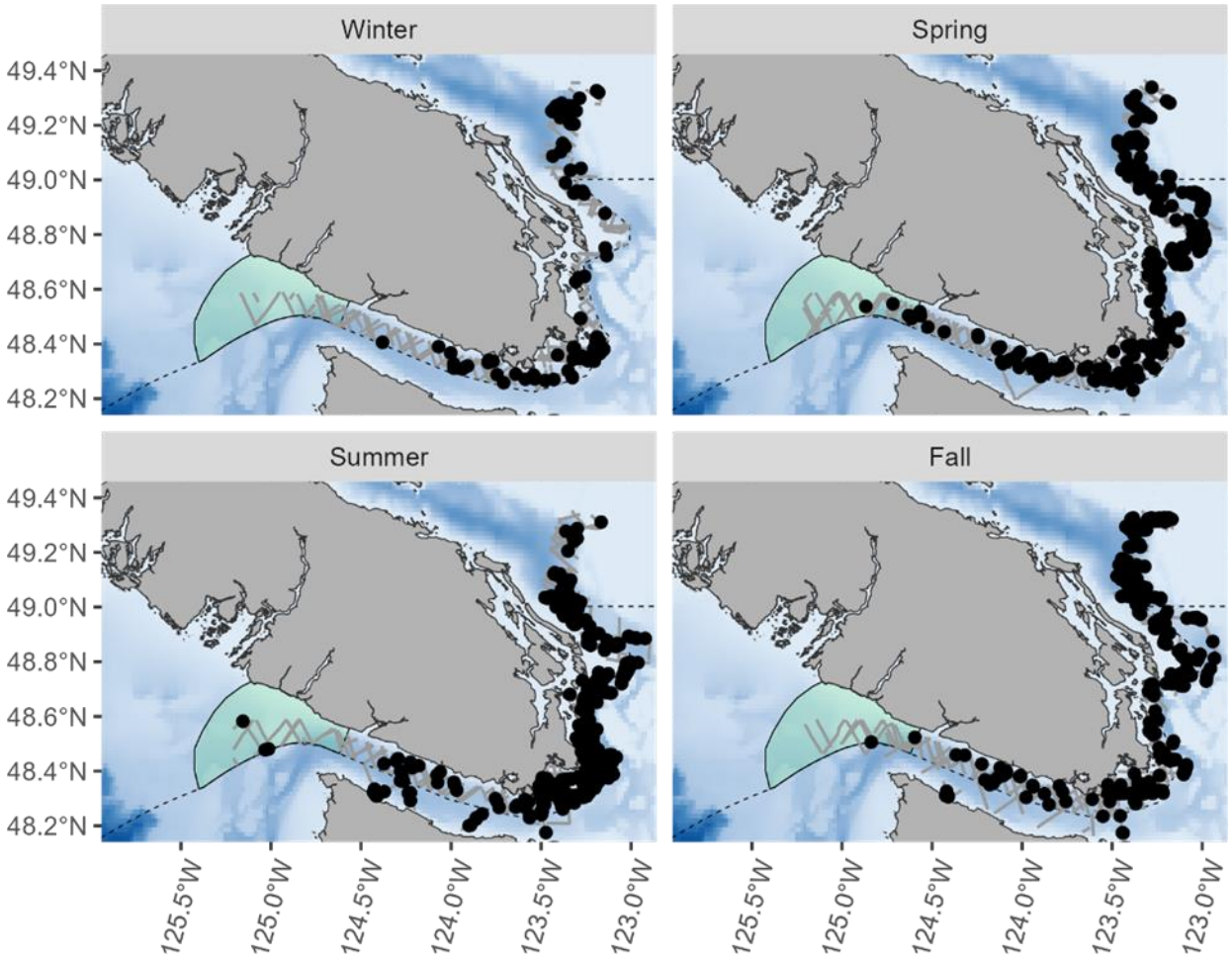


Figure 172. Harbour Porpoise sightings and effort data from DFO surveys in McMillan et al. (2022), updated with additional data to November 2023. Juan de Fuca Eddy EBSA polygon in ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area is delineated in green.*

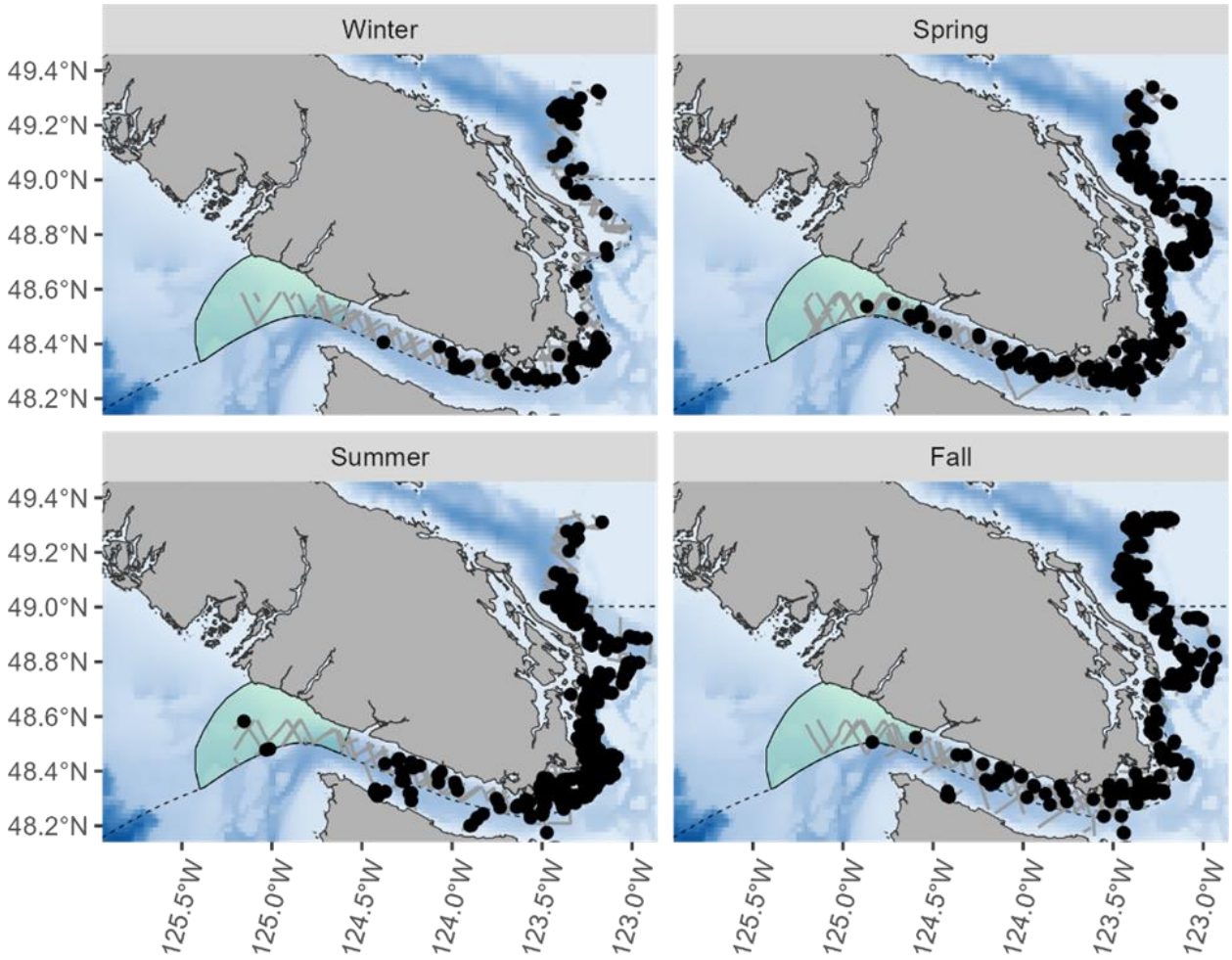


Figure 173. Dall's Porpoise sightings and effort data from DFO surveys in McMillan et al. (2022), updated with additional data to November 2023. Juan de Fuca Eddy EBSA polygon in ***ʎušiiʔaaʔaq****/Swiftsure Bank Area is delineated in green.*

Additional sightings data (not effort-corrected) from DFO surveys from 2002 to 2017 and BCCSN opportunistic sightings from 1985 to 2023 are shown in Figure 174 for Harbour Porpoise and Figure 175 for Dall's Porpoise. Dedicated Parks Canada surveys along the shoreline showed a higher density of Harbour Porpoise from Nitinaht Lake westward (Figure 176).

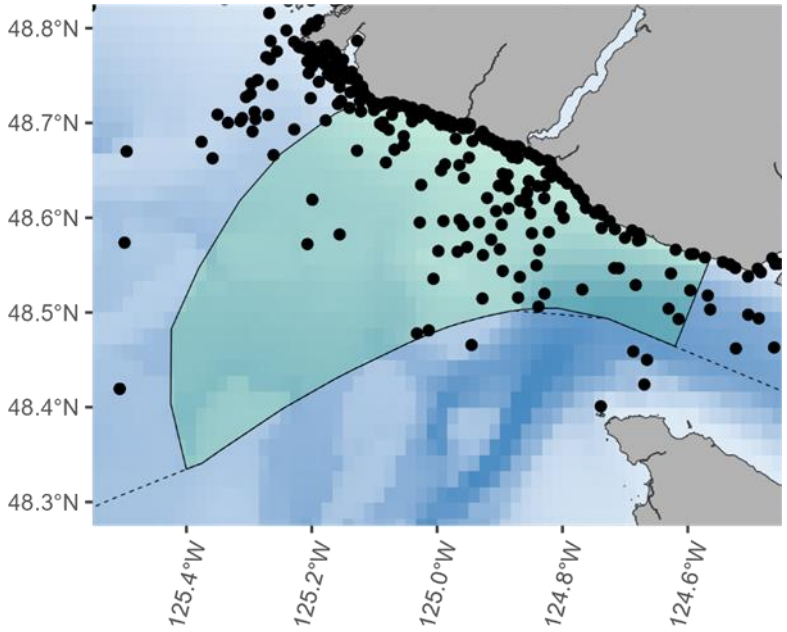


*Figure 174. Harbour Porpoise sightings. Data sources include DFO survey sightings (not corrected for effort) 2002-2017 and BCCSN sightings 1985-2023. Sightings data supplied by the BCCSN are opportunistic and not corrected for effort. Juan de Fuca Eddy EBSA polygon in **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area is delineated in green.*

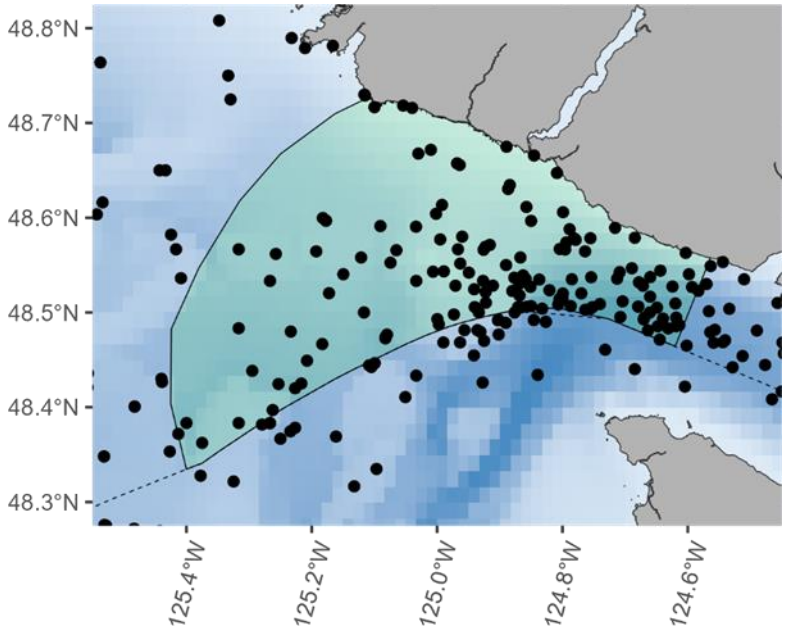


*Figure 175. Dall's Porpoise sightings. Data sources include DFO survey sightings (not corrected for effort) 2002-2017 and BCCSN sightings 1985-2023. Sightings data supplied by the BCCSN are opportunistic and not corrected for effort. Juan de Fuca Eddy EBSA polygon in **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area is delineated in green.*

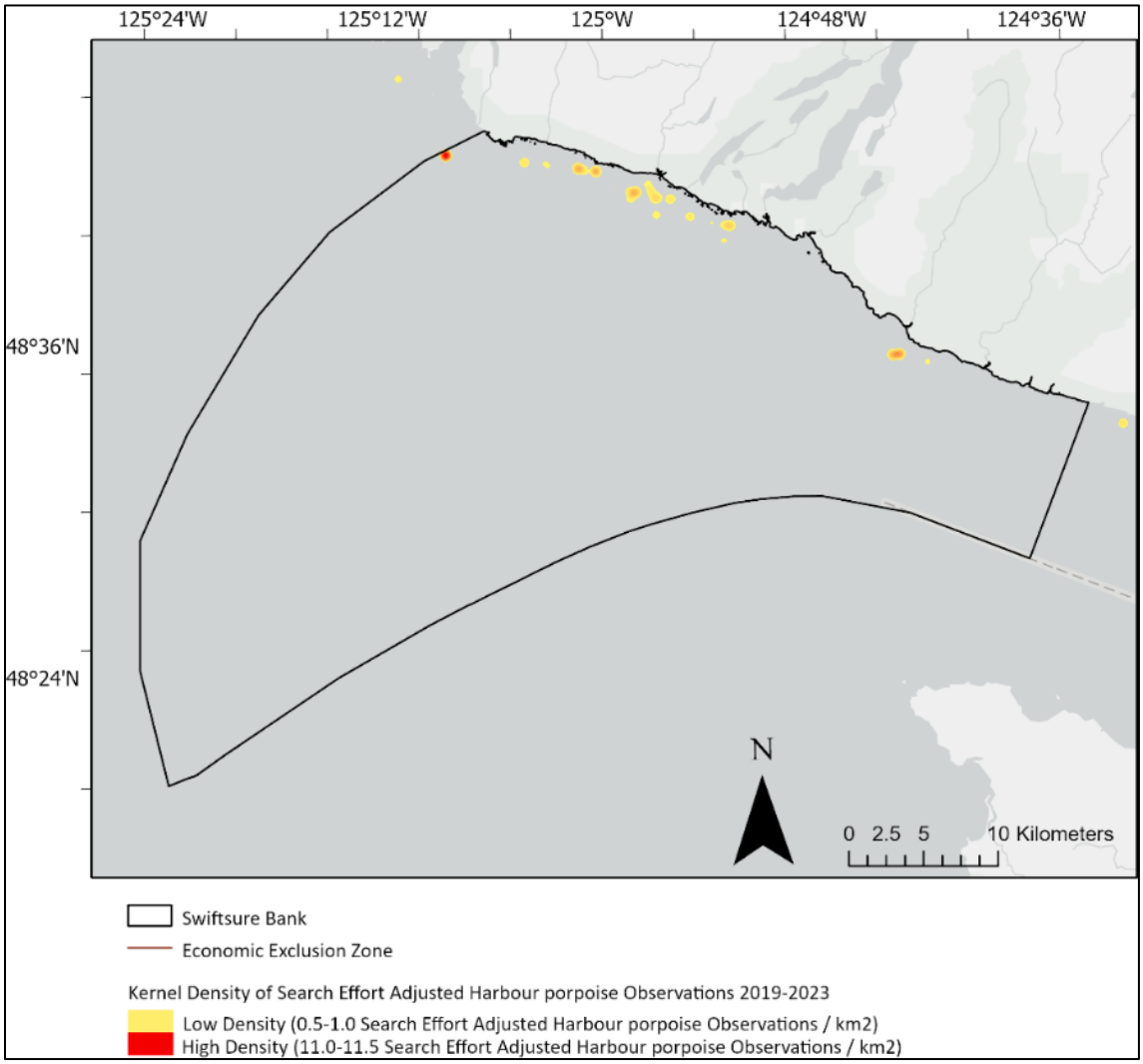


Figure 176. Harbour Porpoise survey adjusted densities along West Coast trail Unit of Pacific Rim National Park Reserve in recent years, from 2019 to 2023. Juan de Fuca Eddy EBSA polygon in ***ʎušiiʔaaʔaq****/Swiftsure Bank Area is delineated as a black line. A survey search area was created along route from the visibility distance and observations were divided by the sum of the applicable search areas resulting in a search effort adjusted population for each observation. Fixed kernel density layers using a search radius of 500m, a cell size of 25m and the adjusted population were generated for each set of observations. Data from Parks Canada surveys, 2019-2023. Map provided by Parks Canada.*

6.2.6.1.4.3 North Pacific Right Whale

North Pacific Right Whales (NPRW) were widely distributed in the northern Pacific Ocean prior to the commercial whaling period, and are now listed as Endangered under SARA. They were not hunted commercially in waters around southwestern Vancouver Island (Ford et al. 2016), though bones from this species have been found in archaeological sites on southern Vancouver Island (Scarff 1986) and in northern Washington State (Arndt 2011; Ford et al. 2016). The last known kill in BC was in 1951 (Nichol et al. 2002), after which there were no confirmed sightings in BC waters until 2013.

In June 2013 there was a confirmed NPRW sighting off the northwest coast of Haida Gwaii (Ford et al. 2016). A second sighting of a different individual in October of the same year was confirmed on **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank (Ford et al. 2016). Since then, one sighting has occurred farther north on the west coast of Vancouver Island (2020), and two more sightings have occurred on the west coast of Haida Gwaii (2018 and 2021) (Figure 177).

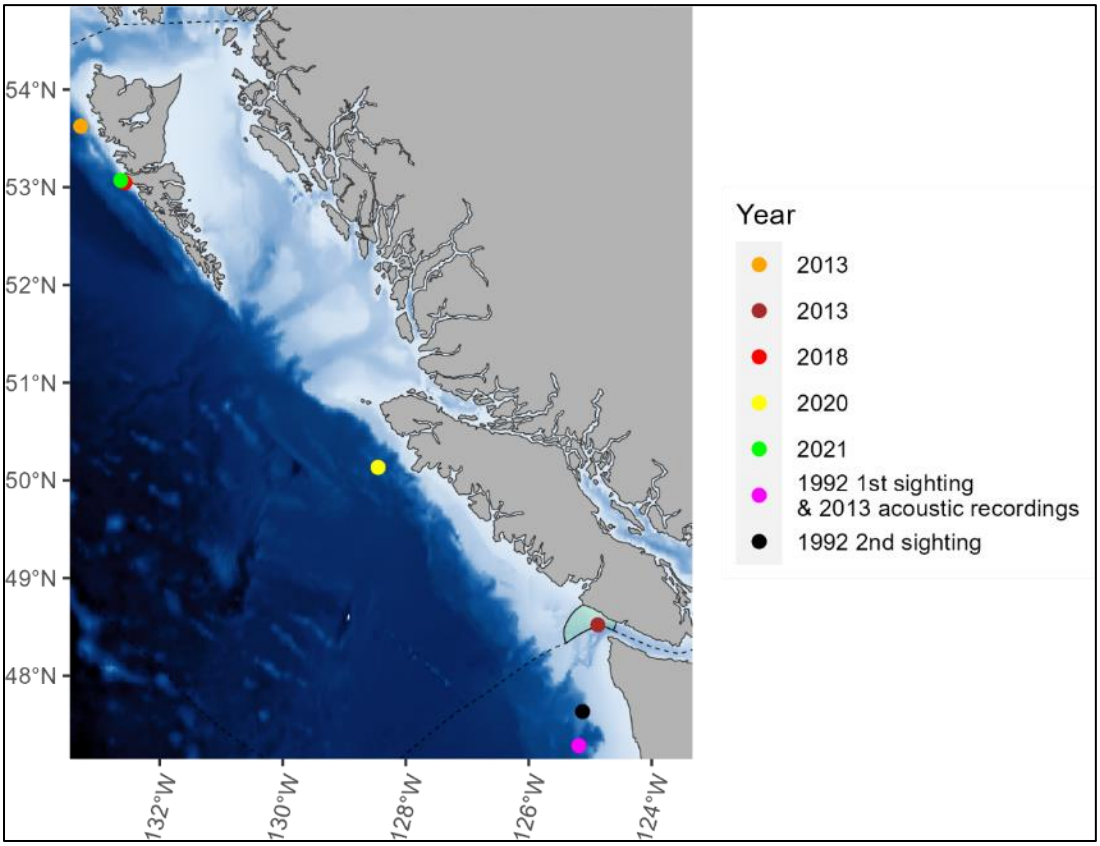


Figure 177. Recent sightings of North Pacific Right Whales in Canadian waters, and locations off Washington State of two sightings of a North Pacific Right Whale 6 hours apart heading north in 1992, and two Right Whale acoustic recordings in 2013. The location of the first 1992 sighting which was near the same location of the 2013 acoustic recordings is shown in pink, and the location of the second 1992 sighting of the same individual 6 hours later is shown in black. Juan de Fuca Eddy EBSA polygon in ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area is delineated in green. Data source: DFO.*

In Washington State, there was a confirmed NPRW sighting in 1992 offshore of Cape Elizabeth, which was then resighted farther north off Destruction Island 6 hours later (Rowlett et al. 1994). The animal was not resighted again, though the direction of travel would put it on a trajectory that would bring it in the region of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Near the location of the first 1992 sighting, NPRW calls were detected in acoustic recordings in 2013 (Širović et al. 2015). There was also a reported sighting of two Right Whales in the **ƛ̓ušiiʔaaʔaq** in 1983 (Reeves and Leatherwood 1985), though the species identification was not confirmed (Ford 2014).

6.2.6.2 Pinnipeds

Five species of Pinniped are observed in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, including two phocid (i.e., seal), and three otariid (i.e., sea lion/fur seal) species, which are detailed separately below. There is potentially a third, albeit likely rare, otariid species (Guadalupe Fur Seals)

although sightings in BC waters have not been confirmed to date. Only three of these species routinely haul out; the other two are mainly pelagic. Haul-outs are terrestrial sites used by pinnipeds to temporarily leave the water to rest, molt, and give birth. Haul-outs in BC include sand bars, mud banks, and boulders but are most often located in the rocky intertidal zone of isolated islands, islets, or reefs. Several pinniped haul-out locations exist in the **ƛ̓ušiiʔaaʔaq** along the coast (Figure 178). Data on presence within the area come from Fisheries and Oceans Canada and Parks Canada Pacific Rim National Reserve.

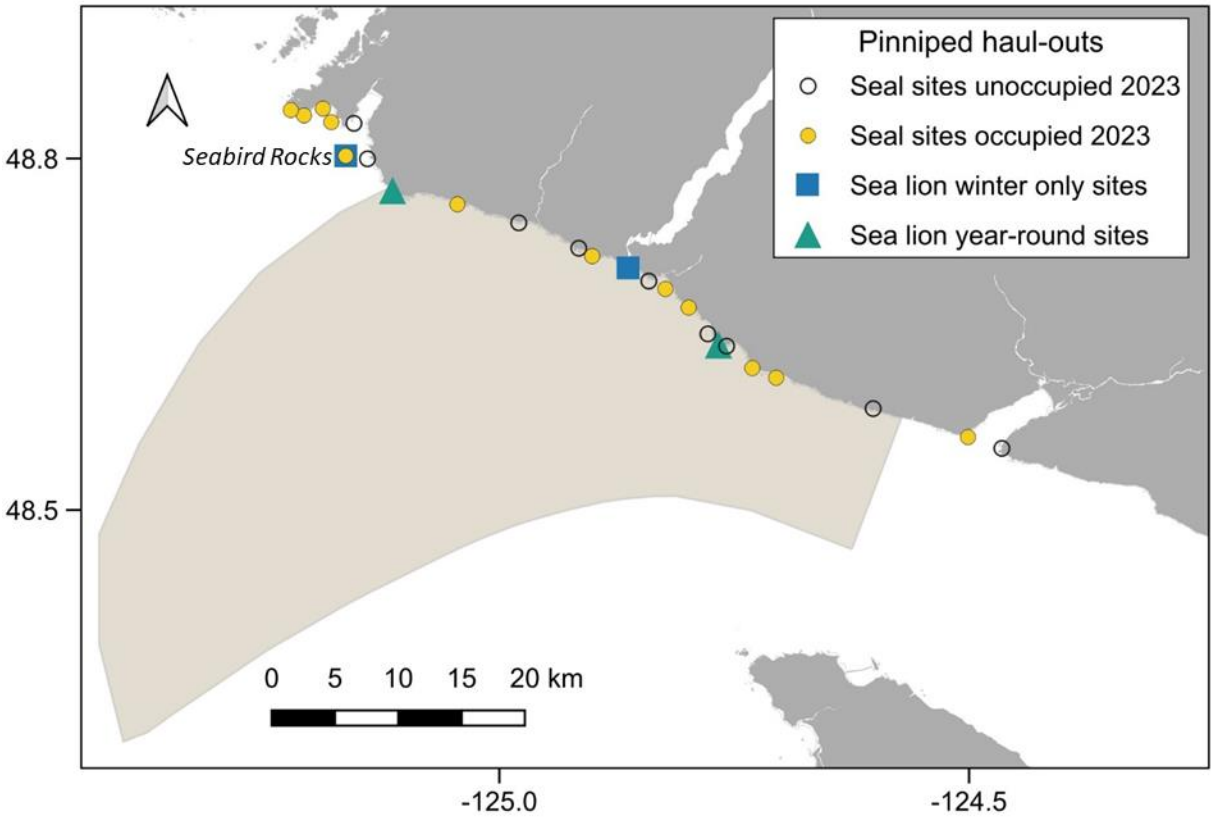


*Figure 178. Pinniped haul-out locations within 10km of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, based on the Juan de Fuca Eddy EBSA polygon. Data from DFO BC Coastwide Harbour Seal Aerial Surveys (DFO 2022c).*

6.2.6.2.1 Seals

6.2.6.2.1.1 Harbour Seals

Harbour Seals (*Phoca vitulina*) are one of BC's most abundant pinniped species. They are not considered at risk by the COSEWIC. Abundance is thought to have returned to historic norms following protection in the 1970's (Olesiuk et al. 1990). Harbour Seals were most recently assessed in BC following a multi-year aerial survey covering 90% of the coast from 2015 – 2019 (DFO 2022c). The coastal portion of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank is part of the BC Coastwide Harbour Seal Aerial Survey and Assessment area which photographs all islands, rocks and coastline from a plane during standardized low-tide windows (DFO 2022c). Coastwide, the stock is considered stable or slightly declining. However, Harbour Seal abundance on the west coast of Vancouver Island (which represent 15% (~12,000) of the total BC stock) continue to increase (DFO 2022c; McDonald 2023), one of only two survey regions with a slightly increasing estimate

of abundance (DFO 2022c). The coastline within the **ƛ̓ušiiʔaaʔaq** Area was surveyed 4 times previously, from 1976 to 2016. The most recent standardized survey of the **ƛ̓ušiiʔaaʔaq** Area in 2023 generated a preliminary count of 900 seals, up from 804 animals counted 7 years prior in 2016. Given the relatively small coastline within the **ƛ̓ušiiʔaaʔaq**, even when buffered by 10 km (Figure 178), it would be premature to extrapolate the increase in the number of Harbour Seals from the preliminary count from 2023 to a larger regional trend without context as counts from neighbouring Barkley Sound have yet to be completed. Anecdotal evidence hints at a shift in site use from the less exposed area of Barkley Sound proper to the outer reefs, which may account for the additional seals counted in 2023. Using all available regional data and appropriate corrections will be required to assess whether the regional seal population is stable or has increased (or declined) relative to the 2016 and prior surveys (DFO 2022c).

Harbour Seals are generalist carnivores. While Harbour Seals are capable of long-distance movements (> 100 km, see Peterson et al. 2012), they typically show a high degree of site fidelity and routinely make use of a limited number of haul-out sites (e.g., Cordes et al. 2011, Dietz et al. 2013, London et al. 2012). Localized foraging movements (tens of km) are characteristically interspersed with resting bouts centered around low tides when haul-out substrates are available. Recent telemetry data from 33 Harbour Seals instrumented in the spring/summer in the central Strait of Georgia (2019 - 2021) show Harbour Seals typically remain within 10 - 15 km of the haul-out at which they were tagged (C. Nordstrom, DFO, pers. comm.). Studies from southern BC and Washington State show Harbour Seals to be generalist feeders that consume a wide variety of fish and cephalopod prey (DFO, unpublished data, Thomas et al. 2022; Trzcinski et al. 2024) with gadids and small forage fish making up the bulk of their diet, while flat-fish and salmonids are seasonally important). However, a recent study of diets at multiple locations around Vancouver Island suggest Harbour Seals ate a wide size range of prey which varied by species, season, and region. These results indicate that Harbour Seal foraging is influenced by the local composition of prey, and that the local diet is dominated by 3 to 5 prey species (Trzcinski et al. 2024).The mean diversity of Harbour Seal diets was highest on the West Coast of Vancouver Island (~16.5 primary species). Diets are dominated by rockfish, sole and Lingcod. As marine mammals, Harbour Seals are top piscivorous predators in the ecosystem but are themselves the main prey species for Bigg's Killer Whales and occasional prey for larger shark species. Their abundance has the potential to influence the population dynamics of both their primary prey through top-down processes and their main predators via bottom-up limitation (see Sensitivities and Recoverability for Salmonids).

6.2.6.2.1.2 Elephant Seals

Elephant Seals, or Northern Elephant Seals (*Mirounga angustirostris*), are found throughout the northeastern Pacific and their population is approximately 110,000 mature individuals (Hückstädt 2015), having recovered from near extinction from historic hunting. Their at-sea distribution and habitat preferences are very poorly described in BC, and present a major data gap. In a recent mammal survey, Elephant Seals were the least frequently sighted of all marine mammal species analysed (Best et al. 2015); however, the West Coast of Vancouver Island, including **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank was not well surveyed. There is no active monitoring of Elephant Seals in Canadian waters, and the species is considered by the International Union for the Conservation of Nature (IUCN) as a species of 'Least Concern', listed as 'Not at Risk' in Canada and as 'Not Applicable' within British Columbia (Best et al. 2015). There are no current, independent assessments of their abundance, distribution and demographics in Canadian waters, although some animals do haul out (in low numbers; Figure 179) and a scattering of

weaned pups are seen at West Coast Vancouver Island haul-outs (S. Tucker, DFO, pers. comm.).

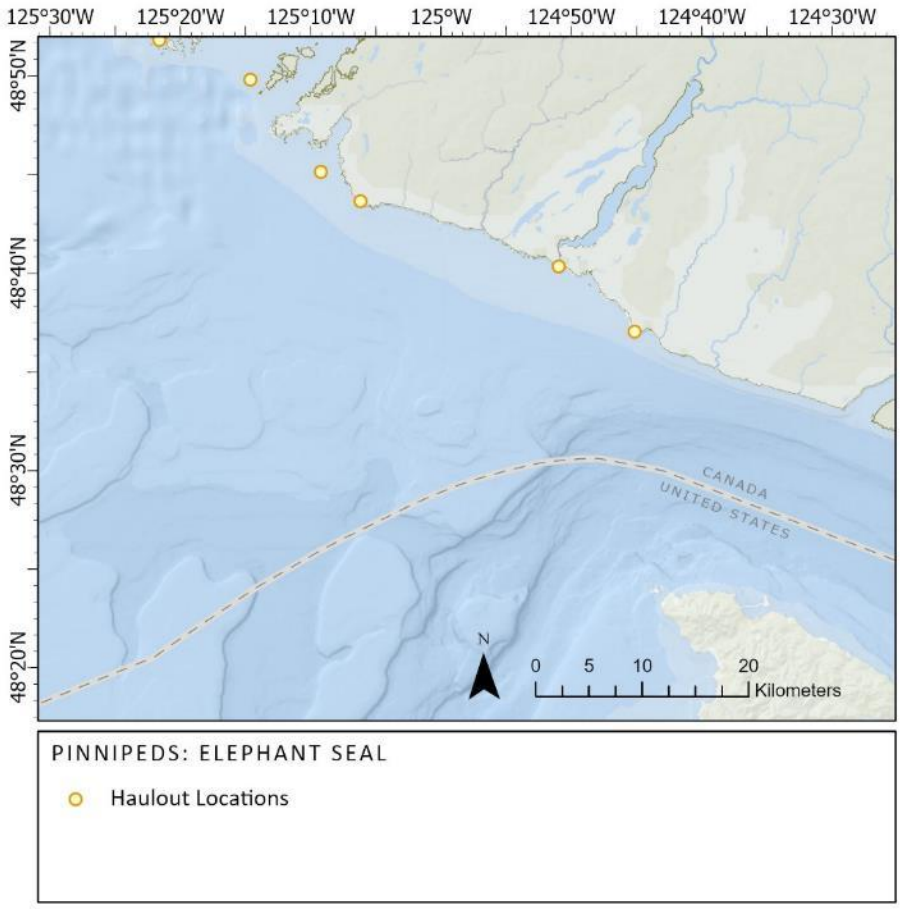


*Figure 179. Elephant Seal observations within and near the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Data come from DFO surveys, as of 2019. Note that point locations are shown larger than they occur for ease of viewing and points overlap.*

6.2.6.2.1.3 Northern Fur Seals

Northern Fur Seals (NFS; *Callorhinus ursinus*) are another seasonally abundant pinniped in BC, although categorized as threatened (COSEWIC 2006). They are often sighted offshore, travelling through BC between California and their breeding colonies in Alaska and Russia (Ford 2014). The population of NFS breeds entirely in the USA and Russia; Canadian waters are used by some portion of the population (typically female and immature animals) as an overwintering ground. Our understanding of the influx and abundance of NFS into Canadian waters is drawn from four sources which were compiled and summarized into an assessment framework by Olesiuk (2012). These are 1) historic sealing logbooks from 1882-1911, 2) North Pacific Fur Seal Commission (NPFSC) research collections and sightings from 1958-1974, 3) the National Marine Mammal Laboratory (NOAA) platform of opportunity sighting database from 1957-2007, and 4) published reports on satellite tags deployed since 1991. Together these are used to describe the distribution and migration patterns of northern fur seals in the northeastern Pacific Ocean. Essentially the timing and abundance of NFS in Canadian waters are estimated by

bringing together these different lines of evidence. There is no active monitoring of NFS in Canadian waters; no current, independent assessment of the abundance, distribution and make-up (whom and from where) of NFS in Canadian waters. Northern Fur Seals have an Important Area identified for the West Coast Vancouver Island Ecoregion that overlaps with the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area (Figure 180). This Important Area accounts for 50% of the West Coast Vancouver Island sightings.

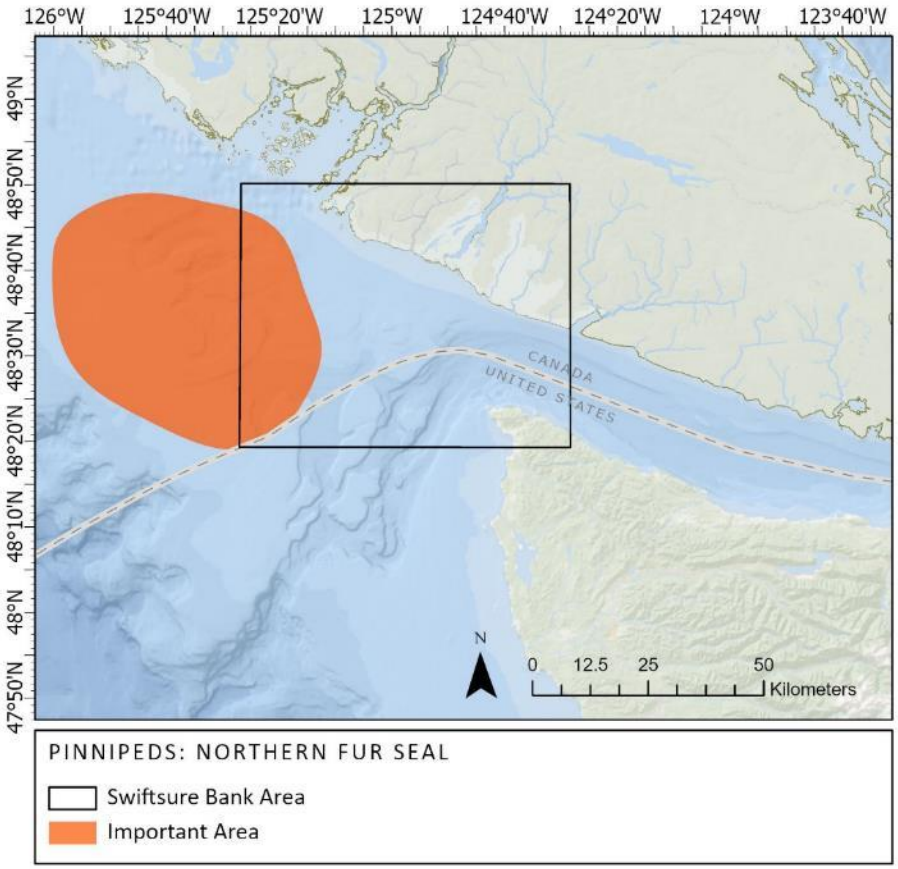


Figure 180. Northern Fur Seal Important Area identified for the West Coast Vancouver Island Ecoregion from 2004-2009 (Levesque and Jamieson 2015). This Important Area accounts for 50% of the West Coast Vancouver Island sightings.

6.2.6.2.2 Sea Lions

6.2.6.2.2.1 Steller Sea Lions

Steller Sea Lions in BC are part of the eastern stock/population in the North Pacific. They are designated as a Species of Special Concern in Canada (COSEWIC 2013) and listed as threatened in the US. Population monitoring via aerial surveys has been conducted regularly during the summer breeding season at all known and suspected sea lion haul-outs since the early 1970's with additional periodic winter surveys to examine changes in abundance and distribution of Steller overwintering in BC. Haul-out sites have been classified as rookeries (sites with > 50 pups born annually), year-round sites (occupied all seasons), and winter only sites. Most recent survey results from the area include the 2021 winter (Jan/Feb/Mar) survey and the 2021 summer breeding survey (DFO, unpublished data). There are currently no rookery sites

within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Confirmed Year-round Steller sites include haul-outs at Pachena Point (winter counts since 1971; summer since 2006) and Carmanah Point (winter counts since 1976; summer since 1977) (Figure 181). Further, Seabird Rocks haul-out is now used year round by Steller Sea Lions, impacting nesting bird species (see Figure 178 for location; J. Yakimishyn, PCA, pers. comm.). As of winter 2021, there is a combined count of 1,083 sea lions (combined median counts from Jan-Mar) and 1,679 Steller Sea Lions in the summer of 2021. 200 Steller Sea Lions were observed at the mouth of Nitinaht Narrows in the fall of 2016 but have not been documented since (possibly temporary or a highly seasonal haul-out location). Steller Sea Lions were first noted occupying Seabird Rocks in the winter of 2003 (5 animals) with a regular but variable occupation in winter of 2020 (median count from Jan-Mar = 462 animals) and 2021 (median count = 26 animals). While not as populous as other haul-out sites to the north of west coast Vancouver Island Sound, the population trends for Steller Sea Lions counted within the **ƛ̓ušiiʔaaʔaq** generally mirrors the increasing population trend observed province-wide and which is currently estimated at 4.3% per year for non-pups.

