SUBTIDAL SURVEY OF PHYSICAL AND BIOLOGICAL FEATURES OF ESQUIMALT HARBOUR

REPORT
& MAP FOLIO

DRAFT VERSION - November 2000
REVISED AND UPDATED – February 2004

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EXECUTIVE SUMMARY

Esquimalt Harbour encompasses approximately 354 hectares of seabed (50 hectares of intertidal area and 304 hectares of subtidal area) and 21.5 km of shoreline. The entrance to the harbour is bounded by Duntze Head to the east and Fisgard Island to the west. Esquimalt Harbour is relatively shallow, with a maximum depth of 16m at the harbour entrance. Most of the subtidal seabed within the harbour is 5 to 12m deep. Millstream Creek flows into the head of the harbour, draining a watershed of 3,245 hectares. The Millstream Creek delta forms a large intertidal mudflat across the entire head of the harbour northwest of Cole Island. Within Esquimalt Harbour there are several smaller bays and coves (Tovey Bay, Limekiln Cove, Thetis Cove, Lang Cove) and numerous rocky islets (Inskip, Cole, Smart and McCarthy Islands) providing shoreline complexity and diversity.

A subtidal inventory of the physical and biological features of Esquimalt Harbour was conducted during the late spring and summer of 2000. A towed, underwater video system (Seabed Imaging and Mapping System, or SIMS) was used to obtain extensive, geo-positioned imagery of the seabed. Following preliminary classification and mapping of this video imagery, SCUBA and snorkel observations were conducted to ground truth the imagery and obtain more detailed information on the biotic community and specific seabed features. The survey was conducted using a 100m trackline grid, however finer resolution (5-10m spacing) was used where important physical or biological features were anticipated. The video survey encompassed a total of 100 km of vessel tracklines and 36 hours of video imagery. These survey methods are comparable to subtidal surveys conducted in Victoria Harbour, the Gorge and Portage Inlet as well as Esquimalt Lagoon.

The video imagery was reviewed by a geologist and biologist using a standard substrate and biotic classification system which records data for each second of video imagery. Classified features include:

- Substrate type
- Sediment class
- Gravel content
- Shell content
- Organic material (wood and vegetative debris)
- Man-made features
- Total vegetation cover
- Eelgrass
- Kelps
- Filamentous and foliose red algae
- Green algae
- Macrointertebrates (e.g. anemones, tubeworms, sea urchins, crab).

This report provides a map folio of these features for Esquimalt Harbour at 1:12,000 scale. In addition, an interactive CD-ROM of the mapped biophysical themes as well as geo-referenced video imagery from the underwater survey is available as a product of this project.

The most notable subtidal biophysical features of Esquimalt Harbour identified by the video survey are:

A. Physical Features

- A mud/sand or gravelly mud/sand basin
- Gravel (cobble/boulder) areas primarily associated with the shoreline, likely as a result of wave action, rather than tidal current.
- Numerous coves and pocket beaches, particularly in the upper harbour area.
- Tidal current influences around Smart/McCarthy Islands and Paddy Passage.
- A large area of the subtidal seabed is impacted by bark/wood debris from past and present log booming activities.

B. Biological Features:

- Diverse and dense kelp community (*Laminaria* sp. and *Costaria*) at harbour entrance and Inskip Islands.
- Kelp communities dominated by *Laminaria* sp. and *Desmerestia* in less exposed areas of the harbour.
- A small bull kelp *(Nereocystis* sp.) bed at Whale Rock.
- Sparse cover of filamentous red and foliose green algae across harbour entrance.
- Very little eelgrass, some small beds in coves and small bays.
- An abundance of crabs (*Cancer magister* and *C. gracilis*) at the time of the survey.
- Intertidal clam beds, particularly around Cole Island Tovey Bay.

The biophysical features of Esquimalt Harbour are influenced by a number of factors including:

- The southerly exposure of the harbour entrance which permits growth of the more exposed kelp community at the harbour entrance and Inskip Islands.
- The depositional nature of much of the subtidal seabed, particularly in the upper harbour and Constance Cove.
- Historic and ongoing industrial activities, particularly log storage, dredging and infilling.

From a habitat perspective the most notable features of Esquimalt Harbour include:

Valued Areas

Densely Vegetated Kelp Areas

Several of the more exposed rocky nearshore areas within the harbour (Duntze Head, Fisgard Island, the south facing side of Inskip Island, Ashe Head) support a dense and diverse algal community dominated by two species of bladed kelp, *Laminaria saccarina* and *Costaria costata.* Several algal groups (coralline algae, filamentous and foliose red and foliose green algae) form an understory below the larger kelp plants and support a diversity of invertebrates (e.g. sea urchins). Whale Rock is also a valued feature, being the largest subtidal rock outcrop in the harbour and the only area within the harbour which supports canopy kelps (*Nereocystis luetkeana*).

Coves and Small Bays

Tovey Bay, Limekiln Bay, Thetis Cove, Dallas Bank and Lang Cove contain valued habitat features such as intertidal mudflats, rocky islets or outcrops. Most of the small eelgrass beds identified in the harbour occur in these areas. Coves and bays are not a common feature of

Victoria Harbour (Emmett *et al.* 2000), and these areas provide nearshore physical complexity and diversity for both marine and terrestrial species.

Current Dominated Channels
Seabed dominated by tidal current are not as common in Esquimalt Harbour as Victoria Harbour or the Gorge Waterway, however these areas support a variety of suspension feeding invertebrates (bryozoans, sponges, tube worms). The two areas of note in Esquimalt Harbour are Paddy Passage and the channel between Smart and McCarthy Island and these current dominated, coarse sediment areas contributed to the diversity of physical and biological features within the harbour.

Eelgrass Beds
The area of eelgrass in Esquimalt Harbour is small, approximately 0.5 hectares, distributed in 7 or 8 locations. Some of these beds have been impacted by industrial activities in the harbour. All remaining beds within the harbour should be considered valued and sensitive as this habitat provides rearing habitat for a variety of juvenile fish and invertebrates, including chinook, coho and chum salmon, lingcod and Dungeness crab. Biological productivity and species abundance and diversity also tends to be high in this habitat. Eelgrass is also sensitive to foreshore development impacts particularly foreshore fill, dredging and shading.

Degraded Areas
A number of subtidal areas within Esquimalt Harbour have been physically degraded by historic and ongoing industrial activities, primarily log booming and sorting, dredging and foreshore fill. Ship repair and dock use have contributed to accumulations of man-made debris on the harbour seabed, but the major impact from these activities is sediment contamination.

Areas of Bark and Wood Debris
About 16% of the harbour seabed (47.9 hectares) is impacted by a significant amounts of bark and wood debris (>30% cover). The largest areas of organic debris are former and current log booming areas located in Plumper Bay/Thetis Cove and the upper part of the harbour north of Smart Island. Decomposing organic material generates anoxic sediments with impacts to benthic community structure, and possibly mobilizes sediment contaminants.

Dredge Pockets
There are a number of areas in the harbour where dredging has created small pockets 1-2m below the grade of the seabed. There are two dredge pockets in Lang Cove and a third south of the Graving Dock in Constance Cove. Anaerobic bacterial mats (*Beggiotoa* sp.) were also observed in these areas, and sediments are likely anoxic due to the lack to tidal exchange within the pockets.

Accumulations of Man-Made Debris
Much of the man-made debris (bottles, cans, certain garbage items) observed in the harbour is relatively benign with respect to impacts to habitat value but there are accumulations of debris around many of the heavily used docks and past as well as present log boomimg areas.

Potential subtidal habitat restoration initiatives in Esquimalt Harbour include:

- Removal or capping of areas of bark debris.
- Filling dredge pocket areas with clean, appropriately sized fill to meet the surrounding seabed grade.
- Transplanting or encouraging the natural colonization of eelgrass to appropriate sites in the harbour.
- Targeted clean up of documented areas of man-made debris.

ACKNOWLEDGEMENTS

Doug Hartley of Arrawac Marine Services piloted the survey vessel for the SIMS video survey. Dale McCullough of Seaconsult Marine Research Ltd. was responsible for the SIMS field survey. Pam Thuringer of Archipelago Marine Research Ltd. supervised the biological classification and dive survey components of the project. Jason Clarke and Luc Bonneau, also of Archipelago, assisted in the dive survey. Sarah Cook and Xanthe Brown conducted the biological classification of the video imagery. Angela Forrester was responsible for GIS mapping. Sheri Ward conducted the substrate classification and John Harper (Coastal and Ocean Resources Inc.) supervised the interpretation of the substrate data. Brian Emmett (Archipelago Marine Research Ltd.) acted as the project manager and supervised the interpretation of the biological data.

1.0 INTRODUCTION

1.1 BACKGROUND

Esquimalt Harbour has been the principal naval base on Canada's west coast since the 1850's. The harbour has had a history of industrial use including sawmills, log storage, shipbuilding and ship repair. Historic use of harbour since 1850 is well documented by Bright and Reimer (1993). The Dept. of National Defense continues to have major interests and holdings in Esquimalt Harbour. In addition log storage and ship repair are on-going industrial activities. Over the past 15 years, industrial activity has diminished with the closure of ship building/repair facilities in Lang Cove (Yarrows Shipyard) and the plywood mill in Plumper Bay. There has been considerable residential development along the north and east shores of the harbour over the last thirty years but civilian transportation, tourism and retail activities remain less significant in Esquimalt Harbour as compared to Victoria Harbour.

The 1924 Six Harbours Treaty between Canada and the Province of British Columbia confirmed the federal government's jurisdiction of all areas below the high water mark in Esquimalt Harbour (including filled areas) inside a line between Duntze Head and Fisgard Island (Figure 1). The land surrounding the harbour is held by a variety of private, municipal, provincial and federal interests, including large holdings by the Department of National Defence. In 1996, under the National Marine Policy, Esquimalt Harbour was identified as one of a number of Transport Canada's harbours and ports on the Pacific coast to be divested to local interests.

An important component of the divestiture process was the documentation of environmental conditions and features of Esquimalt Harbour, including recognition of valued habitat and areas which have been historically degraded. To support the information requirements for this process Transport Canada contracted Archipelago Marine Research to conduct an inventory of the subtidal physical and biological features of Esquimalt Harbour in 2000. A draft report, dated November 2000, was prepared for Transport Canada. (Archipelago Marine Research Ltd. 2000a). A similar subtidal inventory of Victoria Harbour, also funded by Transport Canada and using comparable methods and similar seasonal timing, was completed in 1999 (Emmett *et al.* 2000). In addition, the Victoria and Esquimalt Harbours Environmental Action Program (VEHEAP), a multi-agency initiative whose objective is to improve and protect the environmental quality of Victoria and Esquimalt Harbours, undertook a subtidal inventory of the Gorge Waterway and Portage Inlet (Archipelago Marine Research Ltd. 2000b) as well as Esquimalt Lagoon (Archipelago Marine Research Ltd. 2000c).

In anticipation of Transport Canada transferring administrative control of Esquimalt Harbour to the federal Dept. of National Defence (DND), Archipelago Marine Research Ltd. was engaged by DND in November 2003 to update and revise the draft 2000 subtidal survey report for Esquimalt Harbour (Archipelago Marine Research Ltd. 2000a), with the objective of ensuring compatible report and mapping formats with the Victoria Harbour, Gorge/Portage Inlet and Esquimalt Lagoon subtidal inventories. This report addresses this objective, however no new surveys or inventory information has been incorporated into this report update.

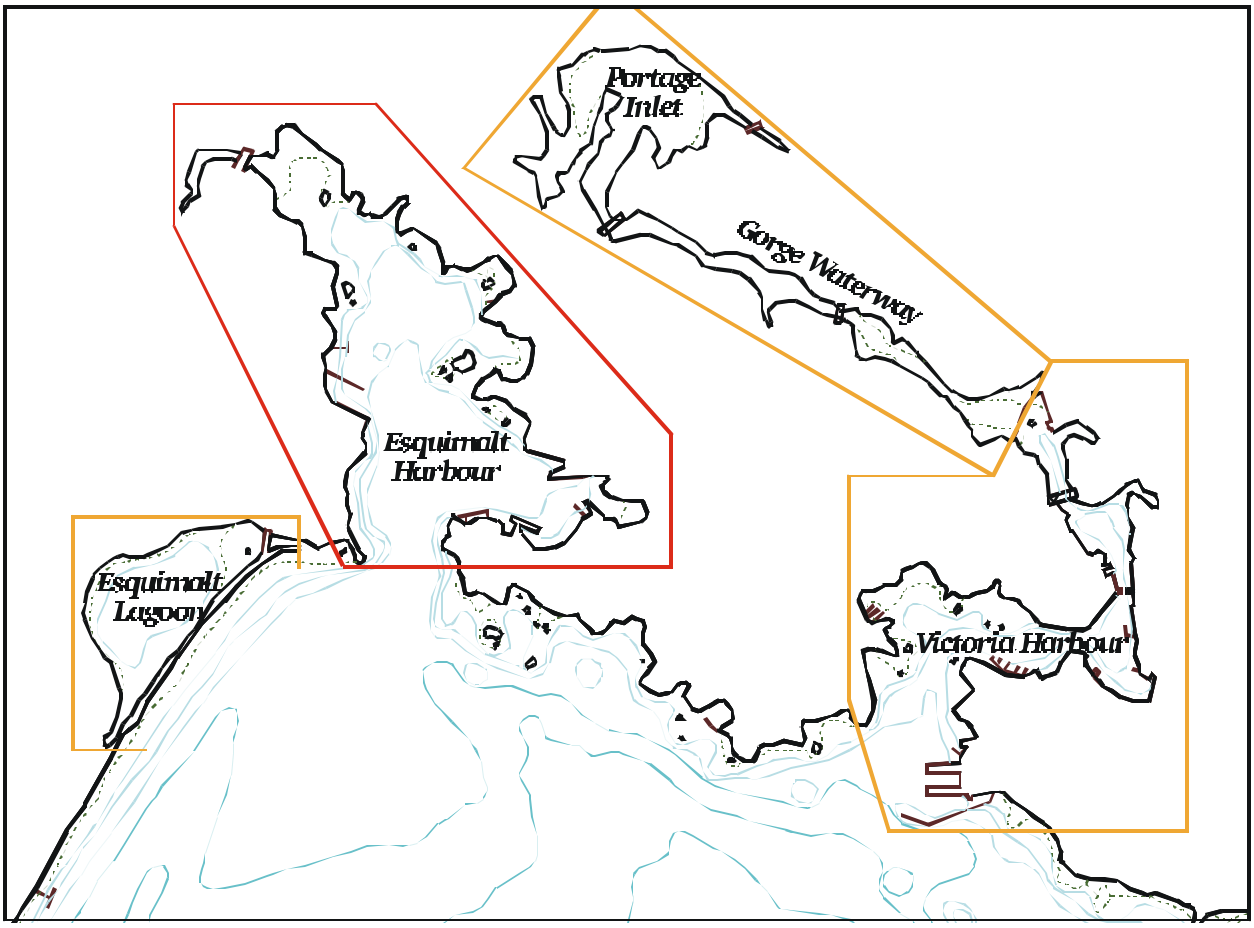

Figure 1. Victoria and Esquimalt Harbours. The Esquimalt Harbour survey area is shown in red. Orange areas (Victoria Harbour, Esquimalt Lagoon, the Gorge and Portage Inlet) have been surveyed in a similar manner (see text for references).

1.2 OBJECTIVES AND PROJECT DELIVERABLES

The subtidal survey of Esquimalt Harbour was designed to address the following objectives:

1. Complete an inventory and mapping of physical and biological features.
2. Identify valued/sensitive habitat such as eelgrass beds, areas of dense or diverse algal vegetation and important invertebrate resources.
3. Describe important subtidal community features.
4. Identify physically degraded habitats including areas of extensive man-made debris, log and bark accumulations or sediment deposition.
5. Produce digital (GIS) maps of these physical and biological features compatible with existing subtidal inventories of Victoria Harbour, Gorge/Portage Inlet and Esquimalt Lagoon.

Project deliverables include:

- An interpretive report with a hardcopy map folio,
- Electronic inventory data including an Access database and associated GIS (ArcView) files,

- An interactive CD-ROM providing mapped biophysical themes and geo-referenced video imagery from the underwater survey,
- Copies of the underwater video imagery in SVHS format.

1.3 SURVEY AREA

Esquimalt Harbour (Figure 2) encompasses approximately 354 hectares of seabed (50 hectares of intertidal area and 304 hectares of subtidal area) and 21.5 km of shoreline. The entrance to the harbour is bounded by Duntze Head to the east and Fisgard Island to the west. Fisgard Island is joined to Rodd Point via a causeway which has altered the longshore transport of sand such that a large tidal flat has developed west of the harbour mouth. Like Victoria Harbour, Esquimalt Harbour is relatively shallow, with a maximum depth of 16m at the harbour entrance. Most of the subtidal seabed within the harbour is 5 to 12m deep. Millstream Creek flows into the head of the harbour, draining a watershed of 3,245 hectares. The Millstream Creek delta forms a large intertidal mudflat across the entire head of the harbour northwest of Cole Island. Within Esquimalt Harbour there are several smaller bays and coves (Tovey Bay, Limekiln Cove, Thetis Cove, Lang Cove) and numerous rocky islets (Inskip, Cole, Smart and McCarthy Islands) which provide shoreline complexity and diversity.

Within Esquimalt Harbour the most extensive shore modifications are in Constance Cove (CFB Esquimalt and the Graving Dock) as well as the east side of the harbour from Yew Point to F-jetty (DND dock facilities), including a causeway built across Dunn's Nook in the 1940's. However, in contrast to Victoria Harbour, there are still extensive lengths of unmodified shore in the upper harbour and at Fort Rodd Hill.

Millstream Creek has several blockages to upstream fish passage and salmon spawning is limited. However, in recent years, there have been local enhancement efforts for coho salmon in Millstream Creek. Herring have historically spawned on the west side of Esquimalt Harbour (Yew Point) and, more recently, near the DND Dockyard (Hay and McCarter 1999). The recreational and commercial harvest of Dungeness crab (*Cancer magister*) is permitted in the harbour, but the area is closed to the harvest of intertidal clams due to faecal coliform contamination.

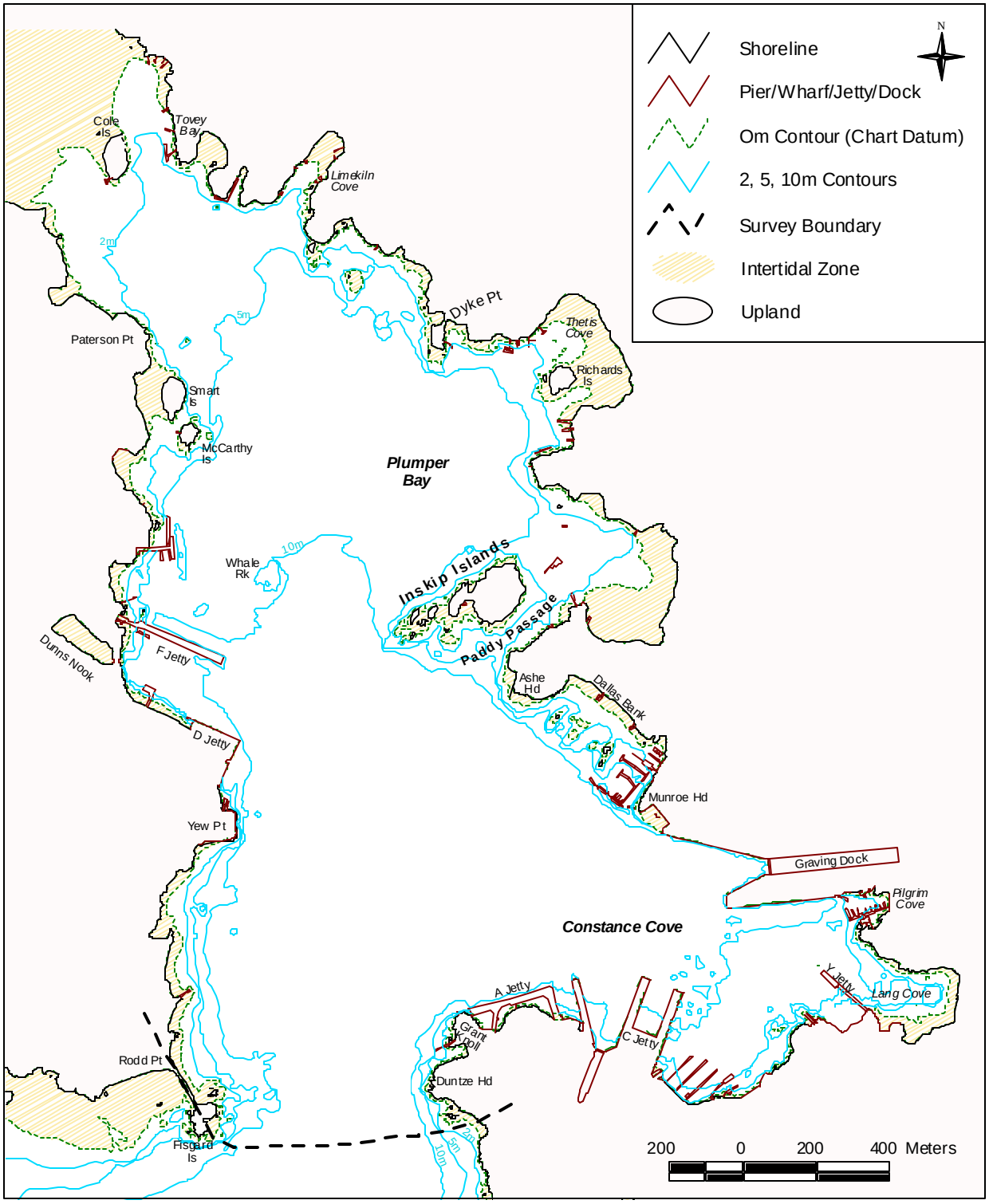

Figure 2. Esquimalt Harbour Survey Area.

2.0 METHODS

The survey plan called for use of a towed, underwater video system (Seabed Imaging and Mapping System, or SIMS) to obtain extensive, geo-positioned imagery of the seabed. Following preliminary classification and mapping of this video imagery, SCUBA and snorkel observations were used to ground truth the imagery and obtain more detailed information on the biotic community of specific seabed features.

2.1 FIELD SURVEY

A towed, underwater video system (Seabed Imaging and Mapping System or SIMS) was used to obtain geo-positioned imagery of the seabed. SIMS involves the use of a GPS positioned, towed video camera that collects imagery of the seabed (see Harper *et al.* 1998a&b; Harper *et al.* 1999). Towing speed is approximately 2 knots or 3.5 km/hr. Each image (defined as one second of video imagery) is geo-referenced to differential global positioning system (DGPS) standards ($\pm$5m) and is mapped using ArcView software. Time (GMT) and depth of the video camera (corrected to chart datum) are recorded for each image.

The SIMS survey of Esquimalt Harbour took place over 7 days, March 21 to 24, March 30 to 31, and May 18, 2000. A 6-metre aluminium boat equipped with a portable winch was used to tow the SIMS camera. Visibility over the seabed ranged from 0.5 to 1.0m and was generally greater on the east side of the harbour.

The video survey encompassed a total of 100 km of vessel tracklines (Figure 3 – Map Folio). In general, the survey used a 100m trackline grid, however finer resolution (5-10m spacing) was used in areas anticipated to contain important physical or biological features (e.g. Inskip Islands). A total of 129,270 image points, defined as one second of video imagery, were collected. This represents 36 hours of video imagery and direct observations of about 100,000m^2 (10.0 ha) of seabed, assuming an average field of view width of 1.0m. Approximately 10 ha of the subtidal seabed was not surveyed, the largest section being the active log booming area northeast of Inskip Islets which was not accessible due to a log boom enclosure. In addition a number of areas immediately adjacent docks and piers were not accessible due to the presence of ships and small boats.

2.2 CLASSIFICATION AND MAPPING

The video imagery was reviewed by a geologist and by a biologist using a substrate and biotic classification system initially developed for the British Columbia Land Use Coordination Office (LUCO) (Harper *et al*. 1998b). Using this system, substrate and biota classes are provided for each image, resulting in a data record for each second of video imagery. The geology database provides for nine seabed substrate data fields including substrate type, sediment class and gravel content (Table 1). Man-made features are also classified as part of the geological inventory. The biological database captures detail on seabed biota within two general categories, vegetation and fauna, and contains a total of 13 data fields (Table 2). Primary, secondary and tertiary vegetation types are classified for each image and also evaluated for percent cover. Each classified faunal type is assigned a distribution code. A data dictionary for the geology and biology classification system is given in Appendix A. The biotic component of the classification system also included

prominent, non-aggregating macroinvertebrates (e.g. crabs, Appendix A) as well as observations of fish.

Of the 129,270 video images, 99,608 (77.0%) were classified for substrate and 114,834 (88.8%) were classified for biota. The remaining imagery could not be classified primarily due to poor visibility. As the position of each image is known, plots of the various substrate and biota classes are generated, providing the basis for characterising habitat. Many of the biophysical features are then mapped as polygons by manually contouring the point data. Certain features (e.g. crab distribution) are represented as point features on the trackline plots. All reported depths are expressed relative to chart datum. The report folio maps (Section 7.0) displays all images classified (primary, secondary and tertiary combined) for each mapped attribute.

The database files are in MDB format (Microsoft Access). Information was then extracted from these databases and exported to an ArcView geographic information system (GIS). The basemap is taken from the vector version of Canadian Hydrographic Service (CHS) chart 3419 and includes the CHS shoreline, depth contours and selected navigational and shoreline features.

