Rocky Shore Monitoring of Scorching Bay, Makara and Baring Head, Wellington

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Diverse rock pool assemblage at Scorching Bay.

RECOMMENDED CITATION

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EXECUTIVE SUMMARY

This report describes a baseline assessment and characterisation of three rocky shore sites in January 2018: one site in Wellington Harbour (Scorching Bay) and two in the greater Wellington region (Makara and Baring Head). Only the Scorching Bay assessment involved a comprehensive survey approach, whereas the focus of the Makara and Baring Head surveys was a cursory characterisation of rocky shore biota. The locations ranged from relatively wave-sheltered at Scorching Bay, to increasingly wave exposed at Makara and Baring Head, respectively.

Despite gross physical differences in the type and extent of rocky substratum, all three locations surveyed in 2018 provided physically complex habitats that supported reasonably diverse intertidal assemblages. The results revealed a species-poor supra-tidal zone, a high shore dominated by barnacles and periwinkles, transitioning to increasingly diverse assemblages with progression toward the low tide mark, where macroalgae were conspicuous and diverse around the lower shore fringes. These are expected trends that reflect a progression from very harsh conditions in the highest parts of the shore (e.g. long periods of air exposure) that are tolerated by only a few specialised species, to relatively benign lower shore conditions that are suitable for a far greater diversity of organisms. Although a greatly reduced suite of species was recorded at Baring Head, this result was almost undoubtedly due to access to the lower parts of the shore being restricted by a wave surge on the day the survey was undertaken.

Overall, the range of species and higher taxa recorded was typical of "healthy" New Zealand rocky shores across the spectrum of wave exposures at the three sites, and similar to that described from previous surveys conducted at Flat Point on the Wairarapa coast. No species of special interest were identified in the present survey, although the invasive Asian kelp <u>Undaria</u> was recorded at Scorching Bay. This find was not unexpected, as <u>Undaria</u> has been established in Wellington Harbour for at least three decades.

The fixed quadrats installed at Scorching Bay provide a basis for repeated long-term monitoring. For reasons discussed in the report, it is suggested that full repeat surveys at that location be conducted at 5 yearly intervals in order to capture long-term trends. This same interval has previously been recommended for Flat Point. A hybrid option would be to photograph the quadrats annually and archive the images for later processing as necessary. Additional monitoring considerations are discussed in the report, including: the need for relatively undisturbed reference sites against which to compare results from monitoring higher use areas; ideas for revising the methodology to ensure it is fit for purpose; and the concept of developing a nationally consistent regional council State of the Environment (SOE) monitoring methodology for rocky shores.

1. INTRODUCTION

Developing an understanding of the state of coastal habitats is critical to the management of biological resources. The "Kapiti, Southwest, South Coasts and Wellington Harbour - Risk Assessment and Monitoring" report (Robertson and Stevens 2007) identified the nature and extent of risk from a range of stressors to coastal habitats in the Wellington region. Subsequent to that report, Greater Wellington Regional Council (GWRC) implemented a programme of coastal habitat mapping, baseline assessment and ongoing monitoring of representative estuaries, beaches and rocky shores. For rocky shores, Robertson and Stevens (2007) recommended baseline assessment and long-term monitoring of the abundance and diversity of plants and animals at regionally representative sites using a subset of the rapid assessment methods developed under the UK Marine Biodiversity and Climate Change Project (Hiscock 1996).

Rocky habitats are a dominant and visually dramatic element of parts of Wellington Harbour and the region's coastline. Intertidal rocky shores are physically complex, with rock pools, gullies, crevices and boulders providing a diverse range of habitats that can support a high diversity of species. The harsh and variable physical conditions, including degree of wave-exposure and large shifts in temperature, as well as aspect and substratum type – together with biotic interactions - lead to the development of a characteristic zonation of species in stable rocky habitats. These include supra-tidal (i.e. wave-splash) and high shore zones dominated by lichens, periwinkles, and barnacles, with a transition to lower shore zones that are typically characterised by an increasing diversity of species. The lowest shore is often visually dominated by seaweeds, in particular canopy-forming brown algae, which are a dominant biogenic habitat along temperate rocky shores worldwide (e.g. Tomanek and Helmuth 2002).

The relationship between stressors (both natural and human influenced) and changes to rocky shore assemblages is complex and can be highly variable. However, there are established links between the degradation of rocky shore habitat and the individual or combined effects of a range of different stressors (see Appendix 1). These include: habitat loss or modification (e.g. over-harvesting of living resources), fine-sediment inputs, eutrophication, the introduction of invasive species, and chemical contaminants. Monitoring of representative rocky shore sites enables the influence of these types of stressors to be characterised, and provides a benchmark for assessing the possible impacts from infrequent events such as oil spills or toxic algal blooms, should they occur. Moreover, long-term monitoring provides a basis for assessing gradual changes from processes that occur across broad spatial scales, such as sea temperature and sea level rise, changes in freshwater input and wave-climate (e.g. due to altered storm frequency or intensity), and ocean acidification.

The baseline assessment and monitoring programme put in place by GWRC is intended to provide a defensible, cost-effective way to help rapidly identify the condition of rocky shore habitats, and will provide a platform for prioritising ongoing monitoring needs. To date, a two year baseline assessment has been undertaken at Flat Point on the Wairarapa coast in 2016 and

Figure 1. Regional map of survey locations.

Figure 2. Location of sampling areas - Scorching Bay (left), Baring Head (top right) and Makara (bottom right).

2017 (Stevens and O'Neill-Stevens 2017). To provide a further characterisation of the condition of some of the region's rocky shores, Salt Ecology was contracted by GWRC to undertake baseline assessments of rocky habitats in Wellington Harbour (Scorching Bay), Makara (southern west coast) and Baring Head (Figures 1 and 2).

The Scorching Bay assessment involved the establishment of permanent sampling stations (quadrats) for the purpose of long-term monitoring. By contrast the focus of the Makara and Baring Head surveys was a cursory characterisation of the rocky habitats and associated biota. The selection of these sites for the 2018 surveys was based on GWRC or community interest in their general condition. The Scorching Bay site was intended to represent a "typical" harbour site, subject to a range of direct pressures associated with considerable use by the public (e.g. shellfish gathering, fossicking) as well as the influence of human activities in the wider harbour and catchment. The Makara site, with its greater wave-exposure than Scorching Bay, was chosen as a location also subject to high pressure from human activities. The Baring Head site was highly wave-exposed due to its southerly aspect, and was more remote from human activities, being ~2.5km from the nearest public road access.