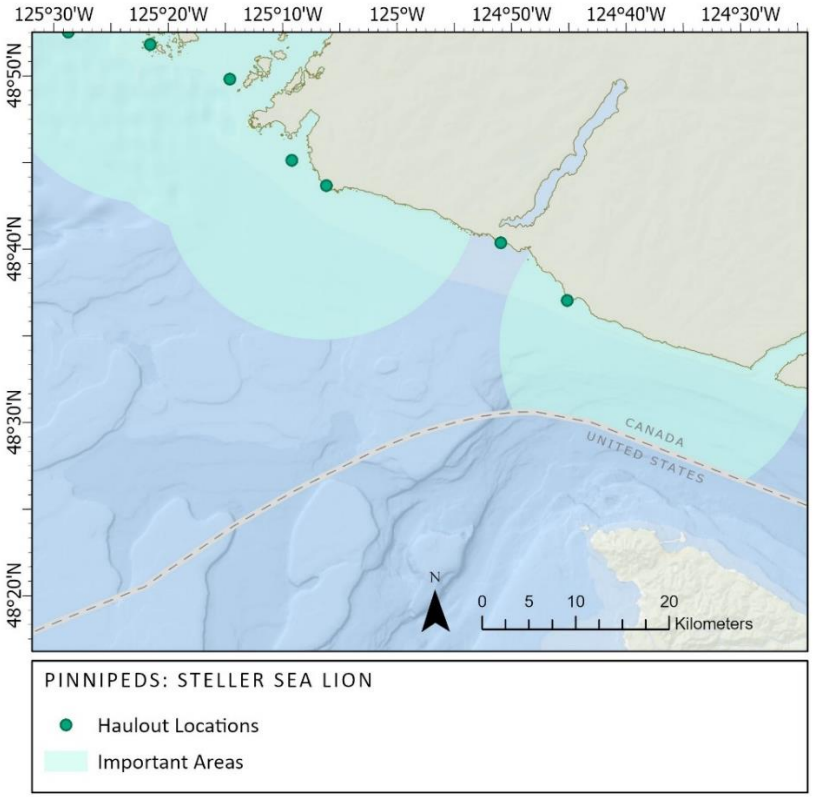


*Figure 181. Steller Sea Lion observations within and near the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Data come from DFO surveys and Parks Canada Pacific Rim National Park surveys. Note that point locations are shown larger than they occur for ease of viewing and points overlap. Stellar Sea Lion Important Area identified for the West Coast Vancouver Island Ecoregion from 2004-2009. Sites selected for haulout locations with a 17km buffer for foraging.*

Seasonal changes in distribution are common for Steller Sea Lions with increased concentrations at rookeries and select year-round sites occurring from May through August followed by a general diffusion in fall to occupy additional sites through the winter months. Winter abundance is typically higher than during the breeding season which suggests there is a net immigration of Steller Sea Lions into BC during the non-breeding season. This trend is

notable for the west coast of Vancouver Island as a whole but the trend is less obvious for the smaller haul-outs within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Figure 182).

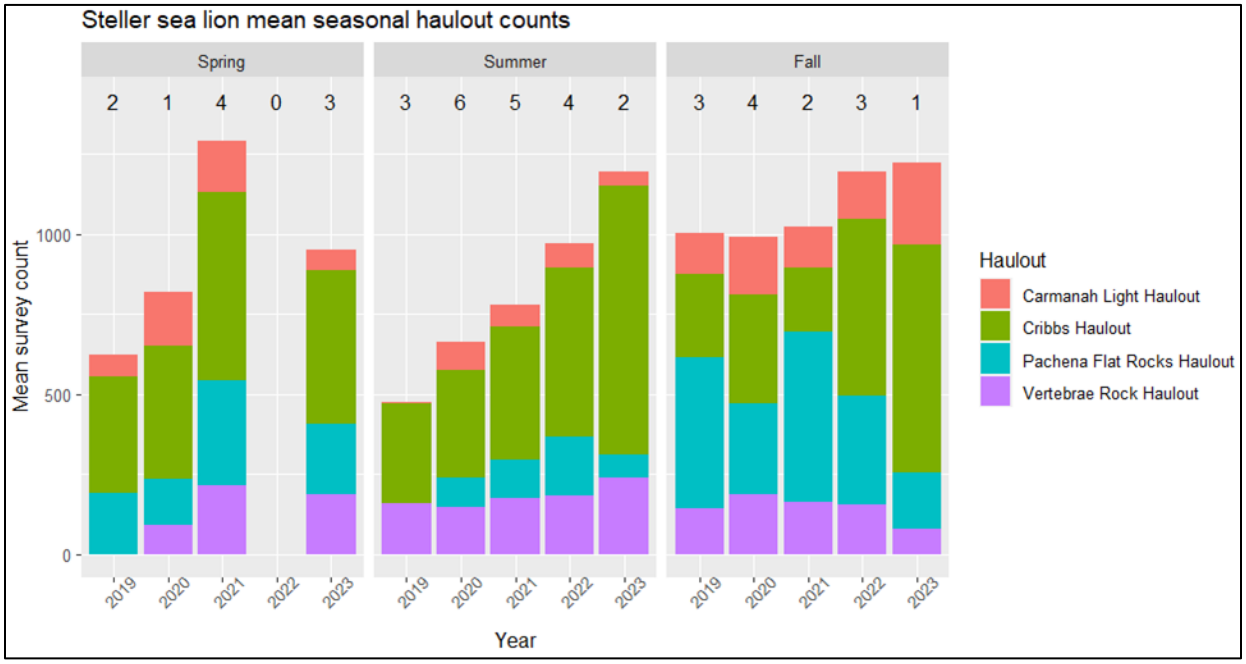


*Figure 182. Steller Sea Lion mean seasonal haulout counts within and near **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Data come from Parks Canada Pacific Rim National Park surveys. Haulout locations are shown in Figure 181.*

In general, Steller Sea Lions have a diverse diet, with major contributions from gadids (e.g., Walleye Pollock, Pacific Cod), forage fish (e.g., Pacific Herring, Eulachon), cephalopods (e.g., Giant Pacific Octopus), flatfish (e.g., Starry Flounder, English Sole, Sand Sole) and lesser contributions from salmonids (Pink, Chum, Sockeye) and rockfish (various species) (COSEWIC 2003). Like Harbour Seals, Steller Sea Lions are top piscivorous predators in the ecosystem while also being an important prey species for *Bigg's K*iller Whales and occasional prey for larger shark species (COSEWIC 2003). Limited scat collections at sites with **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank are currently being analyzed by DFO. Additional scat collections and biopsy samples at neighbouring sites in Barkley Sound have occurred sporadically during late summer and fall since 2013, showing that Steller Sea Lions have a diverse diet in general. Data from 2013 and 2015 show major contributions from gadids (Walleye Pollock, Pacific Cod), forage fish (Pacific Herring, Eulachon), cephalopods (Giant Pacific Octopus), flat-fish (Starry Flounder, English Sole, Sand Sole) and lesser contributions from salmonids (Pink, Chum, Sockeye) and rockfish (various) (DFO, unpublished data). Like Harbour Seals, Steller Sea Lions are top piscivorous predators in the ecosystem while also being an important prey species for Bigg's Killer Whales and occasional prey for larger shark species. Their abundance has the potential to influence the population dynamics of both their primary prey through top-down processes and their main predators via bottom-up limitation (see Sensitivities and Recoverability for Salmonids).

The Steller Sea Lions in BC represent approximately one third of the Eastern Stock (extending from California to Alaska). COSEWIC last assessed Steller Sea Lion as Special Concern (SC) in 2013, and the species is SARA-listed as Special Concern (COSEWIC 2013). Like seals,

Steller Sea Lions have increased dramatically following protection. However, the 2017 breeding season abundance of 43,200 (95% CI of 38,700 to 48,200) represents no significant change from the previous assessment in 2013. Of note, there was a slowing in the rate of pup production since 2013-– pup production is still increasing, but we are observing a decline in the rate of increase with an inflection in the mid-2000's. Their abundance increased to approximately 52,700 animals in winter, and a similar trend is observed across the Eastern stock as a whole (i.e. the stock is stable) (DFO 2021c).

6.2.6.2.2.2 California Sea Lions

California Sea Lions (*Zalophus californianus*) breed at rookery sites in southern California and Mexico during May-June, after which sub-adult and adult males typically migrate northward over the fall and winter to sites in Oregon, Washington, and British Columbia (BC) with a limited number of sightings in southern Alaska. Animals start arriving in coastal BC as early as August with a departure by May, and often share haul-out sites with Steller Sea Lions. Typically, large numbers of individuals are observed by October, with a departure from BC waters by May. An average residency of seven months (from October to the end of April), was used to represent the period during which the majority of the animals remain in BC. California Sea Lions are highly mobile, and animals range widely during the non-breeding season with their distribution thought to be highly influenced by prey availability.

Although California Sea Lions have been counted in winter Steller Sea Lion surveys, 2020-2021 marked the first survey dedicated to this species. Abundance of California Sea Lions overwintering in southern British Columbia (BC) was estimated through five monthly aerial photographic surveys conducted from November 2020 to March 2021. A mean abundance of 13,600 (95% CI 11,300-16,300) California Sea Lions was estimated in 2020-21 (DFO, unpublished data). This represents a threefold increase since 2009-10 and no significant increase since 2017. The threefold increase in California Sea Lions overwintering in Canadian Pacific waters since 2009-10 cannot be solely explained by an increase in the overall US population of California Sea Lions, which appears to have stabilized in recent years. A redistribution/increase in the proportion of males overwintering in coastal BC may be linked to changes in prey availability in other parts of their range. There is evidence that the proportion of the total population overwintering in BC has increased in recent years, and that the range of overwintering haulouts has expanded in southern BC (Figure 183) (DFO, unpublished data). A large influx of California Sea Lions was observed in the 2016 at Seabird Rocks (2,841 animals) but with far fewer numbers detected since in the winters of 2020 (median count = 404 sea lions) and 2021 (median count = 53) These increases in abundance and range in Canadian Pacific waters have raised questions over the past decade about potential impacts on local ecosystems, including competition for prey resources, and impacts on local fisheries (DFO 2023/016). Assessments of potential resource competition with Steller Sea Lions would benefit from consideration of abundance, distribution, and diet of California Sea Lions.

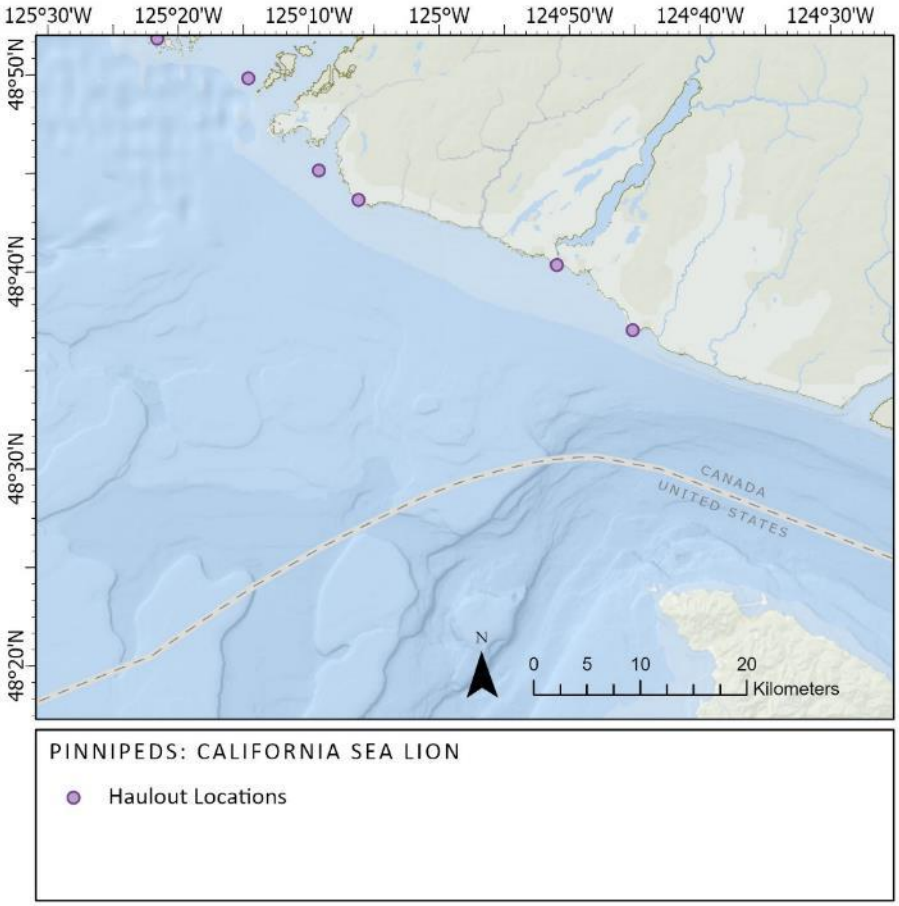


*Figure 183. California Sea Lion observations within and near **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Data come from DFO surveys and Parks Canada Pacific Rim National Park surveys. Note that point locations are shown larger than they occur for ease of viewing and points overlap.*

California Sea Lions are not present in BC in the summer months (to date) and typically arrive in early fall (October) with most departing by the following spring (March). The southern portion of the west coast of Vancouver Island, including sites within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, is one of the first areas encountered by male California Sea Lions travelling north. Numbers of California Sea Lions in **ƛ̓ušiiʔaaʔaq** typically peak in the fall and then decrease as winter progresses and animals appear to shift to more protected waters such as the Strait of Georgia (Figure 183).

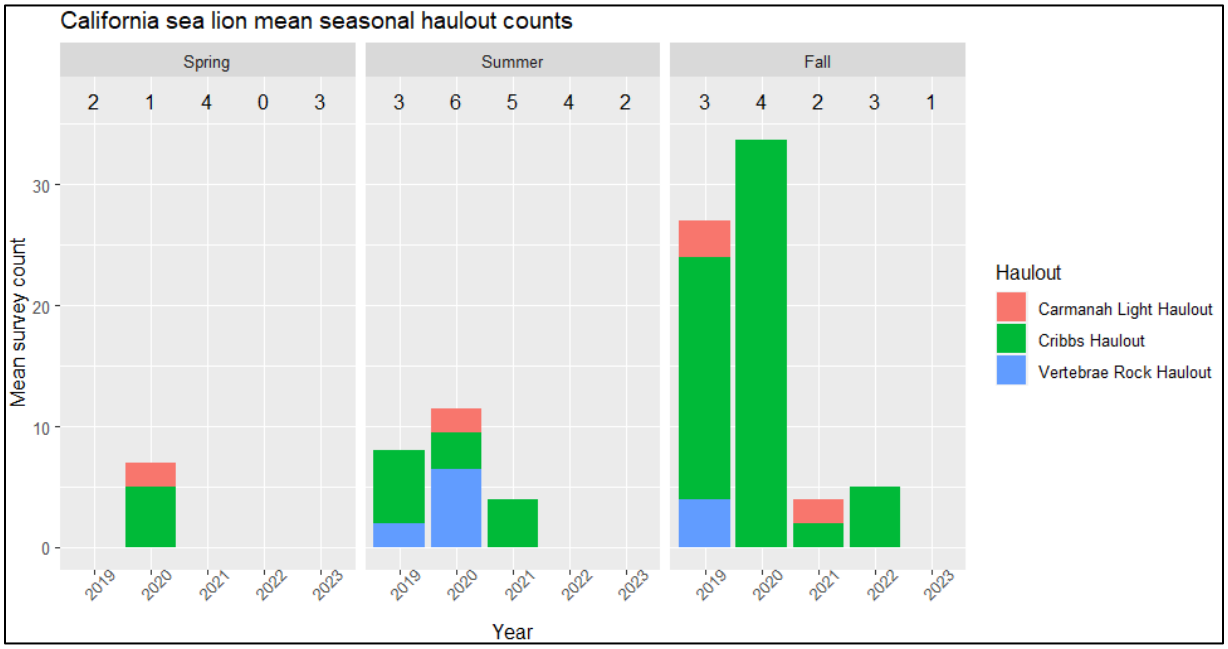


*Figure 184. California Sea Lion mean seasonal haulout counts within and near **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Data come from Parks Canada Pacific Rim National Park surveys. Haulout locations are shown in Figure 182 at the beginning of this report section.*

6.2.6.3 Sea Otters

The Sea Otter population on the West Coast of Vancouver Island has a significant impact on the local ecosystem. Sea Otters are recognized as a keystone species because they alter nearshore subtidal community structure due to their metabolic need to consume large quantities of food (primarily invertebrates). Watson and Estes (2011) found that the presence of Sea Otters leads to a trophic cascade; their consumption of urchins allows algae to dominate in areas where otters are present, including sites to the north of **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank and in Barkley Sound. In rocky exposed areas, the relationship between Sea Otters, urchins, and kelps is well documented (Estes and Palmisano 1974; Estes and Duggins 1995; Watson and Estes 2011). As of 2017, BC's Sea Otters population was estimated at 8,110, and growing, of which 5,497 occurred along the west coast of Vancouver Island (Nichol et al. 2020). Gregr et al. (2008) estimated the carrying capacity for Sea Otters along the BC coast, suggesting a potential upper limit of 52,459 otters, although the range didn't extend as far south as **ƛ̓ušiiʔaaʔaq**. There are incidental documented occurrences of Sea Otters along the shore in **ƛ̓ušiiʔaaʔaq** (Figure 185). Surveys in Pacific Rim National Park by Parks Canada show a low number of Sea Otter observations overall with most observations made in the south, off Pachena Bay (Figure 185). Sea Otters are a nearshore species, occurring typically less than 2 km from shore unless extensive shallows extend further. They are usually found in depths of 40 m or less, occasionally out to 100 m depth. The shoreline area of **ƛ̓ušiiʔaaʔaq** should be considered potential range for Sea Otters but not likely in any big numbers (L. Nichol, DFO, pers. comm.).

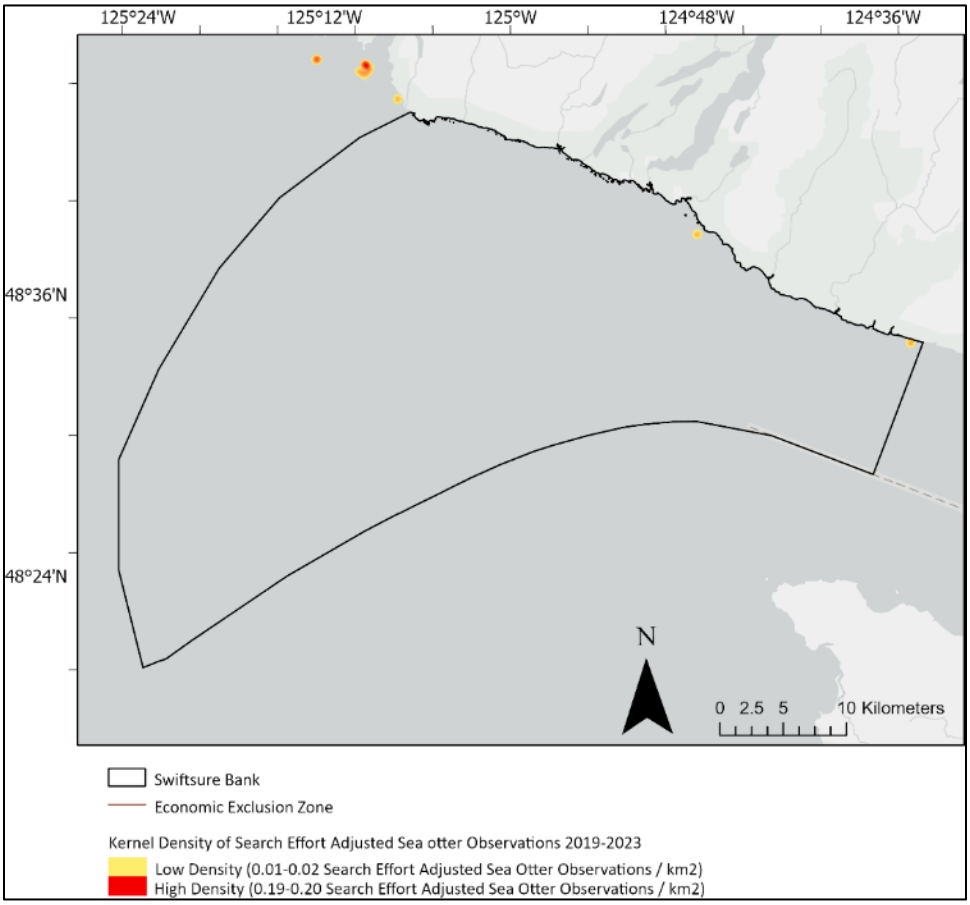


Figure 185. Sea otter survey adjusted densities along West Coast trail Unit of Pacific Rim National Park Reserve from 2019 to 2023. A survey search area was created along route from the visibility distance and observations were divided by the sum of the applicable search areas resulting in a search effort adjusted population for each observation. Fixed kernel density layers using a search radius of 500m, a cell size of 25m and the adjusted population were generated for each set of observations. Data from Parks Canada surveys, 2019-2023. Map provided by Parks Canada.

6.2.6.4 Sea Turtles

Four species of sea turtle have been sighted in the waters of Southern British Columbia: Leatherback (*Dermochelys coriacea)*, Green (Chelonia mydas), Olive Ridley (*Lepidochelys olivacea*), and Loggerhead (*Caretta caretta*). The Leatherback Sea Turtle is the most frequently sighted sea turtle species, and is the only Pacific sea turtle listed under the Canadian *Species At Risk Act* (Endangered). Hard shelled sea turtles sightings, are less frequent than Leatherbacks and are not always possible to identify to species from the available details. BC strandings confirm that Green Sea Turtles are the most common of all hard-shelled sea turtles seen in southern BC, while Olive Ridley and Loggerhead Sea Turtle sightings are even more sporadic and rare, and are not currently documented in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Figure 186).

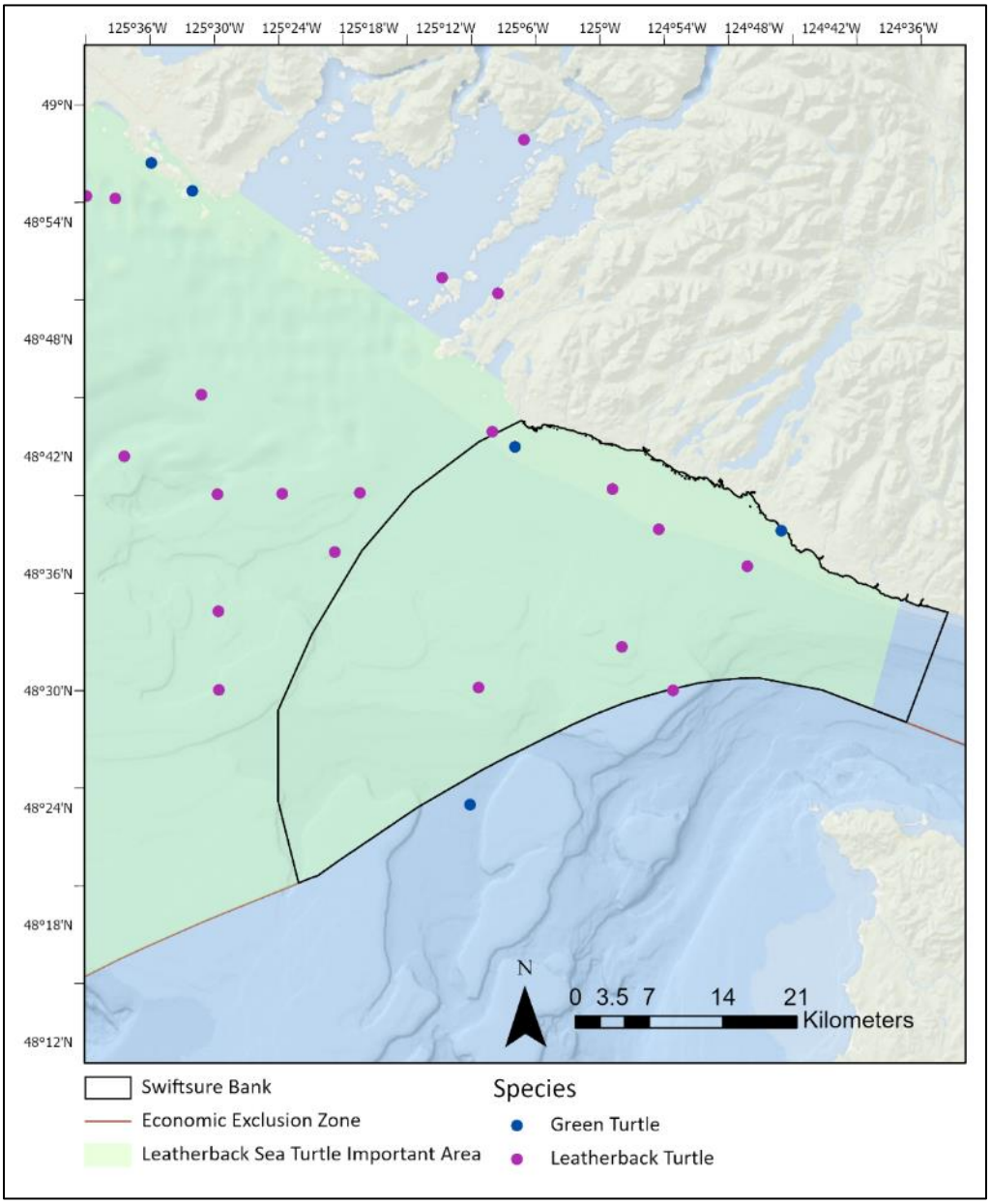


Figure 186. Sea turtle sightings (data comes from DFO/BCCSN questionnaires, surveys, hotline reporting, and publications; data provided by DFO's Cetacean Research Program) and important feeding areas (green shaded area; Pacific North Coast Integrated Management Area (PNCIMA) Atlas) in ***ʎušiiʔaaʔaq****/Swiftsure Bank (black outlined areas). Most locations are approximations and may include dead individuals that drifted from their original location.*

No sea turtle distribution or abundance data is available for BC waters, despite thousands of kms and hours of observations concurrent with marine mammal survey effort. Thus, sea turtle sightings records in BC are opportunistic in nature – dependent on boaters' availability to observe and to report. As such, fewer reports are expected in winter months and in remote areas. Fifty-seven percent of sea turtle sightings in BC have been reported off the west coast of Vancouver Island (n=141), eight of which were seen within the **ʎušiiʔaaʔaq**/Swiftsure Bank boundary (6 Leatherback Sea Turtles, and 2 Green Sea Turtles) (Figure 186). Sea turtles

visiting BC waters are in search of gelatinous zooplankton prey. Upwelling shadows and retention areas, along with sea surface temperature and the thermocline are habitat features that tend to entrain jellies, the main prey of leatherbacks sea turtles (Benson et al. 2007). Sea turtles have been seen in BC waters during all months of the year, though occurrences are most common in summer months (68%, n=139). Sightings in the **ƛ̓ušiiʔaaʔaq** Area have mainly occurred during summer and fall when water temperatures are warmest.

The majority of sea turtle sightings, as previously mentioned, are for Leatherback Sea Turtles (*Dermochelys coriacea)*, 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 (Pacific Leatherback Turtle Recovery Team 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). Leatherback Sea Turtles 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, the species 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). The adult Leatherback Sea 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 (Pacific Leatherback Turtle Recovery Team 2006).

6.2.6.5 Sensitivities and Recoverability

Compared to marine mammals found in offshore waters of the Canadian Pacific, many marine mammal populations found in continental shelf waters tend to have greater vulnerabilities due to their increased overlap with and frequency of exposure to human activities in nearshore habitats. Below is a brief overview of the characteristics of marine mammal populations in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area that make them sensitive to and resilient to anthropogenic stressors.

The relatively long generation time and low fecundity of all whale species make them particularly sensitive to the impacts of anthropogenic stressors. Baleen whales, such as Fin and Humpback Whales (Figure 187), are found throughout the northern BC coast and the broader Canadian Pacific (Dalla Rosa et al. 2012; Best et al. 2015; Wright et al. 2021b). In addition to the sensitivities caused by generation time and fecundity, all three Killer Whale ecotypes that use the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area (Figure 187) also have quite small population sizes (several hundred or less) that may make them less resilient to anthropogenic threats. While pinnipeds and Sea Otters generally have shorter generation times and higher fecundity than cetaceans, they also aggregate in large groups (on haul-outs or rafts) and could be disproportionately impacted by anthropogenic stressors compared to less gregarious species.



Figure 187. Observations of Humpback Whales and Southern Resident Killer Whales within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area (photo credit: Pacheedaht First Nation Marine Mammal Team).*

Notable stressors for marine mammal species in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area include increased vessel traffic (Williams et al. 2015; Nichol et al. 2017), anthropogenic noise (Erbe et al. 2012, 2014; Williams et al. 2015), entanglement risk (Williams et al. 2011), and hydrocarbon spills. Pinnipeds are most vulnerable to anthropogenic disturbances when stressors are near rookeries and haul-outs or occur during the breeding season (COSEWIC 2013). Pinnipeds may be more disturbed by vessel noise and presence than vessel strikes, although strikes are still possible. Vessels approaching haul-outs and vessels changing gear have been known to cause pinnipeds to flush (i.e., quickly rush back into the water) (Erbe et al. 2019). Other threats that are broadly known to impact marine mammal populations and likely also have an impact in this area include climate-related ecosystem perturbations (McCabe et al. 2016) and other anthropogenic threats (e.g., fisheries competition, microplastics, oil spills, persistent pollutants). Because marine mammals are often at or near the top of marine food webs, stressors that negatively impact key prey species (e.g., climate change stressors) can also decrease their survivability.

The resilience of marine mammal populations to the current and emerging anthropogenic stressors listed above is extremely difficult, if not impossible, to quantify. However, some insight into the recoverability of these species may be gained from examining how populations that were depleted or extirpated by commercial whaling or the maritime fur trade responded after these sources of mortality were removed. For instance, Humpback Whales and Fin Whales both experienced severe declines in the Canadian Pacific as a result of commercial whaling but have since increased in numbers, and these species have even returned to areas from which they were completely extirpated by whalers (e.g., the Salish Sea for Humpback Whales and the Caamaño-Douglas Area for Fin Whales).

Despite showing signs of recovery since commercial whaling ended in Canadian Pacific waters in 1967, cetacean populations in this region are still vulnerable to anthropogenic stressors.

Species that live in proximity to the coast may have a greater chance of overlap with anthropogenic activities and their associated impacts. Principle stressors for cetaceans in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area include vessel strikes, entanglement in fishing gear and marine debris, acoustic disturbance, reduced availability or quality of prey or destruction of foraging habitat, and hydrocarbon spills. Cetacean populations can also be adversely impacted by environmental contaminants and climate change impacts, such as marine heat waves.

Coastwide, Harbour Seals were also depleted in BC due to predator control programs and harvesting in the late 1800s through the mid-1900s (reduced to an estimated ~10,000 animals; DFO (2022c). This population had fully recovered by the early 2000s to just over 100,000 animals following a complete ban on hunting that began in the 1970s. Harbour Seal populations have been stable or declining for the last 20 years, probably because they have reached carrying capacity in most regions of the BC coast. Juvenile 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 both Harbour Seals and Steller Sea Lions have the potential to influence and be influenced by the population dynamics of both their primary prey (through bottom-up limitation) and their main predators (via top-down processes). Predator control is the main stressor limiting many pinniped populations in the 20th century (Allen and Angliss 2012; COSEWIC 2013). However, predator removal licenses for Harbour Seals are no longer being distributed in BC, and there is a proposal to remove the “nuisance seal” license in Canada[85].

More information on specific stressors is provided below.

6.2.6.5.1.1 Vessel strikes

Vessel strikes are a source of mortality and injury that can have population-level impacts on cetaceans, particularly for baleen whales, which exhibit a limited ability to respond to oncoming vessels or do not avoid ships (Nowacek et al. 2004; Harris et al. 2012; McKenna et al. 2015; Nichol et al. 2017). Collisions with vessels have been identified as a threat for several cetacean species in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, including Humpback Whales (Ford et al. 2009; DFO 2013d, 2013c; Nichol et al. 2017; Keen et al. 2023), Grey Whales (Ford et al. 2013a; Gavrilchuk and Doniol-Valcroze 2021), Fin Whales (Nichol et al. 2017; COSEWIC 2019) and Killer Whales (DFO 2018c). The year-round abundance monitoring of large cetaceans throughout the Yuułuʔiłʔatḥ Government and Maa-nulth Nations’ Southern Marine Territory often observed large aggregations of whales in conflict with designated shipping lanes, particularly on **ƛ̓ušiiʔaaʔaq** (Crosby 2024). Though the impact of vessel strikes on North Pacific Right Whales is not known as sightings are so rare and data for this species is very limited, vessel strikes are one of the primary threats to North Atlantic Right Whales (DFO 2014), which do not exhibit avoidance responses to real or played-back recordings of vessel noise (Nowacek et al. 2004). The risk of ship strikes is high in the waters off southern Vancouver Island, where shipping traffic becomes concentrated as it approaches the traffic lanes in the Strait of Juan de Fuca. This risk is likely to increase in the near future due to planned port expansions and development, and recreational and fishing boat traffic also common in the region (DFO 2017; Nichol et al. 2017; COSEWIC 2022).

Humpbacks are the most frequently reported species to be involved in vessel-whale collisions in BC (Nichol et al. 2017). They exhibit high variability in their responsiveness to cruise ships in

[85] https://www.dfo-mpo.gc.ca/fisheries-peches/consultation/mmr-par-rmm-rap-eng.html

southeast Alaska, with some whales not responding at all to close approaches and some displaying last-second flight responses (Harris et al. 2012). A study conducted in September 2020 near the eastern edge of **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank surveyed Humpback Whale foraging behaviour using active acoustic prey mapping, whale-borne tag data, and focal follows (Reidy, R., unpublished data). The responses of four tagged Humpback Whales to ship encounters were documented. Behavioural disruptions, including changes in vertical movement and abrupt feeding cessation, were observed when ships passed within 1 km (Reidy, R., unpublished data). A portion of the Humpback Whale population in Canadian Pacific waters migrates to Central American wintering grounds; under the US *Endangered Species Act* these whales belong to an Endangered subpopulation (NOAA 2016). Humpbacks that overwinter in Central America have almost exclusively been documented (all but one photo-identification match) in BC off southwestern Vancouver Island, and have been identified in all months except April and May (McMillan et al. 2023). These whales therefore spend a greater amount of time in areas with high vessel traffic and may be more vulnerable to mortality or injury from vessel strikes.

Similarly, a portion of the Grey Whale population in the Canadian Pacific also spends more time in southern BC waters. While most Grey Whales migrate through BC coastal waters to feeding areas farther north, Pacific Coast Feeding Group (PCFG) whales remain between southern Alaska and northern California for the summer (Gavrilchuk and Doniol-Valcroze 2021), exhibiting high site fidelity and returning to the same feeding grounds over multiple years (Calambokidis et al. 2017). For PCFG whales off southwest Vancouver Island, the waters on and around **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank provide important feeding habitat (Darling et al. 1998; Calambokidis et al. 2017; Gavrilchuk and Doniol-Valcroze 2021), resulting in these individuals spending large periods of time in an area with high vessel presence and thus greater risk of vessel strike.

Fin Whales were assessed along with Humpback Whales for ship strike risk off the west coast of Vancouver Island, including the **ʎ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Due to a lower probability of encountering Fin Whales in this region, the probability of a collision between a vessel and a Fin Whale was lower than for Humpback Whales (Nichol et al. 2017). However, more recent sightings of Fin Whales in nearshore waters on the west coast of Vancouver Island (B. Gisborne, pers. comm.) could increase the probability of ship-whale encounters, and therefore vessel strike risk, for Fin Whales.

Killer Whales are also at risk of being struck by vessels (Ford et al. 2007; DFO 2018c; Raverty et al. 2020), particularly in high traffic areas such as **ʎ̓ušiiʔaaʔaq**Swiftsure Bank, and are particularly vulnerable to loss of reproductive females due to their small population size, slow maturation rate, and low fecundity (DFO 2018c). The **ʎ̓ušiiʔaaʔaq** Area provides important habitat especially for the Southern Resident population that is notably present during summer months (May through October), when the predominant behaviour is foraging (Thornton et al. 2022a, 2022b), and also provides important foraging habitat for the Northern Resident population (Ford et al. 2017) and for Offshore Killer Whales feeding on sharks (August to October) (DFO, unpublished data). In addition to vessel strikes, the threat of physical disturbance by intense vessel traffic can elicit behaviours such as avoidance which can have detrimental effects. For example, physical disturbance could drive a species out of primary foraging habitat and have an impact on prey accessibility, or force animals to expend more resources travelling to find other foraging areas, potentially reducing overall fitness (DFO 2018c; Thornton et al. 2022a). In the northeast Pacific, the mortality of three Northern Resident Killer Whales were recorded between 1974 and 2016 (Murray et al. 2021). Mortality of one Bigg’s

Killer Whale in 2007 was attributed to vessel strikes (Raverty et al. 2020). However, these records are likely a substantial underestimate, as most carcasses sink and cannot be recovered for necropsy, not all collisions are reported, and strikes may go undetected by mariners in the case of very large ships. In addition to collision risk, the presence of, or acoustic additions from, vessels may result in physical disturbances by disrupting natural behaviours or causing Killer Whales to leave an area.

6.2.6.5.1.2 Entanglement

Entanglement in fishing gear is another anthropogenic threat to cetaceans, particularly for species inhabiting shallow, nearshore waters that overlap with fisheries. Fishing gear entanglement can lead to reduced feeding ability and starvation, increased energy expenditure and drowning, or wounds or mutilations that reduce survival or reproductive fitness (Gavrilchuk and Doniol-Valcroze 2021; COSEWIC 2022). Documented Humpback Whale entanglements in Canadian Pacific waters were summarized by COSEWIC (2022), and for Grey Whales in northeastern Pacific waters by Gavrilchuk and Doniol-Valcroze (2021). However, as with ship strikes, the number of reported entanglements underestimates the actual incidence, as evidenced by the proportion of photo-identified individuals bearing scars indicative of previous entanglement. In 2017, 48% of analyzed Humpback Whale photo-identifications exhibited scars consistent with a previous entanglement (C. McMillan, DFO, pers. comm.). For Grey Whales off of Sakhalin Island in the western North Pacific, 18.7% of individuals exhibited scarring from entanglements (Bradford et al. 2009). There is little evidence of entanglement of Fin Whales in the northeastern Pacific, though the risk for this species could rise as the population increases and more sightings occur in nearshore waters. There is similarly little evidence of Killer Whale entanglement in fishing gear in Canadian Pacific waters, though where depredation (taking fish directly from fishing gear) occurs, deterrent methods, entanglement, and accidental hooking can increase the injury or mortality rates of whales (DFO 2018c).