Table 1. Geology Data Fields (See Appendix A for further detail)

FIELD	DESCRIPTION
INDEX	Unique point identification number
DATE	Month/day/year
TIME (UTC)	UTC time of frame (hr:min:sec)
SUBSTRATE	the general substrate of the seabed (rock, veneer, clastics, biogenic)
SED_CLASS	11 classes of clastic sediment
BOULDER	% pebbles on the seabed by class
COBBLE	% cobbles on the seabed by class
PEBBLE	% boulders on the seabed by class
GRAVEL	% gravel; sum of pebbles, cobbles and boulders by class
ORGANICS	% of visible wood or organic debris on the seabed by class
SHELL	% of coarse shell on the seabed by class
MORPH	Primary secondary and tertiary morphologic features of the seabed
MAN_MADE	man-made objects seen on the seabed
GEOMAPPER	last name of individual responsible for the mapping interpretation
COMMENT	field for recording non-standard information

Table 2. Biology Data Fields (See Appendix A for further detail)

FIELD	DESCRIPTION
INDEX	unique point identification number
DATE	month/day/year
TIME(UTC)	UTC time of frame (hr:min:sec)
FISH_DEPTH	water depth of towfish/camera corrected to chart datum
VEGMAP	code for vegetation map types
VEG1	primary vegetation assemblage on the seabed
COV1	coverage of the VEG1 vegetation (1,2,3 or 4)
VEG2	secondary vegetation assemblage on the seabed
COV2	coverage of the VEG2 vegetation (1,2,3 or 4)
VEG3	tertiary vegetation assemblage on the seabed
COV3	coverage of the VEG3 vegetation (1,2,3 or 4)
TOT_COV	total coverage of vegetation on the seabed
FAUN1	primary faunal type
DIST1	Distribution of the FAUNA1 type
FAUN2	secondary faunal type
DIST2	Distribution of the FAUNA2 type
FAUN3	tertiary faunal type
DIST3	Distribution of the FAUNA3 type
BIOMAPPER	last name of the biology mapper
COMMENT	field for non-standard data comments

A number of representative images from the towed video survey and subsequent dive survey were captured as digital image files to illustrate seabed types and biota. These image captures are geo-referenced to the biophysical maps on an interactive CD-ROM, which has been produced as a separate project product. In addition selected images are provided in Appendix C of this report. The video images are intended to assist the reader in understanding both the application of the classification system and the mapped harbour features.

2.3 DIVE SURVEYS

After completing the image classification and a preliminary review of the mapped results, SCUBA dive observations were conducted on May 25, 29 and June 27, 28, 2000 at sites selected from a review of the video imagery. The objectives of the dive observations were to:

1. Ground truth the position and extent of highly valued features such as eelgrass beds,
2. Compile more detailed community descriptions for selected subtidal features such as vegetated rocky areas,
3. Collect additional video imagery of the biophysical features and community structure.

Observations were made at 26 dive sites in the survey area (Table 3, Figure 3 – Map Folio). The position (DGPS) of each site was recorded. A summary of the habitat observations for each site (position, depth, substrate, algal species and estimated percent cover, invertebrates and fish species) is given in Appendix B. In addition, spot dives or snorkel observations were made to verify the extent of the eelgrass beds mapped during the SIMS survey. The positions of these observations were also recorded using DGPS.

Table 3. Dive Sites

SITE #	LOCATION	HABITAT FEATURES
1	Duntze Head	Sediment
2	Duntze Head	Kelp
3	Duntze Head	Kelp
4	Grant Knoll	Eelgrass
5	Lang Cove	Eelgrass
6,7	Dallas Bank	Eelgrass
8	Dallas Bank	Kelp
9, 10, 11	Inskip Islands	Kelp/Sediment
12	Upper Paddy Passage	Sediment
13, 14	Upper Paddy Passage	Wood Debris/Piddock Clams
15, 16	Thetis Cove	Wood Debris
17	Thetis Cove	Eelgrass
18	Limekiln Cove	Eelgrass
19, 20	Upper Harbour	Sediment
21	Smart Island	Eelgrass
22, 23	McCarthy Island	Kelp
24	Whale Rock	Kelp
25, 26, 27	Yew Pt. to Fisgard Is.	Kelp

3.0 RESULTS

This section summarizes the physical and biological features obtained from the classification of the video survey imagery, and provides a description of subtidal community features from the SCUBA dive observations. Tabulated summaries of the video imagery classification are provided within the text of the following subsections. These tables summarize the estimated area or number of classified features. The mapped physical and biological features (Figures 4 to 23) are provided in Section 7.0, the Map Folio. Selected video images, from both the SIMS survey and dive observations, are provided in Appendix C.

3.1 SUBSTRATE TYPE

Substrate type provides a general description of material at the surface of the seabed. The distribution of these substrates in Esquimalt Harbour is mapped in Figure 4 and the area of various substrate types summarised in Table 4.

Table 4. Substrate Type

SUBSTRATE TYPE	DESCRIPTION	SUBTIDAL AREA	
		HA	%
Sediment	gravel, sand or mud-sized material	265.7	87.4
Rock or Rock with Sediment Veneer[1]	bedrock outcrop or intermittently visible bedrock covered with a veneer of sediment	6.5	2.0
Wood Debris	seabed surface obscured by wood and bark debris	24.1	7.9
Biogenic	seabed surface obscured by vegetation	0.0	0
Not Surveyed		8.1	2.7
TOTAL		**304**	**100**

Most of the substrate is classified as sediment (mud, sand, or gravel), which forms 87% of the subtidal seabed area. Rock substrate comprises about 2% of the subtidal seabed and includes both isolated bedrock outcrops (e.g. east of Fisgard Light) as well as rocky seabed contiguous with rock islands (e.g. Inskip Islands). In contrast about 6% of subtidal substrate in Victoria Harbour is classified a rock or rock with sediment veneer (Emmett *et al.* 2000). Most of the areas of rock substrate in Esquimalt Harbour are charted or noted as rocky bottom on CHS chart 3419. Approximately 8% (24 ha) of the surveyed seabed was obscured by wood and bark debris. These areas are former log booming areas and are summarised more fully in Section 3.3. The unsurveyed area northeast of Inskip Islets (4.1 ha)) is currently used for log booming, and the seabed in this area is also likely obscured by wood and bark debris. Approximately 2.5% of all images were classified as biogenic (substrate obscured by vegetation), but distribution of these images was scattered throughout the harbour and discrete biogenic areas were not identified.

[1] About 4% of all images were classified as rock with sediment veneer, however these images were mixed heterogeneously with images classified as rock, and both classifications were combined to produce "rock or rock with sediment veneer" polygons (see legend, Figure 4).

3.2 SEDIMENT SIZE CLASS

Sediment size classes are assigned to the *sediment* substrate type. The distribution of these sediments in Esquimalt Harbour is mapped in Figure 5 and estimates of the subtidal area of the various sediment size classes are provided in Table 5. Further detail on sediment class codes is given in Table A-3 and A-4 of the data dictionary (Appendix A). Sediment size classes were difficult to distinguish in many areas due to poor visibility. It is particularly difficult to distinguish mud from mud/sand substrate in the video imagery and most of these images have been classified as mud/sand.

Table 5. Sediment Size Class

SEDIMENT SIZE	SUBTIDAL AREA	
	HA	%
Gravel[2] (>30% gravel)	41.0	15.3
Gravelly Mud/Sand (trace to 30% gravel)	122.5	45.8
Sand	3.5	1.3
Mud/Sand	100.5	37.6
Mud	0	0
TOTAL	**267.5**	**100**

Most of the sediments in Esquimalt Harbour are classified as mud /sand (33% of total subtidal area) or gravelly mud/sand (40% of total subtidal area). The latter category includes imagery with trace to 30% gravel, although most (85%) of these images were classified as trace to 5% gravel. The finer mud/sand sediments are located in the upper portion of Esquimalt Harbour, primarily at depths greater than 2.0m. The seabed of the outer portion of Constance Cove is also primarily mud/sand substrate. Gravelly sand/mud sediments dominate the outer portion of Esquimalt Harbour (particularly at depths greater than 10m), the upper portion of Constance Cove, and the uppermost part of the harbour near Cole Island and Tovey Bay. Sand sediments were observed only at the western entrance to the harbour off Fisgard Island.

The gravel areas shown in Figure 5 are greater than 30% gravel cover and comprise about 13% of total subtidal area. These areas are mostly associated with sediment shorelines (e.g. Rodd Point to Yew Point) or rock and sediment shorelines (e.g. Dyke Point to Limekiln Bay). In addition, gravel content is greater than 30% in Lang Cove, along the shoreline between Y and C Jetty at CFB Esquimalt, and in the central area of Constance Cove. Further detail on gravel content is provided in Figure 6, with percent gravel categories being determined by standard geological size ranges (Appendix A; Table A4). Areas with slight amounts of gravel (Trace to 5%) correspond to the gravelly sand/mud areas shown in Figure 5. The small amount of gravel in these areas may be related to source input (e.g. Millstream Creek in the upper harbour) or to slightly higher energies that occur near the mouth of the harbour.

[2] gravel = total pebble, cobble, boulder

In Esquimalt Harbour gravel, including cobbles and boulders (Figure 7), is primarily associated with the shore. In contrast, there is less subtidal gravel substrate in Victoria Harbour (about 5% of subtidal area, Emmett *et al*. 2000) which is mostly associated with central areas of the Inner and Outer Harbour, either narrow current dominated channels such as the Johnson St Bridge or surrounding rocky outcrops.

Gravel content provides a good index of energy in that the higher the gravel content, the higher the assumed energy generated by waves or currents. Areas of higher gravel content are usually erosional areas where currents have removed the finer sediment from the glacial parent material and left a "lag" deposit of coarse gravel. These gravel areas are often associated with areas of shell debris (see Section 3.3). Gravelly shores (e.g. Rodd Point to Yew Point, Dallas Bank) are likely non-depositional as a result of wave action. The gravelly bar near McCarty Island may result from the action of tidal currents. In some areas of the harbour the observed gravel material may not result from natural processes. The dive observations noted large amounts of coal on the seabed just inside Duntze Head, which were likely classified as gravel. Dredgate from the seabed around C Jetty was deposited in Lang Cove in 1987-88 (Drinnan and Gorden 1991, cited in Bright and Reimer 1993). This dredgate may be the origin of the gravel material in this area. Gravel capping was added to the foreshore on both sides of Y Jetty during the recent restoration of the Yarrows shipyard site. The gravel area in the middle of Constance Cove could be either undocumented dredgate or a remnant area of glacial till.

3.3 ORGANIC MATERIAL AND SHELL COVER

The distribution of organic material is shown in Figure 8. Table 6 summarises estimates of seabed area with greater than 5% organic material. A total of 46.9 ha of seabed (16% of the subtidal seabed of Esquimalt Harbour) contained greater than 30% organic material. The majority of this area is comprised of bark and wood debris associated with present and former log booming areas in Plumper Bay and the head of Esquimalt Harbour (Figure 8). The booming area in the head of the harbour was used extensively from the 1930s to the 1970s (Bright and Reimer 1993) but has not been active since 1990 and was "little used" for 10 years prior to that date (W. Trocher, Transport Canada, pers. comm.). The Plumper Bay booming grounds were established sometime after 1945 and are identified on the 1973 edition of the CHS chart of Esquimalt Harbour (Bright and Reimer 1993). The actual area of harbour seabed impacted by wood and bark debris is higher than 16% as an additional 4.1 hectares northeast of Inskip Islands, which was not surveyed, is an active log booming area**.** A very small amount of organic cover is classified as "vegetative detritus" in isolated spots along the shoreline or "riparian branches and leaves" associated with stream mouths.

Table 6. Organic material (primarily bark and wood debris)

ORGANIC CONTENT (%)	SUBTIDAL AREA (HA)
5-30	19.5
30-80	11.0
>80	36.9
TOTAL	**67.4**

Logs were common on the seabed of Esquimalt Harbour and are closely associated with the booming areas (Figure 8). More than 600 individual logs (Table 7) were classified. A simple estimate of the total number of logs on the seabed was made by determining the number of logs per metre of trackline survey (assuming each trackline was 1m wide) and extrapolated over the booming ground area. Using this method, it is estimated that there are 5,000 to 10,000 logs on the seabed of the surveyed two booming areas in Esquimalt Harbour.

Shell material (Figure 9) was commonly found in gravelly areas throughout the harbour**.** Most shell material was butter clam (*Saxidomus giganteus*), Japanese littleneck clam (*Tapes japonica*) and/or native littleneck clams (*Protothaca stamina*). One of the largest aggregations of shell material (>30%) was off Tovey Bay and Cole Island at the head of the harbour. The shells in this area were primarily whole butter clam (*Saxidomus giganteus*) shells. A second area of shell fragments (mixed in mud/sand sediment) was located at the northeast end of Paddy Passage.

3.4 MAN-MADE OBJECTS

A variety of man-made objects were identified from the imagery and classified in the database. These objects are summarized in Table 7 and their distribution mapped in Figure 10. A total of 3,178 man-made objects were identified in 100km of survey trackline (32 objects/km). In Victoria Harbour (Emmett *et al.* 2000) 6,482 man-made objects were identified in 79 km of trackline (82 objects/km). Some of the most numerous man-made objects (garbage, logs) reflect the industrial use of Esquimalt Harbour (ship mooring, ship repair, log storage), whereas the most numerous objects in Victoria Harbour (aggregations of bottles, bottle, garbage) reflect the mix of recreational, residential and industrial activity characteristic of the Victoria waterfront.

Much of the man made debris (garbage, bottles and metal objects) are concentrated around docks and wharves. Log debris is concentrated in former booming areas (also see Figure 8). Many cable observations were the charted submarine cables that run from Duntze Head to Rodd Point. Items reported as "Other" include a variety of industrial and domestic material (bricks, cups, crab traps).

Table 7. Man-made Objects

MAN-MADE OBJECT	# IMAGE POINTS
Garbage	1,176
Logs	647
Bottles	350
Metal Objects	248
Cable/Wire/Rope	244
Other	220
Cans	148
Aggregations of Bottles	78
Tire	35
Pipe	23
Lumber	9
Total	**3,178**

3.5 VEGETATION COVER AND VEGETATION TYPE

Vegetation cover is the estimate of percent cover for all vegetation observed in each image (Appendix A, Table A8). Table 8 summarises estimates of vegetated cover in Esquimalt Harbour by percent cover categories: (1) sparse = trace to <5% cover; (2) low = 5-25% cover; (3) moderate = 25-75% cover; (4) dense = >75% cover). The distribution of subtidal vegetation in the harbour is shown in Figure 11.

Table 8. Estimated Area of Major Vegetation Types by Cover Category

CODE	TYPE	VEGETATED AREA (HA)			% OF TOTAL SUBTIDAL AREA
		SPARSE-LOW COVER	MODERATE-DENSE COVER	TOTAL	
FIR1&2	Filamentous Red Algae	74.1	6.2	80.3	26.3
FOG	Foliose Green Algae	38.0	8.5	46.5	15.2
BKS	Bladed Kelps	17.4	13.2	30.6	10.0
ZOS	Eelgrass	0.2	0.3	0.5	0.2
	Total Vegetation	**66.5**	**23.3**	**89.8**	**29.5**

Approximately 30% of Esquimalt Harbour is vegetated with macroalgae or eelgrass, with about one third of the vegetated area being moderate to dense cover. Vegetation cover in Victoria Harbour is similar, about 40% with 35% of the vegetated area being moderate to dense cover (Emmett *et al*. 2000). Overall, less than 10% of the total subtidal area of both harbours supports moderate to dense vegetative cover. In Esquimalt Harbour vegetation cover is densest along the shore margins, particularly at the harbour entrance, Inskip Islands and Dallas Bank. These are the more exposed shore sections shore within the harbour. The channel between Smart Island and McCarthy Island, which is influenced by tidal current, and Whale Rock also support moderate to dense vegetative cover. The area of densest vegetative cover is dominated by kelp and foliose green algae (Table 8). Much of the area of sparser cover is comprised of filamentous red algae at trace to 5% cover (see subsequent sections). Most of the mud/sand sediments of harbour basin are not vegetated. Vegetation is sparse or lacking on most of the gravelly mud/sand sediments except at the harbour entrance and the upper harbour between Paterson Point and Limekiln Bay.

Sixteen marine vegetation types are identified in the SIMS classification table (see Appendix A, Table A-9). Some vegetation types are single species or genus groupings such as eelgrass and *Agarum*. Other types are broader taxonomic groupings such as filamentous red algae (FIR1 and FIR2) and bladed kelps (BKS). Species within these vegetative types are grouped by similar morphologies (which aids recognition in the video imagery) and by habitat association (see definition of FIR1 And FIR2, Appendix A, Table A-9). The sixteen vegetation types provide a reasonably comprehensive description of the nearshore (<20m depth) vegetation of coastal British Columbia. The classification system permits a primary (most common) vegetation type, secondary (next most common) and tertiary (third most common) vegetation type to be identified for each image point. The report folio maps (Section 7.0) displays all images classified (primary, secondary and tertiary combined) for each mapped attribute.

Ten of the 16 vegetation types were identified in Esquimalt Harbour (Table 9). The most common vegetation types are bladed kelps, filamentous and foliose red algae, and foliose green algae. Bladed kelps often occurred with foliose green algae, filamentous and foliose red algae as a secondary (understory) vegetation type. Further information on the extent and distribution of these vegetation types is provided in Sections 3.6 to 3.9.

Table 9. Frequency of Classified Vegetation Types

CODE	TYPE	IMAGE POINTS			
		PRIMARY	SECONDARY	TERTIARY	TOTAL
NOV	No Observed Vegetation	86,174	0	0	**86,174**
BKS	Bladed Kelps	12,664	3,309	1,073	**17,046**
FIR1&2	Filamentous Red Algae	6,155	3,693	2,036	**11,884**
FOG	Foliose Green Algae	5,361	4,106	2,409	**11,876**
FOR	Foliose Red Algae	957	3,546	1,642	**6,145**
SAR	*Sargassum*	1,713	689	384	**2,786**
AGR	*Agarum*	1,250	98	141	**1,489**
COR	Coralline Red Algae	155	330	374	**859**
ZOS	Eelgrass	242	1	3	**246**
FUC	*Fucus*	123	54	27	**204**
NER	*Nereocystis*	26	36	42	**104**
	Total	**114,820**	**15,862**	**8,131**	

3.6 EELGRASS

Eight small eelgrass (*Zostera marina*) beds, ranging in size from 60m^2 (Grant Knoll) to 1,630m^2 (Limekiln Cove) were identified in Esquimalt Harbour (Table 10, Figure 12). Most of these beds were identified in the video survey and bed areas subsequently mapped by dive survey. The depth range for eelgrass in the harbour is +0.5m to –0.9m. Substrate ranged from mud/sand (Thetis Cove) to gravelly (Lang Cove and Dallas Bank). Shell content (barnacle hash) was high (>50%) in the eelgrass bed at Grant Knoll. This bed is entirely subtidal and the bed south of Smart Island is wholly within the intertidal zone. Three eelgrass beds were classified as sparse to low (<25%) cover (north and south Lang Cove, Thetis Cove). At the time of the survey the eelgrass blades were covered with diatoms and, in some beds, epiphytic red algae (*Smithora naiadum*) also grew on the blades. Other algal species co-occurring with *Zostera* include *Laminaria* sp., *Ulva* sp., *Sargassum muticum*, *Alaria* sp. and *Neoagardhiella* sp.

Invertebrate species most common in the eelgrass beds include crabs; red rock crab (*Cancer productus*), Dungeness crab (*Cancer magister*), Graceful crab (*Cancer gracilis*), Helmet crab (*Telmessus cheiragonus*) as well as horse clams (*Tresus* sp.). Fish were common in the eelgrass beds and include striped (*Embiotoca lateralis*), pile perch (*Rhacochilus vacca*), stickleback (*Gasterosteus aculeatus*), pipefish (*Syngnathus griseolineatus*), Northern ronquil (*Ronguilus jordani*) and gunnels.

Only one eelgrass bed (Limekiln Cove) was greater than 1,000m^2 and the total area of eelgrass within Esquimalt Harbour is approximately 0.5 ha. This compares to 2.4 hectares of eelgrass surveyed in Victoria Harbour (Emmett *et al*. 2000), 80 hectares in Portage Inlet and the Gorge

Waterway (Archipelago Marine Research Ltd. 2000b) and 15 hectares in Esquimalt Lagoon (Archipelago Marine Research Ltd. 2000c).

Likely, the area of eelgrass in Esquimalt Harbour was historically larger than today. Lang Cove has been subject to dredging and infilling, and Thetis Cove is highly impacted by bark and wood debris. The eelgrass in these two areas is currently sparse and limited. The upper area of the harbour may have contained eelgrass beds, but the seabed has been impacted by bark and wood debris from log booming activity.

Table 10. Estimate of Eelgrass Bed Areas (based on video survey and dive verification)

Bed #	Location	Area (m^2)
1	Grant Knoll	60
2	Lang Cove south	810
3	Lang Cove north	620
4	Munroe Head North	900
5	Ashe Head South	120
6	Thetis Cove	700
7	Limekiln Cove	1,320
8	Smart Island	820
TOTAL		**5,350**

3.7 KELPS AND OTHER BROWN ALGAE

Kelps are a group of brown algae generally characterized by a holdfast, stalk and blade. The holdfast anchors the plant to the substrate. Figure 13 shows the distribution of kelp in Esquimalt Harbour. Thirty-one hectares of kelp vegetation were mapped (Table 8), of which 13.2 hectares was moderate to dense vegetation cover. Kelps were recorded on both bedrock and gravel (primarily cobble/boulder) sediments throughout the harbour, but the densest areas occurred in most exposed locations such as the harbour entrance, Inskip Islands and Ashe Head.

Brown algae (including kelps) occurred on rock and coarse sediment substrates throughout the harbour, however there was considerable variation in kelp community composition depending on the degree of exposure. Dive observations were made at 11 sites with kelp throughout Esquimalt Harbour (Table 3, Figure 3). Bladed kelp cover was moderate to dense in all these sites and often provided a canopy for underlying coralline algae, foliose red algae (*Mazzaella/Chondracanthus*) as well as foliose green algae (*Ulva* sp.). In the more dense kelp areas the substrate is primarily bedrock and boulder with the exception of two sites on the western shore between Rodd and Yew Points (Sites 25, 26), where the substrate is unconsolidated material comprised of pebble/coarse sand and some cobble. *Laminaria saccharina* and a wide bladed form of *Costaria costata* were dominant kelp species at more exposed sites, including Duntze Head, Inskip Islands, Fisgard Light and Whale Rock. *Desmerestia* (foliose form) ranging from 20 to 80% cover, occurs with *Laminaria* sp. along the shoreline between Rodd Point and Yew Point (Sites 25, 26) and at Inskip Islands (Site 9).

In some of the more protected areas of the harbour, *Laminaria saccharina* is the dominant kelp species (Lang Cove, Smart/McCarthy Islands). In the upper part of the harbour (Cole Island and Tovey Bay to Dyke Point) filamentous and foliose forms of *Desmersetia* were the dominant brown algae, and *Laminaria* sp. was not present. *Desmerestia* is an opportunistic species with an

annual life cycle, whereas *Laminara* sp. is a perennial species typically found in more stable algal communities. It is possible that freshwater flow to the upper end of the harbour in winter prevents the establishment of a perennial kelp community.

Agarum sp. is usually found in depths greater than *Laminaria* sp., and was most abundant (40-80% cover) at Whale Rock (4 to 7.5m depth) but also occurs on the bedrock along the southwest portion of the Inskip Islands, Ashe Head, and on the bedrock outcrop just east of Fisgard Light (Figure 14). *Agarum* was also found growing in the gravelly areas below bedrock at Duntze Head.

Sargassum muticum is a large filamentous brown algae introduced from Japan with the Pacific oyster, *Crassostrea gigas,* and now widespread throughout the southern British Columbia coast. In Esquimalt Harbour, *Sargassum* occurs between the depths of +0.5 to –1.0m on both bedrock and boulder and is often associated with the upper end of the bladed kelp zone (Figures 13 and 14). *Sargassum* does not occur in the most exposed areas of the harbour (Fisgard Light and Duntze Head). *Sargassum* may be more abundant along the harbour shoreline than depicted in Figure 14, as this species also grows at elevations above chart datum, which was not extensively surveyed with the towed video system.

Nereocystis leutkeana (bull kelp) occurred within Esquimalt Harbour at Dunze Head, Paddy Passage and Monroe Head but was most abundant at Whale Rock (Figure 14). *Nereocystis* did not occur around Fisgard Island but is found in abundance outside the harbour along the shoreline between Victoria and Esquimalt Harbours. Bull kelp is an annual species and, although bed locations tend to be stable from year to year, some annual variation is expected. In addition, the timing of the SIMS survey (March) may have been too early to observe the full extent of bull kelp growth in Esquimalt Harbour.

Invertebrate species present within areas of moderate to dense kelp cover are listed in Appendix B, and include crabs (*Cancer magister*, C. *productus*, C. *gracilis*, T. *cheiragonus*, *Pugettia productus*/*gracilis*), sea stars (*Pycnopodia helianthoides*, *Evasterias troschelli*), anemones (*Metridium giganteum*, *Utricina coriacea*), tubeworms (Eunicid, Sabellid, *Eudistylia vancouveri*, and other parchment tubeworms). Typical species found on bedrock include sponges (Bread Crumb sponge, *Halichondria* spp. and purple encrusting sponge, *Haliclona permollis*), ascidians (the colonial ascidian *Didemnun carnulentum*) and hydroids (*Ectopleura* sp.). Notable invertebrates include rock scallops (*Crassodoma gigantea*) and red sea urchins (*Strongylocentrotus franciscanus*), with rock scallops found on bedrock at Whale Rock and Inskip Islands. Red sea urchins are present around Dunze Head and Fisgard Island.

