Chatham Sound Eelgrass Study Final Report

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Research carried out by Ocean Ecology
1662 Parmenter Ave.
Prince Rupert, BC V8J 4R3
Telephone: (250) 622-2501
Email: blueseas@oceanecology.ca

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Prepared for: Mike Ambach
Program Manager
World Wildlife Fund - Prince Rupert
#3-437 3rd Ave. West
Prince Rupert BC
V8J 1L6

Prepared by: Ocean Ecology

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Executive Summary

Generally situated in shallows and along complex shorelines highly valued by recreational users, eelgrass meadows are both ecologically valuable and potentially threatened. They provide rearing habitats for the juvenile stages of many species of fish, foraging habitats for both migratory and resident bird species, and recent research also suggests that eelgrass plays a critical role in carbon sequestration. However, our understanding of the specifics of their ecological functions, including vulnerability to human activities and climate change, is still limited.

Chatham Sound is situated in the northern part of British Columbia, located between Dundas and Stephens Islands and the Tsimpsean Peninsula near Prince Rupert and bordering on Alaska. As a result of the fresh water discharges of the Nass and Skeena Rivers, the whole of Chatham Sound is essentially a large estuary. Recent studies at the Lucy Islands found substantial amounts of previously unmapped subtidal eelgrass in Chatham Sound. Clearly, we are still learning about the geographical extent and roles of eelgrass in the Chatham Sound estuary system. Thus, the objectives of the Chatham Sound Eelgrass Study were:

- To provide relevant management authorities with high quality data and recommendations regarding eelgrass presence in priority areas on the North Coast of BC.
- To assess the overall abundance and health of subtidal eelgrass in the Chatham Sound estuary region.
- To compare the status of eelgrass beds in the region based on riverine influence, recreational use, and industrial activities.
- To assess temporal changes in eelgrass beds at those sites where data has been collected previously.
- To provide baseline data for subtidal eelgrass beds in regions where the British Columbia Marine Conservation Analysis has indicated that eelgrass is a priority habitat.
- To provide data for the future development of an oceanographic model relating changes in riverine sediment deposition resulting from global climate change with eelgrass bed health.

To this end, benthic video footage was collected on subtidal eelgrass at 29 sites throughout the Chatham Sound region. The eelgrass beds that were studied during this project were chosen to be representative of a variety of locations and conditions throughout Chatham Sound. They do not necessarily include the healthiest, largest, or most vulnerable eelgrass beds in the region. There are many other eelgrass beds in Chatham Sound that were not surveyed.

While the analysis of this data brought many surprises, and probably generated as many new questions as it answered old ones, a few of the important conclusions are as follows:

- The presence of intertidal eelgrass is not an absolute indicator of the presence of subtidal eelgrass.
- Aerial surveys using the standard visible spectrum for photography and video do not adequately assess the abundance of subtidal eelgrass. Therefore, the Shorezone data set does not provide a reliable estimate of total eelgrass on the North Coast.
- A diverse range of fish and invertebrates, including commercial species such as rockfish and Dungeness crab, were observed utilizing the eelgrass beds. The value of eelgrass habitat to these species should be a topic for further research.
- Chatham Sound is dominated by rocky intertidal habitats. Only about 14% of the coast in the study area is classified as a shore type where eelgrass might be expected. Much of the coastline within that 14% may be unsuitable habitat for eelgrass for a number of other reasons.

- Large amounts of unmapped intertidal eelgrass were observed in some locations. This suggests that our knowledge of the geographical extents of intertidal eelgrass in Chatham Sound is limited. More effort needs to be expended on mapping intertidal eelgrass in the Chatham Sound region.
- Subtidal eelgrass varied widely in terms of its health and abundance.
- Each eelgrass bed was unique, with variations in substrates, ecotypes, associated flora and fauna, and tolerance to turbidity, wave action, and tidal currents.
- North Coast eelgrass prefers a greater degree of wave exposure and a larger average substrate particle size than that observed in previous studies of more southern eelgrass.
- A qualitative health index was calculated for each of the eelgrass study sites. This index involved factors such as turbidity, presence or absence of local freshwater, salinity, current velocity, wave exposure, sedimentation, cumulative sewage impact, substrate particle size, and bottom topography. The health index was able to estimate the maximum eelgrass abundance that could be expected at a given site; however, many eelgrass beds do not appear to be at or near their maximum abundance.
- Collection of new quantitative data on the Skeena/Nass estuary system, particularly for turbidity, salinity, and nitrate, is necessary to improve our ability to determine the health of a site.
- The development of an oceanographic model for the Chatham Sound region would greatly improve our abilities to assess the factors affecting eelgrass at a particular site, and to predict future changes in these factors.
- Further study into factors, such as herbivory, bioturbation, pathogens, oxygen depletion, and temperature, which may be limiting eelgrass growth is necessary.
- Given the number of eelgrass beds which seem to be growing at less than optimum rates, and our current inability to explain what factors may be limiting their growth, the use of the precautionary approach when managing eelgrass habitat would be strongly suggested.
- Some eelgrass beds exist in less than ideal environmental conditions, and this is reflected by their very low abundance values. These beds should not be considered "expendable". In times of changing climate conditions, these beds may serve as sources of seeds and material for vegetative propagation to sites with more favorable environmental conditions. Alternatively, large changes in the environment may favor these beds, and they may begin to thrive in the future.
- Short term seasonal changes in eelgrass abundance are generally larger than long term changes over a period of several years.
- If long term baseline data are to be collected at a particular eelgrass site, it is very important that the site be surveyed along the same transect line, at the same tidal elevation, and during the same time of year. Failure to do this will lead to inconclusive results regarding long terms trends in the health and abundance of the eelgrass bed.

1 Introduction

Generally situated in shallows and complex shorelines highly valued by recreational users, eelgrass meadows are both ecologically valuable and potentially threatened. They provide rearing habitats for the juvenile stages of many species of fish, foraging habitats for both migratory and resident bird species, and recent research also suggests that eelgrass plays a critical role in carbon sequestration. Their value can be likened to kelp forests, mangroves in tropical areas or coral reefs in that they provide essential functions for a wide array of marine life. However, our understanding of the specifics of their ecological functions, including vulnerability to human activities and climate change, is still limited.

Eelgrass beds fall within the "critical" category of DFO's habitat rating system, and are considered a "habitat essential because of its rarity, productivity and sensitivity" and/or a "habitat essential to sustaining a subsistence, commercial or recreational fishery or species at risk". Furthermore, they may have the "presence of high-value spawning or rearing habitat" and/or "areas high in primary productivity" (G3 Consulting Ltd., 2003). In 2009, a DFO Science Advisory Report made the following conclusion:

> "Eelgrass (*Zostera marina*) in eastern Canada has characteristics which meet the criteria of an Ecologically Significant Species. If the species were to be perturbed severely, the ecological consequences would be substantially greater than an equal perturbation of most other species associated with this community."

Loss of eelgrass and other seagrass populations is a worldwide phenomenon largely associated with anthropogenic stresses. Eelgrass populations have been lost in virtually all areas of intense human settlement. On the east coast of the U.S., loss of eelgrass as of 2003 was estimated to be in the order of 20% north of Cape Cod, Massachusetts, while as much as 65% of eelgrass had been lost south of Cape Cod where the coast is more heavily populated and industrialized (DFO, 2009). The United Nations recently estimated a 15% loss in seagrass habitat globally over the last decade (Wright, 2004). Recent reports by the United Nations Environmental Protection Department demonstrate the value and urgency of seagrass conservation:

> "We are becoming aware of the role that seagrasses plays in the climatic and oceanic carbon cycles and in coastal protection. The true economic value is difficult to measure, but work suggests it is immense. Seagrass beds have been overlooked by conservationists and coastal development planners throughout their range. Biosphere restoration must include seagrass conservation and restoration."
>
> Dr. Mark Collins, Director, United Nations Environmental Protection (quote taken from Wright, 2004).

Chatham Sound is situated in the northern part of British Columbia, located between Dundas and Stephens Islands and the Tsimpsean Peninsula near Prince Rupert and bordering on Alaska (see Figure 1). It is a semi-enclosed basin with an area of approximately 1500 km^2, and is influenced by fresh water from two large rivers, the Skeena and the Nass (Trites, 1956). The Nass River discharges into Portland Inlet, and fresh water flows from there into the northern end of Chatham Sound and eventually out through Dixon Entrance (Tera Planning Ltd., 1993). Water from the Skeena River enters Chatham Sound through a series of channels. Approximately 75% of the Skeena River flows equally through Marcus Passage (separating Smith and DeHorsey Islands from Kennedy Island) and Telegraph Passage, while the remaining 25% of the Skeena River flows through Inverness Passage (Trites, 1956).

As a result of the fresh water discharges of the Nass and Skeena Rivers, the whole of Chatham Sound is essentially a large estuary (Tera Planning Ltd., 1993). Figure 1 and Figure 2 show the regions in Chatham Sound affected by freshwater outflows from the Skeena and Nass Rivers.

Generally, estuarine circulation occurs when a large volume of fresh water from a river flows out along the surface at the head of an inlet. As it moves seaward, this layer entrains saline water from the layer beneath it, and carries this entrained water seaward. The loss of water from the lower layer is replenished by a deep water flow which has a net landward movement. However, as a result of the fresh water influx from two rivers, a highly irregular coastline, and a large horizontal extent, the circulation patterns in Chatham Sound are considerably more complex than most coastal BC inlets (Tera Planning Ltd., 1993).

Recent studies at the Lucy Islands (Faggetter, 2011) found substantial amounts of previously unmapped subtidal eelgrass in Chatham Sound. This eelgrass played an important role in sustaining marine diversity at the site, which in turn provided rich feeding grounds for the bird colonies found on the islands. Clearly, we are still learning about the geographical extent and roles of eelgrass in the Chatham Sound estuary system. Thus, the objectives of the Chatham Sound Eelgrass Study were:

- To provide relevant management authorities – specifically DFO, BC Parks and North Coast First Nations whose traditional territories include the Chatham Sound area - with high quality data and recommendations regarding eelgrass presence in priority areas on the North Coast of BC.
- To assess the overall abundance and health of subtidal eelgrass in the Chatham Sound estuary region.
- To compare the status of eelgrass beds in the region based on riverine influence, recreational use, and industrial activities.
- To assess temporal changes in eelgrass beds at those sites where data has been collected previously.
- To provide baseline data for subtidal eelgrass beds in regions where the British Columbia Marine Conservation Analysis has indicated that eelgrass is a priority habitat.
- To provide data for the future development of an oceanographic model relating changes in riverine sediment deposition resulting from global climate change with eelgrass bed health.

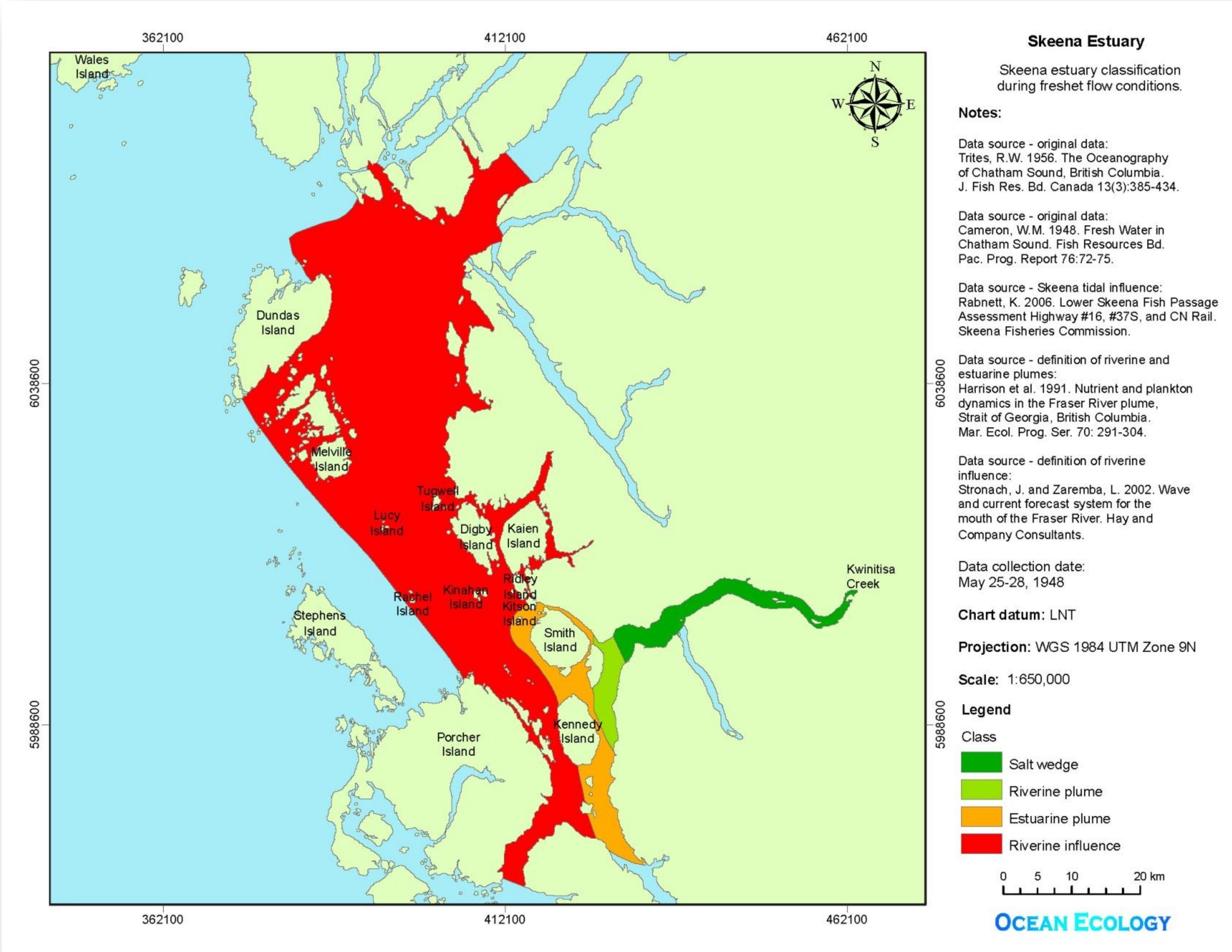


Figure 1. Location of the Chatham Sound and the Skeena/Nass River estuary.

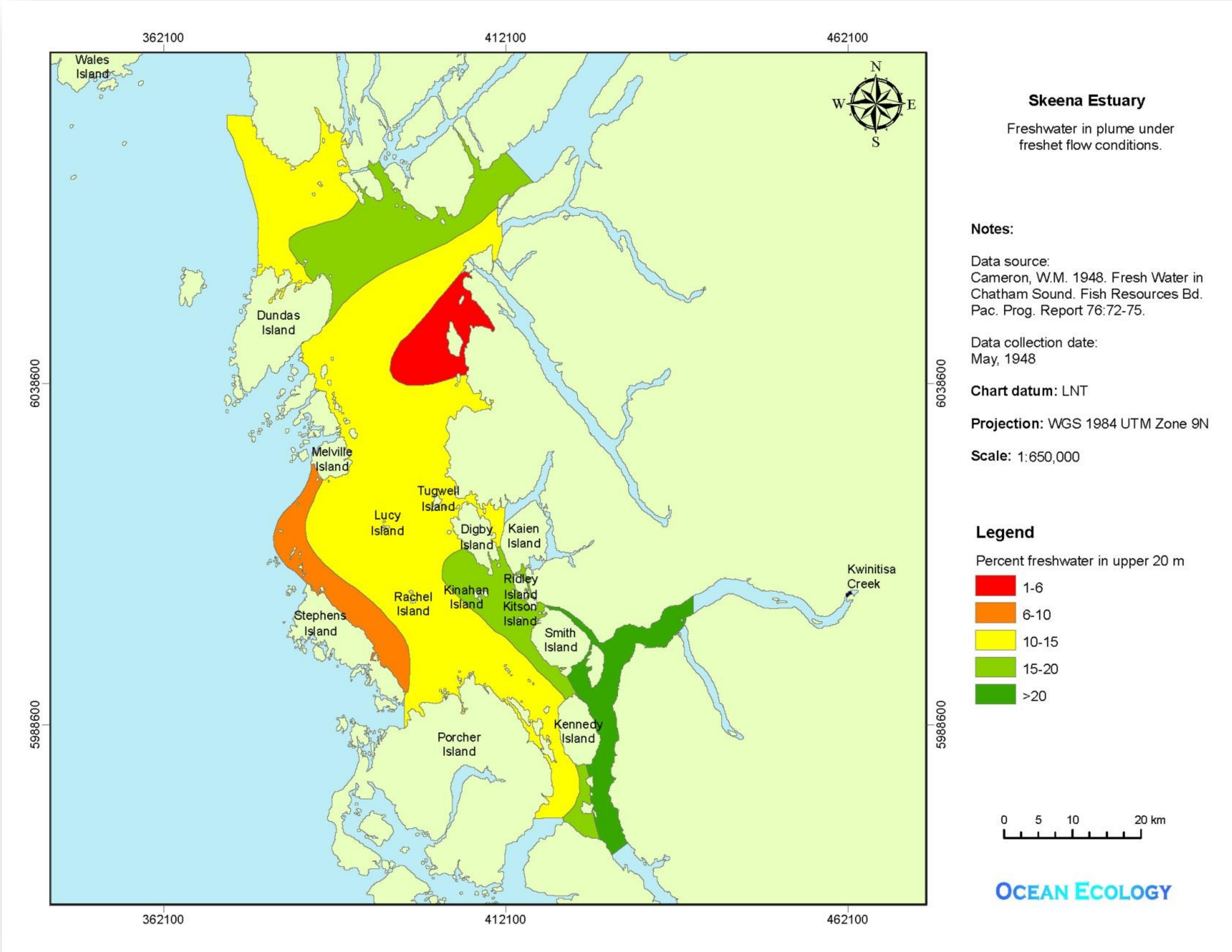


Figure 2. Location of the Chatham Sound and freshwater from the Skeena/Nass River plume.

2 Chatham Sound Eelgrass Survey Methodology

2.1 Overall Project Design

The Chatham Sound Eelgrass Study consisted of 36 sites selected throughout the region based on:

- Location within a proposed Conservancy area.
- Location within a priority habitat area.
- Location relative to industrial activities.
- Degree of riverine influence.
- Presence of intertidal eelgrass from previous studies.
- Presence of site morphology which indicated a high likelihood of eelgrass presence.

2.2 Towed Benthic Video Survey

2.2.1 Towed Video System

A DGPS-positioned, towed video system was used to collect imagery of the seabed (similar to the Seabed Imaging and Mapping System [SIMS] used by CORI). This system was a custom-built model (e.g., not commercially available) designed for use in the steep, rugged terrain characteristic of British Columbia fjords (see Figure 3). Typical tow speed for the system was 0.9 knots. The towed video system has two video cameras - one in a forward-looking orientation and one in a downward-looking orientation. Both cameras have a Sony 1/3" super HAD color CCD with 480 lines horizontal resolution (768 x 494 pixels) and 0.5 lux @ F 2.0. These cameras provided composite video signals to an overlay unit that stamped the DGPS position data (latitude/longitude), together with date and time, on each video frame. The video signal was also displayed in real-time on the vessel, where it was used to adapt the survey to particular features that were seen while underway. High intensity white LEDs were mounted on the camera to provide additional illumination when it was required.

The altitude of the underwater camera was controlled using a hydraulic winch which was operated from the bridge while monitoring the real-time video feed from the camera. Typically, the camera was towed approximately 1 m above the seabed.

Figure 3. Towed video camera system about to be deployed.

2.2.2 Video Recording System

The dual analog camera signals were recorded using a digital video recorder directly onto a hard drive. After the survey was completed, the raw video data was copied onto DVDs. As the digital video recorder creates video files in a proprietary format, software to view and convert the video data into other formats was also provided on each raw video DVD.

2.2.3 Survey Design

During the summer of 2012, Ocean Ecology undertook three field trips as part of the Chatham Sound eelgrass study:

- July 22 to July 26, 2012
- August 18 to August 22, 2012
- September 3 to September 5, 2012

At each selected site, a rapid tow was performed with the video camera system to determine if eelgrass was present. If eelgrass was observed, one or two slower tows were performed while recording the video data. At the majority of sites, two transects were carried out, one parallel to the shore, and one perpendicular to the shore. However, if the site was very small or had navigational dangers, only a single shore perpendicular transect was done.

2.3 Bathymetric Data Collection

Seafloor hardness and depth data were collected using a hull-mounted transducer while carrying out the video survey. Sounding data were recorded every second and logged on a computer.

2.4 Classification and Mapping

2.4.1 Database of Eelgrass Observations

Raw video of the transects was reviewed, and a data record of eelgrass presence/absence and percent cover was produced for each second of video imagery. General observation on benthic flora, fauna, and substrate were made for each eelgrass study site. Note that very small species (e.g., barnacles, small tube worms, small algal species), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) were often not identified in the video footage.

Video annotation created a linked, random-access database of all the video data which can be readily searched using keywords from the classification scheme. Additionally, the provided “Transect Player” software links video and GPS data, allowing simultaneous viewing of the camera’s geographical position on a map and the video images captured by the camera at that location.

All classification data was also entered into a relational Access database, which was then used to generate the data for mapping. This database contains a “Filter by Video” function which allows the user to browse through the data for each transect as a series of data recording forms.

2.4.2 ArcGIS Mapping

Maps of the observed distribution of eelgrass were produced using ArcGIS. These maps have been provided as an ArcGIS project which can be viewed using the supplied ArcReader.

3 Chatham Sound Eelgrass Study Results and Discussion

3.1 General Observations

Thirty-six sites throughout Chatham Sound (see Figure 4) were investigated for the presence of eelgrass. Twenty-nine of these sites were found to have subtidal eelgrass present (see Table 1 and Table 6). The following qualitative observations were made during the field work:

- The subtidal eelgrass varied widely in terms of its health and abundance. At some sites, the eelgrass blades were clean and free of epiphytic algae and bryophyes, whereas at other sites, the eelgrass blades had extensive epiphytic growth and were already showing signs of erosion and fall die-back.
- At many sites, there was a clear distinction between the intertidal eelgrass (ecotype *Zostera marina typica* with short, narrow blades) and the subtidal eelgrass (ecotype *Z. marina latifolia* with very long, wide blades). At a few sites, the eelgrass ecotypes were actually separated by a narrow zone of seafloor where no eelgrass was present. Although filming often took place at a high tide, this clear separation confirmed that the majority of the eelgrass being observed was actually subtidal rather than intertidal.
- Not all sites had both intertidal and subtidal eelgrass. In some cases, the eelgrass bed was strictly subtidal or intertidal, whereas in other cases, the eelgrass bed extended through both the intertidal and subtidal zones. Clearly there are factors, such as turbidity, fresh water input, substrate, and wave exposure, which are controlling eelgrass distribution and morphology at each site. These factors will be examined more closely in the quantitative data analysis.
- In the regions that we studied, the majority of the previous eelgrass surveys were carried out aerially, with limited or no ground truthing. The three aerial surveys covering Chatham Sound were: (1) the 1980 Haegele Survey; (2) the 2000 Shorezone Eelgrass Bioband Survey; and (3) the 1997 Borstad CASI Survey. The Shorezone survey was the most extensive and comprehensive of the three; however, the methodology used did not capture subtidal eelgrass. The Haegele and Borstad surveys used techniques which were at least somewhat successful in mapping subtidal eelgrass.
- Data from the Shorezone survey was used as a measure of whether or not the presence of intertidal eelgrass at a site was a good indicator of the presence of subtidal eelgrass. Of the 28 sites that we investigated which were indicated as having intertidal eelgrass present based on the Shorezone survey, 23 sites (82%) actually had subtidal eelgrass. Interesting, of the 8 sites that were investigated based on likely habitat type, but which did not show eelgrass in the Shorezone survey, 6 (75%) had subtidal eelgrass. Thus, while the presence of intertidal eelgrass may mean that subtidal eelgrass is likely to be present, there are probably a significant number of places where subtidal eelgrass can be found in the absence of intertidal eelgrass.
- While only covering limited areas, the Haegele and Borstad surveys were much better indicators of subtidal eelgrass than the Shorezone survey. At all 5 sites that we surveyed where one of these two surveys indicated subtidal eelgrass, there was, in fact, subtidal eelgrass present.
- A wide variety of fish and invertebrates, including commercial species such as rockfish and Dungeness crab, were observed utilizing the eelgrass beds.

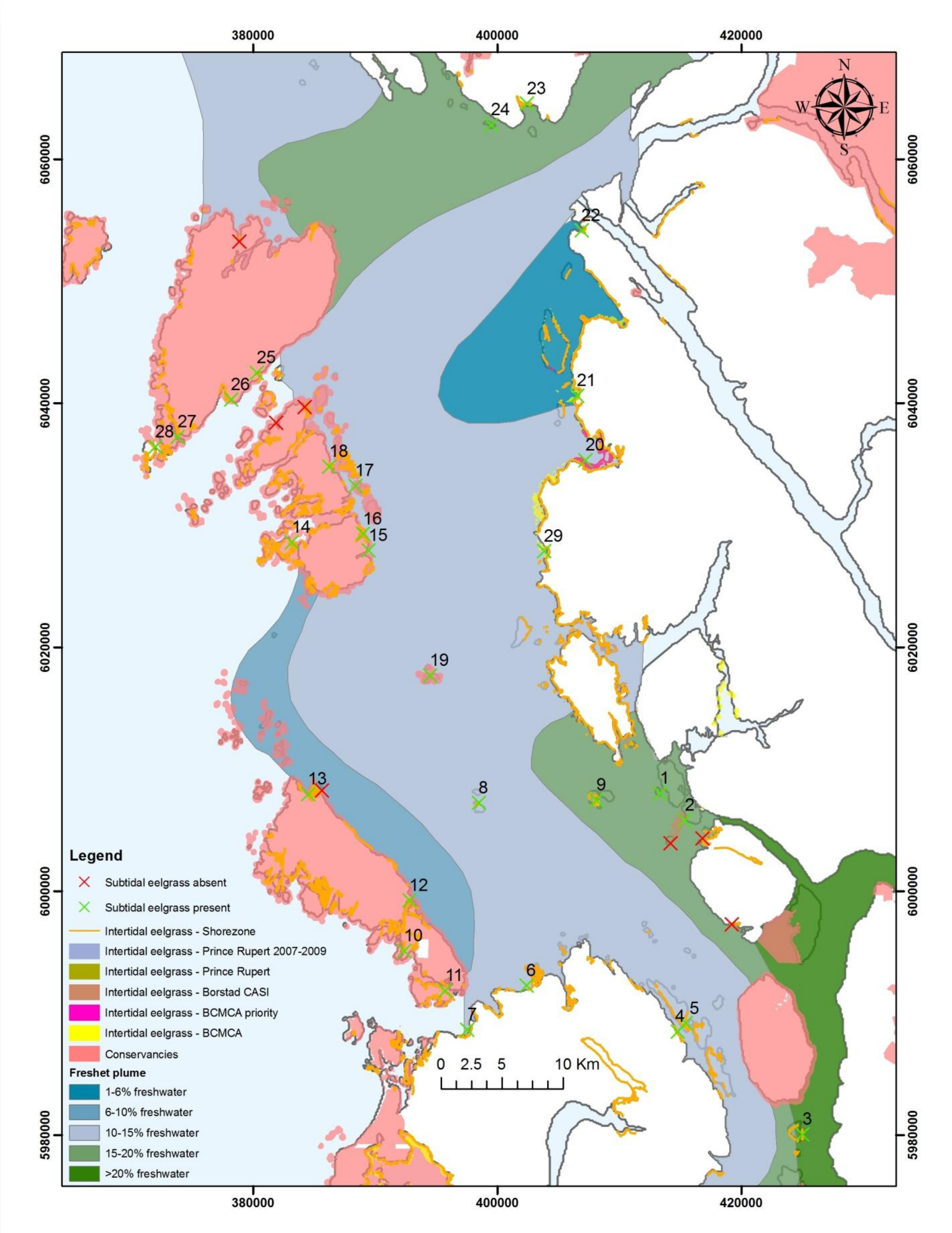


Figure 4. Location of eelgrass sites throughout the Chatham Sound estuary region. Locations of eelgrass based on previous studies are also shown (BCILMB, 2008; Casey, 2012; Community Mapping Network, 2012; BCMCA, 2012). Conservancy locations are from GeoBC (2012).

Table 1. Location of sites observed during the Chatham Sound eelgrass study.

Site Location	Subtidal Eelgrass Present?	Video Footage Recorded?	Eelgrass Observed at Site During Previous Surveys?		
			1980 Haegele Survey[a]	2000 Shorezone Eelgrass Bioband Survey[b]	1997 Borstad CASI Survey[c]
Coast Island (1)	Y	Y	N	N	N
Flora Bank (2)	Y	Y	N	N	Y
Kitson Island	N	N	N	N	N
Smith Island (near Tsum Tsadai Inlet)	N	N	N	Y	N
Smith Island (near Hazel Point)	N	N	N	Y	N
Marrack Island (3)	Y	Y	N	Y	N
Porcher Island (in Chismore Passage) (4)	Y	Y	N	Y	N
McMicking Island (5)	Y	Y	N	Y	N
Porcher Island (near Creak Islands) (6)	Y	Y	N	Y	N
Porcher Island (near Useless Point) (7)	Y	Y	N	Y	N
South Rachel Island (8)	Y	Y	N	Y	N
West Kinahan Island (9)	Y	Y	N	Y	N
Parry Island (10)	Y	Y	N	Y	N
Arthur Island (11)	Y	Y	N	Y	N
Stephens Passage (12)	Y	Y	N	Y	N
Avery Island	N	N	N	Y	N
Qlawdzeet Anchorage (13)	Y	Y	N	Y	N
West Melville Island (14)	Y	Y	N	Y	N
East Melville Island (15)	Y	Y	N	N	N
Northeast Melville Island (16)	Y	Y	N	Y	N
Moffat Islands (17)	Y	Y	N	N	N
West Dunira Island (18)	Y	Y	N	Y	N
Baron Island (Clam Inlet)	N	Y	N	Y	N
Northwest Baron Island	N	N	N	N	N
Lucy Islands (19)	Y	Y	N	N	N
Big Bay on the Tsimpsean Peninsula (near Curlew Rock) (20)	Y	Y	Y	Y	N
Pearl Harbour on the Tsimpsean Peninsula (21)	Y	Y	Y	Y	N

Site Location	Subtidal Eelgrass Present?	Video Footage Recorded?	Eelgrass Observed at Site During Previous Surveys?		
			1980 Haegele Survey[a]	2000 Shorezone Eelgrass Bioband Survey[b]	1997 Borstad CASI Survey[c]
North Tsimpsean Peninsula (near Dudevoir Passage) (22)	Y	Y	Y	Y	N
Wales Island (near Tracey Island) (23)	Y	Y	N	Y	N
Boston Islands (24)	Y	Y	N	N	N
Dundas Island (Goose Bay)	N	Y	N	Y	N
Dundas Island (near Nares Islets) (25)	Y	Y	N	Y	N
Dundas Island (Gore-Langton Point) (26)	Y	Y	N	Y	N
Dundas Island (Edith Harbour) (27)	Y	Y	N	Y	N
Prince Lebo Island (28)	Y	Y	N	Y	N
Tsimpsean Peninsula (near Swamp Island) (29)	Y	Y	Y	Y	N

[a]***1980 Haegele Survey***: In 1980, the Department of Fisheries and Oceans undertook eelgrass mapping from Port Simpson to Big Bay and in Kitkatla Inlet utilizing a methodology developed by Haegele (1975) which applied the use of low-level color infrared and color aerial photographs. This survey method captures both intertidal and subtidal eelgrass. There was no ground truthing by divers in these areas (Bennett, 2003).

[b]***2000 Shorezone Eelgrass Bioband Survey***: In 2000, Coastal & Oceans Resources Inc. carried out the North Coast 2000 Aerial Video Imaging Survey (CORI, 2000) based on the shorezone mapping methodology. The British Columbia biophysical shorezone mapping system was developed in 1979 to support the systematic inventory of the British Columbia coastal zone. The biological component of the shoreline mapping records shoreline biological 'bio-bands' and species data. This mapping relies on oblique, low tide aerial video imagery flown at spring low tides as the primary source of information (Howes, 2001), and only captures intertidal eelgrass. There was no intertidal ground truthing done in the North Coast region.

[c]***1997 Borstad CASI Survey***: A Compact Airborne Spectrographic Imager (CASI) is a small, but extremely flexible multispectral imager operating in the visible and near infra-red (405 to 916 nm) region of the spectrum, which can be configured for quantitative digital mapping of marine or terrestrial targets. During August, 1996, Borstad Associates Ltd. of Sidney, B.C. were commissioned to conduct a CASI survey of Prince Rupert Harbour and vicinity. The study was timed to correspond with maximum vegetation development at the end of the summer, extreme low tides and high sun angle to allow for optimum observation conditions. Habitats to be mapped included kelp and eelgrass beds, sandflats, and intertidal vegetation. Bad weather prevented acquisition of useful data in 1996, and the area was reflown in August, 1997 during the next extreme daytime low tide (Forsyth *et al*., 1998). Imagery was acquired from an altitude of 10,000 feet. To cover the full survey area, the aircraft made 18 passes over Prince Rupert Harbour. In order to obtain ground truth data upon which to base habitat analysis of the imagery, a ground level survey was conducted by J. O. Thomas & Associates of Prince Rupert during September 1996, approximately one year prior to acquisition of the image data and during the first CASI flights. Their team explored numerous areas on Ridley, Kaien and Digby Islands and recorded observations and GPS coordinates for 40 transects at each area (Borstad Associates Ltd., 1996). Further ground truthing was carried out during September/October, 1998 by Ocean Ecology (Archipelago Marine Research Ltd., 1999).

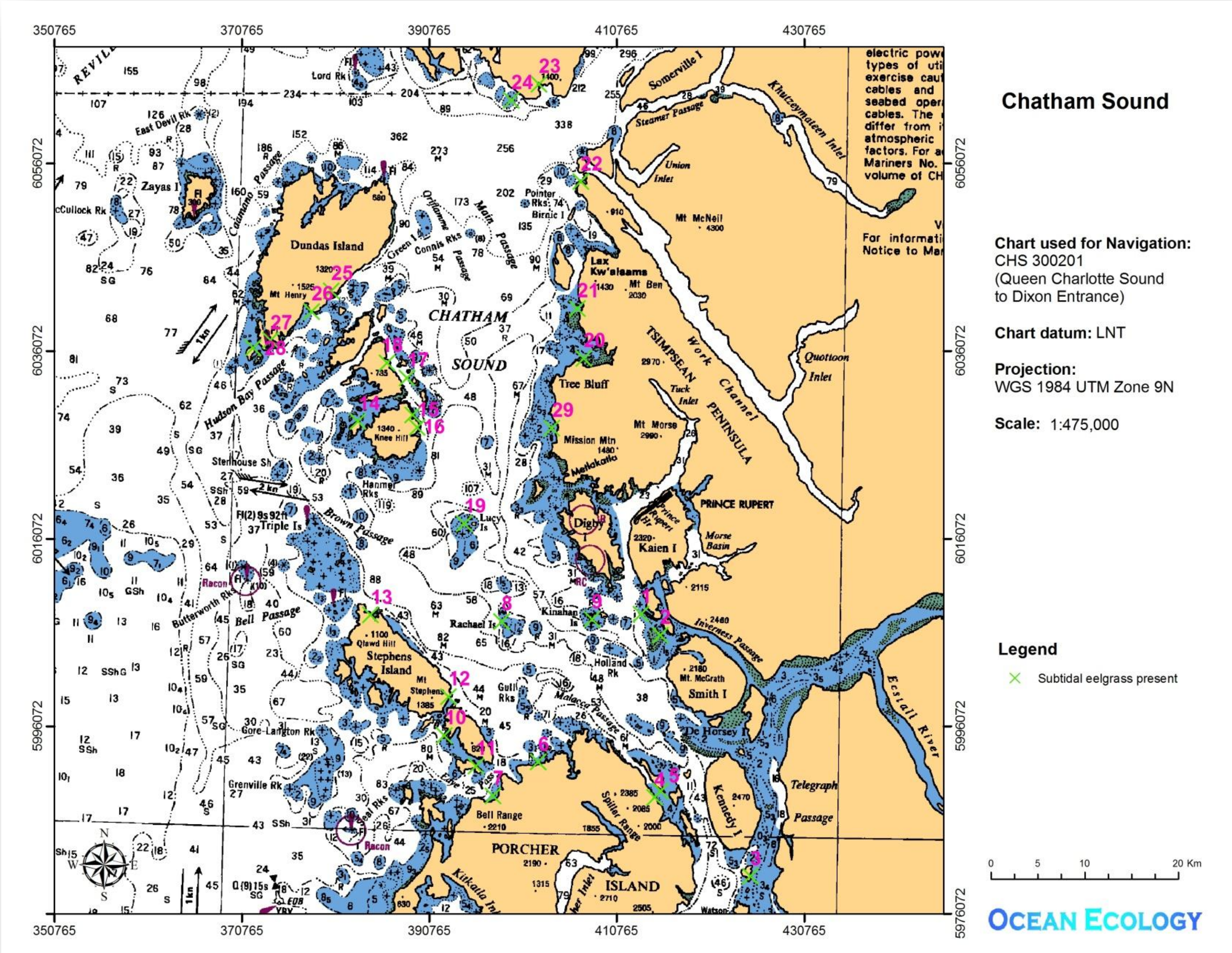


Figure 5. Chatham Sound showing the location of the 29 study sites where eelgrass was present.

3.2 Site Mapping of Eelgrass

Descriptions of the 29 sites in Chatham Sound where eelgrass was observed are given below. In order to assist in identifying the location of each site, a chart of Chatham Sound showing the names of the major land masses and water bodies, along with the locations of all the study sites, is provided in Figure 5.

3.2.1 Coast Island

The eelgrass bed on Coast Island is located on the east side of the smaller and southernmost of the two islets comprising the Coast Island group. Coast Island itself is located just west of Ridley Island, where a number of large port facilities are located. Coast Island is Federal Crown land (owned by Prince Rupert Port Authority) located within the Prince Rupert Harbour limits, and is under the jurisdiction of the Prince Rupert Port Authority. As such, it falls under the Port of Prince Rupert 2020 Land Use Management Plan (AECOM & Prince Rupert Port Authority, 2011). While not directly impacted by potential construction, this eelgrass bed is located very close to the proposed Canpotex Potash Export Terminal site (Stantec, 2011).

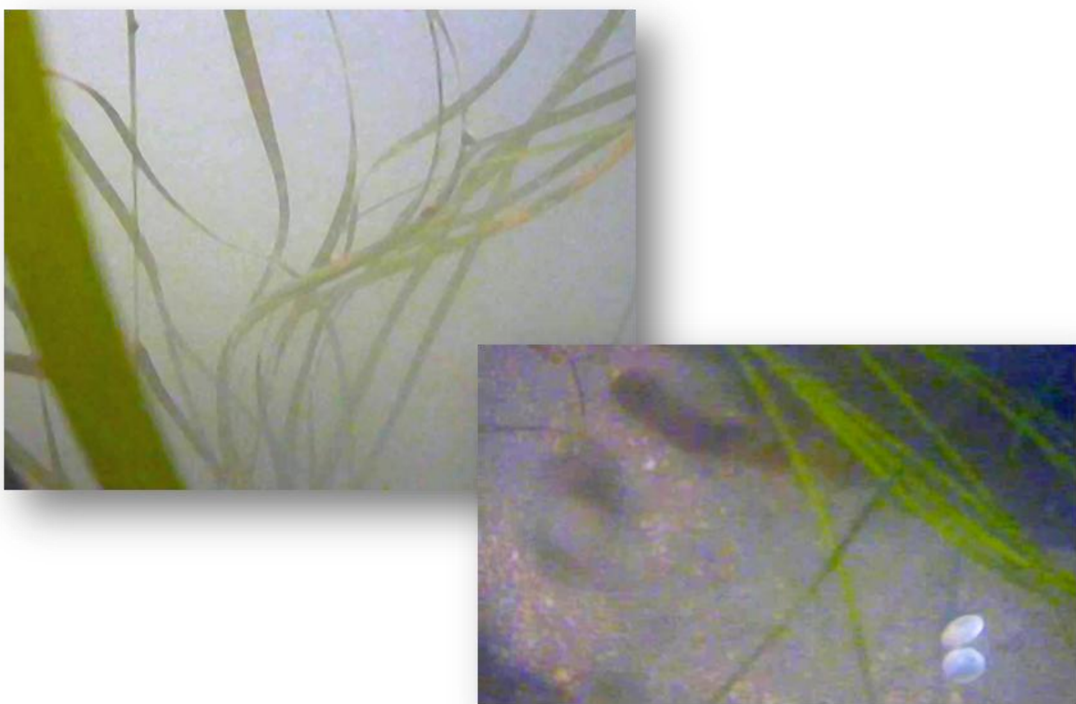


Figure 6. Images from the video footage of the Coast Island eelgrass bed.

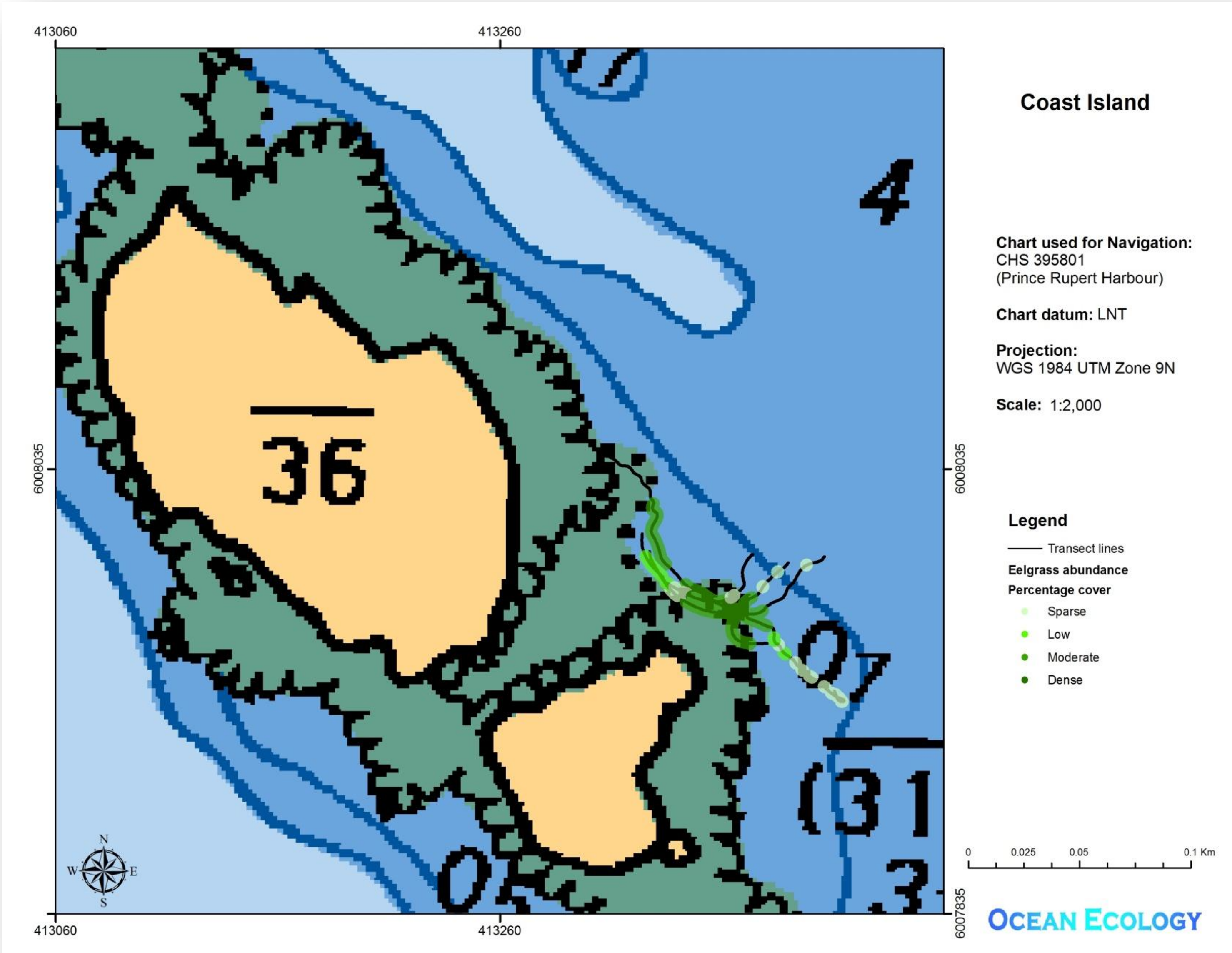


Figure 7. Coast Island eelgrass bed (Site 1).

3.2.2 Flora Bank

Flora Bank is recognized as one of the largest eelgrass beds in British Columbia, and a region of high habitat value. Flora Bank is located southwest of Lelu Island between Porpoise Channel and Inverness Passage. At the southwest edge of Flora Bank is Kitson Island, a Class A provincial marine park. Flora Bank is located within the Prince Rupert Harbour limits, and is under the jurisdiction of the Prince Rupert Port Authority. As such, it falls under the Port of Prince Rupert 2020 Land Use Management Plan (AECOM & Prince Rupert Port Authority, 2011). A proposed liquefied natural gas export facility, the Petronas Pacific Northwest LNG Project, may potentially be sited on Lelu Island, with a jetty extending along the northwest edge of Flora Bank out to deeper water past Agnew Bank, where the loading facility will be located. This proposed project may have as yet unknown impacts on the Flora Bank eelgrass bed.

During August, 1997, Borstad Associates Ltd. of Sidney, B.C. conducted a CASI (Compact Airborne Spectrographic Imager) survey of Prince Rupert Harbour and vicinity. The study was timed to correspond with maximum vegetation development at the end of the summer, extreme low tides and high sun angle to allow for optimum observation conditions. The amount of eelgrass present on Flora Bank during 1997, as estimated from the CASI study, was approximately 0.80 km^2. Almost all of the reported eelgrass was located in the intertidal zone (Borstad Associates Ltd., 1996; Archipelago Marine Research Ltd., 1999).

During 2009, Ocean Ecology carried out a towed benthic video and side scan sonar survey of Flora Bank (Faggetter, 2009b). From this survey, it was determined that approximately 97% of the observed eelgrass was intertidal, and appeared to be *Zostera marina typica* based on the blade width and plant height as seen in the video images. Given the high turbidity of the site (see Figure 8), the subtidal environment was most likely severely light limited, and thus the eelgrass bed was limited to only those regions where the depth was shallow enough to allow good light penetration. Approximately 96% of the observed eelgrass was either within, or in very close proximity to, those areas where the 1997 Borstad CASI survey indicated eelgrass to be present. Thus, it appeared that the eelgrass had not spread very much since 1997 (e.g., the bed was not actively expanding).

Since the focus of this study was subtidal eelgrass, a single location on Flora Bank where subtidal eelgrass had been previously observed during 2009 was selected. This location was on the northeast side of Flora Bank, just offshore of Lelu Island.

Figure 8. Image from the video footage of the Flora Bank eelgrass bed.

