Observations of Rocky Shore Habitats in Lower Otago Harbour

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A supplemental study to accompany

"Benthic Habitat Structures and Macrofauna of Lower Otago Harbour"[1].

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Table of Contents

Summary

Port Otago Limited is proposing to modify the primary shipping channel in the lower portion of Otago Harbour, Dunedin, New Zealand. This report is a supplement to a study of the soft-sediment habitats of the lower Otago Harbour. It forms one portion of the impact assessment work. Eighty four 0.25 m^2 quadrats were examined at four rocky shore sites in the lower harbour to develop an overview of the habitat structures present and collect semiquantitative data on macroalgal cover and large invertebrate abundance and diversity. The sites represented a gradient of exposure to the prevailing southwesterly winds, nearness to the primary shipping channel, and, consequently, tidal currents. Site 4, on Quarantine Island, was most sheltered from these influences and possessed rocky shores, subtidal seagrass, a sheltered-inlet fauna, and silty tube-mat sediments dominated by macrofaunal bioturbation. The other three sites were on headlands on the northern shore of the harbour. Site 1, at Rocky Point, had a steeper shore slope and was dominated by mid-littoral and subtidal algal beds. Site 2, at Acheron Point, and site 3, at Pulling Point, had increasingly rocky seabeds. Almost all large intertidal animals were restricted to the upper 9 m of shoreline. All identified animals are common inhabitants of sheltered inlet and euhaline portions of southern NZ estuaries and are known to be abundant elsewhere in the harbour. Because there have been no regional monitoring programme data nor published rocky-shore data from the study area, comparisons through time were not possible.

Introduction

Port Otago Limited (POL) is the corporate body responsible for commercial shipping operations within Otago Harbour, adjacent to Dunedin, New Zealand. POL is undertaking several studies of the lower harbour to understand the connectivity of existing harbour communities to inform operational decisions, specifically modifications to the shipping channel. Channel modifications by dredging will safely accommodate the next generation of large container ships.

The present work contains the brief survey findings of benthic habitats at four rocky shore locations in the lower Otago Harbour. As it is written for a restricted and informed audience, no attempt has been made to include a comprehensive literature review. This supplemental study focused on rocky intertidal zones and their transitition to subtidal habitats described in the related report[1] (Figure 1).

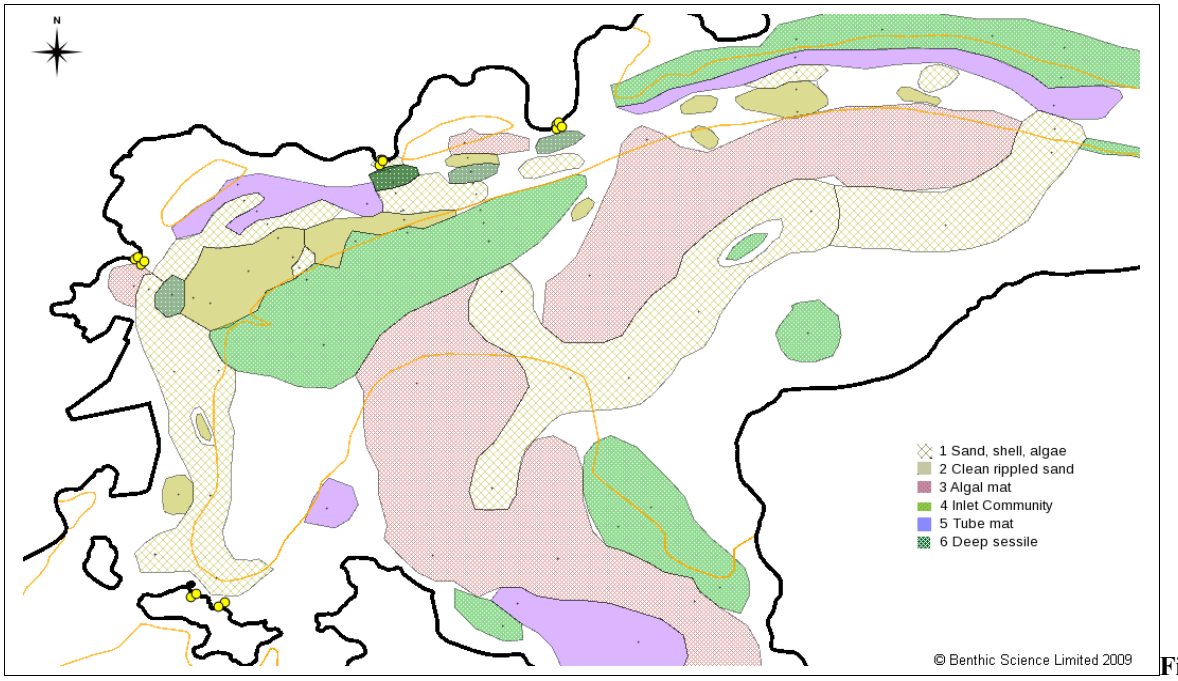


Figure 1. Estimated[1] extent of gross habitat types in the lower Otago Harbour as interpolated using data from benthic photo surveys (black dots) and evaluation of bathymetry, intersite observations, presumed flow patterns, and experience[1]. Areas outlined in yellow represent shallow sand flats (see Figure 2). Regions between coloured areas were not classified. Rocky shore study sites are represented by yellow circles.

Methods

Survey Locations

Four exposed rocky shore sites were examined in the lower Otago Harbour (Figure 2) between 18 and 23 March 2009. Site 1 was located at Rocky Point which forms the headland boundary of Careys Bay just east of Port Chalmers. Site 2 was Acheron Point, similarly the eastern limit of Deborah Bay. Site 3 was at Pulling Point, east of Hamilton Bay. Site 4 was on the northeastern shoreline of Quarantine Island, also known as St. Martin's Island or *Kamau Taurua*. Geographic coordinates and site activities are presented in Appendix 1.

Tidal zonation acronyms are frequently used in the report to indicate broad tidal inundation categories such as Mean High Water Spring (MHWS), Mean High Water (MHW), Mean Low Water (MLW), and Mean Low Water Spring (MLWS). Tide state measurements (measured at Port Chalmers) were provided by Port Otago Limited and are referenced to chart datum.

Figure 2. Intertidal rocky shore survey sites (yellow circles) in lower Otago Harbour, Dunedin, New Zealand.

Survey Methods

The sampling protocol was chosen to accommodate small-scale (metres) habitat heterogeneity observed along the shore slope within pragmatic limitations. At each site two shore-normal transects were anchored at separated (≈15 m) points above MHWS or the

extent of the horizontal shoreline (defined by the artificial sea wall at sites 1–3 and by the cliff face at site 4). The transects extended to 5 m depth or the obvious subtidal habitat within safety limits imposed by the channel, natural features, and conditions present at the seaward extremity of each headland.

A 0.25 m^2 quadrat (500 × 500 mm) was placed at each metre interval of shore-slope from the shoreward to the seaward end of the transect. The quadrat's horizontal position at each interval was randomly assigned among 0.5 m increments within 5 m either side of the transect line (Figure 3) leaving a 0.5 m wide tread path. Quadrats were photographed where tidal and visibility conditions permitted. Macroscopic animals and algae were identified and quantified to practical field limits within every third quadrat (typically positions 0, 3, 6, 9, etc.). Transect placement was chosen to avoid coming within five metres of stormwater discharge points or impacting artificial structures such as channel markers.

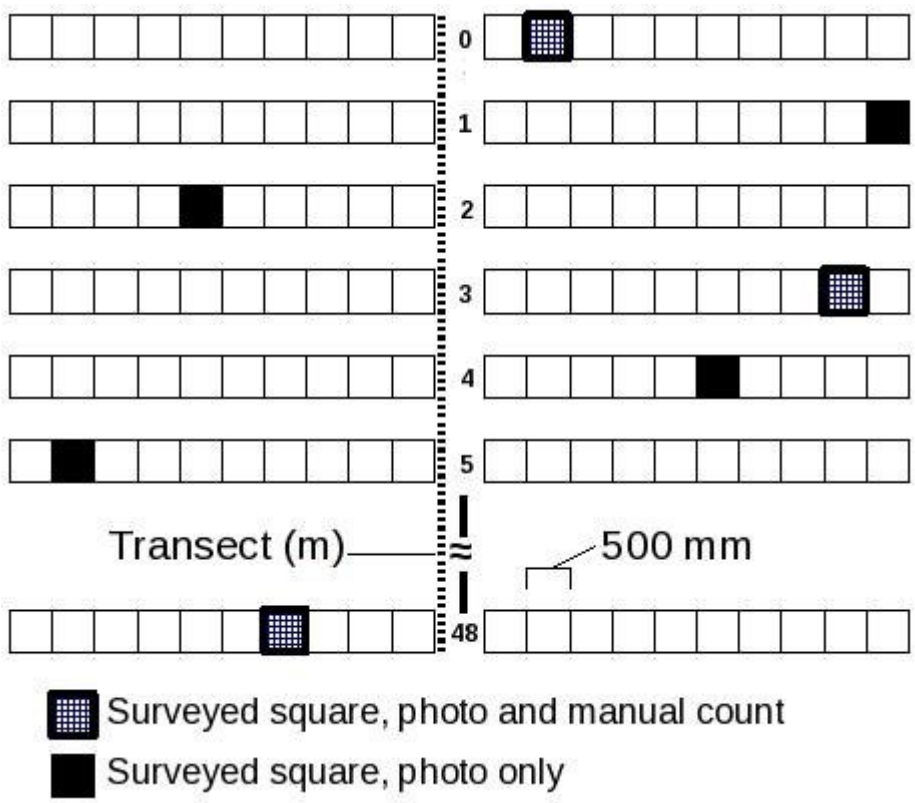


Figure 3. General intertidal survey plan (to scale). The shoreward extent of each transect (position 0 m) was located at the base of the artificial seawall (sites 1–3) or cliff face(site 4). A quadrat (500 mm × 500 mm) was placed at randomly chosen horizontal positions (0.5 m intervals) at each metre-mark along the shore slope. Macrofauna and macroalgae were quantified in every third transect.

Image Acquisition, Processing, Qualitative Analysis, and Archival

Digital photographs were collected by shore personnel, snorkellers, or divers depending upon tidal conditions. Photographs were taken with either of two digital cameras in underwater housings mounted on identical quadrat frames which supported them at a constant height above the quadrat. Most images were illuminated by natural light. Marks along the quadrat frame allowed size reference in the fixed focal plane for each photo. Images were automatically contrast- and colour-corrected in a batch process using Photoshop v6.0 (Adobe, Inc.) using fixed black and white standards on the frame. The images were manually masked to extract the seafloor area of interest from frame obstructions and place a 100 mm scale bar onto images. Processing artefacts are present as linear incongruities where the underwater camera was removed from the frame and sections were photographed separately to accommodate poor water clarity.

Habitat descriptions of each site, a composite of all images and other observations collected, were also collated from all field team members. Collected images in the three states of processing are available on the compact disc which accompanies this report. The three states are the 1) original images, 2) colour and geometry-corrected images, and the 3) masked and standardised images.

Semi-Quantitative Observations

Gross macroalagal cover was estimated for every third quadrat. As algae typically formed multi-species aggregations it was not feasible to identify most individual algal taxa from several quadrats. Only large, well-documented taxa could be identified individually. Where such identifications were not feasible in the the field, the basic algal growth form was recorded categorically. For example, the category of 'Brown branching' could contain *Cystophora retroflexa, C. torulosa, C. scalaris,* small *Gracilis,* and even *Carpophyllum flexuosum*, but when occuring individually, the distinctive zig-zag stipe of *Cystophora scalaris* allowed it to be identified more specifically. Filamentous, turf, and microalgal species were present, but could not be quantified in the field. Similarly, colonial or cryptic animal species which were commonly encountered (particularly sponges, colonial tunicates, and bryozoans) cannot be reliably identified in the field.

Conspicuous macrofauna were counted as they were removed from each quadrat whenever feasible. Only living animals were counted. Rocks and algae were manipulated

and carefully examined in each counted quadrat. Where high abundances made individual counts impractical (such as for some small molluscs and barnacles), the number observed within 10% of the quadrat were enumerated and extrapolated to the quadrat area. In subsequent reporting, such extrapolated numbers are indicated by the approximation notation (≈).