No stalked kelps (e.g. *Pterogophera*) were observed in Esquimalt Harbour. This perennial species favours semi-exposed rocky substrate and occurs in the outer portion of Victoria Harbour (Emmett *et al*. 2000) and along the shoreline between Victoria and Esquimalt Harbours.

3.8 FOLIOSE GREEN ALGAE

Approximately 46 hectares of green algae (15% of the subtidal area) were mapped in Esquimalt Harbour (Table 8, Figure 15). The densest areas of green algae are associated with the bladed kelp beds at the entrance to the harbour, the outer shoreline of Inskip Islands and Dallas Bank.

Ulva cover was also moderate to dense in the tidal channel between Smart and McCarthy Islands. Most of the lower cover green algae was found at the harbour entrance at depths of 5-15m. In this area *Ulva* occurred with filamentous red algae on the gravelly mud/sand sediment, and cover of both species was generally sparse (trace to 5%).

Both *Ulva* and thinner bladed green algae *Enteromorpha* also grows on in intertidal areas (mud flats and rocky shorelines). *Enteromorpha* is commonly found in areas with freshwater influence. These species are annual plants, which die back in the fall. It is important to recognise that fast growing algae such as *Ulva* and *Enteromorpha* may be denser and more widely distributed in mid-summer as compared to the March survey date and, correspondingly, scarce or absent in winter. In addition, the intertidal extent of green algae has not been mapped by the current survey.

3.9 FILAMENTOUS AND FOLIOSE RED ALGAE

Both filamentous and foliose red algae co-occur on rock and coarser sediments along the east and west shore of the harbour entrance, Inskip Islands and Ashe Head (Figures 15 and 16). In these areas filamentous red algae generally occur at moderate to dense cover (>25%). Filamentous red algae were also sparsely distributed on finer sediments across the harbour entrance and in the upper portion of the harbour between Paterson Point and Limekiln Cove. In the upper portion of the harbour, the sparse cover of filamentous red algae was associated with areas of bark and wood debris (Figure 8). This was the only algal group identified in this area. Due to the patchy and sparse distribution of foliose red algae, area estimates could not be reliably made.

The dive survey observations (Appendix B) show that the filamentous red algae in areas with softer substrate (sand/mud with some pebble/cobble or shell mix) was primarily *Neoagardhiella* sp. Filamentous red algae growing on bedrock and boulder in the shallower subtidal zone (<3m deep) was primarily *Odonthalia floccosa*. At Inskip Island and Ashe Head branched coralline red algae (*Corallina* sp.) grew on the bedrock and boulders in depths <2m (Figure 16), and were found as an understory beneath large bladed kelps. *Corallina* was not common in other rocky substrate areas of the harbour. Foliose red algae growing on bedrock and boulder substrate in the shallower subtidal zone (<2m) include the species complex *Mazzaella* (*Iridea/Rhodoglossum*) and *Chondracanthus* (*Gigartina* sp.), while *Opuntiella californica* was present in the deeper subtidal zone.

3.10 MACROFAUNA

Thirty faunal types are included in the SIMS classification table (see Appendix A, Table A-11 for a complete description of the faunal classification). Some faunal types are single species or genus groupings such as the anemone *Metridium.* Others are broader taxonomic groupings such as brittle stars and bryozoan complexes. Unlike the vegetation types, these faunal types do not provide a comprehensive description of the nearshore (<20m depth) fauna, but rather were developed to document larger, aggregating macrofauna. In addition, several faunal codes describing mobile species (e.g. crabs) were added to the original classification in order to document mobile resource features. The classification system permits faunal types to be identified for each image point. A distribution code (Appendix A, Table A-10) is used to describe both abundance and the pattern of distribution within the image point.

Table 11. Faunal Types

CODE	TYPE	# OF IMAGES
HLF	Unmounded Infaunal burrows	**21,898**
HLM	Mounded infaunal burrows	**8,088**
ANM	*Metridium*	**3,005**
CAN	Cancer sp. (*C. magister, C. gracilis*)	**1,283**
CUC	Burrowing sea cucumber-*Cucumaria*	**829**
PCL	Piddock clams	**528**
TEA	Anemone (*Urticina* sp.)	**212**
BRY	Bryozoans	**195**
RSU	Red sea urchin	**53**
RRK	Red rock crab (*C. productus*)	**44**
TUB	Parchment Tubeworms	**37**
OCL	Other clam species	**29**
PAR	Sea cucumber (*Parastichop*us)	**17**
TUC	Calcareous tube dwellers (*Serpula*)	**8**
TUN	Tunicates	**3**
HCL	Horseclam	**1**
	Total	**36,230**

Macrofauna were classified for about 32% of the 115,000 classified images (Table 11). Most (81%) of the classified fauna were infaunal burrows, which are indicative of large, burrowing infauna (e.g. burrowing shrimp, larger worms, bivalves). The infaunal burrows are mostly located in the gravelly mud/sand sediments at the harbour entrance as well as the western side of the upper harbour (Figure 18). Infaunal burrows were not evident in the bark and wood debris cover of former log booming areas. In certain areas the identification of infaunal burrows may have been obscured by poor visibility. For this reason as well as the fact that smaller infaunal organisms cannot be identified in the video images, the distribution of infaunal burrows should not be considered as a quantitative index of infaunal richness, but rather as an indication of distribution of larger infauna.

Plumose anemone (*Metridium senile and M. giganteum)* are common in the former log booming areas, growing on logs and large wood debris (Figure 19). These anemones are also quite common on rocky substrate along the shoreline between Tovey Bay and Dyke Point, and on debris in Lang Cove and off the Graving Dock. *Urticina* sp. (*Tealia),* a genus of anemone often associated with coarser gravel and rock substrates, was observed in the outer area of the harbour at depths greater than 5m as well as on rock or gravel sediments at Duntze Head, Grant Knoll, McCarthy Island and the rocky islets off Dallas Bank.

Crabs (*Cancer magister* and *C. gracilis*) were distributed throughout the harbour seabed (Figure 20) on mud/sand and gravelly mud/sand sediments. Dungeness crab (*Cancer magister*) can not readily be distinguished from the graceful crab (*C. gracilis*) in the video imagery and both species have been classified as *Cancer* sp. From the dive observations, *Cancer gracilis* appeared more common than *Cancer magister*, particularly on sediment impacted by wood debris (Sites 13-16) as well as in the mud near the head of the harbour (Site 19). Both species were seen

within the eelgrass beds of Lang Cove and Smart Island. Red rock crab (*C. productus*) were mostly observed on coarser gravel and rocky substrates.

Crab appear to be particularly abundant in the outer and upper area of the harbour as well as near a number of DND docks, however differences in visibility between survey days may have affected the ability of classifiers to identify crab in certain areas. Over 1,200 crab observations (12 per km of trackline) were made in the harbour area. In contrast less than 1 crab per km of trackline was observed in the video survey of Esquimalt Lagoon (Archipelago Marine Research Ltd. 2000c) and Portage Inlet/Gorge waterway (Archipelago Marine Research Ltd. 2000b). Crabs were not classified in the subtidal survey of Victoria Harbour (Emmett *et al*. 2000). As crabs are highly mobile, their abundance will likely vary throughout the year.

Other notable invertebrates identified in the video survey include red sea urchins (*Strongylocentrotus franciscanus*) and California sea cucumber (*Parastichopus californicus*) on rocky substrate at the harbour entrance (Fisgard Island and Duntze Head) and Inskip Islands (Figure 21). Piddock clams (*Ziphaea pilsbryi*) were observed in Lang Cove (in and adjacent dredged areas) and in Paddy Passage, between Inskip Islands and Ashe Head. Piddock clams inhabit clay and coarse gravel substrates and are quite common in Victoria Harbour (Emmett *et al*. 2000).

Figure 22 summarises fish observations from the video imagery classification. At the time of the survey, flatfish (or sole) were most common in the outer area of the harbour and off Inskip Islands. The dive observations (Appendix B) provided additional information on fish distribution in the harbour. Schools of perch, both striped (*Embiotoca lateralis*) and pile (*Rhacochilus vacca*), were common on most dives in eelgrass beds and areas of kelp. Quillback rockfish (*Sebastes malinger*) and tubesnouts (*Aulorhynchus flavidus*) were seen in areas of dense kelp (Dunze Head and Yew Point), while northern ronquils (*Ronguilus jordani*) were seen in eelgrass beds at Smart Island and the docks off Dallas Bank (Site 6). A lingcod was observed at Whale Rock (in dense *Agarum*) and a few pipefish (*Syngnathus griseolineatus*) were observed in the eelgrass at Smart Island and in kelp between McCarthy and Smart Island.

4.0 DISCUSSION

The subtidal environmental features of Esquimalt Harbour are influenced by three main factors:

1. The depositional nature of most of the seabed, particularly in the upper harbour and Constance Cove. Most of the subtidal seabed of the harbour is formed of finer sediments and Millstream Creek is likely an important source of these sediments.
2. Wave exposure in the outer harbour and at Whale Rock/Inskip Islands. The biological features of shoreline between Fisgard Island and Yew Point, Duntze Head/Grant Knoll, and the southern shoreline of Inskip Islands are characteristic of semi-exposed rocky habitats of the Georgia Basin.
3. Historic and ongoing industrial activities. A significant portion of the harbour seabed is physically impacted by historic and ongoing log storage activities. The quantity of organic debris on the bottom has likely altered benthic infaunal community composition, although this was not the subject of the current subtidal inventory. Dredging has also altered benthic habitats in specific areas.

The most notable biophysical features of Esquimalt Harbour are summarized in Table 12. Further detail on valued and degraded subtidal areas within the harbour follows. It is important to note that the subsequent discussion focuses on features identified in the video survey and subsequent dive observations (substrate, exposure, large physical debris, macrovegetation and larger epiphytic invertebrates). There may be additional valued and degraded areas (e.g. rich infaunal communities, heavily contaminated areas) which cannot be identified using these inventory methods, but may be identified in previous or ongoing studies.

Table 12. Summary of the biophysical features of Esquimalt Harbour

BIOPHYSICAL FEATURES		
PHYSICAL	**VEGETATION**	**FAUNA**
• Most of the basin is formed of mud/sand and gravelly mud/sand sediment except around margins. • Gravel is primarily associated with shoreline (wave influence), some gravel areas result from dredging or dumping. • Coves and small bays are important shore features. • Current influence around Smart/McCarthy Islands and Paddy Passage. • Man-made objects reflect industrial use (logging, ship repair). • Still a significant amount of natural shoreline along west and northeast side of harbour. • Over 15% of the seabed is significantly impacted by bark/wood debris.	• Very little eelgrass, primarily in coves and small bays. • Diverse and dense kelp community (*Laminaria* and *Costaria*) at harbour entrance and Inskip Islands. • *Laminaria* sp. and *Desmerestia* dominate kelp communities in less exposed areas of the harbour. • Bull kelp (*Nereocystis leutkeana)* bed was noted at Whale Rock. • Sparse cover of filamentous red and foliose green algae across harbour entrance.	• Crabs (*Cancer magister* and *C. gracilis*) were abundant at the time of the survey. • Intertidal clam beds, particularly around Cole Island/Tovey Bay). • Herring spawning. • Potential for coho spawning in Millstream Creek.

4.1 VALUED AREAS

4.1.1 Densely Vegetated Kelp Areas

Several of the more exposed rocky nearshore areas within the harbour (Duntze Head, Fisgard Island, the south facing side of Inskip Island, Ashe Head) support a dense and diverse algal community dominated by two species of bladed kelp, *Laminaria saccharina* and *Costaria costata.* Several algal groups (coralline algae, filamentous and foliose red and foliose green algae) form an understory below the larger kelp plants and support a diversity of invertebrates (e.g. sea urchins).

The shoreline between Rodd Point and Yew Point, as well as the rock and gravel substrates around Smart and McCarthy Islands, support a dense but less diverse kelp community dominated by *Laminaria saccharina* and *Desmerestia* sp. These areas are less exposed, particularly to southerly winds, than the more diverse kelp communities at the harbour entrance and Inskip Islands. Whale Rock is also a valued feature, being the largest subtidal rock outcrop in the harbour and one of the few areas within the harbour which supports canopy kelps (*Nereocystis luetkeana*).

4.1.2 Coves and Small Bays

Esquimalt Harbour has a number of coves and small bays, particularly along the eastern shoreline (Tovey Bay, Limekiln Bay, Thetis Cove, Dallas Bank and Lang Cove). Most of these bays contain valued habitat features such as intertidal mudflats, rocky islets or outcrops. Most of the small eelgrass beds identified in the harbour occur in these bays (Lang, Thetis and Limekiln Coves, Dallas Bank). Coves and bays are not a common feature of Victoria Harbour (Emmett *et al.* 2000), and these areas provide Esquimalt Harbour with nearshore physical complexity and diversity for both marine and terrestrial species.

4.1.3 Current Dominated Channels (Gravelly Substrates)

Areas of seabed dominated by tidal current are not as common in Esquimalt Harbour as Victoria Harbour or the Gorge Waterway. These areas tend to support a variety of suspension feeding invertebrates (bryozoans, sponges, tube worms). The two areas of note in Esquimalt Harbour are Paddy Passage and the channel between Smart and McCarthy Island. As much of the harbour is formed of depositional sediments, these current dominanted, coarse sediment areas contributed to the diversity of physical and biological features within the harbour.

4.1.4 Eelgrass Beds

Eelgrass beds provides rearing habitat for a variety of juvenile fish and invertebrates, including chinook, coho and chum salmon, lingcod and Dungeness crab. Biological productivity and species abundance and diversity also tends to be high in this habitat. Eelgrass is also sensitive to foreshore development impacts particularly foreshore fill, dredging and shading. Currently the area of eelgrass in Esquimalt Harbour is extremely small, approximately 0.5 hectares, distributed in 7 or 8 locations (Table 10). Some of these beds have been impacted by industrial activities in the harbour (dredging and foreshore fill in Lang Cove, log booming in Thetis Cove). All remaining beds within the harbour should be considered valued and sensitive, and management efforts should be undertaken to both conserve as well as restore eelgrass to degraded areas, with the overall goal of increasing the area of eelgrass within the harbour.

4.2 DEGRADED AREAS

A number of subtidal areas within Esquimalt Harbour have been physically degraded by historic and ongoing industrial activities, primarily log booming and sorting, dredging and foreshore fill. Ship repair and dock use have contributed to accumulations of man-made debris on the harbour seabed, but the major impact from these activities is sediment contamination. Impacts resulting from sediment contamination are not directly addressed in this inventory, but have been reviewed previously in Esquimalt Harbour (Bright and Reimer 1993).

4.2.1 Areas of Bark and Wood Debris

As noted in Section 3.3, about 16% of the harbour seabed is impacted by a bark and wood debris (>30% cover). Of this area, approximately 37 hectares are impacted by heavy (>80%) wood and bark debris cover. The largest areas of organic debris are former and current log booming areas located in Plumper Bay/Thetis Cove and the upper part of the harbour north of Smart Island (Figure 8). Decomposing organic material generates anoxic sediments with impacts to benthic community structure, and possibly mobilize sediment contaminants. It is likely that the eelgrass bed in Thetis Cove has been adversely impacted, both in terms of bed size and plant density, by bark and wood debris. Figure 23 shows the distribution of anaerobic bacterial mats (*Beggiotoa* sp.) on the seabed sediments within the harbour. These mats are concentrated in areas of highest organic debris areas (Plumper Bay) as well as in dredge pockets in Lang Cove and south of the Graving Dock (see below). Despite the degraded nature of these areas, some invertebrate species (crab, plumose anemones) are relatively abundant in former log storage areas.

4.2.2 Dredge Pockets

There are a number of areas in the harbour where dredging has created small pockets 1-2m below the grade of the seabed. There are two dredge pockets in Lang Cove and a third south of the Graving Dock in Constance Cove. Anaerobic bacterial mats (*Beggiotoa* sp.) were also observed in these areas (Figure 23), and sediments are likely anoxic due to the lack to tidal exchange within the pockets. The Lang Cove area has been described in detail in a separate assessment conducted for the Dept. of National Defence in 1999 (Archipelago Marine Research Ltd. 2000d).

4.2.3 Accumulations of Man-Made Debris

Much of the man-made debris (bottles, cans, certain garbage items) observed in the harbour is relatively benign with respect to impacts to habitat value. As mentioned in Section 3.3, sunken logs (est. 5,000 to 10,000) are abundant in the former log booming areas (Figure 8). Metal objects, primarily cable and chain, are also abundant in these areas. There are also accumulations of debris around many of the heavily used docks (A Jetty, the small jetties east of C Jetty, Pilgrim Cove and the docks at Dallas Bank). Much of this debris is classified as garbage, bottles, and "other". Despite the recent remediation efforts in a area of Y Jetty, there appears to still be a large number of metal objects in the dock area below chart datum elevation.

4.3 POTENTIAL RESTORATION INITIATIVES

Restoration initiatives should be assessed for a number of the degraded areas within Esquimalt Harbour. In addition, efforts could be made to obtain information on the historic extent of certain biophysical features such as eelgrass beds and intertidal clam beds, prior to the initiation of a detailed habitat restoration plan for the harbour. First Nation consultation and traditional resource use information will be essential in the development of an appropriate restoration plan. Further detail on potential restoration initiatives is provided below:

Areas of Bark and Wood Debris

There are three possible restoration strategies for these areas, (A) remove the bark and wood debris, (B) cap the wood debris with clean, appropriately sized sediment, (C) permit natural sedimentation processes to cap the organic material. Selection of the appropriate strategy requires assessment of the natural rate of sedimentation, the possible impact of re-mobilizing the organic material during removal, and the potential for erosion of capping material by natural processes. A strategy appropriate for one site may not be applicable at another. For example, it appears that a former log booming area in Upper Selkirk Waters (Victoria Harbour) has been capped by natural sedimentation, and eelgrass has re-established at the site over the past five years (Archipelago Marine Research 2000b). Over a similar period (10-15 years) the former booming area in upper Esquimalt Harbour appears to have experienced little natural sedimentation.

Dredge Pockets

These areas can be readily restored by the addition of clean, appropriately sized fill (fine sands) to meet the natural grade of the harbour bottom. In Lang Cove, this could be coupled with efforts to enhance the remnant eelgrass bed (see below). A detailed video survey of the subtidal features of Lang Cove was conducted in 1999 (Archipelago Marine Research Ltd. 2000d), and the results of this project should be consulted prior to initiating restoration efforts in this area of the harbour.

Eelgrass Beds

The quantity and extent of eelgrass habitat in Esquimalt Harbour is very small and, likely, less than historic levels (Section3.6). Bark and wood debris has impacted eelgrass habitat in Thetis Cove, dredging and foreshore fill has reduced eelgrass habitat in Lang Cove. Three possible remediation strategies for eelgrass beds in the harbour are (A) provide appropriate sized sediments at the right vertical elevation (+0.5m to –1.0m) then transplant eelgrass to these areas, (B) provide appropriate sized sediments at the right vertical elevation (+0.5m to –1.0m) and monitor natural colonization, (C) permit natural sedimentation to cap impacted areas, then either plant eelgrass or monitor natural colonization. Strategies may differ for individual sites. The success of eelgrass transplants in British Columbia have been mixed and factors such as appropriate substrate, elevation, source of transplant material, transplant methods and the experience of the restoration team are important to the success of transplant projects. A pilot scale assessment should be made before a large eelgrass transplant project in conducted in the harbour.

Accumulations of Man made Debris

As outlined in Section 4.2, clean up of accumulations of man-made debris in certain heavily used docks (A Jetty, the small docks east of C Jetty, Pilgrim Cove, and the docks at Dallas Bank), may remove potential sources of metal and hydrocarbon contaminants.

5.0 REFERENCES

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6.0 PERSONAL COMMUNICATIONS

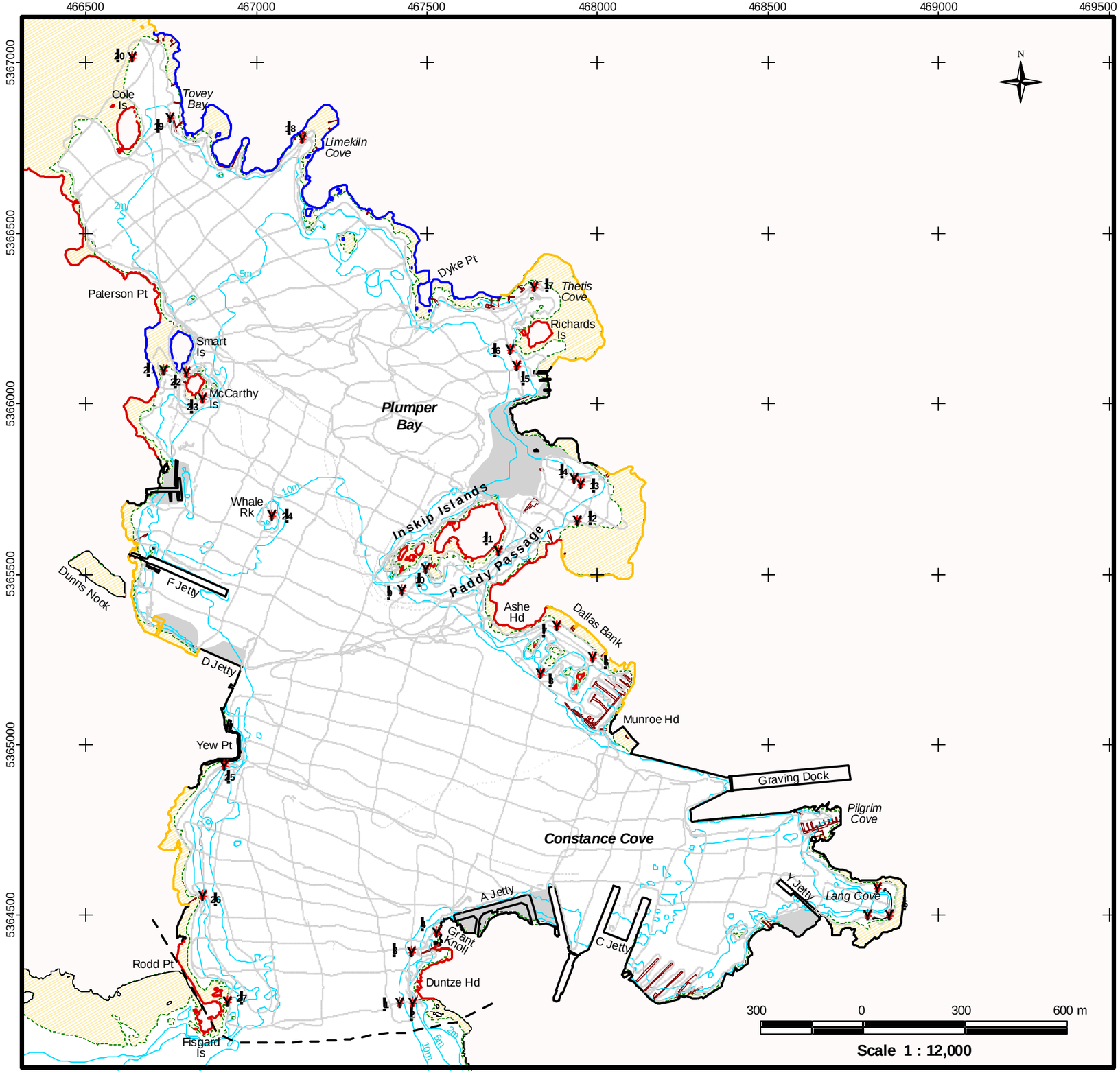
MacDonald, Robert. Transport Canada, Victoria and Esquimalt Harbours Environmental Program.

Trocher, Wade. Transport Canada, Victoria and Esquimalt Harbours Environmental Program.

