Epifaunal Communities Associated with Hard-Substrate Seabeds in Southern British Columbia

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EPIFAUNAL COMMUNITIES ASSOCIATED WITH HARD-SUBSTRATE SEABEDS IN SOUTHERN BRITISH COLUMBIA

by

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Sutherland, T.F., Sterling, A.M., and Ou, M. 2016. Epifaunal communities associated with hard-substrate seabeds in southern British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 3163: vii + 48 p.

Benthic video surveys were collected in Western Vancouver Island (WVI), Queen Charlotte Strait (QCS), Johnstone Strait (JS), Jervis Inlet (JI) and Sechelt Inlet (SI). Substrate composition and epifaunal abundance were estimated at 2-m segment intervals for each video survey (~100m length). Substrate categories consisted of fine sediments (<4mm), pebble (4-64 mm), cobble (64-256mm), shell hash (shell fragments), boulder (>256mm), skeletal sponge-matrix, veneer overlying bedrock, bedrock, and rock wall. Substrate composition and taxa abundance were plotted in three-dimensions against water depth and transect distance. The relationship between substrate and epifauna were discussed for each video survey.

RÉSUMÉ

Sutherland, T.F., Sterling, A.M., and Ou, M. 2016. Epifaunal communities associated with hard-substrate seabeds in southern British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 3163: vii + 48 p.

Des relevés vidéo sur les communautés benthiques ont été effectués à l'ouest de l'île de Vancouver, dans le détroit de la Reine-Charlotte, dans le détroit de Johnstone, dans l'anse Jervis et dans l'anse Sechelt. Pour chaque relevé vidéo, la composition du substrat et l'abondance de l'épifaune ont été estimées à des intervalles de deux (2) mètres entre les segments (longueur d'environ 100 m). Les catégories de substrat étaient les suivantes : sédiments fins (<4 mm), cailloux (4-64 mm), galets (64-256 mm), débris de coquillages (fragments de coquilles), grosses pierres (>256 mm), matrice de squelettes d'éponges, placage recouvrant une couche rocheuse et parois rocheuses. Les catégories de taxons épifauniques étaient les suivantes : anémones plumeuses, anémones tubicoles, autres espèces d'anémones, madréporaires, sabelles, serpules, galatées, grosses crevettes, éponges *Rhabdocalyptus dawsoni*, éponges *Aphrocallistes vastus*, éponges *Phakellia*, bourgeons d'éponges, ophiures, autres espèces d'étoiles de mer, oursins, holothuries du Pacifique, holothuries *Creeping-pedal*, nudibranches géants et ascidies jaunes. La composition du substrat et l'abondance des taxons ont été tracées en trois dimensions par rapport à la profondeur de l'eau et à la distance du transect. La relation entre le substrat et l'épifaune a fait l'objet d'une discussion pour chaque relevé vidéo.

INTRODUCTION

STUDY SITE CHARACTERISTICS

Jervis Inlet and Sechelt Inlet: This study was carried out in both Jervis and Sechelt Inlets, which are located in southwestern British Columbia approximately 65 km northwest of Vancouver (Figure 1). Jervis Inlet is approximately 80 km in length and consists of a series of basins with water depths ranging between 350 – 680 m, which are separated by shallow sills. This inlet is considered one of the deepest fjords on the British Columbia coastline. Sechelt Inlet is a fjordic system consisting of 3 Inlets: Sechelt Inlet, Salmon Inlet, and Narrows Inlet. The entrance to Sechelt Inlet is located along the southern border of lower Jervis Inlet and has a shallow sill of 14 metres in depth. The main inlet (Sechelt) has a length of 29 km, an average width of 1.2 km and a maximum depth of 300 m. Two adjoining inlets, Salmon Inlet and Narrows Inlet, enter the main inlet on the eastern border. Estuarine flow in Sechelt Inlet is driven by freshwater inputs from the head of Salmon Inlet which is controlled by a hydro-electric dam. Salmon Inlet is 20 km in length and approximately 250 m in depth. Narrows Inlet has a length of 14 km, a maximum depth of 85 m and is separated into an inner and outer region by a 11-m deep sill located at Tzoonie Narrows. In general, the fjordic attributes of Sechelt Inlet are based on the rocky steeply-sloped shoreline, long and narrow shaped inlets, deep water-depths, and shallow-silled entrance. For a description of water circulation patterns within Sechelt Inlet, refer to Pickard (1961), Lazier (1963) and Tinis and Pond (2001). Previous oceanographic and production studies in Jervis and Sechelt Inlets are discussed in Sutherland (1991), Haigh *et al*. (1992), Tinis and Pond (1992), and Timothy and Pond (1997).

West Vancouver Island, Queen Charlotte Strait and Johnstone Strait:
Upwelling is prevalent on the west coast of Vancouver Island between July to

August keeping near-shore temperatures below 5°C and slightly higher salinities than offshore waters (Ricker et al. 1989). Salinities drop in the surface waters due to seasonal river runoff. Salinities in the inlet surface waters may reach near-zero values at the inlet head or during periods of intense freshwater runoff (up to 5m thick). In contrast, QSS and JS waters are vertically-mixed, especially within the latter region due to strong currents generated in the network of narrow channels (Zacharias et al. 1995). Given the open water state of QCS, currents are generally weaker than those in JS in the absence of wind-generated currents across the large cross-sectional area of QCS. In terms of substrate composition, a description of the benthic environment in this region was not possible due to a paucity of information available in the scientific literature. The observations recorded in the current study will provide descriptions of fine, mixed, and hard substrates according to Wentworth classifications (Wentworth, 1929).

MATERIALS AND METHODS

COLLECTION OF BENTHIC VIDEO TRANSECTS

A collection of benthic video surveys was obtained from the British Columbia Ministry of Environment (BCMOE) and assessed for seabed attributes and faunal diversity. Figure 1 shows the locations of the benthic video surveys which were collected between 2008 – 2011 (Table 1,2, and 3). The spatial design of the video surveys was based on the Protocols for Marine Environmental Monitoring (Ministry of Water, Land and Air Protection, 2002) using remotely operated vehicles (ROVs). A communication cable between the ROV and the boat allowed for live feed of the seafloor video to be viewed on the boat deck computers. The GPS coordinate was recorded and a weighted rope was dropped straight down at the starting point of the video transect. The weighted rope guided the ROV which was lowered to the seafloor and then flown at a bearing to an end point approximately 100 to 150 m away from the starting point. The direction of the boat and ROV was maintained using a deck-mounted compass and a bearing stamp on the live video feed, respectively. The ROV was flown at a consistent speed (between 0.15 and 0.25 m s^{-1}) about 0.5 m above the seafloor with two halogen lights illuminating the seabed. The ROV cameras were usually angled at roughly 45˚ from the seabed. Where possible, lasers were attached to the ROV to aid in the quantification of substrate proportion and faunal enumeration within a known image area. At the end of the video transect, the ROV was flown to the water surface and the GPS coordinate was recorded.

ANALYSIS OF BENTHIC VIDEO IMAGERY

Video metadata and operations*:* To avoid the potential for biases related to assessments carried out by multiple video analysts, the video transects were viewed by the same individual on a cathode ray tube monitor (CRT). The CRT monitor provided the best resolution for viewing the digital .vob format of the video files. The LCD monitor, while a newer technology, did not perform as well as the CRT monitor in terms of colour contrast or resolution. The blue portion of colour spectrum was emphasised by the LCD monitor, while the red portion of the spectrum was emphasised with the CRT monitor. The red spectrum is important for underwater video as these shorter wavelengths do not travel as far in water and disappear at deeper depths. Small particles maintained a higher definition when viewed with the CRT monitor relative to that of the LCD monitor.

The ROV fly speed was used to determine the time period required to view a 2-m long seafloor segment and transect length in order to standardize the observed biota across a known area. For example, if the ROV fly speed was 0.2 m s^{-1} and the video segment length was 2 m, each segment would be viewed for 10 seconds. If the ROV paused or significantly sped up during the segment, this variation in time was accounted for during that observation period. Each transect began when the ROV started to move away from the weighted rope along the pre-determined bearing. For each video segment, the following parameters were recorded: start and end time; start and end depth, bearing at transect starting position; visibility score and comments; lighting area (%); time period laser is visible (%); fishing behaviour (deviations from benthos into water column); ROV touch downs and reversals; ROV stoppages (pauses to zoom in on organisms or ROV cable entanglement). The plotted transects were ground-truthed against the recorded depth and bearing from the ROV. Some transects were re-plotted to better align with the recorded depth and bearing.

Seabed substrate*:* The percent cover for each substrate type was recorded for each video segment (2-m length). The substrate categories pertaining to fine sand/mud, coarse sand, pebble, cobble, shell hash, boulder, and bedrock were based on the Wentworth grain size scale (Wentworth, 1922), while additional substrate categories observed in the video footage were considered as they make up a proportion of the seabed in B.C. (Table 2). The following substrate categories were estimated according to the Wentworth scale (1929): 1) Fine sediments (< 4 mm); 2) pebble (4-64 mm); 3) cobble; (64-256 mm); 4) boulder (> 256 mm). Additional categories were included in the substrate classification made up of shell-hash material, bedrock, veneer (fine-sediments overlying rock shelves), sponge-matrix (skeletal sponge-spicule fabric), and rock wall (vertical slope).

Three broad substrate classifications were developed based on the application of grab sampling mechanisms: 1) Fine sediments (FS) were considered a true "grabbable" soft-bottom seabed which required an aerial coverage of > 85% of mud-sand and veneer; 2) Rock wall substrate (RWS) were considered a true "non-grabbable" hard-bottom substrate that required an aerial coverage of >85% of bedrock and/or vertical rock wall; and 3) Mixed substrate (MS) may have been comprised of a composite of both the Wentworth classifications and additional substrate categories (shell-hash, bedrock, sponge-matrix, and RWS). The latter category may be conducive to surface grabs under certain conditions related to the presence of a critical mass of fine sediments.

Epifauna enumeration*:* Epifauna were identified to the finest possible taxonomic level using references that provided both photo identification as well morphological descriptions of taxa observed in the Pacific region (Harbo, 1999; Lamb and Edgell, 2010; Lamb and Hanby, 2005). The epifaunal taxa categories consisted of plumose anemone, tube-dwelling anemone, snakelock anemone, painted anemone, gorgonian coral, cup coral, sea pen, sabellid worm, serpulid worm, three-section worm, squat lobster, prawn, pink scallop, boot sponge, spaghetti sponge, cloud sponge, funnel sponge, sponge bud, brittle star, feather sea star, vermillion sea star, other sea star, urchin, giant cucumber, creeping-pedal cucumber, giant nudibranch, brachiopods, vase tunicate, and bristly tunicate. Individual counts of each taxa were recorded for each 2-m video segment. Once the analysis of each transect was completed, count data were standardized according to organisms *per* square meter. Each 2-m segment was equivalent to 1 square meter of surface area as the field of view was 0.5 m wide. The abundance data were then log(x+1) transformed to improve the normality of the epifaunal population and reduce the scale of the data range (Osborne, 2002).

RESULTS AND DISCUSSION

JERVIS INLET AND SECHELT INLET

Sites JI1-R1W and JI1-R2E (Ahlstrom, Fig. 8): The composition of substrate type is similar between transects R1W and R2E. Both transects are composed of 100% Rock Wall Substrate (RWS) with sponge matrix and vertical rock wall as the two most abundant substrate types. Bedrock and rock veneer substrates are also found in R2E but in lower proportions. In the R1W transect, the proportion of sponge matrix increases as distance along the transect increases, whereas in the R2E transect, the proportion of sponge matrix decreases with transect distance. The average depth of the two transects are 80.3 and 97.8 m (R1W and R2E, respectively).

Both transects in Ahlstrom are similar in species diversity and abundance. The most dominant taxa in R1W and R2E are sponge buds, squat lobsters and serpulid worms. In R1W, the abundance of sponge buds appears to decrease as transect distance increases and the proportion of vertical rock wall deceases. Squat lobsters, on the other hand, increase in abundance as the proportion of vertical rock wall decreases and the proportion of sponge matrix increases. Unlike R1W, sponge buds and squat lobsters appear to be relatively uniform in their distribution. Serpulid worm abundance is high in habitats with a high proportion of vertical rock wall substrate in both transects.

Sites JI2-R1E and JI2-R2W (Culloden, Fig. 9): R1E and R2W transects are composed of 100% Rock Wall Substrate (RWS) with sponge matrix and vertical rock wall as the two most abundant substrate types. Unlike the R1W transect, R2E also contains bedrock substrate. In R1E, the shorter of two transects, the abundance of sponge matrix substrate decreases while the abundance of vertical wall substrate increases with transect distance. In R2W, sponge matrix abundance is high near both the beginning and end of the transect, whereas vertical rock wall abundance is high in the middle of the transect. The average depth of the two transects are 115.7 and 84 m (R1E and R2W, respectively).

With respect to species abundance, similar species are found in both transects with sponge buds, serpulid worms and squat as the most abundant species. In both transects, squat lobster abundance appears to be high in areas with a high proportion of sponge matrix while serpulid worm abundance appears to be high in areas with a high proportion of vertical rock wall substrate.

Sites SI1-R1W and SI1-R2E (Kunechin, Fig. 10): R1W and R2E are both composed of 100% FS. FS is found in high proportions and is distributed uniformly throughout the two transects. Minor amounts of cobble also occur in both transects; however, relative to R1W, R2E has a higher proportion of cobble substrate that is more uniformly distributed. The average depth of the two transects are 87.4 and 92.5 m (R1W and R2E, respectively).

Overall, total species abundance is low in both transects relative to other reference sites in this study. The dominant taxa in R1W are sabellid worms, tube-dwelling anemones and squat lobsters. Sabellid worms are the most abundant species in R1W and occur in the highest abundance in the middle of the transect. Tube-dwelling anemones are the second most abundant species and are uniformly distributed throughout the transect. Squat lobsters, prawns and sabellid worms are the three most dominant taxa in R2E. Interestingly, squat lobsters are highly abundant in this 100% FS site and are distributed uniformly throughout the transect.

Sites SI2-R1W and SI2-R2E (Newcomb, Fig. 11): Transects R1S and R2N show a large difference in their substrate composition. R1S is composed of 61% RWS, 36% MS and 4% FS. Vertical rock wall, bedrock and rock veneer substrate occur in the highest proportions along the transect. Substrate composition becomes more varied towards the end of the transect. The depth range of R1W is 53.4-100.3 m with an average of 71.7 m. Overall, species diversity and abundance is relatively high in this transect. The three most abundant taxa are vase tunicates, serpulid worms and tube anemones. Vase tunicates are the most dominant taxa and appear to be uniformly distributed throughout the transect. Serpulid worms are present throughout the transect; however, they are the most abundant near the end of the transect, where substrate type becomes more varied. The abundance of tube-dwelling anemones is relatively uniform along the transect but appears to slightly decrease at the beginning and the end of R1W.

R2E is composed of 58% MS, 29% RWS and 13% FS. Sponge matrix, cobble and boulder substrate types occur in the highest proportions with lower amounts of fine sediment and cobble present in the last half of the transect. Sponge matrix is high in the first half of R2E and decreases as distance increases. Near the end of this transect, higher proportions of fine sediment and cobble are present. The depth range of this transect is 67-112.8 m with an average of 93.5 m. Similar to R1W, total species abundance is high relative to other reference sites. The top three dominant taxa are vase tunicates, squat lobsters and tube-dwelling anemones. Vase tunicate abundance is highest in the latter half of the transect, where fine sediment and cobble are the major substrate types present. The abundance of squat lobsters is the highest in the first half of R2E, where the coverage of sponge matrix is high. From 30 m and onwards, tube-dwelling anemones are uniformly distributed and occur in medium to high abundance. Similar to vase tunicates, serpulid worms also occur in higher abundance in the last half of R2E, where fine sediment and cobble substrates are more prevalent.

