An Assessment of Benthic Species Richness and Macroalgal Habitat Near Igluligaarjuk (Chesterfield Inlet), Nunavut, Using ROV Exploration

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ABSTRACT

Kozakewich, W.M., M^cNicholl, D.G., Gully, K.R., O'Brien, J.M., and Dunmall, K.M. 2024. An Assessment of Benthic Species Richness and Macroalgal Habitat Near Igluligaarjuk (Chesterfield Inlet), Nunavut, Using ROV Exploration. Can. Tech. Rep. Fish. Aquat. Sci. 3623: viii + 43 p.

There is limited information on the diversity and distribution of nearshore (depths < 20 m) benthic fishes, invertebrates, and their associated habitats near Chesterfield Inlet, which resides in the Southampton Island Area of Interest (SI AOI). Coastal community-led fieldwork was completed between July 25th and 26th, 2023 near the hamlet of Chesterfield Inlet, to address these knowledge gaps and categorize the nearshore benthic ecosystem. This fieldwork included a unique approach to non-invasive ecosystem observation and monitoring, using a remotely operated vehicle (ROV) that was deployed at sites selected by the Aqigiq Hunters and Trappers Organization (AHTO). Using BIIGLE, a web-based application designed for the annotation of images and videos, benthic invertebrates, fish, and macroalgae were identified and labelled to the lowest possible taxonomic level. Analyses also included categorizing the habitat of each site with respect to substratum, percent vegetation cover, and visibility. There were 12 different macroalgal taxa observed, in which the dominant taxa were sieve kelp, *Agarum clathratum*, sugar kelp (*Saccharina latissima*), and witch's hair (*Desmarestia aculeata*). Two fish species were identified, the Arctic shanny *(Stichaeus punctatus*) and the banded gunnel (*Pholis fasciata*), which were observed within the kelp. Numerous invertebrates were observed among 32 total faunal taxa, such as cone worms (*Cistenides* sp.), stalked jellies (Stauromedusae), and various sea stars (Asteroidea). These data will contribute to better understanding the benthic biodiversity and associated habitats in Hudson Bay, and the method for analyzing underwater footage will provide an option for gathering biodiversity data without disturbing benthic habitats.

RÉSUMÉ

Kozakewich, W.M., McNicholl, D.G., Gully, K.R., O'Brien, J.M., and Dunmall, K.M. 2024. An Assessment of Benthic Species Richness and Macroalgal Habitat Near Igluligaarjuk (Chesterfield Inlet), Nunavut, Using ROV Exploration. Can. Tech. Rep. Fish. Aquat. Sci. 3623: viii + 43 p.

Il existe peu de renseignements sur la diversité et la répartition des poissons et invertébrés benthiques des zones littorales (profondeur < 20 m) et de leurs habitats associés près de Chesterfield Inlet, qui se trouve dans le site d'intérêt de l'île de Southampton (SI de l'IS). La communauté côtière a mené des travaux sur le terrain entre le 25 et le 26 juillet 2023 près du hameau de Chesterfield Inlet afin de combler ces lacunes en matière de connaissances et de catégoriser l'écosystème benthique des zones littorales. Ces travaux sur le terrain comprenaient une approche unique de l'observation et de la surveillance non invasives de l'écosystème, notamment grâce à l'utilisation d'un véhicule téléguidé (VTG) déployé sur des sites sélectionnés par l'Organisation de chasseurs et de trappeurs d'Aqigiq (Aqigiq Hunters and Trappers Organization - AHTO). À l'aide de BIIGLE, une application web conçue pour l'annotation d'images et de vidéos, on a identifié et étiqueté les poissons, les macroalgues et les invertébrés benthiques au niveau taxonomique le plus bas possible. Les analyses comprenaient également la catégorisation de l'habitat de chaque site en fonction du substrat, du pourcentage de couverture végétale et de la visibilité. On a observé douze taxons macroalgaux différents, les taxons dominants étant la laminaire criblée (*Agarum clathratum)*, la laminaire sucrée (*Saccharina latissima*) et *Desmarestia aculeata*. On a identifié deux espèces de poissons, la stichée arctique *(Stichaeus punctatus*) et la sigouine rubanée (*Pholis fasciata*), qui ont été observées dans le varech. On a observé de nombreux invertébrés parmi les 32 taxons fauniques, comme des vers trompettes (*Cistenides* sp.), des lucernaires campanulées (stauroméduse) et diverses étoiles de mer (Asteroidea). Ces données permettront de mieux comprendre la biodiversité benthique et les habitats associés dans la baie d'Hudson, et la méthode d'analyse des séquences sous-marines permettra de recueillir des données sur la biodiversité sans perturber les habitats benthiques.

1.0 INTRODUCTION

Chesterfield Inlet (Igluligaarjuk), Nunavut, is home to a diverse set of Arctic and Atlantic benthic species, including invertebrates and macroalgae (Filbee-Dexter et al. 2019; Pierrejean et al. 2020). Located on the northwestern coast of the Hudson Bay, this environment lies within an area prioritized for protection, the Southampton Island Area of Interest (SI AOI), which is over 93,000 km^2 and was designated in May 2019 (Loewen et al. 2020a). The area is ecologically and culturally important, due to its migratory pathways for whales, such as belugas (*Delphinapterus leucas*), and narwhals (*Monodon monoceros*), and contains habitats for seabirds and polar bears (*Ursus maritimus*) (Loewen et al. 2020a). As such, the area is of high ecological importance, with rightsholders having great interest in its preservation.

Dynamic oceanographic conditions support the rich ecosystem around Chesterfield Inlet, including wind driven upwellings of nutrient-rich water that stimulate the nearshore benthic macroalgal communities (Mann and Lazier 2005; Filbee-Dexter et al. 2019). These habitat-forming macroalgae communities, dominated by kelp, provide shelter to diverse benthic invertebrates (Christie et al. 2003) and contribute substantially to primary productivity in the nearshore (Krumhansl K. and Scheibling R. 2012). Near Chesterfield Inlet, the Kivalliq Polynya slows ice buildup and creates more open-water days (Bruneau et al. 2021). This allows more photosynthetically active radiation to reach the benthos, creating longer periods favourable for macroalgal growth (Filbee-Dexter et al. 2022). In the winter, bentho-sympagic grazers which feed on sea ice algae, migrate vertically to the sea ice underside (Siferd et al. 1997). During the spring ice melt, the ice algae sink to the seafloor, where they are predominately consumed by the benthic invertebrates, such as brittle stars and gastropods, which have a preference for sympagic algae (Fortier et al. 2002; Mundy et al. 2014; Amiraux et al. 2023). Ice algae that is not consumed will either photooxidize, or enter the substratum, where it becomes available to consumers year-round (Grebmeier and Barry 1991; Fortier et al. 1994; Koch et al. 2023). As the ice melts in the spring time, phytoplankton blooms begin to form, and are then consumed by zooplanktonic pelagic grazers and filter feeding benthic invertebrates, such as bivalves and sea cucumbers (Amiraux et al. 2023). During the summer, holoplankton, such as the Arctic comb jelly (*Mertensia ovum*), feed on the various zooplankton in the coastal waters (Loewen et al. 2020b). The wealth of ecosystem interactions in the benthos make Chesterfield Inlet a prime location of study, especially within the confines of the SI AOI.

There is little data available on the nearshore habitat around Chesterfield Inlet, with most information either surrounding depths greater than 20 m, or other locations within the SI AOI. The most predominant habitat type observed was a mix of rock, gravel, and scallops, found at depths deeper than 40 m (Kamula et al. 2016; DFO 2020). The benthoscape around Chesterfield Inlet, has other areas consisting largely of muddy sand with rocks, shell hash, and overall low species diversity (Kamula et al. 2016; DFO 2020). Areas of sand and coralline-encrusted rock populated with various echinoderms such as the crevice brittle star (*Ophiopholis aculeata*) (DFO 2020) can also be found. Additionally, there are areas of coralline-encrusted rock, containing gravel, shell hash, and hosting a wider variety of macroalgae, including sieve kelp, *Agarum clathratum*. More broadly, in Roes Welcome Sound where substratum supported macroalgal growth, the kelp species: badderlocks (*Alaria esculenta*), sugar kelp (*Saccharina latissima*), and Arctic suction-cup kelp, *Laminaria solidungula*, were the most abundant among observed macroalgae (Filbee-Dexter et al. 2019).

Given the lack of available information regarding nearshore communities, it is currently uncertain which species can be found near coastal communities of the Kivalliq Region, such as Chesterfield Inlet. In an effort to analyze existing information on the SI AOI, the DFO (2020) collated a number of studies analyzing the habitat, benthic structure, and surrounding environment. The supplemental document provided for that report listed over 1000 benthic taxa present within Canadian Arctic waters (Loewen et al. 2020b), however, most of this information covers areas outside of Chesterfield Inlet, and depths greater than 20 m. Unfortunately, it is difficult for studies to operate in shallower water, as the larger survey vessels are unable to sample the area safely, and can encounter issues trawling and dredging in areas of rocky habitat. Additionally, there are significant logistical challenges associated with deploying divers in these nearshore areas, necessitating new approaches to their benthic study. This knowledge gap prevents a firm understanding of benthic biodiversity at the local scale. Furthermore, while there is significant research surrounding the ice algae, phytoplankton, and fish communities of the SI AOI (Bursa 1961a, 1961b; Swanson et al. 2010; Yurkowski et al. 2023; Furist et al. 2024), the information surrounding the macroalgal community and associated benthic invertebrates is left largely understudied, including those with potential for a fishery (sea urchins, sea cucumbers, scallops).

The objective of this report is to use a minimally invasive approach to analyze remotely operated vehicle (ROV) footage taken off the coast of Chesterfield Inlet, to a maximum depth of approximately 10 m. The study focuses on both the macroalgal and benthic invertebrate communities to identify dominant habitats types and the species found within. DFO biologists held two, in-person consultations with the Aqigiq Hunters and Trappers Organization (AHTO) on January 20th and July 24th 2023, where the AHTO identified research priorities, including knowledge gaps associated with scallops. Scallops had been collected historically in Chesterfield Inlet (Atkinson and Wacasey 1989), but there is limited knowledge of their presence or abundance in nearshore areas. Therefore, specific objectives are:

1.1 Objectives

1) Evaluate the occurrence and taxonomic richness of macroalgal and benthic invertebrate taxa from ROV video footage.
2) Assess benthic habitat characteristics by estimating substratum composition and vegetation percent cover from benthic imagery.
3) Evaluate presence and abundance of scallops from ROV video footage.

2.0 METHODS

2.1 AHTO Consultation

Arctic Coast, a DFO-supported community-based coastal field work program among communities throughout Inuit Nunangat (Christie et al. 2023; McNicholl et al. 2024), began the work in Chesterfield Inlet in January 2023. After requesting support from the AHTO and confirming study sites, summer fieldwork was conducted, with a component of the program including focus on the benthic habitat to address research priorities. As part of the benthic program, a remotely operated vehicle (ROV) was approved for use by the AHTO, as a potential new tool to assess nearshore habitats and species biodiversity. Community-based technicians worked with DFO researchers to deploy the ROV, with the intent of locating sites best representing the local biodiversity, with emphasis on scallops.

2.2 ROV Deployment

To characterize diversity and distribution among nearshore habitats, video footage was collected on July 25th and 26th, 2023, from four different areas off the coast of Chesterfield Inlet. On July 25th, ROV footage was collected at three sites in the Chesterfield Inlet harbour. On July 26th, ROV footage was taken at three additional sites: one site at Fish Bay, one in a channel situated south of the community, and the last site at False Inlet (Figure 1).

