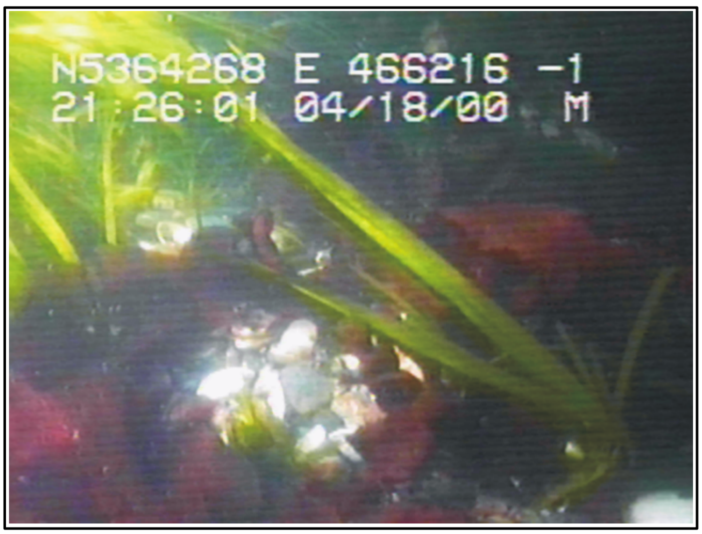
SUBTIDAL SURVEY OF THE PHYSICAL AND BIOLOGICAL FEATURES OF ESQUIMALT LAGOON



ARCHIPELAGO
MARINE RESEARCH LTD.

2ND FLOOR, 525 HEAD STREET
VICTORIA, B.C. V9A 5S1
TEL: (250) 383-4535 FAX: (250) 383-0103
EMAIL: AMR@ARCHIPELAGO.BC.CA

SUBTIDAL SURVEY OF THE PHYSICAL AND BIOLOGICAL FEATURES OF ESQUIMALT LAGOON

REPORT
& MAP FOLIO

NOVEMBER 2000

Prepared for: Victoria and Esquimalt Harbours Environmental Action Program
Capital Regional District
524 Yates St.
Victoria, BC
V8W 2S6

Prepared by: Archipelago Marine Research Ltd.
#200 – 525 Head Street
Victoria, BC
V9A 5S1

In association with:
Coastal and Oceans Resources Inc., Victoria, BC
Seaconsult Marine Research Ltd., Vancouver, BC

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EXECUTIVE SUMMARY

The Victoria and Esquimalt Harbours Environmental Action Program (VEHEAP) is a multi-agency group currently implementing an environmental action plan for Victoria and Esquimalt Harbours, which includes Esquimalt Lagoon. A key element of the VEHEAP plan is the Harbours Ecological Inventory and Rating (HEIR) project, which consists of a systematic inventory of the backshore, intertidal and subtidal ecological features of the harbours, as well as a subsequent rating of the ecological value of these features. This report contains subtidal inventory information for Esquimalt Lagoon which will be incorporated into the overall HEIR project.

Esquimalt Lagoon is located immediately west of Esquimalt Harbour and encompasses 82 hectares of subtidal seabed. The outer boundary of the lagoon is a gravel and sand spit (Coburg Peninsula) formed by the alongshore transport of sediments from the southwest. The lagoon flows to the Strait of Juan de Fuca via several channels at the northeast end. The lagoon is shallow, with depths generally less than 3m relative to chart datum. Tidal circulation is restricted by narrow tidal channels at the lagoon entrance, and the tidal amplitude in Esquimalt Lagoon is less than 50% of the tidal amplitude of Victoria and Esquimalt Harbours. There are several small creeks draining into the lagoon, including Colwood Creek which drains into a small brackish marsh just east of the Royal Roads University dock.

A subtidal inventory of the physical and biological features of Esquimalt Lagoon 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 on a 100m trackline grid, however finer resolution (5-10m spacing) was used where important physical or biological features were anticipated (e.g. eelgrass beds). The video survey encompassed a total of 29.9 km of vessel tracklines and approximately 11 hours of video imagery. These methods are comparable to recently conducted subtidal surveys of Victoria Harbour, Esquimalt Harbour, the Gorge Waterway and Portage Inlet.

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
- macroinvertebrates (e.g. anemones, tubeworms, sea urchins, subtidal clams, crab)

The report provides a map folio of these features at 1:10,000 scale. In addition, an HTML format interactive CD-ROM of the mapped biophysical themes as well as georeferenced still and video imagery from the underwater survey is available as a product of this project.

The most notable biophysical features Esquimalt Lagoon, as identified by the video survey are:

- mud and mud/sand sediment except around shore margins
- gravel/sand spit (Coburg Peninsula) formed by alongshore sediment transport with evidence of historic overtopping of gravel sediments into the lagoon basin
- most of basin, particularly south end, contains depositional sediments
- gravel sediments in tidal channels at lagoon entrance
- few man-made objects due to low use and depositional nature of sediments
- eelgrass beds around shore margins (0-2m depths)
- kelps restricted to northern portion of the basin
- extensive area of foliose green algae (*Ulva* and *Enteromorpha)*
- filamentous and foliose red algae in tidal channels

Some of the important biophysical features of Esquimalt Lagoon include:

1. **Eelgrass (*Zostera marina*) Beds**
   Approximately 15 hectares of eelgrass beds were mapped in Esquimalt Lagoon. This represents 16% of the eelgrass beds identified in the Victoria and Esquimalt Harbours area (including the Gorge Waterway and Portage Inlet). Eelgrass is generally recognized as productive and important rearing habitat for many species of juvenile fish and invertebrates, as well as being sensitive to impacts from foreshore development.

2. **Abundance of Intertidal Bivalves**
   The intertidal gravel bars at the entrance to the lagoon support butter and littleneck clams as well as mussels and the Japanese oyster. The Coburg Peninsula and the intertidal gravel bars inside and outside the entrance to Esquimalt Lagoon are the only intertidal clam beds documented by Fisheries and Oceans Canada in Victoria/Esquimalt Harbours, indicating that they are likely the largest and most significant intertidal clam beds in the harbours area.

3. **Herring Spawning**
   Herring have historically (1940-51) spawned in Esquimalt Lagoon and were also recorded in 1991-93 at the entrance to the lagoon. Although Esquimalt Lagoon is not currently considered one of the more important herring spawning areas in the harbours region, the historic record indicates that the area could be important in future years.

4 Marine Associated Birds.

Esquimalt Lagoon is a designated migratory bird sanctuary and a substantial number of birds are present on a year round basis. In particular the lagoon is important overwintering (October to April) habitat for waterfowl (ducks and geese) and other marine associated birds.