Sites SI3-R1E and SI3-R2W (Site 9, Fig. 12): Transects R1E and R2W show a large difference in their substrate composition. R1E is composed of 59% MS, 27% RWS and 14% FS with vertical rock wall, cobble and rock veneer as the most abundant substrate types. There is a high proportion of vertical rock wall substrate near the beginning and end of the transect. Substrate composition becomes more varied in the middle and end of the transect and consists of a mixture of cobble, rock veneer, and vertical rock wall substrate. The depth range of this transect is 56-132 m with an average of 100.4 m. Vase tunicates, serpulid worms and squat lobsters are the three most dominant taxa in R1E. Vase tunicates and serpulid worms occur in higher abundance in the latter half of the transect, where MS is more prevalent. Conversely, squat lobster only occur in the first half of this transect where vertical rock wall substrate is main substrate type.

R2W is composed of 90% MS and 10% FS. Fine sediment and cobble occur in the highest proportion in this transect, with minor amounts of pebble and boulder present. The proportion of cobble substrate is the highest throughout the entire transect with the exception of the mid-transect section where fine sediment are high. The depth range of R2W is 53-91 m with an average of 72.7 m. Compared to R1E, total species abundance is lower than that of R2E. The top three dominant taxa are serpulid worms, sabellid worms and vase tunicates.

Sites SI4-R1S and SI4-R2N (Site 13, Fig. 13): Transects R1S and R2N show a large difference in their substrate composition. R1S is composed of 100% FS with minor amounts of boulder and cobble occurring in the middle of this transect. The depth range of this transect is 56-80 m with an average of 72.5 m. Overall, the total abundance of species in SI4-R1S is lower than the total abundance of species at other reference sites in this study. Sabellid worms, tube-dwelling anemones and plumose anemones are the three most dominant taxa in R1S. Sabellid worm abundance is the highest near both the beginning and end of this transect, where only fine sediment is present. Tube-dwelling-anemones occur in low abundance and are uniformly distributed throughout the entire transect.

R2N is composed of 95% MS and 5% RWS. Compared to R1S, the substrate composition of this site is highly diverse and consists of vertical wall, rock veneer, fine sediment, bedrock, cobble, shell hash as the main types of substrate. Vertical rock wall substrate is the most abundant substrate type and is highest in the first half and the last quarter of this transect. The middle of R2N is composed of MS and consists of higher proportions of rock veneer, fine sediment, cobble, pebble and shell hash. The depth range of this transect is 28-64 m with an average of 42.3 m. Similar to R1S, total species abundance is low relative to other reference sites. The top three dominant taxa are serpulid worms, tube anemones and brittle stars. Tube-dwelling anemones occur in high abundance in the middle of this transect, where MS is high. Serpulid worm abundance is the highest near both the beginning and end of this transect, where RS is high.

Sites SI5-R1S and SI5-R2N (Salten, Fig. 14): R1S and R2N are similar in substrate composition and are both composed mainly of a sponge-matrix substrate. The substrate composition of R1S is 100% RWS, consisting also of minor amounts of vertical rock wall and bedrock substrates. The substrate composition of R2N is 88% RWS and 12% MS. Unlike R1S, R2N only consists of the two substrate types, sponge matrix and cobble. In both transects, the proportion of sponge matrix deceases while the proportion of other substrate types increase near the end of each transect. The average depth of the two transects are 64.1 and 57.7 m (R1S and R2N, respectively).

The diversity and distribution of species is similar between transects R1S and R2N. Squat lobsters, brittle stars, vase tunicates are the three most dominant taxa in R1S. Sabellid worm, vase tunicates and brittle star are the three most dominant taxa in R1S. In both transects, high brittle star abundance appears to correlate with a lower proportion of sponge matrix and a higher proportion of vertical rock wall, bedrock and cobble substrate. The distribution of sabellid worms appears to be more uniformly distributed in R2N relative to R1S, where sabellid worms mainly occur further down the transect. In R1S, squat lobster abundance is high in the first half of this transect and appears to decrease in the latter half of this transect, where the proportion of sponge matrix decreases and the substrate composition becomes more varied.

Sites SI6-R1S and SI6-R2N (Vantage, Fig. 15): Transects R1S and R2N show a large difference in their substrate composition. R1S is composed of 89% FS and 11% Mixed Substrate (MS) with fine sediment and pebble as the most abundant substrate types. There is a high proportion of fine sediment near the beginning of this transect and in the latter half of the transect. The depth range of this transect is 33.3-68.9 m with an average of 52.7 m. Vase tunicates, tube-dwelling anemones and serpulid worms are the three most dominant taxa in R1S. Tube-dwelling-anemones occur in medium abundance and are uniformly distributed throughout the entire transect. Vase tunicates are highly abundant in the region where the proportion of fine sediment is low and the proportion of pebble substrate is high.

R2N is composed of 58% RWS and 42% MS. The substrate composition of this site is highly diverse and consists of vertical wall, fine sediment, bedrock, cobble, shell hash as the main types of substrate. Vertical rock wall substrate occurs in the highest proportion throughout the entire transect. The depth range of R2N is 25.4-35.6 m with an average of 30.2 m. Relative to R1S, R2N is more diverse in terms of species richness despite having a shorter transect area. The top three dominant taxa are vase tunicates, brittle stars and serpulid worms.

QUEEN CHARLOTTE STRAIT AND JOHNSTONE STRAIT

Sites JS2-R1E and JS2-R2W (Barnes Bay, Fig. 16): R1E is composed of 100% MS with rock veneer, bedrock, and shell hash as the most abundant substrate types. For the first two thirds of this transect, rock veneer is present in the highest proportion but is absent in the last third of the transect, which is composed mainly of bedrock. Shell hash is found in lower proportions and is distributed uniformly throughout the entire transect. The depth range of R1E is 28-40 m with an average of 33.8 m. The three most dominant taxa in R1E are pink scallops, three-section worms and sea stars. This transect contains the highest abundance of pink scallops compared to all other transects in this study. Pink scallop abundance is high throughout most of R1E but begins to decrease slightly in the last half of this transect, where rock veneer is absent and bedrock substrate abundance increases. Similarly, the abundance of three section worms is highest in the first two thirds of this transect, where bedrock is absent and rock veneer occurs in high proportions. Other taxa groups (sea stars and tube-dwelling anemones) occur in lower abundance but are more uniformly distributed than scallops and three-section worms.

R2W is also a 100% MS site; however, unlike R1E, R2E is mainly composed of fine sediment and pebble substrate types. As transect distance increases, there is a slight decrease in the proportion of fine sediment and a slight increase in the proportion of cobble. Shell hash is present in very low proportions and is uniformly distributed throughout this transect. The depth range of R2W is 23-35 m with an average of 27.7 m. The most dominant taxa in R2W are tube-dwelling anemones, urchins, sabellid worms and cup corals. Tube-dwelling anemones are uniformly distributed throughout the transect and appear to increase in abundance as distance increases.

Sites QCS1-R1SE and QCS1-R2NW (Doyle, Fig. 17): Transects R1SE and R2NW show a large difference in their substrate composition. R1SE is composed of 70% FS, 26% MS and 4% RWS with rock veneer, fine sediment, vertical rock wall and cobble as the most abundant substrate types. The first half of this transect is predominantly composed of either rock veneer or fine sediment, while the second half of this transect is more varied in substrate composition and consists of a combination of cobble, vertical rock wall, rock veneer, boulder and fine sediment. The depth range of R1SE is 77-92 m with an average of 87.9 m. The three most dominant taxa in R1SE are three-section worms, sabellid worms and scallops. Three section worms occur in the greatest abundance in this transect and are highest in regions where fine sediment is abundant. Sabellid worms and scallops on the other hand, are more uniform in their distribution. In addition, spaghetti sponges are found in medium abundance in the first half of R1SE, where rock veneer is present in high proportions.

In contrast, R2NW has lower substrate and species diversity than R1SE. R2NW is composed entirely of fine sediment. The depth range of R2NW is 80-91 m with an average of 87.9 m. With respect to species diversity, R2NW contains fewer species than R1SE; however, the abundance of dominant taxa is higher in R2NW. Three section worms, sabellid worms, squat lobsters and prawns are the most dominant species R2NW. Three-sections worms are uniformly distributed and occur in the greatest abundance throughout the transect. Sabellid worms, the second most abundant species, appear to decrease in abundance as transect distance increases while squat lobsters are only present in the first half of the transect.

Sites QCS3-R1E and QCS3-R2W (Simmonds Bay, Fig. 18): R1E and R2W are similar in substrate composition and are composed mainly of vertical rock wall and fine sediment. The substrate composition is 68% MS and 32% FS in R1E and 79% MS, 17% FS and 4% RWS in R2W. In R1E, fine sediment is present in the greatest proportion near the beginning and the last half while vertical rock wall and is present in the greatest proportions near the middle of the transect. Conversely, the first two thirds of R2W is almost entirely composed of vertical rock wall substrate and transitions into mainly fine sediment in the last third of the transect. Both transects become more varied in their substrate composition in the last half of this transect. Although shell hash is present in minor proportions in both transects, it is more abundant and occurs more frequently in R1E. The average depth is 78.3 (72-82.1) m in R1E and 82.8 (68.3-100.7) m in R2W.

Similar types of species are found in R1E and R2W transects in Simmons Bay. In R1E, cup corals, prawns and scallops are the three top dominant species. Cup corals, the most dominant species, are absent near the beginning of this transect, where the proportion of fine sediment is high; however, their abundance increases dramatically as the proportion of vertical rock wall increases. Alternately, prawn abundance is the greatest near the beginning of the transect and starts to decrease as the proportion of fine sediment decreases and the proportion of vertical rock wall increases. In R2W, the most dominant taxa are cup corals, serpulid worms and giant cucumbers. Unlike R1E, prawns are not found within this transect. Cup corals are the most dominant species in R2W and are found in high abundance near the beginning of the transect, where the substrate type is dominated by vertical rock wall. Cup coral abundance is low in the mid-section of the transect but appears to increase near the end of the transect. Serpulid worms are the most abundant near the end of this transect and giant cucumbers are the most abundant in the middle of the transect.

Sites QCS4-R1W and QCS4-R2E (Wehlis Bay, Fig. 19): R1W is composed of 89% MS and 11% FS. This transect is highly variable in substrate composition with fine sediment, boulder, cobble and shell hash as the main types of substrate. Fine sediment is found in the greatest proportion and is the most abundant substrate type near the beginning and the end of this transect. The first half of R1W consists of fine sediment, cobble and shell hash, while in the last half of the transect, the proportions of shell hash and cobble decrease with increasing proportions of boulder. The depth range of R1W is 25.5-83 m with an average of

56.5 m. The three most dominant taxa in R1W are cup corals, serpulid worms and urchins. Cup corals are the most dominant species and are most abundant in the last half of this transect, where the proportion of boulder substrate type is the greatest. Similar to cup corals, serpulid worms and sea pens also occur in high abundance in the last half of the transect. Conversely, urchins occur in high abundance in the first half of the transect and are absent in the second half of R1W.

Compared to R1W, R2E is less varied in substrate composition. R2E is composed of 58% MS and 42% FS with fine sediment and vertical rock wall as the main substrate types. The first half of this transect is composed mainly of fine sediment with very minor amounts of cobble. The second half of the transect is composed almost entirely of vertical rock wall. The depth range of R2E is 30.4-86 m with an average of 61.5 m. With respect to species diversity, prawns, cup corals and serpulid worms are the most dominant taxa in R2E. Prawns are distributed uniformly in the first half of the transect, where fine sediment is present in high proportions. In contrast, cup corals and serpulid worms are absent in the first half of the transect but are highly abundant in the last half of the transect, where vertical rock wall is the dominant substrate type.

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Sites WV1-R1N and WV1-R2W (Atrevida, Fig. 20): Transects R1N and R2W show a large difference in their substrate composition. R1N is composed of 72% MS, 2% FS and 8% RWS with fine sediment and cobble as the most abundant substrate types. Rock veneer, vertical rock wall and boulder substrate types are also found in R1N but in lower proportions and frequency. Fine sediment is the most abundant type of substrate and is distributed uniformly throughout most of this transect. Although lower in abundance, cobble is also distributed uniformly throughout this transect. Near the end of the transect, the proportion of fine sediment decreases dramatically and the proportion of vertical rock wall substrate increases. The depth range of R1N is 83-88.9 m with an average of

84.9 m. The three most dominant taxa in R1N are serpulid worms, prawns and brachiopods. Serpulid worms are the most dominant species in this transect. Serpulid worm abundance is highest near the beginning of the transect and at the end of the transect. Prawns are the second most dominant species but are only found near the beginning of the transect.

R2W is composed of 59% RWS, 22% FS and 19% MS. Compared to R1N, the substrate composition is less diverse and consists predominantly of vertical rock wall and rock veneer substrate. Vertical rock wall is the most dominant substrate type and makes up 100% of the substrate composition in most areas of this transect. There are 2 regions in the first half of the transect that consists of 100% rock veneer. The depth range of R2W is 114.2-118.4 m with an average of 116 m. Species diversity in is higher in R2W than in R1N. The most dominant taxa in R2W are serpulid worms, squat lobsters and plumose anemones. Serpulid worms are the most dominant species and are found in the greatest abundance, where vertical rock wall is the dominant substrate type. Similarly, squat lobsters and plumose anemones are more abundant in areas with a high proportion of vertical rock wall and a low proportion of rock veneer. In general, species diversity and species abundance appear to be low in areas where rock veneer occurs in high proportions and vertical rock wall is absent.

Sites WV2-R1N and WV2-R2S (Concepcion, Fig. 21): Transects R1N and R2S are not very diverse in substrate composition. R1N is composed of 96% RWS and 4% MS with bedrock as the most dominant substrate type. R2S is composed of 88% RWS, 8% FS and 4% MS with vertical rock wall as the most dominant substrate type. Both transects consists almost entirely of the dominant substrate type. The average depth is 66.1 (64.2-67.8) m in R1N and 60 (58.3-62.4) m in R2S.

Of the two transects, R1N is lower in species diversity and species abundance. The three most dominant species in R1N are brachiopods, serpulid worms and sabellid worms. Brachiopods are the most dominant species and are distributed uniformly throughout the entire transect. Alternately, serpulid worms, occur mainly in the last two thirds of the transect. Brachiopods, serpulid worms and squat lobsters are the top three dominant species in R2S. The most abundant species are brachiopods, which are highly abundant in the first half of R2S. Compared to all other transects in this study, WV12-R2S contains the highest abundance of brachiopods. Serpulid worms and squat lobsters appear to be distributed uniformly throughout the entire transect.

Sites WV3-R1N and WV3-R2S (Esperanza, Fig. 22): R1N is composed of 60% RWS, 24% FS and 16% MS with vertical rock wall and fine sediment as the most dominant types of substrate. Vertical rock wall is the most dominant substrate type and makes up 100% of the substrate composition in most areas of R1N. In the third quarter of the transect, vertical rock wall is absent while fine sediment makes up nearly 100% of this region's substrate composition. The depth range of R1N is 36-73 m with an average of 55.2 m. Serpulid worms, tube-dwelling anemones and feather stars are the three most dominant taxa in R1N. The feather star appears to increase with decreasing water depth. The most dominant species are serpulid worms, which are relatively uniform in their distribution with the exception of regions with high sediment, where abundance drops to zero. Similarly, feather star and brachiopod abundance is high in areas with a high proportion of vertical rock wall and a low proportion of fine sediment. Tube-dwelling anemones, on the other hand, are highly abundant in the region, where fine sediment makes up almost 100% of the region's substrate composition.