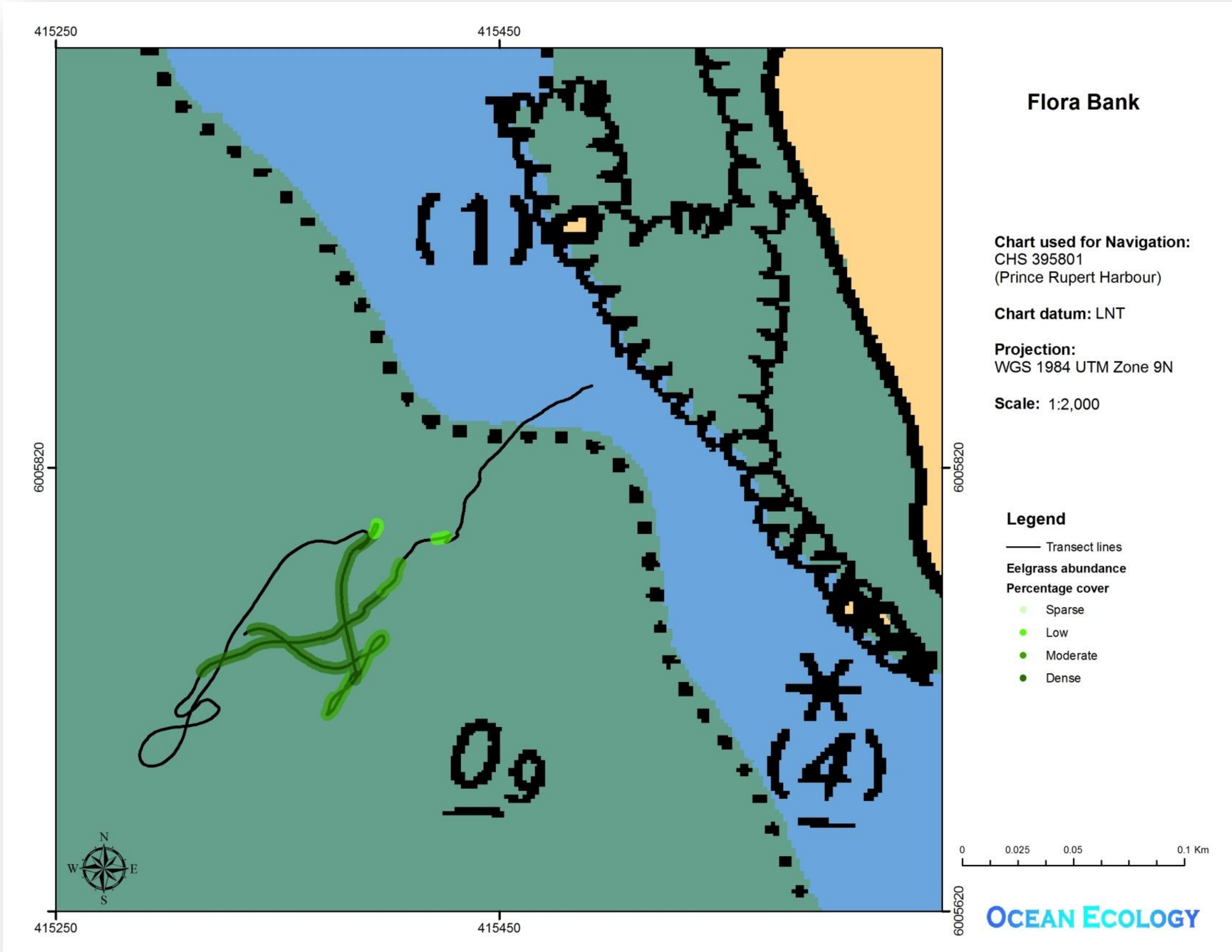


Figure 9. Flora Bank eelgrass bed (Site 2).

3.2.3 Marrack Island

The eelgrass study site on Marrack Island is located on the eastern side of the island just north of Cecil Point. Marrack Island belongs to a small group of islands called the Gibson Group, which are located south of Kennedy Island and west of the mainland. Telegraph Passage runs on the east side of the group of islands, and Ogden Channel runs on the west side. This site is the southernmost of the 29 study sites surveyed for this project.

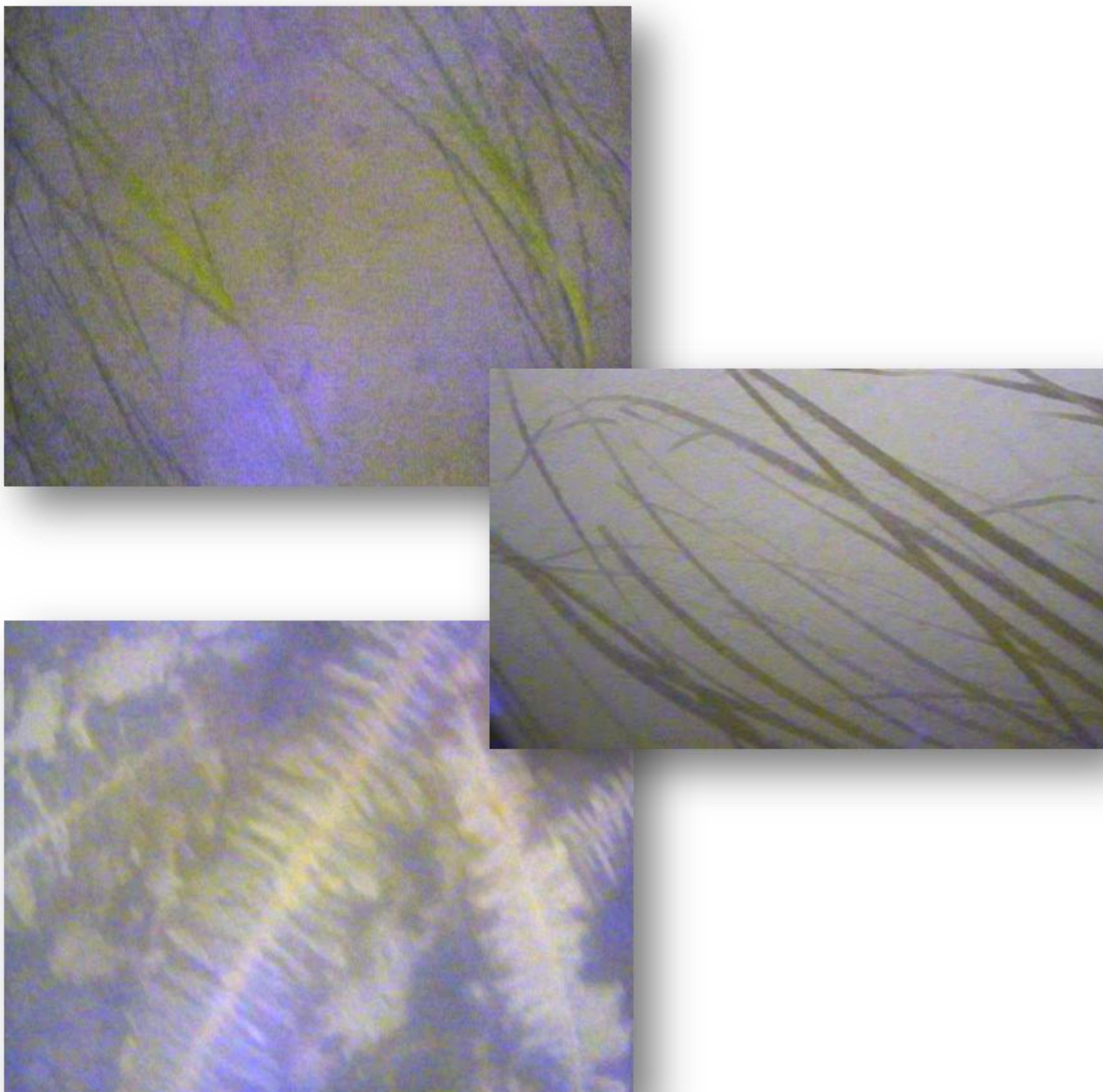


Figure 10. Images from the video footage of the Marrack Island eelgrass bed.

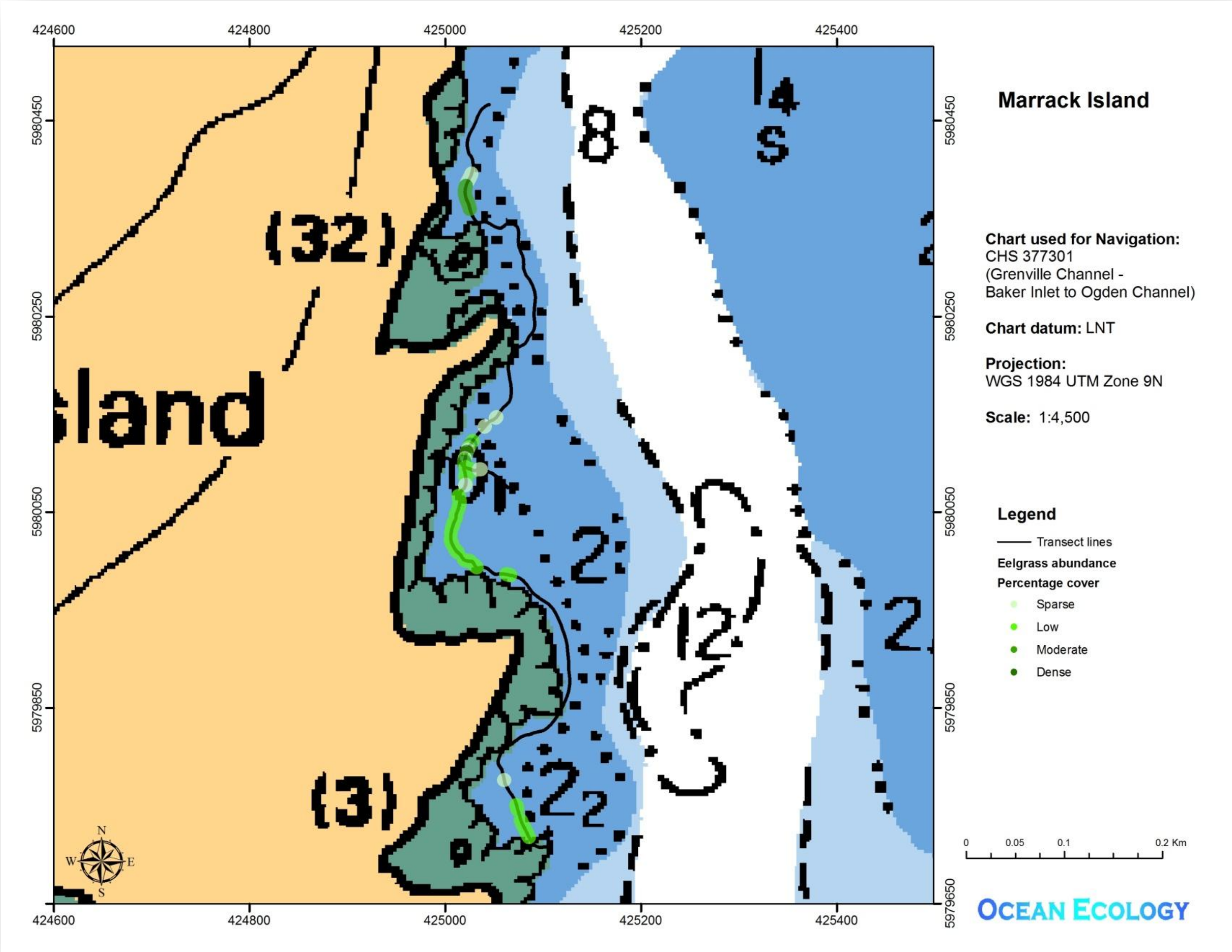


Figure 11. Marrack Island eelgrass bed (Site 3).

3.2.4 Porcher Island (in Chismore Passage)

The eelgrass bed in Chismore Passage is located on Porcher Island just north of the Spiller River estuary. Chismore Passage is a narrow passage bounded by Porcher Island to the southwest and McMicking and Elliott Islands to the northeast.

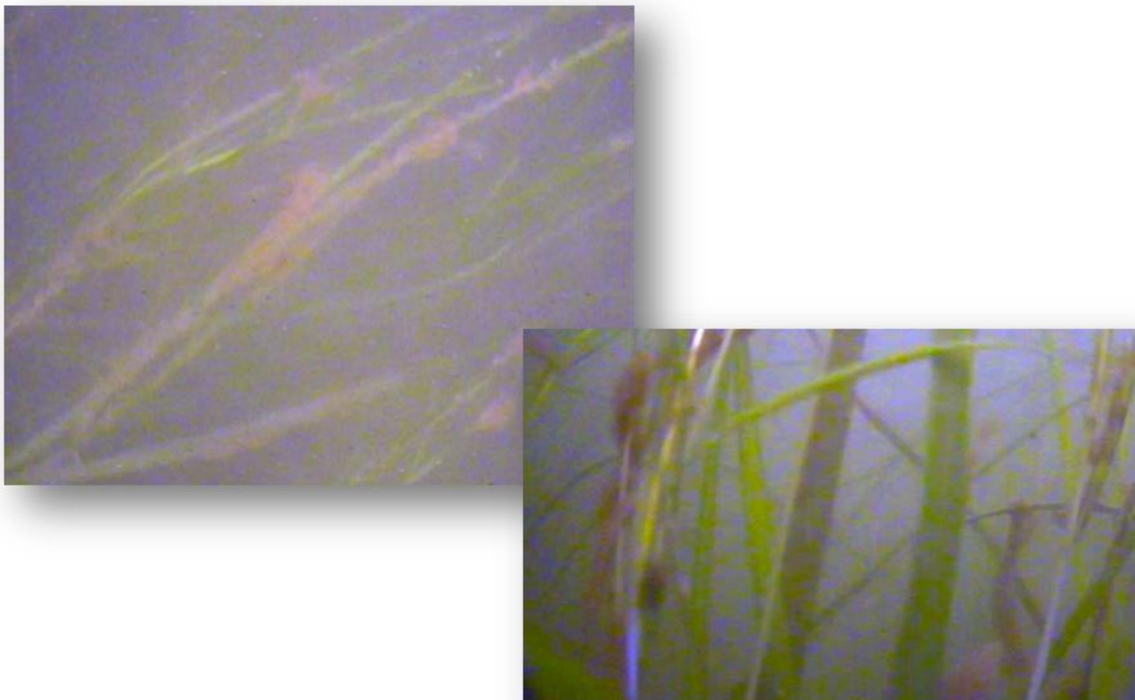


Figure 12. Images from the video footage of the Chismore Passage eelgrass bed.

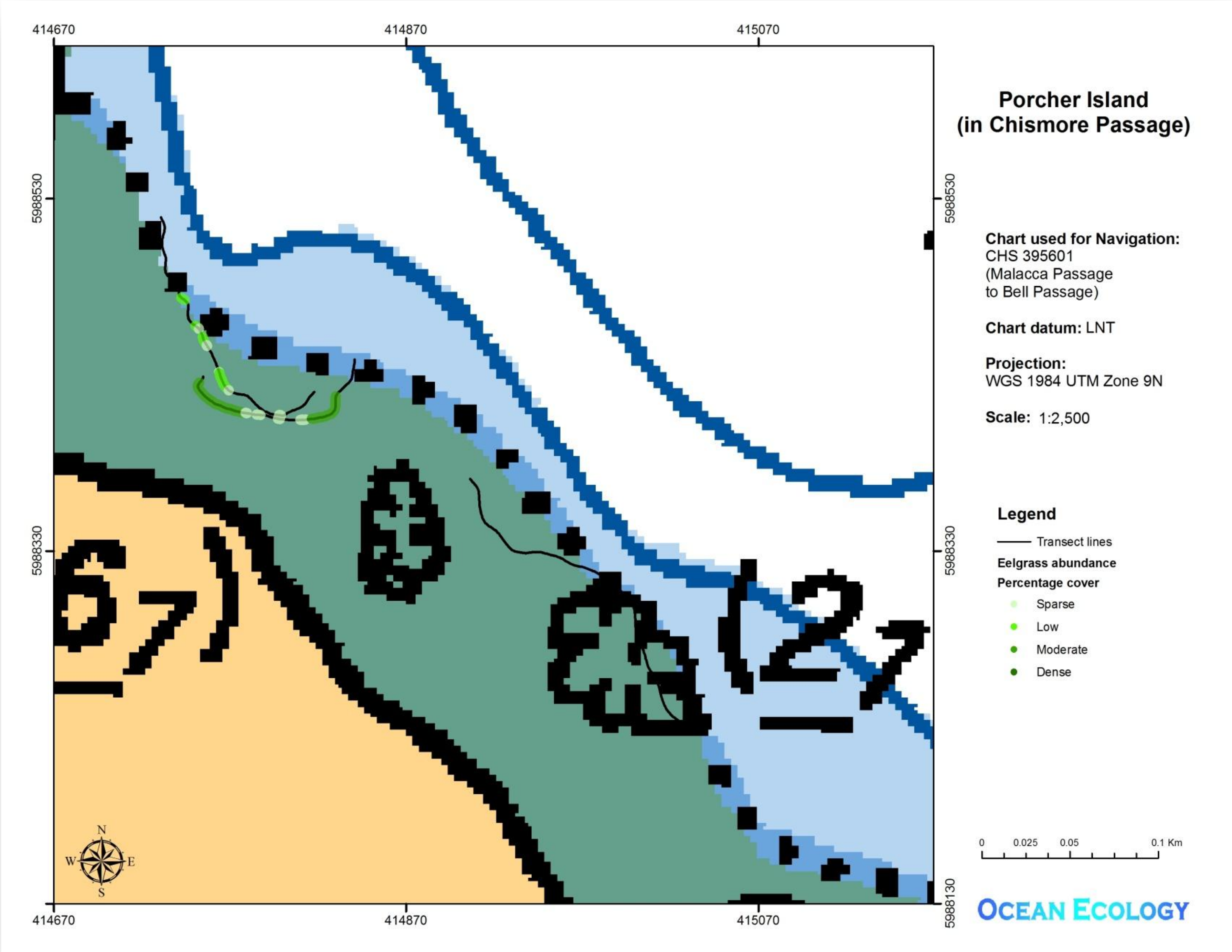


Figure 13. Eelgrass bed on Porcher Island in Chismore Passage (Site 4).

3.2.5 McMicking Island

The eelgrass study site on McMicking Island is located at the southern end of the island in the protected waters between McMicking Island and Elliott Island, not far from Chalmers Anchorage.

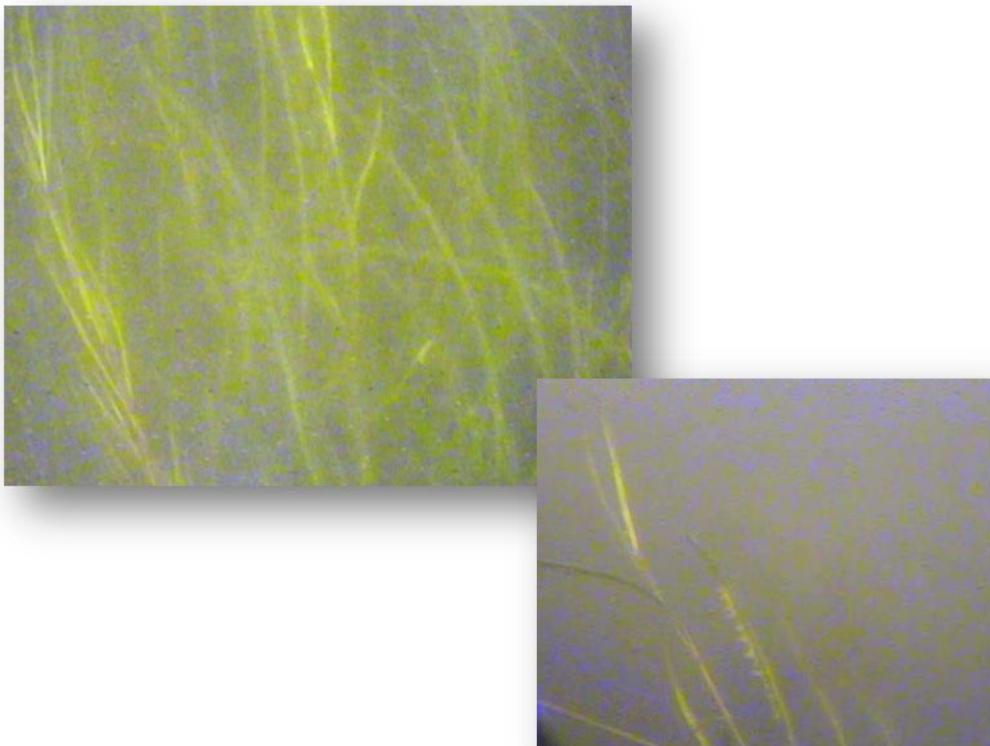


Figure 14. Images from the video footage of the McMicking Island eelgrass bed.

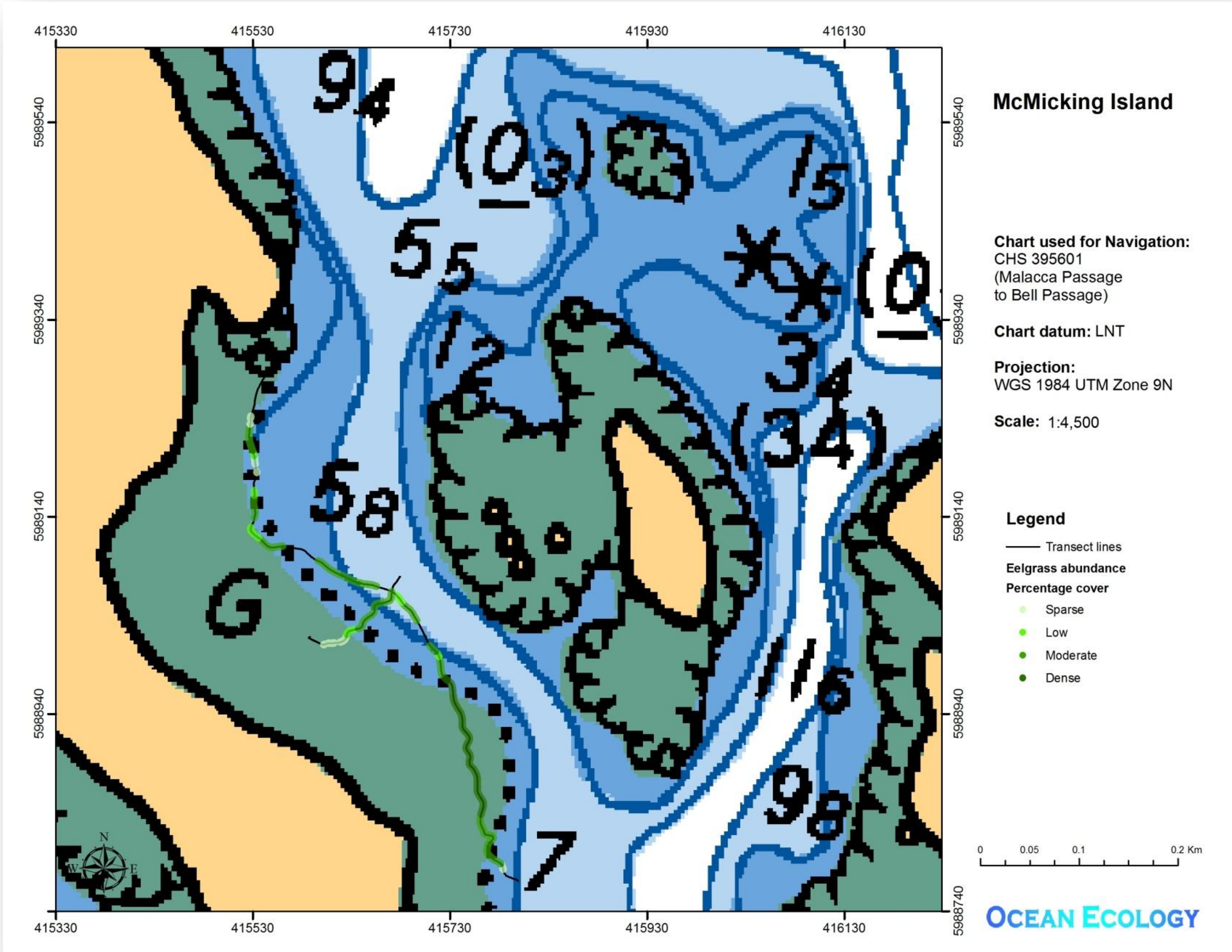


Figure 15. McMicking Island eelgrass bed (Site 5).

3.2.6 Porcher Island (near Creak Islands)

The study site near Creak Islands is located on the northwest corner of Porcher Island just south of Creak Point and north of Table Point. The site is quite exposed to wave action, and is outside of the Skeena/Nass plume influence.

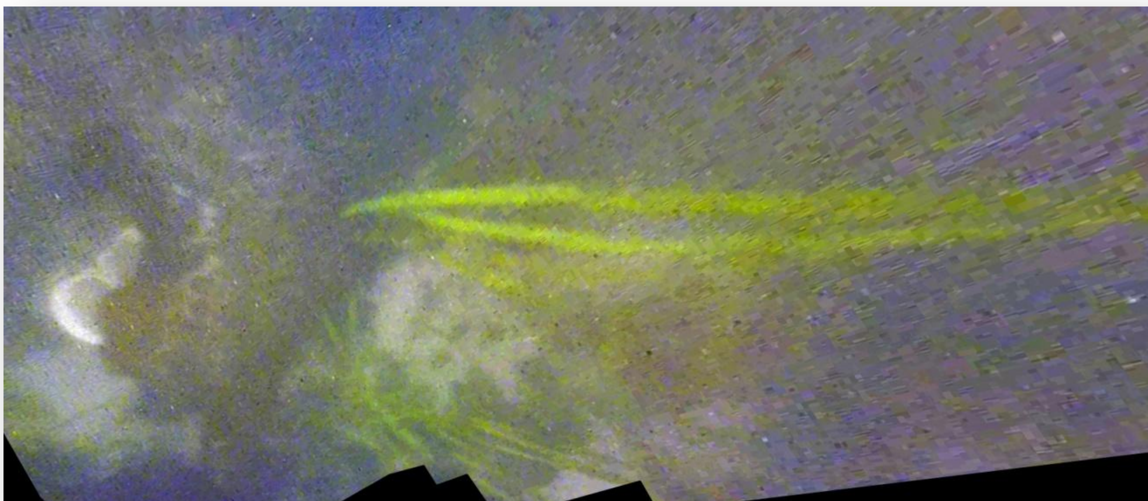


Figure 16. Panorama from the video footage of the Creak Islands eelgrass bed.

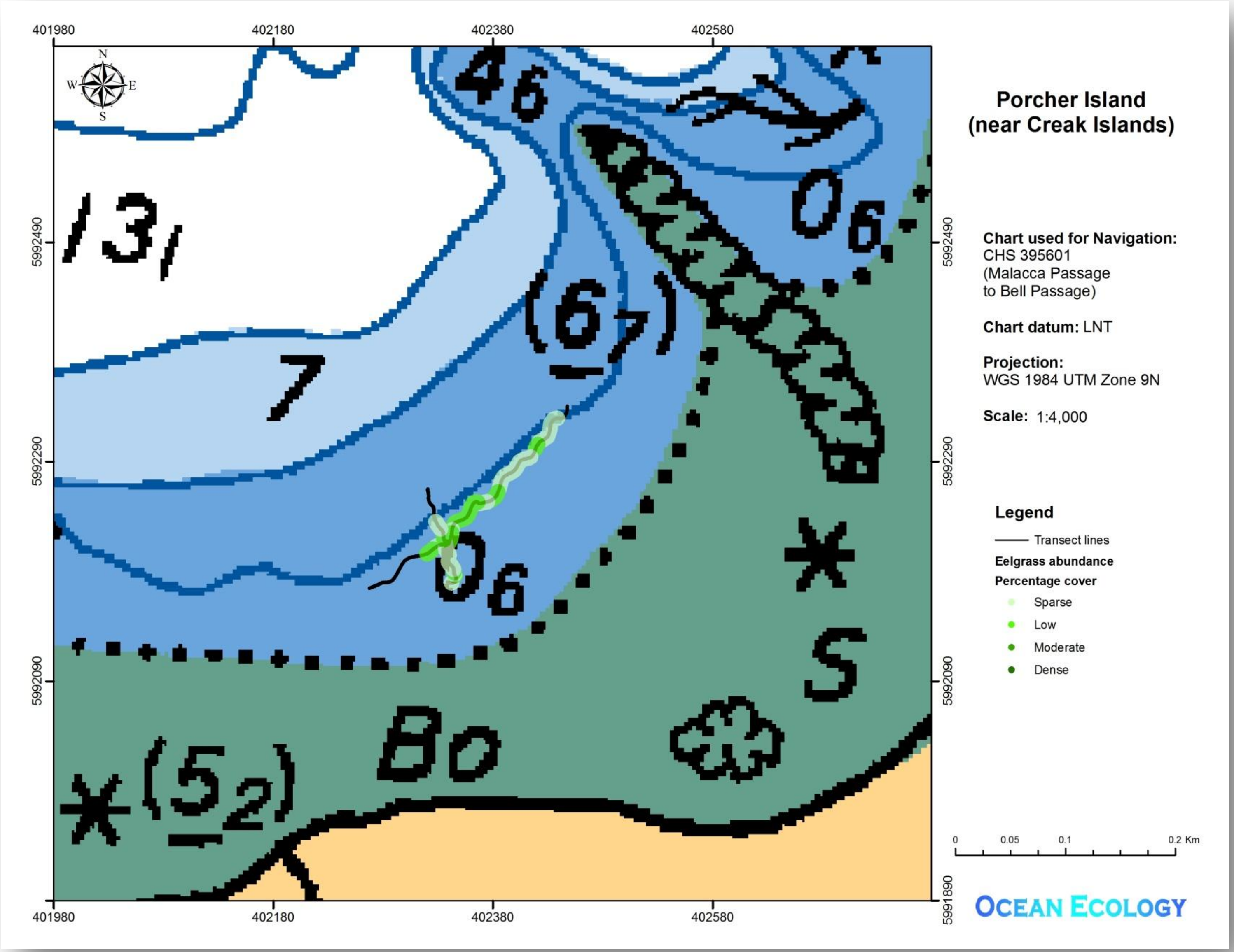


Figure 17. Eelgrass bed on Porcher Island near Creak Islands (Site 6).

3.2.7 Porcher Island (near Useless Point)

Useless Point is located on the northwest side of Porcher Island in Edye Pass across from Prescott and Arthur Islands. The eelgrass study site is found in the bay between Useless Point and Edwin Point. Like the previous study site (near Creak Islands), this site is quite exposed to wave action, and is outside of the Skeena/Nass plume influence. However, unlike the Creak Islands site, this study site is a very large and abundant eelgrass bed.

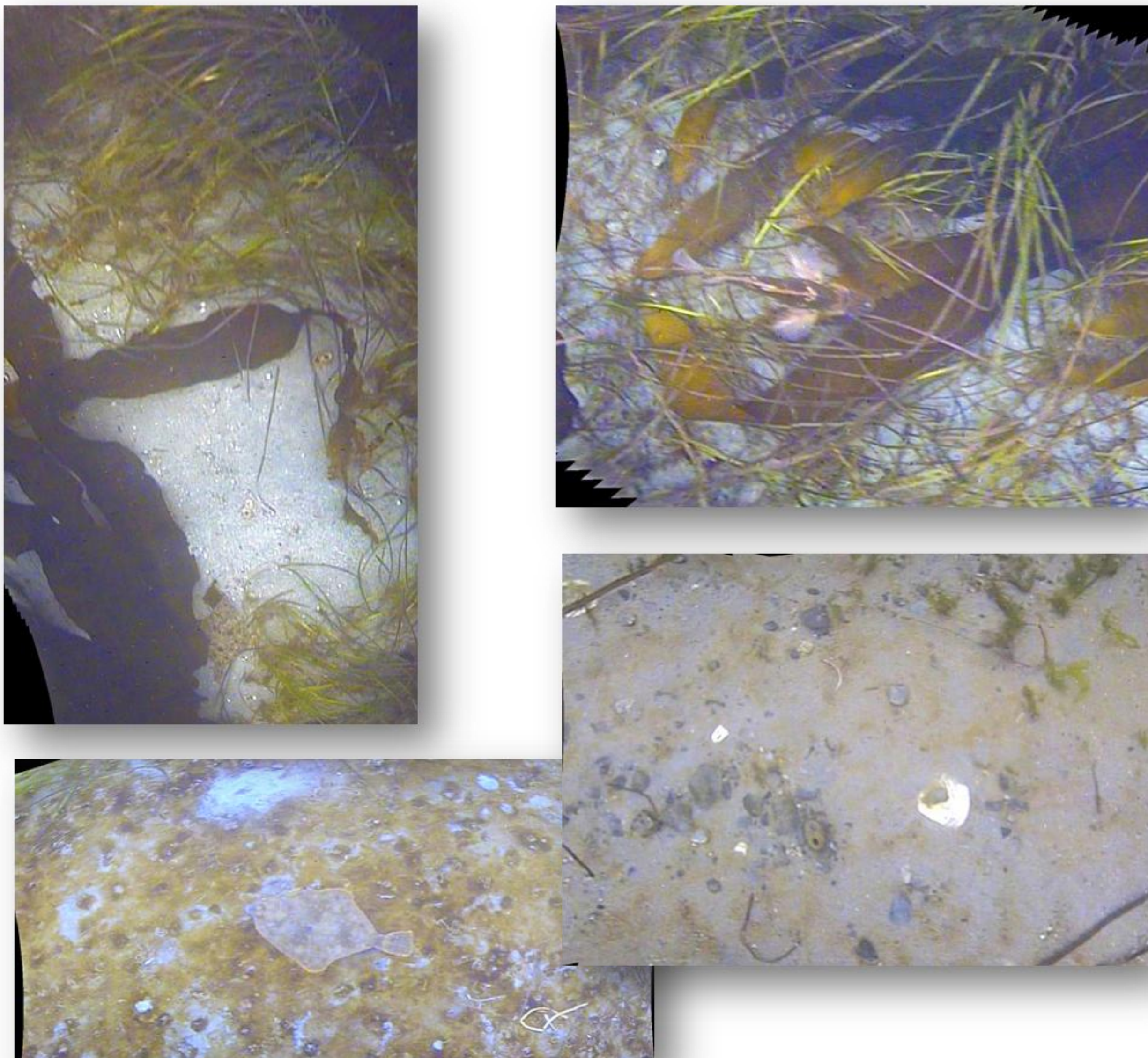


Figure 18. Panoramas from the video footage of the Useless Point eelgrass bed.

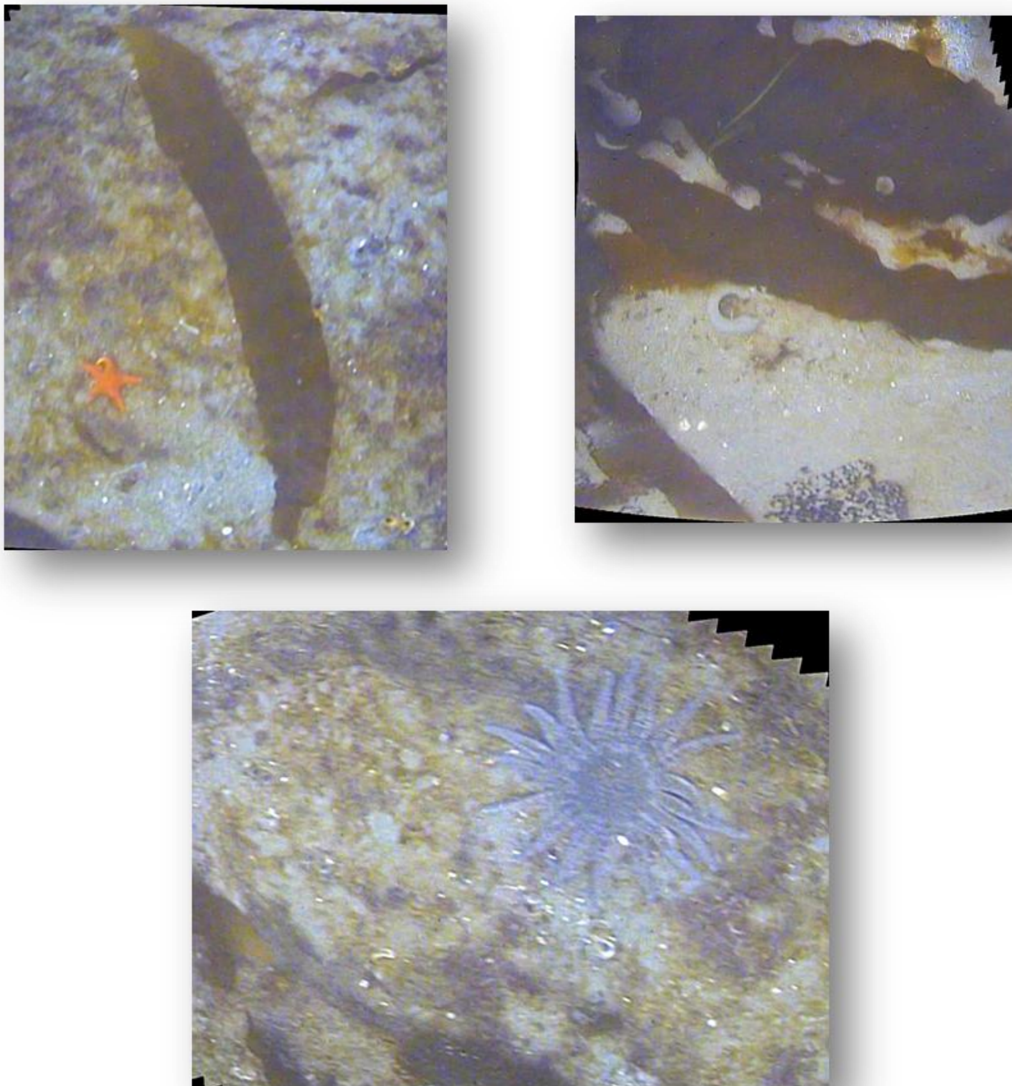


Figure 19. Panoramas from the video footage of the Useless Point eelgrass bed.

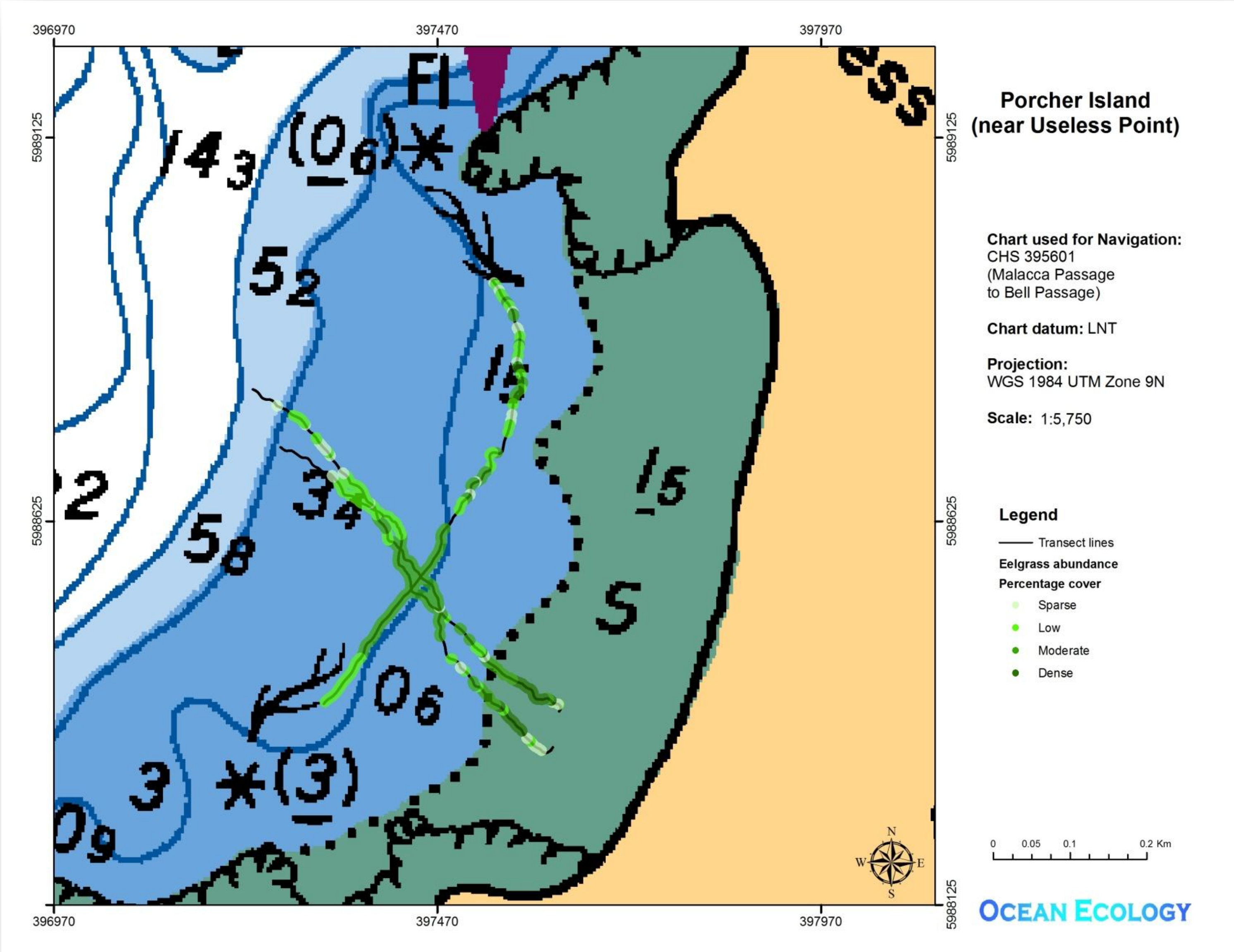


Figure 20. Eelgrass bed on Porcher Island near Useless Point (Site 7).

3.2.8 South Rachel Island

An eelgrass bed is located on the northern end of South Rachel Island, just below the three islets which mark the northernmost extension of South Rachel Island. South Rachel Island has a white sand beach, and is a popular destination with kayakers. A small cabin is located on the island.

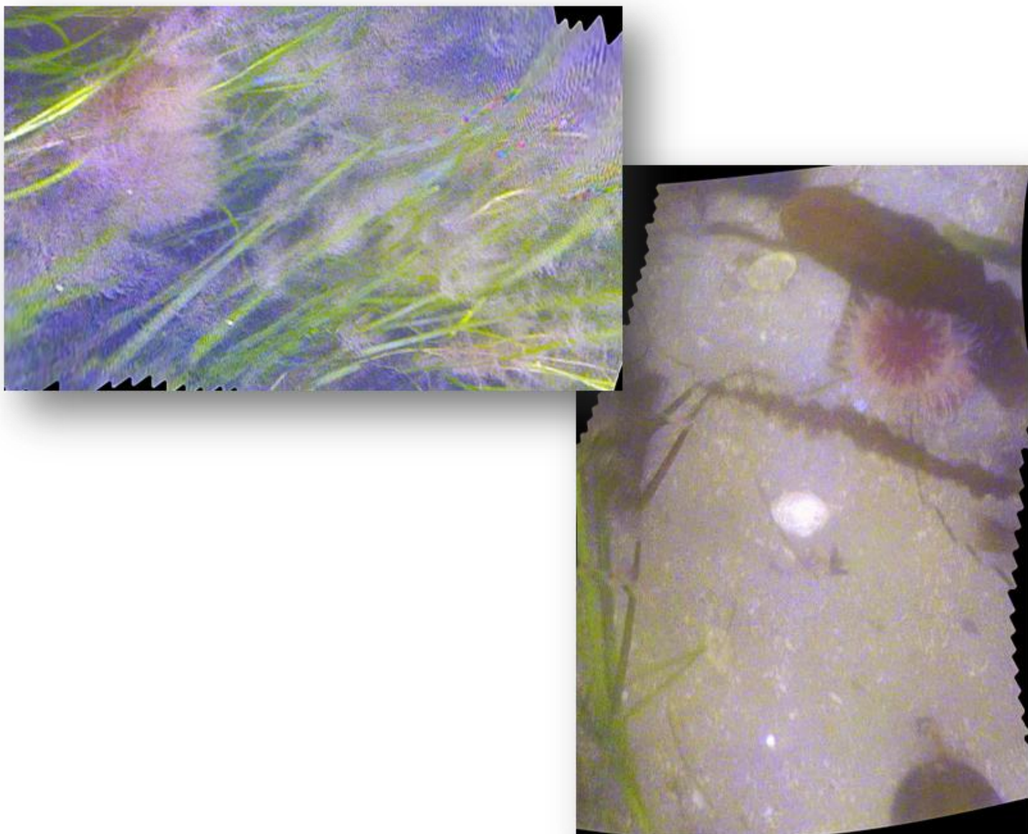


Figure 21. Panoramas from the video footage of the South Rachel Island eelgrass bed.

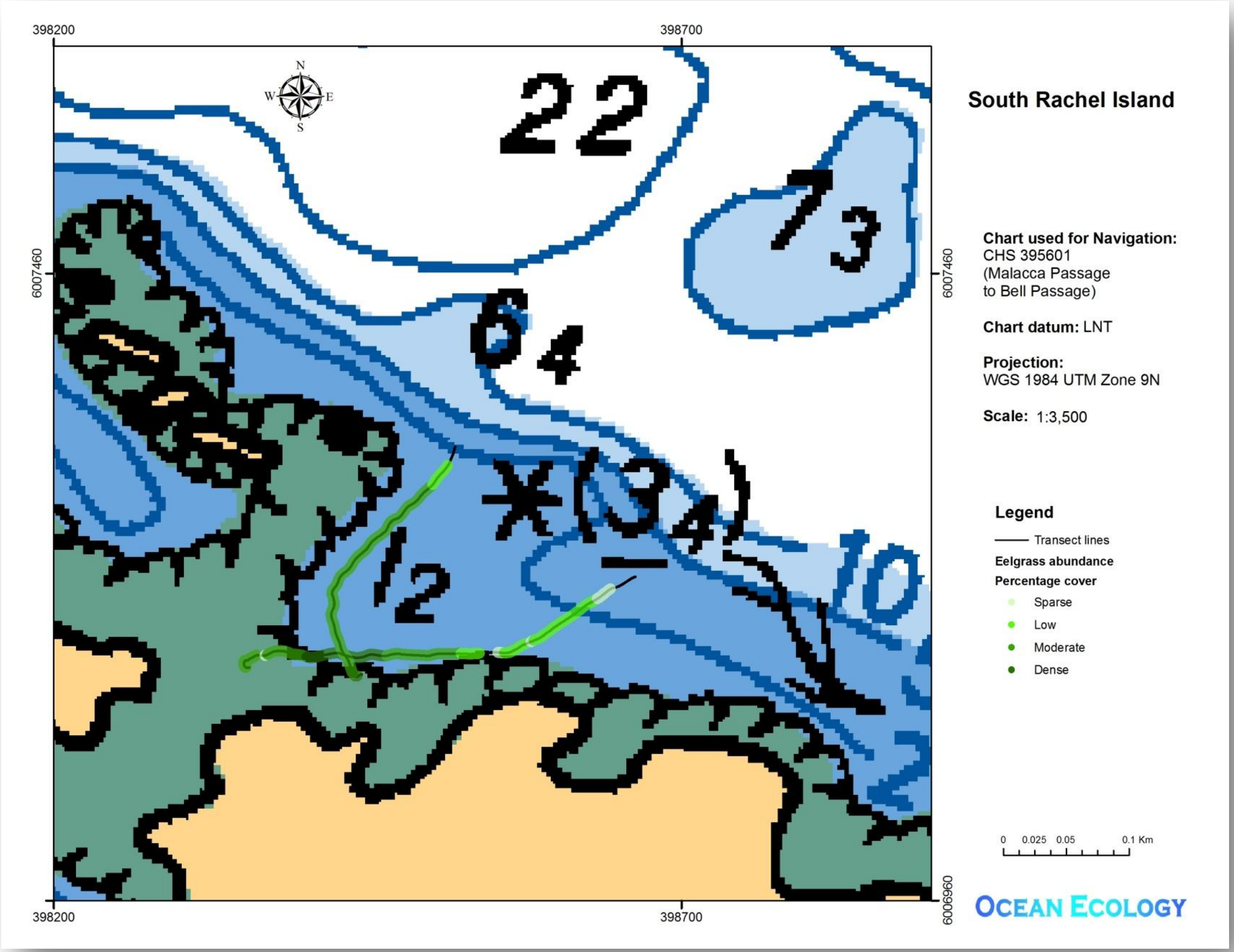


Figure 22. South Rachel Island eelgrass bed (Site 8).