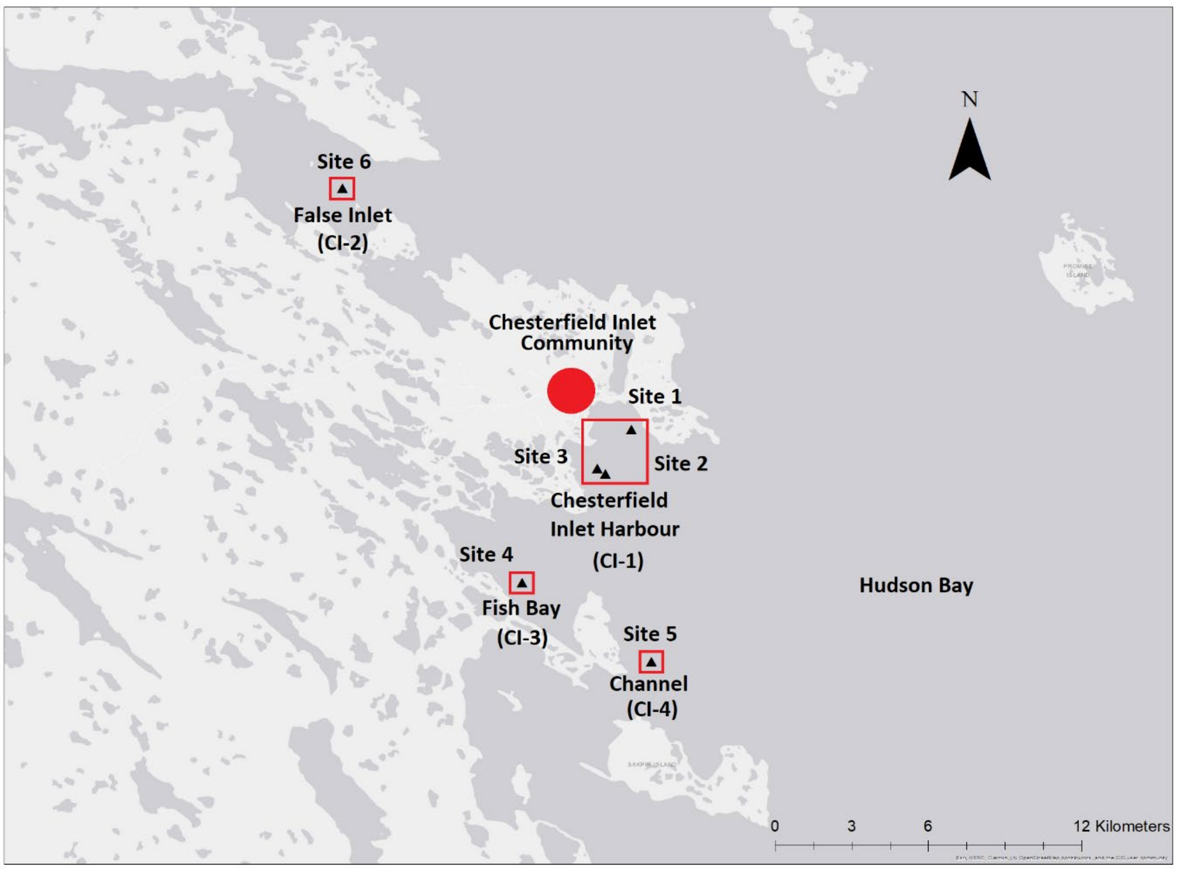

Figure 10. Map of the area around Chesterfield Inlet, where ROV footage was obtained. The four areas selected by the Aqigiq Hunters and Trappers Organization for sampling are indicated by red boxes.

The video footage was collected using a FIFISH V6 Expert remotely operated vehicle (ROV), filming at 120 frames per second. The ROV was equipped with both a temperature (°C) and depth sensors (m). As this was a pilot study for us to assess the utility of an ROV in documenting species occurrence and habitat type data, there was no predetermined protocol to collect video footage. The ROV operator directed sampling towards features of interest as encountered, rather than along a set dive plan. The seafloor depth at each site ranged between 3 m, and 10 m, averaging 6.3 m deep among the six sites (Table 1). Duration of footage from each site ranged from 8 to 36 minutes, and depended largely on the strength of the current. Once footage was uploaded and labelled in the video annotation software (see below), the compiled data was sorted in Excel. Figures were prepared using R (Version 4.1.2) to visually depict the different environmental conditions of each area (RCoreTeam 2021)

Table 7. Coordinates of each site, along with associated depth, in situ temperature, and duration of footage.

Location	Site #	Longitude (DD)	Latitude (DD)	Duration of footage (m:s)	Depth (m)	Temperature (°C)
Chesterfield Inlet Harbour (CI-1)	Site 1	63.33552	-90.691768	31:53	10.3	5.0
Chesterfield Inlet Harbour (CI-1)	Site 2	63.32859	-90.701019	12:21	4.5	5.0
Chesterfield Inlet Harbour (CI-1)	Site 3	63.32939	-90.703837	7:55	3.0	5.0
False Inlet (CI-2)	Site 4	63.37357	-90.793423	36:10	6.0	6.0
Fish Bay (CI-3)	Site 5	63.31136	-90.730256	21:13	5.8	5.5
Channel (CI-4)	Site 6	63.29894	-90.684912	24:56	8.3	4.0

2.3 Image Annotation With BIIGLE

To generate a collection of still imagery for analysis, frame grabs were taken from each video file every 5 seconds using VLC Media Player. To add annotations for the observed species and habitats, stills were then uploaded into BIIGLE 2.0 (Bio-Image Indexing and Graphical Labelling Environment), a web-based image and video annotation and labelling software (Langenkämper et al. 2020). Image or video footage can be uploaded in BIIGLE, with the user able to apply annotation labels to objects (e.g., macroalgae, fish), which can then be sorted through to determine the presence or absence of species, species abundance, or habitat composition. Various sources focusing on the identification of the numerous fishes, macroalgae, and benthic invertebrates around the Arctic and northern Atlantic were used to identify the observed species (Coad and Reist 2018; Grégoire et al. 2022; NorwegianSeaweeds 2023; GBIF 2024; Guiry and Kuipers 2024; iNaturalist 2024; WoRMS 2024).

On BIIGLE, a label tree was created to annotate observed habitats and organisms (Appendix A). Seven main branches were created, most of which contained nested sub-labels for further specificity, and were adapted from a guide created by Grégoire et al. (2022). The seven branches were “Fauna”, “Flora”, “Habitat Notes”, “Substratum”, “Unknown”, “Vegetation Cover %”, and “Visibility” (Figure 2). “Flora” and “Fauna” were used for annotating the biota. “Flora” was split among brown, red, and green macroalgae. Given the superficial morphological similarity between many algal species, and the inability to observe discerning features for higher resolution taxonomic assignment from imagery, macroalgae were further divided into functional groups denoting foliated, filamentous, and foliated filamentous macroalgae (Grégoire et al. 2022). Due to more observable differences in brown macroalgal structures, many brown macroalgae were able to be classified to more precise taxa. Special labels were also made to denote brown crustose algae (“Ralfsiales”) and crustose coralline red algae (“Corallinales”), within the brown and red macroalgae categories, respectively. Like brown macroalgae, the “Fauna” branch flowed down into more precise taxa. “Habitat Notes” described observations that did not fit into other categories, such as worm casts and macroalgal detritus. “Vegetation Cover %” was determined by visual estimation, with ranges of 0-1%, 1-25%, 25-50%, 50-75%, and 75-100%. Benthic substratum was classified as “Boulders”, “Coarse Sediment”, “Multiple Substrate Types”, “Soft Sedimentation Mat”, “Soft Sediments” and, for high vegetation cover, low visibility, or a mixture of the two, “Undetermined Substratum”. “Multiple Substrate Types” was often used to denote substratum with coarse sediments and shell hash (which was often undistinguishable from surrounding coarse sediments), and boulders.

Within the stills, many individuals were obscured due to foliage or motion blur. Additionally, due to the frequency at which stills were taken, many individuals did not appear within them (Appendix B). To ensure a greater chance of observing obscured individuals, or individuals that did not appear for very long, the videos were viewed alongside the corresponding stills to gain different angles of view. Videos were first viewed to observe and note common individuals of each area, and then viewed in tandem with the stills being annotated. The movement of organisms such as the Arctic comb jelly (*Mertensia ovum*) made it possible for them to be discerned from the otherwise camouflaging background, allowing them to be more easily spotted within the stills during annotation.

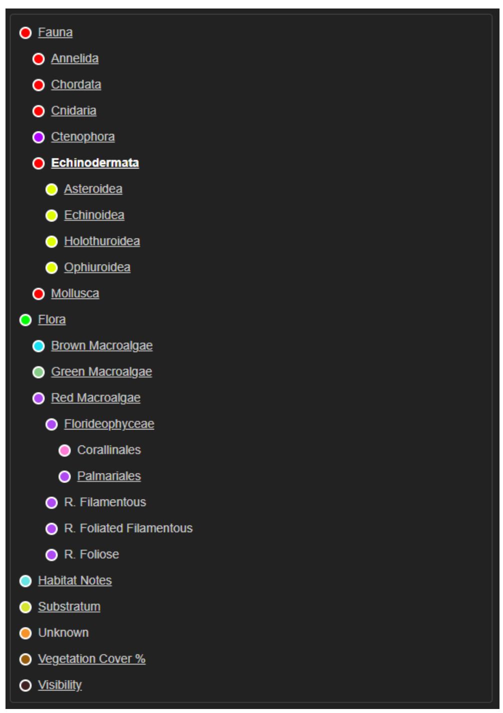

Figure 11. Label tree showing the top labels used to annotate ROV footage in BIIGLE, with select labels expanded to show sub-labels.

In situations where flora or fauna were unable to be identified to species, they were instead labelled to the lowest possible taxonomic level. Many invertebrate species could only be identified to the genus level, as no discerning characteristics were observable that allowed a species-level classification. For example, scarlet (*Psolus fabricii*) and brown sea cucumbers

(*Psolus phantapus*) were labelled as *Psolus* spp. due to morphological resemblance *in situ* (Figure 3). In cases for which two similar-looking species of different genera could not be distinguished *in situ*, a mixed species label was created. For example, due to the striking similarities between the two kelp species *Laminaria digitata* and *Hedophyllum nigripes* (Figure 4), one label was created, named "L. digitata/H. nigripes" to account for both.

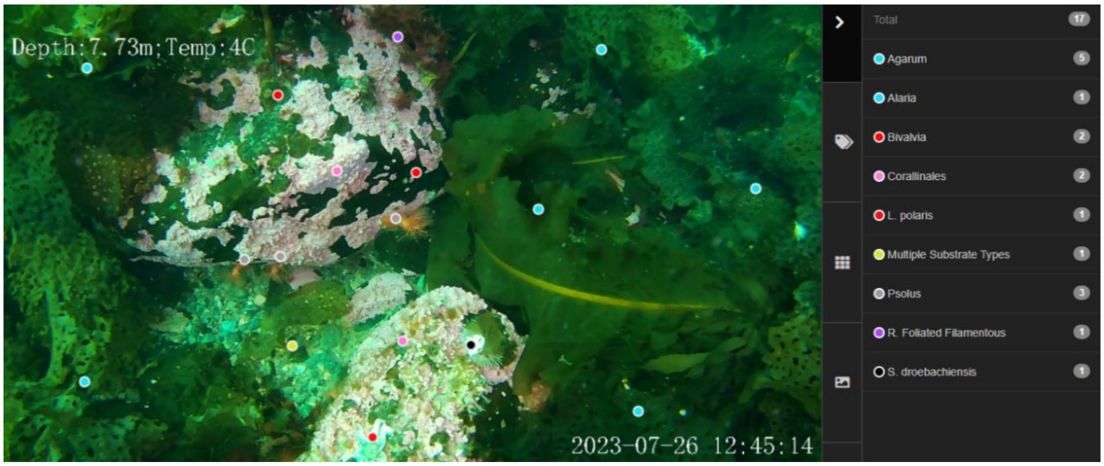

Figure 3. An example of the image annotations performed at the channel.

Figure 4. *Laminara digitata* (Struwe 2008, via iNaturalist; left). *Hedophyllum nigripes* (gsaunders 2017, via iNaturalist; right). The branching of the blade make these nearly indistinguishable.

A protocol was designed to explain the process of image uploading, project creation, and image annotation. As BIIGLE already contains a well-documented manual on their website, this protocol is not meant to serve as a user manual. Instead, it provides specific instructions for conducting similar analyses using footage gathered in nearshore areas (Appendix B). The protocol was reviewed and tested by someone with no prior experience using BIIGLE, and improvements were made to the protocol following their input.

3.0 RESULTS

3.1 Fauna

Across all six sites, 32 faunal taxa were identified , with 11 of them identified to the genus or species level (Table 4). Numerous brittle stars were observed within False Inlet, associated with the blades of *S. latissima*. Additionally, a dense aggregation of gastropods were observed on the beds of *A. clathratum* within the channel. Annelid worm casts were found throughout Fish Bay, and a single worm cast was found within the channel, although no annelids were observed around them. Within site 1 of the harbour, several adult cone worms (*Cistenides* sp.) were observed within the blade perforations of *A. clathratum* (Table 2). There are three species of cone worm which could have been observed: *C. granulata*, found in the Atlantic and Pacific oceans (Loewen et al. 2020b); *C. brevicoma*, ubiquitous across North America, but not currently documented around Chesterfield Inlet (GBIF.org 9 April 2024b); or *C. hyperborea*, which has been found in both the northeast Pacific Ocean and in Hudson Bay (Loewen et al. 2020b). Since each species appears as small worms coated in camouflaging sand particles, it is difficult to tell the species apart. The most likely identification for these annelids is *C. granulata* (McNicholl et al. 2024) or *C. hyperborea* (Loewen et al. 2020b); however, it is possible that *C. brevicoma* resides in the area, and has yet to be documented.

