IMPACTS OF DOCKS IN PENDER HARBOUR: PHASE 2 ASSESSMENT

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Prepared By:

M.C. Wright and Associates Ltd.
2231 Neil Drive
Nanaimo, BC
V9R 6T5
Tel. 250-753-1055
www.mcwrightonline.com

Prepared For:

Ministry of Forests, Lands, and Natural Resource Operations and Rural Development
South Coast Natural Resource Region
#200 – 10428 153 Street
Surrey, BC
V3R 1E1

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AUTHORSHIP

Sacha M. O'Regan, MSc, RPBio .... Author
Miranda Smith, BSc, ADGIS, RPBio .... Diver and GIS Specialist
Cameron Dexter, BA .... GIS Technician
Michael C. Wright, BSc, RPBio .... Senior Biologist

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LIST OF ABBREVIATIONS

BC	**British Columbia**
CCA	**Chromated copper arsenate**
CRA	**Commercial, recreational, and Aboriginal**
CRIMS	**Coastal Resource Information Management System**
DFO	**Fisheries and Oceans Canada**
DMP	**Dock Management Plan**
DO	**Dissolved oxygen**
GPS	**Global positioning system**
MFLNRORD	**Ministry of Forests, Lands, and Natural Resource Operations and Rural Development**
NOAA	**National Oceanic and Atmospheric Administration**
PAHs	**Polycyclic aromatic hydrocarbons**
PCBs	**Polychlorinated biphenyls**
SCRD	**Sunshine Coast Regional District**
TBT	**Tributyl tin**
TOC	**Total organic carbon**
TSS	**Total suspended solids**
VCH	**Vancouver Coastal Health**

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1.0 INTRODUCTION

In British Columbia (BC), waterfront property owners have the Common Law Right of riparian access to their properties. However, as foreshore land from the high to low watermarks is aquatic Crown land (i.e., owned by the provincial government), this does not give waterfront property owners the right to construct a dock, wharf, or other moorage facility. To construct these structures, property owners may apply to the Ministry of Forests, Lands and Natural Resource Operations and Rural Development (MFLNRORD) for private moorage authorizations, referred to as Licenses of Occupation, “leases” or “tenures”. MFLNRORD may grant or refuse authorizations based on established policy.

In August 2003, in response to a specific Pender Harbour dock tenure renewal application, *shíshálh* First Nation questioned Land and Water BC Inc. — the agency responsible for issuing private moorage authorizations at the time — as to whether environmental impacts were being adequately considered in the dock approval process. In January 2004, *shíshálh* Nation and Land Water BC Inc. agreed to conduct a joint study of potential environmental impacts of dock proliferation in Pender Harbour. No new private moorage applications were to be accepted until after the study was complete.

In April 2015, MFLNRORD released to the public a Dock Management Plan (DMP) developed in collaboration with the *shíshálh* Nation. The objective of the DMP is to promote responsible dock development in Pender Harbour by (1) minimizing and mitigating impacts to marine resource values; (2) protecting archaeological resources from future disturbance; (3) addressing individual and cumulative impacts of dock development on Aboriginal interests; and (4) advancing collaborative management between the *shíshálh* Nation and the Province of BC. It proposes to divide Pender Harbour into four zones within which specific dock construction and maintenance guidelines will apply (Figure 1 in Appendix 1): Zone 1 – no new docks permitted; Zone 2 – new docks only if for multi-party use or commercial use; Zone 3 – new docks of all types permitted, if consistent with DMP requirements and not overlapping with critical habitat; Zone 4 – new docks of all types permitted, if consistent with DMP requirements.

Following several public information sessions where attendees expressed concerns about the new dock approval process outlined in the DMP, MFLNRORD sought an independent review of the DMP to explore options for an appropriate land use management framework that will both achieve the DMP’s objectives and help address community concerns (Penner 2015). Noting that there was still an absence of empirical studies on the environmental impacts of docks in Pender Harbour, the resulting report recommended that MFLNRORD, “conduct an in-depth environmental study of the impact of docks in Pender Harbour, with a focus on but not limited to Zone 1 as defined in the DMP. Such a study should, among other things, examine whether sewage from boats or onshore dwellings and commercial operations is having an impact. Ongoing monitoring of environmental conditions and habitat impacts should be undertaken, and an annual limit on new tenure applications should be considered depending on the outcome of studies/monitoring.”

This report details the results of the two-phase study of dock development impacts to the marine environment commissioned by MFLNRORD to address the recommendation above. Phase 1 of the study was completed by MC Wright and Associates Ltd. (MCW) for MFLNRORD in June 2017, and involved conducting an extensive review of peer-reviewed and grey literature on the topic of dock and dock-associated impacts to marine and foreshore environments, with site-specific spatial analyses of Pender Harbour habitat condition, potential sources of pollutants, and dock development over time. This literature and data synthesis was used to inform the design of a Phase 2 field-based assessment of Pender Harbour's marine and foreshore habitats, and aquatic and terrestrial species richness and abundance, which was then completed by MCW in October 2017.

1.1 Objectives

There are four primary objectives of this report:

1) To summarize the results of the Phase 1 desktop assessment of dock impacts on water and sediment quality, marine and foreshore habitats, and aquatic and terrestrial species richness and abundance.
2) To summarize the results of the Phase 2 field surveys conducted to characterize intertidal and subtidal habitats and community composition in Pender Harbour and identify evidence of impacts to these communities from docks or urban development.
3) To identify knowledge gaps that could be investigated through future fieldwork.
4) To provide empirical information to support management decisions pertaining to the Pender Harbour Dock Management Plan.

1.2 Overview of Pender Harbour

Pender Harbour is a small coastal inlet on the Sechelt Peninsula opening into Malaspina Strait (Hall 1992). It is comprised of an outer basin with several small islands, bays, and peninsulas where the majority of the permanent residents and seasonal visitors live. The most populated regions, South Pender Harbour and Garden Bay, have a total population of 1,187 and 369, respectively, though just less than half of these are permanent residents (StatCan 2016). A smaller, shallower and less populated inner basin begins at Gunboat Bay and ends in two shallow bays, the larger of which is Oyster Bay.

1.2.1 Physical Description

1.2.1.1 Climate

As part of the Sechelt Peninsula, Pender Harbour has a mild climate and low rainfall relative to nearby Vancouver, BC. Long-term climatic data are not available for Pender Harbour; however, Environment Canada meteorological data is available from nearby Merry Island up to 2006. From 1997 to 2006, the mean annual temperature for Merry Island ranged between 10.5 ˚C and 11.9˚C.

The prevailing winds in the area come primarily from the east or south east, with about 32% coming from the west or west southwest (Hall 1992). No wind measurements are available from Pender Harbour, but the western approaches to the harbour are relatively protected while Bargain Bay is vulnerable to southeast winds.

1.2.1.2 Geology

During the postglacial period, sea levels were 180 m higher than at present and Pender Harbour was completely submerged (Hall 1992). Today, the area has a shallow overburden of unconsolidated materials and frequently exposed bedrock.

1.2.1.3 Oceanography and Hydrology

There are few freshwater inputs to Pender Harbour. A few small streams enter each of the two shallow bays at the end of the inner basin. As a result, water circulation and mixing are driven primarily by tidal exchange. The mixing effect of the tides is constrained by the deeper depth of the harbour and by the shallow sills that constrict the harbour entrances. Hall (1992) estimated the 1988 tidally-induced flushing time for Pender Harbour to be a median 2.9 days (range of 1.7–17.1 days). This value is likely an underestimate of the actual flushing time because it assumes complete mixing during each tidal cycle.

From November to March, winter high rainfall events increase runoff from the creeks that drain into Gunboat Bay (Hall 1992). This generates estuarine-type circulation and enhances the flushing of Pender Harbour. During the summer, thermal stratification reduces mixing of the basin's deeper water.

1.2.2 Watershed Use

1.2.2.1 Aboriginal

As communicated to MCW by the elders of the *shíshálh* Nation, Pender Harbour was used by the *shíshálh* Nation both seasonally and permanently to harvest marine invertebrates and fish, edible marine plants, edible seaweeds, and waterfowl (*shíshálh* Nation pers. comm. 2018).

1.2.2.2 Commercial and Recreational

In the late 1800s and early 1900s, Pender Harbour's main local industries were commercial fishing, fish processing, and logging. The harbour remained relatively isolated until the 1950s when paved roads became available. Since then, the harbour has become a popular destination for sports fishers and recreational boaters who wish to launch, moor, or rent boats. Commercial fishing vessels also continue to use the harbour. Heavy boating use is reflected by the large number of private docks, community docks and commercial marinas along the foreshore. Based on the most current spatial data from 2014, moorage is available at 326 private docks throughout the harbour and at 22 community docks and marinas.

2.0 PHASE 1 DESKTOP BASELINE ASSESSMENT

2.1 Baseline Data Sources

2.1.1 Literature and Spatial Data

Baseline information for the desktop comparative assessments of dock impacts was compiled by synthesizing available peer-reviewed and grey literature; and publicly available databases of species distributions (i.e., Coastal Resource Information Management System (CRIMS)). Spatial data in the form of historical air photos from the University of British Columbia and recent orthophotographs from the Sunshine Coast Regional District (SCRD) were obtained to compare the extent of habitat alterations and change in dock footprint over time. Data on the number and distribution of septic disposal fields and water treatment facilities around Pender Harbour was requested from the SCRD and Vancouver Coastal Health (VCH).

2.1.2 Traditional Knowledge

Traditional Knowledge about marine fish and fish habitat in Pender Harbour was shared by the *shíshálh* Nation elders with MCW in January 2018 and is summarized in Sections 2.3.2 and 2.4.2. Traditional Knowledge complements the western scientific data presented in this report in establishing historic and current environmental conditions (Canadian Environmental Assessment Agency 2015). For the purposes of this report, Traditional Knowledge is defined as spatial and non-spatial information about relationships between humans, other living organisms, and their environment that is uniquely held by Aboriginal people and transmitted over generations (Canadian Environmental Assessment Agency 2015). Spatial Traditional Knowledge includes ecological knowledge such as species distributions, migration routes, locations of culturally and ecologically significant species, wildlife features, and habitats; and knowledge about land use, such as the locations of hunting, fishing, or gathering areas (Lewis 2012). Non-spatial Traditional Knowledge includes such elements as information pertaining to community ecology, animal behavior, and natural phenomena (Lewis 2012).

2.1.3 Local Ecological Knowledge

Prior to this Phase 1 baseline assessment, it was intended that local ecological knowledge also be collected from members of the public through interview-based surveys. However, due to the politically sensitive nature of this project this was not undertaken.

2.2 Assessment of Marine Water and Sediment Quality

2.2.1 Existing Pollutant Sources

2.2.1.1 Point Sources

There are currently two permitted effluent discharges by ocean outfall into Pender Harbour, one to the northwest of John Henry's Marina that empties into the centre of Pender Harbour, and the other off Henry Point (Figure 2 in Appendix 1). Historical records indicate that in 1992, there were three permitted effluent discharges in the harbour (Hall 1992). These permits were issued to the Sundowner Inn, John Henry's Marina, and Tidal Wave Seafoods fish processing plant (under the name Pender Harbour Fishing Company Ltd.). Two additional permits were issued to a private residence and a residential complex south of Edgecombe Island. By contrast, in 1978 there were 29 direct effluent discharges into the harbour from private residences (Hall 1992).

Hall (1992) calculated that in 1992, three effluent discharges did not constitute a threat to marine fish populations in the harbour due to the restricted spatiotemporal scale of contamination, and based on his estimates of rates of water column vertical mixing and harbour flushing. However, it is unknown to what degree contaminants from effluent are trapped in Pender Harbour's deep basin water because of the absence of temperature, salinity and dissolved oxygen (DO) concentration data. Hall (1992) acknowledged the potential for entrapment of effluent to cause high nitrogen levels, noxious phytoplankton blooms, and consequently depleted DO, which can cause short-term fish mortality and constitute a health hazard to humans.

2.2.1.2 Non-point Sources

Non-point sources of water pollution have historically been a greater concern for the sediment and water quality of Pender Harbour, and this is still the case today. The main non-point sources are septic disposal fields, boating, agriculture, and urban development.

Septic Disposal Fields

At the time of Hall's (1992) report, nearly all effluent from private residences and businesses in Pender Harbour was disposed by discharge to tile fields. This was identified to be a problem because the steeper rocky slopes around the harbour and shallow, coarse soils characteristic of the region do not allow for adequate functioning of septic disposal fields. In 1977, the coastal areas that experienced the highest bacteriological impacts all had particularly steep shorelines and/or were composed of bedrock: South Hospital Bay, North Garden Bay, around Madeira Park, and Donnelly Landing.

Coarse soils promote rapid nitrification of ammonia to nitrate, a nutrient that stimulates primary productivity and potentially toxic phytoplankton blooms in marine environments. Soil and contaminant scientist, Dr. N. Nagpal, assessed that all of the land bordering the harbour was moderately to severely limited in its potential to support effective disposal fields and that an estimated 80% of the nitrate produced in the septic fields around Pender Harbour likely leaches straight into the harbour (Hall 1992). Some leaching of coliform bacteria from septic disposal fields is also likely; however, soils are better able to filter out bacteria than nitrogenous compounds. Even small amounts of coliform bacteria leaching to the intertidal zone may result in sanitary closures of shellfish harvesting (Hall 1992).

Since the time of Hall's (1992) report, Pender Harbour has not made a significant shift away from disposal field effluent treatment and has continued to experience increased urban development. Consequently, current levels of nutrient leaching from septic disposal fields into the harbour are expected to be just as substantial. VCH estimates that 90% of the population around Pender Harbour continue to treat their sewage by private septic disposal fields (D. Moulder pers. comm.). The exact number of private septic disposal fields is not readily available as individual land-owner records are not digitized.

In addition, the SCRD operates five community wastewater treatment and disposal systems in Pender Harbour (SCRD 2017): Greaves Road (a septic system with effluent discharge to disposal field), Lily Lake (permitted allowable discharge of 38.2 m^3 per day; unspecified discharge method), Canoe Road (a septic system with effluent discharge to disposal field), Lee Bay Road (permitted allowable discharge of 135 m^3 per day to disposal field), and Merrill Crescent Road (discharge to disposal field). The spatial data received from the SCRD in response to a request for information on the number of private and publicly managed disposal fields or other waste treatment facilities around Pender Harbour indicate that there are only two septic fields on the north shore of Pender Harbour (T. Halladay pers. comm; Figure 2 in Appendix 1). Given the above-mentioned information from VCH and the SCRD website, the available spatial data provides an incomplete record.

Hall (1992) noted that should the areas around Gunboat Bay and Oyster Bay be subject to urban development, there may be significant negative effects on water quality.

Boating
As mentioned in Section 1.2.2, Pender Harbour experiences high boating traffic, particularly during the summer tourism season.

Marine vessels can be a source of several types of pollutants, from sewage discharge, fuel spills and exhaust emissions, and antifouling paints. Because most vessels tend to moor in relatively shallow areas where there is less water volume for dilution of these pollutants, there may be localized effects on sediment and water quality (Hall 1992). Until relatively recently, sewage discharge from boats into Pender Harbour was the most problematic type of marine vessel pollution. Hall (1992) could not easily determine the amount of sewage discharge from boats into Pender Harbour; however, he estimated that boats were as significant a cause of bacterial contamination and sanitary closures of shellfish harvesting in the harbour as onshore sources.

Unlike with municipal sewage, which is combined with various water sources and typically passes through soil that tends to trap bacteria before reaching the ocean, boat sewage was freshly discharged directly into the harbour water. As of 2012, the *Transport Canada Vessel Pollution and Dangerous Chemicals Regulations* require vessels carrying fewer than 15 people to have a holding tank for sewage and prohibit discharge of the tank within one nautical mile (~1.8 km) from any shore. Discharge of raw sewage is permitted if the vessel is greater than three miles from any shore.

Antifouling and anticorrosive paints are used on vessels to protect them from biological, chemical, and physical degradation. Historically, copper has been the primary heavy metal biocide used to discourage growth of algae and invertebrates (Martin and Richards 2009). Lead was a less used stabilizer, biocide, and anticorrosive heavy metal that has generally been replaced with zinc. Tributyl tin (TBT) were used to extend the life of the paint and polychlorinated biphenyls (PCBs) were added to paints to increase paint adhesion and provide anti-corrosion protection (Martin and Richards 2009). Over time, these chemicals leached into the water column with sloughing of paint and also through power washing of boats and were deposited in sediments. They are known to cause acute and chronic toxicity to invertebrates such as mussels and Pacific oysters (*Crassostrea gigas*) and bioaccumulate in fish (Hall 1992). TBT had recently been banned for use on non-aluminum vessels less than 25 m in length at the time of Hall's (1992) report. No data are available on levels of heavy metals, TBT, and PCBs in the sediments of Pender Harbour. PCBs are no longer released into the environment from recreational boating activities because they have been banned from general use under the *PCB Regulations* enacted in 2008.

Minor fuel spills are expected to be a relatively common occurrence around refuelling docks and marinas in Pender Harbour. These would be a source of polycyclic aromatic hydrocarbons (PAHs) to Pender Harbour sediments (Hall 1992, Kennish 2002).

Agriculture
Agriculture has traditionally been a source of nutrient and coliform contamination to Pender Harbour and Bargain Bay. Hall (1992) described that livestock grazing in the upland area surrounding Oyster Bay, East Bay, and Gunboat Bay was likely the primary source of marine pollution in those bays. Rain accelerates the drainage of wastes from upland areas both into the small streams that drain into the bays and through the thin soils into the harbour.

Urban Development

Impermeable surfaces such as roofs and roads and altered surfaces such as lawns accumulate contaminants from land-based human activities and shed contaminants more easily and rapidly than natural substrates and habitats.

2.2.2 Sediment and Water Quality

Sediment and water quality help define marine habitats, influence species composition and abundance, and provide a spatiotemporal record of contaminant accumulation in the environment from point and non-point sources. Marine sediments, in particular, act as a sink for pollutants because of the affinity of many chemicals for particle surfaces. For example, PAHs exhibit high sediment-binding due to their hydrophobicity, low vapour pressure, and aromaticity. Decreased flow and increased salinities from freshwater to estuarine waters cause fine-grained suspended sediments and associated contaminants to settle at the bottom of estuaries and coastal marine areas (as summarized by Kennish 2002). Sediment characteristics such as particle size and total organic carbon can also reveal important information about the particle transport and depositional history of a location.

Little water quality data have been collected from Pender Harbour. Surface water bacterial loading (fecal coliform) was sampled throughout the harbour relatively regularly between 1964 and 1991, motivated by public concerns about the safe consumption of shellfish from the harbour (Table 1; Hall (1992)). Based on the results of the 1964 sampling, Oyster Bay was closed to shellfish harvesting and by 1988, all of Pender Harbour and Bargain Bay were closed (Table 1). As synthesized by Hall (1992), median fecal coliform concentrations ranged from 1/100 mL to 2300/100 mL during the sampling years (BC Water Quality Guidelines require a median concentration of ≤ 14/100 mL for shellfish harvesting and a mean of ≤ 200/100 mL for primary-contact recreation (Warrington 2001)), and there were no discernible trends over time. There were only a few incidences where Pender Harbour sampling sites did not meet the provincial criteria for primary-contact recreation.

Harbour water metal levels have only been measured on one occasion and sampled only from one site, but suggest that there may be elevated levels of copper, zinc, and iron in water close to bottom sediments in areas of high boat traffic (Hall 1992). The literature review conducted for this Phase 1 study did not yield any sediment quality data from Pender Harbour. As a result, historic levels of chemicals sorbed to sediments, such as PAHs and PCBs, are also unknown.

2.2.3 Potential Impacts of Docks on Sediment and Water Quality

The main impacts of docks on sediment and water quality are caused by the associated boat traffic around the docks. As discussed in Section 2.2.1.2, marine vessel use is problematic in shallow coastal areas and estuaries because fuel and oil spills and vessel exhaust are a source of PAHs and other hydrocarbons.

Boat propeller wash and pressure waves from boat hulls travelling through shallow water also cause sediment resuspension and dispersal and elevated water turbidity and total suspended solids (TSS) concentrations (as reviewed by Kennish 2002). PAHs, PCBs, and heavy metals bind to and persist for a long time in marine sediments; therefore, remobilizing sediments can promote desorption of contaminants and increase their bioavailability to marine fish and invertebrates. Elevated turbidity and TSS concentrations decrease the amount of underwater light available to vascular plants such as eelgrass (*Zostera marina*), which provide important habitat for both adult and juvenile fish. These effects are expected to be short-term and localized, but occur continuously over the life of the dock, driving modification or loss of habitat over time.

Table 1. Known water quality testing in Pender Harbour (data from Hall (1992)).

Agency	Year	Tests	No. of sample sites	Management decision
Department of Fisheries and National Health and Welfare (federal) and Department of Health and Hospital Insurance (provincial)	1964, 1967	Fecal coliform	unknown	Closure of Oyster Bay shellfish harvesting
Department of Health and Hospital Insurance	1967	Fecal coliform	unknown	Closure of shellfish harvesting east of power lines at entrance to Gunboat Bay
Environmental Protection Service (federal)	1974	Fecal coliform	20 marine, 1 freshwater	Closure of shellfish harvesting in all of Pender Harbour
Ministry of the Environment and Health (provincial)	1977	Fecal coliform	15 marine, 5 freshwater	
Coast Garibaldi Health Unit	1978	Fecal coliform	16 freshwater	
Ministry of the Environment and Health	1978	Select metals	1 marine	
Environmental Protection Service	1981	Fecal coliform	12 marine, 12 freshwater	
Coast Garibaldi Health Unit	1987, 1988	Fecal coliform	2 marine	
Environmental Protection Service	1988	Visual survey for potential contamination only		Closure of shellfish harvesting in Bargain Bay
Environmental Protection Service	1989, 1990, 1991	Fecal coliform	11 marine	

Docks also directly impact sediment and water quality in cases where docks or dock pilings are constructed of preservative-coated lumber. Chromated copper arsenate (CCA), which contains chromium, copper and arsenic, is widely used to prevent the rot of wood structures in the marine environment, as well as of land-based wood decks and patios, fences, and foundation lumber (Environment and Climate Change Canada 2014). When new wood is installed, the heavy metals leach into water and accumulate in sediments, where they may have deleterious effects on marine organisms. Harmful impacts that have been observed, particularly from copper, include reduced species richness and diversity of epifauna growing directly on the wood and in sediment benthic communities; genotoxic effects, and trophic transfer (e.g., from algae and oysters to consumers) (as reviewed by Weis and Weis 2002).

The magnitude of effects from CCA-treated wood depends on the surface area and age of the wood, amount of water available for dilution, and flushing of the water column. Wendt et al. (1996) found that in a South Carolina tidal creek system, metal concentrations from CCA-treated docks exceeded natural background levels only within one meter of dock pilings and were not high enough to cause biological harm. Toxicity tests suggest that the bioavailability of CCA metals to marine fish and wildlife may be low in less oxygenated sediments with a high concentration of acid-volatile sulfide (Sanger and Holland 2002). Several metals, including copper, react with sulfides to create insoluble metal sulfides that cannot be taken up by biota (Di Toro et al. 1992).

2.3 Assessment of Marine and Foreshore Habitats

2.3.1 Methods

Foreshore habitat types around Pender Harbour were classified and mapped in ArcGIS based on visual assessment of 2014 SCRD orthophotographs. Any additional spatial marine habitat data available from DataBC was also mapped.

The change in number of docks over time was quantified based on an analysis of historical air photos from 1957 to 2005, and 2014 SCRD orthophotographs (the most recent orthophotographs available). The total length of decking in each dock and the orientation (i.e., azimuths) of the longest edge of each dock present in the 2014 orthophotographs were calculated in ArcGIS. The 2014 dock footprints were also compared with Crown land lease and license data from DataBC to quantify the number of docks that are licensed versus unlicensed.

2.3.2 Marine Habitat Conditions

Both historic and current marine habitat conditions in Pender Harbour are poorly documented. The subtidal benthic habitat of Pender Harbour is dominated by mud, whereas the 2014 SCRD orthophotographs reveal that the high intertidal shoreline of Pender Harbour is dominated by bedrock (approximately 53%) and mixed rocky substrates (i.e., mixed boulder, cobble; 33%) (Figure 3 in Appendix 1). Bedrock and other rocky substrates typically support species-rich communities of epifaunal invertebrates (i.e., invertebrates that live on the substrate), such as barnacles (*Chthamalus dalli*, *Balanus glandula*, and *Semibalanus cariosus*), Pacific oysters (*Crassostrea gigas*), mussels (*Mytilus* spp.), periwinkles (e.g., *Littorina* spp.), limpets (*Lottia* spp.), and chitons (e.g., *Mopalia* spp., *Tonicella* spp.) (Dethier 1990). The interstitial spaces in rocky habitat offer refuge and foraging habitat for juvenile salmon, juvenile rockfish, and other species of commercial, recreational, and

Aboriginal (CRA) importance. Rocky substrates also provide a surface for diverse assemblages of red, green, and brown algae, including kelp, to attach.

Kelps are prevalent in low intertidal and subtidal rocky habitat along the Pacific coast and may form multilayered assemblages referred to as kelp forests. In BC, kelp forests typically consist of understory-forming species such as sugar kelp (*Saccharina* spp.) or winged kelp (*Alaria* spp.), and the canopy-forming species bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis*). These kelps increase the structural complexity of rocky substrates and provide refuge, food, and spawning habitat for CRA fishery species (Lucas et al. 2007).

Soft substrates (mudflats and sand) make up 10% of Pender Harbour's foreshore (Figure 3 in Appendix 1). In East Bay and Oyster Bay, where Anderson, Myers, and Kleindale Creeks drain into the harbour, rocky substrates are interrupted by large mudflats and estuarine vegetation, which includes salt marsh habitat. These soft substrates generally support less species diversity due to lack of sites for species to anchor themselves. However, soft substrates support infaunal communities (i.e., organisms that live within the seafloor sediments) (Wilson 1990) and may provide habitat for many CRA fishery species, including shallow-water bivalves (e.g., cockles and clams), *Pandalus* shrimps, Dungeness crab (*Metacarcinus magister*), and flatfish, as well as provide spawning habitat for foraging fish such as pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretious*). These substrates provide a medium for the growth of diatom mats known to be an important food source for juvenile salmonids and also support eelgrass beds.

As mentioned in Section 2.2.3, eelgrass is a vascular plant that provides important habitat for marine invertebrates and fish. Eelgrass grows in intertidal and subtidal areas on unconsolidated substrate (i.e., mud, sand, gravel, cobble) with an extensive network of underground roots and rhizomes. It produces shoots that create complex three-dimensional habitat, contributing to higher densities and/or different species compositions of algae and marine organisms than in unstructured habitats (DFO 2009). For instance, juvenile Pacific salmon are known to rear and forage in eelgrass beds, which support important prey species such as copepods, gammarid amphipods, and cumaceans (e.g., Sibert 1979, and as reviewed by Blackmon et al. 2006) and provide structure in which to hide from predators (Semmens 2008). Pacific herring use eelgrass as spawning substrate (Penttila 2007) and young-of-year Dungeness crabs can use eelgrass beds for rearing (as reviewed by Blackmon et al. 2006).

Eelgrass additionally plays a key structural and functional role in the nearshore marine environment by filtering the water column, trapping particles and stabilizing sediment, and buffering against shoreline erosion (DFO 2009). By trapping suspended matter and burying organic carbon in marine sediments, eelgrass beds sequester substantial amounts of carbon. On a per area basis, eelgrass ecosystems are more efficient carbon sinks than most terrestrial forests (Mcleod et al. 2011), and therefore preserving eelgrass beds is a key climate-change mitigation strategy (Howard et al. 2017, Macreadie et al. 2017). There are no substitute structuring organisms that perform the same functions as eelgrass that can grow on mud/sand flats; in the absence of eelgrass, these areas would consist only of mud/sand. For the reasons discussed in this section, eelgrass is considered by Fisheries and Oceans Canada (DFO) to be an Ecologically Significant Species (DFO 2009).

Traditional Knowledge from *shíshálh* Nation elders indicates that kelps historically grew wherever there were rocky substrates and eelgrass grew wherever both suitable depths for adequate light penetration and soft-bottom substrate were present, including (but not restricted to) throughout Gerrans Bay, Gunboat Bay, Oyster Bay and East Bay, and Bargain Bay. Additionally, Gunboat Bay and Oyster Bay were traditionally areas where culturally-important marine plants were harvested. At present, spatial data obtained from DataBC suggest that there may be four potential eelgrass beds within Pender Harbour, the largest eelgrass bed being located in Gerrans Bay (Figure 3 in Appendix 1). There is no indication from the spatial data that there are kelp forests in Pender Harbour.

2.3.3 Change in Dock Footprint

Comparing historical air photos to the most recent orthophotographs from 2014 reveals that the period of most rapid dock development in Pender Harbour was from 1978 to 1990, primarily in DMP Zone 4 (Figure 1; Figure 4 in Appendix 1). Over that time period, the number of docks across all zones increased from 104 to 256. Dock construction continued at a slow pace primarily in Zone 1 since 2003, when a moratorium on dock development was introduced in Pender Harbour.

In 2014, there were 326 private docks throughout the harbour and 22 community docks and marinas. 19 of the 22 community docks and marinas were in Zone 4 and 3 were in Zone 2. The majority of docks were built on mixed rocky substrates (n = 160), closely followed by bedrock (n = 126) (Figure 2). Three docks were constructed on mudflat habitat. Almost one third of the private docks in Pender Harbour have at least one boathouse (73 docks with one boathouse and 16 with at least two boathouses). Two of the community docks/marinas have one boathouse, and three community docks/marinas have 11–21 boathouses.

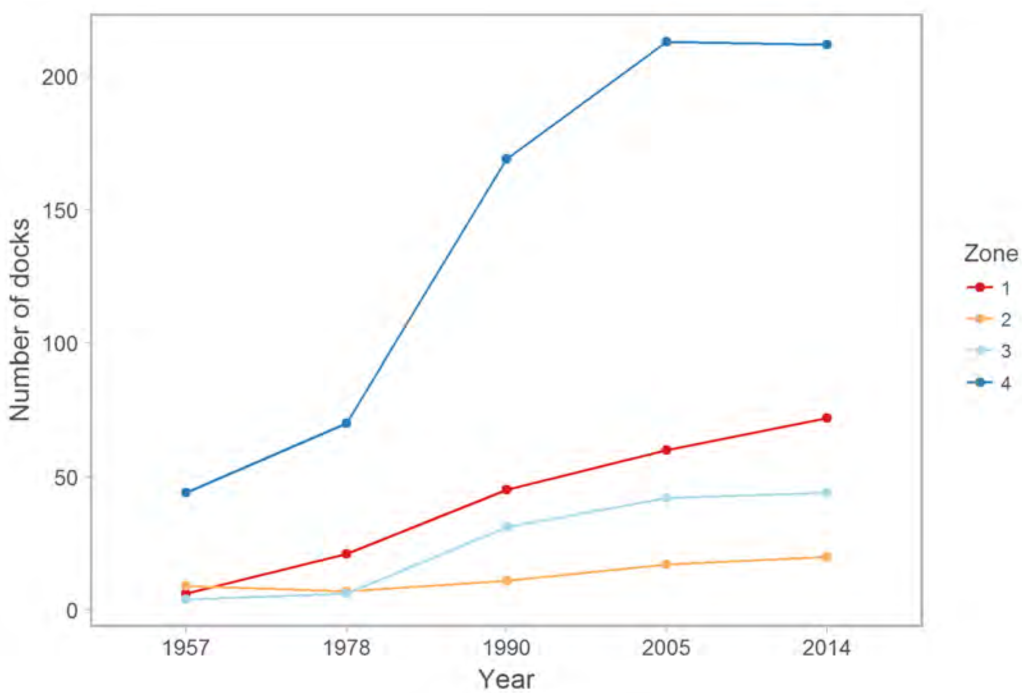

Figure 1. Change in number of docks over time in each Pender Harbour Dock Management Plan Zone.

Overlying spatial Crown land lease and license data from DataBC on the 2014 orthophotographs indicates that over one third of docks in Zones 1, 2, and 3 are unlicensed, and 15% of docks in Zone 4 are unlicensed (Figure 2). Of the 267 docks with associated leases or licenses, 163 did not fall entirely within the bounds of the tenured area permitted for dock construction or were often entirely outside the bounds of the tenured area. These figures pose a concern for the level of public compliance with dock permitting and construction processes, and the effective management of cumulative adverse effects to marine habitats.

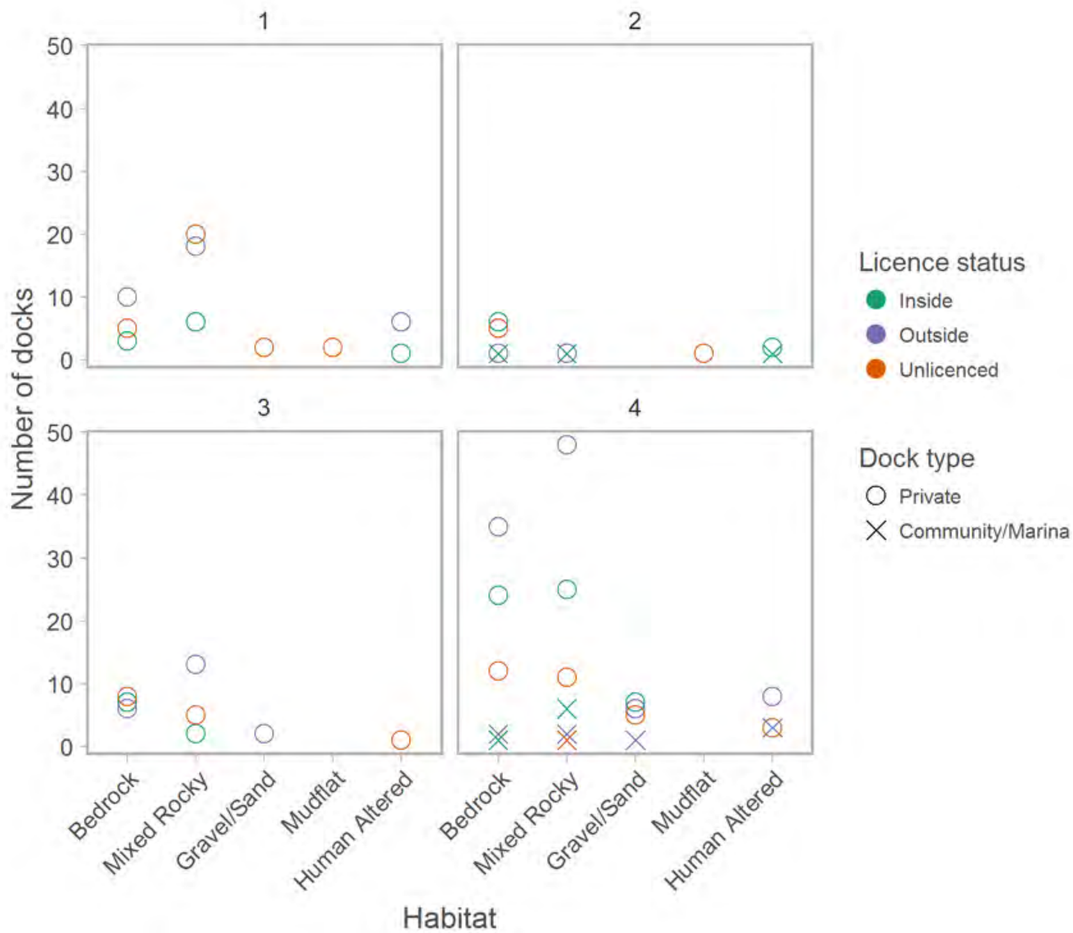

Figure 2. Number of docks constructed on each foreshore habitat type within each Dock Management Plan Zone (panel numbers correspond to zone numbers) by license status and dock type.

The mean total length of decking in community docks and marinas is significantly greater than that of private docks, at 265 m (range of 48–463 m) compared to 25 m (range of 2.6–131 m) for private docks (Figure 3, Figure 4). Six community docks and marinas have their longest edge oriented in a north-south direction (defined as facing within 10° of north or 10° of south) and five are oriented east-west (defined as facing within 10° of east or 10° of west) (Figure 4). The longest edge of 37 private docks are oriented north-south and 44 are oriented east-west (Figure 3).