The majority of threats to sea turtles occur near nesting beaches (i.e. beach development, poaching, predation) rather than where they are dispersed and foraging throughout the Pacific. Due to the infrequency of sea turtle occurrence in Pacific Canadian waters, the risk of threat from entanglement (n=12), blunt force trauma likely attributed to vessel strike (n=3) are considered relatively low but do still occur. As sea turtles swim through the top few meters of the water column in search of food their long pectoral flippers pose entanglement risk with nets and fishing line. Sea turtle entanglement in gillnet (n=7) are the most frequently reported in BC, followed by seine (n=3) as well as troll and trap (n = 1, respectively). The only entanglements to be reported within the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area involved two leatherback sea turtles in salmon gillnets, both in the late 1980s. Discarded plastics bags and other debris bear a similar resemblance to the soft gelatinous zooplankton prey of sea turtles, and thus pose a real, but not well documented threat here and globally.

6.2.6.5.1.3 Acoustic disturbance

Noise disturbance is considered a significant threat for whales in general and is noted as a key concern with increased marine traffic by several interested organizations and First Nations within the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank Area. Cetaceans are susceptible to acute and chronic effects of disturbance by underwater noise from vessels and other anthropogenic activities (DFO 2007, 2018c; COSEWIC 2019, 2022). Acoustic disturbance is recognized as a threat to all cetaceans in the **ƛ̓ušiiʔaaʔaq̓**. Acute effects of acoustic disturbance can include physical injury (i.e., lung injury/barotrauma due to underwater explosives or physiological injury due to military sonar) and temporary or permanent hearing loss, while chronic effects can include behavioural

impacts, production of stress hormones, and the impacts of noise masking the use of sound for communication, feeding, navigation, and socialization (COSEWIC 2019, 2022). Responses of whales to underwater noise depends on the source level and intensity, and the behavioural context of exposed individuals, and can include avoidance, decreased echolocation and communication distances, reduced calling, altered foraging and social behaviour, and altered migration paths (DFO 2018c; Gavrilchuk and Doniol-Valcroze 2021; COSEWIC 2022; Thornton et al. 2022a).

Acute noise exposure is potentially lethal for baleen whales (Gailey et al. 2007; Dunlop et al. 2017; Harris et al. 2018), and chronic ambient noise can contribute to a variety of issues ranging from stress, acoustic masking, and hearing loss to behavioural disturbance and displacement from habitat (Croll et al. 2001; Wright et al. 2007a; Weilgart 2007; Rolland et al. 2012). In particular, most ship noise energy is concentrated at low frequencies, which are similar to the frequency at which Fin Whales communicate (< 100 Hz) (Clark et al. 2009; Erbe et al. 2016) ;Tasker et al. 1998. Resting mother-calf pairs of Humpback Whales are sensitive to increases in anthropogenic noise levels and respond by spending less time resting, swimming faster, and increasing their respiration rates (Sprogis et al. 2020).

Vessel noise, which includes both engine noise and high-frequency noise from echo sounders (e.g., depth sounders and fish finders), is also likely to disrupt the natural behaviours of toothed whales and dolphins, including Killer Whales (Burnham et al. 2022). In particular, Resident Killer Whales may experience reduced foraging efficiency, given their reliance on echolocation for finding and capturing fish (Dahlheim et al. 2008; Wright et al. 2021a; Burnham et al. 2022). Resident Killer Whales are known to alter their call amplitudes (Holt et al. 2009), movement patterns, swimming speeds and respiration rates (Williams et al. 2002, 2009) and will increase surface active behaviours (Noren et al. 2009) and reduce the amount of time spent foraging (Lusseau et al. 2009) in response to vessel presence and associated underwater noise. Bigg's Killer Whales rely on silence and stealth attacks for hunting marine mammals, so underwater noise also impacts their foraging efficiency by interfering with prey detection via passive listening (Barrett-Lennard et al. 1996; Ford et al. 2013b). Vessel noise could also disrupt communication calls between individuals (Holt et al. 2009) and thus prevent Killer Whales from locating one another, potentially reducing reproductive opportunities and interfering with important cooperative behaviours, such as prey sharing or coordinated hunting.

Harbour Seals and Steller Sea Lions show disturbance reactions and flush into the water when vessels (including unpowered craft, such as kayaks) approach their haul-outs (Kucey 2005; Johnson and Acevedo-Gutiérrez 2007), which may have physiological implications related to energetics and stress. Low-flying aircraft, including Unmanned Aerial Vehicles (UAVs), will have similar disturbance impacts on hauled-out pinnipeds (Liu et al. in press).

ʎ̓ušiʔaaʔaq/Swiftsure Bank lies at the western entrance for commercial vessels transiting international shipping lanes to ports including Victoria, Vancouver, Nanaimo, Port Angeles, Tacoma and Seattle (Vagle et al. 2021) and is an area heavily used by recreational vessels as well. In a recent assessment of the acoustic environment in the Salish Sea and **ʎ̓ušiiʔaaʔaq** areas, a scenario with a seven-fold increase in TransMountain (TMX) tanker traffic (the predicted change when the TMX pipeline expansion project proceeds) was examined, and much of the increase in noise occurred in the **ʎ̓ušiiʔaaʔaq** Area (Vagle et al. 2021).

Research has consistently shown that vessel slowdowns can have a positive impact on the foraging habitat of the SRKW (Burnham et al. 2021; Burnham and Vagle 2023). Trounce (2020)

found that a 22% reduction in "lost foraging time" was achieved through a voluntary slowdown program in Haro Strait, while Joy (2019) reported a 22% reduction in "potential lost foraging time" and a 40% reduction with 100% 11 knot participation in Haro Strait. MacGillivray (2019) demonstrated that slowing down vessels can effectively reduce underwater radiated noise, with significant reductions in mean broadband source levels for various types of commercial vessels in Haro Strait. Williams et al. (2021) further supported this, demonstrating a strong relationship between received noise level from ships and the probability of SRKW foraging activity. These findings underscore the potential benefits of vessel slowdowns for the protection of SRKW; however, Burnham and Vagle (2023) showed limited noise reductions in the interim sanctuary zone (ISZ) at **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank due to lower compliance with vessel exclusions in the ISZ and increased vessel presence in the summer months. Currently, within **ƛ̓ušiiʔaaʔaq**, the ECHO-led voluntary vessel slowdown will run from June 1 to October 31, 2024, across both the outbound and inbound shipping lanes, a total distance of 23 nautical miles. During the slowdown, large commercial ships transiting through **ƛ̓ušiiʔaaʔaq** are asked to voluntarily slow down, when it is safe and operationally feasible to do so (14.5 knots or less through the water for vehicle carriers, cruise ships and container vessels;11 knots or less through the water for bulkers, tankers and government vessels)[86].

6.2.6.5.1.4 Reduced availability or quality of prey or destruction of feeding habitat

Resident Killer Whales depend on sufficient availability and quality of Chinook and Chum Salmon, on which they selectively feed (Ford and Ellis 2005, 2006). Vulnerability to prey depletion is enhanced by strong prey specialization of Resident Killer Whales, and the markedly small population size of SRKW (75 individuals) further amplifies this threat to their survival (DFO 2018c). Correlations have been documented between Chinook Salmon abundance and Resident Killer Whale mortality and birth rates (Ford et al. 2005, 2010b).

Resident Killer Whales occur in high concentrations on salmon migration routes when salmon are returning to natal rivers and streams to spawn (DFO 2018c). **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank, part of the designated Critical Habitat for both northern and Southern Resident Killer Whales, lies in front of the mouth of Juan de Fuca Strait, a corridor for salmon returning to the Nitinaht River, Fraser and Thompson Rivers, and Puget Sound (DFO 2018c; Thornton et al. 2022b). Both Resident Killer Whale populations forage for salmon in this area, and Southern Resident Killer Whales were recently shown to spend significant time foraging in the **ƛ̓ušiiʔaaʔaq** Area from May to October (Thornton et al. 2022b; Stredulinsky et al. 2023). Reduced spawner abundance has been seen in Chinook Salmon populations from southern British Columbia in recent decades (Riddell et al. 2013; Doutaz et al. 2021; Dionne et al. 2023), reduced fecundity and size at age was reported in spawner surveys (Brown et al. 2019), and lower average age in populations (lower proportion of older age classes) and declines in average body size were reported for Chinook throughout the Northeast Pacific (Ohlberger et al. 2019). Fishery management measures have been implemented recently to address prey availability and reduce disturbance in this area important for Resident Killer Whale recovery[87]. Recent West Coast Vancouver Island (WCVI) Chinook stock analyses have forecasted above average terminal returns in 2024; however, WCVI natural-origin Chinook remains a stock of concern (Brown 2024).

[86] https://vfpa-archive.edlfb.net/wp-content/uploads/2024/05/2024-Swiftsure-Bank-fact-sheet.pdf

[87] https://www.pac.dfo-mpo.gc.ca/fm-gp/mammals-mammiferes/whales-baleines/srkw-measures-mesures-ers-eng.html

Marine heatwaves can cause significant changes to ecosystems and habitat quality, and are predicted to increase in frequency and intensity with climate change. For Northeast Pacific Humpback Whales, feeding grounds in northern latitudes provide essential habitat that Humpbacks return to annually; reduction in prey availability was previously identified as a threat to Humpback recovery (Ford et al. 2009; DFO 2013e). A recent marine heatwave in the Northeast Pacific (2014-2016) resulted in overall decreased marine productivity and a reduction in prey availability and quality for Northeast Pacific Humpback Whales, due to sustained abnormally high-water temperatures (Gabriele et al. 2022). This degradation of foraging habitat has been associated with reduced survival (i.e., reflected in higher stranding rates and reduced body condition of individuals, and decreased population abundance) and reproductive success (declines in calving rates) in Southeast Alaska and likely other areas in Alaska (Gabriele et al. 2022).

Grey Whales forage using benthic and epibenthic strategies in shallow waters, which bring them close to shorelines (Gavrilchuk and Doniol-Valcroze 2021) where there is a high probability of interacting with anthropogenic activities. The central to southern coast of western Vancouver Island provides important habitat for Grey Whales, especially those in the Pacific Coast Feeding Group (PCFG) (Darling et al. 1998; Dunham and Duffus 2001, 2002; Burnham and Duffus 2018, 2022; Gavrilchuk and Doniol-Valcroze 2021). In the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, heavy shipping traffic and commercial and recreational fishing activity could adversely impact productive feeding habitat and disrupt foraging via physical and acoustic disturbance. Potential responses, such as avoidance of primary feeding grounds, foraging on less profitable prey species, or expending more resources to seek out alternative foraging areas could reduce the whales' fitness, while those that remain in the area could face increased risk of ship strikes, interactions with fishing gear, or acoustic disturbance, as previously mentioned.

6.2.6.5.1.5 Hydrocarbon spills

Toxic spills present risks to marine mammals (Jarvela Rosenberger et al. 2017) that depend on the nature of the contaminant, volume of the spill, and environmental conditions at the time of the spill (DFO 2007, 2018c; Gavrilchuk and Doniol-Valcroze 2021). Though vulnerability of cetaceans to spills is poorly understood, Humpback and Fin Whales are considered to be at low risk to toxic spills that could result from ingestions of contaminated prey or inhalation of toxic vapours (Nichol and Ford 2018; COSEWIC 2022). Grey Whales may be at greater risk because of their benthic feeding patterns, due to potential ingestion of denser contaminants that sink to the seafloor (Gavrilchuk and Doniol-Valcroze 2021). Killer Whales in Prince William Sound, Alaska, during the Exxon Valdez spill in 1989 did not avoid the spill and were in fact seen surfacing directly in the oil slick (Matkin et al. 2008). Both Resident and Bigg's Killer Whales experienced unprecedented mortalities following the spill, likely from inhalation of petroleum vapours (Matkin et al. 2008). Killer Whale populations may also be quite vulnerable because they often travel in large groups, so whole matrilines or multiple matrilines could be impacted if they swim through a contaminated area. Anticipated increases in tanker traffic in coastal BC, and particularly around southern Vancouver Island, increase the risk of toxic spills in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

6.2.6.6 Data and Knowledge Gaps

Survey effort varies throughout year, which influences observations of marine mammals and reptiles in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. The year round aerial monitoring surveys conducted throughout the Yuułuʔiɬʔatḥ Government and Maa-nulth Nations' Southern Marine Territory fills an important seasonal data gap in terms of species occurrence and

abundance. However, much of the marine mammal survey effort (e.g., visual surveys) focuses on the surface behaviour of marine mammals and reptiles, while underwater behaviour (e.g., how they react to different vessel types in different areas) remains an important data gap. While acoustic receivers are easy to deploy, time and resources are required to retrieve the devices and interpret the recordings, particularly when trying to identify species and how they're using the space. In addition, comparisons to local knowledge and historical records or observations through time may provide helpful information, particularly for species sited infrequently.

For cetacean species, the challenging nature of studying minke whales means little is known about their occurrence in and use of **ƛ̓ušiiʔaaʔaq** and the surrounding area. Minke whales are known to use coastal waters on the BC coast but further study is required to understand their distribution within the **ƛ̓ušiiʔaaʔaq**. Harbour Porpoise and Dall's Porpoise have not been well-studied on **ƛ̓ušiiʔaaʔaq** but ongoing surveys and acoustic research may improve understanding of the spatial distribution and abundance of porpoises and other cetaceans in the **ƛ̓ušiiʔaaʔaq**.

Several data gaps related to pinniped behaviour and distributions also exist. Winter movements and winter diet of Harbour Seals are poorly described in BC. No Harbour Seal tagging data exists for the west coast of Vancouver Island but there is no reason to suspect movement patterns for seals in **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank deviate dramatically from the norms observed in southern BC or from other Harbour Seal studies globally. Further, how diet and prey dynamics influence population dynamics of Harbour Seals are a knowledge gap throughout BC. Elephant Seal at-sea distribution and habitat preferences are very poorly described in BC, and present a major data gap. Sea lion winter diet is also poorly understood. Assessments of potential resource competition of Elephant Seals with Steller Sea Lions would benefit from consideration of abundance, distribution, and diet of California Sea Lions. There is also no active monitoring or surveys of Northern Fur Seals in Canadian waters and no current assessments of the abundance, distribution and composition of Northern Fur Seals in the **ƛ̓ušiiʔaaʔaq** area or in Canadian waters more generally.

No sea turtle distribution or abundance data is available for BC waters, despite thousands of kms and hours of observations concurrent with marine mammal survey effort. Thus, sea turtle sightings records in BC are opportunistic in nature – dependent on boater availability to observe and to report.

7 SUMMARY, KNOWLEDGE GAPS, AND RESEARCH OPPORTUNITIES

The purpose of this biophysical and ecological overview was to compile available knowledge and data on the physical and biological oceanography, potential climate changes, human uses, and ecological diversity present within **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank. Throughout this report we have chosen a rectangular map extent that includes **ƛ̓ušiiʔaaʔaq** and a surrounding region (Figure 7 in the**ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area section) in order to communicate the ecological importance of the area without placing too much visual importance on boundaries. However, some of the data analysis used the Juan de Fuca Eddy EBSA boundaries to describe **ƛ̓ušiiʔaaʔaq**, a feature characterized by high primary productivity and high biomass. Habitat and species-level vulnerabilities and potential recoverability from disturbance were identified where possible. Knowledge gaps and opportunities for further research were highlighted throughout. Together, this report outlines the oceanography and ecology of **ƛ̓ušiiʔaaʔaq** and area, both locally and regionally to the West Coast of Vancouver Island and the Southern Shelf Bioregion. This summary provides a brief overview of the report and its conclusions, knowledge gaps, and future research opportunities for **ƛ̓ušiiʔaaʔaq**.

7.1 Summary

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is a critical and biodiverse coastal ecosystem, encompassing the nutrient rich Juan de Fuca Eddy, an anoxic estuary, nearshore habitats, and continental shelf habitats that are host to species from a variety of taxonomic groups. **ƛ̓ušiiʔaaʔaq** provides spawning, rearing, and foraging habitats for commercially, culturally, and ecologically important invertebrates and fish, and an abundance of marine birds and marine mammals (notably Southern Resident Killer Whales). In addition, many traditional and contemporary First Nation areas of cultural and spiritual significance, such as harvest sites, archaeological sites, and recreational areas, are represented within or in close proximity to this area. The marine, terrestrial, and freshwater ecosystems are interconnected with each other and the First Nations that have relationships with the area.

"Our *nuučaaʕuł* identity, who we are and what we value, is founded in our enduring connection to our *ḥaḥuułi* – our lands and seas. Our ancestors' teachings say we are connected spiritually to all creatures, plants and birds with whom we share life. This is reflected in our *nuučaaʕuł* principle of *hišukiš ċawaak* (everything is one). The Creator placed us where we belong, here, as stewards of our territories, countless generations ago. This is reflected in our *nuučaaʕuł* principle of *ʔuuʔałuk* (taking care of). Our wisdom says we were created together and equal with all other creatures. This is reflected in our *nuučaaʕuł* principle of *ʔiisaak* (utmost respect). These principles and our responsibilities to all life forms, form the foundation of who we are as Indigenous peoples."

~ the Maa-nulth Treaty Nations
(Huu-ay-aht First Nations, Ka:'yu:'k't'h'/Che:k'tles7et'h' First Nations, Toquaht Nation, Uchucklesaht Tribe, and the Yuułuʔiłʔath Government)

Collaborative research and co-management with local First Nations communities, where cocreating research and management strategies is prioritized, will be key to developing holistic knowledge informed by ecological principles and contribute to sustainable conservation.

The following summary bullets outline the unique and important oceanographic and ecological features of **ƛ̓ušiiʔaaʔaq**, summarizing existing conservation tools, representation of habitat and species, human uses and cultural importance.

Protected Areas overlapping with ƛ̓ušiiʔaaʔaq/Swiftsure Bank

- Parks Canada Protected Areas: West Coast Trail Unit of Pacific Rim National Park Reserve
- Rockfish Conservation Areas (RCAs): The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area has three long-term fisheries closures to protect inshore rockfish populations, RCAs, at Dare Point, Carmanah, and Pachena Point.
- Southern Resident Killer Whale (SRKW) Protection Areas: From 2019 to 2021, an Interim Sanctuary Zone was implemented under the *Canada Shipping Act* to protect SRKW, prohibiting vessels from entering a designated zone at certain times of the year. In 2022, two Speed Restricted Zones at **ƛ̓ušiiʔaaʔaq** replaced the Interim Sanctuary Zone, limiting vessels to travel at no more than 10 knots to protect key foraging areas for SRKW. Additionally, a voluntary ship slowdown for commercial vessels and tugboats was initiated in 2020 to reduce underwater noise. Since 2020, DFO has also implemented fishing closures for commercial and recreational salmon fishing in the **ƛ̓ušiiʔaaʔaq** Area, at specific times of the year.

7.1.1 Oceanographic Setting

- The Juan de Fuca Eddy, a prominent oceanographic feature in this region, is a significant driver of nutrient dynamics and biological productivity. This eddy, formed by the interaction of currents, tides, and bathymetry, creates a retention zone for nutrients and plankton, contributing to the ecological significance of the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. The Juan de Fuca Eddy is generated by tides, estuarine flow, and winds and influences local circulation patterns, nutrient levels, and phytoplankton production and is primarily observed in late spring and early summer.
- Water properties of the **ƛ̓ušiiʔaaʔaq** are highly connected with the California Undercurrent, a subsurface current that transports water from the south, and estuarine circulation patterns in the Juan de Fuca Strait.
- Marine bathymetry ranges from 0 to 262 m below sea level and the total mean elevation/bathymetry for the boundary has a depth of 106 m below sea level.
- A total of 12 seafloor types, morphologies, and structures have been identified within the bounds of the Juan de Fuca Eddy EBSA in the **ƛ̓ušiiʔaaʔaq**, including bedrock, glacial diamictions/moraines, glaciomarine sediment, postglacial mud, postglacial sand, bedforms, gas masking, MTD, ridges, channels, gullies, and linear features.
- The geomorphology of the **ƛ̓ušiiʔaaʔaq** includes three typical zones: 1) incised shelf in the west; 2) terraces and moraine in the middle and the north; and 3) deep glacial trough in the east. Moraines and deep troughs are common in the incised shelf; deformed seafloor with bedforms, ridges, channels, gullies, and linear features characterizes terraces and moraine zone; thick postglacial sand is common on the seafloor of the glacial trough zone with an eroded seafloor at the southeast corner.
- The geomorphology of the **ƛ̓ušiiʔaaʔaq** is formed from various geological processes. However, its basic morphologic frame of a broad moraine complex, incised troughs and onlapping storm and tidal shelf features was mainly controlled by the receding ice sheet on southwestern Vancouver Island during the last glacial period and the subsequent

period of post glacial rebound and sea level rise. Thereafter, hydrodynamic forces such as currents and waves modified the surficial sediment and the geomorphology of the seabed.

- Wind patterns influence the region's physical dynamics. Winter winds are predominantly from the southeast and cause downwelling, while summer winds from the northwest lead to upwelling. The area is exposed to significant wave action due to the lack of sheltering islands.
- Tidal motion facilitates material exchange, as seen in satellite imagery of suspended particulate matter and phytoplankton.
- Most precipitation near the **ƛ̓ušiiʔaaʔaq** falls as rainfall during fall and winter. Water exchanges on **ƛ̓ušiiʔaaʔaq** are influenced by freshwater runoff created from melting snow in the Fraser and Columbia River watersheds, as well as freshwater from smaller watersheds influenced by local rainfall.

7.1.2 Climate Change

Climate change is significantly impacting the ocean's physio-chemical properties, including seawater temperature, chemistry, and oxygen levels. These changes have substantial consequences for marine life, affecting their distribution, fitness, survival, and phenology.

- Lighthouse stations along the BC coast, including Amphitrite Point and Race Rocks near the **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Area, have recorded statistically significant increases in Sea Surface Temperature (SST). Regionally downscaled climate change models project this warming trend to continue until at least 2070.
- Climate change is causing more frequent and intense marine heatwaves, leading to mass mortality events in intertidal and marine systems.
- As water temperatures rise, the ocean's dissolved oxygen content declines, while oxygen demand from organisms increases. This poses a significant challenge for marine species as they shift their ranges to deeper, colder waters.
- Rising atmospheric carbon dioxide levels are absorbed by seawater, increasing acidity and lowering pH, which can negatively impact marine organisms, particularly calcifying species.
- Global sea level rise is projected to continue, with estimates ranging from 0.2 to 2.0 meters by 2100. This threatens intertidal areas, estuaries, and coastal communities, leading to habitat loss, altered ecosystem function, and increased vulnerability to flooding. For the **ƛ̓ušiiʔaaʔaq**, sea level rises between 0.525 and 0.625 meters are projected by 2099.
- Model projections for the **ƛ̓ušiiʔaaʔaq** indicate a decline in aragonite saturation state, a crucial parameter for the shell-building capacity of marine organisms.
- Climate change is expected to significantly impact the shallow shelf and exposed coastline of the **ƛ̓ušiiʔaaʔaq**. These impacts include altered salinity levels, increased exposure to extreme temperatures during low tides, and potential shifts in the distribution of species.
- While the **ƛ̓ušiiʔaaʔaq** is located in a high tsunami run-up zone, rising sea levels will exacerbate the inland reach and flooding associated with tsunamis.

7.1.3 Human Uses of Area

The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is ecologically significant and supports a variety of human uses, including Indigenous activities, commercial and recreational fisheries, and other industries. Understanding the spatial and temporal patterns of these activities, their potential impacts, and the interactions between different user groups is crucial for developing effective management strategies that incorporate ecological, economic, social, and cultural values.

- The area holds cultural and ecological significance for various First Nations, including the Ditidaht, Pacheedaht, Huu-ay-aht, and the Makah Tribe. They engage in food, social, and ceremonial fisheries for species such as salmon, rockfish, and Pacific Halibut, which are integral to their nutrition, culture, and well-being.
- The Maa-nulth First Nations hold domestic and commercial fishing allocations.
- The **ƛ̓ušiiʔaaʔaq** Area supports a diverse range of commercial fisheries, primarily targeting groundfish, shellfish, and salmon.
- Groundfish, particularly Pacific Hake caught using midwater trawls, dominate the commercial fishery, accounting for approximately 88% of total annual landings (by weight), averaging 6.8 million kg from 2017 to 2021.
- Other notable fisheries include Chum Salmon seine and gillnet fisheries. Shellfish, primarily crab caught using traps, also contribute to commercial landings.
- Recreational fishing is prevalent throughout the area, targeting species such as crab, groundfish (including Lingcod), and various salmon species.
- The West Coast Trail is a well-known multi-day backpacking trail stretching along the coast of the **ƛ̓ušiiʔaaʔaq**, and welcomes around 7000 users from May 1 to September 30 each year.
- The **ƛ̓ušiiʔaaʔaq** experiences significant vessel traffic, particularly along the edges of the Traffic Separation Scheme, coastal areas, and deeper regions of the continental shelf.
- Vessel traffic raises concerns about potential impacts on marine ecosystems, including ship strikes, underwater noise pollution, release of pollutants, and introduction of invasive species.

7.1.4 Ecological Setting

Important Ecosystems

- Four EBSAs are located within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area: the continental shelf off of Barkley Sound, the Juan de Fuca Eddy, the Juan de Fuca Strait, and cold seeps.
    - The Juan de Fuca Strait EBSA, located southeast of the **ƛ̓ušiiʔaaʔaq**, is a crucial pathway for many fish species, including salmon and Pacific Herring, that migrate between the Strait of George and the outer Pacific Ocean.
    - 217 cold seep bubble streams have been identified within the Juan de Fuca Eddy EBSA, and a confirmed benthic cold seep ecosystem is located roughly 20 km outside of this area.
- Estuaries, salt marshes, and freshwater systems like Nitinaht Lake and Cheewaht Lake support a wide range of species and help maintain the ecological integrity of the region.

- Seven estuaries are in the **ƛ̓ušiiʔaaʔaq** Area: Camper Creek, Carmanah Creek, Cheewaht River, Cullite Creek, Klanawa River, Logan Creek, Nitinaht River, Pachena River, and Walbran Creek.

Plankton and Marine Plants

- Phytoplankton, microscopic plants, form the foundation of the marine food web and influence the abundance and distribution of many marine species in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Diatoms are the most abundant type of phytoplankton in the **ƛ̓ušiiʔaaʔaq**, followed by flagellates and cryptophytes.
- Zooplankton, small animals that drift in ocean currents, are the primary food source for many marine species, including forage fish and juvenile salmon. Euphausiids (krill) and medium-sized copepods constitute the majority of zooplankton biomass in the **ƛ̓ušiiʔaaʔaq**.
- Canopy-forming kelp, such as Bull Kelp, create crucial habitats for other marine species and contribute to the ecological richness of the **ƛ̓ušiiʔaaʔaq**. The distribution of kelp forests and beds is dynamic, and recent observations by the Huu-ay-aht First Nations indicate a decline in kelp coverage.
- Eelgrass meadows in shallow, sheltered coastal waters, provide essential habitat for various marine organisms and have demonstrated persistence and stability in fish assemblages over time within the Pacific Rim National Park Reserve.

Invertebrates and Fishes

- The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is home to a diverse array of invertebrate species, including corals, sponges, mollusks, crustaceans, and echinoderms. These invertebrates play critical roles in the marine ecosystem, contributing to nutrient cycling, habitat formation, and serving as food sources for higher trophic levels.
    - Dungeness Crab and Spot Prawns are commercially and ecologically significant species.
- **ƛ̓ušiiʔaaʔaq** supports a diverse fish community, encompassing at least 75 species of bony and cartilaginous fishes.
    - Forage fish, including Pacific Sand Lance and Surf Smelt, use the **ƛ̓ušiiʔaaʔaq** for foraging and possible spawning, and are important prey for marine birds, salmon and marine mammals in area. The species is also of cultural importance to Ditidaht First Nation and Pacheedaht First Nation as a food fish species.
    - At least 19 species of rockfish are found in the area, including Canary, China, Copper, Quillback, Pacific Ocean Perch, Rougheye/Blackspotted Rockfish complex, Yelloweye, and Yellowtail Rockfish. Many of these are commercially and culturally important, and some are facing conservation concerns, including the Rougheye/Blackspotted Rockfish complex, Yelloweye Rockfish, Quillback Rockfish, and Copper Rockfish.
    - At least 13 species of flatfish occur in the area, including Pacific Halibut, Dover Sole, Petrale Sole, and Rex Sole. Eight flatfish species are considered biologically important to the Juan de Fuca Eddy EBSA.
    - Pacific Hake and Pollock, both roundfish, are significant food sources for other marine life and exhibit population fluctuations.
    - Lingcod and Sablefish are both commercially important in the area, and Sablefish are an SRKW food resource.
    - Salmonids, including Chinook, Coho, Sockeye, Chum, and Pink Salmon, use the **ƛ̓ušiiʔaaʔaq** for migration and foraging, connecting the region to watersheds

throughout the Pacific Northwest. Chinook Salmon are a key food source for SRKW.
    - At least 13 elasmobranch species (sharks, skates, and rays) have been observed in the area. Four of these species are biologically important to the Juan de Fuca Eddy EBSA, including the Basking Shark. Many cartilaginous fish populations have declined due to overfishing, bycatch, and habitat degradation.

Marine Birds, Mammals, and Reptiles

- The **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area is an ecologically significant region for marine birds, supporting a diverse range of species, including albatrosses, shearwaters, auklets, gulls, marbled murelets, and waterfowl.
    - The Juan de Fuca Eddy EBSA polygon within the **ƛ̓ušiiʔaaʔaq** overlaps with the Amphitrite and **ƛ̓ušiiʔaaʔaq/**Swiftsure Bank Important Bird Area, recognized for its global and national significance for seabird populations.
    - The area's nearshore habitats, including rocky shorelines, estuaries, salt marshes, kelp and eelgrass beds, and coastal islands, provide essential resources for marine birds throughout their annual cycles, including critical breeding and foraging grounds.
    - The protected waters of Nitinaht Lake provide a vital habitat for marine birds, particularly sea ducks, waterfowl, and gull species.
    - Marine birds in the **ƛ̓ušiiʔaaʔaq** face various threats, including shifts in prey availability due to ocean warming, habitat degradation, invasive species, human disturbance, marine pollution, and bycatch in fisheries.
- The **ƛ̓ušiiʔaaʔaq** Area is home to a diverse array of marine mammals, including baleen whales, toothed whales, pinnipeds, and sea otters.
    - Baleen whales, such as Humpback Whales and Grey Whales, are attracted to the area's high primary and secondary productivity, feeding on copepods, euphausiids, amphipods, and small schooling fishes.
    - Toothed whales, including Killer Whales, dolphins, and porpoises, are drawn to the area's abundance of fish, cephalopods, and marine mammals.
    - Pinnipeds, such as Harbor Seals, Northern Elephant Seals, Steller Sea Lions, and California Sea Lions, utilize the area's haul-out sites for resting, molting, and pupping.
    - The implementation of vessel speed restrictions, reduction of marine debris and pollution, and protection of key foraging areas are crucial for safeguarding marine mammal populations in the **ƛ̓ušiiʔaaʔaq**, including Southern Resident Killer Whales.
- Marine reptiles, including Leatherback Sea Turtles, Green Sea Turtles, Olive Ridley Sea Turtles, and Loggerhead Sea Turtles, also occur in the waters of the **ƛ̓ušiiʔaaʔaq**.

7.2 Knowledge Gaps and Research Opportunities

This report compiled the knowledge and available ecological, oceanographic and human use data of the area. Despite the comprehensiveness of the report, several knowledge gaps and uncertainties remain. In this section we summarize these gaps by section heading in the report and highlight opportunities for future work to address these gaps. It is important to note that these are not necessarily all of the knowledge gaps that exist in relation to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area.

A general knowledge gap that is relevant to the oceanographic setting, climate change, human uses of the area, and the ecological setting is the limitation posed by temporal, seasonal and spatial gaps in data (described below). These gaps can limit the ability to understand long term trends, make projections across space and time and understand the complex dynamics of this ecologically important space.

7.2.1 Oceanographic Setting

- Limited data exists on water properties during the winter season, and is primarily gathered from the La Perouse program and programs sampling in the Salish Sea. Explore existing conductivity-temperature-depth (CTD) fluorescence data from the DFO database to supplement understanding of phytoplankton seasonality in the water column.
- The acquisition of high-resolution multibeam echosounder data for additional areas within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area would help better inform the geological setting and is an identified data gap.
- Additional data collection in the winter and ocean colour studies using satellite data would enhance knowledge of the water properties of the **ƛ̓ušiiʔaaʔaq** Area.
- A better understanding of the seasonal variability of tides, currents and winds in the area would support knowledge and understanding of the trajectory and impacts of potential oil spills. This information could be coupled with vessel traffic and associated pollution-risk information to provide information on the movement of pollutants in the area.

7.2.2 Climate Change

- Further research is needed to better understand the specific impacts of climate change on nearshore areas, as current oceanographic models are not accurate for these regions.
- It is crucial to investigate the potentially synergistic effects of multiple climate-related stressors, such as temperature, hypoxia, and ocean acidification, on marine ecosystems. Continued monitoring of key environmental parameters, such as SST, dissolved oxygen, and aragonite saturation state, is essential to track changes and inform management decisions.
- Detailed studies are needed to assess the vulnerability and resilience of key species to climate change, including their thermal tolerances, dispersal abilities, and responses to altered food webs.

7.2.3 Human Uses of Area

- DFO is continuing to discuss the spatial representation of commercial fishing with advisory board members, which may result in including a different year span to describe the activity within this area in the future.
- The coarse spatial resolution of salmon logbook data and recreational fisheries data lead to greater uncertainty in estimating harvest and vessel counts for seine and recreational fisheries compared to other fisheries.
- Relying exclusively on Automatic Identification System (AIS) data to understand vessel traffic patterns has limitations, as smaller commercial fishing and recreational vessels are not required to use AIS. This potentially results in significant underestimations of

vessel presence and activity. It is recommended to supplement AIS data with aerial surveillance information, which can detect vessels regardless of AIS transponder usage.
- While environmental monitoring programs for biotoxins are in place, further research is needed to understand the known and potential risks of biotoxins, especially for coastal Indigenous populations who regularly consume various seafood species. This research should focus on the dynamics of biotoxin accumulation in shellfish and developing effective management strategies to protect public health and support the local economy.
- Ongoing surveys are being conducted to track the spread and impact of the invasive European Green Crab, including an expansion of the monitoring program in Nitinaht Lake to include the Cheewaht Estuary.

7.2.4 Ecological Setting

Important Ecosystems

- Repeat surveys of nearshore habitats (e.g., salt marsh, eelgrass beds, kelp forests) are crucial for monitoring the health and extent of these ecologically important habitats. The most recent Shorezone mapping for the outer coastline and estuaries was completed in 2021. The most recent Shorezone mapping for Nitinaht Lake was done in 2007. Incorporating additional survey methods to delineate nearshore habitat boundaries more precisely and gather data on habitat condition would improve understanding of these habitats and complement ongoing survey work being conducted by the Ditidaht Nation.
- More research is needed to understand the dynamics of cold seep activity in the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, specifically the persistence and location of seeps. The limited visual data from these sites makes it difficult to confirm the presence of cold seeps and analyze their ecological impact. Additional echosounder data collection and ROV surveys would contribute to a more thorough understanding of the characteristics of these sites.

Plankton and Marine Plants

- While more phytoplankton and zooplankton sample data exist for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area compared to other remote areas of the BC coast, consistent, year-round sampling at regular intervals (e.g., quarterly) and at consistent depths is necessary to monitor changes and seasonal variability in species composition.
- While satellite data on surface chlorophyll-a concentration is informative, it does not capture deep-water features like deep chlorophyll maxima. Further research should focus on summarizing existing CTD fluorescence data and incorporating high-resolution satellite data, such as that from Sentinel-3 and Sentinel-2 satellites, to better understand phytoplankton dynamics throughout the water column.
- While the **ƛ̓ušiiʔaaʔaq** Area is well-represented in zooplankton databases, a knowledge gap exists in understanding the long-term impacts of recurring marine heatwaves on zooplankton composition and distribution. More data is needed on copepod distribution in nearshore habitats, as they are a critical food source for various species.
- Long-term monitoring is needed to understand how environmental factors and local stressors affect the resilience of canopy-forming kelp in the face of climate change. This includes investigating the impact of salinity on kelp growth and persistence, particularly given the potential for climate change to alter freshwater inputs in coastal areas.
- Research efforts have primarily focused on canopy-forming kelp, neglecting the ecological significance of understory kelp and other macroalgae species. More

comprehensive surveys are needed to record coastal macroalgae diversity, particularly in Strait of Georgia/north Salish Sea.
- Further research on surfgrass is necessary to understand its habitat preferences, environmental tolerances, and importance for at-risk species.
- Continued monitoring and mapping of eelgrass beds are needed, with a focus on identifying and mapping uncharted areas and ground-truthing existing data.
- Identifying and mapping of salt marsh habitats is also needed for area.

Invertebrates and Fishes

- Research surveys are limited for many invertebrate species that are not commercially harvested, including marine snails, chitons, barnacles, and echinoderms. Additionally, bivalve occurrence data, particularly in nearshore areas, require further investigation and ground-truthing to better understand their distribution and develop more accurate species distribution models.
- The specific habitat preferences of rockfish species within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area, particularly their inclination towards various rock types and biocover, require further investigation.
- A dedicated groundfish diet monitoring program is important for developing robust ecosystem models but is currently lacking. Further, a general lack of regional and coastwide ecosystem models limits the ability for complex interactions, feedback loops and dependencies between ecosystem components to be incorporated into decision making and the management within the **ƛ̓ušiiʔaaʔaq** Area.
- A more detailed understanding of factors affecting forage fish population abundance and their role in food webs is crucial for accurate assessments and ecosystem modeling. For many non-commercially important fish species, surveys and assessments are undeveloped, need updating, and/or important life history information is lacking.
- Despite extensive research, the specific drivers of Pacific Herring recruitment and the impacts of marine heatwaves on their stocks remain poorly understood. Further research on early life history stages is crucial to identify the factors influencing recruitment variability and predict future stock dynamics.
- Comprehensive stock assessment of Fraser River Eulachon, including age composition data, is needed. Additionally, research is needed to fill knowledge gaps related to their life history parameters, carrying capacity, population growth rates, and the relationship between their population dynamics and environmental factors.
- Knowledge of Pacific Sand Lance and Surf Smelt intertidal spawning habitat and winter ecology is limited. Research focusing on Pacific Sand Lance potential winter burying and Pacific Sand Lance and Surf Smelt spawning behaviour in shallow subtidal areas of **ƛ̓ušiiʔaaʔaq** is necessary.

Marine Birds, Mammals, and Reptiles

- More comprehensive baseline data on marine bird distribution, abundance, and species composition is needed for the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank Area. Research should focus on conducting year-round surveys and incorporating traditional ecological knowledge to address data gaps and assess threats.
- Further research is needed to gain a better understanding of the distribution, abundance, and habitat use of less-studied cetacean species, such as Fin Whales, Harbour Porpoises, and Dall's Porpoises, in the **ƛ̓ušiiʔaaʔaq** Area. Continued monitoring and research efforts are crucial for assessing the impacts of anthropogenic threats, such as vessel traffic and entanglement in fishing gear on marine mammal populations.