Three taxa of pelagic ctenophores were observed in the water column throughout most of the observed areas (Table 2). A large amount of unidentified blue, strand-like ctenophores, each with around four long, thin tentacles, presumably for locomotion, were observed floating in the water column throughout Fish Bay, as well as a small number within the water column of False Inlet (Table 2). These ctenophores were observed at depths below four meters, but most prevalent at a depth around five meters. In False Inlet, the ctenophores of class Tentaculata was observed towards the top of the water column. These individuals appeared to have tentacles consistent with an Arctic comb jelly, however their central masses were not positioned to allow proper identification. Arctic comb jellies were observed predominantly within site 1 of the harbour, but were also found at Fish Bay and False Inlet (Table 2).

Numerous individuals, often attached to the rock or sediment, were unable to be closely observed throughout the course of this study, often as a result of strong prevailing currents preventing the ROV from approaching safely. As an example, bivalves were observed throughout the study areas, although none were identified past the class Bivalvia. Bivalves were observed most often attached to boulders or coarse substratum; however, several observations were made of bivalves attached to *A. clathratum*, and one observation was made of a bivalve sitting in the sandy substratum. Two polyplacophorans were observed on the coarse substratum of the channel; however, identification beyond the class level was not possible (Table 2). Four taxa of ascidians were observed between Fish Bay and False Inlet, although they could not be further identified. Within False Inlet, two taxa, Ascidiacea sp. 3 and Ascidiacea sp. 4, were observed once each, attached to the same small boulder. In contrast, the remaining ascidian taxa were observed embedded in the soft sediments of both areas.

Three fish species were observed among the kelp (Figure 5), comprising three Arctic shanny (*Stichaeus punctatus*), three banded gunnel (*Pholis fasciata*), and an individual from an unknown species of cod (*Gadus* sp.). There was a further observation of an unknown Perciformes, which was assumed to be a banded gunnel. Additionally, a suspected cephalopod was observed within the channel (Figure 6), but consultation with taxonomic experts did not yield a definitive identification because it was partially occluded by kelp (Table 2).

Several taxa were only observed a nominal amount of times within the study. This included the sea star, *Leptasterias* sp. 3 which was observed only twice, both times within the channel, while *Leptasterias* sp. 1 and sp. 2 were each observed only once, with sp. 1 found within Fish Bay, and sp. 2 found within the channel. Further, a single unidentified feather duster worm, Sabellidae, was observed within the channel (Table 2).

No faunal species were observed within site 2 of the harbour. Brittle stars (Ophiuroidea) were the dominant faunal taxa when found, along with sea cucumbers (*Psolus* sp.). Within the channel, green sea urchins (*Strongylocentrotus droebachiensis*) were among the dominant species. Further, in both the channel and False Inlet, gastropods (*Littorina obtusata*, Gastropoda) were the dominant taxa (Table 5). Among all six sites examined, no scallops were observed. Fauna observations by site can be found in Appendix C.

Figure 12. Arctic shanny (*Stichaeus punctatus*, left) and banded gunnel (*Pholis fasciata*, right), among the kelp of the harbour, at approximate depths of 10 m.

Figure 13. A possible cephalopod observed between the rocks within the channel on July 26th, at a depth of approximately 7.2 m.

Table 8. Faunal species observed in each surveyed area.

	Chesterfield Inlet Harbour (CI-1)			False Inlet (CI-2)	Fish Bay (CI-3)	Channel (CI-4)
Observations	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**
Sabellidae	-	-	-	-	-	Y
***Cistenides* sp.**	Y	-	-	-	-	-
Ascidiacea sp. 1	-	-	-	-	Y	-
Ascidiacea sp. 2	-	-	-	Y	-	-
Ascidiacea sp. 3	-	-	-	Y	-	-
Ascidiacea sp. 4	-	-	-	Y	-	-
Perciformes	-	-	-	Y	-	-
***Gadus* sp.**	-	-	-	-	-	Y
Pholis fasciata	Y	-	-	-	-	-
Stichaeus punctatus	Y	-	-	-	-	Y
Cnidaria sp. 1	Y	-	-	-	-	-
Cnidaria sp. 2	-	-	-	-	-	-
Stauromedusae	Y	-	Y	Y	-	-
Ctenophora	-	-	-	Y	Y	-
Tentaculata	-	-	-	Y	-	-
Mertensia ovum	Y	-	Y	Y	Y	-
Asteroidea	-	-	-	Y	Y	Y
***Leptasterias* sp. 1**	-	-	-	-	Y	-
***Leptasterias* sp. 2**	-	-	-	-	-	Y
***Leptasterias* sp. 3**	-	-	-	-	-	Y
Leptasterias polaris	-	-	-	Y	-	Y
Strongylocentrotus droebachiensis	-	-	-	-	-	Y
***Psolus* sp.**	-	-	Y	Y	-	Y
Ophiuroidea sp. 1	Y	-	-	-	-	Y
Ophiuroidea sp. 2	-	-	-	Y	-	Y
Ophiuroidea sp. 3	-	-	-	Y	-	-
Ophiuroidea sp. 4	Y	-	-	Y	-	Y
Bivalvia	-	-	Y	Y	-	Y
Cephalopoda	-	-	-	-	-	Y
Gastropoda	Y	-	Y	Y	-	Y
Littorina obtusata	-	-	-	Y	-	-
Polyplacophora	-	-	-	-	-	Y

3.2 Flora

Across all six sites, 12 macroalgal taxa were observed, of which 9 were identified to the genus or species level (Figures 7 and 8). Additionally, six functional groups were identified across the six sites (Table 4). The dominant macroalgae overall were *S. latissima*, *A. clathratum*, *D. aculeata*, and *D. viridis,* which were found across most areas. Site 2 of the harbour was nearly devoid of all macroalgae, likely due to the substratum, which consisted entirely of soft sediments. Within site 2 of the harbour, sparse *S. latissima* was found. Furthermore, the only macroalgal species observed across all six sites was *S. latissima*, which was especially abundant in False Inlet. The macroalgae throughout this site appeared in large sections, interspersed with areas of soft sediment containing with no vegetation. Blades of *S. latissima* in this site were densely populated by brittle stars (Ophiuroidea sp. 4) and gastropods (*L. obtusata*) that were not observed elsewhere (Table 3). *A. clathratum* appeared in high quantities in the channel, blanketing most of the hard substrate, leaving only small patches with no vegetation. *A. clathratum* was found across all major areas, except site 2 of the harbour. In both site 3 of the harbour and in the channel, numerous rocks and boulders were seen encrusted with both brown and red crustose algae, with an additional sighting of Corallinales beside some ascidians on a boulder in False Inlet (Table 3). Encrusting algae (Ralfsiales and Corallinales) were also prevalent at site 3 of the harbour, as well as in the channel (Table 5). Macroalgae observations by site can be found in Appendix C. Appendix D contains a compendium of all macroalgae observed to the genus or species level, as well as the two crustose algae taxa.

Table 9. Macroalgal species observed in each surveyed area.

	Chesterfield Inlet Harbour (CI-1)			**False Inlet (CI-2)**	**Fish Bay (CI-3)**	**Channel (CI-4)**
Species Observed	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**
Brown Filamentous Algae	-	-	Y	Y	Y	-
Brown Foliose Algae	Y	Y	Y	-	-	-
Ralfsiales	-	-	Y	-	-	Y
Desmarestia aculeata	Y	-	-	Y	Y	-
Desmarestia viridis	Y	-	-	Y	-	Y
***Fucus* spp.**	Y	-	Y	-	Y	-
Agarum clathratum	Y	-	Y	Y	Y	Y
Alaria esculenta	Y	-	Y	-	-	Y
Laminariaceae	Y	-	Y	-	Y	-
Laminaria digitata / Hedophyllum nigripes	-	-	Y	-	-	Y
Laminaria solidungula	Y	-	-	-	-	-
Saccharina latissima	Y	Y	Y	Y	Y	Y
Green Filamentous Algae	-	Y	-	-	-	Y
Corallinales	-	-	Y	Y	-	Y
Palmaria Palmata	Y	-	-	Y	-	-
Red Filamentous Algae	Y	-	Y	Y	-	Y
Red Foliated Filamentous Algae	Y	-	-	-	-	Y
Red Foliose Algae	Y	-	Y	Y	Y	Y

Table 10. Total number of species and taxa identified in each area.

Observation Type	Chesterfield Inlet Harbour (CI-1)	False Inlet (CI-2)	Fish Bay (CI-3)	Channel (CI-4)
Number of Fauna Identified to genus or species level	5	4	2	7
Total number of Faunal Taxa Identified	11	18	5	16
Number of Macroalgae Identified to genus or species level	9	5	4	5
Total number of Macroalgal Taxa Identified	12	6	5	7
Number of Macroalgal Function Groups Identified	6	3	2	4

Table 11. Dominant Macroalgal and Faunal Taxa within each area.

Site #	Dominant Macroalgal Taxa	Dominant Faunal Taxa
The harbour (CI-1)	*S. latissima*, *D. aculeata*, *A. clathratum*, Corallinales, Ralfsiales	Gastropoda, Ophiuroidea sp. 1, *Cistenides* sp., *Psolus* sp.
False Inlet (CI-2)	*S. latissima*	Ascidiacea sp. 2, Ophiuroidea sp. 1, *Psolus* sp.
Fish Bay (CI-3)	*S. latissima*, *D. aculeata*	Ctenophora
Channel (CI-4)	*A. clathratum,* Ralfsiales, Corallinales, *A. esculenta*	Ophiuroidea sp. 1, Gastropoda, Bivalvia, *Psolus* sp.

3.3 Environment

There were large amounts of particulate matter in the water column within the harbour, as well as a moderate amount in False Inlet, reducing visibility (Table 6). Within the harbour, the substratum of site 1 was entirely obscured by vegetation (Figure 10), in direct contrast to sites 2 and False Inlet, which consisted entirely of soft sediments (Table 6). False Inlet had one area with substratum that was either bedrock, or a clay deposit, but could not be identified as it was only observed for a short time, with a large amount of motion blur obscuring it. In Fish Bay, extensive mats of undetermined brown filamentous macroalgae laden with large amounts of sediment were observed (Table 6, Figure 10), as well as red foliose macroalgae (Table 3). Where vegetation grew outside of these sediment-laden mats, the substratum was almost completely obscured. Areas without growth revealed a substratum of predominately soft sediments, with small boulders also present. The substratum consisted of coarse sediments and boulders, within site 3 of the harbour, as well as in the channel (Table 6, Figure 10). Shell hash, a layer of small shells the size of pebble gravel, was found in the channel; however, due to a lack of substratum footage in site 3 of the harbour, the presence of shell hash could not be confirmed there. The harbour had the highest degrees of vegetation cover, with site 1 having complete vegetation cover, and 3 having cover predominately over 50%, which is also consistent with the vegetation cover found within the channel. In contrast, Fish Bay and False Inlet had sections of high cover, broken up by sections of soft sediments with low cover, overall averaging less than 50% cover within the areas (Figure 11). Additionally, within site 1 of the harbour, two articles of trash were observed: a blue solo cup, and food packaging (Table 6).

Table 12. Site specific characteristics observed in each surveyed area.