2. METHODS

2.1 GENERAL APPROACH

The rocky shore surveys were undertaken by three scientists during relatively calm to moderate sea conditions in January 2018. Specific survey locations are indicated in Figure 2. Scorching Bay was surveyed on 24 January when the tidal range was 0.9m, and Baring Head was surveyed on 26 January when the range was 1.0m. Makara was also surveyed on 26 January when the range was 0.3m.

The tidal ranges represent mid range tide conditions at Scorching Bay and Baring Head, and neap range tide conditions at Makara (neap and spring tide ranges reported by LINZ for Wellington Harbour are 0.76m and 1.39m, respectively, and 0.2m and 1.0m for Makara.

GWRC's rocky shore monitoring programme involves measuring the abundance and diversity of conspicuous plants and animals. Monitoring targets both the supra-tidal zone (which is regularly splashed, but not submerged, by seawater) and the intertidal zone, which extends from the rarely inundated spring high water tide line, to the almost-always inundated neap low tide line. The assessment methodology is based on that used in the United Kingdom Marine Biodiversity and Climate Change (MarClim) Project (MNCR 1990, Hiscock 1996, 1998), and consisted of two parts:

- A semi-quantitative assessment to develop a checklist of the species present and assess their relative abundance across representative sampling areas from the supra-tidal to low shore.
- Recording the abundance and diversity of species in 0.25m^2 (0.5 x 0.5m) fixed quadrats positioned in the dominant rocky habitat type at the site, and stratified across the intertidal zone.

Note that the term "species" as used in this report can also refer to pooled taxonomic groups representing morphologically similar organisms that cannot reliably be separated into different species. Note also that the relatively narrow tidal range in the Wellington region meant that the designation of shore zones differed from the discrete high, mid and low shore zones described in the MarClim protocol and applied in the surveys at Flat Point. Instead, the semi-quantitative assessment was conducted in three shore zones (supra-tidal, high shore, and a combined mid-low shore zone), while fixed quadrats were placed in two zones only (high shore, mid-low shore).

2.2 SEMI-QUANTITATIVE ASSESSMENT

The semi-quantitative assessment involved walking over and photographing the wider sampling area, and recording the relative abundance of the conspicuous species present in the three sampling strata. For the 2018 survey, a time limit of 60 minutes was used to guide the sampling effort, with extensively shaded areas, rock pools or heavily fissured areas excluded from the assessment. Details were recorded on pre-prepared data sheets that included the range of species likely to be found at the site. In addition, a photographic guide was used to assist with field identifications, and samples were collected (where necessary) for later species identification.

The abundance of each species was categorised into one of six "SACFOR" ratings described in

Table 1, ranging from super-abundant (S) to rare (R). The SACFOR assessment procedure preferentially uses percentage cover to characterise two growth types of sessile (i.e. fixed in place) organisms: "Crust/Meadow" (e.g. lichen, barnacles, coralline paint), or "Massive/Turf" (e.g. bull kelp, coralline turf), with the SACFOR rating scaled differently for each of these two types of growth form. Where two or more layers exist, for instance foliose algae overgrowing crustose algae, total percentage cover can be over 100%. All other individual organisms (both sessile and mobile species) >5mm in size were counted, with the average individual organism size used to determine the relevant SACFOR size class rating for each species.

2.3 FIXED QUADRATS

The semi-quantitative assessment guided the positioning of fixed quadrats at Scorching Bay, in each of the two intertidal shore heights described above. Within the wider sampling area at Scorching Bay, three sites were identified on near-vertical bedrock faces, within which two quadrats were positioned at each of the two shore heights. Hence, in total there were six quadrats at each of the two shore heights. Quadrats were chosen so as to have similar physical characteristics, and positioned in locations that were relatively sheltered from the direct effect of prevailing wind and waves so that sampling could be undertaken safely. In addition to the Scorching Bay fixed quadrats, counts were made from single quadrats at each of the two shore heights at Makara.

Quadrats were deliberately placed in areas with attached plants or animals, as the change in these features was the primary focus of the monitoring. Mid-low shore quadrats were positioned with the lower quadrat edge at the low neap tide line, and each was paired with a high shore quadrat that extended across the top of the barnacle zone into the bare rock above. The rationale for positioning high shore quadrats in this way was that one of the possible long-term changes on the shore will be a change in the distribution of this barnacle zone.

At Scorching Bay, the upper true left-hand corner of each quadrat was marked by drilling and fixing a stainless steel bolt in the rock, thereby enabling repeat sampling as part of future monitoring. Fixed markers were not installed at Makara. The GPS position of each station was recorded, and each quadrat was photographed. The following information was then recorded:

- Percent cover of all sessile biota, including barnacles, mussels, and algae
- Numbers of each limpet or chiton (individuals >10mm), or other topshell or mobile organism (individuals >5mm).
- Where periwinkles were present, numbers were counted from representative 10cm x 10cm sections within each quadrat.

SACFOR ratings were derived from the quadrat data for each species according to the methodology described above and in Table 1 based on mean cover or abundance values.

Table 1. Summary of SACFOR rating tables.

S = Super Abundant	A = Abundant	C = Common	F = Frequent	O = Occasional	R = Rare

% cover	Growth form Crust/meadow	Massive/Turf	Size of individuals/colonies <1cm	1-3cm	3-15cm	>15cm	Density	
>80%	S	-	S	-	-	-	>1/0.001 m2 (1x1cm)	>10,000 / m^2
40-79%	A	S	A	S	-	-	1-9/0.001 m^2	1000-9999 / m^2
20-39%	C	A	C	A	S	-	1-9 / 0.01 m2 (10 x 10cm)	100-999 / m^2
10-19%	F	C	F	C	A	S	1-9 / 0.1 m^2	10-99 / m^2
5-9%	O	F	O	F	C	A	1-9 / m^2	
1-5% or density	R	O	R	O	F	C	1-9 / 10m^2 (3.16 x 3.16m)	
<1% or density	-	R	-	R	O	F	1-9 / 100 m^2 (10 x 10m)	
					R	O	1-9 / 1000 m^2 (31.6 x 31.6m)	
						R	<1/1000 m^2	

2.4 PRESENTATION AND ANALYSIS OF RESULTS

Species richness, dominance (i.e. abundance or % cover), and SACFOR ratings are presented graphically and/or in Tables for each of the semi-quantitative and/or quadrat sampling data sets. Where helpful for illustrating main patterns, data are presented for species aggregated into broader groups or organism types. For species richness calculations, four aggregation groups were used: lichens, macroalgae, sessile invertebrates and mobile invertebrates.