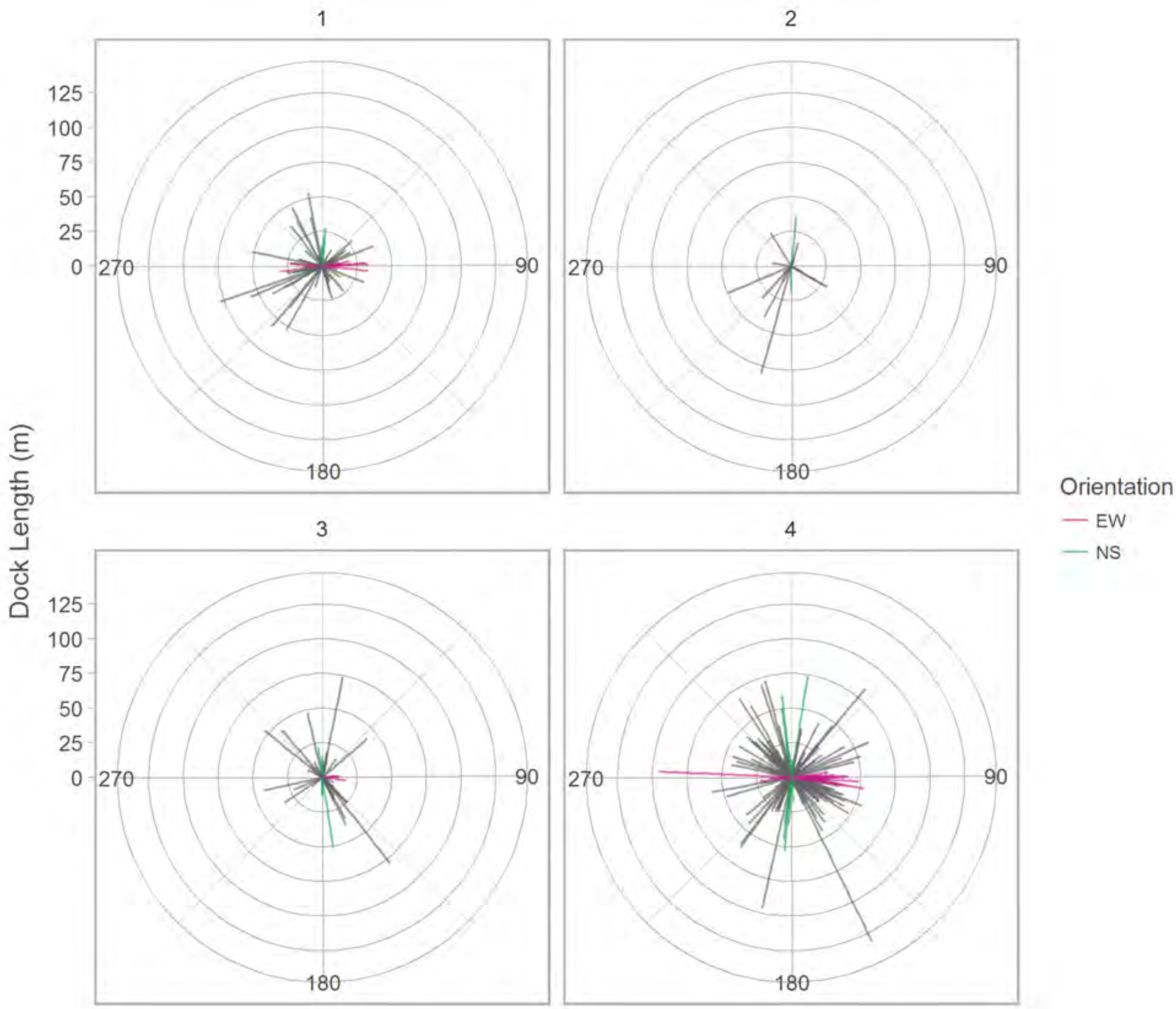

Figure 3. Total dock length (m) and orientation of the longest edge of private docks in Pender Harbour, by Dock Management Plan Zone (panel numbers correspond to zone numbers). East-west (EW) oriented docks were defined as being within 10° of east or west. North-south (NS) oriented docks were defined as being within 10° of north or south.

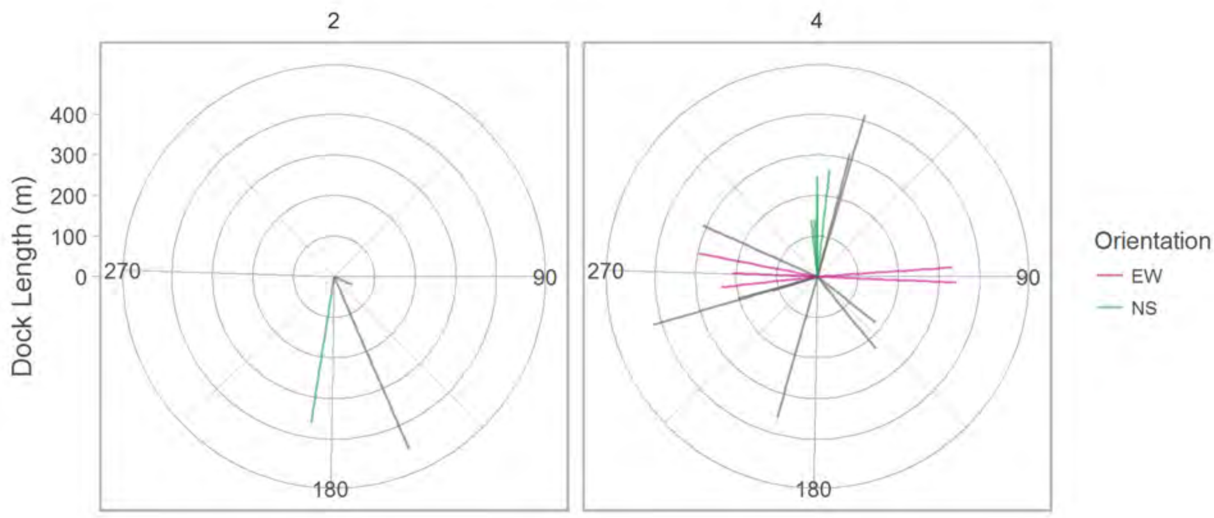

Figure 4. Total dock length (m) and orientation of the longest edge of community docks and marinas in Pender Harbour, by Dock Management Plan Zone. East-west (EW) oriented docks were defined as being within 10° of east or west. North-south (NS) oriented docks were defined as being within 10° of north or south.

2.3.4 Potential Impacts of Docks on Marine and Foreshore Habitats

There are a variety of mechanisms by which docks may temporarily or permanently alter marine and foreshore habitats or result in the loss of these habitats. These mechanisms are discussed in the following subsections (see Appendix 2 for the results and management recommendations contained in the papers/reports cited in this section).

2.3.4.1 Direct Alteration or Loss of Habitats due to Dock Construction

Dock construction results in permanent loss of marine and foreshore habitats wherever the dock makes direct contact with the substrate. Dock pilings, and typically floating docks, permanently destroy vegetation immediately under their footprints (Burdick and Short 1999, Kelty and Bliven 2003). Foot traffic and heavy machinery involved in constructing the docks may destroy vegetation both above (e.g., *Spartina* salt marsh grass) or below (e.g., *Zostera* eelgrass) the tide line by damaging their root systems and compacting the substrate (Kelty and Bliven 2003, Sanger et al. 2004a). Depending on the magnitude of damage, vegetation may recover over time. For example, *Spartina alterniflora* was able to recolonize an area of salt marsh largely destroyed by dock construction activities after approximately one year (Kelty and Bliven 2003).

The method of dock installation also influences the magnitude of adverse effects (as reviewed by Kelty and Bliven 2003). Pile installation by jetting causes greater sedimentation and loss of vegetation than pile driving. Sharpening the piles beforehand and using only low-pressure jetting followed by a pile hammer can reduce sedimentation. Likewise, floating building materials in and working from the water side or from existing structures can reduce damage to vegetation and substrate compaction.

2.3.4.2 Shading

Light levels under docks are typically lower than required for maintenance and growth of habitat-forming vegetation. Shading from docks has consistently been shown to decrease the stem/shoot density of *Spartina* salt marsh grasses (Kearney et al. 1983, McGuire 1990, Colligan and Collins 1995, Sanger et al. 2004a) and *Zostera* eelgrass (Burdick and Short 1999, Kelty and Bliven 2003) found under docks, with effects decreasing with distance from the dock. In two studies, *Spartina* stem density was 65% and 71% less, on average, under docks compared to next to docks (McGuire 1990, Sanger et al. 2004a). Burdick and Short (1999) found that eelgrass was mainly absent under docks. Docks may also reduce the biomass of seagrasses while causing compensatory increases in blade chlorophyll content and length relative to unshaded plots (Shafer 1999). Even in cases where shading from docks does not result in the complete loss of vegetation, decreased plant stem/shoot density and biomass may reduce local primary productivity and the provision of habitat services such as detrital decomposition, and decrease the value of the habitat as a nursery for juvenile fish (Sanger et al. 2004a).

Dock height (over the marine bottom or above mean sea level) and dock orientation are the most important predictors of light reaching vegetation under docks. Eelgrass and salt marsh grass stem density and biomass increase with dock height (Kearney et al. 1983, Burdick and Short 1999). Docks running east-west shade the area under the dock throughout the day and therefore support less seagrasses (or sometimes none) than docks running north-south (e.g., Burdick and Short 1999, Shafer 1999). In Pender Harbour, only 11% of private docks and 27% of community docks and marinas are within 10° of north-south along the docks' longest edge (Figure 3, Figure 4).

After synthesizing the results of dock shading studies at a National Oceanic and Atmospheric Administration (NOAA)-hosted workshop on marine dock impacts, Kelty and Bliven (2003), outlined mitigation measures to reduce shading effects on vegetation from docks: Docks should be (1) oriented north-south; (2) a minimum 1.2 m over the surface of a salt marsh or mean high water, in the case of eelgrass; (3) a maximum 1.2 m wide; (4) no longer than needed to reach navigable water; and (5) incorporate light transmitting materials, such as glass blocks instead of wood, metal grating, or sun tunnels. Note that spacing between deck planks on the order of one inch or two has not been found to significantly reduce shading impacts (Kelty and Bliven 2003). Mitigation measures (2) and (3) assume that the dock is oriented north-south. A higher minimum height is required to allow survival and growth of vegetation under a dock oriented in an east-west direction (Burdick and Short 1999). Burdick and Short (1999) developed a predictive model based on field data from Massachusetts, with which they recommended that docks less than 2 m wide oriented outside 10° of north-south be 0.2 m higher for every additional 10° increment.

To achieve the same mitigative effect in BC, the minimum dock height specified by Kelty and Bliven (2003) likely would need to be greater because the authors' value is based on studies conducted at lower latitudes. Regions at higher latitudes receive less sunlight and may require more conservative dock guidelines (Shafer 1999).

2.3.4.3 Scour and Sedimentation

Dock pilings and other dock structures may modify water flow and cause scour, erosion, or sediment deposition around the dock that may affect the suitability of the substrate for habitat-forming vegetation such as eelgrass. Eelgrass burial of 25% of the above ground shoot length has been shown to result in 50% mortality to eelgrass over 24 days (this equates to a burial thickness of 4 cm) (Mills and Fonseca 2003, Cabaço and Santos 2007).

Another study indicated that critical sedimentation thresholds for eelgrass range from 2 to 10 cm/year (Erftemeijer and Robin Lewis III 2006). Change in water flow and sediment characteristics around the dock may also affect the suitability of the habitat for infaunal (e.g., shellfish) and epifaunal marine invertebrates (Kelty and Bliven 2003).

2.3.4.4 Boat-Associated Impacts

Boating in the vicinity of dock structures may alter or destroy habitat through several mechanisms (as reviewed by Crawford et al. 1998). Boat propellers may cause direct damage to vegetation and their rhizome systems. For instance, short seagrass canopy height observed adjacent to docks suggests shading and/or disturbance impacts from boat activities (Burdick and Short 1999, Shafer 1999). Damage or destruction of vegetation represents a loss of habitat and decreases sediment stability, which can in turn make it difficult for vegetation to recolonize after disturbance.

Boat traffic may also resuspend and mobilize bottom sediments. Boats produce two kinds of wake, a bow wake and a secondary wake referred to as prop wash, which is the primary cause of sediment resuspension and damage to submerged vegetation. Slow-moving, heavy boats have been noted to cause more turbidity than lighter, faster-moving boats. Depending on the sediment characteristics, resuspended sediments may settle 7 s to 10 min after the passage of a recreational vessel. As discussed in Section 2.2.3, remobilizing sediments degrades habitat quality because it increases TSS levels and turbidity, and promotes desorption of contaminants (Kennish 2002). The latter increases contaminant bioavailability to marine fish and invertebrates.

Boats are additionally a source of contaminants that may degrade marine and foreshore habitats (see Section 2.2.1.2): PAHs from fuel spills and outboard motors, which release unburned fuel with exhaust gases, and leaching of heavy metals and TBT from antifouling paints.

2.3.4.5 Exposure to Contaminants

Contaminants from boats and docks may decrease the productive capacity of marine and foreshore habitats. Habitats with elevated water and sediment contaminant concentrations may be less able to support healthy populations of aquatic and terrestrial species due to the acute and chronic toxic effects of contaminant exposure on invertebrate and fish growth, reproduction, and survivorship.

For instance, elevated concentrations of chromium, copper, and arsenic leached from CCA-treated wood can be found in biota living on or near pilings (Kelty and Bliven 2003). However, at sites with adequate dilution and flushing, toxic effects are likely to be spatiotemporally localized and of low magnitude. Approximately 99% of leaching from CCA-treated wood occurs within the first 90 days of installation in water.

Sanger et al. (2004b) compared sites in tidal creeks with varying numbers of docks and suburban development (quantified based on the percentage of impervious cover (e.g., roofs, paved surfaces) in the associated watershed). They found that in small tidal creeks, sediment concentrations of metals that may be derived from CCA-treated wood were not associated with dock abundance. In large tidal creeks, sediment cadmium levels were higher in the suburban-dock category than the suburban-no dock category, and the average concentration of CCA metals was positively associated with dock abundance. Chromium and copper concentrations did not reach biologically harmful levels at any site; arsenic concentrations exceeded values reported to cause biological harm at a few sites with docks, though arsenic levels were naturally elevated in the region.

In both small and large tidal creeks, there were significantly higher cumulative concentrations of 14 metals and PAHs at sites with docks compared to sites with no docks. Fecal coliform levels were not associated with dock abundance. The amount of PCBs was not associated with dock abundance but with the amount of impervious cover in the associated watersheds. Dock abundance was positively associated with amount of impervious cover in the watershed; therefore, the effects of watershed development and docks on marine habitats could not be easily separated. However, the patterns of PAHs, PCBs, and fecal coliform indicated that much or most of these were from land-based sources. The authors noted that urban development is the ultimate cause of degradation to foreshore and marine habitats; contamination of marine waters and sediments from land-based sources and construction of docks only follow from this.

2.4 Assessment of Aquatic and Terrestrial Species Richness and Abundance

2.4.1 Marine Fish

The sheltered bays and estuaries of Pender Harbour provide feeding, spawning and rearing habitat for many fish species of CRA importance. Anderson, Kleindale, and Myers Creeks, which drain into Oyster Bay, support spawning populations of chum (*Oncorhynchus keta*), coho (*O. kisutch*), and pink salmon (*O. gorbuscha*) (DFO NuSEDS 2017a). Historical escapement records for Anderson and Myers and Kleindale Creeks (combined), report that yearly spawner counts ranged from 25–3000 coho and 375–30,000 chum over 1947 to 1976 (Marshall et al. 1976). From 2010 to 2016, the median estimate of maximum spawners in Anderson Creek was 420 (range of 0–670) coho, 1370 (range of 0–6700) chum, and 460 (range of 0–58,600) pink (DFO NuSEDS 2017a). Coho salmon also spawn in Paq Creek and a small unnamed creek in Gunboat Bay (Hall 1992). Chinook salmon are found in the harbour basins, and unlike the other two species, are winter residents in the harbour (Hall 1992). Cutthroat and rainbow trout spawn in the majority of the creeks that drain into the harbour (Hall 1992).

Pender Harbour historically supported large Pacific herring (*Clupea pallasi*) spawns; with Gerrans Bay and Bargain Bay being preferred historical spawning habitats, according to Hall (1992). However, herring spawns have significantly declined in size and become more erratic. Hall (1992) noted that the most recent herring spawn at the time occurred in the vicinities of Irvines Landing and Gunboat Bay.

A variety of shellfish species are found in the harbour. Clams and oysters were traditionally abundant in the intertidal mudflat habitats of Oyster Bay, East Bay, Bargain Narrows, and the head of Gerrans Bay (Hall 1992). Crabs and rockfish are also found in the harbour’s subtidal habitats.

shíshálh Nation traditionally harvested many fish and invertebrates throughout Pender Harbour. A traditional weir was used to trap salmon near the head of Oyster Bay. Lingcod and rockfish were fished from more exposed areas with rocky substrates, particularly around Bargain Bay and Edgecombe Island, the Francis Peninsula, and the islands at the entrance to Pender Harbour. *shíshálh* Nation Traditional Knowledge likewise reinforces that large herring spawns occurred throughout Pender Harbour — wherever there were kelps or eelgrass on which to lay eggs — including in Oyster Bay, Gunboat Bay, East Bay, Bargain Bay and Bargain Narrows. *shíshálh* Nation traditionally harvested cod roe, herring, and herring roe. Herring roe was collected off kelps or by placing cedar and hemlock bows in the water on which the herring would spawn. Clams and cockles were harvested wherever there was access to a suitable soft-bottom beach, whereas limpets were harvested around more exposed rocky intertidal areas. Sea cucumbers and urchins were also harvested.

2.4.2 Aquatic and Terrestrial Wildlife

According to *shíshálh* Nation Traditional Knowledge, Gunboat Bay and Oyster Bay were good locations to hunt waterfowl. The salt marsh of Oyster Bay has historically provided particularly important foraging and wintering for bird species (Hall 1992). Diving ducks and birds (loons, grebes, and cormorants), alcids (e.g., murres), and gulls have been reported to winter in Pender Harbour. The Salt Lagoon adjacent to Bargain Narrows is a foraging area for goldeneye ducks, buffleheads, scoters, Canada geese, and trumpeter swans (Hall 1992).

Pender Harbour notably provided foraging and nesting habitat for a colony of at-risk Pacific great blue heron (COSEWIC- and SARA-listed as *Special Concern*). The herons feed in the harbour on a variety of fish and crustacean prey species, including sculpins, mud and ghost shrimps, gobies, marine worms (*Nereis* spp.), threespine stickleback (*Gasterosteus aculateus*), gunnels, starry flounder (*Platichthys stellatus*), perch, chum salmon fry, and bay pipefish (*Syngnathus griseolineatus*) (Forbes and Simpson (1982); as reported by Gebauer and Moul 2001).

In 1977, 75 active Pacific great blue heron nests were located in Gunboat Bay (Gebauer and Moul 2001); and in 1978, it was estimated that there were about 120 adult birds in the colony (Simpson and Kelsall 1979). In the following decades, the population significantly declined in size as a combined consequence of rapid urban development, human disturbance, and bald eagle depredation (Gebauer and Moul 2001). In 1999, there were only 12 active nests in the Sunshine Coast (Gebauer and Moul 2001). The literature search conducted for this study did not yield information on the modern-day use of Pender Harbour marine and foreshore habitats by Pacific great blue herons.

2.4.3 Commercial Activities and Harvest

Commercial fishing does not occur within Pender Harbour (Hall 1992). The harbour does, however, support commercial fisheries for herring and salmon by providing important feeding, spawning, and rearing habitat for these stocks. Aquaculture is restricted within the harbour due to heavy boat traffic and sanitary contamination.

2.4.4 Public Harvest and Consumptive Use

Dungeness crabs, trout, salmon, and rockfish are recreationally fished within the harbour (Hall 1992). Note that no data was available at the time of writing with respect to qualitative trends in public harvest activities in Pender Harbour.

Pender Harbour is closed to shellfish harvesting due to sanitary contamination (DFO 2017b). As discussed in Section 2.2.2, Oyster Bay was first closed to shellfish harvesting in 1964, and the closure was subsequently expanded to Gunboat Bay (1967), Pender Harbour east of Donnelly Point (1974), and Bargain Bay (1988) (Hall 1992). However, Hall (1992) noted that people continued to harvest clams and oysters despite the closures. It is unknown whether this is still the case today.

2.4.5 Impacts of Docks on Aquatic and Terrestrial Species Richness and Abundance

Docks may have numerous impacts on marine habitat (as discussed in Section 2.3.4), with associated effects on aquatic and terrestrial species that use these habitats. Higher cumulative concentrations of heavy metals and PAHs found in waters with high numbers of docks and suburban development (e.g., Sanger et al. 2004b) may have toxic effects on marine epi- and infaunal invertebrates, in particular, and bioaccumulate at higher trophic levels (Kennish 2002). Resuspension of sediments due to boating is one mechanism by which fish such as juvenile salmonids may be exposed to and take up these accumulated contaminants (Martens and Servizi 1993). Elevated TSS levels and turbidity due to boating may also cause functional habitat degradation or loss by generating physiological stress in fish or simply causing adult fish and highly mobile invertebrates to avoid areas around docks (Newcombe and Jensen 1996, Wilber and Clarke 2001).

Sanger et al. (2004b) found no difference in the total abundance of juvenile fish and crustaceans in tidal creeks with many docks compared to creeks with few or no docks. This is possibly because docks, somewhat like artificial reefs, may attract some fish and provide solid substrates for epifauna to colonize. However, the abundance of macro invertebrates found in sediments — which may represent food resources for fish species — was negatively associated with number of docks. Further, the relative abundance of stress-tolerant benthic macroinvertebrate species compared to stress-sensitive species was higher in areas with suburban development (both with and without docks). Indeed, evidence indicates that species assemblages on or around artificial structures are often less diverse and may differ greatly from those on natural substrates for several reasons (as reviewed by Bulleri and Chapman 2010).

Docks provide a vertical surface (or even a mobile floating surface) for species to colonize whereas natural intertidal surfaces are sloped and have heterogeneous topography (e.g., Chapman 2003, Lam et al. 2009). As species of marine animals and plants are limited in their distribution by the slope of the habitat, the substitution of a vertical surface can result in higher densities of organisms and higher intra- and interspecific competition, including between species that would otherwise not occupy the same space. The consequence of this may be reduced growth, smaller size at maturity, and reduced reproductive output (e.g., Moreira et al. 2006). Docks are often constructed of unnatural materials (e.g., plastic or metal) that may impact what species colonize the surface (e.g., Chapman and Clynick 2006). It is possible that older docks may, through a period of successional development, support species assemblages that more closely resemble those of natural habitats (e.g., Pinn et al. 2005).

The reduced complexity of artificial surfaces provides fewer microhabitats and refuges from predators, which can influence post-settlement survival of larvae or propagules that naïvely or passively settle on the structures. The altered abundance or distribution of species due to docks can in turn affect the behaviour and distribution of aquatic and terrestrial predators. For example, mussels growing on shellfish aquaculture structures grew larger with a lower shell mass and had weaker byssal attachment than those growing on natural intertidal substrates, which caused wintering sea ducks to alter their feeding habits and distribution (Kirk et al. 2007).

Docks may also affect species assemblages living on adjacent habitats by fragmenting natural habitats, shading substratum or creating areas with reduced water flow and wave exposure. For instance, sheltering of rocky shores by infrastructure has been shown to cause consumer-dominated (e.g., barnacles, limpets) intertidal assemblages to become dominated instead by primary producers (i.e., algae), ultimately altering the ecological function of the community (Martins et al. 2009).

On a regional scale, the impacts of dock structures on species' source-sink dynamics are just as difficult to predict. Disruption of shoreline hydrodynamics by infrastructure such as docks may limit or stop the dispersal of larvae and propagules (Bulleri and Chapman 2010). Conversely, dock proliferation may cause genetic homogenization of invertebrate communities that naturally colonize rocky substrates by providing stepping stones to connect otherwise separated populations (Fauvelot et al. 2009).

3.0 PHASE 2 BASELINE ASSESSMENT FIELDWORK

3.1 Methods

In September 2017, MFLNRORD contracted MCW to conduct a baseline field survey of Pender Harbour to characterize the marine and foreshore habitats and species in each Dock Management Plan zone. MCW conducted this field survey October 8–22, 2017 as outlined in the following subsections.

3.1.1 Shoreline Photographs

MCW took photos of the shoreline throughout the study area (see Appendix 3). These photos were used to help ground truth the foreshore characterization completed during Phase 1, which was based only on 2014 orthophotographs. The photos were also taken to visualize for MFLNRORD what the docks in Pender Harbour typically look like; and to provide examples of impacts of docks and urban development on the marine environment.

3.1.2 Intertidal to Shallow Subtidal Transect Surveys

MCW characterized the intertidal and shallow subtidal community composition of the proposed DMP zones by conducting a transect survey, based on the recommended survey procedures established by DFO (Williams 1990). The transects were surveyed by dive because of the high fall tides.

To adequately sample the communities present in each zone, transects were distributed in each of eight smaller geographical subareas defined to better capture spatial differences in marine foreshore habitat types: Gunboat Bay, Central Pender, Pender Islands, Northwest Pender, Lee Bay, Francis Peninsula, Bargain Bay, and South of Bargain Bay (see Figure 5 in Appendix 1). Transects extended perpendicular to the waterline for 50 m, from the present high-water mark to a maximum depth of 60 ft (the maximum depth permitted by WorkSafeBC for a three-person dive team). Coordinates of the landward end of each transect were obtained using a Trimble differential GPS and the transect bearing was recorded by the dive team. MCW also took photos of and notes on the biological and physical characteristics of the backshore bordering each transect. A total of 36 transects were surveyed throughout the study area (see Figure 5 in Appendix 1).

The dive team sampled 10 or 11 quadrats (0.5 m x 0.5 m) along each transect, spaced at 5 m increments, except in cases where a full 50 m transect could not be surveyed because the dive team reached the WorkSafeBC maximum depth limit. The divers recorded the marine substrate type(s) (Table 2) in each quadrat as a percent cover of the quadrat area. The algae, vegetation, invertebrates, and fish present in each quadrat were identified to the lowest taxonomic level possible. The abundance of these taxa was recorded as a count for motile animals and clams, cockles, and siphon holes, and as a percent cover of the quadrat area for algae, vegetation, and sessile invertebrates (e.g., barnacles, oysters). Percent cover was coded as one of six classes: 1 = 1–15%; 2 = 16–30%; 3 = 31–50%; 4 = 51–65%; 5 = 66–80%; 6 = 81–100%.

Table 2. Substrate type classification (DFO 2011).

Substrate	Definition
Silt/clay/mud	Loose sedimentary deposit; <0.06 mm
Sand	Loose granular material; 0.06–2 mm
Gravel	Loose rounded fragments of rock; 2–64 mm
Cobble	Loose stone larger than gravel, smaller than a boulder; 64–256 mm
Boulder	A detached massive rock; >256 mm
Bedrock	Solid rock underlying unconsolidated surface material
Shell debris	Shell fragments of various organisms
Organic detritus	Organic materials such as logs, sticks, leaves, remnants of decayed aquatic plants, etc.

The dive team photographed each quadrat. They also took a continuous GoPro video moving shoreward along the length of each transect, pausing every 5 m to record the time and depth. On a rising tide, the dive team additionally completed a drift dive through Gunboat Narrows, the narrow channel entrance to Gunboat Bay, and recorded video footage of this dive using the GoPro camera.

Following the field survey, MCW completed a video analysis of the GoPro footage. Within each 5 m stretch of the transect, the dominant and subdominant substrate type (classified as per Table 2) was identified. The algae, vegetation, invertebrates, and fish observed in each 5 m stretch of the transect were identified to the lowest taxonomic level possible. Sessile invertebrates were simply coded as either present or absent. The abundance of motile animals was recorded as a count, and the relative abundance of algae and vegetation was coded as sparse, moderate, or abundant.

The video analysis provided an additional and complementary means of characterizing the marine communities along the transects. The GoPro videos are more likely to detect fish in the water column than the quadrat survey, whereas small or cryptic animals and algae detectable during the quadrat survey may not be visible or easily identifiable during video review.

3.1.3 Benthic Infauna Characterization

The dive team sampled benthic infauna from one location along each transect if suitable soft substrates for bivalves were present (i.e., mud or sand). The sediments were excavated with a trowel and sifted to visually search for bivalves and other infaunal invertebrates.

3.1.4 Eelgrass Bed Delineation and Characterization

MCW conducted a dedicated survey to locate eelgrass beds in Pender Harbour, beginning first at each of the four locations identified in the spatial data from DataBC as potentially supporting eelgrass (Figure 3 in Appendix 1), and then surveying more widely around any additional eelgrass shoots or beds observed during the intertidal to shallow subtidal transects.

The perimeter of each eelgrass bed was delineated by mapping the movements of the dive team around the outer margin of the bed with a Trimble differential GPS. The divers described the distribution of eelgrass within the beds as continuous if there was almost one hundred percent cover, or patchy if the bed contained patches of eelgrass (Precision Identification 2002). The edge of a bed was defined as the point beyond which shoot density decreased to 0 shoots/m^2 for at least 5 m. During each eelgrass bed delineation, the divers used a GoPro video camera to record periodic video footage of the eelgrass they were observing.

At six eelgrass beds bordering docks, the divers established a transect extending perpendicularly from the nearest dock to a distance reasonably far away from dock impacts (Transects EG1–EG6, Figure 6 in Appendix 1). As per Burdick and Short (1999)'s survey design, four quadrats were sampled along this transect to measure the number of eelgrass shoots per quadrat, shoot width, and canopy height (consistent with the SeagrassNet protocol; Short et al. (2006)). The first quadrat was placed under the dock (coded as "Under") and the last placed reasonably far away from possible dock impacts ("Far"). If there was no eelgrass under the dock, a quadrat was sampled in the first eelgrass encountered ("Adjacent"); if there was eelgrass under the dock, the Adjacent quadrat was placed within 2 m of the dock. A middle station ("Mid") was placed between the Adjacent and Far quadrats. MCW recorded the materials with which the dock was made, measuring the dock orientation, dock height above water, height above the marine bottom, and dock length along the eelgrass bed. MCW also recorded whether the dock was fixed or floating. In combination with the eelgrass bed delineation, these measurements were used to more fully characterize dock effects on eelgrass growth.

In addition to these transects, the divers photographed six quadrat locations along a transect through a subtidal area of Gerrans Bay found to have very patchily distributed eelgrass shoots (Transect EG7, Figure 6 in Appendix 1). This was done to better characterize the substrate and eelgrass characteristics.

3.1.5 Wildlife Observations

Birds or other wildlife observed during the habitat surveys were identified if possible to gather information on wildlife species presence and habitat use. Particular attention was paid to the presence of the at-risk Pacific great blue heron.

3.1.6 Statistical Analyses

3.1.6.1 Effects of Docks on Marine Species Abundance and Diversity

Quadrat Data

MCW fit regression models to assess the effects of docks on seven response variables: the probability of observing kelp, kelp percent cover, infaunal bivalve abundance, epibenthic polychaete worm abundance, and the diversity of marine algae, sessile invertebrates, and motile animals observed during the transect-quadrat surveys. Fish were excluded from the motile animals because of the lower detectability of fish in the water column during a quadrat survey, which as mentioned in Section 3.1.2 is focused more on detecting epibenthic species. Effects on fish, alone, were instead analyzed using the data extracted from the GoPro video footage of the transects (this statistical analysis is discussed in the following subsection). The models expressed the response variables as a function of quadrat water depth (adjusted for tide height) and water depth squared (to allow for a quadratic relationship between depth and the response variable; adjusted for tide height), whether the dominant substrate type in the quadrat was soft substrate (i.e., mud, sand, or organic) or hard substrate (i.e., shell, gravel, cobble, boulder, or bedrock), and the number of docks plus marinas within 200 m of each transect (hereafter referred to as number of docks).

The midpoint of the percent cover ranges indicated by the six percent cover classes (1–6) was used as the response variable to model the abundance and diversity of taxa coded as one of these cover classes. The effective species diversity of each quadrat was calculated as the inverse of Simpson's concentration index (D) — a measure of diversity that accounts for the number of species present and the relative abundance of each species (Simpson 1949, Jost 2006):

$$D = 1/\sum_{i=1}^{s} p_i^2,$$

where p_i represents the proportion of species i from 1 through s. MCW log transformed the number of docks predictor to allow for the ability to predict what effect a percent change in the number of docks would have on the response variables. Since it is not possible to log a zero, one dock was added to each value prior to log transforming the predictor.

To model the probability of observing kelp, MCW fit a generalized linear mixed effects model (GLMM) with a binomial error distribution and logit link. For response variables that could only take on positive values (i.e., kelp percent cover and the diversity indices), MCW fit linear mixed effects models to log-transformed response variables. This ensured that predictions remained positive when exponentiated and changed the interpretation of slope coefficients to be multiplicative. For response variables representing counts (e.g., motile animals), MCW fit negative binomial GLMMs with a log link using the NB2 parameterization (Hilbe 2011) where the variance is modeled as increasing quadratically with the mean. All GLMMs were fit with a random intercept for the individual transect to control for pseudo-replication. The random intercept coefficients were plotted against the transect latitudes and longitudes to check for spatial patterns.

The models were fit in a Bayesian framework with the package rstanarm 2.13.1 (Stan Development Team 2016) for the statistical software R 3.3.2 (R Core Team 2017). The package rstanarm runs regression models in Stan (Stan Development Team 2017), which are fit with Hamiltonian Markov chain Monte Carlo sampling. Fitting the models in a Bayesian framework allows the modeller to calculate the probability of a coefficient being in a specific range (e.g., the probability of a coefficient being < 0). The models were fit with default priors and 4000 iterations across four chains, discarding the first 2000 iterations of each chain as warm-up. MCW ensured the chains had converged by inspecting the chains visually.

GoPro Data

The above statistical analysis was repeated with the data extracted from the GoPro video footage of each transect. Here, MCW assessed the effects of docks on several response variables: the probability of observing kelp, kelp relative abundance, the probability of observing sessile invertebrates, the abundance of motile animals and, separately, the abundances of crabs, sea stars, and fish, and the diversity of motile animals observed during the video survey of the transects. The models expressed the response variables as a function of water depth (adjusted for tide height) and water depth squared (adjusted for tide height) at each 5 m mark of the transect, whether the dominant substrate type in each 5 m stretch of the transect was soft substrate or hard substrate, and the number of docks within 200 m of each transect.

To model the probability of observing kelp (and additionally of observing moderate to abundant kelp) or sessile invertebrates, MCW fit a GLMM with a binomial error distribution and logit link. As with the quadrat data, for response variables that could only take on positive values (i.e., the diversity indices), MCW fit GLMMs to log-transformed response variables. For response variables representing counts (e.g., motile animals), MCW again fit negative binomial GLMMs with a log link using the NB2 parameterization.

3.1.6.2 Effects of Land Use on Marine Species Abundance and Diversity

The growth in the number of docks in Pender Harbour has followed urban development of the land surrounding the harbour. To assess the effects of urban development itself on the marine environment, MCW fit regression models that expressed the seven response variables listed in Section 3.1.6.1 as a function of the area of impervious land cover (i.e., roads, buildings) within 200 m of the shoreward end of the transects. Quadrat water depth and whether the dominant substrate type in the quadrat was soft substrate or hard substrate were again included as predictors in the model.

The area of impervious land cover within 200 m of each transect was calculated through a land use classification analysis performed in ArcGIS using high resolution (i.e., 1x1 m) multispectral satellite imagery collected by the Pléiades satellite system on September 16, 2017 and February 17, 2017 (obtained from Land Info World Wide Mapping). The near infrared, red, and green bands of the imagery were used to create a false color composite image of the study area. Trees and other local vegetation have a higher reflectance in the near infrared band and appear as shades of red in a false color composite image; whereas impervious cover has a low reflectance in the near infrared band and appears white in a false color composite. Supervised maximum likelihood classification was then used to classify the land features into different classes (e.g., road, building, forest, grass) based on the spectral signatures of the features in this composite image. Multiple ground truthed training polygons were used for each land class. The Anderson level 1 classification level was used.

