Dundavin Sponge Reef: Methods and Results from ROV Survey PAC2017-094

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by

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ABSTRACT

Nephin, J., Loeffler, R., Jeffery, S., Archer, S., Dunham, A. 2026. Dundavin Sponge Reef: Methods and Results from ROV Survey PAC2017-094. Can. Tech. Rep. Fish. Aquat. Sci. 3803: viii + 25 p. https://doi.org/10.60825/frs6-j831

In 2017, a scientific survey (PAC2017-094) was led by Fisheries and Oceans Canada (DFO) to map and assess the ecological status and character of the 48km^2 glass sponge reef in Chatham Sound and to survey a smaller unmapped sponge reef, referred to as Dundavin Reef, in Seaforth Channel, northwest of Bella Bella. The focus of this report is to summarize the methods and results from the survey of Dundavin Reef. Six remotely operated vehicle (ROV) transects, totaling 2.45 km in length and spanning depths of 74–276 m, were conducted, and a sound recording device was deployed. Video and still imagery were collected using the ROV and annotated for species presence and reef-building glass sponge cover.

A total of 1,947 species annotations were recorded from video and 7,510 from still images (differing due to image quality, camera angle, and species lists), including sponges, corals, anemones, echinoderms, crustaceans, and fishes. Only one anthropogenic object (e.g., debris or equipment) was observed across the six transects. Live and dead reef-building glass sponge cover annotations were used to categorize reef habitat in video segments. All transects had more than 45% (up to 75%) of their area covered by living visible sponge reef cover, categorized as mixed, live, or dense live habitat. Small amounts (<4% of the transect area) of dense live reef habitat were observed on four out of six transects. Sound was recorded on the reef for 62 days and analyzed for boat and fish sounds. Boat noise was most frequent during daylight hours, and fish noise during the night, the latter perhaps in part due to masking by boat noise.

This survey is the first assessment of the status, extent, and sponge coverage of Dundavin Reef: a small glass sponge reef possibly interspersed with glass sponge gardens on bedrock. The imagery and sound data collected have shown that the reef supports a diversity of reef-associated fishes, invertebrates, and emergent corals; the reef appears to be relatively intact compared to available survey data for other glass sponge reefs. Complete mapping of Dundavin Reef requires further data collection, including high-resolution multibeam echosounder data.

RÉSUMÉ

Nephin, J., Loeffler, R., Jeffery, S., Archer, S., Dunham, A. 2026. Dundavin Sponge Reef: Methods and Results from ROV Survey PAC2017-094. Can. Tech. Rep. Fish. Aquat. Sci. 3803: viii + 25 p. https://doi.org/10.60825/frs6-j831

En 2017, une mission océanographique (PAC2017-094) a été menée par Pêches et Océans Canada pour cartographier et évaluer l'état écologique et les caractéristiques un récif d'éponges siliceuses de 48 km^2 dans le détroit de Chatham, ainsi que pour explorer un plus petit récif d'éponges non cartographié, appelé récif Dundavin, dans le canal Seaforth, au nord-ouest de Bella Bella. Ce rapport résume les méthodes et les résultats de l'étude du récif Dundavin. Six transects ont été échantillonnés avec un véhicule télécommandé, totalisant 2,45 km et couvrant des profondeurs de 74 à 276 m, et un dispositif d'enregistrement sonore a été déployé. Des images vidéo et fixes ont été annotées afin d'identifier la présence d'espèces et la couverture des éponges siliceuses constructrices de récifs.

Au total, 1 947 annotations d'espèces ont été enregistrées à partir des vidéos et 7 510 à partir des images fixes (les différences étant dues à la qualité des images, à l'angle de la caméra et aux listes d'espèces), notamment des éponges, des coraux, des anémones, des échinodermes, des crustacés et des poissons. Un seul objet anthropique, tel que des débris ou du matériel, a été observé sur les six transects. Les annotations de couverture d'éponges siliceuses constructrices de récifs, vivantes et mortes, ont servi à catégoriser les habitats récifaux dans les segments vidéo. Tous les transects présentaient plus de 45 % (jusqu'à 75 %) de leur superficie recouverte par une éponge siliceuses vivante visible, classée en habitats patchés, vivants ou denses. De petites zones d'habitat récifal dense et vivant, représentant moins de 4 % de la superficie des transects, ont été observées sur quatre des six transects. Les sons ont été enregistrés sur le récif pendant 62 jours et analysés afin de détecter les bruits de bateaux et de poissons. Le bruit des bateaux était plus fréquent pendant la journée, tandis que celui des poissons l'était la nuit, ce dernier étant peut-être en partie masqué par le bruit des bateaux.

Cette étude représente la première évaluation de l'état, de l'étendue et de la couverture d'éponges du récif Dundavin: un petit récif d'éponges siliceuses pouvant être parsemé de jardins d'éponges siliceuses sur substrat rocheux. Les images et les données sonores collectées ont révélé que le récif abrite une diversité de poissons, d'invertébrés et de coraux émergents associés aux récifs; le récif semble relativement intact en comparaison avec les données disponibles pour d'autres récifs d'éponges siliceuses. Une cartographie complète de l'étendue du récif Dundavin nécessiterait des collectes de données supplémentaires, notamment des données de sondeur multifaisceaux à haute résolution.

1 Introduction

Glass sponge reefs (GSRs) on Canada's west coast are globally unique features that were only known from fossil records until the 1980s when the first GSRs were detected in Queen Charlotte Sound and Hecate Strait on geophysical surveys undertaken by the Geological Survey of Canada (Conway et al. 1991). They are formed by Hexactinellid dictyonine glass sponges, which are distinguished from other sponges by their skeletons comprised of fused silica spicules (Reiswig 2002; Leys et al. 2004). GSRs are a bioconstruction formed by reef-building glass sponges (*Aphrocallistes vatus, Heterochone calyx, and/or Farrea occa*) growing atop previous generations of sponges. The reef consists of a sedimented base of glass sponge skeletal material with live and dead emergent sponges above (Krautter et al. 2006; Dunham et al. 2018b; Conway et al. 2020). Individual sponges within a reef can potentially live for over 200 years (Government of Canada 2019). After the sponges die, their skeletons can persist and accumulate sediment, creating a rigid structure that acts as substrate for the attachment of larval sponges (Krautter et al. 2006). The resulting reef structures can persist for thousands of years (Conway et al. 1991; Leys et al. 2004).

GSRs form valuable biogenic habitat whose three dimensional structure is used by vertebrates and invertebrates seeking refuge areas from predators (Cook et al. 2008; Stone et al. 2014; Dunham et al. 2018a; Chu and Leys 2010) and/or prey (Archer et al., 2020a; Archer et al., 2020b; Chu & Leys, 2012; Leys et al., 2007). GSRs also play an important role in biogeochemical cycling, filtering bacteria, recycling nitrogen and carbon, and acting as a silica sink (Chu et al. 2011; Kahn et al. 2015; Dunham et al. 2018a).

GSRs are vulnerable to damage from direct physical contact such as from bottom -contact fishing (Jamieson and Chew 2002; Dunham et al. 2026). Many of the discovered reefs in BC have been protected from fishing impacts through a variety of legislative tools (Conway et al. 1991; Dunham et al. 2018b; Government of Canada 2019), although some (such as Chatham Sound sponge reefs) have not been protected to date. Protection measures range include Fishery Closures, Marine Refuges and Marine Protected Areas. Dundavin Reef now falls within the newly established Mia-yaltwa Ha'lidzogm hoon National Marine Conservation Area Reserve (NMCAR), a part of the Great Bear Sea Marine Protected Area Network (MPA Network BC Northern Shelf Initiative 2024). Future management planning, to be undertaken collaboratively by the six Partner Nations, Canada, and British Columbia, will determine the zoning and the specific protections for the area.

Many reefs in BC have been identified and mapped on geophysical surveys using remote sensing technology (e.g., multibeam echosounders). Subsequently, sediment cores or visual imagery are needed to confirm the presence of live reef-building glass sponges. Using both remote acoustic and visual tools to confirm the presence of a reef is ideal because remote acoustic tools cannot differentiate between live, dead, and buried patches of dead glass sponges, and visual surveys cannot examine the underlying substrate (e.g., sub-surface reef structure).

The reef at Dundavin was not identified from available geophysical data. The aggregations of sponges at the Dundavin site (Figure 1) were first recorded by the Central Coast Indigenous Resource Alliance (CCIRA) as a part of their work mapping hotspots of coral, sponge, and rockfish (Frid et al. 2021). CCIRA documented the reef on June 8, 2017 while conducting towed video surveys for their research work. The focus of this report is to summarize the methods and results from the follow up DFO survey of Dundavin Reef, which took place on August 21, 2017.