7.0 MAP FOLIO

A Subtidal Survey of the Physical and Biological Features of Esquimalt Harbour

Figure 3. Video Survey Tracklines & Dive Observation Sites



¥ Dive Sites

(#) Site number (see Report text, Table 3)

- Shoreline
- Pier/Wharf/Jetty/Dock
- 0m Contour (Chart Datum)
- 2, 5, 10m Contours
- Survey Boundary
- Intertidal Zone
- Upland
- No Survey
- Survey Trackline

Physical Shore Type *

- Rock
- Rock and Sediment
- Sediment
- Estuary, Marsh or Lagoon
- Man-Made

* Source: Westland, 2000

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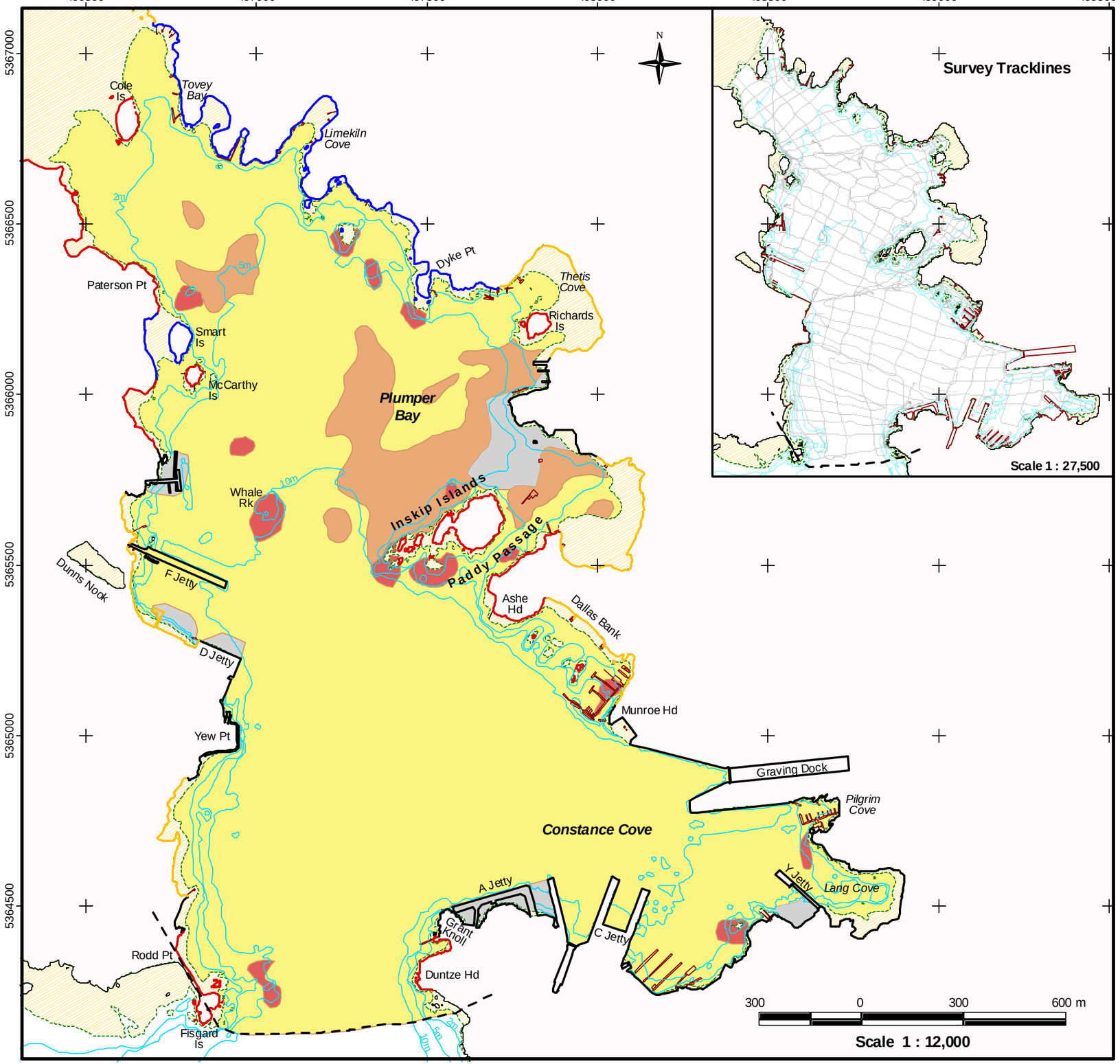
Figure 4. Substrate Type



Sediment

Rock or rock with sediment veneer

Wood & bark debris (substrate obscured)

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

Physical Shore Type *

Rock

Rock and Sediment

Sediment

Estuary, Marsh or Lagoon

Man-Made

* Source: Westland, 2000

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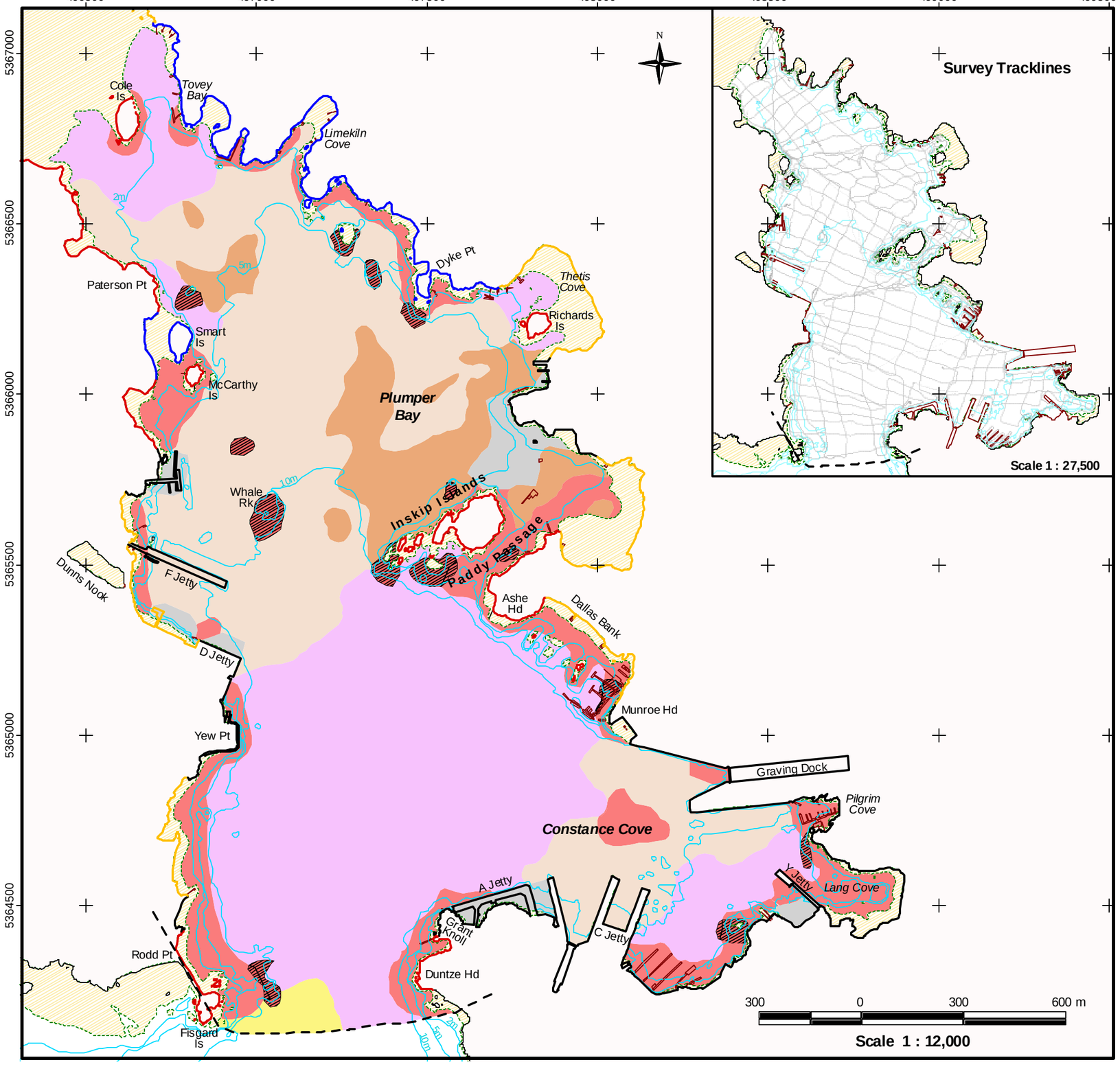
Figure 5. Sediment Size Class



- Gravel
- Gravelly Mud/Sand
- Mud/Sand
- Sand
- Rock or rock with sediment veneer
- Wood & bark debris (substrate obscured)

- Shoreline
- Pier/Wharf/Jetty/Dock
- 0m Contour (Chart Datum)
- 2, 5, 10m Contours
- Survey Boundary
- Intertidal Zone
- Upland
- No Survey
- Survey Trackline

Physical Shore Type *

- Rock
- Rock and Sediment
- Sediment
- Estuary, Marsh or Lagoon
- Man-Made

* Source: Westland, 2000

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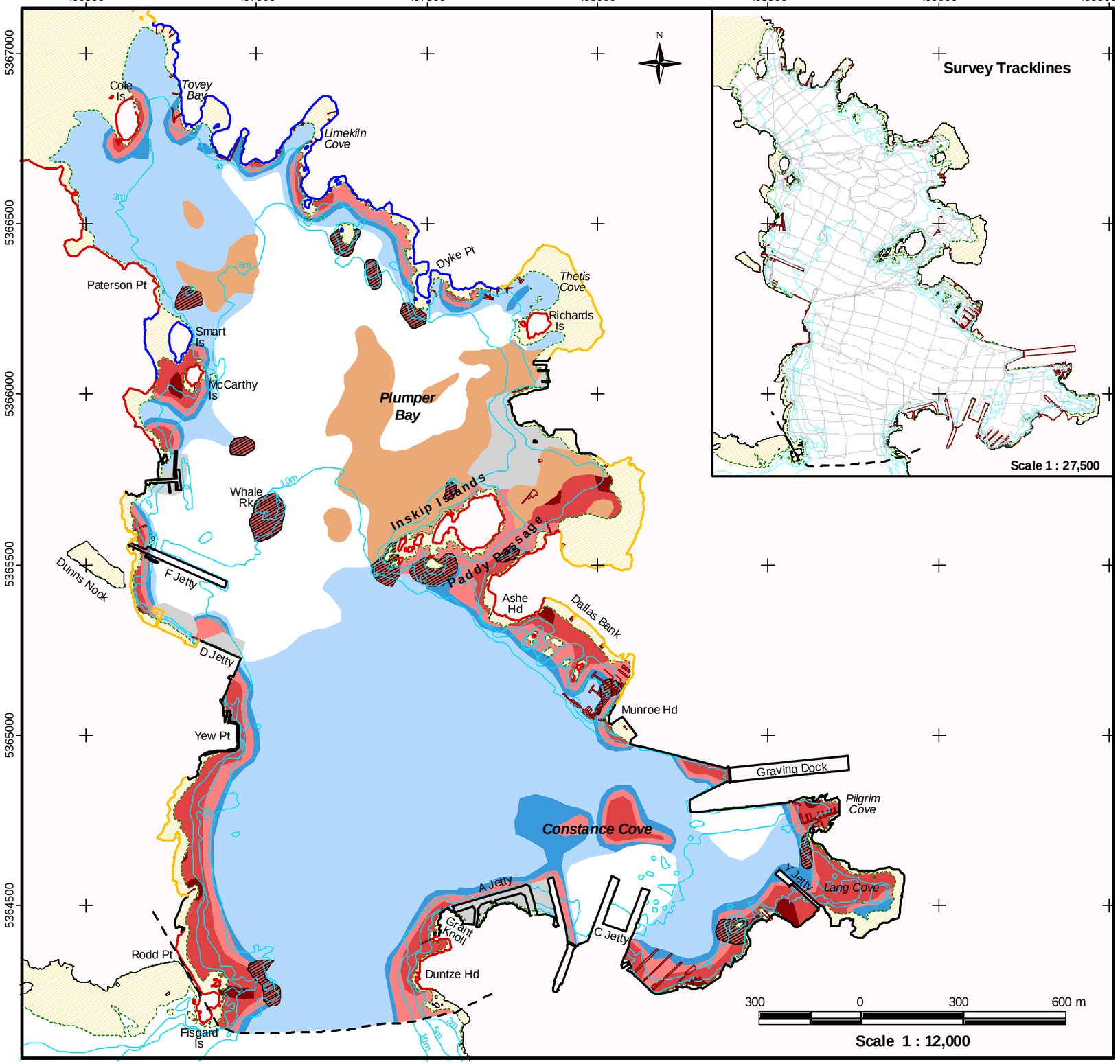
Figure 6. Gravel Cover



- Trace - 5%
- 5 - 30%
- 30 - 50%
- 50 - 80%
- > 80%
- Rock or rock with sediment veneer
- Wood & bark debris (substrate obscured)

- Shoreline
- Pier/Wharf/Jetty/Dock
- 0m Contour (Chart Datum)
- 2, 5, 10m Contours
- Survey Boundary
- Intertidal Zone
- Upland
- No Survey
- Survey Trackline

Physical Shore Type *

- Rock
- Rock and Sediment
- Sediment
- Estuary, Marsh or Lagoon
- Man-Made

* Source: Westland, 2000

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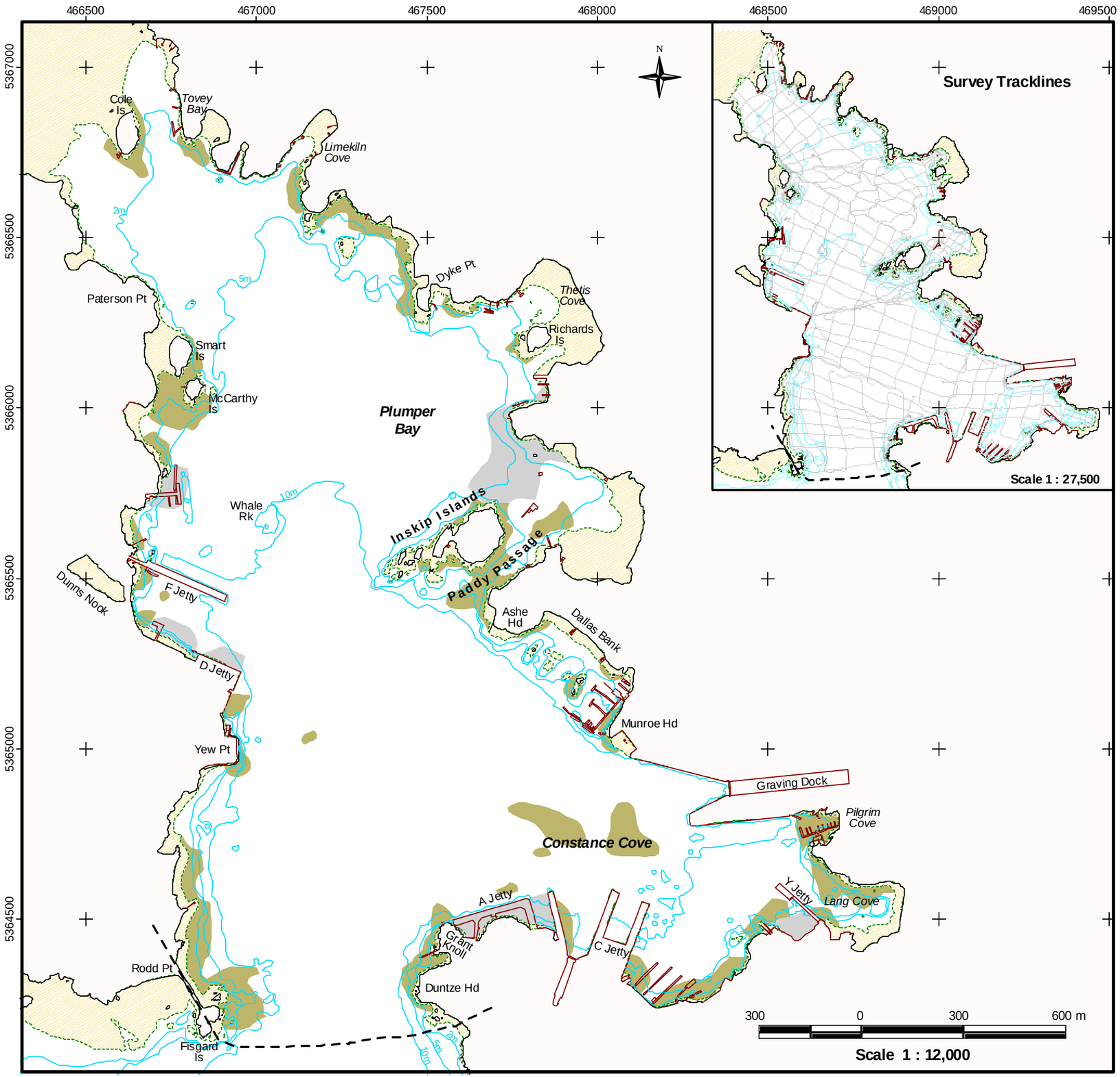
Figure 7. Boulder and Cobble Cover



Trace to 5%

- Shoreline
- Pier/Wharf/Jetty/Dock
- 0m Contour (Chart Datum)
- 2, 5, 10m Contours
- Survey Boundary
- Intertidal Zone
- Upland
- No Survey
- Survey Trackline

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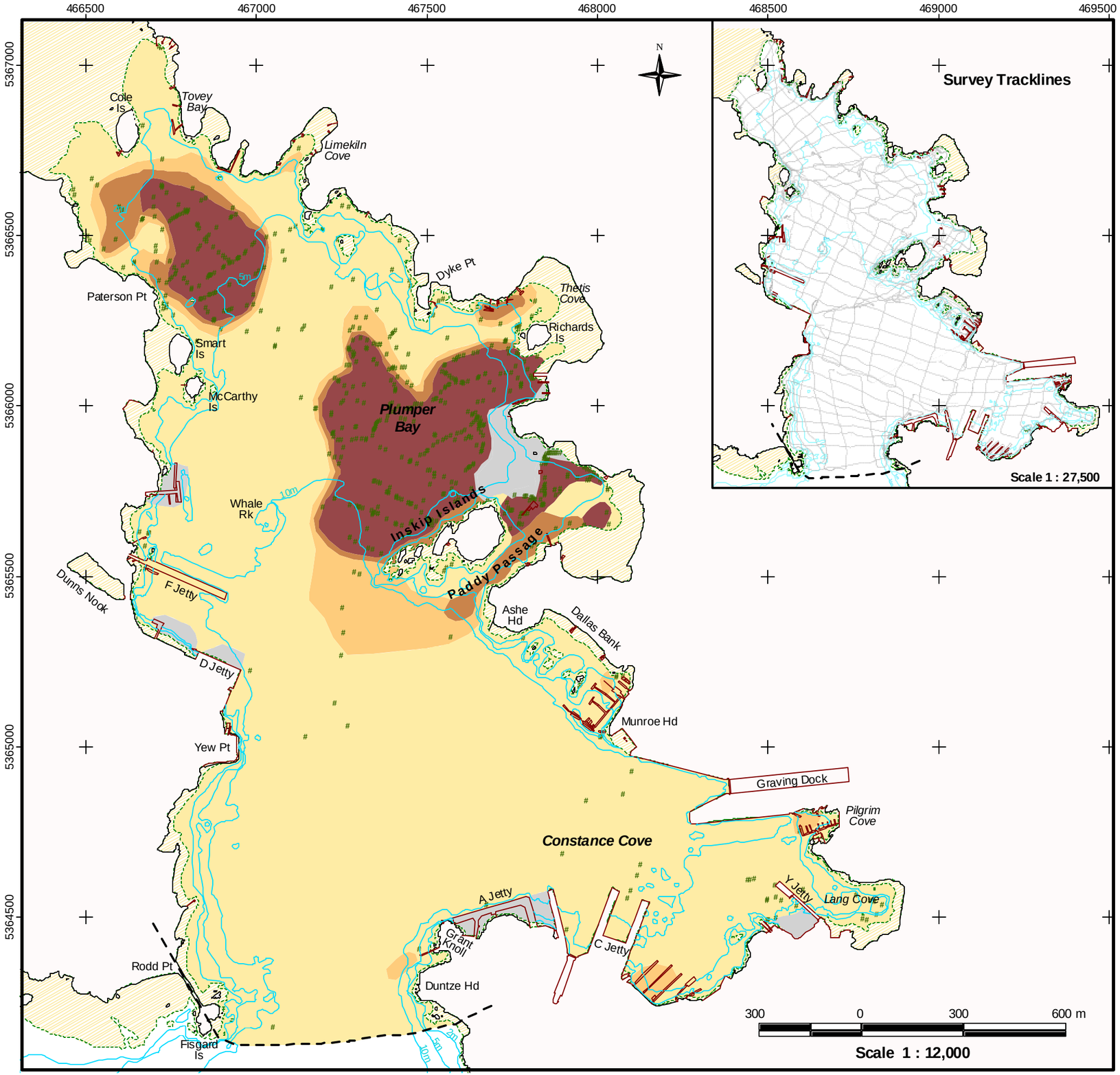
Figure 8. Organic Cover



Trace - 5%

5 - 30%

30 - 80%

> 80%

\# Logs

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

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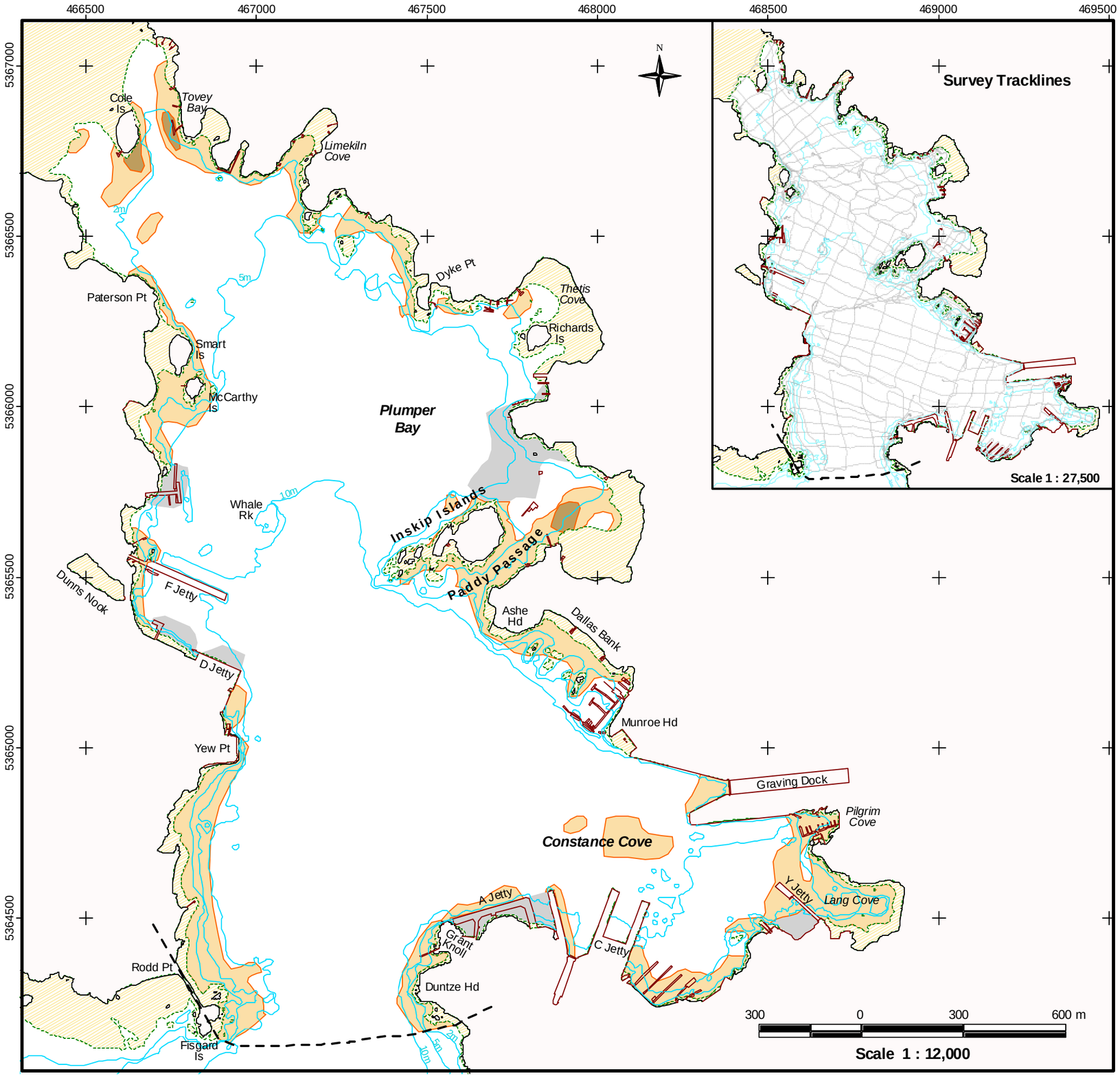
Figure 9. Shell Cover



5 - 30%

30 - 50%

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

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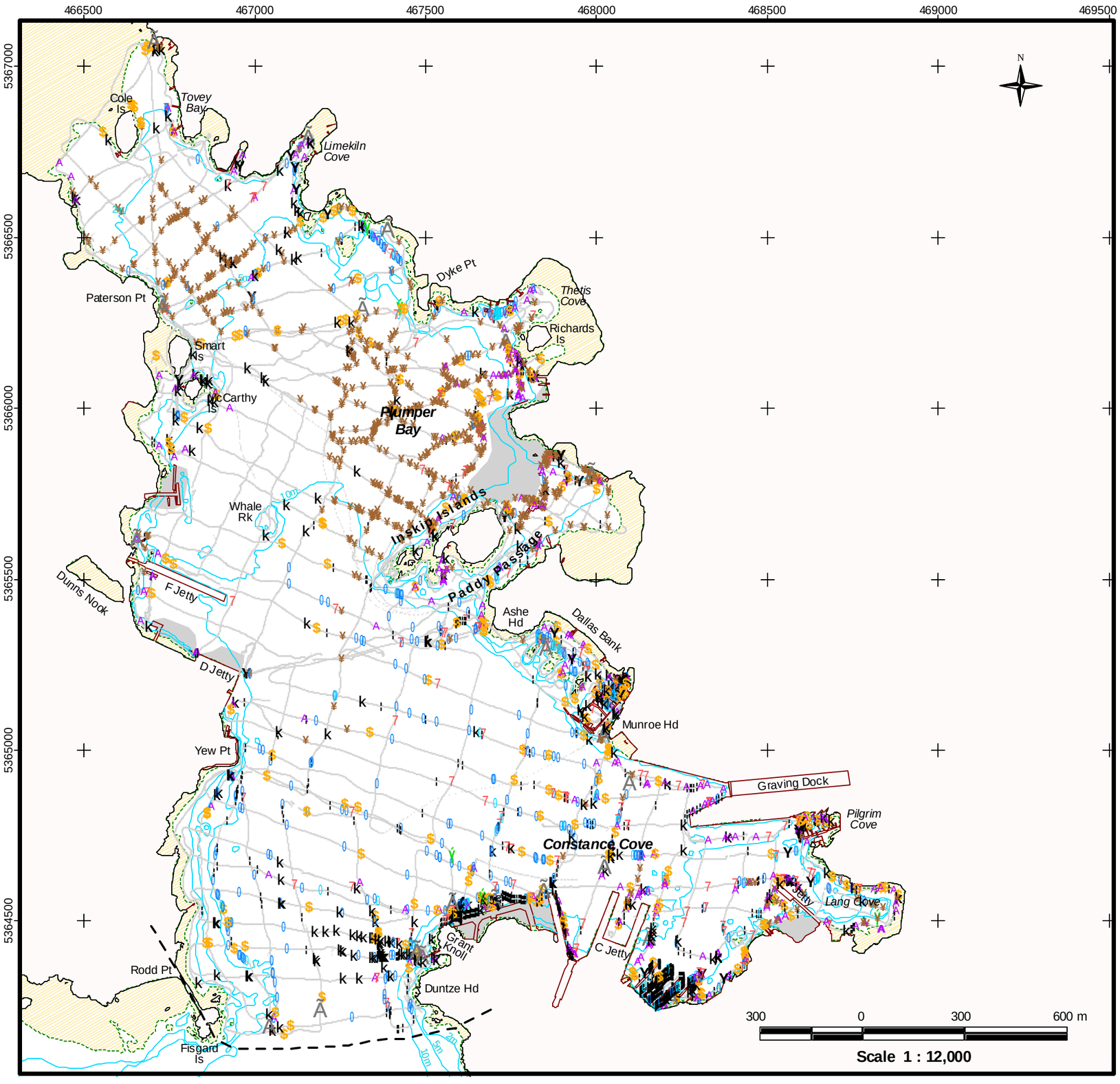
Figure 10. Man-made Objects