5 Restricted Tidal Exchange

There is evidence of episodic anoxic conditions in the sediment and water column of Esquimalt Lagoon, particularly the southern portion. Occasionally, fish and crab mortalities have been reported. These events usually occur in August or September, are associated with a low tide cycle, a chalky white turbidity, sulphide odour and low oxygen levels in the water. This condition likely results from a combination of elevated water temperature, reduced tidal exchange and organic decomposition (either as a result of a plankton bloom or macrovegetation decomposition). Nutrient input and the control of washover and breaks in the spit due to the road construction may have exacerbated this process.

Much of the important habitat value of Esquimalt Lagoon can be attributed to backshore and intertidal features as well as the physical form of the lagoon. The recent HEIR intertidal inventory and rating (Westland 2000) rated the backshore and intertidal ecological value of all the shoreline in the lagoon as high or very high. This is due to the degree of naturally vegetated backshore, marsh grasses and intertidal sand/gravel flats containing important bivalve beds. The value of the lagoon as habitat for marine associated birds is similarly high. Much of the wildlife value of the lagoon is derived from these intertidal and backshore features, although the eelgrass beds and tidal channels are also important for certain bird species. In addition, the sheltered nature of the lagoon, in close proximately to the more exposed marine environment, is important to many marine associated bird species. The next step in the HEIR process is to develop ecological ratings for subtidal habitats in a manner compatible with the recent rating of intertidal habitats within the VEHEAP area.

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 field observations. Pam Thuringer and Xanthe Brown of Archipelago Marine Research Ltd. conducted the biological classification of the video imagery. Sheri Ward (Coastal and Oceans Resources Inc.) and Angela Forrester (Archipelago Marine Research Ltd.) were responsible for GIS mapping. Sheri Ward also 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

The Victoria and Esquimalt Harbours Environmental Action Program (VEHEAP) is a multi-agency group currently implementing an environmental action plan for the Victoria and Esquimalt Harbours area, which includes Esquimalt Lagoon (Figure 1). A key element of the VEHEAP plan is a systematic inventory of the backshore, intertidal and subtidal ecological features of the harbour areas, and a subsequent ecological rating of these features.

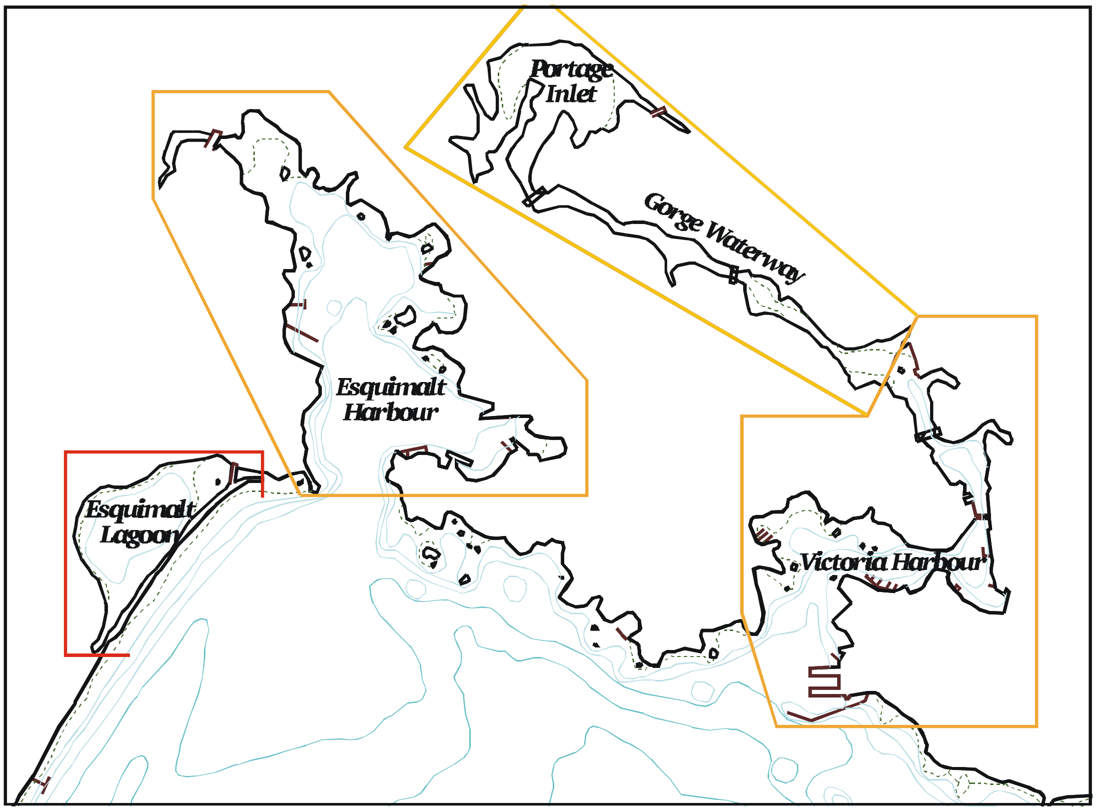

Figure 1. Victoria and Esquimalt Harbours. Esquimalt Lagoon subtidal survey area is shown in red. Yellow areas (Victoria and Esquimalt Harbours, Portage Inlet and the Gorge Waterway) have also been surveyed in a similar manner (see Section 1.1).

The Harbours Ecological Inventory and Rating (HEIR) project has been underway since 1997. Phase 1 of the project, an inventory and ecological rating of the intertidal and backshore zones of the harbours, was completed in 1999 (Westland 2000). Phase Two of the project will address the subtidal areas of the harbour and consists of two components:

Component 1 - a subtidal inventory of the harbour areas;
Component 2 - the development and application of a systematic ecological rating to these subtidal areas.

This project addresses the requirement for a subtidal inventory of biophysical features of Esquimalt Lagoon. A companion report (Archipelago Marine Research Ltd. 2000a) provides an inventory and mapping of subtidal areas of Portage Inlet and the Gorge Waterway. A subtidal inventory of Victoria Harbour, funded by Transport Canada, was completed in 1999 (Emmett *et al.* 2000). Transport Canada has also undertaken a subtidal inventory of Esquimalt Harbour (Archipelago Marine Research Ltd. 2000b). These initiatives complete the subtidal inventory component of the HEIR project (Figure 1). The next step in the HEIR process is Component 2, the development of ecological ratings for subtidal habitats in a manner compatible with the recent rating of intertidal habitats within the VEHEAP area (Westland 2000). This will be undertaken when the information from the four subtidal inventory initiatives is made available to VEHEAP.

These inventory projects recognise the importance of using comparable methods. For this reason, underwater video and dive survey methods, as well as seasonal timing comparable to the previous Transport Canada inventories, have been used for the current surveys of Esquimalt Lagoon, Portage Inlet and the Gorge Waterway. These methods are outlined in Section 2.0.