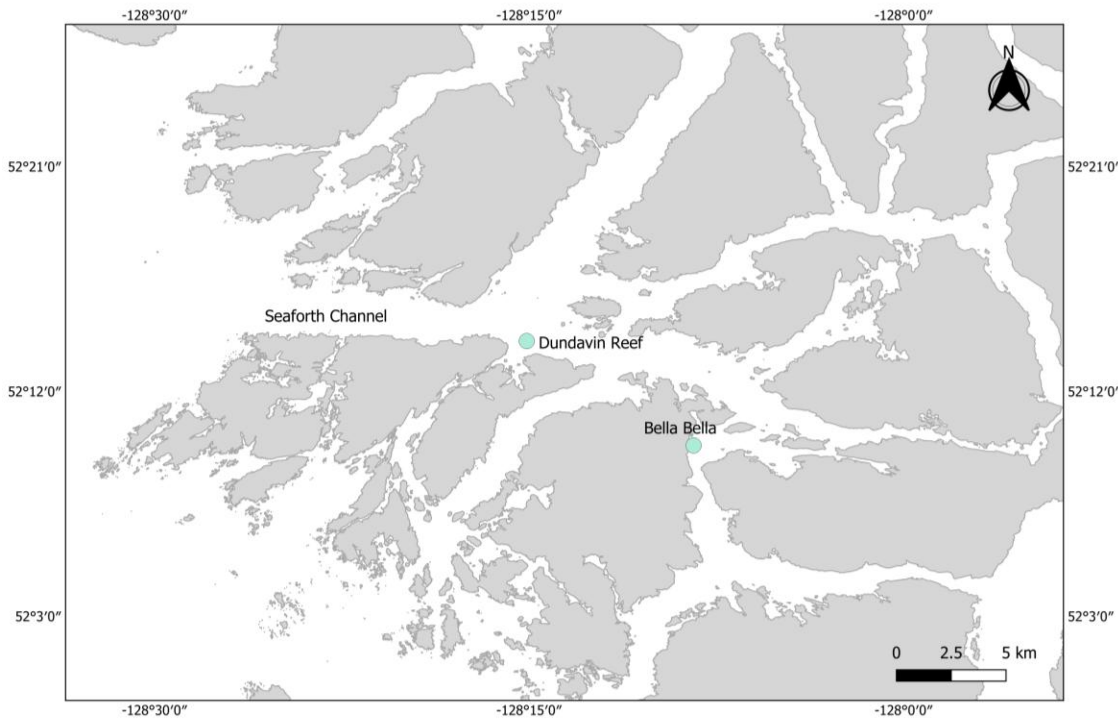

Figure 1: Map showing the location of Dundavin Reef on the Central Coast of British Columbia.

2 Methods

We assessed the Dundavin Reef using two methods: collection and subsequent annotation of benthic imagery, and also through the interpretation of passive acoustic data from hydrophone deployment.

2.1 Data collection

ROV operations were conducted from the Coast Guard vessel CCGS Vector on August 21, 2017 using a Deep Ocean Engineering Phantom HD2+2 ROV, an upgraded HD2 (Figure 2).

Videos were recorded with an Insite Pacific MiniZeus high-definition (1080i) video camera. The camera tilt was controlled by ROV pilots, and was set at an angle relative to the seafloor (tilted slightly forward and down, toward the seafloor). The ROV was also equipped with a downward facing still camera (the “Cyclops”, C-Map Systems Inc, 3264 x 2448 pixels resolution). Still images were captured every 15 seconds while the ROV was on transect. The ROV was driven in close proximity to the seafloor, with a target altitude of 0.5 to 1 m above the seafloor when on transect.

Forward illumination for the MiniZeus HD camera was provided by two DeepSea Power and Light SLS-5200 LED lights and two Remote Ocean Systems Q-LED II LED floodlights, both of which supplied a warm white illumination. The ROV was equipped with a set of parallel green scaling lasers. They were affixed to the bottom of the MiniZeus camera, spaced 10 cm apart and orientated to point in the middle of the video camera’s field of view. The latitudinal and longitudinal position of the ROV was calculated using an EdgeTech Broadband Acoustic Tracking System, from an Applied Acoustic 300 series transponder.

Figure 2: Phantom ROV on the aft deck of the CCGS Vector. Acoustic recorders for deployment were mounted inside the PCV pipes on either side of the ROV.

In addition to collecting benthic imagery, the ROV was also used to deploy a single acoustic recorder (SoundTrap 300 Stardard Model, Ocean Instruments) with an extended battery pack. The acoustic recorder was attached to an acoustic release and deployed in the center of the observed sponge distribution using the ROV (cross icon in Figure 3).

Six ROV transects were completed over Dundavin Reef; five orientated east-west and one north-south (Figure 3). The transects varied from 284 to 633 meters in length. Start and end positions and depth ranges of each transect are shown in Table 1.

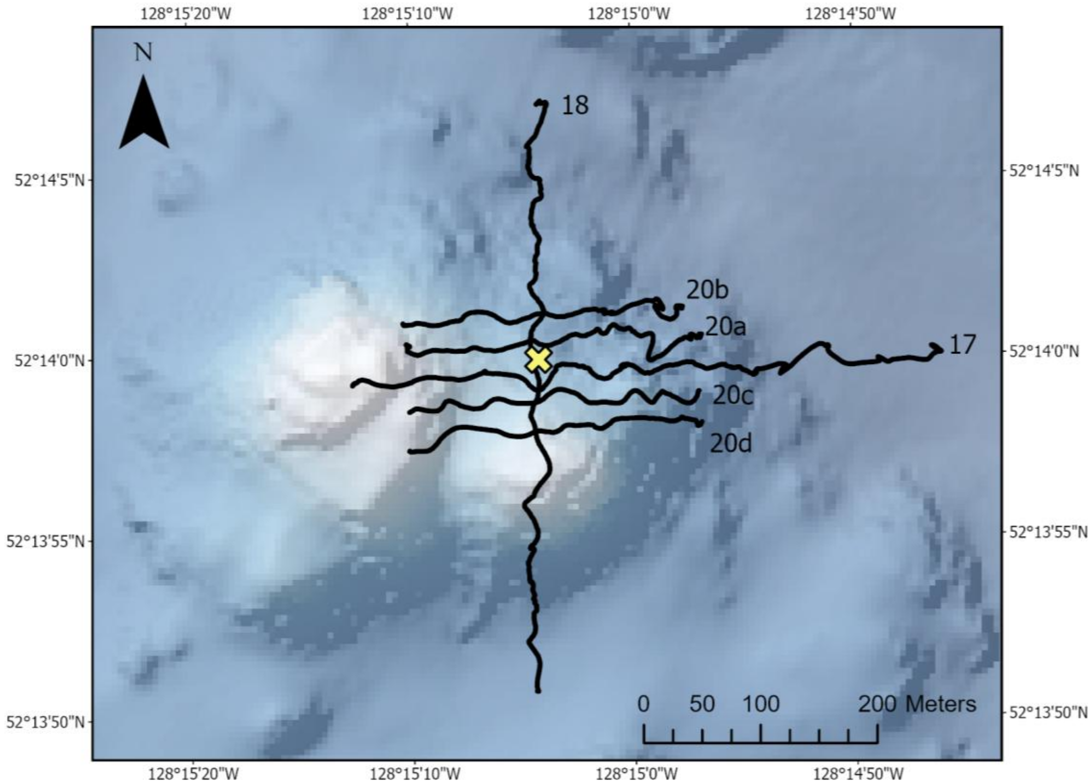

Figure 3: Map of transects completed by the ROV Phantom on Dundavin Reef, NW of Bella Bella. Yellow cross showing location of the acoustic recorder.

Table 1: Transects completed by the ROV Phantom on Dundavin Reef, NW of Bella Bella.

Transect	Latitude Start	Longitude Start	Latitude End	Longitude End	Length of Transect (m)	Min depth (m)	Max depth (m)
17	52.23336	-128.24619	52.23313	-128.25349	633	74	276
18	52.23529	-128.25113	52.23075	-128.25123	603	88	227
20A	52.23349	-128.24912	52.23341	-128.25278	331	93	206
20B	52.23368	-128.24937	52.23359	-128.25287	310	107	222
20C	52.23305	-128.24917	52.23290	-128.25279	289	88	171
20D	52.23281	-128.24913	52.23261	-128.25280	284	91	181

2.2 Imagery annotation

2.2.1 Video annotation protocol

Video imagery was annotated using BIIGLE, a web-based tool for collaborative annotation of marine images and videos (Langenkämper et al. 2017). The videos and the annotations are available to view in BIIGLE upon request.

To characterize the reef, we annotated continuously (within segments of video with sufficient quality for annotation) for substrate and glass sponge cover, and annotated a selection of fish and invertebrate species that were consistently identifiable from the video imagery (see Table 5 for species list). We also annotated fishing gear, other anthropogenic objects, and damaged or unhealthy glass sponges.

Invertebrates and fishes were annotated with point annotations, with a focus on reef-associated species including octopus, crabs, sea stars, anemones, sea cucumbers, sea urchins, nudibranchs, emergent corals, boot sponges and most fish species. Annotations were only made when the annotator was at least 90% certain of the identification. Species smaller than 5cm were not annotated. Several reef-associated crustaceans, for example spot prawns and squat lobsters, were not included as they were too small and often too well hidden within the reef to be consistently visible in the video imagery.