With the software Primer v7 (Clarke & Gorley 2015), non-metric multidimensional scaling (nMDS) and cluster analysis methods were used to explore similarities among shore heights and sites in terms of the relative dominance of the species. For this purpose, SACFOR ratings from the semi-quantitative survey were converted into ranked dominance scores, simply by assigning values from 1 to 6 to reflect SACFOR ratings ranging from rare to super abundant, respectively. Using these relative dominance scores, the nMDS ordination was constructed from a matrix of Bray-Curtis similarity values, calculated for pairwise combinations of each shore height. A cluster analysis overlay was projected onto the ordination biplot to show how shore heights and sites were grouped according to similarities in their taxonomic composition. The Similarity Percentages (SIMPER) procedure was then used to identify the species that contributed to the clusters or discriminated them from each other.

Using the same ranked SACFOR data, and to illustrate relative patterns of dominance among shore heights and sites, kite diagrams were constructed using the kitechart function in the plotrix library of the software R. For this purpose, species composition data were aggregated to thirteen higher taxa (Appendix 3), facilitating a high-level comparison of shore height and location differences.

3. RESULTS AND DISCUSSION

3.1 GENERAL SITE FEATURES

The gross physical characteristics of the rocky shores differed among the three locations, with the most extensive and continuous rocky habitat being at Makara. At that location, a relatively flat rock platform ~30m wide was bisected by tidal channels and pools, which were partially infilled in places by gravel and cobbles.

Makara intertidal rocky reef.

The rocky habitat at Scorching Bay was less extensive and less continuous than Makara, and consisted of high outcrops of rock separated by channels and pools, which together made traversing the area relatively difficult.

Scorching Bay showing typical broken intertidal rock outcrops amongst shallow subtidal rock and sand.

The Baring Head site was different again in that the rocky habitat consisted of high outcrops of discontinuous rock, with fewer channels and quiescent pools than was common at the other two sites. The rock outcrops at the Baring Head site were interspersed and surrounded by a relatively steep beach of coarse sands, and patches of gravel and small cobbles.

The habitat sampled at Baring Head consisted of large outcrops of rock amongst the coarse sand, gravel and cobbles of the beach.

3.2 OVERALL SACFOR ASSESSMENT

3.2.1 Species richness patterns and dominant taxa across shore zones and sites

Despite their gross physical differences, the rocky substrata at all sites provided physically complex habitats that supported reasonably diverse intertidal assemblages. The broad-scale semi-quantitative assessment recorded a total of 40 species at each of the Scorching Bay and Makara sites, with 25 species recorded from Baring Head (Table 2). The lower apparent total richness at Baring Head is likely to under-represent the true situation, as the low shore at this location was difficult to access due to a 1-2m wave surge on the day of sampling. As expected, species richness increased markedly down the shore, with very few organisms in the supra-tidal splash zone, and most in the mid-low shore zone (Figure 3). Concomitant with the increased richness, bare space on the rock decreased across the shore profile (Table 2), with most of the space in the low shore fringe occupied by a relatively high diversity of species.

Taxa in the supra-tidal consisted of one or two lichen species, and one or two periwinkle species (see photos this page); however, none of these were notably abundant. A SACFOR rating of common (C) was given to the yellow/orange lichen (Xanthoria ?parietina) at Baring Head, and the blue banded periwinkle (Austrolittorina antipodum) at Scorching Bay. Supra-tidal taxa were otherwise relatively sparse, being rated as few (F) or occasional (O) (see Table 3), while bare rock was rated as abundant (A) or super abundant (S).

In the high shore zone, a range of mobile and sessile invertebrates dominated the biota (Figure 3), characterised by mobile grazing periwinkles and sessile filter-feeding barnacles.

Scorching Bay impoverished very high shore and supra-tidal, with blue banded periwinkles, Austrolittorina antipodum.

Baring Head supra-tidal with conspicuous yellow/orange lichen, Xanthoria ?parietina.

Makara supra-tidal white pore lichen, Pertusaria sp., and Yellow/orange lichen, Xanthoria ?parietina.

Table 2. Results of the SACFOR assessment at the three rocky shore sites, for the three shore zones; S = supra-tidal, H = high, M-L = mid-low. Common names for the species and higher taxa are given in Appendix 3.