3.2.9 West Kinahan Island

The Kinahan Islands are located just offshore from Ridley Island, and are within the Prince Rupert Harbour limits. As a result, they are under the jurisdiction of the Prince Rupert Port Authority, and they fall under the Port of Prince Rupert 2020 Land Use Management Plan (AECOM & Prince Rupert Port Authority, 2011). The eelgrass study site is located in a little cove at the south end of West Kinahan Island, and is partially sheltered by a rocky reef between West Kinahan Island and South Kinahan Island.

The Kinahan Islands are heavily used by a number of groups. Commercial crab, salmon, shrimp, and halibut fishers and trawlers use the islands as an overnight anchorage. DFO patrol ships also anchor at these islands during the monitoring of fisheries openings. Recreational sport fishers use the islands extensively, and they are a popular destination for kayakers. A freighter anchor berth is located to the southeast of the islands. Crab and salmon are fished, both commercially and recreationally, in the waters surrounding the islands.

Ocean Ecology tried unsuccessfully to find subtidal eelgrass around the Kinahan Islands in two previous attempts, once during 2006 and once during 2008. Only a small amount was located during the 2012 survey; thus, it appears that subtidal eelgrass is not particularly abundant around the islands. However, anecdotal evidence clearly suggested that there was significant amounts of eelgrass present on the Kinahans. Since Ocean Ecology arrived at the Kinahan Islands during a spring low tide, it was decided to carry the search for eelgrass inland on foot. This resulted in the discovery of a large, previously unmapped, bed of intertidal eelgrass located in the area between West Kinahan, South Kinahan, and Little Kinahan Islands (see Figure 24, Figure 25, Figure 26, Figure 27, Figure 28, Figure 29, and Figure 31). This eelgrass was largely of the ecotype *Zostera marina typica*, although some *Zostera marina latifolia* was present in deeper channels which didn't dry at low tide. There was a clear demarcation between areas colonized by the *typica* ecotype and areas colonized by the *latifolia* ecotype, often with a band of uncolonized substrate between the two ecotypes. This discovery of unmapped eelgrass in a region where there has been some previous mapping work done clearly illustrates the need to increase the efforts expended on both intertidal eelgrass and subtidal eelgrass mapping, especially in high use, and potentially vulnerable, areas.

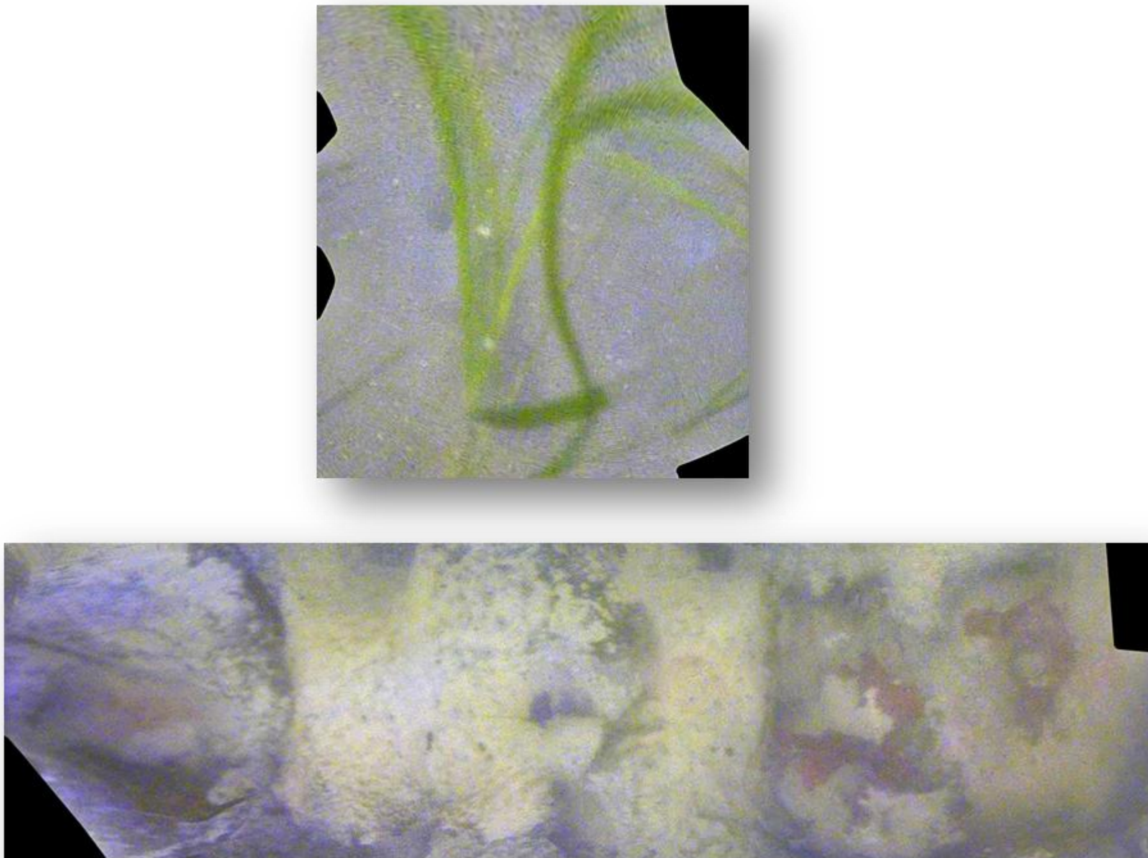


Figure 23. Panoramas from the video footage of the West Kinahan Island eelgrass bed.

Figure 24. Intertidal eelgrass at the north end of South Kinahan Island, looking out towards the protecting rocky reef.

Figure 25. Photographs identifying eelgrass ecotype as *Zostera marina typica.*

Figure 26. *Zostera marina* flower.

Figure 27. Intertidal eelgrass between West and South Kinahan Islands, with Little Kinahan Island in the background.

Figure 28. Eelgrass, both *typica* and *latifolia* ecotypes, located between West and South Kinahan Islands.

Figure 29. Narrow, northwestward heading tidal channel containing eelgrass, with West Kinahan Island in the background.

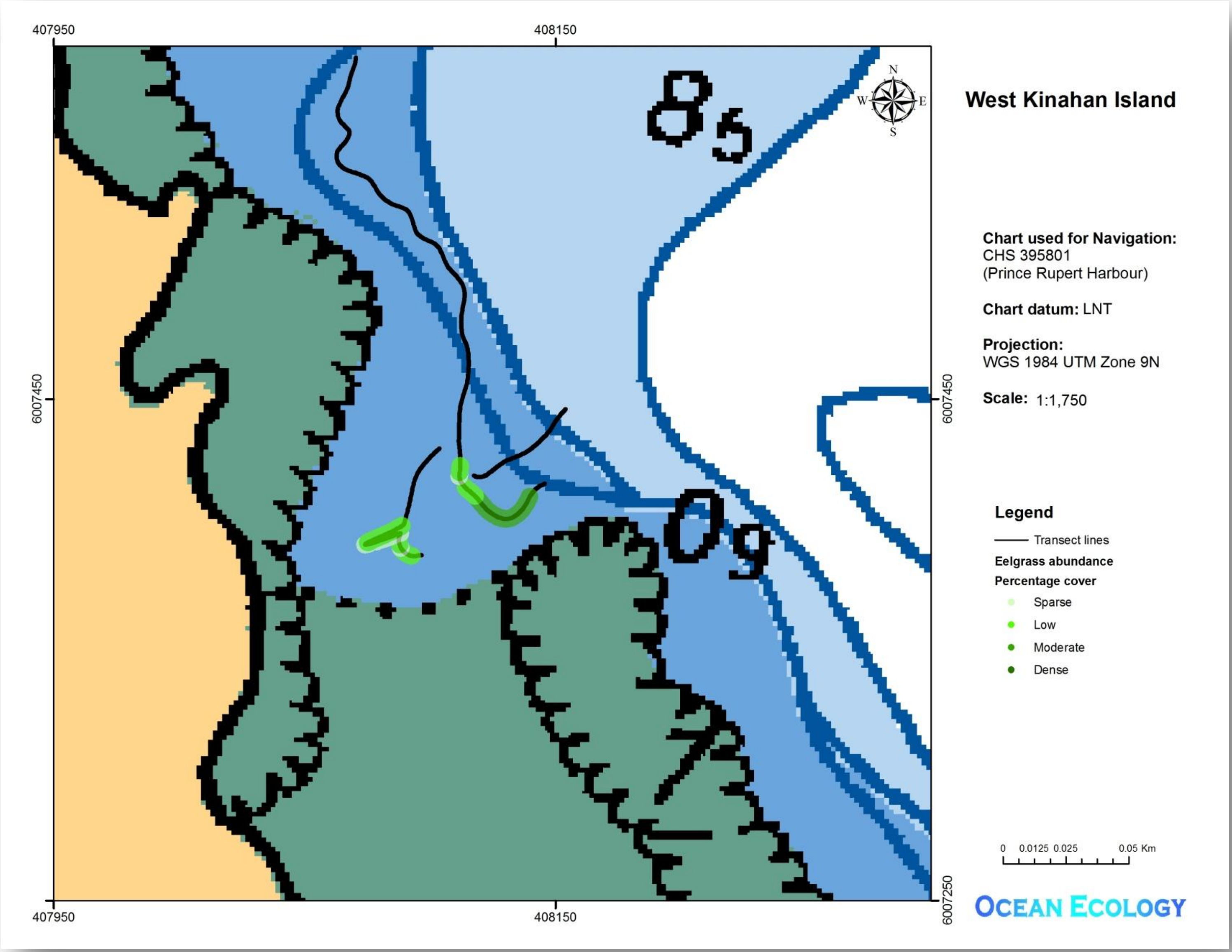


Figure 30. West Kinahan Island eelgrass bed (Site 9).

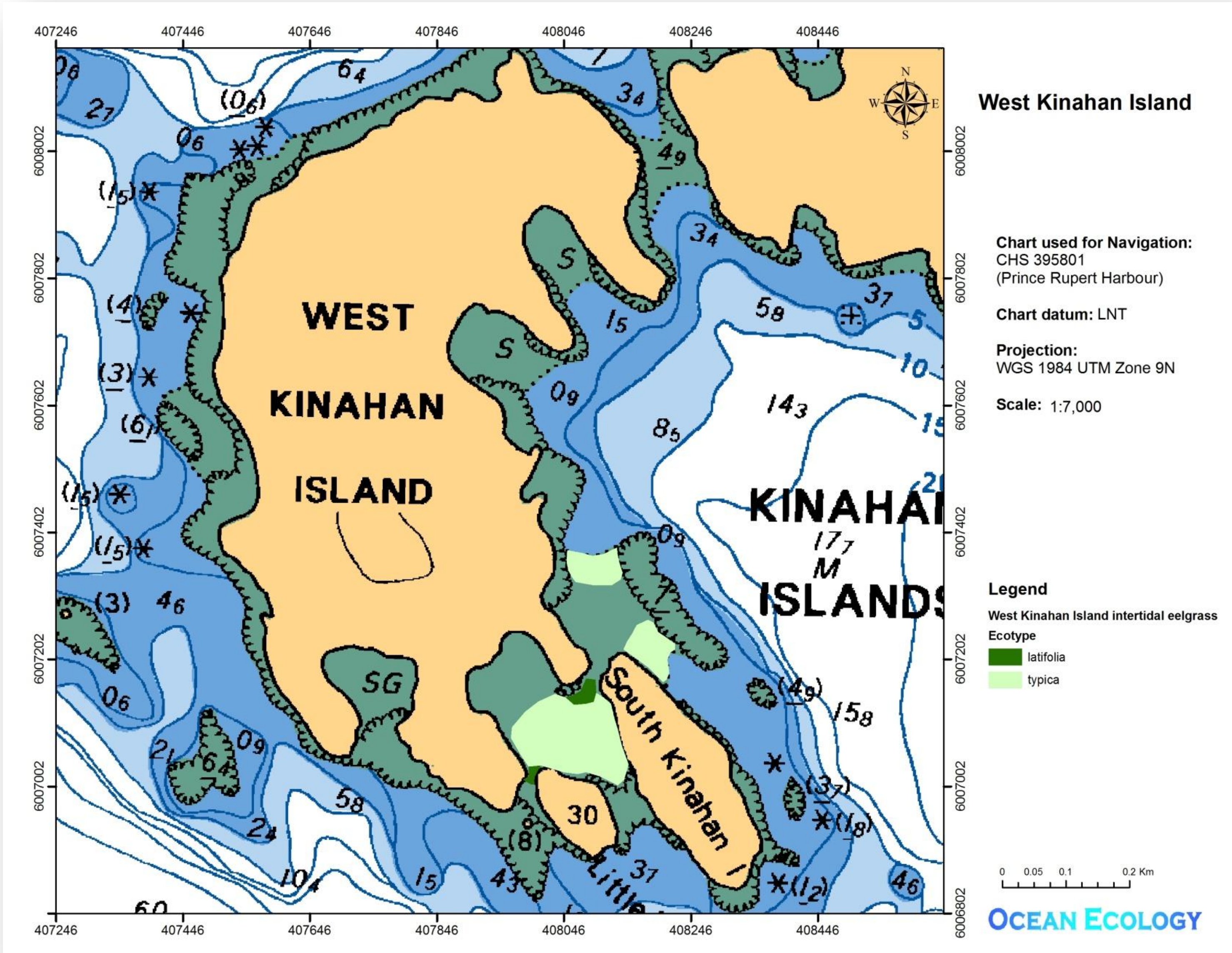


Figure 31. Intertidal eelgrass observed on West Kinahan Island (Site 9).

3.2.10 Parry Island

Parry Island is a small island located to the west of Prescott Island near the entrance to Prescott Passage. Parry Island is located within the Ksgaxl/Stephens Islands Conservancy. The eelgrass study site on Parry Island is situated in a sheltered cove between the east side of Parry Island and the west side of Prescott Island. This site is outside the influence of the Skeena/Nass plume.

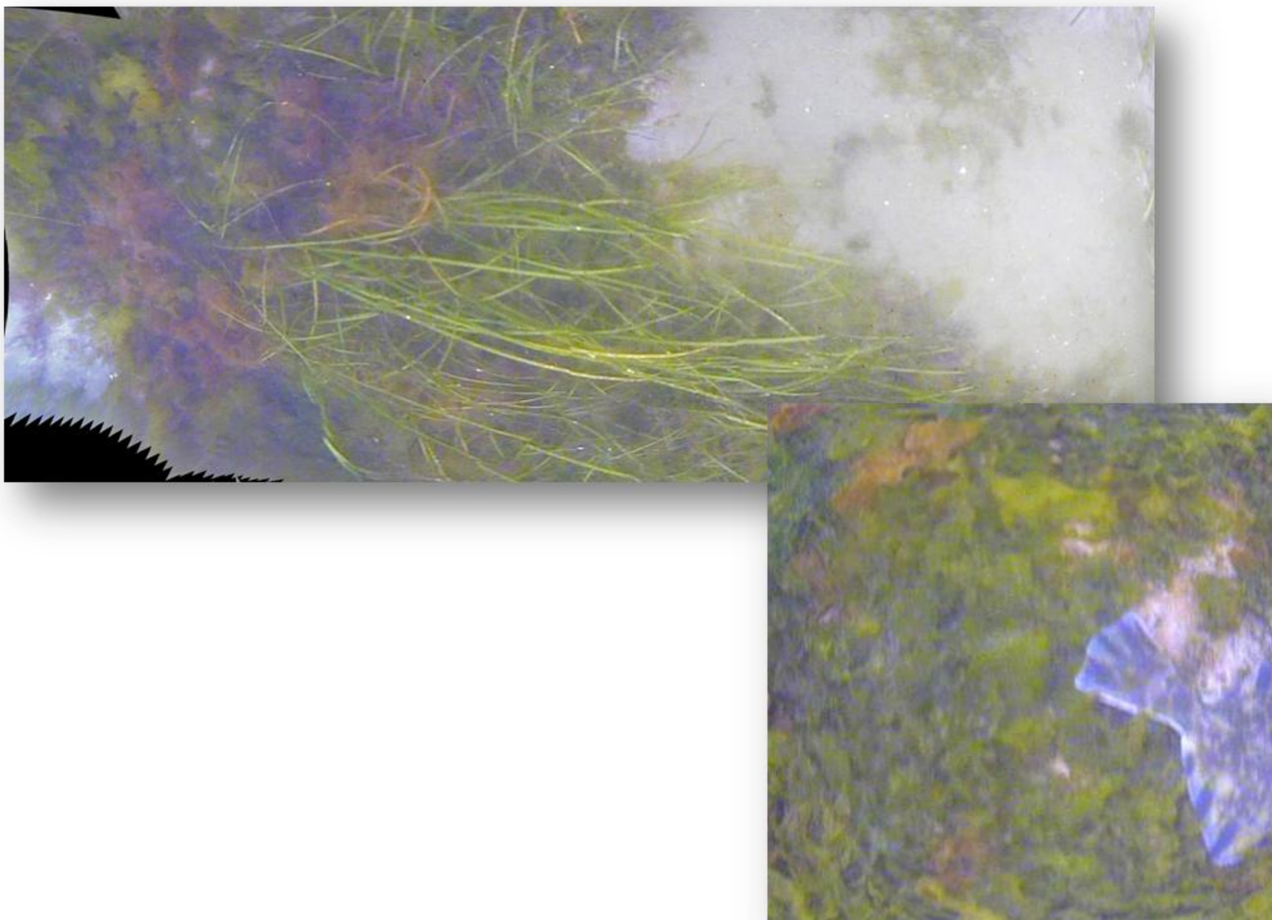


Figure 32. Panoramas from the video footage of the Parry Island eelgrass bed.

Figure 33. Parry Island eelgrass bed (Site 10).

3.2.11 Arthur Island

Arthur Island is to the west of Prescott Island, with Edye Passage to the southwest and Prescott Passage to the northeast. Arthur Island is located within the Ksgaxl/Stephens Islands Conservancy. The eelgrass study site on Arthur Island is located on the northeast side of Arthur Island in Prescott Passage. This site is outside the influence of the Skeena/Nass plume.

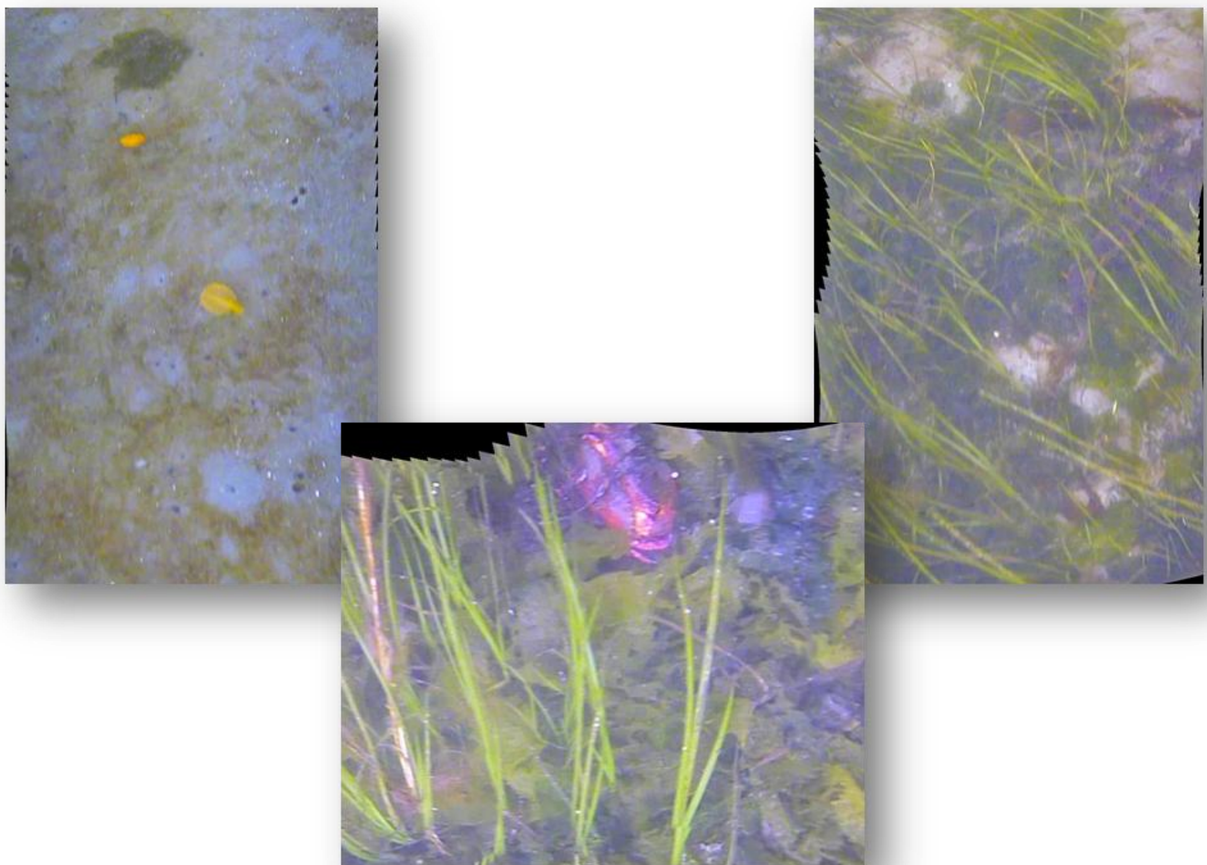


Figure 34. Panoramas from the video footage of the Arthur Island eelgrass bed.

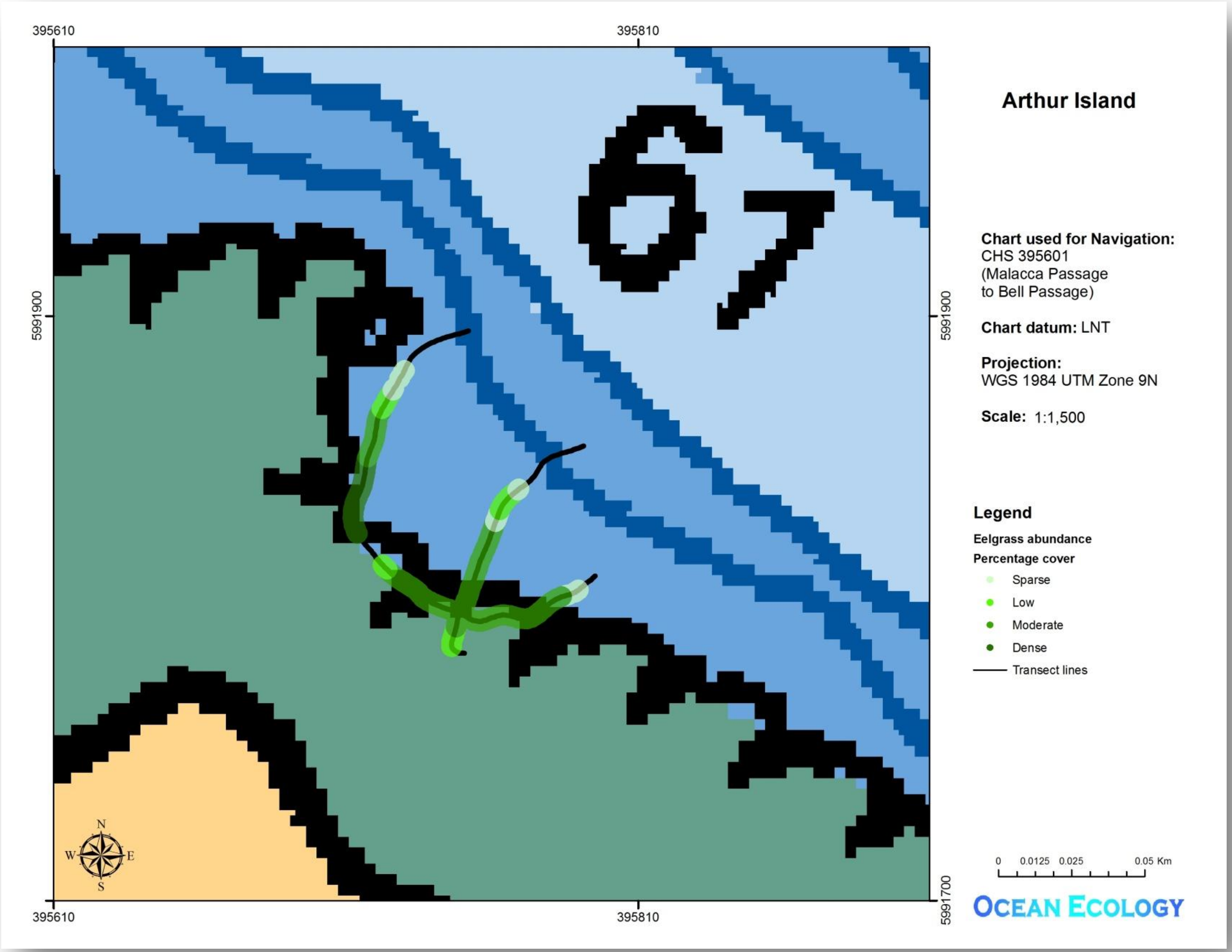


Figure 35. Arthur Island eelgrass bed (Site 11).

3.2.12 Stephens Passage

Stephens Passage is a narrow northeast-southwest oriented pass between Stephens Island and Prescott Island. Stephens Passage is located within the Ksgaxl/Stephens Islands Conservancy. The eelgrass study site is situated in a sheltered cove near the northeast entrance to the pass.

Stephens Passage is a popular location for recreational fishers. A sports lodge is anchored at the study site, and is probably situation over a portion of the eelgrass bed. A cabin is located at the head of the cove. Stephens Passage is also used frequently by kayakers.

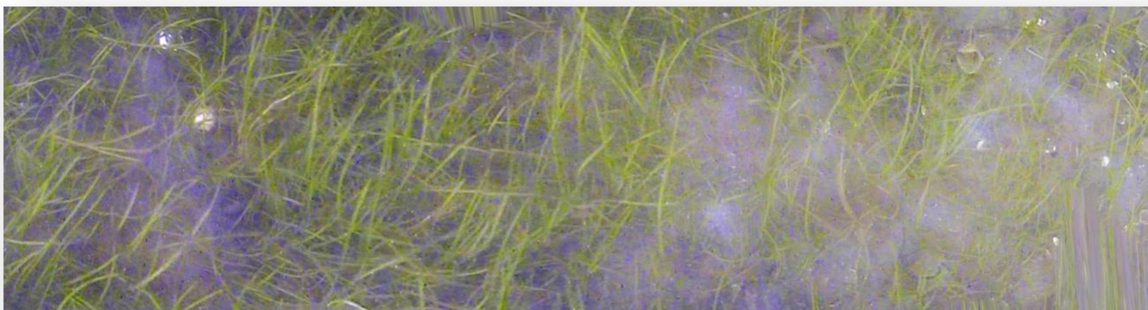


Figure 36. Panorama from the video footage of the Stephens Passage eelgrass bed.

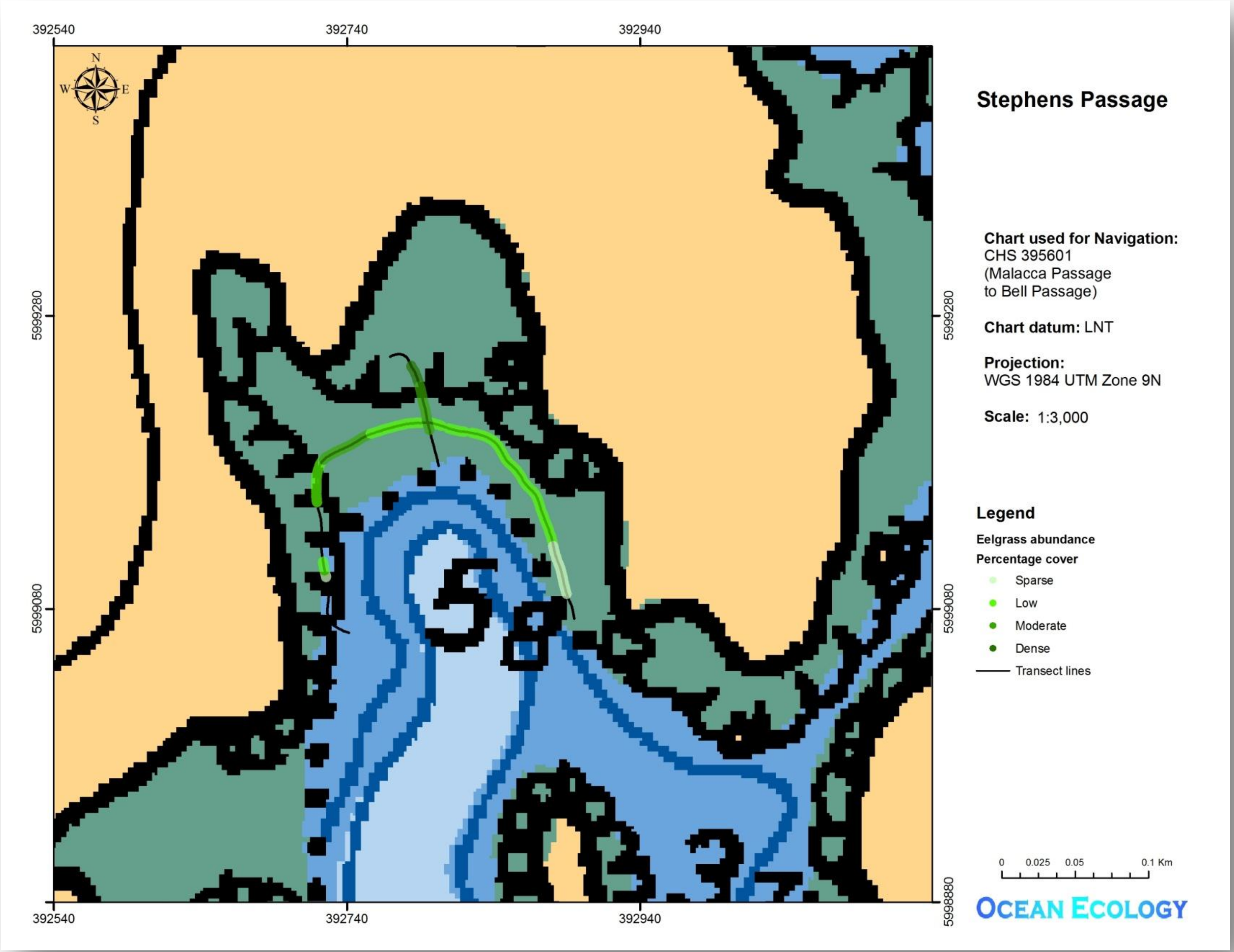


Figure 37. Stephens Passage eelgrass bed (Site 12).

3.2.13 Qlawdzeet Anchorage

Qlawdzeet Anchorage is located at the north end of Stephens Island between Hooper Point and Avery Island. Qlawdzeet Anchorage is a popular location for recreational fishers who troll for salmon in Bell Passage, and is situation within the Ksgaxl/Stephens Islands Conservancy. A number of pilings are still present in the southernmost protected region of the anchorage, behind Dunn Island. At the time of the survey, a small float with a utility building was tied to these pilings. The eelgrass study site is located in the southwest corner of the anchorage.

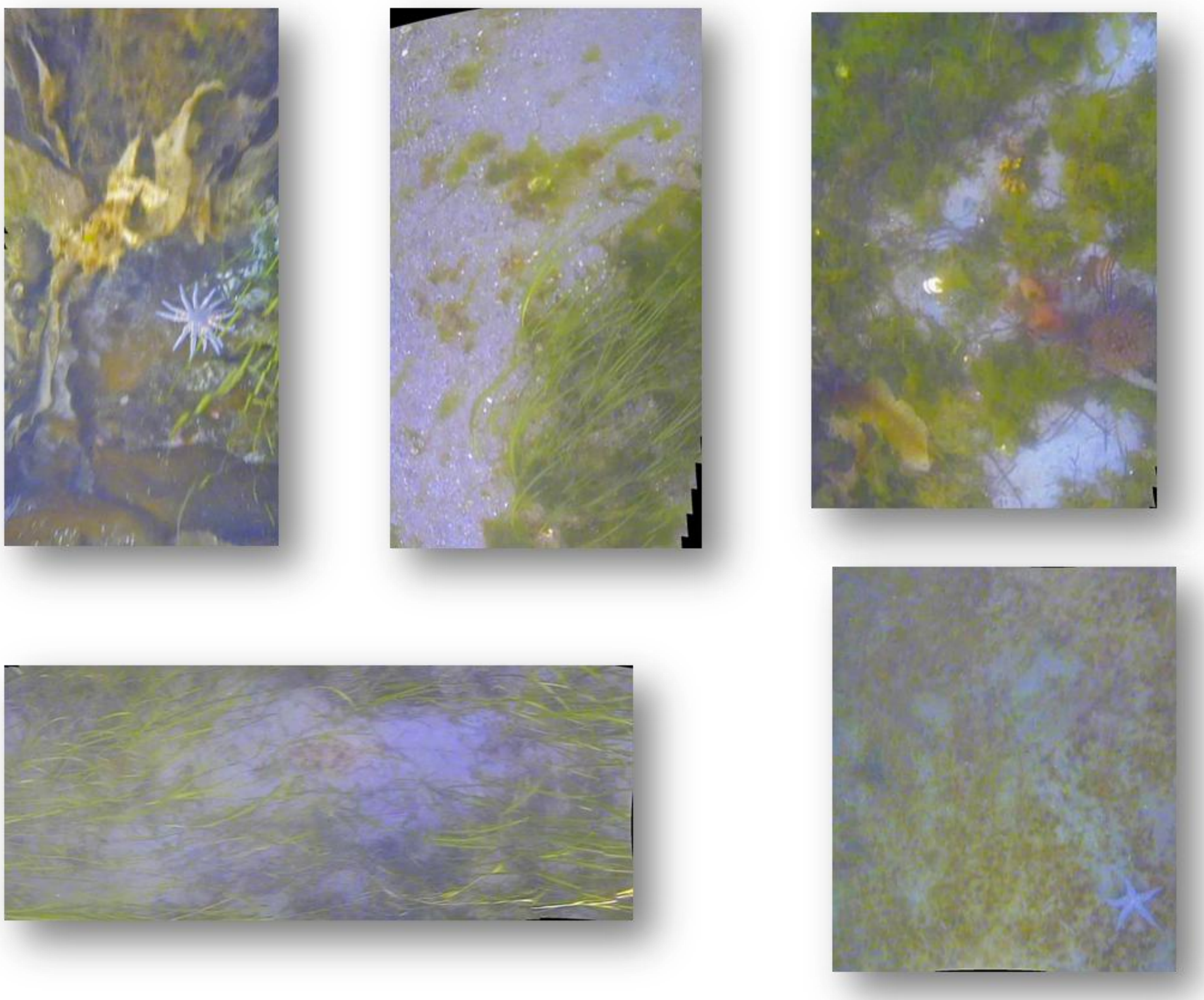


Figure 38. Panoramas from the video footage of the Qlawdzeet Anchorage eelgrass bed.

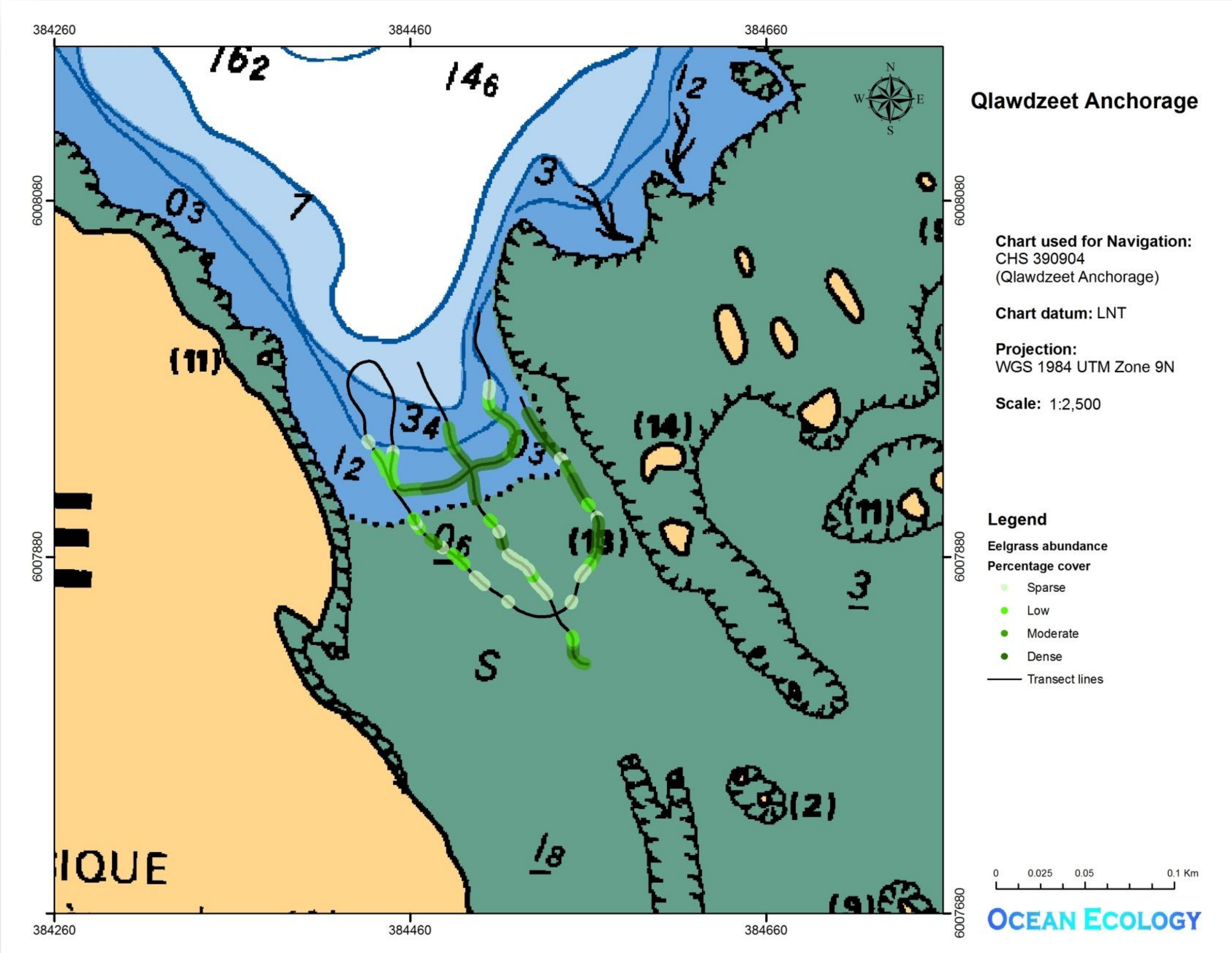


Figure 39. Qlawdzeet Anchorage eelgrass bed (Site 13).

3.2.14 West Melville Island

Melville Island forms part of the Lax Kwaxl/Dundas and Melville Islands Conservancy. Melville Island is a very popular destination for kayakers, and is an important location to First Nations for collection of traditional foods. The eelgrass study site on the west side of Melville Island is found along a cobble beach where a First Nations archeological site is situation.

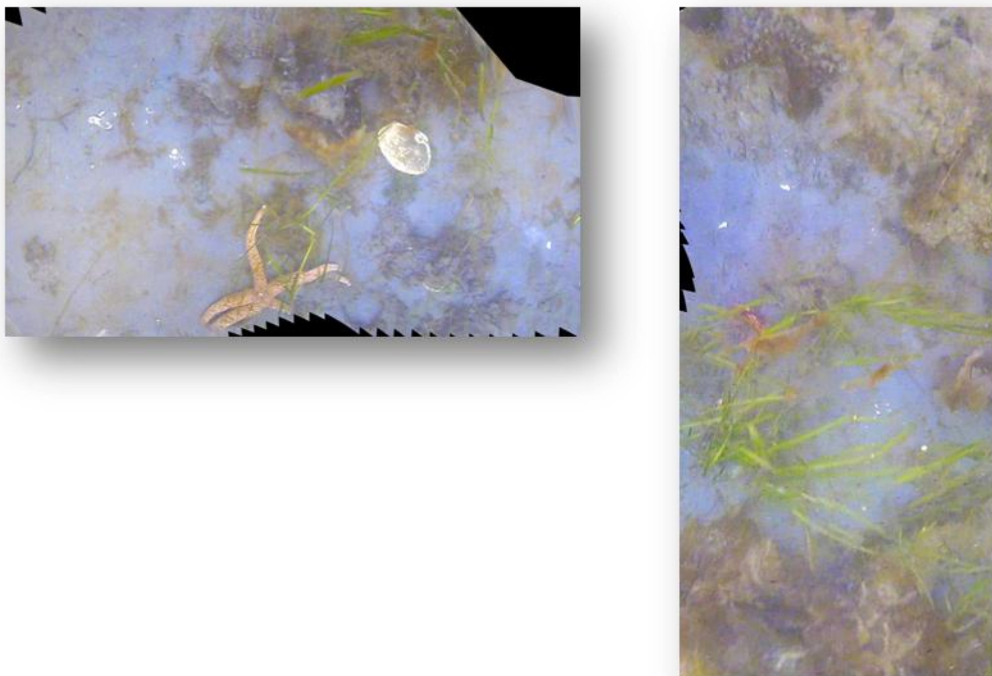


Figure 40. Panoramas from the video footage of the eelgrass bed on the west side of Melville Island.

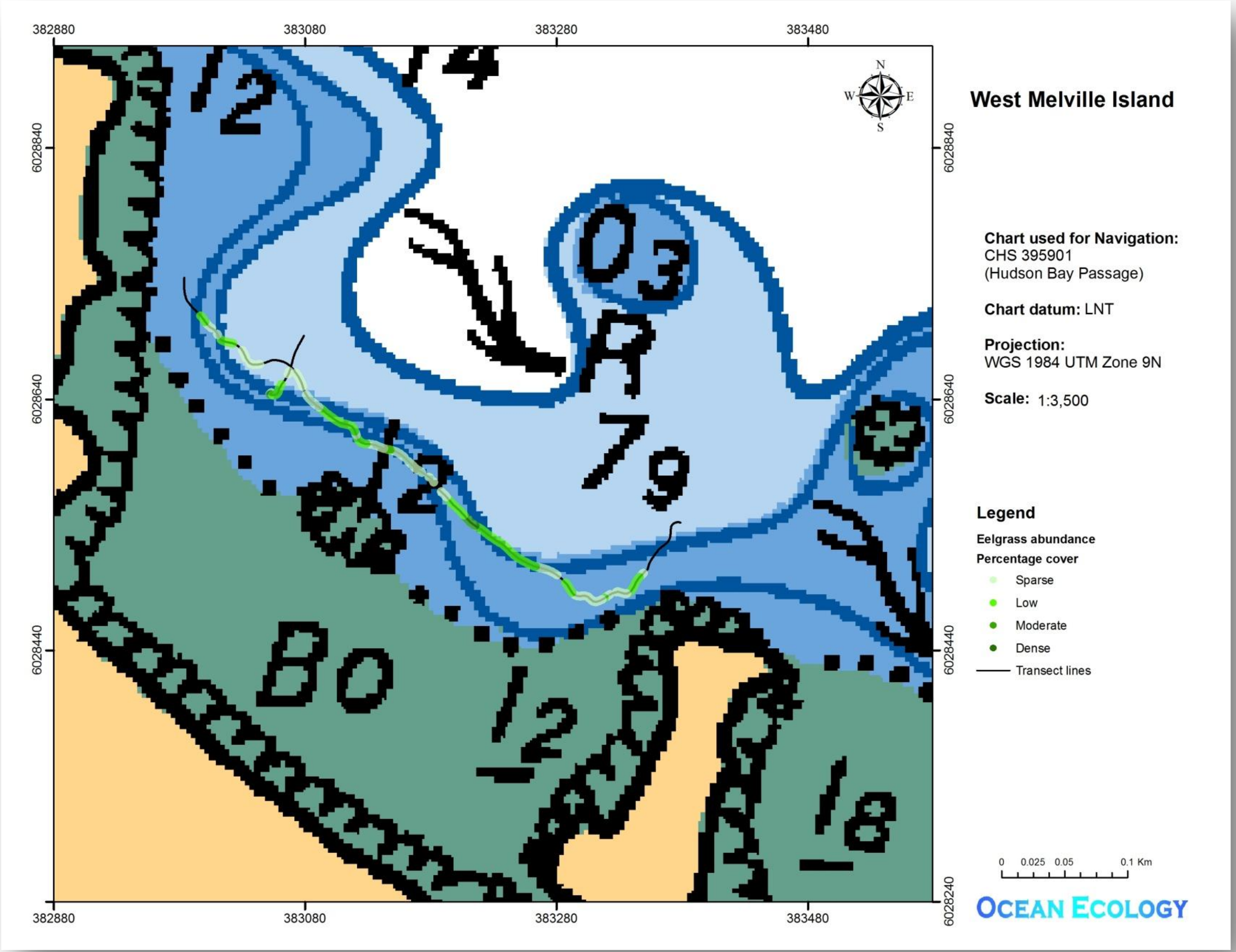


Figure 41. West Melville Island eelgrass bed (Site 14).

3.2.15 East Melville Island

Melville Island forms part of the Lax Kwaxl/Dundas and Melville Islands Conservancy. Melville Island is a very popular destination for kayakers, and is an important location to First Nations for collection of traditional foods. The eelgrass study site on the east side of Melville Island is located north of Deans Point, about halfway along the east side of the island. No shore parallel transect was possible at this site due to the presence of kelp beds.

Figure 42. Panorama from the video footage of the eelgrass bed on the east side of Melville Island.