Infauna were not enumerated unless they were clearly identifiable as individuals at the sediment surface (such as for cockles *Austrovenus stutchburyi*). Other infaunal signs were conspicuous in several quadrats including the crabs *Macrophthalmus hirtipes* and *Metacarcinus novazelandiae,* the bivalve *Macomona liliana,* the ghost shrimp *Callianasa filholi,* the lugworm *Abarenicola afferens,* and the mantis shrimp *Heterosquilla* among others. Small fish, most notably the triplefins (*Tripterygion varium* and *T. lapillum),* were frequently observed stationary within quadrats, but were not recorded. Hydroids were present on many algal and rock surfaces, but were not enumerated.

Data Analysis

Geospatial plotting was done using QGIS v1.0.0 (Kore)[5] operated within a Mandriva Linux environment. Grid systems of coastline and bathymetric data were converted to the WGS84 datum. Where animal densities are reported as individuals m^{-2} the values have been extrapolated from the actual sample area under consideration (0.25 m^2 unless stated otherwise). All faunal data reflect abundances except for colonial animals (bryozoans, porifera, etc.) where total percent cover within the quadrat was estimated. Algal data also represent total estimated percentage cover of each quadrat. The estimated algal cover within any one transect was calculated as the sum of the individual algal areas divided by the areal sum of the manually counted quadrats.

Results

Surveys identified 66 taxa. A total of 16 were algal taxa, two were colonial animals (sponges and colonial ascidians), and the rest were solitary invertebrates (7 242 individuals among 48 taxa). Reporting for each site begins with a brief narrative of site occupation and a qualitative description followed by a summary of taxon richness and organismal abundance. A description of the distribution of these taxa within the tidal zones is then given. The

description derives from an examination of kite diagrams (see example Figure 4) which were frequently too large to reproduce here*. Complete quadrat data are presented in Appendix 2.

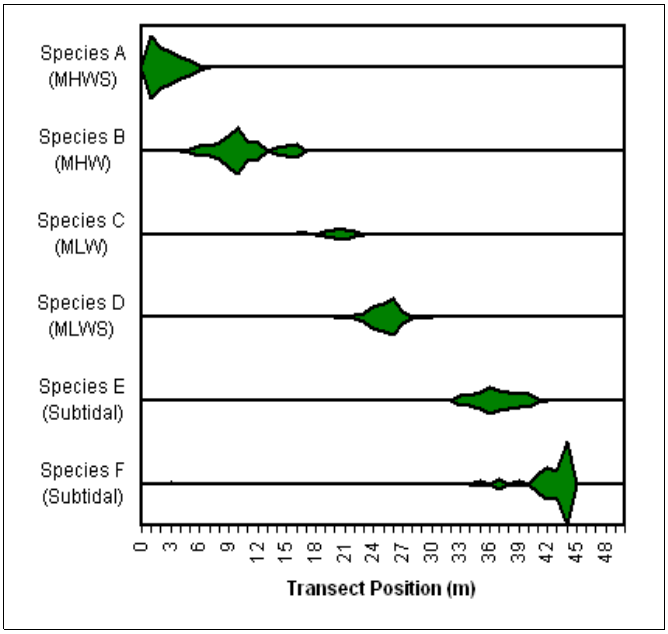


Figure 4. Sample kite diagram similar to those used to examine species distributions along the rocky shore transects. The abundance of each species along the vertical axis is shown by the width of the coloured area at the transect position indicated on the horizontal axis.

Site 1 – Rocky Point

The shoreward end of both Rocky Point transects terminated at the artificial seawall edging the roadway (Figure 5). Scattered, uncolonised, building material was present and potentially influenced results at positions 0–5 m. The cobble shore was dominated by basaltic rock sparsely colonised by marine organisms. Anthropogenic debris (paper, nails, and peelings) were present. Boulders or emergent bedrock with a vertical relief of approximately 500 mm were present in the upper intertidal zone and matched by the larger, more heavily colonised eponymous rocks in the shallow subtidal zone (Figure 6). Along the beach slope below mid-tide level (around position 9 m) sand and then silt was increasingly present between cobbles until giving way to a dense, uniform algal bed below MLW (beginning near position 15 m). The multi-species algal bed, dominated by red algae superficially similar to *Stenogramme interrupta, Lenormandia chauvinii,* and *Hymenocladia sanguinea* (collectively *Stenogramme* sp.?) held large quantities of silt and clay-sized sediment particles such that any disturbance raised persistent sediment clouds. Patches of multiple brown macroalgae

*At least not at an appropriate scale to include all taxa with abundances that ranged over three orders of magnitude.

species became larger with greater depth, and finally merged around position 28 m to form a distinctly different bed. This deeper community had some *Ulva* sp., and several filamentous, bladed, and laminar red species, but it was dominated by *Carpophyllum* spp., *Undaria pinnatifida,* and other brown algae. Live encrusting corraline algae were present in small patches where hard surfaces lay above the silty sediments. Algae grew sparse with greater depth. A brief swim beyond the seaward end of the transect revealed decreasing algal cover and increasing sand and silt of the same habitat type identified in Figures 1 and 5 (which can now be extended to the NE by about 150 m).

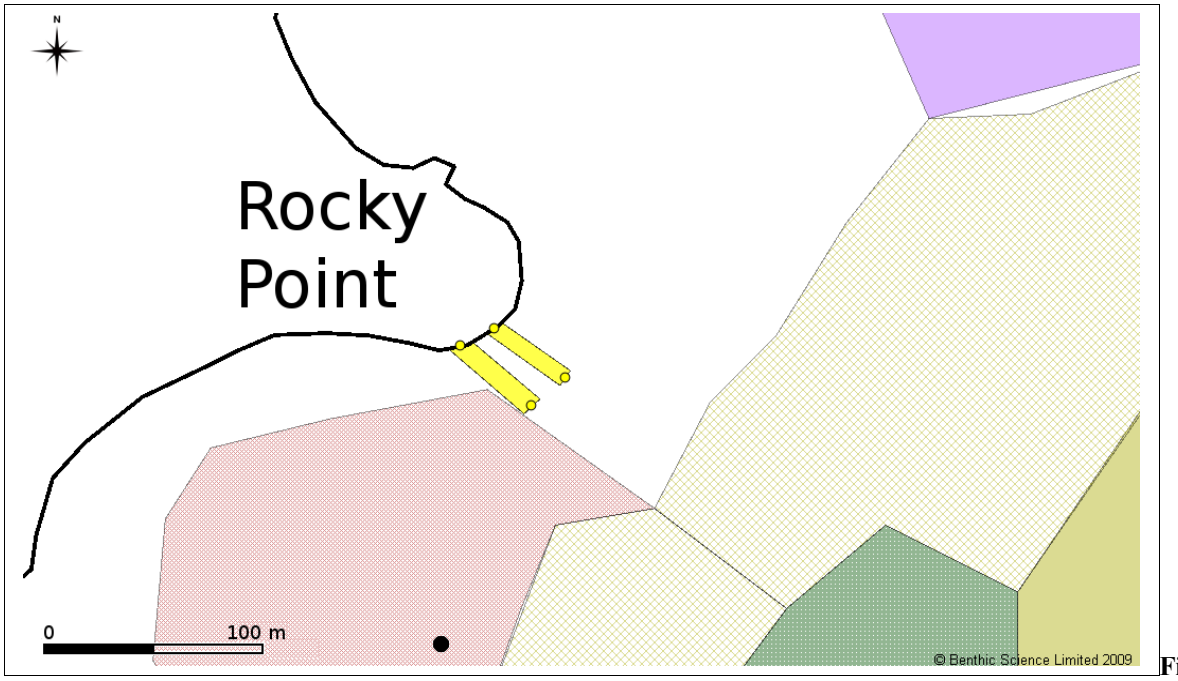


Figure 5. Rocky Point survey area (yellow polygons, T1 is SW of T2) within the context of the soft-sediment habitat classification (Figure 1). Several large emergent rocks are not outlined on the chart (see Figure 6).

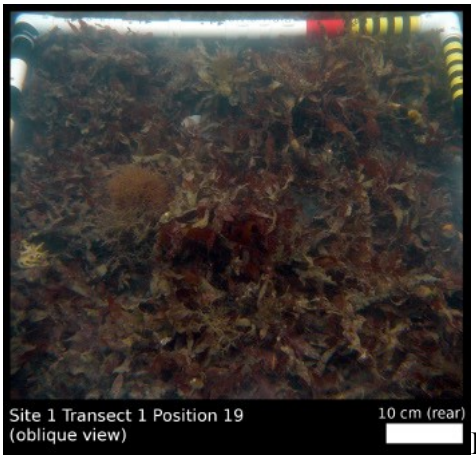
Figure 6. Rocky Point survey area showing the small MLWS kelp bed (*Macrocytis pyrifera*) in the foreground and channel marker beacon in the background.

Although not recorded in quadrats, reproductive nudibranchs *Archidoris wellingtonensis* and *Aphelodoris luctosa* were common along the transect. A single courting or gravid male seahorse (*Hippocampus abdominalis*) and schools of yellow-eyed mullet (*Aldrichetta forsteri*) were observed within the kelp bed. Currents were weak even at peak tidal flows and tidal zonation was apparent as conspicuous bands (Figure 7). Only site 4 appeared to be more sheltered from the mixing influences of tides and waves of the study sites. The relatively shallow profile differentiated site 1 from sites 2 and 3 further down the harbour.

A

B

C



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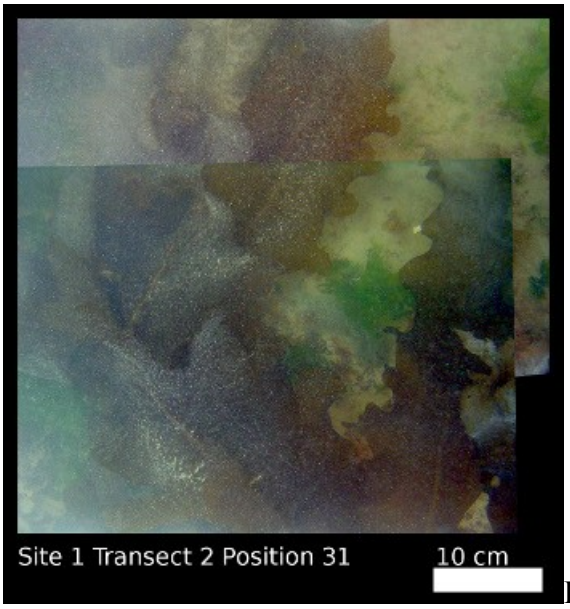


E

Figure 7. Representative views of habitats at site 1.

Eleven algal, two colonial animal, and 25 solitary animal taxa were found in Rocky Point quadrats. The shore-normal distribution of algal cover (and colonial animal) measurements are shown in Figure 8. Rocks of the upper shore and the upper parts of the emergent rocks had a felt of *Stichtosiphonia arbuscula*. Small patches of encrusting corralline algae were present above MLW. Just below MLW the dense red algal bed (*Stenogramme* sp.?) supported many filamentous algal taxa. Brown macroalgae such as *Carpophyllum* spp. and *Undaria pinnatifida* were most common below MLWS further than 40 m seaward of the seawall. Approximately 18% of the seabed was covered by algae around transect 1, while there was 14% cover around transect 2 distributed at depths as shown in Figure 8. Both transects were dominated by *Stenogramme* sp.? and *Carpophyllum* cover.