The categories used to annotate substrate are shown in Table 2. These categories were previously used by DFO for Rockfish Conservation Area research and were originally adapted from video annotation protocols that CCIRA developed for benthic imagery surveys in RCAs (Frid et al. 2018). Substrate labels were selected based on the dominant (>50%) substrate within the field of view and annotated as whole frame annotations to provide a continuous description throughout the video.

The categories used to annotate live and dead glass sponge cover are shown in Table 3. These categories were selected to align with former DFO annotation protocols that used these percent cover categories to quantify the relative amount of each substrate type, including live and dead sponge reef. Live and dead sponge cover were annotated separately as whole frame annotations.

For live sponge cover annotations, the threshold between 0% and >0 – <25% live reef is based on a minimum size of sponge (more than 5 cm diameter) within a 10 second segment of video. The 5 cm threshold was based on previous sponge annotation protocols and the definition of sponge reef habitat categories (Dunham et al. 2018b) that did not consider an area within a 10 second segment of video to be live reef if there was only a single small sponge. For dead sponge reef, we considered any amount of intact and standing dead sponge to be greater than 0% dead sponge cover. Examples of live and dead sponge percent cover can be seen in Figure 4 and Figure 5, and reef-building sponge species in Figure 6.

In addition to sponge cover, we annotated individual reef-building juvenile sponges (5cm or less) that were present within video segments with 0% live cover annotations to note areas of potential reef recovery. We also annotated individual boot sponges, a group of non reef-building glass sponges, that can grow on the reefs.

Table 2: Substrate categories used in video annotation.

Category	Description
Fines (low complexity)	Silt, Sand, Shell, Gravel (100%) or Silt, Sand, Shell, Gravel (>50%) with a secondary biogenic substrate (i.e. sponge, not rock)(<50%)
Fines with cobble or boulder (low complexity)	Mud, Sand, Shell, Gravel (<100% of the seafloor) with some cobble or boulder or bedrock (<50%)
Cobble or low complexity bedrock	Cobbles or bedrock with small and few crevices over >50% of the seafloor
Small boulder or medium complexity bedrock	Boulders mostly <50 cm in diameter, or medium cracks/crevices in bedrock often present over >50% of the seafloor
Large boulder or high complexity bedrock	Boulders mostly >50 cm in diameter, or abundant large cracks/crevices in bedrock (>50% of the seafloor)
Standing sponge (live + dead) (>50%)	Intact reef-building glass sponges (live and dead combined) comprise >50% visible seafloor
Sponge rubble (>50%)	The seafloor is primarily composed of rubble (i.e., Dead sponges that are broken up)

Table 3: Reef-building glass sponge cover categories used in video annotation. Reef-building glass sponges include Farrea occa, Aphrocallistes vastus, and Heterochone calyx. For examples of these sponge cover categories see Figure 4 and Figure 5. These categories describe only intact reef-building sponge cover, they do not include coverage of sponge rubble (non-intact dead reef-building glass sponges).

Category	Description
Live reef-building glass sponge cover ~0%	Can have no more than a single 5 cm sized (diameter) live reef-building glass sponge in a 10 second segment of video. All reef-building glass sponges 5 cm or less will be indicated with a point annotation of 'Individual reef-building glass sponge'.
Live reef-building glass sponge cover >0 - <25%	Low density of live reef-building glass sponge from more than a single 5cm sized live sponge in a 10 second segment of video to covering less than a quarter of the seafloor within the field of view.
Live reef-building glass sponge cover 25 - <50%	Moderate density of live reef-building glass sponge. Live sponge covers less than half of the seafloor in the field of view.
Live reef-building glass sponge cover ≥50%	Highest density of live reef-building glass sponge. Live sponge covers at least half of the seafloor within the field of view.
Dead reef-building glass sponge cover 0%	No intact dead reef-building glass sponge is present.
Dead reef-building glass sponge cover >0 - <25%	Low density of intact dead reef-building glass sponge. Dead sponge covers less than a quarter of the seafloor within the field of view.
Dead reef-building glass sponge cover 25 - <50%	Moderate density of intact dead reef-building glass sponge. Dead sponge covers less than half of the seafloor within the field of view.
Dead reef-building glass sponge cover ≥50%	Highest density of intact dead reef-building glass sponge. Dead sponge covers at least half of the seafloor within the field of view.

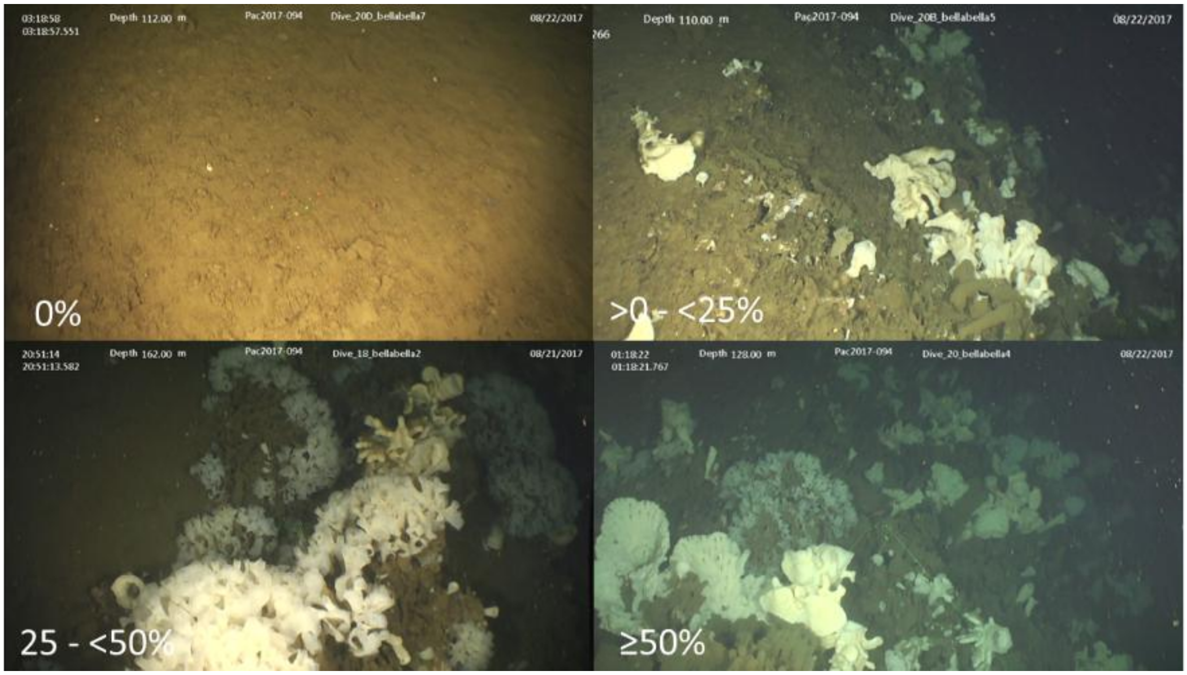

Figure 4: Examples of percent cover categories for live reef-building glass sponges for the purposes of this annotation protocol.

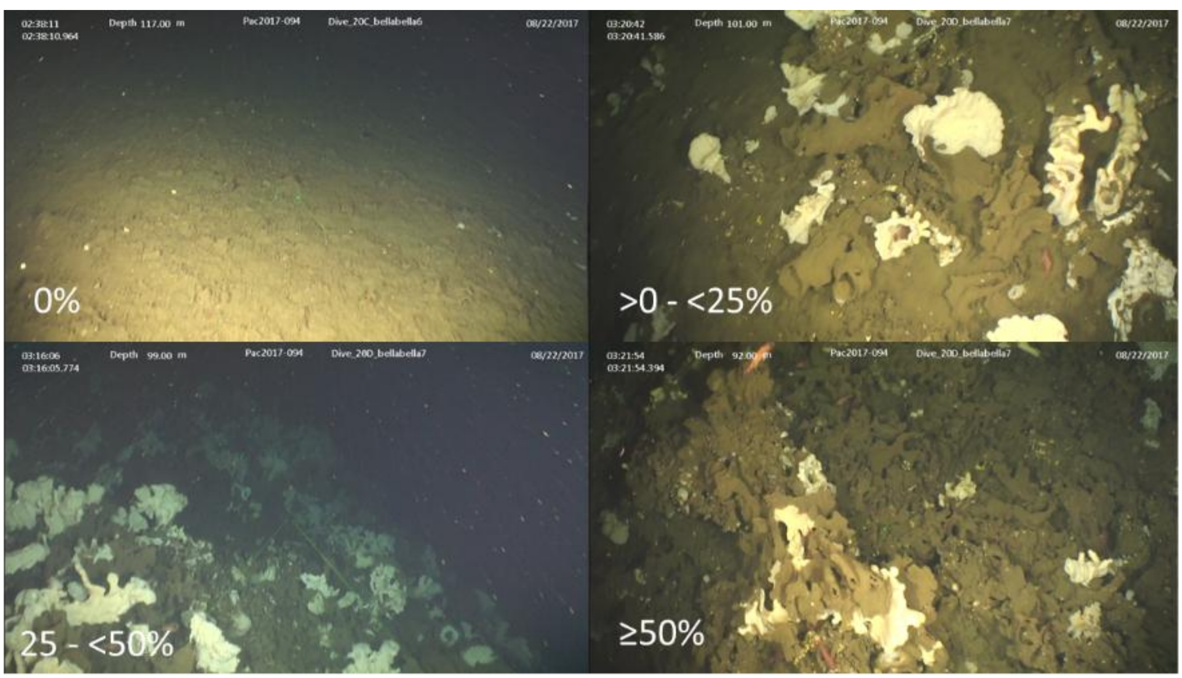

Figure 5: Examples of percent cover categories for dead reef-building glass sponges for the purposes of this annotation protocol.