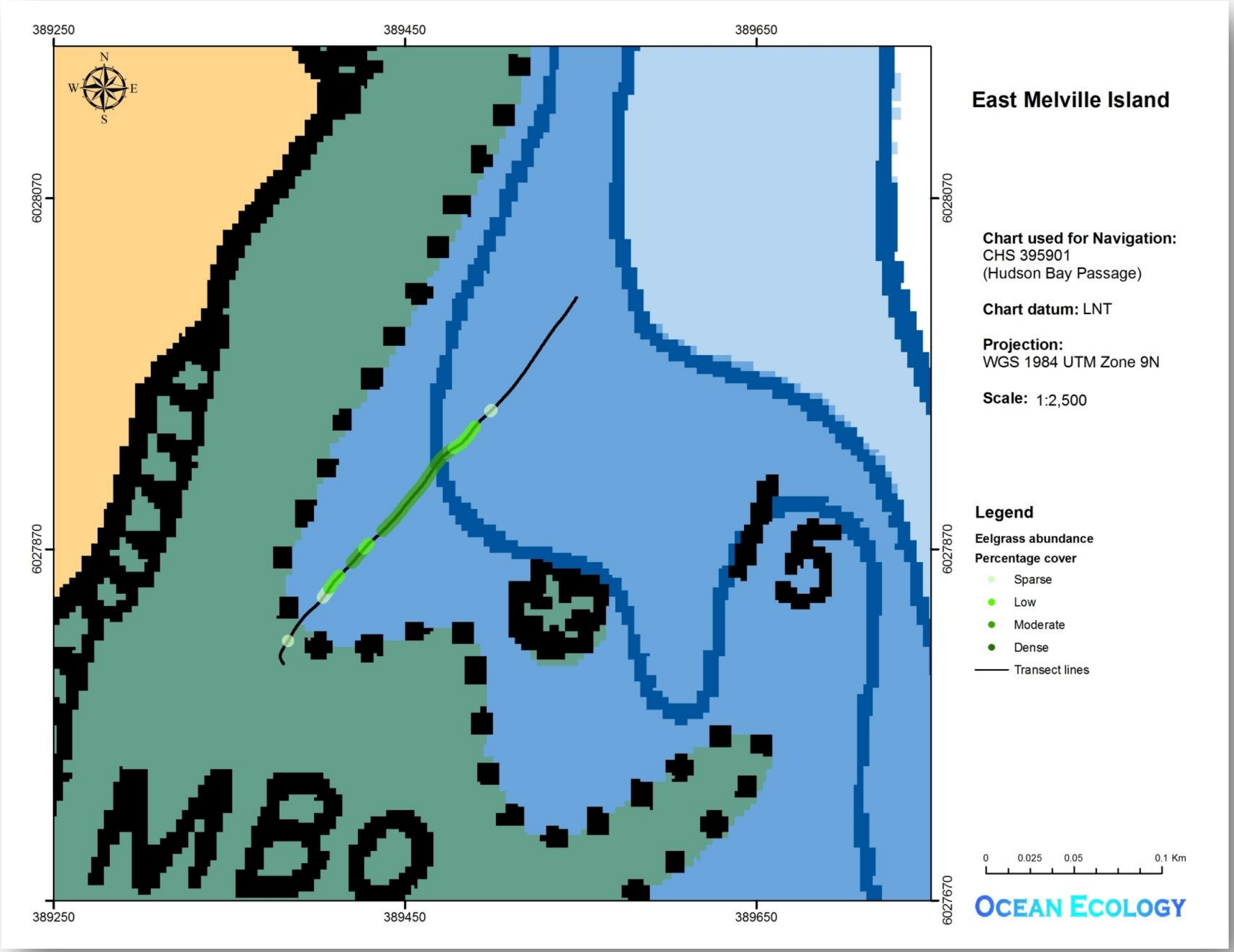


Figure 43. East Melville Island eelgrass bed (Site 15).

3.2.16 Northeast Melville Island

Melville Island forms part of the Lax Kwaxl/Dundas and Melville Islands Conservancy. Melville Island is a very popular destination for kayakers, and is an important location to First Nations for collection of traditional foods. The eelgrass study site on the northeast side of Melville Island is situated in a small bay below Knee Hill, and receives freshwater drainage from the uplands.

Figure 44. Panoramas from the video footage of the eelgrass bed on the northeast side of Melville Island.

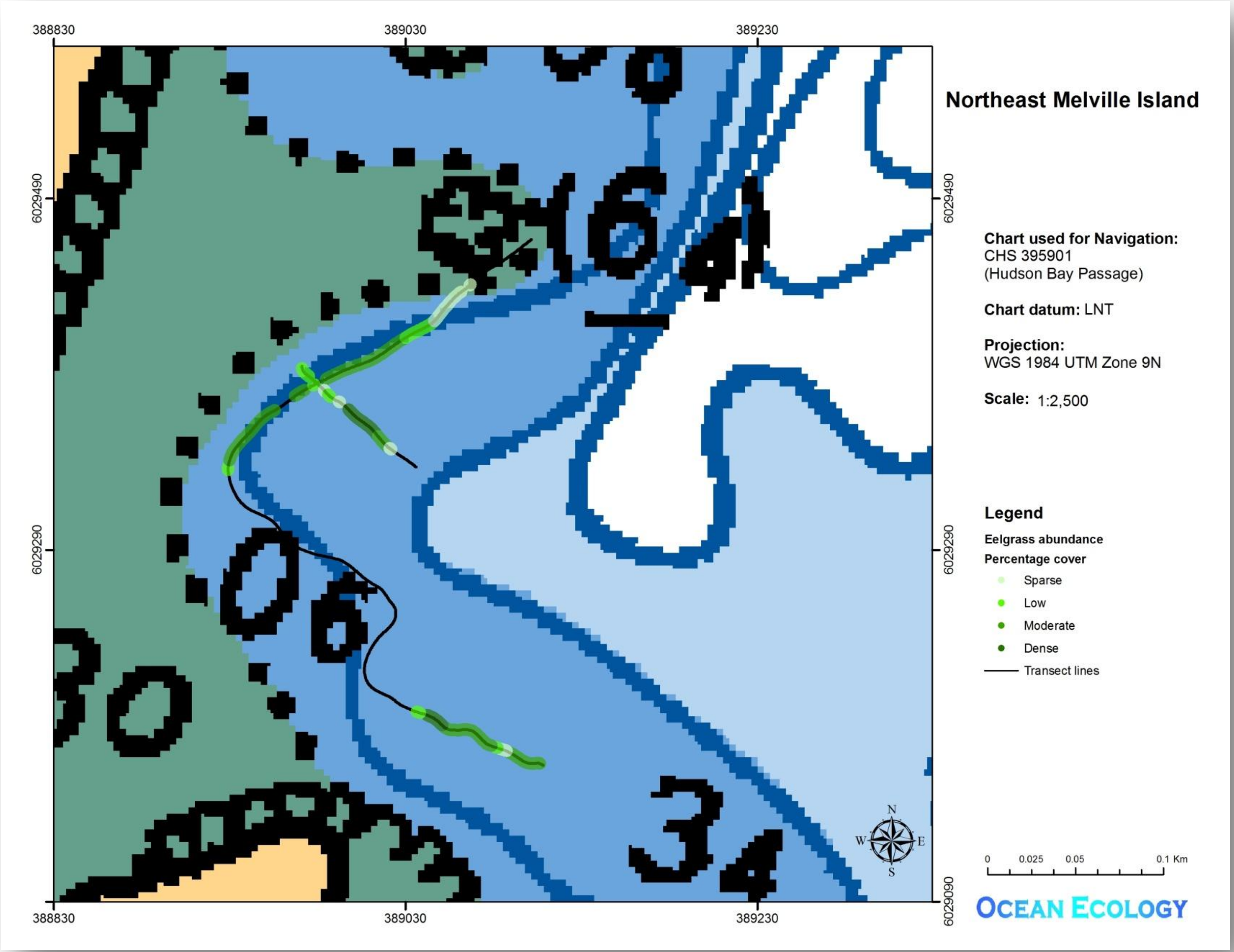


Figure 45. Northeast Melville Island eelgrass bed (Site 16).

3.2.17 Moffat Islands

The Moffat Islands are a linear cluster of islands located on the east side of Dunira Island. The Moffat Island group is a component of the Lax Kwaxl/Dundas and Melville Islands Conservancy. The eelgrass study site is situated between several islets approximately midway along the chain of islands. This site was too narrow for a shore parallel transect to be carried out safely.

Figure 46. Panorama from the video footage of the Moffat Islands eelgrass bed.

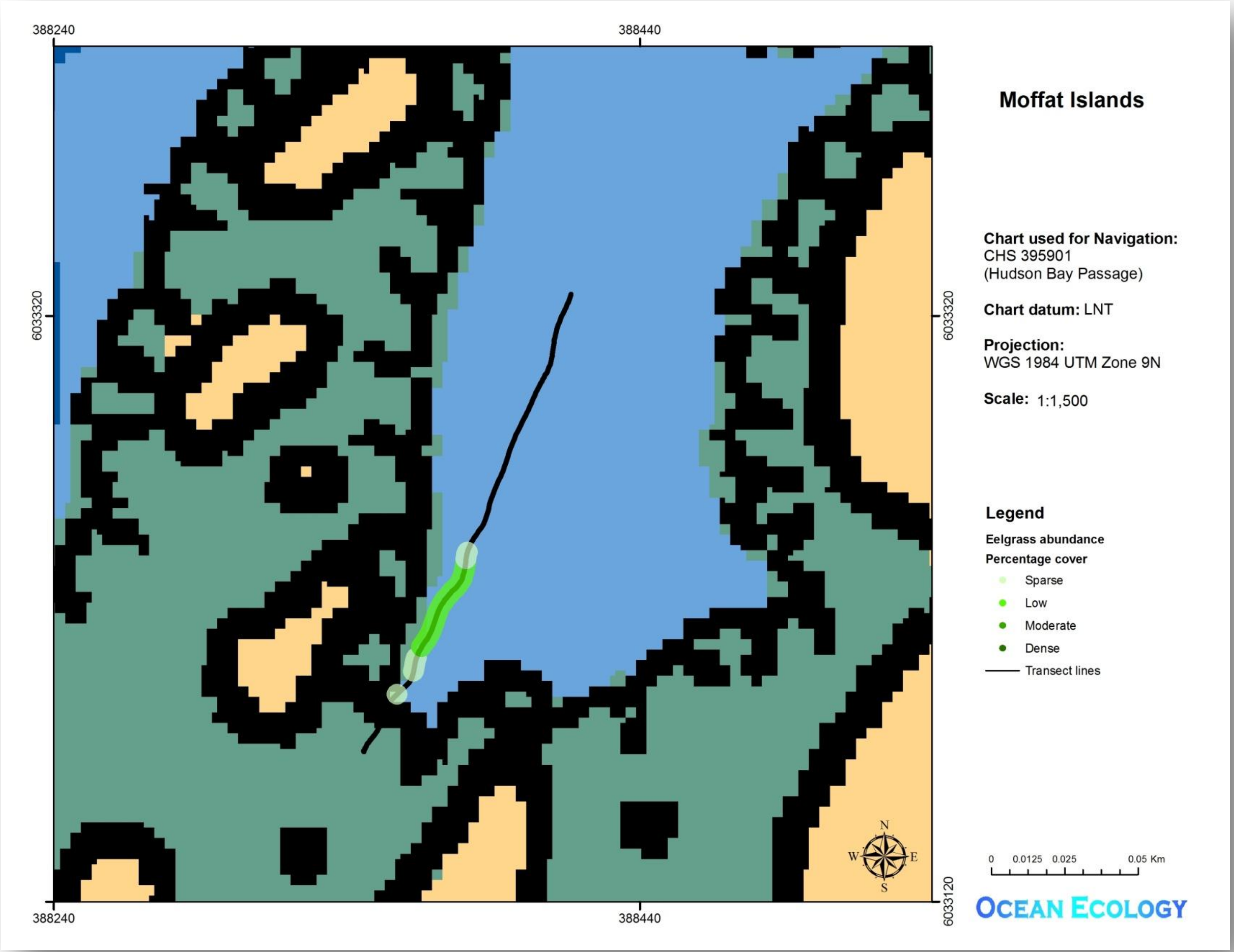


Figure 47. Moffat Islands eelgrass bed (Site 17).

3.2.18 West Dunira Island

Dunira Island is a component of the Lax Kwaxl/Dundas and Melville Islands Conservancy. The eelgrass study site on the west side of Dunira Island is located approximately midway along the west coast of the island. There are sources of freshwater both to the north and south of site as a result of drainage from several small lakes to the east of Coast Mound.

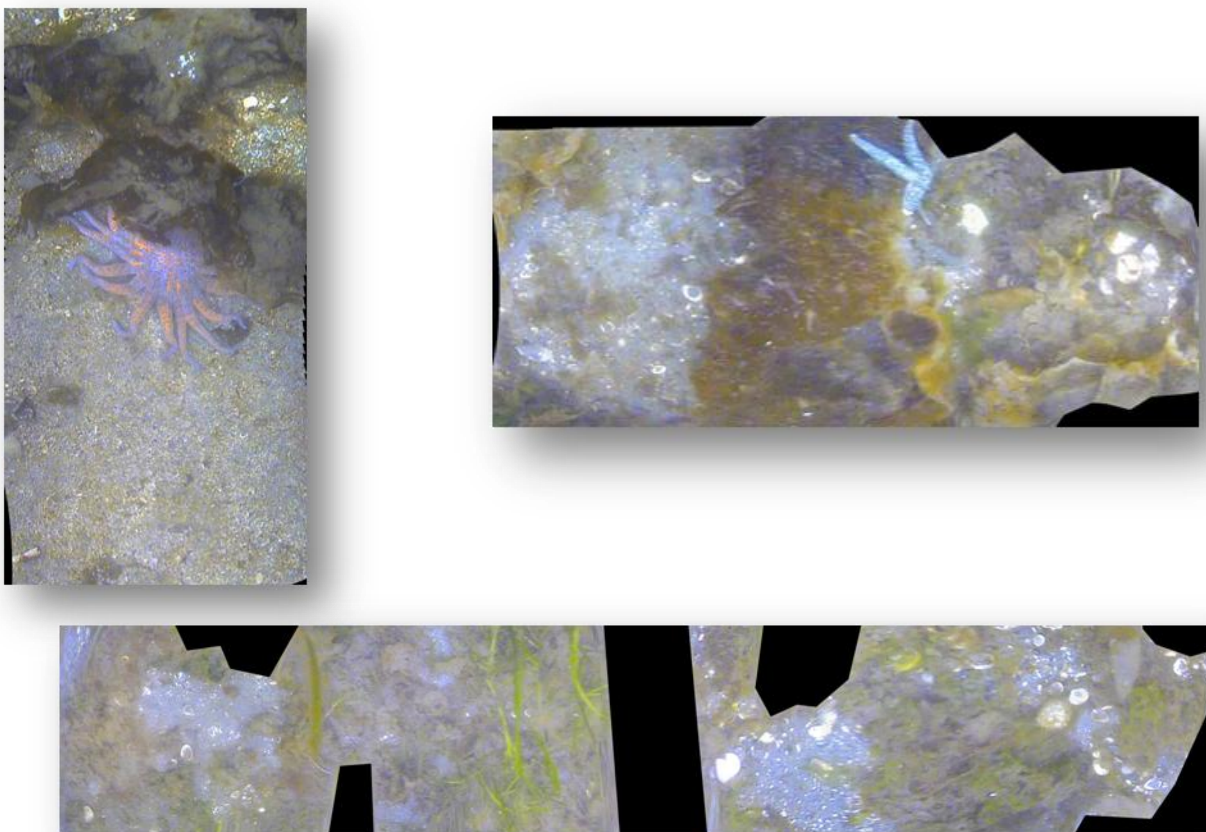


Figure 48. Panoramas from the video footage of the eelgrass bed on the west side of Dunira Island.

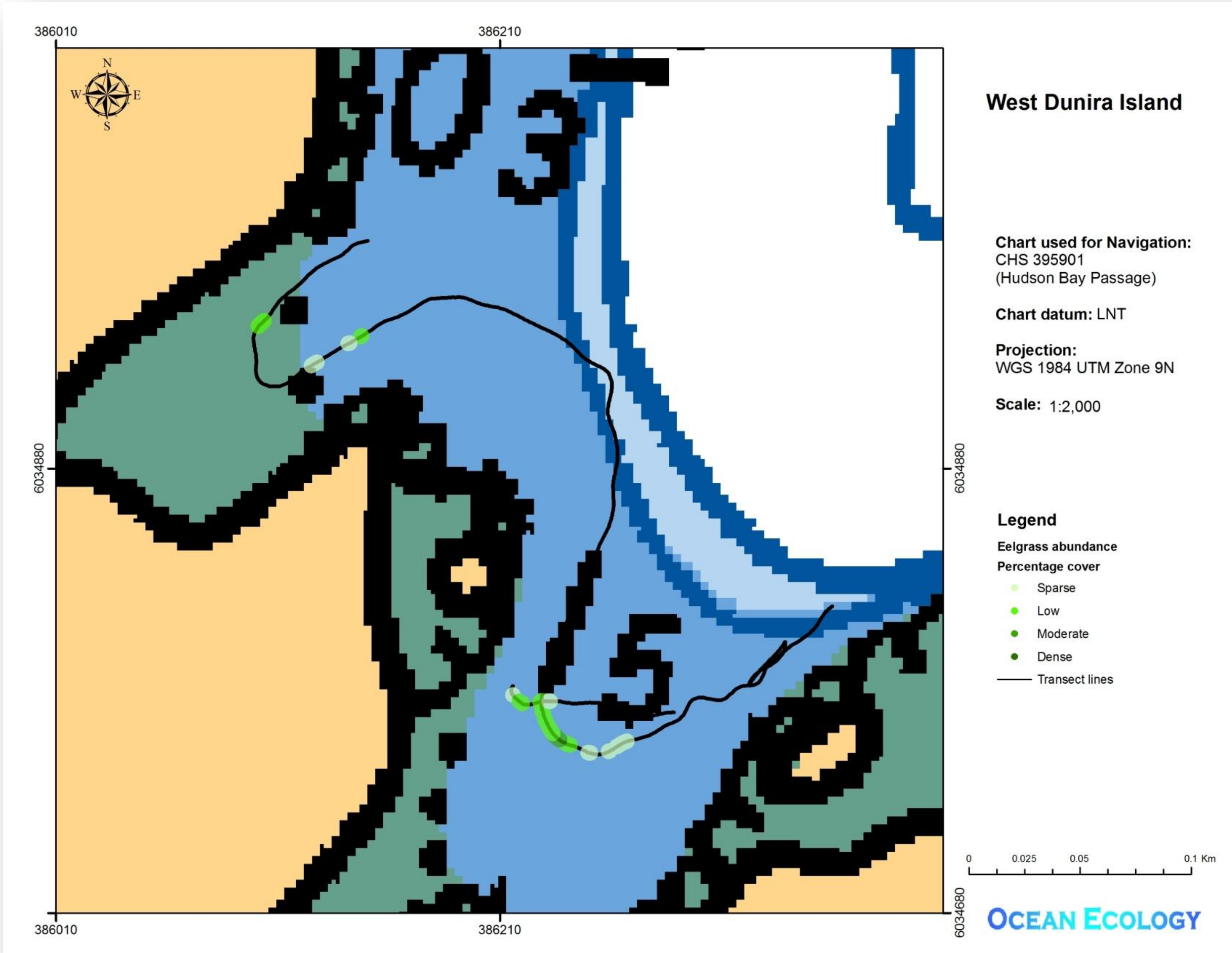


Figure 49. West Dunira Island eelgrass bed (Site 18).

3.2.19 Lucy Islands

The Lucy Islands lie in the middle of Chatham Sound, approximately 21 km west of the city of Prince Rupert, and form the Lucy Islands Conservancy. The Lucy Islands are a nationally listed important bird area (IBA). They support a globally significant population of rhinoceros auklets. The islands, which are crown land, are currently uninhabited. A light station was located on the east point of the main island, but the light keeper’s house was dismantled in 1988. The light tower itself still remains; however it is fully automated and no keepers are stationed on the islands (IBA Canada, 2011). The shallows south of the islands offer excellent fishing, making the Lucy Islands a popular destination for Prince Rupert residents. These islands are also frequented by kayakers crossing from Prince Rupert to the Melville-Dundas Islands. This conservancy is an important area for First Nation resource gathering. However, the Lucy Islands proximity to Prince Rupert, a major port in northern British Columbia, places them at greater risk for oil spills, due to frequent boat traffic. In 2010, Ocean Ecology and WWF jointly applied for, and received, a research grant from MEC to carry out a study of the eelgrass beds at Lucy Islands. The purpose of the Lucy Islands Eelgrass Study was to investigate the productivity and ecological roles of, as well as the impacts of climate change and human activities on, eelgrass in northern B.C. (Faggetter, 2011).

The eelgrass study site is located between the two largest islands in the Lucy Islands group, to the north of the sand bar which joins the two islands.

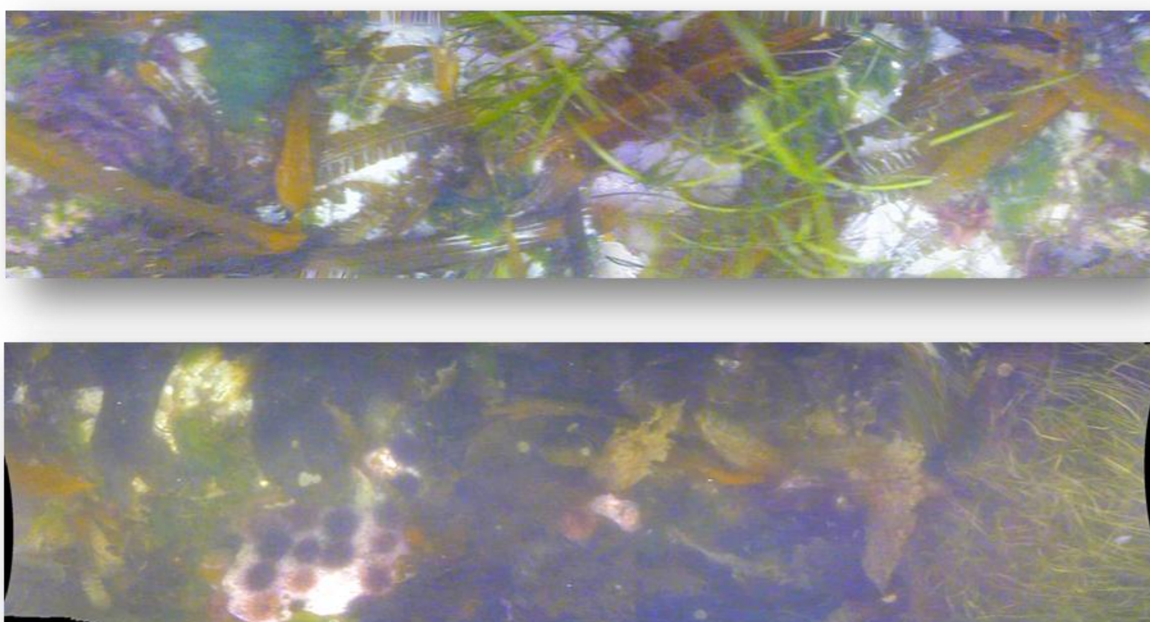


Figure 50. Panoramas from the video footage of the Lucy Islands eelgrass bed.

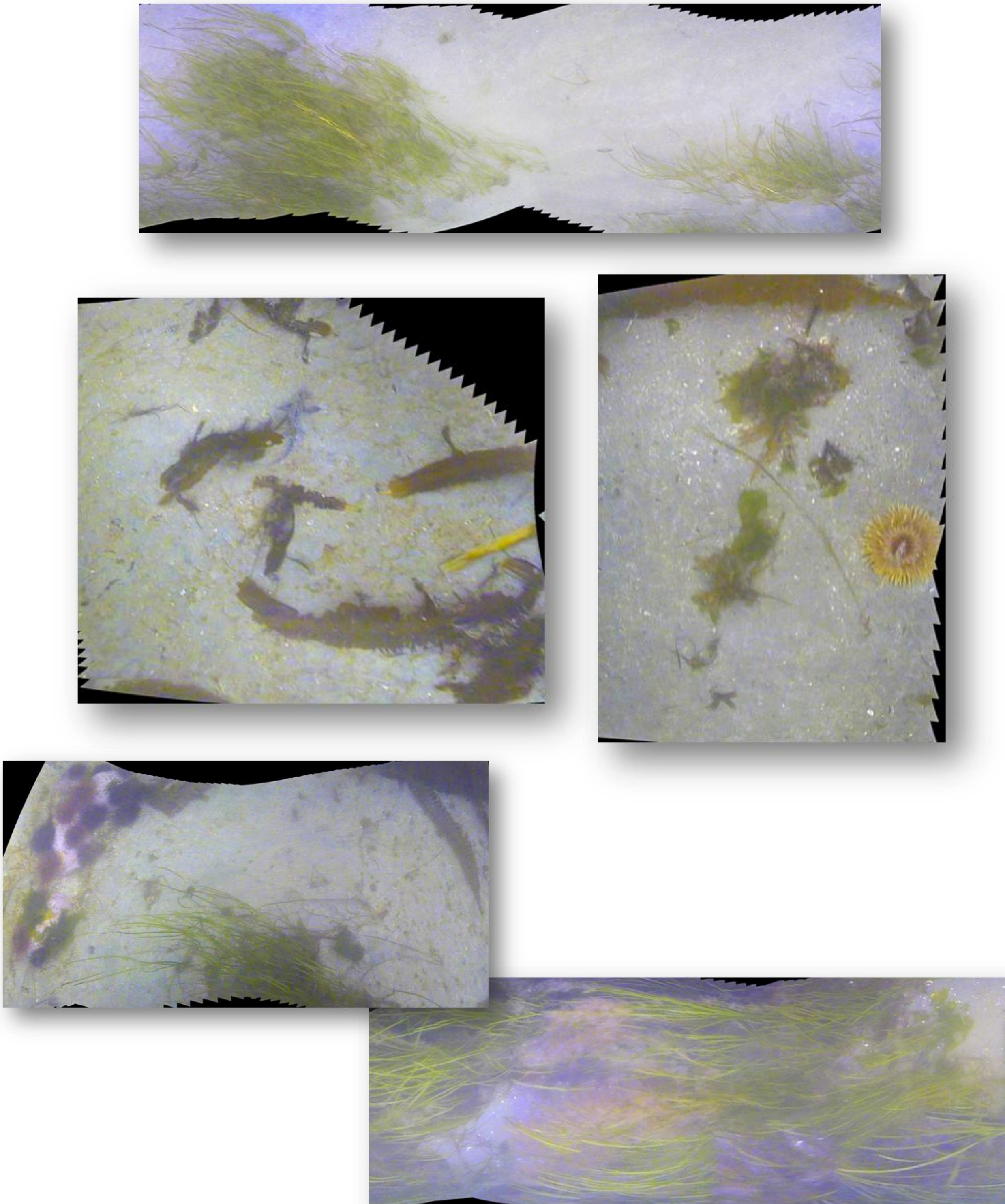


Figure 51. Panoramas from the video footage of the Lucy Islands eelgrass bed.

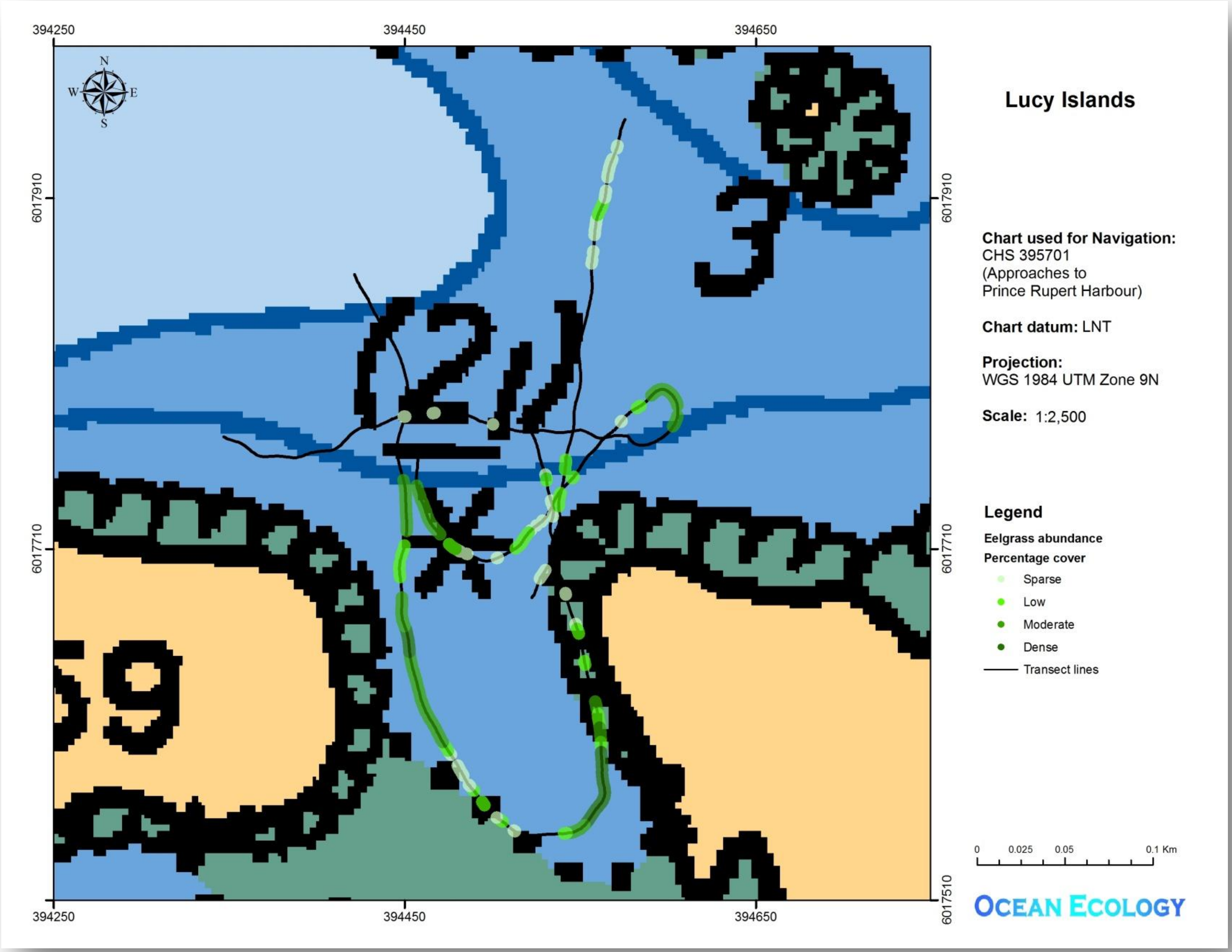


Figure 52. Lucy Islands eelgrass bed (Site 19).

3.2.20 Big Bay on the Tsimpsean Peninsula (near Curlew Rock)

Big Bay is located on the Tsimpsean Peninsula about halfway between the villages of Lax Kw'alaams and Metlakatla. Big Bay is well known as a major spawning area for herring. In the British Columbia Marine Conservation Analysis (BCMCA) Atlas, it is marked as a region of priority eelgrass habitat, which is defined as an area that shows habitat of importance to the lifecycle of herring, Great Blue Heron and Brant. Big Bay is an important site for First Nations spawn-on-kelp operations.

During the springs of 2009 and 2010, Ocean Ecology carried out experimental herring spawn video surveys in Big Bay for the Herring Conservation and Research Society (HCRS). In addition to quantifying and mapping the presence and location of herring spawn, these surveys also mapped the presence and abundance of eelgrass (Faggetter, 2009c, 2010).

The eelgrass study site is situated on the south side of Big Bay, near Curlew Rock.

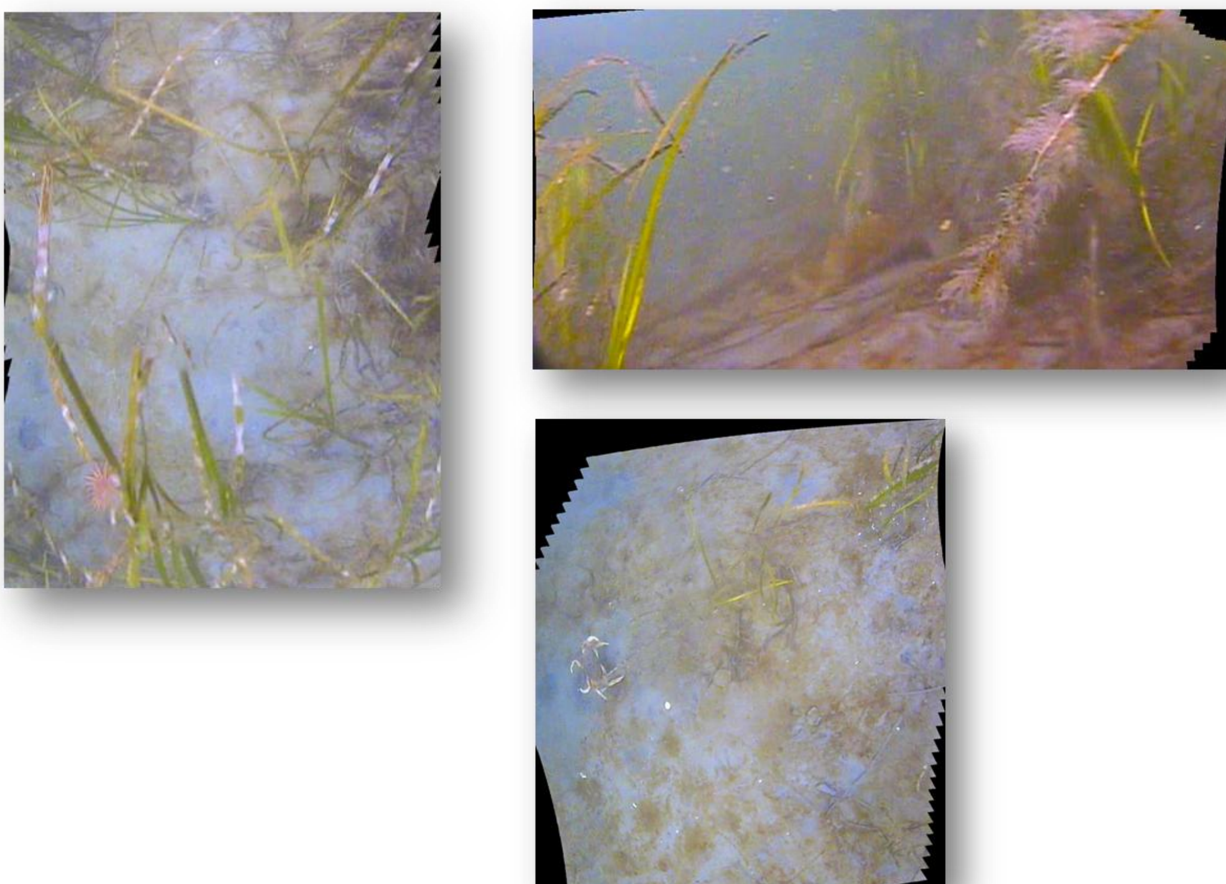


Figure 53. Panoramas from the video footage of the eelgrass bed in Big Bay.

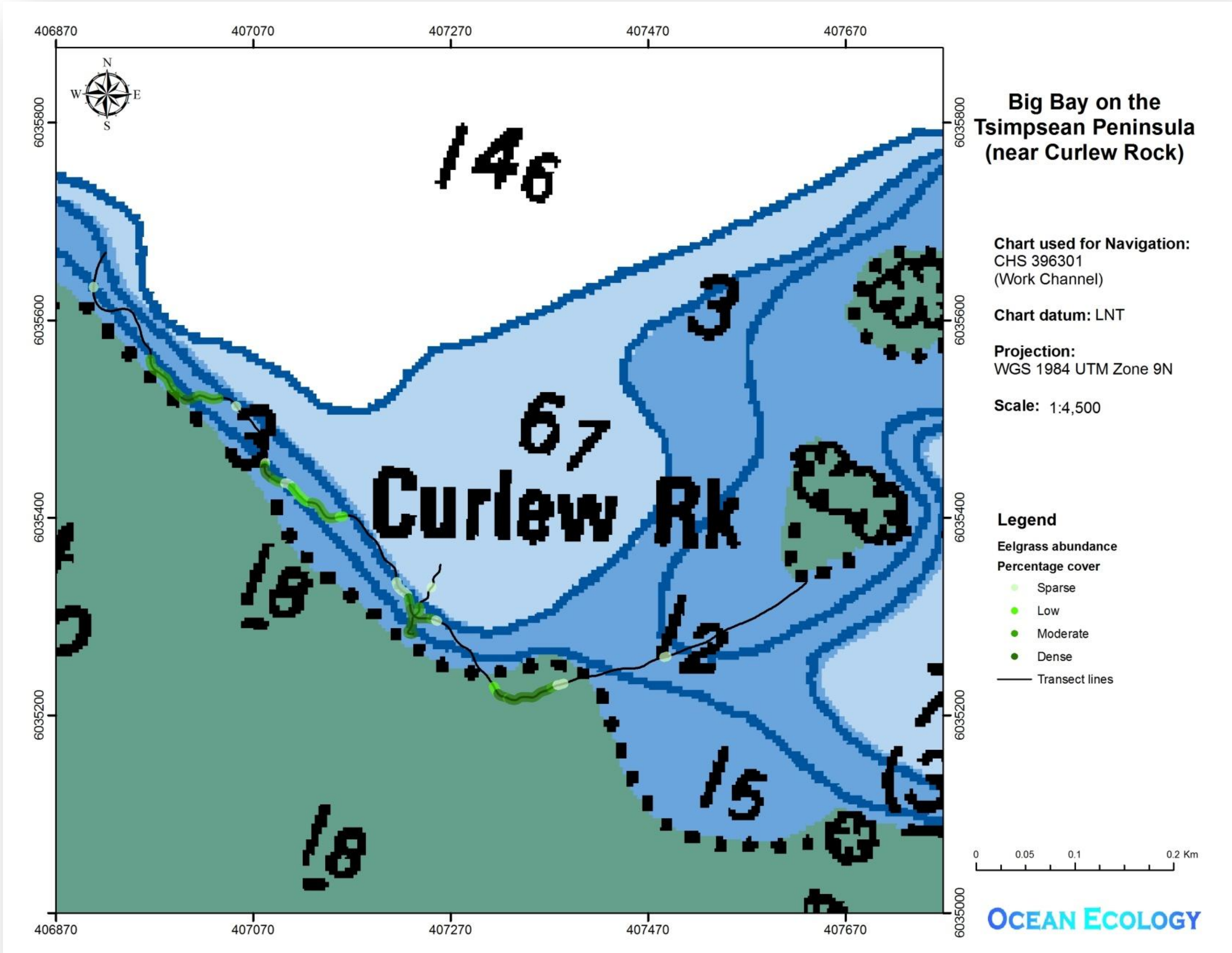


Figure 54. Eelgrass bed in Big Bay on the Tsimpsean Peninsula near Curlew Rock (Site 20).

3.2.21 Pearl Harbour on the Tsimpsean Peninsula

Pearl Harbour is located on the Tsimpsean Peninsula between Burnt Cliff Island and Finlayson Island. A series of rocks and islets shelter Pearl Harbour from Chatham Sound, and for this reason, it is a popular anchorage (both Pearl Harbour and Otter Anchorage). Herring spawn regularly in Pearl Harbour, and it is an important site for First Nations spawn-on-kelp operations.

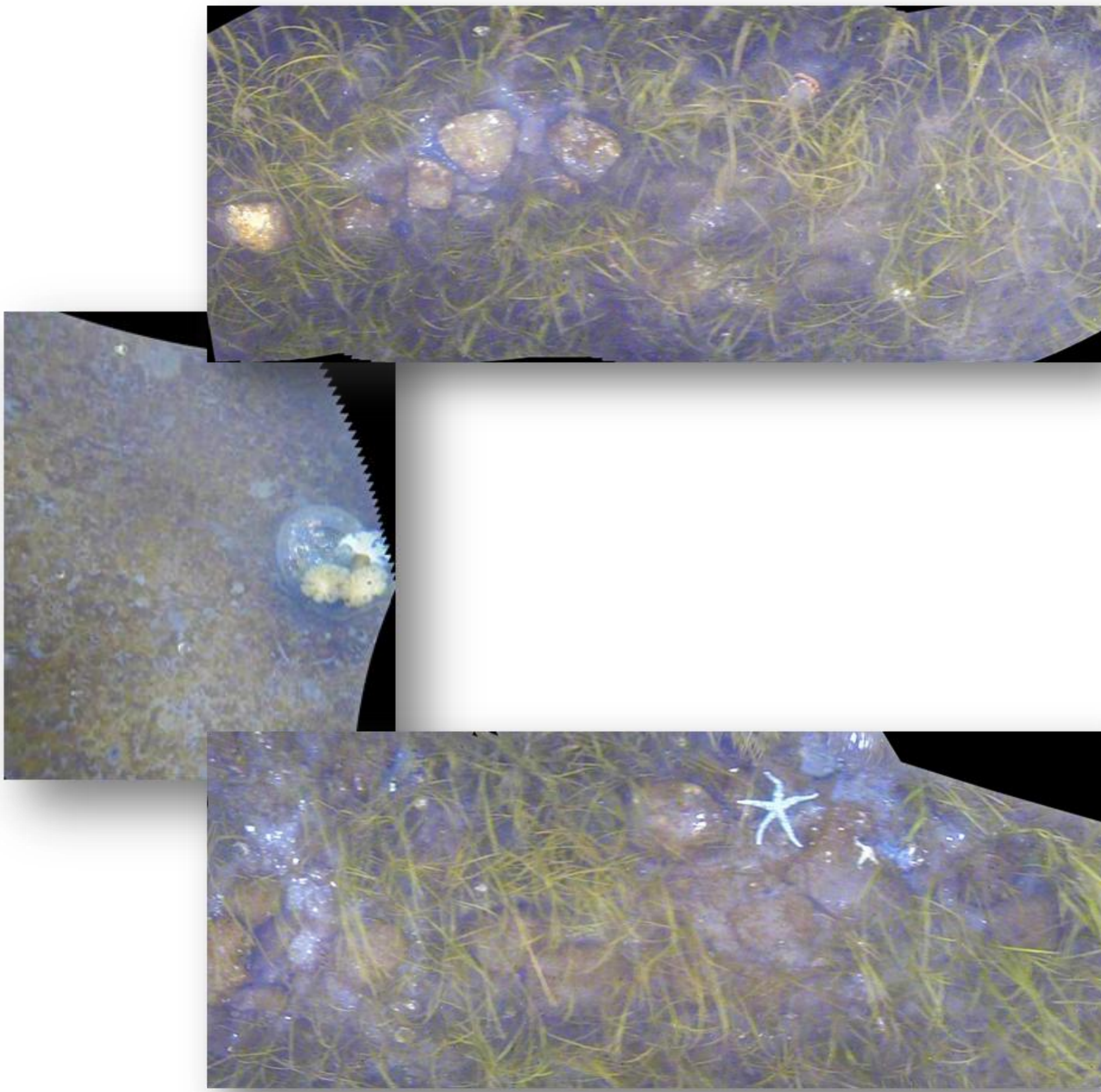


Figure 55. Panoramas from the video footage of the eelgrass bed in Pearl Harbour.

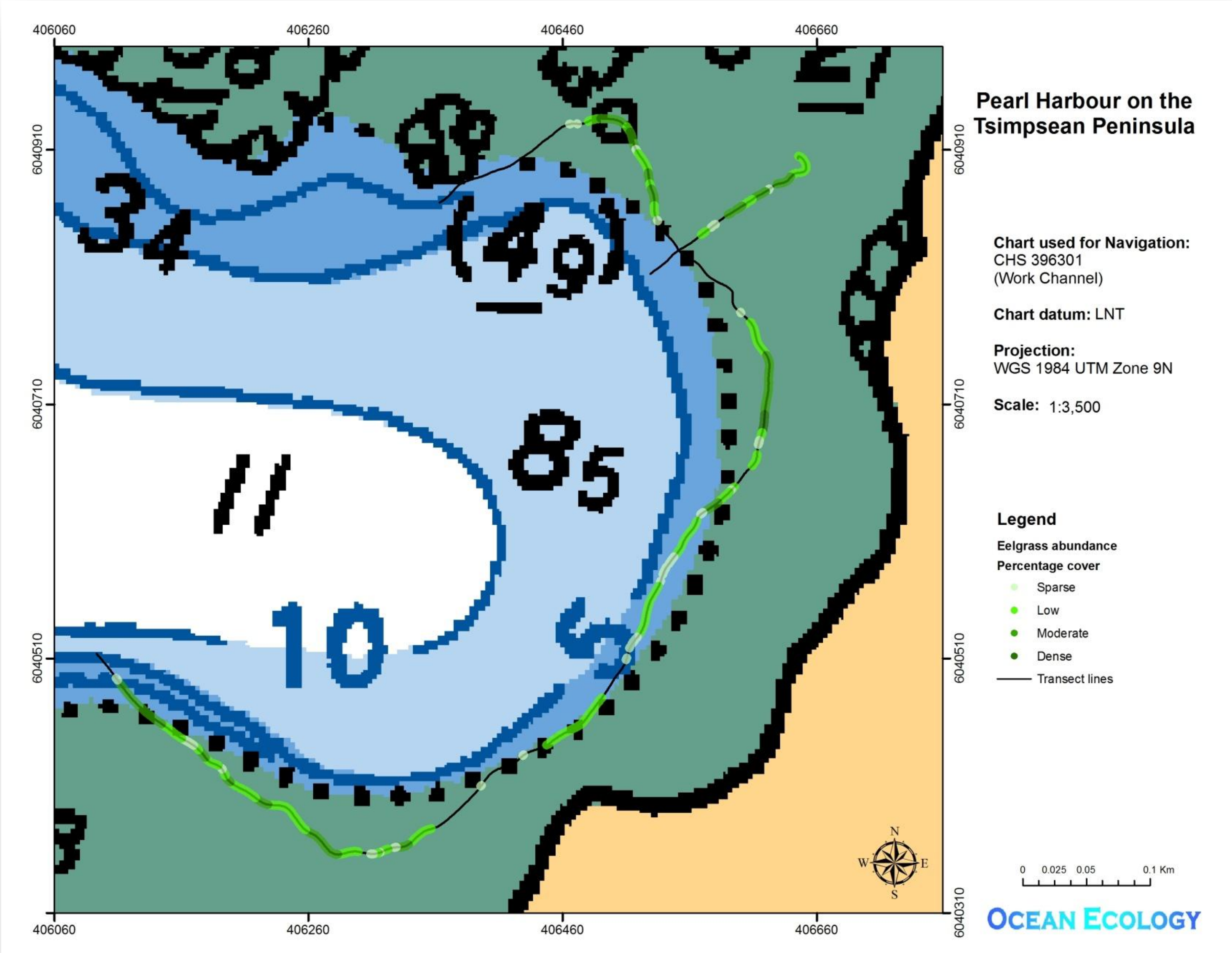


Figure 56. Eelgrass bed in Pearl Harbour on the Tsimpsean Peninsula (Site 21).

3.2.22 North Tsimpsean Peninsula (near Dudevoir Passage)

Dundevoir Passage is located at the most northerly end of the Tsimpsean Peninsula. The eelgrass study site is located in a cove just to the south of Dundevoir Passage. In the British Columbia Marine Conservation Analysis (BCMCA) Atlas, this site is marked as a region of priority eelgrass habitat, which is defined as an area that shows habitat of importance to the lifecycle of herring, Great Blue Heron and Brant.