	Noted Characteristics	**Chesterfield Inlet Harbour (CI-1)**			**False Inlet (CI-2)**	**Fish Bay (CI-3)**	**Channel (CI-4)**
Label Tree Categories		**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**
Habitat Notes	**Detritus**	-	Y	-	-	-	-
	Soft Sedimentation Mat	-	-	-	Y	Y	-
	Trash	Y	-	-	-	-	-
	Worm Casts	-	-	-	-	Y	Y
	Isolated Shell Hash	-	-	-	-	Y	-
Substratum	**Multiple Substrate Types**	-	-	Y	-	Y	Y
	Soft Sediments	-	Y	-	Y	Y	-
	Undetermined Substratum	Y	-	-	Y	Y	-
Vegetation Cover %	**0-1% Vegetation**	-	Y	-	-	Y	-
	1-25% Vegetation	-	-	Y	Y	Y	Y
	25-50% Vegetation	-	-	Y	Y	Y	Y
	50-75% Vegetation	-	-	Y	Y	Y	Y
	75-100% Vegetation	Y	-	Y	Y	Y	Y
Visibility	**Excellent Visibility**	Y	Y	-	-	-	Y
	Good Visibility	Y	Y	Y	Y	Y	Y
	Fair Visibility	Y	Y	Y	Y	Y	Y
	Low Visibility	Y	Y	Y	Y	Y	Y
	No Visibility	Y	-	Y	Y	-	-

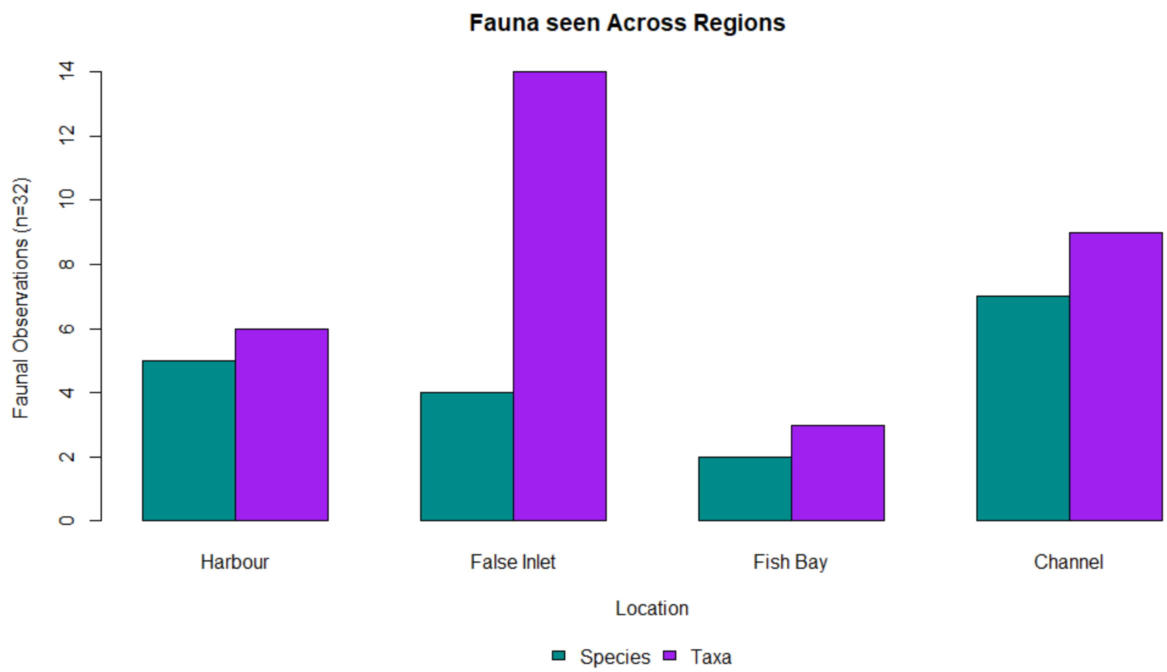

Figure 14. The number of unique animal species and animal taxa that were identified across all four areas.

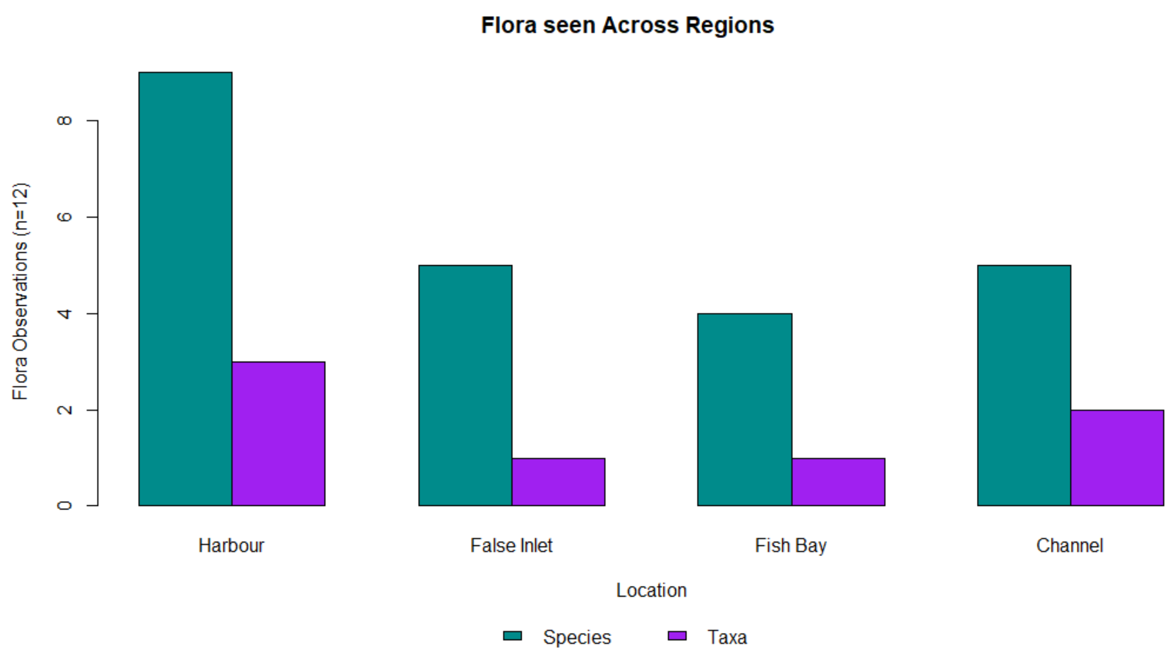

Figure 15. The number of flora species, higher taxa, and functional groups that were identified across all four areas.

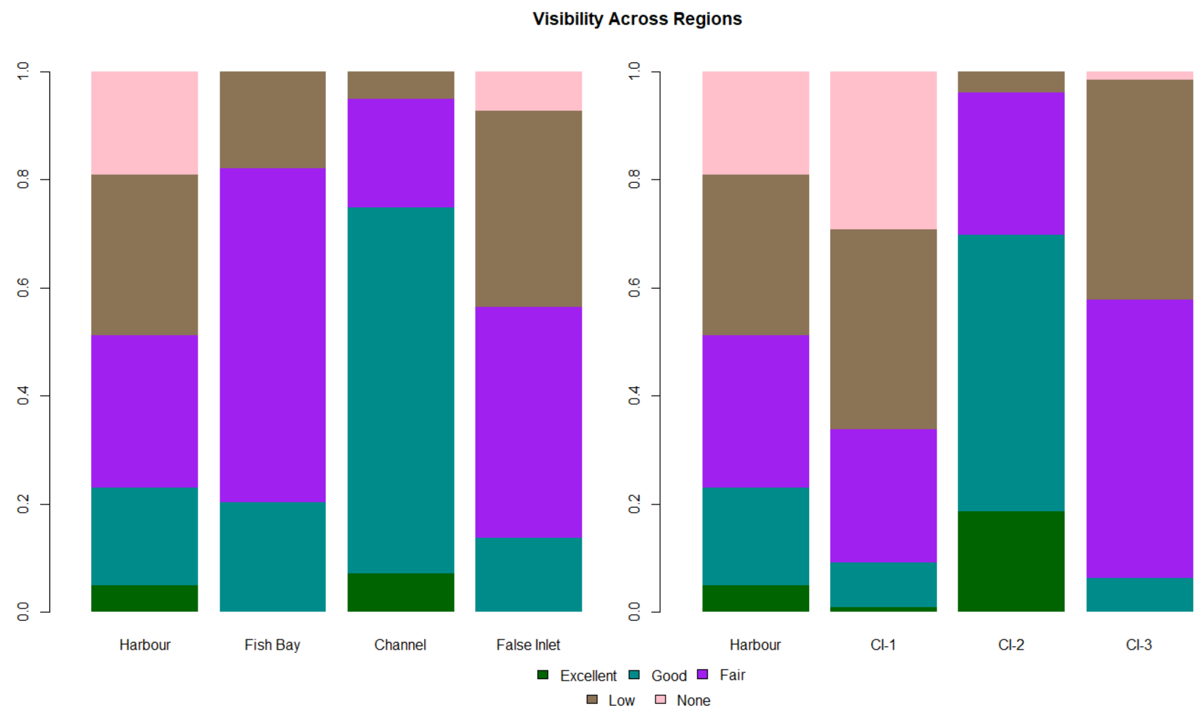

Figure 16. Cumulative percentage of all visibility categories in all four areas, as well as compared within all three sites of Chesterfield Inlet Harbour.

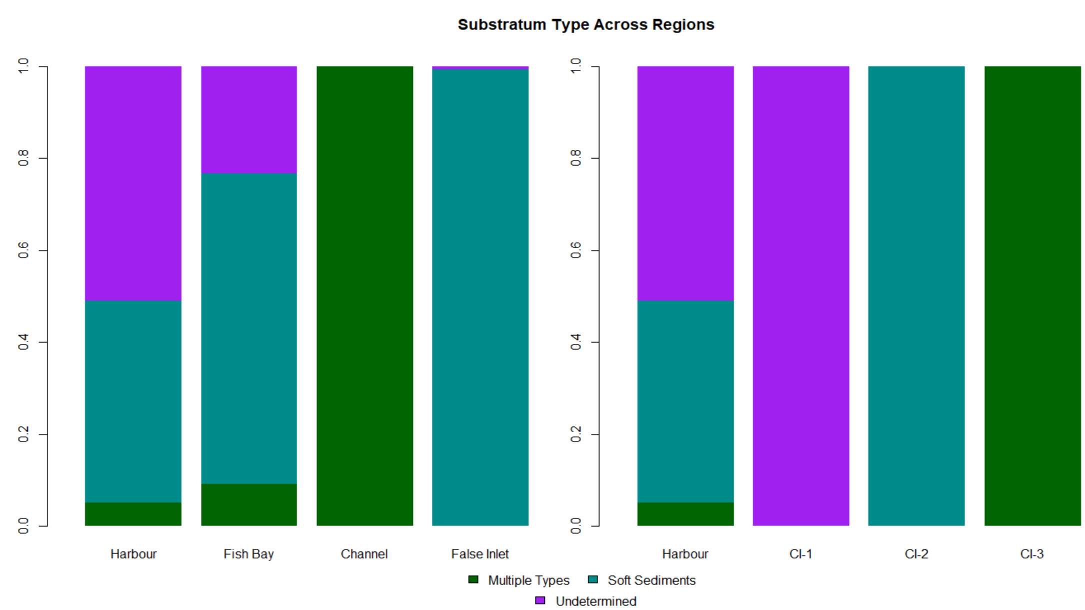

Figure 17. Cumulative percentage of all substratum categories in all four areas, as well as compared within all three sites of Chesterfield Inlet Harbour.

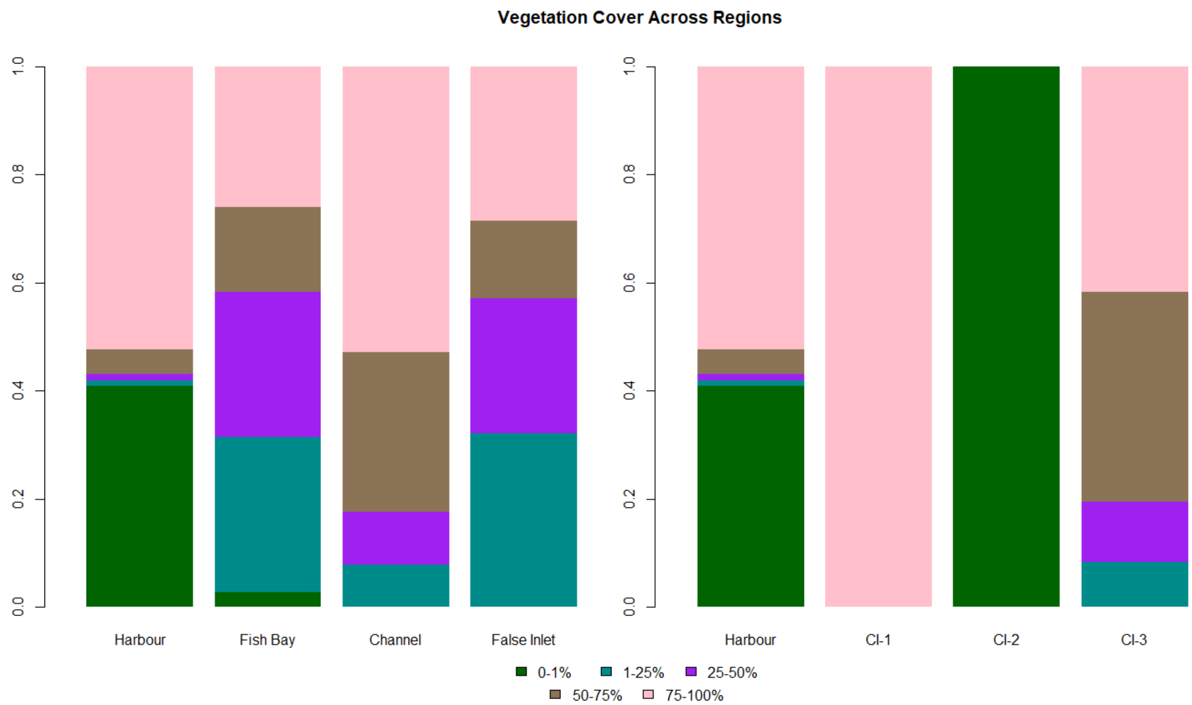

Figure 18. Cumulative percentage of all vegetation coverage categories in all four areas, as well as compared within all three sites of Chesterfield Inlet Harbour.