0	Bottle
0	Aggregation of Bottles
k	Cable/Wire/Rope
7	Cans
!	Garbage
¥	Logs
A	Metal Objects
$	Other
Ã	Pipe
Y	Tire
Ý	Wood Debris

Shoreline	Intertidal Zone
Pier/Wharf/Jetty/Dock	Upland
0m Contour (Chart Datum)	No Survey
2, 5, 10m Contours	Survey Trackline
Survey Boundary	

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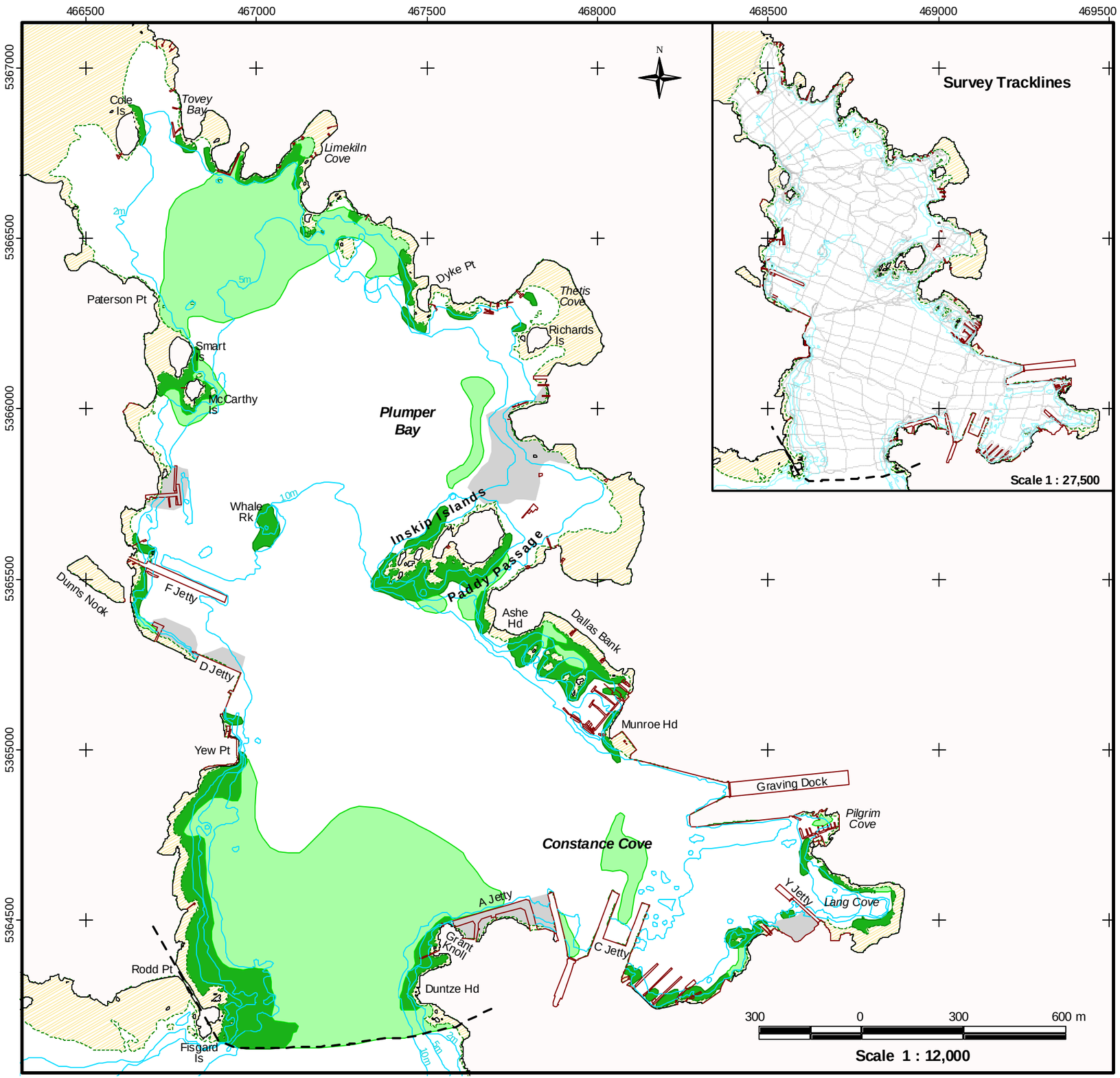
Figure 11. Vegetation Cover



Sparse - Low Cover (Trace - 25%)

Moderate - Dense Cover (25 - 100%)

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

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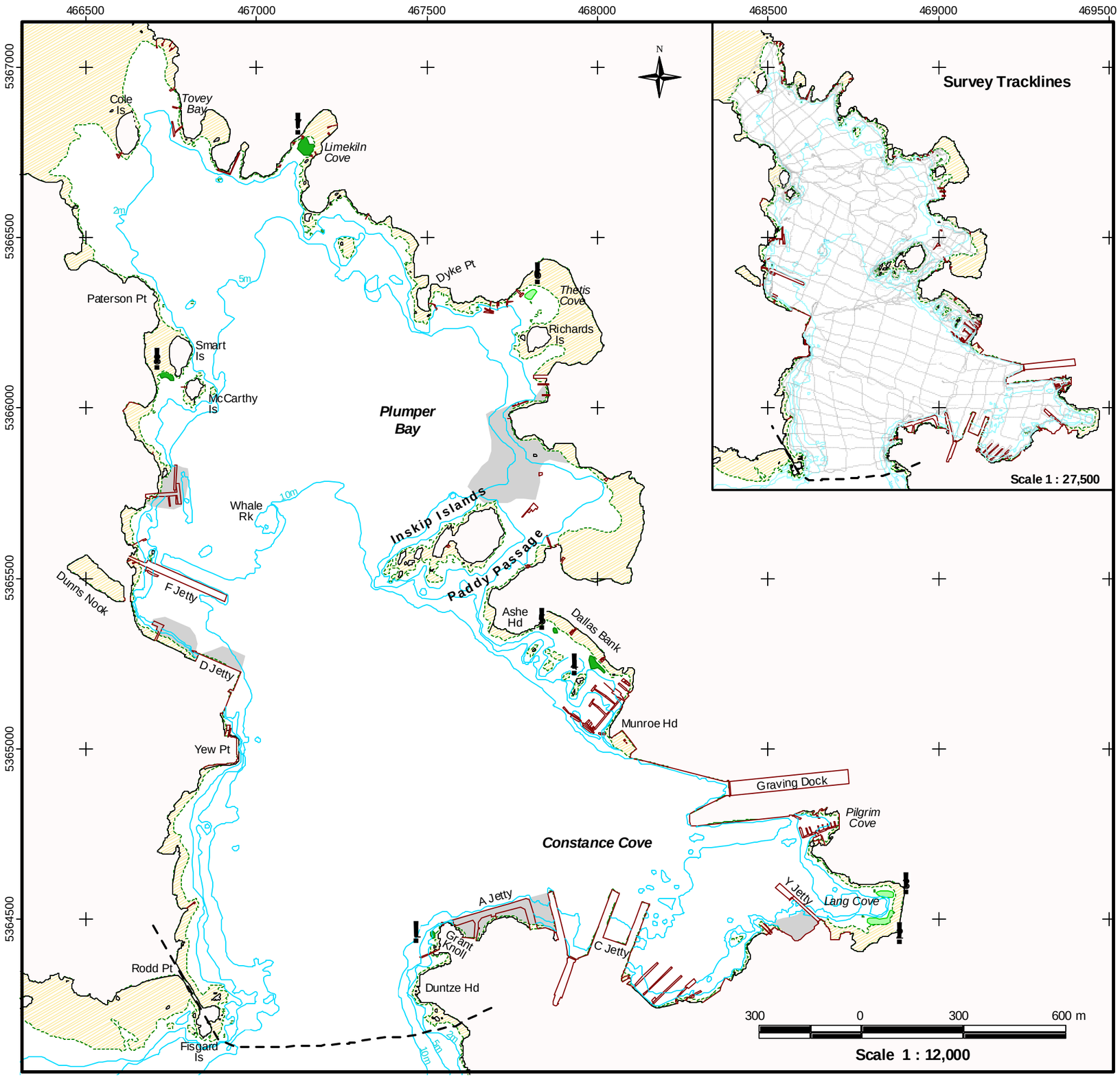
Figure 12. Eelgrass Beds *(Zostera marina)*



Sparse - Low Cover (Trace - 25%)

Moderate - Dense Cover (25 - 100%)

(#) Eelgrass Bed number (see Report text, Table 10)

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

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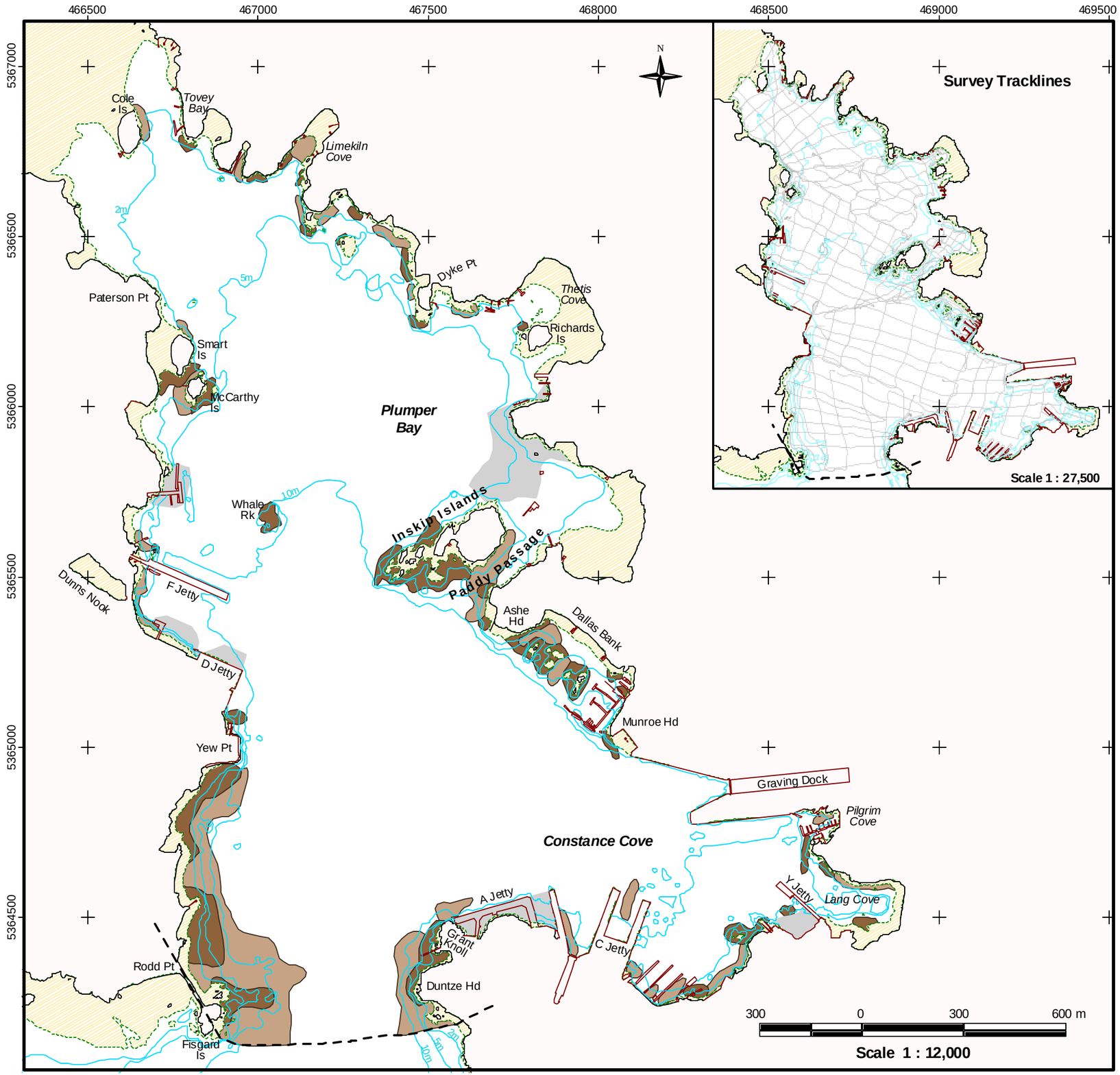

A Subtidal Survey of the Physical and Biological Features of Esquimalt Harbour

Figure 13. Kelps

Sparse - Low Cover (Trace - 25%)

Moderate - Dense Cover (25 - 100%)

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

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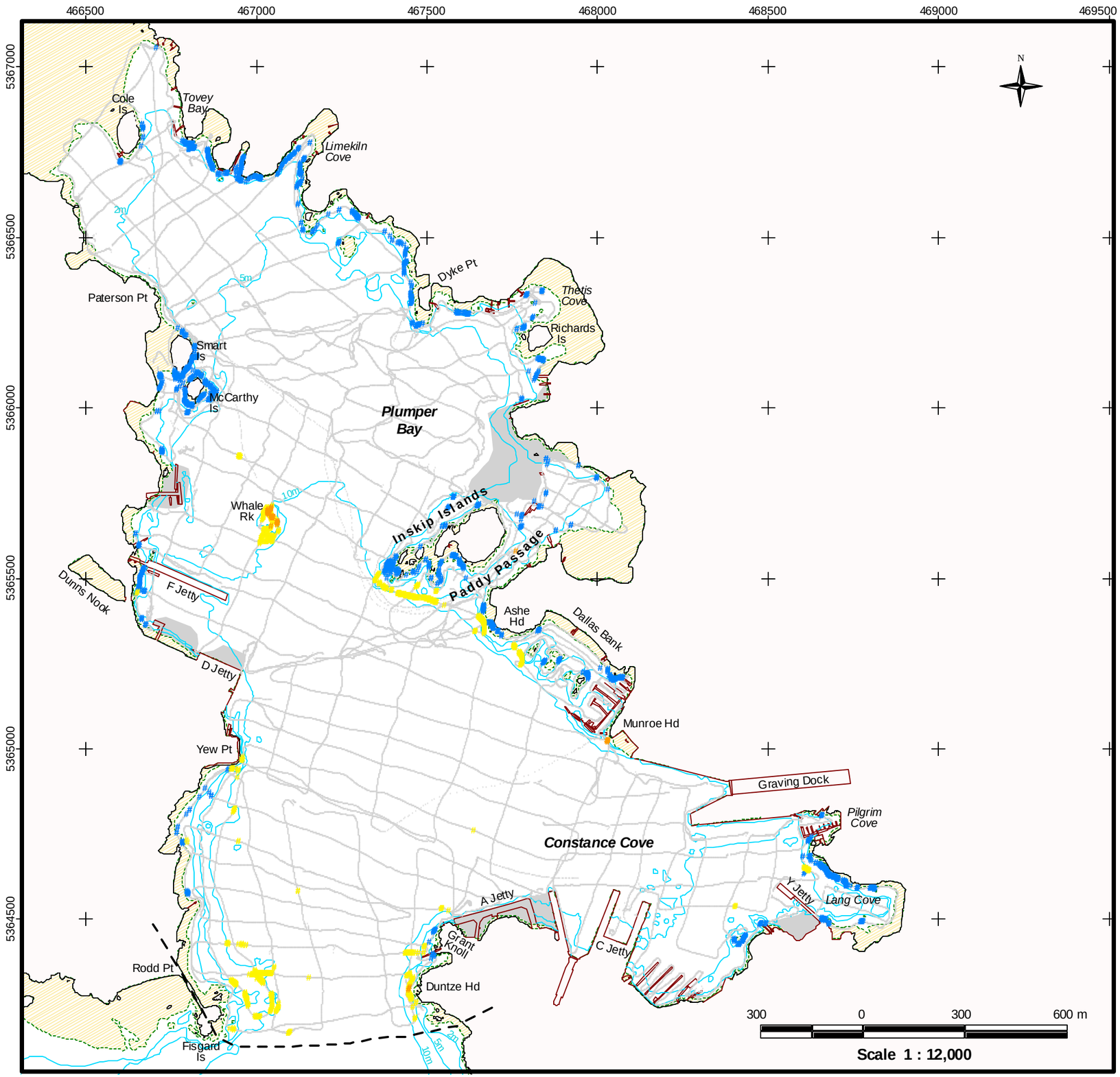

A Subtidal Survey of the Physical and Biological Features of Esquimalt Harbour

Figure 14.
Agarum, Nereocystis and Sargassum

\# ***Nereocystis leutkeana***

\# ***Agarum***

\# ***Sargassum muticum***

Shoreline
Pier/Wharf/Jetty/Dock
0m Contour (Chart Datum)
2, 5, 10m Contours
Survey Boundary
Intertidal Zone
Upland
No Survey
Survey Trackline

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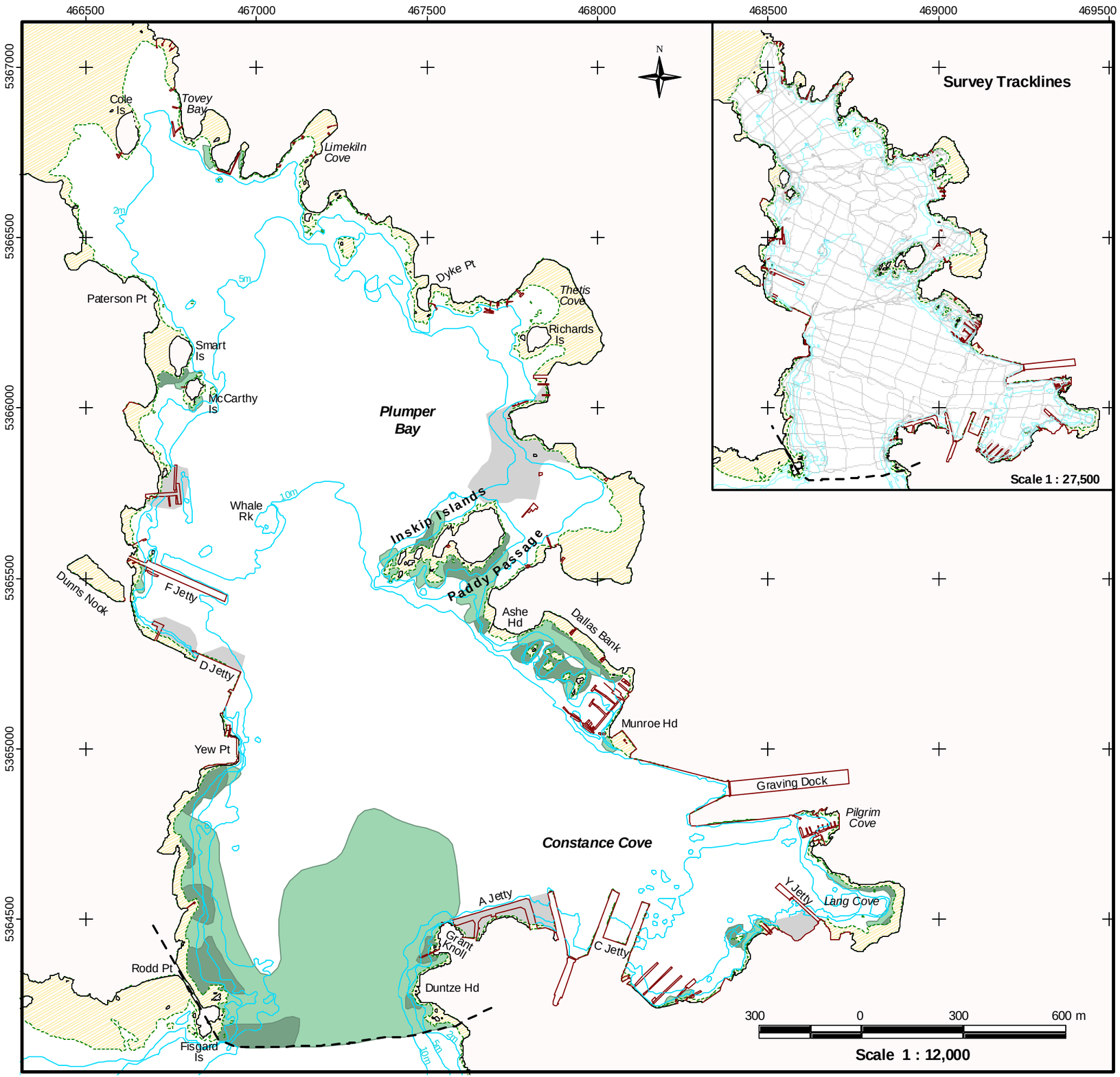
Figure 15. Foliose Green Algae



Sparse - Low Cover (Trace - 25%)

Moderate - Dense Cover (25 - 100%)

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

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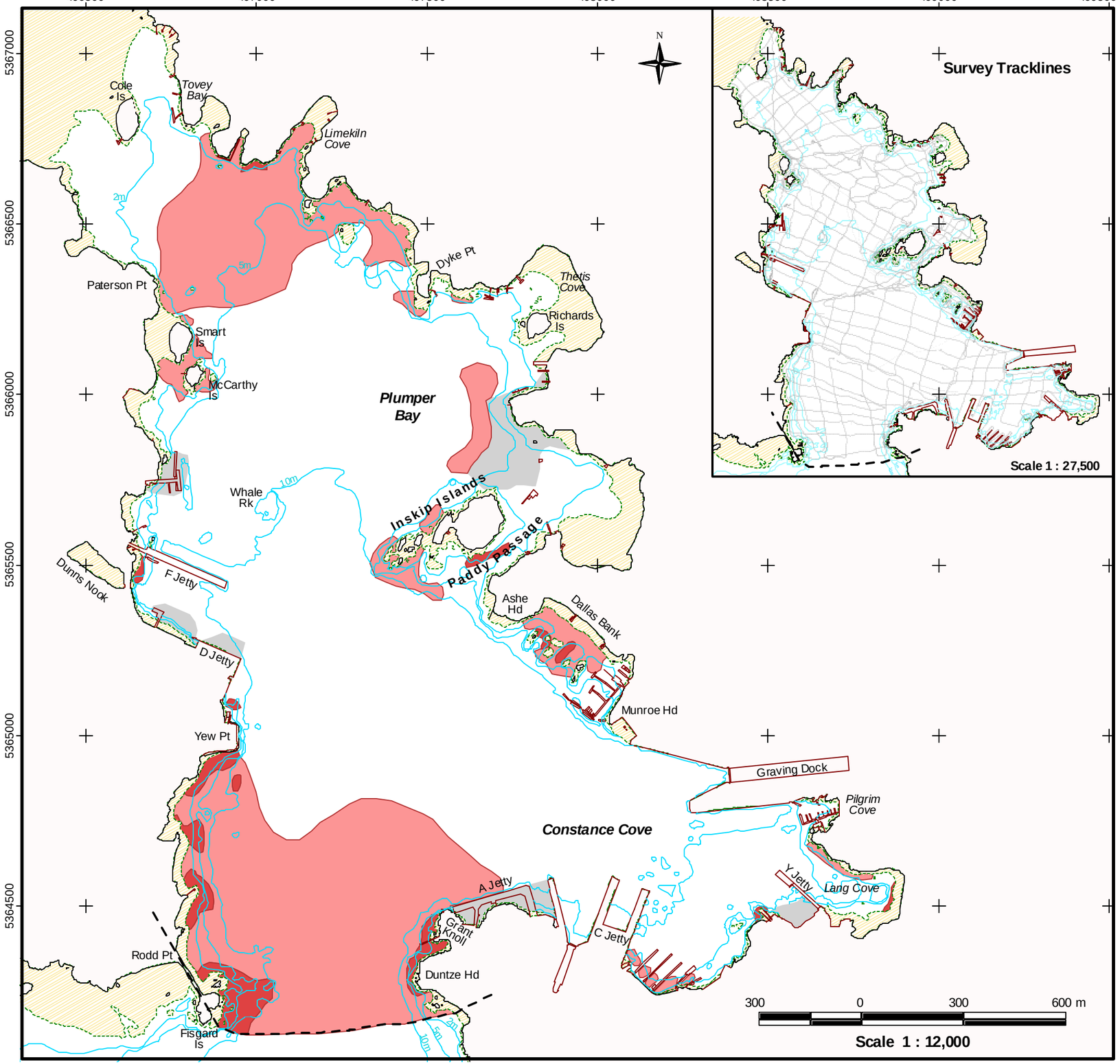
Figure 16. Filamentous Red Algae