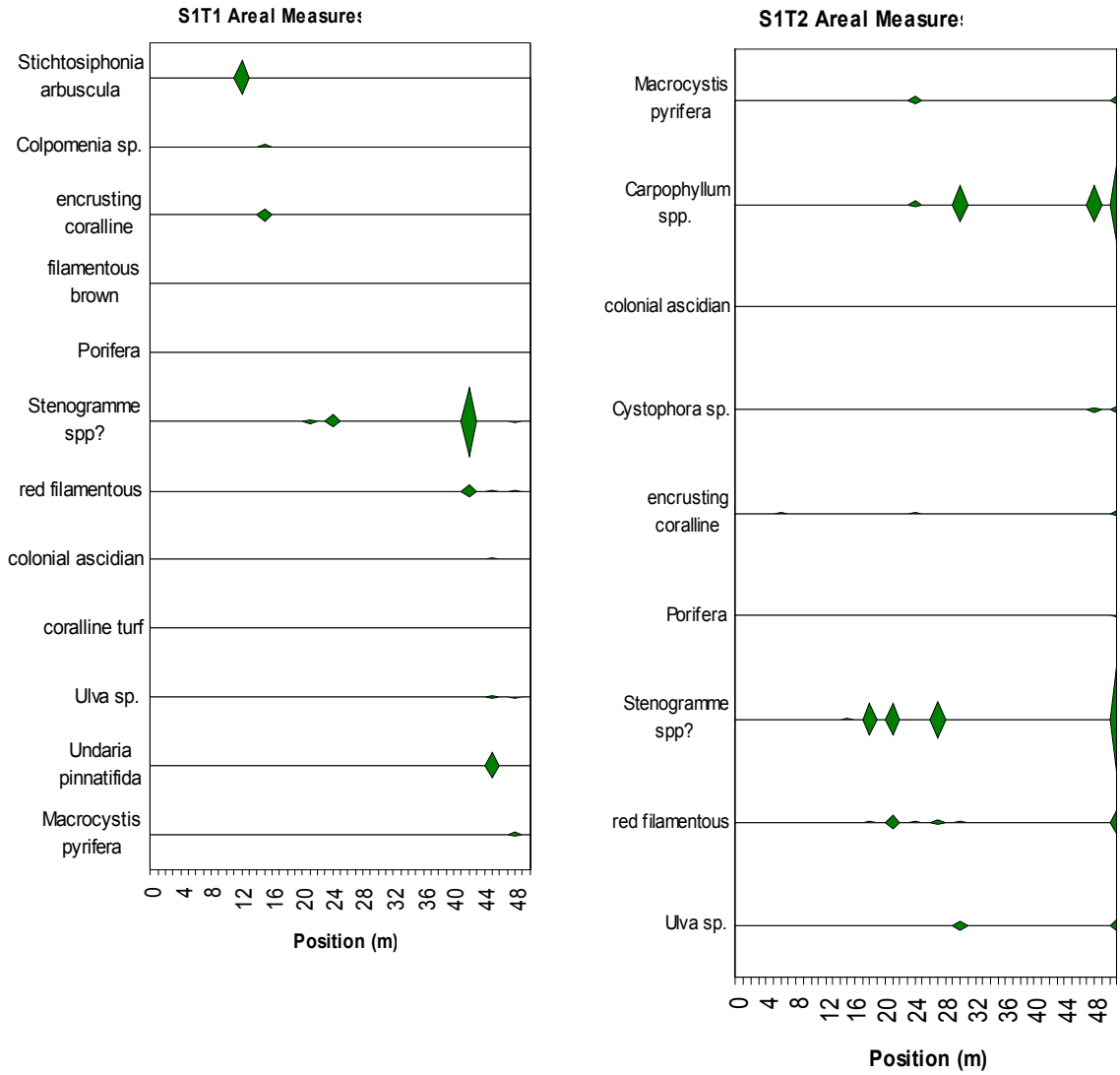


Figure 8. Relative areal measures (% cover of algae, sponge, and tunicates) at site 1 transect 1 (left) and transect 2 (right). The percent cover of each taxon along the vertical axes is shown by the width of the coloured area at the shore-normal transect position indicated on the horizontal axes.

The most numerous animals were snails and barnacles located between positions 3–9 m (Table 1). The numerically dominant 5 taxa on transect 1 (70% of all individuals) were present only within positions 0–6 m. The remaining fauna were almost exclusively located between positions 9–15 m. Transect 2 presented a similar pattern with 46% of animals located between positions 0–3 m and the rest located near the 6 m position. Surface tracks and holes in the soft sediments below the 9 m position suggested that much of the biological activity was the result of in- or epifauna movements.

Table 1. Rank abundance of invertebrate taxa at site 1.

Rank	T١ - Taxon (individuals)	T٢ - Taxon (individuals)
١	*Austrolittorina antipodum* (365)	*Chaemosipho columna* (325)
٢	*Austrolittorina cincta* (106)	*Cellana radians* (92)
٣	*Elminius modestus* (105)	*Diloma coracina* (68)
٤	*Diloma coracina* (≈100)	*Ostrea* sp. (22)
٥	*Zeacumantus* sp. (33)	*Zeacumantus* sp. (22)
٦	*Cellana radians* (20)	*Chiton glaucus* (7)
٧	*Cellana strigilis* (16)	*Sypharochiton pelliserpentis* (5)
٨	*Pomatoceros caeruleus* (9)	*Turbo smaragdus* (4)
٩	*Sypharochiton pelliserpentis* (9)	*Hemigrapsus sexdentatus* (2)
١٠	*Chiton glaucus* (7)	*Petrolisthes elongatus* (2)
١١	solitary ascidian (٧)	*Cantharidella tesselata* (1)
١٢	*Petrolisthes elongatus* (6)	*Haustrum scobina* (1)
١٣	*Melagraphia aethiops* (5)	Isopoda (١)
١٤	*Ostrea* sp. (5)	*Scutus antipodes* (1)
١٥	*Turbo smaragdus* (3)	Terebellidae (١)
١٦	*Halicarcinus varius* (1)	
١٧	Ophiuroidea (١)	
١٨	*Risellopsis varia* (1)	
١٩	*Scutus antipodes* (1)	
٢٠	Terebellidae (١)	

Site 2 – Acheron Point

The shoreward end of both Acheron Point transects terminated at the recently constructed and sparsely colonised artificial seawall edging the roadway (Figure 9). Scattered building material from the seawall was present in the area, potentially influencing the results at transect positions 0–5 m. The seaward end of transect 1 (position 30 m) was located at a depth of 5 metres during a tidal state of +1.5 m (3.5 m deep relative to chart datum). The seaward end of transect 2 extended only to MLW (position 9). The moderately steep cobble shore was dominated by rocks mostly immobilised by a pebble base on the upper shore and sand only beyond MLW (Figure 10). During fieldwork at this site (tide +0.5 m) a passing container ship caused a wake to wash along the intertidal transition zone. Small clumps of *Adenocystis utricularis* were present on rocks located in small puddles at low tide, but were not observed deeper. Though the seabed was largely composed of cobbles and pebbles, the brown macroalgal bed (beginning around position 14 m) trapped silt as observed at site 1. This sparse bed was primarily occupied by *Carpophyllum* spp., *Cystophora* spp., and an alga which superficially resembled *Gigartina* before being dominated by a small patch of *Macrocystis pyrifera* stretching from position 16 or 17 m to around 30 m. At this point and

deeper, the bottom became sandy with fewer rocks and isolated algal clumps representing the sand/algae community type identified in Figures 9 and 1 with obvious signs of macrofaunal activities (mostly gastropods and small tube-dwelling worms and crustaceans).

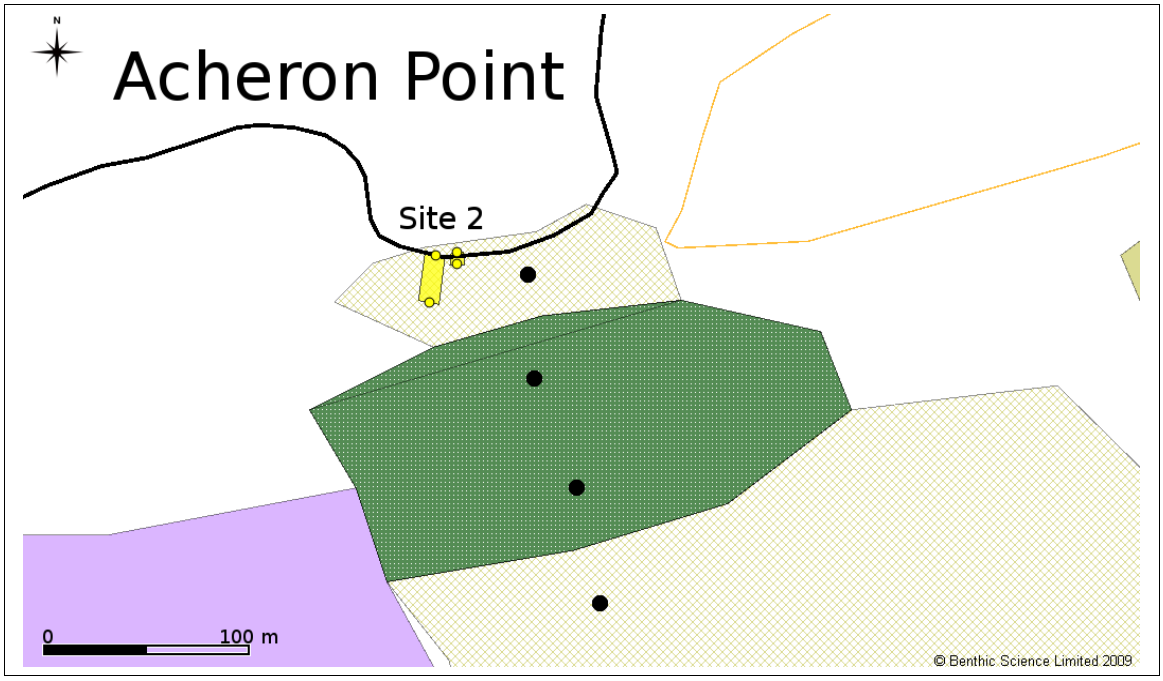


Figure 9. Acheron Point survey area, site 2, (yellow polygons) within the context of the soft-sediment habitat classification (see Figure 1). Transect 2 (on right) encompassed the intertidal area from MHWS to MLW.

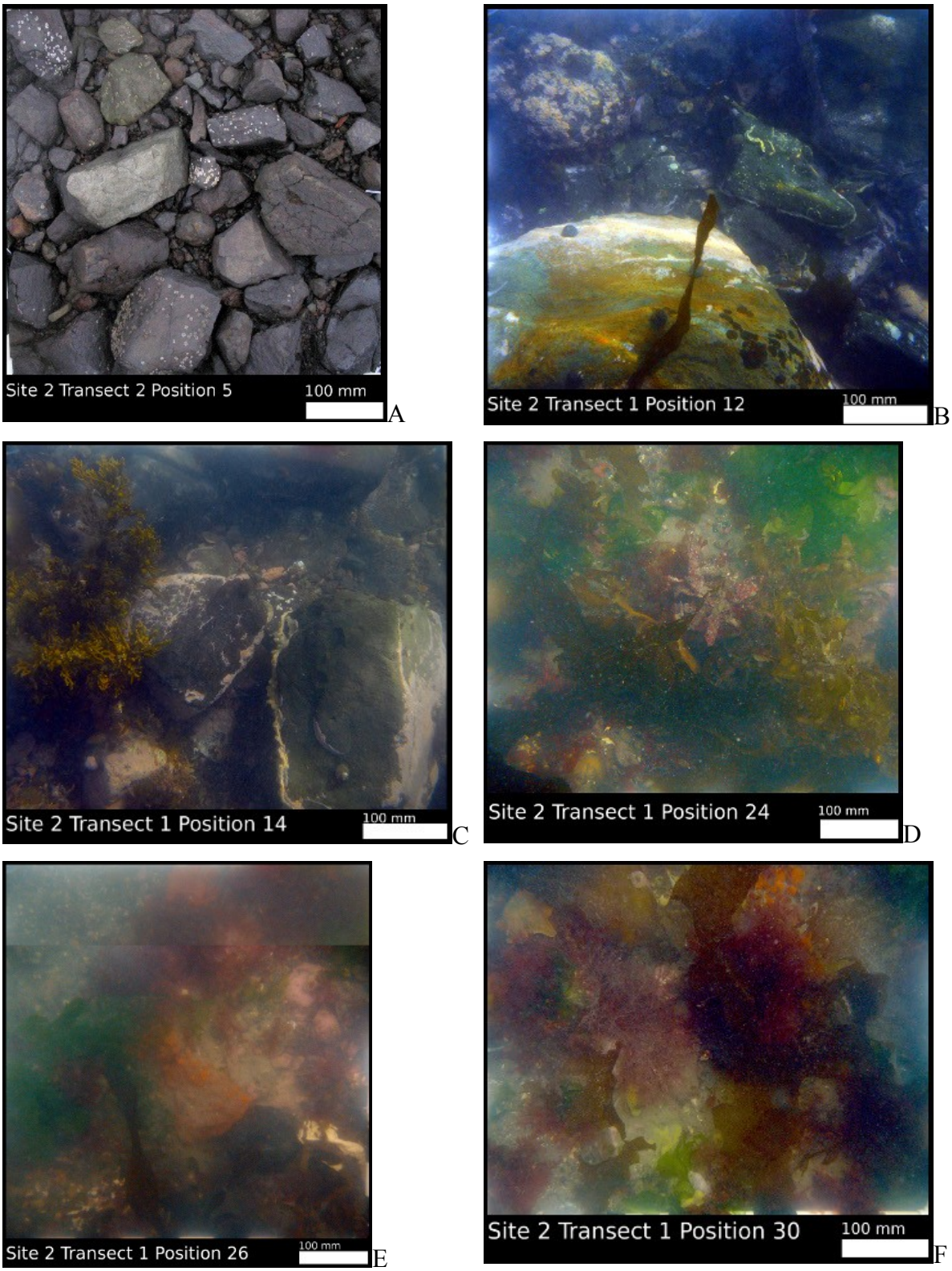


Figure 10. Representative habitat bands observed at Acheron Point (site 2).