1.2 OBJECTIVES AND PROJECT DELIVERABLES

The subtidal physical and biological survey 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 with extensive man-made debris, log and bark accumulations or sediment deposition.
5. Produce digital maps compatible with the existing HEIR intertidal and Transport Canada subtidal inventories of Victoria and Esquimalt Harbours.

Project deliverables include:

1. A hardcopy map folio and accompanying interpretative report,
2. Electronic survey data including the Access database and associated GIS (ArcView) files,
3. An HTLM format interactive CD-ROM providing mapped biophysical themes and georeferenced still and video imagery from the underwater survey,
4. Copies of the underwater video imagery in SVHS format.

1.3 SURVEY AREA

Esquimalt Lagoon is located immediately west of Esquimalt Harbour (Figure 1, Figure 3 - Map Folio)) and encompasses 82 hectares of subtidal area and 6.3 km of shoreline (defined as the higher high water mark). The physical setting and ecological characteristics of the lagoon are well described by Westland (1993). The outer boundary of the lagoon is a gravel and sand spit (Coburg Peninsula) formed by the alongshore transport of sediments from the southwest. The lagoon flows to the Strait of Juan de Fuca via several channels at the northeast end of the lagoon. There are extensive intertidal gravel and sand flats inside the lagoon entrance (flood-tidal delta) and outside the lagoon between the tip of Coburg Peninsula and Fisgard Light (ebb-tidal delta). The position of the tidal inlet has been more or less permanently fixed by the road construction on the spit, which prevents additional entrance channels from forming during washover events. Also the construction of a solid-fill causeway to Fisgard Light has altered the longshore transport of sand such that a series of beach ridges and very large tidal flat have developed outside the mouth of the lagoon.

The lagoon is quite shallow with depths generally less than 3m relative to chart datum. Tidal circulation is restricted by the narrow tidal channels at the lagoon entrance. These channels are quite dynamic and can change as a result of severe winter storms. The mean tidal amplitude in Esquimalt Lagoon is less than 50% of the mean tidal amplitude of Victoria and Esquimalt Harbours Harbour (0.7m versus 1.8m, Figure 2). In addition, the tidal level is generally lower than the outer marine waters, seldom exceeding +1.0m relative to chart datum (Tides and Currents Ver 3.0 tidal software).

Westland (2000) classified the shoreline of Esquimalt Lagoon into seven subunits based on intertidal and backshore physical features (Figure 3 - Map Folio). Most of the backshore and intertidal zone is formed of sediments except for the northeast corner of the lagoon, which is a mix of bedrock cliff and sand/gravel beach. The Westland subunits include the gravel islet just inside of the lagoon entrance and the rock islet 400m to the southwest. At a regional scale the provincial Land Use Coordination Office (Howes and Wainwright 1983) classified the entire shoreline as estuary/lagoon. Much of the sediment shore units are characterised by fringing brackish marsh vegetation including *Carex sp.*, *Salicornia* and salt tolerant grasses. There are several small creeks draining into Esquimalt Lagoon, including Colwood Creek which drains into a brackish marsh just east of the Royal Roads University dock, Bee Creek draining west of Royal Roads, and Selleck Creek at the west end of the lagoon (Figure 3 - Map Folio).

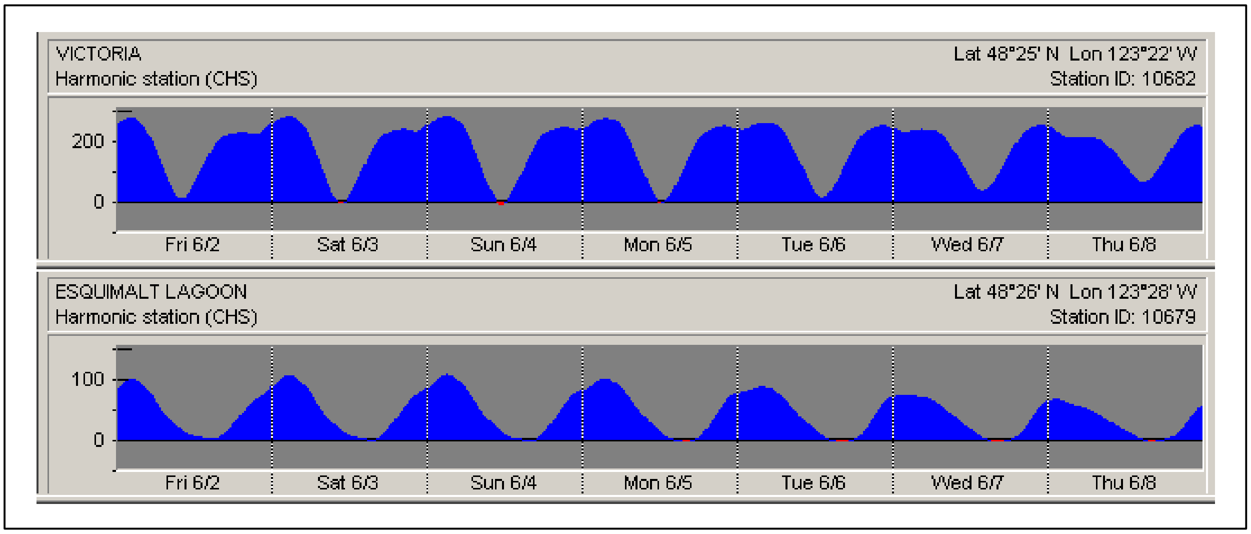

Figure 2. Comparison of tides for Victoria Harbour and Esquimalt Lagoon over a summer tidal cycle. (Note difference in vertical scale)

2.0 METHODS

The project 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, intertidal 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

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 (3.5 km/hr). Each image (defined as one second of video imagery) is geo-referenced to differential global positioning system (DGPS) standard ($\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 Lagoon took place over two days, April 17 and 18th, 2000. A 15 foot inflatable boat equipped with a portable winch was used to tow the SIMS camera in these shallow water areas. Visibility over the seabed ranged from 0.5 to 1.0m. Visibility was slightly better in the northeastern portion of the lagoon, towards the outflow channel.

The video survey encompassed a total of 29.9 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. eelgrass beds). Tracklines were also run in a zig zag fashion through the two entrance channels where, at times, it was necessary to hand haul the survey boat. A total of 39,238 image points were collected. This represents 11 hours of video imagery and direct observations of about 30,000m^2 (3.0 ha) of seabed, assuming an average field of view width of 1.0m.

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 includes 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. In Esquimalt Lagoon, the biotic component of the classification system also included prominent, non-aggregating macroinvertebrates (e.g. crabs, Appendix A), which were not classified in the initial LUCO system.