3.1.6.3 Effects of Docks on Eelgrass Beds

With the eelgrass bed transect data, MCW assessed the effects of docks on the number of eelgrass shoots per quadrat by fitting a negative binomial generalized linear model (GLM). To examine the effect of docks on eelgrass mean shoot length (cm) and mean shoot width (cm), MCW fit GLMs with a gamma error distribution and a log link function. The models expressed the eelgrass response variables as a function of quadrat position in relation to dock (Under, Adjacent, Mid, Far), dock orientation, quadrat water depth (adjusted for tide height), and dock height above marine bottom (adjusted for tide height). Dock height above water and whether the dock was fixed or floating were not included as predictors in the models because all docks were floating on the water's surface. MCW fit all GLMs using the rstanarm package for R with default priors and 2000 iterations across four chains, discarding the first 1000 iterations of each chain as warm-up. MCW ensured the chains had converged by inspecting the chains visually.

MCW calculated the area devoid of eelgrass under and around the docks in Bargain Bay with the most evident footprints to estimate the area of eelgrass that appears to have been lost due to shading by docks (and presumably boats moored at the docks).

3.2 Results

3.2.1 Backshore Habitats

Backshore vegetation adjacent to transects in areas with little urban development (i.e., Transects 10, 14, 16, 30, 34, 35, and 36) were dominated by mature coniferous trees such as western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*), followed by arbutus trees (see photos in Appendix 4). Understory vegetation consisted of shrubs such as salal (*Gaultheria shallon*), and other species such as ferns, mosses, and lichens. In areas with high numbers of docks, homes and other forms of urban development line the backshore of the transects (photos in Appendix 4). Deciduous trees, non-native plants and grasses are more prevalent in these areas.

3.2.2 Marine Habitats

3.2.2.1 Substrate

The substrate along the transects in the Gunboat Bay area (which includes East Bay and Oyster Bay) was dominated by mud, followed by shell debris (Figure 5, Figure 6A). With the exception of along Transect 12, rocky substrates (e.g., primarily boulder, with some bedrock) tended to be found only within 5–20 m of shore in the intertidal zone. The GoPro video footage obtained by the divers during the drift dive of Gunboat Narrows indicates that this channel is comprised of rocky substrates.

In Central Pender, Northwest Pender, and around the Pender Islands, the substrate along most transects was again dominated by mud and shell debris up to about 5–20 m from shore, where rocky substrates dominated (Figure 5). Some transects had markedly higher coverage by bedrock (i.e., Transect 8, Transect 19, and the more exposed Transect 27, on Mary Islet). Quadrats in half of the transects in Central Pender, and particularly along Transect 4, in Northwest Pender, also had anthropogenic substrates, typically tires, glass bottles, old chains, batteries, and fishing nets (Figure 6F).

In Lee Bay, two of the transects, particularly Transect 1 on the east side of Daniel Point, had notably high amounts of organic substrate that looked like wood debris of anthropogenic origin (e.g., from log booms; Figure 5, Figure 6E). Henry Point, on the eastern edge of the bay, was by contrast rocky, with bedrock, boulder, and cobble substrate.

Transects 30 and 31, off the Francis Peninsula, were in bays comprised of soft bottom substrates. Transect 29, which was located on more exposed shoreline, was dominated by rocky substrates (Figure 6D) with some shell debris.

In Bargain Bay, the substrate along the two transects on the eastern shore of the bay was primarily mud and sand (Figure 5). Rocky substrates were found within 10–20 m of shore in the intertidal zone. The substrate of Transect 32, at the entrance to the Bargain Narrows, was primarily composed of gravel, with shell, cobble (Figure 6B), and boulder dominating at the shoreward end. In the South of Bargain Bay subarea, the transect substrates were dominated by boulders and shell (Figure 6C).

3.2% of the foreshore in the field study area was human-altered (see photos in Appendix 5). See other examples of anthropogenic impacts to habitats in Appendix 6.

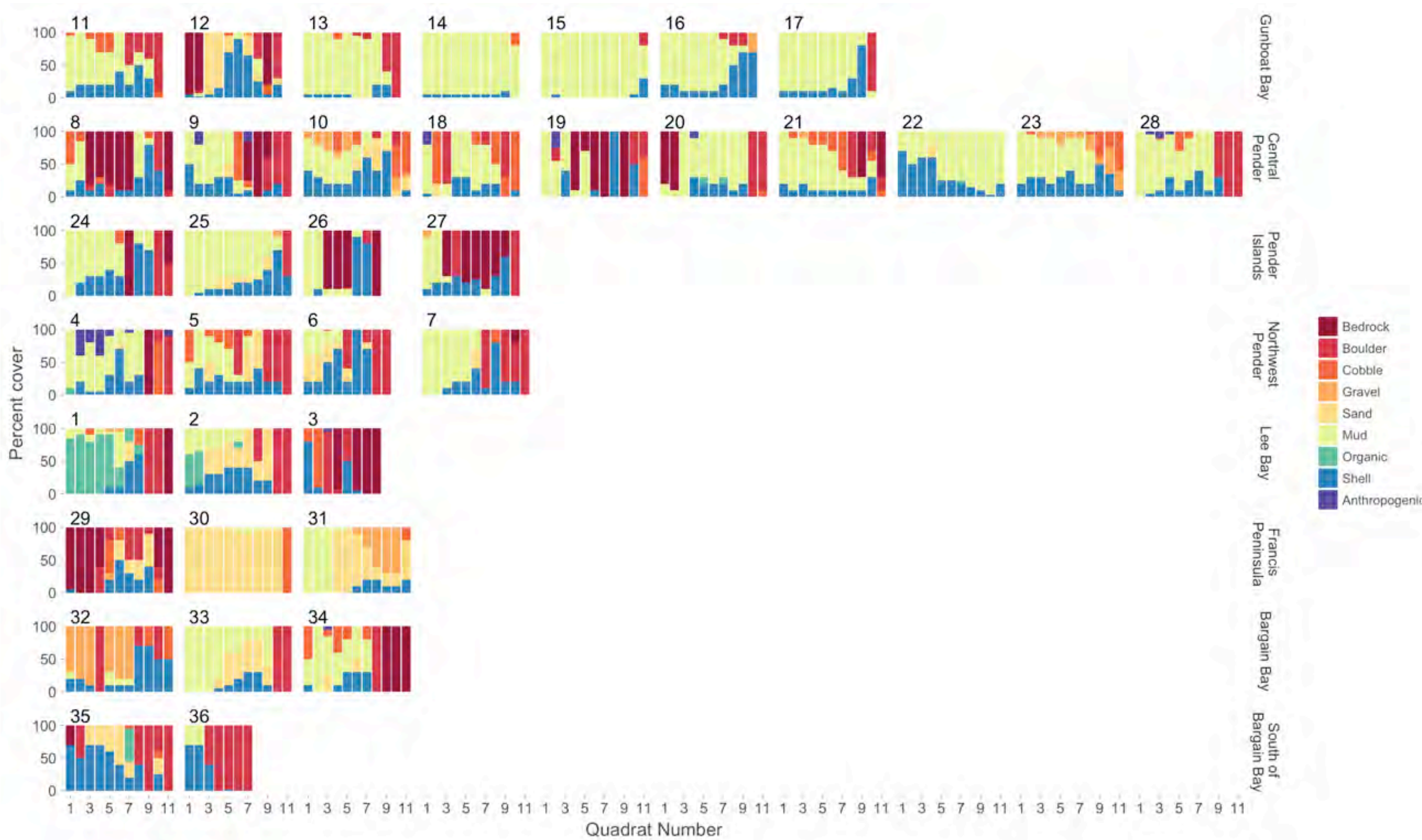

Figure 5. Percent cover of substrate types observed along transects surveyed in the each of the geographical subareas of Pender Harbour. Quadrat number 1 corresponds to the most seaward quadrat, with subsequent quadrats being spaced at five meter intervals in a shoreward direction up to the present water line.

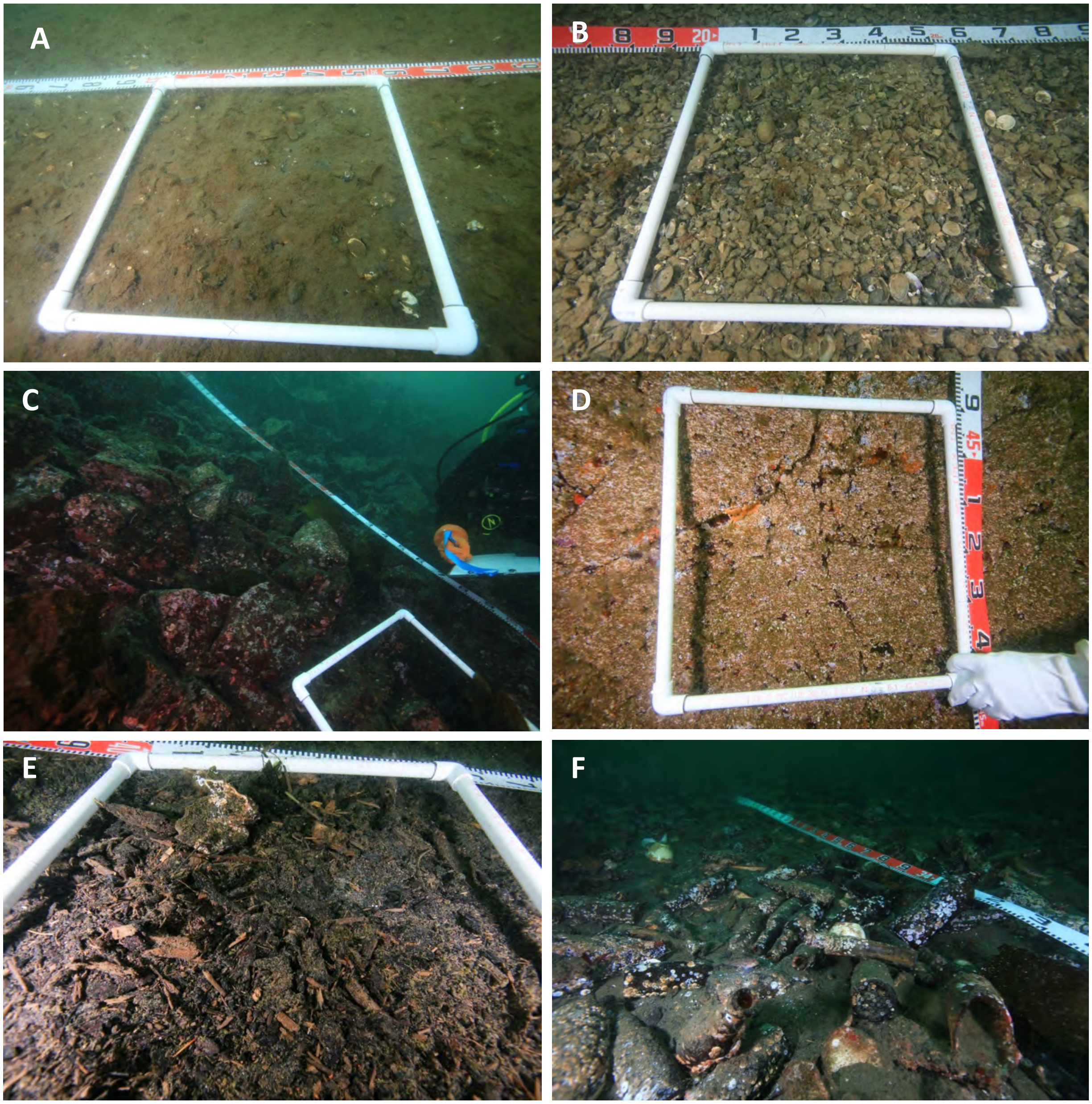

Figure 6. Substrate types observed in Pender Harbour. Mud and shell substrates typical along Gunboat Bay transects (A); shell and gravel along Transect 32 (B); boulders along Transect 36 (C); bedrock along Transect 29 (D); organic/wood debris substrate along Transect 1 (E); and anthropogenic substrates such as glass bottles along Transect 4 (F).

3.2.2.2 Algae and Marine Plants

Algae

Algae species diversity was 32% (95% credible interval [CI] = 22–40%) lower on soft-bottom substrates than rocky substrates. The odds of finding kelps growing in benthic habitats dominated by mud, sand, or organic substrates was 7% (95% CI = 3–18%) that of the odds of finding kelps on rocky substrates, consistent with the fact that kelps require hard substrates on which to attach. Accordingly, transects located primarily on sand- or mudflats naturally had lower algal diversity. For example, algae were only rarely observed growing on the mudflats of the Gunboat Bay subarea. No algae were observed in quadrats along Transects 14 and 15 and kelp was only observed growing in one quadrat along Transect 11. When algae were present, however, the geometric mean algal diversity was not markedly different across subareas (Figure 7). Higher geometric mean algal diversities for Northwest Pender and Lee Bay were driven by the higher number of algae species observed in quadrats along Transects 5, 7, and 2, respectively.

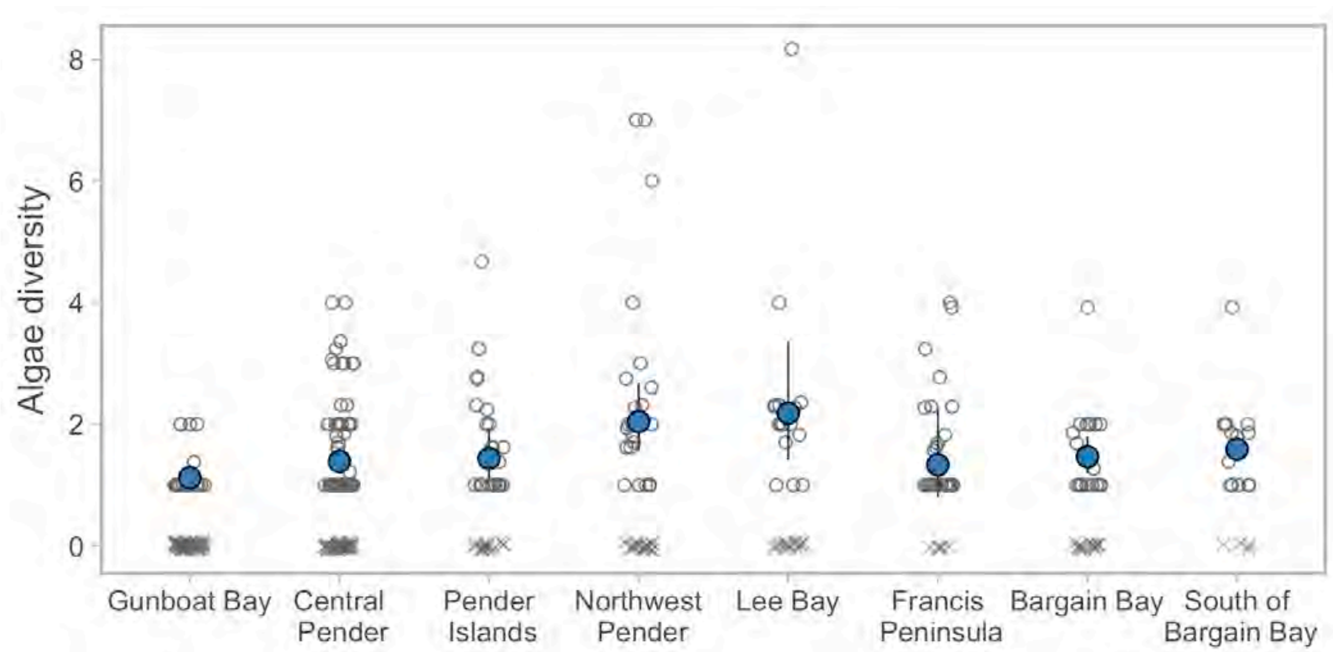

Figure 7. Local algae diversity by subarea. Blue points represent the geometric mean of the mean algal diversities for each transect in the subarea and thin lines represent the 95% confidence intervals. Small points represent the algal diversity of each quadrat, with the 'x's representing those quadrats with no algae. Species diversity of each quadrat was calculated as the inverse of Simpson's concentration index.

The dominant algal species in the high- to mid-intertidal zone were rockweed (*Fucus* spp.), sea lettuce (*Ulva* spp.), and dwarf sea hair (*Blidingia minima* var. *minima*) (Figure 8B,C). The invasive Japanese wire weed (*Sargassum muticum*), and red spaghetti (*Gracilaria* spp.) were common and often abundant in the low intertidal to shallow subtidal (Figure 8D,E). Sea laurel (*Osmundea spectabilis*) and branched corallines (family Corallinaceae) were also observed growing on rocks in this zone, though infrequently. Simple-bladed (e.g., *Palmaria* sp.) and branched red algae (e.g., *Callophyllis* spp., *Rhodymenia* spp.) were commonly observed on subtidal rocky or anthropogenic substrates. Crustose red algae (e.g., coralline crusts) were found throughout the study area growing on subtidal rocky substrates (Figure 8F). Kelps (primarily sugar kelp (*Saccharina latissima*) and some *Agarum* sp.) were observed primarily in the subtidal zone but also less commonly in the low intertidal (Figure 8A). The GoPro video footage from the drift dive of Gunboat Narrows indicates that the rocky substrates support abundant large-bladed red algae (possibly *Wildemania* spp. and/or *Porphyra* spp.) and kelps.

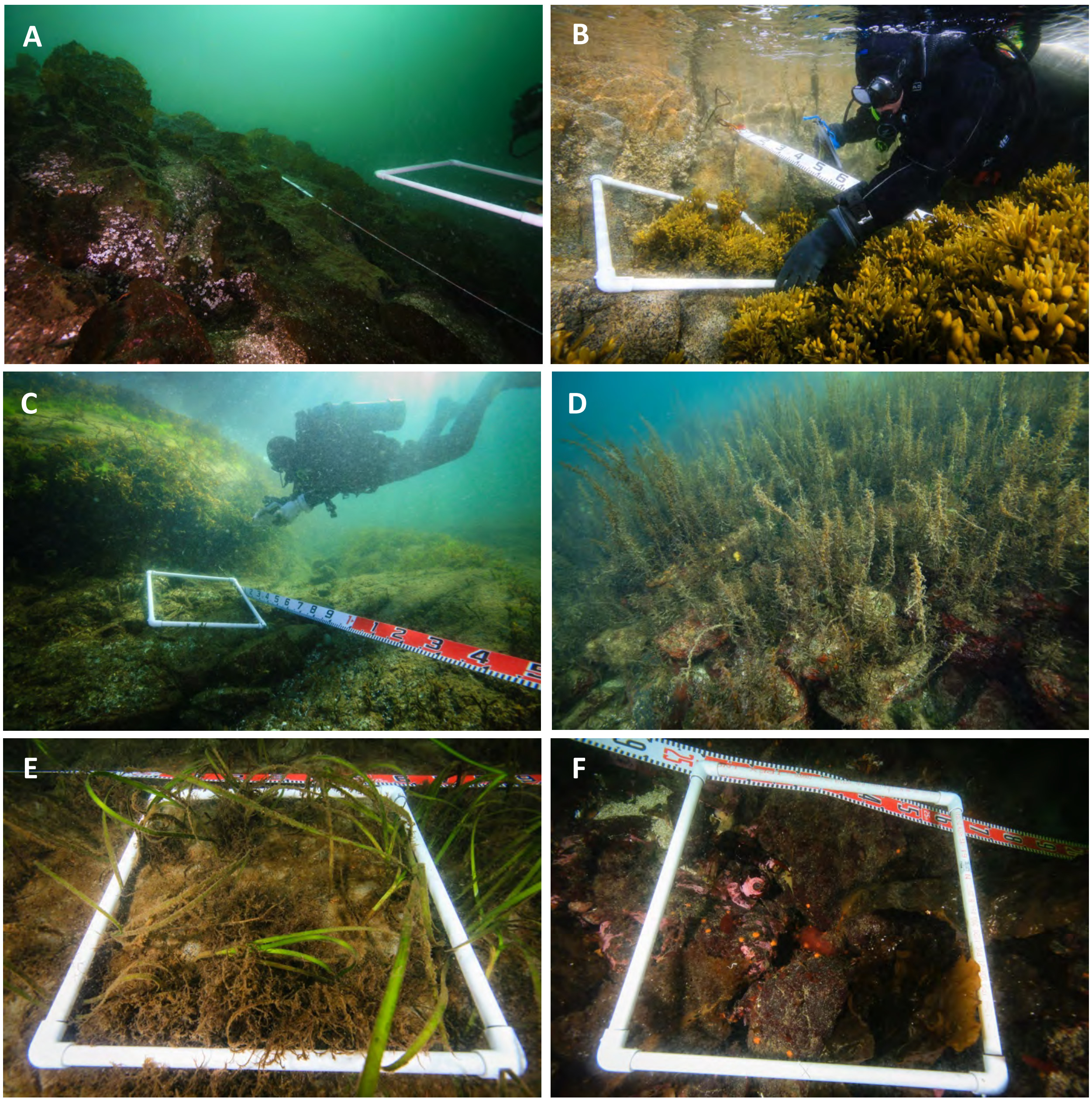

Figure 8. Examples of algae observed during the field survey. Kelps growing on bedrock on Transect 27 (A); *Fucus* sp. growing on Transect 3 (B); green algae (*Blidingia minima*) growing on Transect 29 (C); abundant S*argassum muticum* growing on Transect 29 (D); *Gracilaria* growing throughout the eelgrass bed along Transect 30 (E); red bladed and encrusting algae on Transect 3 (F).

Eelgrass

MCW found that Bargain Bay had the largest and densest eelgrass beds within the study area, covering 21,148 m^2. The eelgrass beds were patchy and extended along the western shore of the bay from the entrance to the northwest end (Figure 9A,B; Figure 6 in Appendix 1). A continuous, approximately 615 m^2 eelgrass bed was also observed along Transect 30, in Middle Bay (Figure 9C). Very patchy and low density eelgrass beds (frequently the patches consisted of a single eelgrass shoot) were observed in Gerrans Bay: at the southwest end (302 m^2) (Figure 9D–F; Figure 6 in Appendix 1), along the eastern shore of the Francis Peninsula near Calder Island and Dusenbury Island (369 m^2), and in the southeastern end near the Painted Boat Marina Resort and Coho Marina Resort (166 m^2) (Figure 5 in Appendix 1). A similarly patchy and low density eelgrass bed (approximately 80 m^2) was mapped in Bill Bay (Figure 5 in Appendix 1).

No eelgrass was observed in Gunboat Bay or Malcolms Bay, contrary to what was indicated by DataBC's spatial eelgrass data (Figure 3 in Appendix 1). Two eelgrass beds covering 413 m^2 in Lee Bay previously identified in SCRD spatial data were missed in the Phase 1 spatial synopsis and noticed during the Phase 2 data analysis so were not re-surveyed. Without a survey to show otherwise, these beds are presumed to still exist and are mapped in Figure 5 in Appendix 1.

Salt Marsh

The heads of Gunboat Bay and East Bay contain salt marsh habitat (see photos in Appendix 3). These areas were not surveyed on foot due to the high fall tides, but MCW approached the marshes by boat on high tide as close as the depth of water would allow and was able to observe brackish marsh vegetation such as sedges (*Carex* spp.).

3.2.2.3 Invertebrates and Fish

Benthic Infauna

In keeping with expectations about infaunal bivalve habitat use, clams (including cockles (*Clinocardium* spp.) and horse clams (*Tresus* spp.)) and siphon holes were 16-fold (95% CI = 6–42) more numerous in quadrats dominated by soft-bottom substrates.

One sediment sample was excavated from 33 transects to sample benthic infauna. No samples were obtained from Transects 1, 3, and 28 because they lacked suitable soft substrates. The Gunboat Bay area had the highest abundance of benthic infauna, with a total of 21 bivalves (primarily macoma clams (*Macoma* sp.), followed by cockles (*Clinocardium* spp.), one littleneck clam, and one unidentified clam) and 8 worms (primarily unidentified polychaetes, and less commonly bloodworms (*Glycera* spp.)). A total of 14 and 10 bivalves were collected from the Francis Peninsula and Central Pender subareas, respectively. However, the majority of the bivalves collected during the field survey were obtained from only three transects, all located in mudflat habitat (Figure 10): Transect 31 in Malcolms Bay (12 bivalves; Figure 11), Transect 15 in East Bay (10 bivalves), and Transect 22, at the south end of Gerrans Bay (8 bivalves). Transect 31 was the only transect where ghost shrimp (*Neotrypaea californiensis*) were excavated.

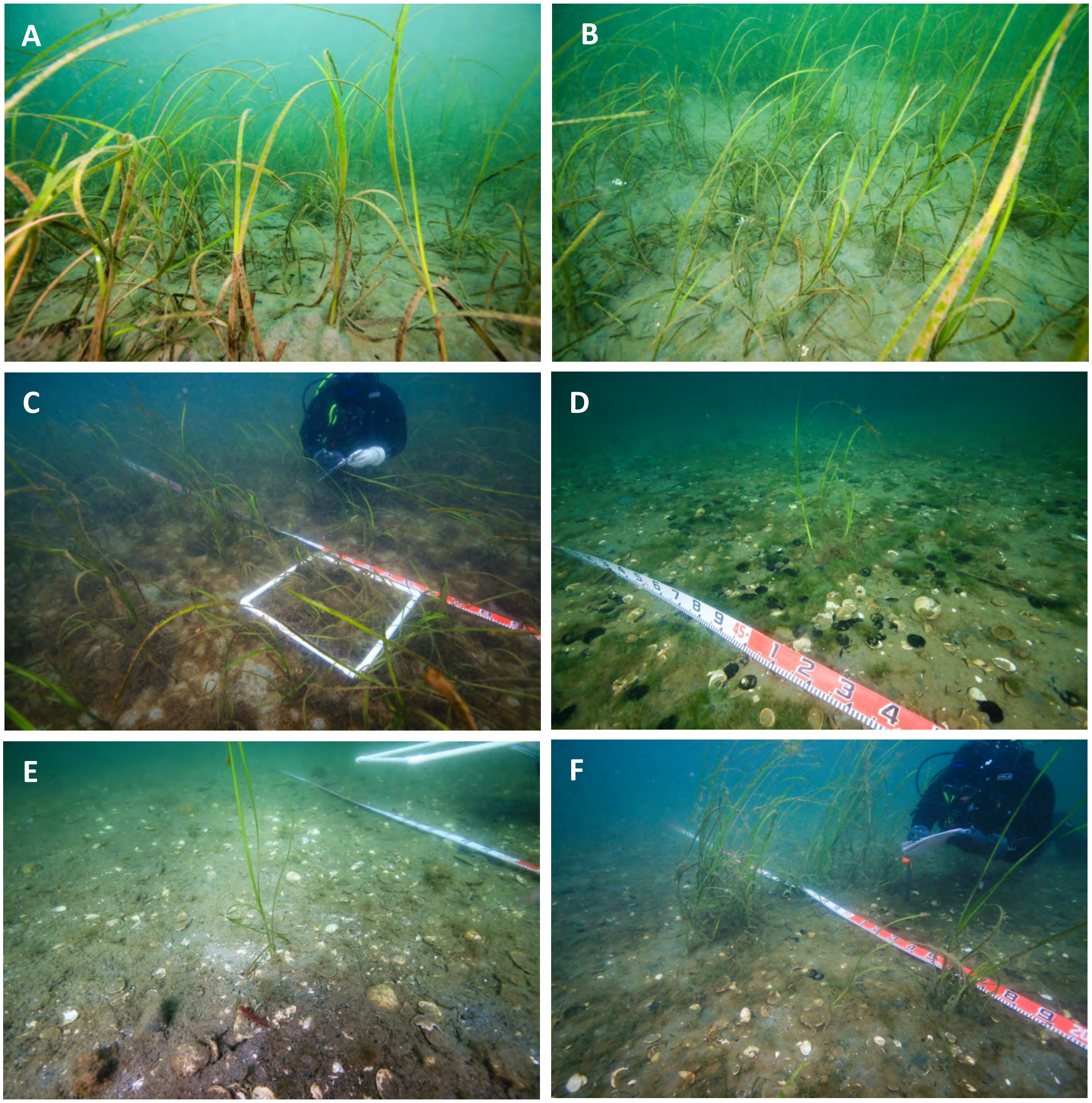

Figure 9. Examples of eelgrass observed during the field survey. Continuous eelgrass bed around Transect EG4 (A, B) and Transect 30 (C); and sparse, patchy eelgrass shoots along EG7 (D–F).

Figure 10. Examples of benthic infauna excavated from transects. Macoma clams (*Macoma* sp.) from Transect 15 (A), cockles (*Clinocardium* spp.) from Transect 16 (B), littleneck clams from Transect 22 (C), and clams and ghost shrimp (*Neotrypaea californiensis*) from Transect 31 (D). Note that transect labels in the photographs were later changed for the analysis.

Sessile Epifaunal Invertebrates

Sessile animal diversity was 10% (95% CI = 4–16%) lower on soft-bottom substrates than rocky substrates. Barnacles (primarily *Balanus glandula*) were generally abundant in intertidal zones dominated by hard substrates such as rock or shell. Pacific Oysters (*Crassostrea gigas*) formed dense beds in the intertidal zone in various areas of Gunboat Bay (Transects 12, 16, 17) and Oyster Bay (Transect 14), by John Henry's Marina (Transect 9), throughout Gerrans Bay (Transects 19, 22 and 23), along the northeast shore at the head of Bargain Bay (Transect 32), and at the head of Malcolms Bay (Transect 31) (Figure 11). Blue mussels (*Mytilus* spp.) were patchily distributed in the mid- to low-intertidal zone along Transect 22 in Gerrans Bay and Transects 14 and 16 in the Gunboat Bay subarea. MCW also incidentally observed oysters growing in the vicinity of the old oyster processing shack in Oyster Bay and in southwest Gerrans Bay; and blue mussels on rocky outcroppings in southeast Gerrans Bay, near Bargain Narrows and the Painted Boat Resort and Marina. Green false-jingles (*Pododesmus macrochisma*) were relatively abundant on bedrock and boulders along Transect 26, and could also be found along a few other transects in each of the Central Pender, Northwest Pender, Pender Islands, and Bargain Bay subareas.

Tube-dwelling anemones (*Pachycerianthus fimbriatus*) were observed growing in mainly subtidal soft-bottom substrates along select transects in each of the subareas except the Pender Islands subarea (Figure 11). They formed large fields along the muddy bottom of Transect 14 in Gunboat Bay, and along Transect 1 in Lee Bay, where they grew on the organic substrate that looked like anthropogenic wood debris. Plumose anemones (*Metridium* spp.) were observed in most of the subareas growing on hard subtidal substrates, both natural and anthropogenic (e.g., chains, tires, dock floats and pilings). The GoPro video footage from the drift dive of Gunboat Narrows reveals that the channel contains notably large, dense colonies of plumose anemones.

Orange cup corals (*Balanophyllia elegans*) were observed growing on subtidal boulders and bedrock in Lee Bay (Transect 3) and off the Francis Peninsula (Transect 29). Broadbase tunicates (*Cnemidocarpa finmarkiensis*), encrusting sponges, and bryozoans were also present where such substrates were available.

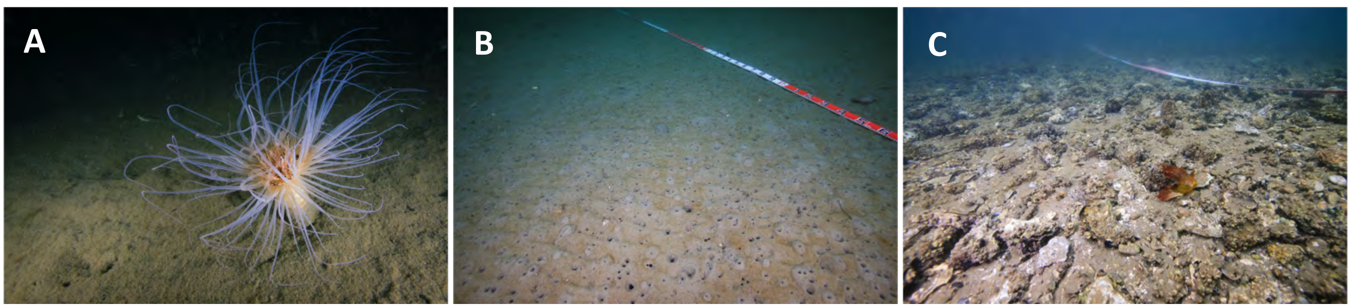

Figure 11. Examples of sessile invertebrates observed during the field study. Tube-dwelling anemones (A); siphon holes in mudflat habitat along Transect 31 (B); oyster bed (C).

Motile Epifaunal Invertebrates and Fish

Chitons, limpets, and snails were found on subtidal to intertidal rocky substrates such as bedrock and boulder throughout the entire study area. One Lewis's moonsnail (*Euspira lewisii*) was incidentally observed on Transect 25 (Figure 12). An unidentified epi-benthic polychaete worm was found in high abundances along several transects, and was 8-fold (95% CI = 3–27) more abundant in quadrats dominated by soft-bottom substrates than rocky substrates.

Sea stars were the most abundant large motile invertebrates observed during the field study and were primarily found on rocky substrates (Figure 12). Sea star abundance was in fact 65% (95% CI = 43–79%) lower on soft-bottom substrates than rocky substrates (based on the GoPro data). Leather stars (*Dermasterias imbricata*) were the most abundant species (22 quadrat observations, 98 observations in GoPro data), followed by mottled star (*Evasterias troschelii*) (4 quadrat observations, 40 observations in GoPro data), ochre star (*Pisaster ochraceus*) (6 quadrat observations, 31 observations in GoPro data), and pink star (*Pisaster brevispinus*) (1 quadrat observations, 8 observations in GoPro data). One sunflower star (*Pycnopodia helianthoides*) was observed on Transect 26.

Graceful crab (*Cancer gracilis*) and red rock crab (*Cancer productus*) were also abundant, and both were found throughout all subareas of the study area. Graceful crabs were found primarily on subtidal soft-bottom substrates whereas red rock crabs were found on both subtidal soft-bottom and rocky substrates. For example, while only one red rock crab was found in the Gunboat Bay subarea, graceful crabs were found on all but one of the transects in this subarea. Kelp crabs (*Pugettia* spp.) in Northwest Pender Harbour, Central Pender, and Bargain Bay. Smaller crabs species were more difficult to observe. However, hermit crabs (*Pagarus* spp.) were found in one quadrat each in Bargain Bay, Gunboat Bay, and the Pender Islands; and shore crabs (*Hemigrapsus* spp.) were found in two quadrats in Central Pender and in one quadrat in Northwest Pender Harbour. MCW did not see any Dungeness crabs.

Moon jellyfish (*Aurelia labiata*) were relatively abundant in Gunboat Bay and were observed along three transects in this subarea (Figure 12). A few moon jellyfish were also observed in Central Pender. Giant nudibranchs (*Dendronotus iris*), which prey upon tube-dwelling anemones, were observed in Lee Bay wherever there were large fields of the anemones (Figure 12). One frosted nudibranch (*Dirona albolineata*) was also found in Lee Bay. *Flabellina* spp. nudibranchs were observed in subtidal quadrats along Transects 34 and 36. MCW also incidentally observed a sea-clown triopha (*Triopha catalinae*) on Transect 27. A California berthella (*Berthella californica*) sea slug was observed along Transect 26.

The commercially valuable giant red sea cucumber (*Parastichopus californicus*) was relatively abundant along Transect 3. It was not observed along the other transects. Orange sea cucumber (*Cucumaria miniata*) and a different unidentified *Cucumaria* spp. sea cucumber visible only by its tentacles among rocks were found on select transects in all of the subareas, excluding those surveyed off the Francis Peninsula and in the Gunboat Bay subarea (Figure 12).