Main group	Species	Unit	Class	Scorching Bay			Makara			Baring Head		
				S	H	M-L	S	H	M-L	S	H	M-L
Anemones	*Actinia tenebrosa*	#	ii	-	R	F	-	-	F	-	-	O
	Anthothoe albocincta	#	ii	-	-	R	-	-	-	-	-	-
	Isactinia olivacea	#	ii	-	-	R	-	-	R	-	-	-
	Oulactis muscosa	#	ii	-	-	R	-	-	R	-	-	-
Barnacles	*Calantica spinosa*	#	ii	-	-	-	-	-	-	-	-	R
	Chamaesipho brunnea	%	i	-	-	-	-	O	S	-	F	R
	Chamaesipho columna	%	i	-	S	S	-	-	F	-	O	F
	Epopella plicata	%	i	-	-	-	-	-	O	-	R	-
Bivalves	*Aulacomya maoriana*	%	ii	-	-	R	-	-	-	-	-	R
	Mytilus galloprovincialis	%	i	-	F	C	-	-	R	-	O	-
	Perna canaliculus	%	iii	-	R	O	-	-	-	-	-	-
Brown algae	*Carpophyllum flexuosum*	%	ii	-	-	-	-	-	R	-	-	-
	Carpophyllum maschalocarpum	%	ii	-	-	C	-	-	S	-	-	R
	Colpomenia sinuosa	%	ii	-	-	R	-	-	O	-	-	-
	Cystophora retroflexa	%	ii	-	-	R	-	-	R	-	-	-
	Cystophora scalaris	%	ii	-	-	-	-	-	R	-	-	-
	Dictyota kunthii	%	ii	-	-	-	-	-	A	-	-	-
	Durvillaea antarctica	%	ii	-	-	-	-	-	-	-	-	S
	Hormosira banksii	%	ii	-	-	-	-	-	C	-	-	-
	Lessonia variegata	%	ii	-	-	-	-	-	-	-	-	R
	Petalonia binghamiae	%	ii	-	-	-	-	-	R	-	-	-
	Ralfsia spp.	%	i	-	-	R	-	R	F	-	-	R
	Scytothamnus spp.	%	ii	-	-	-	-	-	O	-	-	-
	Splachnidium rugosum	%	ii	-	-	O	-	-	F	-	-	-
	Undaria pinnatifida	%	ii	-	-	R	-	-	-	-	-	-
	Zonaria aureomarginata	%	ii	-	-	-	-	-	F	-	-	-
Chitons	*Sypharochiton pelliserpentis*	#	ii	-	C	-	-	R	F	-	R	R
Green algae	*Chaetomorpha coliformis*	%	ii	-	-	R	-	-	-	-	-	-
	Codium convolutum	%	i	-	-	A	-	-	C	-	-	-
	Ulva lactuca	%	i	-	-	R	-	-	-	-	-	-
	Ulva spp.	%	i	-	-	-	-	-	O	-	-	-
Lichens	*Pertusaria* sp.	%	i	O	-	-	O	-	-	-	-	-
	Xanthoria ?parietina	%	i	O	-	-	O	-	-	C	-	-
Limpets	*Cellana denticulata*	#	ii	-	-	R	-	F	R	-	R	C
	Cellana ornata	#	ii	-	C	-	-	R	C	-	O	-
	Cellana radians	#	ii	-	R	-	-	O	O	-	-	-
	Notoacmea pileopsis	#	i	-	-	-	-	-	-	-	R	-
	Onchidella nigracans	#	i	-	-	R	-	-	-	-	-	-
	Patelloida corticata	#	ii	-	-	R	-	-	-	-	-	-
Red algae	*Chondria* spp.	%	ii	-	-	-	-	-	-	-	-	F
	Corallina paint	%	i	-	-	C	-	-	A	-	-	A
	Corallina turf	%	ii	-	-	C	-	-	C	-	-	R
	Gelidium spp.	%	ii	-	-	R	-	R	O	-	-	-
	Gigartina spp.	%	ii	-	-	-	-	-	-	-	-	O
	Laurencia thyrsifera	%	ii	-	-	-	-	-	F	-	-	-
	Pyropia sp.	%	ii	-	R	-	-	R	-	-	O	-
	Sarcothalia livida	%	ii	-	-	-	-	-	-	-	-	R
Sea squirts	*Cnemidocarpa bicornuta*	#	ii	-	-	R	-	-	-	-	-	-
Sea star	*Patiriella regularis*	#	ii	-	-	C	-	-	-	-	-	-
Topshells	*Austrolittorina antipodum*	#	i	C	C	-	F	A	-	-	C	-
	Austrolittorina cincta	#	i	O	F	-	-	R	-	-	O	-
	Buccinulum linea	#	ii	-	-	R	-	-	-	-	-	-
	Diloma aethiops	#	ii	-	-	O	-	O	F	-	-	-
	Diloma aridum	#	ii	-	-	-	-	R	R	-	-	-
	Diloma nigerrima	#	ii	-	-	-	-	-	-	-	R	-
	Haustrum haustorium	#	ii	-	-	R	-	-	R	-	-	-
	Haustrum lacunosum	#	ii	-	-	-	-	-	R	-	-	-
	Haustrum scobina	#	ii	-	O	C	-	-	O	-	-	-
	Risellopsis varia	#	i	-	R	-	-	R	-	-	-	-
	Turbo smaragdus	#	ii	-	-	C	-	-	-	-	-	-
Tube worms	*Spirobranchus cariniferus*	%	i	-	R	C	-	-	-	-	-	-
Other	Bare rock	%	i	S	O	R	S	A	R	A	A	R

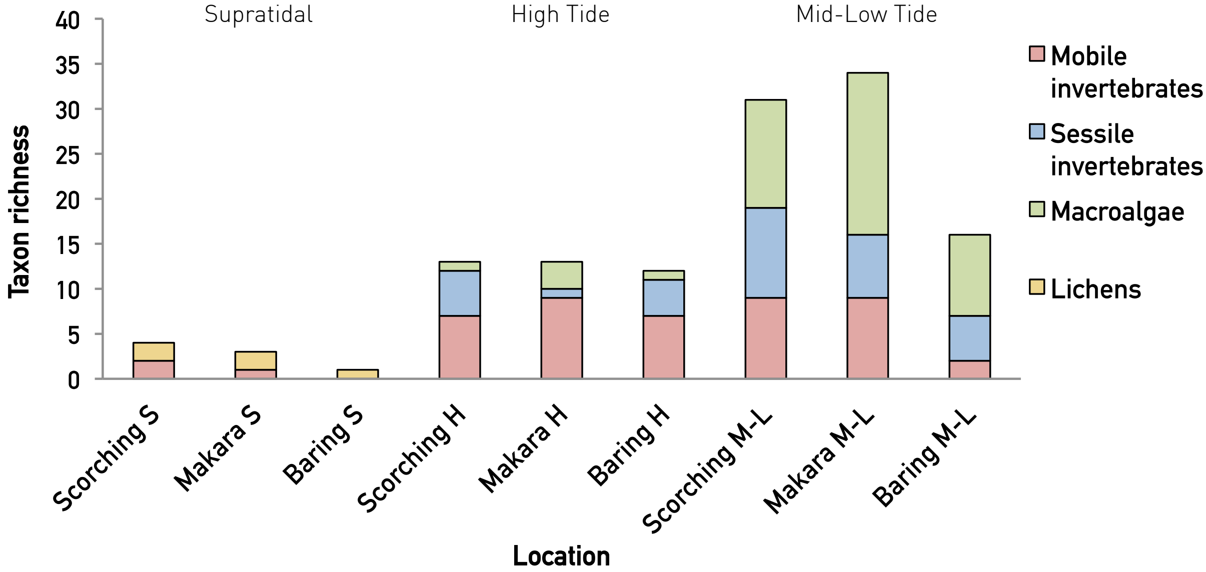

Figure 3. Taxon richness for each shore height and site within broad functional groups, derived from the broad-scale SACFOR assessment.

Species rated as super abundant or abundant were column barnacles (Chamaesipho columna; Super abundant) at Scorching Bay and blue banded periwinkles (Abundant) at Makara.