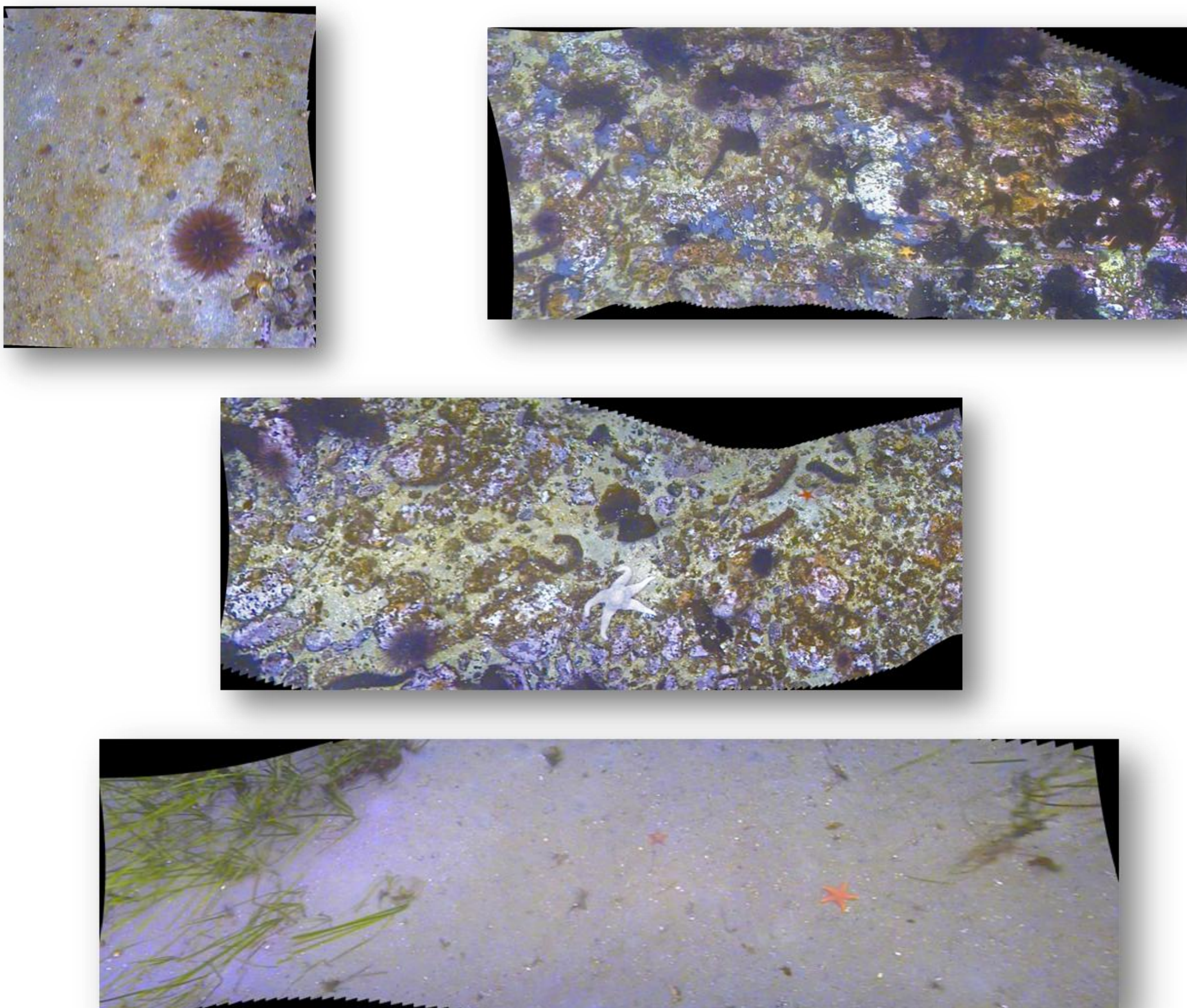


Figure 57. Panoramas from the video footage of the eelgrass bed near Dundevoir Passage.

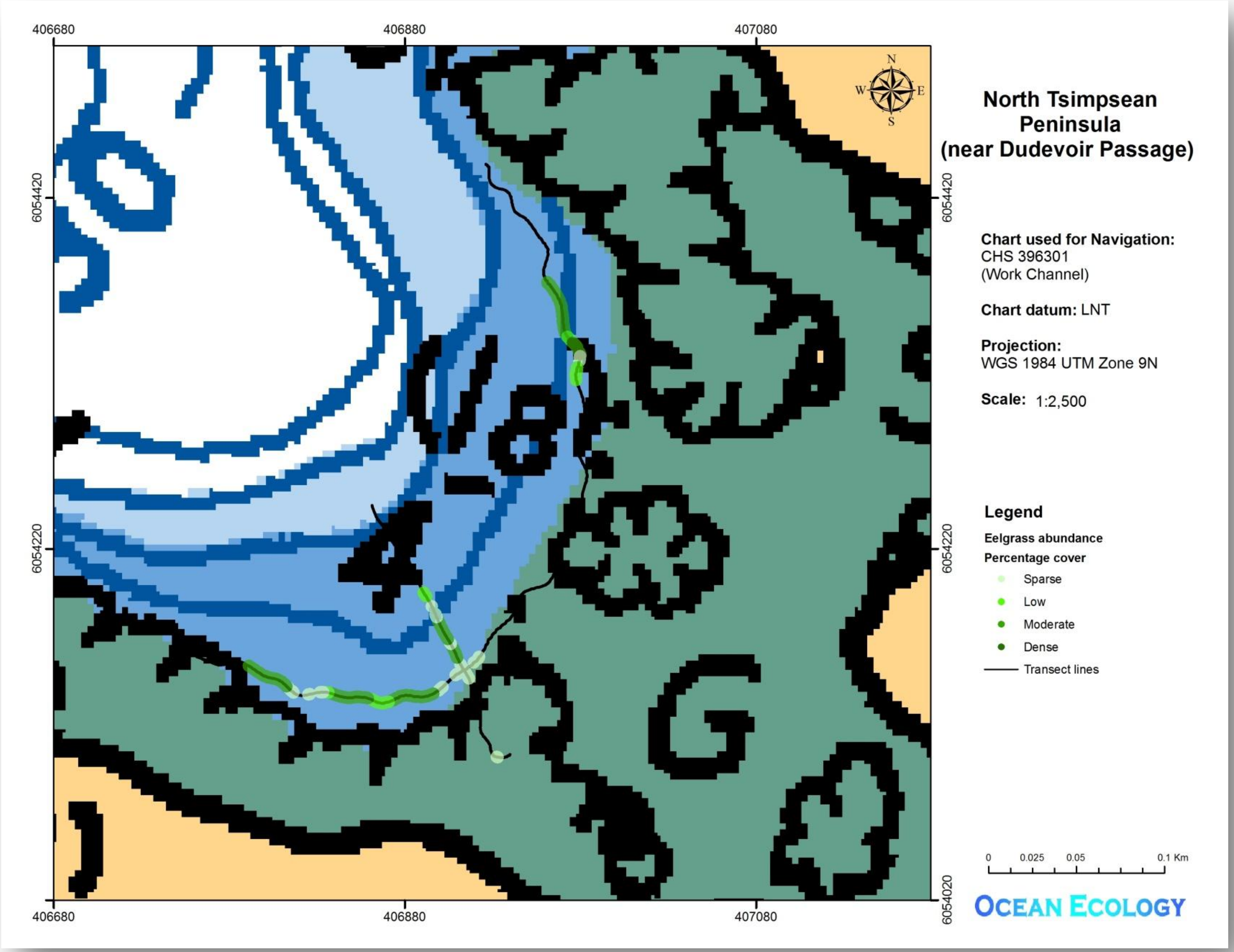


Figure 58. Eelgrass bed on the North Tsimpsean Peninsula near Dudevoir Passage (Site 22).

3.2.23 Wales Island (near Tracey Island)

The eelgrass study site on Wales Island is the most northerly study site in this project. Wales Island defines the northern boundary of Chatham Sound. The study site is located in a bay at the southern end of Wales Island which is known as Tracey Bay by the local population. This bay is frequently used as an anchorage by both commercial and recreational fishers. Tracey Bay receives significant freshwater inflows from the uplands of Wales Island.

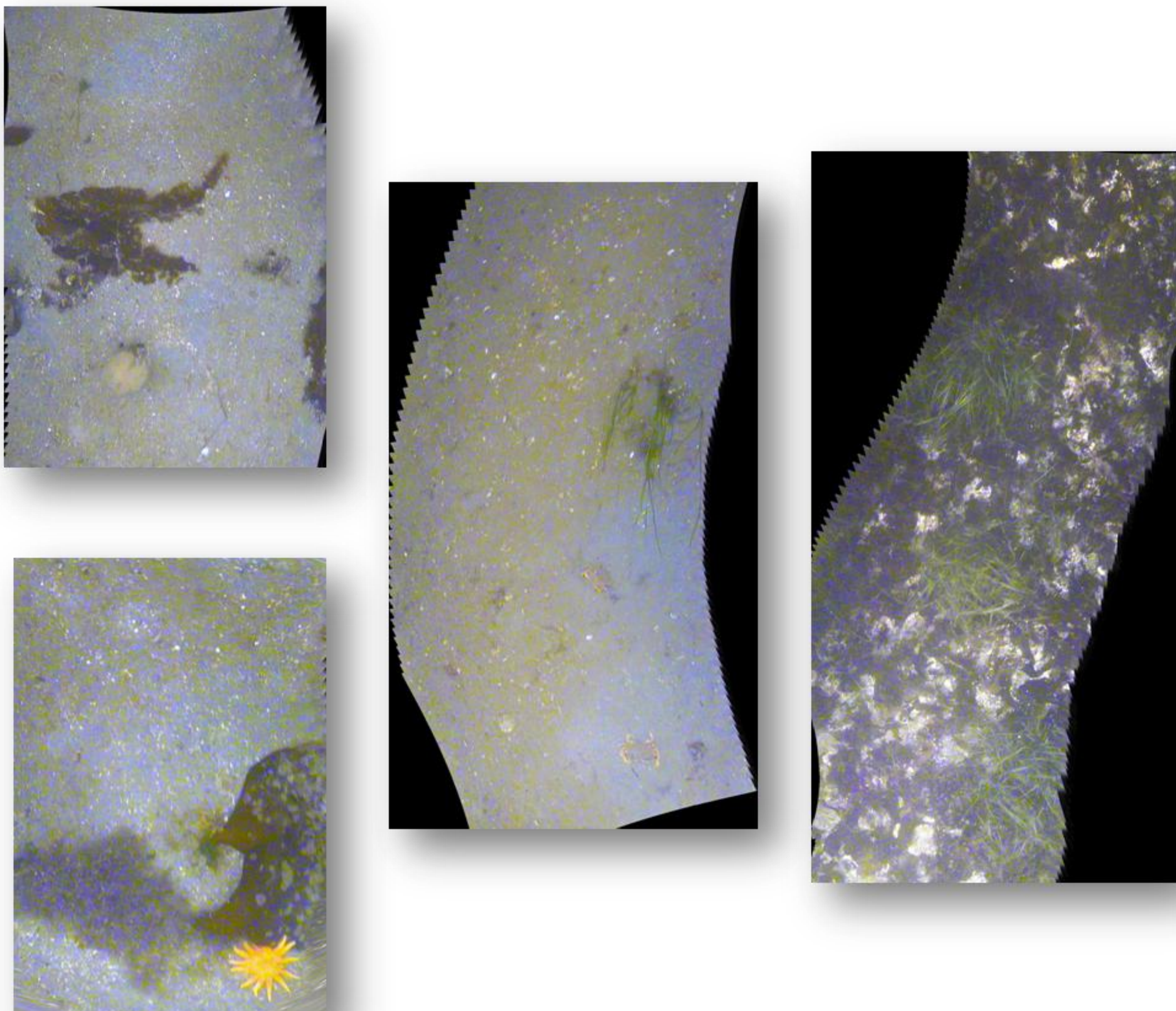


Figure 59. Panoramas from the video footage of the eelgrass bed near Tracey Island.

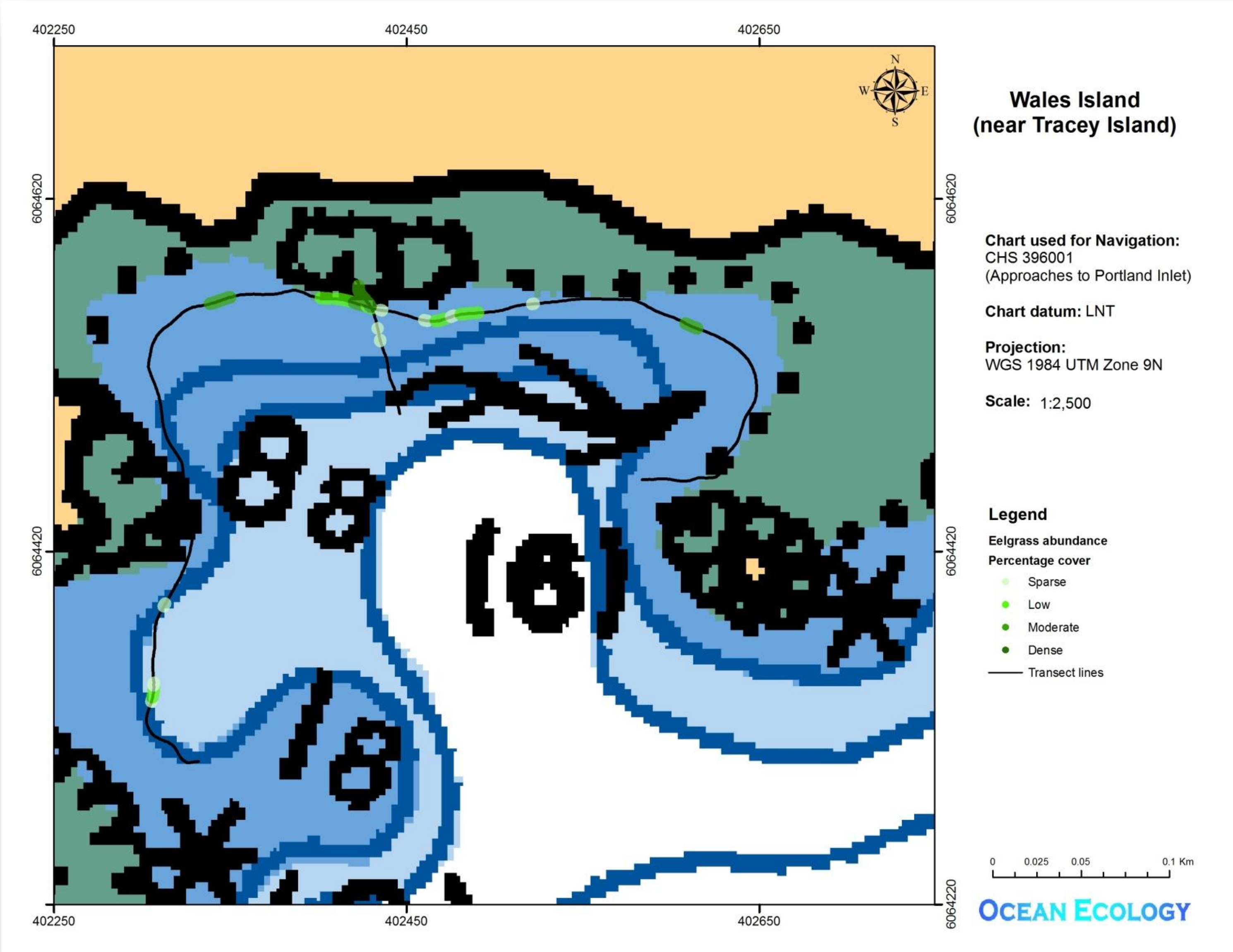


Figure 60. Eelgrass bed on Wales Island near Tracey Island (Site 23).

3.2.24 Boston Islands

Boston Islands are a small group of islands located just southwest of the north end of Wales Island. Boston Islands are close to the U.S. border. They are a popular site for commercial and recreational fishing, and boats often anchor in the sheltered waters of the island group. The eelgrass study site is located on the northeast side of the Boston Islands. The site was too narrow for completion of a shore parallel transect.

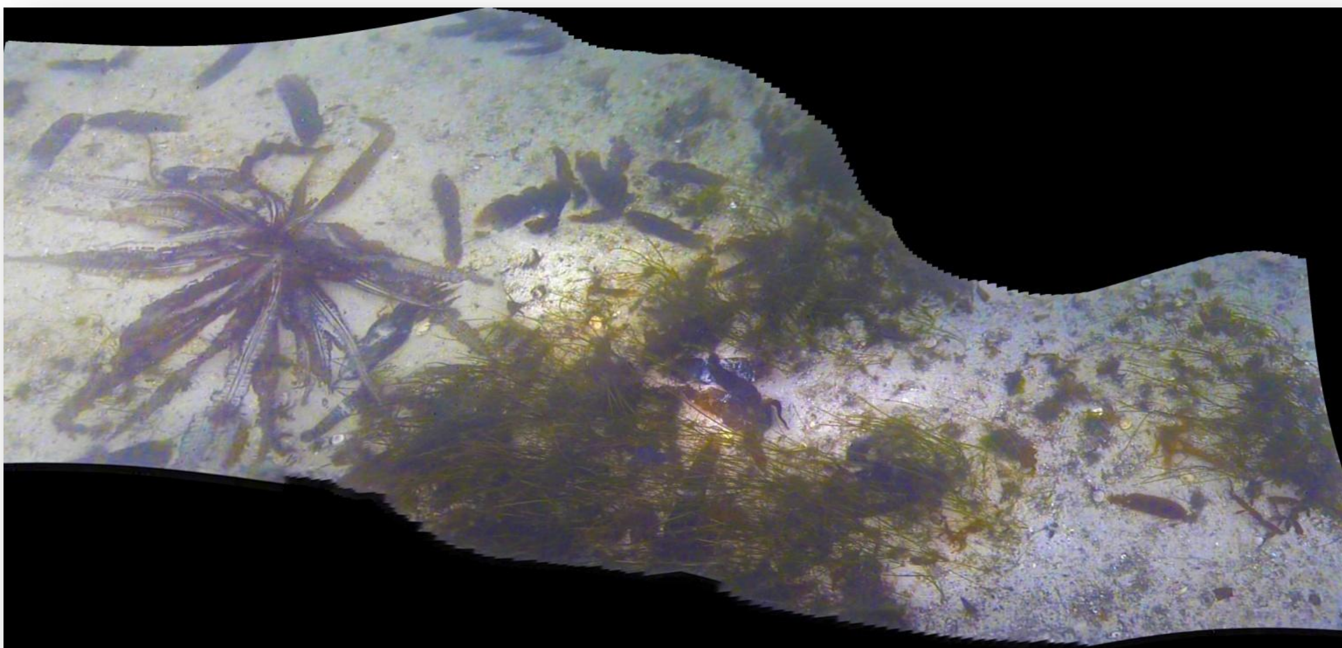


Figure 61. Panorama from the video footage of the Boston Islands eelgrass bed.

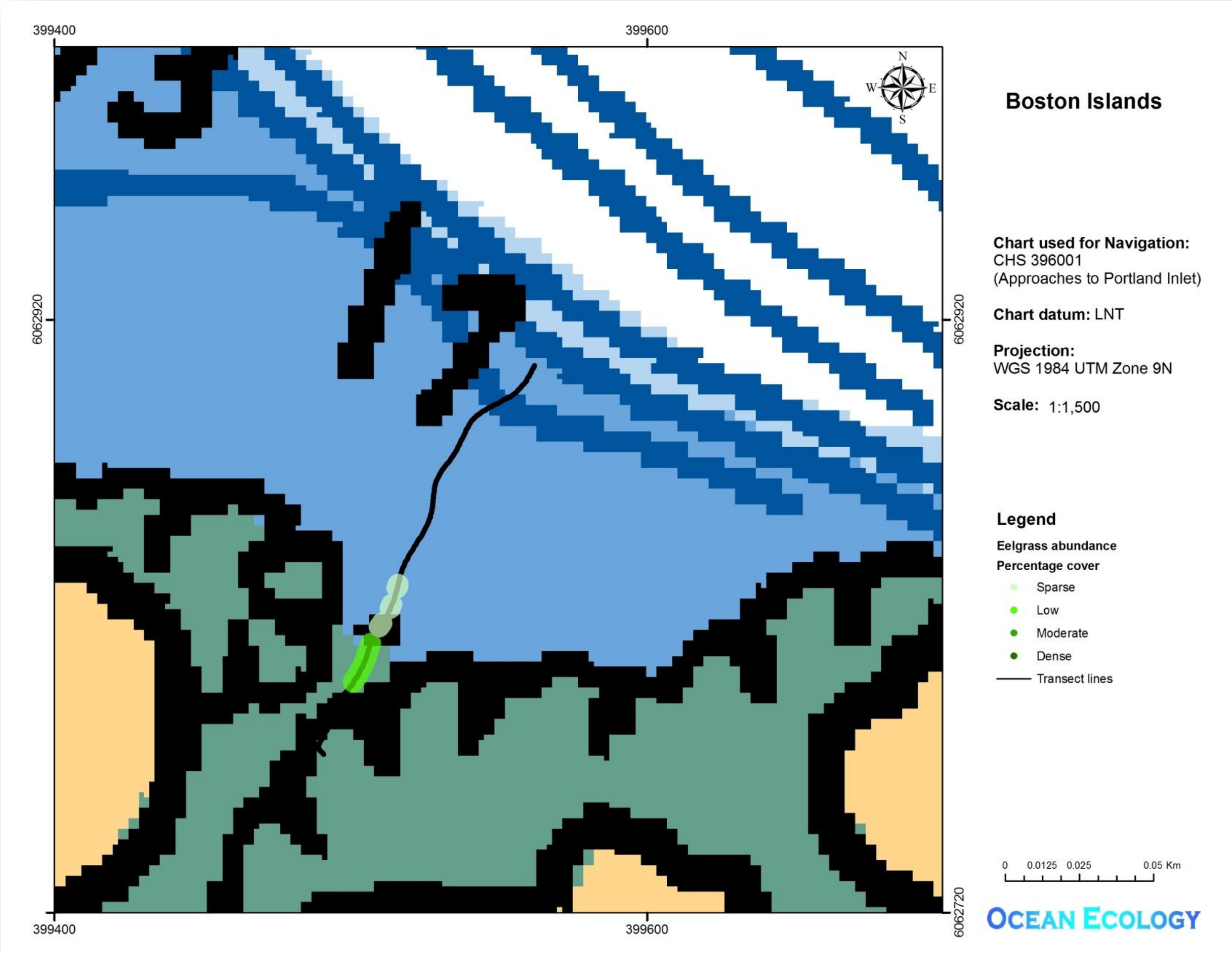


Figure 62. Boston Islands eelgrass bed (Site 24).

3.2.25 Dundas Island (near Nares Islets)

Nares Islets are a linear chain of islands just to the east of Dundas Island. The eelgrass study site is a small cove on Dundas Island across from the northern end of the Nares Islets chain, and just north of Gore-Langton Point on Dundas Island. The site is within the Lax Kwaxl/Dundas and Melville Islands Conservancy. This cove is a popular anchorage with both commercial and recreational fishers. The cove receives freshwater input from the uplands of Dundas Island.

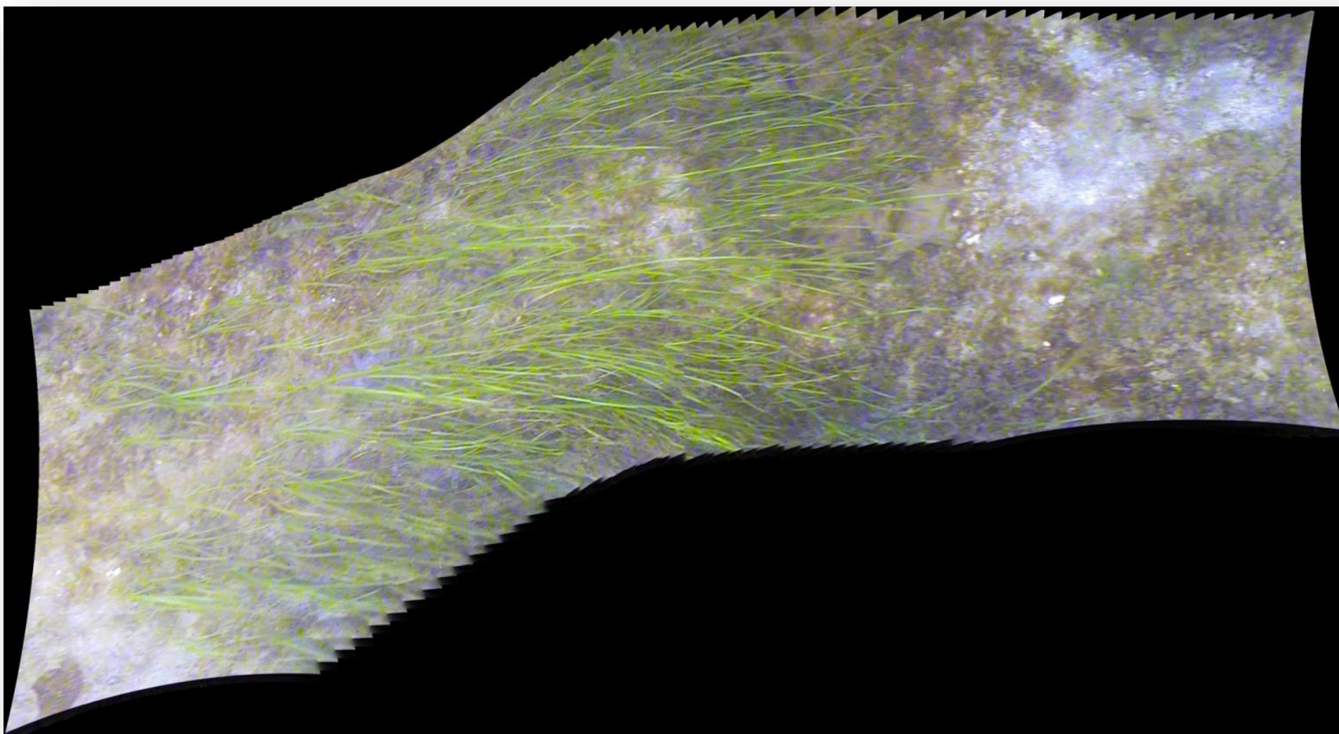


Figure 63. Panorama from the video footage of the eelgrass bed near Nares Islets.

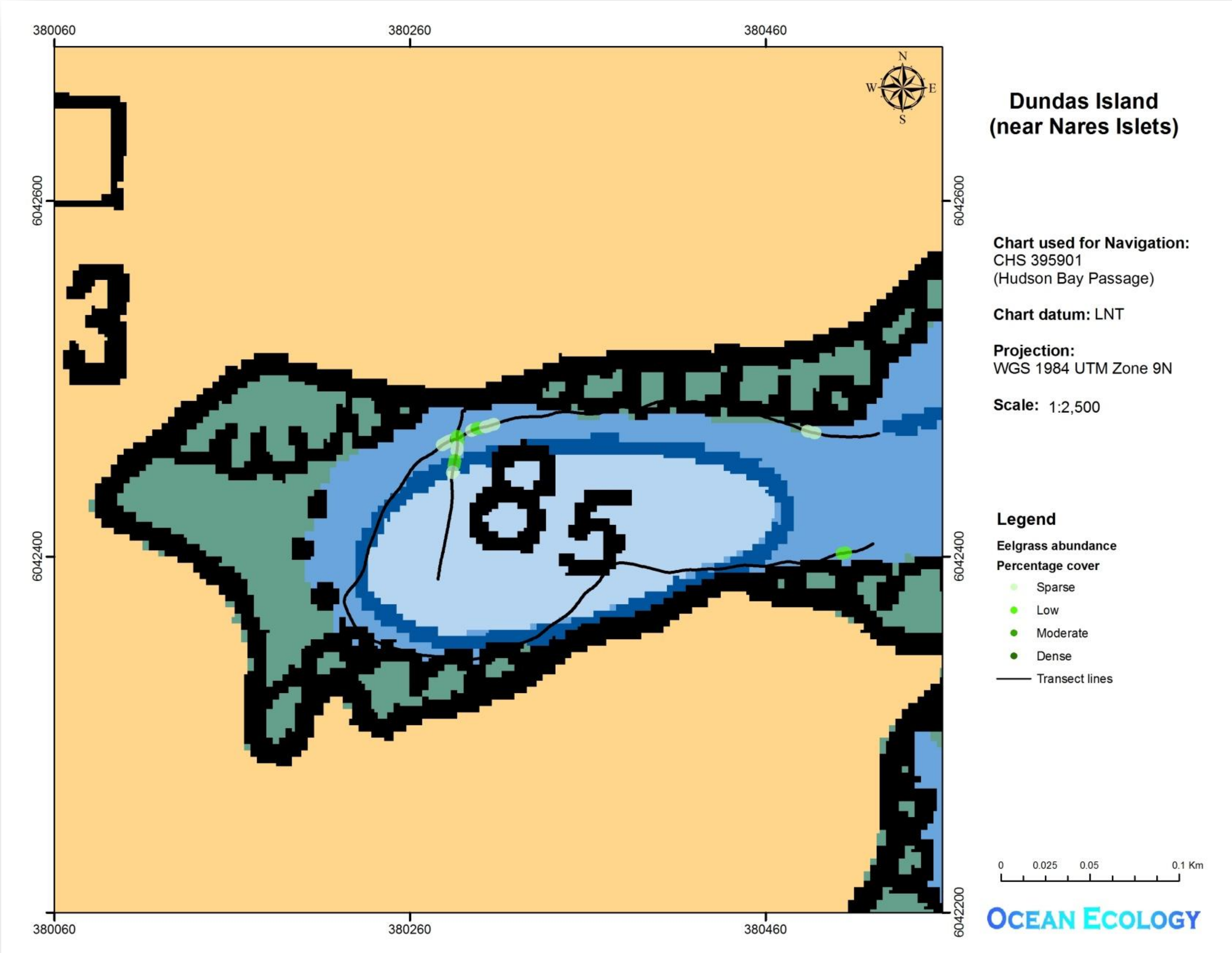


Figure 64. Eelgrass bed on Dundas Island near Nares Islets (Site 25).

3.2.26 Dundas Island (Gore-Langton Point)

Gore-Langton Point is located on the east side of the southern half of Dundas Island. The eelgrass study site is situated within the bay that is just south of Gore-Langton Point, and which opens out onto Hudson Bay Passage. This bay receives freshwater drainage from both Mount Henry and Mount Bonwick on Dundas Island. The site is within the Lax Kwaxl/Dundas and Melville Islands Conservancy. Although once a popular site with commercial salmon fishers, very little activity now occurs at this location (area 4-1) as it is currently closed to many fisheries. The east side of Dundas Island is in the area of confluence between the Nass River plume from the north and the Skeena River plume from the south (see Figure 2), which probably explains why it was a popular commercial salmon fishing area in the past.

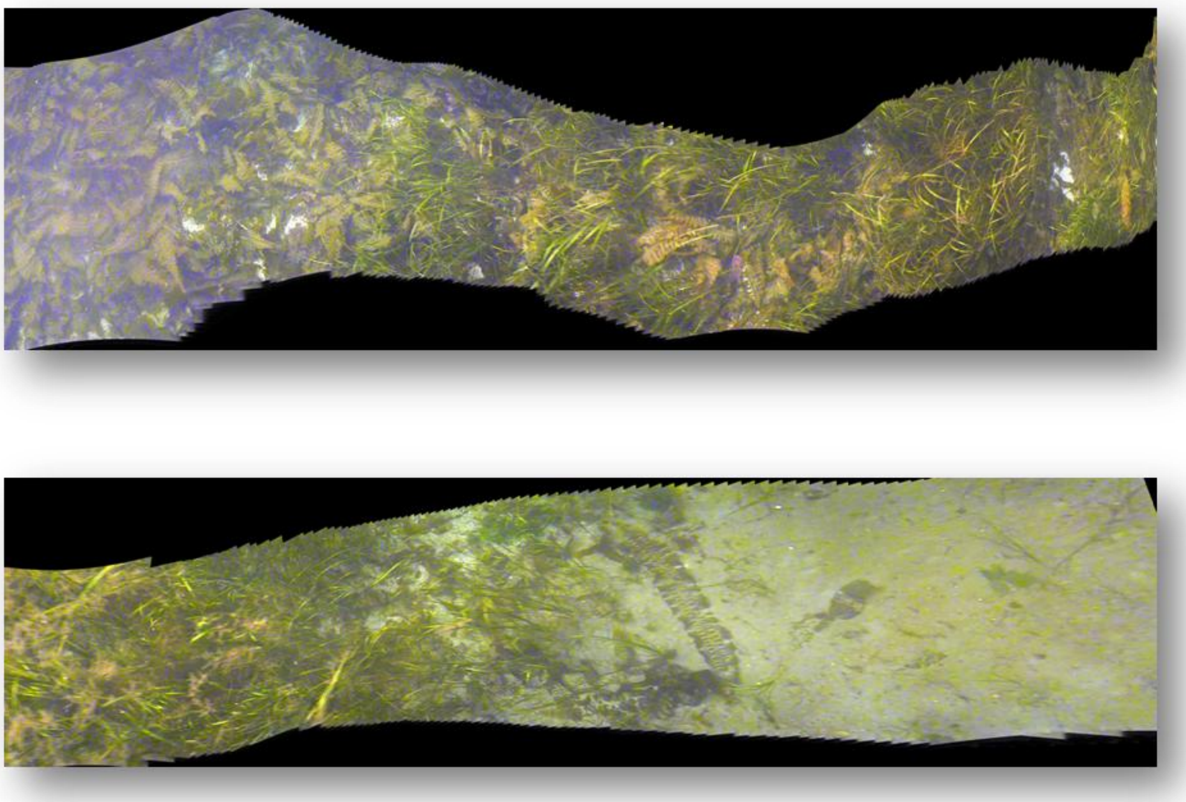


Figure 65. Panoramas from the video footage of the eelgrass bed near Gore-Langton Point.

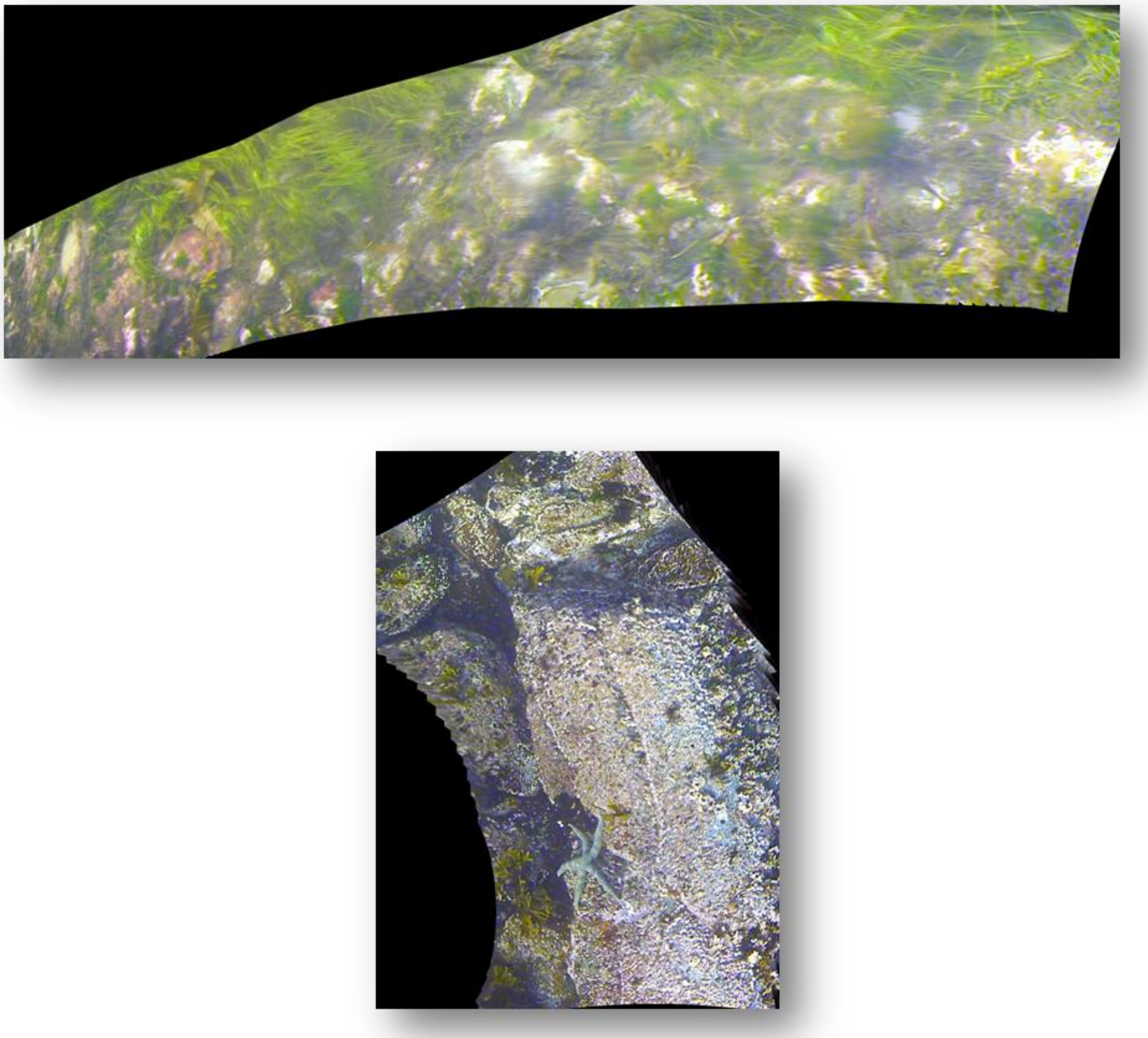


Figure 66. Panoramas from the video footage of the eelgrass bed near Gore-Langton Point.

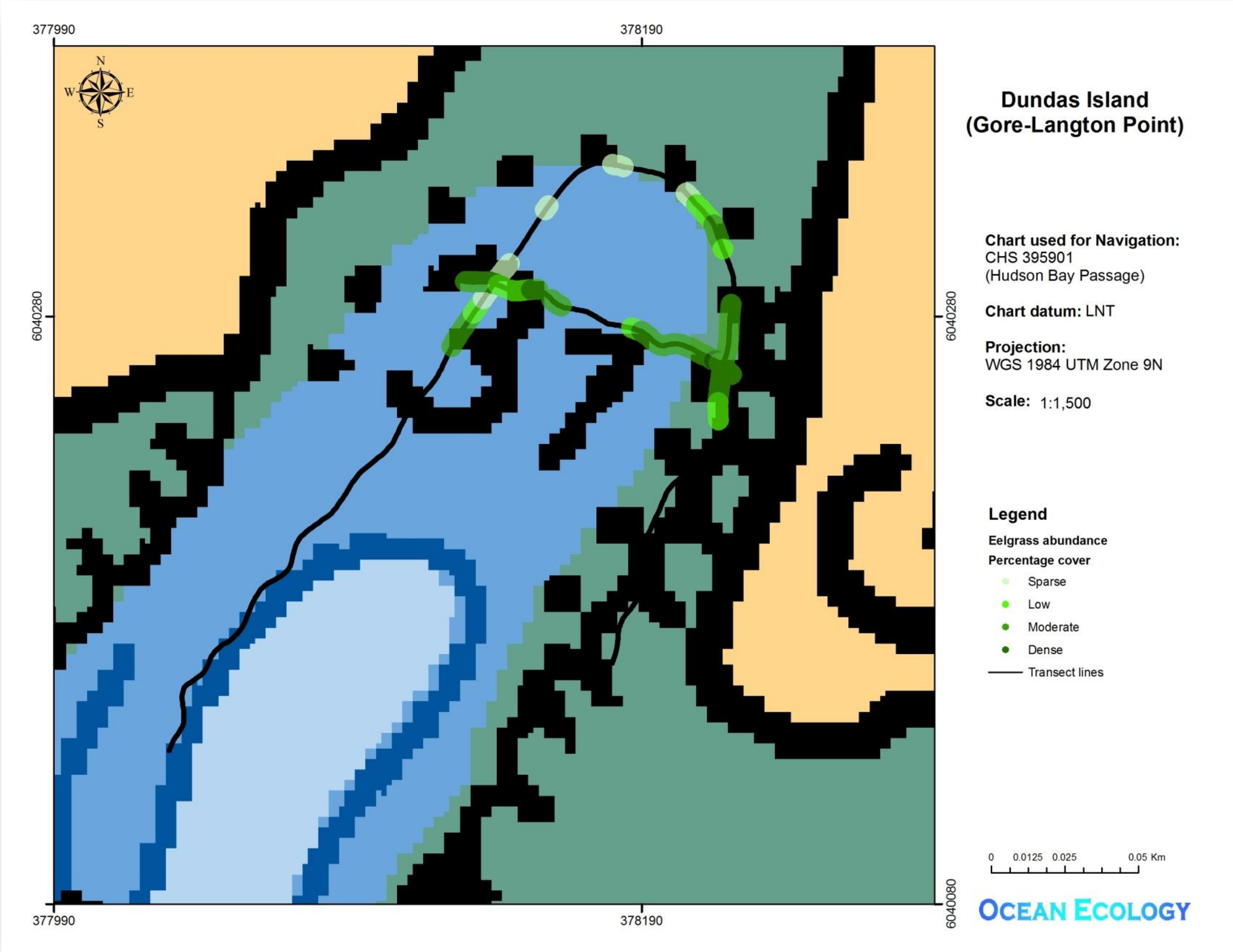


Figure 68. Eelgrass bed on Dundas Island at Gore-Langton Point (Site 26).

3.2.27 Dundas Island (Edith Harbour)

Edith Harbour is located on the east side of the southern tip of Dundas Island and is within the Lax Kwaxl/Dundas and Melville Islands Conservancy. Edith Harbour is a popular anchorage for both commercial and recreational fishers. Three mooring buoys were once present in the harbour; however, Coast Guard has removed them since they were unable to maintain them in a safe operating condition. A small First Nation's IR is located on the north side of the harbour, and historically a small cabin had once been built on the beach that fronts the reserve. The harbour receives freshwater drainage from the Dundas Island uplands. The east side of Dundas Island is in the area of confluence between the Nass River plume from the north and the Skeena River plume from the south (see Figure 2), which probably explains why it was a popular commercial salmon fishing area in the past (area 4-1 has been closed to commercial salmon fishing for a number of years).

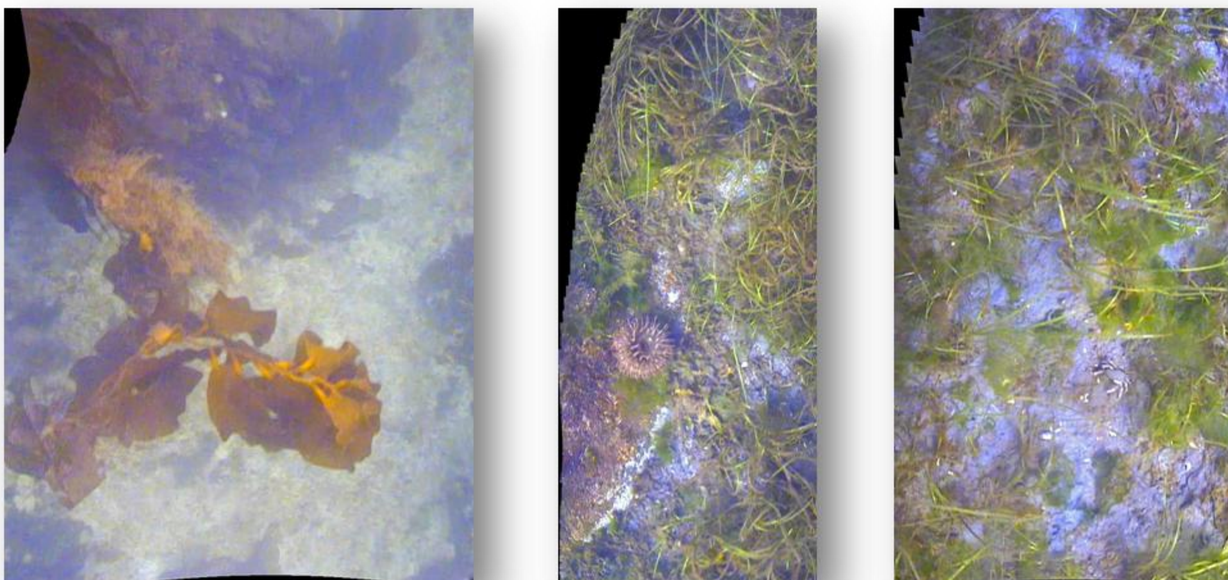


Figure 69. Panoramas from the video footage of the eelgrass bed in Edith Harbour.

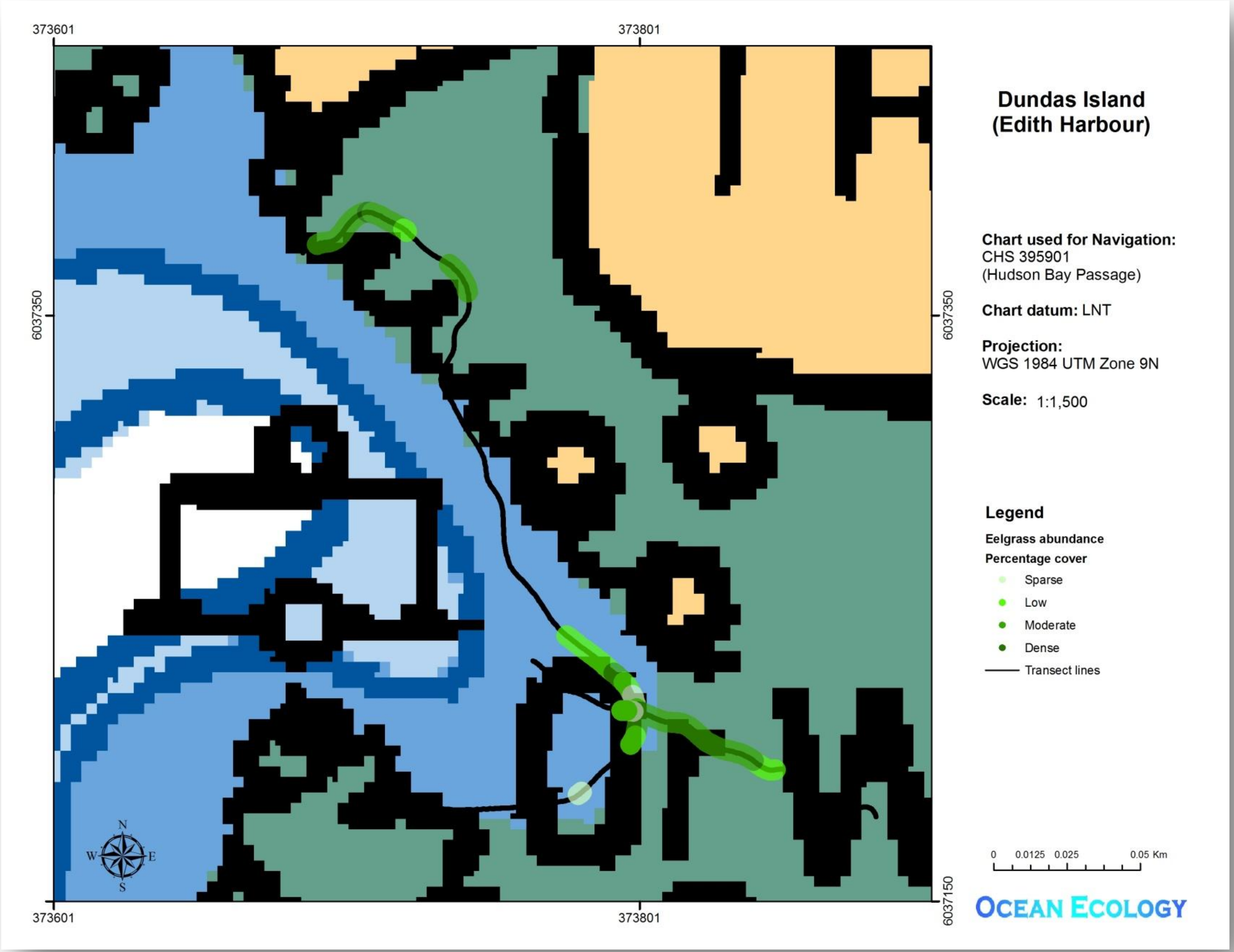


Figure 70. Eelgrass bed in Edith Harbour on Dundas Island (Site 27).

3.2.28 Prince Lebo Island

Prince Lebo Island is located at the southern tip of Dundas Island. While Prince Lebo Island itself is a First Nation's IR, the sheltered waters between it and Dundas Island are a part of the Lax Kwaxl/Dundas and Melville Islands Conservancy. This area is very popular with recreational fishers, and the sheltered area between Prince Lebo Island and Dundas Island is frequently used as an anchorage by boaters. The eelgrass study site is situated to the north of the sand bar that connects Prince Lebo Island to Dundas Island at low tides. This area is outside of the influence of the Skeena/Nass plume.