Of the 39,238 video images, 33,487 (85%) were classified for substrate and 29,299 (75%) 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 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 3440 and includes the CHS shoreline, depth contours and selected navigational and shoreline features. CHS chart 3440 was not sufficiently fine scale to accurately depict the intertidal gravel bars at the outlet of the lagoon. For this area, the intertidal shoreline provided on CHS chart 3417 (1:8,000 scale, but not available in digital format) was digitised and added to the base map.

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 (m) 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 video images were captured to digital image files (either as still images or video 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 HTML data product of the project. The video images are intended to assist the reader in understanding both the application of the classification system and the mapped features.

2.3 FIELD OBSERVATIONS

After a preliminary review of the video classification, intertidal and snorkel observations were conducted on July 08 and 13th, 2000 in a number of areas in Esquimalt Lagoon where the identification of biota or substrate classification was uncertain. Systematic site surveys were not conducted, rather the field observations were conducted to verify or clarify the video image classification. For this reason, no specific field survey sites are identified in Esquimalt Lagoon.

3.0 RESULTS

This section summarizes the physical and biological features obtained from the classification of the video imagery and field 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 18) are provided in Section 6.0, the report Map Folio. Selected video images are provided in Appendix B.

3.1 SUBSTRATE TYPE

Substrate type provides a general description of material at the surface of the seabed. The distribution of these substrates in the Esquimalt Lagoon is mapped in Figure 4, and the estimated area of the various substrate types summarised in Table 3.

Table 3. Substrate Type

SUBSTRATE TYPE	DESCRIPTION	SUBTIDAL AREA (HA)
Sediment	gravel, sand, or mud-sized material	77.0
Rock	bedrock outcrop	0.0
Rock with Sediment Veneer	Intermittently visible bedrock covered with a veneer of sediment	0.0
Biogenic	seabed surface obscured by material of biological origin such as vegetation	3.2
TOTAL		**80.2**

Most of the substrate is classified as sediment (mud, sand, gravel), which accounts for 94% of the classified subtidal seabed area. No rock or rock with sediment veneer substrates were identified. In places, dense vegetation (green algae, eelgrass, vegetative detritus) obscured the subtidal seabed. The substrate in these areas is also likely sediment and the entire subtidal area of Esquimalt Lagoon is considered to be sediment substrate. Bedrock does occur within the intertidal zone, including a small rocky islet in the northeast portion of the lagoon and a the bedrock cliff shoreline on the north side of the lagoon entrance.

3.2 SEDIMENT SIZE CLASS

Sediment size classes are assigned to the *sediment* and *rock with sediment veneer* substrate types. The distribution of these sediments in the Esquimalt Lagoon is mapped in Figure 5 and the estimated area of the various sediment size classes summarised in Table 4. Further detail on sediment class codes are provided in Tables A-3 and A-4 of the data dictionary (Appendix A). In some areas, sediment types were difficult to classify due to poor visibility. It is often difficult to distinguish sand from mud on the video imagery and sediments are classified as mud/sand (i.e., the term mud/sand does not necessarily mean a mixture of mud and sand but rather that it is one or the other or both). As well, trace to 5% gravel is included in the mud/sand category due to poor visibility (Table 4). In some areas, it is possible to distinguish either sand or mud and they are classified separately.

Table 4. Sediment Size Class

SEDIMENT SIZE	SUBTIDAL AREA (HA)
Gravel (>30% gravel*)	6.9
Gravelly Mud/Sand (5-30% gravel)	4.9
Sand	0.0
Mud/Sand (T-5% gravel)	45.6
Mud	23.2
TOTAL	**80.6**

* gravel = total pebble, cobble, boulder

Most (46.6 ha) of the sediments in Esquimalt Lagoon are classified as mud/sand. There are two areas of mud sediment in the deeper, central part of the lagoon. These are depositional areas where sediments are slowly accumulating over time. Sediment size class was difficult to classify in the lagoon basin due to poor visibility.

Gravel content provides a good index of energy in that the higher the gravel content, the higher the assumed energy generated by waves or tidal 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. In Esquimalt Lagoon, the higher gravel content areas are the shore margins including several areas on the inside of the spit (Figure 6). These coarse deposits are likely relict features resulting from overwash of the spit, now prevented by the placement of the road. Local wind-wave generation within the lagoon is probably responsible for the erosion and coarsening of the south and southwestern lagoon shore. The highest gravel content is in the tidal channels at the lagoon entrance, which are >80% gravel (Figure 6). The intertidal flats at the lagoon entrance are also classified as gravel. The gravel areas are usually associated with high shell content (see Figure 8) which indicates that the channels are non-depositional environments.

The gravel in Esquimalt Lagoon is almost exclusively pebble size material. There is a trace of cobble in the tidal channels at the lagoon entrance and several small areas around the shore margin which may originate from man-made fill. No boulder size material was identified in the subtidal sediments.

3.3 ORGANIC MATERIAL AND SHELL CONTENT

The distribution of organic material, as estimated from the video images, is shown in Figure 7. Most of the organic material is vegetative detritus associated with the more densely vegetated parts of the survey area. The areas of highest (>30%) detritus cover are associated with eelgrass beds (see Figure 11) and most of the vegetative detritus is eelgrass or algal fragments. The quantity and extent of this material is expected to vary considerably throughout the year.

Wood debris (logs, branches, bark and wood fragments) was noted along the north-eastern side of the tidal channel at the lagoon outlet (Figure 7). This material may originate from inside (i.e. the backshore) or outside (i.e. drift debris) the lagoon.

The pattern of distribution of shell (whole and fragments) in the Esquimalt Lagoon sediments (Figure 8) closely resembles the distribution of gravels (Figure 6). Shell and shell fragments are most abundant in the gravelly shore margins, including the overwash areas on the inside of Coburg Peninsula. Shells are also relatively abundant in the tidal channels at the lagoon entrance, except downstream of the bridge where higher current flow may transport shells to other areas. Trace amounts of shell were classified in the north-eastern portion of the lagoon which is predominantly mud/sand with a trace of gravel. Shell material was not classified in the mud sediments in the southwest portion of the lagoon**.** Most of the shell in the sediments are whole or shell fragments of Japanese littleneck clams (*Tapes japonica*), native littlenecks (*Protothaca staminea*), cockles (*Clinocardium nuttallii*), butter clams (*Saxidomas giganteus*) and mussels (*Mytilus* sp.).

3.4 MAN-MADE OBJECTS

Very few man-made objects were identified on the seabed of Esquimalt Lagoon. These objects are summarized in Table 5 and their distribution mapped in Figure 9. A total of 27 man-made objects were identified in the 30 km of survey trackline (0.9 objects/km). In contrast, 6,482 man-made objects were identified in 79 km of trackline (82 objects/km) in Victoria Harbour (Emmett *et a*l. 2000). Poor visibility may have limited the identification of some smaller man-made objects, but, clearly, Esquimalt Lagoon is relatively free of man-made debris. Debris was identified off the dock at Royal Roads University, along the shore margins of the residential area in the southwest side of the lagoon, and on the inside of Coburg Peninsula.