High density sheets of column barnacles (Chamaesipho columna) were rated as super abundant in the high shore zone at Scorching Bay.

These small topshells, while highly tolerant of air exposure, tend to aggregate in cracks and fissures in the rock that provide protection from the elements during the day.

Less dominant but notable taxa included highly mobile grazing limpets (three Cellana species), snakeskin chitons (Sypharochiton pelliserpentis; rated common at Scorching Bay), topshells (e.g. Diloma aethiops at Makara), and scattered bivalves, most notably small blue mussels (Mytilus galloprovincialis).

Blue banded periwinkles in crevices at Scorching Bay .

Macroalgae were present but not particularly conspicuous in the high shore zone. The very few species present were rated as rare (R), with the single exception being at Baring Head where a rosette-shaped edible red seaweed, referred to here as Pyropia sp. (often referred to as Porphyra or Karengo), was rated as occasional.

The rosette-shaped red alga commonly referred to as "Pophyra" (here appearing golden brown) was quite common in places across the high shore at Baring Head.

The mid-low shore zone was by far the most species-rich, within macroalgae being visually dominant, and comprising between 39% (Scorching Bay) and 56% (Baring Head) of the taxa present (Figure 3).

The low shore fringe at Makara was characterised by Coralline "paint" and turf, and a relatively high richness of other seaweeds.

The greatest total richness in the low shore was recorded at Makara (34 taxa), with richness at Baring Head being less than half that, probably reflecting the sampling limitations described. The only invasive species recorded was the Asian kelp, Undaria pinnatifida, which was present at Scorching Bay in the low tide fringe (rated as rare). Many of the main groups listed in Table 2 were represented in the mid-low shore zone, the obvious exceptions being the absence of truly high shore or supra-tidal species (i.e. lichens and periwinkles). Also, green algae and topshells were not recorded from the Baring Head mid-low shore; the absence of the latter perhaps reflecting that species in this group would be vulnerable to dislodgement by sediment scour or bull kelp in the wave-exposed conditions.

By contrast, the richness and abundance of topshells was greatest in the more sheltered mid-low shore waters of Scorching Bay and Makara (Table 2), with Scorching Bay being the only location where the common cats eye, Turbo smaragdus, was recorded (C). Similarly, Scorching Bay was the only location where patches of blue mussels were common on lower parts of the shore in the more wave-exposed areas.

Bull kelp, Durvillaea antarctica, characterised the mid-low shore rocks at Baring Head.

Conspicuous at all three sites in the mid-low shore zone was coralline "paint" (rated A or C), with the brown seaweed Carpophyllum maschalocarpum being visually dominant in the low tide fringe at Scorching Bay (C) and Makara (S).

Scorching Bay typical low shore in the more wave-exposed areas, with a patch of blue mussels, Mytilus galloprovincialis, fringed by the abundant brown seaweed, Carpophyllum maschalocarpum.

The brown seaweed Carpophyllum maschalocarpum dominated the low shore fringe at Scorching Bay and Makara.

Brown surf barnacles, Chamaesipho brunnea, were abundant at Makara around mid-shore, above a band of crustose coralline algae (a.k.a. coralline "paint").

The strap-like brown seaweed Dictyota kunthii also rated as abundant at the latter site, and Neptune's necklace (Hormosira banksii) was common. By contrast, the dominant brown seaweed at Baring Head was bull kelp, Durvillaea antarctica. The dominance of bull kelp at that site, together with the occurrence of species such as the gooseneck barnacle Calantica spinosa (Table 2), are clear biological indicators of the high wave-exposure of that location.

Among the mid-low shore invertebrates, column barnacles were rated as super abundant at Scorching Bay, along with the green velvet seaweed Codium convolutum.

Scorching Bay mid-low shore showing column barnacles, chitons, limpets and topshells, along with the abundant green velvet seaweed Codium convolutum and calcareous tube worm Spirobranchus cariniferus.

Barnacles were similarly super abundant at Makara, but the brown surf barnacle Chamaesipho brunnea was the dominant species at that site. The range of other less prevalent mid-low shore species tended to be quite variable among sites (Table 3).

The brown surf barnacle Chamaesipho brunnea formed a conspicuous band in the mid-low shore at Makara.

3.2.2 Species-assemblage patterns and main taxonomic groups across shore zones and sites

The nMDS ordination biplot (Figure 4) and kite diagrams (Figure 5) help to tease out the similarities or differences among shore zones and sites in terms of the contribution of the less dominant species and taxonomic groups.

The nMDS method clusters sampling stations according to similarities in their species composition and abundance; in this instance the low "stress" value of the ordination (i.e. stress = 0.02) can be interpreted to mean that shore heights positioned nearest to each other (in a 2-dimensional biplot) are the most similar in terms of their composition. In this context, the pattern in Figure 4 reveals a clustering of all supra-tidal stations, reflecting their biotic similarity. This reasonably tight clustering is to a lesser extent also evident in the high shore; however, none of the low shore stations clustered together, indicating more pronounced differences in species composition among sites with progression towards low tide.

One interpretation of the ordination pattern is that increasing air exposure during long periods of tidal emersion creates harsh physical conditions, which override the influence of the other broad-scale physical differences among the sites. There are very few species that are adapted to life on the highest parts of shore, and these tend to be commonly occurring around New Zealand. By contrast, in the mid-low shore, the duration of air exposure is less physically limiting, meaning it is inhabited by a more diverse suite of species (as described above). As such, biotic interactions (e.g. predation, grazing, competition for space) become more significant towards the lower parts of the shore, which interact with the variable physical environment to create compositional differences in the species assemblage.

Despite the differences that emerge from the species-level analysis in Figure 4, the main taxonomic groups were shared across most sites (Figure 5). The only exceptions were an apparent absence of green algae at Baring Head, as noted above, and the occurrence of sea squirts (Cnemidocarpa bicornuta), cushion stars (Patiriella regularis) and calcareous tube worms (Spirobranchus cariniferus) at Scorching Bay alone. Other than these minor presence/absence differences in the main taxonomic groups, the contrasts in the main taxa among sites that are evident from Figure 5 relate more to changes in dominance across shore zones, rather than any major differences in the groups represented.

Various limpets amongst coralline paint and turf on the high shore at Makara.