4.0 DISCUSSION

4.1 Fauna

Published nearshore data surrounding the benthic community composition around Chesterfield Inlet is limited, with studies at depths > 40 m. This study addresses data gaps at shallower depths (<20 m) and contributes to a baseline understanding of species occurrence and habitat composition around Chesterfield Inlet. We identified the presence of 32 faunal taxa, although many of the organisms identified in this study could not be identified to the genus or species level, and require future studies to identify them. As such, a voucher program for specimen collection would be helpful, allowing both a confirmation of observed species present, and an indication of presence for individuals not observed within this study.

While scallops were not found within the study areas, sea cucumbers and sea urchins were observed. As such, further study should assess the viability of local fisheries focused on these species, given the local interest in developing a fishery. In other regions, there is significant research surrounding the potential for sea urchin fisheries, with the predominant interest focused on the gonads, the only edible section. There are also markets centered on the entire sea urchin, which could be of interest to the community (Sato et al. 2017; Stefánsson et al. 2017). While sea cucumber fisheries support a growing market exported largely to Asia, there are concerns regarding a potential fishery collapse. Sea cucumber fisheries tend to follow a “boom and bust” cycle, and under poor management, this can lead to the collapse of the fishery (Uthicke et al. 2009; Purcell et al. 2013; Rogers et al. 2018; Eggertsen et al. 2020). With these concerns at the forefront, further research should explore the viability of a sea cucumber fishery within the waters around Chesterfield Inlet.

4.1.1 Annelida

The genus of cone worm (*Cistenides* sp.) was the predominant annelid species observed throughout the study, and was found exclusively within the harbour. Interestingly, these cone worms were found inside the perforations of *A. clathratum* blades, although there is currently no documented association between the two species. The observed worms appeared to be fully developed adults, making it unique to find them among the kelp, instead of deposit-feeding in sediments as they are normally believed to do (Whitlach and Weinberg 1982). It is unclear whether this association arises by chance, or as a result of habitat selection at the planktonic larval stage or other life-history phase and requires further research.

While worm casts were spotted within Fish Bay and False Inlet, no annelids were spotted near them. Many benthic marine annelids are infaunal species (Alves et al. 2018; Glasby et al. 2021; Worsaae et al. 2021), making it difficult to observe them directly with ROV footage. As such, different methods of data collection, such as ponar grabs, may be required to properly assess the benthic annelid compositions around Chesterfield Inlet.

4.1.2 Chordata

Few fish species were observed throughout the study areas, predominately the Arctic shanny, and banded gunnel. While an unidentified cod was observed within the channel, and an unknown Perciformes was observed in False Inlet, the three banded gunnels and three Arctic shanny were observed in unique environments. They were predominately observed within an area of the harbour without any visible hard substrate, which is unusual as both species are believed to prefer environments consisting of large boulders and a gravel or muddy substrate (Brown and Green 1976; Jewett et al. 1995; Coad and Reist 2018). While the various macroalgae of the area obscured any presence of gravel or mud, there were no boulders observed at all within the area, making it an unexpected location for both species to be observed. Furthermore, banded gunnels are thought to prefer depths between 30 m and 40 m (Coad and Reist 2018), making it unusual to observe in an area only 10 m deep. One Arctic shanny was observed by a bed of *A. clathratum* in the channel. As Arctic shanny prefer gastropods, it is unsurprising to observe one here, considering the large presence of gastropods on the kelp (Coad and Reist 2018).

Several different taxa of Ascidiacea were observed across the study sites, although they could not be identified further. No tunicates were observed within the harbour or channel, although it is possible they were obscured by heavy vegetation cover. Considering most Ascidiacea are filter feeders (Fiala-Médioni 1978), it seems likely that the high presence of Ascidiacea sp. 2 reflects a high concentration of plankton in the area. Furthermore, the high presence of suspension feeding brittle stars in the area would also suggest a high concentration of plankton.

4.1.3 Cnidaria

Three taxa of Cnidarians were observed throughout the course of this study, predominantly stalked jellies (Order Stauromedusae). As this was a pilot study, however, little time was spent within the harbour. It is very likely that there are other Cnidarian species that are present in the area that were not observed, either due to foliage cover from macroalgae, visibility constraints, low seasonal abundance, or were otherwise not captured within the footage. Both the harbour and the channel had dense foliage cover which could have obscured Cnidarians, as well as other taxa, from view. Additionally, due to a strong current within areas of the harbour, the ROV was unable to move closer to the seafloor, which could have prevented the observation of several taxa. The most likely areas for cnidarians to be found would be areas of coarse or rocky substrata, such as the channel and areas of the harbour, or the sandy substrata of Fish Bay, False Inlet, and other areas of the harbour (Gili and Hughes 1995; Gimenez and Brante 2021; Meyer-Kaiser et al. 2021).

4.1.4 Ctenophora

The ctenophores that were observed were all pelagic. The information summarized in this report helps elucidate the presence of the taxa *Mertensia ovum*, Tentaculata, and Ctenophora around Chesterfield Inlet.

4.1.5 Echinodermata

Echinoderms were widely distributed around Chesterfield Inlet, with the largest number of taxa present in the channel. Brittle stars (Ophiuroidea) were the most common invertebrate found, present at each site except Fish Bay. In False Inlet, the brittle star taxa Ophiuroidea sp. 4 was found in substantially higher quantities than the other sites visited, but without close observation of the oral side, a more specific identification was not possible, even with the larger number of individuals. It is suspected that abundance of *S. latissima*, grown much larger here than in any other observed site, has facilitated a greater observed abundance of brittle stars. As many brittle stars are suspension feeders (Volage et al. 2021), it is possible that they are taking advantage of the elevated height the kelp provides to feed higher in the water column, taking advantage of the greater amount of water movement.

Among other Echinoderms, sea cucumbers (*Psolus* sp.) were observed in large numbers across all areas except Fish Bay, attached to the hard substrata. Unfortunately, their colouration could not be adequately distinguished to confirm species. Past surveys have confirmed *Psolus fabricii* at sites near Chesterfield Inlet, and it is possible that the individuals observed in this study were *P. fabricii* (DFO 2020). The green sea urchin (*S. droebachiensis*) was only found within the channel, but was seen numerous times. Considering their preference for coarse substratum, and with *S. latissima* being a preferred food (Vadas 1977; Larson et al. 1980; Gagnon et al. 2005), their absence from the harbour is notable. Due to low volume of footage, however, it is possible that the green sea urchin is present, and that it was simply not observed. While sea stars (Asteroidea) were observed everywhere except the harbour, the majority of them were observed within the channel. This is not surprising, as this site also contained the most observations of their primary food sources, bivalves and gastropods, as well as their secondary food sources, such as sea cucumbers, brittle stars, and sea urchins (Gaymer et al. 2001a, 2001b; Baeta and Ramón 2013; North et al. 2019).

4.1.6 Mollusca

The high density of gastropods on *A. clathratum* in the channel is surprising, as many gastropods are thought to accumulate on *A. clathratum* in the winter months, rather than in the summer (Dubois and Iken 2012; Blain and Gagnon 2014). Phlorotannins are secondary metabolites produced by kelp as a means to deter grazers, such as gastropods, with especially high concentrations of phlorotannins occurring in the blades of *A. clathratum* during the summer (Dubois and Iken 2012; Blain and Gagnon 2014). Grazing studies on fucoids by gastropods such as *Littorina obtusata*, show that grazing causes increased phlorotannins in the fucoids, reducing overall grazing efforts by *L. obtusata* (Pavia and Toth 2000). While *L. obtusata* may relocate to find an alternative food patch, the same effect is not always observed among gastropods, (e.g., *Littorina littorea*) (Putnam and Peckol 2018). Further research should be done to determine whether the species of gastropods in the channel are the same as those in False Inlet, and determine the effects of phlorotannins on these species.

Although one of the main goals of this survey was to identify scallops around Chesterfield Inlet, no scallops were found throughout any of the examined areas. Scallops are usually found at depths between 10-100 m, although models surrounding Chesterfield Inlet suggest they are more likely at depths greater than 40 m (Misiuk and Edinger 2017).

In the channel, a possible cephalopod was observed within a bed of *A. clathratum*, attached to a large boulder and partially hidden beneath kelp cover. The individual did not attempt to hide from the ROV, nor did it seem to acknowledge the ROV in any way. Octopodes have never been observed in the area before, and would be a novel observation to occur in this nearshore area, with a depth of about eight meters.

4.2 Flora

Across the study sites, large areas of soft sediment were found, accompanied with lower vegetation cover. Macroalgae prefer areas with hard substrate for the holdfast to latch onto, with areas of soft sediment limiting their distribution (Hamm and Humm 1976; Coutinho and Seeliger 1984; Middelboe et al. 2002). Further, while some macroalgae can grow in shallower waters, ice scour occurring over the winter can prevent long-term macroalgal growths, limiting species abundance and diversity at shallow depths (Filbee-Dexter et al. 2022). Macroalgae were most extensive and abundant in the harbour and channel (> 50% cover), and shared many of the same species, such as *S. latissima*, *A. clathratum*, and *A. esculenta*. Moreover, the harbour was observed to contained individuals from each macroalgal taxa found throughout this study. The macroalgae of the harbor tended to be substantially smaller than was seen in any other occupied site, and was much more densely packed. Due to poor visibility throughout the area, however, proper observation of much of the macroalgae, especially the red macroalgae, could not be determined. Furthermore, many species of red macroalgae, especially filamentous ones, can only be distinguished with microscopy, preventing any distinctions from being made in ROV footage. The predominately soft sediment substrate of Fish Bay and False Inlet provided similar proportions of vegetative coverage, with most of the stills showing less than 50% macroalgal cover.

Several macroalgae species are known to be present in the waters around Chesterfield Inlet, including the kelp *Laminaria solidungula*, which is thought to be present in high abundance in the area (Filbee-Dexter et al. 2019). However, *L. solidungula*, was only observed within the harbour of Chesterfield Inlet among our sampling sites.

The predominant macroalgae observed were *S. latissima*, *A. clathratum*, *D. aculeata* and *D. viridis*, along with the two crustose algae taxa, Ralfsiales and Corralinales. Throughout both the harbour and channel, large amounts of crustose algae were found covering boulders, which were further covered with bivalves. Within these sites, *S. latissima* was often found in small patches, except for False Inlet, where it was observed forming large kelp beds. Similarly, *A. clathratum* was observed in small clusters, except for the channel, where it blanketed the seafloor in an extensive kelp bed. Over the course of this study, 12 taxa of macroalgae were identified, with 9 identified to at least genus level.

4.3 Environment
The substratum around Chesterfield Inlet varied among study sites, but was relatively consistent within each area. The harbour was found to have diverse substrate types, from coarse sediments with boulders encrusted with coralline algae, to fine soft sediments devoid of vegetation. Fish Bay and False Inlet predominately consisted of soft sediment substrata, and within Fish Bay, the underlying substrata was often obscured by sediment-laden mats bound by thin algal growths. Additionally, visibility varied among the areas, with the harbour having the lowest visibility, making it difficult to positively identify some individuals. In contrast, the channel had the best visibility of all four areas, and allowed for more precise identifications. Visibility at each site was in part limited by the time of day and weather conditions, given that the harbour was surveyed late in the day on July 25th, and the channel was surveyed at mid-day with clear skies on July 26th, 2023.

4.4 Project Limitations
While video footage provides an approach to collecting benthic data without removing organisms or seafloor samples, much information remained unobserved regarding the benthic environment. Benthic Annelids and Cnidarians were unlikely to be observed with an ROV, as they tend to reside either within the substrata, or under the macroalgal foliage, obscuring them from view. Further, the primary characteristics of ascidians are difficult to differentiate in ROV footage, preventing proper identification. Ponar grabs and other physical sampling methods (e.g., diving surveys) offer the opportunity of acquiring occurrence data on cryptic taxa and species difficult to identify *in situ*.

The ROV did not have the capability to travel on a set transect with a constant downward view, nor was it outfitted with scaling lasers. An ROV equipped with these abilities would be better suited to more accurately assess vegetation coverage than was possible in this study. Furthermore, scaling lasers would have allowed individuals to be categorized by size, and would additionally allow density estimates to be performed, providing further opportunities for comparisons between areas and transects. As a the ROV was not equipped with these mechanics, only presence/absence data could be collected from the ROV footage.

4.5 Recommendations on using an ROV for BIIGLE Annotation
The process of developing this protocol, and annotating footage collected among Arctic coastal sites provides insight into how these techniques may be used in future ROV surveys. This study recommends the following to optimize underwater footage for annotation in BIIGLE:

1. To assess abundance of the dominant taxa, a transect should be performed, otherwise only presence/absence can be determined
2. As a transect requires the ROV to maintain a set distance above the seafloor, it is not possible to examine individual organisms clearly, or from multiple angles. As such, we suggest that in addition to the transect, time should be allotted for the ROV to explore the seafloor, stopping to provide different angles of observed individuals, as well as allowing for time to observe the behaviour of the observed fauna.
3. A standardized time should be allotted for ROV deployment at each site, to best maximize the possibility of observing individuals previously undocumented for the area.