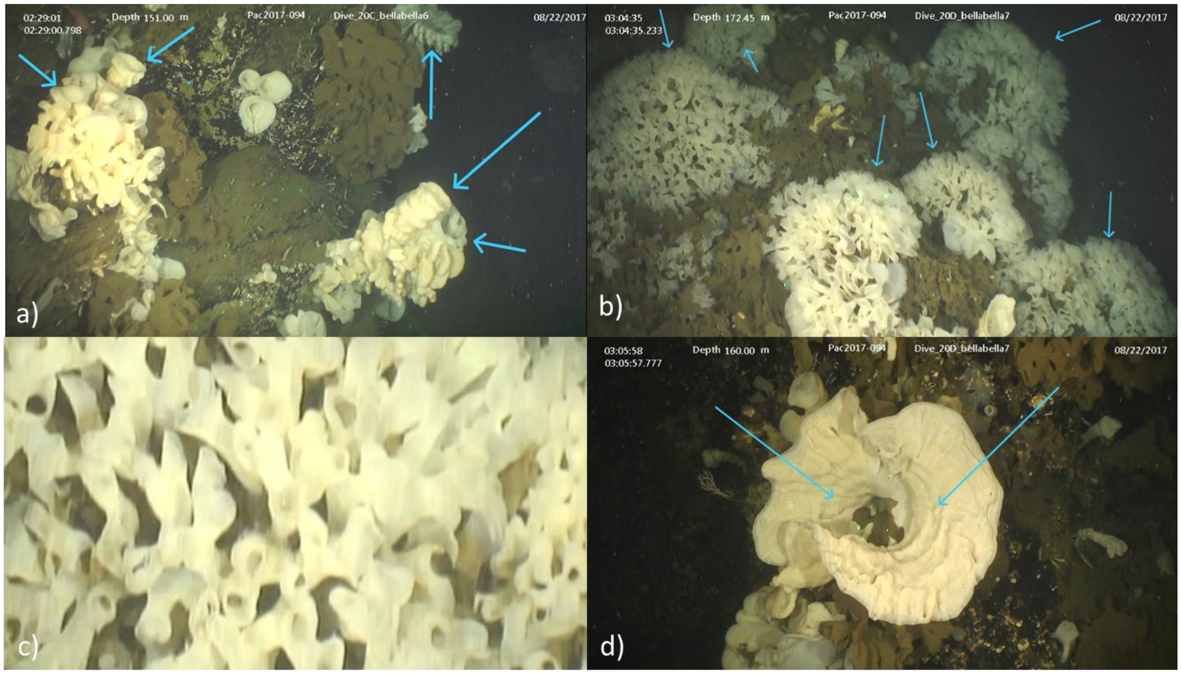

Figure 6: Examples of reef-building sponges: a) Aphrocallistes vastus, b) Farrea occa, c) Farrea occa closeup, d) Heterochone calyx. Arrows point to examples of the specific species mentioned within the reef.

2.2.2 Still image annotation protocol

Still imagery was annotated using an image viewer. The annotator counted all fish, octopus, crustaceans, sea stars, brittle stars, and nudibranchs observed in the image and recorded the data in a spreadsheet. Several reef-associated crustaceans that were not included in the video annotation protocol species list were included here, for example spot prawns and squat lobsters. Those species were easier to find and identify in the still imagery due to the higher image quality and downward facing view. In total, 619 images were annotated.

2.2.3 iNaturalist imagery protocol

When annotating videos, we captured screenshots of species of interest that showed clear images for sharing on iNaturalist. At least two screenshots were taken for each specimen, one zoomed in and one full frame capture to record the associated metadata from the video data overlay (e.g., position, depth, date). Screenshots were subsequently annotated with arrows to mark the species of interest.

Following this, we uploaded the images to iNaturalist under the MSEA Glass Sponge Reef and the Marine Life of the Northeast Pacific projects. Six metadata fields are included with each image: transect, depth, platform, survey, BC sponge reef and laser scale distance. The images are georeferenced using the location of the ROV.

2.3 Sponge reef habitat categories

Following Dunham et al. (2018b) and DFO (2018, 2020), we used continuous annotations of live and dead reef-building glass sponge cover from video imagery to calculate sponge reef habitat categories: dense live reef, live reef, mixed reef, dead reef, and no visible reef. Reef habitat categories describe the type of benthic habitat based on the amount of reef-building sponge present (DFO 2018). See Table 4 for a description of the reef habitat categories. Note that we adapted the definitions from Dunham et al. (2018b). They differ to account for changes to the annotation protocols.

To map reef habitat categories along the transects at Dundavin Reef we used the live and dead reef-building glass sponge cover annotations (see Table 3). We assigned each unique set of live and dead cover annotations to a habitat category based on the definitions in Table 4. For example, a segment of video with live reef-building glass sponge cover >0 - <25% and dead reef-building glass sponge cover >50% was assigned to mixed sponge reef.

Table 4: Descriptions of sponge reef habitat categories. Adapted from Dunham et al. 2018b.

Category	Percent Cover Thresholds	Description
Dense live reef	>50% live sponge	Highest density of live reef-building glass sponge. Live sponge covers more than half of the seafloor. Intact dead reef-building glass sponge and other substrates (e.g., mud) may occur in these areas as well.
Live reef	25-50% live sponge	Moderate density of live reef-building glass sponge. Live sponge covers at least a quarter and up to half of the seafloor. Intact dead reef-building glass sponge and other substrates (e.g., mud) may occur in these areas as well.
Mixed reef	>0-25% live sponge	Low density of live reef-building glass sponge. From more than a single 5 cm sized live sponge in a 10 second segment of video to less than a quarter of the seafloor covered by live reef-building glass sponge. Other substrates like mud or dead reef-building glass sponge are dominant.
Dead reef	~0% live sponge and >0% dead sponge	Intact dead reef-building glass sponge is visible. No live reef-building glass sponge is present other than a single <=5 cm sized live sponge in a 10 second segment of video. Other substrates (e.g., mud) may occur in these areas as well.
No visible reef	~0% live sponge and 0% dead sponge	No intact live or dead reef-building glass sponge is visible. Can have no more than a single <=5 cm sized live reef-building glass sponge in a 10 second segment of video.
No data	Not applicable	Segment of videos that were not annotated due to low video quality (e.g., where the ROV was too high above the seafloor).

2.4 Acoustic data analysis

One acoustic recorder was placed on the reef on Aug 21, 2017 and set to record continuously at a sample rate of 96 kHz (16 bit) on the 'high gain' setting. It was left on the reef until October 26, 2017, but stopped recording on October 22, 2017.

The recorder was calibrated by the manufacturer and had a high gain clip level of -172.8. With these settings the hydrophone could record for 2 months. Power spectral densities were calculated in MATLAB following (Merchant et al. 2015) between 0.2-48 kHz based on 1-minute averages, FFTs of 1 second of data in 1 Hz bins with 50% overlap using a Hann Window (smoothing function). Using this data we calculated sound pressure level (dB re 1 μPa) in multiple frequency bands associated with sounds produced by potential taxa of interest, as well as the frequency range associated with boat noise (see Table 6). We used a custom-built boat noise detector to identify minutes of data with shipping tonals present and a deep-neural net-based detector to identify fish calls (Mouy et al. 2024). A subset of 200 fish calls identified by the detector were manually checked and agreement was 80.5% with an 8% false positive rate.

3 Results and Discussion

3.1 Substrate

Analysis of video imagery revealed considerable variability in dominant substrate types both across and within transects (Figure 7). Fines were the most prevalent substrate category, observed over 735 meters. This was followed by reef-building sponge (660 m) and large boulders (630 m). While cobble was present, it occurred in smaller quantities. Sponge rubble was not classified as a dominant substrate, as it never constituted more than 50% of the seafloor within the field of view.