Shrimp were less commonly observed. Approximately 12 humpy shrimp (*Pandalus goniurus*) and two spot prawns (*Pandalus platyceros*) were found on mud at a depth of approximately 17 m on Transect 7. One spot prawn was also seen on Transect 27 and the odd shrimps of unidentified species were found on Transects 3, 4, and 28. Other uncommonly observed invertebrate species included white sea pen (*Virgularia tuberculata*; 10 observed at a depth of about 15 m on Transect 34 in Bargain Bay), common feather star (*Florometra serratissima*; several observed along Transect 26; Figure 12). One Giant Pacific octopus (*Enteroctopus dofleini*) was captured by the GoPro video taken along Transect 3 (Figure 12).

Motile animal diversity and fish abundance were 20% (95% CI = 9–29%) and 84% (95% CI = 70–92%) lower, respectively, on soft-bottom substrates than rocky substrates (based on the GoPro data). Accordingly, lower abundances of fish were noted in mudflat habitat. For example, fewer fish were observed in the Gunboat Bay subarea (Figure 13). The highest abundances of fish within a given 5 m stretch of transect were observed in the South of Bargain Bay subarea, Lee Bay, and Francis Peninsula (Figure 13). These were due to the presence of large schools of perch (Figure 14). Schools of adult shiner perch (*Cymatogaster aggregata*), pile perch (*Rhacochilus vacca*), and striped seaperch (*Embiotoca laterali*) were present in all subareas over rocky substrates. Blackeye goby (*Rhinogobiops nicholsii*) and other species of goby were found in the low intertidal to subtidal in all subareas except Gunboat Bay. Sculpins (Cottidae) were primarily found in Gunboat Bay, but were also found in four other subareas. Pacific snake prickleback (*Lumpenus sagitta*), tubesnout (*Aulorhynchus flavidus*), and bay pipefish (*Syngnathus leptorhyncus*) were also uncommonly observed.

Figure 12. Examples of motile epifaunal invertebrates observed during the field study: moon jellyfish (A); giant nudibranch (B); common feather star (C); orange sea cucumber (D); leather star (E); pink star (F); giant Pacific octopus (G); Lewis's moonsnail (H).

Whitespotted greenling (*Hexagrammos stelleri*) adults were only spotted on bedrock and boulder-dominated substrates on three transects in the Pender Islands subarea (Figure 14). Juvenile whitespotted greenling, by contrast, were found on one transect each in Northwest Pender, Central Pender, Pender Islands, and Bargain Bay, and only in areas dominated by soft substrates. Painted greenling (*Oxylebius pictu*) and was only found on Transects 3, 7, and 27 and the kelp greenling (*Hexagrammos decagrammus*) only on Transect 18. A kelp greenling was also incidentally observed in the GoPro video footage from the drift dive of Gunboat Narrows.

CRA fishery species were also observed during the field study but in lower numbers. Flatfish were found on soft bottom substrates primarily in Northwest Pender and Central Pender. One lingcod (*Ophiodon elongates*) was found along Transect 4 (Figure 14). Copper rockfish (*Sebastes caurinus*) (Figure 14) and yellowtail rockfish (*Sebastes flavidus*) were only observed in Bargain Bay and South of Bargain Bay, and on Transect 26.

Though motile animal diversity and abundance was lower in areas dominated by soft-bottom substrates, these substrates sometimes supported eelgrass habitat, which was used by a variety of taxa (Figure 15). For instance, large schools of juvenile perch were incidentally observed in eelgrass, and a whitespotted greenling was observed guarding eggs on the margin of an eelgrass bed along the west shore of Bargain Bay.

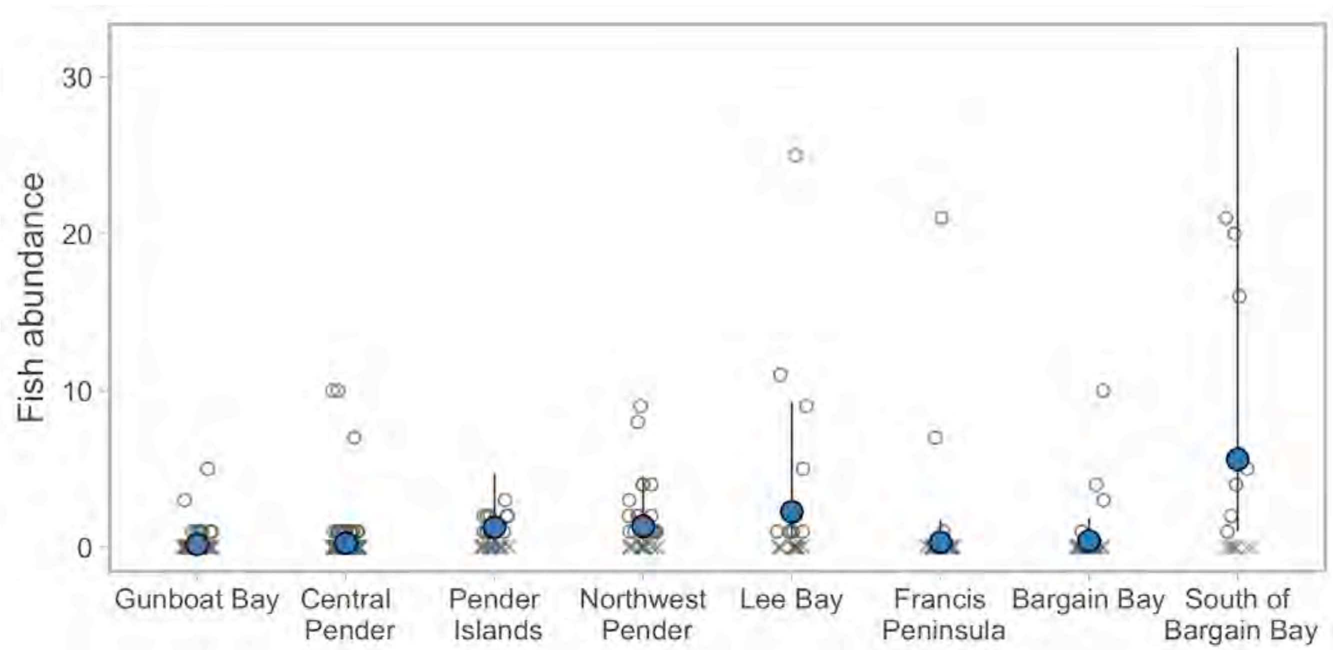

Figure 13. Fish abundance by subarea. Blue points represent the mean fish abundance per area, estimated with a GLMM with a negative binomial error distribution, a log link, and a random intercept for transect. Thin lines represent the 95% confidence intervals. Small points represent the fish abundance within each 5 m stretch of transect, with the 'x's representing those quadrats with no fish.

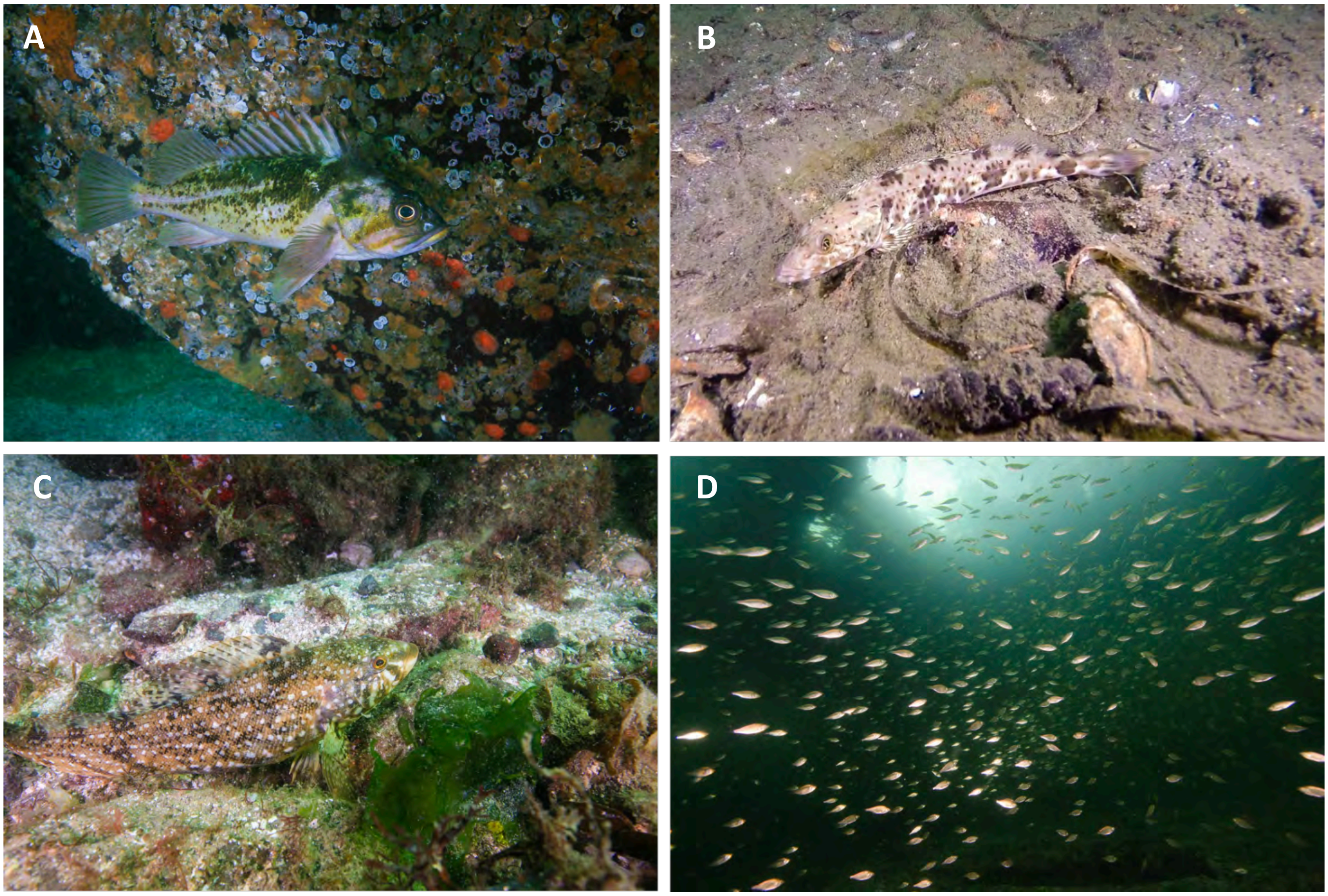

Figure 14. Examples of fish species observed during the field study. Copper rockfish (A); lingcod (B); whitespotted greenling (C); and perch (D).

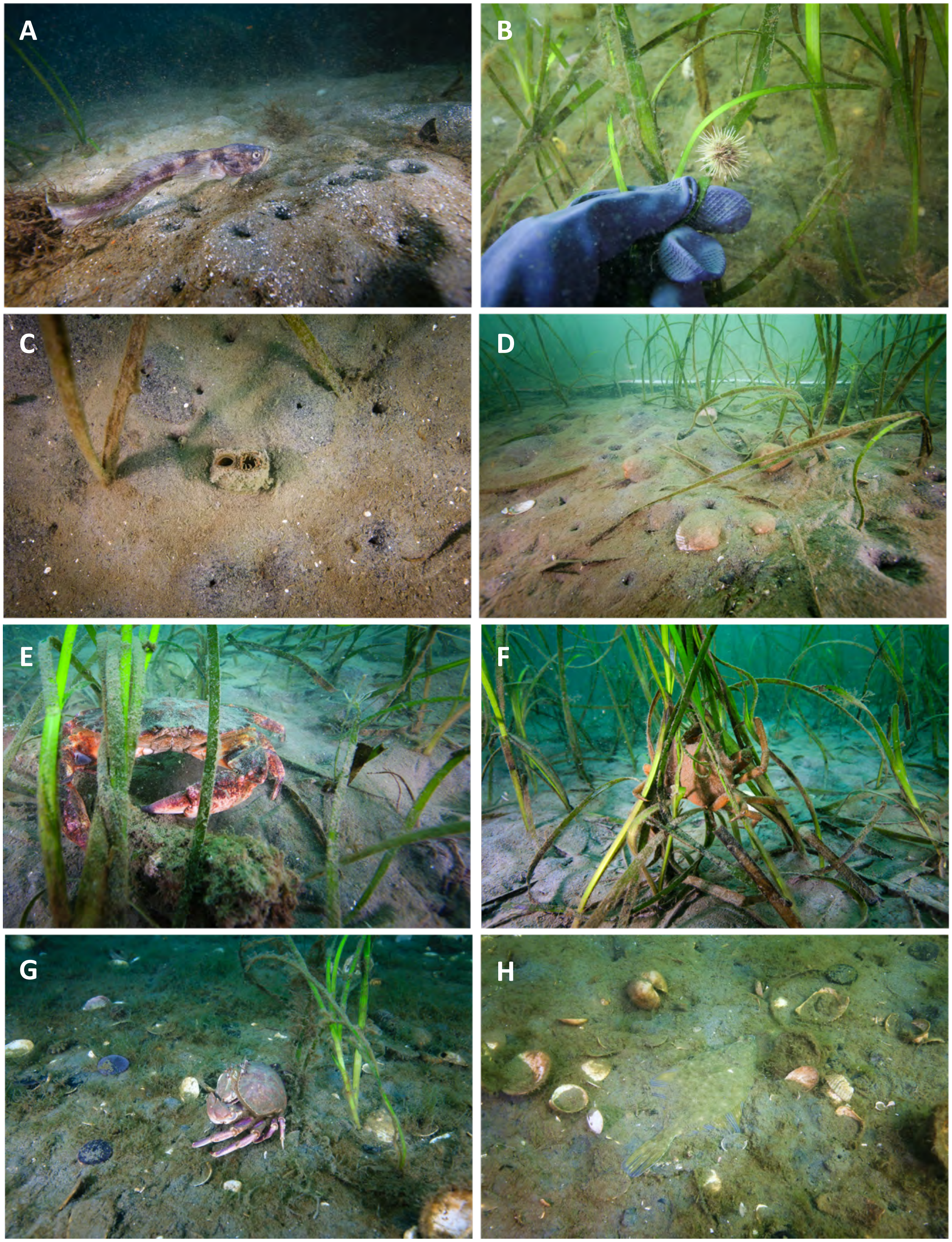

Figure 15. Examples of species found using eelgrass bed habitat. Midshipman fish along Transect 30 (A); sea urchin along Transect EG7 (B); horse clams (C), clams and cockles (D), red rock crab (E), and kelp crab (F) in Bargain Bay; graceful crabs (G) and flatfish (H) along Transect EG7.

3.2.3 Effects of Docks and Urban Development

3.2.3.1 Marine Species Abundance

As discussed in Section 3.2.2.2, the probability of observing kelp in the transect quadrats or within a given 5 m stretch of the transect was driven by quadrat depth and dominant substrate type, not by dock abundance. Both the quadrat and GoPro video analysis agreed that when kelp was present, however, kelp cover decreased with increasing number of docks within 200 m of the transect (Figure 16A, Figure 17G). For instance, an approximately 50% increase in the number of docks translated to a 15% (95% CI = 4–23%) decrease in kelp cover.

Fish abundance decreased with increasing number of docks (Figure 17C). An approximately 50% increase in the number of docks resulted in a 21% (95% CI = 11–31%) decrease in the number of fish. The abundance of the unidentified epi-benthic polychaete worms increased with increasing number of docks. An approximately 50% increase in the number of docks resulted in a 2.3 (95% CI = 1.5–4.0) fold increase in worm abundance (Figure 16B). There was no effect of dock abundance on infaunal bivalve abundance (Figure 16C), on crab or sea star abundance, or on the probability of observing sessile animals (Figure 17B,D,E).

There was no detectable effect of area of impervious land cover within 200 m of the transect on the quadrat marine species abundance response variables.

3.2.3.2 Marine Species Diversity

Algal diversity decreased slightly with increasing number of docks within 200 m of the transects (Figure 16D). For example, an approximately 50% increase in the number of docks resulted in a 4% (95% CI = 1–7%) decrease in algal diversity. There was no detectable effect of dock abundance on sessile (Figure 16F) or motile animal diversity (the latter based on both the quadrat and GoPro video analyses; Figure 16E, Figure 17A).

There was no detectable effect of area of impervious land cover within 200 m of the transect on the quadrat marine species diversity response variables.

3.2.3.3 Eelgrass

With the exception of one eelgrass bed found under a newly constructed dock (based on a comparison of present-day photographs and the 2014 orthophotographs), MCW never observed eelgrass growing under docks and often not where boats might moore (Figure 6 in Appendix 1; Figure 18). The data from the six transects surveyed through eelgrass beds bordering docks likewise indicate that the number of shoots observed per quadrat increased with distance from the dock (Figure 19). The number of shoots per quadrat was nearly 2-fold greater (95% CI = 1.0–3.19) in the Mid quadrats than the Adjacent quadrats. In the one case where there was not a complete loss of eelgrass under the dock, the eelgrass had a lower number of shoots per quadrat under the dock. Mean shoot width and mean shoot length were not significantly affected by dock proximity (Figure 19). The slight decrease in the number of shoots per quadrat, mean shoot width, and mean shoot length observed along a few transects in the Far quadrat as compared to the Mid quadrat is likely a result of the far end of the transects approaching the edge of an eelgrass bed.

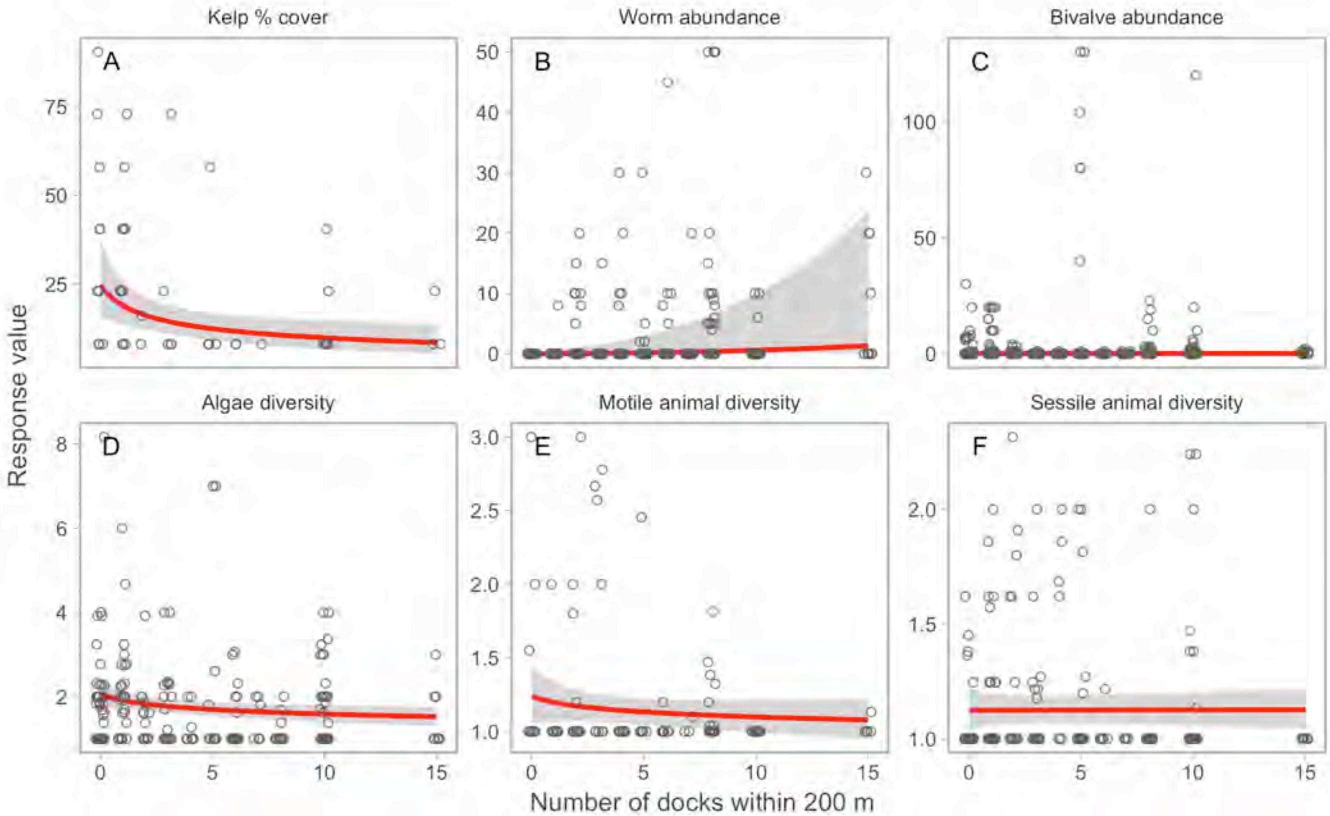

Figure 16. Abundance and diversity of marine algae and animals with increasing number of docks within 200 m of the transects. Points represent raw quadrat data without removing the effects of depth and substrate, lines represent median posterior predictions of the response at mean depth and substrate type, and shaded areas represent 95% credible intervals. Species diversity of each quadrat was calculated as the inverse of Simpson's concentration index.

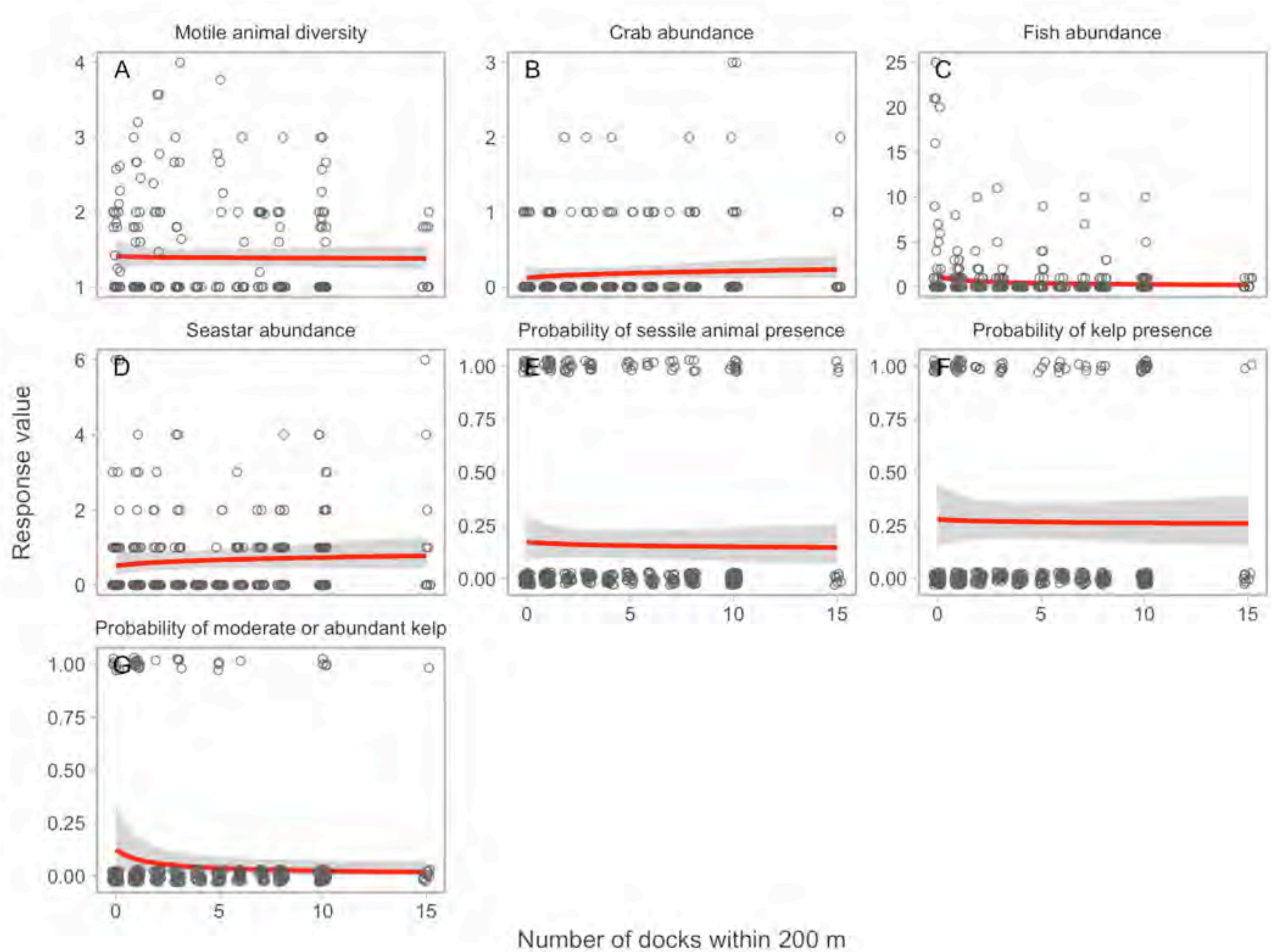

Figure 17. Abundance and diversity of marine algae and animals with increasing number of docks within 200 m of the transects. Points represent raw GoPro data from each 5 m stretch of transect, lines represent median posterior predictions of the response at mean depth and substrate type, and shaded areas represent 95% credible intervals. Species diversity of each 5 m transect stretch was calculated as the inverse of Simpson's concentration index.

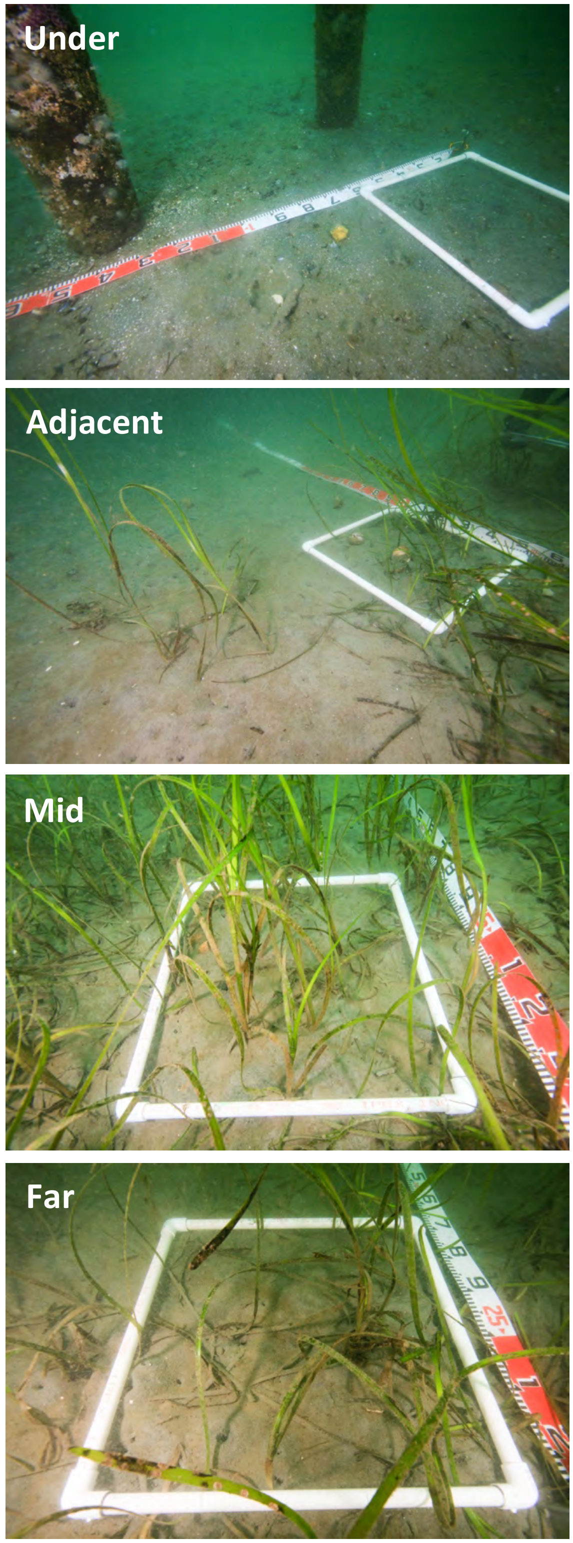

Figure 18. Example of the effects of dock shading on eelgrass growth. Photos of the Under, Adjacent, Mid, and Far quadrats along Transect EG4. Eelgrass growth stops short of the dock due to inadequate light penetration.

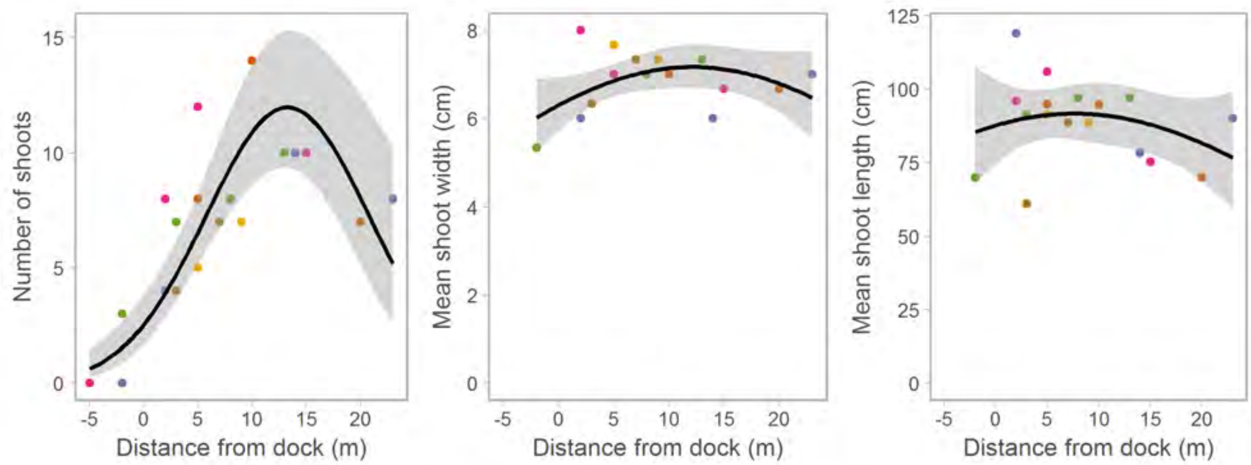

Figure 19. Effects of dock proximity on the number of shoots observed in an eelgrass bed, and on eelgrass mean shoot width (cm) and mean shoot length (cm). Points represent individual quadrats, colour-coded by transect. The solid black lines represent the predictions for GLMs fit with quadratic effects for distance from dock and the grey shaded region represents the 95% confidence interval.

The median area of eelgrass lost in Bargain Bay around and under each dock with an evident footprint was 170 m^2 (range of 83 to 881 m^2). These areas were a median 4.4 (range of 2.6 to 5.4) times larger than the area of the docks themselves. The total area of eelgrass bed lost in Bargain Bay is conservatively estimated as 2337 m^2 or 11% of the eelgrass in Bargain Bay.

3.2.4 Aquatic and Terrestrial Wildlife

MCW observed two species of diving ducks in the study area: hooded merganser (*Lophodytes cucullatus*) in Oyster Bay, East Bay, the entrance to Gerran's Bay, and around Dusenbury Island; and surf scoters (*Melanitta perspicillata*; blue-listed in BC) in Oyster Bay (approximatley 90 individuals), and between Charles Island and the Francis Peninsula (Figure 20). Western grebes (*Aechmophorus occidentalis*; red-listed in BC and ranked of Special Concern by COSEWIC) were observed in Central Pender. Common loons (*Gavia immer*) were observed in Hospital Bay, Central Pender, and west of the Francis Peninsula. Killdeer (*Charadrius vociferus*) were observed feeding on the lawn of a private property in East Bay (Figure 20).

Great blue herons were frequently observed throughout the study area, and often found standing on docks (Figure 21). An active bald eagle (*Haliaeetus leucocephalus*) nest was observed along the southern shoreline of Gunboat Bay.

In addition to these birds, MCW observed deer or elk (*Cervus elaphus*) footprints in the mud at the east end of Oyster Bay, and Pacific chorus frog (*Pseudacris regilla*), which were heard calling from the Francis Peninsula and Wilkinson Cove. Harbour seals (*Phoca vitulina*) were observed throughout the study area.

Figure 20. Diving birds and shorebirds observed in Pender Harbour. Approximately 90 surf scoters in Oyster Bay (A); hooded mergansers (B); common loons (C); surf scoters (D); killdeer (E).

Figure 21. Pacific great blue herons observed in Pender Harbour.

4.0 DISCUSSION

This report presents the results of a two-phase environmental study designed to review the potential impacts of docks on the marine environment, to characterize intertidal and subtidal habitats and community composition in Pender Harbour, BC, and to identify evidence of dock development impacts to these habitats and communities in Pender Harbour. The extensive review of peer-reviewed and grey literature on the topic of dock and dock-associated impacts completed for Phase 1 of the study indicates that there are many potential adverse impacts of docks on water and sediment quality, aquatic habitats, and species composition. Adverse impacts may stem from shading of habitat-forming vegetation, increased turbidity due to boat traffic, release of contaminants into the water column from boats and docks, and the replacement of natural surfaces with artificial substrates that affect local to regional species assemblages.

In this study, MCW found evidence that increasing numbers of docks (including marinas) had adverse impacts to marine habitats and community composition in Pender Harbour. Increasing number of docks was associated with decreased algae diversity, kelp percent cover, and fish abundance. MCW also found that, with one exception, eelgrass was absent under docks in Bargain Bay wherever eelgrass was found growing adjacent to docks. In the one case where there was not a complete loss of eelgrass under the dock (a newer dock that appeared to have replaced a smaller dock), the eelgrass had a lower number of shoots per quadrat under the dock.

The results from the eelgrass delineation are consistent with the body of literature on dock shading effects on seagrasses reviewed in Phase 1 of this study. Based on this body of literature, it was expected that dock orientation would be a predictor of the amount of light reaching vegetation under docks in Pender Harbour and that docks oriented closer to north-south might support more eelgrass. However, this was not the case. It may be that none of the docks along the western shore of Bargain Bay were oriented close enough to true north-south. Additionally, eelgrass was primarily found in the subtidal zone and so much of the eelgrass observed in Pender Harbour may already be growing close to the lower light level limit required for growth and therefore has a lower tolerance for shading. Both of these points seem to support the statement by Shafer (1999) that as a higher latitude region that receives less sunlight, BC may require more conservative dock guidelines than regions in the southeastern United States where dock impacts are comparatively well studied.

The results of the field study are also consistent with historical information synthesized by Hall (1992) and traditional aboriginal knowledge, which indicate that Pender Harbour historically had more kelps and larger eelgrass beds (e.g., in Gerrans Bay), supported larger fish populations, and also more wildlife dependent on the marine environment (e.g., great blue herons). Regional anthropogenic stressors, primarily commercial fishing, have likely played a role in Pender Harbour fish population declines (e.g., herring, salmon); however, the cumulative, local impacts of urban development, docks, and boating on the marine environment must also be acknowledged.

MCW did not detect any effect of area of impervious land cover on marine species abundance and diversity; yet, as discussed in Phase 1 of this report, contamination of marine waters and sediments from land-based sources with PAHs, PCBs, and nutrients and construction of docks only follow from urban development (Sanger et al. 2004b). For instance, the Central Pender subarea has a longer history of urban development and dock construction than Bargain Bay, and accordingly more markers of anthropogenic change, such as human-altered foreshores, garbage on the seafloor, abandoned boats, and higher turbidity, the latter particularly among high-traffic mooring areas. Often, the rocky substrates along the transects in this subarea were coated in a thin layer of silt. This may be further indication of higher rates of sediment resuspension or nutrient additions. Though MCW was unable to identify the polychaete worm that was positively associated with docks, their presence may indicate some change in environmental condition. For instance, MCW's dive team incidentally noted that the mud substrate around the marinas in southeastern Gerrans Bay had only sparse, isolated shoots of eelgrass but was covered in worms and filamentous green algae. All of these may be contributing mechanisms as to why less complex habitats were observed along transects in proximity to high numbers of docks than would be expected based on substrate and depth alone.

4.1 Dock Management Recommendations

A successful dock management approach must combine protection of critical habitats, dock design regulations, public education and engagement, and regulatory oversight. We emphasize that the recommendations apply not just in Pender Harbour, but in BC more broadly.

4.1.1 Protection of Critical Habitats

The first step in curtailing adverse effects of docks on the marine environment is to prohibit the construction of new docks over eelgrass or saltmarsh or the enlargement of an existing dock footprint over eelgrass or saltmarsh. As discussed in this report, eelgrass and saltmarsh provide critical habitat for marine fish, and as such are protected from destruction under the federal *Fisheries Act*. Moreover, such habitats also perform invaluable services that help to maintain the integrity of nearshore marine environments and mitigate against climate change.