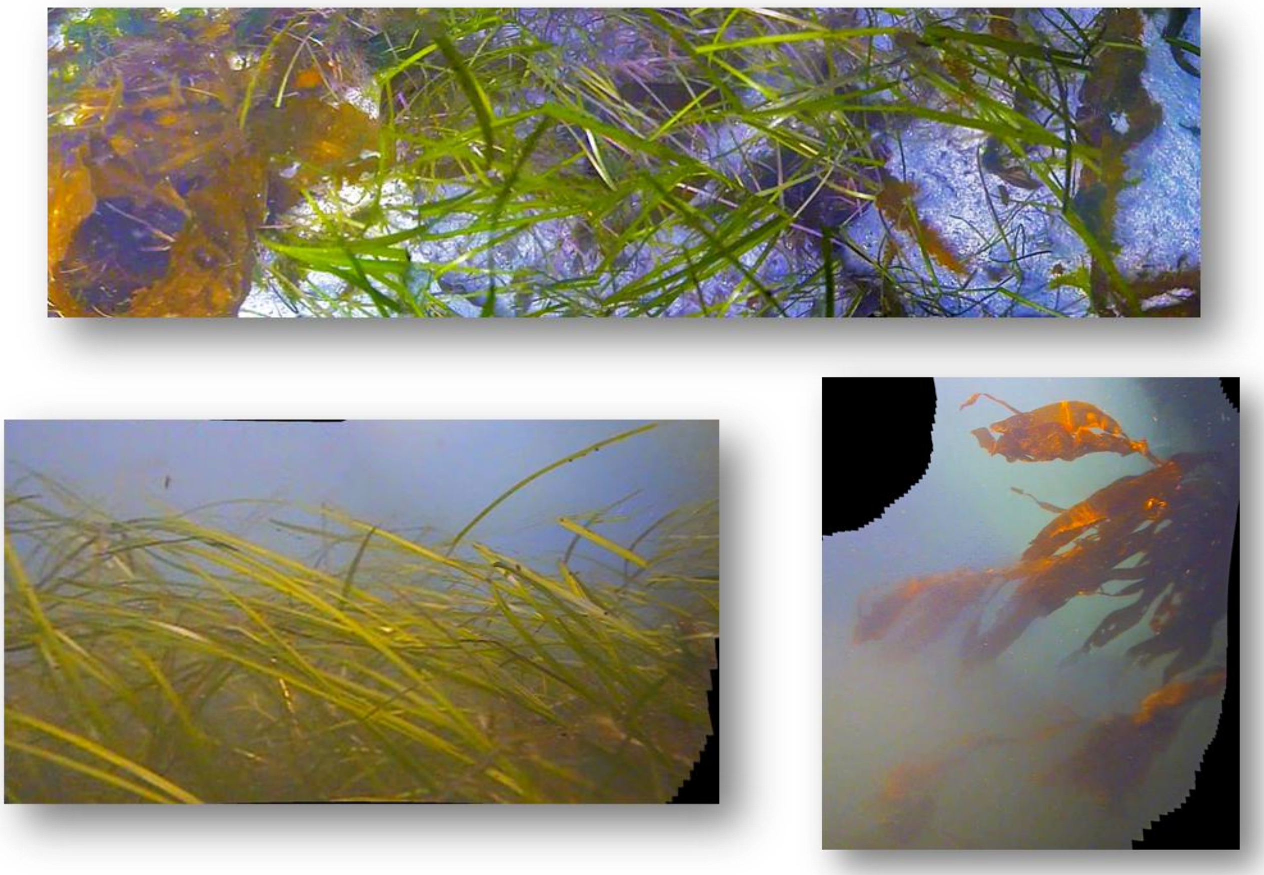


Figure 71. Panoramas from the video footage of the Prince Lebo Island eelgrass bed.

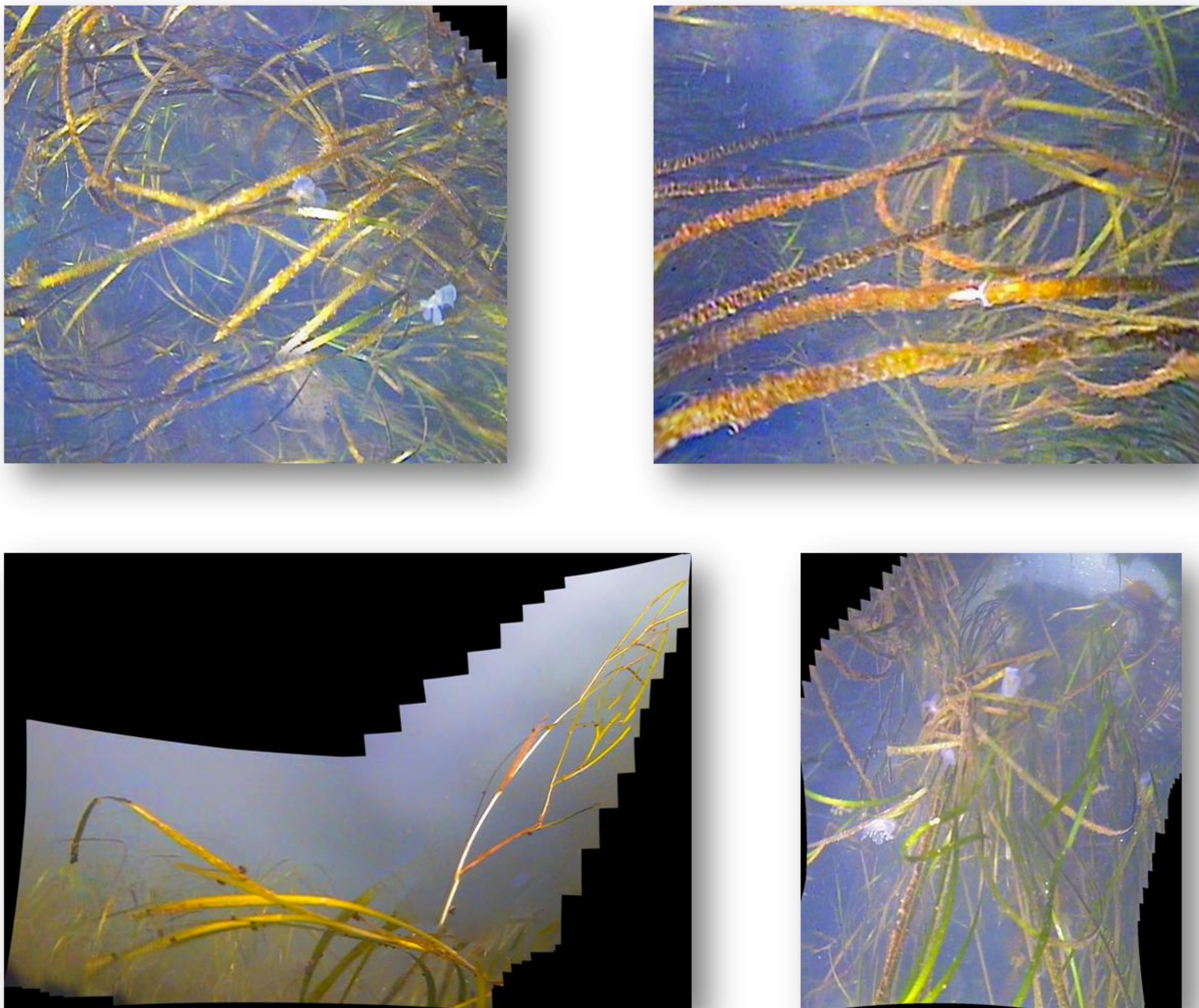


Figure 72. . Panoramas from the video footage of the Prince Lebo Island eelgrass bed.

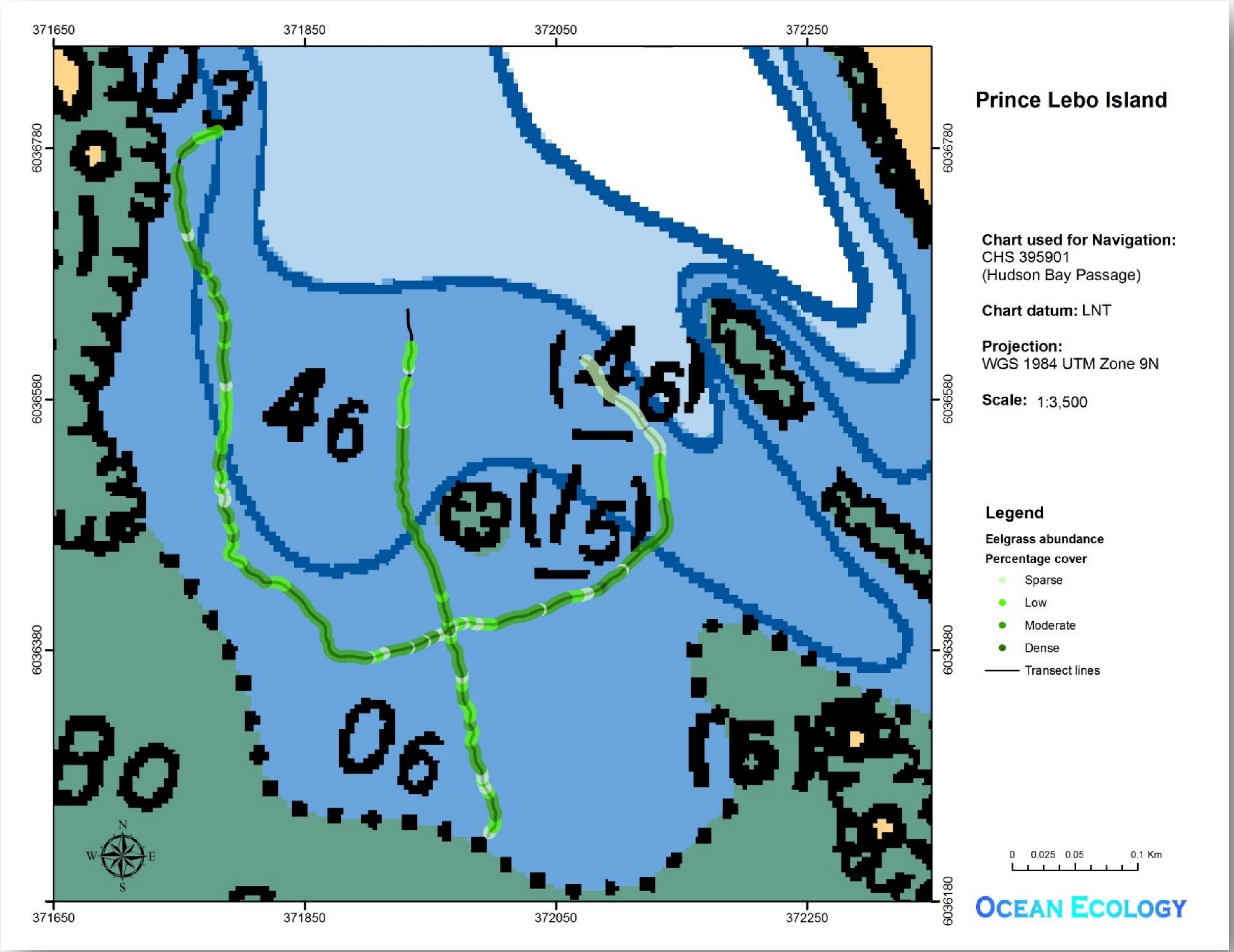
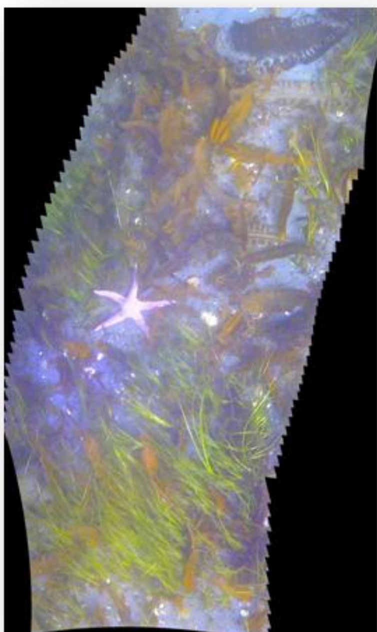
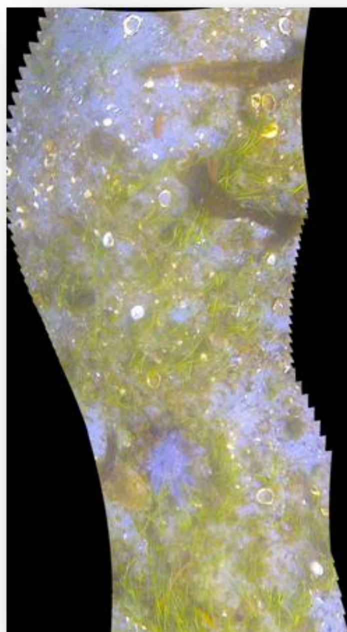


Figure 73. Prince Lebo Island eelgrass bed (Site 28).

3.2.29 Tsimpsean Peninsula (near Swamp Island)

Swamp Island is located just north of Ryan Point on the Tsimpsean Peninsula. Both Swamp Island and the Hodgson Reefs provide some shelter to the mainland coast. This area is a known herring spawning site. The eelgrass study site is situated just north of Swamp Island on the mainland coast.

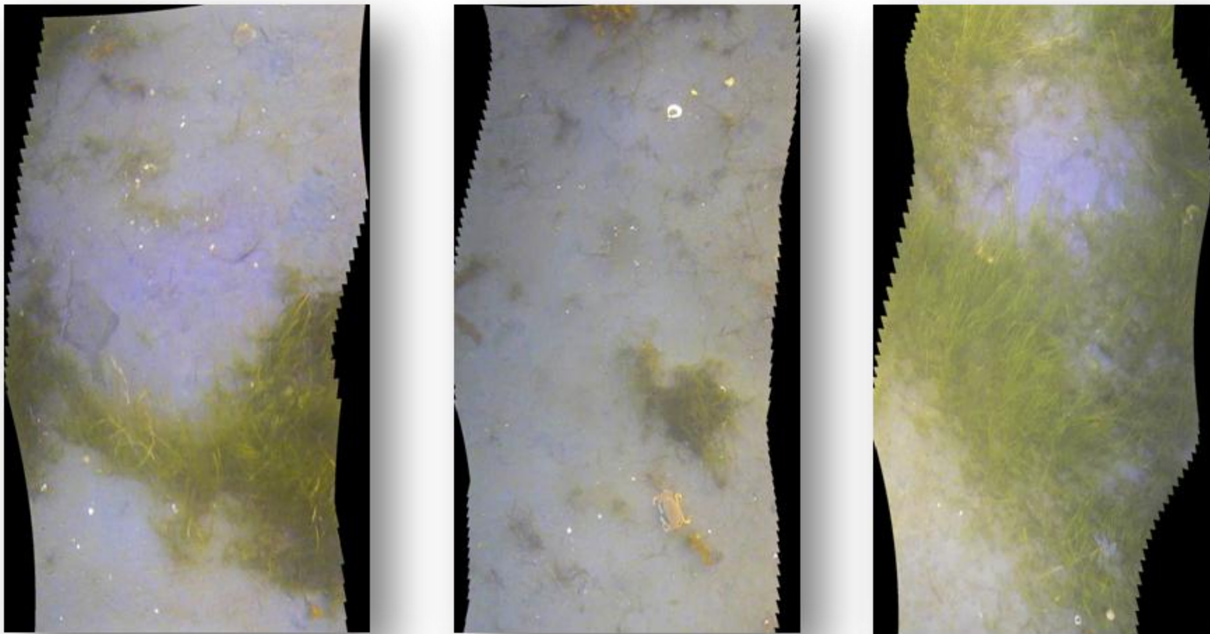



Figure 75. Panoramas from the video footage of the eelgrass bed near Swamp Island.

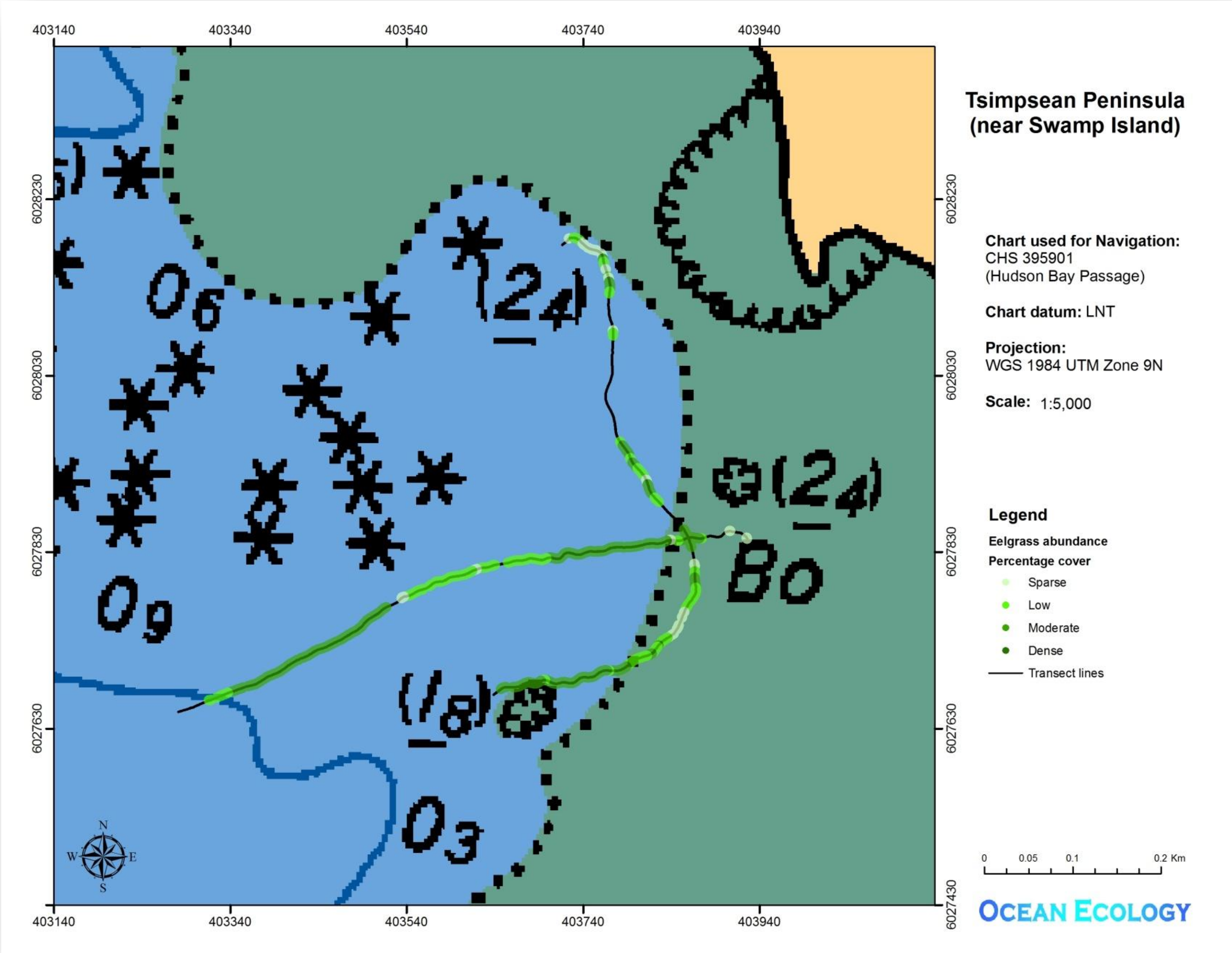


Figure 76. Eelgrass bed on the Tsimpsean Peninsula near Swamp Island (Site 29).

3.2.30 Summary of Chatham Sound Eelgrass Study Sites

Table 2 gives a brief summary of some of the physical and biological characteristics of the 29 eelgrass study sites in Chatham Sound. Table 3 and Table 4 provide the common names for the organisms listed in Table 2.

Table 2. Summary of Chatham Sound eelgrass study sites.

Site	Eelgrass ecotype (*typica*, *phillipsi*, *latifolia*)	Bed width (m shore perpendicular)	Bed length (m shore parallel)	Eelgrass height (short, medium, tall)	Average eelgrass density (% cover)	Deepest recorded eelgrass depth (m)	Bed substrate (description)	Bed position relative to the Skeena River estuary at freshet (salt wedge, riverine plume, estuarine plume, riverine influence, ocean)	Skeena freshet plume freshwater at bed location (%)	Wave exposure category (very protected, protected, semi-protected, semi-exposed, exposed, very exposed)	Turbidity (low, moderate, high, very high)	Tannins (present, absent)	Local freshwater input (yes, no)	Associated flora (species)	Associated fauna (species)*	Epiphyte abundance (none, low, moderate, high)
Coast Island (1)	*latifolia*	59	140	Tall	34	1.91	Silt to fine sand; some shell debris	Riverine influence	15 - 20	Protected	High	Absent	No	*Alaria* spp.; *Laminaria* spp.; *Ulva* spp.	*Alia carinata; Clinocardium nuttallii; Ptilosarcus gurneyi;* Unidentified flatfish	Low
Flora Bank (2)	*latifolia*	129	52	Medium to tall	71	1.84	Silt	Estuarine plume	15 - 20	Protected	Very high	Absent	No		*Clinocardium nuttallii*	Low
Marrack Island (3)	*phillipsi*; *latifolia*	18	681	Medium to tall	17	1.32	Silt	Estuarine plume	> 20	Semi-protected	Very high	Absent	No	*Laminaria* spp.	*Cancer magister; Pisaster ochraceus*	Low
Porcher Island (in Chismore Passage) (4)	*latifolia*	54	105	Tall	28	6.59	Mixed substrate - sand, cobble, shell debris	Riverine influence	10 - 15	Protected	High	Present	Yes	Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Pisaster ochraceus;* Unidentified flatfish	Moderate
McMicking Island (5)	*typica; phillipsi*; *latifolia*	88	528	Short to tall	50	3.52	Mixed substrate - sand, cobble, some shell debris	Riverine influence	10 - 15	Protected	High	Present	Yes	*Cymathere triplicata; Laminaria* spp.; *Smithora naiadum; Ulva* spp.	*Alia carinata; Lottia alveus paralella*	Moderate
Porcher Island (near Creak Islands) (6)	*phillipsi*; *latifolia*	59	174	Medium to tall	7	6.27	Mixed substrate - sand, cobble	Ocean	10 - 15	Semi-exposed	High	Absent	Yes	Filamentous reds; Foliose reds; *Laminaria* spp.; *Ulva* spp.		Low
Porcher Island (near Useless Point) (7)	*typica; phillipsi*; *latifolia*	571	596	Short to tall	36	5.66	Sand; some pebble	Ocean	10 - 15	Semi-exposed	Moderate	Present	Yes	*Alaria* spp.; *Cymathere triplicata*; Filamentous greens; Filamentous reds; Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Citharichthys stigmaeus; Cymatogaster aggregata; Euspira lewisii* egg case; *Mediaster aequalis; Pachycerianthes fimbriatus; Parophrys vetulus; Pleuronichthys decurrens; Pycnopodia helianthoides; Sebastes maliger;* Unidentified flatfish	Moderate

Site	Eelgrass ecotype (*typica*, *phillipsi*, *latifolia*)	Bed width (m shore perpendicular)	Bed length (m shore parallel)	Eelgrass height (short, medium, tall)	Average eelgrass density (% cover)	Deepest recorded eelgrass depth (m)	Bed substrate (description)	Bed position relative to the Skeena River estuary at freshet (salt wedge, riverine plume, estuarine plume, riverine influence, ocean)	Skeena freshet plume freshwater at bed location (%)	Wave exposure category (very protected, protected, semi-protected, semi-exposed, exposed, very exposed)	Turbidity (low, moderate, high, very high)	Tannins (present, absent)	Local freshwater input (yes, no)	Associated flora (species)	Associated fauna (species)*	Epiphyte abundance (none, low, moderate, high)
South Rachel Island (8)	*latifolia*	300	164	Tall	39	11.37	Sand, pebble; some shell debris; some cobble	Riverine influence	10 - 15	Semi-exposed	Moderate	Absent	No	*Alaria* spp.; *Cymathere triplicata;* Filamentous reds; Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Cribrinopsis fernaldi; Cucumaria miniata; Lottia alveus paralella; Solaster* spp.; *Urticina* spp.	High
West Kinahan Island (9)	*latifolia*	73	31	Tall	18	12.78	Silt to fine sand; shell debris; some cobble	Riverine influence	15 - 20	Protected	High	Present	No	Foliose reds; *Laminaria* spp.; *Ulva* spp.	*Cancer magister*	Low
Parry Island (10)	*latifolia*	26	80	Tall	35	7.48	Silt to find sand	Ocean	0	Protected	Moderate	Absent	No	Foliose reds; *Laminaria* spp.; *Smithora naiadum;* *Ulva* spp.	*Alia carinata; Cancer magister; Platichthys stellatus; Pycnopodia helianthoides; Solaster* spp.; Unidentified flatfish; *Urticina* spp.	Moderate
Arthur Island (11)	*latifolia*	60	96	Tall	39	6.82	Sand; some shell debris	Ocean	0	Protected	Moderate	Absent	No	Foliose reds; *Laminaria* spp.; *Smithora naiadum;* *Ulva* spp.	*Alia carinata; Cancer productus; Mediaster aequalis; Melibe leonina; Parastichopus californicus; Parophrys vetulus; Ptilosarcus gurneyi; Pycnopodia helianthoides; Urticina* spp.	Moderate
Stephens Passage (12)	*phillipsi*; *latifolia*	48	167	Medium to tall	21	2.13	Silt to fine sand; some shell debris	Ocean	6 - 10	Protected	High	Absent	No	Filamentous reds; *Fucus* spp.; *Laminaria* spp.; *Scytosiphon lomentaria*; *Smithora naiadum*; *Ulva* spp.	*Alia carinata*	Moderate
Qlawdzeet Anchorage (13)	*typica*; *latifolia*	154	92	Short and tall	44	5.48	Mixed substrate - sand, cobble	Ocean	6 - 10	Semi-protected	Moderate	Absent	No	*Alaria* spp.; *Costaria costata*; *Cymathere triplicata;* Filamentous greens; Filamentous reds; Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Euspira lewisii; Euspira lewisii* egg case; *Pisaster ochraceus; Pycnopodia helianthoides; Strongylocentrotus purpuratus; Urticina* spp.	Low to moderate

Site	Eelgrass ecotype (*typica*, *phillipsi*, *latifolia*)	Bed width (m shore perpendicular)	Bed length (m shore parallel)	Eelgrass height (short, medium, tall)	Average eelgrass density (% cover)	Deepest recorded eelgrass depth (m)	Bed substrate (description)	Bed position relative to the Skeena River estuary at freshet (salt wedge, riverine plume, estuarine plume, riverine influence, ocean)	Skeena freshet plume freshwater at bed location (%)	Wave exposure category (very protected, protected, semi-protected, semi-exposed, exposed, very exposed)	Turbidity (low, moderate, high, very high)	Tannins (present, absent)	Local freshwater input (yes, no)	Associated flora (species)	Associated fauna (species)*	Epiphyte abundance (none, low, moderate, high)
West Melville Island (14)	*phillipsi*; *latifolia*	27	408	Medium to tall	9	6.85	Silt to fine sand	Riverine influence	0	Protected	Moderate	Absent	No	Filamentous reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Cancer magister ; Cancer productus ; Euspira lewisii* egg case; *Pisaster brevispinus; Platichthys stellatus*	Moderate to high
East Melville Island (15)	*typica*; *latifolia*	175	N/A	Short and tall	30	4.33	Sand; some shell debris	Riverine influence	10 - 15	Semi-protected	Low	Absent	Yes	*Cymathere triplicata*; Filamentous reds; *Laminaria* spp.; *Smithora naiadum*	*Pycnopodia helianthoides*	Moderate to high
Northeast Melville Island (16)	*typica; phillipsi*; *latifolia*	68	276	Short to tall	35	7.28	Sand; some pebble	Riverine influence	10 - 15	Semi-protected	Moderate	Absent	Yes	*Alaria* spp.; Filamentous reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Cancer magister; Dermasterias imbricata; Euspira lewisii* egg case*; Pachycerianthes fimbriatus; Pycnopodia helianthoides; Sebastes maliger; Solaster* spp.	Moderate to high
Moffat Islands (17)	*latifolia*	54	N/A	Tall	11	3.78	Sand with shell debris; some cobble	Riverine influence	10 - 15	Semi-exposed	Moderate	Absent	No	Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Dermasterias imbricata; Pycnopodia helianthoides*	Moderate
West Dunira Island (18)	*latifolia*	19	102	Medium to tall	11	1.31	Sand with lots of shell debris; some cobble	Riverine influence	10 - 15	Protected	Moderate	Absent	Yes	Filamentous greens; Filamentous reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Orthasterias koehleri; Pisaster ochraceus*	Low
Lucy Islands (19)	*typica; phillipsi*; *latifolia*	392	161	Short to tall	28	4.90	Mixed substrate - sand; some shell debris; some pebble, cobble and boulder	Riverine influence	10 - 15	Protected	High	Absent	No	*Alaria* spp.; *Costaria costata; Cymathere triplicata*; Filamentous reds; Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Cancer magister; Euspira lewisii* egg case; *Luidia foliolata; Pycnopodia helianthoides; Solaster* spp.*; Strongylocentrotus franciscanus; Strongylocentrotus purpuratuss; Urticina* spp.	Moderate to high
Big Bay on the Tsimpsean Peninsula (near Curlew Rock) (20)	*phillipsi*; *latifolia*	52	691	Medium to tall	50	6.97	Silt to fine sand; some shell debris	Riverine influence	10 - 15	Protected	High	Absent	Yes	*Costaria costata;* Filamentous reds; Foliose reds; *Laminaria* spp.; *Smithora naiadum*	*Cancer magister; Dermasterias imbricata; Henricia* spp.*; Pisaster brevispinus; Platichthys stellatus; Pycnopodia helianthoides*	High

Site	Eelgrass ecotype (*typica*, *phillipsi*, *latifolia*)	Bed width (m shore perpendicular)	Bed length (m shore parallel)	Eelgrass height (short, medium, tall)	Average eelgrass density (% cover)	Deepest recorded eelgrass depth (m)	Bed substrate (description)	Bed position relative to the Skeena River estuary at freshet (salt wedge, riverine plume, estuarine plume, riverine influence, ocean)	Skeena freshet plume freshwater at bed location (%)	Wave exposure category (very protected, protected, semi-protected, semi-exposed, exposed, very exposed)	Turbidity (low, moderate, high, very high)	Tannins (present, absent)	Local freshwater input (yes, no)	Associated flora (species)	Associated fauna (species)*	Epiphyte abundance (none, low, moderate, high)
Pearl Harbour on the Tsimpsean Peninsula (21)	*typica; phillipsi; latifolia*	120	565	Short to tall	22	3.27	Silt to fine sand; some cobble; some shell debris	Riverine influence	1 - 6	Semi-protected	High	Absent	Yes	Filamentous reds; Foliose reds; *Laminaria* spp.; *Smithora naiadum*	*Alia carinata; Cancer magister; Evasterias troschelii; Henricia* spp.; *Metridium farcimen; Orthasterias koehleri; Pycnopodia helianthoides*	Low to moderate
North Tsimpsean Peninsula (near Dudevoir Passage) (22)	*typica; phillipsi; latifolia*	104	277	Short to tall	27	1.82	Sand; some shell debris	Riverine influence	1 - 6	Semi-exposed	Low	Absent	No	Filamentous reds; *Fucus* spp.; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Dermasterias imbricata; Mediaster aequalis; Parastichopus californicus; Pisaster ochraceus; Pycnopodia helianthoides*	Low
Wales Island (near Tracey Island) (23)	*latifolia*	33	375	Tall	22	2.11	Sand; some shell debris; some cobble	Riverine influence	15 - 20	Semi-exposed	Moderate	Present	Yes	*Cymathere triplicata;* Filamentous reds; Foliose reds; *Fucus* spp.; *Laminaria* spp.; *Nereocystis luetkeana*; *Smithora naiadum*; *Ulva* spp.	*Cancer magister; Cucumaria miniata; Metridium farcimen; Orthasterias koehleri; Pisaster ochraceus; Pycnopodia helianthoides*	Low
Boston Islands (24)	*latifolia*	37	N/A	Tall	10	1.78	Sand	Riverine influence	15 - 20	Protected	Moderate	Absent	No	*Cymathere triplicata*; *Laminaria* spp.; *Nereocystis luetkeana*; *Ulva* spp.	*Cancer magister; Pycnopodia helianthoides*	Low
Dundas Island (near Nares Islets) (25)	*phillipsi; latifolia*	23	214	Medium to tall	7	2.30	Sand; some cobble; some shell and wood debris	Riverine influence	0	Protected	Moderate	Present	Yes	*Laminaria* spp.; *Ulva* spp.	*Pycnopodia helianthoides*	Low
Dundas Island (Gore-Langton Point) (26)	*typica; phillipsi; latifolia*	97	87	Short to tall	31	0.57	Mixed substrate - sand, cobble; pebble; shell debris	Riverine influence	0	Semi-exposed	Low	Absent	Yes	*Alaria* spp.; *Cymathere triplicata;* Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Cymatogaster aggregata; Pycnopodia helianthoides; Urticina* spp.	Low

Site	Eelgrass ecotype (*typica*, *phillipsi*, *latifolia*)	Bed width (m shore perpendicular)	Bed length (m shore parallel)	Eelgrass height (short, medium, tall)	Average eelgrass density (% cover)	Deepest recorded eelgrass depth (m)	Bed substrate (description)	Bed position relative to the Skeena River estuary at freshet (salt wedge, riverine plume, estuarine plume, riverine influence, ocean)	Skeena freshet plume freshwater at bed location (%)	Wave exposure category (very protected, protected, semi-protected, semi-exposed, exposed, very exposed)	Turbidity (low, moderate, high, very high)	Tannins (present, absent)	Local freshwater input (yes, no)	Associated flora (species)	Associated fauna (species)*	Epiphyte abundance (none, low, moderate, high)
Dundas Island (Edith Harbour) (27)	*typica*; *latifolia*	58	208	Short and tall	33	2.60	Silt to fine sand; some wood and shell debris	Riverine influence	0	Very protected	Low	Absent	Yes	Filamentous greens; Filamentous reds; Foliose reds; *Laminaria* spp.; *Smithora naiadum*; *Ulva* spp.	*Alia carinata; Cancer magister; Urticina* spp.	High
Prince Lebo Island (28)	*latifolia*	393	485	Tall	30	8.97	Sand; some cobble	Ocean	0	Semi-exposed	Moderate	Absent	No	*Costaria costata; Cymathere triplicata*; Filamentous reds; Foliose reds; *Laminaria* spp.; *Macrocystis integrifolia; Smithora naiadum*; *Ulva* spp.	*Alia carinata; Dermasterias imbricata; Haliclystus stejnegeri; Hermissenda crassicornis; Melibe leonina; Psettichthys melanostictus; Pycnopodia helianthoides; Sebastes maliger;* Unidentified juvenile rockfish	Moderate
Tsimpsean Peninsula (near Swamp Island) (29)	*typica; phillipsi*; *latifolia*	641	520	Short to tall	29	2.64	Sand; pebble; some cobble; shell debris	Riverine influence	10 - 15	Semi-exposed	High	Absent	Yes	*Cymathere triplicata;* Filamentous reds; Foliose reds; *Laminaria* spp.; *Macrocystis integrifolia*; *Smithora naiadum;* *Ulva* spp.	*Alia carinata; Cancer magister; Cucumaria miniata; Pisaster brevispinus; Pisaster ochraceus; Platichthys stellatus; Pycnopodia helianthoides*	Low

*List does not include clam siphons and worm holes.

Table 3. Scientific and common names of flora associated with eelgrass.

Scientific Name	Common Name
Alaria spp.	Narrow- and broad-winged kelps
Costaria costata	Seersucker kelp
Cymathere triplicata	Three-ribbed kelp
Fucus spp.	Rockweeds
Laminaria spp.	Dark brown wrack kelp; sugar wrack kelp; split kelp; suction-cup kelp
Macrocystis integrifolia	Giant kelp
Many species	Filamentous reds
Many species	Foliose reds
Nereocystis luetkeana	Bull kelp
Scytosiphon lomentaria	Whip tube
Smithora naiadum	Red fringe
Spongomorpha/Cladophora spp.	Filamentous greens
Ulva spp.	Sea lettuces

Table 4. Scientific and common names of fauna associated with eelgrass.

Scientific Name	Common Name
Alia carinata	Carinate dovesnail
Cancer magister	Dungeness crab
Cancer productus	Red rock crab
Citharichthys stigmaeus	Speckled sanddab
Clinocardium nuttallii	Nuttall's cockle
Cribrinopsis fernaldi	Snakelock anemone
Cucumaria miniata	Red sea cucumber
Cymatogaster aggregata	Shiner perch
Dermasterias imbricata	Leather star
Euspira lewisii	Moon snail
Evasterias troschelii	Mottled star
Haliclystus stejnegeri	Oval-anchored stalked jelly
Henricia spp.	Blood stars
Hermissenda crassicornis	Opalescent nudibranch
Lottia alveus paralella	Eelgrass limpet
Luidia foliolata	Spiny mudstar
Many species	Unidentified flatfish
Many species	Unidentified juvenile rockfish
Mediaster aequalis	Vermilion star
Melibe leonina	Hooded nudibranch
Metridium farcimen	Giant plumose anemone
Orthasterias koehleri	Painted star
Pachycerianthes fimbriatus	Tube-dwelling anemone
Parastichopus californicus	California sea cucumber

Scientific Name	**Common Name**
Parophrys vetulus	English sole
Pisaster brevispinus	Short-spined seastar
Pisaster ochraceus	Ochre star
Platichthys stellatus	Starry flounder
Pleuronichthys decurrens	Curlfin sole
Psettichthys melanostictus	Sand sole
Ptilosarcus gurneyi	Orange sea pen
Pycnopodia helianthoides	Sunflower star
Sebastes maliger	Quillback rockfish
Solaster spp.	Sun stars
Strongylocentrotus franciscanus	Red sea urchin
Strongylocentrotus purpuratus	Purple sea urchin
Urticina spp.	Painted and rose anemones

3.3 Factors Affecting Eelgrass Health, Distribution, and Abundance

During the field work for this project, it became very clear that each eelgrass bed was unique, with variations in substrates, ecotypes, associated flora and fauna, and tolerance to turbidity, wave action, and tidal currents. Although certain patterns and trends could be seen at most of the sites, there were always outlier beds which had unexpected characteristics. This made analysis of the data somewhat difficult, and in a number of cases, the "outlier" sites were omitted from the analyses so that the general trends at the other sites could be more readily visualized. Four of the larger eelgrass beds tended to commonly be outliers - site 7 (Porcher Island near Useless Point), site 19 (Lucy Islands), site 20 (Big Bay on the Tsimpsean Peninsula near Curlew Rock), and site 29 (Tsimpsean Peninsula near Swamp Island).

For the purposes of this study, eelgrass health will be estimated by a measure of eelgrass abundance, as calculated by the following equation:

$$Eelgrass\ Abundance = \frac{(Bed\ width)(Bed\ length)(Average\ eelgrass\ density)}{100}$$

where "*Bed width"* and "*Bed length"* are in meters, and "*Average eelgrass density"* is in percent cover. The eelgrass abundance calculations are given for each site in Table 23.

One of the challenges in assessing the health of the eelgrass beds distributed throughout Chatham Sound is the difficulty in uncoupling the variety of factors which can affect the growth, abundance, and distribution of eelgrass. From previous studies, we can list a number of factors which negatively impact the health of eelgrass (Precision Identification, 2002; Vandermeulen, 2005). At the moment, we do not have quantitative values for many of these factors; however, we can convert our qualitative observations into values which should give us an approximation of how these factors are affecting eelgrass health in Chatham Sound.

3.3.1 Turbidity

Increasing turbidity results in reduced water column light, and leads to a decrease in photosynthesis (e.g., eelgrass health decreases as turbidity increases). The qualitative turbidity observations were converted into values by assigning a code from 1 to 4 (see Table 9), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 77 below. The relationship between turbidity and eelgrass health is clearly not a simple one. It is likely that turbidity correlates with other factors that also have an impact on eelgrass productivity. For example, turbidity is often highest closest to the mouths of rivers, where freshwater and terrestrially-derived nutrients are also highest. While high turbidity reduces photosynthesis, nutrients are required for eelgrass growth, and estuarine environments are often the most productive regions for eelgrass beds, due in part to freshwater input. Thus, up to a point, increasing turbidity is offset by other factors that are beneficial to eelgrass growth, which probably explains why eelgrass abundance increases with increasing turbidity at low turbidity levels. However, at very high levels of turbidity, the reduction of photosynthesis becomes the most important factor limiting eelgrass productivity, and we observe declining eelgrass abundance with increasing turbidity.

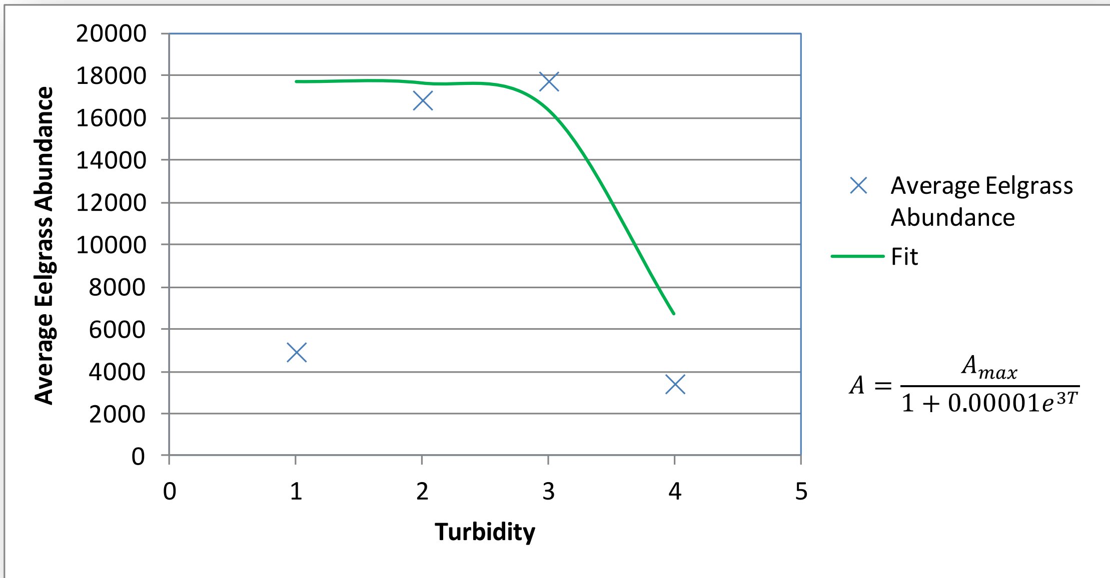


Figure 77. Affects of turbidity on eelgrass abundance.

3.3.2 Color

Increasing color, such as that produced by tannins in the water, results in reduced water column light, and can also lead to a decrease in photosynthesis (e.g., eelgrass health decreases as the tannin concentration increases). The qualitative tannin observations were converted to values by assigning a code from 1 to 2 (see Table 10)), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 78 below. Since there were only two categories (tannins absent and tannins present), the graph is a simple straight line. The graph shows a slight increase in eelgrass abundance with increasing tannin concentration; however, a quick look at the error bars indicates that the two points on the graph are not significantly different from each other. Thus, it appears that, at least for the study sites that were observed in Chatham Sound, tannins, at the concentrations that they were occurring naturally in the waters at the sites, did not have any noticeable effect on eelgrass growth.

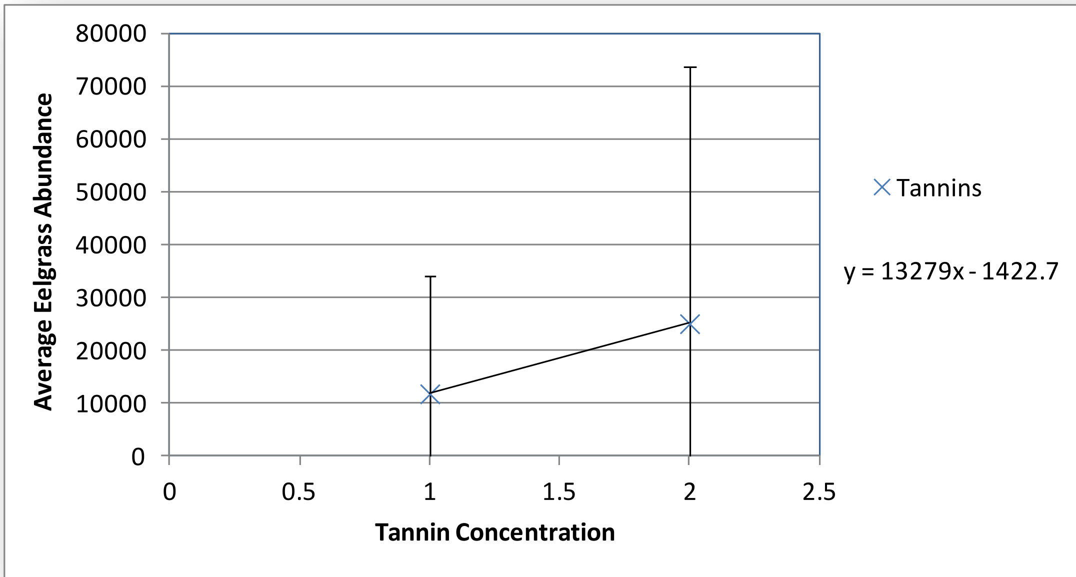


Figure 78. Affects of tannins on eelgrass abundance.

3.3.3 Salinity

Although eelgrass can survive in conditions ranging from freshwater to seawater with a salinity of42‰, their optimum growth occurs between salinities of 10‰ to 30‰. Studies have shown that increasing salinities, especially above 26‰, can have negative impacts on eelgrass health (e.g., eelgrass health decreases as salinity increases above 26‰).

Salinity in the Hecate Strait region ranges from 28‰ to 32‰ (Thompson, 1981). In Chatham Sound, eelgrass receives freshwater either as a result of the plumes from the large river systems (Skeena and Nass) or locally through small streams. Where freshwater is received locally, it is probably the dominant source of freshwater to the eelgrass bed. To analyze the effects of both sources of freshwater, the sites were divided into two groups - those sites which received freshwater locally, and those which did not. The qualitative local freshwater input observations were converted to values by assigning a code from 1 to 2 (see Table 12), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 79 below. Since there were only two categories (freshwater absent and freshwater present), the graph is a simple straight line. The graph shows a strong increase in eelgrass abundance with increasing local freshwater. Unfortunately, due to the wide variability between sites, this result is not statistically significant. However, it does support previous studies that suggest that eelgrass growth is optimum at lower salinities, particularly as the two largest beds studied, site 7 (Porcher Island near Useless Point) and site 29 (Tsimpsean Peninsula near Swamp Island), were located near sources of fresh water.

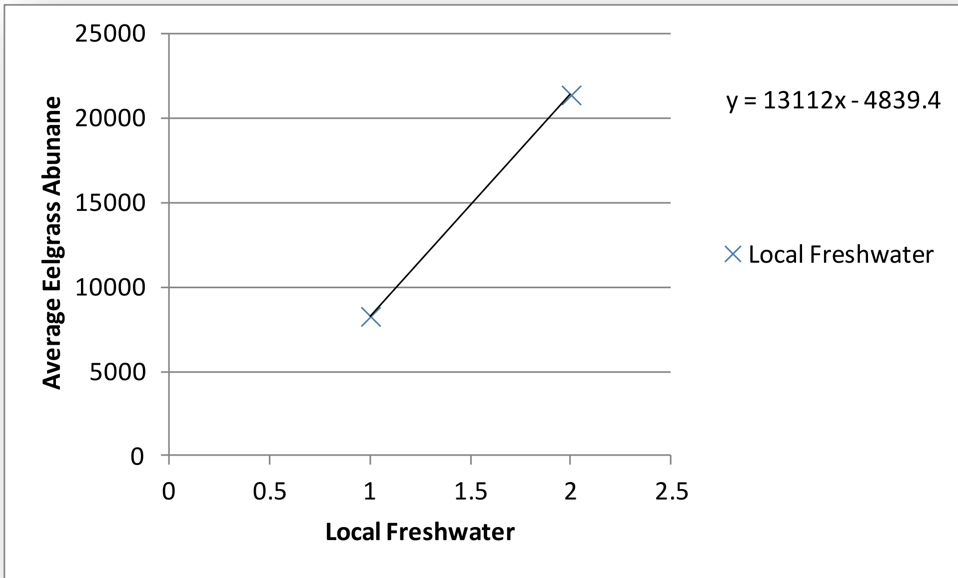


Figure 79. Affects of local freshwater on eelgrass abundance.