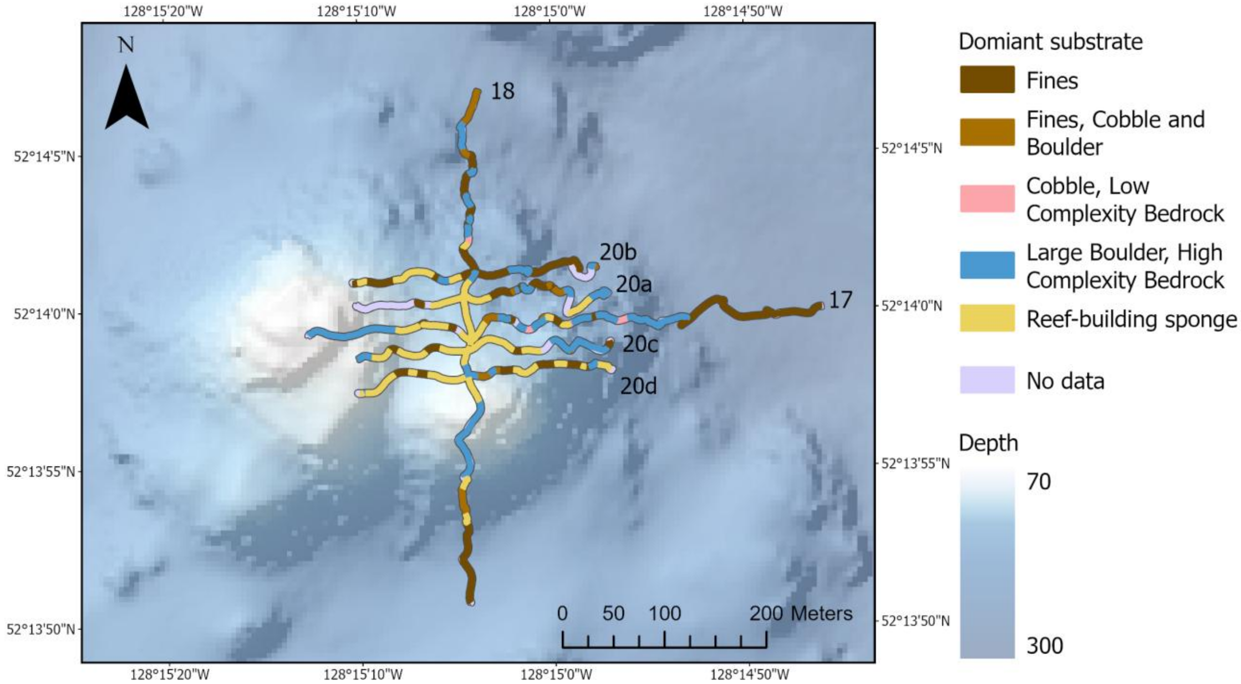

Figure 7. Substrate categories mapped along the Dundavin transects. See Table 2 for definitions of the substrate categories. No data segment of videos were not annotated due to low video quality.

3.2 Species abundance

A total of 1947 species annotations were made on the Dundavin transect videos, including 653 boot sponges, 686 fishes, 277 Anthozoa species (corals and anemones), and 327 echinoderms. Annotations on still images were predominantly of taxa within the phylum Echinodermata. Table 5 details the species counts for all taxa annotated in both video and still imagery.

Boot sponges, non reef-building sponges from the family Rossellidae, were relatively abundant. These sponges were frequently observed with invertebrates and rockfishes nearby. Example images of boot sponges with associated species are shown in Figure 8. Reef-building sponges were annotated using percent cover with the exception of juveniles in areas of no other visible reef-building sponge cover. Forty-seven juvenile reef-building sponges (sized 5 cm or less) were counted within areas of dead or no visible reef habitat.

Of the fish species observed, most were rockfishes. Most rockfish were only identified to genus (574 individuals in the videos). Of those identified to species, Rosethorn and Sharpchin were the most abundant. Example images of rockfishes found on Dundavin Reef can be seen in

Figure 9.

Table 5: Species abundance by taxonomic groups from video and still image annotations. Totals are bolded. N/A indicates taxa that were not annotated under video or still imagery protocols.

Taxonomic grouping	Common name	Scientific classification	Video counts	Stills counts
Porifera	Boot sponges	Family Rossellidae	653	n/a
	Juvenile reef-building sponges (5cm or less)	*Aphrocallistes vastus, Farrea occa*, or *Heterochone calyx*	47	n/a
			700	-
Anthozoa	Bubblegum coral	*Paragorgia pacifica*	56	n/a
	Red tree coral	*Primnoa pacifica*	13	n/a
	Anemones	Order Actiniaria	208	n/a
			277	-
Cephalopoda	Octopuses	Order Octopoda	1	1
			1	**1**
Nudibranchia	Sea slugs	Order Nudibranchia	1	3
			1	**3**
Crustacea	Other crabs	Infraorder Brachyura and Anomura	2	n/a
	Shrimps and prawns	Infraorder Caridea	n/a	4551
	Decorator crabs	Superfamily Majoidea	n/a	35
	Squat lobsters	Superfamily Galantheoidea	n/a	972
	Spot prawns	*Pandelus platyceros*	n/a	129
	Unidentifiable spot prawns, crabs and other shrimp	Order Decapoda	n/a	1354
			2	**7041**
Echinodermata	Sea stars	Class Asteroidea	143	45
	Brittle stars	Class Ophiuroidea	n/a	39
	California sea cucumber	*Apostichopus californicus*	27	n/a
	White-Knobbed sea cucumber	*Apostichopus leukothele*	143	n/a
	Sea urchins	Class Echinoidea	14	n/a
			327	**84**
Pisces	Rockfish	Genus Sebastes	574	280
	Sharpchin rockfish	*Sebastes zacentrus*	19	n/a
	Yelloweye rockfish	*Sebastes ruberrimus*	8	n/a
	Pygmy Rockfish	*Sebastes wilsoni*	1	n/a
	Boccacio rockfish	*Sebastes pauscispinus*	2	n/a
	Greenstripe rockfish	*Sebastes elongatus*	1	n/a
	Quillback rockfish	*Sebastes maliger*	14	n/a
	Rosethorn rockfish	*Sebastes helvomaculatus*	18	n/a
	Cod	Family Gadidae	4	n/a
	Lingcod	*Ophiodon elongatus*	4	n/a
	Sablefish	*Anoplopoma fimbra*	9	n/a
	Sculpins	Family Cottidae	n/a	9
	Flatfishes	Order Pleuronectiformes	14	n/a
	Spotted ratfish	*Hydrolagus colliei*	9	n/a
	Other or unidentifiable fishes	Various families	9	92
			686	**381**

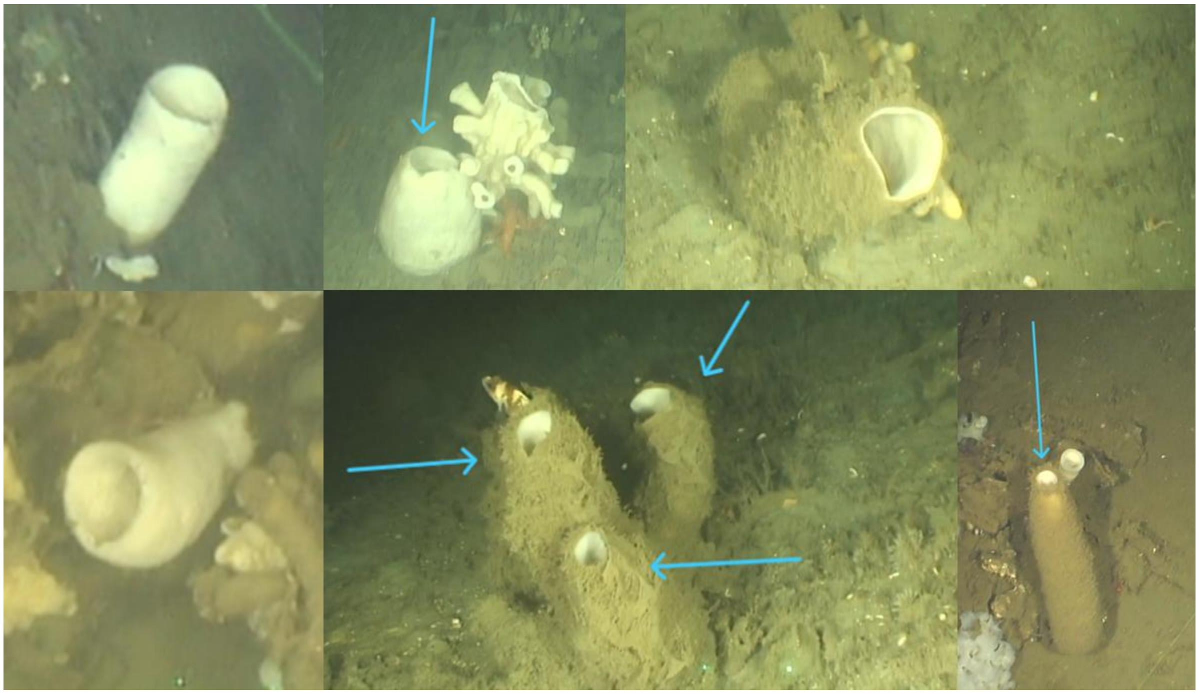

Figure 8: Examples of non reef-building boot sponges from family Rossellidae. Species associations with rockfish can be seen in the lower middle panel image.