R2S has higher substrate diversity than R1N. R2E is composed of 76% RWS, 21% MS and 3% FS. The main substrate types in this transect are vertical rock wall, fine sediment and bed rock. Vertical rock wall is the most dominant substrate type and makes up almost 100% of the substrate composition throughout most of the transect. However, near the last quarter of the transect, substrate composition becomes more varied with fine sediment, bedrock, and cobble occurring in greater proportions. The depth range of R2S is 96-143 m with an average of 120.3 m. With respect to species diversity, serpulid worms, squat lobsters, sabellid worms and brachiopods are the most dominant species in R2S.

Serpulid worms and squat lobsters occur in high abundance and are uniformly distributed throughout most of the transect. In contrast, sabellid worm abundance appears to decrease near the end of the transect, where substrate composition becomes more varied.

Sites WV4-R1W and WV4-R2E (Hecate, Fig. 23): R1W is composed of 46% RWS, 33% FS and 21% MS with vertical rock wall and fine sediment as the main substrate types. The most abundant substrate type is vertical rock wall, which represents almost 100% of the substrate composition in the last two thirds of R1W. In the first third of this transect, fine sediment is present in high proportions and only a very minor amount of shell hash is present. The depth range of R1W is 58-87 m with an average of 74.4 m. The most dominant taxa in R1W are tube-dwelling anemones, serpulid worms, brachiopods and squat lobsters. Tube-dwelling anemones and squat lobsters are highly abundant in the first third of the transect, where fine sediment occurs in high proportions. They are absent in the remaining section of the transect, where vertical rock wall occurs in high proportions. Similarly, prawns only appear to be present in areas of high fine sediment and absent in areas with high vertical rock wall substrate. In contrast, serpulid worms and brachiopods are highly abundant in the last two thirds of R1W, where vertical rock wall is present high proportions, and absent near the beginning of the transect, where fine sediment is present in high proportions.

R2E is composed of 60% FS, 20% MS and 20% RWS. Similar to R1W, the main substrate types in R2E are fine sediment and vertical rock wall. Fine sediment is the most dominant substrate type and is highly abundant in the first half of this transect. Minor amounts of shell hash are also present in this area. In the last half of R2E, the substrate composition can be divided into 2 sections consisting of a highly varied substrate type and a 100% vertical rock wall near the end of the transect. The depth range of R2E is 47-62 m with an average of 53.6 m. The most dominant taxa in R2E are serpulid worms, squat lobsters, prawns and tube anemones. The types and distribution of species are similar between R1E and R2W. As with R1E, squat lobsters, prawns and tube-dwelling anemones are found in high abundance in the first half of R2E, where fine sediment is high and vertical rock wall substrate is absent. In addition, serpulid worms and brachiopods are highly abundant in the last half of R2E, where rock wall substrate is high and fine sediment is absent.

Sites WV6-R1W and WV6-R2E (Muchalat North, Fig. 24): Transects R1W and R2E show a large difference in their substrate composition. R1W is composed of 54% RWS, 43% MS and 4% FS with vertical rock wall and rock veneer as the most abundant substrate types. Vertical rock wall is the most dominant substrate type in R1W. In the first third of the transect, vertical rock wall makes up nearly 100% of the substrate composition in this area. In the last two thirds of the transect, the proportion of vertical rock wall decreases slightly and the proportions of less dominant substrate types (rock veneer, cobble, fine sediment and boulder) increases. The depth range of R1W is 101-118 m with an average of 111.4 m. The most dominant taxa in R1W are serpulid worms, squat lobsters, brachiopods and boot sponges. Serpulid worms are the most dominant species in this transect and appear to be uniformly distributed throughout. Squat lobsters, on the other hand, appear to slightly decrease in abundance as transect distance increases and as the proportion of vertical rock wall decreases. Additionally, brachiopod abundance is greatest near the middle of the transect and boot sponge abundance is greatest near the beginning and the end of the transect.

R2E is composed of 39% MS, 32% FS and 29% RWS with vertical rock wall and fine sediment as the most dominant substrate types. Vertical rock wall makes up 100% of the substrate composition in the first third of R2E. The last two thirds of the transect contains very little vertical rock wall and is more varied in substrate composition. Fine sediment is the most dominant substrate in this area of the transect. The depth range of R2E is 47-62 m with an average of 53.6 m. Brachiopods, serpulid worms and tube-dwelling anemones are the most abundant taxa in R2E. Brachiopods are the most dominant species and are the most abundant near the beginning of the transect, where vertical rock wall abundance is high. Conversely, serpulid worms and tube-dwelling anemones appear to be most abundant in the last two thirds of the transect, where fine sediment is present in high proportions and vertical rock wall is present in low proportions.

Sites WV8-R1W and WV8-R2E (Williamson, Fig. 25): R1W and R2E are similar in substrate composition and are composed mainly of fine sediment and vertical rock wall. The substrate composition is 36% FS, 32% MS and 32% RWS in R1W and 38% MS, 33% FS and 29% RWS in R2E. Fine sediment, vertical rock wall and rock veneer are the most abundant substrate types in both transects. In R1W, the first quarter of the transect is dominated by fine sediment while the rest of the transect is dominated by vertical rock wall and rock veneer. Similarly, fine sediment makes up nearly 100% of the substrate composition in the first half of R2E while vertical rock wall and rock veneer becomes more abundant in the last half of the transect. The average depth is 105.5 (86-119) m in R1W and 92.9 (77-113) m in R2E.

Similar types of species are found in R1W and R2E transects in Williamson. Serpulid worms, prawns and cup corals are some of the most dominant taxa in these two transects. Squat lobsters are present in both transects; however, they are much more abundant in R1W than R2E. Sabellid worms, on the other hand, appear to be more dominant in R2E than R1W. In R1W, serpulid worms are the most dominant species and appear to be uniformly distributed throughout this transect. Squat lobster abundance decreases as transect distance increases, whereas prawn abundance increases as transect distance increases. In R2E, serpulid worms are the most dominant species and are highly abundant in the last half of the R2E, where vertical rock wall and rock veneer occur in high proportions. Similar to serpulid worms, sabellid worms are the most abundant in areas where vertical rock wall and rock veneer make up almost 100% of the substrate composition. In contrast to R1W, prawns in R2E are the most abundant in areas of high fine sediment. Cup corals occur in the greatest abundance in the middle region of both transects.

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TABLES AND FIGURES

Table 1: Site locations for video surveys in Jervis Inlet and Sechelt Inlet.

Site	Date	Lattitude – Longitude Starting Location	Bearing	Depth (m)
JI1	2009/06	W: 49˚ 46.619; -124˚ 11.316 E: 49˚ 47.479; -124˚ 06.611	313˚ 23˚	75.6-84.7 75.5-116.1
JI2	2008/04	W: 49˚ 47.479; -124˚ 06.611 E: 49˚ 47.830; -124˚ 05.116	50˚ 230˚	74.6-92.0 109.0-120.2
SI1	2011/07	W: 49˚ 37.972; -123˚ 47.470 E: 49˚ 38.267; -123˚ 46.435	270˚ 10˚	81-91 86-99
SI2	2010/10	W: 49˚ 38.281; -123˚ 40.187 E: 49˚ 38.607; -123˚ 38.806	230˚ 25˚	53.4-100.3 67-112.8
S13	2010/05	W: 49˚ 38.735; -123˚ 44.063 E: 49˚ 38.861; -123˚ 42.769	250˚ 348˚	53.0-91.0 56.0-132.0
S14	2010/05	N: 49˚ 38.023; -123˚ 50.763 S: 49˚ 37.270; -123˚ 50.378	300˚ 166˚	28.0-64.0 56.0-80.0
S15	2010/08	N: 49˚ 37.411; -123˚ 50.424 S: 49˚ 36.482; -123˚ 49.329	293˚ 250˚	49.4-70.6 50.3-86.5
SI6	2011/08	N: 49˚ 40.615; -123˚ 51.819 S: 49˚ 40.011; -123˚ 51.690	284˚ 200˚	25.4-35.6 33.3-68.9

Table 2: Site locations for video surveys in Queen Charlotte Strait and Johnstone Strait.

Site	Date	Lattitude – Longitude Starting Location	Bearing	Depth (m)
JS2	2010/10	E: 5˚ 18.915; - 125˚ 16.807 W: 50˚ 19.078; - 125˚ 14.702	28˚ 112˚	28-40 23-35
QCS1	2010/11	SE: 50˚ 49.215; - 127˚ 31.014 NW: 50˚ 48.190; - 127˚ 28.165	82˚ 248˚	77-92 80-91
QCS3	2011/01	E: 50˚ 53.001; - 126˚ 53.747 W: 50˚ 52.175; - 126˚ 54.794	0˚ 220˚	72-82.1 68.3-100.7
QCS4	2011/04	W: 50˚ 51.295; - 126˚ 56.105 E: 50˚ 51.159; - 126˚ 54.369	241˚ 130˚	25.5-83 30.4-86

Table 3: Site locations for video surveys in West Vancouver Island.

Site	Date	Lattitude – Longitude Starting Location	Bearing	Depth (m)
WVI1	2008/06	N: 49˚ 39.950; - 126˚ 28.931 W: 49˚ 38.763; - 126˚ 29.545	114˚ 23˚	83-88.9 114.2-118.4
WVI 2	2010/07	N: 49˚ 40.084; - 126˚ 29.081 S: 49˚ 38.936; - 126˚ 29.571	300˚ 346˚	64.2-67.8 58.3-62.4
WVI3	2010/04	N: 49˚ 53.031; - 126˚ 45.880 S: 49˚ 52.388; - 126˚ 45.208	310˚ 290˚	36-73 96-143
WVI4	2010/04	W: 49˚ 52.477; - 126˚ 46.023 E: 49˚ 51.272; - 126˚ 43.623	288˚ 82˚	58-87 42-87
WVI6	2011/09	W: 49˚ 38.221; - 126˚ 20.635 E: 49˚ 38.366; - 126˚ 18.139	103˚ 115˚	101-118 47-62
WVI8	2011/01	W: 49˚ 38.790; - 126˚ 29.472 E: 49˚ 39.604; - 126˚ 25.128	202˚ 29˚	86-119 77-113

Table 4: Substrate categories observed in video footage.

Substrate Type	Size Category
Fine sand/mud	≤0.2 mm
Coarse sand	0.2-2 mm
Pebble	2-60 mm
Cobble	>60 mm
Shell hash	Shell hash
Boulder	
Sponge skeleton matrix	Fabric of skeletal sponge spicules attached to bedrock
Bedrock with veneer	Fine sediment layer overlying bedrock
Bedrock	Flat / sloped grade
Rock wall	Vertical cliff

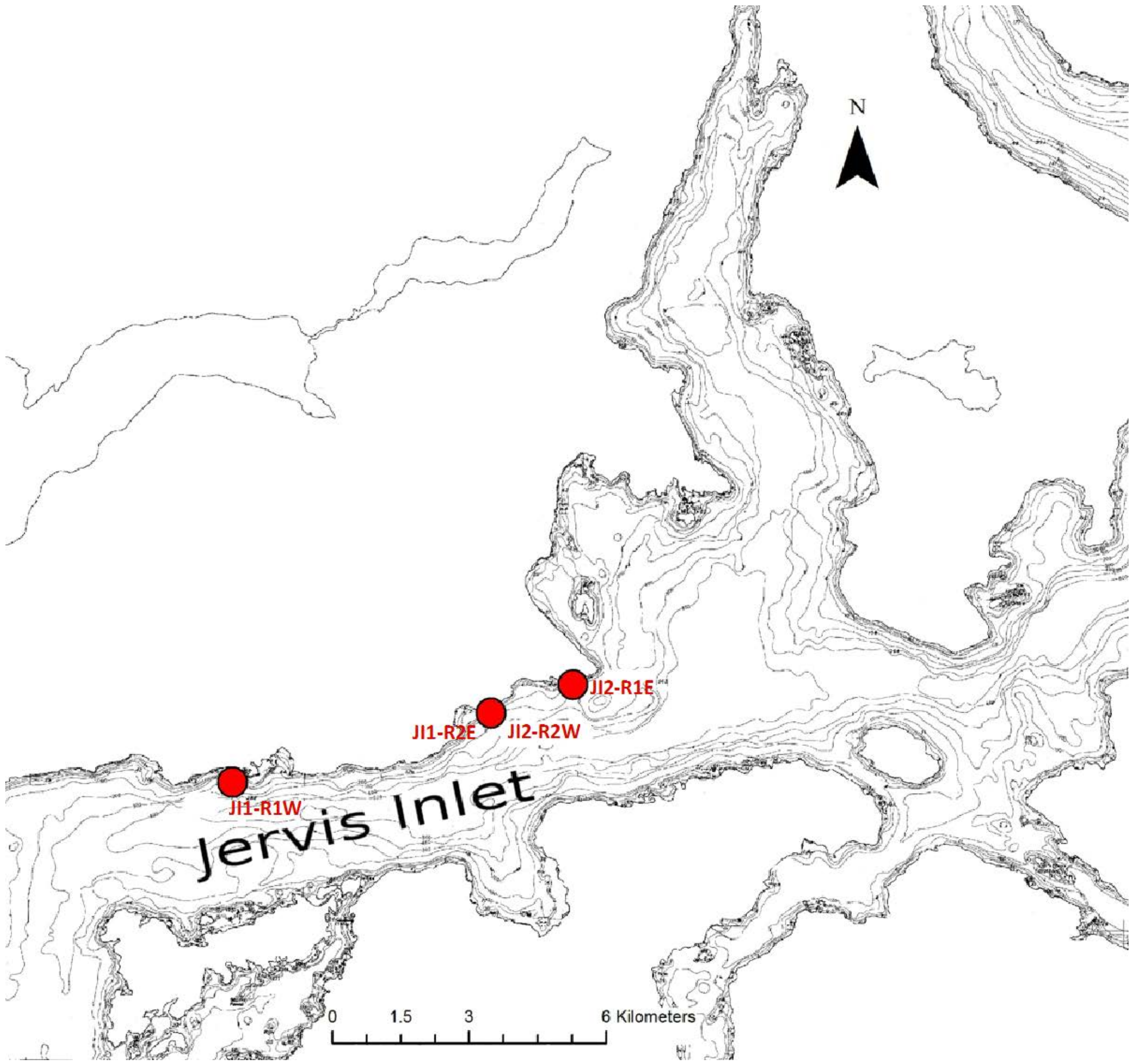

Figure 1: The location of benthic video transects in Jervis Inlet, British Columbia.