The effects of freshwater from the Nass/Skeena plumes was analyzed using the group of sites that did not receive freshwater from a local source. The qualitative plume freshwater values were converted by assigning a code from 1 to 6 (see Table 11), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 80 below. This generated a curve with maximum eelgrass abundance occurring at a value of 4, or an approximate salinity of 28‰. Eelgrass abundance was low below a salinity of 26‰ or above a salinity of 30‰.

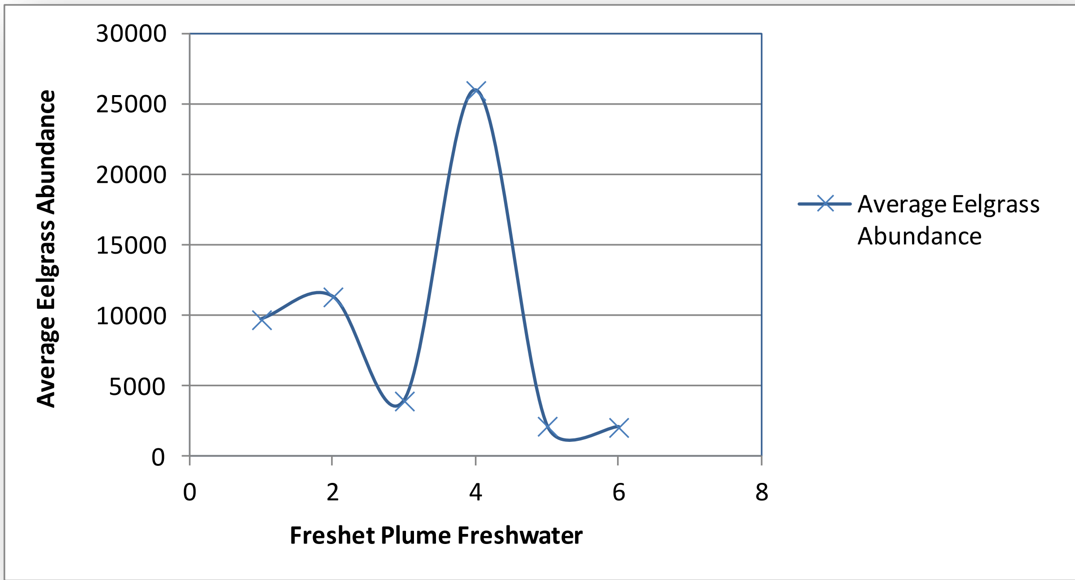


Figure 80. Affect of freshet plume freshwater on eelgrass abundance.

3.3.4 Current Velocity

While eelgrass can tolerate current velocity conditions ranging from stagnant water to 3.5 knots, increasing tidal current velocities can cause scour, which may uproot eelgrass plants (e.g., eelgrass health decreases as tidal current velocity increases). Optimum conditions for eelgrass abundance appear to be at velocities less than 0.5 knots. Above that current speed, eelgrass is unlikely to occur as contiguous beds. Without an oceanographic model of Chatham Sound, an accurate value of maximum tidal current velocity at each study site is very difficult to determine; however, an approximate value can be estimated from the marine charts and current stations for the region (see Table 21). These values were then plotted against eelgrass abundance to generate Figure 81 below. The data are very scattered, although there is a slight (not statistically significant) decrease in eelgrass abundance as tidal velocity increases. However, it is worth noting that the three largest eelgrass beds, site 7 (Porcher Island near Useless Point), site 28 (Prince Lebo Island), and site 29 (Tsimpsean Peninsula near Swamp Island), occur at maximum tidal velocities of 2.0 knots or less.

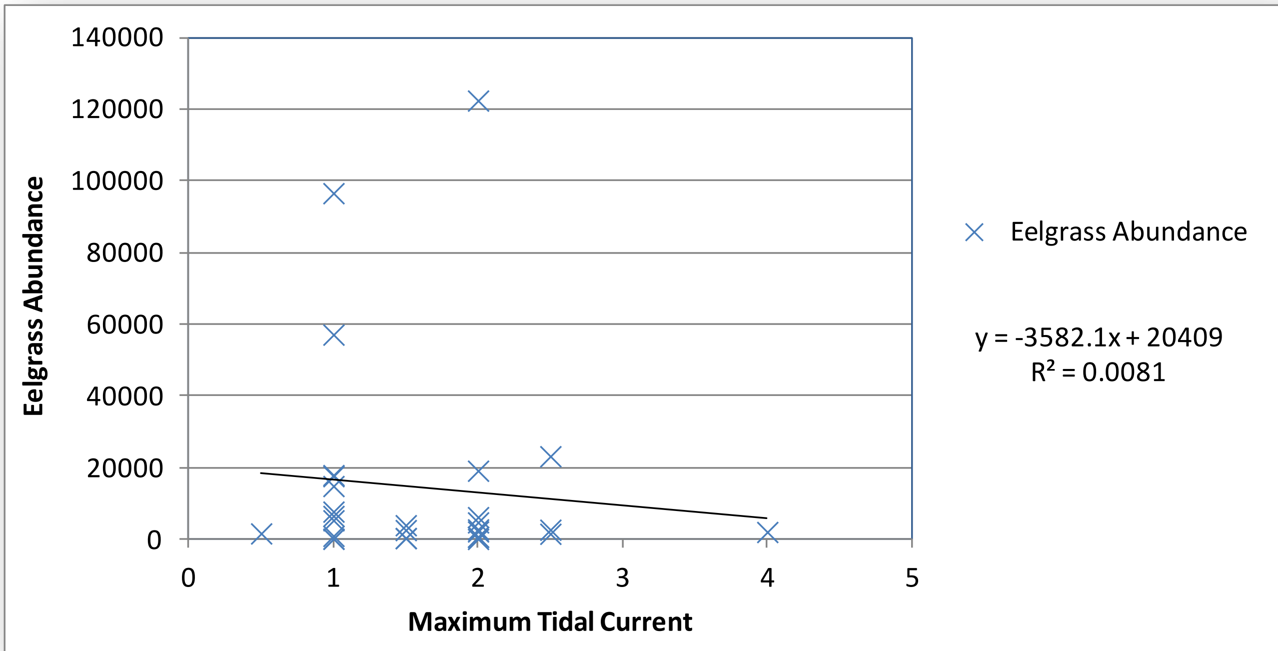


Figure 81. Affect of tidal current velocities on eelgrass abundance.

3.3.5 Wave Action

Increasing wave action in shallow water may also cause scouring and eelgrass uprooting (e.g., eelgrass health decreases as wave exposure increases). According to previous studies, eelgrass tolerates relatively little wave action. Qualitative wave exposure categories were converted to values by assigning a code from 1 to 6 (see Table 19), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 82 below. Unexpectedly, there is a fairly clear increase in eelgrass abundance as wave exposure increases. The three largest eelgrass beds, site 7 (Porcher Island near Useless Point), site 28 (Prince Lebo Island), and site 29 (Tsimpsean Peninsula near Swamp Island), were classified as semi-exposed. However, none of the study sites were classified as exposed or very exposed. From our observations of the eelgrass beds, it would seem that a certain amount of wave action was beneficial to the eelgrass in that it assisted in the removal of accumulated sediment and epiphytes and thus improved photosynthesis.

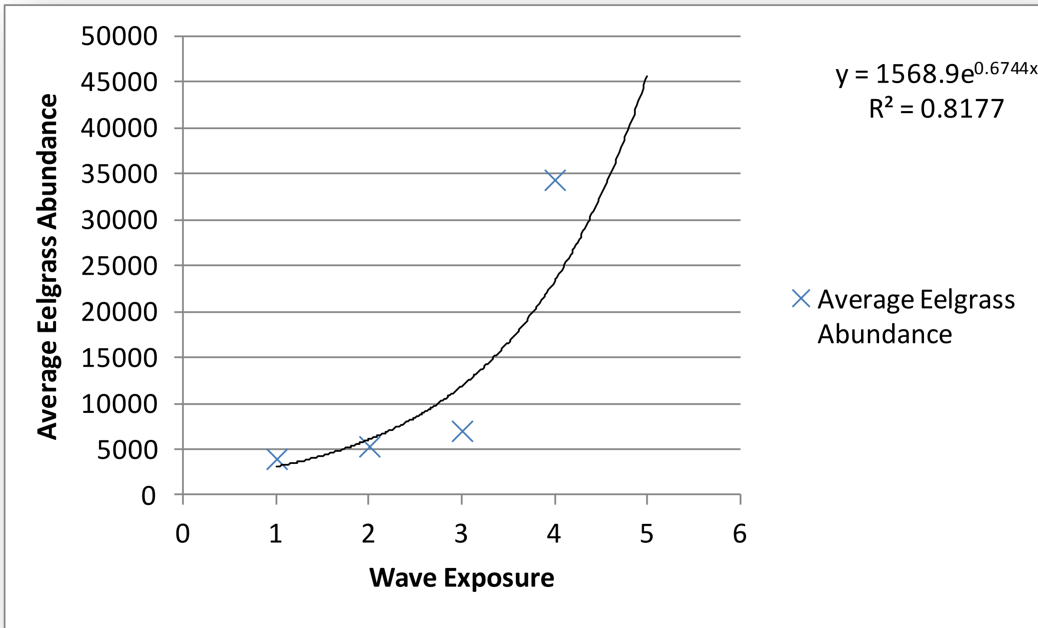


Figure 82. Affect of wave exposure on eelgrass abundance.

3.3.6 Sedimentation

Increasing sedimentation can result in eelgrass burial and reduced photosynthesis (e.g., eelgrass health decreases as sediment input from the Skeena and Nass Rivers increases). Since the majority of sediment in the region is derived from the Skeena/Nass plumes during freshet, the location of the site relative to the freshet plume influence can be used as a surrogate for sedimentation rate. The qualitative observations for the location of the site relative to the plume influence were converted to values by assigning a code from 1 to 5 (see Table 13), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 83 below. Eelgrass abundance was highest outside of the plume influence, and decreased as the mouth of the rivers were approached. No eelgrass in the study was found in the salt wedge or riverine plume. Two of the three largest eelgrass beds, site 7 (Porcher Island near Useless Point) and site 28 (Prince Lebo Island), were located outside the plume influence.

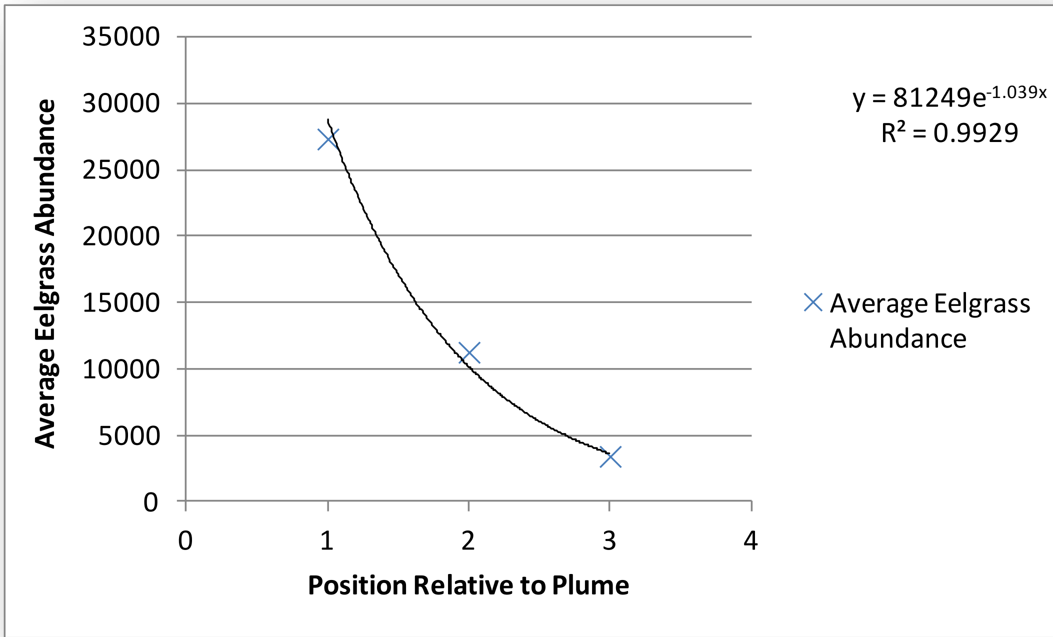


Figure 83. Affect of site position relative to the Skeena/Nass plume on eelgrass abundance.

3.3.7 Epiphytes

Increasing abundance of algal epiphytes on the eelgrass blades can result in reduced photosynthesis (e.g., eelgrass health decreases as epiphyte abundance increases). The qualitative epiphyte abundance observation were converted to values by assigning a code from 1 to 4 (see Table 14), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 84 below. The graph shows a slight increase in eelgrass abundance with increasing epiphyte abundance; however, this is not a statistically significant result, and there is clearly a lot of scatter in the data. Thus, it appears that, at least for the study sites that were observed in Chatham Sound, epiphyte abundance did not have any noticeable effect on eelgrass growth.

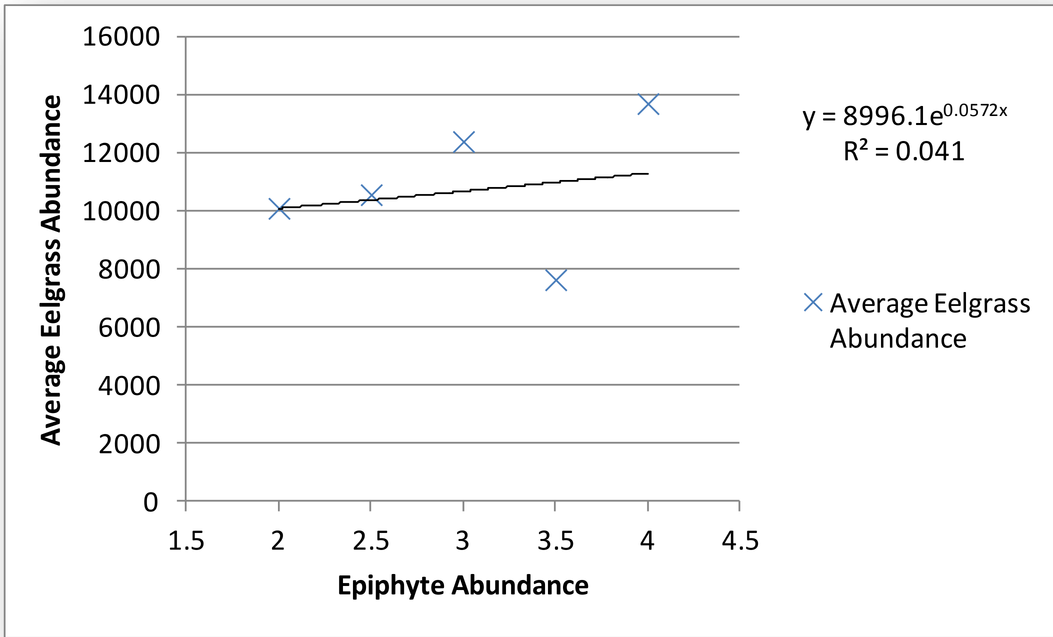


Figure 84. Affect of epiphyte abundance on eelgrass abundance.

3.3.8 Sewage Pollution

Increasing nitrate concentrations from sewage pollution may be directly toxic to eelgrass even at the relatively low nitrate loading rates of 3.5 μM NO_3-N day^{-1} (e.g., eelgrass health decreases as nitrate concentration increases). Sewage pollution can result in eutrophication (nutrient enrichment), which in turn can lead to phytoplankton blooms, excessive algal epiphyte growth, increased carbon content in the sediments, decreased water column oxygen levels, and increased macrophyte (seaweed) growth, all of which can have indirect negative impacts of eelgrass abundance. Point source sewage pollution is approximately proportional to the size of the community generating the sewage, and the effects of the sewage on the surrounding environment roughly decreases by the distance from the point source squared (e.g., obeys the inverse square law). Thus, for each study site, an estimate of the sewage impact can be given by:

$$Cumulative\ sewage\ impact \propto \sum_{i=1}^{n} \frac{population_i}{(distance_i)^2}$$

where *i* is a particular community in Chatham Sound region, $population_i$ is the population of that community (based on Census 2011 data; see Table 15), and $distance_i$ is the distance between the site and community *i* (see Table 16). This cumulative sewage impact value was plotted against averaged eelgrass abundance to generate Figure 85 below. Although the relationship is weak, there is an observable decrease in eelgrass abundance as the sewage impact increases.

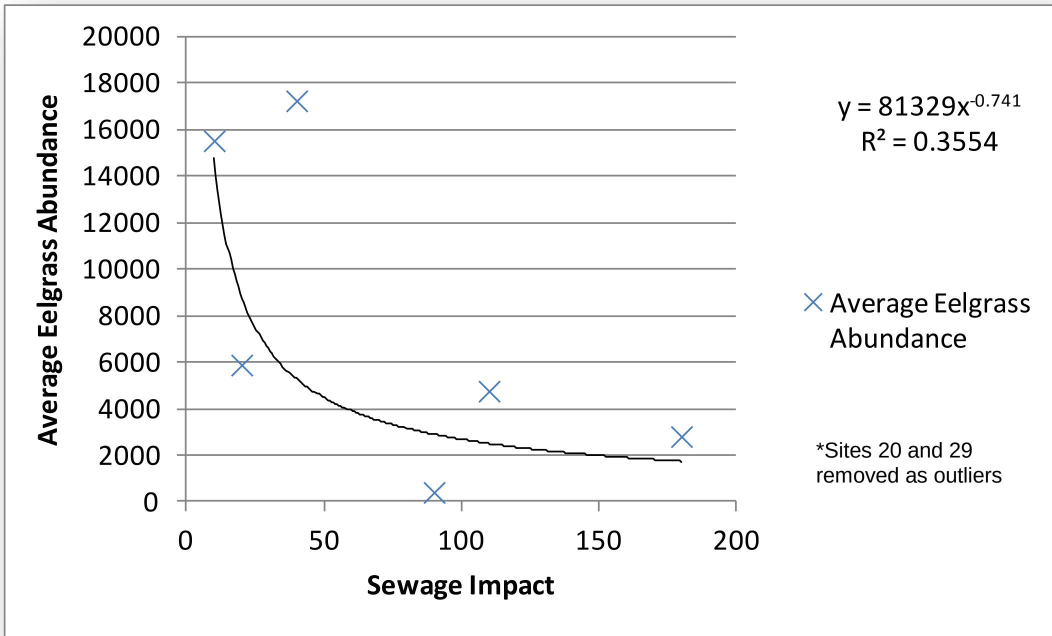


Figure 85. Affects of sewage on eelgrass abundance.

3.3.9 Substrate Particle Size

In British Columbia, eelgrass can grow in a variety of substrates, ranging from soft mud to substrates with significant amounts of gravel and cobble. In a few rare cases, eelgrass has even adapted to grow over hard substrates (rock or cement). However, in most cases, the optimum substrate for eelgrass is a mix of sand and mud (e.g., a substrate particle size of ≤ 2mm). Previous research has shown that eelgrass beds are less abundant as substrate particle size increases away from this optimum value (e.g., eelgrass health decreases as substrate particle size increases). Qualitative substrate particle size observations were converted to values by assigning a code from 1 to 7 (see Table 17), and plotted against eelgrass abundance averaged over the sites in each category to generate Figure 86 below. Although the relationship is not strong, there is clearly a trend showing increased eelgrass abundance with larger substrate particle size. Conversely, no eelgrass beds were observed in the complete absence of sand. This is somewhat unexpected based on previous studies of eelgrass beds in southern B.C.; however, eelgrass in northern B.C. is subject to large tidal ranges, strong currents, and heavy winter storm activity. Previous studies at Lucy Islands (Faggetter, 2011) showed that eelgrass was most abundant at the site in areas of mixed pebble, cobble, and sand substrate, rather than in areas composed primarily of sand alone. The presence of pebbles and cobbles probably reduced the sand migration, thus increasing substrate stability and preventing up-rooting and loss of eelgrass plants. This may explain why eelgrass in northern B.C. is found more commonly in mixed substrate than in southern B.C.

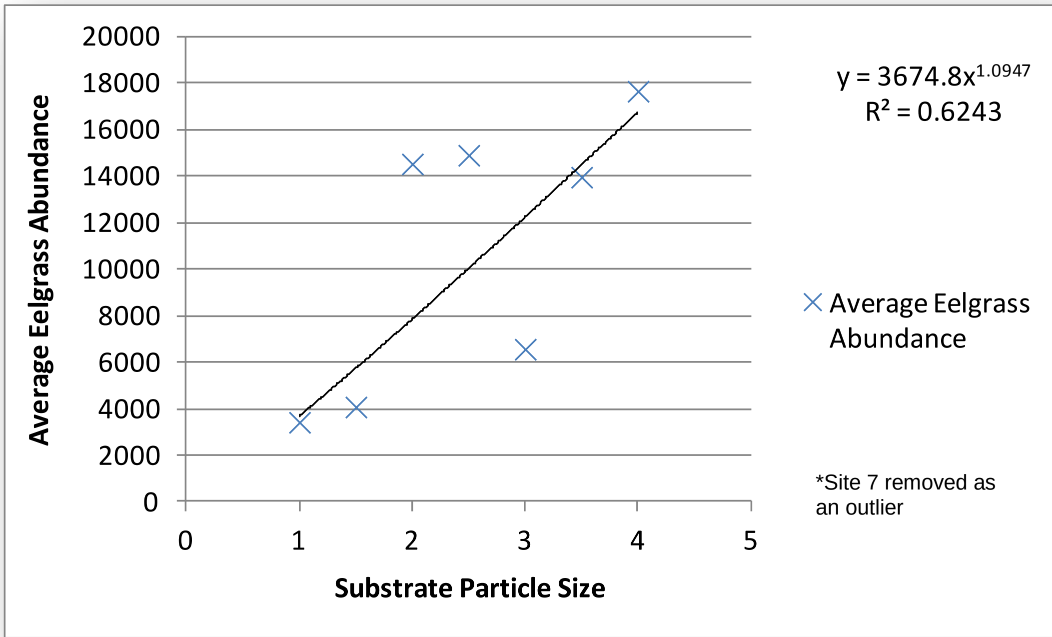


Figure 86. Affects of particle size on eelgrass abundance.

3.3.10 Bottom Slope

Eelgrass can grow at depths ranging from the shallow intertidal (up to 1.8 m above LNT) to subtidal depths of 30 m. The main factor controlling the depth at which the eelgrass can grow is the penetration of sunlight into the water column which, in turn, is affected by turbidity and water color. The optimum depth for eelgrass growth is the shallow subtidal, ranging from 0 m to 6.6 m depth. As a result of this narrow optimum depth range, increasing slope in site bottom topography will result in a decrease in amount of suitable habitat within the optimum depth range (e.g., eelgrass health decreases as site slope increases). A rough estimate of the average bottom slope of a site can be made using the following equation (see Table 22):

$$bottom\ slope = \frac{(Depth\ of\ deepest\ observed\ eelgrass) - (Depth\ of\ shallowest\ observed\ eelgrass)}{Bed\ width}$$

This bottom slope value was plotted against averaged eelgrass abundance to generate Figure 87 below. This graph clearly illustrates the expected relationship - eelgrass abundance declines rapidly as the bottom slope increases.

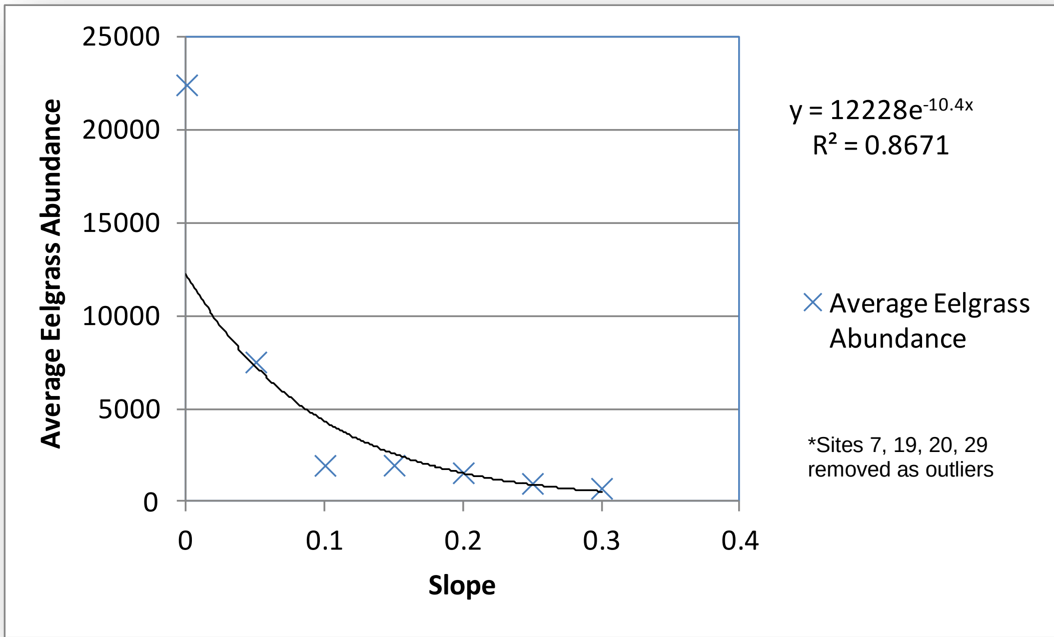


Figure 87. Affect of bottom slope on eelgrass abundance.

3.4 A Possible Health Index for Chatham Sound Eelgrass

Based on previous reports and the present study of eelgrass sites in Chatham Sound, it should, in theory, be possible to create an index of eelgrass health. Given the qualitative nature of our data, this can be achieved by assigning a "health value" to the various states of each of the factors which we have observed to have an impact on eelgrass abundance (see Table 5), and then summing all the "health values" to get a cumulative health index which ranges from 0 (site is very poor for eelgrass growth) to 9 (site is very good for eelgrass growth). One of the best means for visualizing this approach is a flow chart, as shown in Figure 88. Using this method, the health index was calculated for each of the eelgrass study sites (see Table 25), and this health index was plotted against eelgrass abundance to generated Figure 89.

Table 5. Health values for factors affecting eelgrass abundance.

Factor	State	Health value
Turbidity	Low to high	1
	Very high	0
Local freshwater	Present	1
	Absent	0
Salinity	≥ 30‰	0
	> 26‰ and < 30‰	1
	≤ 26‰	0
Current velocity	≤ 2.0 knots	1
	> 2.0 knots	0
Wave exposure	Very protected or protected	0
	Semi-protected or semi-exposed	1
	Exposed o very exposed	0
Sedimentation	Outside of plume (ocean)	1
	Riverine influence	0.5
	Estuarine plume	0
Cumulative sewage impact	≤ 50	1
	> 50	0
Average substrate particle size	< 2 mm	0
	2 mm - 4 mm	0.5
	> 4 mm	1
Bottom slope	≤ 0.1	1
	> 0.1	0

A number of observations can be made regarding Figure 89. Probably the most obvious is that there is a significant amount of scatter in the data. This corresponds to the unique and highly individualistic natures of each of the study sites. The eight sites with highest eelgrass abundance have green markers and are labeled by their site numbers on the graph. These sites are (listed in order from highest to lowest eelgrass abundance):

7	Porcher Island (near Useless Point)
29	Tsimpsean Peninsula (near Swamp Island)
28	Prince Lebo Island
5	McMicking Island
8	South Rachel Island
20	Big Bay on the Tsimpsean Peninsula (near Curlew Rock)
19	Lucy Islands
21	Pearl Harbour on the Tsimpsean Peninsula

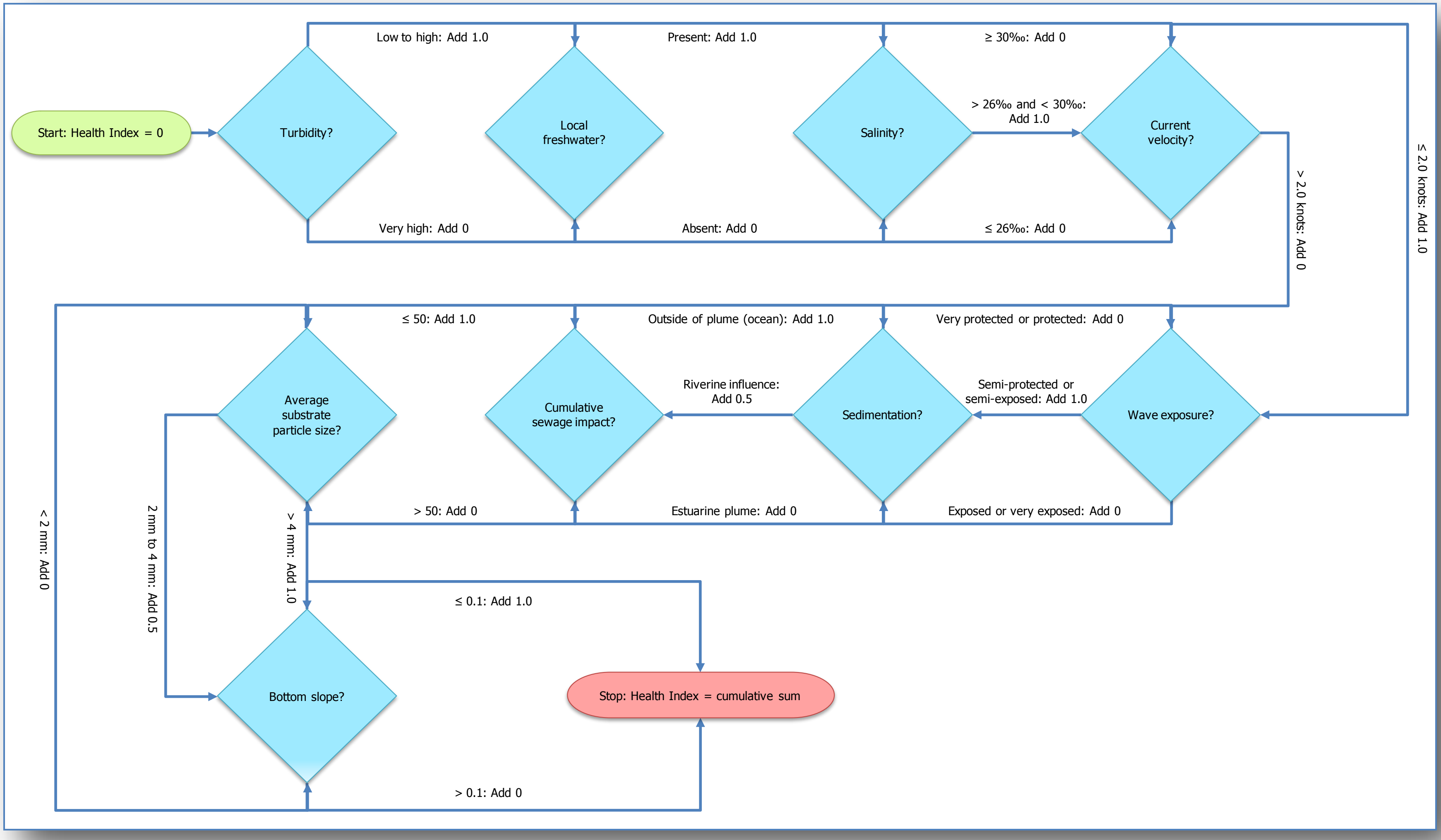


Figure 88. Flow chart for calculating the eelgrass health index.

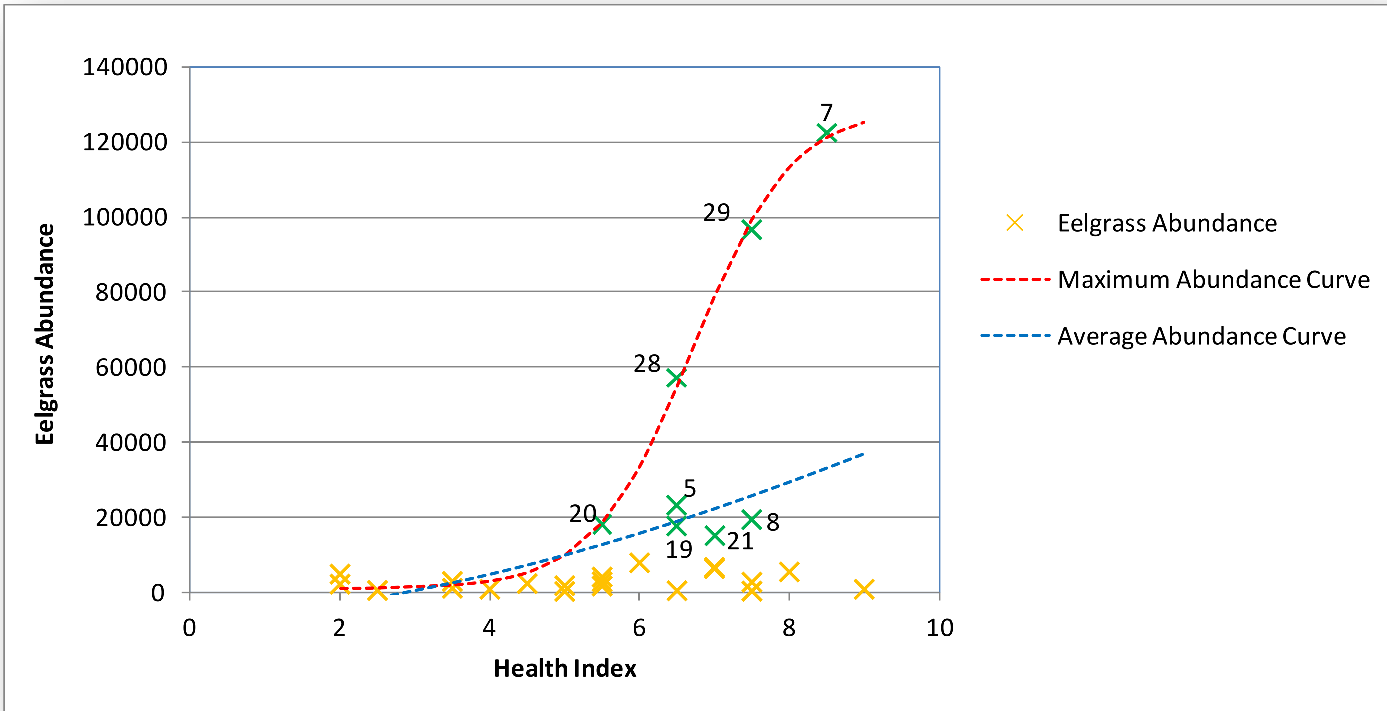


Figure 89. Relationship between the health index and eelgrass abundance.

Sites 7, 20, 28, and 29 are readily fitted with a sigmoidal curve (dotted red line in the graph). Sigmoidal, or logistic, curves are very typical of biological phenomena, ranging from growth to nutrient uptake to dose-response, or exposure-response, relationships. Thus, it is not surprising that the relationship between eelgrass abundance and the calculated health index takes this form. This curve is most likely an indication of the maximum eelgrass abundance that could be expected at a site given its particular health index value. Note; however, that the majority of the study sites have abundance values which fall below the red line. A second line on the graph (dotted blue line) is a sigmoidal curve showing where the average abundance values for the sites should lie. The remaining four sites with highest eelgrass abundance (sites 5, 8, 19, and 21) have abundance values with fall near this average abundance curve. This leaves 21 sites (shown with yellow markers) that fall well below even an average abundance value. This has significance, and can be interpreted in a couple of ways:

- the qualitative data that is available is not sufficient to accurately calculate a health index for these sites. Some of the data that was used for this analysis is very dated (the Skeena/Nass plume location data dates back to 1956, and the plume freshwater data dates back to 1948). No comprehensive studies of the physical properties of the Skeena/Nass estuary system have been done since. New quantitative data, particularly for turbidity, salinity, and nitrate, could improve our ability to determine the health of a site considerably.

- there may be other, unknown, factors, both natural and anthropogenic, which may be limiting eelgrass growth and abundance at these sites. Further research at these sites may provide some clues as to what these limiting factors may be.

As a last comment on Figure 89, it is interesting to note that there are nine sites with a health index of 5 or less. These sites exist in less than ideal environmental conditions, and this is reflected by their very low abundance values. However, the fact that they exist at all is worthy of note. Clearly, while eelgrass does not thrive under these conditions, the fact that it does survive is ecologically significant, especially during times of climate change.

As an indication of the impact that the factors comprising the health index have in a broader ecological sense, sites 7, 20, 28, and 29 (the four sites which delimit the maximum abundance curve) also had some of the greatest diversity of associated flora and fauna amongst all of the sites studied. Thus, it appears that a healthy and abundant eelgrass bed equates to a healthy environment for many other organisms.

3.5 Temporal Changes in Eelgrass Distribution and Abundance

One of the purposes of monitoring baseline data on eelgrass beds is to determine whether the beds are changing in health, distribution, or abundance over time in response to changing environmental and anthropogenic factors. Several of the eelgrass beds surveyed during this project had been surveyed previously using a towed benthic video camera. As a preliminary attempt at comparing eelgrass data temporally, the following four previous surveys were compared to the 2012 surveys:

- Big Bay, April 17th to April 19th, 2009 (Faggetter 2009c) [compared to Big Bay, September 3rd, 2012]
- Lucy Islands, July 17th, 2010 (Faggetter, 2011) [compared to Lucy Islands, August 22nd, 2012]
- Flora Bank, May 21st, 2009 (Faggetter, 2009b) [compared to Flora Bank, July 26th, 2012]
- Coast Island, May 18th to May 20th, 2009 (Faggetter, 2009a) [compared to Coast Island, July 22nd, 2012]

Ideally, the best comparisons would be made between data sets collected at the same time of the year and at the same tidal height. Eelgrass abundance varies throughout the year in an annual cycle, with the greatest growth occurring during the summer. On the North Coast, eelgrass does not appear to reach its maximum biomass until sometime after July (Faggetter, 2011). Tidal height has an impact on the amount of the eelgrass bed which can be surveyed using a towed video camera system. During high spring tides, it is possible to survey most beds as high as their upper intertidal limit; however, during lower tides, the towed video camera system may miss some or all of the intertidal eelgrass. Thus, comparisons between two data sets are unlikely to be accurate in terms of upper bed limits if the data were collected during different tidal conditions.

3.5.1 Big Bay

Figure 90 shows the two data sets for the Big Bay site. The 2012 survey is shown in greens and the 2009 survey is show in blues. As requested by the Herring Conservation and Research Society (HCRS), the funders for the 2009 survey, the survey was carried out at a high spring tide in order to capture as much of the intertidal region as possible during the survey. Thus, the shore parallel transect is considerably further inland in the 2009 survey than in the 2012 survey, by as much as 270 m in some places. Additionally, the 2009 survey was designed to cover the entire extent of Big Bay, whereas the 2012 survey only examined the section between Curlew Rock and the rocky reef off Simpson Point.

Using the data points from the 2009 survey that fall between Curlew Rock and the rocky reef off Simpson Point, the average percent cover in 2009 was 3%. This is considerably lower than the average percent cover in 2012, which was 50% (see Table 24). There are two possible explanations for this:

- The 2009 survey occurred in April when seasonal eelgrass biomass is much lower than during the summer, and this may have been reflected in the average percent cover values.

- The 2009 survey data were mostly from the intertidal region. Our general observations have shown that, at least on the North Coast, intertidal eelgrass is much sparser than subtidal eelgrass.

In 2009, the eelgrass bed width was 203 m and the length was 686 m. The calculated abundance value was 4178. This is much lower than the 2012 abundance value of 17966 (see Table 24). However, since the 2009 calculation includes regions of the bed that were not surveyed during 2012, this may not be a very valid comparison. Possibly a better comparison would be to limit the comparison as follows:

- calculate the bed width for each survey as the distance between the furthest offshore eelgrass observation for that survey and the furthest off shore upper limit of all the surveys being compared.
- all data points are within a certain maximum range of each other (e.g. 50 m).

Using these limitations, the region of the 2009 survey which overlaps with the 2012 survey is approximately 35 m wide. The average eelgrass percent cover of the 2009 survey still remains 3%, and the calculated eelgrass abundance value is 720 (see Table 24).

One minor, possibly relevant, observation is that the 2012 survey showed more eelgrass further offshore than the 2009 survey.

Clearly, these two surveys are not easily compared due to the seasonal differences between the surveys, and the significant variation in amount of bed surveyed resulting from differences in tidal heights during the surveys. Thus, very little can be concluded about temporal changes in the Big Bay eelgrass bed between 2009 and 2012 based on these two surveys.

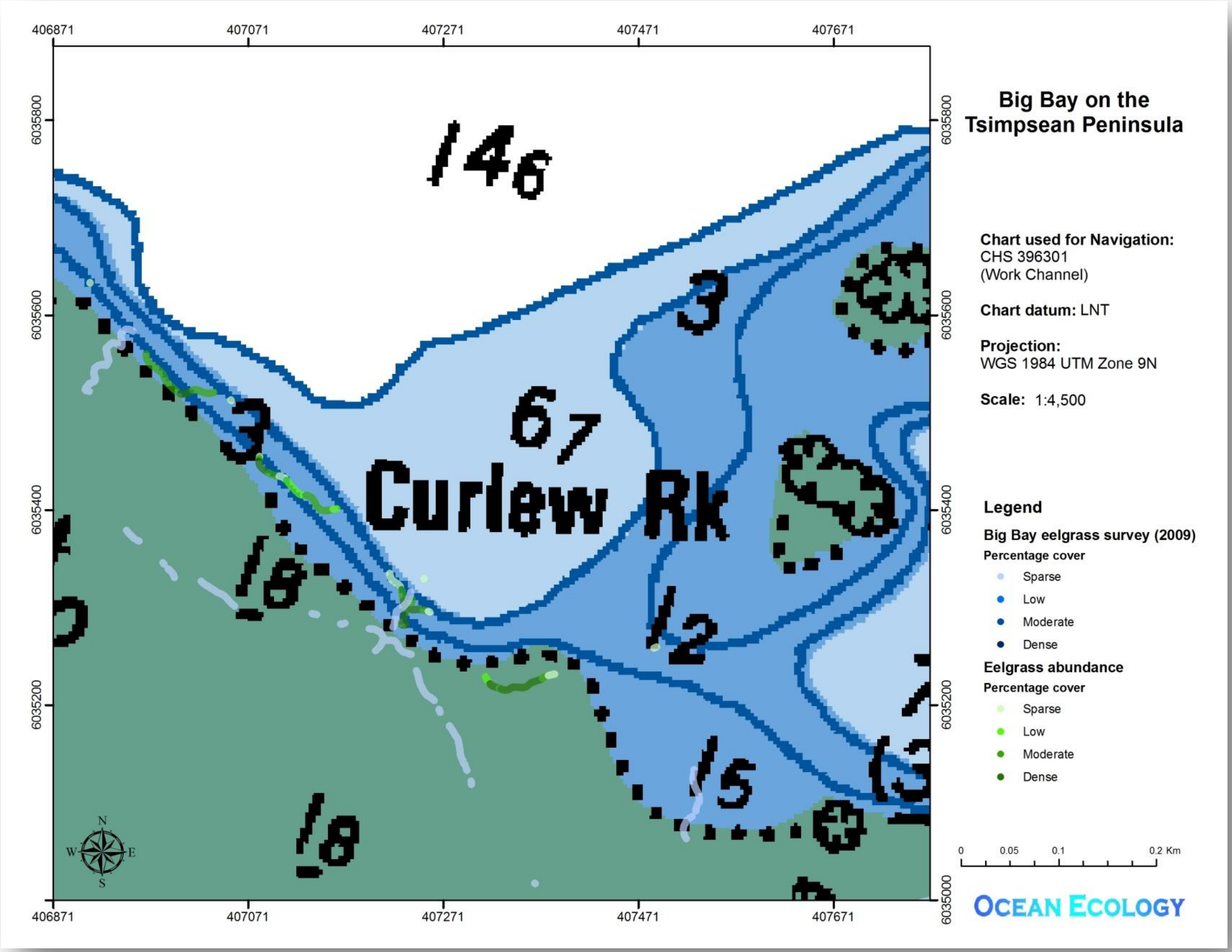


Figure 90. Comparison of eelgrass bed in Big Bay using subtidal video surveys from 2009 and 2012.

3.5.2 Lucy Islands

Figure 91 shows the two data sets for the Lucy Islands site. The 2012 survey is shown in greens and the 2010 survey is show in blues. Each survey was subject to specific restrictions based on the objectives of that particular survey. In 2010, the focus of the survey was an intensive study of the eelgrass bed located between the Lucy Islands. As a result, survey transects were not performed beyond the 2.5 m contour of the chart. Also, some transects were done on the west side of the sand bar connecting the two largest islands of the Lucy Islands group. Additionally, the 2010 survey was carried out at a higher tide than the 2012 survey, and extends further inshore. In 2012, the objective of the survey was to determine the full extent of the eelgrass bed on the north side of the sand bar. Thus, transects were extended offshore until no further eelgrass was observed.

For a valid comparison to be made between the two surveys, the following limitations were used:

- all data points must be north of the 0 m contour delimiting the sand bar
- all data points must be south of the 2.5 m contour

Using the above restrictions, the average percent cover for the 2010 survey was 50% and the average percent cover for the 2012 survey was 32%. The calculated eelgrass abundance value for 2010 was 14835 and the value for 2012 was 6912 (see Table 24). Since both surveys occurred during the period of maximum eelgrass abundance (July and August), and since there was good overlap between the regions covered by the surveys, the difference between 2010 and 2012 surveys may indicate a decline in eelgrass density at this site. The survey effort on the 2010 survey was more intensive, and may have captured more patches of eelgrass, thus this may be a partial explanation for the difference between the two surveys.