Schools of yellow-eyed mullet (*Aldrichetta forsteri*) were observed several times. A large bull sea lion (*Phocarctos hookeri*) was present in the transect area during surveys. Though densities were not calculated, triplefins (*Tripterygion varium*) were seemingly encountered much more frequently at site 2 than at any other site. The site was visited during ebb and flood conditions. Tidal currents were stronger than those experienced at site 1 only a few minutes earlier. Acheron Point also seemed more exposed to the dominant southwesterly wind than site 1. A supposition supported by the presence of the barnacle *Elminius modestus*. An unidentified yellow sponge (Figure 11) was particularly conspicuous at site 2 in addition to the *Tethya* sp. and many cryptic species frequently seen in the harbour.

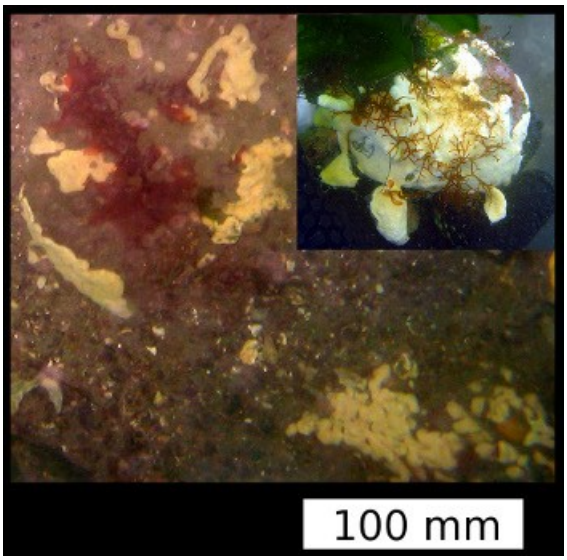


Figure 11. Unidentified sponge particularly conspicuous at sites 2 and 3, not observed at sites 1 and 4.

Eight algal, two colonial animal, and 19 solitary invertebrate taxa were found in Acheron Point quadrats. The algal cover relative to the shore is shown in Figure 12. Only encrusting coralline algae were present (10%) within a single quadrat of transect 2 (not shown). The area encompassed by transect 1 contained about 11% algal cover, dominated by encrusting coralline species (8%) spread broadly from MLWS to the subtidal zone in patches as opposed to distinct dense bands (Figure 12). The most numerous animal at site 2 was the barnacle *Elminius modestus* found in the upper 6 m of transect (Table 2). Only one duck's bill limpet (*Scutus antipodes*) was recorded in a single counted quadrat at the subtidal position 21 m, but a band of the animals with densities ranging up to about 12 m^{-2} were observed from positions 19 to 26 m beyond which they were less common on the increasingly sandy (coarse) bottom.

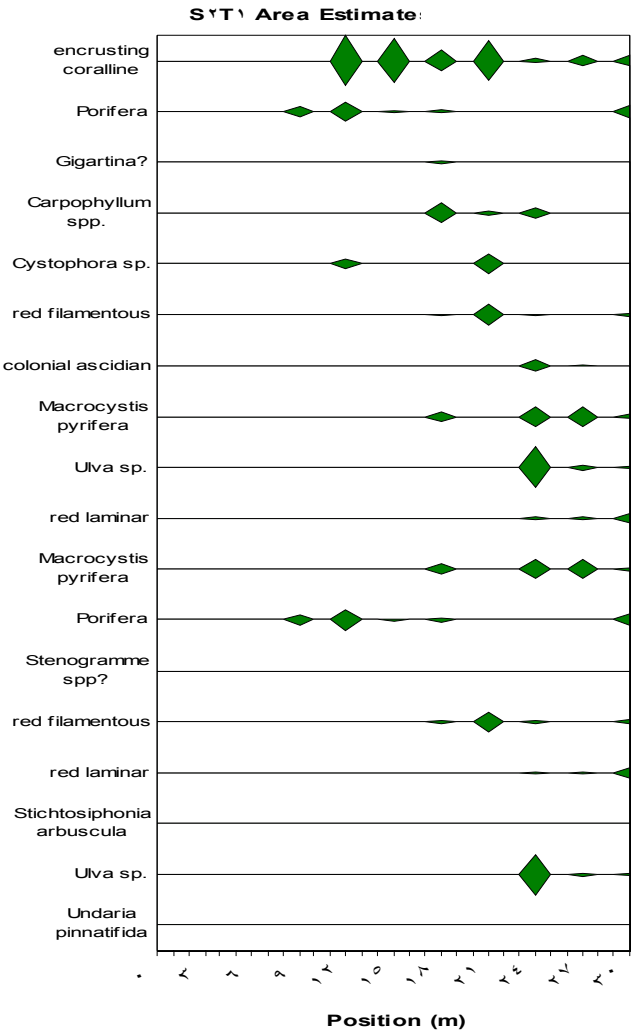


Figure 12. Relative areal measures (% cover of algae, sponge, and tunicates) at site 2 transect 1.

Table 2. Rank abundance of invertebrate taxa at site 2, transects 1 and 2.

Rank	T١- Taxon (Individuals)	Range (Position)	T٢ - Taxon (Individuals)	Range (Position)
١	*Elminius modestus* (≈1200)	٣ - ٦ m	*Elminius modestus* (≈2020)	٠ - ٦ m
٢	*Diloma coracina* (144)	٣ - ٦ m	*Diloma coracina* (116)	٠ - ٦ m
٣	*Petrolisthes elongatus* (50)	٠ - ٦ m	*Petrolisthes elongatus* (35)	٠ - ٦ m
٤	*Chaemosipho columna* (30)	٩ m	*Cellana radians* (30)	٠ - ٦ m
٥	*Melagraphia aethiops* (25)	٩ - ١٥ m	*Zeacumantus* sp. (9)	٠ - ٦ m
٦	*Cellana radians* (16)	٣ - ٩ m	*Chiton glaucus* (4)	٣ - ٦ m
٧	*Sypharochiton pelliserpentis* (13)	٧ - ٦ m	*Haustrum scobina* (4)	٠ - ٣ m
٨	*Chiton glaucus* (11)	٧ - ٦ m	*Hemigrapsus sexdentatus* (3)	٠ m
٩	*Ostrea* sp. (6)	٩ m	*Aulacomya atra maoriana* (1)	٣ m
١٠	*Pomatoceros caeruleus* (6)	٣ - ١٢ m	*Paphies australis* (1)	٦ m
١١	*Zeacumantus* sp. (6)	٠ - ٦ m	*Sypharochiton pelliserpentis* (1)	٠ m
١٢	*Hemigrapsus sexdentatus* (5)	٠ - ٣ m		
١٣	*Buccinulum linea* (1)	٩ m		
١٤	*Patiriella regularis* (1)	٣٠ m		
١٥	*Pyura pachydermatina* (1)	٢١ m		
١٦	*Scutus antipodes* (1)	٢١ m		

Site 3 – Pulling Point

The shoreward end of both transects at Pulling Point terminated at the artificial seawall adjacent to the roadway (Figure 13). Scattered, uncolonised wall building material was present at the top end of the transects which potentially influenced positions 0−3 m. There were fewer pieces of building stones at site 3 than sites 1 or 2. The upper cobble shore was sparsely colonised, and rocks were noticeably more rounded and worn than sites 1 and 2 (Figure 14). During fieldwork at this site (tide +0.6 m) a passing ship caused a wake of approximately 0.2 m high to wash along the shore. Native rocks with vertical relief of over 500 mm had a felt of *Stichtosiphonia arbuscula* algae. *Corrallina* was present. Transect 1 extended seaward only to position 4 m, slightly above MLW. The seaward end of transect 2 (position 30 m) was located at a depth of 3.5 m (relative to chart datum) in gravel sediments. The shore-profile at Pulling Point was steeper than other sites and a short swim from the end of the transect indicated that the slope was relatively consistent to the channel. Just beyond the end of the transect a long-abandoned fishing trap, heavily colonised by sponges and tunicates, may serve as a future landmark.

Pulling Point appeared to be the study site most exposed to SW winds. Though occupied at two slack tides, the slack-water period was brief and currents were stronger than

those experienced at other study sites. Low visibility and currents forced a modification of the survey protocol. Subtidal quadrats at site 3 were located adjacent to the transect line itself (right looking shoreward) at each 1 m interval. Horizontal travels 5 m either side of the line were impractical in the existing conditions.

Although not recorded in quadrats, the seaward end of the transect supported many large feather-duster worms (Sabellidae in pockets of finer sediment), several seven-armed sea stars (*Astrostole scabra*), and the sea slugs *Archidoris wellingtonensis* and *Aphelodoris luctuosa*. Individual duck's bill limpets (*Scutus antipodes*) were recorded in several quadrats at densitites of about 4 m^{-2}, which represent portions of a a dense band of these animals from positions 18 to 29 m. Densities estimated in the field ranged up to 12 m^{-2}.

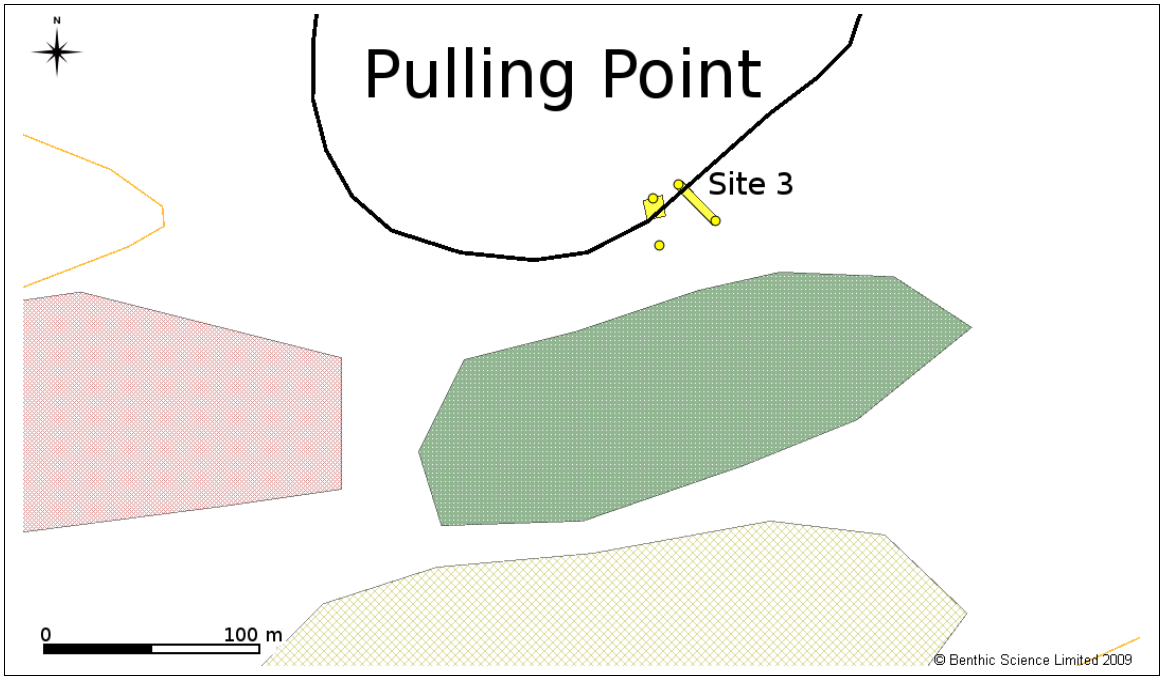


Figure 13. Pulling Point survey area (yellow polygons) within the context of the soft-sediment habitat classification (Figure 1). Transect 1 (on left) encompassed the intertidal area from MHWS to just above MLW.