Sparse - Low Cover (Trace - 25%)

Moderate - Dense Cover (25 - 100%)

Shoreline

Pier/Wharf/Jetty/Dock

0m Contour (Chart Datum)

2, 5, 10m Contours

Survey Boundary

Intertidal Zone

Upland

No Survey

Survey Trackline

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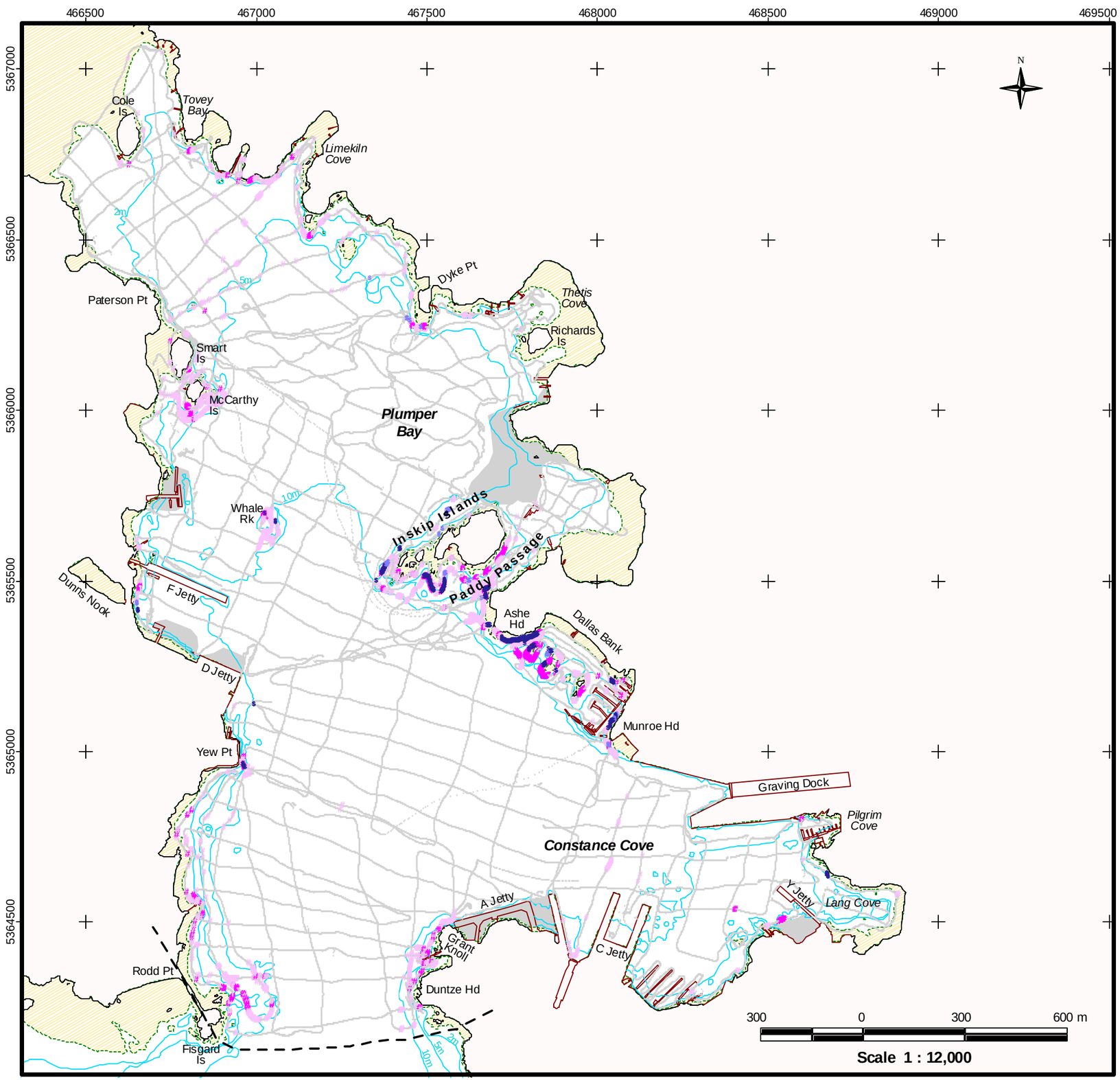
Survey Dates:
SIMS: March 21-31, 2000
Dive: May 25-29, 2000
June 27-28, 2000

Map Edition:
February 5, 2004



A Subtidal Survey of the Physical and Biological Features of Esquimalt Harbour

Figure 17. Foliose & Coralline Red Algae

Foliose Red Algae

\# Sparse - Low Cover (Trace - 25%)

\# Moderate - Dense Cover (25 - 100%)

Coralline Red Algae

$ Sparse - Low Cover (Trace - 25%)

$ Moderate - Dense Cover (25 - 100%)

- Shoreline
- Pier/Wharf/Jetty/Dock
- 0m Contour (Chart Datum)
- 2, 5, 10m Contours
- Survey Boundary
- Intertidal Zone
- Upland
- No Survey
- Survey Trackline

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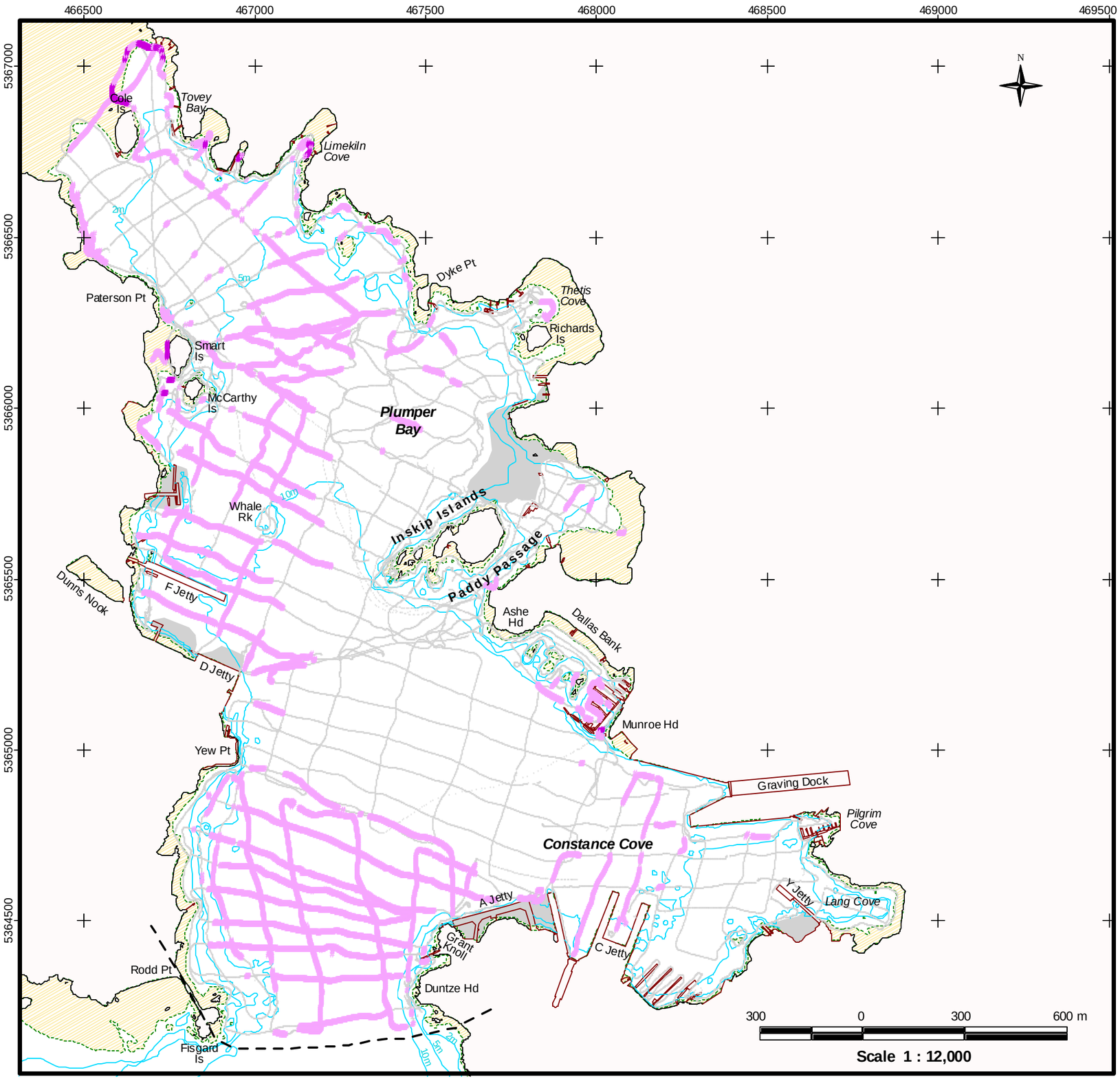
Figure 18. Infaunal Burrows



Distribution

- # Few/Patchy
- # Continuous

- Shoreline
- Pier/Wharf/Jetty/Dock
- 0m Contour (Chart Datum)
- 2, 5, 10m Contours
- Survey Boundary
- Intertidal Zone
- Upland
- No Survey
- Survey Trackline

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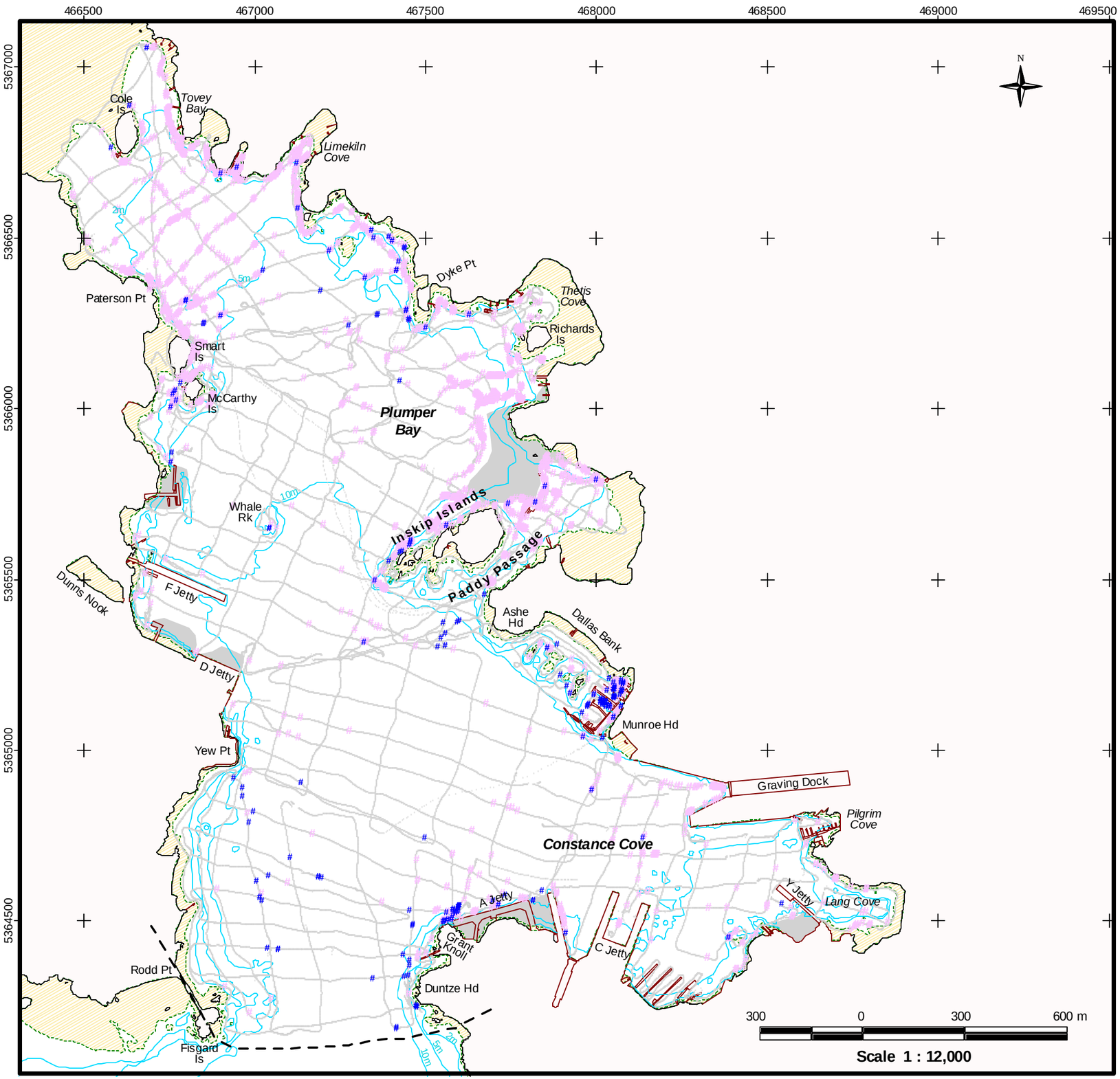
Figure 19. Anemones



- # *Metridium*
- # *Urticina sp. (Tealia)*

Shoreline
Pier/Wharf/Jetty/Dock
0m Contour (Chart Datum)
2, 5, 10m Contours
Survey Boundary
Intertidal Zone
Upland
No Survey
Survey Trackline

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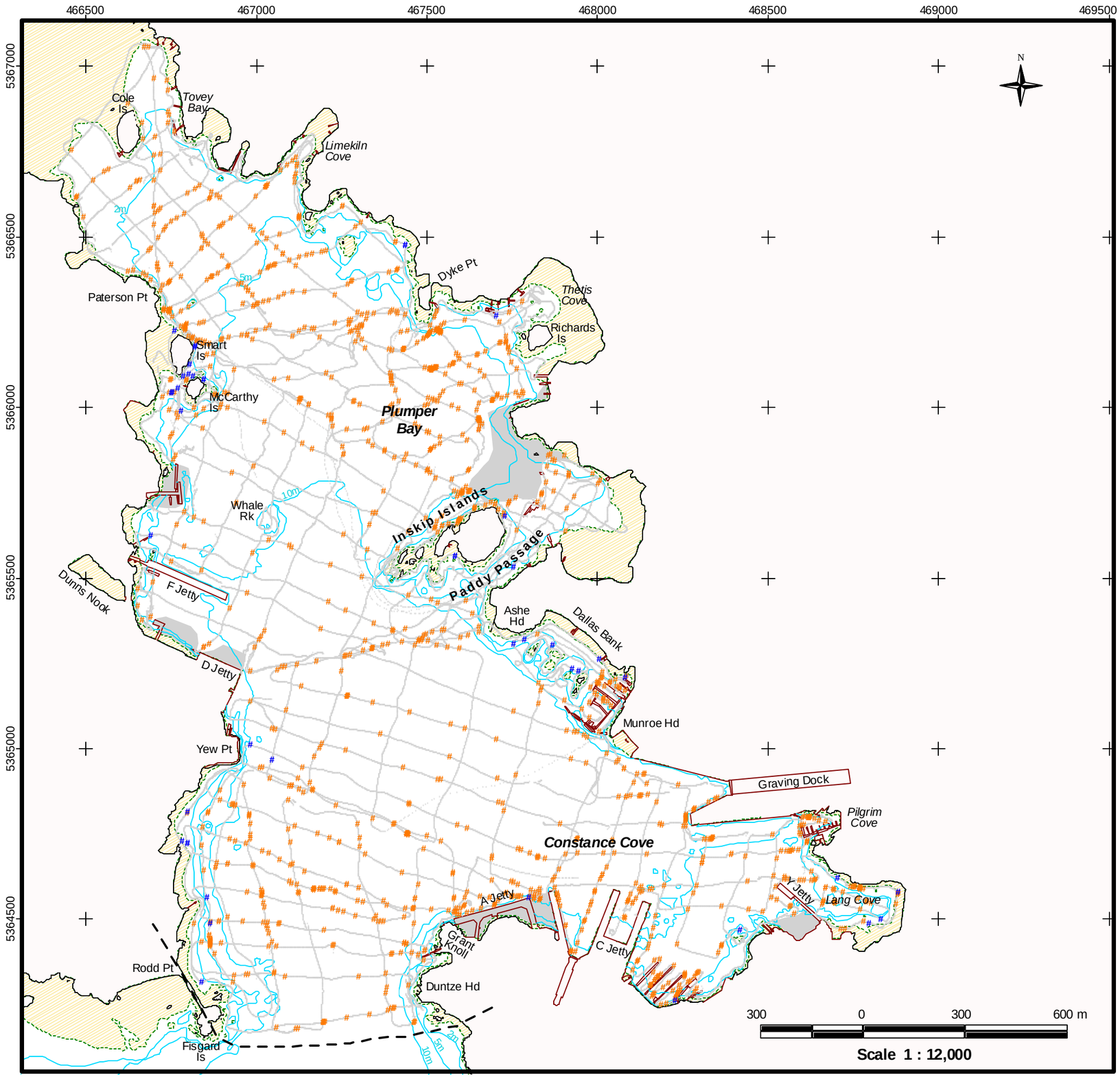

A Subtidal Survey of the Physical and Biological Features of Esquimalt Harbour

Figure 20. Crabs

\# ***Cancer sp. (C. magister, C. gracilis)***

\# **Red Rock Crabs**
(Cancer productus)

Shoreline
Pier/Wharf/Jetty/Dock
0m Contour (Chart Datum)
2, 5, 10m Contours
Survey Boundary
Intertidal Zone
Upland
No Survey
Survey Trackline

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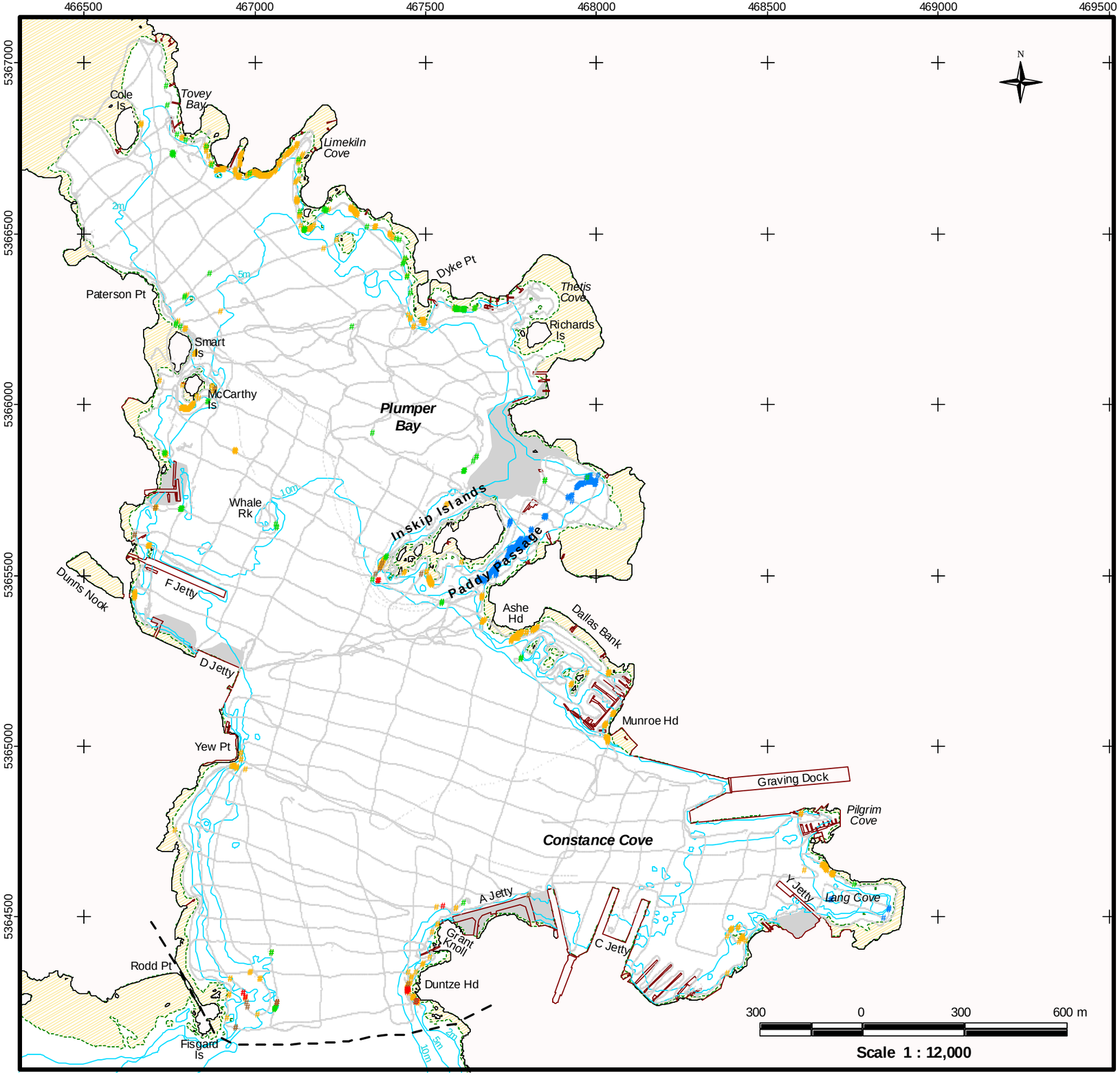
Figure 21. Other Invertebrates



- # **Red Sea Urchins** *(Strongylocentrotus franciscanus)*
- # **California Sea Cucumbers** *(Parastichopus californicus)*
- # **Burrowing Sea Cumbers** *(Cucumaria miniata)*
- # **Piddock Clams** *(Zirfaea pilsbryi)*
- # **Bryozoans**

Shoreline
Pier/Wharf/Jetty/Dock
0m Contour (Chart Datum)
2, 5, 10m Contours
Survey Boundary
Intertidal Zone
Upland
No Survey
Survey Trackline

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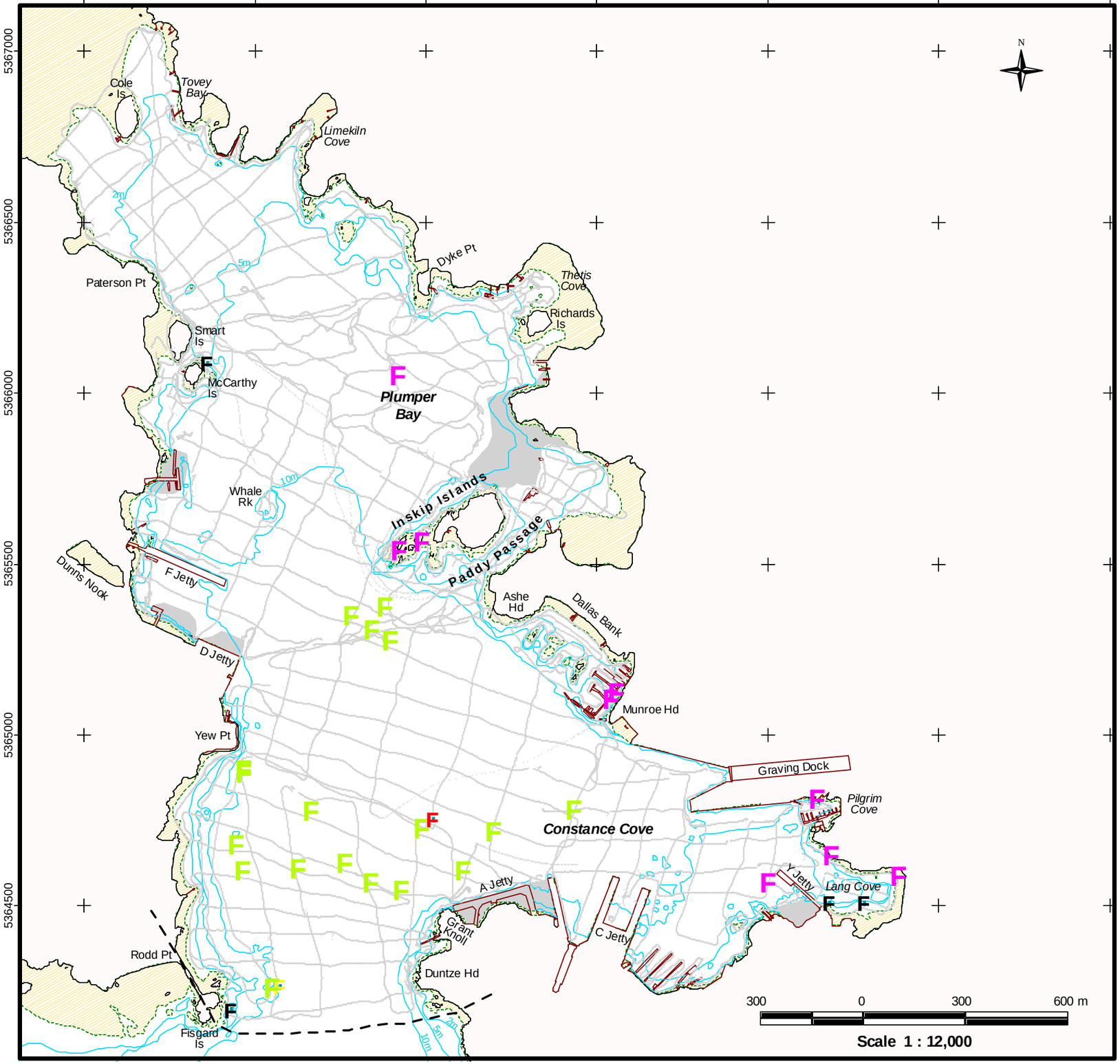
Figure 22. Fish Observations



F Greenling
F Perch
F Sculpin
F Sole
F Unidentified Fish

Shoreline
Pier/Wharf/Jetty/Dock
0m Contour (Chart Datum)
2, 5, 10m Contours
Survey Boundary
Intertidal Zone
Upland
No Survey
Survey Trackline