- Winter movements and diets of Harbour Seals and sea lions in the area are not well-documented. Further research, including tagging studies, would provide valuable insights into their winter ecology and the factors influencing their population dynamics.
- The at-sea distribution and habitat preferences of Northern Elephant Seals in British Columbia remain largely unknown. Research to determine the at-sea distribution and habitat preferences of Northern Elephant Seals within British Columbia waters is currently lacking.
- Assessments of potential resource competition between Steller Sea Lions and other species, such as California Sea Lions, would benefit from considering the abundance, distribution, and diet of these species.
- No sea turtle distribution or abundance data is available for BC waters, despite the observation efforts already made through marine mammal surveys. Currently, sea turtle sightings in BC are opportunistic and reliant on the availability and reporting practices of boaters, resulting in potential underreporting, particularly during winter months and in remote regions. Establishing a dedicated sea turtle monitoring program in British Columbia could leverage existing marine mammal survey efforts and incorporate citizen science initiatives to collect more comprehensive data on sea turtle distribution and abundance.

8 ACKNOWLEDGEMENTS

We are grateful for the support and feedback from many individuals in the making of this report. We would like to acknowledge and thank Tammy Norgard and Katherine Charles for chairing and/or facilitating logistics for the workshop to review this report as well as the DFO Oceans team for their guidance and feedback: Spencer Chaisson, Robyn Pearce, Clayton Manning, and James Mortimor. In particular, we would like to thank our many contributors, reviewers, and workshop participants for their time and expertise. In addition to the author list, many individuals provided writing, editing, or data (Table 1) or attended the review workshop and provided expert review of report sections (Appendix C).

We are grateful for our collaboration with the CHS for multibeam data acquisition and all crew members of the CCGS Vector and CCGS Tully for their safe operation and dedication during expeditions to the **ƛ̓ušiiʔaaʔaq̓**/Swifsure Bank area. Figures in the Bathymetry section including multibeam bathymetry data have been produced by Natural Resources Canada and incorporate Canadian Hydrographic Service data, pursuant to CHS MOU 2022-0408-1260-CHS-SGB for illustrative, non-navigational purposes only. The incorporation of data sourced from CHS in this product shall not be construed as constituting an endorsement by CHS of this product. Thank you to Anna Bartnik for her assistance in figure creation for the Bathymetry and Benthic Floor sections, Anna Podhorodeski for her help with data compilation, and Maya Buckner for creating many of the maps found throughout the report.

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10 APPENDICES

10.1 Appendix A: Nuu-chah-nulth names and sources

References used:

Nuu-chah-nulth Tribal Council. Nuu-chah-nulth Language, Learn our language. Accessible at: Nuu-chah-nulth Language, Learn our language (nuuchahnulth.org)
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Additional online language resources:

nuučaaʕuł Language Lessons (ncnlessons.com)
Nuu-chah-nulth Language | Nuu-chah-nulth Living Archive (nuuchahnulthlivingarchive.com)

Note: The spelling and definition of the Nuu-chah-nulth words were reviewed by hinatinyis, language coordinator for Huu-ay-aht First Nations.

Table A1. Nuu-chah-nulth words and names for topics or words used in or related to the report. Please note that this document and table are not meant to be used as a language reference and this table is not a comprehensive list or representation of the Nuu-chah-nulth language.

Nuu-chah-nulth name	English name	Category
ƛaaʕuł	barnacle	sea creature
yeʔisi/yaʔisi	butter clam	sea creature
saċup	chinook salmon	sea creature
hayištup	chiton	sea creature
hinḵuʔas/hinḵuuʔas	chum (dog) salmon	sea creature
huupisi	cockles	sea creature
cuwit	coho salmon	sea creature
ḥixia	dentalium	sea creature
yačaa	dog fish	sea creature

Nuu-chah-nulth name	English name	Category
hicswin	dolphin	sea creature
hasaamac	dungeness crab	sea creature
ƛ̓iiṅa	eulachon fish, eulachon oil	sea creature
ƛ̓iiṅaqsit	eulachon oil	sea creature
piiš	fish	sea creature
ṗuuḥu	flounder	sea creature
k̓iɬanuus	fur seal	sea creature
c̓aʔinwa/c̓eʔinwa	goose barnacles	sea creature
ciɬciɬṅi	grey whale	sea creature
kuukuḥẇisa	hair seal (harbour seal)	sea creature
ṗuuʔi	halibut	sea creature
ƛusmit	herring	sea creature
k̓ʷaqmis/siiḥṁuu	herring eggs	sea creature
ʕamiiq	horse clam	sea creature
kakaẇin	Killer whale (orca)	sea creature
tuškuuḥ	ling cod	sea creature
ƛ̓uč̓im	big mussels	sea creature
tiiɬuup	octopus	sea creature
ƛ̓isapiiḥ/ƛ̓isapaḥ	perch	sea creature
č̓aapi	pink salmon	sea creature
hicwin	porpoise	sea creature
ɬiɬimakƛi	prawn	sea creature
ƛ̓iḥapiiḥ	red snapper	sea creature
waaxni	river otter	sea creature
teʔinawa/teeʔinawa	sea cucumber	sea creature
qʷinii	sea gull	sea creature
tukuuk	sea lion	sea creature
k̓ʷak̓ʷaƛ	sea otter	sea creature
qasqiip	sea star	sea creature

Nuu-chah-nulth name	English name	Category
ƚuċup	sea urchin/big sea urchin	sea creature
ḥiix	small sea urchin	sea creature
miʔaat/hissit	River/Ocean Sockeye	sea creature
maaʔak/čičičẇin	sperm whale	sea creature
suuḥa/suuḥaa	spring salmon	sea creature
qiẇaḥ	steelhead salmon	sea creature
qaxqaayuuš	tanner crab	sea creature
ƚaatwin	trout	sea creature
łiłikʕim	turtle	sea creature
ʔiiḥtuup	whale	sea creature
husmin	kelp	seaweeds
čims	black bear	land animals
kaaʔin	crow	land animals
ċixʷatin	eagle	land animals
huqsim	goose	land animals
naana	grizzly bear	land animals
čaastumc	mink	land animals
quʔušin	raven	land animals
waaxnii	river otter	land animals
qʷayaċiik	wolf	land animals
saštup	land animal	land animals
ċaċaałuk	fisheries boat	boats/fisheries
čiicsac	troll boat	boats/fisheries
čapac	canoe	boats/fisheries
yašmaqsac	sealing canoe	boats/fisheries
ṗinẇał	oceangoing freight canoe	boats/fisheries
xʷaaḵaana	northern style canoe	boats/fisheries
ċaʔak	river	natural world
čaačišt	island in ocean	natural world

Nuu-chah-nulth name	English name	Category
čaʔak	island	natural world
čaʔak	water	natural world
hiɬc̓aat	out on the ocean	natural world
hinaayiɬ	sky, heaven	natural world
hitaaqƛ̓as	forest, inland	natural world
hitinqis	beach	natural world
hupaɬ	sun, moon, month	natural world
ɬiẇaḥmis	cloud	natural world
maḥtii	house	natural world
maʔas	village, home, house	natural world
ṁuksy̓i	rock, stone	natural world
nisṁa	land	natural world
sučas	tree	natural world
supi̓cmis	sand	natural world
tupi̓ał	salt water, ocean	natural world
ṁałaa	cold weather	weather
ƛ̓upaa	hot weather/sunny	weather
ƛ̓upaa	sunny	weather
ɬiẇaḥyu	cloudy	weather
yuʔi	windy	weather
ʔučqak	foggy	weather
ṁiƛaa	raining	weather
kʷisaa	snowing	weather
ʔuuqumḥi	calm weather	weather
wiiqsii	stormy	weather

10.2 Appendix B: Ditidaht Traditional Places – Locations and Names

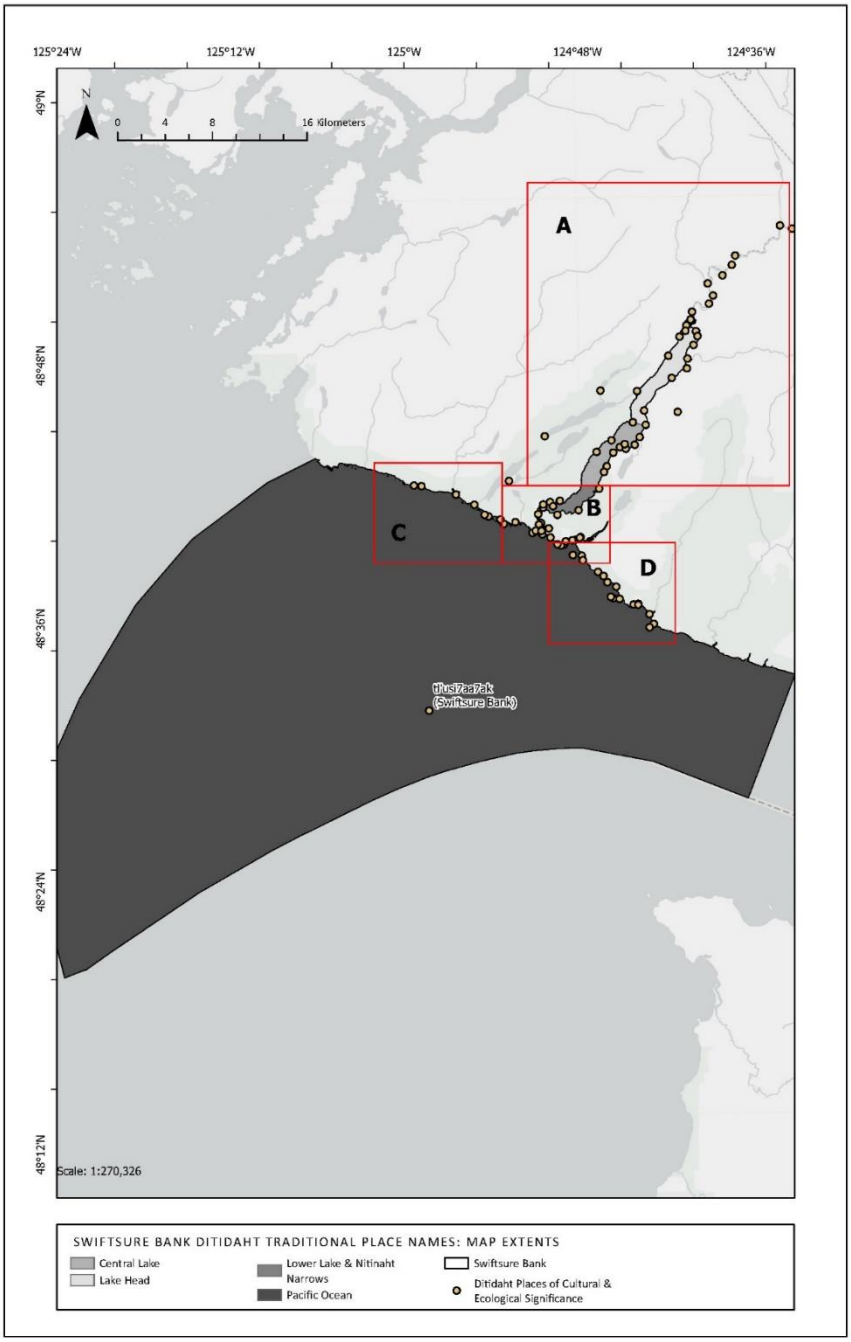


Figure D1. Extents of maps showing Ditidaht traditional place names, locations and areas of cultural importance located on the outer coast of ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank.*

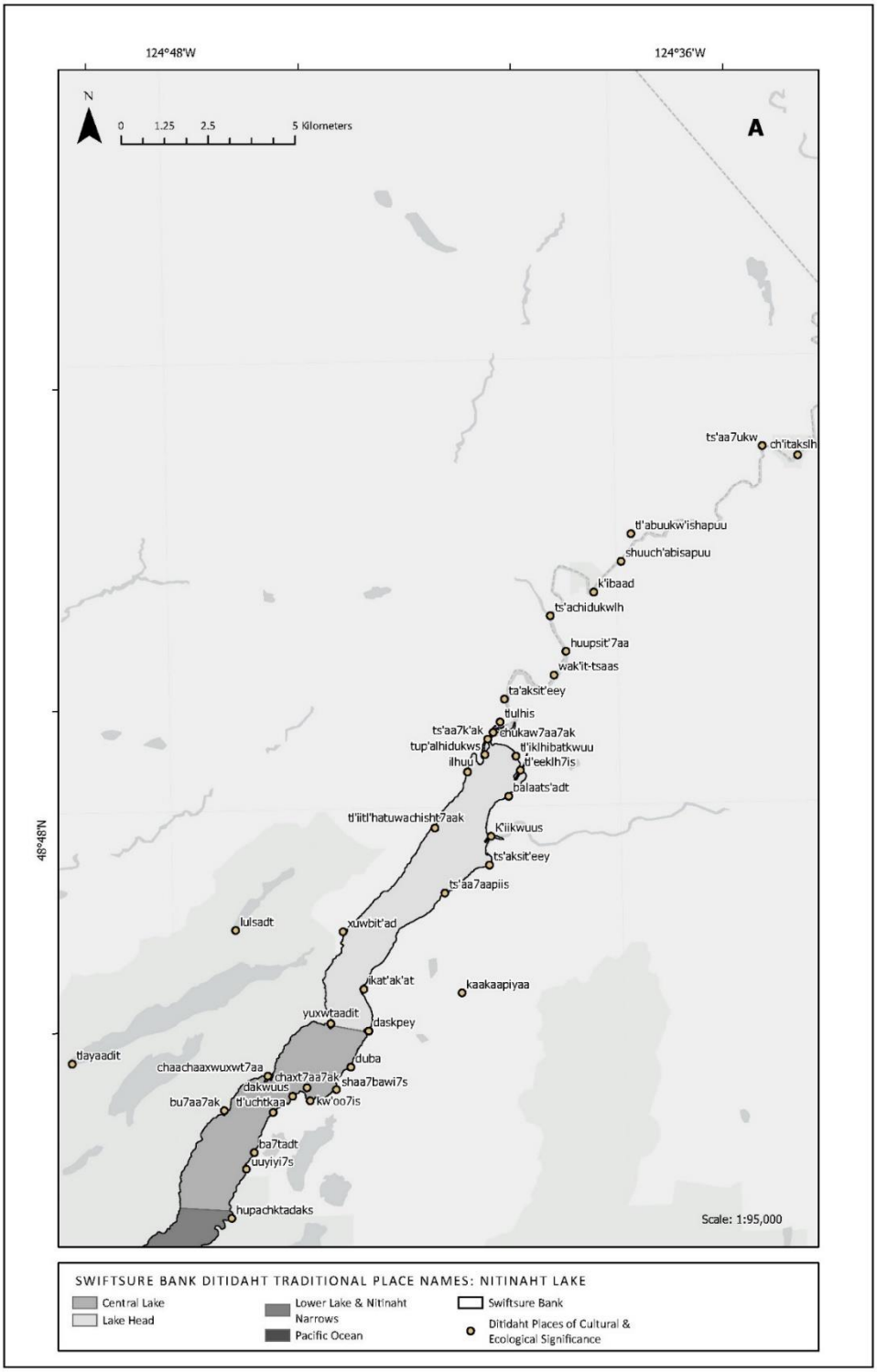


Figure D2. Ditidaht traditional place names, locations and areas of cultural importance located in the Nitinaht Lake area.

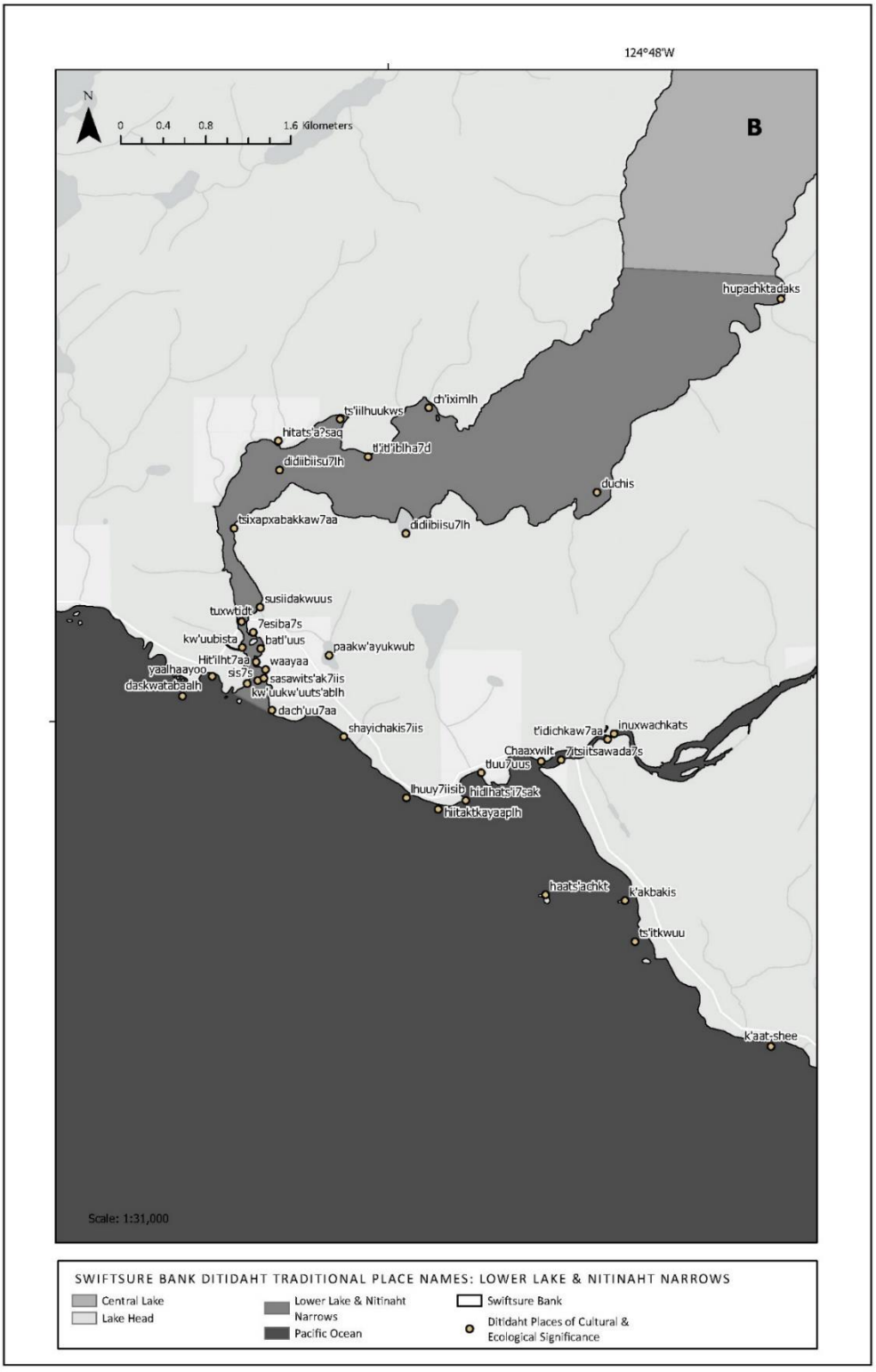


Figure D3. Ditidaht traditional place names, locations and areas of cultural importance located in the Lower Nitinaht Lake and Nitinaht Narrows area.



Figure D4. Ditidaht traditional place names, locations and areas of cultural importance located on the northern (C) and southern (D) outer coast of ***Ƛ̓ušiiʔaaʔaq****/Swiftsure Bank.*

Table D1. Details of Ditidaht traditional place names located in the Nitinaht Lake area (Figure D2).

Swiftsure Bank: Ditidaht Traditional Place Names					
Map A: Nitinaht Lake					
Traditional Name	**Translation**	**English Place Name**	**Latitude**	**Longitude**	**Details**
ba7tadt	Place for sockeye	N/A	48.71834913	-124.7745203	At one time it was full of sockeye here and the people fished here. Carl Edgar said that his partner, Webster, saw them while falling in 1970 - 1971. The people took roe here and took it to Hobiton Creek, but no one is sure when this happened.
balaats'adt	Little fish (DFN). Place of jumping fleas (Maka)	Malachan / Nitinaht Village	48.80942321	-124.6726237	This was not a traditional site for a village prior to 1914 and was only used as a camping place. Joe Edgar's wife, Molly Chipps, claimed ownership of this area. There used to lots of fleas here until the area was opened up for houses.
bu7aa7ak	burned out place	Martins Point	48.729367	-124.785917	There was a creek just north of hear where people were forbidden to drink water. The creek was said to have red water, i,e blood.
chaachaaxwuxwt7aa	point with a bunch of islands offshore	Dickinson Point/Grassy Point	48.738112	-124.768681	
chaxt7aa7ak	island offshore	Campbell Island	48.734923	-124.753503	The largest of a group of three islets off Daykins Bay. Sam Campbell was born here. Seals roost on the two nearby islands.
ch'itakslh	Blocked at the mouth	Nitinat River Falls	48.89635082	-124.556975	There was a trail that went from here to Cowichan Lake. This is as far as fish can go up the river.
chukaw7aa7ak	Peeking around the point	N/A	48.82601902	-124.6782746	This is a fishing area where the river is calm, you could stand on the point and spear fish. Martin Edgar stated that a certain type of fish trap was only used just below here.
dakwuus	Drinking place	N/A	48.73276211	-124.7591408	A small creek that flows onto the beach and disappears into the sand and rock. The people used to drink from a small ledge on the bluff that collects water.
daskpey	"In the dark" or "Noise made by creek"	Marchand Creek	48.74929835	-124.7289808	According to Joshua and Joe Edgar, people used to fish salmon and obtain cedar here. This creek was noted for its late run of Dog Salmon (December - January).
duba	Place where people from many areas live	Doobah	48.740052	-124.7362242	This was a dog salmon fishing station that was intermittently occupied. Fishing was done here with spears or gaff hooks. There was one house here owned by either the Gibbs family or Jimmy Smith. The house was located on the east side of the creek.

huupsit'7aa	Big boulder in stream	Red Rock	48.84669269	-124.6491696	
ikat'ak'at	Makah word for suicide	Suicide Bluffs	48.760151	-124.73062	Various stories exist all about a young women who took her life jumping from these cliffs. There were lots of yellow cedars above these bluffs
ilhuu	A medicinal plant scattered all over the beach	Ilclo IR 12	48.81589581	-124.6885504	This was used as a dog salmon fishing station for approximately two months of the year. In the bay at the north end there was an "underwater fence" of saplings for defensive purposes.
kaakaapiyaa	Highest peak	Mount Rosander	48.75876802	-124.6922697	This peak is mentioned in the Ditidaht Great Flood story. It is said that the people took refuge in canoes that landed on Mount Rosander. When the water went down, the canoe became stuck half way down the mountain.
k'ibaad	Belly button	N/A	48.86186692	-124.6378761	Coho used to go here and the people used to gaff hook them here when Carl Edgar was a small child. The name also refers to the mountain that the small stream entering here flows from.
K'iikwuus	Burning the bottoms of canoes	Caycuse River	48.7991423	-124.6798483	Martin Edgar used to trap racoon and mink here. About one mile up the Caycuse there was a smoke house on the river and the south side. Dog salmon were smoked here, and steelhead and trout were caught.
kw'oo7is	None recorded in the reviewed documents	Daykins Bay	48.73150411	-124.7523267	There used to be lean-to shelters here, and Martin Charles said there used to be 2 or 3 houses here.
lulsadt	Spawned-out sockeye place	Hitchie Creek & Lake	48.77596525	-124.7802878	It is thought that sockeye were obtained here. It was said the sockeye spawned at the outlet of Hitchie Lake. Martin Charles said that his parents went there to smoke fish.
shaa7bawi7s	So scared he shit himself	Daykins Bay (east side)	48.73430836	-124.7420335	The name is based on a story about a thief who was being chased; the pursuers caught him here and he shit himself because he was so afraid.
shuuch'abisapuu	Place of big timber	Jasper Creek / Chuchummisapo IR 15	48.86968756	-124.6269657	In 1892 this was an old salmon fishing station, as evidenced by the weir that crosses the river here. The weir was "V" shaped with the apex facing downstream. In 1914 it was identified as a seasonally occupied fishing station.
ta'aksit'eey	Water running in the back	Glory Hole Slough	48.83459319	-124.6736015	500 meter long lake parallel to the river. Likely an old streambed of the river. The place where it drains into the river is called ts'aalhats'7aa.
tl'abuukw'ishapuu	Where stink currant grows	Worthless Creek	48.87679071	-124.6228837	This location and name is uncertain.
tlayaadit	Lots there/give or get more	Hobiton Lake (south end)	48.74203286	-124.8449949	The name of the creek that connects Hobiton Lake to Hitchie Lake. A place where sockeye salmon spawn.

tl'eeklh7is	Brings little bit of water	Campus Creek	48.8161251	-124.6678639	There were houses near the mouth of this creek, and coho used to be caught in the creek using hooks and spears. Martin Charles and Martin Edgar said that coho go up this creek and that only the coho could get past the sandbar.
tl'iitl'hatuwachishht7aak	Shallow spot outside	Knob Point	48.80155234	-124.7017027	Used to be called Lighthouse Point
tl'iklhibatkwuu	also called da?owaqts. No translation in the reviewed materials	Guss Bay	48.8197988	-124.6695158	Mike Thompson said that there used to be four houses in the bay where the provincial wharf is located.
tl'uchtkaa	Mussel point	N/A	48.72867238	-124.7668779	There are huge mussels found in the water here, and whale hunters used to dive for them in order to fashion them into harpoon heads. Seals rest on an islet near here known as Sam Campbell Islet.
tlulhis	Clean beach	Poison Slough	48.82870942	-124.6754637	A slough near the mouth of the Nitinaht River.
ts'aa7aapiis	Little creek/ Creek on point	N/A	48.78469204	-124.6982752	Name refers to both the point and the creek. The creek here never goes dry. People used to hunt deer just east of here. Martin Charles said old George Gibbs reported that he found a place way up high where a whale had been stranded.
ts'aa7k'ak	None recorded in the reviewed documents	Nitinaht River	48.82432428	-124.6804172	This name refers to the Nitinaht River in its entirety. There used to be lots of bears around in the 1920's, and they were hunted for their fur. They were trapped up the river, or taken from hibernation trees by smoking them out. Before the steel trap ca
ts'aa7ukw	Another little creek on the side (Makah)	Parker Creek / Saouk IR 16	48.89894146	-124.5707792	The head of canoe navigation on the Nitinaht River. This place was used primarily as a salmon fishery area. In 1982 two families had built houses here and commenced clearing and fencing. By 1893 there were four houses located here.
ts'achidukwlh	Confluence	Little Nitinaht River	48.8559488	-124.655039	Joshua Edgar had a house here on the west side of Nitinaht River, where the powerline now crosses now. He ran a trap line for mink, otter, marten and racoon. Coho were fished in the Little Nitinaht River not far from the confluence.
ts'aksit'eey	Water in back	N/A	48.79171273	-124.6806444	Dog salmon went up this creek and people used to fish there. There were houses on the north side of the creek, and the women used to gather basketry grass here. This was a late run of fish.
tup'alhidukws	Where fresh water meets salt water	Nitinat River (mouth)	48.8203347	-124.6816408	Large chinook salmon were speared here during August and September.

uuyiyi7s	Way down there on the beach	Oyees IR 9	48.71410405	-124.7777432	This was a place used by the people for canoe construction, and they often camped there while construction was going on. Cedar planks and cedar bark were also found here. It was also a dog salmon fishing station.
wak'it-tsaas	Frog making sound (Makah)	Wokitsas IR 14	48.84058633	-124.65405	There was a substantial stone weir located here about 4 feet high. There were fish traps located here and the people came here to obtain their winter supply of salmon. The people also fished with drag nets here for sockeye and chum.
xwubit'ad	snoring sound made by a river or a waterfall	Hobiton Creek	48.77513595	-124.7383346	The most prized fishery of the Ditidaht people. Hobiton Lake is frequented by the sockeye salmon (called lulsad when silver and luaals when red). The creek supports chum, steelhead and coho as well. There were at least four weir sites in the creek.
yuxwtaadit	wind blowing directly onto rocks	Hobiton Creek	48.751399	-124.743748	The winds going up and down the lake meet here so it is always windy. People would take advantage of the winds when sailing up and down the lake.

Table D2. Details of Ditidaht traditional place names located in the Lower Nitinaht Lake and Nitinaht Narrows area (Figure D3).

Swiftsure Bank: Ditidaht Traditional Place Names					
Map B: Nitinaht Narrows					
Traditional Name	**Translation**	**English Place Name**	**Latitude**	**Longitude**	**Details**
7esiba7s	Stinging nettle ground	N/A	48.67395449	-124.8516824	This is where the graveyard for Whyac is located, Morris Dick was the last person buried here. Before it was a graveyard, it was used for wolf rituals and other ceremonies.
7itsiitsawada7s	thimble berries in middle of flat area	N/A	48.6627341	-124.8127325	Harvest location for Berries
ba7tadt	Place for sockeye	N/A	48.71834913	-124.7745203	At one time it was full of sockeye here and the people fished here. Carl Edgar said that his partner, Webster, saw them while falling in 1970 - 1971. The people took roe here and took it to Hobiton Creek, but no one is sure when this happened.
batl'uus	tying-up whale place	N/A	48.6725723	-124.850758	Harvest location for Whale
Chaaxwilt	Freshwater meeting saltwater	Cheewaht River estuary	48.66264699	-124.815271	
ch'iximlh	Spooky island	Saltery Bay	48.692724	-124.828841	Name refers to both the bay and the islet. This was a burial island with tree burials. The corpses in the trees were still visible when Ida Thompson came to Wyah. A small creek enters this bay where the Ditidaht used to harvest coho.

dach'uu7aa	lookout point	Whyac Point	48.6673411	-124.8494574	Once lookouts were posted here to look for enemy raiders, later they would watch for halibut fishers coming in from Swiftsure Bank. Harvest location for Kelp Greenling and spring salmon the latter which would swim close to the rocks here.
daskwatabaalh	"Echoing sound of waves" / "Innards"	Effie Tate's Rock	48.66865337	-124.8608284	The Ditidaht would observe this little rock to see if it was safe to go through the narrows. If the sounds of the waves crashing on the rock was too loud it wasn't safe. Other names: kilistakabaalh (innards), hiid7ayaaxwlh.
didiibiisu7lh	Look for crab using hoop	N/A	48.68765368	-124.8479926	Carl Edgar and his family have fished crabs commercially here for well over twenty years. Described as a shallow area where crab fishing occurred.
didiibiisu7lh	look for crabs using hoop	Brown's Bay and surrounding area	48.68211813	-124.8320271	Browns Bay and the surrounding lower Nitinaht Lake where crabs were fished. there used to be a store and a fish buyer here. Crabs go into Nitinaht Lake as far as Brown's Bay and people would pick bog cranberries here.
duchis	Mountain on the beach	Goose Island	48.68533	-124.807607	The name is applied to the larger of the two islets in Dooches Bay as well as the shore of the bay and two peaks of Nitinaht cone.
haats'achkt	Long Island	N/A	48.6513436	-124.8149981	An area of elongated rock islets which was a good place to harvest seafood and fish for red snapper and lingcod. Baabiiks, a high rock at the southeast end was a marker for a halibut bank and a good place for fishing.
hidlhats'i7sak	rock point	N/A	48.659438	-124.824957	Harvest location for Kelp Greenling
hiitaktkayaaplh	Underneath the Bluff	N/A	48.6587286	-124.8284807	Harvest location for All
hitats'a?saq	Inside a little ways	The flats	48.69012221	-124.8480938	Generally agreed that the original Ditidaht population (extremely numerous) lived in a very large village here. Lots of middens here. Was used considerably during the winter and spring months. A 150-fathom drag net belonging to George Tate was used here
Hit'ilht7aa	End of point/small rock point	Dan Daniels point	48.67145226	-124.851369	The Shaw family owned the tupaat (hereditary privilege) to use a duck net here. The net was strung across the narrows and people in the narrows would scare the ducks into the net.
hupachktadaks	Has Island in bay	Eelgrass Cove	48.701436	-124.783741	The name of a semicircular bay where that was a camp where people would stay while making canoes. There was a house here where people lived periodically, including chief Dick.
inuxwachkats	small island on the water	N/A	48.6648685	-124.8059402	Harvest location for Salmon Sockeye
k'akbakis	Grassy Beach	N/A	48.6507422	-124.804888	Harvest location for Seaweed
kw'uubista	A type of mussel	N/A	48.6726955	-124.8531101	Harvest location for Fowl

kw'uukw'uuts'ablh	small mussels on ears	N/A	48.6696304	-124.8525511	Harvest location for Seal, Shellfish, Spring Salmon
lhuuy7iisib	Flat edge of the beach	Stanley Beach (south end)	48.65974251	-124.8325068	Flat rock on the south end of Stanley Beach. A good place to harvest Chitons, mussels and gooseneck barnacles. There is a blow hole in the rocks on the east side of the beach.
paakw'ayukwub	Water runs down towards the bush	Whyac Lake	48.67190775	-124.8420598	Whyac Lake was a bathing place. Some of the women were taken here to bathe when they became women after their seclusion. Three cornered grass is found here. It was noted that ch'iid7aa7tx (sasquatch) are supposed to be there.
sasawits'ak7iis	sand always falling down	Whyac outside beach	48.67006309	-124.8504196	At "outside beach" south from the village of Whyac, salmon could be harpooned and gaff-hooked right from shore. The people were using this site as recently as the 1940's. Joshua Edgar was the owner of the outside beach at Whyac.
shayichakis7iis	Hard, sharp noise on entire beach	Stanley Beach	48.66500661	-124.8403521	Name comes from the sharp noise made by the beach rocks when someone walks over them. Good area for collecting mussels and gooseneck barnacles. Numerous shipwrecks have occurred here.
sis7s	shallow along beach	N/A	48.6698751	-124.8512029	Harvest location for Salmon Spring
susiidakwuus	Place to swim ashore	Cannery Bay	48.67608164	-124.8507522	This location was named because the people used to make animals swim ashore here and then kill them. The area near the creek used be a habitation site. A cannery was built here in the 1920's. Years ago there used to be lots of deer on the flats here.
t'idichkaw7aa	points of rocks	N/A	48.6644067	-124.8067603	Harvest location for Coho Salmon, Sockeye Salmon
tluu7uus	Camping beach	Clo-oose	48.66176231	-124.8229306	Ditidaht village and halibut station situated in Clo-oose Bay.
tl'itl'iblha7d	Shooting around the water	Onion Point	48.688665	-124.836678	The name is applied to the cape between Mud Bay and Saltery Bay and comes from a story of two brothers who were transformed into rocks whilst rowing around the cape.
ts'iilhuukws	Soft muddy place on beach	Mud Bay	48.69188448	-124.8401656	Three corner grass was harvested on the flats of Mud Bay. The grass is ready to pick here when the seed heads are bursting. Coho go up the small stream here.
tsixapxabakkaw7aa	Crabapples on point	Crabapple Point	48.68278818	-124.853917	On the E bank of Nitinaht Narrows, N of Cannery Bay. Lots of crabapples grew there but bears got most of them. The people would sometimes eat them when soft and almost rotten. There's an underwater reef just off this point.
tuxwtidt	garbage place	N/A	48.6748859	-124.8531439	Harvest location for Fowl
uuyiyi7s	Way down there on the beach	Oyees IR 9	48.71410405	-124.7777432	This was a place used by the people for canoe construction, and they often camped there while construction was going on. Cedar planks and cedar bark were also found here. It was also a dog salmon fishing station.
waayaa	High place	Whyac	48.67079317	-124.8501841	The largest Ditidaht village in historic times was located at the entrance to the narrows known locally as the Gap. This village was occupied until the 1960s.

					Houses were laid out so that they all faced the ocean. All of the big houses had names. The
yaalhaayoo	Oh, right here	N/A	48.6702923	-124.8569972	A small beach located on the coast immediately to the west of Nitinaht Narrows. Smelt (baadaw) come to this beach in June and July.

*Table D3. Details of Ditidaht traditional place names located on the outer coast of **ƛ̓ušiiʔaaʔaq**/Swiftsure (Figure D4).*

Swiftsure Bank: Ditidaht Traditional Place Names					
Map C: Outer Coast North					
Traditional Name	**Translation**	**English Place Name**	**Latitude**	**Longitude**	**Details**
7a7ukw	Where canoes were lowered down the cliff	Tsusiat Lake	48.70841095	-124.8867616	The Ditidaht found profitable employment in the construction of canoes due to the high-quality cedar in the environs of the lake. In 1914 this area was still being used for this purpose.
daskwatabaalh	"Echoing sound of waves" / "Innards"	Effie Tate's Rock	48.66865337	-124.8608284	The Ditidaht would observe this little rock to see if it was safe to go through the narrows. If the sounds of the waves crashing on the rock was too loud it wasn't safe. Other names: kilistakabaalh (innards), hiid7ayaaxwlh.
kiila	One translation believed to be "torchlight used for pit-lamping"	N/A	48.67587703	-124.8932999	Large rock in the middle of xee7idt, according to Mike Thompson.
kuxsiiwii7ilth	Hole point	Tsusiat Point	48.6816873	-124.9107235	Harvest location for Sea Urchin
paatee	No Translation	N/A	48.7053982	-124.9869293	Harvest location for Seal
shuchkee7ak	No Translation	N/A	48.7059792	-124.9955267	Harvest location for Halibut, Seal
Tl'aadiiwa	Whale blubber	Klanawa River	48.69869177	-124.9476711	Seafood and large mussels were gathered here from the rocks, salmon (chinook, steelhead and coho) run up this river, and elk and deer were located in the nearby meadow.
tl'aats'tl'axwadlh	prying up seafood	N/A	48.6829764	-124.9152165	Harvest location for Sea Urchin
tsusiiyit	Water coming down	Tsusiat Falls	48.69075765	-124.9267857	At one time there was a temporary campsite on the northwest side of the falls. Elmer Thompson's father told him that this was a good place to get beaver, whose teeth were used as chisels, but that was long ago.

tsuxwkaada	Water pouring out at end of beach	Tsuquanah IR 2	48.67709639	-124.8801576	This was the largest of the villages of the Ditidaht Nation and most important in terms of warfare, because most of the warriors lived here or gathered here when the nation was threatened by a raiding party.
xee7idt	Go after sea rock food	Barge Beach	48.67924061	-124.8972003	In the 1940s, a barge full of lumber drifted ashore here. Mike Thompson and Carl Edgar learned about this place from George Gibbs and old Jimmy Chester.
Map D: Outer Coast South					
Traditional Name	**Translation**	**English Place Name**	**Latitude**	**Longitude**	**Details**
buulhkaw7aa	Water around point	Bonilla Point	48.59791681	-124.7238253	Generally recognized as the boundary between Ditidaht and Pacheedaht territory. The surrounding area was a good place to harvest seafood like chitons, seal, & snapper. There is a halibut bank offshore of the point.
ch'aach'aapkwak'kw	Bonilla Rock Islet	N/A	48.59791681	-124.7238253	Rock islet southeast of Bonilla point that served as a marked for an offshore halibut bank. Harvest location for gooseneck barnacles and chiton.
ch'itachkt	Rock on edge on edge in water	N/A	48.6179669	-124.7696554	Harvest location for Shellfish
ihoochiikt	Flat rock in the water	N/A	48.619107	-124.7724247	Harvest location for Shellfish
iixachkats	big in water	N/A	48.6266552	-124.7660259	Harvest location for Sedge Grass
ka7awats's	Caramanah Halibit Bank	N/A	48.61331483	-124.7413879	Harvest location for Halibut
k'aat-shee	Place of bad landing	N/A	48.6381836	-124.7866211	Harvest location for Seaweed
kwaabaaduwa7	Canoe landing in front of village	Carmanah Indian Reserve No.6	48.60534128	-124.7285595	Westernmost end of the beach where it is possible to take a canoe in at any tide
lixwati7s	Big river coming out	Carmanah Creek	48.60534128	-124.7285595	Spruce roots hanging over bank were harvested from lower Carmanah Creek for making pack baskets. The lower river was also used for ritual bathing while training for spirit power; one who trained here was Joshua Edgar.
pakw'a	Crossed in front of	N/A	48.6301899	-124.7760844	Harvest location for Mallard Duck
t'aachkis		N/A	48.61268	-124.7412584	Harvest location for Seaweed

	Flat rock in front of beach				
tl'atl'aay7aa	Slippery rocks	N/A	48.6350024	-124.7804163	Harvest location for Seaweed, Fish, Chiton, Sea Urchin
ts'itkwuu	Place to lie down	N/A	48.6472494	-124.8037065	Harvest location for Kelp Greenling
waawaax7adis	Sounding/farting beach	Coal Creek Beach (south end)	48.61740882	-124.7624915	

10.3 Appendix C. Expert Reviewers and Workshop Participants

Table C1. Name and affiliation of experts who reviewed sections of the overview report through, or in advance of, the December 6, 2024 review workshop. DFO = Fisheries and Oceans Canada; ESD = Ecosystem Science Division; OSD = Ocean Sciences Division; StAR = Stock Assessment and Research Division.