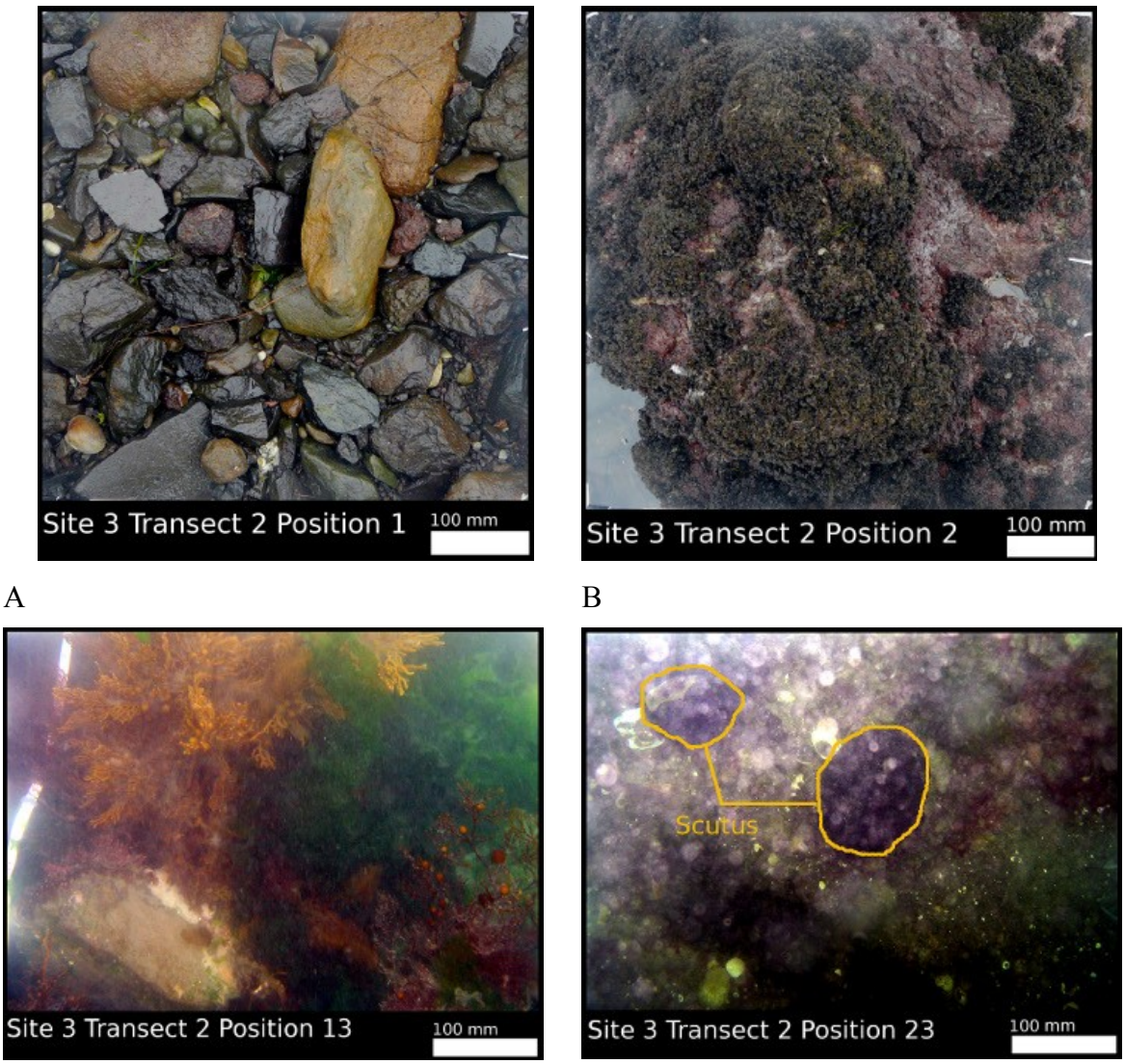


Figure 14. Representative habitats observed at site 3.

The most numerous animals recorded at Pulling Point were snails and crabs of the upper shore (Table 3). Nine algal taxa were identified at the site and 20 solitary invertebrate taxa (313 individuals). The most numerous large animals were concentrated in the upper 8 m of the transects. Colonial tunicates were recorded and an unidentified sponge (Figure 11) was particularly conspicuous. The area evaluated by transect 2 had about 40% algal cover. Most of the cover was present between positions 12 and 30 m with small amounts of the upper shore species *Stichtosiphonia arbuscula* and pieces of green *Ulva* higher (Figure 15).

Table 3. Rank abundance of invertebrate taxa at site 3, transects 1 and 2.

Rank	T١- Taxon (Individuals)	Range (Position)	T٢- Taxon (Individuals)	Range (Position)
١	*Diloma coracina* (61)	٠ - ٨ m	*Diloma coracina* (73)	٠ - ٣ m
٢	*Petrolisthes elongatus* (24)	٠ - ٨ m	*Petrolisthes elongatus* (41)	٠ - ٣ m
٣	*Risellopsis varia* (20)	٣ m	*Cellana radians* (26)	٠ - ٣ m
٤	*Cellana radians* (17)	٠ - ٣ m	*Chiton glaucus* (3)	٣ m
٥	*Chaemosipho columna* (10)	٣ m	*Haustrum scobina* (2)	٠ m
٦	*Sypharochiton pelliserpentis* (9)	٠ - ٣ m	*Zeacumantus* sp. (1)	٠ m
٧	*Chiton glaucus* (5)	٠ - ١٢ m	*Sypharochiton pelliserpentis* (1)	٠ m
٨	*Notacmea* sp. (4)	٨ m	Platyhelminthes (١)	٣ m
٩	*Scutus antipodes* (4)	١٨ - ٢٧ m		
١٠	solitary ascidian (٣)	١٢ - ٢١ m		
١١	*Cantharidella tesselata* (2)	٢٤ m		
١٢	*Hemigrapsus sexdentatus* (1)	٠ m		
١٣	*Melagraphia aethiops* (1)	٨ m		
١٤	Nereididae (١)	٣ m		
١٥	*Notomithrax* sp. (1)	١٢ m		
١٦	*Ostrea* sp. (1)	٨ m		
١٧	*Turbo smaragdus* (1)	١٢ m		

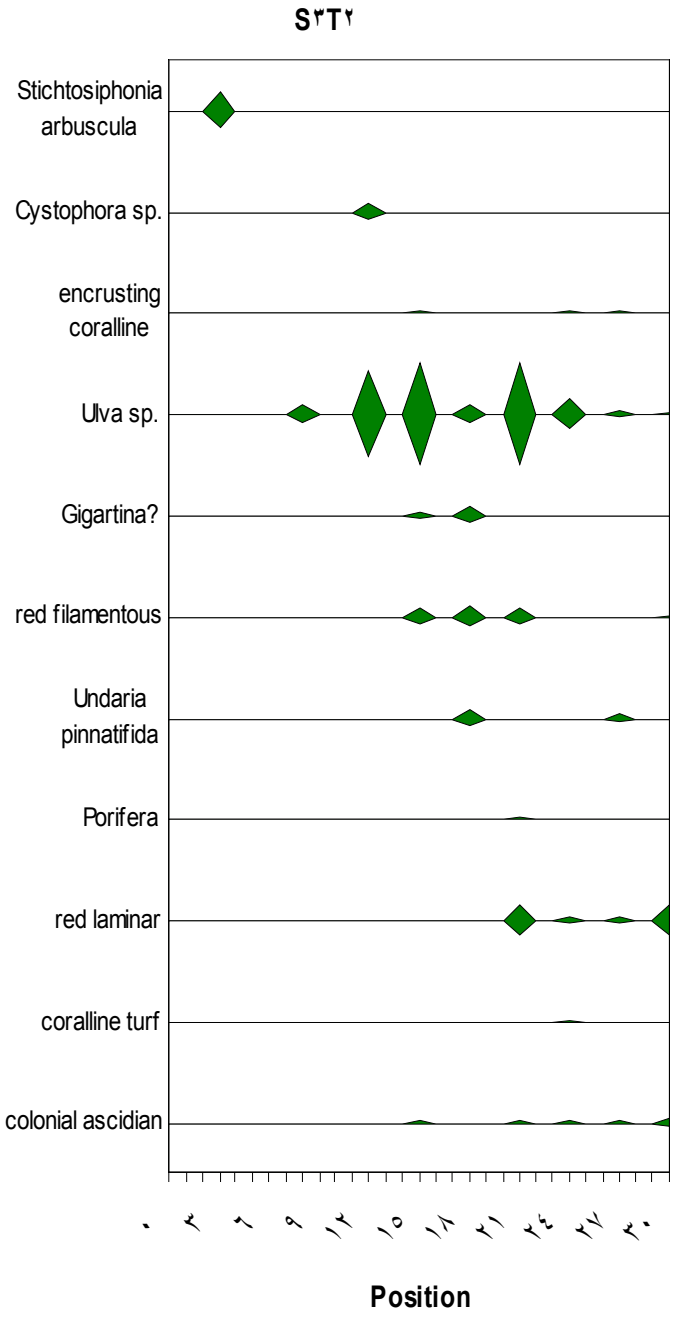


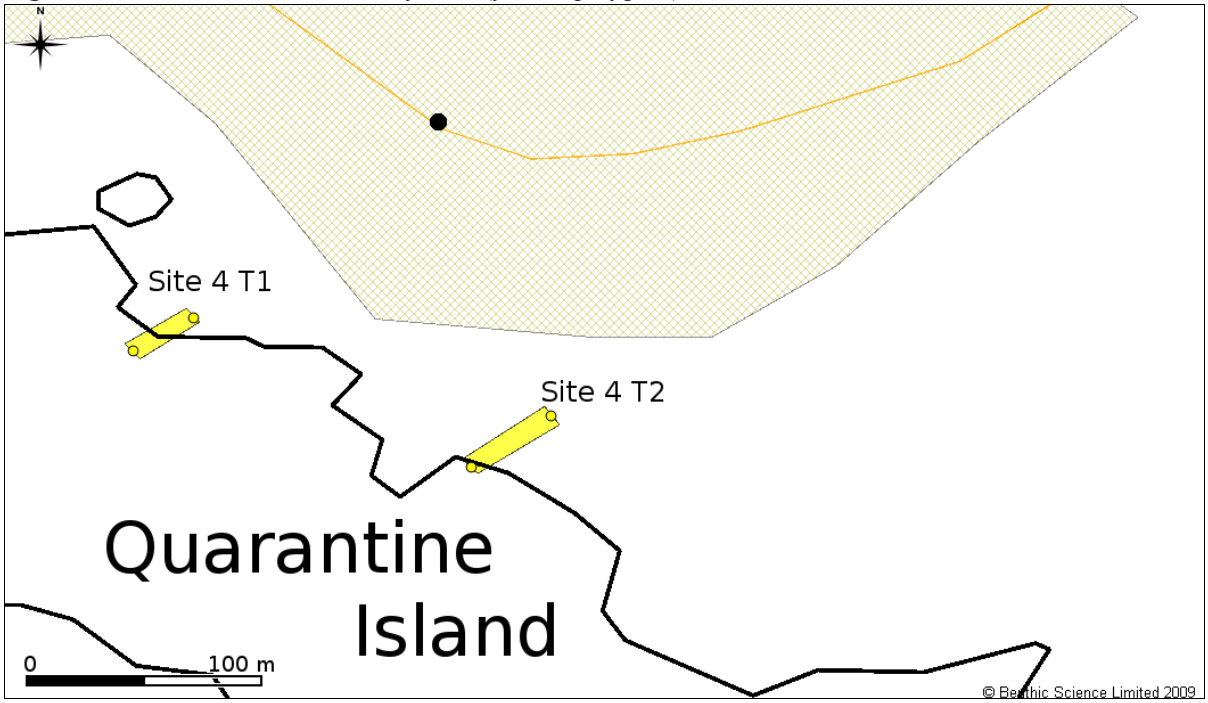
Figure 15. Relative areal measures (% cover of algae, sponges, and tunicates) at site 3, transect 2.

Site 4 – Quarantine Island

The two transects surveyed on Quarantine Island were more widely separated than other sites due to the pocket beaches between cliff faces and emergent offshore rocks (Figure 16). Underwater structures and above water features (Figure 17) protected transect 2 more than transect 1, though both transects were more sheltered from prevailing winds and currents

than all other study sites. The shoreward end of each transect terminated against the eroded cliff face of native mudstone (Figures 17 and 18).