4. Light availability and turbidity heavily affect the ability to observe and identify benthic species. When possible, the studies should be performed unnder high light availability, and low turbidity, to increase visibility as best as possible.
    a. Note that high light availability with high turbidity will reduce visibility, as the light scatters off the particles.
5. We recommend to perform future studies in calm water, such as in between tides, as currents can make it difficult to pilot the ROV, preventing it from exploring the seafloor.
6. The addition of scaling lasers to the ROV will provide data on the size of various invertebrates and macroalgae, allowing more informed comparisons between research areas.
7. To make the footage more clear during analysis, ensure the footage was filmed at 30 frames per second or greater, with the ROV operating at a speed slow enough to prevent motion blur.
8. To confirm ROV assessment, we recommend taking physical samples in the same areas. An ideal physical specimen of macroalgae should include the holdfast, stipe, and an intact blade.

5.0 Conclusion

This pilot study successfully identified several benthic floral and fauna species on the nearshore benthic community around Chesterfield Inlet, and included the additional observation of several pelagic invertebrates, and demersal fish species. Substratum data and vegetation cover data were collected in order to categorize the habitat, and revealed areas of large macroalgal growth with hard substrata, as well as areas with low macroalgal growth with soft substrata.

This study observed several interactions that raised several new research questions. For instance, dense dwelling brittle stars that were associated with large sugar kelp beds. Similarly, gastropods were observed in large numbers on sieve kelp beds during the summer, when they are usually present in the winter in northern latitudes. Moreover, cone worms were found inside the perforations on sieve kelp, potentially signalling a previously undocumented linkage between these species. The video footage from this study also revealed the possible presence of an octopus among the nearshore waters.

Information compiled in this report serves to document species occurrence among benthic sites selected by the AHTO near Chesterfield Inlet. The knowledge gained and summarized here, adds to our understanding of the existing species and their associated habitats in the Southampton Island Area of Interest.

6.0 Acknowledgements

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Appendix A – BIIGLE Label Tree

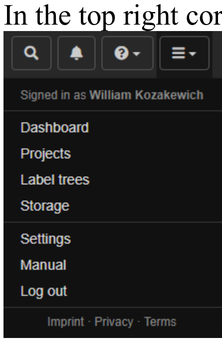
Table A1: Label tree from BIIGLE, used to annotate footage and assign labels to the habitat, as well as the observed individuals within.

Fauna	**Annelida**	**Polychaeta**	**Terebellida**	**Pectinariidae**	**Cistenides**
			Sabellida	Sabellidae	
	Chordata	Teleostei	Perciformes	Pholidae	*Pholis fasciata*
				Stichaeidae	*Stichaeus punctatus*
		Ascidiacea	Ascidiacea sp. 1		
			Ascidiacea sp. 2		
			Ascidiacea sp. 3		
			Ascidiacea sp. 4		
	Cnidaria sp. 1				
	Cnidaria sp. 2				
	Cnidaria	Staurozoa	Stauromedusae		
	Ctenophora	Tentaculata	Cydippida	Mertensiidae	*Mertensia ovum*
	Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Leptasterias* sp. 1
					Leptasterias sp. 2
					Leptasterias sp. 3
					Leptasterias polaris
		Echinoidea	Camarodonta	Strongylocentrotidae	*Strongylocentrotus droebachiensis*
		Holothuroidea	Dendrochirotida	Psolidae	*Psolus* sp.
		Ophiuroidea sp. 1			
		Ophiuroidea sp. 2			
		Ophiuroidea sp. 3			
		Ophiuroidea sp. 4			
	Mollusca	Bivalvia			
		Cephalopoda			
		Gastropoda			
		Polyplacophora			
Flora	Brown Macroalgae	B. Filamentous			
		B. Foliose			
		Ralfsiales			
		Desmarestiales	Desmarestiaceae	*Desmarestia aculeata*	
				Desmarestia viridis	
		Fucales	Fucaceae	*Fucus* spp.	
		Laminariales	Agaraceae	*Agarum clathratum*	
			Alariaceae	*Alaria esculenta*	
			Laminariaceae	*Laminaria digitata/Hedophyllum nigripes*	
				Laminaria solidungula	
				Saccharina latissima	
	Green Macroalgae	G. Filamentous			
	Red Macroalgae	Corallinales			
		Florideophyceae	Palmariales	Palmariaceae	*Palmaria palmata*
		R. Filamentous			
		R. Foliated Filamentous			
		R. Foliose			

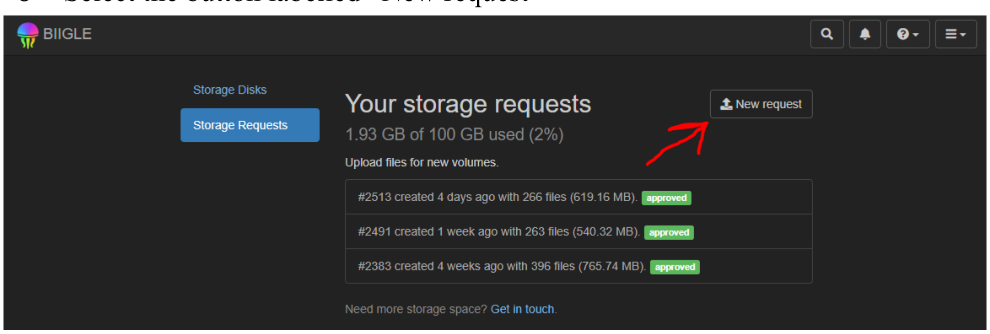
Habitat Notes	Detritus
	Shell Hash
	Soft Sedimentation Mat
	Trash
	Worm Casts
Substratum	Boulders
	Coarse Sediment
	Multiple Substrate Types
	Soft Sediments
	Undetermined Substratum
Unknown	
Vegetation Cover %	0-1% Vegetation
	1-25% Vegetation
	25-50% Vegetation
	50-75% Vegetation
	75-100% Vegetation
Visibility	Excellent Visibility
	Fair Visibility
	Good Visibility
	Low Visibility
	No Visibility

Appendix B – Video Analysis Protocol

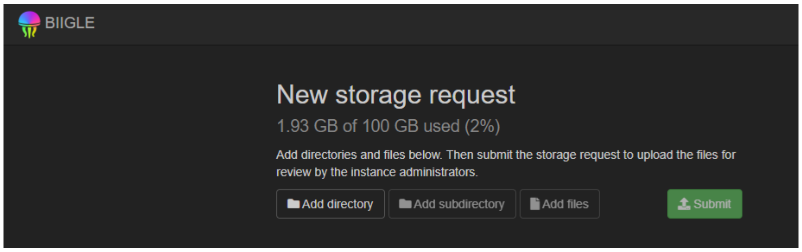
1. Review footage in VLC
2. Take note of, and where applicable, mark the timestamps of:
    - What organisms you see
    - The number of each fauna species seen (as macroalgae are too plentiful to count, and it is unclear where one organism ends, and another begins)
    - Take note of habitat conditions (what kind of seabed is it, where are things growing in it)
3. Decide on an interval of time to take screenshots with. Our footage had a lot of motion caused by the currents, along with the motion from the ROV, so our interval was 5 seconds.
4. Using VLC, take a snapshot of the video along the interval decided in step 3.
    - The snapshot button can be found pressing View -> Advanced Controls. This opens an extra bar at the bottom of the screen with a camera icon
5. Label these snapshots according to some naming convention. As an example, mine is as follows:
    - Location-SiteID-Year-CameraType-BT-FileName-Timestamp
        - Where Site ID's are the names of the waypoints being evaluated
        - Where Camera type is either ROV, or downward (DW)
        - Where BT represents that this is a benthic analysis
        - Where Timestamp is measured in minutes (m) and seconds (s)
    - An example of this would be: Chesterfield Inlet-181-2023-ROV-BT-NORM0001-0m0s
        - *Note: Our SiteIDs were adjusted after the creation of this protocol*
6. Create a BIIGLE account (https://biigle.de/)
    - BIIGLE will need to authorize your account before you can upload images. You will need to wait until you are verified on BIIGLE's end
7. Upload into BIIGLE
    - In the top right corner of BIIGLE, select the box with 3 lines, and then select "Storage"

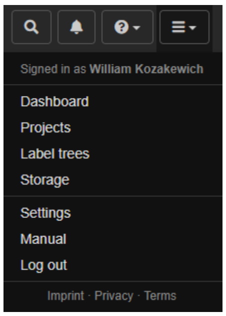


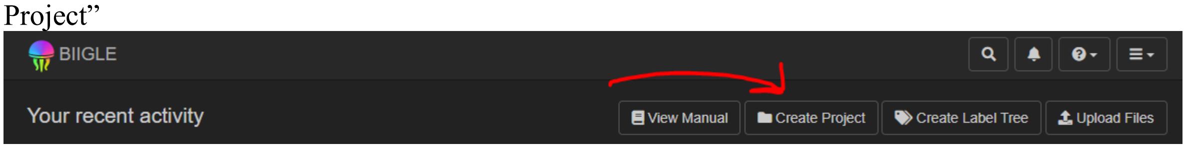
    - Select the button labelled "New request"



    - Add directories and sub directories as needed
        i. Suggested to make a directory for each site, and a subdirectory for each video of that site. Fill the subdirectory with the stills of that relevant video, and fill the directory with all the subdirectories made for the relevant videos of that site.

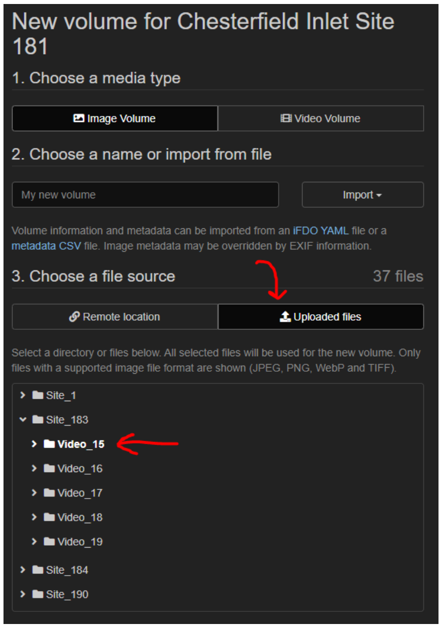
- 

- Once you've made your storage request, you will need to wait until BIIGLE approves it. This is usually done within one business day
- Once the request has been approved, select the box with 3 lines again, and this time select "Dashboard"
- 

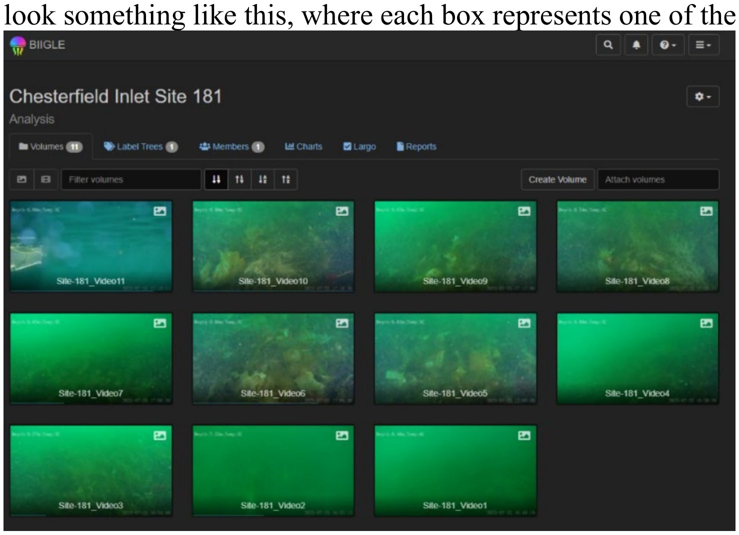
- This will create a new panel at the top of the screen; from this menu, select "Create Project"
- 

- Once the project has been created, select the button "Create Volume"
- 

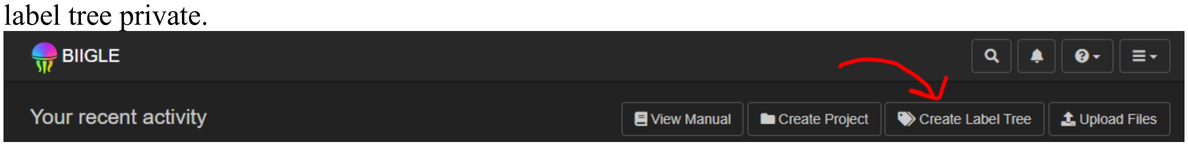
- In the menu for creating a new volume, select "Uploaded files" to use the files you've uploaded into storage. You won't be able to select the full directory containing all the subdirectories for that site, so instead, select one of the subdirectories, name it, and upload the subdirectories one by one, each as a new volume