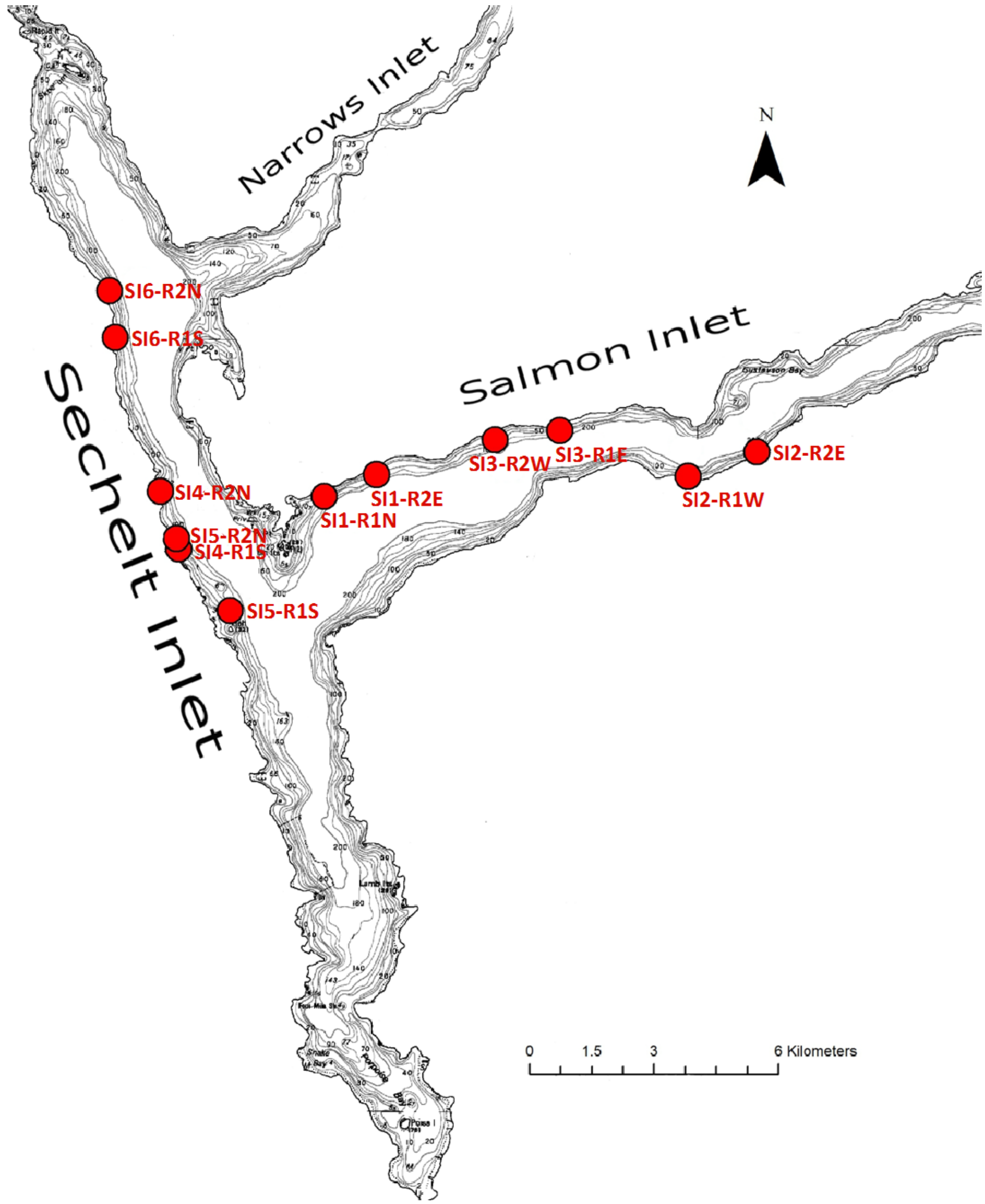

Figure 2: The location of benthic video transects in Sechelt Inlet, British Columbia.

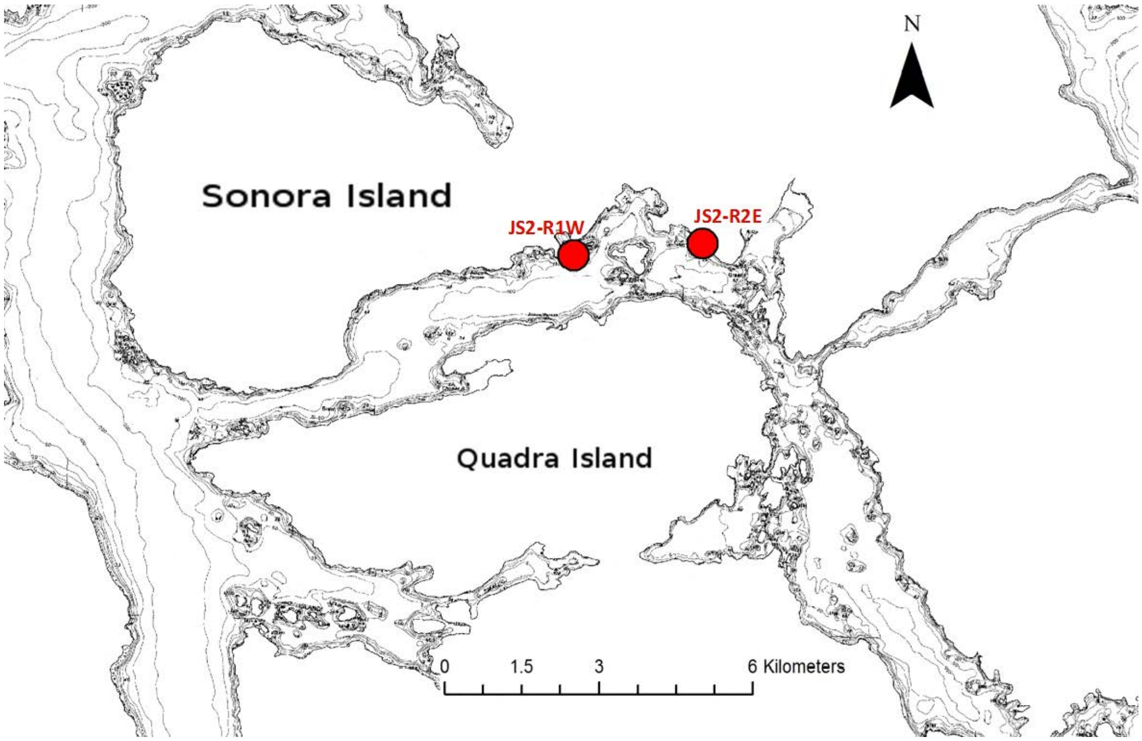

Figure 3: The location of benthic video transects in Johnstone Strait, British Columbia.

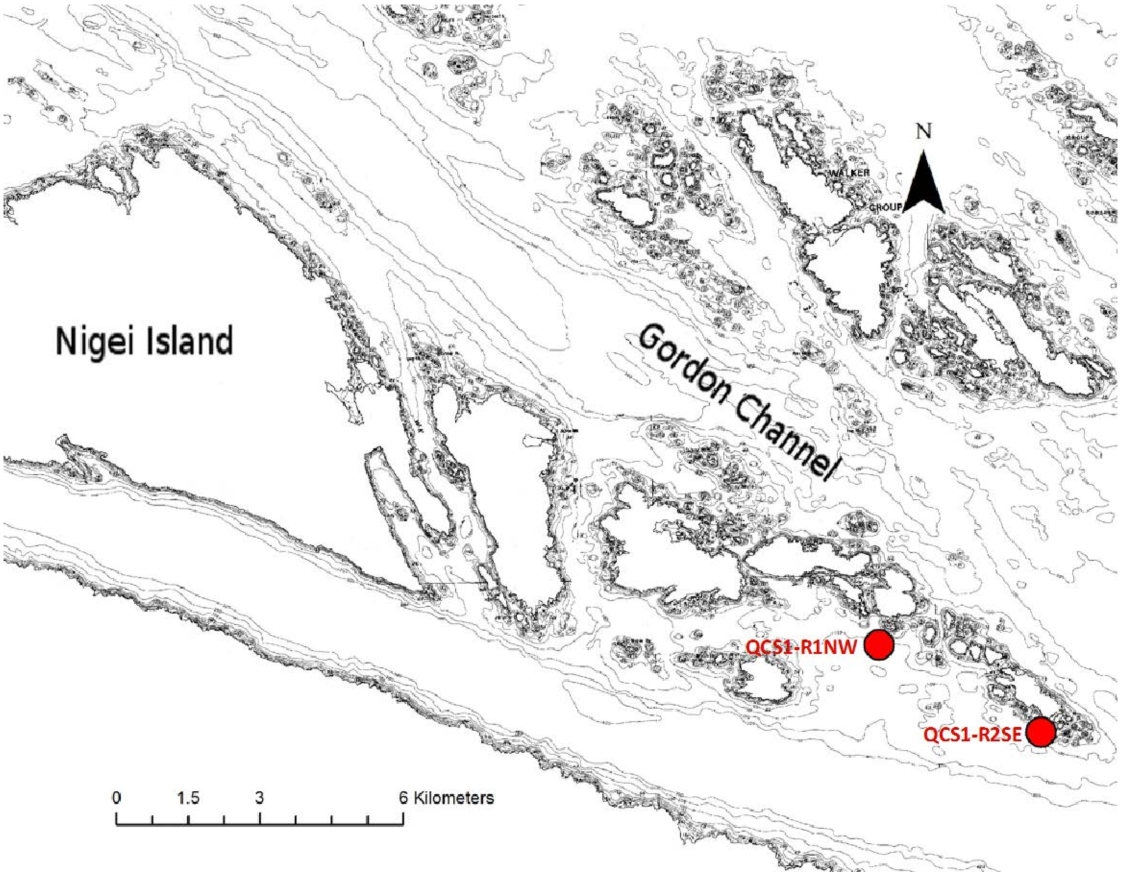

Figure 4: The location of benthic video transects in Queen Charlotte Strait, British Columbia.

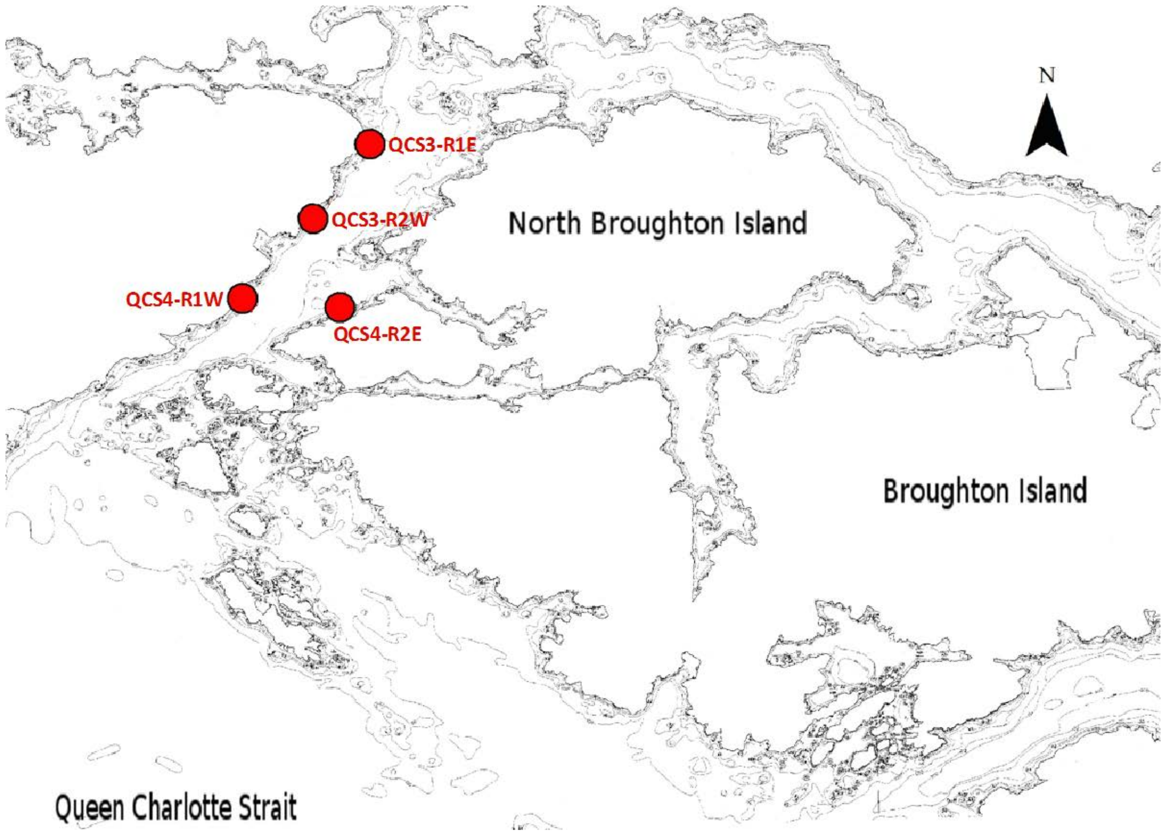

Figure 5: The location of benthic video transects in Queen Charlotte Strait, British Columbia.

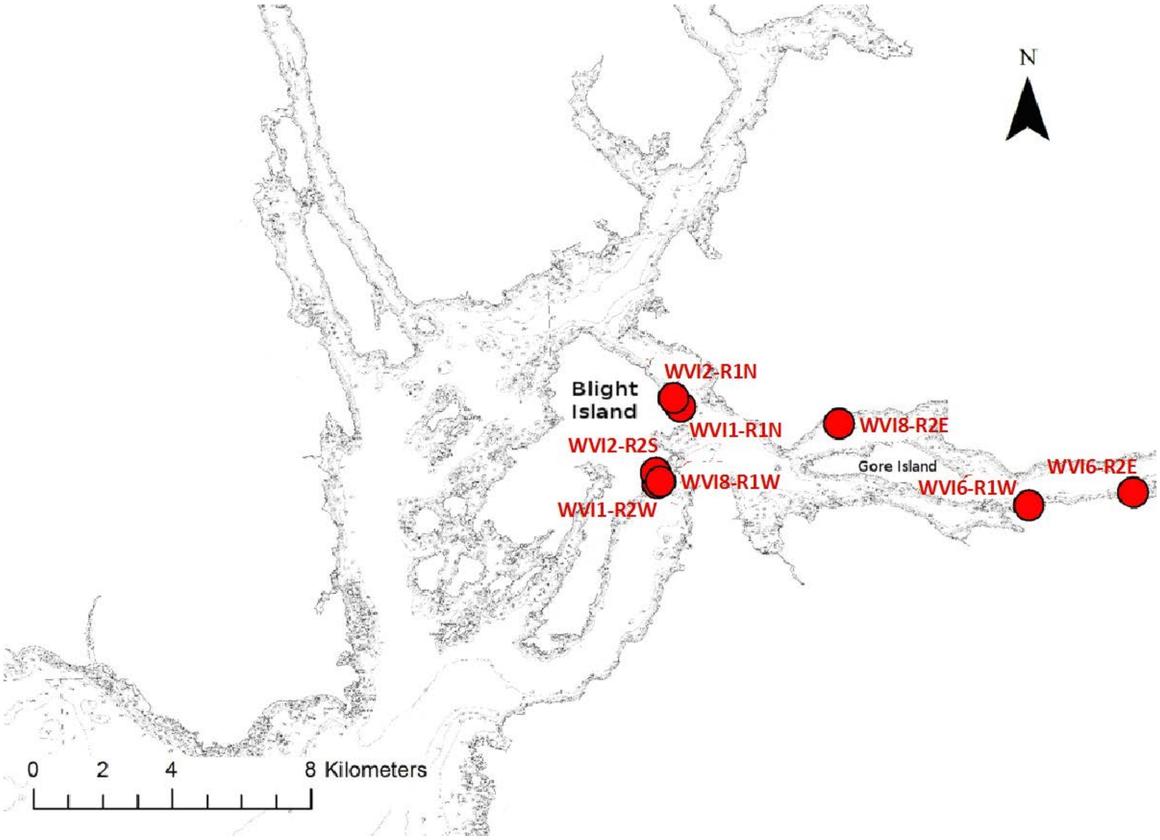

Figure 6: The location of benthic video transects in Nootka Sound and Muchalat Inlet, British Columbia.