Figure 16. Quarantine Island survey area (yellow polygons) within the context of the soft-sediment habitat classification (see Figure 1). Transect 2 actually lies five metres beyond an emergent rock (near vertical face, not outlined on chart) on its northwestern edge.



A

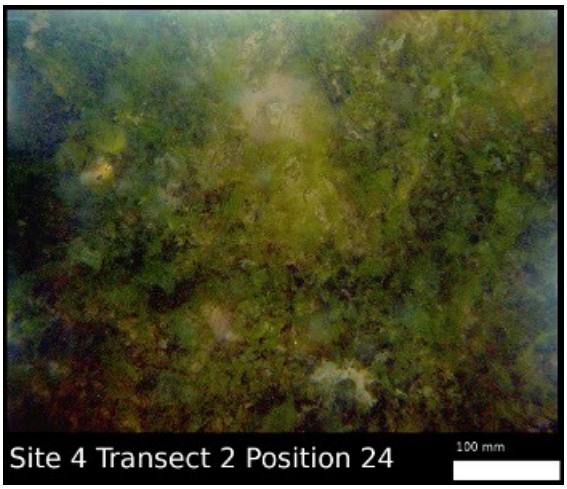
B

Figure 17. Quarantine Island site 4, transect 1 (A) and transect 2 (B). The underwater portion of transect 2 was angled due east to remain 5 m away from emergent rock face to avoid vertical quadrats.

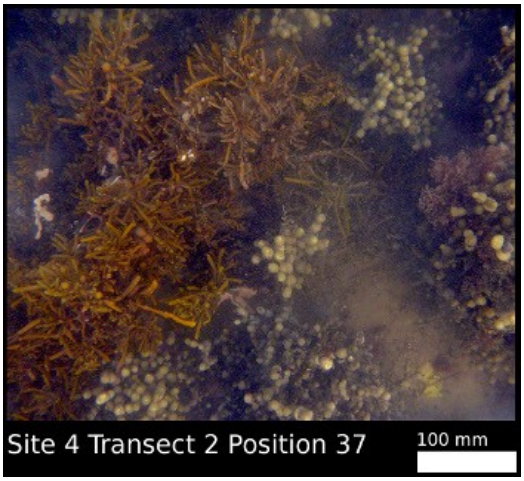
A

B

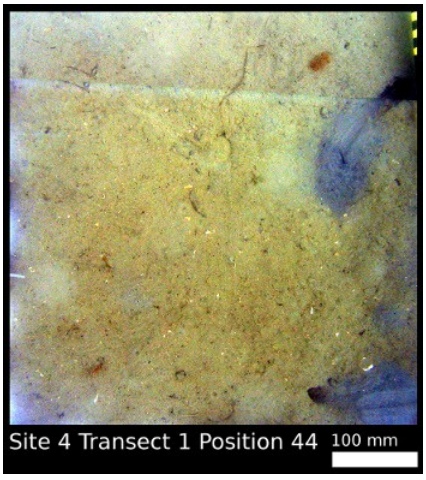
C



D



E



F

Figure 18. Representative habitat observations from Site 4 transects.

At transect 1 the cobble shore descended to a fine sand bottom with organisms equivalent to the soft-sediment study 'inlet-like' habitat (Figure 1) by position 20 m. Continuing down the transect the amount of silt increased and the seafloor became characterised by annelid and amphipod tubes comparable to the 'tube-mat' habitat described in the associated soft sediment study (Figure 1) beyond position 30 m. The seaward end of transect 1 (position 50 m) was located at a depth of 0.5 m (with reference to chart datum). A short swim 10 m beyond this point reached a depth of 1.2 m (chart datum). The bottom was heavily worked by the crab *Macrophthalmus hirtipes* at densities greater than 8 m^{-2}. A further 10 m along (approximately 70 m from cliff face) a dense algal bed (*Stenogramme* sp?) was present at a depth of 4 m (chart datum). Though not encountered in quadrats, sparse clumps of *Macrocystis pyrifera* were present at the seaward end of the transect while *Undaria pinnatifida* was also common on the occasional hard surfaces available beyond position 20 m. Both were present on the vertical rock wall.

Just beyond the hard shore, transect 2 paralleled a large emergent rock. Below the 0.5 m tide water level the sediments were silty sand. Ghost shrimp (*Callianassa filholi*) mounds were frequently observed on the margins of subtidal seagrass (*Zostera novazelandiae*) patches. Below the seagrass patches were aggregations of pie-crust crabs (*Metacarcinus novazelandiae*) reaching densities up to 3 m^{-2} (field estimate). Although not found in counted quadrats, cat's eye snails (*Turbo smaragdus*) were abundant on *Ulva* patches (especially between positions 30 and 40 m). The *T. smaragdus* at site 4 appeared to be noticeably larger than specimens observed at other sites. Many exceeded 60 mm in shell diameter. Wherever the silty bottom was exposed, the surface bore gastropod tracks and large numbers of crustacean and annelid tubes. The seaward end of transect 2 was situated at a depth only 0.5 m below chart datum. A short swim 10 m beyond the terminus (position 60 m) found a depth of 1.4 m (chart datum) at a sharp break in the seafloor indicating that the muddy bottom was a thin layer on hard rock. The break was colonised by several large sponges (*Polymastia* sp, approximatly 0.10 m^2 and larger). *Macrocystis pyrifera* and *Undaria pinnatifida* colonised hard surfaces along with a variety of red and brown algae. There were dense aggregations of *Scutus antipodes* and multiple schools of spotties (*Notolabrus celidotus*). At about 63 m from the cliff face the depth was 4 m below chart datum.

A total of nine algal and 30 solitary invertebrate taxa were found at site 4 (1 834 individuals). Poriferans and colonial tunicates were also found. Algae covered

approximately 39% of the transect 1 surveyed area and 31% of the transect 2 area (Figure 19). The cover was overwhelmingly dominated by *Ulva* sp. in the sub-littoral zone. Site 4, transect 2 was the only study area in which Neptune's necklace (*Hormosira banksii*) was found. The green alga *Codium fragile* was found in both site 4 transects, but was not observed at any of the other sites.

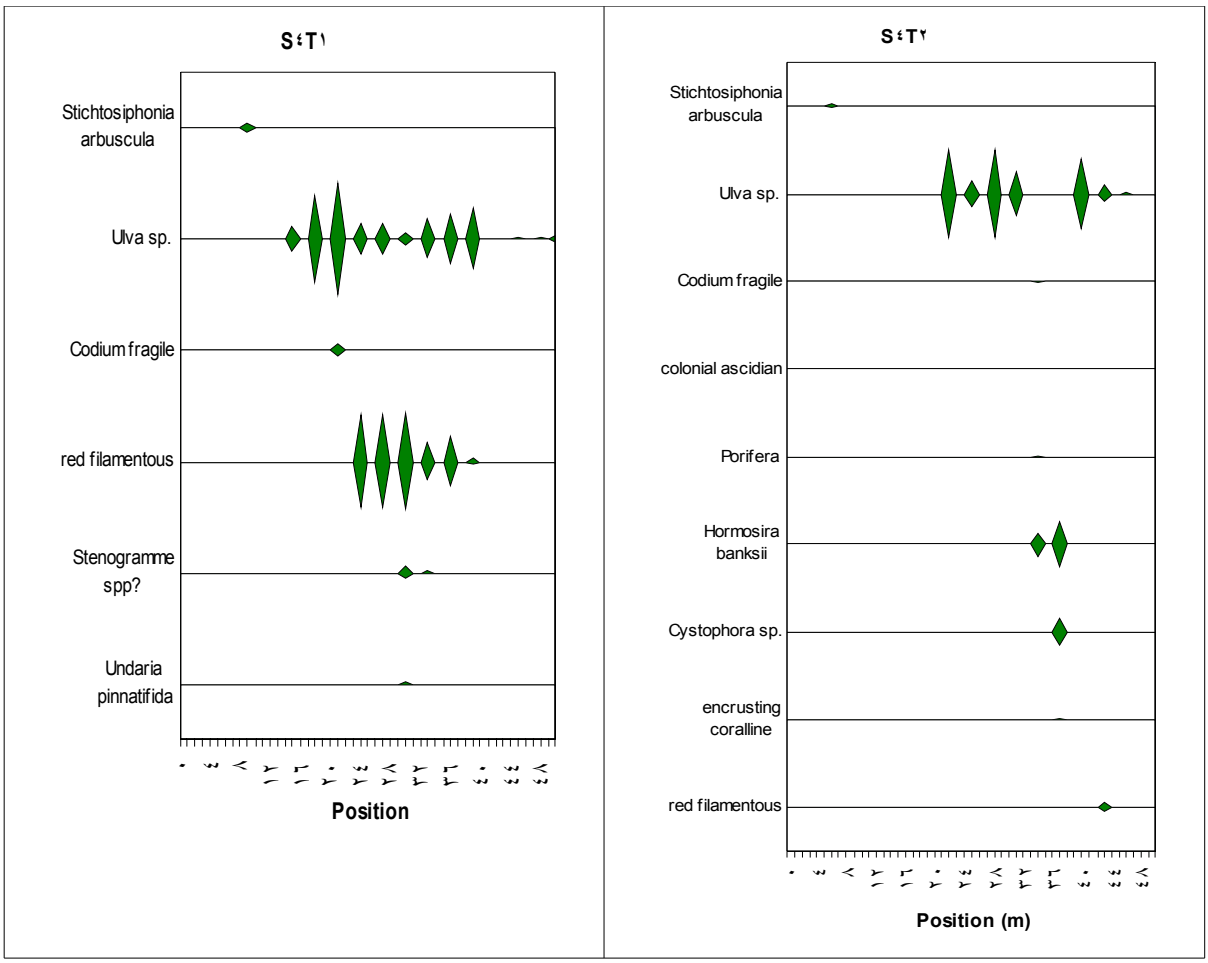


Figure 19. Relative areal measures (% cover of algae, sponges, and tunicates) site 4 transects 1 (left) and 2 (right).

The most numerous animals at site 4 were the snails, tubeworms, bivalves, and chitons of the upper shore (Table 4). The single most numerous taxon (especially at transect 2) was a small (approximately 10 mm) gastropod that has not yet been identified. Its white shell resembles many Turritellidae species. It was observed moving along the surface of the muddy bottom, sometimes with conspicuous trails through the microphytobenthos.

Table 4. Rank abundance of invertebrate taxa at site 4, transects 1 and 2.

Rank	T١- Taxon (Individuals)	Range (Position)	T٢- Taxon (Individuals)	Range (Position)
١	*Zeacumantus* sp. (246)	٦ - ١٢ m	?Turritellidae (٧٩١)	١٤ - ٣٧ m
٢	*Cellana radians* (79)	١٢ - ١٥ m	*Pomatoceros caeruleus* (136)	١٤ - ١٧ m
٣	?Turritellidae (٦٧)	٤٢ - ٥٠ m	*Cellana radians* (131)	٦ - ٢٥ m
٤	*Sypharochiton pelliserpentis* (36)	٦ - ١٢ m	*Zeacumantus sp.* (84)	٩ - ١٧ m
٥	*Pomatoceros caeruleus* (27)	٩ - ١٢ m	*Austrovenus stuchburyi* (48)	٩ - ٢٨ m
٦	*Cellana strigilis* (16)	٦ - ٩ m	*Sypharochiton pelliserpentis* (23)	٩ - ١٧ m
٧	*Micrelenchus* spp. (10)	٢١ - ٣٦ m	*Melagraphia aethiops* (18)	٩ - ١٢ m
٨	*Diloma coracina* (9)	٦ - ١٥ m	Isopoda (١٦)	٦ - ١٢ m
٩	Nereididae (٨)	٦ m	*Diloma coracina* (15)	٦ - ٣٤ m
١٠	*Actinia tenebrosa* (7)	٦ m	*Chiton glaucus* (9)	٩ - ١٤ m
١١	*Austrovenus stuchburyi* (6)	١٥ - ٢١ m	*Cominella glandiformis* (4)	٩ - ٣٧ m
١٢	*Chiton glaucus* (6)	٦ - ١٥ m	*Ostrea* sp. (3)	١٧ m
١٣	*Chaemosipho columna* (5)	٩ - ١٢ m	*Actinothoe* sp. (2)	٣٧ m
١٤	*Macrophthalmus hirtipes* (5)	٣٦ - ٤٨ m	*Heterosquilla* sp. (2)	٢٨ m
١٥	*Hemigrapsus sexdentatus* (4)	٦ - ١٢ m	*Acanthochiton zelandicus* (1)	١٤ m
١٦	Isopoda (٣)	١٢ m	*Actinia tenebrosa* (1)	٦ m
١٧	*Onchidella ?nigricans* (3)	٦ m	*Chaemosipho columna* (1)	١٢ m
١٨	*Notacmea* sp. (2)	١٨ m	*Maoricolpus rosea* (1)	٣٧ m
١٩	Platyhelminthes (٢)	٩ m	*Metacarcinus novaezelandiae* (1)	٤٦ m
٢٠	*Alcithoe wilsonae* (1)	٢١ m	*Micrelenchus* spp. (1)	٣٧ m
٢١	*Maoricolpus rosea* (1)	٢١ m	*Pagurus* sp. (1)	١٧ m
٢٢			*Paphies australis* (1)	١٤ m

Table 5 summarises the semi-quantitative data collected from the counted transects at each transect. Within areas with more complete sampling, algal cover ranged from 11 to 40%. Algal density and invertebrate diversity seemed to vary directly with sampling effort.