Section Reviewers		
Evan Damkjar	DFO Policy & Economics	Commercial Fisheries section
Sarah Dudas	DFO Science, ESD, Marine Spatial Ecology and Analysis	Invertebrates section
Linnea Flostrand	DFO Science, StAR, Quantitative Assessment Methods	Eulachon section
Lu Guan	DFO Science, OSD, Ocean Modelling and Prediction	Oceanography and Phytoplankton sections
Tark Hamilton	Natural Resources Canada, Geological Survey of Canada	Geology section
Melissa Hennekes	DFO Science, OSD, Ocean Ecology and Biogeochemistry	Phytoplankton section
Christie McMillan	DFO Science, ESD, Aquatic Ecosystem & Marine Mammal Science	Cetacean section
Chris Rooper	DFO Science, StAR, Quantitative Assessment Methods	Pacific Herring section
Brianna Wright	DFO Science, ESD, Aquatic Ecosystem & Marine Mammal Science	Killer Whale section

Table C2. Name and affiliation of in-person and virtual participants of the December 6, 2024 review workshop. DFO = Fisheries and Oceans Canada; ESD = Ecosystem Science Division; OSD = Ocean Sciences Division; StAR = Stock Assessment and Research Division; ECCC = Environment and Climate Change Canada; PRNPR = Pacific Rim National Park Reserve.

Workshop Participants	
Katherine Bannar-Martin	DFO Science, ESD, Marine Spatial Ecology and Analysis
Janine Beckett	DFO Ecosystem Management, Oceans
Bob Bocking	LGL, Advisor to Maa-nulth Treaty Society
Krista Bohlen	Parks Canada Agency, PRNPR
Jennifer Boldt	DFO Science, ESD, Regional Ecosystem Effects on Fish and Fisheries
Holly Booker	Marine Liaison Supporting Maa-nulth Nations
Lily Burke	DFO Science, ESD, Marine Spatial Ecology and Analysis
Rianna Burnham	DFO Science, OSD, State of the Ocean
Tracy Charlie	Pacheedaht First Nation
Jonquil Crosby	Yuułuʔiłʔatḥ Government - Ucluelet First Nation
Evan Damkjar	DFO Policy and Economics
Karen Douglas	Natural Resources Canada
Caroline Fox	ECCC, Canadian Wildlife Service
Bob Gallaugher	Sports Fisheries Advisory Board
Heidi Gartner	DFO Science, ESD, Marine Spatial Ecology and Analysis

Workshop Participants	
Christine Gruman	Huu-ay-aht First Nations
Sonja Hennemen	Transport Canada
Matthias Herborg	DFO Science, ESD, Marine Spatial Ecology and Analysis
Andrea Hilborn	DFO Science, OSD, Ocean Modelling and Prediction
Larry Johnson	Huu-ay-aht First Nation/Chairman of Maa-nulth Fisheries Committee
Jeff Jones	Pacheedaht First Nation
Helen Jones	Pacheedaht First Nation
Sean MacConnachie	DFO Science, ESD, Aquatic Ecosystem & Marine Mammal Science
Daniel McClury	Pacheedaht First Nation
Kate McMillan	Canadian Parks and Wilderness Society (CPAWS)
James Mortimor	DFO Ecosystem Management, Oceans
Kevin Neary	Traditions Consulting Services
Eve Neral	Parks Canada Agency, Protected Areas Establishment Branch
Tammy Norgard	DFO Science, ESD, Marine Spatial Ecology and Analysis
Patrick O'Hara	ECCC - Canadian Wildlife Service
Beatrice Proudfoot	DFO Science, ESD, Marine Spatial Ecology and Analysis
Rhonda Reidy	ECCC, post-doctoral researcher
Carrie Robb	DFO Science, ESD, Marine Spatial Ecology and Analysis
Tetjana Ross	DFO Science, OSD, Research of Ocean Properties and Ecosystem Stressors
Akash Sastri	DFO Science, OSD, Ocean Ecology and Biogeochemistry
Paul Sieber	Ditidaht First Nation
Miranda Smith	M.C. Wright and Associates Ltd.
Chris Sporer	Pacific Halibut Management Association
Paul Tate	Ditidaht First Nation
Hilary Thorpe	Parks Canada Agency, Protected Areas Establishment Branch
Sarah Tyne	Parks Canada Agency, PRNPR
Amelia Vos	Huu-ay-aht First Nations
Derek White	Vancouver Fraser Port Authority, Echo Program
Theresa Williams	Pacific Fisheries Management Inc., representative of Commercial Trawl Fisheries
Mike Wright	M.C. Wright and Associates Ltd.
Jennifer Yakimishyn	Parks Canada Agency, PRNPR

10.4 Appendix D: Climate Change RCP 8.5 Results

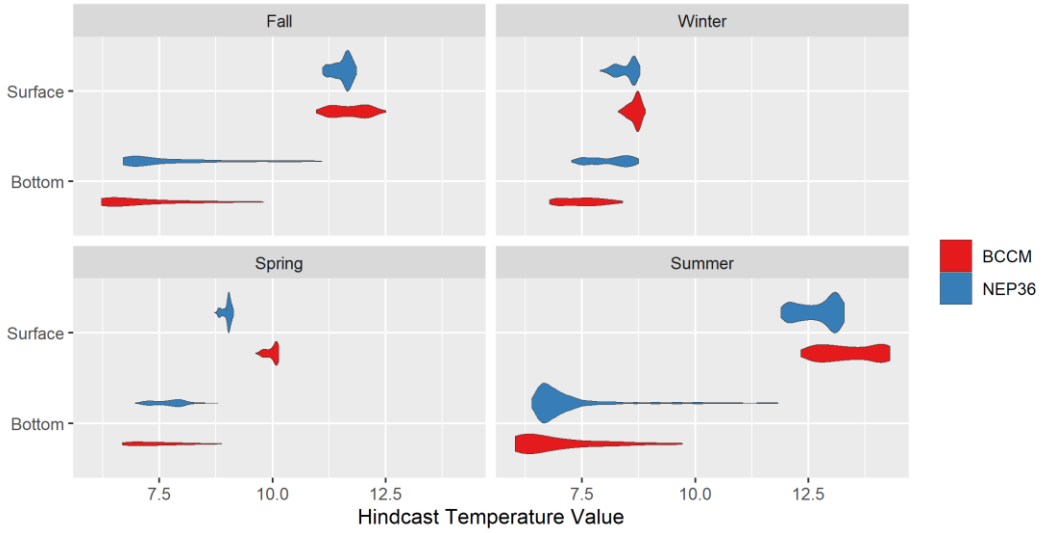


Figure D1. Violin plots of hindcast temperature values (˚C) within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The historical hindcast period is 1981-2010 for BCCM and 1986-2005 for NEP36-CanOE. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb).*

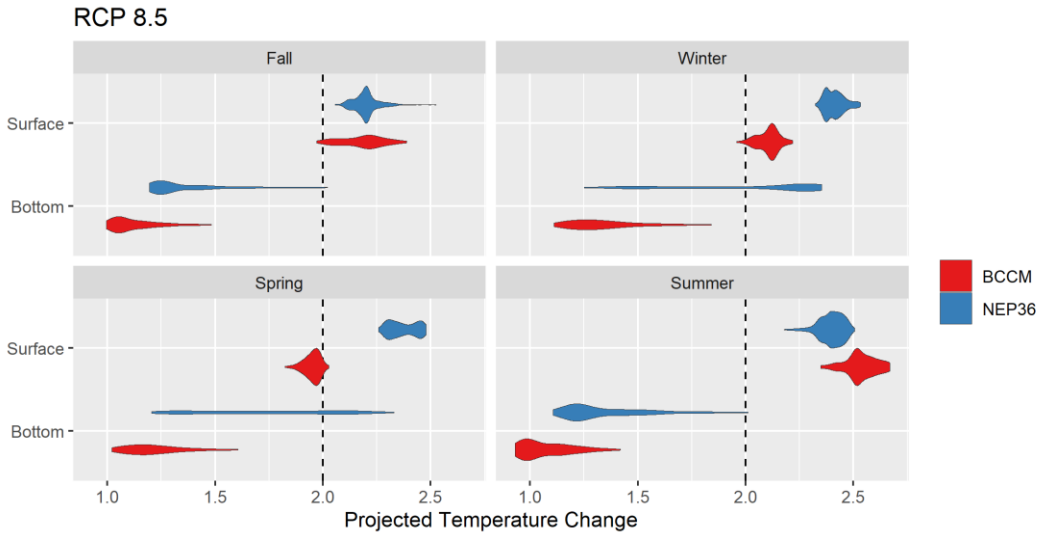


Figure D2. Violin plots of projected temperature changes (˚C) within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank Area using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The projected future period is 2041-2070 for BCCM and 2046-2065 for NEP36-CanOE under the RCP 8.5 emissions scenario in comparison to the historical period of 1981-2010 for BCCM and 1986-2005 for NEP36-CanOE. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows changes in temperature > 2˚C, a potential critical threshold value for biological functioning of marine life.*

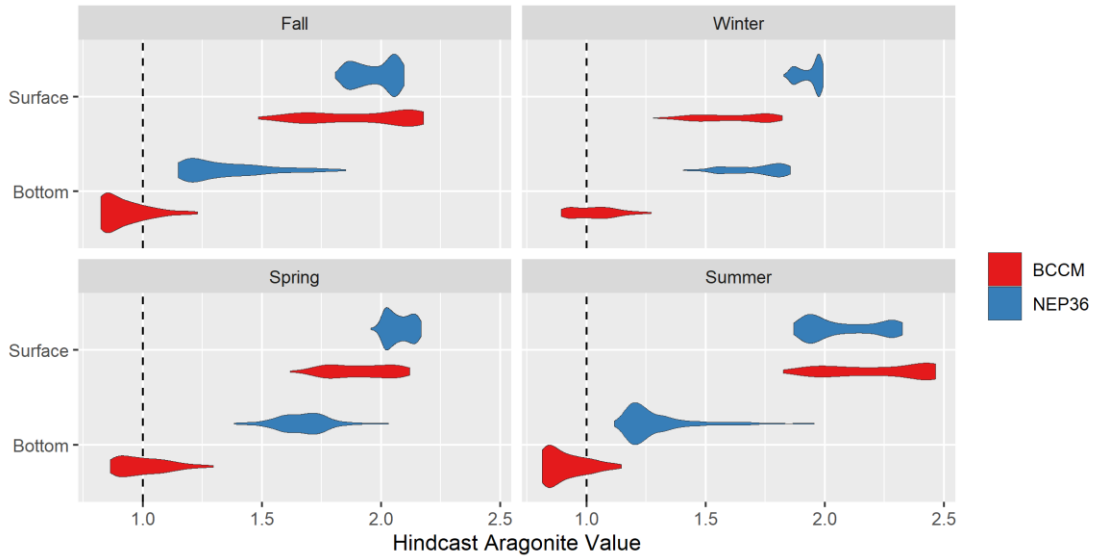


Figure D3. Violin plots of hindcast seasonal aragonite saturation states within the ***ƛ̓ušiiʔaaʔaq̓****/Swiftsure Bank Area using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The historical hindcast period is 1981-2010 for BCCM and 1986-2005 for NEP36-CanOE. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows Ωa < 1, a potential critical threshold value for biological functioning of marine life.*

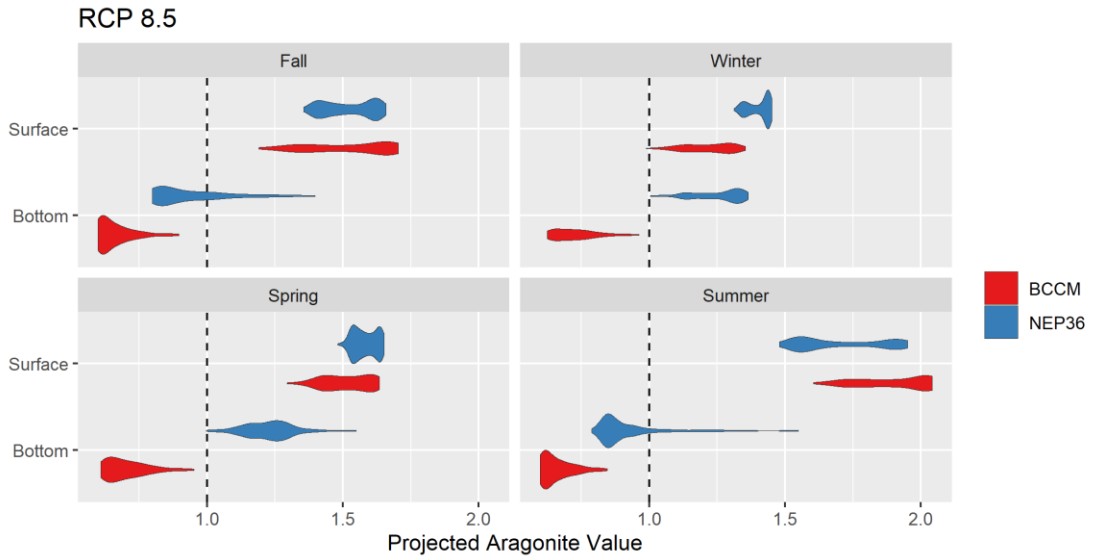


Figure D4. Violin plots of projected seasonal aragonite saturation states within the ***ƛ̓ušiiʔaaʔaq̓****/Swiftsure Bank Area using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The projected future period is 2041-2070 for BCCM and 2046-2065 for NEP36-CanOE under the RCP 8.5 emissions scenario. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows Ωa < 1, a potential critical threshold value for biological functioning of marine life.*

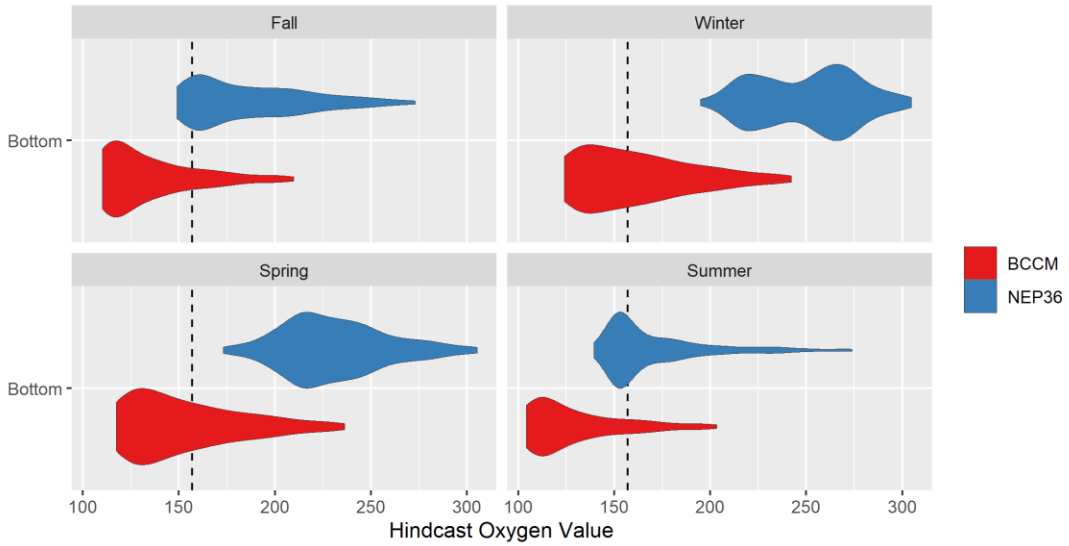


Figure D5. Violin plots of projected seasonal sea bottom dissolved oxygen (µmol/L) within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs The historical hindcast period is 1981-2010 for BCCM and 1986-2005 for NEP36-CanOE. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows dissolved oxygen < 157 µmol/L, a potential critical threshold value for biological functioning of marine life.*

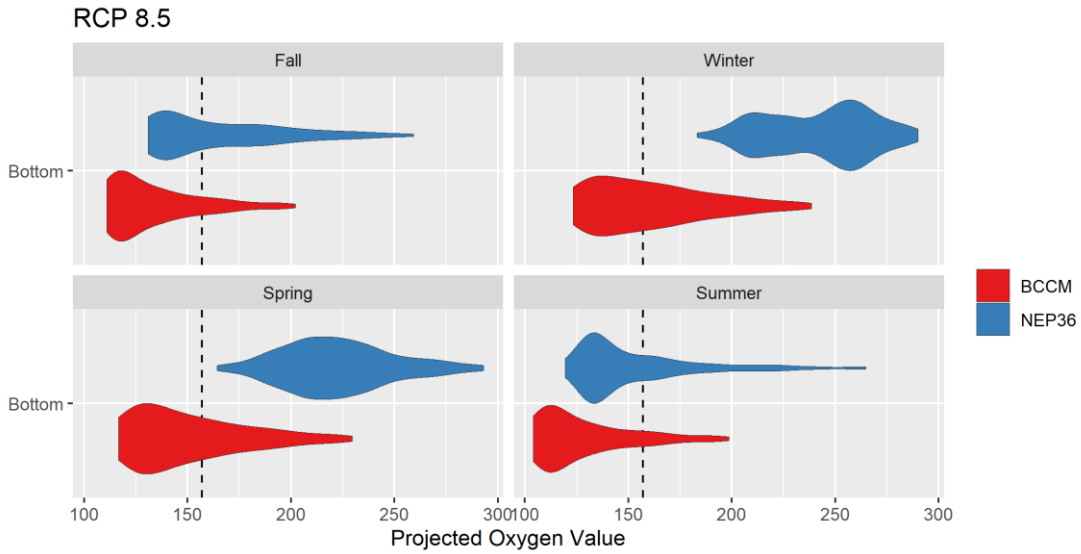


Figure D6. Violin plots of projected seasonal sea bottom dissolved oxygen (µmol/L) within the ***ƛ̓ušiiʔaaʔaq****/Swiftsure Bank using BCCM (Peña et al. 2019; in red) and NEP36-CanOE (Holdsworth et al. 2021; in blue) regional ocean model outputs. The projected future period is 2041-2070 for BCCM and 2046-2065 for NEP36-CanOE under the RCP 8.5 emissions scenario. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). The vertical dotted line shows dissolved oxygen < 157 µmol/L, a potential critical threshold value for biological functioning of marine life.*

10.5 Appendix E: Commercial Fishery Analysis

This section is adopted from the Data Sources section in Appendix A of Compendium 3 of the MPA Network Action Plan for the Northern Shelf Bioregion (MPA Network BC Northern Shelf Initiative 2023). Below are more details regarding the analyses of the commercial logbook data to support the description of commercial fishing activity in the **ƛ̓ušiiʔaaʔaq̓**/Swiftsure Bank area.

Table E1. Fishing types and date ranges uses in commercial fishery analysis.

Gears	Fishery	Year Range/ data format	Reason for year range
Trawl	Groundfish	5 years (2017 – 2021) Fishing event lines and points	Most recently available. Shorter period to recent fisher responses to quota choke species.
	Shrimp	10 years (2012 – 2021) Fishing event points	Most recently available.
Hook and line	Groundfish	5 years (2017 – 2021) Fishing event lines and points	Most recently available. Shorter period to recent fisher responses to quota choke species.
	Halibut		
	Lingcod		
	Rockfish		
Gillnet	Coho salmon	10 years (2012 – 2021) Pacific Fisheries Management subarea species harvest totals as polygons, RCAs removed for troll.	Most recently available. Captures multiple harvest cycles of stocks.
	Pink salmon		
	Sockeye salmon		
Seine	Pink salmon	10 years (2012 – 2021) Pacific Fisheries Management subarea species harvest totals as polygons, RCAs removed for troll.	Most recently available. Captures multiple harvest cycles of stocks.
Other	Sea Cucumber dive	9 years (2013 – 2021) Fishing event points	Most recently available Captures 3 complete harvest rotation.
	Red Sea Urchin dive		
	Geoduck dive		
	Herring Roe seine	5 years (2017 – 2021)	Most recently available. Shorter period to reflect changing balance of Swiftsure Bank vs rest of coast herring harvests.
	Prawn trap	10 years (2012 – 2021)	Most recently available.
	crab trap	10 years (2012 – 2021)	Most recently available.

Some small, experimental, and historic fisheries were also analyzed, but those results are not presented due to the negligible amount of overlap with this area, and privacy concerns. Such fisheries include, euphausiid trawl, scallop trawl, dogfish (in recent years), and octopus dive.

Methods – Overlap analysis

The first step of the analysis is a Geographic Information Systems (GIS) mapping exercise to overlap and assess the spatial relationship between all fishery events and fishing areas, within the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank boundaries (based on the Juan de Fuca Eddy EBSA polygon).

The fisheries with points and lines (shellfish and groundfish) are loaded into the R scripts and compared directly to the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank area. A random duplication check is done, ensuring that each fishing event only be selected once. Results represent the current estimated total amount of fishing activity that directly overlaps **ƛ̓ušiiʔaaʔaq** for shellfish and groundfish fisheries.

A fishery-specific buffer is then applied to each feature (point, line, polygon) to ensure that all features that may overlap the planning space are included. The buffers are to account for recording Global Positioning System (GPS) drift (the 'drift' is the difference between an actual location and the location recorded by a GPS receiver - this is a natural occurrence with any GPS hardware and software) and recording ambiguity (e.g., where a kilometre-long shrimp trawl event is represented by a point when it should be a line), as well as gear drift (in-direct harvesting gear movement activity).

A suite of fishery specific buffers, presented below in Table A2, were developed in April 2021. Initial review with fisheries managers, regional Oceans Advisory Committee (OAC) members from the MPA Network planning process in the Northern Shelf Bioregion (MPA Network BC Northern Shelf Initiative 2023), and commercial fishing sector representatives was conducted, with further discussion to refine buffers to occur.

Table E2. Spatial buffers applied to each fishery (m).

Fishery	Selection Buffer (M)	Application Notes
Groundfish trawls – Line segment	500	Assess how much of each event overlaps proposed MPA Network, account for point recording inaccuracies.
Groundfish hook & line – Line segment	500 /750 for Halibut	Assess how much of each event overlaps proposed MPA Network, account for point recording inaccuracies. 750m halibut from industry advice to account for max drift in outside sites.
Salmon	n/a	Moved away from grid process, buffer no longer applicable due to subarea method.
Herring	500	Ensure to get grid cells (PUIDs) that are just outside of a given area.
Dive shellfish – points	500	Account for point recording inaccuracies.
Other shellfish – points	1080	Max gear drift and length from start to end of gear deployment.
Crab	2500	Logbooks are ambiguous to a large degree, to be supplemented with Electronic Monitoring Systems.

Salmon logbooks are recorded at the Pacific Fisheries Management Area (PFMA) subarea level, and do not have point or line geometry. To assess the amount of overlap from these fisheries, the percentage of the overlap the **ƛ̓ušiiʔaaʔaq**/Swiftsure Bank area has with each subarea is calculated and then applied to the harvest records in those given areas. It assumes a flat or even distribution, which is not a perfect representation of where harvest actually occurs

but is a reasonable extraction from the logbook data. Confirming exactly where activity may occur is more easily addressed as part of zone-level implementation processes.

Rockfish Conservation Areas (RCAs) currently already restrict salmon troll activity, with subarea harvest for that fishery applied evenly throughout the subarea, mirroring the process for salmon after cutting out any area that is part of an RCA.

The main measures are the landed weight of species (kilograms).

References

MPA Network BC Northern Shelf Initiative (2023). Network Action Plan – Compendium 3: Socio-Economic Overview of the Northern Shelf Bioregion. Access at: https://mpanetwork.ca/wp-content/uploads/2022/11/NAP-Compendium-3-web.pdf

10.6 Appendix F: Taxonomic Diversity Table

Reference: Global Biodiversity Information Facility (GBIF). 2025. Accessible at: http://gbif.org

Table G1. Plant and phytoplankton species and data sources mentioned in the overview report. GBIF = Global Biodiversity Information Facility (http://gbif.org).

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Phaeophyceae	Canopy-forming kelps	Bull Kelp	*Nereocystis leutkeana*		X	
Vascular plant	Eelgrass and surfgrass	Dwarf Eelgrass	*Zostera japonica*		X	
Vascular plant	Eelgrass and surfgrass	Eelgrass	*Zostera marina*		X	X
Vascular plant	Eelgrass and surfgrass	Surfgrass	*Phyllospadix* sp.		X	
Phaeophyceae	Other marine macroalgae	Southern Stiff-stiped Kelp	*Laminaria setchelii*		X	
Phaeophyceae	Other marine macroalgae	Suction-Cup Kelp	*Laminaria yeozensis*		X	
Phaeophyceae	Other marine macroalgae	Sugar Kelp	*Saccharina latissima*		X	X
Phaeophyceae	Other marine macroalgae	Woody Stalked Kelp	*Pterygophora californica*	X	X	X
Phaeophyceae	Other marine macroalgae		*Cystoseira* spp.		X	
Phaeophyceae	Other marine macroalgae		*Laminaria longipes*		X	
Phaeophyceae	Other marine macroalgae		*Lessoniopsis littoralis*		X	X
Phaeophyceae	Other marine macroalgae		*Sargassum muticum*		X	X
Prymnesiophyceae	Phytoplankton taxonomy		*Corymbellus aureus*		X	
Dinophyceae	Phytoplankton taxonomy		*Alexandrium spp.*		X	
Dictyochophyceae	Phytoplankton taxonomy		*Apedinella spinifera*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Chaetoceros cf. danicus*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Chaetoceros debilis*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Chaetoceros socialis*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Chaetoceros spp. (hyalochaete)*		X	
Dinophyceae	Phytoplankton taxonomy		*Dinophysis acuminata*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Ditylum brightwellii*		X	X
Bacillariophyceae	Phytoplankton taxonomy		*Gonyaulax spinifera*		X	

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Raphidophyceae	Phytoplankton taxonomy		*Heterosigma/chattonella*		X	
Raphidophyceae	Phytoplankton taxonomy		*Heterosigma akashiwo*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Myrionecta rubra*		X	
Prymnesiophyceae	Phytoplankton taxonomy		*Phaeocystis cf. globosa*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Pseudo-nitzschia australis*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Pseudo-nitzschia cf. delicatissima*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Pseudo-nitzschia cf. pseudodelicatissima*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Pseudo-nitzschia cuspidata*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Pseudo-nitzschia multiseries*		X	
Bacillariophyceae	Phytoplankton taxonomy		*Pseudo-nitzschia* spp.		X	
Bacillariophyceae	Phytoplankton taxonomy		*Skeletonema costatum/marinoi*		X	X

Table G2. Additional plant and phytoplankton species reported in the ***ƛ̓ušiiʔaaʔaq*** */Swiftsure Bank Area from the Global Biodiversity Information Facility (GBIF).*

Class	Scientific Name
Bacillariophyceae	*Asterionella glacialis*
Bacillariophyceae	*Corethron hystrix*
Bacillariophyceae	*Coscinodiscus concinnus*
Bacillariophyceae	*Coscinodiscus wailesii*
Bacillariophyceae	*Cylindrotheca closterium*
Bacillariophyceae	*Lauderia annulata*
Bacillariophyceae	*Navicula comoides*
Bacillariophyceae	*Neodenticula seminae*
Bacillariophyceae	*Odontella aurita*
Bacillariophyceae	*Paralia sulcata*
Bacillariophyceae	*Podosira stelligera*
Bacillariophyceae	*Proboscia alata*
Bacillariophyceae	*Proboscia inermis*
Bacillariophyceae	*Pseudo-nitzschia delicatissima*
Bacillariophyceae	*Pseudo-nitzschia seriata*
Bacillariophyceae	*Pseudosolenia calcar-avis*
Bacillariophyceae	*Rhizosolenia styliformis*
Bacillariophyceae	*Sundstroemia setigera*
Bacillariophyceae	*Tabularia fasciculata*
Bacillariophyceae	*Thalassionema nitzschioides*
Bacillariophyceae	*Thalassiothrix longissima*
Bacillariophyceae	*Zygoceros rhombus*
Bangiophyceae	*Bangia fuscopurpurea*
Bangiophyceae	*Neoporphyra perforata*
Bangiophyceae	*Porphyra abbottae*
Bangiophyceae	*Porphyra kanakaensis*
Bangiophyceae	*Porphyra pseudolanceolata*
Bangiophyceae	*Porphyra schizophylla*
Bangiophyceae	*Porphyra smithii*
Bangiophyceae	*Porphyra variegata*
Bangiophyceae	*Pyropia kanakaensis*
Bangiophyceae	*Pyropia nereocystis*
Bangiophyceae	*Pyropia perforata*
Bangiophyceae	*Pyropia pulchella*
Bangiophyceae	*Pyropia smithii*
Bangiophyceae	*Wildemania amplissima*
Bangiophyceae	*Wildemania miniata*
Bangiophyceae	*Wildemania occidentalis*
Compsopogonophyceae	*Smithora naiadum*
Dinophyceae	*Adenoides eludens*
Dinophyceae	*Ceratium pentagonum*
Dinophyceae	*Symbiodinium microadriaticum*
Dinophyceae	*Tripos brevis*
Dinophyceae	*Tripos furca*
Dinophyceae	*Tripos fusus*
Dinophyceae	*Tripos lineatus*
Dinophyceae	*Tripos muelleri*
Florideophyceae	*Acrochaetium arcuatum*
Florideophyceae	*Ahnfeltia fastigiata*
Florideophyceae	*Ahnfeltia gigartinoides*
Florideophyceae	*Ahnfeltia plicata*
Florideophyceae	*Ahnfeltiopsis gigartinoides*
Florideophyceae	*Ahnfeltiopsis linearis*
Florideophyceae	*Amplisiphonia pacifica*
Florideophyceae	*Antithamnion defectum*
Florideophyceae	*Antithamnionella pacifica*

Class	Scientific Name
Florideophyceae	*Besa leptophylla*
Florideophyceae	*Bossiella californica*
Florideophyceae	*Bossiella chiloensis*
Florideophyceae	*Bossiella cretacea*
Florideophyceae	*Bossiella exarticulata*
Florideophyceae	*Bossiella frondescens*
Florideophyceae	*Bossiella frondifera*
Florideophyceae	*Bossiella heteroforma*
Florideophyceae	*Bossiella plumosa*
Florideophyceae	*Bossiella schmittii*
Florideophyceae	*Botryoglossum farlowianum*
Florideophyceae	*Calliarthron tuberculosum*
Florideophyceae	*Callilithophytum parcum*
Florideophyceae	*Callithamnion pikeanum*
Florideophyceae	*Callophyllis beringensis*
Florideophyceae	*Callophyllis crenulata*
Florideophyceae	*Callophyllis edentata*
Florideophyceae	*Callophyllis flabellulata*
Florideophyceae	*Callophyllis heanophylla*
Florideophyceae	*Callophyllis marginifructa*
Florideophyceae	*Callophyllis pinnata*
Florideophyceae	*Callophyllis schneideri*
Florideophyceae	*Callophyllis thompsonii*
Florideophyceae	*Callophyllis violacea*
Florideophyceae	*Ceramium californicum*
Florideophyceae	*Ceramium codicola*
Florideophyceae	*Ceramium pacificum*
Florideophyceae	*Ceramium washingtoniense*
Florideophyceae	*Chamberlainium decipiens*
Florideophyceae	*Chiharaea americana*
Florideophyceae	*Chiharaea bodegensis*
Florideophyceae	*Chondracanthus canaliculatus*
Florideophyceae	*Chondracanthus corymbiferus*
Florideophyceae	*Chondracanthus exasperatus*
Florideophyceae	*Constantinea rosa-marina*
Florideophyceae	*Constantinea subulifera*
Florideophyceae	*Corallina officinalis*
Florideophyceae	*Corallina vancouveriensis*
Florideophyceae	*Crusticorallina muricata*
Florideophyceae	*Crusticorallina painei*
Florideophyceae	*Cryptonemia ovalifolia*
Florideophyceae	*Cryptopleura lobulifera*
Florideophyceae	*Cryptopleura ruprechtiana*
Florideophyceae	*Cryptopleura violacea*
Florideophyceae	*Cryptosiphonia woodii*
Florideophyceae	*Cumagloia andersonii*
Florideophyceae	*Cumathamnion decipiens*
Florideophyceae	*Delesseria decipiens*
Florideophyceae	*Devaleraea mollis*
Florideophyceae	*Dilsea californica*
Florideophyceae	*Dilsea pygmaea*
Florideophyceae	*Endocladia muricata*
Florideophyceae	*Erythrophyllum delesserioides*
Florideophyceae	*Erythrophyllum oblongifructum*
Florideophyceae	*Erythrophyllum wynnei*
Florideophyceae	*Euthora timburtonii*

Class	Scientific Name
Florideophyceae	*Farlowia compressa*
Florideophyceae	*Farlowia mollis*
Florideophyceae	*Fauchea laciniata*
Florideophyceae	*Fredericqia chiton*
Florideophyceae	*Fredericqia decewii*
Florideophyceae	*Fryeella gardneri*
Florideophyceae	*Gastroclonium coulteri*
Florideophyceae	*Gelidium coulteri*
Florideophyceae	*Gelidium purpurascens*
Florideophyceae	*Gigartina agardhii*
Florideophyceae	*Gigartina corymbifera*
Florideophyceae	*Gigartina papillata*
Florideophyceae	*Gloiocladia fryeana*
Florideophyceae	*Gloiocladia laciniata*
Florideophyceae	*Gloiopeltis furcata*
Florideophyceae	*Gloiosiphonia verticillaris*
Florideophyceae	*Gonimophyllum skottsbergii*
Florideophyceae	*Gracilaria longissima*
Florideophyceae	*Gracilaria pacifica*
Florideophyceae	*Gracilariopsis andersonii*
Florideophyceae	*Grateloupia californica*
Florideophyceae	*Grateloupia doryphora*
Florideophyceae	*Grateloupia setchellii*
Florideophyceae	*Griffithsia pacifica*
Florideophyceae	*Gymnogongrus chiton*
Florideophyceae	*Halosaccion americanum*
Florideophyceae	*Halosaccion glandiforme*
Florideophyceae	*Halymenia gardneri*
Florideophyceae	*Halymenia schizymenioides*
Florideophyceae	*Herposiphonia plumula*
Florideophyceae	*Herposiphonia rigida*
Florideophyceae	*Herposiphonia verticillata*
Florideophyceae	*Hildenbrandia occidentalis*
Florideophyceae	*Hollenbergia subulata*
Florideophyceae	*Hymenena flabelligera*
Florideophyceae	*Hymenena multiloba*
Florideophyceae	*Hymenena setchellii*
Florideophyceae	*Hypnea nidifica*
Florideophyceae	*Iridaea splendens*
Florideophyceae	*Johansenia macmillanii*
Florideophyceae	*Kallymenicola penetrans*
Florideophyceae	*Kallymenicola superficialis*
Florideophyceae	*Leptofauchea pacifica*
Florideophyceae	*Lithothamnion phymatodeum*
Florideophyceae	*Lithothamnium crassiusculum*
Florideophyceae	*Lithothamnium phymatodeum*
Florideophyceae	*Mastocarpus cristatus*
Florideophyceae	*Mastocarpus jardinii*
Florideophyceae	*Mastocarpus latissimus*
Florideophyceae	*Mastocarpus pachenicus*
Florideophyceae	*Mastocarpus papillatus*
Florideophyceae	*Mastocarpus rigidus*
Florideophyceae	*Mazzaella affinis*
Florideophyceae	*Mazzaella californica*
Florideophyceae	*Mazzaella flaccida*
Florideophyceae	*Mazzaella linearis*
Florideophyceae	*Mazzaella oregona*
Florideophyceae	*Mazzaella parksii*
Florideophyceae	*Mazzaella rosea*

Class	Scientific Name
Florideophyceae	*Mazzaella sanguinea*
Florideophyceae	*Mazzaella splendens*
Florideophyceae	*Melobesia mediocris*
Florideophyceae	*Membranoptera dimorpha*
Florideophyceae	*Mesophyllum conchatum*
Florideophyceae	*Mesophyllum vancouveriense*
Florideophyceae	*Microcladia borealis*
Florideophyceae	*Microcladia coulteri*
Florideophyceae	*Nemalion elminthoides*
Florideophyceae	*Nemalion multifidum*
Florideophyceae	*Nemalion vermiculare*
Florideophyceae	*Neopolyporolithon reclinatum*
Florideophyceae	*Neoptilota asplenioides*
Florideophyceae	*Neoptilota californica*
Florideophyceae	*Neoptilota hypnoides*
Florideophyceae	*Neorhodomela larix*
Florideophyceae	*Odonthalia floccosa*
Florideophyceae	*Odonthalia kamtschatica*
Florideophyceae	*Odonthalia washingtoniensis*
Florideophyceae	*Opuntiella californica*
Florideophyceae	*Osmundea spectabilis*
Florideophyceae	*Ozophora lanceolata*
Florideophyceae	*Palmaria palmata*
Florideophyceae	*Petrocelis franciscana*
Florideophyceae	*Peyssonnelia pacifica*
Florideophyceae	*Pikea californica*
Florideophyceae	*Pikea robusta*
Florideophyceae	*Pleonosporium vancouverianum*
Florideophyceae	*Plocamium cartilagineum*
Florideophyceae	*Plocamium oregonum*
Florideophyceae	*Plocamium pacificum*
Florideophyceae	*Plocamium violaceum*
Florideophyceae	*Polyneura latissima*
Florideophyceae	*Polyneuropsis stolonifera*
Florideophyceae	*Polysiphonia hendryi*
Florideophyceae	*Polysiphonia pacifica*
Florideophyceae	*Polysiphonia paniculata*
Florideophyceae	*Polysiphonia scopulorum*
Florideophyceae	*Prionitis filiformis*
Florideophyceae	*Prionitis lanceolata*
Florideophyceae	*Prionitis lyallii*
Florideophyceae	*Prionitis sternbergii*
Florideophyceae	*Pseudogloiophloea confusa*
Florideophyceae	*Pseudolithophyllum whidbeyense*
Florideophyceae	*Pterochondria woodii*
Florideophyceae	*Pterosiphonia bipinnata*
Florideophyceae	*Pterothamnion villosum*
Florideophyceae	*Ptilota densa*
Florideophyceae	*Ptilota filicina*
Florideophyceae	*Ptilota hypnoides*
Florideophyceae	*Ptilota pseudohypnoides*
Florideophyceae	*Ptilota serrata*
Florideophyceae	*Ptilothamniopsis lejolisea*
Florideophyceae	*Pugetia fragilissima*
Florideophyceae	*Rhodochorton purpureum*
Florideophyceae	*Rhodoglossum roseum*
Florideophyceae	*Rhodomela lycopodioides*
Florideophyceae	*Rhodophysema georgei*
Florideophyceae	*Rhodoptilum plumosum*