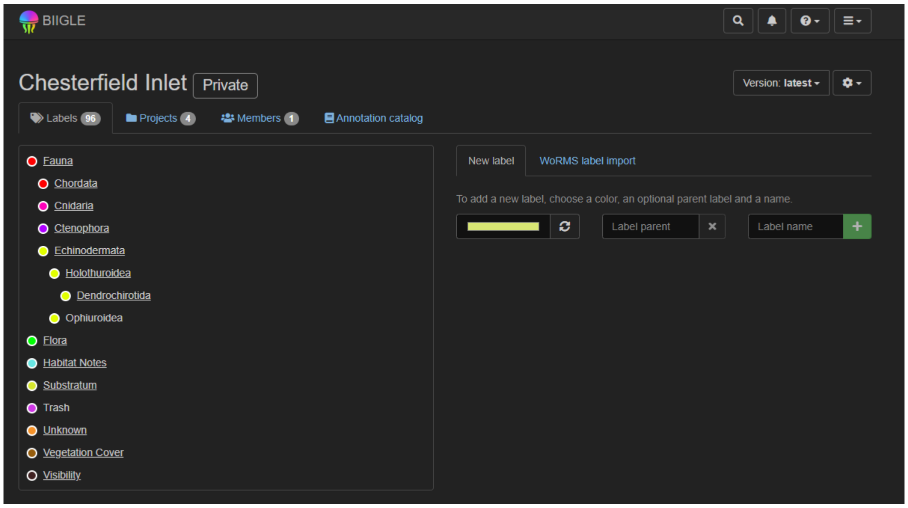
- Once you've done the above, the "Volumes" tab of the new project you've created should look something like this, where each box represents one of the subdirectories uploaded:



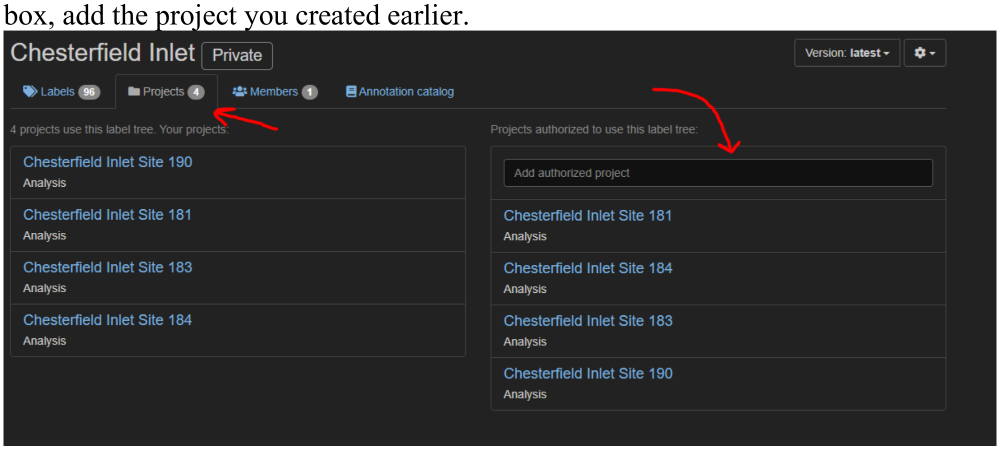
- Now we need to create a label tree so that we can label the stills we just uploaded. Return to the dashboard, and this time, select "Create Label Tree". It is suggested to keep the label tree private.



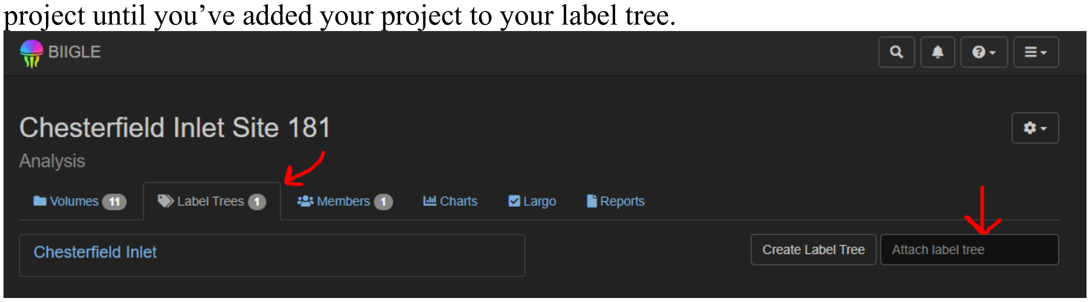
- From here, create a label tree that suits your needs. It's suggested to flow down your labels so that you can label at the order or family level if you're unable to label more specifically. Here's an example from mine, showing each label as a parent label, containing multiple children labels which also have children labels.



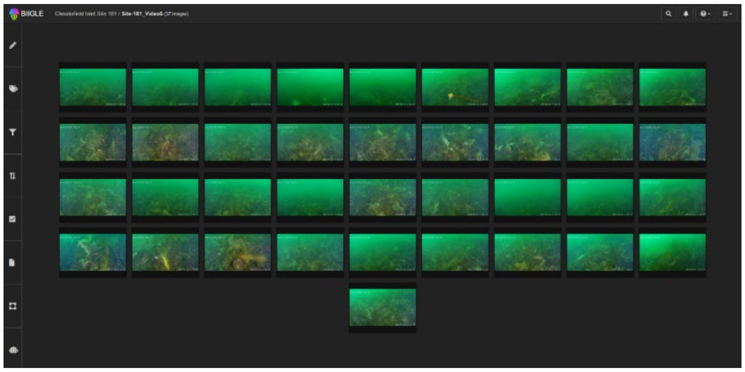
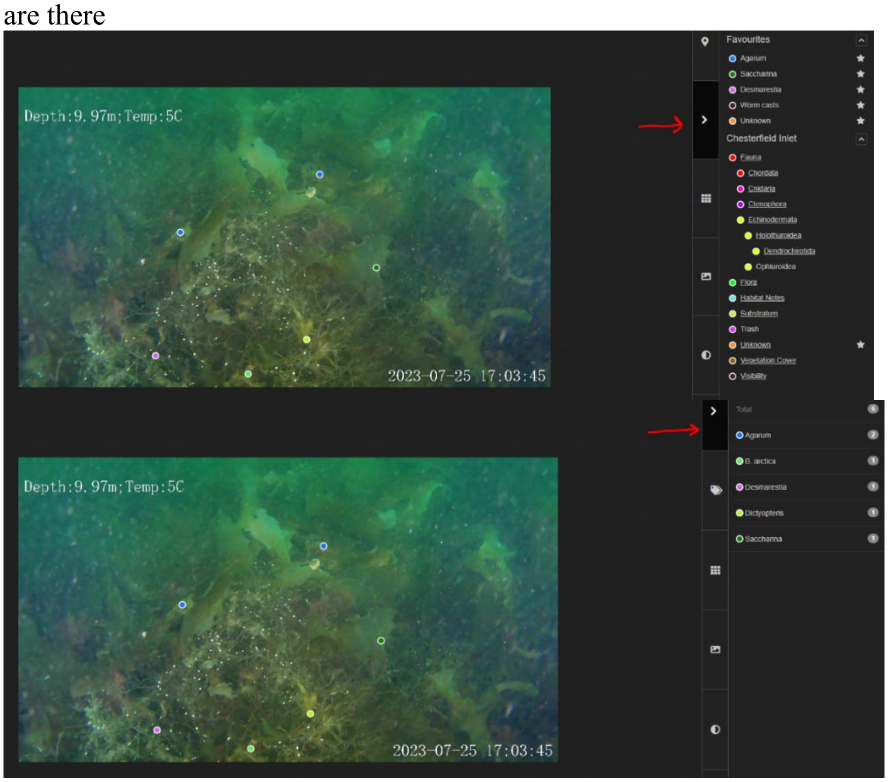
- In that menu, select "Projects" from the top bar, and then in the "Add authorized project" box, add the project you created earlier.



- Now, return to the project you created earlier (which can be accessed via the dashboard, or by clicking the "Projects" button of the three line box shown earlier. Once in the project, select the "Label Trees" box, and then in the "Attach label tree" box, add the label tree that you've just created. You won't be able to add your label tree to your project until you've added your project to your label tree.



- Returning back to the "Volumes" tab of this project, select one of the uploaded files. Once that's done, it should look something like this:

- 
- These are all of the uploaded stills for that video. Remember the subdirectories from earlier? This video is one of those subdirectories, and these stills are the files inside it! To practice labelling, select one of the stills.
- There are several tabs on the right. The one second from the top has your label tree. The one above it shows the labels that you've already put on the still, and how many of them are there
- 

- There is a small bar at the bottom middle of the screen, which will be required to start labelling. The left-most two buttons swap between stills in the subdirectory. Third from the left is the main button which will be used. When you select a label from the label tree on the right bar from earlier, and select the circle from the bottom middle bar, you can then select anywhere on the screen to drop a circular label there, labelling the object. You can then see this label in the bar on the right, shown earlier.

Appendix C – Data Tables

Table C1. Different macroalgae identified throughout the Chesterfield Inlet Harbour, to the lowest taxonomic level.

Class	**Order/Functional Group**	**Family**	**Genus/Species**	**Sites Found**
Phaeophyceae	Desmarestiales	Desmarestiaceae	*Desmarestia aculeata*	1
Phaeophyceae	Desmarestiales	Desmarestiaceae	*Desmarestia viridis*	1
Phaeophyceae	Fucales	Fucaceae	*Fucus* spp.	1, 3
Phaeophyceae	Laminariales	Agaraceae	*Agarum clathratum*	1, 3
Phaeophyceae	Laminariales	Alariaceae	*Alaria esculenta*	1, 3
Phaeophyceae	Laminariales	Laminariaceae	*Laminaria digitata/ Hedophyllum nigripes*	1
Phaeophyceae	Laminariales	Laminariaceae	*Laminaria solidungula*	1
Phaeophyceae	Laminariales	Laminariaceae	*Saccharina latissima*	1, 2, 3
Phaeophyceae	Laminariales	Laminariaceae		1, 3
Phaeophyceae	Ralfsiales			3
Phaeophyceae	Filamentous			3
Phaeophyceae	Foliose			1, 2, 3
Chlorophyta	Filamentous			2
Florideophyceae	Corallinales			3
Florideophyceae	Palmariales	Palmariaceae	*Palmaria palmata*	1
Florideophyceae	Filamentous			1, 3
Florideophyceae	Foliated Filamentous			1
Florideophyceae	Foliose			1, 3

Table C2. Different macroalgae identified throughout False Inlet, to the lowest taxonomic level.

Class	**Order/Functional Group**	**Family**	**Genus/Species**
Phaeophyceae	Desmarestiales	Desmarestiaceae	*Desmarestia aculeata*
Phaeophyceae	Desmarestiales	Desmarestiaceae	*Desmarestia viridis*
Phaeophyceae	Laminariales	Agaraceae	*Agarum clathratum*
Phaeophyceae	Laminariales	Laminariaceae	*Saccharina latissima*
Phaeophyceae	Filamentous		
Florideophyceae	Palmariales	Palmariaceae	*Palmaria palmata*
Florideophyceae	Corallinales		
Florideophyceae	Filamentous		
Florideophyceae	Foliose		

Table C3. Different macroalgae identified throughout Fish Bay, to the lowest taxonomic level.

Class	**Order/Functional Group**	**Family**	**Genus/Species**
Phaeophyceae	Desmarestiales	Desmarestiaceae	*Desmarestia aculeata*
Phaeophyceae	Fucales	Fucaceae	*Fucus* spp.
Phaeophyceae	Laminariales	Agaraceae	*Agarum clathratum*
Phaeophyceae	Laminariales	Laminariaceae	*Saccharina latissima*
Phaeophyceae	Laminariales	Laminariaceae	
Phaeophyceae	Filamentous		
Florideophyceae	Foliose		

Table C4. Different macroalgae identified throughout the channel, to the lowest taxonomic level.

Class	**Order/Functional Group**	**Family**	**Genus/Species**
Phaeophyceae	Desmarestiales	Desmarestiaceae	*Desmarestia viridis*
Phaeophyceae	Laminariales	Agaraceae	*Agarum clathratum*
Phaeophyceae	Laminariales	Alariaceae	*Alaria esculenta*
Phaeophyceae	Laminariales	Laminariaceae	*Laminaria digitata/ Hedophyllum nigripes*
Phaeophyceae	Laminariales	Laminariaceae	*Saccharina latissima*
Phaeophyceae	Ralfsiales		
Chlorophyta	Filamentous		
Florideophyceae	Corallinales		
Florideophyceae	Filamentous		
Florideophyceae	Foliated Filamentous		
Florideophyceae	Foliose		

Table C5. Different fauna identified throughout the Chesterfield Inlet Harbour, to the lowest taxonomic level.