Table 5. Summary of algal cover and invertebrate taxon richness and abundance within each transect.

	Number of Quadrats		Total Algal Cover Counted		% Algal Cover		Algal Taxa		Invertebrate Taxa		Invertebrate Individuals	
	T١	T٢	T١	T٢	T١	T٢	T١	T٢	T١	T٢	T١	T٢
Site ١	١٢	١٢	٢.٢	١.٧	٠.١٨	٠.١٤	٩	٧	٢٠	١٥	≈801	٥٥٤
Site ٢	١١	٣	١.١٩	٠.٠١	٠.١١	٠.٠٠	٨	١	١٦	١١	≈1516	≈2224
Site ٣	٢	١٠	٠.٠٠	٤.٠٢	٠.٠٠	٠.٤٠	٩	٦	٨	١٧	١٤٨	١٦٥
Site ٤	١٨	١٦	٧.٠١	٥.٠٢	٠.٣٩	٠.٣١	٦	٧	٢١	٢٣	٥٤٣	≈1291
Sum	٨٤						١٦		٤٨		≈7242	

Brief Discussion

Within marine science the term 'rocky shore' usually refers to a shoreline of mostly solid bedrock with small amounts of overlying rocky material ranging in size from pebbles to boulders[3]. Only a small fraction of the surveyed shoreline was bedrock. Transects began at the vertical boundaries present at each site, either artificial seawalls (sites 1−3) or natural, eroding, mudstone cliffs (site 4). Because of the harbour's sheltered environment, the supra-littoral or maritime zones were apparently terrestrial and the first mostly horizontal surfaces are covered with each tidal cycle (mid-littoral zone). The majority of the mid-littoral zone surveyed consisted of pebbles, cobbles, and occasional boulders. At each site, the rocky shoreline rapidly gave way to gravel, sandy, or muddy sediments at or just below MLW. The typical intertidal zonation patterns were accordingly shortened in response to the ≈2 m tidal range and limited wave exposure. In the frequent absence of good littorinid and barnacle substrata (non-moving stones) fine resolution of the vertical zonation might depend upon better taxonomic resolution of algae than was possible in the present study.

Biota on these types of shorelines present several difficulties to quantification. Small areas (centimetre scale) with wildly different exposure regimes to dessication, tidal inundation, waves, light, sedimentation, substratum movement, and predation can exist within metres of each other. Such a variable habitat would require correspondingly extensive

sampling effort (at the centimetre scale) to describe completely. Even then, no two surveys would be likely to produce the same numerical results given changes with weather and season. It was therefore the aim of this study to describe the broad intertidal habitat patterns present at each site and examine how they transition into sub-tidal soft-sediment habitats[1] using accepted practices and rocky shore zonation models. Although typical intertidal and subtidal zonation patterns were evident across all study sites, each site had a distinctive shore-normal pattern, detectable within the limits of the present surveys. Each of the sites visited had a distinctly different progression of algae, animals, and sediment texture.

Rocky Point's shoreline developed into the subtidal algal bed predicted by the soft-shore study[1]. The most notable feature of Rocky Point's upper shore fauna was the presence of the littorinids *Austrolittorina antipodum* and *A. cincta* in their expected place among the barnacles *Chaemosipho columna* and *Elminius modestus*. These snails primarily occupied the emergent uppershore basaltic boulders and bedrock present here, but absent at sites 2, 3, and 4. The mutual presence of an oyster taxon (*Ostrea* sp.) and an oyster predator (*Haustrum scobina*) suggests relatively long-term stability of the stones and water quality able to allow oysters to reach shell diameters of 50 mm or so.

The greatest density of the barnacle *Elminius modestus* was recorded at Acheron Point (site 2). This species tends to live at lower tidal levels than *Chaemosipho columna* but *E. modestus* occurred higher or alongside *C. columna* at site 2. *Diloma* spp. abundances remained consistently high throughout the rocky-shore study. Half-crabs (*Pestrolithes elongatus*) were more numerous under rocks at site 2 than site 1 despite the smaller sampling effort. At Acheron Point dense and diverse algal beds lay in narrow (tens of metres) bands in the shallow subtidal zone. The flora became more sparse and the fauna shifted toward a more encrusting sessile fauna with greater depth toward the shipping channel's 'deep sessile' habitat as predicted[1].

Pulling Point was the most exposed site and correspondingly had the greatest amount of rocky surface available for colonisation. Site 3 had the lowest total sampling effort, but produced even fewer individuals than might be expected. The upper surfaces of the rocky shore were not as heavily colonised as at other sites. The mid-littoral zone was dominated by robust grazing *Diloma* snails and the filter-feeding 'half-crab' *Pestrolithes elongatus* congregated under rocks as usual. Barnacles were almost absent, even when the photos were

examined to supplement the counted quadrats. Many more dead *Ostrea* shells and *Pomatoceros caeruleus* tubes were present than living. The actual surveyed area at Pulling Point was lessened due to the steeper shore profile and current conditions, but observations at the seaward transect terminus and beyond indicated that, like site 3, the habitat shifted toward a deep sessile community; algae formed small patches.

Quarantine Island transects differed substantially from the other sites. The rocky shoreline quickly gave way to a fine sand and muddy seabottom in the sublittoral with sheltered-inlet fauna and subtidal seagrass (light green habitat in Figure 1). The shore profile was shallow, but progressed toward the tube-mat habitat[1] to chart datum depths of about 5 m. The transition from this tube-mat habitat to one of sandy bottom with sparse algae, as previously observed, must occur somewhere between 75 m from shore and the centre of the Quarantine Island channel. It was in the tube-mat areas that the Turitellidae (possibly small *Maoricolpus*) were most abundant. The mid-littoral zone at site 4 had a wide variety of substrata ranging from coarse sand and gravel to bedrock and pockets of recently deposited mud. Intertidal animals occupied these microhabitats at wildly varying densities. Site 4 produced the only cockles (*Austrovenus stutchburyi*) in the study. Only living cockles with shells actually piercing the sediment surface could be counted as siphons were withdrawn when the quadrat was placed over them. They occurred between positions 9 and 21 m at densities up to 136 m^{-2} (all counted individuals exceeded 30 mm greatest shell width).

The sites appeared to form an exposure gradient. With site 4 the most sheltered, followed by sites 1, 2, and 3 in order of increasing exposure to tidal currents and winds. Given the shape of the surrounding landforms, site 4 was also likely to receive the most sediment from direct land runoff and deposition from lee eddies. Seabed transport and suspended sediments were probably more important at sites 1, 2, and 3. At first glance, Table 5 suggests there may have been a decrease in algal cover along this gradient, but sampling effort also declined along the same gradient so no such conclusion is supported.

The majority of invertebrate individuals encountered were located high in the mid-littoral zone. The lower littoral and sub-littoral zones were increasingly dominated by soft-sediment macrofauna (as indicated by bioturbation) or potentially by mobile animals such as fish. An exception was the dense bands of duck's bill limpets (*Scutus antipodes*) present in

the shallow subtidal zone wherever continuous rocky surfaces were exposed above muddy substrata (sites 2, 3, and 4).

All of the animals identified were species commonly found in shallow sheltered inlets and the euhaline portions of southern New Zealand estuaries. Though quantitative data are not available, all observed animal species have also been encountered on the southern shore of the harbour as well (*pers. obs*). Given the likelihood of gamete sources, if any of these species were to become absent for a prolonged period of time, it may be indicative of a substantial environmental shift or dramatic population problem. No quantitative rocky shore survey data from within the study area was found despite the comprehensive bibliography compiled by James et al.[4]. In the absence of baseline surveys or a regional monitoring programme, few statements can be made regarding the seasonal variablity of lower harbour rocky shore habitats or community stability over longer time periods.

The present work may represent the most comprehensive rocky shore survey in the lower Otago Harbour and could form the basis of comparative work in the future. The archived photo records, most complete at sites 1 and 4, will also be useful as a one-off record of general site conditions. Relocating many of the quadrat positions is possible with local landmarks and could form the basis for selection of permanent photo-quadrat stations.

Although no specific furhter work of this type is planned by Port Otago, observations and experience from this study may be valuable to others undertaking future work. Alternative survey strategies may be warranted given that the lower littoral to subtidal transition ranged from over 30 m (site 4) to less than 10 metres (site 3) along the shore slope. From our experiences with the fouling algal beds and currents at sites 2 and 3, I believe that a greater number of transects with fewer sampling intervals and little or no horizontal movement may be more efficient.

Conclusions

Gross algal cover, invertebrate diversity, and invertebrate abundance were assessed on approximately 21 m^2 of rocky shore and sub-littoral seabed in the lower Otago Harbour. A greater area was photographed and qualitatively examined within the context of typical sheltered inlet tidal zonation. Detailed algal identifications are not feasible in the field, especially given the lack of a species inventory within the harbour and the general paucity of

information on New Zealand's soft-sediment algae. Given their apparent role in trapping sediments, algae are likely to be important in shaping the mid-littoral rocky shore communities in the harbour. Intertidal fauna may respond to algal diversity and biomass in ways we cannot detect given the effective taxonomic resolution of the present study.

Overall, the mid-littoral zone of the lower Otago Harbour rocky shores, as represented by these four sites, are characterised by sparsely colonised cobble-sized stones. In the absence of significant wave activity intertidal animals are mostly restricted to small fissures and the undersides of the stones. There are no extensive *Fucoid* zones. The lower mid-littoral and shallow subtidal areas are at least partly soft-sediment environments dominated by algal beds and macrofauna. As depth increases, algae become more patchy and scarce, possibly light-limited. Beyond that point, soft-sediment macrofauna dominate in fine sediments and sessile invertebrates take advantage of any hard surface sitting proud of the seafloor, where emergent rocks form a continuous band, the limpet *Scutus antipodes* collects in large numbers.

Although small additions can be made to the existing soft-sediment habitat map[1], the seaward ends of survey transects encountered the habitat types predicted. This finding lends support to the robustness of the map. No particularly rare or unusual species or communities were identified in the surveyed areas. This study focused on the large, conspicuous organisms of the intertidal zone and generally confirmed our overall understanding of benthic processes in the lower Otago Harbour.

Acknowledgments

This work was made possible through the cooperation and funding of Port Otago Limited. I also thank Daniel Ham and Nicola Beer for their diligent work in the field.

References

[1]Paavo, B., Probert, P.K., and James, M. (2008) Benthic habitat structures and macrofauna of lower Otago Harbour. Report to Port Otago Limited, Dunedin, New Zealand. 76 pages.

[2] QGIS (2009) Quantum GIS: an open source project. url: qgis.org/content/ [updated 24 March 2009]

[3] Barker, M. (2003) Rocky shores and kelp beds *in* "The Natural History of Southern New Zealand" *eds*. Darby, J., Fordyce, E., Mark, A., Probert, K., and Townsend, C. University of Otago Press, Dunedin, New Zealand. Pages 270−278.

[4] James, M., Probert, K., Boyd, R., and John, A. (2007) Summary of existing ecological information and scoping of further assessments for Port Otago dredging project. Report HAM2007-156 to Port Otago Limited, National Institute of Water & Atmospheric Research Ltd., Project number POL08201. 65 pages.

Appendix 1 – Survey Sites

The following geographic coordinates (WGS84 datum) represent the start (s) and end (e) points of survey transects noted with site number (S#) and transect number (T#).