Table 5. Man-made Objects

MAN-MADE OBJECT	# IMAGE POINTS
Other	10
Metal Objects	4
Cans	3
Garbage	3
Bottles	2
Tire	2
Logs	2
Cable/Wire/Rope	1
Total	27

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 6 summarises the estimates of vegetated cover in Esquimalt Lagoon 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 lagoon is shown in Figure 10.

Table 6. Estimated Area of Various Vegetation Types by Cover Category

CODE	TYPE	VEGETATED AREA (HA)			% OF SUBTIDAL AREA
		SPARSE-LOW COVER	MODERATE-DENSE COVER	TOTAL	
	Total Vegetation	21.8	18.8	40.6	49.5
ZOS	Eelgrass	4.9	9.7	14.6	18.8
FOG	Foliose Greens	18.3	10.0	28.3	34.5
BKS	Bladed Kelps	4.8	1.2	6.0	7.3

Approximately 50% of Esquimalt Lagoon is vegetated, with about half of the vegetated area being moderate to dense cover. By comparison, vegetation cover in Victoria Harbour is similar (50%), but only 20% of the vegetated area is moderate to dense cover (Emmett *et al*. 2000). The vegetation cover is densest along the shoreline margins of the lagoon (primarily eelgrass), within the northwest portion of the lagoon basin (green algae and kelp), and in the channels at the entrance to the lagoon (eelgrass, kelp, green and red algae).

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 (FIL1 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. All images in which specific vegetation types were identified as either primary, secondary or tertiary vegetation are included in the map folio figures.

Seven of the 16 vegetation types were identified in Esquimalt Lagoon (Table 7). The most common vegetation types are foliose green algae, eelgrass, kelps, filamentous and foliose red algae. Vegetation was notably absent in the southwestern portion of the lagoon basin (see Discussion Section 4.0). Further information on the extent and distribution of these vegetation types is provided in Sections 3.6 to 3.9.

Table 7. Frequency of Classified Vegetation Types

CODE	TYPE	IMAGE POINTS			
		PRIMARY	SECONDARY	TERTIARY	TOTAL
NOV	No Observed Vegetation	17,200	0	0	**17,200**
FOG	Foliose Green Algae	8,904	1,266	192	**10,362**
ZOS	Eelgrass	6,927	217	50	**7,194**
BKS	Bladed Kelps	233	1,738	256	**2,227**
FOR	Foliose Red Algae	74	738	233	**1,045**
FIR1&2	Filamentous Red Algae	76	434	353	**863**
SAR	*Sargassum*	73	50	8	**131**
	Total	**33,487**	**4,443**	**1092**	

3.6 EELGRASS

Figure 11 shows the location of eelgrass (*Zostera marina*) beds in Esquimalt Lagoon. The eelgrass was densest and most extensive along the shore margins and in the tidal channels at the lagoon entrance. The depth of eelgrass throughout the lagoon was remarkably consistent, ranging from 0.0m to 2m (Figure 11). Approximately 15 hectares of eelgrass (19% of the total subtidal area) were mapped (Table 6), of which 10 hectares were of moderate to dense cover. This compares to estimates of 2.0 hectares of eelgrass for Victoria Harbour (Emmett *et al*. 2000), 80 hectares (45 ha of moderate to dense cover) in Portage Inlet and the Gorge Waterway (Archipelago Marine Research Ltd. 2000a) and less than 1.0 hectare in Esquimalt Harbour (Archipelago Marine Research Ltd. 2000b).

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 12 shows the distribution of kelp in Esquimalt Lagoon. Six hectares of kelp vegetation were mapped (Table 6), of which 1.2 hectares were moderate to dense vegetation cover. *Laminaria saccharina* was the dominate kelp species. *Laminaria* is found in the northeast portion of the lagoon and in the tidal channels at the lagoon entrance (e.g. the seaward most end of the lagoon). This is similar to the observations of kelp in the Lower Gorge and Selkirk Waters (Archipelago Marine Research Ltd. 2000a), where *Laminaria saccharina* occurs in areas with higher tidal flow but no other kelp species (e.g. *Agarum* sp.) were observed. *Alaria* sp. was also observed, mostly in the tidal channels seaward of the bridge, and *Desmerestia* sp. was noted to occur in areas with *Laminaria*. *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 Lagoon, *Sargassum* was noted in the tidal channels at the lagoon entrance (Figure 12).

3.8 FOLIOSE GREEN ALGAE

Foliose green algae (primarily *Ulva* sp. but also *Enteromorpha* sp.) were the most abundant and widespread type of vegetation in Esquimalt Lagoon. Approximately 28 hectares of green algae (34% of the subtidal area) were mapped (Figure 13). *Ulva* was most extensive and densest in the northeastern portion of the lagoon, where it occurred with the bladed kelp *Laminaria*. In the tidal channels at the lagoon entrance, *Ulva* occurred with both eelgrass and *Laminaria*. Within the lagoon basin foliose green algae were not observed in the eelgrass beds along the basin margin, and were generally found at depths greater than 2m.

The thinner bladed green algae *Enteromorpha* also occurs in intertidal areas along the shoreline of Esquimalt Lagoon. 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 May survey date and, correspondingly, more scarce or absent in winter.

3.9 FILAMENTOUS AND FOLIOSE RED ALGAE

Both filamentous and foliose red algae co-occur in the tidal channels of the lagoon entrance and immediately southwest of the intertidal sand/gravel bar at the lagoon entrance (Figures 14 and 15). Filamentous algae were also found sparsely scattered throughout the lagoon except in the southern portion of the basin. Due to the patchy and sparse distribution of these species, polygon areas could not be reliably estimated. Field observations documented that *Neoagardhiella baileyi* is the most common filamentous red algae species. In the tidal channels on the inside of the lagoon this algae grows in dense beds several square meters in size. Filamentous red algae also occurs in the tidal channels on the seaward side to the bridge; however foliose red algae (*Mazzaella* sp. or *Rhodoglossum/Iridaea* species complex) were particularly common in this area.