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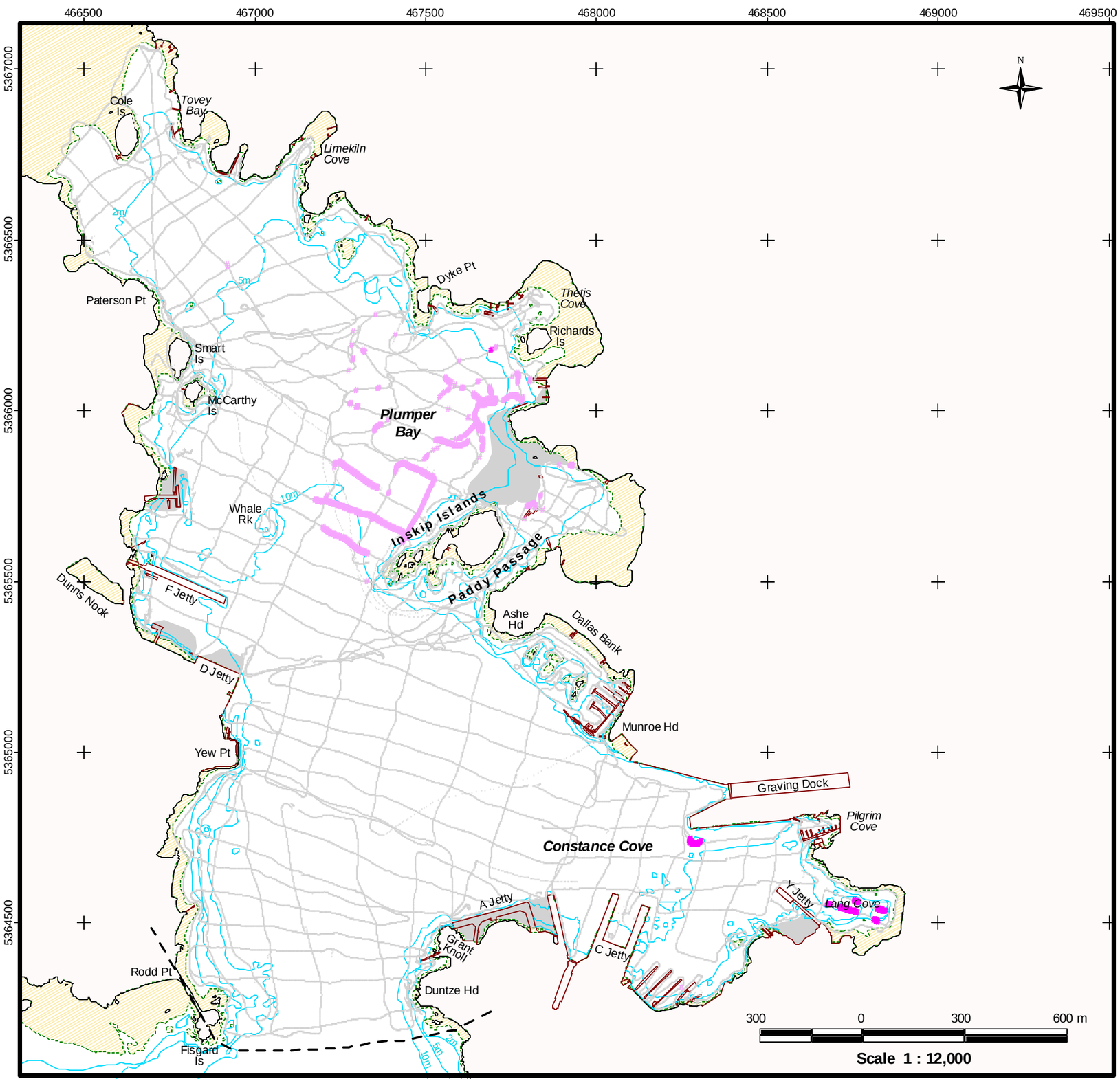
Figure 23. Bacterial Mats



Distribution

- # Few/Patchy
- # Uniform

- Shoreline
- Pier/Wharf/Jetty/Dock
- 0m Contour (Chart Datum)
- 2, 5, 10m Contours
- Survey Boundary
- Intertidal Zone
- Upland
- No Survey
- Survey Trackline

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APPENDIX A

Video Classification Data Dictionary

The UVI database is in ACCESS97. There are three separate tables or databases included:

- **Navigation (NavData)** – includes all navigation data for the survey, including both geographic and UTM locational fixes and uncorrected depth data.
- **Geology (GeoData)** – information of seabed substrate and on seabed geomorphology.
- **Biology (BioData)**– information on epiflora and epifauna classifications.

The UVI Seabed Database is summarized in Tables A-1, A-2 and A-8. The associated data dictionary and field descriptions are outlined to provide users with a defined procedure for professionally classifying video imagery. The data are from the data logging system (date, time, latitude, longitude) or professional classifications.

A.1 Navigation Database (NavData)

A summary of the data fields contained in the navigation database is provided in Table A-1 and detailed explanation of each field follows.

INDEX
A unique identification number identifying the record and linking the navigation, geology and biology data records.

ID2
Temporary index number

DATE
The date is entered in a "month-day-year" format. The date information is provided by the DGPS data string and automatically entered into the database.

TIME(UTC)
The UTC time (GMT) in a combined "hour:minute:second" format. The UTC time is provided in the DGPS data string and automatically entered into the database.

TAPE_NO
The videotape number associated with the fix point.

FISH_DEPTH
Depth of video tow fish corrected to tidal datum using predicted tidal data.

Table A-1 Summary of Navigation Data Fields

Field	Description
INDEX	unique point identification number
ID2	temporary index number indicating sequence on each GPS data file
DATE	month/day/year
TIME	UTC time of frame (hr:min:sec)
TAPE_NO	videotape number
FISH_DEPTH	Depth of tow fish, corrected to chart datum
UTM_N	UTM northing position
UTM_E	UTM easting position

UTM_N
The UTM northing, computed from the DGPS geographic positional data using batch program "Convert", developed by CHS and incorporating project and GEOD considerations. Required for use in ArcView with UTM base maps (e.g., NDI/DXF charts).

UTM_E
The UTM easting, computed from the DGPS geographic positional data using batch program "Convert", developed by CHS and incorporating projection and GEOD considerations. Required for use in ArcView with UTM base maps (e.g., NDI/DXF).

IMAGE
A text field indicating if an image capture exists.

A.2 Geology Database (GeoData)

The geology database (Table A-2) provides a comprehensive summary of seabed characteristics including substrate size, percentages of coarser seabed materials and seabed morphology.

INDEX

A unique identification number identifying the record and linking the navigation, geology and biology data records.

DATE

The date is entered in a "month-day-year" format. The date information is provided by the GPS data string and automatically entered into the database.

TIME(UTC)

The UTC time (GMT) in a combined "hour:minute:second" format. The UTC time is provided in the GPS data string and automatically entered into the database.

SUBSTRATE

The general classification schema follows other provincial mapping guides in terms of substrate classes. Four general classes of substrate provide a very general index of substrate composition:

rock (R) – bedrock outcrop; may be partially covered with a veneer of sediment

veneer over bedrock (vR) – intermittently visible bedrock covered with a thin veneer of clastic sediments.

clastic (C) – seabed comprised of mineral grains of gravel, sand or mud sized material.

biogenic (B) – surface of seabed comprised of material of biogenic origin such as vegetation.

wood (W) – wood debris or bark completely covering the mineral grains.

SED_CLASS

Seabed sediment characteristics are based on visual estimates of clast sizes (Table A-3) on the seabed and percentage occurrence. Each clast category will be estimated in terms of *projected area surface cover*. The *projected area surface cover* is defined as the total projected area in a horizontal plane of each sediment category, estimated to the nearest 10%.

Table A-2 Summary of Geology Data Fields

Field	Description
INDEX	unique point identification number
DATE	month/day/year
TIME(UTC)	UTC time of frame (hr:min:sec)
SUBSTRATE	the general substrate of the seabed (rock, veneer, clastics, biogenic)
SED_CLASS	11 classes of clastic sediment
BOULDER	% pebbles on the seabed by class
COBBLE	% cobbles on the seabed by class
PEBBLE	% boulders on the seabed by class
GRAVEL	% gravel; sum of pebbles, cobbles and boulders by class
ORGANICS	% of visible wood or organic debris on the seabed by class
SHELL	% of coarse shell on the seabed by class
MORPH	primary secondary and tertiary morphologic features of the seabed
MAN_MADE	man-made objects seen on the seabed
GEOMAPPER	last name of individual responsible for the mapping interpretation
COMMENT	field for recording non-standard information

Table A-3 Sediment Categories Used in the UVI Classification

Sediment Category	Size (intermediate axis)	General Category
boulder	>25.6cm	GRAVEL
cobble	6.4 to 25.6cm	
pebble	4mm to 6.4cm	
granules	2-4mm	
sand	0.062 to 2mm	SAND
mud	<0.62mm	MUD
shell (coarse)	>2mm	ORGANICS
organic debris	n/a	
wood debris	n/a	

A description of 11 sediment classes based on a systematic application of percentage of gravel and the sand: mud ratio estimates. The classification system is summarized in Table A-4.

Table A-4 Sediment Class Code

Gravel Content	>90% Mud	Mud/Sand Mixture	>90%Sand
>80%	gravel: **G**		
30-80%	-	muddy-sandy gravel: **msG**	sandy gravel: **sG**
5-30%	-	gravelly mud/sand: **gMS**	gravelly and: **gS**
T-5%	slightly gravelly mud: **(g)M**	slightly gravelly mud/sand: **(g)MS**	slightly gravelly sand: **(g)S**
0%	mud: **M**	mud/sand: **MS**	sand: **S**

BOULDER

An estimate of the percent boulders (>25.6cm) covering the surface of the seabed (Table A-5)

Table A-5 Gravel, Shell and Organic Cover Classes

Class Code	% Clast or Cover
1	none
2	T-5%
3	5-30%
4	30-50%
5	50-80%
6	>80%

COBBLE

An estimate of the percent cobbles (6.4cm to 25.6cm) covering the surface of the seabed (Table A-5).

PEBBLE

An estimate of the percent pebbles (2mm to 6.4cm) covering the surface of the seabed in one of 6 classes (Table A-5).

GRAVEL

The total estimate by class (Table A-5) of pebbles, cobbles and boulders. The percent gravel estimate should be consistent with the categories in the SED_CLASS field.

ORGANICS

An estimate of the percent of organics or wood debris covering the surface of the seabed (Table A-5).

SHELL

An estimate of the percent coarse shell (>2mm) covering the surface of the seabed (Table A-5).

MORPH

The MORPHOLOGY field provides a qualitative indication of features on the seabed. The classification is provisional. Classes are summarized in Table A-6.

Table A-6 Codes for Man-Made Objects

Code	Object
B	bottle or can
BB	aggregation of bottles or cans
C	cable/wire/rope
CN	cans
G	Garbage such as undistinguishable trash
L	log/logs
M	metal object
O	other; specific object listed in comment field
P	pipe
T	tire
WD	wood debris

MAN_MADE

A code for man-made objects that are visible on the seabed (Table A-7).

GEOMAPPER

The last name of the individual responsible for the interpretation of the GeoData fields.

COMMENT

A data field for recording information that may not be captured by the standard data fields.

A.3 Biology Database (BioData)

The biology database provides an overview of the seabed biota and is subdivided into both an *Epiflora* or vegetation section and a *Fauna* or animal section (Table A-8). The data is derived entirely from interpretation of the imagery; no measurements are made as part of the interpretation.

INDEX

A unique identification number identifying the record and linking the navigation, geology and biology data records.

DATE

The date is entered in a "month-day-year" format. The date information is provided by the GPS data string and automatically entered into the database.

TIME(UTC)

The UTC time (GMT) in a combined "hour:minute:second" format. The UTC time is provided in the GPS data string and automatically entered into the database.

FISH_DEPTH

Depth of video tow fish corrected to tidal datum using predicted tidal data.

VEGMAP

Temporary code for vegetation map types.

VEG1

The VEG1 field indicates the primary vegetation type. Marine plant assemblages which are categorised in coastal waters to 20m are summarised in Table A-9; all surveyed areas should be assignable to one of these categories

COV1

The coverage (Table A-10) of the VEG1 type.

VEG2

The VEG2 field indicates the secondary vegetation type (Table A-9).

COV2

The coverage (Table A-10) of the VEG2 type.

Table A-7 Summary of Biology Data Fields

Field	Description
INDEX	unique point identification number
DATE	month/day/year
TIME(UTC)	UTC time of frame (hr:min:sec)
FISH_DEPTH	Depth of tow fish, corrected to chart datum
VEGMAP	code for vegetation map types
VEG1	primary vegetation assemblage on the seabed
COV1	coverage of the VEG1 vegetation (1,2,3 or 4)
VEG2	secondary vegetation assemblage on the seabed
COV2	coverage of the VEG2 vegetation (1,2,3 or 4)
VEG3	tertiary vegetation assemblage on the seabed
COV3	coverage of the VEG3 vegetation (1,2,3 or 4)
TOT_COV	total coverage of vegetation on the seabed
FAUN1	primary faunal type
DIST1	distribution of the FAUNA1 type
FAUN2	secondary faunal type
DIST2	distribution of the FAUNA2 type
FAUN3	tertiary faunal type
DIST3	distribution of the FAUNA3 type
BIOMAPPER	last name of the biology mapper
COMMENT	field for non-standard data comments

VEG3

The VEG3 field indicates the tertiary vegetation type (Table A-9)

COV3

The coverage (Table A-10) of the VEG3 type.

TOT_COV

The total coverage of vegetation on the seabed following Table A-10. This is an independent estimate and not necessarily the sum of the COV1, COV2 and COV3 fields.

Table A-8 Vegetation Coverage Codes

Code	Class	Abundance
0	None	no visible vegetation
1	Sparse	less than 5% cover
2	Low	5 to 25% cover
3	Moderate	26 to 75% cover
4	Dense	>75% cover

Table A-9 Vegetation Classification

ALGAL GROUP	SUBGROUP	CODE	DESCRIPTION
Green Algae	Foliose Greens	FOG	Primarily *Ulva*, but also include *Enteromorpha* and *Monostroma.*
	Filamentous Greens	FIG	The various filamentous green/red assemblages (*Spongomorpha/Cladophora* types).
Brown Algae	Fucus	FUC	*Fucus* and *Pelvetiopsis* species groups.
	Sargassum	SAR	*Sargassum* is the dominant and primary algal species.
	Soft Brown Kelps	BKS	Large laminarian bladed kelps, including *L. saccharina* and *groenlandica*, *Costaria costata, Cymathere triplicata.*
	Dark Brown Kelps	BKD	The LUCO chocolate brown group,. *L. setchelli, Pterygophora, Lessoniopis. Alaria* and *Egregia* may also be present. Generally more exposed than soft browns.
	Agarum	AGR	*Agarum* is the dominant species but other laminarians may also occur. Generally found deeper than the other Laminarian subgroup.
	Macrocystis	MAC	beds of canopy forming giant kelp.
	Nereocystis	NER	beds of canopy forming bull kelp.
Red Algae	Foliose Reds	FOR	A diverse species mix of foliose red algae (*Gigartina*, *Iridea, Rhodymenia, Constantinia*) which may be found from the lower intertidal to depths of 10m primarily on rocky substrate.
	Filamentous Reds	FIR1	A diverse species mix of filamentous red algae (including *Gastroclonium, Odonthalia, Prionitis*) which may be found from the lower intertidal to depths of 10m, often co-occuring with the foliose red group described above.
	Filamentous Reds	FIR2	A mix of red algae (primarily *Neoagardhiella* and *Gracilaria*) which grow on shallow, sub-tidal cobble and pebble in fine sand and silt bottoms.
	Halosaccion	HAL	*Halosaccion glandiforme*
	Coralline Reds	COR	rocky areas with growths of encrusting and foliose forms of coralline algae.
Seagrasses	Eelgrass	ZOS	eelgrass beds.
	Surfgrass	PHY	Areas of surfgrasses (*Phyllospadix*), which may co-occur with subgroup BKS or BKD above.
No Vegetation		NOV	No vegetation observed
Cannot Classify		X	Imagery is not clear, classification not possible.

FAUNA1

FAUNA1 is the primary faunal type noted on the seabed (Table A-11). The faunal classification focuses on sessile, aggregating species or species groups. They are not all epifauna - we have included tube worms, bivalves, burrowing anemones which, although strictly speaking are infauna, are important, visible elements of soft bottom communities. Species have been grouped by feeding habit as this can help to relate faunal composition to the physical environment.

This not a comprehensive faunal classification system; one maps all fauna in all areas. Blank areas do not mean no animals, simply no animal groups which fit easily in the groupings given below.

DIST1

An estimate of the *distribution* of individuals of the FAUNA1 type based on Table A-12.

FAUNA2

FAUNA2 is the secondary faunal type (Table A-11).

DIST2

An estimate of the *distribution* of individuals of the FAUNA2 type based on Table A-12.

FAUNA3

FAUNA3 is the secondary faunal type (Table A-11).

DIST3

An estimate of the *distribution* of individuals of the FAUNA3 type based on Table A-12.

BIOMAPPER

The last name of the individual providing the professional interpretation and classification of biological features visible in the imagery.

COMMENT

Field for recording non-standard information on the seabed biology.

Table A-10 Faunal Distribution Classes

Code	Descriptor	Distribution
1	few	a rare (single) or a few sporadic individuals
2	patchy	a single patch, several individuals or a few patches
3	uniform	continuous uniform occurrence
4	continuous	continuous occurrence with a few gaps
5	dense	continuous dense occurrence

Table A-11. Faunal Classification with Emphasis on Sessile, Aggregating Species or Species Groups (Esquimalt Harbour)

SPECIES OR SPECIES COMPLEX	CODE	DESCRIPTION
Bryozoan Complex	BRY	Bryozoans, Ascidians, sponges - generally on rock substrate.
Tunicates	TUN	Aggregations of tunicates primarily *Ciona* and colonial forms.
Anemone	ANS	Anemones aggregates - strawberry type, generally in high current areas on rock substrates.
	ANM	Aggregations of *Metridium* and other "predator" species.
	TEA	*Urticina (Tealia)* sp.
	ANP	Burrowing anemone (*Pachycerianthes*) on unconsolidated substrates.
Corals	CUP	cup coral (*Balanophyllia elegans*)
	SPN	sea pens (orange and white)
	SWP	sea whips (*Balticina septentrionalis*)
Tube worms	TUB	Aggregations of parchment tube dwelling polychaete worms such as *Mesochaetopterus* found in sand and silty substrates.
	TUC	Calcarious tube dwellers such as *Serpula*.
Crabs	CAN	*Cancer* sp. (C. magister, C. gracilis)
	RRK	*Cancer productus* (Red Rock Crab)
Subtidal Clams	GCL	Geoduck clams.
	HCL	Horseclams.
	PCL	Piddock Clams
	BCL	Butter Clams
	OYS	Oysters
	MUS	Mussels
	OCL	Other clam species.
Brittle Stars	BRT	Aggregations on sand and silt bottoms, may co-occur with burrowing worms.
Sand Dollars	SDD	Aggregations of sand dollars.
Sea Urchins	RSU	Red sea urchin.
	GSU	Green sea urchins.
	PSU	Purple sea urchin.
Sea Cucumber	CUC	Sea cucumber (*Cucumaria*)
	PAR	California Sea cucumber (*Parastichopus californicus)*
In fauna "holes"	HLM	Mounded worm, clam or crustacean holes but species or species group cannot be distinguished.
	HLF	Unmounded (flat) worm or clam holes but species or species group cannot be distinguished.
Bacteria	BEG	"*Beggiatoa* sp"
Unknown	UNK1	macro fauna visible but cannot be identified
No Fauna	NOF	no fauna observed

Table A-12. Fish Classification

FISH	CODE	DESCRIPTION
Unidentified fish	FSH	Unidentified fish
Eelpout	ELP	Unidentified Eelpout (Zoarcidae)
Poacher	SPO	Sturgeon poacher (*Agonus acipenserinus*)
Gunnel	GUN	Unidentified Gunnel species (Pholidae)
Pricklebacks	PSP	Pacific Snake Prickleback (*Lumpenus sagitta*)
Sticklebacks	TSB	Threespine Stickleback (*Gasterosteus aculeatus*)
Snailfish	SFH	Unidentified snailfish (Cyclopteridae)
Goby	GOB	Gobiidae
Perch	PRH	Unidentified Perch
	PLP	Pile Perch (*Rhacochilus vacca*)
	KLP	Kelp Perch (*Brachyistius frenatus*)
	PST	Striped Seaperch (*Embiotoca lateralis*)
	PSH	Shiner Perch (*Cymatogaster aggregata*)
Flatfish	FTF	Unidentified Flatfish
	SAN	Pacific Sanddab (left-eyed flounder) (*Citharichthys sordidus*)
	SOL	Sole (Dover, Flathead, Curlfin, Slender or Rex)
	ENG	English Sole (*Parophys vetulus*)
	SFD	Starry flounder (*Platichthys stellatus*)
Herring	HER	Pacific Herring (*Clupea harengus*)
Gadids	COD	Unidentified Gadids
	PCD	Pacific Cod (*Gadus macrocephalus*)
	POL	Walleye Pollock (*Theragra chalcogramma*)
	HKE	Pacific Hake (*Merluccius productus*)
Dogfish	SDG	Spiny Dogfish (*Squalus acanthias*)
Rockfish	CRK	Copper Rockfish (*Sebastes caurinus*)
Greenling	GLG	Unidentified Hexagrammid
	KGR	Kelp Greenling (*Hexagrammos decagrammus*)
Pacific Sand Lance	SLA	Pacific sand lance (*Ammodytes hexapterus*)
Sculpin	SCU	Unidentified Sculpin (Cottidae)

APPENDIX B

Subtidal Dive Observations

Location	Date Time	Vertical Elevation (relative to chart datum (m)	Substrate	Vegetation		Invertebrates			Fish
				Scientific Name	% cover	Scientific Name	Common Name	Abund.*	
Dive Site 1	May 25/00	-10.5m	mud/sand with cobble/pebble	Filamentous and foliose red algae	5%	*Pandalus danae*	Dock shrimp	C	Flatfish
Dunze Head	9:30		whole shell	Diatom cover		*Cancer gracilis*	Graceful crab	P	
Sediment						*Ectopleura* sp.	Stalked hydroid	P	
Verification						*Cancer magister*	Dungeness Crab	P	
Dive Site 2		-8.5m	sand/shell with cobble	*Neoagardhiella* (filamentous red)	10-30%	*Cancer productus*	Red rock crab	P	
Dunze Head	9:40			Foliose red algae	5-10%	*Urticina* sp.	Anemone	P	
				Ulva sp.	5%	*Cancer magister*	Dungeness Crab	P	
		-7.6m	sand/shell with cobble	*Laminaria* sp.	30-50%				
				Agarum sp.	20-30%				
		-5.8m	shell/sand	*Neoagardhiella* (filamentous red)	20-30%	*Cancer productus*	Red rock crab	P	
Kelp				*Ulva* sp.	10%		Parchment tubeworms	P/C	
				Desmerestia (filamentous)	10%				
				Nereocystis leutkeana	<5%				
		-4.6m	bedrock/boulder	*Laminaria* sp. (large blades)	70-90%	*Stongylocentrotus franciscanus*	Red sea urchins	P/C	Quillback rockfish (*Sebastes maliger*)
				Costaria costata (large blades)	30-40%	*Pugettia producta*	Northern kelp crab	C	
				Cymathere triplicata	10%				
				Agarum sp.	10%				
				Encrusting coralline red algae					
		-1.8m	bedrock	*Laminaria* sp. (large blades)	70%	*Halichondria spp.*	Bread crumb sponge	P	
				Costaria costata (large blades)	30%	*Haliclona? permollis*	Purple encrusting sponge	P	
				Odonthalia floccosa (under kelp)	10-20%	*Boltenia villosa*	Stalked hairy sea squirt	P	
				Ulva sp.	10-20%		Unidentified ascidian	P	
				Desmerestia (Filamentous/foliose)	10-20%				
				Encrusting coralline red algae					
Dive Site 3			mud/sand with pebble/shell/coal	Foliose red algae	5%	*Cancer productus*	Red rock crab	P	
Grant's Knoll	10:30	-8.7m		*Laminaria* sp. (large blades)	5-10%	*Metridium giganteum*	Plumose anemone	C	
			debris:bottles,wood,misc debris	*Neoagardhiella* (filamentous red)	5%	*Urticina sp.*	anemone	P	
				Ulva sp.	5%	*Cancer magister*	Dungeness Crab	P	
Substrate				Diatom cover			unidentified yellow sponge	P	
Verification									
Dive Site 25	11:06	-3.5m	Sand/shell with pebble	*Desmerestia* (foliose)	80%	*Pycnopodia helianthoides*	Sunflower star	P	Striped perch (*Embiotoca lateralis*)
Western Shore				*Laminaria* sp.	20-40%				Quillback rockfish (*Sebastes maliger*)
Outer Harbour				*Neoagardhiella* (filamentous red)	10-20%				
		-2.5m	conglomerate	*Alaria* sp.	5-10%	*Pugettia productus*	Northern kelp crab	P	
Kelp				*Agarum* sp.	5%	*Metridium giganteum*	Plumose Anemone	P	
						Eudistylia vancouveri	Northern Feather Duster Worms	P (on rock)	
		-1.5m	Sand/shell	*Desmerestia* (foliose)	100%	*Cancer productus*	Red rock crab	P	
				Sargassum muticum	20%	*Telmessus cheiragonus*	Helmet crab	P	

Vertical height/depth given in metres relative to chart datum.
Invertebrates: A = Abundant, C = Common, P = Present.
Vegetation: % cover estimated for dominant vegetation.