Phylum	**Class**	**Order**	**Family**	**Genus/Species**	**Sites Found**
Annelid	Polychaeta	Terebellida	Pectinariidae	*Cistenides* sp.	1
Chordata	Teleostei	Perciformes	Pholidae	*Pholis fasciata*	1
Chordata	Teleostei	Perciformes	Stichaeidae	*Stichaeus punctatus*	1
Cnidaria sp. 1					1
Cnidaria	Staurozoa	Stauromedusae			1, 3
Ctenophora	Tentaculata	Cydippida	Mertensiidae	*Mertensia ovum*	1, 3
Echinodermata	Holothuroidea	Dendrochirotida	Psolidae	*Psolus* sp.	3
Echinodermata	Ophiuroidea sp. 1				1
Echinodermata	Ophiuroidea sp. 4				1
Mollusca	Bivalvia				3
Mollusca	Gastropoda				1, 3

Table C6. Different fauna identified throughout False Inlet, to the lowest taxonomic level.

Phylum	Class	Order	Family	Genus/Species
Chordata	Ascidiacea sp. 2			
Chordata	Ascidiacea sp. 3			
Chordata	Ascidiacea sp. 4			
Chordata	Teleostei	Perciformes		
Cnidaria sp. 2				
Cnidaria	Staurozoa	Stauromedusae		
Ctenophora	Tentaculata	Cydippida	Mertensiidae	*Mertensia ovum*
Ctenophora	Tentaculata			
Ctenophora				
Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Leptasterias polaris*
Echinodermata	Asteroidea			
Echinodermata	Holothuroidea	Dendrochirotida	Psolidae	*Psolus* sp.
Echinodermata	Ophiuroidea sp. 2			
Echinodermata	Ophiuroidea sp. 3			
Echinodermata	Ophiuroidea sp. 4			
Mollusca	Bivalvia			
Mollusca	Gastropoda			

Table C7. Different fauna identified throughout Fish Bay, to the lowest taxonomic level.

Phylum	Class	Order	Family	Genus/Species
Chordata	Ascidiacea sp. 1			
Ctenophora	Tentaculata	Cydippida	Mertensiidae	*Mertensia ovum*
Ctenophora				
Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Leptasterias* sp. 1
Echinodermata	Asteroidea			

Table C8. Different fauna identified throughout the channel, to the lowest taxonomic level.

Phylum	**Class**	**Order**	**Family**	**Genus/Species**
Annelida	Polychaeta	Sabellida	Sabellidae	
Chordata	Teleostei	Gadiformes	Gadidae	*Gadus sp.*
Chordata	Teleostei	Perciformes	Stichaeidae	*Stichaeus punctatus*
Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Leptasterias polaris*
Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Leptasterias* sp. 2
Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Leptasterias* sp. 3
Echinodermata	Asteroidea			
Echinodermata	Echinoidea	Camarodonta	Strongylocentrotidae	*Strongylocentrotus droebachiensis*
Echinodermata	Holothuroidea	Dendrochirotida	Psolidae	*Psolus* sp.
Echinodermata	Ophiuroidea sp. 1			
Echinodermata	Ophiuroidea sp. 2			
Echinodermata	Ophiuroidea sp. 4			
Mollusca	Bivalvia			
Mollusca	Cephalopoda			
Mollusca	Gastropoda			
Mollusca	Polyplacophora			

Appendix D - Macroalgae Photos

Figure D1. The blade of *Alaria esculenta* observed within the channel on July 26th 2023, at an approximate depth of 8 m. Note the distinct thin midrib that runs between the blade crenulations, which can help distinguish it from *Saccharina latissima*.

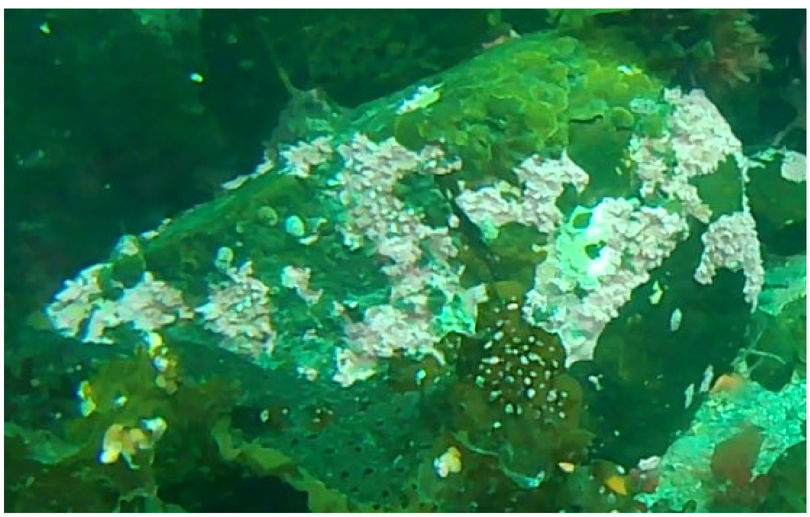


Figure D2. Brown crustose algae (brown, top of the rock) and crustose coralline algae (pink, bottom of the rock), observed within the channel on July 26th 2023, at a depth of approximately 8 m.

Figure D3. The Thallus of *Desmarestia aculeata* observed within the harbour on July 25th 2023, at an approximate depth of 10 m.

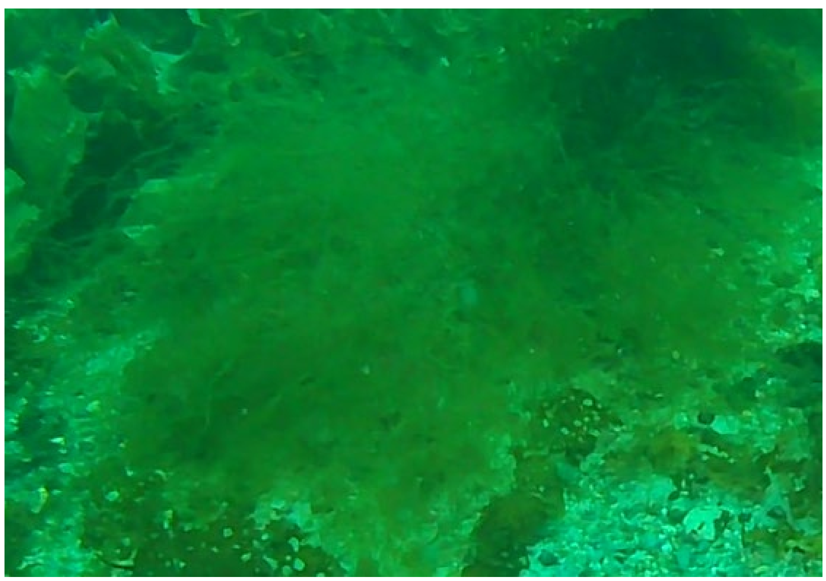


Figure D4. The thallus of *Desmarestia viridis* observed within the channel on July 26th 2023, at an approximate depth of 8 m.

Figure D5. The blade of *Laminaria digitata/Hedophyllum nigripes* observed within the harbour on July 25th 2023, at an approximate depth of 4.5 m.

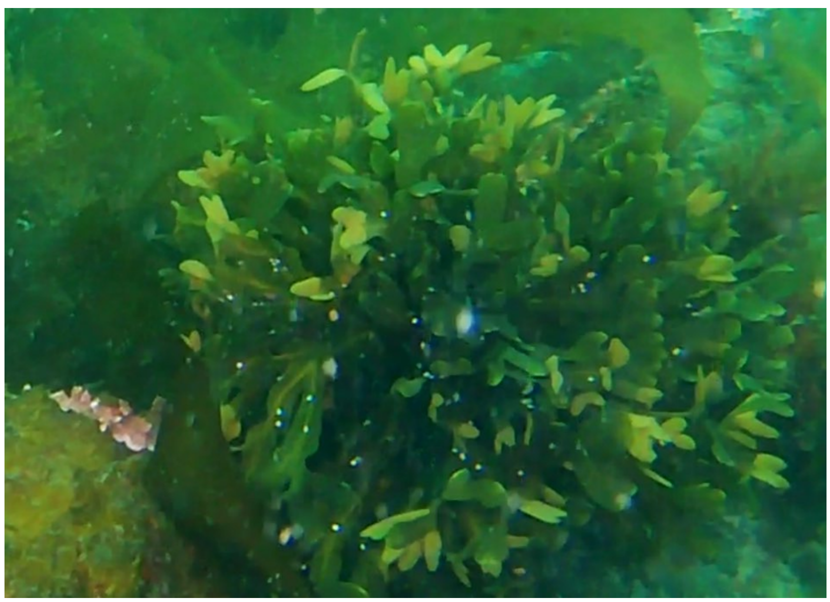


Figure D6. The blades of *Fucus* spp. observed within the harbour on July 25th 2023, at an approximate depth of 4.5 m.

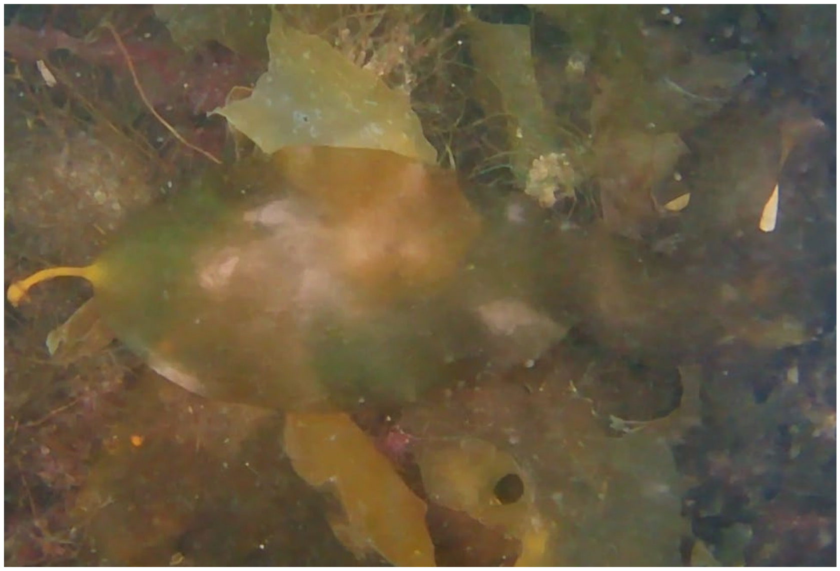


Figure D7. The blade of *Laminaria solidungula* observed within the harbour on July 25th 2023, at an approximate depth of 10 m.

Figure D8. The blades of *Palmaria palmata* observed within False Inlet on July 26th 2023, at an approximate depth of 6 m.

Figure D9. Several *Saccharina latissima* from the channel on July 26th 2023, at an approximate depth of 7.5 m. Note that the central band down the blade is not a midrib, and can be very pronounced, or almost non-existent.

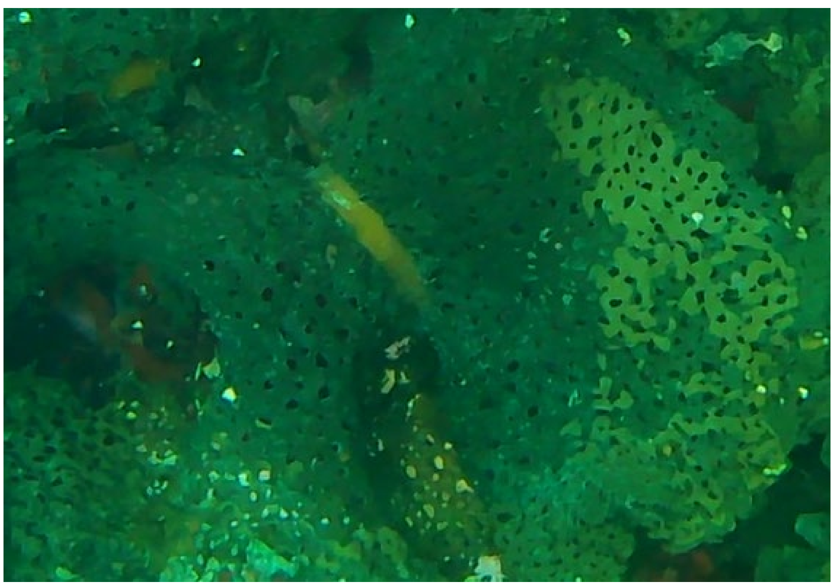


Figure D10. The perforated blade of *Agarum clathratum* observed within the channel on July 26th 2023, at an approximate depth of 8 m.