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 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 non-aggregating mobile species (e.g. crabs) were added to the original classification system in order to document prominent mobile resource features. The classification system permits a primary (most common) faunal type, secondary (next most common) and tertiary (third most common) faunal type 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 8. Faunal Types

CODE	TYPE	# OF IMAGE POINTS
HLF	Unmounded Infaunal burrows	2,365
HLM	Mounded infaunal burrows	185
ANM	*Metridium*	16
TUBP	Parchment Tubeworms	20
BRY	Bryozoans	94
TEA	Anemone (*Tealia* sp.)	6
CAN	Cancer sp. (*C. magister, C. gracilis*)	25
RRK	Red rock crab (*C. productus*)	1
CUC	Burrowing sea cucumber-*Cucumaria*	4
UNK	Unknown	39
Total		**2,755**

Macrofauna were classified for about 8% of the 33,000 classified images (Table 8). Most (92%) of the classified fauna were infaunal burrows, which indicative of large, burrowing infauna (e.g. burrowing shrimp, larger worms, bivalves). The classified infaunal burrows are mostly located just below chart datum along the inner edge of the eelgrass beds (Figure 16), however other areas of large burrowing infauna may have been obscured by dense vegetation such as eelgrass beds and green algae. The distribution of infaunal burrows should not be considered an index of infaunal richness, as smaller infaunal organisms cannot be identified visually.

Very few crabs (25 classified images, 0.8 per km of trackline) were noted at the time of the survey (Figure 17). By way of contrast, there were over 3,000 crab observations (30 per km of trackline) in the video survey of Esquimalt Harbour (Archipelago Marine Research Ltd. 2000b). 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. The crab were located in the tidal channels at the lagoon entrance and along the margins of the lagoon at depths less than 2.0m. The low abundance of crab in Esquimalt Lagoon was unexpected. Crabs in eelgrass and other densely vegetated areas may have been obscured from view and, as crabs are highly mobile, they may be more abundant at other times of the year. Dungeness crab were harvested commercially in Esquimalt Lagoon prior to 1995 however, in recent years, crab have not been sufficiently abundant to justify a commercial fishing effort (R. Jolly, pers. comm.). This may be due to increased fishing effort outside the lagoon, which could reduce the number of crab moving into the area, or a result of die off from the episodic anoxic conditions within the lagoon (summarized in Section 4.0).

Plumose anemone (*Metridium* sp.) were found sparsely scattered throughout the lagoon basin, often growing on erratic pieces of hard substrate including cobble, wood and other man-made debris (Figure 18). A second species of anemone (*Tealia* sp.) was observed nearer the shore margin, generally in areas with coarser substrate. A few bryozoans, characteristic of higher current regimes, were observed in the tidal channels at the lagoon entrance (Figure 18). Starfish were not observed in subtidal areas of Esquimalt Lagoon at the time of the survey. Starfish were also absent from the upper portion of the Gorge Waterway and Portage Inlet (Archipelago Marine Research Ltd. 2000a).

The number of observed large, epifaunal organisms was surprisingly low (Table 8). Only 205 images with epifauna (7 per km of trackline) were classified in Esquimalt Lagoon. This contrasts with 8,186 classified epifaunal images (163 per km of trackline) in Portage Inlet and the Gorge Waterway (Archipelago Marine Research 2000a) and 6,700 classified epifaunal images (67 per km of trackline) in Esquimalt Harbour (Archipelago Marine Research Ltd. 2000b). For these three surveys visibility conditions were similar and the same epifaunal types (both aggregating and mobile) were classified. In Victoria and Esquimalt Harbour plumose anemone (*Metridium*), and piddock clams (*Zirphaea pilsbryi*) were commonly observed. Bryozoans and ascidians, organisms often found in areas with higher tidal currents, were common in the Gorge Waterway and Victoria Harbour. Native oysters (*Ostera lurida*) were abundant in Portage Inlet. None of these organisms, which should have visible to the classifiers given the similar visibility conditions of all the surveys, were abundant in Esquimalt Lagoon.

Although not observed in the subtidal video imagery, field observations indicate that littleneck clams (*Tapes japonica* and *Protothaca staminea*), butter clams (*Saxidomis gigantus*) and mussels (*Mytilus* sp.) appear to be abundant on the intertidal sand/gravel flats just inside the lagoon entrance. Some of the mussels are extremely large, likely due to the lack of starfish predators in the lagoon. The Japanese oyster (*Crassostrea gigas*) was also common. This area, and the clam beds outside the lagoon entrance, are closed to harvesting due to coliform contamination, however they probably represent the largest intertidal clam beds in the Victoria/Esquimalt Harbour area (see Section 4.0).

4.0 DISCUSSION

Esquimalt Lagoon is a typical barrier spit/lagoon complex where sediment transport from the south has created the barrier spit and enclosed the lagoon. There are however important anthropogenic influences on the system. The sediment source for the spit was formerly eroding till and outwash sediment cliffs. Gravel mining in the area since the early 1900's has altered the sedimentation pattern such that the spit is dominated by sand-sized material whereas it was formerly a mixture of sand and gravel. The spit would have been occasionally washed over during storm surges, road construction has limited the washovers and prevented new inlets from forming. The ebb tidal delta at the lagoon mouth has likely expanded as a result of construction of the Fisgard Light causeway, which limits alongshore sediment transport.

The lagoon is a relatively quiescent environment with low wave exposure and tidal currents. Most of the lagoon appears to be a sediment sink and will gradually infill over time, further reducing the tidal prism of the lagoon (volume of the lagoon affected by tides). The exception is the northern portion where tidal currents associated with the inlet and flood-tidal delta can resuspend material as tidal channels migrate across the tidal flats.

Areas within the Capital Regional District with similar physical features include Albert Head, Whitty's Lagoon and Sidney Island Lagoon. Sherwood Pond in Devonian Regional Park may be an example of a lagoon formed by a spit, where the lagoon entrance to the sea has been has been closed, and marshes and wetlands have developed in the old lagoon basin.

Input of nutrients (particularly nitrate) to Esquimalt Lagoon is a continuing environmental concern (Watanabe and Robinson 1980, Burke *et al*. 1998). Nitrogen may be entering the lagoon from a variety of sources including failing septic fields, fertilisers, birds and other natural sources. The resultant biological productivity, particularly plankton blooms (including organisms causing red tide), may contribute both to the episodic anoxic conditions described below as well as the muddy, depositional substrate present in the southern portion of the basin.

There is evidence of episodic, anoxic conditions in the sediment and water column of Esquimalt Lagoon, particularly the southern portion (Watanabe and Robinson 1979; D. Bright, W. Drinnan, S. Beckman, pers. comm). Occasionally, fish (primarily sculpins) and crab mortalities have been reported. During these events crab have been observed to move out of the water and even across Coburg Peninsula to open water. These events usually occur in August or September and are associated with a lower tidal cycle, a chalky white turbidity (possibly calcium carbonate) and sulphide odour in the water. Water samples confirm that dissolved oxygen levels are extremely low (S. Beckman, pers. comm.). This condition likely results from a combination of elevated water temperature, reduced tidal exchange and organic decomposition (either as a result of plankton blooms or vegetative decomposition).