Location	Date Time	Vertical Elevation (relative to chart datum (m)	Substrate	Vegetation		Invertebrates			Fish
				Scientific Name	% cover	Scientific Name	Common Name	Abund.*	
Dive Site 27	11:50	-2.9m	Shell (barnacle) with pebble	*Desmerestia* (filamentous/foliose)	90%	*Cancer productus*	Red rock crab	P	
Fisgard				*Laminaria* sp. (large blades)	10%	*Myxicolla infundibulum*	Sabellid tube worms	P	
Lighthouse				*Costaria costata* (large blades)	10%	*Evasterias troschelii*	Mottled sea star	P	
				Neoagardhiella (filamentous red)	5-10%	*Clinocardium nuttallii*	Cockle	P	
		-2.5m	Bedrock	*Laminaria* sp.(large blades)	50-70%	*Pycnopodia helianthoides*	Sunflower star	P	
Kelp				*Costaria costata* (large blades)	50-70%	*Cucumaria miniata*	Orange sea cucumber	P	
				Odonthalia floccosa	10-20%	*Evasterias troschelii*	Mottled sea star	P	
				Encrusting coralline red algae		*Halichondria spp.*	Bread crumb sponge	C	
						Haliclona? permollis	Purple encrusting sponge	C	
						Dodecaceria sp.	Fringed tubeworms	C	
						Telmessus cheiragonus	Helmet crab	P	
		-0.3m	Bedrock	*Costaria costata* (large blades)	50%	*Tonicella* sp.	Chiton	P	
				Chondracanthus (*Gigartina*) sp.	10-20%		Unidentified orange ascidian	P	
				Odonthalia floccosa	10-20%				
				Desmerestia (filamentous)	10-20%				
				Laminaria sp.	10%				
				Mazzaella (*Iridea*) sp.	10-20%				
				Ulva sp.	5-10%				
				Encrusting coralline red algae					
Dive Site 22	14:15	-0.6 to -0.9m	Sand/mud with pebble/shell	*Neoagardhiella* (filamentous red)	10%	*Urticina coriacea*	Buried anemone	P	
Between Smart/			sparse wood debris	*Laminaria* sp.	10%	*Tresus* sp.	Horse clam	P	
McCarthy Island				*Ulva* sp.	10-30%	*Crangon* sp.	Shrimp	P	
McCarthy Island (se)			bedrock/boulder	*Laminaria* sp.	50%	*Cancer productus*	Red rock crab	P	Pipefish (*Syngnathus griseolineatus*)
Smart Island (north)				*Sargassum muticum*	30-50%	*Metridium giganteum*	Plumose anemone	P	
				Ulva sp.	5%	*Pugettia productus*	Northern kelp crab	P	
kelp						*Pycnopodia helianthoides*	Sunflower star	P	
							Unidentified yellow sponge	P	
							Orange sponge	P	
						Didemnum carnulentum	Colonial ascidian	C	
Dive Site 13	15:25	-3.3m	mud with shell	None		*Zirphaea pilsbryi*	Piddock clam	C	
			wood debris (sparse to moderate)			*Cancer gracilis*	Graceful crab	P	
Piddock Clams						*Pandalus danae*	Dock shrimp	P	
Dive Site 14	15:45	-2.6m	dense wood debris (medium to fine)	None		*Pandalus danae*	Dock shrimp	C	
						Cancer gracilis	Graceful crab	A	
Boom Grounds						*Crangon* sp.	Shrimp	P	
						Metridium giganteum	Plumose anemone	P (on log)	
Dive Site 4	May 29,2000 9:25	-0.2m to -0.9m	sand/shell hash (barnacle)	*Zostera marina* (eelgrass) with dense diatom cover	60-80%	*Pugettia gracilis*	Graceful kelp crab	P	Buffalo sculpin (*Enophyrus bison*)
						Cancer productus	Red rock crab	P	
Grant's Knoll				*Smithora naiadum* (Foliose red algae) -epiphytic on eelgrass blades			Tubeworms with shells (Eunicid)	C	
						Pagurus sp.	Hermit crab		
Eelgrass				*Laminaria* sp.	10%				
				Alaria sp.	5-10%				
Dive Site 18	10:25	+0.4m to -0.5m	Sand/mud	*Zostera marina* (eelgrass) with diatom	5-10%	*Pugettia gracilis*	Graceful kelp crab	C	Flatfish
Limekiln Bay	11:25			cover (except SW corner=30-40%)		*Cancer magister*	Dungeness crab	P	
				Sargassum muticum		*Cancer productus*	Red rock crab	P	
Eelgrass						*Metridium giganteum*	Plumose anemone	P	
						Tresus sp.	Horse clam	P	

Vertical height/depth given in metres relative to chart datum.
Invertebrates: A = Abundant, C = Common, P = Present.
Vegetation: % cover estimated for dominant vegetation.

Location	Date Time	Vertical Elevation (relative to chart datum (m)	Substrate	Vegetation		Invertebrates			Fish
				Scientific Name	% cover	Scientific Name	Common Name	Abund.*	
Dive Site 17		+0.3m to -0.4m	sand/mud with bark debris/some shell	*Zostera marina* (eelgrass) with diatom	sparse/	*Cancer gracilis*	Graceful crab	P	
Thetis Cove	12:00			cover	patchy	*Tresus* sp.	Horse clam	P	
				Ulva sp.	5%	*Cancer productus*	Red rock crab	P	
Eelgrass				*Sargassum muticum*	5%	*Metridium giganteum*	Plumose anemone	P	
				Laminaria sp.	5%	*Myxicolla infundibulum*	Sabellid tube worms	P	
Dive Site 6	14:45	+0.4 to -0.5	sand/mud with bark debris/some shell	*Zostera marina* (eelgrass)	60-80%	*Cancer productus*	Red rock crab	P	Buffalo sculpin (*Enophyrus bison*)
Dallas Bank				-approx 1m tall, covered with diatoms		*Telmessus cheiragonus*	Helmet crab	P	Striped perch (*Embiotoca lateralis*)
(south)				*Neoagardhiella* (filamentous red)	10%	*Leptasterias hexactis*	Six ray star	P	Pile Perch (*Rhacochilus vacca*)
				Ulva (foliose green)	10%		dense holes		Northern Ronquil (*Ronguilus jordani*)
Eelgrass				*Laminaria* sp.	10%				Unidentified Gunnel
Dive Site 7	15:30	+0.2 to -0.5	sand/mud with bark debris/some shell	*Zostera marina* (eelgrass)	60-80%	*Cancer productus*	Red rock crab	P	Pile Perch (*Rhacochilus vacca*)
Dallas Bank				-approx 1m tall, covered with diatoms		*Telmessus cheiragonus*	Helmet crab	P	
(north)				*Neoagardhiella* (filamentous red)	10%				
				Ulva (foliose green)	10%				
Eelgrass				*Laminaria* sp.	10%				
Dive Site 5	16:15	+0.3 to -0.9m	Sand/mud with shell(whole and broken)	*Zostera marina* (eelgrass)- diatom cover	sparse	*Cancer productus*	Red rock crab	P	Pipefish (*Syngnathus griseolineatus*)
Lang Cove				*Ulva* (foliose green)	50%	*Cancer gracilis*	Graceful crab	P	Buffalo sculpin (*Enophyrus bison*)
				Filamentous red algae	20-30%	*Cancer magister*	Dungeness crab	C	Striped perch (*Embiotoca lateralis*)
Eelgrass				*Neoagardhiella* (filamentous red)	10%	*Telmessus cheiragonus*	Helmet crab	P	Flatfish
				Laminaria sp.	5-10%	*Metridium giganteum*	Plumose anemone	P	
						Pandalus danae	Dock shrimp	P	
						Tresus sp.	Horse clams	P	
							Tubeworms with shells (Eunicid)	P	
						Zirphaea pilsbryi	Piddock clam (below eelgrass)	P	
Dive Site 24	June 27/2000	-7.3	Bedrock with sand/shell	*Agarum* sp.	60-80%	*Halicondria spp.*	Bread crumb sponge	C	
Whale Rock	10:00			Foliose red algae (*Opuntiella californica* /	5-10%	*Metandrocarpa taylori*	Orange social ascidians	C	
				Mazzaella)		*Ectopleura* sp.	Stalked hydroid	P	
Kelp						*Pycnopodia helianthoides*	Sunflower star	P	
						Pandalus danae	Dock shrimp	C	
						Crassadoma gigantea	Rock scallop	P	
		-6.3	Bedrock (base of bedrock/broken	*Agarum* sp.	40-80%	*Henricia leviuscula*	Blood star	P	Lingcod (*Hexagrammos decagrammus*)
			rock at -5.5m depth)			*Pododesmus macrochisma*	Jingle shell	P	
			heavy chain			*Pycnopodia helianthoides*	Sunflower star	P	
		-3.9	Broken rock on sand/shell	*Laminaria* sp.(large blade)	30-	*Balanus* sp.	Barnacles	P	
				Costaria costata (large blade)	80%	*Ectopleura* sp.	Stalked hydroid	P	
				Nereocystis leutkeana	canopy	*Pugettia gracilis*	Graceful kelp crab	P	
				Encrusting coralline red algae		*Halicondria spp.*	Bread crumb sponge	P	
						Evasterias troschelli	Mottled star	P	
						Metridium giganteum	Plumose anemone	P	
						Henricia leviuscula	Blood star	P	

Vertical height/depth given in metres relative to chart datum.
Invertebrates: A = Abundant, C = Common, P = Present.
Vegetation: % cover estimated for dominant vegetation.

Location	Date Time	Vertical Elevation (relative to chart datum (m)	Substrate	Vegetation		Invertebrates			Fish
				Scientific Name	% cover	Scientific Name	Common Name	Abund.*	
Dive Site 9	10:50	-8.4	Cobble on mud/sand	*Laminaria* sp.	50-70%	*Pycnopodia helianthoides*	Sunflower star	P	
Inskip Islands			Petrified logs	*Agarum* sp.	20-30%	*Cancer productus*	Red rock crab	P	
						Cancer magister	Dungeness crab	P	
				Desmerestia (foliose)	20-40%	*Crassadoma gigantea*	Rock scallop	P	
						Ectopleura sp.	Stalked hydroid	P	
							Unidentified tubeworms (tiny)	C	
						Cryptochiton stelleri	Gumboot chiton	P	
		-6.5	Sand/mud/shell	*Neoagardhiella* (filamentous red)	5-10%	*Cancer productus*	Red rock crab	P	
Substrate						*Pisaster brevispinus* (large)	Spiny pink star	P	
Verification						*Tresus* sp.	Horse clam	P	
						Oregonia gracilis	Decorator crab	P	
Kelp		-3.4	Bedrock	*Agarum/Laminaria* sp.	100%	*Evasterias troschelli*	Mottled star	P	Black eyed goby (*Coryphopterus nicholsi*)
				Corallina sp.	30-50%	*Halicondria spp.*	Bread crumb sponge	C	
				Foilose red algae	10%	*Didemnum carnulentum*	Colonial ascidian	P	
						Haliclona? permollis	Purple encrusting sponge	P	
						Dodecaceria sp.	Fringed tubeworms	C	
						Pugettia gracilis	Graceful kelp crab	P	
						Cucumaria miniata	Orange sea cucumber	C	
		-2.3 to -0.6	Bedrock/boulder	*Laminaria* sp./Desmerestia/		*Dodecaceria* sp.	Fringed tubeworms	C	
			Pockets of sand/shell	*Costaria costata*	60-90%	*Pugettia gracilis*	Graceful kelp crab	P	
				Corallina sp. (understory)	40-60%	*Leptasterias hexactis*	Six ray star	P	
				Foliose red algae	10%	*Cancer productus*	Red rock crab	P	
				Encrusting red coralline algae		*Cucumaria miniata*	Orange sea cucumber	C	
						Crassadoma gigantea	Rock scallop	P	
						Evasterias troschelli	Mottled star		
Dive Site 10	11:14	-1.3 to -0.1	Boulder on sand/shell (barnacle hash)	*Laminaria* sp.	100%	*Metridium giganteum*	Plumose anemone	P	Tubesnouts (*Aulorhynchus flavidus*)
Inskip Islands			Bedrock (shallow)	*Corallina* sp.	30-50%	*Cancer productus*	Red rock crab	P	Unidentified Sculpin
				Prionitis sp.	10-20%	*Telmessus cheiragonus*	Helmet crab	P	
Kelp				Encrusting red coralline algae		*Dodecaceria* sp.	Fringed tubeworms	C	
				Sargassum muticum (shallow)	20%	*Cucumaria miniata*	Orange sea cucmber	C	
				Foliose red algae (*Mazzaella* /	10%	*Pugettia gracilis*	Graceful kelp crab	P	
				Chondracanthus)			Unidentified terebellid tubeworm	P	
						Utricina coriacea	Buried anemone	P	
							Unidentified tubeworms (tiny)	C	
						Metridium giganteum	Giant plumose anemone	P	
						Leptasterias hexactis	Six ray star	P	
Dive Site 11	11:40	-1.5	Shell/mud with some pebble/boulder	*Ulva* sp.	100%	*Zirphaea pilsbryi*	Piddock clam	P	
Inskip Islands									
		-1.3 to -0.6	Shell/sand with scattered rock	*Laminaria* sp.	100%	*Metridium giganteum*	Giant plumose anemone	P	
Kelp			Petrified logs	*Corallina* sp. (on rock)	30-50%	*Cancer productus*	Red rock crab	P	
				Sargassum muticum (shallow)	10%	*Didemnum carnulentum*	Colonial ascidian	P	
				Porphyra sp. (shallow)	5%		Unidentified orange ascidian	P	
				Chondracanthus (*Gigartina*) sp. (shallow)	10-20%		Yellow compound ascidian	P	
				Prionitis sp.	10-20%	*Hermissenda crasicornis*	Aeolid nudibranch	P	
						Cucumaria miniata	Orange sea cucmber	C	

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Vegetation: % cover estimated for dominant vegetation.

Location	Date Time	Vertical Elevation (relative to chart datum (m)	Substrate	Vegetation		Invertebrates			Fish
				Scientific Name	% cover	Scientific Name	Common Name	Abund.*	
Dive Site 16 Thetis Cove wood debris	13:25	-3.4	Silt/mud with bark debris Sparse boudler/logs Bacterial mat (patchy)	drift *Laminaria* sp. *Laminaria* sp. on boulder		*Cancer productus* *Metridium giganteum* *Metridium senile* *Pandalus danae*	Red rock crab Gigantic plumose anemone (on log) Short plumose anemone Dock shrimp	P P P P	
Dive Site 15 Thetis Cove wood debris	13:39	-2.9 to -1.9	Silt/mud with wood debris and fine wood fibre/few logs sparse boulder Bacterial mat (patchy)	*Laminaria* sp. on boulder	10%	*Metridium giganteum* *Cancer gracilis* *Crangon* sp.	Gigantic plumose anemone Graceful crab Shrimp	P C P	
Dive Site 21 Smart Island Eelgrass	14:50	+0.5 to +0.2	Sand/mud/shell	*Zostera marina* (eelgrass) -approx 1m tall, covered with diatoms *Ulva* sp. (denser on west side of bed) At +0.2m: *Sargassum muticum* (at +0.2m) *Laminaria* sp. *Neoagardhiella* (filamentous red)	50-70% 10-20% 5-10% 10% 10%	*Tresus* sp. *Cancer magister* *Cancer gracilis* *Telmessus cheiragonus* *Pugettia gracilis* *Cancer productus* *Pugettia productus* Unidentified parchment tubeworms	Horse clam Dungeness crab Graceful crab Helmet crab Graceful kelp crab Red rock crab Northern kelp crab	C P C P P P P P	Stickleback (*Gasterosteus aculeatus*) Northern Ronquil (*Ronguilus jordani*) Striped perch (*Embiotoca lateralis*) Pipefish (*Syngnathus griseolineatus*) Unidentified Gunnel
Dive Site 23 McCarthy Island Kelp	16:03	-1.7	Boulder/cobble on sand/shell	*Laminaria* sp. *Porphyra* sp.	70-100% 5%	*Balanus* sp. (shallow) *Cancer gracilis* *Evasterias troschelli* *Cancer productus* *Cancer magister* *Pugettia productus* *Cucumaria miniata* *Dodecaceria* sp. *Metridium giganteum* *Haliclona? permollis* *Didemnum carnulentum* *Tonicella* sp. *Utricina coriacea*	Barnacles Graceful crab Mottled star Red rock crab Dungeness crab Northern kelp crab Orange sea cucumber Fringed tubeworms Orange/yellow compound ascidian Gigantic plumose anemone Purple encrusting sponge Colonial ascidian Chiton Buried anemone	P/C C C P P P C C P P P P P P	Striped perch (*Embiotoca lateralis*) Tubesnouts (*Aulorhynchus flavidus*)
		-1.1 to -0.5	Boulder/cobble on shell hash	*Laminaria* sp. *Ulva* sp. *Sargassum muticum* *Leathesia difformis* *Prionitis* sp. *Odonthalia flocossa*	10-30% 50-70% 10% 5% 5-10% 10%	*Cucumaria* sp. *Haliclona? permollis* *Didemnum carnulentum* *Evasterias troschelli* *Pisaster ochraceus* *Metridium giganteum* *Pyura haustor* *Balanus* sp. (shallow) *Utricina coriacea*	Orange/white sea cucumber Purple encrusting sponge Colonial ascidian Mottled star Ochre star Gigantic plumose anemone Large orange compound ascidian Wrinkled sea squirt Barnacles Buried anemone	C C P P P P P P P P	
Dive Site 26 North of Fisgard Lighthouse Kelp	June 28/2000 9:37	-2.6 to -0.8	Sand/pebble/cobble Gravel (coarse sand) Base of beach face at +0.4m	*Laminaria* sp *Desmerestia* (foliose/filamentous) *Neoagardhiella* (filamentous red)-understory *Ulva* sp. (from -0.2m to +0.8m)	100% 20% 10-30%	*Cancer magister* *Telmessus cheiragonus* *Cancer productus* *Pandalus danae* *Tresus* sp. *Pycnopodia helianthoides* *Hermissenda crasicornis*	Dungeness crab Helmet crab Red rock crab Dock shrimp (*common in gravel) Parchment tubeworms (in gravel) Horse clams Sunflower star Aeolid nudibranch	C C C *C *C P P P	Saddleback gunnel (*Pholis ornata*)

Vertical height/depth given in metres relative to chart datum.
Invertebrates: A = Abundant, C = Common, P = Present.
Vegetation: % cover estimated for dominant vegetation.

Location	Date Time	Vertical Elevation (relative to chart datum (m)	Substrate	Vegetation		Invertebrates			Fish
				Scientific Name	% cover	Scientific Name	Common Name	Abund.*	
Dive Site 8	10:30	-4.4	Bedrock	*Agarum/Laminaria*	100%	*Balanus* sp. (shallow)	Barnacles	C	Unidentified sculpin
Boat Club			Pockets of sand/shell			*Cancer productus*	Red rock crab	P	
						Halicondria spp.	Bread crumb sponge	P	
Kelp						*Pandalus danae*	Dock shrimp	P	
						Metandrocarpa taylori	Orange social ascidians	C	
						Henricia leviuscula	Blood star	P	
							Yellow compound ascidian	P	
						Boltenia villosa	Stalked hairy sea squirt	P	
						Pugettia productus	Northern kelp crab	P	
							Unidentified tubeworms (tiny)	C	
		-1.7 to -1.0	Bedrock	*Laminaria* sp.	20-40%	*Halicondria spp.*	Bread crumb sponge	P	Striped perch (*Embiotoca lateralis*)
			Pockets of shell/sand	*Costaria costata*	20-40%	*Dodecaceria* sp.	Fringed tubeworms	P	
				Corallina sp.	10%	*Didemnum carnulentum*	Colonial ascidian	P	
				Desmerestia (filamentous)	5%	*Cucumaria miniata*	Orange sea cucumber	P	
				Sargassum muticum	5%	*Evasterias troschelli*	Mottled star	P	
		-1.0 to -0.5	Bedrock	*Laminaria* sp.	30-50%	*Dodecaceria* sp.	Fringed tubeworms	C	
				Corallina sp.	30-50%	*Telmessus cheiragonus*	Helmet crab	P	
				Ulva sp.	30-50%	*Cancer productus*	Red rock crab	P	
				Sargassum muticum	10%	*Didemnum carnulentum*	Colonial ascidian	P	
				Prionitis sp.	10%		Unidentified compound ascidian		
Dive Site 19	11:19	-1.8	Mud with whole shell (mostly Butter clam)	None		*Cancer gracilis*	Graceful crab	C	Striped perch (*Embiotoca lateralis*)
NE End of Harbour			up to 100% shell			*Metridium giganteum*	Gigantic plumose anemone	C	
		-0.8				*Pandalus danae*	Dock shrimp	P	
Substrate						*Evasterias troschelli*	Mottled star	P	
Verification							Unidentified orange sponge	P	
Dive Site 20	11:40	0.0	Sand/mud with some whole shell	None		*Cancer gracilis*	Graceful crab	P	
Substrate									
Verification									
Dive Site 12	12:10	-0.2	Mud/shell/sand	None		None			
Substrate									
Verification									

Vertical height/depth given in metres relative to chart datum.
Invertebrates: A = Abundant, C = Common, P = Present.
Vegetation: % cover estimated for dominant vegetation.

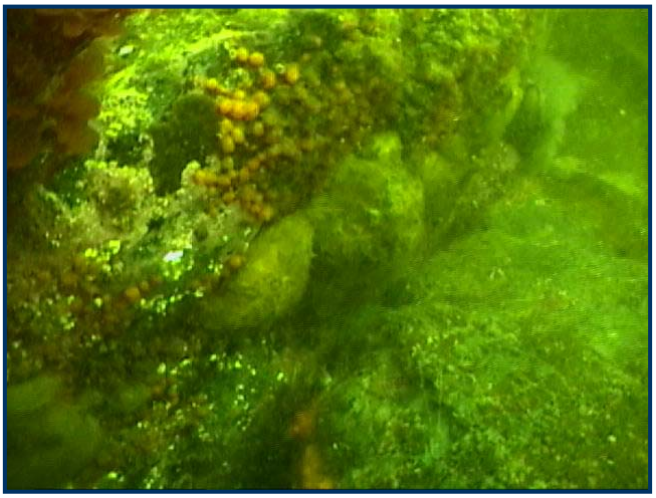
APPENDIX C

Images of Characteristic Biophysical Features

Rock scallop (*Crassadoma gigantea*) with bladed kelp (*Laminaria* sp.) and coralline red algae.

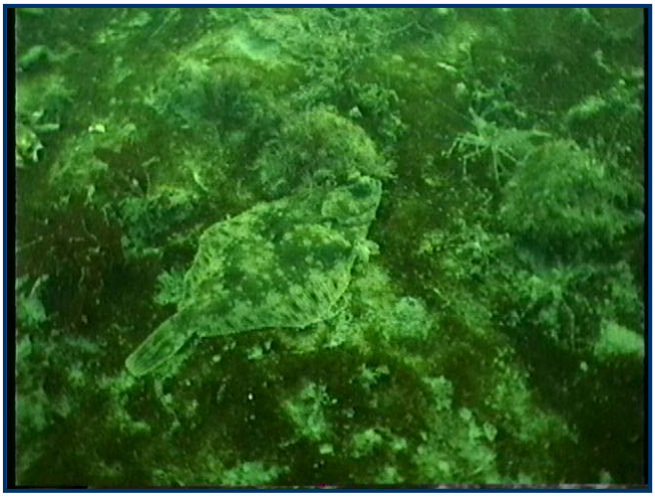
Red sea urchin (*Strongylocentrotus franciscanus*) and bladed kelp on bedrock.

Orange sea cucumber (*Cucumaria miniata*) on bedrock with bladed kelp.



Acsidians and sponges on bedrock.

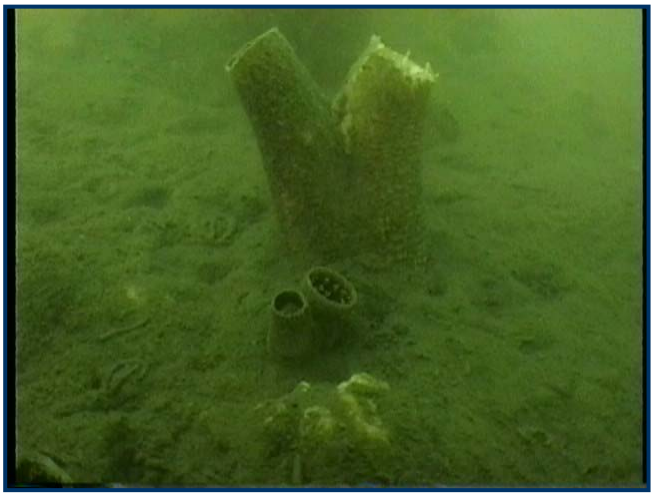
Anemone (*Urticina* sp.) in shell and gravel.



C-O (*Pleuronichthys coenosus*) sole on gravelly mud/sand.

Kelp crab (*Puggettia producta*) in eelgrass bed.

School of tubesnouts (*Aurlorhynchus flavidus*) with *Sargassum* and bladed kelp (*Laminaria* sp.).



Horse clam (*Tresus* sp.) in mud/sand and shell.

Piddock clams (*Zirphaea pilsbryi*) in mud/clay.

Crab (*Cancer* sp.) with dense bark debris.

White bacteria (*Beggiatoa* spp.) on log.