Class	Scientific Name
Florideophyceae	*Rhodymenia bamfieldensis*
Florideophyceae	*Rhodymenia californica*
Florideophyceae	*Rhodymenia pacifica*
Florideophyceae	*Salishia sanguinea*
Florideophyceae	*Sarcodiotheca gaudichaudii*
Florideophyceae	*Savoiea robusta*
Florideophyceae	*Schizymenia pacifica*
Florideophyceae	*Schizymenia tenuis*
Florideophyceae	*Serraticardia macmillani*
Florideophyceae	*Sparlingia pertusa*
Florideophyceae	*Stenogramma rhodymenioides*
Florideophyceae	*Symphyocladiella dendroidea*
Florideophyceae	*Tiffaniella snyderae*
Liliopsida	*Phyllospadix scouleri*
Liliopsida	*Phyllospadix torreyi*
Oligohymenophorea	*Thalassomyces capillosus*
Oligotrichea	*Parafavella gigantea*
Phaeophyceae	*Alaria marginata*
Phaeophyceae	*Alaria nana*
Phaeophyceae	*Analipus japonicus*
Phaeophyceae	*Battersia racemosa*
Phaeophyceae	*Coilodesme bulligera*
Phaeophyceae	*Colpomenia peregrina*
Phaeophyceae	*Costaria costata*
Phaeophyceae	*Cymathaere triplicata*
Phaeophyceae	*Dactylosiphon bullosus*
Phaeophyceae	*Desmarestia aculeata*
Phaeophyceae	*Desmarestia ligulata*
Phaeophyceae	*Desmarestia viridis*
Phaeophyceae	*Dictyoneurum californicum*
Phaeophyceae	*Ectocarpus acutus*
Phaeophyceae	*Egregia menziesii*
Phaeophyceae	*Eisenia arborea*
Phaeophyceae	*Fucus distichus*
Phaeophyceae	*Fucus gardneri*
Phaeophyceae	*Fucus spiralis*
Phaeophyceae	*Haplogloia andersonii*
Phaeophyceae	*Hecatonema primarium*
Phaeophyceae	*Hedophyllum sessile*
Phaeophyceae	*Hesperophycus californicus*
Phaeophyceae	*Laminaria platymeris*
Phaeophyceae	*Laminaria setchellii*
Phaeophyceae	*Laminaria sinclairii*
Phaeophyceae	*Leathesia marina*
Phaeophyceae	*Macrocystis integrifolius*
Phaeophyceae	*Macrocystis pyrifera*

Class	Scientific Name
Phaeophyceae	*Melanosiphon intestinalis*
Phaeophyceae	*Microspongium globosum*
Phaeophyceae	*Myrionema phyllophilum*
Phaeophyceae	*Nereocystis luetkeana*
Phaeophyceae	*Pelvetiopsis limitata*
Phaeophyceae	*Petalonia fascia*
Phaeophyceae	*Phaeostrophion irregulare*
Phaeophyceae	*Pleurophycus gardneri*
Phaeophyceae	*Postelsia palmaeformis*
Phaeophyceae	*Postelsia palmiformis*
Phaeophyceae	*Ralfsia fungiformis*
Phaeophyceae	*Ralfsia pacifica*
Phaeophyceae	*Saundersella simplex*
Phaeophyceae	*Scytosiphon lomentaria*
Phaeophyceae	*Scytosiphon promiscuus*
Phaeophyceae	*Soranthera ulvoidea*
Phaeophyceae	*Stephanocystis geminata*
Phaeophyceae	*Stictyosiphon tortilis*
Prymnesiophyceae	*Emiliania huxleyi*
Ulvophyceae	*Acrosiphonia mertensi*
Ulvophyceae	*Acrosiphonia spinescens*
Ulvophyceae	*Bryopsis corticulans*
Ulvophyceae	*Bryopsis plumosa*
Ulvophyceae	*Cladophora albida*
Ulvophyceae	*Cladophora columbiana*
Ulvophyceae	*Cladophora hutchinsiae*
Ulvophyceae	*Cladophora laetevirens*
Ulvophyceae	*Cladophora stimpsonii*
Ulvophyceae	*Codium fragile*
Ulvophyceae	*Codium setchellii*
Ulvophyceae	*Derbesia marina*
Ulvophyceae	*Gomontia polyrhiza*
Ulvophyceae	*Kornmannia leptoderma*
Ulvophyceae	*Monostroma grevillei*
Ulvophyceae	*Spongomorpha coalita*
Ulvophyceae	*Ulva californica*
Ulvophyceae	*Ulva compressa*
Ulvophyceae	*Ulva expansa*
Ulvophyceae	*Ulva fenestrata*
Ulvophyceae	*Ulva intestinalis*
Ulvophyceae	*Ulva lactuca*
Ulvophyceae	*Ulva linza*
Ulvophyceae	*Ulva lobata*
Ulvophyceae	*Ulva prolifera*
Ulvophyceae	*Ulva stenophylla*

Table G3. Invertebrate species and data sources mentioned in the overview report. GBIF = Global Biodiversity Information Facility (http://gbif.org).

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Malacostraca	Aquatic Invasive and Non-Indigenous Species	European Green Crab	*Carcinus maenas*		X	X
Maxillopoda	Barnacles	Goose Barnacle	*Pollicipes polymerus*			X
Cephalopoda	Cephalopods	Giant Pacific Octopus	*Enteroctopus dofleini*		X	X
Cephalopoda	Cephalopods	Opal Squid	*Doryteuthis opalescens*		X	X
Cephalopoda	Cephalopods	Pacific Bobtail Squid	*Rossia pacifica*		X	X
Scyphozoa	Cnidarians	Fried Egg Jellyfish	*Phacellophora camtschatica*		X	X
Scyphozoa	Cnidarians	Lion's Mane Jellyfish	*Cyanea capillata*		X	X
Scyphozoa	Cnidarians	Moon Jellyfish	*Aurelia labiata*		X	
Scyphozoa	Cnidarians	Pacific Sea Nettle	*Chrysaora fuscescens*		X	X
Hydrozoa	Cnidarians	Water Jelly	*Aequorea* sp.		X	
Hexactinellida	Cold water corals and sponges	Boot Sponges	*Rossellidae*		X	
Hexactinellida	Cold water corals and sponges	Cloud Sponge	*Aphrocallistes vastus*		X	X
Hexacorallia	Cold water corals and sponges	Crimson Anemone	*Cribrinopsis fernaldi*		X	
Demospongiae	Cold water corals and sponges	Demosponges	*Auletta* sp.		X	
Demospongiae	Cold water corals and sponges	Demosponges	*Demospongiae*		X	
Demospongiae	Cold water corals and sponges	Demosponges	*Polymastia ap.*		X	
Hexactinellida	Cold water corals and sponges	Glass Sponges	*Hexactinellida*		X	
Hexacorallia	Cold water corals and sponges	Hard or Stony Corals/Cup Corals	*Scleractinia*	X	X	
Demospongiae	Cold water corals and sponges	Moon Sponge	*Latrunculia cf. austini*		X	
Octocorallia	Cold water corals and sponges	Orange Sea Pen	*Ptilosarcus gurneyi*		X	X
Demospongiae	Cold water corals and sponges	Plate Sponge	*Poecillastra tenuilaminaris*		X	
Octocorallia	Cold water corals and sponges	Red Gorgonian	*Swiftia* sp.		X	
Octocorallia	Cold water corals and sponges	Sea Pens	*Pennatulacea*	X	X	
Octocorallia	Cold water corals and sponges	Sea Whips	*Gorgonacea*		X	
Polychaeta	Cold water corals and sponges	Serpulid Worms	*Serpulidae*		X	
Demospongiae	Cold water corals and sponges	Velvety Red Sponge	*Ophlitaspongia pennata*		X	

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Malacostraca	Crabs	Dungeness Crab	*Metacarcinus magister*	X	X	X
Malacostraca	Crabs	Inshore Tanner crab	*Chinoecetes bairdi*		X	
Malacostraca	Crabs	Puget Sound King Crab	*Lopholithodes mandtii*		X	X
Malacostraca	Crabs	Red Rock Crab	*Cancer productus*		X	X
Ophiuroidea	Echinoderms	Basket Star	*Gorgonocephalus eucnemis*		X	X
Asteroidea	Echinoderms	Blood Star	*Henricia* sp.		X	
Ophiuroidea	Echinoderms	Brittle Stars	*Ophiuroids*		X	
Holothuroidea	Echinoderms	Giant Orange Cucumber	*Apostichopus leukothele*		X	X
Holothuroidea	Echinoderms	Giant Red Cucumber	*Apostichopus californicus*	X	X	X
Echinoidea	Echinoderms	Green Sea Urchin	*Strongylocentrotus droebachiensis*	X	X	X
Asteroidea	Echinoderms	Morning Sun Stars	*Solaster dawsoni*		X	X
Asteroidea	Echinoderms	Ochre Sea Star	*Pisaster ochraceus*		X	X
Echinoidea	Echinoderms	Orange-pink Sea Urchin	*Strongylocentrotus fragilis*		X	X
Echinoidea	Echinoderms	Purple Sea Urchin	*Strongylocentrotus purpuratus*	X		X
Echinoidea	Echinoderms	Red Sea Urchin	*Mesocentrotus franciscanus*	X		X
Asteroidea	Echinoderms	Rose Star	*Crossaster papposus*		X	X
Asteroidea	Echinoderms	Sand star	*Luidia foliolata*		X	X
Asteroidea	Echinoderms	Spiny Red Star	*Hippasteria spinosa*		X	
Asteroidea	Echinoderms	Sunflower Sea Star	*Pycnopodia helianthoides*		X	X
Asteroidea	Echinoderms	Velcro Star	*Stylasterias forreri*		X	X
Asteroidea	Echinoderms	Vermillion Star	*Mediaster aequalis*		X	X
Bivalvia	Infauna and epibenthic bivalves	California Mussel	*Mytilus californianus*			X
Bivalvia	Infauna and epibenthic bivalves	False Jingleshell	*Pododesmus macrochisma*		X	X
Bivalvia	Infauna and epibenthic bivalves	Geoduck	*Panopea generosa*	X		
Bivalvia	Infauna and epibenthic bivalves	Macoma Clam	*Macoma* sp.			
Bivalvia	Infauna and epibenthic bivalves	Pandora Clam	*Pandora glacialis*			X
Bivalvia	Infauna and epibenthic bivalves	Pandora Clam	*Pandora wardiana*			X
Bivalvia	Infauna and epibenthic bivalves	Razor Clam	*Siliqua patula*			X

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Bivalvia	Infauna and epibenthic bivalves	Rock Scallop	*Crassodoma gigantea*		X	
Bivalvia	Infauna and epibenthic bivalves	Swimming Scallops	*Chlamys* sp.		X	
Bivalvia	Infauna and epibenthic bivalves	Weathervane Scallop	*Patinopecten caurinus*		X	X
Gastropoda	Marine snails, sea slugs and chitons	Giant Gumboot Chiton	*Cryptochiton stelleri*			X
Gastropoda	Marine snails, sea slugs and chitons	Hairy Triton	*Fusitriton oregonensis*			X
Gastropoda	Marine snails, sea slugs and chitons	Leopard Dorid	*Diaulula sandiegensis*		X	X
Gastropoda	Marine snails, sea slugs and chitons	Lewis' Moon Snail	*Neverita lewisii*		X	X
Gastropoda	Marine snails, sea slugs and chitons	Mossy Chiton	*Mopalia muscosa*		X	X
Gastropoda	Marine snails, sea slugs and chitons	Northern Abalone	*Haliotis kamtschatkana*	X		X
Gastropoda	Marine snails, sea slugs and chitons	Opalescent Nudibranch	*Hermissenda crassicornis*		X	X
Gastropoda	Marine snails, sea slugs and chitons	Smooth Velvet Snail	*Velutina prolongata*		X	
Gastropoda	Marine snails, sea slugs and chitons	Top Snail	*Calliostoma* sp.		X	
Malacostraca	Shrimps and prawns	Coonstripe/Dock Shrimp	*Pandalus danae*		X	X
Malacostraca	Shrimps and prawns	Sidestripe Shrimp	*Pandalopsis dispar*		X	
Malacostraca	Shrimps and prawns	Smooth Pink Shrimp	*Pandalus jordani*		X	
Malacostraca	Shrimps and prawns	Spiny/Northern Pink Shrimp	*Pandalus borealis*		X	
Malacostraca	Shrimps and prawns	Spot Prawn	*Pandalus platyceros*		X	X
Malacostraca	Shrimps and prawns	Rough Patch Shrimp	*Pandalus stenolepis*		X	X
Malacostraca	Shrimps and prawns	Yellowleg Pandalid	*Pandalus tridens*		X	X
Calenoida	Zooplankton	Calanoid Copepods	*Calanus marshallae*		X	X
Calenoida	Zooplankton	Calanoid Copepods	*Pseudocalanus* spp.		X	
Crustaceans	Zooplankton	Crustacean Zooplankton			X	X
Euphausiacea	Zooplankton	Euphausiids	*Euphausia pacifica*		X	X
Euphausiacea	Zooplankton	Euphausiids	*Thysannoessa spinifera*		X	

Table G4. Additional invertebrate species reported in the ***ƛ̓ušiiʔaaʔaq*** */Swiftsure Bank Area from the Global Biodiversity Information Facility (GBIF).*

Class	Scientific Name
Allomalorhagida	*Pycnophyes ilyocryptus*
Anthozoa	*Anthopleura artemisia*
Anthozoa	*Anthopleura elegantissima*
Anthozoa	*Anthopleura xanthogrammica*
Anthozoa	*Aulactinia incubans*
Anthozoa	*Balanophyllia elegans*
Anthozoa	*Balticina californica*
Anthozoa	*Balticina willemoesi*
Anthozoa	*Callistephanus spauldingi*
Anthozoa	*Caryophyllia arnoldi*
Anthozoa	*Chromoplexaura marki*
Anthozoa	*Cribrinopsis albopunctata*
Anthozoa	*Discophyton rudyi*
Anthozoa	*Epiactis lisbethae*
Anthozoa	*Epiactis prolifera*
Anthozoa	*Epiactis ritteri*
Anthozoa	*Epizoanthus scotinus*
Anthozoa	*Halcampa decemtentaculata*
Anthozoa	*Leptogorgia caryi*
Anthozoa	*Leptogorgia chilensis*
Anthozoa	*Metridium farcimen*
Anthozoa	*Metridium senile*
Anthozoa	*Paracyathus stearnsii*
Anthozoa	*Paragorgia arborea*
Anthozoa	*Paragorgia stephencairnsi*
Anthozoa	*Swiftia torreyi*
Anthozoa	*Thrombophyton trachydermum*
Anthozoa	*Urticina clandestina*
Anthozoa	*Urticina coriacea*
Anthozoa	*Urticina eques*
Anthozoa	*Urticina felina*
Anthozoa	*Urticina grebelnyi*
Anthozoa	*Urticina piscivora*
Asteroidea	*Patiria miniata*
Asteroidea	*Orthasterias koehleri*
Asteroidea	*Ceramaster patagonicus*
Asteroidea	*Ctenodiscus crispatus*
Asteroidea	*Dermasterias imbricata*
Asteroidea	*Evasterias troschelii*
Asteroidea	*Henricia aspera*
Asteroidea	*Henricia leviuscula*
Asteroidea	*Henricia pumila*
Asteroidea	*Heterozonias alternatus*
Asteroidea	*Hippasteria californica*
Asteroidea	*Hippasteria phrygiana*
Asteroidea	*Leptasterias hexactis*
Asteroidea	*Leptychaster anomalus*
Asteroidea	*Odontohenricia fisheri*
Asteroidea	*Pisaster brevispinus*
Asteroidea	*Poraniopsis inflata*
Asteroidea	*Pteraster tesselatus*
Asteroidea	*Solaster endeca*
Asteroidea	*Solaster paxillatus*
Asteroidea	*Solaster stimpsoni*
Bivalvia	*Acila castrensis*
Bivalvia	*Adula californiensis*

Class	Scientific Name
Bivalvia	*Austroneaera coanscotti*
Bivalvia	*Bankia setacea*
Bivalvia	*Chlamys hastata*
Bivalvia	*Chlamys rubida*
Bivalvia	*Ciliatocardium ciliatum*
Bivalvia	*Clinocardium nuttallii*
Bivalvia	*Coanicardita ventricosa*
Bivalvia	*Compsomyax subdiaphana*
Bivalvia	*Crassadoma gigantea*
Bivalvia	*Cyclocardia gouldii*
Bivalvia	*Entodesma navicula*
Bivalvia	*Glycymeris septentrionalis*
Bivalvia	*Hiatella arctica*
Bivalvia	*Keenaea centifilosa*
Bivalvia	*Kellia laperousii*
Bivalvia	*Leukoma laciniata*
Bivalvia	*Leukoma staminea*
Bivalvia	*Lucinoma annulata*
Bivalvia	*Macoma balthica*
Bivalvia	*Macoma calcarea*
Bivalvia	*Macoma elimata*
Bivalvia	*Macoma inquinata*
Bivalvia	*Macoma lipara*
Bivalvia	*Macoma nasuta*
Bivalvia	*Megayoldia thraciaeformis*
Bivalvia	*Modiolus modiolus*
Bivalvia	*Modiolus rectus*
Bivalvia	*Mya arenaria*
Bivalvia	*Mytilus edulis*
Bivalvia	*Mytilus galloprovincialis*
Bivalvia	*Mytilus trossulus*
Bivalvia	*Nutricola lordi*
Bivalvia	*Nuttallia obscurata*
Bivalvia	*Ostrea lurida*
Bivalvia	*Pandora filosa*
Bivalvia	*Penitella conradi*
Bivalvia	*Penitella penita*
Bivalvia	*Petrasma pervernicosa*
Bivalvia	*Petricola carditoides*
Bivalvia	*Pseudocadella nuculoides*
Bivalvia	*Ruditapes philippinarum*
Bivalvia	*Saccella taphria*
Bivalvia	*Saxidomus gigantea*
Bivalvia	*Saxidomus nuttalli*
Bivalvia	*Solemya dalli*
Bivalvia	*Tellina tenella*
Bivalvia	*Thracia condoni*
Bivalvia	*Thracia curta*
Bivalvia	*Tresus allomyax*
Bivalvia	*Tresus capax*
Bivalvia	*Tresus nuttallii*
Bivalvia	*Waldo arthuri*
Bivalvia	*Xylophaga washingtona*
Bivalvia	*Yoldia aeolica*
Bivalvia	*Yoldia hyperborea*
Bivalvia	*Yoldia myalis*

Class	Scientific Name
Bivalvia	*Zirfaea pilsbryi*
Calcarea	*Leucosolenia eleanor*
Cephalopoda	*Berryteuthis magister*
Cephalopoda	*Dosidicus gigas*
Cephalopoda	*Gonatus onyx*
Cephalopoda	*Muusoctopus leioderma*
Cephalopoda	*Nautilus alabamensis*
Cephalopoda	*Nautilus cookana*
Cephalopoda	*Octopus rubescens*
Clitellata	*Limnodriloides barnardi*
Clitellata	*Limnodriloides victoriensis*
Clitellata	*Nootkadrilus gracilisetosus*
Clitellata	*Ostreobdella papillata*
Clitellata	*Tectidrilus diversus*
Copepoda	*Acartia longiremis*
Copepoda	*Acartia tonsa*
Copepoda	*Bathycalanus richardi*
Copepoda	*Calanus pacificus*
Copepoda	*Centropages abdominalis*
Copepoda	*Epilabidocera longipedata*
Copepoda	*Eucalanus bungii*
Copepoda	*Haplostomella oceanica*
Copepoda	*Lepeophtheirus salmonis*
Copepoda	*Metridia pacifica*
Copepoda	*Neocalanus plumchrus*
Copepoda	*Schistobrachia tertia*
Copepoda	*Tortanus discaudatus*
Copepoda	*Triconia derivata*
Copepoda	*Triconia redacta*
Crinoidea	*Florometra serratissima*
Demospongiae	*Amphilectus digitatus*
Demospongiae	*Antho graceae*
Demospongiae	*Antho illgi*
Demospongiae	*Chalinula ecbasis*
Demospongiae	*Clathria pennata*
Demospongiae	*Cliona californiana*
Demospongiae	*Craniella spinosa*
Demospongiae	*Craniella villosa*
Demospongiae	*Halichondria panicea*
Demospongiae	*Haliclona cinerea*
Demospongiae	*Haliclona edaphus*
Demospongiae	*Haliclona gellindra*
Demospongiae	*Haliclona gracilis*
Demospongiae	*Homaxinella amphispicula*
Demospongiae	*Hymeniacidon ungodon*
Demospongiae	*Isodictya rigida*
Demospongiae	*Lissodendoryx barkleyensis*
Demospongiae	*Lissodendoryx firma*
Demospongiae	*Mycale adhaerens*
Demospongiae	*Mycale bamfieldensis*
Demospongiae	*Mycale psila*
Demospongiae	*Mycale richardsoni*
Demospongiae	*Myxilla incrustans*
Demospongiae	*Neopetrosia vanilla*
Demospongiae	*Plocamionida lyoni*
Demospongiae	*Polymastia pachymastia*
Demospongiae	*Suberites latus*
Demospongiae	*Tethya californiana*
Echinoidea	*Brisaster latifrons*

Class	Scientific Name
Echinoidea	*Dendraster excentricus*
Echinoidea	*Strongylocentrotus pallidus*
Enteropneusta	*Harrimania planktophilus*
Gastropoda	*Cryptonatica affinis*
Gastropoda	*Tegula funebralis*
Gastropoda	*Lirabuccinum dirum*
Gastropoda	*Doris odhneri*
Gastropoda	*Tonicella lineata*
Gastropoda	*Doris montereyensis*
Gastropoda	*Nucella ostrina*
Gastropoda	*Lottia digitalis*
Gastropoda	*Diodora aspera*
Gastropoda	*Diaulula odonoghuei*
Gastropoda	*Acanthodoris hudsoni*
Gastropoda	*Acanthodoris nanaimoensis*
Gastropoda	*Acmaea mitra*
Gastropoda	*Admete viridula*
Gastropoda	*Aldisa sanguinea*
Gastropoda	*Alia carinata*
Gastropoda	*Alvania compacta*
Gastropoda	*Amphissa columbiana*
Gastropoda	*Amphissa reticulata*
Gastropoda	*Antiopella fusca*
Gastropoda	*Antiplanes thalaea*
Gastropoda	*Antiplanes voyi*
Gastropoda	*Ariolimax columbianus*
Gastropoda	*Armina californica*
Gastropoda	*Barleeia subtenuis*
Gastropoda	*Bathybembix bairdii*
Gastropoda	*Boreotrophon disparilis*
Gastropoda	*Boreotrophon multicostatus*
Gastropoda	*Buccinum strigillatum*
Gastropoda	*Cadlina luteomarginata*
Gastropoda	*Caecum dextroversum*
Gastropoda	*Caesia fossata*
Gastropoda	*Calinaticina oldroydii*
Gastropoda	*Callianax alectona*
Gastropoda	*Callianax biplicata*
Gastropoda	*Calliostoma annulatum*
Gastropoda	*Calliostoma costatum*
Gastropoda	*Calliostoma ligatum*
Gastropoda	*Calliostoma variegatum*
Gastropoda	*Catriona columbiana*
Gastropoda	*Ceratostoma foliatum*
Gastropoda	*Cerithiopsis columna*
Gastropoda	*Cidarina cidaris*
Gastropoda	*Corolla spectabilis*
Gastropoda	*Coryphella trilineata*
Gastropoda	*Coryphella trophina*
Gastropoda	*Coryphella verrucosa*
Gastropoda	*Crepidula adunca*
Gastropoda	*Crepidula lessonii*
Gastropoda	*Crepidula nummaria*
Gastropoda	*Crepidula perforans*
Gastropoda	*Cuthona divae*
Gastropoda	*Dendronotus albus*
Gastropoda	*Diaphoreolis flavovulta*
Gastropoda	*Dirona albolineata*
Gastropoda	*Dirona pellucida*

Class	Scientific Name
Gastropoda	*Discurria insessa*
Gastropoda	*Epitonium indianorum*
Gastropoda	*Epitonium tinctum*
Gastropoda	*Eulithidium pulloides*
Gastropoda	*Euspira pallida*
Gastropoda	*Fissurellidea bimaculata*
Gastropoda	*Flabellinopsis iodinea*
Gastropoda	*Geitodoris heathi*
Gastropoda	*Gigahomalopoma carpenteri*
Gastropoda	*Gigahomalopoma luridum*
Gastropoda	*Halistylus pupoideus*
Gastropoda	*Haminoea vesicula*
Gastropoda	*Hipponix cranioides*
Gastropoda	*Lacuna marmorata*
Gastropoda	*Lacuna porrecta*
Gastropoda	*Lacuna variegata*
Gastropoda	*Lacuna vincta*
Gastropoda	*Latisipho hallii*
Gastropoda	*Latisipho ritteri*
Gastropoda	*Lepeta concentrica*
Gastropoda	*Limacia cockerelli*
Gastropoda	*Limneria prolongata*
Gastropoda	*Lirobittium attenuatum*
Gastropoda	*Lirobittium munitum*
Gastropoda	*Lirularia lirulata*
Gastropoda	*Lirularia parcipicta*
Gastropoda	*Lirularia succincta*
Gastropoda	*Littorina scutulata*
Gastropoda	*Littorina sitkana*
Gastropoda	*Littorina subrotundata*
Gastropoda	*Lottia fenestrata*
Gastropoda	*Lottia gigantea*
Gastropoda	*Lottia instabilis*
Gastropoda	*Lottia paradigitalis*
Gastropoda	*Lottia pelta*
Gastropoda	*Lottia persona*
Gastropoda	*Lottia scutum*
Gastropoda	*Lottia triangularis*
Gastropoda	*Margarites pupillus*
Gastropoda	*Marsenina rhombica*
Gastropoda	*Marsenina zadei*
Gastropoda	*Melanochlamys diomedea*
Gastropoda	*Melibe leonina*
Gastropoda	*Minolia peramabilis*
Gastropoda	*Mitrella gausapata*
Gastropoda	*Nassarius mendicus*
Gastropoda	*Neadmete unalashkensis*
Gastropoda	*Neostylidium eschrichtii*
Gastropoda	*Neptunea heros*
Gastropoda	*Neptunea ithia*
Gastropoda	*Neptunea phoenicea*
Gastropoda	*Neptunea stilesi*
Gastropoda	*Neptunea tabulata*
Gastropoda	*Niveotectura pallida*
Gastropoda	*Nucella analoga*
Gastropoda	*Nucella canaliculata*
Gastropoda	*Nucella emarginata*
Gastropoda	*Nucella lamellosa*
Gastropoda	*Odostomia satura*

Class	Scientific Name
Gastropoda	*Oenopota levidensis*
Gastropoda	*Oenopota tabulata*
Gastropoda	*Onchidella carpenteri*
Gastropoda	*Onoba carpenteri*
Gastropoda	*Opalia wroblewskyi*
Gastropoda	*Paciocinebrina interfossa*
Gastropoda	*Paciocinebrina lurida*
Gastropoda	*Peltodoris lentiginosa*
Gastropoda	*Peltodoris nobilis*
Gastropoda	*Phyllaplysia taylori*
Gastropoda	*Pomaulax gibberosus*
Gastropoda	*Puncturella cucullata*
Gastropoda	*Puncturella galeata*
Gastropoda	*Rostanga pulchra*
Gastropoda	*Scabrotrophon stuarti*
Gastropoda	*Siphonaria thersites*
Gastropoda	*Tegula pulligo*
Gastropoda	*Testudinalia testudinalis*
Gastropoda	*Tochuina gigantea*
Gastropoda	*Trichotropis cancellata*
Gastropoda	*Triopha catalinae*
Gastropoda	*Triopha modesta*
Gastropoda	*Tritonia diomedea (Tochuina gigantea)*
Gastropoda	*Tritonia tetraquetra*
Gymnolaemata	*Celleporina robertsoniae*
Gymnolaemata	*Dendrobeania murrayana*
Gymnolaemata	*Flustrellidra corniculata*
Gymnolaemata	*Leieschara coarctata*
Gymnolaemata	*Membranipora membranacea*
Gymnolaemata	*Phidolopora pacifica*
Gymnolaemata	*Primavelans insculpta*
Hexactinellida	*Acanthascus solidus*
Hexactinellida	*Heterochone calyx*
Hexactinellida	*Rhabdocalyptus dawsoni*
Holothuroidea	*Cucumaria miniata*
Holothuroidea	*Cucumaria pallida*
Holothuroidea	*Cucumaria piperata*
Holothuroidea	*Cucumaria pseudocurata*
Holothuroidea	*Eupentacta quinquesemita*
Holothuroidea	*Molpadia intermedia*
Holothuroidea	*Pentamera calcigera*
Holothuroidea	*Pentamera populifera*
Holothuroidea	*Pentamera pseudocalcigera*
Holothuroidea	*Pseudocnus lubricus*
Holothuroidea	*Psolidium bidiscum*
Holothuroidea	*Psolus chitonoides*
Holothuroidea	*Thyone benti*
Holothuroidea	*Thyonidium kurilensis*
Hydrozoa	*Abietinaria traski*
Hydrozoa	*Abietinaria variabilis*
Hydrozoa	*Aequorea victoria*
Hydrozoa	*Aglaophenia diegensis*
Hydrozoa	*Bonneviella regia*
Hydrozoa	*Chelophyes appendiculata*
Hydrozoa	*Dictyocladium flabellum*
Hydrozoa	*Ectopleura marina*
Hydrozoa	*Halecium halecinum*
Hydrozoa	*Mitrocoma cellularia*
Hydrozoa	*Nemertesia antennina*

Class	Scientific Name

Class	Scientific Name

Hydrozoa	Polyorchis penicillatus
Hydrozoa	Rhizocaulus verticillatus
Hydrozoa	Sertularella tanneri
Hydrozoa	Sertularia fabricii
Hydrozoa	Sertularia robusta
Hydrozoa	Stomotoca atra
Hydrozoa	Stylantheca papillosa
Hydrozoa	Stylaster venustus
Hydrozoa	Thuiaria thuja
Hydrozoa	Velella velella
Malacostraca	Lopholithodes foraminatus
Malacostraca	Alienacanthomysis macropsis
Malacostraca	Acantholithodes hispidus
Malacostraca	Alatajassa similis
Malacostraca	Alloniscus mirabilis
Malacostraca	Americhelidium rectipalmum
Malacostraca	Americhelidium shoemakeri
Malacostraca	Americorophium brevis
Malacostraca	Americorophium salmonis
Malacostraca	Americorophium spinicorne
Malacostraca	Ampelisca brevisimulata
Malacostraca	Ampelisca pugetica
Malacostraca	Ampithoe dalli
Malacostraca	Ampithoe lacertosa
Malacostraca	Anisogammarus slatteryi
Malacostraca	Aoroides inermis
Malacostraca	Aoroides intermedius
Malacostraca	Apolochus litoralis
Malacostraca	Archaeomysis grebnitzkii
Malacostraca	Argeia pugettensis
Malacostraca	Argis alaskensis
Malacostraca	Argis dentata
Malacostraca	Argis lar
Malacostraca	Bathycopea daltonae
Malacostraca	Bopyroides hippolytes
Malacostraca	Caprella californica
Malacostraca	Caprella equilibra
Malacostraca	Caprella laeviuscula
Malacostraca	Caprella penantis
Malacostraca	Caprella verrucosa
Malacostraca	Carinonajna bicarinata
Malacostraca	Carinonajna bispinosa
Malacostraca	Carinonajna carli
Malacostraca	Chionoecetes bairdi
Malacostraca	Chondrochelia dubia
Malacostraca	Chorilia longipes
Malacostraca	Chromopleustes lineatus
Malacostraca	Chromopleustes oculatus
Malacostraca	Cirolana harfordi
Malacostraca	Crangon alaskensis
Malacostraca	Crangon alba
Malacostraca	Crangon franciscorum
Malacostraca	Crangon nigricauda
Malacostraca	Cryptolithodes sitchensis
Malacostraca	Cryptolithodes typicus
Malacostraca	Cymadusa uncinata
Malacostraca	Desdimelita barnardi
Malacostraca	Desdimelita californica
Malacostraca	Desdimelita desdichada
Malacostraca	*Desdimelita microdentata*
Malacostraca	*Desdimelita transmelita*
Malacostraca	*Deutella californica*
Malacostraca	*Disacanthomysis dybowskii*
Malacostraca	*Discorsopagurus schmitti*
Malacostraca	*Dynamene glabra*
Malacostraca	*Echidnocerus cibarius*
Malacostraca	*Elasmopus antennatus*
Malacostraca	*Elassochirus tenuimanus*
Malacostraca	*Eogammarus confervicolus*
Malacostraca	*Eohaustorius sawyeri*
Malacostraca	*Eohaustorius washingtonianus*
Malacostraca	*Ericthonius difformis*
Malacostraca	*Ericthonius punctatus*
Malacostraca	*Eualus avinus*
Malacostraca	*Eualus barbatus*
Malacostraca	*Eualus berkeleyorum*
Malacostraca	*Eualus lineatus*
Malacostraca	*Eualus pusiolus*
Malacostraca	*Eualus suckleyi*
Malacostraca	*Eudorella pacifica*
Malacostraca	*Eusergestes similis*
Malacostraca	*Exacanthomysis davisi*
Malacostraca	*Excirolana chiltoni*
Malacostraca	*Exosphaeroma amplicauda*
Malacostraca	*Exosphaeroma rhomburum*
Malacostraca	*Foxiphalus xiximeus*
Malacostraca	*Gammaropsis ellisi*
Malacostraca	*Glebocarcinus oregonensis*
Malacostraca	*Gnathopleustes den*
Malacostraca	*Gnathopleustes pachychaetus*
Malacostraca	*Gnathopleustes pugettensis*
Malacostraca	*Gnathopleustes serratus*
Malacostraca	*Gnorimosphaeroma oregonense*
Malacostraca	*Grimothea quadrispina*
Malacostraca	*Hapalogaster mertensii*
Malacostraca	*Hemigrapsus nudus*
Malacostraca	*Hemigrapsus oregonensis*
Malacostraca	*Heptacarpus brevirostris*
Malacostraca	*Heptacarpus decorus*
Malacostraca	*Heptacarpus kincaidi*
Malacostraca	*Heptacarpus sitchensis*
Malacostraca	*Heptacarpus tenuissimus*
Malacostraca	*Heptacarpus tridens*
Malacostraca	*Heterophoxus oculatus*
Malacostraca	*Heteropleustes setosus*
Malacostraca	*Hippomedon columbianus*
Malacostraca	*Holmesiella anomala*
Malacostraca	*Hyas lyratus*
Malacostraca	*Ianiropsis kincaidi*
Malacostraca	*Ianiropsis tridens*
Malacostraca	*Idotea fewkesi*
Malacostraca	*Inusitatomysis insolita*
Malacostraca	*Jassa staudei*
Malacostraca	*Kamptopleustes spinosus*
Malacostraca	*Laticorophium baconi*
Malacostraca	*Lebbeus groenlandicus*
Malacostraca	*Leonardsaxius spinulicauda*
Malacostraca	*Leucothoe alata*

Class	Scientific Name
Malacostraca	*Leucothoe spinicarpa*

Class	Scientific Name
Malacostraca	*Parapleustes americanus*

Malacostraca	*Ligia pallasii*
Malacostraca	*Lissocrangon stylirostris*
Malacostraca	*Lophopanopeus bellus*
Malacostraca	*Loxorhynchus crispatus*
Malacostraca	*Lycaea pulex*
Malacostraca	*Maera jerrica*
Malacostraca	*Maera similis*
Malacostraca	*Megalorchestia californiana*
Malacostraca	*Megalorchestia columbiana*
Malacostraca	*Megalorchestia pugettensis*
Malacostraca	*Megamoera subtener*
Malacostraca	*Megokkos feldmanni*
Malacostraca	*Melita oregonensis*
Malacostraca	*Mesocrangon munitella*
Malacostraca	*Metacaprella kennerlyi*
Malacostraca	*Metacrangon munita*
Malacostraca	*Metacrangon spinosissima*
Malacostraca	*Metacrangon variabilis*
Malacostraca	*Metaphoxus frequens*
Malacostraca	*Microjassa boreopacifica*
Malacostraca	*Microjassa litotes*
Malacostraca	*Micropleustes nautilus*
Malacostraca	*Monoculodes emarginatus*
Malacostraca	*Munidion parvum*
Malacostraca	*Munna fernaldi*
Malacostraca	*Neocrangon communis*
Malacostraca	*Neocrangon resima*
Malacostraca	*Neotrypaea californiensis*
Malacostraca	*Oedignathus inermis*
Malacostraca	*Oligochinus lighti*
Malacostraca	*Oregonia gracilis*
Malacostraca	*Pachycheles pubescens*
Malacostraca	*Pachycheles rudis*
Malacostraca	*Pachygrapsus crassipes*
Malacostraca	*Pacifacanthomysis nephrophthalma*
Malacostraca	*Pacifastacus leniusculus*
Malacostraca	*Pacifoculodes spinipes*
Malacostraca	*Paguristes turgidus*
Malacostraca	*Pagurus aleuticus*
Malacostraca	*Pagurus armatus*
Malacostraca	*Pagurus caurinus*
Malacostraca	*Pagurus confragosus*
Malacostraca	*Pagurus dalli*
Malacostraca	*Pagurus granosimanus*
Malacostraca	*Pagurus hemphilli*
Malacostraca	*Pagurus hirsutiusculus*
Malacostraca	*Pagurus kennerlyi*
Malacostraca	*Pagurus ochotensis*
Malacostraca	*Pagurus samuelis*
Malacostraca	*Pakynus chelatum*
Malacostraca	*Pandalus borealis*
Malacostraca	*Pandalus dispar*
Malacostraca	*Pandalus goniurus*
Malacostraca	*Pandalus hypsinotus*
Malacostraca	*Pandalus jordani*
Malacostraca	*Paracrangon echinata*
Malacostraca	*Parallorchestes americana*
Malacostraca	*Paramoera suchaneki*
Malacostraca	*Pasiphaea pacifica*
Malacostraca	*Pentidotea montereyensis*
Malacostraca	*Pentidotea resecata*
Malacostraca	*Pentidotea schmitti*
Malacostraca	*Pentidotea wosnesenskii*
Malacostraca	*Petrolisthes cinctipes*
Malacostraca	*Petrolisthes eriomerus*
Malacostraca	*Photis brevipes*
Malacostraca	*Photis parvidons*
Malacostraca	*Pleurogonium rubicundum*
Malacostraca	*Pleusirus secorrus*
Malacostraca	*Polycheria mixillae*
Malacostraca	*Pontogeneia intermedia*
Malacostraca	*Porcellio scaber*
Malacostraca	*Pugettia foliata*
Malacostraca	*Pugettia gracilis*
Malacostraca	*Pugettia producta*
Malacostraca	*Pulalius vulgaris*
Malacostraca	*Quadrimaera reishi*
Malacostraca	*Quadrimaera vigota*
Malacostraca	*Rathbunixa occidentalis*
Malacostraca	*Rhachotropis inflata*
Malacostraca	*Rhachotropis oculata*
Malacostraca	*Rhepoxynius daboius*
Malacostraca	*Rhepoxynius fatigans*
Malacostraca	*Rocinela belliceps*
Malacostraca	*Rocinela propodialis*
Malacostraca	*Romaleon antennarium*
Malacostraca	*Romaleon branneri*
Malacostraca	*Scyra acutifrons*
Malacostraca	*Spirontocaris arcuata*
Malacostraca	*Spirontocaris holmesi*
Malacostraca	*Spirontocaris lamellicornis*
Malacostraca	*Spirontocaris prionota*
Malacostraca	*Spirontocaris sica*
Malacostraca	*Spirontocaris spinus*
Malacostraca	*Spirontocaris truncata*
Malacostraca	*Stilomysis grandis*
Malacostraca	*Synidotea angulata*
Malacostraca	*Synidotea bicuspida*
Malacostraca	*Synidotea pettiboneae*
Malacostraca	*Tecticeps convexus*
Malacostraca	*Thorlaksonius brevirostris*
Malacostraca	*Thorlaksonius carinatus*
Malacostraca	*Thorlaksonius subcarinatus*
Malacostraca	*Thorlaksonius truncatus*
Malacostraca	*Thysanoessa spinifera*
Malacostraca	*Trachypleustes trevori*
Malacostraca	*Traskorchestia traskiana*
Malacostraca	*Tritella laevis*
Malacostraca	*Tritella pilimana*
Malacostraca	*Westwoodilla caecula*
Malacostraca	*Xenacanthomysis pseudomacropsis*
Maxillopoda	*Balanus balanus*
Maxillopoda	*Balanus crenatus*
Maxillopoda	*Balanus glandula*
Maxillopoda	*Balanus nubilus*
Maxillopoda	*Chthamalus dalli*