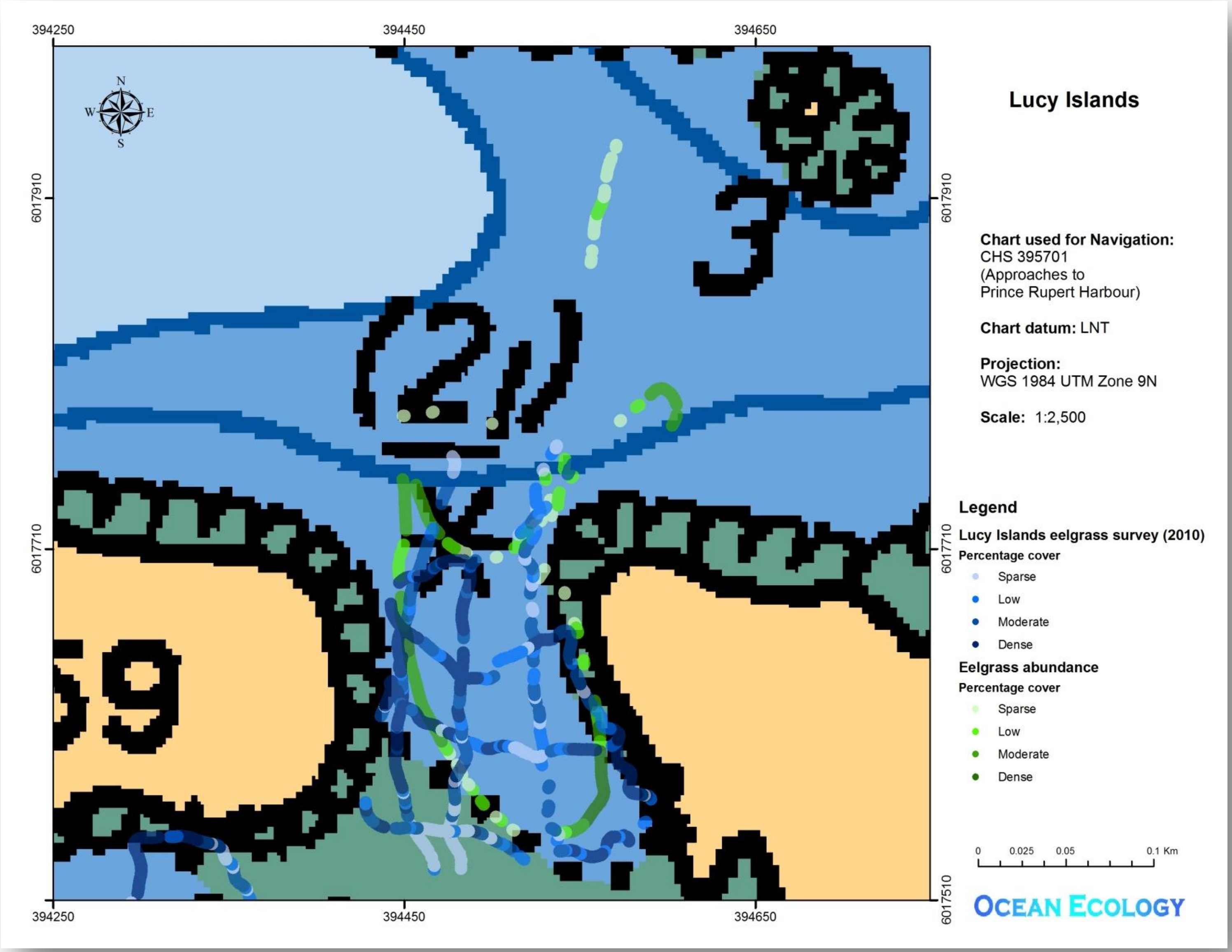


Figure 91. Comparison of Lucy Islands eelgrass bed using subtidal video surveys from 2010 and 2012.

3.5.3 Flora Bank

Figure 92 shows the two data sets for the Flora Bank site. The 2012 survey is shown in greens and the 2009 survey is show in blues. The objective of the 2009 survey was to assess the presence, if any, of subtidal eelgrass on Flora Bank. Flora Bank is an extremely difficult and dangerous location to carry out benthic video surveys. A combination of very high turbidity, shallow sand bars, strong currents, and woody debris from the Skeena River make navigation and safe camera handling very challenging. High turbidity limits the depth at which light can penetrate the water, and this creates an environment which is poor for subtidal eelgrass growth. During the 2009 survey, very little subtidal eelgrass was found. As a result, the site selected for the 2012 survey was a location at which a reasonably significant amount of subtidal eelgrass had been observed during the 2009 survey. The 2012 survey was carried out at a slightly higher tide that the 2009 survey. Additionally, although the goal was to duplicate the 2009 transect, strong currents made this impossible, and the overlap between the two surveys is not very good.

A comparison between the two surveys was made using the following limitation:

- calculate the bed width for each survey as the distance between the furthest offshore eelgrass observation for that survey and the furthest off shore upper limit of all the surveys being compared.

Using the above restriction, the average percent cover for the 2009 survey was 13% and the average percent cover for the 2012 survey was 67%. The calculated eelgrass abundance value for 2009 was 468 and the value for 2012 was 2093 (see Table 24). However, the 2009 survey was carried out in May, whereas the 2012 survey was carried out in July. Since eelgrass has not reached its full seasonal biomass in May, this may explain why the average percent cover for the 2009 survey was much lower than the 2012 survey. The furthest observed offshore eelgrass only differs by about 15 m between the two surveys, suggesting that there is little, if any, change with respect to bed width.

Overall, any conclusions regarding temporal changes in the Flora Bank eelgrass bed between 2009 and 2012 based on these two surveys are weak at best, due seasonal differences between the surveys.

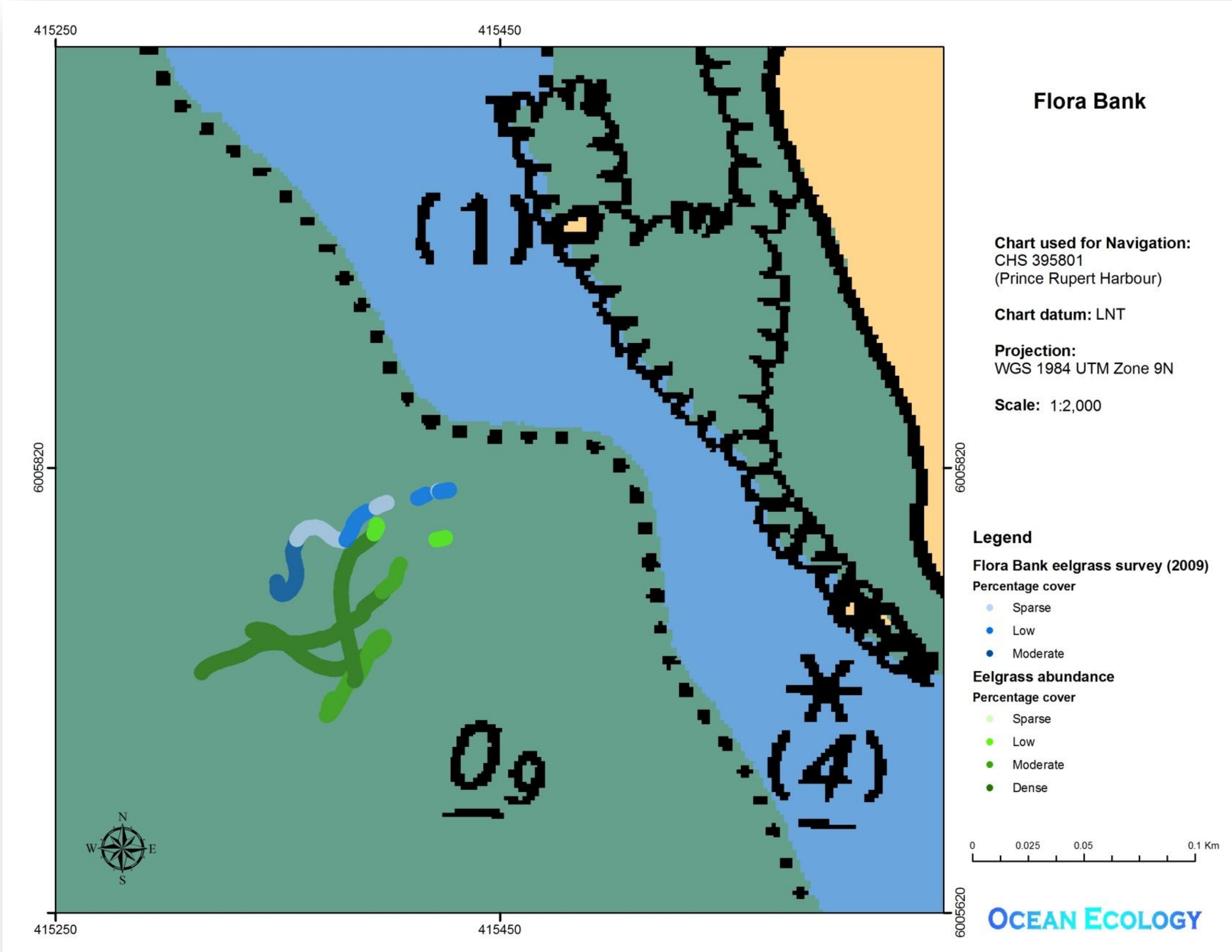


Figure 92. Comparison of Flora Bank eelgrass bed using subtidal video surveys from 2009 and 2012.

3.5.4 Coast Island

Figure 93 shows the two data sets for the Coast Island site. The 2012 survey is shown in greens and the 2009 survey is show in blues. Both surveys cover the same region reasonably well with good overlap; however, the 2009 survey was carried out in May and the 2012 survey was carried out in July. The timing of the 2009 survey was determined by the needs of the client, whereas the timing of the 2012 survey was based on the best time of the year to observe eelgrass (e.g., late summer when eelgrass has the greatest biomass).

The average percent cover for the 2009 survey was 15% and the average percent cover for the 2012 survey was 34%. The calculated eelgrass abundance value for 2009 was 421 and the value for 2012 was 2808 (see Table 24). However, since eelgrass has not reached its full seasonal biomass in May, this may explain why the average percent cover for the 2009 survey was much lower than the 2012 survey. The 2012 survey found eelgrass approximately 40 m further offshore than the 2009 survey. This may be an indication that the eelgrass bed is expanding slightly.

Again, as with the previous survey comparisons, any conclusions regarding temporal changes in the Coast Island eelgrass bed between 2009 and 2012 based on these two surveys are weak at best, due seasonal differences between the surveys.

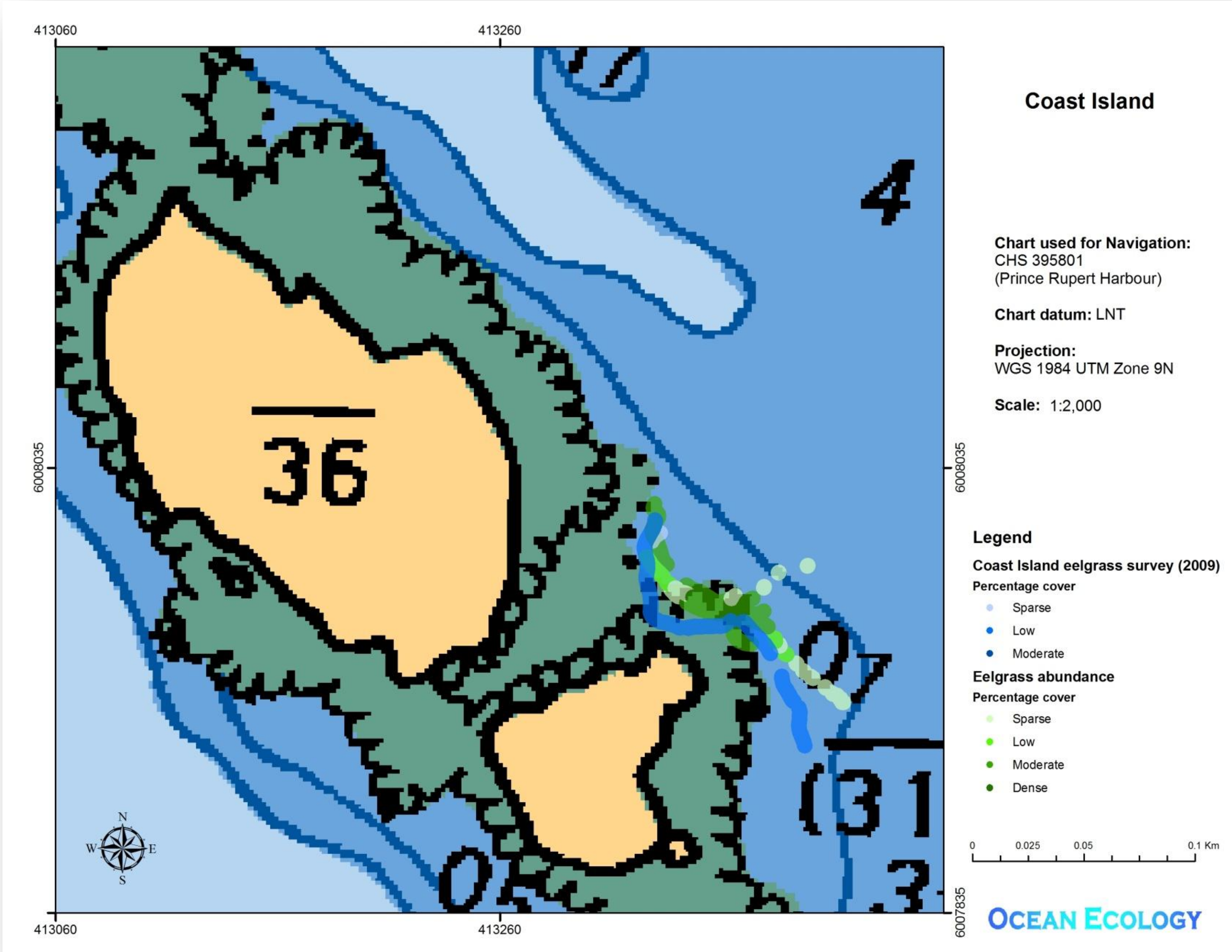


Figure 93. Comparison of Coast Island eelgrass bed using subtidal video surveys from 2009 and 2012.

4 Conclusions and Recommendations

The following conclusions and recommendations can be made based on the 2012 Chatham Sound eelgrass study:

- The presence of intertidal eelgrass is not an absolute indicator of the presence of subtidal eelgrass. 82% of the sites investigated during this study had both intertidal and subtidal eelgrass. However, there are probably a significant number of places where subtidal eelgrass can be found in the absence of intertidal eelgrass.

- Aerial surveys using the standard visible spectrum for photography and video do not adequately assess the abundance of subtidal eelgrass. Both the Haegele (visible and infrared) and the Borstad (visible and near infrared) surveys were much better indicators of subtidal eelgrass than the Shorezone (visible only) survey. Recent studies have shown that airborne hyperspectral imaging systems may be promising for remotely sensing eelgrass beds (O'Neill *et al.*, 2011). Side scan sonar is also very useful in rapid assessment of subtidal eelgrass (Faggetter, 2011).

  Recommendation #1: Do not rely on the Shorezone data set to provide a reliable estimate of total eelgrass on the North Coast. In some cases it underestimates eelgrass since it does not record subtidal eelgrass; in others, it has identified eelgrass where none currently exists (may have been a misidentification originally, or the eelgrass has disappeared since the survey).

- The 29 eelgrass beds that were studied during this project were chosen to be representative of a variety of locations and conditions throughout Chatham Sound. They do not necessarily include the healthiest, largest, or most vulnerable eelgrass beds in the region. There are many OTHER eelgrass beds in Chatham Sound that were not surveyed.

- A diverse range of fish and invertebrates, including commercial species such as rockfish and Dungeness crab, were observed utilizing the eelgrass beds. Clearly, eelgrass beds are valued habitat to a variety of organisms on the North Coast, and any changes to the health, abundance, and distribution of these eelgrass beds will have wide-ranging impacts.

  Recommendation #2: Traditionally, eelgrass has been considered important habitat for commercial species such as salmon and herring. However, it seems likely that eelgrass is important for a much wider range of species. The value of eelgrass habitat to these other species should be a topic for further research.

- On first examination, this report may appear to suggest that eelgrass is a common and abundant habitat in Chatham Sound. However, our search for eelgrass was highly-directed, based on previous studies, anecdotal reports, and previous personal knowledge. It was assisted by the use of technology, such as forward looking sonar, to locate underwater patches of eelgrass, and personal experience in identifying locations where eelgrass was likely to occur. Thus, this study was definitely not a random survey of Chatham Sound for eelgrass. Chatham Sound is dominated by rocky intertidal habitats. Soft substrate habitats in relatively protected waters are relatively rare. Only about 14% (based on Physical Shore-Zone Mapping System Data, 2005) of the coast in the study area is classified as a shore type where eelgrass might be expected (e.g., low slope, sand or mud substrate, relatively protected from wave action). Much of the coastline within that 14% may be unsuitable habitat for eelgrass for a number of other reasons.

- Large amounts of unmapped intertidal eelgrass were observed on the Kinahan Islands during this survey, and also on the Lucy Islands during previous surveys (Faggetter, 2011). This suggests that even our knowledge of the geographical extents of intertidal eelgrass in Chatham Sound is limited.

  Recommendation #3: More effort needs to be expended on mapping intertidal eelgrass in the Chatham Sound region.

- Subtidal eelgrass varied widely in terms of its health and abundance. At some sites, the eelgrass blades were clean and free of epiphytic algae and bryophyes, whereas at other sites, the eelgrass blades had extensive epiphytic growth and were already showing signs of erosion and fall die-back.

- Each eelgrass bed was unique, with variations in substrates, ecotypes, associated flora and fauna, and tolerance to turbidity, wave action, and tidal currents. Although certain patterns and trends could be seen at most of the sites, there were always outlier beds which had unexpected characteristics.

- North Coast eelgrass differs in its tolerance to certain environmental factors from that observed in previous studies of more southern eelgrass. In particular, North Coast eelgrass prefers a greater degree of wave exposure and a larger average substrate particle size than that observed in other studies. Given the high level of turbidity in the Skeena/Nass system, it would seem that a certain amount of wave action was beneficial by assisting in the removal of accumulated sediment and epiphytes and thus improving photosynthesis. Since the North Coast is subject to significant storm activity and strong tidal currents, the presence of larger sized substrate particles probably reduces sand migration, thus increasing substrate stability and preventing up-rooting and loss of eelgrass plants.

  Recommendation #4: Resource managers and biologists should start to take the unique features of North Coast eelgrass into account when evaluating eelgrass habitat and making decisions regarding habitat mitigation, compensation, and restoration. More study is required to better define the optimum growth requirements of eelgrass on the North Coast.

- A qualitative health index was calculated for each of the eelgrass study sites. This health index was able to estimate the maximum eelgrass abundance that could be expected at a given site; however, many eelgrass beds do not appear to be at or near their maximum abundance. Lack of recent, accurate, good quality data on the Skeena/Nass estuary system may partially explain these results. However, there may be other, unknown, factors, both natural and anthropogenic, which may be limiting eelgrass growth and abundance at these sites.

Recommendation #5: Collection of new quantitative data on the Skeena/Nass estuary system, particularly for turbidity, salinity, and nitrate, is necessary to improve our ability to determine the health of a site. The development of an oceanographic model for the Chatham Sound region would also greatly improve our abilities to assess the factors affecting eelgrass at a particular site, and to predict future changes in these factors.

Recommendation #6: Further study into factors which may be limiting eelgrass growth is necessary. In particular, the 2012 eelgrass study was unable to assess factors such as the affects of herbivory, bioturbation, pathogens, oxygen depletion, and temperature.

Recommendation #7: Given the number of eelgrass beds which seem to be growing at less than optimum rates, and our current inability to explain what factors may be limiting their growth, the use of the precautionary approach when managing eelgrass habitat would be strongly suggested.

- Some eelgrass beds exist in less than ideal environmental conditions, and this is reflected by their very low abundance values. Clearly, while eelgrass does not thrive under these conditions, the fact that it does survive is ecologically significant, especially during times of climate change.

Recommendation #8: Small eelgrass beds growing in less than ideal environmental conditions should not be considered "expendable". In times of changing climate conditions, these beds may serve as sources of seeds and material for vegetative propagation to sites with more favorable environmental conditions. Alternatively, large changes in the environment may favor these beds, and they may begin to thrive in the future.

- Short term seasonal changes in eelgrass abundance are generally larger than long term changes over a period of several years. As a result, long term changes are easily masked by short term variability.

- Tidal elevation is very important during a towed video survey of subtidal eelgrass. During high spring tides, it is possible to survey most beds as high as their upper intertidal limit; however, during lower tides, the towed video camera system may miss some or all of the intertidal eelgrass.

Recommendation #9: If long term baseline data are to be collected at a particular eelgrass site, it is very important that the site be surveyed along the same transect line, at the same tidal elevation, and during the same time of year. Failure to do this will lead to inconclusive results regarding long terms trends in the health and abundance of the eelgrass bed.

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7 Appendix

7.1 Survey Dates

Table 6. Survey dates and tidal stations used for depth corrections for Chatham Sound sites.

Site	Survey date	Tidal station for depth correction
Coast Island	22/07/2012	Casey Cove
Flora Bank	26/07/2012	Casey Cove
Marrack Island	22/07/2012	Seabreeze Point
Porcher Island (in Chismore Passage)	23/07/2012	Godfrey Point
McMicking Island	23/07/2012	Godfrey Point
Porcher Island (near Creak Islands)	24/07/2012	Hunt Inlet
Porcher Island (near Useless Point)	24/07/2012; 19/08/2012	Refuge Bay
South Rachel Island	26/07/2012	Qlawdzeet Anchorage
West Kinahan Island	26/07/2012	Qlawdzeet Anchorage
Parry Island	19/08/2012	Refuge Bay
Arthur Island	19/08/2012	Refuge Bay
Stephens Passage	19/08/2012	Qlawdzeet Anchorage
Qlawdzeet Anchorage	19/08/2012	Qlawdzeet Anchorage
West Melville Island	21/08/2012	Hudson Bay Passage
East Melville Island	21/08/2012	Moffatt Islands
Northeast Melville Island	21/08/2012	Moffatt Islands
Moffat Islands	21/08/2012	Moffatt Islands
West Dunira Island	21/08/2012	Moffatt Islands
Lucy Islands	22/08/2012	Qlawdzeet Anchorage
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	03/09/2012	Moffatt Islands
Pearl Harbour on the Tsimpsean Peninsula	03/09/2012	Moffatt Islands
North Tsimpsean Peninsula (near Dudevoir Passage)	03/09/2012	Birnie Island
Wales Island (near Tracey Island)	03/09/2012	Birnie Island
Boston Islands	03/09/2012	Birnie Island
Dundas Island (near Nares Islets)	04/09/2012	Hudson Bay Passage
Dundas Island (Gore-Langton Point)	04/09/2012	Hudson Bay Passage
Dundas Island (Edith Harbour)	04/09/2012	Hudson Bay Passage
Prince Lebo Island	05/09/2012	Hudson Bay Passage
Tsimpsean Peninsula (near Swamp Island)	05/09/2012	Moffatt Islands

7.2 Vegetation Codes

Table 7. Vegetation coverage codes.

Code	Class	Abundance Range	Average Abundance (%)
1	Sparse	Less than 5% cover.	2.5
2	Low	5 to 25% cover.	15
3	Moderate	26 to 75% cover.	50
4	Dense	>75% cover.	87.5

The vegetation coverage code can be related to the average abundance by the following equation:

$$Average\ abundance\ in\ percent = 2.5236 * (Average\ code\ value)^{2.6133}$$

Table 8. Average eelgrass abundance calculations for Chatham Sound sites.

Site	Average code value	Average eelgrass abundance (%)
Coast Island	2.71	34
Flora Bank	3.58	71
Marrack Island	2.09	17
Porcher Island (in Chismore Passage)	2.50	28
McMicking Island	3.13	50
Porcher Island (near Creak Islands)	1.49	7
Porcher Island (near Useless Point)	2.76	36
South Rachel Island	2.84	39
West Kinahan Island	2.10	18
Parry Island	2.74	35
Arthur Island	2.85	39
Stephens Passage	2.26	21
Qlawdzeet Anchorage	2.99	44
West Melville Island	1.61	9
East Melville Island	2.57	30
Northeast Melville Island	2.74	35
Moffat Islands	1.76	11
West Dunira Island	1.76	11
Lucy Islands	2.50	28
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	3.13	50
Pearl Harbour on the Tsimpsean Peninsula	2.30	22
North Tsimpsean Peninsula (near Dudevoir Passage)	2.49	27
Wales Island (near Tracey Island)	2.30	22
Boston Islands	1.69	10
Dundas Island (near Nares Islets)	1.51	7
Dundas Island (Gore-Langton Point)	2.63	31
Dundas Island (Edith Harbour)	2.66	33
Prince Lebo Island	2.57	30
Tsimpsean Peninsula (near Swamp Island)	2.55	29

7.3 Turbidity Codes

Table 9. Turbidity codes.

Code	Turbidity
1	Low
2	Moderate
3	High
4	Very high

7.4 Tannins Codes

Table 10. Tannins codes.

Code	Tannins
1	Absent
2	Present

7.5 Plume Freshwater Codes

Table 11. Plume freshwater codes.

Code	Percentage Freshwater from Plume	Equivalent Salinity (‰)*	Average Salinity (‰)
1	0	> 32	> 32
2	1 - 6%	30.1 - 31.7	31
3	6 - 10%	28.8 - 30.1	30
4	10 - 15%	27.2 - 28.8	28
5	15 - 20%	25.6 - 27.2	26
6	> 20%	< 25.6	< 26

*Assuming full ocean salinity for the region is 32‰.

7.6 Local Freshwater Codes

Table 12. Local freshwater codes.

Code	Local Freshwater Input
1	No
2	Yes

7.7 Codes for Site Location Relative to Estuary Plume at Freshet

Table 13. Codes for site location relative to estuary plume at freshwater.

Code	Site Location Relative to Estuary Plume at Freshet
1	Ocean
2	Riverine influence
3	Estuarine plume
4	Riverine plume
5	Salt wedge

7.8 Epiphyte Abundance Codes

Table 14. Epiphyte abundance codes.

Code	Epiphyte Abundance
1	None
2	Low
3	Moderate
4	High

7.9 Population Estimates for Communities in the Chatham Sound Region

Table 15. Population estimates, based on BC Stats (2011), for communities in the Chatham Sound region.

Community	Population
Prince Rupert	12508
Port Edward	544
Metlakatla	83
Kitkatla	405
Port Simpson	678
Oona River	25
Dodge Cove	29
Hunts Inlet	12

7.10 Matrix for Study Site Distances from Communities in the Chatham Sound Region

Table 16. Matrix for study site distances from communities in the Chatham Sound region.

Site	Distance from Community (km)							
	Prince Rupert	Dodge Cove	Port Edward	Metlakatla	Hunts Inlet	Oona River	Kitkatla	Port Simpson
Coast Island	11.017	9.562	2.692	15.635	17.756	29.690	46.857	39.071
Flora Bank	13.443	12.451	3.779	18.575	16.901	27.249	45.060	41.630
Marrack Island	40.766	39.870	30.994	45.904	22.976	7.675	26.675	68.899
Porcher Island (in Chismore Passage)	30.605	28.829	21.101	34.512	10.006	10.218	28.215	58.621
McMicking Island	29.951	28.269	20.388	34.012	10.411	10.750	29.096	58.018
Porcher Island (near Creak Islands)	28.849	25.655	21.753	29.865	3.083	20.339	30.597	54.566
Porcher Island (near Useless Point)	34.148	30.709	27.610	34.332	8.648	22.310	27.988	58.765
South Rachel Island	18.780	14.746	17.224	16.510	16.659	34.347	45.967	40.316
West Kinahan	12.599	9.515	7.722	14.560	15.578	30.320	45.716	39.154

Site	Distance from Community (km)							
	Prince Rupert	**Dodge Cove**	**Port Edward**	**Metlakatla**	**Hunts Inlet**	**Oona River**	**Kitkatla**	**Port Simpson**
Island								
Parry Island	31.666	27.794	27.327	30.105	13.429	30.032	35.794	53.598
Arthur Island	32.260	28.624	26.583	31.778	9.731	25.449	31.591	55.943
Stephens Passage	28.359	24.393	24.994	26.270	14.539	32.166	39.537	49.505
Qlawdzeet Anchorage	30.671	26.697	31.098	25.710	26.285	44.146	50.722	44.813
West Melville Island	31.423	28.995	37.570	23.910	42.773	60.635	70.448	30.009
East Melville Island	25.246	23.041	31.902	17.706	39.234	56.716	68.049	25.733
Northeast Melville Island	26.186	24.124	33.076	18.644	40.662	58.125	69.475	25.108
Moffat Islands	28.506	26.868	36.039	21.056	44.538	61.889	73.461	23.068
West Dunira Island	31.151	29.529	38.692	23.712	46.839	64.302	75.518	24.029
Lucy Islands	18.645	15.193	22.565	12.344	27.830	45.327	56.956	31.574
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	17.313	18.640	27.071	13.496	43.256	57.626	73.532	11.274
Pearl Harbour on the Tsimpsean Peninsula	22.553	23.975	32.331	18.745	48.522	62.955	78.810	6.016
North Tsimpsean Peninsula (near Dudevoir Passage)	35.676	37.427	45.436	32.304	62.081	76.287	92.368	7.576
Wales Island (near Tracey Island)	46.767	48.270	56.549	42.852	72.528	87.259	102.807	18.585
Boston Islands	45.864	47.103	55.639	41.491	70.984	86.118	101.209	17.958
Dundas Island (near Nares Islets)	40.327	38.996	48.244	33.036	56.324	73.913	84.543	27.200
Dundas Island (Gore-Langton Point)	40.874	39.257	48.382	33.450	55.379	73.137	83.125	29.666
Dundas Island (Edith Harbour)	43.300	41.254	50.085	35.767	55.129	73.103	81.837	34.660
Prince Lebo Island	44.652	42.481	51.196	37.110	55.554	73.576	81.827	36.651
Tsimpsean Peninsula (near Swamp Island)	12.790	12.466	21.728	6.403	35.798	51.103	66.077	19.027

7.11 Substrate Particle Size Codes

Table 17. Substrate particle size codes.

Substrate Particle Size	Code	Average Size (mm)
Silt-mud	1	0.62
Sand	2	2
Granules	3	4
Pebble	4	64
Cobble	5	256
Boulder	6	512
Rock	7	10000

7.12 Wave Exposure Calculations

Effective fetch calculation involves the measurement of the fetch distance along several directions from a given point from the shore (see Figure 94), and is a standard engineering measurement for shore protection studies (CERC, 1977). The "***modified effective fetch***" technique involves the measurement of three fetch distances: the shore-normal or perpendicular to the general trend of the shore unit, 45° to the left of the shore-normal and 45° to the right of the shore normal (see Figure 94).

The wave climate of a particular point cannot be characterized by effective fetch alone because waves may be generated in an area remote from the shore unit and propagate into the area of the shore unit. These waves are commonly referred to as swell. The ***maximum fetch*** of a shore unit is intended to provide an index of the swell waves and, to a lesser extent, refraction effects. The maximum fetch is the maximum fetch distance, in kilometers, that can be measured from a centre point of the shore unit (see Figure 94).

Effective Fetch Calculation (CERC, 1977)

$$F_e = \frac{\sum(F_i * \cos\alpha_i)}{\sum \cos\alpha_i}$$

where F_e = effective fetch in kilometers

α_i = the angle between the shore normal and the direction I

F_i = the fetch distance in kilometers along direction i

Modified Effective Fetch Calculation (Harper *et al*., 1991)

$$F_m = \frac{[(\cos 45° * F_{45L}) + (\cos 90° * F_{090}) + (\cos 45° * F_{45R})]}{[\cos 45° + \cos 90° + \cos 45°]}$$

$$= \frac{[(0.707 * F_{45L}) + (1.0 * F_{090}) + (0.707 * F_{45R})]}{2.414}$$

where F_m = modified effective fetch in kilometers

F_{45L} = the fetch distance in kilometers along direction 45° left of the shore normal

F_{090} = the fetch distance in kilometers along direction the shore normal

F_{45R} = the fetch distance in kilometers along direction 45° right of the shore normal

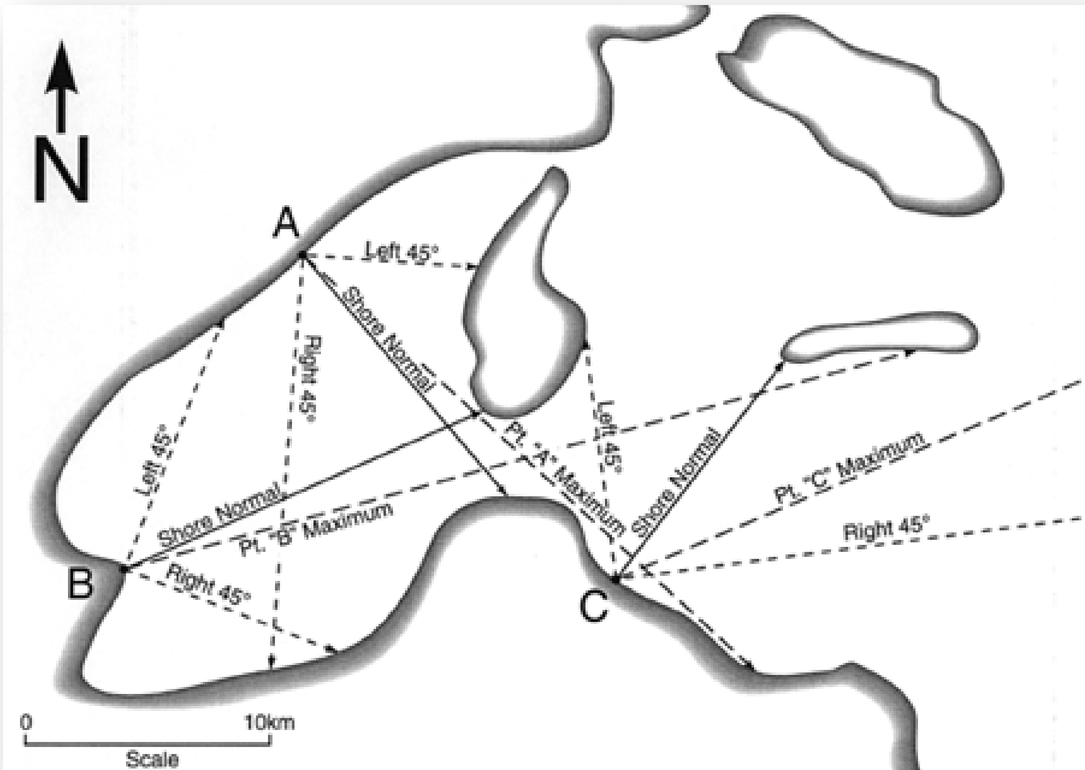

Figure 94. Fetch calculations (Howes *et al.*, 1997).

The ***exposure category*** provides a summary indicator of wave exposure for the unit. It is determined using the modified effective fetch and maximum fetch values.

Table 18. Effective and maximum fetch wave exposure matrix.

Maximum Fetch (km)	Modified Effective Fetch (km)				
	<1	1 - 10	10 - 50	50 - 500	> 500
<1	Very protected	N/A	N/A	N/A	N/A
1 - 10	Protected	Protected	N/A	N/A	N/A
10 - 50	N/A	Semi-protected	Semi-protected	N/A	N/A
50 - 500	N/A	Semi-exposed	Semi-exposed	Semi-exposed	N/A
500 - 1000	N/A	N/A	Semi-exposed	Exposed	Exposed
> 1000	N/A	N/A	N/A	Very exposed	Very exposed

Table 19. Wave exposure codes.

Code	Wave Exposure
1	Very protected
2	Protected
3	Semi-protected
4	Semi-exposed
5	Exposed
6	Very exposed

Table 20. Exposure calculations for the Chatham Sound sites.

Site	F_{45L}	F_{090}	F_{45R}	F_m	Maximum Fetch	Exposure
Coast Island	0.7	0.5	0.6	0.6	2.1	Protected
Flora Bank	0.4	0.2	0.3	0.3	1.9	Protected
Marrack Island	3.4	2.6	5.7	3.8	19.0	Semi-protected
Porcher Island (in Chismore Passage)	0.9	0.8	1.7	1.1	1.9	Protected
McMicking Island	0.3	0.2	0.2	0.2	9.7	Protected
Porcher Island (near Creak Islands)	6.4	36.1	0.9	17.1	81.3	Semi-exposed
Porcher Island (near Useless Point)	1.7	3.0	4.1	2.9	1430.0	Semi-exposed
South Rachel Island	61.8	11.4	26.6	30.6	66.5	Semi-exposed
West Kinahan Island	0.4	0.7	6.2	2.2	7.0	Protected
Parry Island	0.1	0.4	0.1	0.2	6.2	Protected
Arthur Island	0.5	0.3	0.5	0.4	1.3	Protected
Stephens Passage	0.1	0.6	0.1	0.3	1.0	Protected
Qlawdzeet Anchorage	0.1	24.5	0.1	10.2	19.3	Semi-protected
West Melville Island	1.2	0.8	0.8	0.9	1.5	Protected
East Melville Island	0.4	21.0	16.3	13.6	32.7	Semi-protected
Northeast Melville Island	1.9	19.4	14.7	12.9	21.8	Semi-protected
Moffat Islands	0.2	51.3	0.2	21.4	51.3	Semi-exposed
West Dunira Island	1.3	1.0	0.7	1.0	3.6	Protected
Lucy Islands	0.1	0.6	0.1	0.3	10.2	Protected
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	2.0	2.0	1.6	1.9	3.7	Protected

Site	F_{45L}	F_{090}	F_{45R}	F_m	Maximum Fetch	Exposure
Pearl Harbour on the Tsimpsean Peninsula	1.3	1.2	0.7	1.1	22.1	Semi-protected
North Tsimpsean Peninsula (near Dudevoir Passage)	0.2	30.1	0.5	12.7	59.4	Semi-exposed
Wales Island (near Tracey Island)	0.5	72.6	1.6	30.7	72.9	Semi-exposed
Boston Islands	0.0	0.9	1.1	0.7	1.1	Protected
Dundas Island (near Nares Islets)	0.1	1.6	0.1	0.7	1.9	Protected
Dundas Island (Gore-Langton Point)	2.6	8.8	0.2	4.4	132.9	Semi-exposed
Dundas Island (Edith Harbour)	0.1	0.3	0.2	0.2	0.3	Very protected
Prince Lebo Island	0.7	52.7	0.6	22.2	83.9	Semi-exposed
Tsimpsean Peninsula (near Swamp Island)	27.5	14.6	26.9	22.0	115.9	Semi-exposed

7.13 Maximum Tidal Current Velocities

Table 21. Maximum tidal current velocities for the Chatham Sound sites.

Site	Maximum tidal current velocity (knots)	Data Source
Coast Island	2.0	CHS marine chart
Flora Bank	2.0	CHS marine chart
Marrack Island	4.0	CHS marine chart
Porcher Island (in Chismore Passage)	2.5	CHS marine chart
McMicking Island	2.5	CHS marine chart
Porcher Island (near Creak Islands)	2.0	CHS marine chart
Porcher Island (near Useless Point)	2.0	CHS marine chart
South Rachel Island	2.0	CHS marine chart
West Kinahan Island	1.5	CHS marine chart
Parry Island	2.0	CHS marine chart
Arthur Island	2.0	CHS marine chart
Stephens Passage*	0.5	Personal observation
Qlawdzeet Anchorage	2.0	CHS marine chart
West Melville Island	1.0	CHS marine chart
East Melville Island	1.0	CHS marine chart
Northeast Melville Island	1.0	CHS marine chart
Moffat Islands	1.0	CHS marine chart
West Dunira Island	1.0	CHS marine chart
Lucy Islands	1.0	CHS marine chart
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	1.0	CHS marine chart
Pearl Harbour on the Tsimpsean Peninsula	1.0	CHS marine chart
North Tsimpsean Peninsula (near Dudevoir Passage)	1.0	CHS marine chart
Wales Island (near Tracey Island)	2.5	NOAA tides and currents
Boston Islands	2.0	NOAA tides and currents
Dundas Island (near Nares Islets)	1.5	CHS marine chart
Dundas Island (Gore-Langton Point)	1.5	CHS marine chart
Dundas Island (Edith Harbour)	1.5	CHS marine chart
Prince Lebo Island	1.0	CHS marine chart
Tsimpsean Peninsula (near Swamp Island)	1.0	CHS marine chart

7.14 Bottom Slope Calculations

Table 22. Bottom slope calculations.

Site Name	Bed width (m shore perpendicular)	Shallowest eelgrass (m)	Deepest eelgrass (m)	Slope
Coast Island	59	-1.3	1.91	0.054
Flora Bank	129	-1.15	1.84	0.023
Marrack Island	18	-1.04	1.32	0.131
Porcher Island (in Chismore Passage)	54	-0.71	6.59	0.135
McMicking Island	88	-1.32	3.52	0.055
Porcher Island (near Creak Islands)	59	0.82	6.27	0.092
Porcher Island (near Useless Point)	571	-0.86	5.66	0.011
South Rachel Island	300	-0.43	11.37	0.039
West Kinahan Island	73	-0.84	12.78	0.187
Parry Island	26	-0.42	7.48	0.304
Arthur Island	60	-0.71	6.82	0.126
Stephens Passage	48	-0.92	2.13	0.064
Qlawdzeet Anchorage	154	-1.07	5.48	0.043
West Melville Island	27	0.15	6.85	0.248
East Melville Island	175	0.11	4.33	0.024
Northeast Melville Island*	68	-0.37	7.28	0.113
Moffat Islands	54	0.89	3.78	0.054
West Dunira Island*	19	-0.39	1.31	0.089
Lucy Islands	392	-0.69	4.9	0.014
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	52	-1.03	6.97	0.154
Pearl Harbour on the Tsimpsean Peninsula	120	-1.8	3.27	0.042
North Tsimpsean Peninsula (near Dudevoir Passage)	104	-2.68	1.82	0.043
Wales Island (near Tracey Island)	33	-1.54	5.34	0.208
Boston Islands*	37	0.17	1.78	0.044
Dundas Island (near Nares Islets)	23	0.02	2.3	0.099
Dundas Island (Gore-Langton Point)	97	-1.66	0.77	0.025
Dundas Island (Edith Harbour)	58	-0.96	2.6	0.061
Prince Lebo Island (28)	393	-0.03	8.97	0.023
Tsimpsean Peninsula (near Swamp Island)	641	-1.7	2.64	0.007

7.15 Eelgrass Abundance Calculations

Table 23. Eelgrass abundance calculations.

Site Name	**Bed width (m shore perpendicular)**	**Bed length (m shore parallel)**	**Average eelgrass density (% cover)**	**Eelgrass Abundance**
Coast Island	59	140	34	2808
Flora Bank	129	52	71	4763
Marrack Island	18	681	17	2084
Porcher Island (in Chismore Passage)	54	105	28	1588
McMicking Island	88	528	50	23232
Porcher Island (near Creak Islands)	59	174	7	719

Site Name	Bed width (m shore perpendicular)	Bed length (m shore parallel)	Average eelgrass density (% cover)	Eelgrass Abundance
Porcher Island (near Useless Point)	571	596	36	122514
South Rachel Island	300	164	39	19188
West Kinahan Island	73	31	18	407
Parry Island	26	80	35	728
Arthur Island	60	96	39	2246
Stephens Passage	48	167	21	1683
Qlawdzeet Anchorage	154	92	44	6234
West Melville Island	27	408	9	991
East Melville Island	175	102	30	5355
Northeast Melville Island*	68	276	35	6569
Moffat Islands	54	31	11	184
West Dunira Island*	19	102	11	213
Lucy Islands	392	161	28	17671
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	52	691	50	17966
Pearl Harbour on the Tsimpsean Peninsula	120	565	22	14916
North Tsimpsean Peninsula (near Dudevoir Passage)	104	277	27	7778
Wales Island (near Tracey Island)	33	375	22	2723
Boston Islands*	37	40	10	148
Dundas Island (near Nares Islets)	23	214	7	345
Dundas Island (Gore-Langton Point)	97	87	31	2616
Dundas Island (Edith Harbour)	58	208	33	3981
Prince Lebo Island	393	485	30	57182
Tsimpsean Peninsula (near Swamp Island)	641	520	29	96663

*Bed length for these sites was calculated from the marine chart.

Table 24. Eelgrass abundance calculations for survey comparisons.

Site Name	Bed width (m shore perpendicular)	Bed length (m shore parallel)	Average eelgrass density (% cover)	Eelgrass Abundance
Big Bay survey 2009 - all points between Curlew Rock and the rocky reef off Simpson Point	203	686	3	4178
Big Bay survey 2009 - points between Curlew Rock and the rocky reef off Simpson Point within 50 m radius of 2012 survey	35	686	3	720
Big Bay survey 2012	52	691	50	17966
Lucy Islands survey 2010 - all points north north of the 0 m contour and south of the 2.5 m contour	230	129	50	14835
Lucy Islands survey 2012 - all points north north of the 0 m contour and south of the 2.5 m contour	216	100	32	6912
Flora Bank survey 2009 - all points	90	40	13	468
Flora Bank survey 2012 - all points below 2009 survey upper limit	71	44	67	2093
Coast Island survey 2009 - all points	23	122	15	421
Coast Island survey 2012 - all points	59	140	34	2808

7.16 Eelgrass Health Index Calculations

Table 25. Eelgrass health index calculations.

Site Name	Turbidity	Salinity	Local Freshwater	Current Velocity	Wave Exposure	Sedimentation	Cumulative Sewage Impact	Average Substrate Particle Size	Bottom Slope	Health
Coast Island	1	0	0	1	0	0.5	0	0	1	3.5
Flora Bank	0	0	0	1	0	0	0	0	1	2
Marrack Island	0	0	0	0	1	0	1	0	0	2
Porcher Island (in Chismore Passage)	1	1	1	0	0	0.5	1	1	0	5.5
McMicking Island	1	1	1	0	0	0.5	1	1	1	6.5
Porcher Island (near Creak Islands)	1	1	1	1	1	1	1	1	1	9
Porcher Island (near Useless Point)	1	1	1	1	1	1	1	0.5	1	8.5
South Rachel Island	1	1	0	1	1	0.5	1	1	1	7.5
West Kinahan Island	1	0	0	1	0	0.5	0	0	0	2.5
Parry Island	1	0	0	1	0	1	1	0	0	4
Arthur Island	1	0	0	1	0	1	1	0.5	0	4.5
Stephens Passage	1	0	0	1	0	1	1	0	1	5
Qlawdzeet Anchorage	1	0	0	1	1	1	1	1	1	7
West Melville Island	1	0	0	1	0	0.5	1	0	0	3.5
East Melville Island	1	1	1	1	1	0.5	1	0.5	1	8
Northeast Melville Island	1	1	1	1	1	0.5	1	0.5	0	7
Moffat Islands	1	1	0	1	1	0.5	1	1	1	7.5
West Dunira Island	1	1	1	1	0	0.5	1	1	1	7.5
Lucy Islands	1	1	0	1	0	0.5	1	1	1	6.5
Big Bay on the Tsimpsean Peninsula (near Curlew Rock)	1	1	1	1	0	0.5	1	0	0	5.5
Pearl Harbour on the Tsimpsean Peninsula	1	0	1	1	1	0.5	1	0.5	1	7
North Tsimpsean Peninsula (near Dudevoir Passage)	1	0	0	1	1	0.5	1	0.5	1	6
Wales Island (near Tracey Island)	1	0	1	0	1	0.5	1	1	0	5.5
Boston Islands	1	0	0	1	0	0.5	1	0.5	1	5
Dundas Island (near Nares Islets)	1	0	1	1	0	0.5	1	1	1	6.5

Site Name	Turbidity	Salinity	Local Freshwater	Current Velocity	Wave Exposure	Sedimentation	Cumulative Sewage Impact	Average Substrate Particle Size	Bottom Slope	Health
Dundas Island (Gore-Langton Point)	1	0	1	1	1	0.5	1	1	1	7.5
Dundas Island (Edith Harbour)	1	0	1	1	0	0.5	1	0	1	5.5
Prince Lebo Island	1	0	0	1	1	1	1	0.5	1	6.5
Tsimpsean Peninsula (near Swamp Island)	1	1	1	1	1	0.5	0	1	1	7.5

8 Disclaimer

The findings presented in this report are based upon data collected during the periods July 22 to July 26, 2012, August 18 to August 22, 2012, and September 3 to September 5, 2012 using the methodology described in the Survey Methodology section of this report. Ocean Ecology has exercised reasonable skill, care, and diligence to collect and interpret the data, but makes no guarantees or warranties as to the accuracy or completeness of this data.

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Any questions concerning the information or its interpretation should be directed to the undersigned.

Prepared By:

Barb Faggetter, Ph.D
Oceanographer, R.P.Bio.

Reviewed By:

Kennard Hall, Captain
Partner, Ocean Ecology