Figure 9: Example species from genus Sebastes. A) Sebastes ruberrimus (yelloweye rockfish) in both juvenile and adult stages from left to right displaying the colour variations during maturation, b) Sebastes helvomaculatus (rosethorn rockfish) c) Sebastes pauscispinus (boccacio rockfish), d) Sebastes wilsoni (pygmy rockfish) e) Sebastes maliger (quillback rockfish), f) Sebastes zacentrus (sharpchin rockfish).

Within the phylum Anthozoa, two species of emergent corals were observed: *Primnoa pacifica* and *Paragorgia pacifica* with a total of sixty-nine corals observed in total. Images of corals and selected examples of anemone species annotated in the videos are shown in

Figure 10. Of the echinoderms observed in the videos, sea stars and white-knobbed sea cucumbers were the most abundant. Example images of echinoderm species observed on the transects are shown in Figure 11.

Cephalopods and nudibranchs were also observed on the reef, but had the lowest abundances across video and still image annotations. Nudibranchs may have been too difficult to detect consistently from ROV imagery. Crustaceans were generally only annotated from the still images in which over 7000 were recorded. The most abundant were shrimps, prawns and unidentified crustaceans.

Only one anthropogenic object was observed across the six transects surveyed; a concrete block with a rope, on transect 20D. No fishing gear or broken sponges were observed on Dundavin Reef.

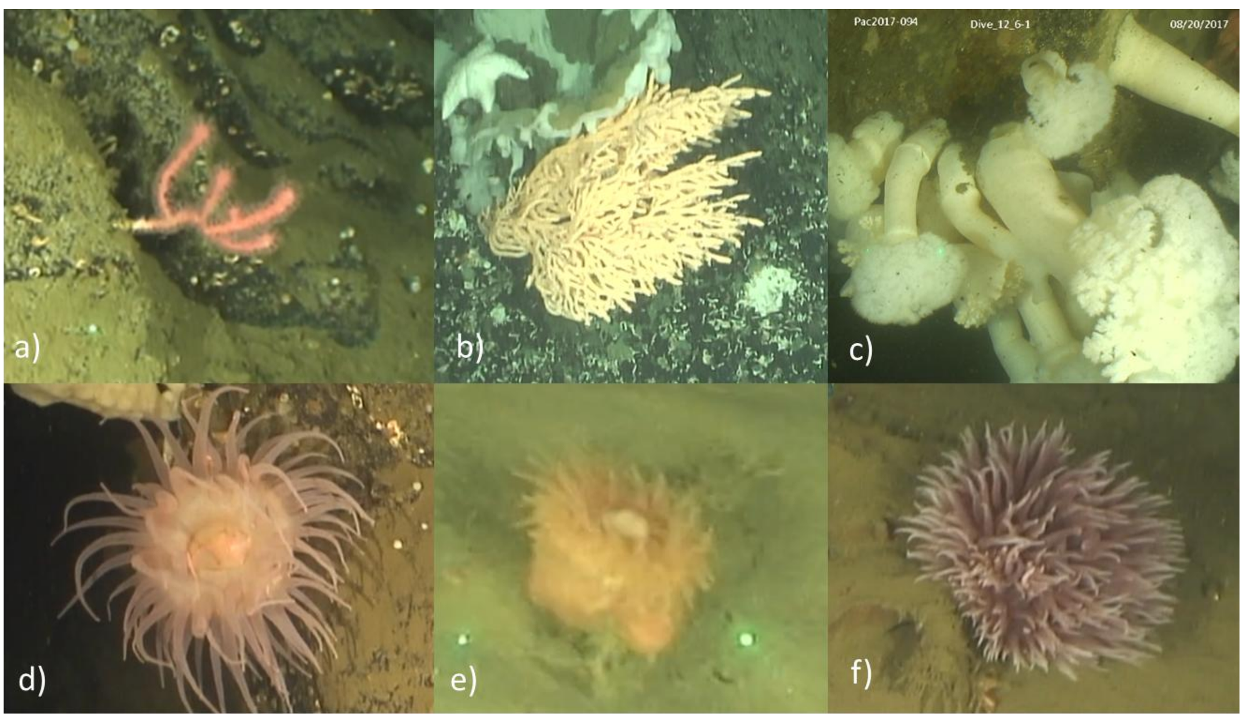

Figure 10: Example species from subphylum Anthozoa found in Dundavin Reef. A) Paragorgia pacifica (bubblegum coral), b)Primnoa pacifica (red tree coral), c) Metridium farcimen (plumose anemone), d) Cribrinopsis fernaldi (crimson anemone), e) a species from genus Stomphia (swimming anemones), f) Liponema brevicorne (pom-pom anemone).

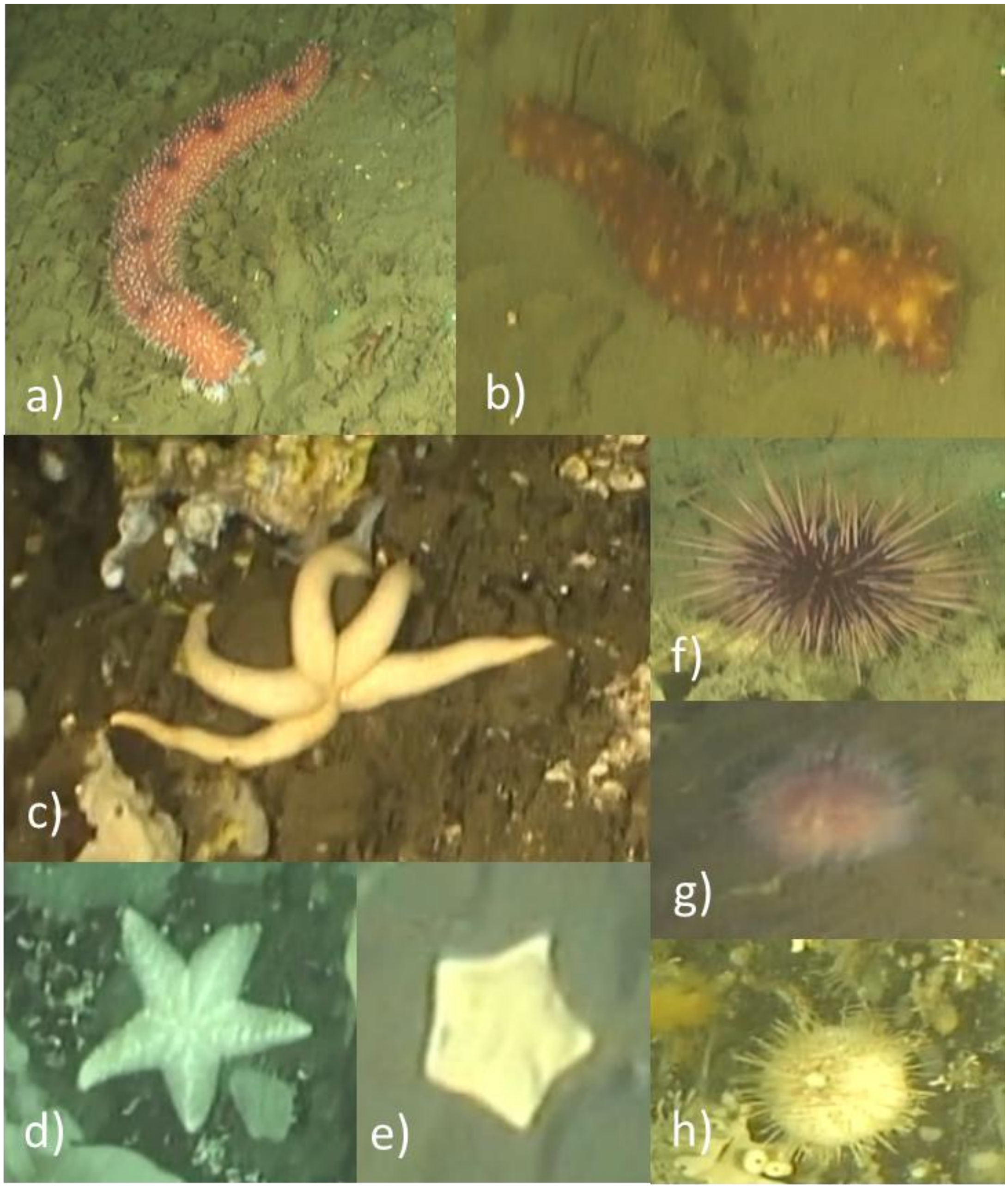

Figure 11: Example species from phylum Echinodermata found in Dundavin Reef. A) Apostiochopus luekothele (White-knobbed Sea Cucumber), B) Apostichopus californicus (California Sea Cucumber) c) a species from the genus Henricia (slender armed stars), d) Porianiopsis inflata (Northeastern Pacific Sea Star) e) Ceramaster patagonicus (Cookie Sea Star) f) Mesocentrotus franciscanus (Red Sea Urchin) g) Strongylocentrotus fragilis (Fragile Sea Urchin) h) Strongylocentrotus droebachiensis (Green Sea Urchin).