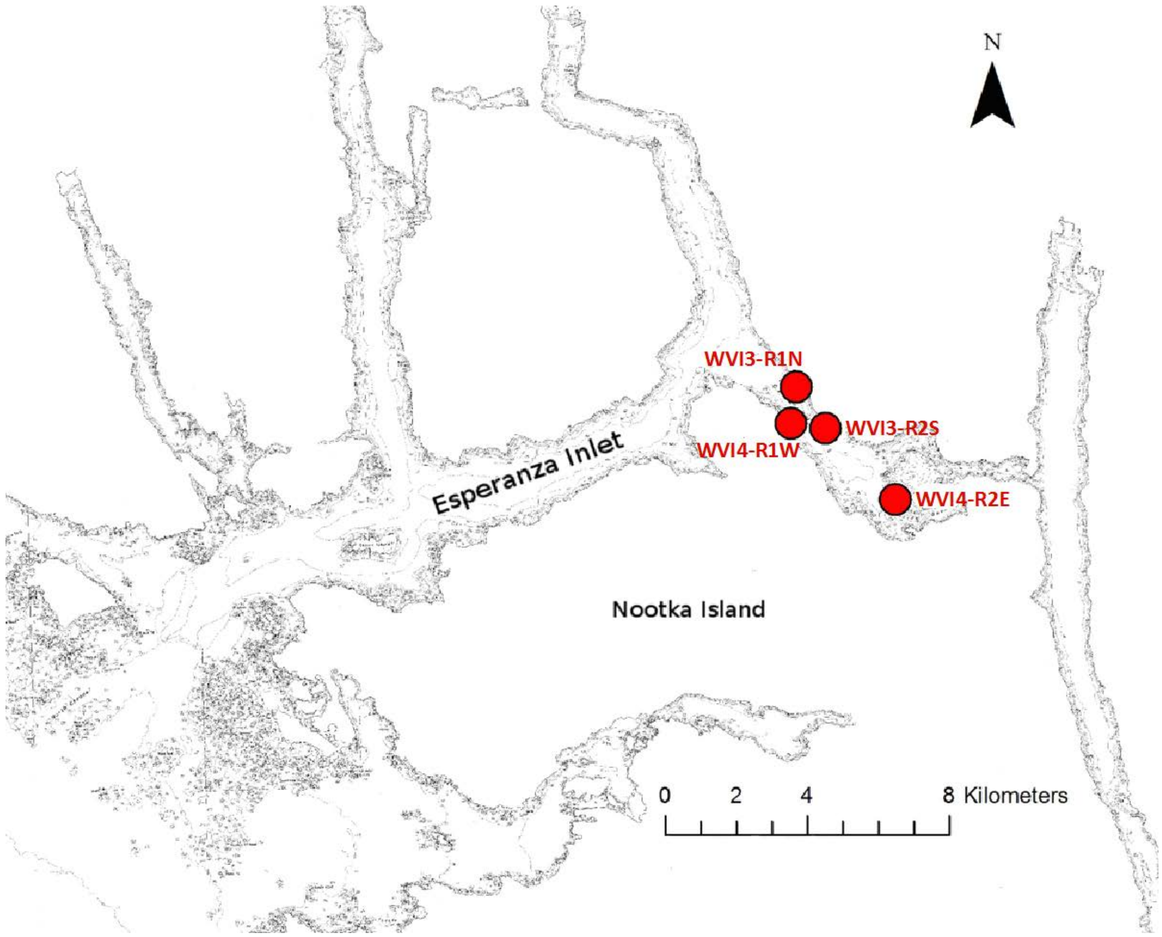

Figure 7: The location of benthic video transects in Esperanza Inlet, British Columbia.

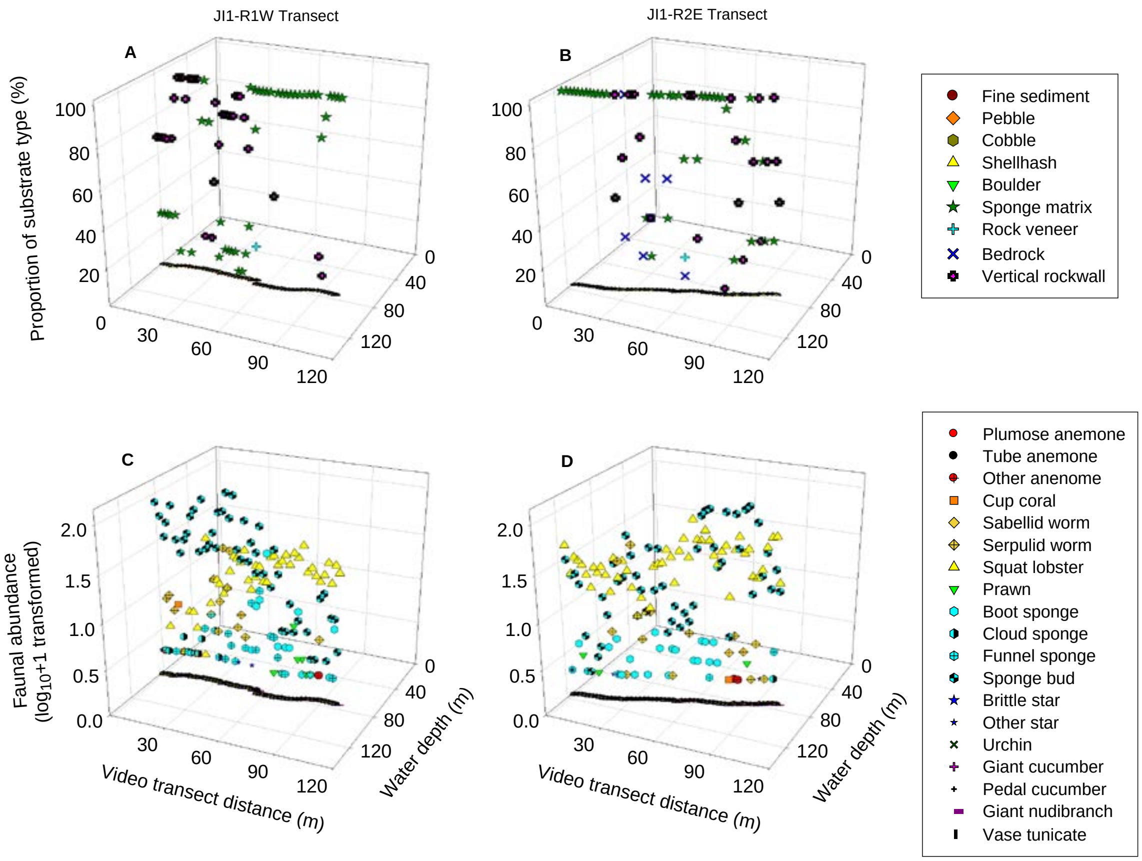

Figure 8: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites JI1-R1W and JI1-R2E (Ahlstrom) in Jervis Inlet. See Figure 1 for transect locations.

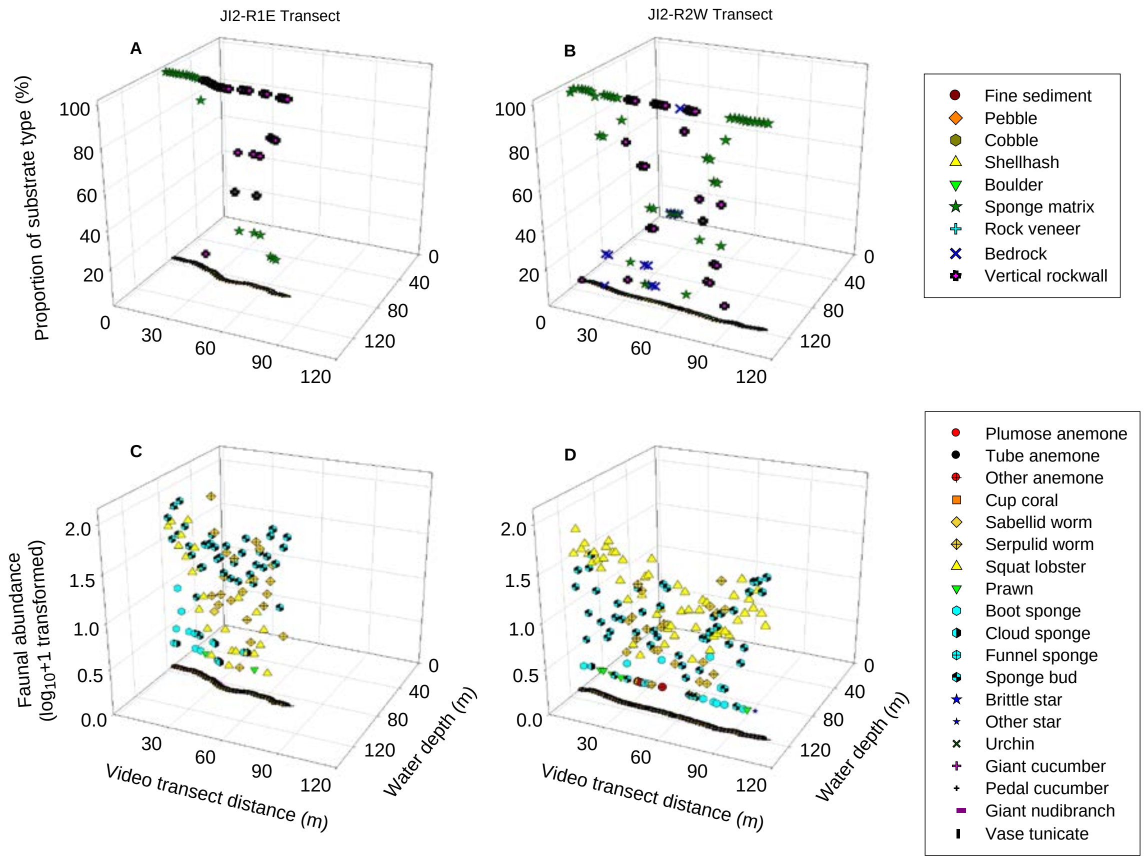

Figure 9: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites JI2-R1E and JI2-R2W (Culloden) in Jervis Inlet. See Figure 1 for transect locations.

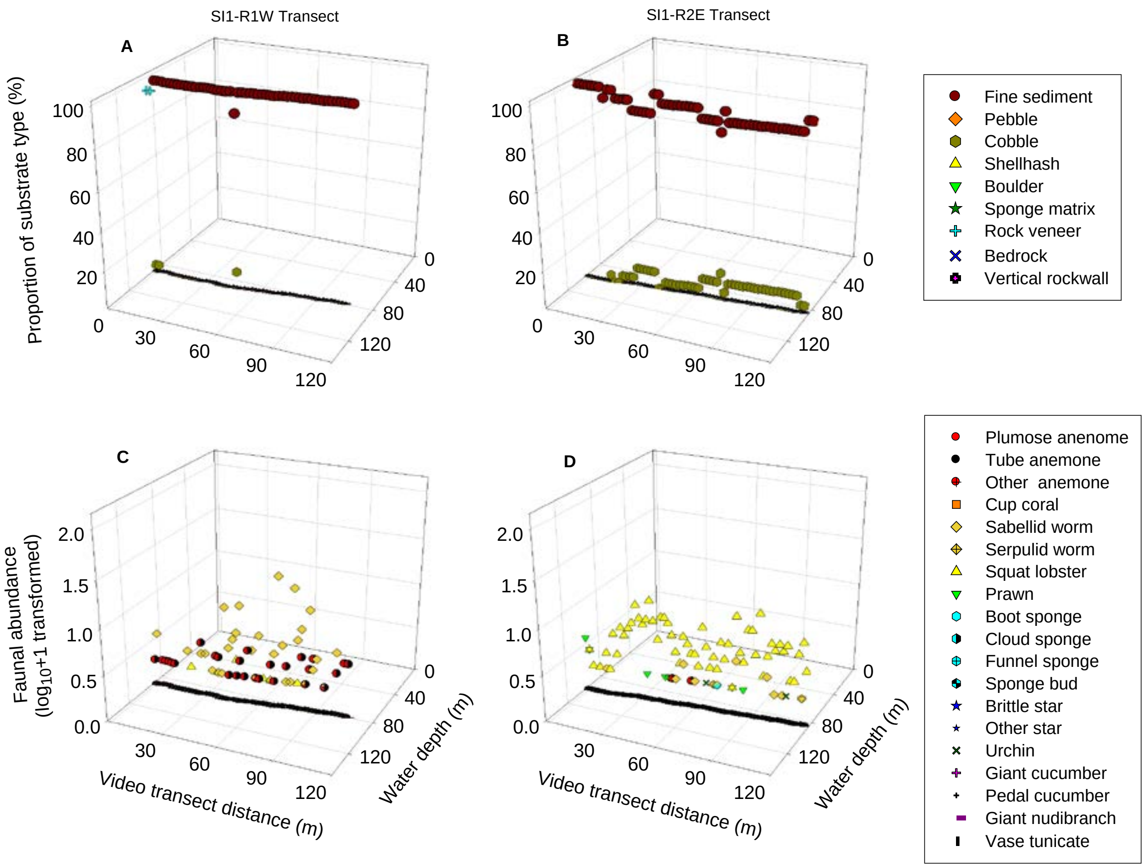

Figure 10: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites SI1-R1W and SI1-R2E (Kunechin) in Sechelt Inlet. See Figure 2 for transect locations.

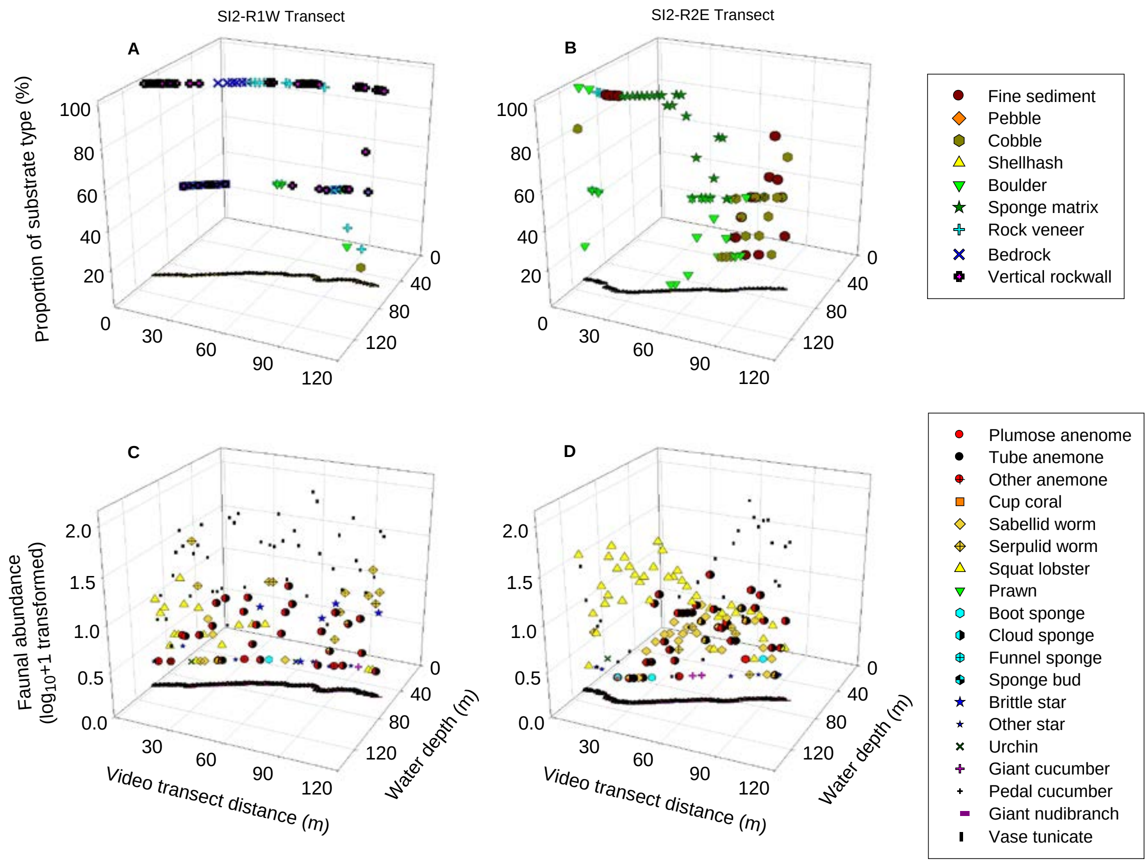

Figure 11: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites SI2-R1W and SI2-R2E (Newcomb) in Sechelt Inlet. See Figure 2 for transect locations.