Ultimately, protection of critical habitats is far more effective and economical than mitigation or restoration after habitat has been lost (Cunha et al. 2012). Restoration of eelgrass habitats by eelgrass transplantation within suitable areas of Pender Harbour may be an option, but is likely to have only limited efficacy in reversing losses due to the fact that anthropogenic stressors (e.g., docks, boating-induced turbidity, runoff of urban pollutants) cannot be eliminated.

4.1.2 Dock Design Regulations

In addition to protecting critical habitats, MCW recommends enacting more stringent dock design regulations in Pender Harbour, and BC more broadly. Such regulations are necessary to help curtail the adverse effects of docks on eelgrass, algae, kelps, and fish abundance that were observed during this field study. The dock design regulations listed below would apply to new applications for private docks or dock replacements/upgrades. They have been sourced and adapted from existing state and federal regulations used in the United States (e.g., Kelty and Bliven 2003, U.S. Army Corps of Engineers/National Marine Fisheries Service 2008), where the majority of the research on dock impacts has been conducted.

Dock Materials Must Be Light Transmitting

Docks should be constructed with light-transmitting materials that have a minimum of 43% open space (e.g., such as those manufactured by ThruFlow™ Inc [http://thruflow.com/], or FiberGrate [http://www.fibergrate.ca]). Light transmitting materials may be made of various materials shaped in the form of grids, grates, and lattices to allow for light passage.

Dock Orientation

The long axis of the dock must be aligned in a north-south direction to the maximum extent that is practicable.

Maximum Dock Widths

The width of the dock must be limited to a maximum of 1.2 m.

Pile Installation

Pile driving should be the preferred method of pile installation, though jetting with a low pressure pump may be acceptable.

Restrictions on Boathouses

The size and number of boathouses that may be constructed within a given area should be restricted, and boathouses could be allowed only in certain DMP zones.

Styrofoam

Most of the docks in Pender Harbour, as throughout BC, are kept afloat with Styrofoam. Styrofoam breaks down as it ages and, if uncontained, contributes to the problem of ocean plastic pollution. Such plastics are taken up from the water column by filter feeders such as mussels (e.g., Van Cauwenberghe and Janssen 2014) or ingested by fish (e.g., Lusher et al. 2013), for example, where they may have acute and chronic effects on animal health (e.g., Rochman et al. 2013, Pitt et al. 2018). Studying the ecological effects of plastics on marine life has in recent years become a high-profile field of research, including in BC (i.e., the Vancouver Aquarium Ocean Pollution Research Program). MCW suggests regulating the use of Styrofoam in new docks and the replacement of old Styrofoam showing evidence of breakdown.

4.1.3 DMP Zone System

If MFLNRORD includes a zone system in the next DMP draft, the zone-based restrictions should be revised to reflect the results of this report. For example, the current DMP draft places Bargain Bay in Zone 3 and the subarea MCW refers to as South of Bargain Bay in Zone 4; however, these subareas collectively had abundant eelgrass and supported the highest abundance of fish species such as rockfish, which are of commercial and conservation importance. From a science perspective, dock construction should therefore be more, not less, restricted in these areas. Requiring multi-party use/community docks over private docks and avoiding site-by-site dock approvals should be incorporated in some form as part of a zone-based system.

As summarized by Kelty and Bliven (2003), additional forms of incentives could also be incorporated into a zone system: For example, landowners could be allowed private docks in exchange for limits on land-use, such as increasing riparian buffer widths and decreasing amount of impervious cover. In another example, the province could provide incentives to landowners that elect not to have docks or choose a shared dock (e.g., short-term reduction in property taxes).

4.1.4 Public Education and Engagement

MCW had the opportunity to communicate with private landowners while delineating eelgrass and these exchanges were with one exception very positive. Landowners have an interest in maintaining the integrity of Pender Harbour's marine environment. The main barrier to effective dock management and protection of marine resources in Pender Harbour is that most landowners are likely not knowledgeable about marine algae or vegetation, how to identify them, their importance as habitat for marine fish and invertebrates and wildlife, or the services they provide to humans. Additionally, most landowners would not be knowledgeable about historical marine conditions in Pender Harbour. Without such a historical reference point, landowners can only measure changes to the marine environment relative to an already changed state. This shift over time in the expectation of what a "natural" ecosystem looks like is referred to as the problem of shifting baselines (Pauly 1995). Last and perhaps most significantly, most landowners are likely unaware that destruction of critical fish habitats without authorization may be flagged as a violation of the *Fisheries Act*.

MCW recommends that MFLNRORD distribute information and/or hold public information sessions focused strictly on the topics in the paragraph above. This recommendation echoes that made by Penner (2015) in his independent review of the DMP. It is also necessary to explain to landowners why new dock management measures are being implemented. Though the management measures recommended in this report may appear unusual or unduly stringent, they are not novel, but applied across North America and founded on at least three decades of scientific study. It would also be important to emphasize that changes apply to new docks. There is the misperception by some that they will have to remove their existing docks. Long-term landowners may additionally have valuable information about both historical and present habitat use by fish (e.g., mapping herring spawns). MFLNRORD could engage with long-term landowners through a formal process (e.g., written survey) to gather local ecological knowledge about past and present conditions.

As part of increasing transparency and public confidence in the results and recommendations included in this report, MCW makes two additional recommendations: 1) to make this report publicly available; and 2) to consider having MCW publish this study on MFLNRORD's behalf as an open-access article in a peer-reviewed journal. To MCW's knowledge, this is the first field assessment of private dock impacts on the marine environment in BC, and perhaps in Canada. On an international scale, this study is one of the few field assessments of dock impacts at such a northerly latitude, which other researchers have previously acknowledged to be a data gap (Shafer 1999).

4.1.5 Regulatory Oversight

MCW observed docks that appeared to have been constructed since the moratorium on new docks took effect. This, in combination with the observation that docks have been constructed over eelgrass in the last several decades indicates that there has been a lack of and/or a breakdown of formal environmental assessment process in permitting docks in Pender Harbour, and likely throughout BC. Regulatory oversight is needed to ensure that there is compliance with any management measures. A lack of regulatory oversight and enforcement has also likely contributed to landowners' misperception that they have always had a right to construct docks, and therefore that rights would be removed by implementing a management plan that places limits on dock construction or materials. As mentioned in Section 1, landowners may misunderstand that having a legal right to riparian access does not include the right to a dock.

To ensure that critical habitats such as eelgrass are protected, landowners must be required by MFLNRORD to engage a registered professional biologist to verify whether there is eelgrass present within the proposed dock footprint, including the area where boats would be moored. This is not unlike with the Riparian Areas Regulation. Currently, the provincial website on private moorage states that a "baseline marine habitat assessment may be required when an application for a marine private moorage is submitted in the vicinity of an ecologically sensitive area, e.g. an eelgrass bed" (MFLNRORD 2017). What is unclear is how this process ensures no loss of eelgrass if there is no previous documentation about the presence of eelgrass beds available to the landowner or regulator. As evidenced by this study, MCW delineated large eelgrass beds that were not included in either the SCRD or DataBC spatial data repositories. Indeed, many coastal areas have not been surveyed for critical habitats. Additionally, it is not unusual that these types of public repositories be incomplete.

An explicit requirement for a formal environmental assessment as part of the private mortgage application process is even more essential because docks may impact resources managed for the public, including CRA fishery species and their habitats. FrontCounterBC's online Crown Land Tenure Application (100231963) form specifies that "some applications may also be passed on to other agencies, ministries or other affected parties for referral or consultation purposes. A referral or notification is necessary when the approval of your application might affect someone else's rights or resources or those of the citizens of BC ... This does not apply to all applications and is done only when required." DFO, separately, however, notes that projects involving "all new construction, repair or rebuild of a floating, cantilever or post dock where total combined footprint does not exceed 20 m^2" do not need to be reviewed by DFO (DFO 2016).

This 20 m^2 criteria is far lower than the average footprint of small private docks constructed in eelgrass habitat in Pender Harbour, and likely elsewhere in BC. As stated in this report, MCW calculated the median area of eelgrass lost around and under an individual dock in Bargain Bay ranged from 83 m^2 to 881 m^2, areas which were approximately three to five times larger than the area of the docks themselves. This suggests that the environmental effects of individual docks are in many cases being underestimated by existing regulatory policy. Further, DFO and MFLNRORD's policies do not consider the cumulative effects of private dock construction on marine fish and fish habitat. MCW calculated that the total area of eelgrass bed lost in Bargain Bay, for example, was conservatively 2,337 m^2. In comparison, the area of eelgrass that was projected to be lost on Flora Bank due to construction of the proposed Pacific NorthWest LNG Project was 1,839 m^2 (Stantec 2014). Also note that destruction of this fish habitat constituted serious harm to fish under the *Fisheries Act* and that authorizing destruction of the habitat would have required the proponent to offset this loss through habitat compensation measures. Given the results of this report, provincial and federal environmental policies on private dock approvals are inadequate and warrant review.

4.1.6 Additional Field Study Opportunities

During Phase 1, MFLNRORD had envisioned that MCW would complete a general characterization of sediment and water quality in Pender Harbour during the Phase 2 field study. However, due to budgetary considerations, this was excluded from the scope of the field study. MCW notes that while the results of this field study provide sufficient information with which to implement a DMP, it would be beneficial to conduct this sampling should the funds be made available. At this point, Hall (1992) provides the only publicly available synthesis of water quality data collected from the area. A water and sediment quality sampling program would allow the province to identify what types of pollutants have accumulated in Pender Harbour, which can be used to better understand the effects of docks, boating, and urban development on the marine environment.

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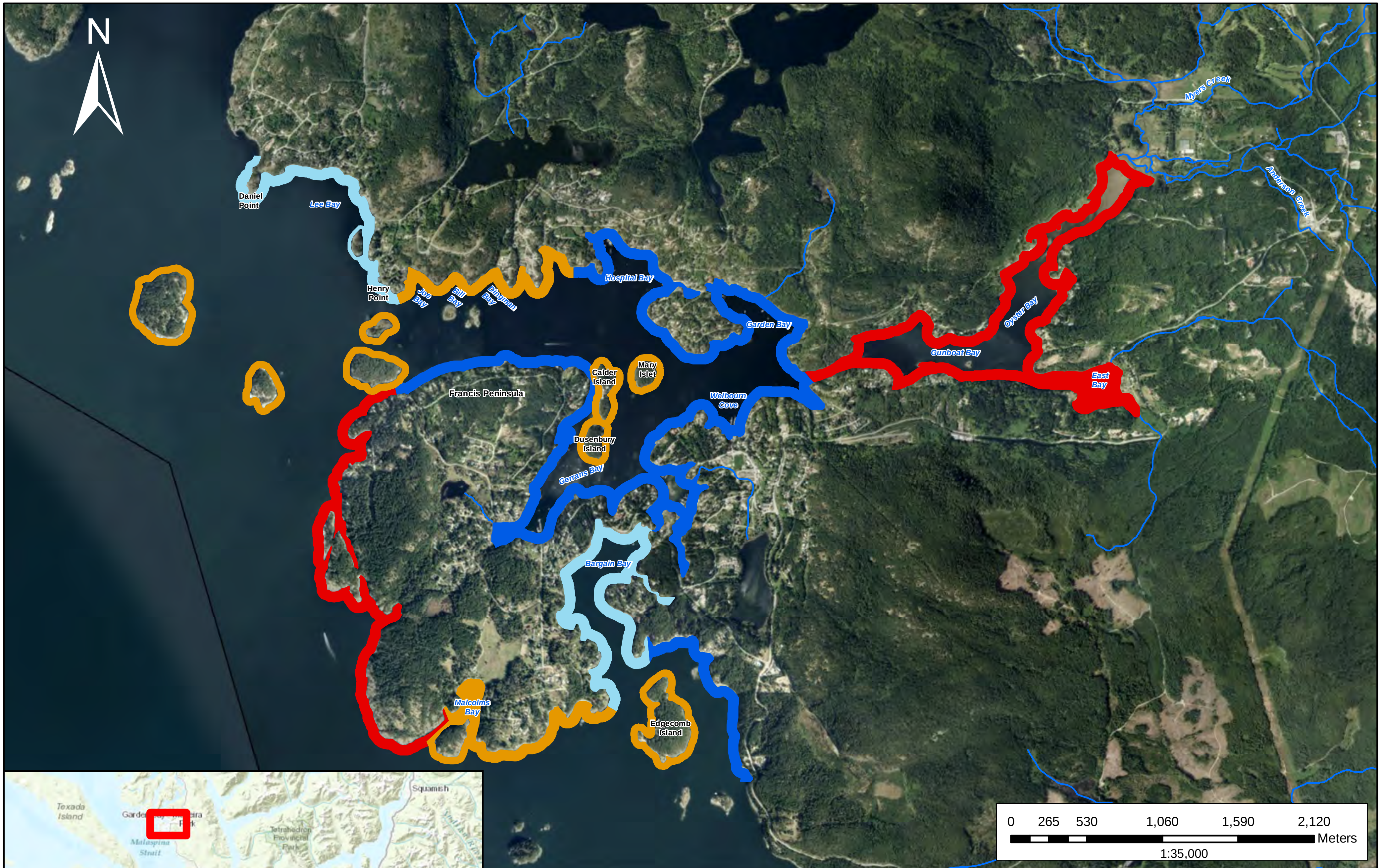
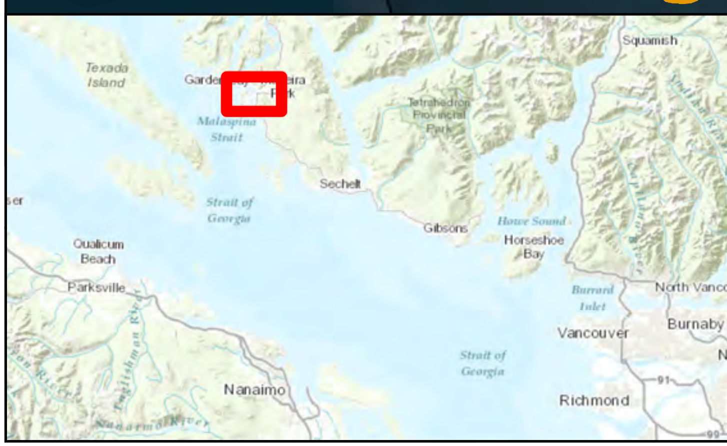
6.0 APPENDIX 1: MAPS OF PENDER HARBOUR





Dock Management Zone

- 1
- 2
- 3
- 4

Pender Harbour Dock Management Zones

Dock Management Zone data obtained from the South Coast Regional District.

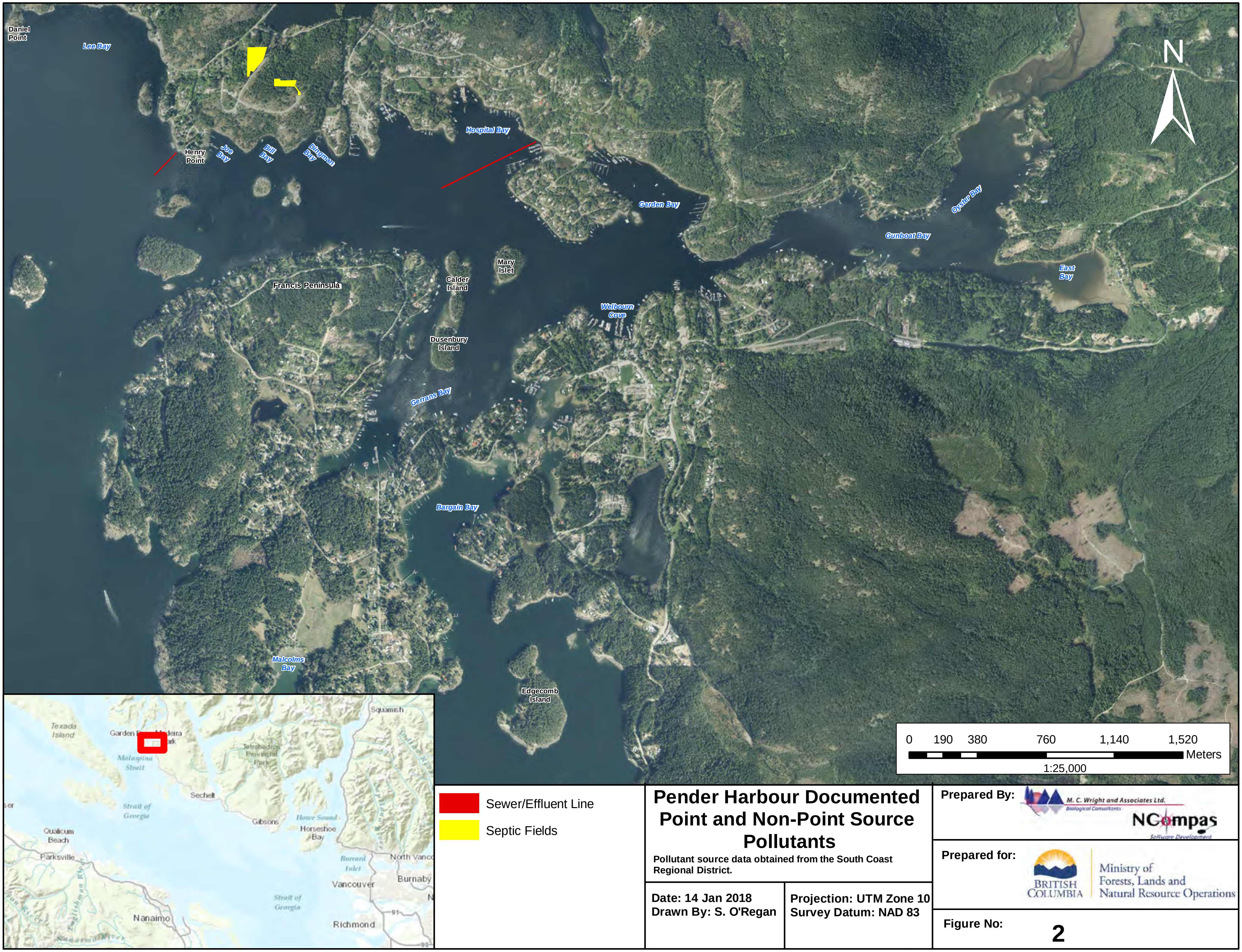
Date: 14 Jan 2018
Drawn By: S. O'Regan

Projection: UTM Zone 10
Survey Datum: NAD 83

Prepared By: M. C. Wright and Associates Ltd. Biological Consultants; NCompas Software Development

Prepared for: British Columbia Ministry of Forests, Lands and Natural Resource Operations

Figure No: 1



Sewer/Effluent Line

Septic Fields

Pender Harbour Documented Point and Non-Point Source Pollutants

Pollutant source data obtained from the South Coast Regional District.

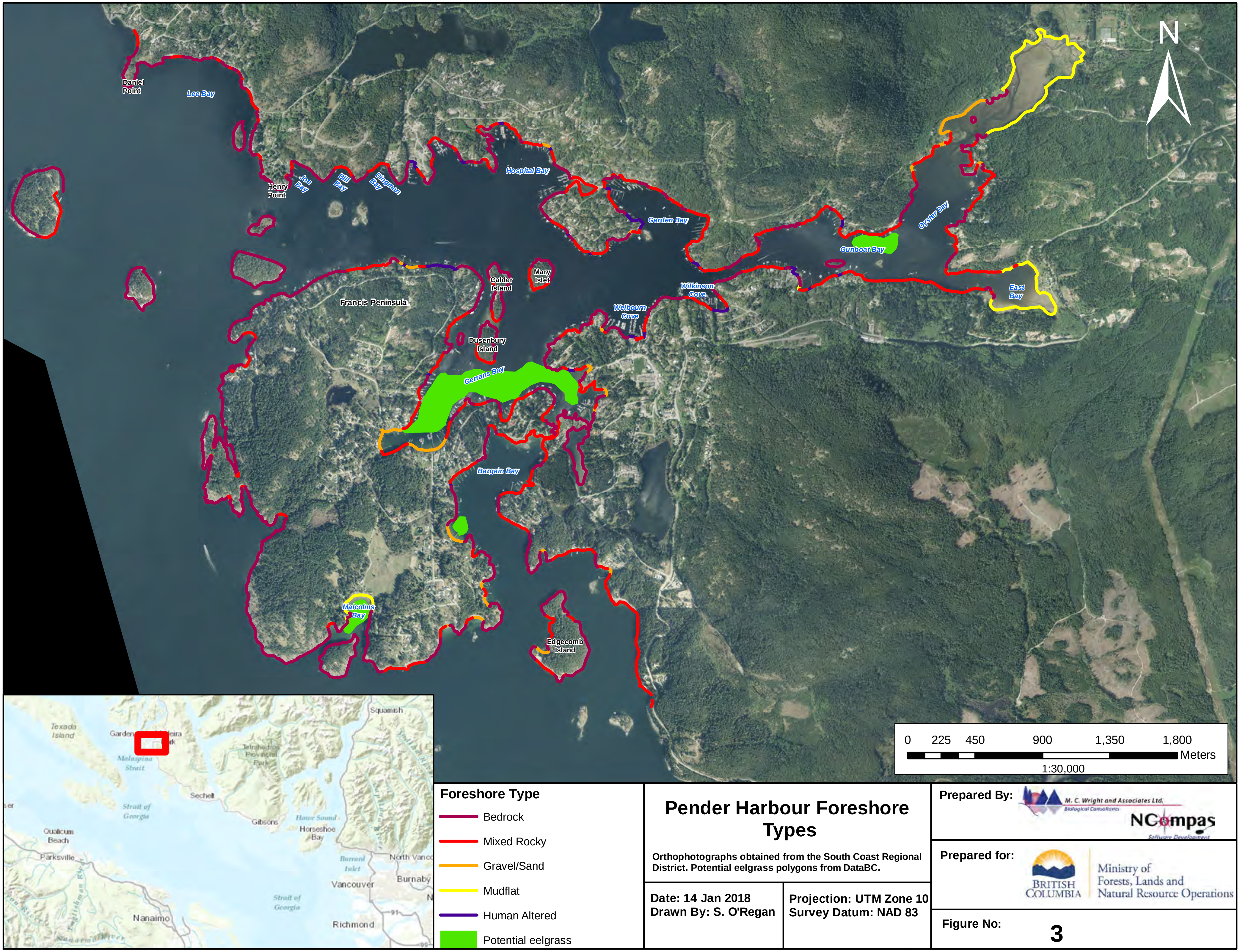
Date: 14 Jan 2018
Drawn By: S. O'Regan

Projection: UTM Zone 10
Survey Datum: NAD 83

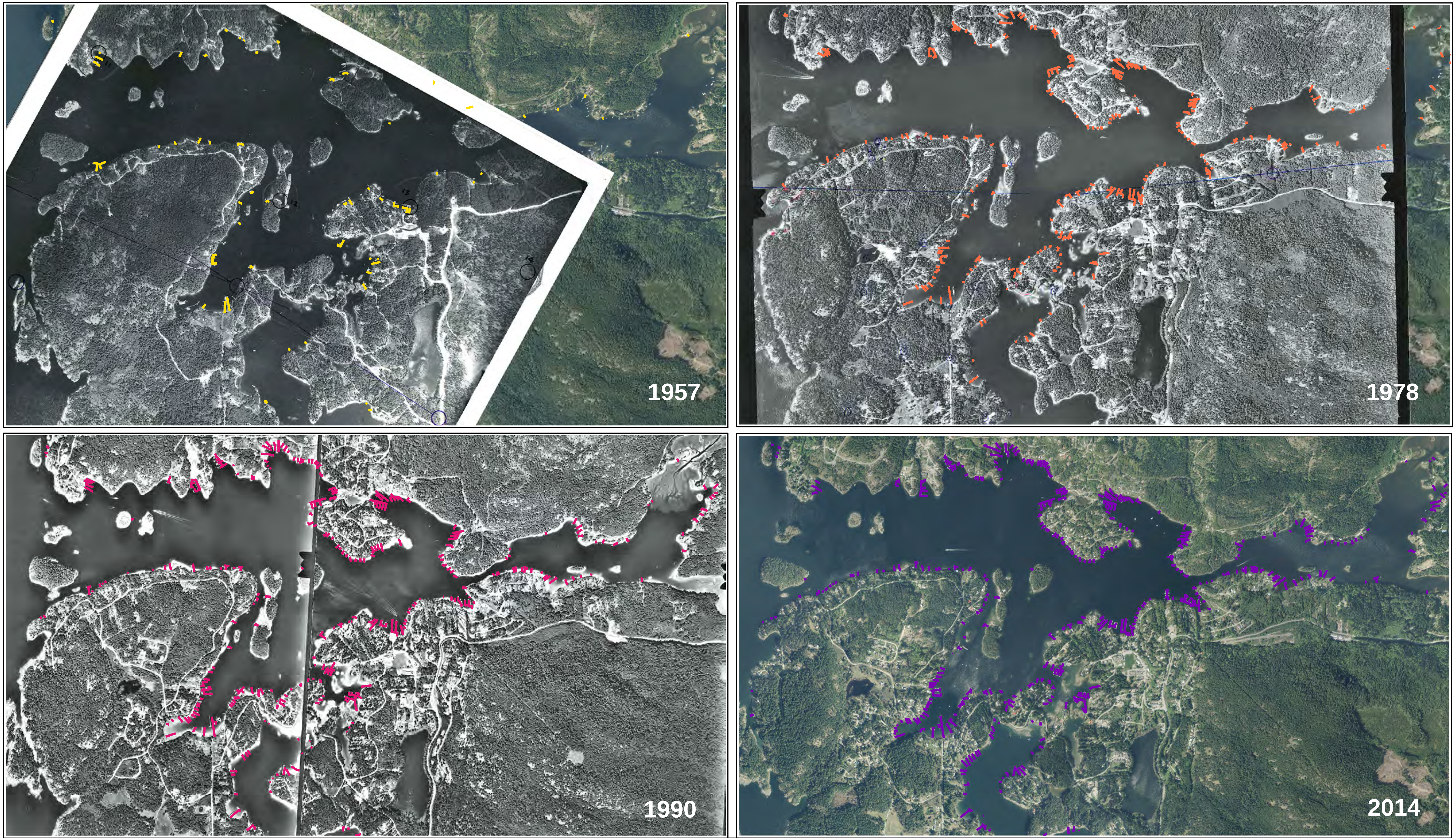
Prepared By: M. C. Wright and Associates Ltd. Biological Consultants; NCompas Software Development

Prepared for: British Columbia; Ministry of Forests, Lands and Natural Resource Operations

Figure No: 2



Daniel Point
Lee Bay
Henry Point
Joe Bay
Bill Bay
Dingman Bay
Hospital Bay
Garden Bay
Oyster Bay
Gunboat Bay
Wilkinson Cove
Welbourn Cove
Calder Island
Mary Islet
Francis Peninsula
Dusenbury Island
Gerrans Bay
Bargain Bay
Malcolms Bay
Edgecomb Island
East Bay
N
0 225 450 900 1,350 1,800
Meters
1:30,000
Squamish
Texada Island
Malaspina Strait
Sechelt
Tetrahedron Provincial Park
Strait of Georgia
Gibsons
Howe Sound
Horseshoe Bay
Qualicum Beach
Parksville
Burrard Inlet
Vancouver
Burnaby
Nanaimo
Richmond
Foreshore Type
Bedrock
Mixed Rocky
Gravel/Sand
Mudflat
Human Altered
Potential eelgrass
Pender Harbour Foreshore Types
Orthophotographs obtained from the South Coast Regional District. Potential eelgrass polygons from DataBC.
Date: 14 Jan 2018
Drawn By: S. O'Regan
Projection: UTM Zone 10
Survey Datum: NAD 83
Prepared By:
M. C. Wright and Associates Ltd.
Biological Consultants
NCompas
Software Development
Prepared for:
BRITISH COLUMBIA
Ministry of Forests, Lands and Natural Resource Operations
Figure No:
3



Legend	
Docks 1957	
Docks 1978	
Docks 1990	
Docks 2014	

Change in Dock Number Over Time in Pender Harbour

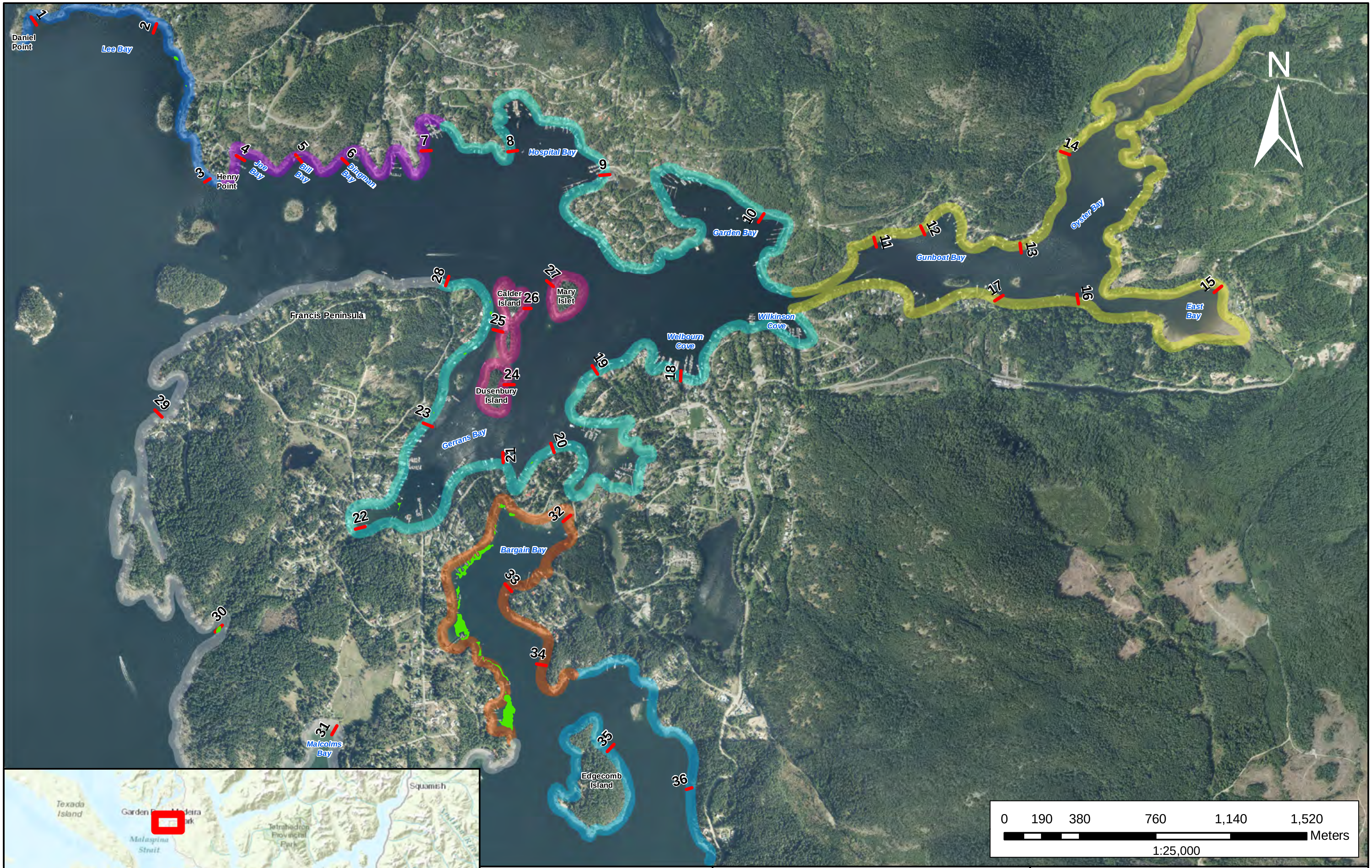
Historical air photos from University of British Columbia library.
2014 orthophotographs obtained from South Coast Regional District.

Date: 14 Jan 2018
Drawn By: S. O'Regan
Projection: UTM Zone 10
Survey Datum: NAD 83

Prepared By: M. C. Wright and Associates Ltd. Biological Consultants; NCompas Software Development

Prepared for: British Columbia Ministry of Forests, Lands and Natural Resource Operations

Figure No: 4



Subareas

- Gunboat Bay
- Central Pender
- Pender Islands
- Northwest Pender
- Lee Bay
- Francis Peninsula
- Bargain Bay
- South of Bargain Bay
- 2017 Transects
- Eelgrass

Pender Harbour Study Area

Transects were surveyed and eelgrass was mapped using differential GPS between October 11-21, 2017. Orthophotographs obtained from the South Coast Regional District.

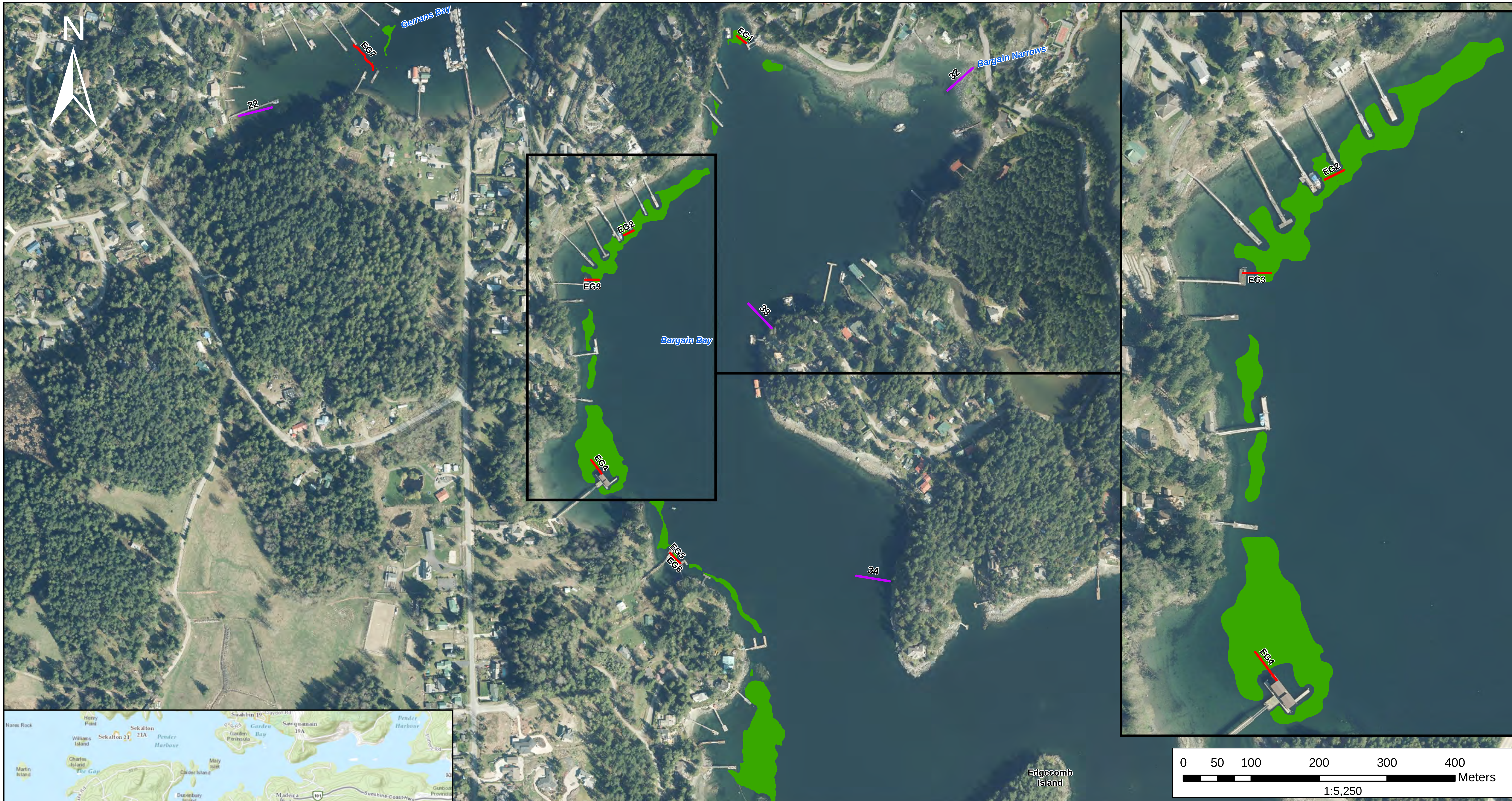
Date: 14 Jan 2018
Drawn By: S. O'Regan

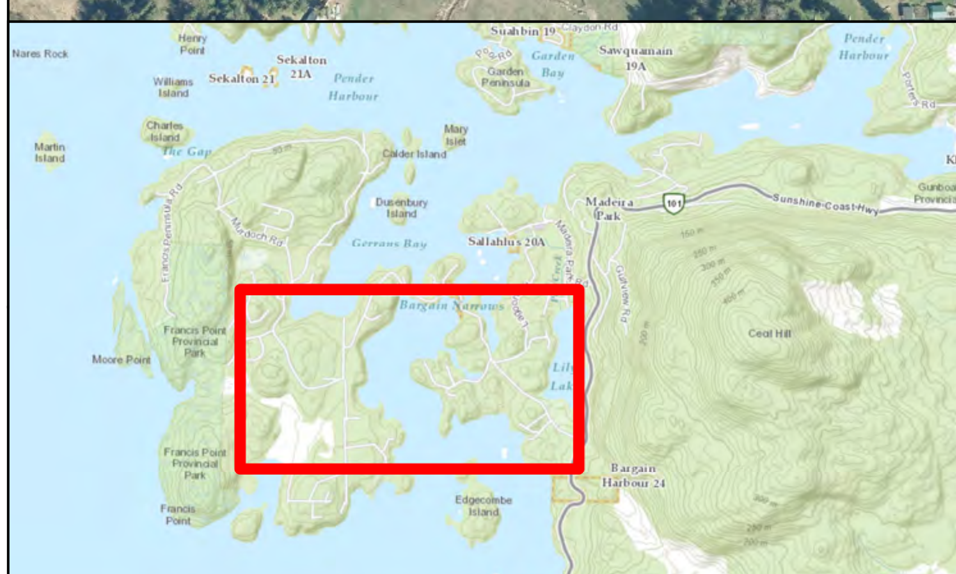
Projection: UTM Zone 10
Survey Datum: NAD 83

Prepared By: M. C. Wright and Associates Ltd. Biological Consultants; NCompas Software Development

Prepared for: British Columbia — Ministry of Forests, Lands and Natural Resource Operations

Figure No: **5**





Eelgrass	
Eelgrass Transect	
Marine Transect	

Bargain Bay Eelgrass Beds

Transects were surveyed and eelgrass was mapped using differential GPS between October 11-21, 2017. Orthophotographs obtained from the South Coast Regional District.