Class	**Scientific Name**
Maxillopoda	*Cryptolepas rhachianecti*
Maxillopoda	*Lepas anatifera*
Maxillopoda	*Lepas hillii*

Class	**Scientific Name**
Polychaeta	*Phyllocomus hiltoni*
Polychaeta	*Phyllodoce madeirensis*
Polychaeta	*Phyllodoce medipapillata*

Maxillopoda	*Lepas pacifica*
Maxillopoda	*Semibalanus cariosus*
Maxillopoda	*Tetraclita squamosa*
Myxozoa	*Kudoa paniformis*
Ophiuroidea	*Amphiodia occidentalis*
Ophiuroidea	*Amphiodia urtica*
Ophiuroidea	*Amphioplus macraspis*
Ophiuroidea	*Amphipholis pugetana*
Ophiuroidea	*Ophiopholis aculeata*
Ophiuroidea	*Ophiopholis bakeri*
Ophiuroidea	*Ophiopholis kennerlyi*
Ophiuroidea	*Ophiopholis longispina*
Ophiuroidea	*Ophiophthalmus normani*
Ophiuroidea	*Ophiura lutkeni*
Ophiuroidea	*Ophiura sarsii*
Palaeonemertea	*Tubulanus polymorphus*
Palaeonemertea	*Tubulanus sexlineatus*
Phascolosomatidea	*Phascolosoma agassizii*
Polychaeta	*Travisia pupa*
Polychaeta	*Acromegalomma splendidum*
Polychaeta	*Alciopa reynaudii*
Polychaeta	*Amphicteis scaphobranchiata*
Polychaeta	*Aphrodita negligens*
Polychaeta	*Arctonoe fragilis*
Polychaeta	*Boccardia columbiana*
Polychaeta	*Branchiomaldane simplex*
Polychaeta	*Chone duneri*
Polychaeta	*Dodecaceria pacifica*
Polychaeta	*Eranno bicirrata*
Polychaeta	*Eudistylia vancouveri*
Polychaeta	*Eulalia quadrioculata*
Polychaeta	*Eunoe depressa*
Polychaeta	*Eupolymnia heterobranchia*
Polychaeta	*Gattyana ciliata*
Polychaeta	*Gaudichaudius iphionelloides*
Polychaeta	*Glycera americana*
Polychaeta	*Glycera capitata*
Polychaeta	*Glycera tesselata*
Polychaeta	*Halosydna brevisetosa*
Polychaeta	*Harmothoe lunulata*
Polychaeta	*Lanice conchilega*
Polychaeta	*Laonice cirrata*
Polychaeta	*Lepidasthenia longicirrata*
Polychaeta	*Lepidonotus spiculus*
Polychaeta	*Lepidonotus squamatus*
Polychaeta	*Lumbrineris bifurcata*
Polychaeta	*Lumbrineris inflata*
Polychaeta	*Micronephthys cornuta*
Polychaeta	*Myzostoma deani*
Polychaeta	*Nephtys punctata*
Polychaeta	*Nephtys rickettsi*
Polychaeta	*Notoproctus pacificus*
Polychaeta	*Odontosyllis phosphorea*
Polychaeta	*Onuphis iridescens*
Polychaeta	*Paradialychone ecaudata*
Polychaeta	*Pectinaria californiensis*
Polychaeta	*Piromis eruca*
Polychaeta	*Pista brevibranchiata*
Polychaeta	*Pista cristata*
Polychaeta	*Pista elongata*
Polychaeta	*Pista moorei*
Polychaeta	*Platynereis bicanaliculata*
Polychaeta	*Praxillella affinis*
Polychaeta	*Scoletoma zonata*
Polychaeta	*Serpula columbiana*
Polychaeta	*Serpula vermicularis*
Polychaeta	*Sternaspis affinis*
Polychaeta	*Syllis alternata*
Polychaeta	*Syllis elongata*
Polychaeta	*Syllis pigmentata*
Polychaeta	*Thelepus crispus*
Polychaeta	*Thelepus japonicus*
Polyplacophora	*Cyanoplax dentiens*
Polyplacophora	*Katharina tunicata*
Polyplacophora	*Lepidozona cooperi*
Polyplacophora	*Lepidozona interstincta*
Polyplacophora	*Lepidozona mertensii*
Polyplacophora	*Lepidozona radians*
Polyplacophora	*Lepidozona retiporosa*
Polyplacophora	*Leptochiton cancellatus*
Polyplacophora	*Mopalia ciliata*
Polyplacophora	*Mopalia hindsii*
Polyplacophora	*Mopalia lignosa*
Polyplacophora	*Placiphorella rufa*
Polyplacophora	*Placiphorella velata*
Polyplacophora	*Tonicella undocaerulea*
Pycnogonida	*Achelia gracilipes*
Pycnogonida	*Ammothea hilgendorfi*
Pycnogonida	*Ammothella tuberculata*
Pycnogonida	*Anoplodactylus viridintestinalis*
Pycnogonida	*Nymphon pixellae*
Pycnogonida	*Nymphopsis spinosissimum*
Rhynchonellata	*Laqueus japonicus*
Rhynchonellata	*Terebratalia transversa*
Rhynchonellata	*Terebratulina unguicula*
Scaphopoda	*Antalis pretiosa*
Scaphopoda	*Rhabdus rectius*
Scyphozoa	*Aurelia aurita*
Scyphozoa	*Cyanea ferruginea*
Staurozoa	*Haliclystus sanjuanensis*
Staurozoa	*Haliclystus stejnegeri*
Staurozoa	*Manania gwilliami*
Stenolaemata	*Bientalophora cylindrica*
Stenolaemata	*Crisia serrulata*
Stenolaemata	*Crisidia cornuta*
Stenolaemata	*Diaperoforma californica*
Stenolaemata	*Disporella astraea*
Stenolaemata	*Disporella separata*
Stenolaemata	*Heteropora pacifica*
Tentaculata	*Pleurobrachia bachei*
Trematoda	*Fellodistomum sebastodis*
Turbellaria	*Kaburakia excelsa*
	Phoronis ijimai

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Table G5. Vertebrate species and data sources mentioned in the overview report. GBIF = Global Biodiversity Information Facility (http://gbif.org).

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Actinopterygii	Flatfish	Arrowtooth Flounder	*Atheresthes stomias*	X	X	X
Actinopterygii	Flatfish	Starry Flounder	*Platichthys stellatus*		X	X
Actinopterygii	Flatfish	Curlfin Sole	*Pleuronichthys decurrens*	X		X
Actinopterygii	Flatfish	Dover Sole	*Microstomus pacificus*	X	X	X
Actinopterygii	Flatfish	English Sole	*Parophrys vetulus*	X	X	X
Actinopterygii	Flatfish	Flathead Sole	*Hippoglossoides elassodon*	X	X	X
Actinopterygii	Flatfish	Pacific Halibut	*Hippoglossus stenolepis*	X	X	X
Actinopterygii	Flatfish	Pacific Sanddab	*Citharichthys sordidus*	X	X	X
Actinopterygii	Flatfish	Petrale Sole	*Eopsetta jordani*	X	X	X
Actinopterygii	Flatfish	Rex Sole	*Glyptocephalus zachirus*	X	X	X
Actinopterygii	Flatfish	Rock Sole	*Lepidopsetta bilineata*	X	X	X
Actinopterygii	Flatfish	Sand Sole	*Pegusa lascaris*	X		
Actinopterygii	Flatfish	Slender Sole	*Lyopsetta exilis*	X		X
Actinopterygii	Forage Fishes	American Shad	*Alosa sapidissima*		X	X
Actinopterygii	Forage Fishes	Eulachon	*Thaleichthys pacificus*	X	X	X
Actinopterygii	Forage Fishes	Kelp Greenling	*Hexagrammos decagrammus*	X		X
Actinopterygii	Forage Fishes	Northern Anchovy	*Engraulis mordax*		X	X
Actinopterygii	Forage Fishes	Northern Lampfish	*Stenobrachius leucopsarus*		X	X
Actinopterygii	Forage Fishes	Pacific Herring	*Clupea pallasii*	X	X	X
Actinopterygii	Forage Fishes	Pacific Sand Lance	*Ammodytes personatus*		X	X
Actinopterygii	Forage Fishes	Pacific Sardine	*Sardinops sagax*		X	X
Actinopterygii	Other Groundfish	Blackbelly Eelpout	*Lycodes pacificus*	X	X	X
Actinopterygii	Other Groundfish	Blackfin Poacher	*Bathyagonus nigripinnis*		X	X
Actinopterygii	Other Groundfish	Blacktip Poacher	*Xeneretmus latifrons*		X	X
Actinopterygii	Other Groundfish	Cabezon	*Scorpaenichthys marmoratus*	X		X
Actinopterygii	Other Groundfish	Dwarf Wrymouth	*Cryptacanthodes aleutensis*		X	X
Actinopterygii	Other Groundfish	Gray Starsnout	*Bathyagonus alascanus*		X	X

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Actinopterygii	Other Groundfish	Lingcod	*Ophiodon elongatus*	X	X	X
Actinopterygii	Other Groundfish	Plainfish Midshipman	*Porichthys notatus*		X	X
Actinopterygii	Other Groundfish	Sablefish	*Anoplopoma fimbria*	X	X	X
Actinopterygii	Other Groundfish	Slim Sculpin	*Radulinus asprellus*		X	X
Actinopterygii	Other Groundfish	Thornback Sculpin	*Paricelinus hopliticus*		X	X
Actinopterygii	Other Groundfish	Threadfin Sculpin	*Icelinus filamentosus*	X	X	X
Actinopterygii	Other Groundfish	Whitebarred Prickleback	*Poroclinus rothrocki*		X	X
Actinopterygii	Rockfish	Bocaccio	*Sebastes paucispinis*		X	X
Actinopterygii	Rockfish	Black Rockfish	*Sebastes melanops*			X
Actinopterygii	Rockfish	Canary Rockfish	*Sebastes pinniger*	X	X	X
Actinopterygii	Rockfish	China Rockfish	*Sebastes nebulosus*	X		X
Actinopterygii	Rockfish	Copper Rockfish	*Sebastes caurinus*	X		X
Actinopterygii	Rockfish	Darkblotched Rockfish	*Sebastes crameri*	X	X	X
Actinopterygii	Rockfish	Greenstriped Rockfish	*Sebastes elongatus*	X	X	X
Actinopterygii	Rockfish	Pacific Ocean Perch	*Sebastes alutus*	X	X	X
Actinopterygii	Rockfish	Pygmy Rockfish	*Sebastes wilsoni*		X	X
Actinopterygii	Rockfish	Quillback Rockfish	*Sebastes maliger*	X		X
Actinopterygii	Rockfish	Redbanded Rockfish	*Sebastes babcocki*	X	X	X
Actinopterygii	Rockfish	Redstripe Rockfish	*Sebastes proriger*	X	X	X
Actinopterygii	Rockfish	Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostichus*	X	X	
Actinopterygii	Rockfish	Sharpchin Rockfish	*Sebastes zacentrus*	X	X	X
Actinopterygii	Rockfish	Shiner Perch	*Cymatogaster aggregata*		X	X
Actinopterygii	Rockfish	Shortspine Thornyhead	*Sebastolobus alascanus*	X	X	
Actinopterygii	Rockfish	Splitnose Rockfish	*Sebastes diploproa*	X	X	X
Actinopterygii	Rockfish	Vermillion Rockfish	*Sebastes miniatus*	X		X
Actinopterygii	Rockfish	Yelloweye Rockfish	*Sebastes ruberrimus*	X	X	X
Actinopterygii	Rockfish	Yellowtail Rockfish	*Sebastes flavidus*	X	X	X
Actinopterygii	Roundfish	Pacific Cod	*Gadus macrocephalus*	X	X	X

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Actinopterygii	Roundfish	Pacific Hake	*Merluccius productus*	X	X	X
Actinopterygii	Roundfish	Pacific Tomcod	*Microgadus proximus*	X	X	X
Actinopterygii	Roundfish	Walleye Pollock	*Gadus chalcogrammus*	X	X	X
Actinopterygii	Molids	Ocean Sunfish	*Mola* sp.		X	
Actinopterygii	Salmonids	Chinook Salmon	*Oncorhynchus tshawytscha*	X	X	X
Actinopterygii	Salmonids	Chum Salmon	*Oncorhynchus keta*	X	X	X
Actinopterygii	Salmonids	Coho Salmon	*Oncorhynchus kisutch*	X	X	X
Actinopterygii	Salmonids	Pink Salmon	*Oncorhynchus gorbuscha*	X	X	X
Actinopterygii	Salmonids	Sockeye Salmon	*Oncorhynchus nerka*	X	X	X
Aves	Marine Birds	Ancient Murrelet	*Synthliboramphus antiquus*		X	X
Aves	Marine Birds	Bald Eagle	*Haliaeetus leucocephalus*		X	X
Aves	Marine Birds	Barrow's Goldeneye	*Bucephala islandica*		X	X
Aves	Marine Birds	Black Oystercatcher	*Haematopus bachmani*		X	X
Aves	Marine Birds	Black Turnstone	*Arenaria melanocephala*			X
Aves	Marine Birds	Black-bellied Plover	*Pluvialis squatarola*			X
Aves	Marine Birds	Black-footed Albatross	*Phoebastria nigripes*			X
Aves	Marine Birds	Black-legged Kittiwake	*Rissa tridactyla*		X	X
Aves	Marine Birds	Blue-winged Teal	*Spatula discors*		X	X
Aves	Marine Birds	Bonaparte's Gull	*Chroicocephalus philadelphia*		X	X
Aves	Marine Birds	Brandt's Cormorant	*Phalacrocorax penicillatus*		X	X
Aves	Marine Birds	Brant	*Branta bernicla*			X
Aves	Marine Birds	Brown Pelican	*Pelecanus occidentalis*			X
Aves	Marine Birds	Bufflehead	*Bucephala albeola*		X	X
Aves	Marine Birds	Buller's Shearwater	*Puffinus bulleri*			X
Aves	Marine Birds	Cackling Goose	*Branta hutchinsii*			X
Aves	Marine Birds	California Gull	*Larus californicus*		X	X
Aves	Marine Birds	Canada Goose	*Branta canadensis*		X	X
Aves	Marine Birds	Caspian Tern	*Hydroprogne caspia*			X

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Aves	Marine Birds	Cassin's Auklet	*Ptychoramphus aleuticus*		X	X
Aves	Marine Birds	Common Goldeneye	*Bucephala clangula*		X	X
Aves	Marine Birds	Common Gull	*Larus canus*			X
Aves	Marine Birds	Common Loon	*Gavia immer*		X	X
Aves	Marine Birds	Common Merganser	*Mergus merganser*		X	X
Aves	Marine Birds	Common Murre	*Uria aalge*		X	X
Aves	Marine Birds	Common Tern	*Sterna hirundo*			X
Aves	Marine Birds	Double-crested Cormorant	*Phalacrocorax auritus*		X	X
Aves	Marine Birds	Flesh-footed Shearwater	*Puffinus carneipes*		X	X
Aves	Marine Birds	Fork-tailed Storm-Petrel	*Oceanodroma furcata*		X	X
Aves	Marine Birds	Glaucous Gull	*Larus hyperboreus*		X	X
Aves	Marine Birds	Glaucous-winged Gull	*Larus glaucescens*		X	X
Aves	Marine Birds	Great Blue Heron	*Ardea herodias*		X	X
Aves	Marine Birds	Greater Yellowlegs	*Tringa melanoleuca*			X
Aves	Marine Birds	Green-winged Teal	*Anas crecca*		X	X
Aves	Marine Birds	Harlequin Duck	*Histrionicus histrionicus*			X
Aves	Marine Birds	Heermann's Gull	*Larus heermanni*			X
Aves	Marine Birds	Herring Gull	*Larus argentatus*		X	X
Aves	Marine Birds	Hooded Merganser	*Lophodytes cucullatus*		X	X
Aves	Marine Birds	Horned Grebe	*Podiceps auritus*		X	X
Aves	Marine Birds	Iceland Gull or Thayer's Gull	*Larus glaucoides/Larus glaucoides thayeri*		X	X
Aves	Marine Birds	Killdeer	*Charadrius vociferus*			X
Aves	Marine Birds	Leach's Storm-Petrel	*Oceanodroma leucorhoa*		X	X
Aves	Marine Birds	Least Sandpiper	*Calidris minutilla*			X
Aves	Marine Birds	Long-billed Dowitcher	*Limnodromus scolopaceus*			X
Aves	Marine Birds	Long-tailed Duck	*Clangula hyemalis*			X
Aves	Marine Birds	Mallard	*Anas platyrhynchos*		X	X
Aves	Marine Birds	Manx Shearwater	*Puffinus puffinus*			X

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Aves	Marine Birds	Marbled Murrelet	*Brachyramphus marmoratus*		X	X
Aves	Marine Birds	Mottled Petrel	*Pterodroma inexpectata*			X
Aves	Marine Birds	Northern Fulmar	*Fulmarus glacialis*		X	X
Aves	Marine Birds	Northern Shoveler	*Spatula clypeata*		X	X
Aves	Marine Birds	Pacific Loon	*Gavia pacifica*		X	X
Aves	Marine Birds	Parakeet Auklet	*Aethia psittacula*		X	X
Aves	Marine Birds	Parasitic Jaeger	*Stercorarius parasiticus*			X
Aves	Marine Birds	Pelagic Cormorant	*Phalacrocorax pelagicus*		X	X
Aves	Marine Birds	Peregrine Falcon	*Falco peregrinus*			X
Aves	Marine Birds	Pigeon Guillemot	*Cepphus columba*		X	X
Aves	Marine Birds	Pink-footed Shearwater	*Ardenna creatopus*		X	X
Aves	Marine Birds	Pomarine Jaeger	*Stercorarius pomarinus*			X
Aves	Marine Birds	Red Phalarope	*Phalaropus fulicarius*		X	X
Aves	Marine Birds	Red-breasted Merganser	*Mergus serrator*			X
Aves	Marine Birds	Red-necked Grebe	*Podiceps grisegena*			X
Aves	Marine Birds	Red-necked Phalarope	*Phalaropus lobatus*		X	X
Aves	Marine Birds	Red-throated Loon	*Gavia stellata*		X	X
Aves	Marine Birds	Rhinoceros Auklet	*Cerorhinca monocerata*		X	X
Aves	Marine Birds	Ring-billed Gull	*Larus delawarensis*		X	X
Aves	Marine Birds	Ring-necked Duck	*Aythya collaris*		X	X
Aves	Marine Birds	Sabine's Gull	*Xema sabini*		X	X
Aves	Marine Birds	Sanderling	*Calidris alba*			X
Aves	Marine Birds	Semipalmated Plover	*Charadrius semipalmatus*			X
Aves	Marine Birds	Semipalmated Sandpiper	*Calidris pusilla*			X
Aves	Marine Birds	Short-billed Gull	*Larus brachyrhynchus*			X
Aves	Marine Birds	Short-tailed Shearwater	*Puffinus tenuirostris*		X	X
Aves	Marine Birds	Sooty Shearwater	*Puffinus griseus*		X	X
Aves	Marine Birds	South Polar Skua	*Stercorarius maccormicki*			X

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Aves	Marine Birds	Spotted Sandpiper	*Actitis macularius*			X
Aves	Marine Birds	Surf Scoter	*Melanitta perspicillata*			X
Aves	Marine Birds	Surfbird	*Calidris virgata*			X
Aves	Marine Birds	Thick-billed Murre	*Uria lomvia*			X
Aves	Marine Birds	Tufted Puffin	*Fratercula cirrhata*		X	X
Aves	Marine Birds	Wandering Tattler	*Tringa incana*			X
Aves	Marine Birds	Western Grebe	*Aechmophorus occidentalis*			X
Aves	Marine Birds	Western Gull	*Larus occidentalis*		X	X
Aves	Marine Birds	Western Sandpiper	*Calidris mauri*			X
Aves	Marine Birds	Western X Glaucous-winged Gull Hybrid	*Larus occidentalis x glaucescens*		X	
Aves	Marine Birds	Whimbrel	*Numenius phaeopus*			X
Aves	Marine Birds	White-winged Scoter	*Melanitta deglandi*			X
Elasmobranchii	Cartilaginous Fishes	Abyssal Skate/Deep Sea Skate	*Bathyraja abyssicola*			
Elasmobranchii	Cartilaginous Fishes	Alaska Skate	*Bathyraja parmifera*			X
Elasmobranchii	Cartilaginous Fishes	Basking Shark	*Catorhinus maximus*		X	
Elasmobranchii	Cartilaginous Fishes	Big Skate	*Beringraja binoculata*	X	X	X
Elasmobranchii	Cartilaginous Fishes	Blue Shark	*Prionace glauca*		X	
Elasmobranchii	Cartilaginous Fishes	Bluntnose Sixgill Shark	*Hexanchus griseus*			X
Elasmobranchii	Cartilaginous Fishes	Longnose Skate	*Beringraja rhina/Rhaja rhina*	X	X	X
Elasmobranchii	Cartilaginous Fishes	Pacific Sleeper Shark	*Somniosus pacificus*			
Elasmobranchii	Cartilaginous Fishes	Roughtail Skate	*Bathyraja trachura*			
Elasmobranchii	Cartilaginous Fishes	Salmon Shark	*Lamna ditropis*		X	
Elasmobranchii	Cartilaginous Fishes	Sandpaper Skate	*Bathyraja kincaidii*	X	X	X
Elasmobranchii	Cartilaginous Fishes	Spiny Dogfish	*Squalus suckleyi*	X	X	X
Elasmobranchii	Cartilaginous Fishes	Thresher Shark	*Alopias vulpinus*		X	
Elasmobranchii	Cartilaginous Fishes	Tope Shark	*Galeorhinus galeus*		X	
Elasmobranchii	Cartilaginous Fishes	Whitespotted Ratfish	*Hydrolagus colliei*	X	X	X
Mammalia	Cetaceans	Dall's Porpoise	*Phocoenoides dalli*	X	X	X

Class	Report Section	Common Name	Scientific Name	Model Data	Survey Data	GBIF
Mammalia	Cetaceans	Fin Whale	*Balaenoptera physalus*	X	X	X
Mammalia	Cetaceans	Grey Whale	*Eschrichtius robustus*		X	X
Mammalia	Cetaceans	Harbour Porpoise	*Phocoena phocoena*	X	X	X
Mammalia	Cetaceans	Hubb's Beaked Whale	*Mesoplodon carlhubbsi*		X	X
Mammalia	Cetaceans	Humpback Whale	*Megaptera novaeangliae*	X	X	X
Mammalia	Cetaceans	Killer Whale (Orca)	*Orcinus orca*	X	X	X
Mammalia	Cetaceans	Minke Whale	*Balaenoptera acutorostrata*		X	
Mammalia	Cetaceans	North Pacific Right Whale	*Eubalaena japonica*		X	X
Mammalia	Cetaceans	Pacific White Sided Dolphin	*Lagenorhynchus obliquidens*		X	X
Mammalia	Cetaceans	Risso's Dolphin	*Grampus griseus*		X	X
Mammalia	Cetaceans	Sei Whale	*Balaenoptera borealis*		X	
Mammalia	Cetaceans	Sperm Whale	*Physeter macrocephalus*		X	
Mammalia	Cetaceans	California Sea Lion	*Zalophus californianus*		X	X
Mammalia	Cetaceans	Elephant Seal	*Mirounga angustirostris*		X	X
Mammalia	Pinnipeds	Harbour Seal	*Phoca vitulina*		X	X
Mammalia	Pinnipeds	Northern Fur Seal	*Callorhinus ursinus*			X
Mammalia	Pinnipeds	Steller Sea Lion	*Eumetopias jubatus*		X	X
Mammalia	Sea Otters	Sea Otter	*Enhydra lutris*		X	X
Reptilia	Sea Turtles	Green Sea turtle	*Chelonia mydas*		X	
Reptilia	Sea Turtles	Leatherback sea turtle	*Dermochelys coriacea*		X	

*Table G6. Additional vertebrate species reported in the **ƛ̓ušiiʔaaʔaq** /Swiftsure Bank Area from the Global Biodiversity Information Facility (GBIF)*

Class	Scientific Name
Actinopterygii	*Alepisaurus ferox*
Actinopterygii	*Lestidiops ringens*
Actinopterygii	*Cololabis saira*
Actinopterygii	*Antimora microlepis*
Actinopterygii	*Aulorhynchus flavidus*
Actinopterygii	*Gasterosteus aculeatus*
Actinopterygii	*Gobiesox maeandricus*
Actinopterygii	*Protomyctophum thompsoni*
Actinopterygii	*Chilara taylori*
Actinopterygii	*Leuroglossus schmidti*
Actinopterygii	*Allosmerus elongatus*
Actinopterygii	*Hypomesus pretiosus*
Actinopterygii	*Osmerus dentex*
Actinopterygii	*Spirinchus starksi*
Actinopterygii	*Ammodytes hexapterus*
Actinopterygii	*Anarrhichthys ocellatus*
Actinopterygii	*Ronquilus jordani*
Actinopterygii	*Trachurus symmetricus*
Actinopterygii	*Icichthys lockingtoni*
Actinopterygii	*Coryphaena hippurus*
Actinopterygii	*Cryptacanthodes giganteus*
Actinopterygii	*Amphistichus koelzi*
Actinopterygii	*Amphistichus rhodoterus*
Actinopterygii	*Embiotoca lateralis*
Actinopterygii	*Hyperprosopon ellipticum*
Actinopterygii	*Rhacochilus vacca*
Actinopterygii	*Apodichthys flavidus*
Actinopterygii	*Scomber japonicus*
Actinopterygii	*Scytalina cerdale*
Actinopterygii	*Anoplarchus purpurescens*
Actinopterygii	*Lumpenus sagitta*
Actinopterygii	*Phytichthys chirus*
Actinopterygii	*Plectobranchus evides*
Actinopterygii	*Xiphister atropurpureus*
Actinopterygii	*Xiphister mucosus*
Actinopterygii	*Peprilus simillimus*
Actinopterygii	*Lycodapus parviceps*
Actinopterygii	*Lycodes brevipes*
Actinopterygii	*Lycodes cortezianus*
Actinopterygii	*Lycodes diapterus*
Actinopterygii	*Lycodes palearis*
Actinopterygii	*Citharichthys stigmaeus*
Actinopterygii	*Isopsetta isolepis*
Actinopterygii	*Lepidopsetta polyxystra*
Actinopterygii	*Psettichthys melanostictus*
Actinopterygii	*Oncorhynchus clarkii*
Actinopterygii	*Oncorhynchus mykiss*
Actinopterygii	*Agonopsis vulsa*
Actinopterygii	*Bathyagonus infraspinatus*
Actinopterygii	*Bathyagonus pentacanthus*
Actinopterygii	*Chesnonia verrucosa*
Actinopterygii	*Odontopyxis trispinosa*
Actinopterygii	*Podothecus accipenserinus*
Actinopterygii	*Xeneretmus leiops*
Actinopterygii	*Xeneretmus triacanthus*
Actinopterygii	*Artedius harringtoni*

Class	Scientific Name
Actinopterygii	*Ascelichthys rhodorus*
Actinopterygii	*Asemichthys taylori*
Actinopterygii	*Chitonotus pugetensis*
Actinopterygii	*Clinocottus acuticeps*
Actinopterygii	*Clinocottus embryum*
Actinopterygii	*Clinocottus globiceps*
Actinopterygii	*Cottus aleuticus*
Actinopterygii	*Cottus asper*
Actinopterygii	*Cottus cognatus*
Actinopterygii	*Enophrys bison*
Actinopterygii	*Hemilepidotus hemilepidotus*
Actinopterygii	*Hemilepidotus jordani*
Actinopterygii	*Hemilepidotus spinosus*
Actinopterygii	*Icelinus borealis*
Actinopterygii	*Icelinus tenuis*
Actinopterygii	*Icelus spiniger*
Actinopterygii	*Jordania zonope*
Actinopterygii	*Leptocottus armatus*
Actinopterygii	*Myoxocephalus polyacanthocephalus*
Actinopterygii	*Oligocottus borealis*
Actinopterygii	*Oligocottus maculosus*
Actinopterygii	*Oligocottus snyderi*
Actinopterygii	*Triglops macellus*
Actinopterygii	*Triglops pingelii*
Actinopterygii	*Blepsias cirrhosus*
Actinopterygii	*Nautichthys oculofasciatus*
Actinopterygii	*Hexagrammos lagocephalus*
Actinopterygii	*Hexagrammos stelleri*
Actinopterygii	*Oxylebius pictus*
Actinopterygii	*Liparis adiastolus*
Actinopterygii	*Liparis dennyi*
Actinopterygii	*Liparis florae*
Actinopterygii	*Liparis fucensis*
Actinopterygii	*Liparis mucosus*
Actinopterygii	*Liparis pulchellus*
Actinopterygii	*Polypera greeni*
Actinopterygii	*Dasycottus setiger*
Actinopterygii	*Malacocottus kincaidi*
Actinopterygii	*Psychrolutes paradoxus*
Actinopterygii	*Rhamphocottus richardsonii*
Actinopterygii	*Sebastes aleutianus*
Actinopterygii	*Sebastes brevispinis*
Actinopterygii	*Sebastes diaconus*
Actinopterygii	*Sebastes emphaeus*
Actinopterygii	*Sebastes entomelas*
Actinopterygii	*Sebastes helvomaculatus*
Actinopterygii	*Sebastes jordani*
Actinopterygii	*Sebastes melanostictus*
Actinopterygii	*Sebastes nigrocinctus*
Actinopterygii	*Sebastes saxicola*
Actinopterygii	*Sebastes serranoides*
Actinopterygii	*Sebastes variegatus*
Actinopterygii	*Sebastolobus alascanus*
Actinopterygii	*Chauliodus macouni*
Actinopterygii	*Syngnathus leptorhynchus*
Actinopterygii	*Mola mola*

Class	Scientific Name
Aves	*Accipiter cooperii*
Aves	*Accipiter striatus*
Aves	*Aquila chrysaetos*
Aves	*Buteo jamaicensis*
Aves	*Buteo lagopus*
Aves	*Circus cyaneus*
Aves	*Cathartes aura*
Aves	*Pandion haliaetus*
Aves	*Aix sponsa*
Aves	*Anas acuta*
Aves	*Anser albifrons*
Aves	*Anser caerulescens*
Aves	*Aythya affinis*
Aves	*Aythya fuligula*
Aves	*Aythya marila*
Aves	*Cygnus buccinator*
Aves	*Cygnus columbianus*
Aves	*Mareca americana*
Aves	*Mareca penelope*
Aves	*Mareca strepera*
Aves	*Melanitta americana*
Aves	*Melanitta fusca*
Aves	*Melanitta nigra*
Aves	*Oxyura jamaicensis*
Aves	*Cepphus carbo*
Aves	*Fratercula corniculata*
Aves	*Synthliboramphus scrippsi*
Aves	*Charadrius nivosus*
Aves	*Pluvialis dominica*
Aves	*Pluvialis fulva*
Aves	*Hydrocoloeus minutus*
Aves	*Larus schistisagus*
Aves	*Leucophaeus pipixcan*
Aves	*Rissa brevirostris*
Aves	*Sterna paradisaea*
Aves	*Arenaria interpres*
Aves	*Bartramia longicauda*
Aves	*Calidris alpina*
Aves	*Calidris bairdii*
Aves	*Calidris canutus*

Class	Scientific Name
Aves	*Calidris melanotos*
Aves	*Calidris minuta*
Aves	*Calidris ptilocnemis*
Aves	*Calidris pugnax*
Aves	*Calidris subruficollis*
Aves	*Gallinago delicata*
Aves	*Limnodromus griseus*
Aves	*Limosa fedoa*
Aves	*Numenius americanus*
Aves	*Phalaropus tricolor*
Aves	*Tringa flavipes*
Aves	*Tringa glareola*
Aves	*Stercorarius longicaudus*
Aves	*Megaceryle alcyon*
Aves	*Megaceryle torquata*
Aves	*Caracara plancus*
Aves	*Falco columbarius*
Aves	*Falco sparverius*
Aves	*Falco subbuteo*
Aves	*Gavia adamsii*
Aves	*Gavia arctica*
Aves	*Grus canadensis*
Aves	*Rallus limicola*
Aves	*Ardea alba*
Aves	*Bubulcus ibis*
Aves	*Butorides virescens*
Aves	*Pelecanus erythrorhynchos*
Aves	*Podiceps nigricollis*
Aves	*Podilymbus podiceps*
Aves	*Phoebastria albatrus*
Aves	*Phalacrocorax urile*
Aves	*Sula leucogaster*
Elasmobranchii	*Bathyraja interrupta*
Mammalia	*Balaenoptera musculus*
Mammalia	*Stenella coeruleoalba*
Mammalia	*Kogia sima*
Hyperoartia	*Entosphenus tridentatus*
Myxini	*Eptatretus deani*
Myxini	*Eptatretus stoutii*

10.7 Appendix G: Nitinaht Narrows and Nitinaht Lake Vertebrate Presence

Table G1. Vertebrate presence at survey locations in Nitinaht Narrows and Nitinaht Lake, including traditional Ditidaht names for each species.