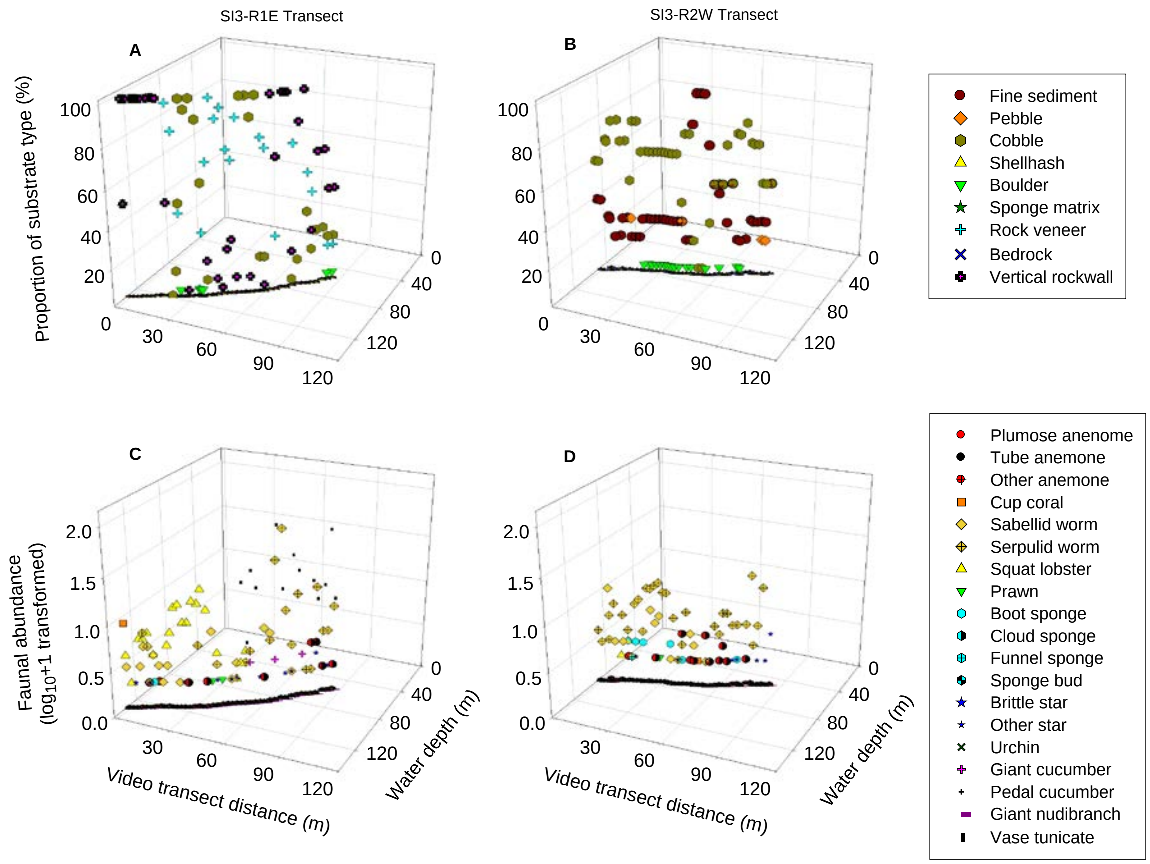

Figure 12: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites SI3-R1E and S13-R2W (Site 9) in Sechelt Inlet. See Figure 2 for transect locations.

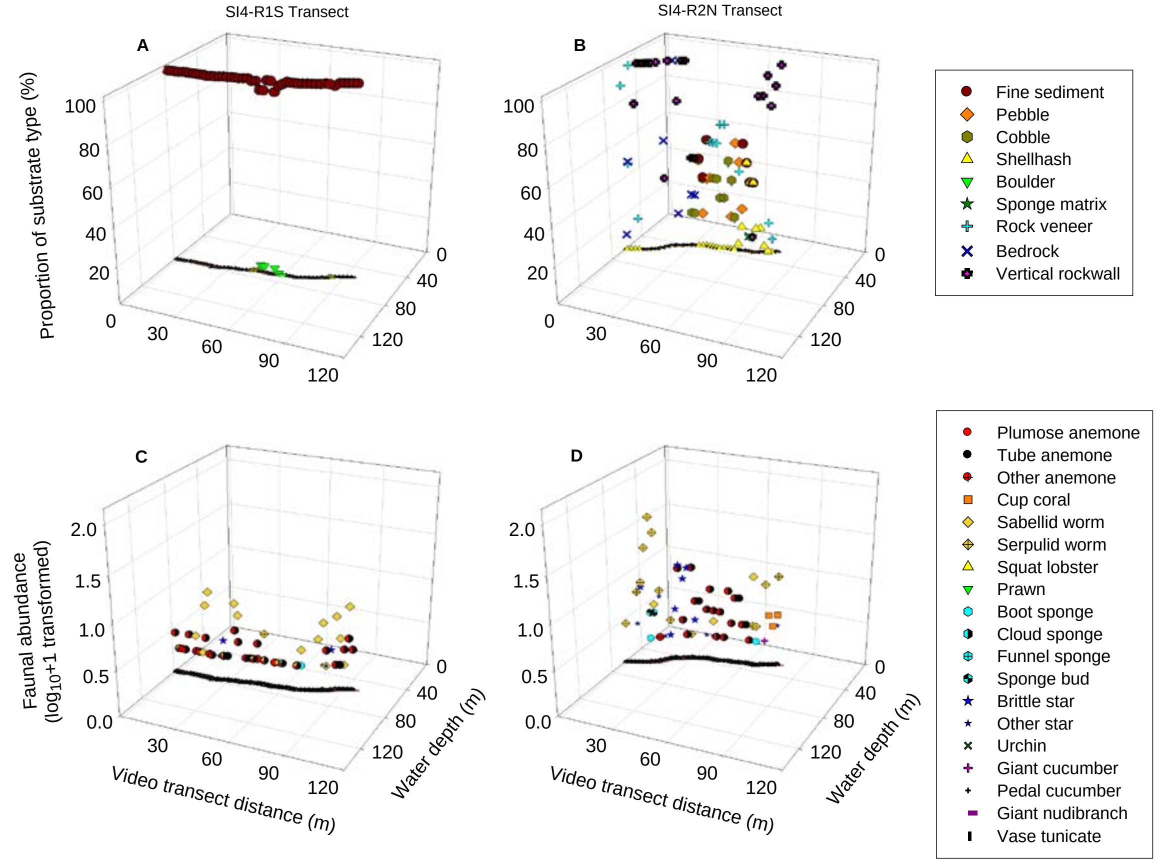

Figure 13: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites SI4-R1S and SI4-R2N (Site 13) in Sechelt Inlet. See Figure 2 for transect locations.

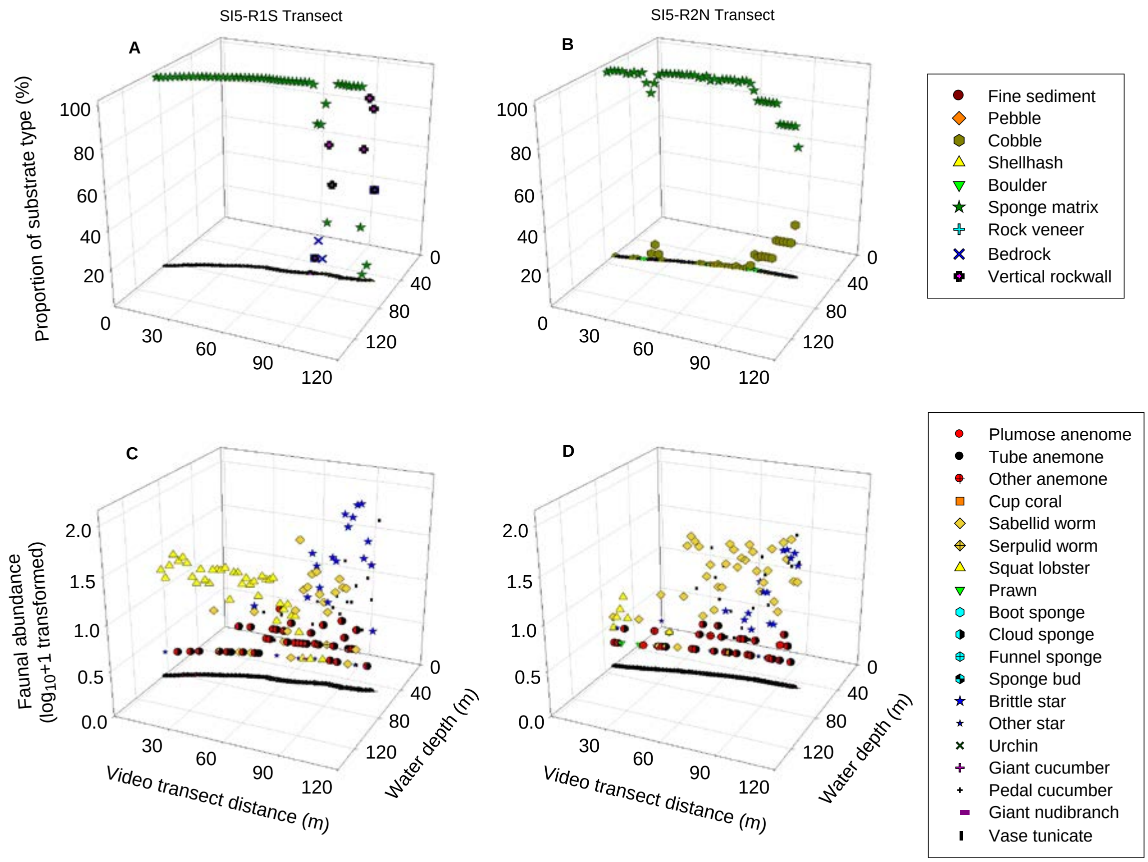

Figure 14: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites S15-R1S and S15-R2N (Salten) in Sechelt Inlet. See Figure 2 for transect locations.

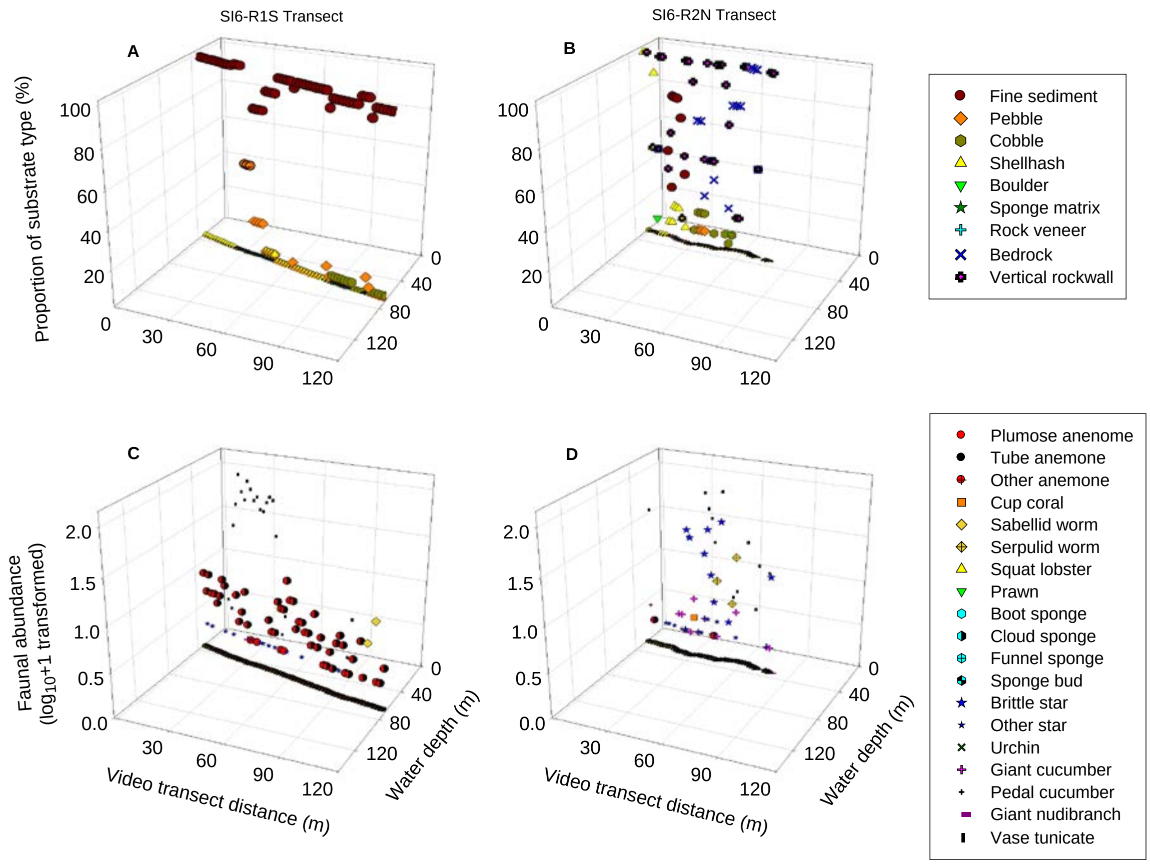

Figure 15: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites S16-R1S and S16-R2N (Vantage) in Sechelt Inlet. See Figure 2 for transect locations.

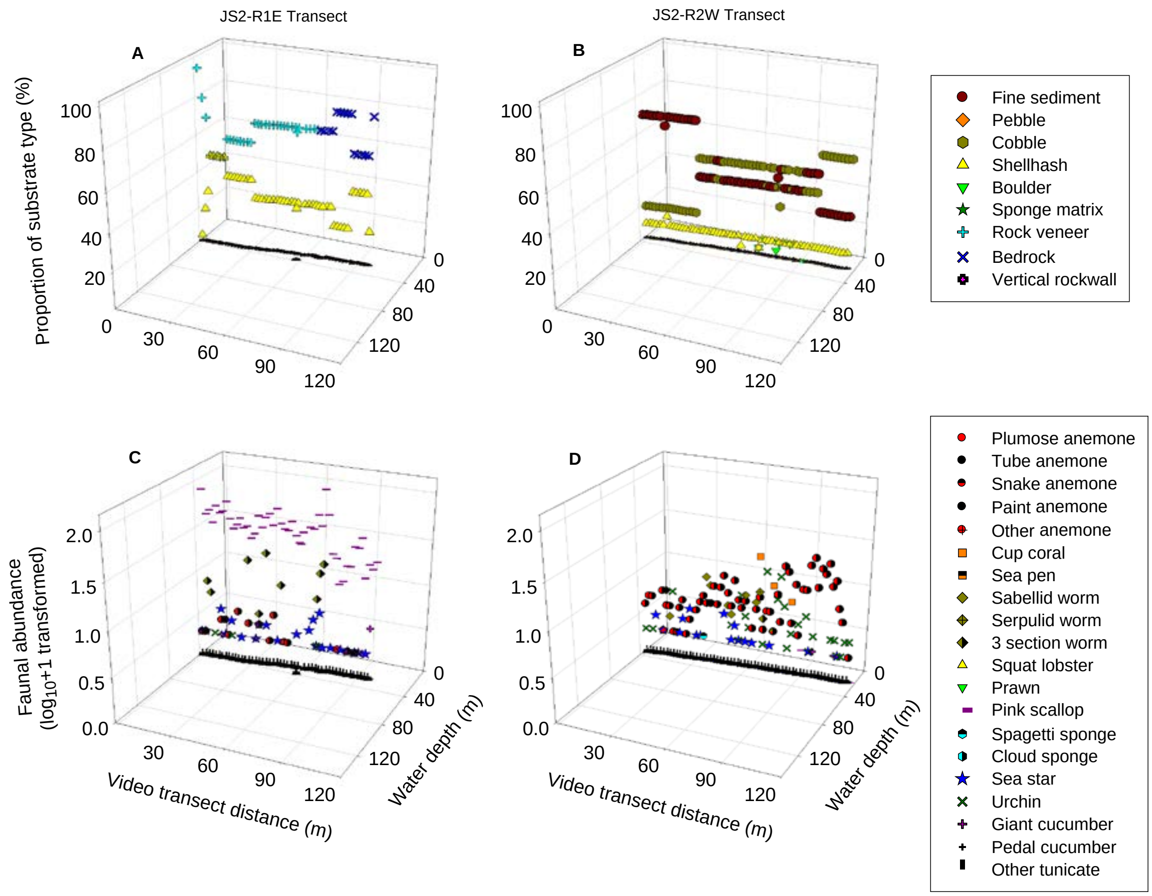

Figure 16: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites JS2-R1E and JS2-R2W (Barnes Bay) in Johnstone Strait. See Figure 3 for transect locations.