Date: 14 Jan 2018
Drawn By: S. O'Regan

Projection: UTM Zone 10
Survey Datum: NAD 83

Prepared By: M. C. Wright and Associates Ltd. Biological Consultants; NCompas Software Development

Prepared for: British Columbia; Ministry of Forests, Lands and Natural Resource Operations

Figure No: 6

7.0 APPENDIX 2: PAPERS/REPORTS ON DOCK IMPACTS TO MARINE AND FORESHORE HABITATS

Appendix 2 Table 1. Results and management recommendations contained in the papers/reports cited in Section 2.3.4.

Authors	Location	Dock impacts assessed	Dock characteristics assessed	Study system or species	Results	Most important predictors	Design or Management Recommendations
Sanger et al. (2004b)	South Carolina	Abundance		Small tidal creek habitats	• Number of docks positively associated with amount of impervious cover (e.g., roofs, paved surfaces) in the watershed • Concentrations of metals derived from CCA-treated wood not associated with number of docks • PCB values not associated with dock abundance but with amount of impervious cover in the associated watershed • Fish and crustacean metrics not associated with the number of docks • Total abundance of benthic macroinvertebrates in sediments negatively associated with number of docks		• Number of docks is strongly associated with the amount of impervious cover, which limits the ability to differentiate dock effects from anthropogenic upland effects. • Dock impacts are small compared to the more serious problem of landscape development and associated environmental degradation from non-point source pollution and hydrologic changes.
		Abundance		Large tidal creek habitats	• Cadmium concentrations increased from the no dock category to the high dock category • In both small and large tidal creeks, there were significantly higher cumulative concentrations of 14 metals and PAHs at sites with docks compared to no docks • In both small and large tidal creeks, fecal coliform levels were not associated with dock density		• South Carolina currently regulates docks using several criteria, including (1) walkway widths and heights that limit shading; (2) limits on the size of the entire dock directly related to watercourse width; (3) requiring 23 m of water frontage to acquire a dock.

					• Fish and crustacean metrics not associated with the number of docks • Total abundance of benthic macroinvertebrates in sediments negatively associated with number of docks • Levels of CCA metals likely not high enough to cause biological harm to fish	• South Carolina requires developers to submit a master dock plan for the community. Community docks are encouraged and developers may build docks in exchange for limits on land-use, such as increasing riparian buffer widths and decreasing amount of impervious cover. This allows managers to better assess the cumulative effects of dock development during the approval process.
Sanger et al. (2004a)	South Carolina	Shading	Dock orientation	*Spartina alterniflora* salt marsh grass	• *Spartina* stem density 71% less, on average, under docks compared to next to docks for both *Spartina* growth forms (short or tall) combined • Density of *Spartina* under docks not significantly different between north-south- and east-west-oriented docks • Decreased stem density may reduce primary productivity in the marsh and the ability of the marsh to provide ecosystem services. Also decreases the value of the habitat as a nursery for fish. • Additional impacts observed but not measured included construction impacts, boats or floats sitting on the marsh, and disposal of debris under docks	• Public education campaigns may help reduce dock construction impacts

Kearney et al. (1983)	Long Island Sound	Shading	Dock height, width, plank width and spacing between planks	*Spartina alterniflora*, *Spartina patens*, *Distichlis spicata* salt marsh grasses	• *Spartina* stem density lower under docks • Stem density increases as dock height increases	Dock height	• Docks less than 0.3–0.4 m above the salt marsh shade out salt marsh grasses
McGuire (1990)	NA	Shading	Dock height, width, orientation	*Spartina alterniflora* salt marsh grass	• *Spartina* stem density 65% lower under docks and also lower immediately adjacent to docks		
Colligan and Collins (1995)	Connecticut, Rhode Island, Massachusetts	Shading		*Spartina* salt marsh grass	• *Spartina* stem density lower under docks		
Burdick and Short (1999)	Massachusetts	Shading, direct physical effects	Dock orientation, length, width, thickness, height above water, height above marine bottom, elevated on fixed piers or floating, age, permanent or seasonal	Eelgrass beds	• Shoot density low (eelgrass mainly absent) under docks and increases with distance from dock • Short canopy height adjacent to docks suggests shading and/or disturbance impacts from boat activities • Prop dredging by boat propellers and turbulence erodes bottom sediments • Height of the dock over the marine bottom most important predictor of light reaching eelgrass • Docks running east-west support less eelgrass than docks running north south • Floating portions of docks typically eliminate eelgrass under them	Height of the dock above the marine bottom, dock orientation, dock width	• Modelling based on field data indicates a north-south dock will support 50% the eelgrass of surrounding beds at 1.7 m above the bottom • Docks running east-west must be 1.8 m taller than those running north-south to support the same amount of eelgrass • Regardless of orientation, a 1-m wide dock must be 3 m above the bottom to support 50% of production • Floating portions of docks should only be placed beyond lower depth limit for eelgrass

Shafer (1999)	Alabama	Shading	Dock orientation, height above mean sea level, width	*Halodule wrightii* seagrass	• Docks reduced shoot density and biomass, and increased chlorophyll content and blade length relative to unshaded plots • Destruction of seagrass beds due to boat impacts and propeller scarring was noted	Height of the dock above sea level, dock orientation, dock width	• Docks 1.2 m wide and 1.0–1.3 m above mean sea level sufficient to allow survival and growth if oriented in a north-south direction • Higher minimum height requirements for docks oriented in an east-west direction • Regions at higher latitudes receive less sunlight; may require different dock guidelines
Kelty and Bliven (2003)	Workshop literature synthesis featuring work from US East Coast	Dock construction, shading, elevated TSS and turbidity, sedimentation, exposure to contaminants, associated boating impacts		Marine and foreshore habitats	• Dock construction may destroy vegetation both above or below the tide line by damaging the root system and compacting the substrate • Pile installation by jetting causes greater sedimentation and disruption of vegetation than pile driving • Dock pilings permanently destroy vegetation immediately under the pilings and may decrease growth adjacent to the pilings due to altered currents, sediment deposition, and leaching of chemicals such as CCA from treated wood • Scour, erosion, or sediment deposition around dock structures from modified water flow may affect the suitability of existing habitat for shellfish or other marine organisms		• Mitigation strategies: 1) Height: minimum 1.2 m over marsh face or mean high water 2) Orientation: North-South 3) Width: maximum 1.2 m 4) Length: minimum needed to reach navigable water 5) Incorporate light transmitting materials into the dock, such as glass blocks instead of wood, metal grating, or sun tunnels. For example, in Florida, light levels never dropped below saturation for seagrasses under docks 1.5 m above mean sea level with fiberglass grating (1x2” holes)

					• Approximately 99% of leaching from CCA-treated wood occurs within the first 90 days • Elevated concentrations of chromium, copper, and arsenic from CCA-treated wood can be found in biota living on or near pilings • Leachate from CCA-treated wood can be toxic to species, but effects are likely to be localized and of low magnitude with adequate dilution and flushing • Light levels under wood docks generally fall below the requirements for minimum plant maintenance and growth • Spacing between deck planks on the order of one inch or two does little to reduce shading impacts • In the Pacific Northwest, *Zostera* shoot density was highest at a light level of 350 µmol PAR in an area with a tidal range of 4–5 m		6) Avoid high-pressure jetting for dock pile installation • Regulation strategies: 1) Charge fees to mitigate for lost or damaged habitats 2) Provide incentives to homeowners not to have docks or to choose a shared dock (e.g., short-term reduction in property taxes) 3) Avoid site-by-site dock approvals and promote community-level dock development plans and assessments to better account for cumulative environmental effects
Crawford et al. (1998)	Workshop proceedings featuring work from US Eastern and Gulf coasts	Associated boating impacts		Marine habitats	• Boat propellers may cause direct damage to plants and their rhizomes, causing loss of habitat and sediment stability • Outboard motors release unburned fuel with exhaust gases, resulting in contamination of water and sediments with PAHs. • Contaminants in sediments may be resuspended and mobilized by boat traffic, potentially increasing their bioavailability to marine fish • Boats produce two kinds of		

wake: a bow wake and a secondary wake referred to as prop wash, which is the primary cause of sediment resuspension and damage to submerged vegetation

• Slow-moving, heavy boats have been noted to cause more turbidity than lighter, faster-moving boats

• Depending on sediment type, resuspended sediments may settle 7 s to 10 min after the passage of a recreational vessel

8.0 APPENDIX 3: PENDER HARBOUR SHORELINE PHOTOS

Pender Harbour Shoreline Photos

Project: Pender Harbour Habitat Survey

Photo: 1
Gunboat Bay
(Latitude: 49°37'43.03'', Longitude: -124°0'49.91'', Date Taken: October-11-17 9:11:28 AM)

Photo: 2
Gunboat Bay
(Latitude: 49°37'42.99'', Longitude: -124°0'49.92'', Date Taken: October-11-17 9:12:12 AM)

Photo: 3
Gunboat Bay
(Latitude: 49°37'43.07'', Longitude: -124°0'48.34'', Date Taken: October-11-17 9:13:49 AM)

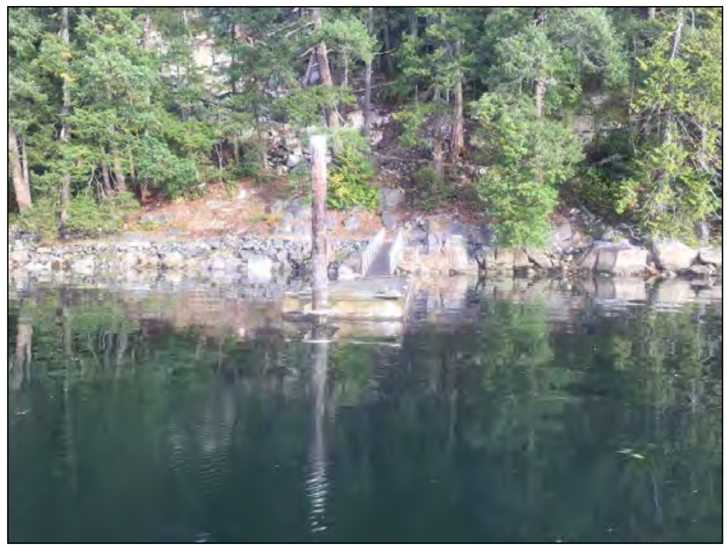


Photo: 4
Gunboat Bay
(Latitude: 49°37'43.54'', Longitude: -124°0'47.76'', Date Taken: October-11-17 9:14:06 AM)

Photo: 5
Gunboat Bay
(Latitude: 49°37'43.97'', Longitude: -124°0'46.31'', Date Taken: October-11-17 9:14:34 AM)

Photo: 6
Gunboat Bay. Great blue heron observed on dock.
(Latitude: 49°37'44.70'', Longitude: -124°0'40.87'', Date Taken: October-11-17 9:16:03 AM)

Photo: 7
Gunboat Bay
(Latitude: 49°37'45.31'', Longitude: -124°0'38.39'', Date Taken: October-11-17 9:22:33 AM)

Photo: 8
Gunboat Bay
(Latitude: 49°37'45.43'', Longitude: -124°0'36.60'', Date Taken: October-11-17 9:23:03 AM)

Photo: 9
Divers preparing to survey a transect in Gunboat Bay.
(Latitude: 49°37'45.95'', Longitude: -124°0'32.94'', Date Taken: October-11-17 9:24:28 AM)

Photo: 10
North shore of Gunboat Bay.
(Latitude: 49°37'47.81'', Longitude: -124°0'28.68'', Date Taken: October-11-17 9:27:09 AM)

Photo: 11
North shore of Gunboat Bay.
(Latitude: 49°37'47.91'', Longitude: -124°0'28.15'', Date Taken: October-11-17 9:27:35 AM)

Photo: 12
North shore of Gunboat Bay. Styrofoam blocks under dock.
(Latitude: 49°37'47.52'', Longitude: -124°0'27.19'', Date Taken: October-11-17 9:28:21 AM)

Photo: 13
North shore of Gunboat Bay.
(Latitude: 49°37'47.83'', Longitude: -124°0'26.76'', Date Taken: October-11-17 9:29:59 AM)

Photo: 14
North shore of Gunboat Bay.
(Latitude: 49°37'47.01'', Longitude: -124°0'25.89'', Date Taken: October-11-17 9:31:17 AM)

Photo: 15
North shore of Gunboat Bay.
(Latitude: 49°37'46.71'', Longitude: -124°0'25.89'', Date Taken: October-11-17 9:31:34 AM)

Photo: 16
North shore of Gunboat Bay.
(Latitude: 49°37'46.02'', Longitude: -124°0'25.59'', Date Taken: October-11-17 9:32:05 AM)

Photo: 17
North shore of Gunboat Bay.
(Latitude: 49°37'45.56'', Longitude: -124°0'25.25'', Date Taken: October-11-17 9:32:27 AM)

Photo: 18
North shore of Gunboat Bay.
(Latitude: 49°37'43.97'', Longitude: -124°0'25.20'', Date Taken: October-11-17 9:33:26 AM)

Photo: 19
North shore of Gunboat Bay.
(Latitude: 49°37'43.04'', Longitude: -124°0'21.16'', Date Taken: October-11-17 9:34:52 AM)

Photo: 20
North shore of Gunboat Bay. Typical wood dock with styrofoam floats.
(Latitude: 49°37'43.55'', Longitude: -124°0'17.46'', Date Taken: October-11-17 9:35:55 AM)

Photo: 21
North shore of Gunboat Bay.
(Latitude: 49°37'43.45'', Longitude: -124°0'16.56'', Date Taken: October-11-17 9:36:34 AM)

Photo: 22
North shore of Gunboat Bay.
(Latitude: 49°37'43.40'', Longitude: -124°0'13.98'', Date Taken: October-11-17 9:37:51 AM)

Photo: 23
North shore of Gunboat Bay.
(Latitude: 49°37'43.27'', Longitude: -124°0'11.10'', Date Taken: October-11-17 9:39:01 AM)

Photo: 24
North shore of Gunboat Bay. Near Transect 13.
(Latitude: 49°37'44.33'', Longitude: -124°0'5.99'', Date Taken: October-11-17 9:42:53 AM)

Photo: 25
North shore of Gunboat Bay.
(Latitude: 49°37'45.16'', Longitude: -124°0'4.21'', Date Taken: October-11-17 9:44:09 AM)

Photo: 26
North shore of Gunboat Bay.
(Latitude: 49°37'47.85'', Longitude: -124°0'0.77'', Date Taken: October-11-17 9:45:42 AM)

Photo: 27
West shore of Oyster Bay. Land for sale.
(Latitude: 49°37'48.61'', Longitude: -123°59'59.99'', Date Taken: October-11-17 9:46:09 AM)

Photo: 28
West shore of Oyster Bay. Land for sale.
(Latitude: 49°37'51.03'', Longitude: -123°59'58.55'', Date Taken: October-11-17 9:47:22 AM)

Photo: 29
West shore of Oyster Bay. Old dock and shack.
(Latitude: 49°37'52.87'', Longitude: -123°59'57.69'', Date Taken: October-11-17 9:48:09 AM)

Photo: 30
West shore of Oyster Bay.
(Latitude: 49°37'57.55'', Longitude: -123°59'55.78'', Date Taken: October-11-17 9:50:11 AM)

Photo: 31
West shore of Oyster Bay. Example of a property without a dock.
(Latitude: 49°38'1.63'', Longitude: -123°59'51.09'', Date Taken: October-11-17 9:52:32 AM)

Photo: 32
West shore of Oyster Bay. Old oyster processing shack. Oyster shells visible.
(Latitude: 49°38'2.82'', Longitude: -123°59'49.03'', Date Taken: October-11-17 9:53:20 AM)

Photo: 33
West shore of Oyster Bay.
(Latitude: 49°38'4.77'', Longitude: -123°59'44.25'', Date Taken: October-11-17 9:56:33 AM)

Photo: 34
West shore of Oyster Bay.
(Latitude: 49°38'7.81'', Longitude: -123°59'36.83'', Date Taken: October-11-17 9:59:53 AM)

Photo: 35
Oyster Bay homes.
(Latitude: 49°38'10.59'', Longitude: -123°59'31.37'', Date Taken: October-11-17 10:01:55 AM)

Photo: 36
West shore of Oyster Bay.
(Latitude: 49°38'15.15'', Longitude: -123°59'26.53'', Date Taken: October-11-17 10:04:30 AM)

Photo: 37
West shore of Oyster Bay.
(Latitude: 49°38'14.66'', Longitude: -123°59'23.95'', Date Taken: October-11-17 10:07:21 AM)

Photo: 38
East shore of Oyster Bay.
(Latitude: 49°38'13.19'', Longitude: -123°59'19.74'', Date Taken: October-11-17 10:09:56 AM)

Photo: 39
East shore of Oyster Bay. Old wood from an old dock. Old foot bridge.
(Latitude: 49°38'16.18'', Longitude: -123°59'17.03'', Date Taken: October-11-17 10:11:51 AM)

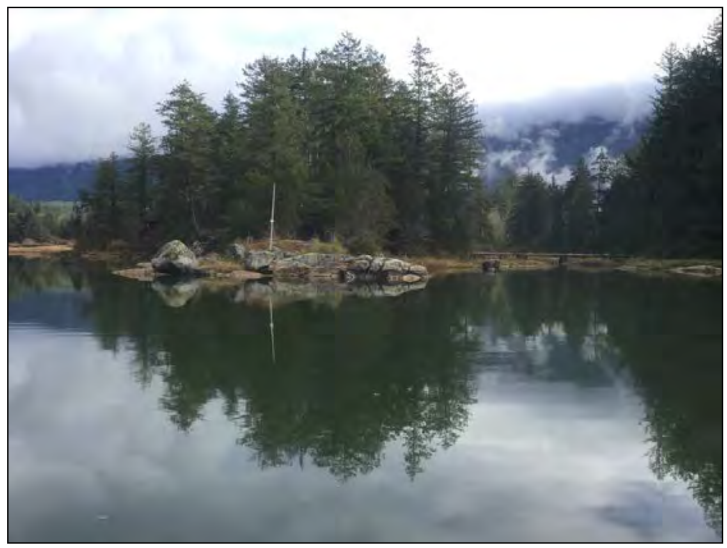


Photo: 40
Old footbridge along east shore of Oyster Bay.
(Latitude: 49°38'17.67'', Longitude: -123°59'17.21'', Date Taken: October-11-17 10:12:57 AM)

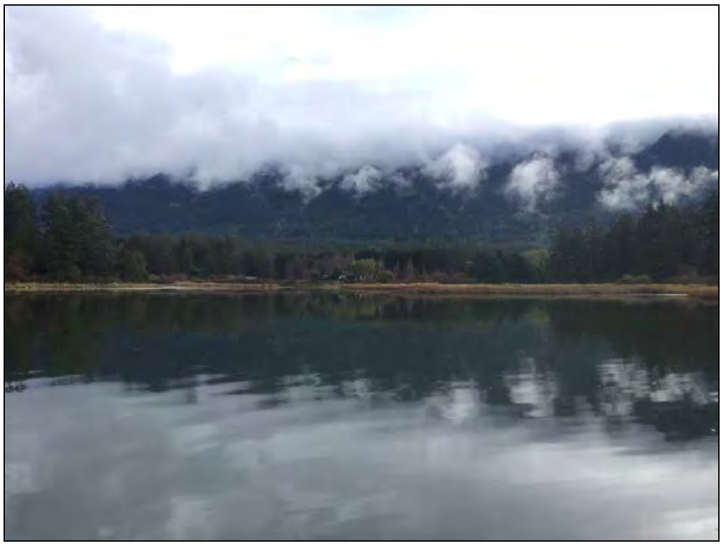


Photo: 41
Salt marsh habitat at north end of Oyster Bay.
(Latitude: 49°38'21.97'', Longitude: -123°59'18.13'', Date Taken: October-11-17 10:16:49 AM)

Photo: 42
East shore of Oyster Bay. Mature forest with intact riparian vegetation.
(Latitude: 49°38'13.43'', Longitude: -123°59'28.32'', Date Taken: October-11-17 10:22:12 AM)

Photo: 43
East shore of Oyster Bay.
(Latitude: 49°38'6.93'', Longitude: -123°59'37.76'', Date Taken: October-11-17 10:25:30 AM)

Photo: 44
East shore of Oyster Bay.
(Latitude: 49°38'5.04'', Longitude: -123°59'41.07'', Date Taken: October-11-17 10:26:32 AM)

Photo: 45
East shore of Oyster Bay. Heading towards East Bay.
(Latitude: 49°37'56.49'', Longitude: -123°59'39.66'', Date Taken: October-11-17 10:33:20 AM)

Photo: 46
East shore of Oyster Bay. Dock ramp fallen apart.
(Latitude: 49°37'57.41'', Longitude: -123°59'35.71'', Date Taken: October-11-17 10:34:38 AM)

Photo: 47
East shore of Oyster Bay.
(Latitude: 49°37'56.48'', Longitude: -123°59'35.85'', Date Taken: October-11-17 10:35:07 AM)

Photo: 48
East shore of Oyster Bay.
(Latitude: 49°37'56.10'', Longitude: -123°59'36.49'', Date Taken: October-11-17 10:35:22 AM)

Photo: 49
Docks along southeast end of Oyster Bay.
(Latitude: 49°37'53.70'', Longitude: -123°59'40.17'', Date Taken: October-11-17 10:36:54 AM)

Photo: 50
Example of boathouse in Oyster Bay.
(Latitude: 49°37'52.05'', Longitude: -123°59'41.28'', Date Taken: October-11-17 10:37:48 AM)

Photo: 51
East shore of Oyster Bay, heading towards East Bay.
(Latitude: 49°37'51.31'', Longitude: -123°59'41.97'', Date Taken: October-11-17 10:38:13 AM)

Photo: 52
Large boathouse in Oyster Bay.
(Latitude: 49°37'50.43'', Longitude: -123°59'43.16'', Date Taken: October-11-17 10:38:36 AM)

Photo: 53
Southeast end of Oyster Bay.
(Latitude: 49°37'49.60'', Longitude: -123°59'44.31'', Date Taken: October-11-17 10:39:08 AM)

Photo: 54
Private boat ramp at southeast end of Oyster Bay.
(Latitude: 49°37'47.99'', Longitude: -123°59'46.34'', Date Taken: October-11-17 10:40:07 AM)

Photo: 55
Southeast end of Oyster Bay.
(Latitude: 49°37'47.26'', Longitude: -123°59'47.25'', Date Taken: October-11-17 10:40:34 AM)

Photo: 56
Southeast end of Oyster Bay.
(Latitude: 49°37'42.42'', Longitude: -123°59'48.40'', Date Taken: October-11-17 10:42:55 AM)

Photo: 57
Southeast end of Oyster Bay.
(Latitude: 49°37'39.40'', Longitude: -123°59'49.47'', Date Taken: October-11-17 10:44:19 AM)

Photo: 58
North shore, entering East Bay.
(Latitude: 49°37'35.04'', Longitude: -123°59'47.15'', Date Taken: October-11-17 10:45:58 AM)

Photo: 59
Mature forest along south shore at entrance to East Bay. Facing Gunboat Bay.
(Latitude: 49°37'33.95'', Longitude: -123°59'42.60'', Date Taken: October-11-17 10:46:59 AM)

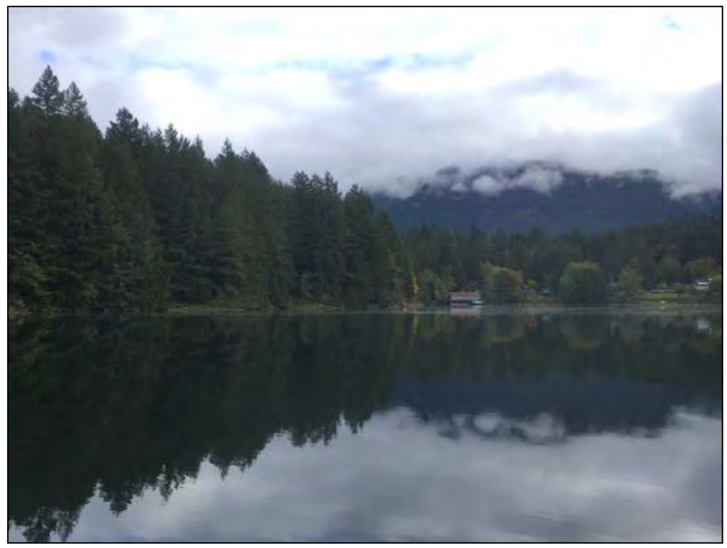


Photo: 60
Mature forest along north shore of East Bay. Facing east.
(Latitude: 49°37'33.96'', Longitude: -123°59'38.37'', Date Taken: October-11-17 10:48:32 AM)

Photo: 61
Backshore adjacent to T15.
(Latitude: 49°37'31.48'', Longitude: -123°59'20.65'', Date Taken: October-11-17 10:55:54 AM)

Photo: 62
Salt marsh at east end of East Bay.
(Latitude: 49°37'32.66'', Longitude: -123°59'18.46'', Date Taken: October-11-17 10:58:06 AM)

Photo: 63
Backshore near T15. Old shack in East Bay.
(Latitude: 49°37'37.58'', Longitude: -123°59'19.13'', Date Taken: October-11-17 11:04:28 AM)

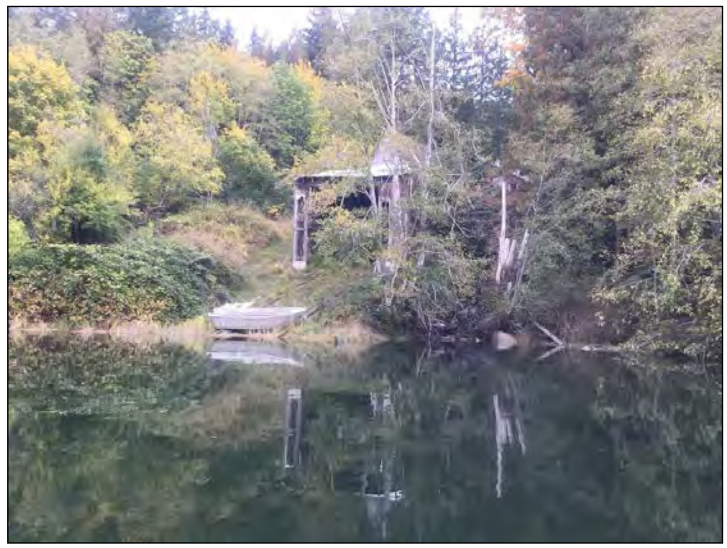


Photo: 64
Stream entering East Bay from the north, located to the right of an old boat launch.
(Latitude: 49°37'38.16'', Longitude: -123°59'20.55'', Date Taken: October-11-17 11:05:55 AM)

Photo: 65
South shore of East Bay.
(Latitude: 49°37'37.37'', Longitude: -123°59'25.06'', Date Taken: October-11-17 11:08:38 AM)

Photo: 66
South shore of East Bay.
(Latitude: 49°37'35.99'', Longitude: -123°59'29.45'', Date Taken: October-11-17 11:10:05 AM)

Photo: 67
South shore of East Bay.
(Latitude: 49°37'33.64'', Longitude: -123°59'41.64'', Date Taken: October-11-17 11:17:34 AM)

Photo: 68
Wood dock with styrofoam floats just west of T16.
(Latitude: 49°37'36.36'', Longitude: -123°59'58.51'', Date Taken: October-11-17 11:23:36 AM)

Photo: 69
South shore of Gunboat Bay, just west of T16. Active eagle nest with eagles observed in conifer southwest of dock.
(Latitude: 49°37'35.94'', Longitude: -124°0'3.37'', Date Taken: October-11-17 11:26:42 AM)

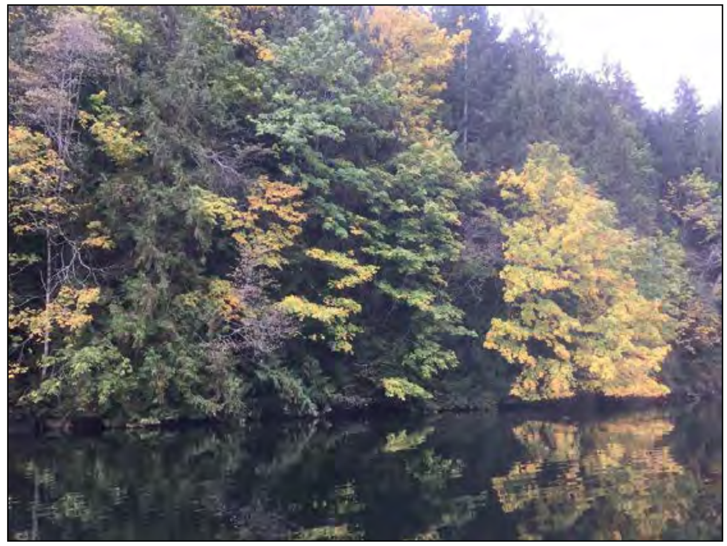


Photo: 70
Mature forest along south shore of Gunboat Bay.
(Latitude: 49°37'35.54'', Longitude: -124°0'8.03'', Date Taken: October-11-17 11:30:02 AM)

Photo: 71
Long ramps to docks along south shore of Gunboat Bay.
(Latitude: 49°37'35.86'', Longitude: -124°0'11.88'', Date Taken: October-11-17 11:30:48 AM)

Photo: 72
Looking west at docks along south shore of Gunboat Bay.
(Latitude: 49°37'37.98'', Longitude: -124°0'17.85'', Date Taken: October-11-17 11:32:39 AM)

Photo: 73
Gunboat Bay south side.
(Latitude: 49°37'37.36'', Longitude: -124°0'20.20'', Date Taken: October-11-17 11:33:20 AM)

Photo: 74
South shore of Gunboat Bay.
(Latitude: 49°37'36.14'', Longitude: -124°0'25.66'', Date Taken: October-11-17 11:34:59 AM)

Photo: 75
Small island along south shore of Gunboat Bay.
(Latitude: 49°37'36.08'', Longitude: -124°0'27.32'', Date Taken: October-11-17 11:35:40 AM)

Photo: 76
South shore of Gunboat Bay.
(Latitude: 49°37'35.51'', Longitude: -124°0'29.16'', Date Taken: October-11-17 11:36:14 AM)

Photo: 77
South shore of Gunboat Bay.
(Latitude: 49°37'34.86'', Longitude: -124°0'31.63'', Date Taken: October-11-17 11:37:01 AM)

Photo: 78
South shore of Gunboat Bay. Long ramps to boathouse and docks.
(Latitude: 49°37'35.41'', Longitude: -124°0'32.15'', Date Taken: October-11-17 11:39:32 AM)

Photo: 79
South shore of Gunboat Bay.
(Latitude: 49°37'36.56'', Longitude: -124°0'34.30'', Date Taken: October-11-17 11:40:27 AM)

Photo: 80
South shore of Gunboat Bay. Boat ramp.
(Latitude: 49°37'37.94'', Longitude: -124°0'39.44'', Date Taken: October-11-17 11:42:19 AM)

Photo: 81
South shore of Gunboat Bay.
(Latitude: 49°37'38.24'', Longitude: -124°0'41.41'', Date Taken: October-11-17 11:42:52 AM)

Photo: 82
South shore of Gunboat Bay.
(Latitude: 49°37'37.99'', Longitude: -124°0'47.78'', Date Taken: October-11-17 11:45:13 AM)

Photo: 83
South shore of Gunboat Bay.
(Latitude: 49°37'37.84'', Longitude: -124°0'48.72'', Date Taken: October-11-17 11:45:43 AM)

Photo: 84
Leaving Gunboat Bay and entering tidal channel along south shore.
(Latitude: 49°37'37.21'', Longitude: -124°0'52.30'', Date Taken: October-11-17 11:46:50 AM)

Photo: 85
Docks along south shore of Gunboat Bay. Old dock ramp fallen in water.
(Latitude: 49°37'36.46'', Longitude: -124°0'55.68'', Date Taken: October-11-17 11:47:58 AM)

Photo: 86
Boathouse at entrance to Wilkinson Cove.
(Latitude: 49°37'33.90'', Longitude: -124°1'5.44'', Date Taken: October-11-17 11:51:27 AM)

Photo: 87
Fisherman's marina in Hospital Bay.
(Latitude: 49°37'50.05'', Longitude: -124°2'3.97'', Date Taken: October-11-17 12:16:43 PM)

Photo: 88
Garden Peninsula shoreline.
(Latitude: 49°37'46.59'', Longitude: -124°2'2.73'', Date Taken: October-11-17 12:18:25 PM)

Photo: 89
Boathouses along Garden Peninsula shoreline. Heading east from Hospital Bay to Garden Bay.
(Latitude: 49°37'45.90'', Longitude: -124°2'1.52'', Date Taken: October-11-17 12:19:16 PM)

Photo: 90
Garden Peninsula shoreline between Hospital Bay and Garden Bay.
(Latitude: 49°37'43.54'', Longitude: -124°1'56.90'', Date Taken: October-11-17 12:21:27 PM)

Photo: 91
Garden Peninsula shoreline between Hospital Bay and Garden Bay.
(Latitude: 49°37'42.49'', Longitude: -124°1'54.89'', Date Taken: October-11-17 12:22:08 PM)

Photo: 92
Garden Peninsula shoreline between Hospital Bay and Garden Bay.
(Latitude: 49°37'41.08'', Longitude: -124°1'52.88'', Date Taken: October-11-17 12:23:14 PM)

Photo: 93
Garden Peninsula shoreline between Hospital Bay and Garden Bay. Human-altered foreshore.
(Latitude: 49°37'39.78'', Longitude: -124°1'50.24'', Date Taken: October-11-17 12:26:15 PM)