Swiftsure Bank: Species Maps					
Vertebrate Presence					
didiibiisu7lh	Browns Bay	Gobies	Bay Goby	*Lepidogobius lepidus*	EDNA
didiibiisu7lh	Browns Bay	Other	Bay Pipefish	*Syngnathus leptorhynchus*	EDNA
didiibiisu7lh	Browns Bay	Salmon	Chinook Salmon	*Oncorhynchus tshawytscha*	Field Detection
didiibiisu7lh	Browns Bay	Salmon	Chum Salmon	*Oncorhynchus keta*	EDNA & Field Detection
didiibiisu7lh	Browns Bay	Gunnels	Crescent gunnel	*Pholis laeta*	EDNA
didiibiisu7lh	Browns Bay	Eelpouts and Pricklebacks	Crescent Gunnel	*Pholis laeta*	Subtidal Survey
didiibiisu7lh	Browns Bay	Invasive Species	European Green Crab	*Carcinus maenas*	Field Detection
didiibiisu7lh	Browns Bay	Eelpouts and Pricklebacks	High Cockscomb	*Anoplarchus purpurescens*	Subtidal Survey
didiibiisu7lh	Browns Bay	Surfperches	Kelp Perch	*Brachyistius frenatus*	EDNA & Field Detection
didiibiisu7lh	Browns Bay	Forage Fish	Pacific Herring	*Clupea pallasii*	EDNA & Field Detection
didiibiisu7lh	Browns Bay	Sculpins	Pacific Staghorn Sculpin	*Leptocottus armatus*	EDNA & Field Detection
didiibiisu7lh	Browns Bay	Surfperches	Perch	*Embiotocidae spp.*	Field Detection
didiibiisu7lh	Browns Bay	Surfperches	Pile Perch	*Rhacochilus vacca*	Field Detection
didiibiisu7lh	Browns Bay	Sculpins	Prickly Sculpin	*Cottus asper*	EDNA
didiibiisu7lh	Browns Bay	Rockfishes	Rockfish jv. (unknown)	*Sebastes spp.*	EDNA & Field Detection
didiibiisu7lh	Browns Bay	Other	Sablefish	*Anoplopoma fimbria*	EDNA & Field Detection
didiibiisu7lh	Browns Bay	Eelpouts and Pricklebacks	Saddleback Gunnel	*Pholis ornata*	Subtidal Survey
didiibiisu7lh	Browns Bay	Sculpins	Sculpin spp.	*Cottidae spp.*	Field Detection
didiibiisu7lh	Browns Bay	Surfperches	Shiner Perch	*Cymatogaster aggregata*	Field Detection
didiibiisu7lh	Browns Bay	Eelpouts and Pricklebacks	Snake Prickleback	*Lumpenus sagitta*	Subtidal Survey
didiibiisu7lh	Browns Bay	Salmon	Sockeye Salmon	*Oncorhynchus nerka*	EDNA & Field Detection
didiibiisu7lh	Browns Bay	Flatfishes	Starry Flounder	*Platichthys stellatus*	Field Detection
didiibiisu7lh	Browns Bay	Other	Three-Spined Stickelback	*Gasterosteus aculeatus*	EDNA
chaxt7aa7ak	Campbell Island	Gobies	Bay goby	*Lepidogobius lepidus*	Subtidal Survey

chaxt7aa7ak	Campbell Island	Surfperches	Perch	*Embiotocidae spp.*	Subtidal Survey
chaxt7aa7ak	Campbell Island	Rockfishes	Yellowtail Rockfish	*Sebastes flavidus*	Subtidal Survey
tluu7uus	Clo-oose	Gobies	Bay Goby	*Lepidogobius lepidus*	EDNA
tluu7uus	Clo-oose	Eelpouts and Pricklebacks	Black Prickleback	*Xiphister atropurpureus*	Subtidal Survey
tluu7uus	Clo-oose	Flatfishes	Butter Sole	*Isopsetta isolepis*	Subtidal Survey
tluu7uus	Clo-oose	Flatfishes	C-O Sole	*Pleuronichthys coenosus*	Subtidal Survey
tluu7uus	Clo-oose	Gunnels	Crescent Gunnel	*Pholis laeta*	Field Detection
tluu7uus	Clo-oose	Flatfishes	Dover Sole	*Solea solea*	EDNA
tluu7uus	Clo-oose	Eelpouts and Pricklebacks	High Cockscomb	*Anoplarchus purpurescens*	Subtidal Survey
tluu7uus	Clo-oose	Flatfishes	Kamchatka Flounder	*Atheresthes evermanni*	EDNA
tluu7uus	Clo-oose	Greenlings	Kelp Greenling	*Hexagrammos decagrammus*	EDNA
tluu7uus	Clo-oose	Forage Fish	Northern Anchovy	*Engraulis mordax*	EDNA
tluu7uus	Clo-oose	Flatfishes	Pacific Hake	*Merluccius productus*	EDNA & Field Detection
tluu7uus	Clo-oose	Flatfishes	Pacific Halibut	*Hippoglossus stenolepis*	EDNA
tluu7uus	Clo-oose	Forage Fish	Pacific Herring	*Clupea pallasii*	EDNA
tluu7uus	Clo-oose	Flatfishes	Pacific Sanddab	*Citharichthys sordidus*	Field Detection
tluu7uus	Clo-oose	Forage Fish	Pacific Sandlance	*Ammodytes personatus*	EDNA
tluu7uus	Clo-oose	Greenlings	Painted Greenling	*Oxylebius pictus*	EDNA
tluu7uus	Clo-oose	Gunnels	Penpoint Gunnel	*Apodichthys flavidus*	EDNA
tluu7uus	Clo-oose	Flatfishes	Rex Sole	*Glyptocephalus zachirus*	EDNA
tluu7uus	Clo-oose	Eelpouts and Pricklebacks	Ribbon Prickleback	*Phytichthys chirus*	Subtidal Survey
tluu7uus	Clo-oose	Flatfishes	Rock Sole	*Lepidopsetta bilineata*	EDNA
tluu7uus	Clo-oose	Gunnels	Saddleback Gunnel	*Pholis ornata*	EDNA
tluu7uus	Clo-oose	Flatfishes	Slender Sole	*Lyopsetta exilis*	EDNA
tluu7uus	Clo-oose	Eelpouts and Pricklebacks	Snake Prickleback	*Lumpenus sagitta EDNA*	Subtidal Survey
tluu7uus	Clo-oose	Flatfishes	Speckeled Sanddab	*Citharichthys stigmaeus*	EDNA
tluu7uus	Clo-oose	Flatfishes	Starry Flounder	*Platichthys stellatus*	EDNA & Field Detection
tluu7uus	Clo-oose	Other	Alaska Pollock	*Gadus chalcogrammus*	EDNA
tluu7uus	Clo-oose	Other	Bay Pipefish	*Syngnathus leptorhynchus*	EDNA
tluu7uus	Clo-oose	Other	Crevice Kelpfish	*Gibbonsia montereyensis*	EDNA
tluu7uus	Clo-oose	Other	Lingcod	*Ophiodon elongatus*	EDNA

tluu7uus	Clo-oose	Other	Northern Clingfish	*Gobiesox maeandricus*	EDNA
tluu7uus	Clo-oose	Other	Pacific Cod	*Gadus macrocephalus*	EDNA
tluu7uus	Clo-oose	Other	Pacific Sandfish	*Trichodon trichodon*	EDNA
tluu7uus	Clo-oose	Other	Pacific Tomcod	*Microgadus proximus*	EDNA
tluu7uus	Clo-oose	Other	Pygmy Poacher	*Odontopyxis trispinosa*	EDNA
tluu7uus	Clo-oose	Other	Ragfish	*Icosteus aenigmaticus*	EDNA
tluu7uus	Clo-oose	Other	Sablefish	*Anoplopoma fimbria*	EDNA
tluu7uus	Clo-oose	Other	Three-Spined Stickleback	*Gasterosteus aculeatus*	EDNA
tluu7uus	Clo-oose	Other	Tube-Snout	*Aulorhynchus flavidus*	EDNA
tluu7uus	Clo-oose	Other	Wolf Eel	*Anarrhichthys ocellatus*	EDNA
tluu7uus	Clo-oose	Perches	Kelp Perch	*Brachyistius frenatus*	EDNA
tluu7uus	Clo-oose	Perches	Pile Perch	*Rhacochilus vacca*	EDNA
tluu7uus	Clo-oose	Perches	Redtail Surfperch	*Amphistichus rhodoterus*	EDNA
tluu7uus	Clo-oose	Perches	Shiner Perch	*Cymatogaster aggregata*	EDNA
tluu7uus	Clo-oose	Perches	Striped Seaperch	*Embiotoca lateralis*	EDNA
tluu7uus	Clo-oose	Rockfishes	Rockfish spp.	*Sebastes spp.*	EDNA
tluu7uus	Clo-oose	Ronquils	Northern Ronquil	*Ronquilus jordani*	EDNA
tluu7uus	Clo-oose	Salmon	Chinook Salmon	*Oncorhynchus tshawytscha*	EDNA & Field Detection
tluu7uus	Clo-oose	Salmon	Chum Salmon	*Oncorhynchus keta*	EDNA
tluu7uus	Clo-oose	Salmon	Coho Salmon	*Oncorhynchus kisutch*	EDNA
tluu7uus	Clo-oose	Salmon	Cutthroat Trout	*Oncorhynchus clarkii*	EDNA
tluu7uus	Clo-oose	Salmon	Dolly Varden	*Salvelinus malma*	EDNA
tluu7uus	Clo-oose	Salmon	Pink Salmon	*Oncorhynchus gorbuscha*	EDNA
tluu7uus	Clo-oose	Salmon	Sockeye Salmon	*Oncorhynchus nerka*	EDNA
tluu7uus	Clo-oose	Sculpins	Arctic Staghorn Sculpin	*Gymnocanthus tricuspis*	EDNA
tluu7uus	Clo-oose	Sculpins	Brown Irish Lord	*Hemilepidotus spinosus*	EDNA
tluu7uus	Clo-oose	Sculpins	Buffalo Sculpin	*Enophrys bison*	EDNA
tluu7uus	Clo-oose	Sculpins	Cabezon	*Scorpaenichthys marmoratus*	EDNA
tluu7uus	Clo-oose	Sculpins	Calico Sculpin	*Clinocottus embryum*	EDNA
tluu7uus	Clo-oose	Sculpins	Fluffy Sculpin	*Oligocottus snyderi*	EDNA
tluu7uus	Clo-oose	Sculpins	Longfin Sculpin	*Ordania zonope*	EDNA
tluu7uus	Clo-oose	Sculpins	Manacled Sculpin	*Synchirus gilli*	EDNA

tluu7uus	Clo-oose	Sculpins	Mosshead Sculpin	*Clinocottus globiceps*	EDNA
tluu7uus	Clo-oose	Sculpins	Northern Sculpin	*Icelinus borealis*	EDNA
tluu7uus	Clo-oose	Sculpins	Pacific Staghorn Sculpin	*Leptocottus armatus*	EDNA
tluu7uus	Clo-oose	Sculpins	Padded Sculpin	*Artedius fenestralis*	EDNA
tluu7uus	Clo-oose	Sculpins	Plain Sculpin	*Myoxocephalus jaok*	EDNA
tluu7uus	Clo-oose	Sculpins	Prickly Sculpin	*Cottus asper*	EDNA
tluu7uus	Clo-oose	Sculpins	Red Irish Lord	*Hemilepidotus hemilepidotus*	EDNA
tluu7uus	Clo-oose	Sculpins	Rosylip Sculpin	*Ascelichthys rhodorus*	EDNA
tluu7uus	Clo-oose	Sculpins	Roughback Sculpin	*Chitonotus pugetensis*	EDNA
tluu7uus	Clo-oose	Sculpins	Sailfin Sculpin	*Nautichthys oculofasciatus*	EDNA
tluu7uus	Clo-oose	Sculpins	Scalyhead Sculpin	*Artedius harringtoni*	EDNA
tluu7uus	Clo-oose	Sculpins	Sharpnose Sculpin	*Clinocottus acuticeps*	EDNA
tluu7uus	Clo-oose	Sculpins	Silverspotted Sculpin	*Blepsias cirrhosus*	EDNA
tluu7uus	Clo-oose	Sculpins	Slimy Sculpin	*Cottus cognatus*	EDNA
tluu7uus	Clo-oose	Sculpins	Smoothhead Sculpin	*Artedius lateralis*	EDNA
tluu7uus	Clo-oose	Sculpins	Soft Sculpin	*Psychrolutes sigalutes*	EDNA
tluu7uus	Clo-oose	Sculpins	Tidepool Sculpin	*Oligocottus maculosus*	EDNA
tluu7uus	Clo-oose	Snailfishes	Ribbon Snailfish	*Liparis cyclopus*	EDNA
tluu7uus	Clo-oose	Snailfishes	Showy Snailfish	*Liparis pulchellus*	EDNA
tluu7uus	Clo-oose	Snailfishes	Slimy Snailfish	*Liparis mucosus*	EDNA
tluu7uus	Clo-oose	Snailfishes	Tidepool Snailfish	*Liparis florae*	EDNA
DFN Marina	DFN Marina	Gobies	Bay goby	*Lepidogobius lepidus*	Subtidal Survey
DFN Marina	DFN Marina	Sculpins	Sculpin spp.	*Cottidae spp.*	Subtidal Survey
duba	Doobah	Eelpouts and Pricklebacks	Black Prickleback	*Xiphister atropurpureus*	EDNA
duba	Doobah	Eelpouts and Pricklebacks	High Cockscomb	*Anoplarchus purpurescens*	EDNA
duba	Doobah	Eelpouts and Pricklebacks	Ribbon Prickleback	*Phytichthys chirus*	EDNA
duba	Doobah	Flatfishes	Butter Sole	*Isopsetta isolepis*	EDNA
duba	Doobah	Flatfishes	Dover Sole	*Solea solea*	EDNA
duba	Doobah	Flatfishes	Kamchatka Flounder	*Atheresthes evermanni*	EDNA
duba	Doobah	Flatfishes	Pacific Hake	*Merluccius productus*	EDNA

duba	Doobah	Flatfishes	Pacific Halibut	*Hippoglossus stenolepis*	EDNA
duba	Doobah	Flatfishes	Pacific Sanddab	*Citharichthys sordidus*	EDNA
duba	Doobah	Flatfishes	Rock Sole	*Lepidopsetta bilineata*	EDNA
duba	Doobah	Flatfishes	Slender Sole	*Lyopsetta exilis*	EDNA
duba	Doobah	Flatfishes	Speckeled Sanddab	*Citharichthys stigmaeus*	EDNA
duba	Doobah	Flatfishes	Starry Flounder	*Platichthys stellatus*	EDNA
duba	Doobah	Forage Fish	Northern Anchovy	*Engraulis mordax*	EDNA
duba	Doobah	Forage Fish	Pacific Herring	*Clupea pallasii*	EDNA
duba	Doobah	Forage Fish	Pacific Sandlance	*Ammodytes personatus*	EDNA
duba	Doobah	Gobies	Arrow Goby	*Clevelandia ios*	EDNA
duba	Doobah	Gobies	Bay Goby	*Lepidogobius lepidus*	EDNA
duba	Doobah	Greenlings	Kelp Greenling	*Hexagrammos decagrammus*	EDNA
duba	Doobah	Gunnels	Crescent Gunnel	*Pholis laeta*	EDNA
duba	Doobah	Gunnels	Penpoint Gunnel	*Apodichthys flavidus*	EDNA
duba	Doobah	Other	Bay Pipefish	*Syngnathus leptorhynchus*	EDNA/Field Detection
duba	Doobah	Other	Crevice Kelpfish	*Gibbonsia montereyensis*	EDNA
duba	Doobah	Other	Lingcod	*Ophiodon elongatus*	EDNA
duba	Doobah	Other	Northern Clingfish	*Gobiesox maeandricus*	EDNA
duba	Doobah	Other	Pacific Sandfish	*Trichodon trichodon*	EDNA
duba	Doobah	Other	Pacific Tomcod	*Microgadus proximus*	EDNA
duba	Doobah	Other	Pygmy Poacher	*Odontopyxis trispinosa*	EDNA
duba	Doobah	Other	Ragfish	*Icosteus aenigmaticus*	EDNA
duba	Doobah	Other	Sablefish	*Anoplopoma fimbria*	EDNA
duba	Doobah	Other	Spotted Ratfish	*Hydrolagus colliei*	EDNA
duba	Doobah	Other	Three-Spined Stickleback	*Gasterosteus aculeatus*	EDNA & Field Detection
duba	Doobah	Other	Tube-Snout	*Aulorhynchus flavidus*	EDNA
duba	Doobah	Other	Wolf Eel	*Anarrhichthys ocellatus*	EDNA
duba	Doobah	Perches	Kelp Perch	*Brachyistius frenatus*	EDNA
duba	Doobah	Perches	Pile Perch	*Rhacochilus vacca*	EDNA
duba	Doobah	Perches	Shiner Perch	*Cymatogaster aggregata*	EDNA
duba	Doobah	Perches	Striped Seaperch	*Embiotoca lateralis*	EDNA
duba	Doobah	Rockfishes	Rockfish spp.	*Sebastes spp.*	EDNA

duba	Doobah	Ronquils	Northern Ronquil	*Ronquilus jordani*	EDNA
duba	Doobah	Salmon	Chinook Salmon	*Oncorhynchus tshawytscha*	EDNA
duba	Doobah	Salmon	Chum Salmon	*Oncorhynchus keta*	Field Detection
duba	Doobah	Salmon	Coho Salmon	*Oncorhynchus kisutch*	EDNA & Field Detection
duba	Doobah	Salmon	Dolly Varden	*Salvelinus malma*	EDNA
duba	Doobah	Salmon	Pink Salmon	*Oncorhynchus gorbuscha*	EDNA
duba	Doobah	Salmon	Sockeye Salmon	*Oncorhynchus nerka*	EDNA & Field Detection
duba	Doobah	Sculpins	Brown Irish Lord	*Hemilepidotus spinosus*	EDNA
duba	Doobah	Sculpins	Buffalo Sculpin	*Enophrys bison*	EDNA
duba	Doobah	Sculpins	Cabezon	*Scorpaenichthys marmoratus*	EDNA
duba	Doobah	Sculpins	Longfin Sculpin	*Ordania zonope*	EDNA
duba	Doobah	Sculpins	Manacled Sculpin	*Synchirus gilli*	EDNA
duba	Doobah	Sculpins	Mosshead Sculpin	*Clinocottus globiceps*	EDNA
duba	Doobah	Sculpins	Pacific Staghorn Sculpin	*Leptocottus armatus*	EDNA & Field Detection
duba	Doobah	Sculpins	Padded Sculpin	*Artedius fenestralis*	EDNA
duba	Doobah	Sculpins	Plain Sculpin	*Myoxocephalus jaok*	EDNA
duba	Doobah	Sculpins	Prickly Sculpin	*Cottus asper*	EDNA
duba	Doobah	Sculpins	Red Irish Lord	*Hemilepidotus hemilepidotus*	EDNA
duba	Doobah	Sculpins	Rosylip Sculpin	*Ascelichthys rhodorus*	EDNA
duba	Doobah	Sculpins	Roughback Sculpin	*Chitonotus pugetensis*	EDNA
duba	Doobah	Sculpins	Scalyhead Sculpin	*Artedius harringtoni*	EDNA
duba	Doobah	Sculpins	Silverspotted Sculpin	*Blepsias cirrhosus*	EDNA
duba	Doobah	Sculpins	Slimy Sculpin	*Cottus cognatus*	EDNA
duba	Doobah	Sculpins	Tidepool Sculpin	*Oligocottus maculosus*	EDNA & Field Detection
duba	Doobah	Snailfishes	Showy Snailfish	*Liparis pulchellus*	EDNA
duba	Doobah	Snailfishes	Slimy Snailfish	*Liparis mucosus*	EDNA
duba	Doobah	Snailfishes	Tidepool Snailfish	*Liparis florae*	EDNA
hupachktadaks	Eelgrass Cove	Eelpouts and Pricklebacks	High Cockscomb	*Anoplarchus purpurescens*	EDNA
hupachktadaks	Eelgrass Cove	Forage Fish	Pacific Sandlance	*Ammodytes personatus*	EDNA
hupachktadaks	Eelgrass Cove	Invasive Species	European Green Crab	*Carcinus maenas*	Field Detection

hupachktadaks	Eelgrass Cove	Salmon	Chinook Salmon	*Oncorhynchus tshawytscha*	Field Detection
hupachktadaks	Eelgrass Cove	Salmon	Chum Salmon	*Oncorhynchus keta*	EDNA & Field Detection
hupachktadaks	Eelgrass Cove	Salmon	Coho Salmon	*Oncorhynchus kisutch*	EDNA & Field Detection
hupachktadaks	Eelgrass Cove	Salmon	Rainbow Trout	*Oncorhynchus mykiss*	EDNA
hupachktadaks	Eelgrass Cove	Sculpins	Padded Sculpin	*Artedius fenestralis*	EDNA
hupachktadaks	Eelgrass Cove	Sculpins	Prickly Sculpin	*Cottus asper*	EDNA
hupachktadaks	Eelgrass Cove	Sculpins	Sculpin spp.	*Cottidae spp.*	Subtidal Survey
hupachktadaks	Eelgrass Cove	Sculpins	Slimy Sculpin	*Cottus cognatus*	EDNA
hupachktadaks	Eelgrass Cove	Surfperches	Perch	*Embiotocidae spp.*	Subtidal Survey
duchis	Goose Island	Eelpouts and Pricklebacks	Black Prickleback	*Xiphister atropurpureus*	Field Detection
duchis	Goose Island	Eelpouts and Pricklebacks	Blackbelly eelpout	*Lycodopsis pacifica*	Subtidal Survey
duchis	Goose Island	Eelpouts and Pricklebacks	High Cockscomb	*Anoplarchus purpurescens*	EDNA
duchis	Goose Island	Eelpouts and Pricklebacks	Snake Prickleback	*Lumpenus sagitta*	EDNA
duchis	Goose Island	Flatfishes	Butter Sole	*Isopsetta isolepis*	EDNA
duchis	Goose Island	Flatfishes	Dover Sole	*Solea solea*	EDNA
duchis	Goose Island	Flatfishes	Flatfish	*Pholis laeta*	Subtidal Survey
duchis	Goose Island	Flatfishes	Pacific Halibut	*Hippoglossus stenolepis*	EDNA
duchis	Goose Island	Flatfishes	Pacific Sanddab	*Citharichthys sordidus*	EDNA
duchis	Goose Island	Flatfishes	Rock Sole	*Lepidopsetta bilineata*	EDNA
duchis	Goose Island	Flatfishes	Starry Flounder	*Platichthys stellatus*	EDNA & Field Detection
duchis	Goose Island	Forage Fish	Pacific Herring	*Clupea pallasii*	EDNA
duchis	Goose Island	Forage Fish	Pacific Sandlance	*Ammodytes personatus*	EDNA
duchis	Goose Island	Gobies	Arrow Goby	*Clevelandia ios*	EDNA
duchis	Goose Island	Gobies	Bay Goby	*Lepidogobius lepidus*	EDNA
duchis	Goose Island	Gobies	Blackeyed goby	*Rhinogobiops nicholsii*	Subtidal Survey
duchis	Goose Island	Greenlings	Kelp greenling	*Hexagrammos decagrammus*	Subtidal Survey
duchis	Goose Island	Greenlings	Painted Greenling	*Oxylebius pictus*	EDNA
duchis	Goose Island	Gunnels	Crescent gunnel	*Pholis laeta*	Subtidal Survey
duchis	Goose Island	Gunnels	Saddleback Gunnel	*Pholis ornata*	EDNA & Field Detection

duchis	Goose Island	Other	Bay Pipefish	*Syngnathus leptorhynchus*	EDNA & Field Detection
duchis	Goose Island	Other	Kelp Clingfish	*Rimicola muscarum*	EDNA
duchis	Goose Island	Other	Lingcod	*Ophiodon elongatus*	EDNA
duchis	Goose Island	Other	Ocean Sunfish	*Mola mola*	EDNA
duchis	Goose Island	Other	Pacific Sandfish	*Trichodon trichodon*	EDNA
duchis	Goose Island	Other	Pacific Tomcod	*Microgadus proximus*	EDNA
duchis	Goose Island	Other	Pygmy Poacher	*Odontopyxis trispinosa*	EDNA
duchis	Goose Island	Other	Ragfish	*Icosteus aenigmaticus*	EDNA
duchis	Goose Island	Other	Sablefish	*Anoplopoma fimbria*	EDNA
duchis	Goose Island	Other	Three-Spined Stickleback	*Gasterosteus aculeatus*	Field Detection
duchis	Goose Island	Other	Tube-Snout	*Aulorhynchus flavidus*	EDNA
duchis	Goose Island	Other	Wolf Eel	*Anarrhichthys ocellatus*	EDNA
duchis	Goose Island	Perches	Pile Perch	*Rhacochilus vacca*	EDNA
duchis	Goose Island	Perches	Shiner Perch	*Cymatogaster aggregata*	EDNA
duchis	Goose Island	Rockfishes	Rockfish jv. (unknown)	*Sebastes spp.*	Subtidal Survey
duchis	Goose Island	Rockfishes	Rockfish spp.	*Sebastes spp.*	EDNA
duchis	Goose Island	Ronquils	Northern Ronquil	*Ronquilus jordani*	EDNA
duchis	Goose Island	Salmon	Chinook Salmon	*Oncorhynchus tshawytscha*	EDNA
duchis	Goose Island	Salmon	Chum Salmon	*Oncorhynchus keta*	Field Detection
duchis	Goose Island	Salmon	Dolly Varden	*Salvelinus malma*	EDNA
duchis	Goose Island	Sculpins	Buffalo Sculpin	*Enophrys bison*	EDNA & Field Detection
duchis	Goose Island	Sculpins	Cabezon	*Scorpaenichthys marmoratus*	EDNA
duchis	Goose Island	Sculpins	Grunt sculpin	*Rhamphocottus richardsoni*	Subtidal Survey
duchis	Goose Island	Sculpins	Longfin Sculpin	*Ordania zonope*	EDNA
duchis	Goose Island	Sculpins	Manacled Sculpin	*Synchirus gilli*	EDNA
duchis	Goose Island	Sculpins	Pacific Staghorn Sculpin	*Leptocottus armatus*	EDNA
duchis	Goose Island	Sculpins	Padded Sculpin	*Artedius fenestralis*	Field Detection
duchis	Goose Island	Sculpins	Plain Sculpin	*Myoxocephalus jaok*	EDNA
duchis	Goose Island	Sculpins	Prickly Sculpin	*Cottus asper*	EDNA

duchis	Goose Island	Sculpins	Red Irish Lord	*Hemilepidotus hemilepidotus*	EDNA
duchis	Goose Island	Sculpins	Rosylip Sculpin	*Ascelichthys rhodorus*	EDNA
duchis	Goose Island	Sculpins	Roughback Sculpin	*Chitonotus pugetensis*	EDNA
duchis	Goose Island	Sculpins	Sailfin Sculpin	*Nautichthys oculofasciatus*	EDNA
duchis	Goose Island	Sculpins	Scalyhead Sculpin	*Artedius harringtoni*	EDNA
duchis	Goose Island	Sculpins	Sculpin spp.	*Cottidae spp.*	Subtidal Survey
duchis	Goose Island	Sculpins	Sharpnose Sculpin	*Clinocottus acuticeps*	EDNA
duchis	Goose Island	Sculpins	Smoothhead Sculpin	*Artedius lateralis*	EDNA & Field Detection
duchis	Goose Island	Sculpins	Tidepool Sculpin	*Oligocottus maculosus*	EDNA
duchis	Goose Island	Snailfishes	Tidepool Snailfish	*Liparis florae*	EDNA
duchis	Goose Island	Surfperches	Kelp Perch	*Brachyistius frenatus*	Subtidal Survey
Ilhuu	ILCLO	Rockfishes	Rockfish jv. (unknown)	*Sebastes spp.*	Subtidal Survey
waayaa	Nitinaht Narrows	Eelpouts and Pricklebacks	Black Prickleback	*Xiphister atropurpureus*	EDNA
waayaa	Nitinaht Narrows	Eelpouts and Pricklebacks	High Cockscomb	*Anoplarchus purpurescens*	EDNA
waayaa	Nitinaht Narrows	Eelpouts and Pricklebacks	Ribbon Prickleback	*Phytichthys chirus*	EDNA
waayaa	Nitinaht Narrows	Eelpouts and Pricklebacks	Snake Prickleback	*Lumpenus sagitta*	EDNA
waayaa	Nitinaht Narrows	Flatfishes	Butter Sole	*Isopsetta isolepis*	EDNA
waayaa	Nitinaht Narrows	Flatfishes	C-O Sole	*Pleuronichthys coenosus*	EDNA
waayaa	Nitinaht Narrows	Flatfishes	Dover Sole	*Solea solea*	EDNA
waayaa	Nitinaht Narrows	Flatfishes	Pacific Halibut	*Hippoglossus stenolepis*	EDNA
waayaa	Nitinaht Narrows	Flatfishes	Speckeled Sanddab	*Citharichthys stigmaeus*	EDNA & Field Detection
waayaa	Nitinaht Narrows	Forage Fish	Northern Anchovy	*Engraulis mordax*	EDNA
waayaa	Nitinaht Narrows	Forage Fish	Pacific Herring	*Clupea pallasii*	EDNA
waayaa	Nitinaht Narrows	Forage Fish	Pacific Sandlance	*Ammodytes personatus*	EDNA
waayaa	Nitinaht Narrows	Greenlings	Kelp Greenling	*Hexagrammos decagrammus*	Field Detection
waayaa	Nitinaht Narrows	Greenlings	Painted Greenling	*Oxylebius pictus*	EDNA
waayaa	Nitinaht Narrows	Gunnels	Crescent Gunnel	*Pholis laeta*	EDNA
waayaa	Nitinaht Narrows	Gunnels	Penpoint Gunnel	*Apodichthys flavidus*	EDNA
waayaa	Nitinaht Narrows	Gunnels	Saddleback Gunnel	*Pholis ornata*	EDNA

waayaa	Nitinaht Narrows	Other	Alaska Pollock	*Gadus chalcogrammus*	EDNA
waayaa	Nitinaht Narrows	Other	Bay Pipefish	*Syngnathus leptorhynchus*	EDNA
waayaa	Nitinaht Narrows	Other	Lingcod	*Ophiodon elongatus*	EDNA
waayaa	Nitinaht Narrows	Other	Pacific Tomcod	*Microgadus proximus*	EDNA
waayaa	Nitinaht Narrows	Other	Pygmy Poacher	*Odontopyxis trispinosa*	EDNA
waayaa	Nitinaht Narrows	Other	Ragfish	*Icosteus aenigmaticus*	EDNA
waayaa	Nitinaht Narrows	Other	Three-Spined Stickleback	*Gasterosteus aculeatus*	EDNA
waayaa	Nitinaht Narrows	Other	Tube-Snout	*Aulorhynchus flavidus*	Field Detection
waayaa	Nitinaht Narrows	Perches	Kelp Perch	*Brachyistius frenatus*	EDNA
waayaa	Nitinaht Narrows	Perches	Pile Perch	*Rhacochilus vacca*	EDNA
waayaa	Nitinaht Narrows	Perches	Shiner Perch	*Cymatogaster aggregata*	EDNA
waayaa	Nitinaht Narrows	Rockfishes	Rockfish spp.	*Sebastes spp.*	EDNA
waayaa	Nitinaht Narrows	Salmon	Chinook Salmon	*Oncorhynchus tshawytscha*	EDNA & Field Detection
waayaa	Nitinaht Narrows	Salmon	Chum Salmon	*Oncorhynchus keta*	Field Detection
waayaa	Nitinaht Narrows	Salmon	Coho Salmon	*Oncorhynchus kisutch*	EDNA & Field Detection
waayaa	Nitinaht Narrows	Salmon	Dolly Varden	*Salvelinus malma*	EDNA
waayaa	Nitinaht Narrows	Salmon	Sockeye Salmon	*Oncorhynchus nerka*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Brown Irish Lord	*Hemilepidotus spinosus*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Buffalo Sculpin	*Enophrys bison*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Cabezon	*Scorpaenichthys marmoratus*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Longfin Sculpin	*Ordania zonope*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Manacled Sculpin	*Synchirus gilli*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Northern Sculpin	*Icelinus borealis*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Padded Sculpin	*Artedius fenestralis*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Plain Sculpin	*Myoxocephalus jaok*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Prickly Sculpin	*Cottus asper*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Rosylip Sculpin	*Ascelichthys rhodorus*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Roughback Sculpin	*Chitonotus pugetensis*	EDNA & Field Detection
waayaa	Nitinaht Narrows	Sculpins	Sailfin Sculpin	*Nautichthys oculofasciatus*	EDNA

waayaa	Nitinaht Narrows	Sculpins	Scalyhead Sculpin	*Artedius harringtoni*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Sharpnose Sculpin	*Clinocottus acuticeps*	EDNA
waayaa	Nitinaht Narrows	Sculpins	Tidepool Sculpin	*Oligocottus maculosus*	EDNA & Field Detection
tup'alhidukws	Nitinaht River Mouth	Other	Pacific Tomcod	*Microgadus proximus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Pygmy Poacher	*Odontopyxis trispinosa*	EDNA
tup'alhidukws	Nitinaht River Mouth	Eelpouts and Pricklebacks	Black Prickleback	*Xiphister atropurpureus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Eelpouts and Pricklebacks	High Cockscomb	*Anoplarchus purpurescens*	EDNA
tup'alhidukws	Nitinaht River Mouth	Eelpouts and Pricklebacks	Ribbon Prickleback	*Phytichthys chirus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Eelpouts and Pricklebacks	Snake Prickleback	*Lumpenus sagitta*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	Butter Sole	*Isopsetta isolepis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	C-O Sole	*Pleuronichthys coenosus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	Pacific Halibut	*Hippoglossus stenolepis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	Pacific Sanddab	*Citharichthys sordidus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	Rock Sole	*Lepidopsetta bilineata*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	Slender Sole	*Lyopsetta exilis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	Speckeled Sanddab	*Citharichthys stigmaeus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Flatfishes	Starry Flounder	*Platichthys stellatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Forage Fish	Northern Anchovy	*Engraulis mordax*	EDNA
tup'alhidukws	Nitinaht River Mouth	Forage Fish	Pacific Herring	*Clupea pallasii*	EDNA
tup'alhidukws	Nitinaht River Mouth	Forage Fish	Pacific Sandlance	*Ammodytes personatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Gobies	Arrow Goby	*Clevelandia ios*	EDNA
tup'alhidukws	Nitinaht River Mouth	Gobies	Bay Goby	*Lepidogobius lepidus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Greenlings	Kelp Greenling	*Hexagrammos decagrammus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Greenlings	Painted Greenling	*Oxylebius pictus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Gunnels	Crescent Gunnel	*Pholis laeta*	EDNA
tup'alhidukws	Nitinaht River Mouth	Gunnels	Penpoint Gunnel	*Apodichthys flavidus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Bay Pipefish	*Syngnathus leptorhynchus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Lingcod	*Ophiodon elongatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Northern Clingfish	*Gobiesox maeandricus*	EDNA

tup'alhidukws	Nitinaht River Mouth	Other	Pacific Cod	*Gadus macrocephalus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Pacific Sandfish	*Trichodon trichodon*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Sablefish	*Anoplopoma fimbria*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Three-Spined Stickleback	*Gasterosteus aculeatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Tube-Snout	*Aulorhynchus flavidus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Other	Wolf Eel	*Anarrhichthys ocellatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Perches	Kelp Perch	*Brachyistius frenatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Perches	Pile Perch	*Rhacochilus vacca*	EDNA
tup'alhidukws	Nitinaht River Mouth	Perches	Shiner Perch	*Cymatogaster aggregata*	EDNA
tup'alhidukws	Nitinaht River Mouth	Perches	Striped Seaperch	*Embiotoca lateralis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Rockfishes	Rockfish spp.	*Sebastes spp.*	EDNA
tup'alhidukws	Nitinaht River Mouth	Salmon	Chinook Salmon	*Oncorhynchus tshawytscha*	EDNA & Field Detection
tup'alhidukws	Nitinaht River Mouth	Salmon	Chum Salmon	*Oncorhynchus keta*	EDNA & Field Detection
tup'alhidukws	Nitinaht River Mouth	Salmon	Coho Salmon	*Oncorhynchus kisutch*	EDNA & Field Detection
tup'alhidukws	Nitinaht River Mouth	Salmon	Cutthroat Trout	*Oncorhynchus clarkii*	EDNA
tup'alhidukws	Nitinaht River Mouth	Salmon	Pink Salmon	*Oncorhynchus gorbuscha*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Buffalo Sculpin	*Enophrys bison*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Cabezon	*Scorpaenichthys marmoratus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Longfin Sculpin	*Ordania zonope*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Manacled Sculpin	*Synchirus gilli*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Mosshead Sculpin	*Clinocottus globiceps*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Northern Sculpin	*Icelinus borealis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Pacific Staghorn Sculpin	*Leptocottus armatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Padded Sculpin	*Artedius fenestralis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Plain Sculpin	*Myoxocephalus jaok*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Prickly Sculpin	*Cottus asper*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Red Irish Lord	*Hemilepidotus hemilepidotus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Roughback Sculpin	*Chitonotus pugetensis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Scalyhead Sculpin	*Artedius harringtoni*	EDNA

tup'alhidukws	Nitinaht River Mouth	Sculpins	Silverspotted Sculpin	*Blepsias cirrhosus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Slimy Sculpin	*Cottus cognatus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Smoothhead Sculpin	*Artedius lateralis*	EDNA
tup'alhidukws	Nitinaht River Mouth	Sculpins	Tidepool Sculpin	*Oligocottus maculosus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Snailfishes	Showy Snailfish	*Liparis pulchellus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Snailfishes	Slimy Snailfish	*Liparis mucosus*	EDNA
tup'alhidukws	Nitinaht River Mouth	Snailfishes	Tidepool Snailfish	*Liparis florae*	EDNA
tup'alhidukws	Nitinaht River Mouth	Snailfishes	Variegated Snailfish	*Liparis gibbus*	EDNA
tl'itl'iblha7d	Onion Point	Greenlings	Kelp greenling	*Hexagrammos decagrammus*	Field Detection
tl'itl'iblha7d	Onion Point	Surfperches	Perch	*Embiotocidae spp.*	Field Detection

10.8 Appendix H: Groundfish Occurrence

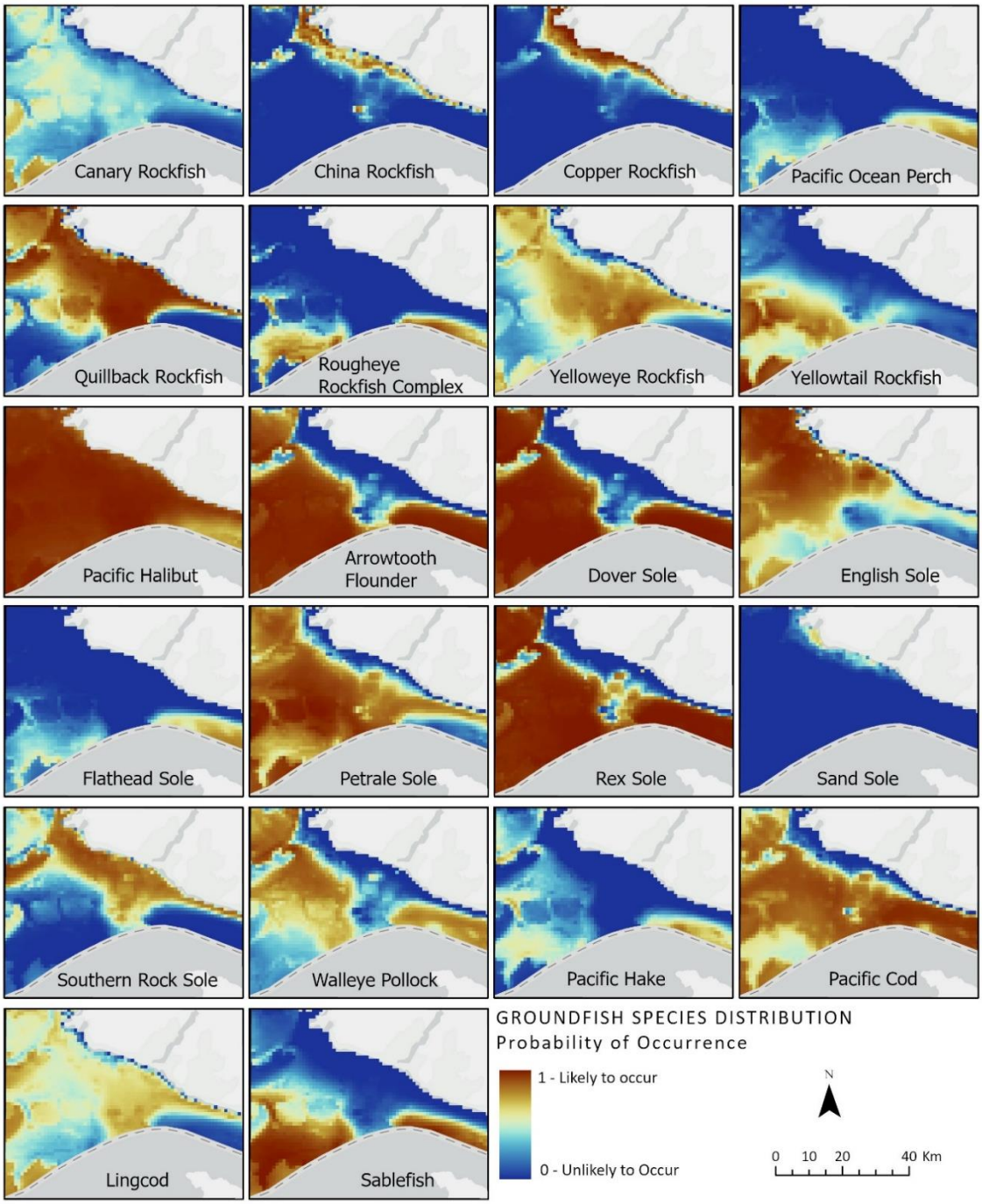


*Figure H1. Summed predicted species density values per grid cell (Species Richness) for selected groundfish species, modeled in the **ƛučii?aa?aq**/Swiftsure Bank Area (black rectangle inset) and featured in the report using the Thompson et al. (2022a) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 57 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used.*