The physical and biological features of Esquimalt Lagoon are summarized in Table 9. Some of the valued biological features include:

1. **Eelgrass (*Zostera marina*) beds.**
   Approximately 15 hectares of eelgrass beds were mapped in Esquimalt Lagoon. This represents 16% of the eelgrass beds identified in the Victoria and Esquimalt Harbours area. Eelgrass is generally recognized as productive and important rearing habitat for many species of juvenile fish and invertebrates, as well as being sensitive to impacts from foreshore development

2. **Intertidal bivalve beds.**
   The intertidal gravel bars at the entrance to the lagoon support butter and littleneck clams as well as mussels and the Japanese oyster. The Coburg Peninsula and the intertidal gravel bars inside and outside the entrance to Esquimalt Lagoon are the only intertidal clam beds documented by Fisheries and Oceans Canada in the Victoria/Esquimalt Harbours area (Harbo *et al*. 1997). This does not mean that these are the only areas in the harbours region with commercial or recreational harvest potential, however it does indicate that they are likely the largest and most significant intertidal clam beds in the area.

3. **Herring Spawning.**
   Herring have historically (1940-1951) spawned in Esquimalt Lagoon and spawn was also recorded in 1991-93 at the entrance to the lagoon. (Hay and MacCarter 1999). Although Esquimalt Lagoon is not currently considered one of the more important herring spawning areas in the harbours region, the historic record indicates that the area could be important in future years.

4. **Marine Associated Birds.**
   Esquimalt Lagoon is a designated migratory bird sanctuary and a substantial number of birds are present on a year round basis (Shepard 1999). In particular the lagoon is important overwintering (October to April) habitat for waterfowl (ducks and geese) and other marine associated birds including American Wigeon, Greater Scaup, and Bufflehead (Shepard 1999). Gulls (Glaucous-winged, Mew and California) are abundant during the summer months.

Emmett *et al*. (2000) and Archipelago Marine Research Ltd. (2000b) identified a number of valued subtidal areas within Victoria and Esquimalt Harbours such as eelgrass beds, areas of high algal diversity and abundance, subtidal bedrock outcrops and gravelly channels. Due to the large areas of eelgrass, important bivalve beds (particularly native oyster) and tidal current invertebrates, it is suggested that the entire subtidal area of the Gorge Waterway and Portage Inlet be considered valued habitat (Archipelago Marine Research Ltd. 2000a). With respect to subtidal habitat value, Esquimalt Lagoon falls somewhere between Victoria/Esquimalt Harbours and the Gorge Waterway/Portage Inlet. The eelgrass beds and tidal channels within the lagoon (approximately 20% of the subtidal area) are valued habitats, contributing to community and habitat diversity of the harbour area.

The southern portion of the lagoon is a depositional environment, lacks macrovegetation and may, at times, be anoxic. While this may be a natural condition and process within a lagoon with restricted tidal exchange, it is probable that nutrient input and the control of washover and breaks in the spit due to the road construction has exacerbated this process. At the time of the survey, areas such as the extreme southwest arm of the lagoon were extremely turbid due to plankton blooms and other particulate matter.

Much of the important habitat value of Esquimalt Lagoon can be attributed to backshore and intertidal features as well as the physical form of the lagoon. The recent HEIR intertidal inventory and rating (Westland 2000) rated the backshore and intertidal ecosystem value of all seven shore units in the lagoon as high or very high. This is due to the amount of naturally vegetated backshore, marsh grasses and intertidal sand/gravel flats with important bivalve beds. The value of the lagoon as habitat for marine associated birds is similarly high. Much of the wildlife value of the lagoon is derived from these intertidal and backshore features, although the eelgrass beds and tidal channels also remain important for certain bird species. In addition, the sheltered nature of the lagoon, in close proximately to the more exposed marine environment, is likely important to many marine associated bird species.

Table 9. Summary of the biophysical features of Esquimalt Lagoon

BIOPHYSICAL FEATURES		
PHYSICAL	**VEGETATION**	**FAUNA**
• Shallow, mud and mud/sand sediment except around margins. • Spit formed by alongshore current with evidence of overtopping. • Most of basin, particularly south end, depositional. • current influence at lagoon entrance, gravel sediments in tidal channels. • Few man-made objects low use and due to depositional nature. • Restricted tidal exchange, with evidence of low oxygen or anoxic conditions in late summer. • Human activities have altered processes (sediment supply, tidal channel formation)	• Eelgrass beds around lagoon margins, do not extend below 2m. depth. • Extensive area of foliose green algae (*Ulva* and *Enteromorpha).* • Kelp restricted to north end. • Filamentous and foliose red algae in tidal channels.	• Intertidal clam beds • Historic herring spawning.

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PERSONAL COMMUNICATIONS

W.R. Drinnan. Environmental Technology Program, Camosun College, Victoria, BC
D.A. Bright. Applied Research Division, Royal Roads University, Victoria, BC
S. Beckman. Fisheries and Oceans Canada, Victoria, BC
R. Jolly, Victoria, BC

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.

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

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 the video tow fish corrected to tidal datum using predicted tidal data.

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 sand: **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**

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).

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.

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.

VEG3

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

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

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 (Gorge/Portage and Esquimalt Lagoon)

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.
	Widgeon Grass	RUP	*Ruppia* sp.
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

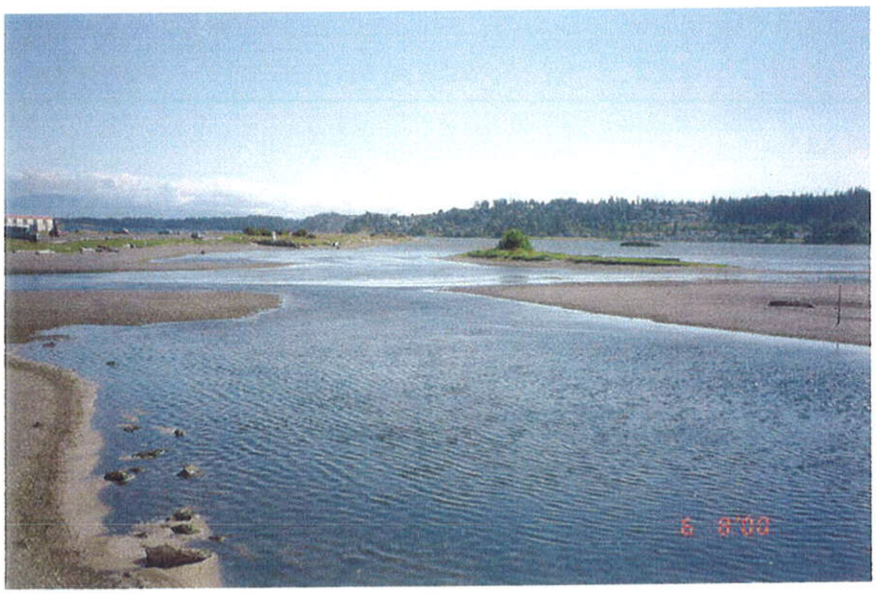
Table A-11. Faunal Classification with Emphasis on Sessile, Aggregating Species or Species Groups (Gorge/Portage and Esquimalt Lagoon)