Site	Dec. Latitude (S)	Dec. Longitude (E)
S1T1s	-45.804333	170.628283
S1T1e	-45.804683	170.628700
S1T2s	-45.804233	170.628483
S1T2e	-45.804517	170.628900
S2T1s	-45.797817	170.644583
S2T1e	-45.798108	170.644543
S2T2s	-45.797800	170.644717
S2T2e	-45.797869	170.644715
S3T1s	-45.795433	170.656300
S3T1e	-45.795710	170.656335
S3T2s	-45.795350	170.656450
S3T2e	-45.795568	170.656672
S4T1s	-45.826617	170.631983
S4T1e	-45.826433	170.632317
S4T2s	-45.827250	170.633833
S4T2e	-45.826968	170.634270

The following table indicates the survey effort completed at each site. T#= Transect number, P = Photographed, C=organisms Counted, N=No photography, U=Unsurveyed position, but within mid-littoral to shallow subtidal zone.

	Site 1		Site 2		Site 3		Site 4	
Transect Position	T1	T2	T1	T2	T1	T2	T1	T2
0	P&C	P&C	P&C	P&C	P&C	P&C	P&C	P&C
1	P	P	P	P	P	P	P	P
2	P	P	P	P	P	P	P	P
3	P&C	P&C	P&C	P&C	P&C	P&C	P&C	P&C
4	P	P	P	P	P	U	P	P
5	P	P	P	P	U	U	P	P
6	P&C	P&C	P&C	P&C	U	P	P&C	P&C
7	P	P	P	P	U	P	P	P
8	P	P	P	U	U	P&C	P	P
9	P&C	P&C	P&C	U	U	P	P&C	P&C
10	P	P	P	U	U	P	P	P
11	P	P	P	U	U	N	P	P
12	P&C	P&C	P&C	U	U	P&C	P&C	P&C
13	P	P	N	U	U	P	U	P
14	P	P	N	U	U	P	U	P&C
15	P&C	P&C	P&C	U	U	P&C	N&C	N
16	P	P	P	U	U	P	N	P
17	N	P	P	U	U	P	N	P&C
18	P&C	P&C	P&C	U	U	P&C	N&C	U
19	P	P	P	U	U	P	N	U
20	P	P	P	U	U	P	N	P
21	C	P&C	P&C	U	U	P&C	N&C	P
22	P	P	P	U	U	P	N	P&C
23	P	P	P	U	U	P	N	P
24	P&C	P&C	P&C	U	U	P&C	N&C	P
25	P	P	P	U	U	P	N	P&C
26	U	P	P	U	U	P	N	P
27	U	P&C	P&C	U	U	P&C	P&C	P
28	U	P	P	U	U	P	P	P&C
29	U	P	P	U	U	P	P	P
30	U	P&C	P&C	U	U	P&C	P&C	P
31	U	U					P	P&C
32	U	U					P	P
33	U	U					P&C	P
34	U	U					P	P&C
35	U	U					P	P
36	U	U					P&C	P
37	U	U					P	P&C
38	U	U					P	P
39	U	U					P&C	P
40	P	U					P	P&C
41	P	U					P	P
42	P&C	U					P&C	P
43	P	U					P	P&C
44	P	U					P	P
45	P&C	U					P&C	P
46	P	N					P	P&C
47	P	P					P	P
48	P&C	P&C					P&C	P
49							P	
50							P&C	

Appendix 2 - Quadrat Data

Data from manual counts in quadrats.

	S1T1P00	S1T1P03	S1T1P06	S1T1P09	S1T1P12	S1T1P15	S1T1P18	S1T1P21	S1T1P24	S1T1P42	S1T1P45	S1T1P48	S1T1P49	S1T1P50	S1T2P00	S1T2P03	S1T2P06	S1T2P09	S1T2P12	S1T2P15	S1T2P18	S1T2P21	S1T2P24	S1T2P27	S1T2P30	S1T2P48
Carpophyllum spp.																							0.1		0.8	0.8
colonial ascidian											0.01										0.01	0.01				
Colpomenia sp.						0.01																				
Corallina sp.											0.01															
Cystophora spp.																							0.02			0.1
encrusting coralline	0	0	0	0	0	0.15	0.01		0	0	0	0.01	0	0	0	0	0.05	0	0	0	0	0	0.07	0	0	0
Macrocystis pyrifera												0.04											0.2			
Porifera										0											0.01		0.01	0.01	0.01	0.01
Stenogramme spp?								0.05	0.15	0.8		0.02					0.02		0.01	0.04	0.7	0.7		0.8		
red filamentous	0	0	0	0	0	0	0	0	0	0.15	0.02	0.01	0	0	0	0	0	0	0	0	0.02	0.3	0.02	0.15	0.01	0
Stichtosiphonia arbuscula					0.4																					
Ulva sp.											0.05	0.02											0.01	0.01	0.2	0.01
Undaria pinnatifida											0.3															
Austrolittorina antipodum	350	14	1																							
Diloma coracina		35	35	26	4										25	33	10									
Cellana radians	0	1	8	5	6	0	0	0	0	0	0	0	0	0	4	77	11	0	0	0	0	0	0	0	0	0
Austrolittorina cincta	25	78	3																							
Chaemosipho columna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	≈250	0	0	0	0	0	0	0	0	0
Zeacumantus sp.		11	3	1	18										6	8	8									
Ostrea sp.						5											22									
Cellana strigilis					16																					
Chiton glaucus						7											7									
Sypharochiton pelliserpentis				2		7									1		4									
Pomatoceros caeruleus	0	0	0	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrolisthes elongatus				3		3									2											
solitary ascidian						7																				
Turbo smaragdus						3											2				2					
Elminius modestus		5		≈100																						
Melagraphia aethiops						5																				
Hemigrapsus sexdentatus																1	1									
Scutus antipodes												1											1			
Terebellidae						1									1											
Risellopsis varia						1																				
Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Haustrum scobina																	1									
Halicarcinus varius						1																				
Cantharidella tesselata																									1	
Ophiuroidea						1																				

	S2T1P00	S2T1P01	S2T1P02	S2T1P03	S2T1P04	S2T1P05	S2T1P06	S2T1P07	S2T1P08	S2T1P09	S2T1P10	S2T1P11	S2T1P12	S2T1P13	S2T1P14	S2T1P15	S2T1P16	S2T1P17	S2T1P18	S2T1P19	S2T1P20	S2T1P21	S2T1P22	S2T1P23	S2T1P24	S2T1P25	S2T1P26	S2T1P27	S2T1P28	S2T1P29	S2T1P30	S2T2P00	S2T2P01	S2T2P02	S2T2P03	S2T2P04	S2T2P05	S2T2P06
Brow n branching																			0.01																		
Carpophyllum spp.																			0.1			0.02			0.05												
colonial ascidian																									0.05			0.01									
Cystophora spp.													0.05									0.1															
encrusting coralline	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0.21	0	0	0.1	0	0	0.2	0	0	0.02	0	0	0.05	0	0	0.05	0	0	0	0	0	0	0.01
Macrocystis pyrifera																			0.05						0.1			0.1			0.02						
Porifera										0.05			0.1			0.01			0.02												0.06						
red filamentous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.1	0	0	0.01	0	0	0	0	0	0.02	0	0	0	0	0	0
red laminar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.01	0	0	0.05	0	0	0	0	0	0
Ulva sp.																									0.2			0.02			0.01						
Elminius modestus				≈1000			≈200																								20			≈1000			≈1000
Diloma coracina	59			50			35																								42			50			24
Petrolisthes elongatus	2			39			9																								4			14			17
Cellana radians	0	0	0	5	0	0	9	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	11	0	0	12
Chaemosipho columna	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melagraphia aethiops										17			4			4																					
Zeacumantus sp.	2			2			2																								4			4			1
Chiton glaucus				9			2																											2			2
Sypharochiton pelliserpentis				7			6																								1						
Hemigrapsus sexdentatus	3			2																											3						
Pomatoceros caeruleus	0	0	0	3	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostrea sp.										6																											
Haustrum scobina																															1			3			
Pyura pachydermatina																						1															
Buccinulum linea										1																											
Paphies australis																																					1
Patiriella regularis																														1							
Aulacomya atra maoriana																																		1			
Scutus antipodes																						1															

	S3T1P00	S3T1P01	S3T1P02	S3T1P03	S3T1P04	S3T1P05	S3T2P00	S3T2P03	S3T2P06	S3T2P09	S3T2P12	S3T2P15	S3T2P18	S3T2P21	S3T2P24	S3T2P27	S3T2P30
Brown branching												0.05	0.1				
colonial ascidian												0.01		0.01	0.01	0.01	0.05
Corallina sp.															0.01		
Cystophora spp.											0.1						
encrusting coralline	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.01	0.01	0
Porifera														0.01			
red filamentous	0	0	0	0	0	0	0	0	0	0	0	0.1	0.15	0.1	0	0	0.01
red laminar	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.05	0.05	0.2
Stichtosiphonia arbuscula								0.25									
Ulva sp.											0.6	0.7	0.1	0.7	0.2	0.05	0.02
Undaria pinnatifida													0.1			0.05	
Diloma coracina	24			49			39	19									
Petrolisthes elongatus	36			5			23										
Cellana radians	25	0	0	1	0	0	6	11	0	0	0	0	0	0	0	0	0
Risellopsis varia								20									
Sypharochiton pelliserpentis	1						8	1									
Chaemosipho columna	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
Chiton glaucus				3			4				1						
Scutus antipodes													1	1	1	1	
solitary ascidian											1			2			
Cantharidella tesselata															2		
Haustrum scobina	1			1													
Zeacumantus sp.	1																
Hemigrapsus sexdentatus							1										
Turbo smaragdus											1						
Platyhelminthes				1													
Notomithrax sp.											1						
Nereididae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

	S4T1P00	S4T1P03	S4T1P06	S4T1P09	S4T1P12	S4T1P15	S4T1P18	S4T1P21	S4T1P24	S4T1P27	S4T1P30	S4T1P33	S4T1P36	S4T1P39	S4T1P42	S4T1P45	S4T1P48	S4T1P50	S4T2P00	S4T2P03	S4T2P06	S4T2P09	S4T2P12	S4T2P14	S4T2P17	S4T2P22	S4T2P25	S4T2P28	S4T2P31	S4T2P34	S4T2P37	S4T2P40	S4T2P43
Codium fragile								0.1																						0.02			0.01
colonial ascidian																														0.01			
Cystophora spp.																															0.3		
encrusting coralline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0
Hormosira banksii																								0.01						0.25	0.5		
Porifera																														0.01			
Stenogramme spp?											0.1	0.01																					
red filamentous	0	0	0	0	0	0	0	0	0.75	0.75	0.78	0.3	0.4	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.01	0.1
Stichtosiphonia arbuscula				0.08																0.05													
Ulva sp.						0.2	0.7	0.9	0.25	0.25	0.1	0.3	0.4	0.5		0.01	0.01	0.05								0.98	0.3	0.98	0.5			0.75	0.2
Undaria pinnatifida											0.02																						
White Turritellidae?I															4	3	10	50						210		120	300			160	1		
Zeacumantus sp.			131	55	60																28	16	40										
Cellana radians	0	0	0	0	63	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43	7	80	0	0	0	1	0	0	0	0	0	0
Pomatoceros caeruleus	0	0	0	4	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	120	0	0	0	0	0	0	0	0
Sypharochiton pelliserpentis			22	11	3																	4	9	6	4								
Austrovenus stuchburyi						2	3	1														6		1	3	34	2	2					
Diloma coracina			4		4	1															5		1	1						8			
Isopoda	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	13	0	0	0	0	0	0	0	0	0	0
Melagraphia aethiops																					9	5	4										
Cellana strigilis			3	13																													
Chiton glaucus			1		1	4																1	2	6									
Micrelenchus spp.								5		1	1		3																		1		
Actinia tenebrosa			7																		1												
Nereididae	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaemosipho columna	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Macrophthalmus hirtipes													1		3			1															
Cominella glandiformis																						3									1		
Hemigrapsus sexdentatus			1	2	1																												
Platyhelminthes				2																			1										
Ostrea sp.																									3								
Onchidella ?nigricans			3																														
Actinothoe sp.																															2		
Notacmea sp.							2																										
Maoricolpus rosea								1																							1		
Heterosquilla sp.																												1					
Acanthochiton zelandicus																								1									
Paphies australis																								1									
Pagurus sp.																									1								