3.3 Sponge reef cover

Sponge reef habitat categories along Dundavin reef transects are shown in Figure 12. All transects had more than 45% of their area covered by living visible reef habitat categories (mixed, live, or dense live) (Figure 13). Transect 17 had the lowest proportion of living visible reef habitat because the transect extended further to the east than the other east-west oriented transects and went past the complex topography that likely delineates the suspected reef area. Transects 20c and 20d had the highest proportion of visible reef; more than 75% of each transect was in the mixed, live, or dense live reef habitat categories. The largest patch of dense live reef structure was observed on transect 20a, and totaled 3.4% of the transect. Dense live reef patches were also observed on transects 17, 18, and 20d.

The definitions for mixed, live, and dense live reef habitat categories in this study were modified from the definitions in Dunham et al. (2018b); therefore, not all of our results can be directly compared to the habitat categories presented for the Strait of Georgia reefs in that paper. However, our definitions for no visible reef, dead reef, and living visible reef (mixed, live and dense combined) are the same, which allows us to compare those results. In comparison to reefs in the Strait of Georgia and Howe Sounds (see DFO 2018, DFO 2020, Dunham et al. 2018b), Dundavin Reef has relatively low proportion of dead reef. Dundavin also appears to have a relatively high proportion of living visible reef, among the top 10 reefs in the Strait of Georgia and Howe Sound. However, the relative amount of visible reef is sensitive to the placement of transects and how much of the transects was placed outside of the reef footprint versus inside, which was unknown at the time of sampling. In addition, changes to protocols, annotators, and annotation software that occurred between this survey and the Strait of Georgia and Howe Sound reef surveys introduce potential differences in the reported proportion of habitat categories between the reefs.

Unlike most reefs in BC, the boundary of the reef at Dundavin has not been mapped using geophysical data (e.g., multibeam bathymetry with acoustic backscatter data). When examining the available geophysical data, the reef at Dundavin did not exhibit a consistent geological signal (high relief and low backscatter) over the entire area; higher-quality geophysical data are needed to map the reef boundary with confidence (Pers. Comm. Cooper Stacey, NRCan). In addition, the reef-building glass sponges at Dundavin were observed both growing on top of previous generations of sponges (evidence of reef formation) and directly on bedrock (see Figure 6 for examples). Therefore, the reef may be surrounded or intermixed with aggregations of glass sponges (also known as glass sponge gardens), which may make it more difficult to map its boundaries. In the absence of high-quality geophysical data such as high-resolution multibeam bathymetry and sub-bottom acoustic data, we can estimate the boundary of the reef and sponge aggregations based on the mapped reef habitat categories (Figure 12). The sponge cover appears to stop at the edge of the mound feature on the north, east, and south sides, but the boundary of the reef to the west is more uncertain. More data collection is required to better understand the boundaries of the reef at Dundavin.

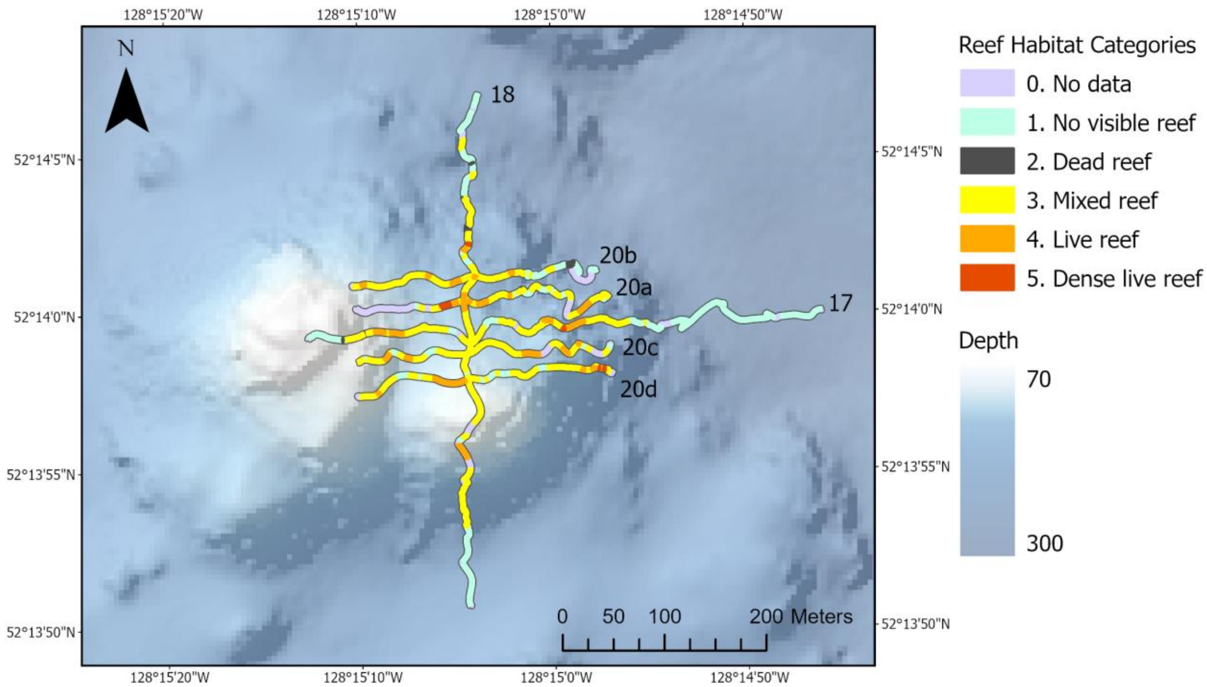

Figure 12: Sponge reef habitat categories mapped along the Dundavin transects.

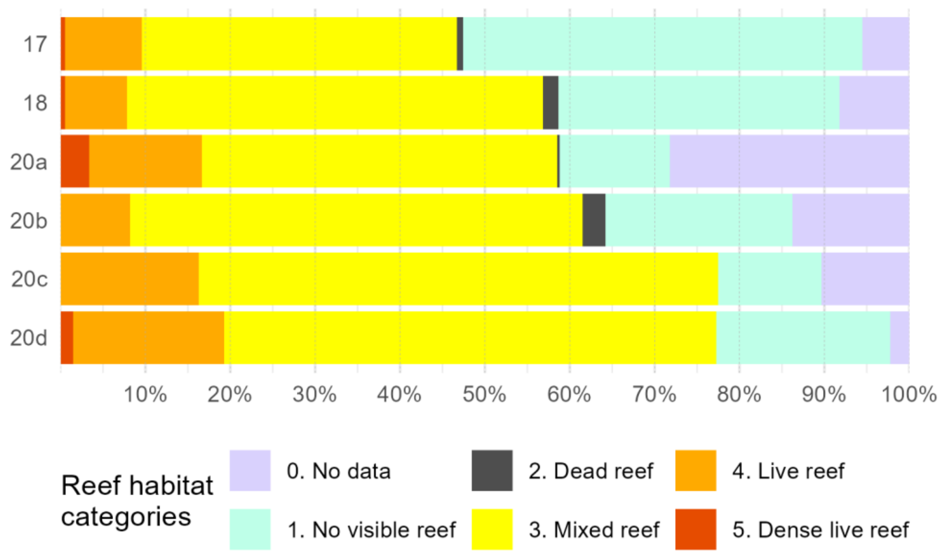

Figure 13: Percentage of sponge reef habitat category type by transect.

3.4 Soundscape

A total of 1,484 hours of sound recordings were analyzed from the 62 day period spanning Aug 17 - October 22, 2017.

Overall sound pressure levels in several frequency bands are reported in Table 6. During manual review of the dataset several instances of boat noise, fish calling, and whales (primarily Humpbacks and Orcas) were detected in the dataset. Boat noise was detected in 49% of the recording with boat noise more prevalent during daylight hours. Between 7:00 and 20:00 there is boat noise present in 61.36% of the minutes recorded, compared to 33.85% of the minutes overnight between 20:00 and 7:00 (Figure 14). We see nearly the exact opposite pattern in fish calling behavior (Figure 15) with fish calls occurring more frequently overnight, between 20:00 and 6:00. Between 7:00 and 20:00 there are fish calling in 7.08% of the minutes recorded, compared to 30.05% of the minutes overnight between 20:00 and 7:00 (Figure 14). This may be due to a behavioral tendency of the fish, compensation – where fish concentrate their communication during quieter hours, or due to masking of the fish calls by boat noise during the day so that we detect fewer fish calls, even though they are calling. Further analysis of the recording is required before any comment can be made about the prevalence or temporal distribution of marine mammal sounds.