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	*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	Burrowing sea cucumber (*Cucumaria miniata*)
	PAR	California Sea cucumber (*Parastichopus californicus*)
Infaunal "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.
Blue green bacteria (alga)	BEG	"*Beggiatoa* sp"
Unknown	UNK1	macro fauna visible but cannot be identified
No Fauna	NOF	no fauna observed

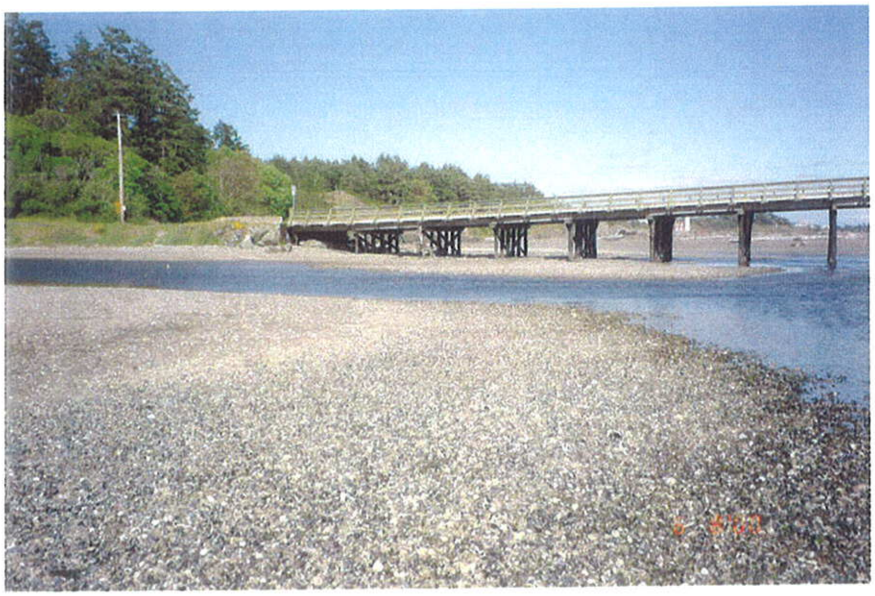
APPENDIX B

Video Images of Characteristic Biophysical Features

Marsh grasses on west side of the lagoon.



Tidal channels at the lagoon entrance.



Gravel bars and clam beds at the lagoon entrance.

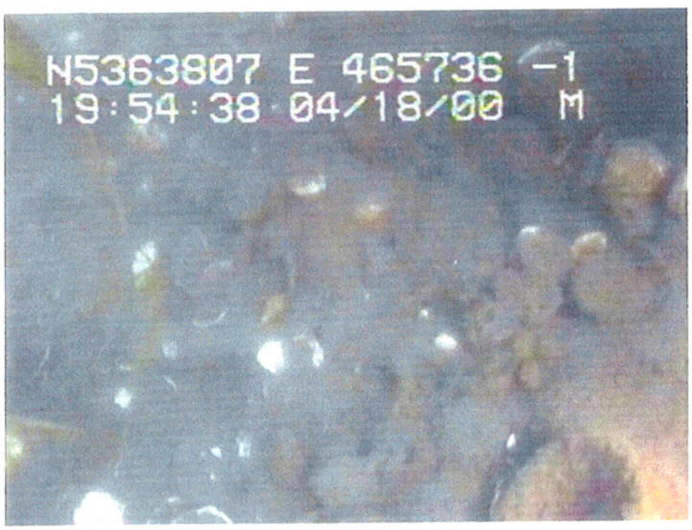
Intertidal and Backshore Features

Tidal Channel Features

Foliose red algae and eelgrass in tidal channels seaward of bridge at lagoon entrance.

Filamentous red and green (*Ulva sp.*) algae in tidal channels inside of bridge at lagoon entrance.

Overwash Features

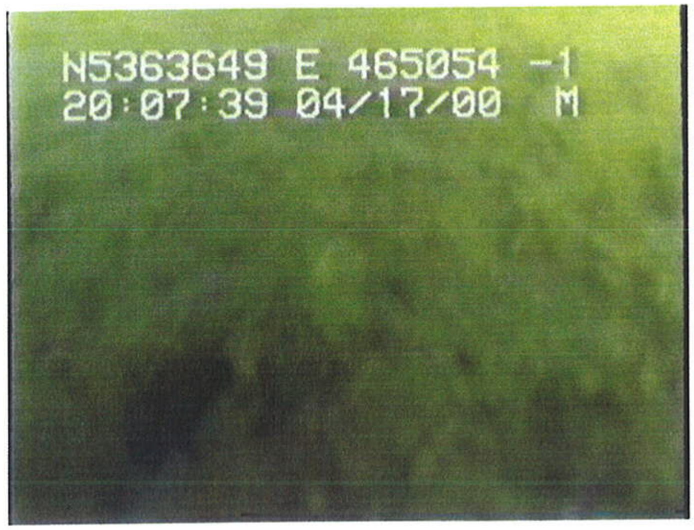


Gravel and shell overwash on the lagoon side of Coburg Peninsula.

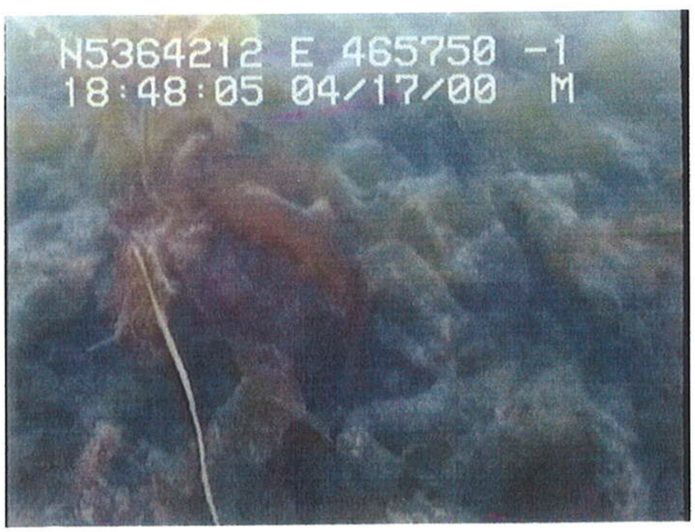
Gravel and shell overwash with eelgrass on the lagoon side of Coburg Peninsula.

Basin Features

Eelgrass in sand/mud substrate.



Unvegetated mud substrate.



Bladed kelps (*Laminaria*) and green algae (*Ulva sp.*).