Photo: 94
Garden Peninsula shoreline between Hospital Bay and Garden Bay.
(Latitude: 49°37'39.98'', Longitude: -124°1'38.83'', Date Taken: October-11-17 12:29:43 PM)

Photo: 95
Garden Peninsula shoreline between Hospital Bay and Garden Bay.
(Latitude: 49°37'41.05'', Longitude: -124°1'35.41'', Date Taken: October-11-17 12:30:57 PM)

Photo: 96
Southwest Garden Bay. Human-altered foreshore.
(Latitude: 49°37'47.61'', Longitude: -124°1'30.72'', Date Taken: October-11-17 12:35:23 PM)

Photo: 97
Southwest Garden Bay.
(Latitude: 49°37'49.24'', Longitude: -124°1'34.81'', Date Taken: October-11-17 12:36:26 PM)

Photo: 98
Garden Bay Royal Vancouver Yacht Club.
(Latitude: 49°37'50.83'', Longitude: -124°1'36.52'', Date Taken: October-11-17 12:38:28 PM)

Photo: 99
Garden Bay Pilothouse Marina.
(Latitude: 49°37'53.06'', Longitude: -124°1'34.95'', Date Taken: October-11-17 12:40:02 PM)

Photo: 100
Garden Bay pub and restaurant.
(Latitude: 49°37'53.69'', Longitude: -124°1'37.93'', Date Taken: October-11-17 12:41:03 PM)

Photo: 101
Garden Bay. Burrard Yacht Club in foreground.
(Latitude: 49°37'51.91'', Longitude: -124°1'24.70'', Date Taken: October-11-17 12:45:07 PM)

Photo: 102
Seattle Yacht Club, east end of Garden Bay.
(Latitude: 49°37'46.32'', Longitude: -124°1'10.57'', Date Taken: October-11-17 12:48:18 PM)

Photo: 103
Seattle Yacht Club, east end of Garden Bay.
(Latitude: 49°37'44.32'', Longitude: -124°1'12.67'', Date Taken: October-11-17 12:49:22 PM)

Photo: 104
East end of Garden Bay.
(Latitude: 49°37'42.64'', Longitude: -124°1'13.39'', Date Taken: October-11-17 12:50:12 PM)

Photo: 105
Boathouse at entrance to Wilkinson Cove.
(Latitude: 49°37'33.21'', Longitude: -124°1'7.99'', Date Taken: October-11-17 12:56:57 PM)

Photo: 106
Wilkinson Cove marina. Facing entrance of cove.
(Latitude: 49°37'28.75'', Longitude: -124°1'2.44'', Date Taken: October-11-17 12:59:32 PM)

Photo: 107
End of Wilkinson Cove. Human-altered shoreline.
(Latitude: 49°37'29.89'', Longitude: -124°1'3.15'', Date Taken: October-11-17 1:00:47 PM)

Photo: 108
Marina between Wilkinson Cove and Welbourn Cove. Blue heron on dock.
(Latitude: 49°37'32.24'', Longitude: -124°1'13.71'', Date Taken: October-11-17 1:04:20 PM)

Photo: 109
Entering Welbourn Cove from east, along south shore.
(Latitude: 49°37'30.44'', Longitude: -124°1'23.24'', Date Taken: October-11-17 1:07:35 PM)

Photo: 110
Entering Welbourn Cove from the east.
(Latitude: 49°37'28.73'', Longitude: -124°1'25.69'', Date Taken: October-11-17 1:08:30 PM)

Photo: 111
Public Wharf in Welbourn Cove.
(Latitude: 49°37'25.42'', Longitude: -124°1'28.29'', Date Taken: October-11-17 1:10:14 PM)

Photo: 112
Madeira Marina, Welbourn Cove.
(Latitude: 49°37'22.35'', Longitude: -124°1'29.28'', Date Taken: October-11-17 1:12:11 PM)

Photo: 113
Backshore east of Public Wharf in Welbourn Cove.
(Latitude: 49°37'22.88'', Longitude: -124°1'30.29'', Date Taken: October-11-17 1:12:54 PM)

Photo: 114
Public Wharf in Welbourn Cove.
(Latitude: 49°37'23.80'', Longitude: -124°1'31.77'', Date Taken: October-11-17 1:16:24 PM)

Photo: 115
Private docks in Welbourn Cove.
(Latitude: 49°37'24.59'', Longitude: -124°1'32.65'', Date Taken: October-11-17 1:17:56 PM)

Photo: 116
Backshore of T18. Welbourn Cove boat ramp.
(Latitude: 49°37'21.99'', Longitude: -124°1'33.23'', Date Taken: October-11-17 1:19:35 PM)

Photo: 117
Private docks in Welbourn Cove.
(Latitude: 49°37'22.98'', Longitude: -124°1'33.73'', Date Taken: October-11-17 1:20:15 PM)

Photo: 118
Private boathouse west of Coho Marina Resort.
(Latitude: 49°37'12.98'', Longitude: -124°1'59.70'', Date Taken: October-11-17 1:32:46 PM)

Photo: 119
Coho Marina Resort.
(Latitude: 49°37'13.48'', Longitude: -124°1'56.15'', Date Taken: October-11-17 1:33:55 PM)

Photo: 120
Coho Marina Resort.
(Latitude: 49°37'10.93'', Longitude: -124°1'54.38'', Date Taken: October-11-17 1:36:48 PM)

Photo: 121
Coho Marina Resort. Truck with styrofoam blocks for docks.
(Latitude: 49°37'12.09'', Longitude: -124°1'50.59'', Date Taken: October-11-17 1:38:08 PM)

Photo: 122
East of Coho Marina Resort.
(Latitude: 49°37'10.63'', Longitude: -124°1'49.65'', Date Taken: October-11-17 1:38:51 PM)

Photo: 123
Painted Boat Resort Marina.
(Latitude: 49°37'7.86'', Longitude: -124°1'48.37'', Date Taken: October-11-17 1:40:32 PM)

Photo: 124
Facing towards lagoon south of Painted Boat Resort.
(Latitude: 49°37'6.82'', Longitude: -124°1'51.83'', Date Taken: October-11-17 1:41:39 PM)

Photo: 125
Private boathouses southwest of Painted Boat Resort.
(Latitude: 49°37'6.46'', Longitude: -124°1'55.39'', Date Taken: October-11-17 1:43:00 PM)

Photo: 126
Facing north towards Coho Marina Resort.
(Latitude: 49°37'4.82'', Longitude: -124°1'57.84'', Date Taken: October-11-17 1:44:08 PM)

Photo: 127
Facing south to Francis Peninsula road that runs between Bargain Bay and Gerrans Bay.
(Latitude: 49°37'3.85'', Longitude: -124°1'58.72'', Date Taken: October-11-17 1:45:25 PM)

Photo: 128
East of T21.
(Latitude: 49°37'7.75'', Longitude: -124°2'12.26'', Date Taken: October-11-17 1:51:25 PM)

Photo: 129
Backshore just west of T21.
(Latitude: 49°37'8.86'', Longitude: -124°2'22.25'', Date Taken: October-11-17 1:53:16 PM)

Photo: 130
South shore of Gerrans Bay.
(Latitude: 49°37'8.55'', Longitude: -124°2'26.83'', Date Taken: October-11-17 1:54:00 PM)

Photo: 131
South shore of Gerrans Bay.
(Latitude: 49°37'6.65'', Longitude: -124°2'30.68'', Date Taken: October-11-17 1:55:19 PM)

Photo: 132
South shore of Gerrans Bay.
(Latitude: 49°37'5.92'', Longitude: -124°2'31.43'', Date Taken: October-11-17 1:55:35 PM)

Photo: 133
Whisky Slough Public Wharf in Gerrans Bay.
(Latitude: 49°37'0.65'', Longitude: -124°2'36.50'', Date Taken: October-11-17 1:57:51 PM)

Photo: 134
Just east of Whisky Slough Public Wharf in Gerrans Bay.
(Latitude: 49°36'58.17'', Longitude: -124°2'37.90'', Date Taken: October-11-17 1:59:12 PM)

Photo: 135
Just west of Whisky Slough Public Wharf in Gerrans Bay.
(Latitude: 49°36'59.19'', Longitude: -124°2'40.76'', Date Taken: October-11-17 2:00:06 PM)

Photo: 136
Backshore of T22 in Gerrans Bay.
(Latitude: 49°36'58.46'', Longitude: -124°2'49.34'', Date Taken: October-11-17 2:02:38 PM)

Photo: 137
West of Whisky Slough Public Wharf in Gerrans Bay. Facing north.
(Latitude: 49°36'59.22'', Longitude: -124°2'47.22'', Date Taken: October-11-17 2:03:11 PM)

Photo: 138
West shore of Gerrans Bay.
(Latitude: 49°37'7.20'', Longitude: -124°2'38.23'', Date Taken: October-11-17 2:07:06 PM)

Photo: 139
West shore of Gerrans Bay.
(Latitude: 49°37'8.87'', Longitude: -124°2'39.95'', Date Taken: October-11-17 2:08:22 PM)

Photo: 140
West shore of Gerrans Bay.
(Latitude: 49°37'10.13'', Longitude: -124°2'38.26'', Date Taken: October-11-17 2:09:03 PM)

Photo: 141
West shore of Gerrans Bay.
(Latitude: 49°37'11.08'', Longitude: -124°2'37.31'', Date Taken: October-11-17 2:09:36 PM)

Photo: 142
West shore of Gerrans Bay, north of T23. Collection of old boats.
(Latitude: 49°37'16.97'', Longitude: -124°2'31.57'', Date Taken: October-11-17 2:13:42 PM)

Photo: 143
West shore of Gerrans Bay. Collection of old boats.
(Latitude: 49°37'17.36'', Longitude: -124°2'28.19'', Date Taken: October-11-17 2:14:59 PM)

Photo: 144
Small island between west shore of Gerrans Bay and Dusenbury Island.
(Latitude: 49°37'19.91'', Longitude: -124°2'30.76'', Date Taken: October-11-17 2:17:30 PM)

Photo: 145
Looking south between small unnamed island and Dusenbury Island.
(Latitude: 49°37'23.68'', Longitude: -124°2'27.84'', Date Taken: October-11-17 2:19:52 PM)

Photo: 146
Large boathouse along west shore of Gerrans Bay, across from Dusenbury and Calder Islands.
(Latitude: 49°37'24.51'', Longitude: -124°2'26.84'', Date Taken: October-11-17 2:20:53 PM)

Photo: 147
West shore of Gerrans Bay across from Calder Island.
(Latitude: 49°37'27.27'', Longitude: -124°2'22.35'', Date Taken: October-11-17 2:22:53 PM)

Photo: 148
Facing south, where Dusenbury and Calder Islands meet.
(Latitude: 49°37'28.77'', Longitude: -124°2'21.14'', Date Taken: October-11-17 2:23:36 PM)

Photo: 149
West shore of Calder Island. Great blue heron on rock.
(Latitude: 49°37'33.61'', Longitude: -124°2'20.79'', Date Taken: October-11-17 2:25:40 PM)

Photo: 150
John Henry's Marina in Hospital Bay.
(Latitude: 49°37'52.35'', Longitude: -124°2'1.88'', Date Taken: October-11-17 3:30:45 PM)

Photo: 151
Facing towards west shore of Hospital Bay.
(Latitude: 49°37'52.64'', Longitude: -124°2'2.82'', Date Taken: October-11-17 3:31:33 PM)

Photo: 152
East shore of Francis Peninsula marine park, entering Bargain Bay.
(Latitude: 49°36'24.99'', Longitude: -124°2'13.48'', Date Taken: October-12-17 8:21:15 AM)

Photo: 153
East shore of Francis Peninsula, entering Bargain Bay.
(Latitude: 49°36'26.75'', Longitude: -124°2'14.23'', Date Taken: October-12-17 8:22:13 AM)

Photo: 154
East shore of Francis Peninsula, entering Bargain Bay.
(Latitude: 49°36'28.50'', Longitude: -124°2'14.45'', Date Taken: October-12-17 8:23:01 AM)

Photo: 155
West shore of Bargain Bay.
(Latitude: 49°36'29.38'', Longitude: -124°2'14.17'', Date Taken: October-12-17 8:23:26 AM)

Photo: 156
West shore of Bargain Bay.
(Latitude: 49°36'33.35'', Longitude: -124°2'16.06'', Date Taken: October-12-17 8:25:25 AM)

Photo: 157
West shore of Bargain Bay.
(Latitude: 49°36'35.53'', Longitude: -124°2'19.80'', Date Taken: October-12-17 8:27:05 AM)

Photo: 158
West shore of Bargain Bay.
(Latitude: 49°36'39.16'', Longitude: -124°2'24.50'', Date Taken: October-12-17 8:29:22 AM)

Photo: 159
West shore of Bargain Bay.
(Latitude: 49°36'40.75'', Longitude: -124°2'27.02'', Date Taken: October-12-17 8:30:53 AM)

Photo: 160
West shore of Bargain Bay. Eelgrass bed growing around boathouses.
(Latitude: 49°36'40.94'', Longitude: -124°2'26.56'', Date Taken: October-12-17 8:38:40 AM)

Photo: 161
West shore of Bargain Bay. Eelgrass bed growing around newer dock. Based on 2014 orthophotographs, the newer dock replaced an old dock.
(Latitude: 49°36'48.14'', Longitude: -124°2'28.49'', Date Taken: October-12-17 8:43:25 AM)

Photo: 162
Small patchy eelgrass bed observed between docks in Bargain Bay.
(Latitude: 49°36'48.99'', Longitude: -124°2'28.56'', Date Taken: October-12-17 8:44:10 AM)

Photo: 163
West shore of Bargain Bay. Eelgrass bed growing around dock.
(Latitude: 49°36'49.05'', Longitude: -124°2'28.50'', Date Taken: October-12-17 8:46:24 AM)

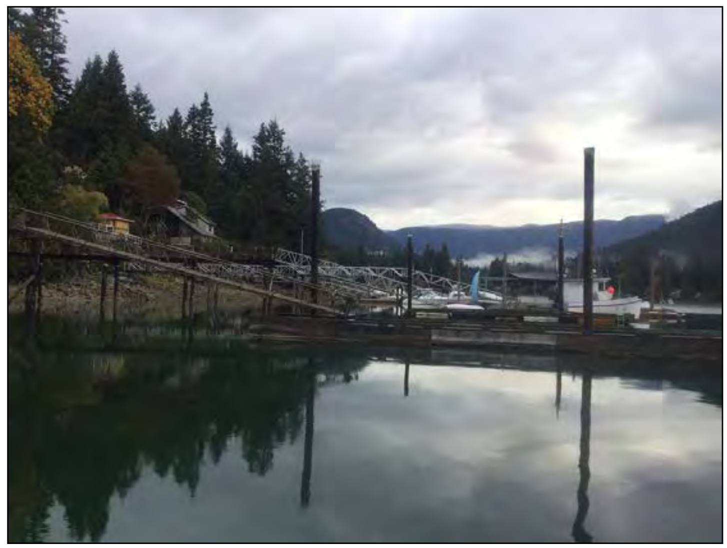


Photo: 164
Looking northeast along west shore of Bargain Bay.
(Latitude: 49°36'50.06'', Longitude: -124°2'28.89'', Date Taken: October-12-17 8:47:14 AM)

Photo: 165
Patchy eelgrass between docks along west shore of Bargain Bay.
(Latitude: 49°36'50.82'', Longitude: -124°2'24.82'', Date Taken: October-12-17 8:50:28 AM)

Photo: 166
Eelgrass continues around docks along west shore of Bargain Bay.
(Latitude: 49°36'52.10'', Longitude: -124°2'23.56'', Date Taken: October-12-17 8:54:11 AM)

Photo: 167
Subtidal eelgrass along west shore of Bargain Bay. Facing south towards west shore.
(Latitude: 49°36'54.19'', Longitude: -124°2'20.57'', Date Taken: October-12-17 8:56:38 AM)

Photo: 168
West shore of Bargain Bay.
(Latitude: 49°36'55.40'', Longitude: -124°2'18.89'', Date Taken: October-12-17 8:58:18 AM)

Photo: 169
West shore of Bargain Bay at north end.
(Latitude: 49°36'56.97'', Longitude: -124°2'18.54'', Date Taken: October-12-17 9:01:18 AM)

Photo: 170
Northwest end of Bargain Bay.
(Latitude: 49°36'58.24'', Longitude: -124°2'18.18'', Date Taken: October-12-17 9:02:12 AM)

Photo: 171
Patchy eelgrass throughout the northwest end of Bargain Bay.
(Latitude: 49°36'59.64'', Longitude: -124°2'16.91'', Date Taken: October-12-17 9:04:18 AM)

Photo: 172
North end of Bargain Bay.
(Latitude: 49°36'58.12'', Longitude: -124°2'12.47'', Date Taken: October-12-17 9:06:58 AM)

Photo: 173
Northeast end of Bargain Bay, showing backshore of T32.
(Latitude: 49°36'56.76'', Longitude: -124°2'11.54'', Date Taken: October-12-17 9:07:53 AM)

Photo: 174
Northeast end of Bargain Bay.
(Latitude: 49°36'53.95'', Longitude: -124°2'4.10'', Date Taken: October-12-17 9:11:45 AM)

Photo: 175
East shore of Bargain Bay.
(Latitude: 49°36'50.05'', Longitude: -124°2'9.18'', Date Taken: October-12-17 9:13:56 AM)

Photo: 176
East shore of Bargain Bay.
(Latitude: 49°36'49.79'', Longitude: -124°2'11.74'', Date Taken: October-12-17 9:14:31 AM)

Photo: 177
East side of Bargain Bay. Facing southwest.
(Latitude: 49°36'48.42'', Longitude: -124°2'14.23'', Date Taken: October-12-17 9:15:32 AM)

Photo: 178
East shore of Bargain Bay. Cobble and boulder shoreline.
(Latitude: 49°36'41.14'', Longitude: -124°2'14.55'', Date Taken: October-12-17 9:18:21 AM)

Photo: 179
Backshore of T34. Arbutus, cedar, and hemlock trees.
(Latitude: 49°36'36.85'', Longitude: -124°2'7.89'', Date Taken: October-12-17 9:20:02 AM)

Photo: 180
Backshore to north of T34.
(Latitude: 49°36'36.15'', Longitude: -124°2'7.03'', Date Taken: October-12-17 9:21:08 AM)

Photo: 181
Backshore to south of T34.
(Latitude: 49°36'35.12'', Longitude: -124°2'7.17'', Date Taken: October-12-17 9:21:35 AM)

Photo: 182
North shore of Edgecomb Island.
(Latitude: 49°36'29.95'', Longitude: -124°2'1.13'', Date Taken: October-12-17 9:25:51 AM)

Photo: 183
Docks in small cove east of entrance to Bargain Bay.
(Latitude: 49°36'31.23'', Longitude: -124°1'59.47'', Date Taken: October-12-17 9:26:25 AM)

Photo: 184
Docks east of entrance to Bargain Bay.
(Latitude: 49°36'33.34'', Longitude: -124°1'50.92'', Date Taken: October-12-17 9:28:37 AM)

Photo: 185
New dock with plastic floats, across from northeast end of Edgecomb Island.
(Latitude: 49°36'32.83'', Longitude: -124°1'45.33'', Date Taken: October-12-17 9:29:59 AM)

Photo: 186
Across from northeast end of Edgecomb Island.
(Latitude: 49°36'30.68'', Longitude: -124°1'42.12'', Date Taken: October-12-17 9:31:15 AM)

Photo: 187
Looking southwest towards Edgecomb Island.
(Latitude: 49°36'30.67'', Longitude: -124°1'40.81'', Date Taken: October-12-17 9:31:39 AM)

Photo: 188
Shoreline across east shore of Edgecomb Island.
(Latitude: 49°36'22.45'', Longitude: -124°1'45.14'', Date Taken: October-12-17 9:34:42 AM)

Photo: 189
East shore of Edgecomb Island.
(Latitude: 49°36'19.80'', Longitude: -124°1'44.76'', Date Taken: October-12-17 9:35:20 AM)

Photo: 190
Edgecomb Island. Facing north towards backshore of T35.
(Latitude: 49°36'18.70'', Longitude: -124°1'45.87'', Date Taken: October-12-17 9:36:06 AM)

Photo: 191
Facing south from near T35.
(Latitude: 49°36'18.22'', Longitude: -124°1'45.56'', Date Taken: October-12-17 9:36:57 AM)

Photo: 192
Backshore of T36. Mature coniferous forest. One house with no dock.
(Latitude: 49°36'15.79'', Longitude: -124°1'34.70'', Date Taken: October-12-17 9:39:03 AM)

Photo: 193
Backshore just south of T36.
(Latitude: 49°36'12.38'', Longitude: -124°1'33.37'', Date Taken: October-12-17 9:40:44 AM)

Photo: 194
Backshore of Francis Peninsula, west of entrance to Bargain Bay.
(Latitude: 49°36'11.19'', Longitude: -124°2'30.39'', Date Taken: October-12-17 9:45:02 AM)

Photo: 195
Backshore of Francis Peninsula, west of entrance to Bargain Bay.
(Latitude: 49°36'11.84'', Longitude: -124°2'31.75'', Date Taken: October-12-17 9:45:37 AM)

Photo: 196
Backshore of Francis Peninsula, west of entrance to Bargain Bay.
(Latitude: 49°36'11.62'', Longitude: -124°2'33.00'', Date Taken: October-12-17 9:46:45 AM)

Photo: 197
Entering Malcoms Bay from the east.
(Latitude: 49°36'10.50'', Longitude: -124°3'0.36'', Date Taken: October-12-17 9:50:03 AM)

Photo: 198
Facing southwest from Malcoms Bay.
(Latitude: 49°36'17.71'', Longitude: -124°3'1.13'', Date Taken: October-12-17 9:52:19 AM)

Photo: 199
West shore of Malcoms Bay.
(Latitude: 49°36'19.42'', Longitude: -124°3'0.60'', Date Taken: October-12-17 9:53:02 AM)

Photo: 200
East side of Malcoms Bay.
(Latitude: 49°36'20.57'', Longitude: -124°3'0.38'', Date Taken: October-12-17 9:53:40 AM)

Photo: 201
Backshore of T31. Field with cows, houses, maple and willow trees. Gravel/sand/mud beach.
(Latitude: 49°36'21.73'', Longitude: -124°3'1.04'', Date Taken: October-12-17 9:54:14 AM)

Photo: 202
Facing west from T31. Cedar and other mature coniferous trees.
(Latitude: 49°36'21.75'', Longitude: -124°3'1.22'', Date Taken: October-12-17 9:55:23 AM)

Photo: 203
Boat launch on west shore of Malcoms Bay.
(Latitude: 49°36'18.99'', Longitude: -124°3'4.04'', Date Taken: October-12-17 9:59:32 AM)

Photo: 204
Dutch Mikes Cove, off Malcolms Bay.
(Latitude: 49°36'16.67'', Longitude: -124°3'9.04'', Date Taken: October-12-17 10:01:40 AM)

Photo: 205
West shore of island at entrance to Malcoms Bay.
(Latitude: 49°36'12.05'', Longitude: -124°3'15.29'', Date Taken: October-12-17 10:04:05 AM)

Photo: 206
Francis Point lighthouse.
(Latitude: 49°36'11.28'', Longitude: -124°3'36.40'', Date Taken: October-12-17 10:05:55 AM)

Photo: 207
Backshore of T30. Mature coastal forest.
(Latitude: 49°36'37.42'', Longitude: -124°3'34.47'', Date Taken: October-12-17 10:08:52 AM)

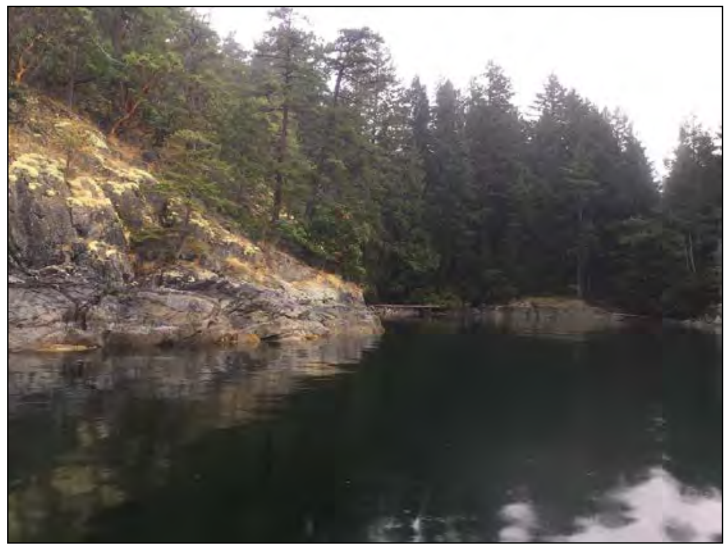


Photo: 208
Backshore looking west from along T30, located in Middle Bay. An eelgrass bed is located in this bay.
(Latitude: 49°36'39.04'', Longitude: -124°3'30.55'', Date Taken: October-12-17 10:09:55 AM)

Photo: 209
Facing north from along T30, end of Middle Bay.
(Latitude: 49°36'40.16'', Longitude: -124°3'28.06'', Date Taken: October-12-17 10:11:39 AM)

Photo: 210
Small cove at south end of Moore Point. Logs, small gravel beach.
(Latitude: 49°36'39.99'', Longitude: -124°3'39.08'', Date Taken: October-12-17 10:14:54 AM)

Photo: 211
Looking north from the mouth of the lagoon south of Moore Point.
(Latitude: 49°37'3.72'', Longitude: -124°3'50.18'', Date Taken: October-12-17 10:23:56 AM)

Photo: 212
Looking south into the lagoon south of Moore Point.
(Latitude: 49°37'1.86'', Longitude: -124°3'48.95'', Date Taken: October-12-17 10:25:18 AM)

Photo: 213
Looking southwest in the lagoon south of Moore Point.
(Latitude: 49°36'59.12'', Longitude: -124°3'48.08'', Date Taken: October-12-17 10:26:28 AM)

Photo: 214
The end of the lagoon south of Moore Point.
(Latitude: 49°36'55.66'', Longitude: -124°3'45.40'', Date Taken: October-12-17 10:28:09 AM)

Photo: 215
Dock that can be lowered or elevated by a crane. West shore of Francis Peninsula, just north of Moore Point.
(Latitude: 49°37'8.04'', Longitude: -124°3'50.39'', Date Taken: October-12-17 10:38:49 AM)

Photo: 216
Looking at shoreline just north of T29.
(Latitude: 49°37'14.90'', Longitude: -124°3'41.55'', Date Taken: October-12-17 10:43:21 AM)

Photo: 217
Facing southwest.towards backshore of T29.
(Latitude: 49°37'16.45'', Longitude: -124°3'42.15'', Date Taken: October-12-17 10:44:34 AM)

Photo: 218
Backshore of T1. Arbutus and coniferous trees.
(Latitude: 49°38'15.97'', Longitude: -124°4'15.99'', Date Taken: October-12-17 10:52:42 AM)

Photo: 219
Shoreline east of T1.
(Latitude: 49°38'17.31'', Longitude: -124°4'11.36'', Date Taken: October-12-17 10:54:46 AM)

Photo: 220
Shoreline east of T1. New dock as of 2014 orthophotographs. Blue heron was observed on dock railing.
(Latitude: 49°38'18.93'', Longitude: -124°4'3.68'', Date Taken: October-12-17 10:56:14 AM)

Photo: 221
Shoreline east of T1 in Lee Bay.
(Latitude: 49°38'18.36'', Longitude: -124°3'51.48'', Date Taken: October-12-17 10:58:51 AM)

Photo: 222
Dock on Fisher Island, in Lee Bay.
(Latitude: 49°38'5.87'', Longitude: -124°3'41.39'', Date Taken: October-12-17 11:03:50 AM)

Photo: 223
Across from Fisher Island, along east shore of Lee Bay.
(Latitude: 49°38'3.06'', Longitude: -124°3'40.77'', Date Taken: October-12-17 11:04:47 AM)

Photo: 224
Across from Fisher Island, along east shore of Lee Bay.
(Latitude: 49°38'2.37'', Longitude: -124°3'40.81'', Date Taken: October-12-17 11:05:01 AM)

Photo: 225
Backshore of T3.
(Latitude: 49°37'52.65'', Longitude: -124°3'33.74'', Date Taken: October-12-17 11:08:45 AM)

Photo: 226
Looking northwest from T3.
(Latitude: 49°37'52.27'', Longitude: -124°3'33.07'', Date Taken: October-12-17 11:09:25 AM)

Photo: 227
Looking east into Pender Harbour from T3.
(Latitude: 49°37'51.93'', Longitude: -124°3'32.11'', Date Taken: October-12-17 11:10:00 AM)

Photo: 228
Irvines Landing in Joe Bay.
(Latitude: 49°37'53.57'', Longitude: -124°3'24.04'', Date Taken: October-12-17 11:12:10 AM)

Photo: 229
Backshore of T4, Irvines Landing in Joe Bay.
(Latitude: 49°37'54.66'', Longitude: -124°3'22.02'', Date Taken: October-12-17 11:12:55 AM)

Photo: 230
Boat ramp at Irvines Landing in Joe Bay.
(Latitude: 49°37'55.77'', Longitude: -124°3'22.86'', Date Taken: October-12-17 11:13:48 AM)

Photo: 231
Lots for sale in Joe Bay. New dock as of 2014 orthophotographs.
(Latitude: 49°37'54.97'', Longitude: -124°3'19.71'', Date Taken: October-12-17 11:14:35 AM)

Photo: 232
Lots for sale in Joe Bay.
(Latitude: 49°37'54.09'', Longitude: -124°3'17.64'', Date Taken: October-12-17 11:15:10 AM)

Photo: 233
Development plan sign in Bill Bay.
(Latitude: 49°37'54.69'', Longitude: -124°3'13.36'', Date Taken: October-12-17 11:17:12 AM)

Photo: 234
Backshore of T18. Mature forest. Lots for sale along all of Bill Bay.
(Latitude: 49°37'54.29'', Longitude: -124°3'10.73'', Date Taken: October-12-17 11:18:18 AM)

Photo: 235
Backshore of T5. Mature forest. Lots for sale along Bill Bay.
(Latitude: 49°37'54.88'', Longitude: -124°3'7.76'', Date Taken: October-12-17 11:19:29 AM)

Photo: 236
Backshore of T6 along west shore of Dingman Bay. Lots for sale.
(Latitude: 49°37'54.50'', Longitude: -124°3'0.79'', Date Taken: October-12-17 11:21:20 AM)

Photo: 237
East shore of Dingman Bay. Three harbour seals outside the bay.
(Latitude: 49°37'55.18'', Longitude: -124°2'56.42'', Date Taken: October-12-17 11:22:10 AM)

Photo: 238
East shore of Dingman Bay.
(Latitude: 49°37'53.57'', Longitude: -124°2'51.00'', Date Taken: October-12-17 11:23:21 AM)

Photo: 239
Farrington Cove.
(Latitude: 49°37'53.58'', Longitude: -124°2'47.98'', Date Taken: October-12-17 11:24:08 AM)

Photo: 240
Farrington Cove.
(Latitude: 49°37'53.42'', Longitude: -124°2'43.83'', Date Taken: October-12-17 11:25:10 AM)

Photo: 241
West shore of Duncan Cove. Coniferous trees and arbutus trees.
(Latitude: 49°37'55.62'', Longitude: -124°2'37.33'', Date Taken: October-12-17 11:26:52 AM)

Photo: 242
Duncan Cove.
(Latitude: 49°38'1.67'', Longitude: -124°2'38.60'', Date Taken: October-12-17 11:29:49 AM)

Photo: 243
Duncan Cove.
(Latitude: 49°38'0.72'', Longitude: -124°2'38.10'', Date Taken: October-12-17 11:30:14 AM)

Photo: 244
Duncan Cove.
(Latitude: 49°37'59.33'', Longitude: -124°2'31.76'', Date Taken: October-12-17 11:32:24 AM)

Photo: 245
Shoreline between Duncan Cove and Hospital Bay.
(Latitude: 49°37'57.34'', Longitude: -124°2'25.36'', Date Taken: October-12-17 11:34:17 AM)

Photo: 246
Entering Hospital Bay from the west.
(Latitude: 49°37'56.39'', Longitude: -124°2'17.88'', Date Taken: October-12-17 11:36:14 AM)

Photo: 247
West end of Hospital Bay.
(Latitude: 49°37'59.66'', Longitude: -124°2'16.67'', Date Taken: October-12-17 11:37:42 AM)

Photo: 248
West end of Hospital Bay.
(Latitude: 49°38'2.12'', Longitude: -124°2'17.88'', Date Taken: October-12-17 11:38:40 AM)

Photo: 249
West end of Hospital Bay.
(Latitude: 49°38'3.46'', Longitude: -124°2'16.46'', Date Taken: October-12-17 11:39:18 AM)

Photo: 250
Northwest end of Hospital Bay.
(Latitude: 49°38'4.39'', Longitude: -124°2'18.43'', Date Taken: October-12-17 11:40:11 AM)

Photo: 251
Northwest end of Hospital Bay.
(Latitude: 49°38'3.92'', Longitude: -124°2'12.56'', Date Taken: October-12-17 11:44:58 AM)

Photo: 252
North shore of Hospital Bay.
(Latitude: 49°38'0.58'', Longitude: -124°2'9.16'', Date Taken: October-12-17 11:45:38 AM)

Photo: 253
North shore of Hospital Bay.
(Latitude: 49°37'57.71'', Longitude: -124°2'5.62'', Date Taken: October-12-17 11:46:18 AM)

Photo: 254
Small boat ramp near T24.
(Latitude: 49°37'20.24'', Longitude: -124°2'16.83'', Date Taken: October-12-17 12:55:15 PM)

Photo: 255
East shore of Dusenbury Island.
(Latitude: 49°37'20.29'', Longitude: -124°2'16.96'', Date Taken: October-12-17 12:56:19 PM)

Photo: 256
Backshore near T24.
(Latitude: 49°37'18.00'', Longitude: -124°2'16.39'', Date Taken: October-12-17 12:57:57 PM)

Photo: 257
Sunken tug boat at south end of Dusenbury Island.
(Latitude: 49°37'15.25'', Longitude: -124°2'22.02'', Date Taken: October-12-17 12:59:34 PM)

Photo: 258
Backshore east of T28.
(Latitude: 49°37'37.26'', Longitude: -124°2'27.83'', Date Taken: October-12-17 1:07:01 PM)

Photo: 259
Backshore of T28. Pender Harbour Fishing Company.
(Latitude: 49°37'37.35'', Longitude: -124°2'29.08'', Date Taken: October-12-17 1:08:19 PM)

Photo: 260
Pender Harbour Fishing Company. North shore of Francis Peninsula.
(Latitude: 49°37'37.45'', Longitude: -124°2'33.14'', Date Taken: October-12-17 1:09:23 PM)

Photo: 261
North shore of Francis Peninsula.
(Latitude: 49°37'37.69'', Longitude: -124°2'42.96'', Date Taken: October-12-17 1:11:25 PM)

Photo: 262
North shore of Francis Peninsula. Human-altered foreshore.
(Latitude: 49°37'38.23'', Longitude: -124°2'47.12'', Date Taken: October-12-17 1:12:17 PM)

Photo: 263
Dock and private boat ramp. North shore of Francis Peninsula.
(Latitude: 49°37'37.56'', Longitude: -124°2'54.49'', Date Taken: October-12-17 1:15:39 PM)

Photo: 264
North shore of Francis Peninsula.
(Latitude: 49°37'36.81'', Longitude: -124°2'59.66'', Date Taken: October-12-17 1:17:02 PM)

Photo: 265
North shore of Francis Peninsula.
(Latitude: 49°37'36.40'', Longitude: -124°3'2.39'', Date Taken: October-12-17 1:17:45 PM)

Photo: 266
Makeshift boat ramp. Dock with metal grating. North side of Francis Peninsula.
(Latitude: 49°37'36.21'', Longitude: -124°3'4.05'', Date Taken: October-12-17 1:18:20 PM)

Photo: 267
North shore of Francis Peninsula.
(Latitude: 49°37'35.75'', Longitude: -124°3'9.31'', Date Taken: October-12-17 1:19:44 PM)

Photo: 268
North shore of Francis Peninsula.
(Latitude: 49°37'34.92'', Longitude: -124°3'13.07'', Date Taken: October-12-17 1:20:57 PM)