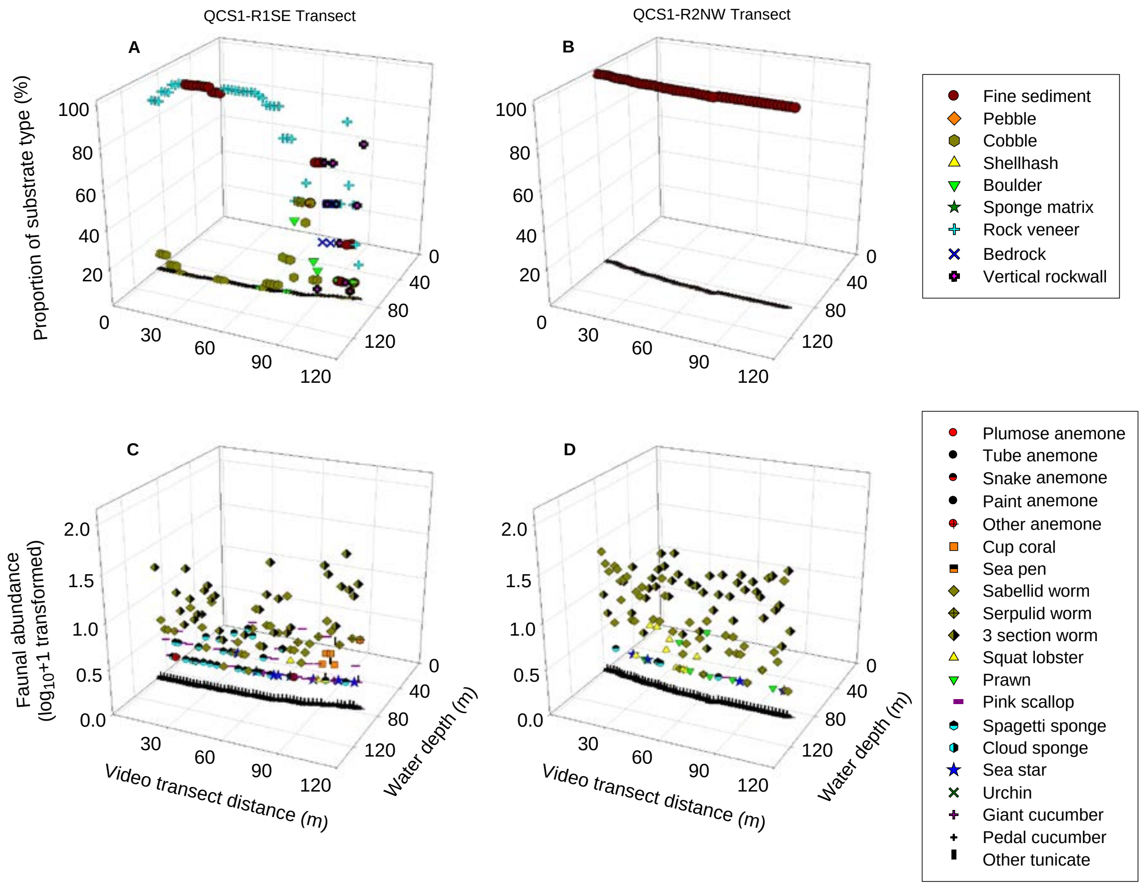

Figure 17: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites QCS1-R1SE and QCS1-R2NW (Doyle) in Queen Charlotte Strait. See Figure 4 for transect locations.

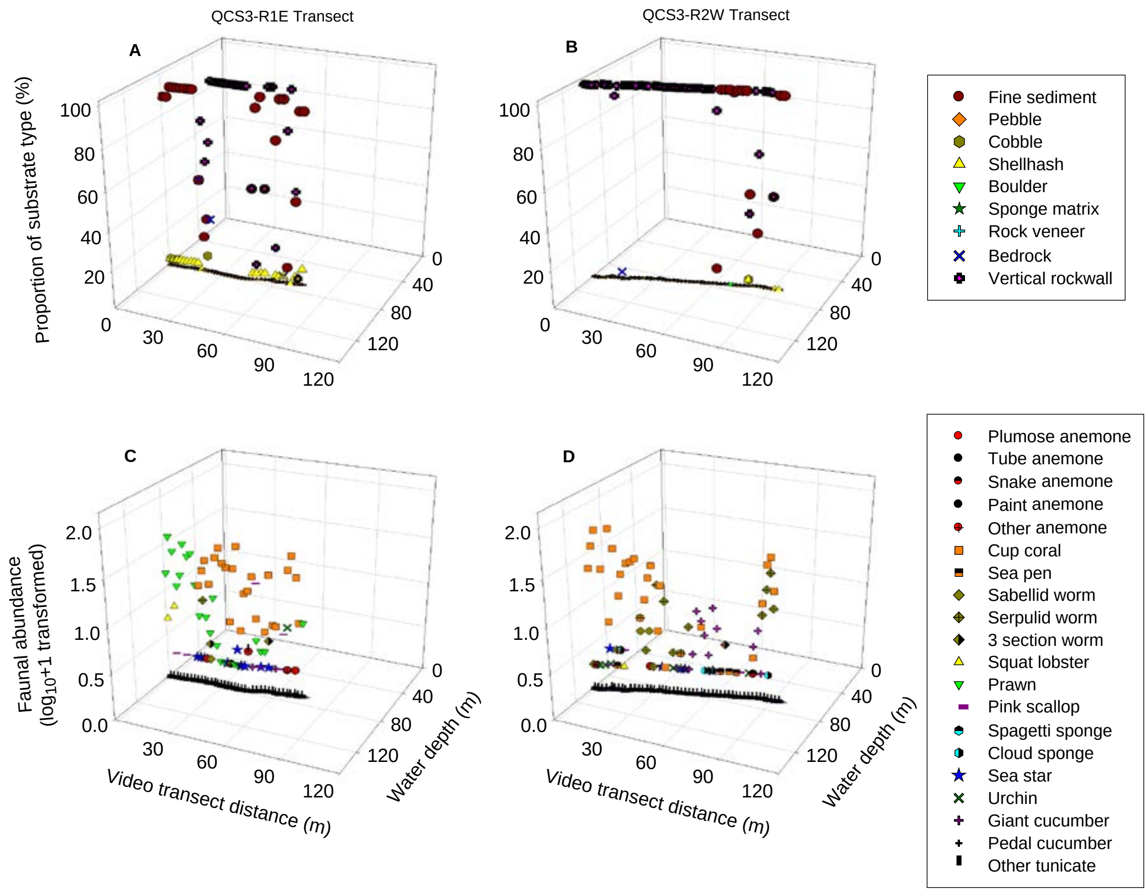

Figure 18: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites QCS3-R1E and QCS3-R2W (Simmonds Bay) in Queen Charlotte Strait. See Figure 5 for transect locations.

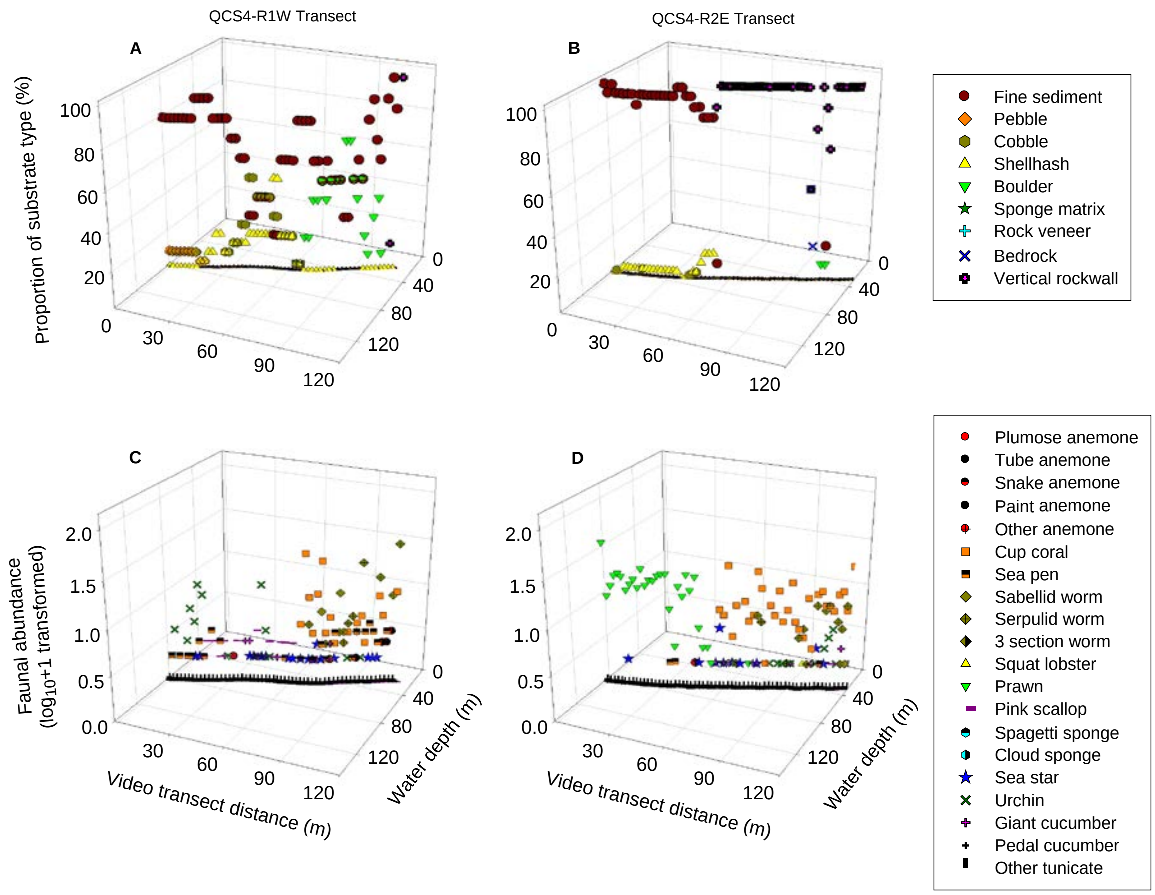

Figure 19: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites QCS4-R1W and QCS4-R2E (Wehlis Bay) in Queen Charlotte Strait. See Figure 5 for transect locations.

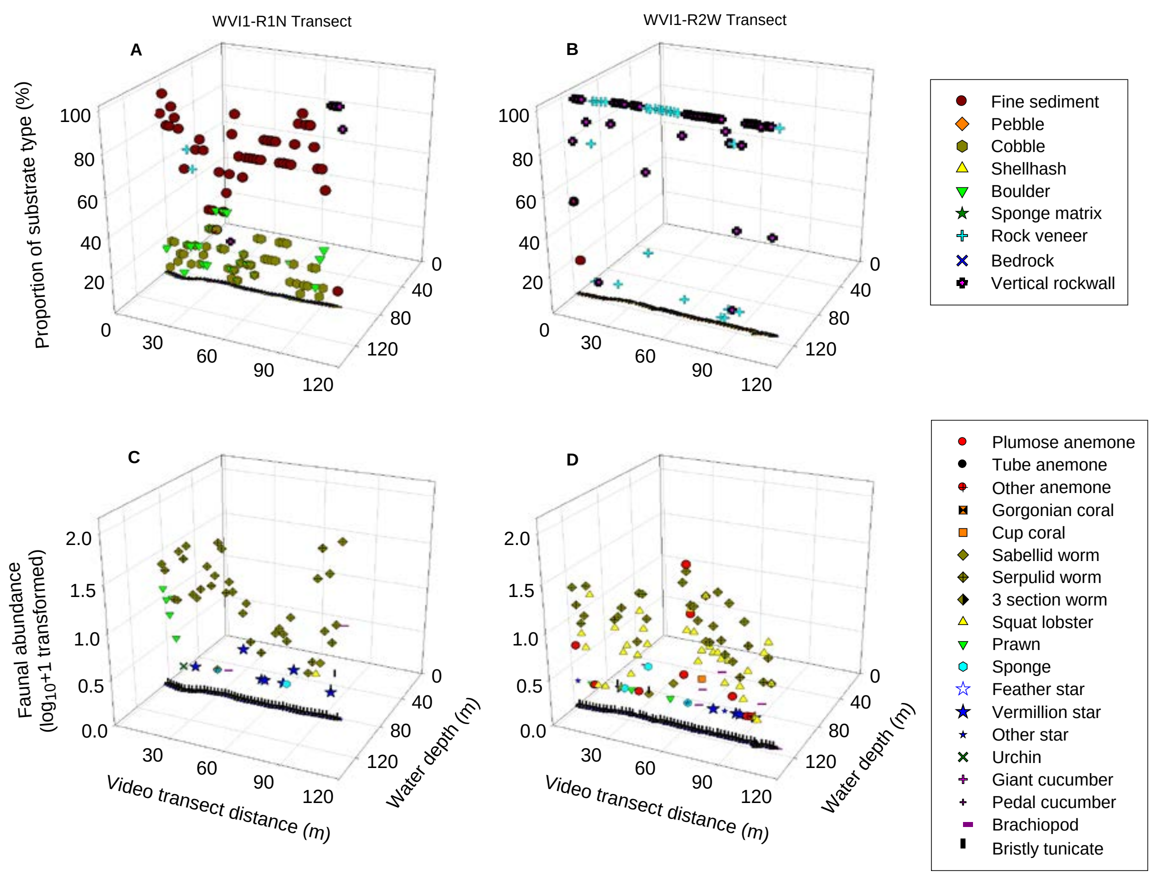

Figure 20: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites WVI1-R1N and WVI1-R2W (Atrevida) in West Vancouver Island. See Figure 6 for transect locations.