Overall, there were a similar number of fish calls detected at the Dundavin Reef (~21/day) as the Outer Gulf Islands Reef in the Strait of Georgia (~8-24/day depending on location within the reef) (Archer et al. 2018). Median broadband SPL ranged from 103.0 – 103.6 dB re 1 μPa at the Outer Gulf Islands Reef (Archer et al. 2018) compared to 87.29 dB re 1 μPa at the Dundavin Reef, suggesting an overall quieter soundscape. This difference is likely attributable to the difference in boat noise at the two reefs; boat noise was detected during 49% of the time recorded at the Dundavin Reef, compared to 85% of the time at the Outer Gulf Islands Reef.

Table 6. Summary statistics of sound pressure level (dB re 1 μPa) across multiple frequency bands at the Dundavin Reef recorded between August 22 and October 22, 2017. The frequency bands are labelled with the sound source of interest most commonly found in that frequency range.

Frequency band (range in kHz)	Root mean square	Median	Minimum	Maximum
Broadband (0.02-48)	90.13	87.29	80.44	133.64
Fish (0.02-0.1)	80.02	76.67	75.23	133.35
Boats (0.1-1.0)	84.34	81.20	71.21	130.22
Invertebrates (1-10)	83.81	81.27	72.66	126.85
Marine Mammals (10-48)	81.90	78.20	76.46	124.20

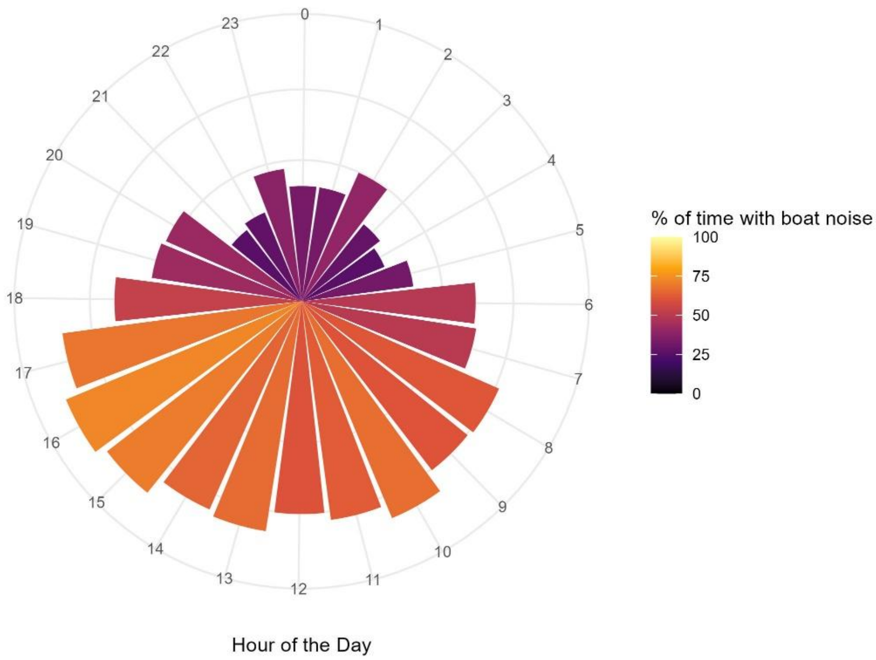

Figure 14. The distribution of boat passages in each hour of the day from August 22 – October 22, 2017.

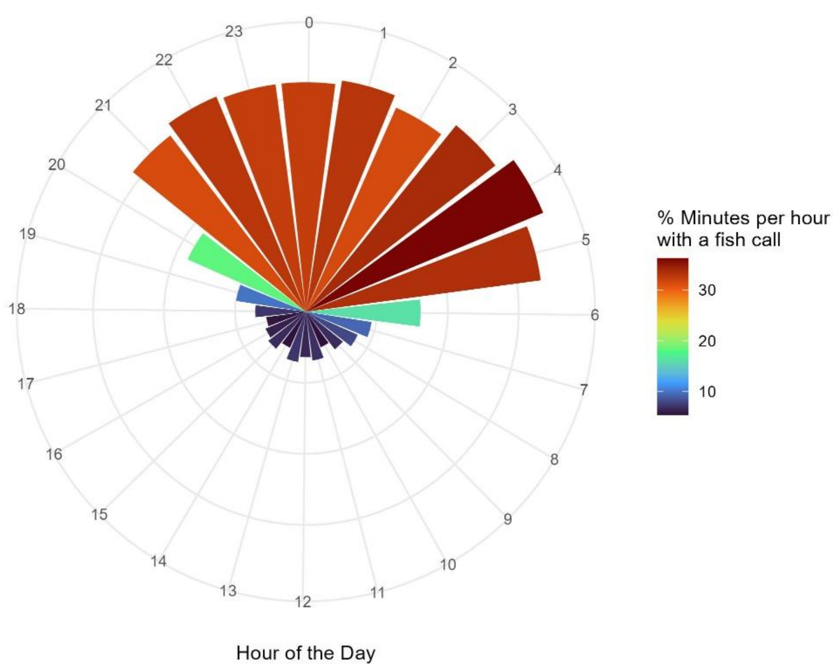

Figure 15. The distribution of fish calls throughout the day (average percent of minutes with a fish call per hour of the day) from August 22- October 22, 2017.

4 Conclusions

The survey of Dundavin Reef conducted in August 2017 has provided the first assessment of the ecological status and sponge coverage of this small glass sponge reef possibly interspersed with glass sponge gardens on bedrock. The combined use of high-definition video, still imagery, and passive acoustics has revealed that Dundavin Reef supports a diversity of reef-associated fish, invertebrates, and emergent corals. We found Dundavin to have a relatively low proportion of dead reef cover compared to groundtruthed reefs in the Strait of Georgia and Howe Sound. We also found limited evidence of anthropogenic disturbances, no fishing gear along the transects, and a relatively quiet soundscape compared to a Strait of Georgia reef. Complete mapping of the extent of Dundavin Reef would require further data collection, including higher quality geophysical data. The baseline information provided by this survey will serve as a valuable reference point for future monitoring, and for comparative studies with other glass sponge reefs on the coast.

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6 Glossary

6.1 Acronyms & Abbreviations

BC – British Columbia

BIIGLE – BioImage Indexing, Graphical Labeling and Exploration (online tool for marine image annotation)

CCIRA – Central Coast Indigenous Resource Alliance

CCGS – Canadian Coast Guard Ship

DFO – Department of Fisheries and Oceans (Canada)

FFT – Fast Fourier Transform (a method for frequency analysis in sound data)

GSR – Glass Sponge Reef

HD – High Definition

NMCAR – National Marine Conservation Area Reserve

NRCan – Natural Resources Canada

RCAs – Rockfish Conservation Areas

ROV – Remotely Operated Vehicle

SPL – Sound Pressure Level

6.2 Definitions of Terms

Acoustic data – Information collected using underwater microphones (called acoustic recorders or hydrophones) to study soundscapes, including animal sounds and anthropogenic noise.

Annotation (in imagery) – The process of labeling parts of an image or video, such as identifying species, substrate, or features.

Anthropogenic – Derived from human activities (e.g., fishing, pollution).

Benthic – Relating to the bottom of a body of water, such as the seafloor.

Bioconstruction – A structure built by a living organism, such as reefs built by glass sponges.

Biogenic habitat – Habitat generated by the presence of living organisms (e.g., reefs formed by sponges or corals).

Boot sponge – A type of non-reef-building glass sponge from the family Rossellidae.

Emergent coral – Coral species that protrude or rise above the seafloor.

Glass sponge – Sponges with skeletons made of silica (glass-like spicules). Reef-building glass sponges, specifically hexactinellid dictyonine sponges *Farrea occa, Heterochone calyx* and *Aphrocallistes vastus*, have fused spicules.

Geophysical surveys – Scientific investigations of the physical properties of the seafloor, often using sonar or multibeam echosounders.

Hydrophone – An underwater microphone used to record or listen to sounds in water.

iNaturalist – An online platform and community for recording biodiversity observations, including photographs of marine species.

Marine Protected Areas – Defined marine spaces that are legally protected under the *Oceans Act* and managed to achieve the long-term conservation of nature.

Marine Refuges – Spatial fisheries closures established under the *Fisheries Act* that provide long-term protection to biodiversity, particularly sensitive species and habitats like corals and sponges.

Multibeam echosounder – A sonar device that maps the seafloor by sending out multiple beams of sound.

Percent cover – A measure of how much of a given area is covered by a particular feature, such as live or dead sponge.

Point annotation – Marking the exact position of a feature or individual organism within an image or video.

Sound pressure level (dB re 1 μPa) – The logarithmic measure of the pressure of a sound relative to one microPascal, used in underwater acoustics.

Sponge rubble – Accumulated broken pieces of dead sponges.

Substrate – The surface or material at the bottom of a body of water on which organisms can grow.

Taxa (Taxon) – Groups of organisms classified by scientists, such as species, genus, family.

Transect – A path along which scientific measurements or observations are made, commonly used in ecological surveys.

Video annotation protocol – The standardized method used to record features and species in video footage for scientific consistency.

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