Photo: 269
North shore of Francis Peninsula.
(Latitude: 49°37'33.67'', Longitude: -124°3'17.58'', Date Taken: October-12-17 1:22:18 PM)

Photo: 270
North shore of Francis Peninsula.
(Latitude: 49°37'33.18'', Longitude: -124°3'18.89'', Date Taken: October-12-17 1:22:45 PM)

Photo: 271
North shore of Francis Peninsula.
(Latitude: 49°37'32.80'', Longitude: -124°3'19.98'', Date Taken: October-12-17 1:23:05 PM)

Photo: 272
North shore of Francis Peninsula.
(Latitude: 49°37'32.27'', Longitude: -124°3'21.75'', Date Taken: October-12-17 1:23:35 PM)

Photo: 273
North shore of Francis Peninsula.
(Latitude: 49°37'31.95'', Longitude: -124°3'22.52'', Date Taken: October-12-17 1:23:51 PM)

Photo: 274
North shore of Francis Peninsula.
(Latitude: 49°37'31.48'', Longitude: -124°3'23.64'', Date Taken: October-12-17 1:24:14 PM)

Photo: 275
South shore of Charles Island, off north shore of Francis Peninsula.
(Latitude: 49°37'29.89'', Longitude: -124°3'31.52'', Date Taken: October-12-17 1:26:36 PM)

Photo: 276
North shore of Francis Peninsula.
(Latitude: 49°37'29.16'', Longitude: -124°3'32.79'', Date Taken: October-12-17 1:27:00 PM)

Photo: 277
North shore of Francis Peninsula.
(Latitude: 49°37'28.15'', Longitude: -124°3'35.44'', Date Taken: October-12-17 1:27:47 PM)

Photo: 278
New dock. Northwest shore of Francis Peninsula.
(Latitude: 49°37'26.51'', Longitude: -124°3'39.89'', Date Taken: October-12-17 1:29:15 PM)

Photo: 279
Northwest shore of Francis Peninsula.
(Latitude: 49°37'25.08'', Longitude: -124°3'42.36'', Date Taken: October-12-17 1:30:06 PM)

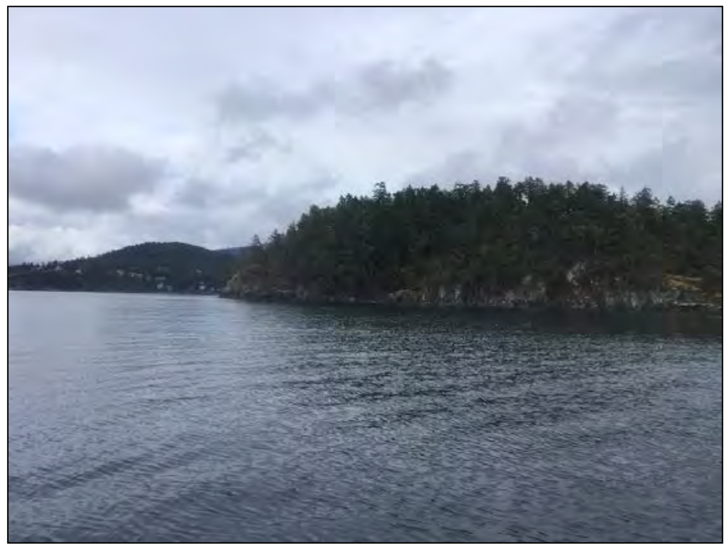


Photo: 280
Martin Island off north shore of Francis Peninsula.
(Latitude: 49°37'25.04'', Longitude: -124°3'43.99'', Date Taken: October-12-17 1:31:17 PM)

Photo: 281
Skardon Islands.
(Latitude: 49°37'51.57'', Longitude: -124°3'12.76'', Date Taken: October-12-17 1:54:18 PM)

Photo: 282
John Henry's fuel dock.
(Latitude: 49°37'52.60'', Longitude: -124°1'59.08'', Date Taken: October-12-17 3:29:19 PM)

Photo: 283
Bridge between Hospital Bay and the pool behind John Henry's Resort.
(Latitude: 49°37'54.67'', Longitude: -124°1'50.35'', Date Taken: October-12-17 3:33:58 PM)

Photo: 284
Facing towards Hospital Bay from bridge. Substrate composed of cobble, boulders, gravel. Live oysters and oyster shells along margin of channel. Perch observed in channel. Barnacles (Balance glandula) over rocks and patchy Fucus sp.
(Latitude: 49°37'54.98'', Longitude: -124°1'49.57'', Date Taken: October-12-17 3:35:58 PM)

Photo: 285
Facing from bridge northeast to the pool behind John Henry's Resort. Barnacles (Balance glandula) and oysters on the rocks adjacent to the bridge. Patchy Fucus sp. Unvegetated gravel in the pool.
(Latitude: 49°37'54.68'', Longitude: -124°1'49.17'', Date Taken: October-12-17 3:39:43 PM)

Photo: 286
Filamentous green algae covering rocks in southeast corner of pool behind John Henry's Resort. Patchy Fucus sp. Barnacles (Balanus glandula) on rocks larger than cobble.
(Latitude: 49°37'52.47'', Longitude: -124°1'48.00'', Date Taken: October-12-17 3:48:39 PM)

Photo: 287
Three hooded mergansers observed feeding in pool behind John Henry's Resort.
(Latitude: 49°37'53.31'', Longitude: -124°1'44.36'', Date Taken: October-12-17 3:52:44 PM)

Photo: 288
Old boats along west shore of Gerrans Bay.
(Latitude: 49°37'18.06'', Longitude: -124°2'29.50'', Date Taken: October-16-17 8:49:01 AM)

Photo: 289
Dock falling apart in southwest Gerrans Bay.
(Latitude: 49°37'0.95'', Longitude: -124°2'35.73'', Date Taken: October-16-17 9:01:57 AM)

Photo: 290
Exposed high intertidal in southeast Gerrans Bay. Oysters and a few ochre stars visible.
(Latitude: 49°37'5.73'', Longitude: -124°1'53.16'', Date Taken: October-16-17 11:01:00 AM)

Photo: 291
Southeast end of Gerrans Bay where a channel leads to a lagoon. Fucus exposed at low tide. Blue heron in photo. Surveying for eelgrass, divers reported the substrate was mud/sand covered with thick filamentous green algae, and abundant worms. Only sparse eelgrass shoots observed.
(Latitude: 49°37'5.71'', Longitude: -124°1'50.50'', Date Taken: October-16-17 11:04:32 AM)

Photo: 292
Blue mussels exposed in southeast Gerrans Bay with low tide. Just east of Coho Marina Resort.
(Latitude: 49°37'11.13'', Longitude: -124°1'54.59'', Date Taken: October-16-17 11:19:06 AM)

Photo: 293
A few eelgrass shoots observed to the west of Coho Marina Resort.
(Latitude: 49°37'14.50'', Longitude: -124°2'1.46'', Date Taken: October-16-17 11:24:33 AM)

Photo: 294
Eelgrass bed delineation around T5.
(Latitude: 49°37'56.38'', Longitude: -124°3'10.83'', Date Taken: October-16-17 11:43:56 AM)

Photo: 295
Dock beside T5.
(Latitude: 49°37'56.23'', Longitude: -124°3'11.00'', Date Taken: October-16-17 11:45:50 AM)

9.0 APPENDIX 4: BACKSHORE OF THE TRANSECTS SURVEYED IN PENDER HARBOUR

Backshore of the Transects Surveyed in Pender Harbour

Project: Pender Harbour Habitat Survey

Photo: 1
Backshore of T1.
(Latitude: 49°38'18.35'', Longitude: -124°4'16.78'')

Photo: 2
Backshore of T1.
(Latitude: 49°38'19.02'', Longitude: -124°4'17.65'')

Photo: 3
Backshore of T1.
(Latitude: 49°38'17.93'', Longitude: -124°4'16.85'')

Photo: 4
Backshore of T2.
(Latitude: 49°38'17.38'', Longitude: -124°3'47.00'')

Photo: 5
Backshore of T3.
(Latitude: 49°37'53.08'', Longitude: -124°3'31.99'')

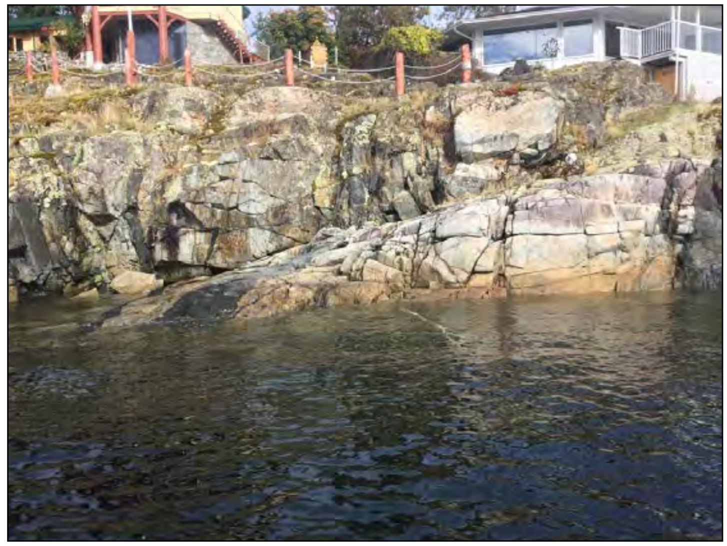


Photo: 6
Backshore of T3.
(Latitude: 49°37'52.64'', Longitude: -124°3'32.57'')

Photo: 7
Backshore of T4.
(Latitude: 49°37'57.21'', Longitude: -124°3'24.43'')

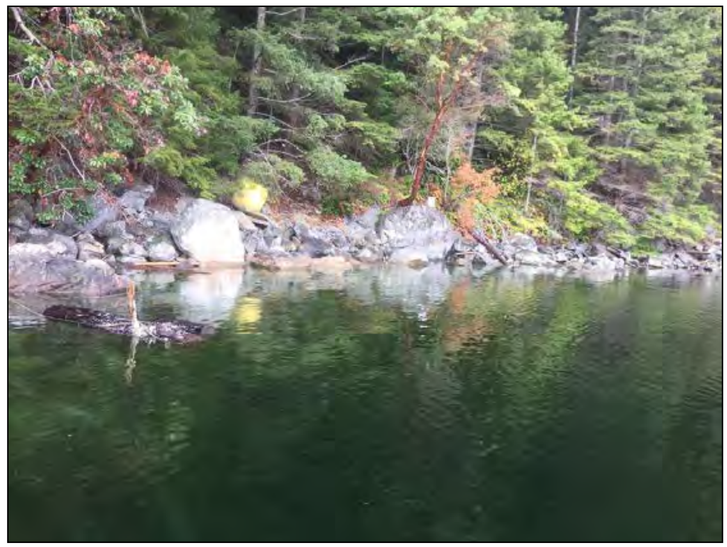


Photo: 8
Backshore of T5.
(Latitude: 49°37'56.79'', Longitude: -124°3'10.82'')

Photo: 9
Backshore of T5.
(Latitude: 49°37'56.02'', Longitude: -124°3'9.89'')

Photo: 10
Backshore of T5.
(Latitude: 49°37'56.99'', Longitude: -124°3'10.87'')

Photo: 11
Backshore of T5.
(Latitude: 49°37'57.24'', Longitude: -124°3'10.92'')

Photo: 12
Backshore of T6.
(Latitude: 49°37'56.70'', Longitude: -124°2'59.32'')

Photo: 13
Backshore of T7.
(Latitude: 49°37'58.39'', Longitude: -124°2'37.47'')

Photo: 14
Backshore of T8.
(Latitude: 49°37'58.06'', Longitude: -124°2'17.07'')

Photo: 15
Backshore of T9.
(Latitude: 49°37'54.51'', Longitude: -124°1'51.82'')

Photo: 16
Backshore of T9.
(Latitude: 49°37'54.28'', Longitude: -124°1'52.39'')

Photo: 17
Backshore of T10.
(Latitude: 49°37'48.03'', Longitude: -124°1'13.97'')

Photo: 18
Backshore of T10.
(Latitude: 49°37'48.90'', Longitude: -124°1'13.22'')

Photo: 19
Backshore of T10.
(Latitude: 49°37'48.83'', Longitude: -124°1'13.14'')

Photo: 20
Backshore of T11.
(Latitude: 49°37'44.99'', Longitude: -124°0'45.38'')

Photo: 21
Backshore of T12.
(Latitude: 49°37'46.77'', Longitude: -124°0'34.10'')

Photo: 22
Backshore of T12.
(Latitude: 49°37'46.59'', Longitude: -124°0'34.11'')

Photo: 23
Backshore of T13.
(Latitude: 49°37'43.53'', Longitude: -124°0'8.17'')

Photo: 24
Backshore of T14.
(Latitude: 49°37'58.62'', Longitude: -123°59'58.44'')

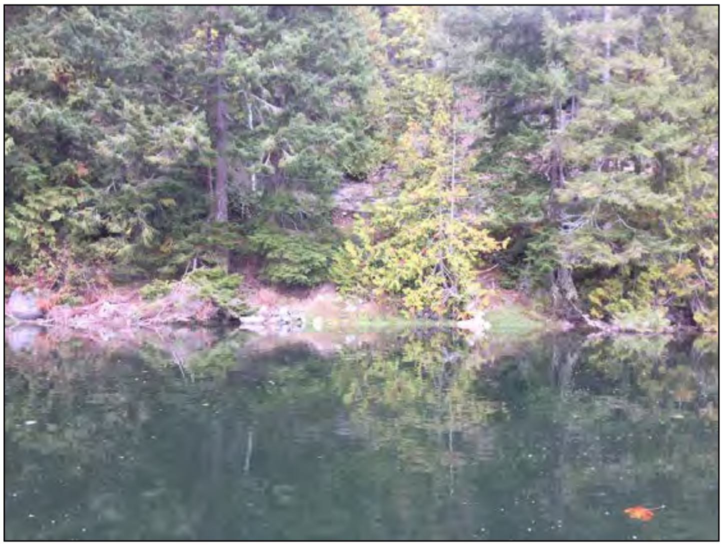


Photo: 25
Backshore of T14.
(Latitude: 49°37'58.58'', Longitude: -123°59'58.50'')

Photo: 26
Backshore of T14.
(Latitude: 49°37'59.05'', Longitude: -123°59'58.93'')

Photo: 27
Backshore of T15.
(Latitude: 49°37'37.74'', Longitude: -123°59'18.10'')

Photo: 28
Backshore of T15.
(Latitude: 49°37'37.72'', Longitude: -123°59'18.15'')

Photo: 29
Backshore of T15.
(Latitude: 49°37'37.80'', Longitude: -123°59'18.10'')

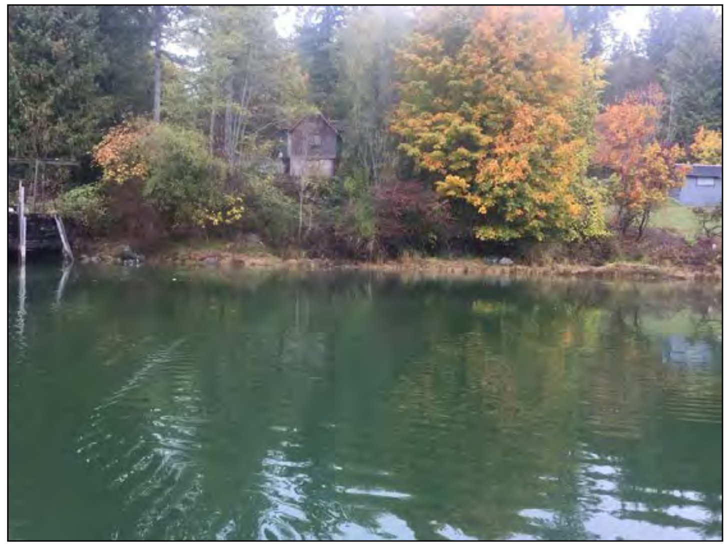


Photo: 30
Backshore of T15.
(Latitude: 49°37'37.00'', Longitude: -123°59'19.57'')

Photo: 31
Backshore of T16.
(Latitude: 49°37'34.74'', Longitude: -123°59'54.17'')

Photo: 32
Backshore of T16.
(Latitude: 49°37'35.16'', Longitude: -123°59'53.85'')

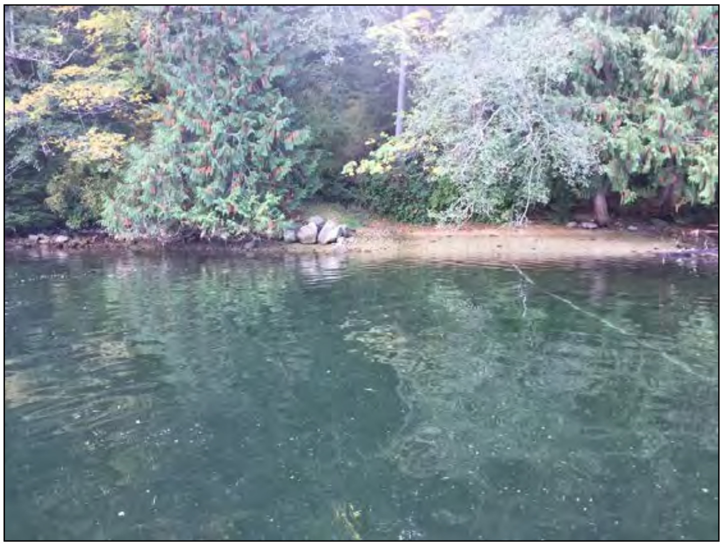


Photo: 33
Backshore of T16.
(Latitude: 49°37'35.25'', Longitude: -123°59'54.10'')

Photo: 34
Backshore of T17.
(Latitude: 49°37'34.84'', Longitude: -124°0'15.00'')

Photo: 35
Backshore of T17.
(Latitude: 49°37'34.88'', Longitude: -124°0'14.94'')

Photo: 36
Backshore of T17.
(Latitude: 49°37'34.75'', Longitude: -124°0'14.88'')

Photo: 37
Backshore of T17.
(Latitude: 49°37'35.33'', Longitude: -124°0'14.14'')

Photo: 38
Backshore of T18.
(Latitude: 49°37'20.96'', Longitude: -124°1'33.36'')

Photo: 39
Backshore of T18.
(Latitude: 49°37'20.94'', Longitude: -124°1'33.37'')

Photo: 40
Backshore of T18.
(Latitude: 49°37'20.94'', Longitude: -124°1'33.41'')

Photo: 41
Backshore of T19.
(Latitude: 49°37'15.92'', Longitude: -124°2'25.35'')

Photo: 42
Backshore of T20.
(Latitude: 49°37'9.35'', Longitude: -124°2'5.16'')

Photo: 43
Backshore of T20
(Latitude: 49°37'9.94'', Longitude: -124°2'5.77'')

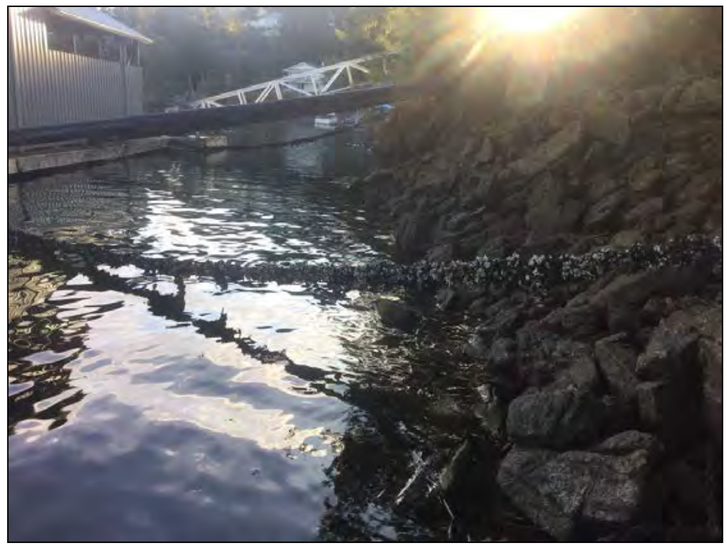


Photo: 44
Backshore of T21.
(Latitude: 49°37'7.44'', Longitude: -124°2'17.65'')

Photo: 45
Backshore of T21.
(Latitude: 49°37'8.59'', Longitude: -124°2'17.50'')

Photo: 46
Backshore of T21.
(Latitude: 49°37'7.41'', Longitude: -124°2'17.71'')

Photo: 47
Backshore of T22.
(Latitude: 49°36'56.30'', Longitude: -124°2'54.47'')

Photo: 48
Backshore of T22.
(Latitude: 49°36'56.31'', Longitude: -124°2'54.44'')

Photo: 49
Backshore of T22.
(Latitude: 49°36'56.33'', Longitude: -124°2'54.47'')

Photo: 50
Backshore of T22.
(Latitude: 49°36'56.26'', Longitude: -124°2'54.44'')

Photo: 51
Backshore of T23.
(Latitude: 49°37'13.77'', Longitude: -124°2'37.99'')

Photo: 52
Backshore of T23.
(Latitude: 49°37'13.81'', Longitude: -124°2'38.00'')

Photo: 53
Divers surveying T23.
(Latitude: 49°37'13.68'', Longitude: -124°2'38.14'')

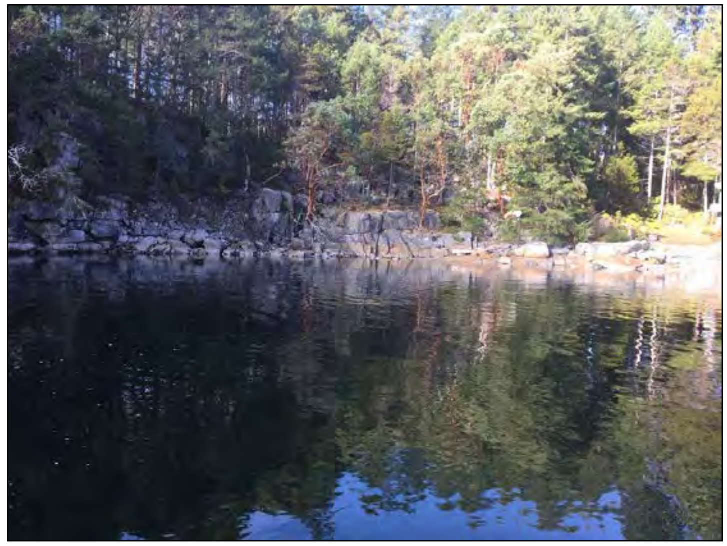


Photo: 54
Backshore of T24.
(Latitude: 49°37'19.26'', Longitude: -124°2'15.91'')

Photo: 55
Backshore of T24.
(Latitude: 49°37'19.25'', Longitude: -124°2'15.86'')

Photo: 56
Backshore of T24.
(Latitude: 49°37'20.16'', Longitude: -124°2'17.61'')

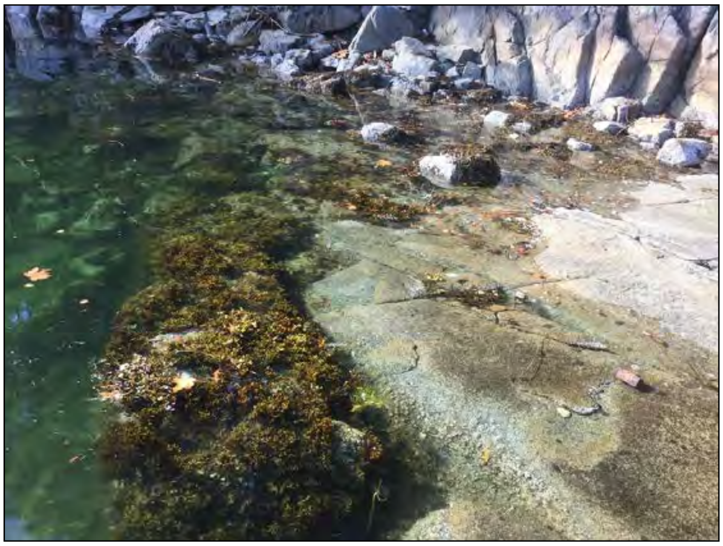


Photo: 57
Backshore of T24.
(Latitude: 49°37'20.18'', Longitude: -124°2'17.80'')

Photo: 58
Backshore of T24.
(Latitude: 49°37'20.07'', Longitude: -124°2'17.78'')

Photo: 59
Backshore of T25.
(Latitude: 49°37'28.18'', Longitude: -124°2'20.29'')

Photo: 60
Backshore of T26.
(Latitude: 49°37'32.33'', Longitude: -124°2'11.84'')

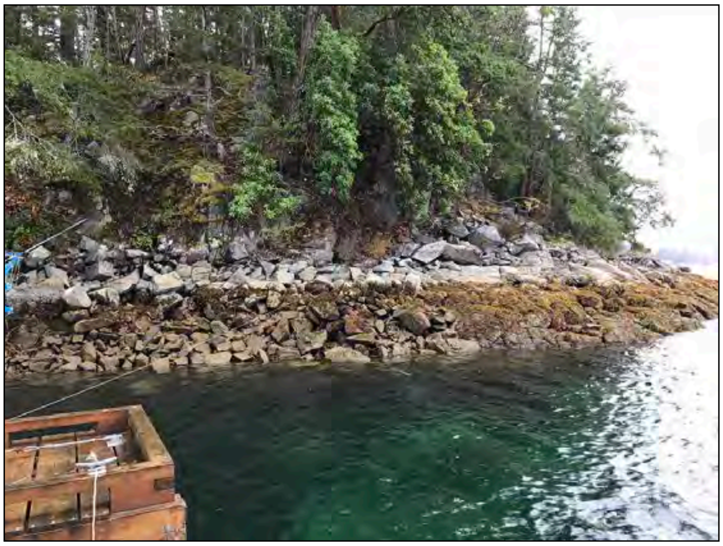


Photo: 61
Backshore of T27.
(Latitude: 49°37'36.58'', Longitude: -124°2'6.43'')

Photo: 62
Backshore of T28.
(Latitude: 49°37'36.62'', Longitude: -124°2'32.43'')

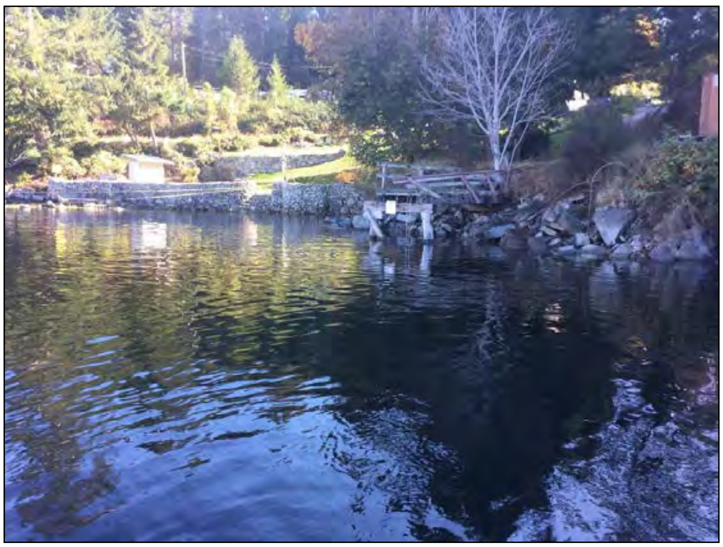


Photo: 63
Backshore of T28.
(Latitude: 49°37'36.50'', Longitude: -124°2'32.28'')

Photo: 64
Backshore of T28. Pender Harbour Fishing Company.
(Latitude: 49°37'36.56'', Longitude: -124°2'32.37'')

Photo: 65
Backshore of T29.
(Latitude: 49°37'14.89'', Longitude: -124°3'44.36'')

Photo: 66
Backshore of T29.
(Latitude: 49°37'14.11'', Longitude: -124°3'43.23'')

Photo: 67
Backshore of T29.
(Latitude: 49°37'14.09'', Longitude: -124°3'43.17'')

Photo: 68
Backshore of T29.
(Latitude: 49°37'14.66'', Longitude: -124°3'43.57'')

Photo: 69
Backshore of T29.
(Latitude: 49°37'14.09'', Longitude: -124°3'43.15'')

Photo: 70
Backshore of T30.
(Latitude: 49°36'40.56'', Longitude: -124°3'27.04'')

Photo: 71
Backshore of T30.
(Latitude: 49°36'40.56'', Longitude: -124°3'27.04'')

Photo: 72
Backshore of T30.
(Latitude: 49°36'40.15'', Longitude: -124°3'28.47'')

Photo: 73
Backshore of T30.
(Latitude: 49°36'40.56'', Longitude: -124°3'27.04'')

Photo: 74
Backshore of T31.
(Latitude: 49°36'22.56'', Longitude: -124°2'59.54'')

Photo: 75
Backshore of T32.
(Latitude: 49°37'0.36'', Longitude: -124°2'3.51'')

Photo: 76
Backshore of T33.
(Latitude: 49°36'46.84'', Longitude: -124°2'16.37'')

Photo: 77
Backshore of T34.
(Latitude: 49°36'34.48'', Longitude: -124°2'6.89'')

Photo: 78
Backshore of T35.
(Latitude: 49°36'21.12'', Longitude: -124°1'51.48'')

Photo: 79
Backshore of T36.
(Latitude: 49°18'6.75'', Longitude: -124°2'19.42'')

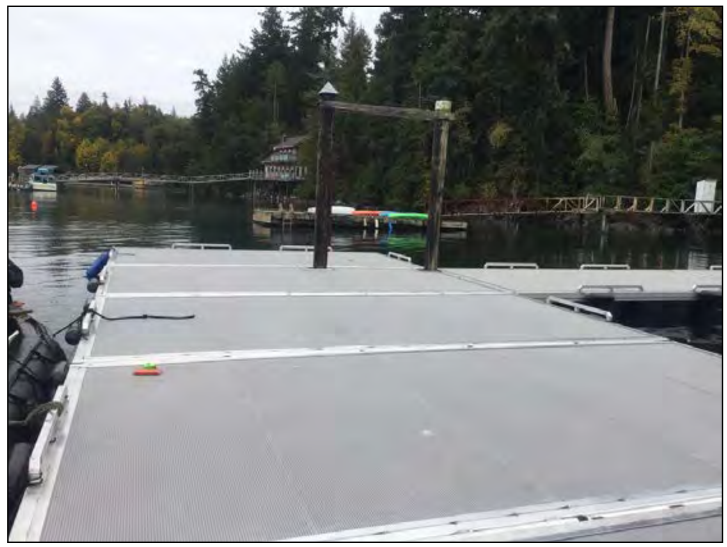


Photo: 80
Location of eelgrass transect EG3. Eelgrass growing around but not under dock. This newer dock has concrete decking with holes, and has replaced the old dock shown in 2014 orthophotographs. New dock has a larger footprint than old dock.
(Latitude: 49°36'48.50'', Longitude: -124°2'28.68'')

Photo: 81
Location of eelgrass transect EG1.
(Latitude: 49°37'1.01'', Longitude: -124°2'14.66'')

Photo: 82
Eelgrass delineation in southwest end of Gerrans Bay.
(Latitude: 49°36'59.93'', Longitude: -124°2'46.03'')

Photo: 83
Location of eelgrass transect EG6.
(Latitude: 49°36'36.19'', Longitude: -124°2'20.29'')

Photo: 84
Location of eelgrass transect EG2. Eelgrass growing around the dock and under end of dock. This newer dock appears to have a longer footprint than the old dock shown in 2014 orthophotographs.
(Latitude: 49°36'50.42'', Longitude: -124°2'25.24'')

Photo: 85
Eelgrass growing around but not under dock. Concrete deck.
Location of eelgrass transect EG4.
(Latitude: 49°36'39.88'', Longitude: -124°2'27.17'')

Photo: 86
Location of eelgrass transect EG5.
(Latitude: 49°36'36.71'', Longitude: -124°2'20.86'')

10.0 APPENDIX 5: PHOTOS OF HUMAN-ALTERED FORESHORE IN PENDER HARBOUR

Photos of Human-Altered Foreshore in Pender Harbour

Project: Pender Harbour Habitat Survey

Photo: 1
South shore of Gunboat Bay. Human-altered foreshore.
(Date Taken: October-11-17 11:34:01 AM, Latitude: 49°37'36.72'', Longitude: -124°0'22.39'')

Photo: 2
South shore of Gunboat Bay. Human-altered foreshore.
(Date Taken: October-11-17 11:38:16 AM, Latitude: 49°37'33.66'', Longitude: -124°0'33.97'')

Photo: 3
South shore of Gunboat Bay. Docks and human-altered shoreline.
(Date Taken: October-11-17 11:41:02 AM, Latitude: 49°37'36.89'', Longitude: -124°0'35.75'')

Photo: 4
South shore of Gunboat Bay. Docks and human-altered foreshore.
(Date Taken: October-11-17 11:41:35 AM, Latitude: 49°37'37.46'', Longitude: -124°0'37.66'')

Photo: 5
Garden Peninsula shoreline between Hospital Bay and Garden Bay. Human-altered foreshore.
(Date Taken: October-11-17 12:27:20 PM, Latitude: 49°37'38.32'', Longitude: -124°1'46.43'')

Photo: 6
Garden Peninsula shoreline between Hospital Bay and Garden Bay. Human-altered foreshore.
(Date Taken: October-11-17 12:30:14 PM, Latitude: 49°37'40.65'', Longitude: -124°1'37.79'')

Photo: 7
Garden Peninsula shoreline between Hospital Bay and Garden Bay. Human-altered foreshore.
(Date Taken: October-11-17 12:31:56 PM, Latitude: 49°37'41.76'', Longitude: -124°1'30.88'')

Photo: 8
Welbourn Cove. Human-altered shoreline.
(Date Taken: October-11-17 1:23:39 PM, Latitude: 49°37'23.10'', Longitude: -124°1'40.74'')

Photo: 9
Northwest end of Hospital Bay. Human-altered foreshore.
(Date Taken: October-12-17 11:42:37 AM, Latitude: 49°38'5.43'', Longitude: -124°2'16.90'')

Photo: 10
Backshore east of T28. Human-altered foreshore.
(Date Taken: October-12-17 1:07:50 PM, Latitude: 49°37'37.32'', Longitude: -124°2'28.80'')

Photo: 11
North shore of Francis Peninsula. Human-altered foreshore.
(Date Taken: October-12-17 1:10:40 PM, Latitude: 49°37'37.59'', Longitude: -124°2'39.19'')

Photo: 12
West shore of Gerrans Bay. Human-altered foreshore.
(Date Taken: October-16-17 8:56:40 AM, Latitude: 49°37'12.01'', Longitude: -124°2'37.42'')

11.0 APPENDIX 6: EXAMPLES OF ANTHROPOGENIC IMPACTS ON THE MARINE ENVIRONMENT IN PENDER HARBOUR

Examples of Anthropogenic Impacts on the Marine Environment in Pender Harbour

Project: Pender Harbour Habitat Survey

Photo: 1
Garden Peninsula shoreline between Hospital Bay and Garden Bay. Tires strung together in intertidal zone.
(Date Taken: October-11-17 12:28:46 PM, Latitude: 49°37'38.73'', Longitude: -124°1'41.23'')

Photo: 2
Sunken boats along west shore of Gerrans Bay.
(Date Taken: October-11-17 2:16:39 PM, Latitude: 49°37'19.08'', Longitude: -124°2'30.60'')

Photo: 3
Old dock with plastic casing falling off styrofoam floats.
(Date Taken: October-12-17 11:40:45 AM, Latitude: 49°38'4.42'', Longitude: -124°2'17.82'')

Photo: 4
Sunken tug boat at south end of Dusenbury Island.
(Date Taken: October-12-17 12:59:34 PM, Latitude: 49°37'15.25'', Longitude: -124°2'22.02'')

Photo: 5
Boathouses and docks shade subtidal habitats. North shore of Francis Peninsula.
(Date Taken: October-12-17 1:25:00 PM, Latitude: 49°37'30.58'', Longitude: -124°3'25.90'')

Photo: 6
Example of a possible private outfall pipe on Trinity Island in Gerrans Bay.
(Date Taken: October-16-17 8:46:55 AM, Latitude: 49°37'21.03'', Longitude: -124°2'27.07'')