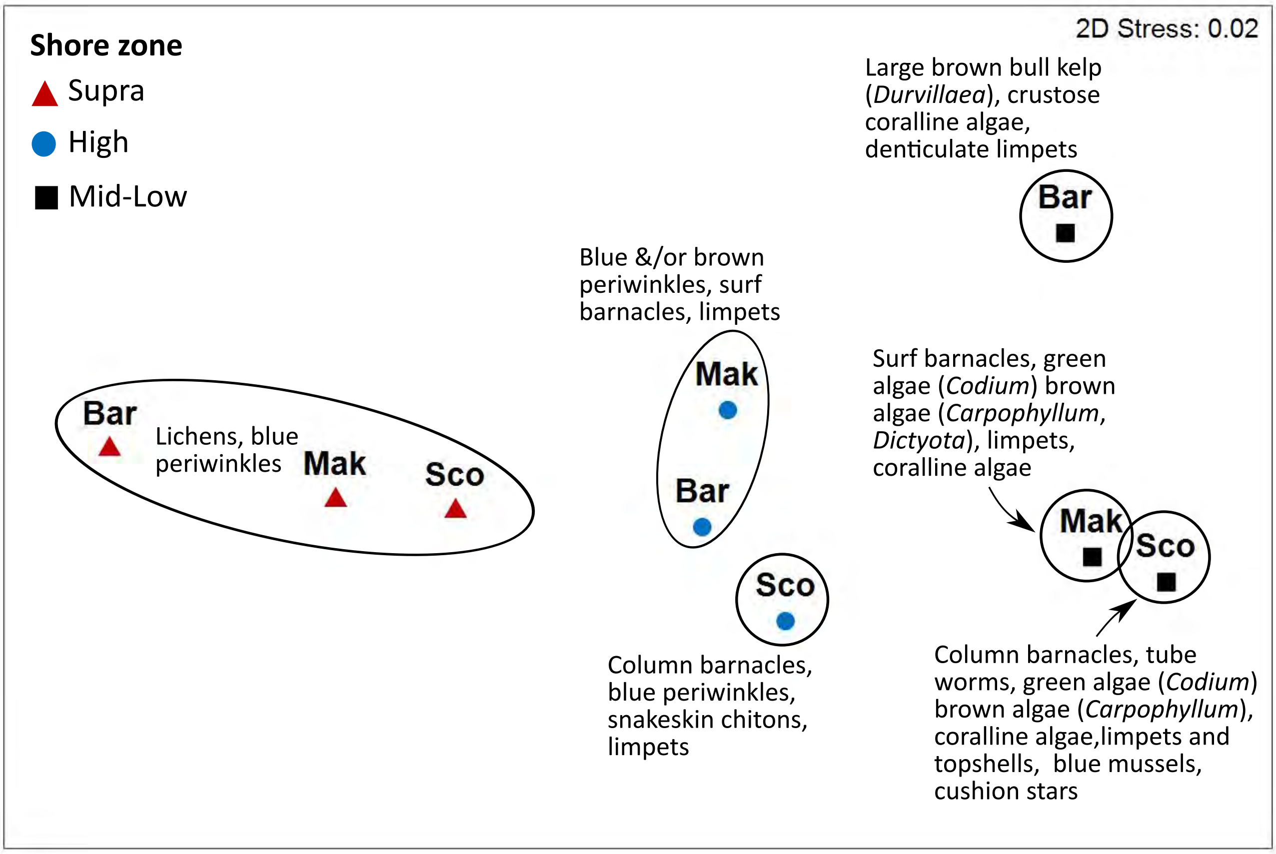

Figure 4. Biplot (nMDS) depicting the grouping of intertidal shore zones among rocky shore sites according to their taxon composition and ranked abundances derived from SACFOR ratings; Sco = Scorching Bay; Mak = Makara; Bar = Baring Head. Circled groups cluster at >60% Bray-Curtis similarity. The main species or higher taxa characterising each cluster are shown. Scientific names listed in Appendix 3.