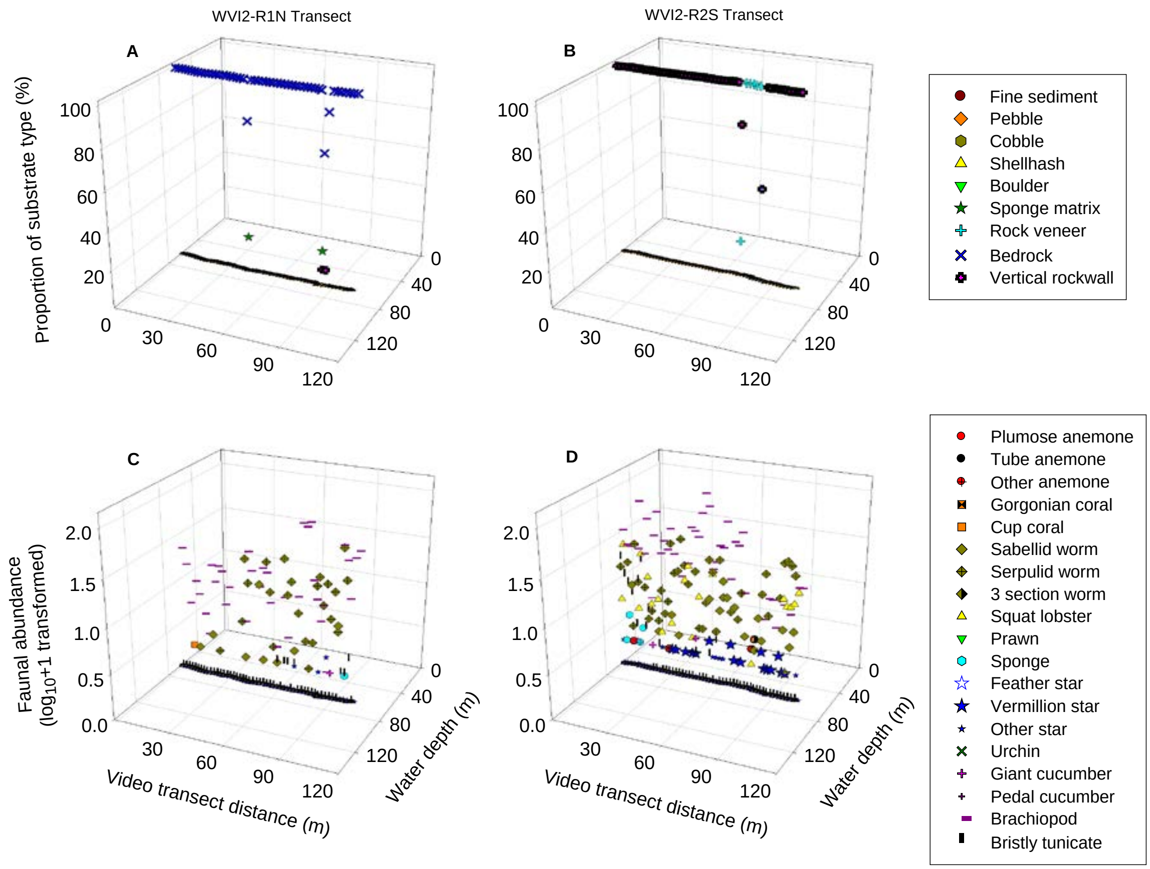

Figure 21: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites WVI2-R1N and WVI2-R2S (Concepcion) in West Vancouver Island. See Figure 6 for transect locations.

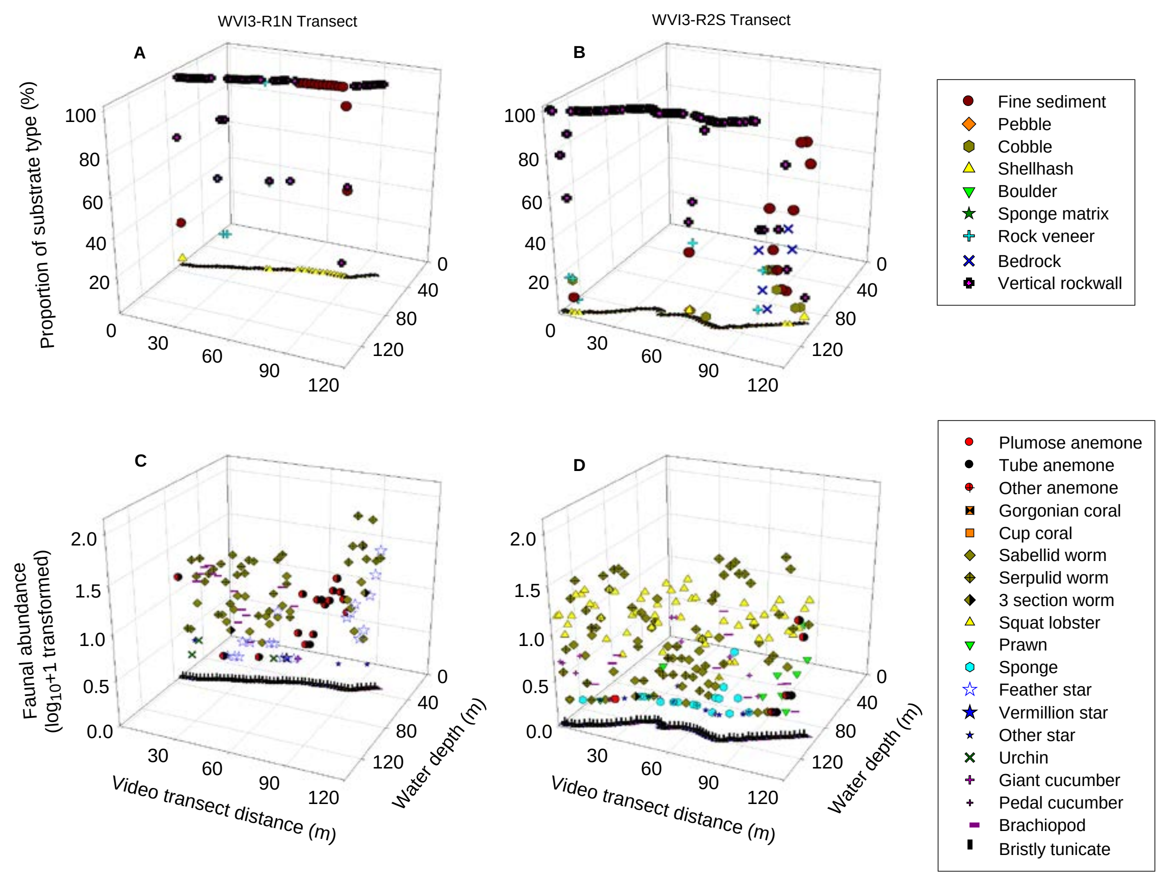

Figure 22: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites WVI3-R1N and WVI3-R2S (Esperanza) in West Vancouver Island. See Figure 7 for transect locations.

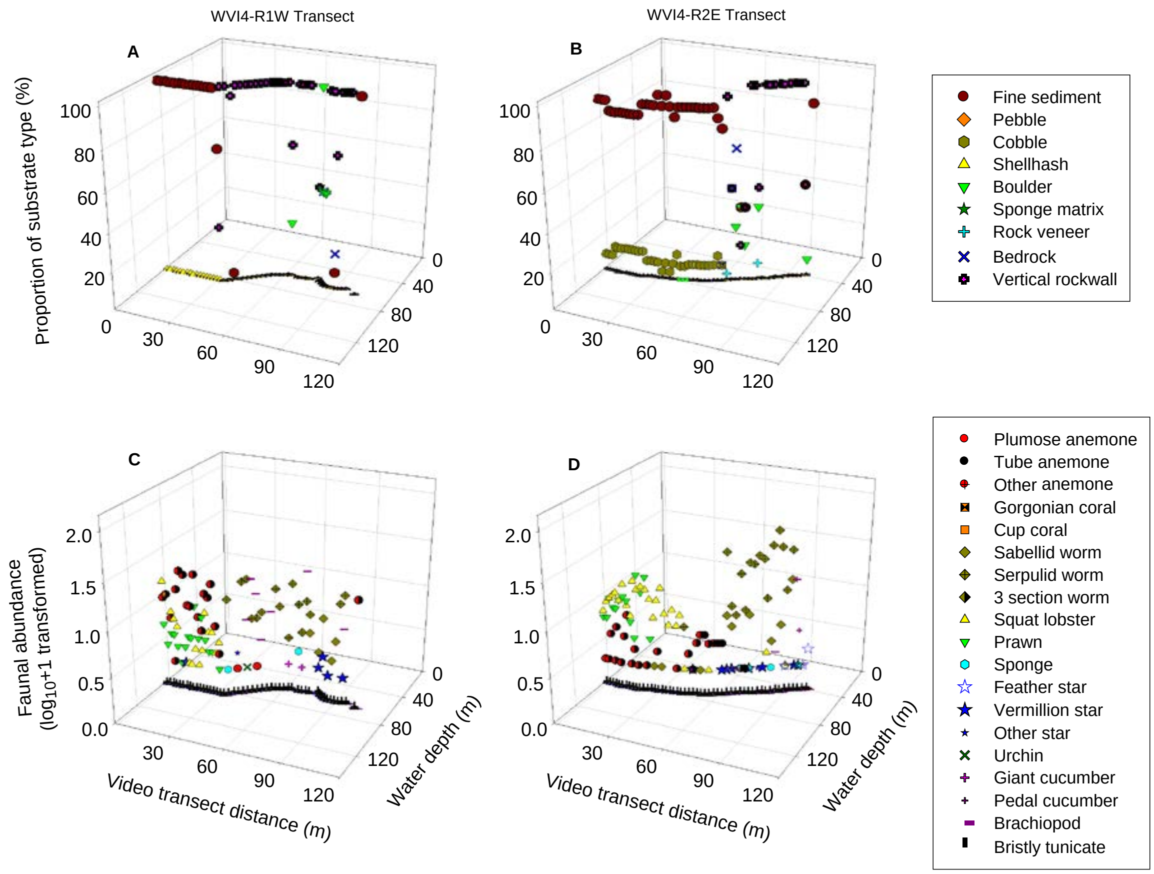

Figure 23: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites WVI4-R1W and WVI4-R2E (Hecate) in West Vancouver Island. See Figure 7 for transect locations.

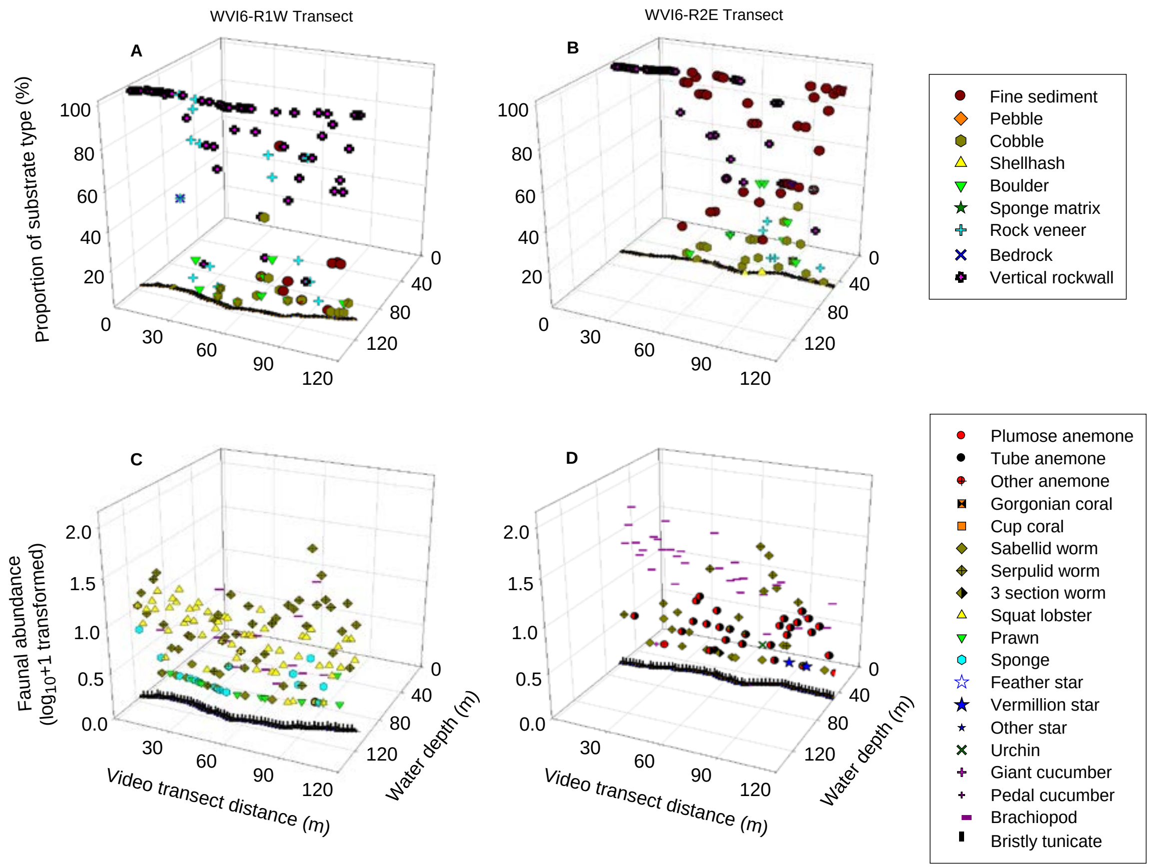

Figure 24: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites WVI6-R1W and WVI6-R2E (Muchalat North) in West Vancouver Island. See Figure 6 for transect locations.

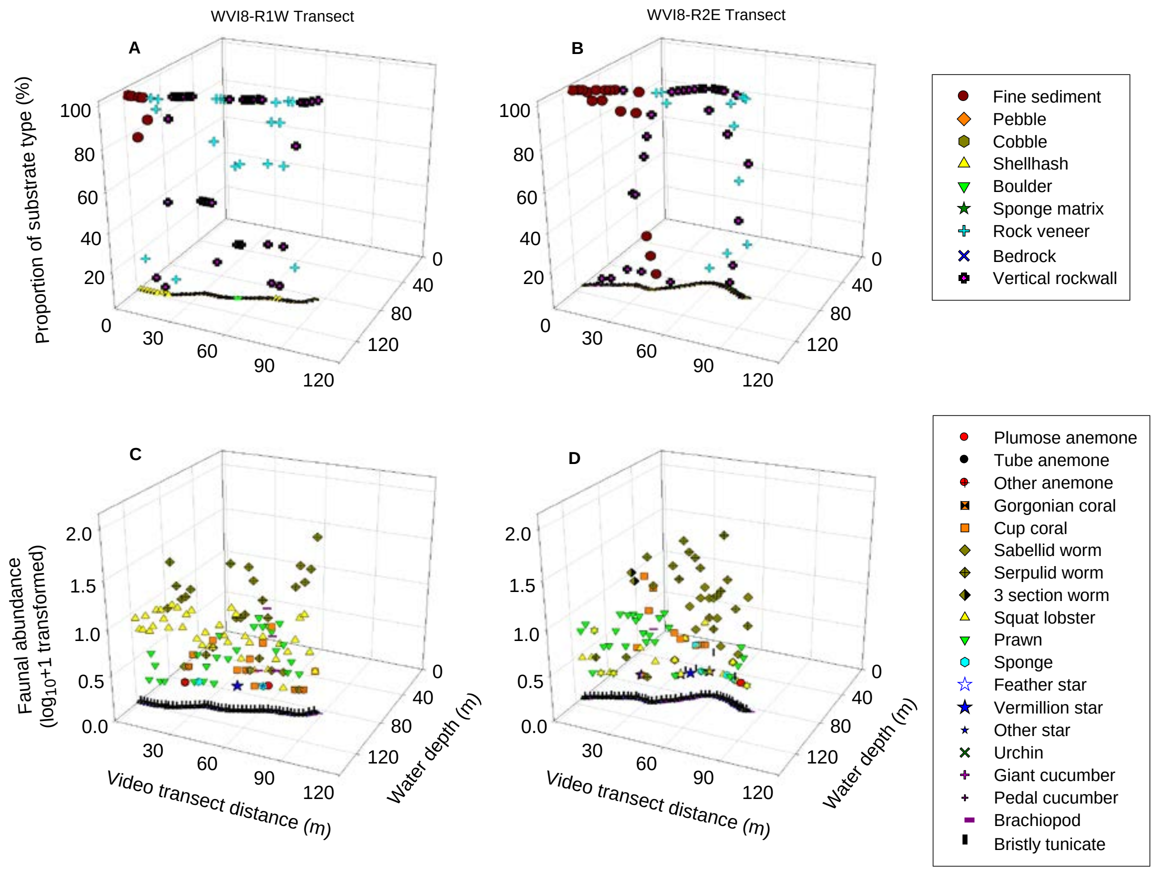

Figure 25: The composition of seabed substrate (A,B) and benthic fauna (C,D) along video transects located at sites WVI8-R1W and WVI8-R2E (Williamson) in West Vancouver Island. See Figure 6 for transect locations.