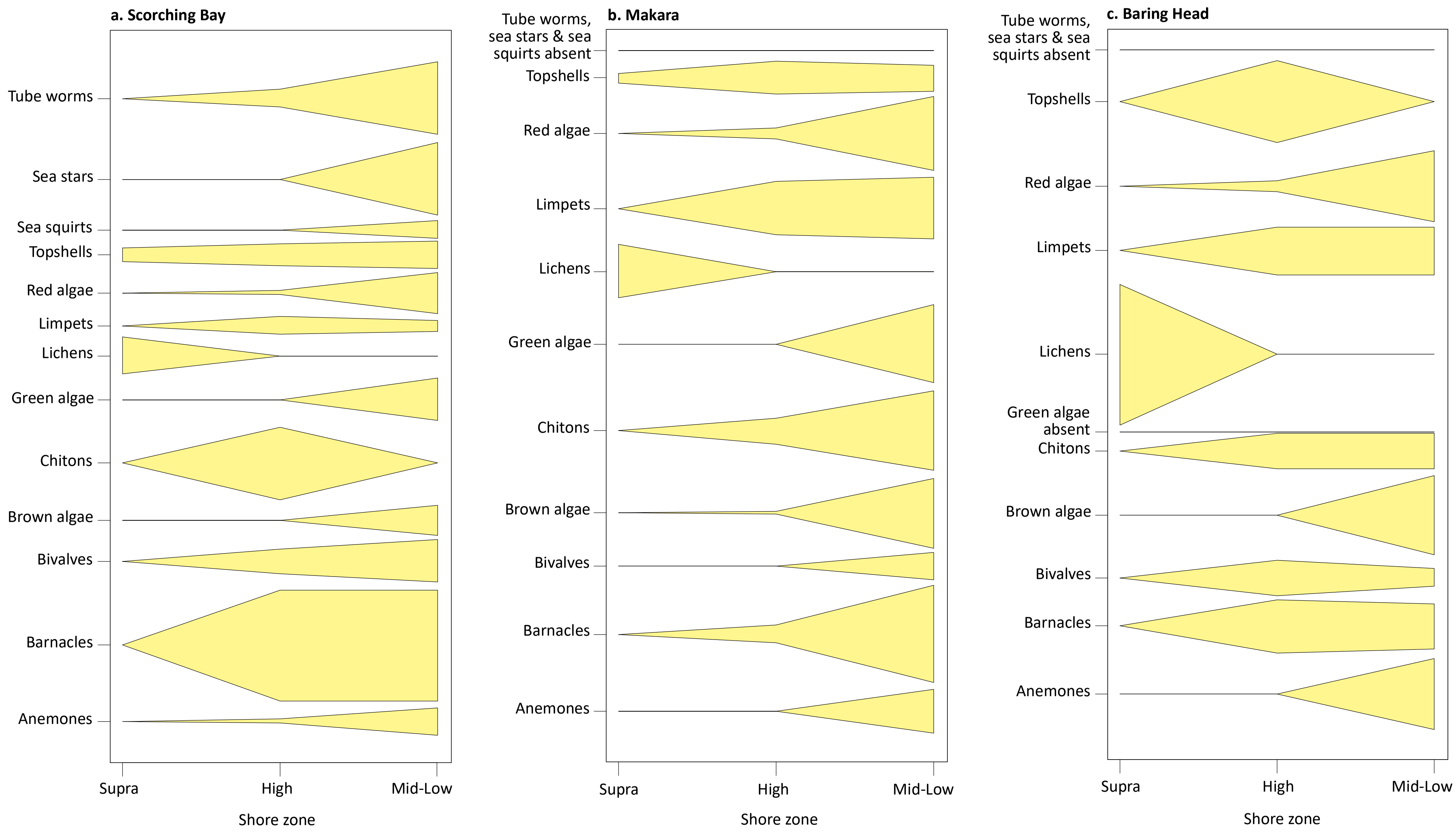

Figure 5. Kite diagrams showing the relative abundance (ranked from 6 to 1 corresponding to SACFOR ratings) and distribution of the main taxonomic groups across shore zones at the three rocky shore sites.

3.3 Fixed Quadrats

Results from the quadrat sampling are summarised in Tables 3 and 4, for Scorching Bay and Makara, respectively, with photos in Appendix 2. The quadrat results show a decrease in bare rock from high to mid-low shore (most pronounced at Scorching Bay) consistent with a simultaneous increase in species richness. However, the data illustrate that the quadrats contained more bare rock, and only a small subset of the taxa, compared with that recorded in the SACFOR assessment. This difference reflects the comparatively small sampling area of a quadrat, meaning that chance sampling plays a role in whether a species is detected, which in turn depends on its distributional pattern (e.g. whether patchy) and abundance (e.g. rarity) on the shore.

The preceding point is emphasised in a comparison of the species counts in Table 3 with the species richness summary in Figure 6. Although the graph shows a similar high to mid-low shore increase in species richness as evident for the SACFOR assessment, it also suggests that mid-low shore richness at Scorching Bay (based on mean values across six quadrats) was surprisingly low. By contrast, when all six mid-shore quadrats at Scorching Bay are considered collectively, a total of 18 species was recorded (Table 3b), which was the highest of all sites and twice that recorded in the six high shore quadrats (Table 3a). The discrepancy in mean vs total species count in the mid-low shore reflects that the suite of minor species differed from quadrat to quadrat, while only the dominant species (like barnacles) were reliably sampled.

Relating to the above, it is worth noting that some of the dominant species described in the SACFOR assessment (especially the macroalgae) were not present in the quadrats. In part this reflects the sampling variation described above, but it also reflects a methodological difference. To reliably sample and count within quadrats, the mid-low shore quadrat needs to be positioned on exposed rock that isn't unduly affected by wave swash. The time taken to sample each quadrat (as well as install fixed markers for the

Table 3. Prevalence (abundance #, or % cover) and SACFOR rating of species and higher taxa recorded in each of six quadrats and three shore zones at Scorching Bay in 2018. SACFOR ratings based on mean values.

SCORCHING BAY

Group	Scientific name	Common Name	Unit	Class	QUADRAT Q1	Q2	Q3	Q4	Q5	Q6	TOTAL Mean	SE	SACFOR
a. High shore													
Barnacles	*Chamaesipho columna*	Column barnacles	%	i	35	5	50	70	30	30	36.7	8.9	C
Chitons	*Sypharochiton pelliserpentis*	Snakeskin chiton	#	ii	-	-	-	-	-	6	1.0	1.0	F
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	-	-	-	1	-	-	0.2	0.2	O
Limpets	*Cellana denticulata*	Denticulate limpet	#	ii	5	2	3	3	-	2	2.5	0.7	C
Red Algae	*Pyropia* sp.	*Porphyra*, Karengo, Nori	%	ii	1	-	1	1	1	-	0.7	0.2	R
Topshells	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	100	60	100	30	50	80	70.0	11.5	C
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	2	7	34	15	15	7	13.3	4.6	F
Topshells	*Risellopsis varia*	Periwinkle	#	i	-	1	-	-	-	-	0.2	0.2	R
Topshells	*Haustrum scobina*	Oyster borer	#	i	-	-	-	-	1	-	0.2	0.2	R
Other	na	Bare Rock	%	i	60	95	50	30	70	70	62.5	8.9	A
b. Mid-low shore													
Anemones	*Isactinia olivacea*	Olive anemone	#	ii	3	-	-	-	-	-	0.5	0.5	O
Barnacles	*Chamaesipho columna*	Column barnacles	%	i	90	50	95	85	85	90	82.5	6.7	S
Bivalves	*Mytilus galloprovincialis*	Blue mussel	%	i	-	-	-	-	2	-	0.3	0.3	R
Brown Algae	*Ralfsia* spp.	Tar spot/Brown crust	%	i	-	1	-	5	-	-	1.0	0.8	R
Chitons	*Sypharochiton pelliserpentis*	Snakeskin chiton	#	ii	-	2	4	9	11	11	6.2	2.0	C
Green Algae	*Codium convolutum*	Encrusting velvet	%	i	-	-	-	-	1	-	0.2	0.2	R
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	-	2	2	1	-	-	0.8	0.4	O
Limpets	*Onchidella nigracans*	Leathery sea slug	#	i	-	-	-	-	1	-	0.2	0.2	R
Limpets	*Cellana denticulata*	Denticulate limpet	#	ii	16	31	3	1	-	-	8.5	5.1	C
Polychaeta	*Spirobranchus cariniferus*	Blue tubeworm	%	i	1	1	-	5	5	5	2.8	1.0	R
Red Algae	*Corallina* spp.	Pink paint	%	i	-	-	-	-	-	1	0.2	0.2	R
Red Algae	*Gelidium* spp.		%	ii	-	1	-	-	-	-	0.2	0.2	R
Topshells	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	60	-	-	-	-	-	10.0	10.0	F
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	7	-	-	-	-	-	1.2	1.2	O
Topshells	*Turbo smaragdus*	Cats eye	#	ii	-	-	-	-	-	2	0.3	0.3	O
Topshells	*Haustrum scobina*	Oyster borer	#	ii	2	2	38	-	-	-	7.0	6.2	C
Topshells	*Diloma aethiops*	Grooved topshell	#	ii	-	-	-	1	-	-	0.2	0.2	O
Sea Squirt	*Cnemidocarpa bicornuta*	Saddle sea squirt	#	ii	-	-	-	-	2	-	0.3	0.3	O
Other	na	Bare Rock	%	i	5	50	3	5	15	5	13.8	7.4	F

first time), and safety considerations when sampling, means that it is not possible to place all of them at the actual low tide mark; this mark will differ over sequential days anyway, according to changes in low tide extent due to the lunar cycle, wind/waves, and barometric pressure. As such, many of the low tide fringing species, in particular the larger abundant macroalgae like Carpophyllum maschalocarpum are not picked up, or may be recorded in one quadrat/site but not another. This methodological issue likely explains the relatively low contribution of macroalgae to mid-low shore richness from the quadrat sampling (Figure 6) compared with the SACFOR assessment (see Figure 3).

Considering the above factors, a further discussion of quadrat differences within and among sites is not justified or helpful at this stage. The primary purpose of the quadrat sampling was to establish a baseline of fixed quadrat positions for long-term monitoring at Scorching Bay. The efficacy of fixed quadrats for this purpose, as well as broader monitoring considerations, are discussed in Section 5.

Table 4. Prevalence (abundance #, or % cover) and SACFOR rating of species and higher taxa recorded in quadrats at Makara in 2018. A single quadrat was sampled at each of two shore heights.

MAKARA

Group	Scientific name	Common Name	Unit	Class	Quadrat	SACFOR
a. High shore						
Barnacles	*Chamaesipho brunnea*	Brown surf barnacle	%	i	20	C
Bivalves	*Mytilus galloprovincialis*	Blue mussel	%	ii	1	R
Red Algae	*Pyropia* sp.	*Porphyra*, Karengo, Nori	%	ii	1	R
Topshells	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	175	C
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	1	O
Other	na	Bare Rock	%	i	80	S
b. Mid-low shore						
Anemones	*Actinia tenebrosa*	Red waratah	#	ii	1	F
Barnacles	*Chamaesipho columna*	Column barnacles	%	i	15	F
Barnacles	*Chamaesipho brunnea*	Brown surf barnacle	%	i	5	O
Brown Algae	*Ralfsia* spp.	Tar spot/Brown crust	%	ii	10	F
Green Algae	*Codium convolutum*	Encrusting velvet	%	i	1	R
Limpets	*Cellana ornata*	Ornate limpet	#	ii	8	C
Limpets	*Cellana denticulata*	Denticulate limpet	#	ii	1	F
Red Algae	*Corallina* spp.	Pink paint	%	i	1	R
Topshells	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	100	C
Topshells	*Risellopsis varia*	Periwinkle	#	i	1	O
Topshells	*Diloma aethiops*	Grooved topshell	#	ii	2	F
Other	na	Bare Rock	%	i	70	A

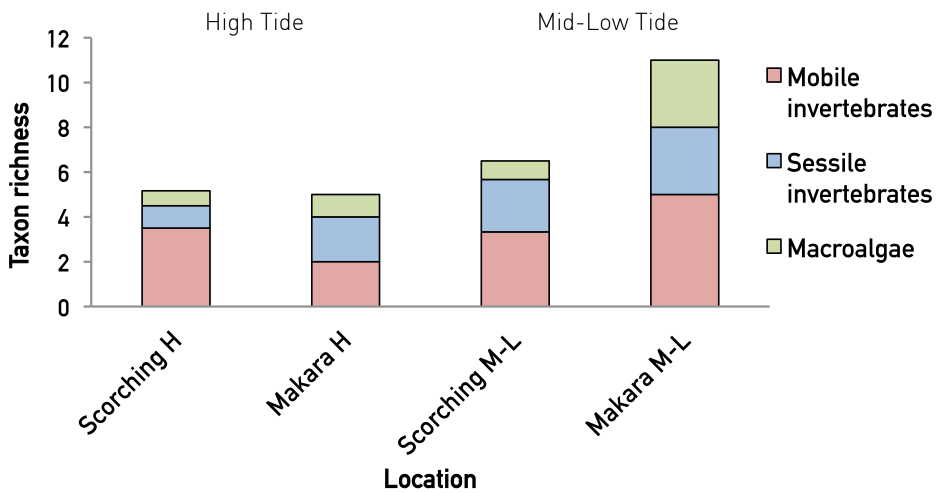

Figure 6. Taxon richness for each shore height and site within broad functional groups, derived from quadrat sampling. Values at Scorching Bay are means from six quadrats, while Makara values are for single quadrats.

4. SYNTHESIS OF RESULTS

The present survey has provided an overview of baseline conditions at three rocky shore sites in the Wellington region, building on the results of previous work conducted at Flat Point in 2016 and 2017. Despite gross physical differences in the type and extent of rocky substratum, all three locations surveyed in 2018 provided physically complex habitats that supported reasonably diverse intertidal assemblages. The results revealed a species-poor supra-tidal zone, a high shore dominated by barnacles and periwinkles, transitioning to increasingly diverse assemblages with progression toward the low tide mark, where macroalgae were conspicuous and diverse around the lower shore fringes. These are expected trends that reflect a progression from very harsh conditions in the highest parts of the shore (e.g. long periods of air exposure) that are tolerated by only a few specialised species, to relatively benign lower shore conditions that are suitable for a far greater diversity of organisms (Schiel 2011). Although a greatly reduced suite of species was recorded at Baring Head, this result almost undoubtedly reflects that access to the lower parts of the shore was restricted by a wave surge on the day the survey was undertaken.

Overall, the range of species and higher taxa recorded is typical of "healthy" New Zealand rocky shores across the spectrum of wave exposures at the three sites (Morton and Miller 1973, Nelson 2013, Carson and Morris 2017). The species list in Table 3 is similar to that described from previous surveys in the GWRC region at Flat Point, which used the same SACFOR approach (Stevens & O'Neill-Stevens 2017). No species of special interest were identified in the present survey, although the invasive Asian kelp Undaria was recorded at Scorching Bay. This species was first noted in Wellington Harbour in 1987, having almost certainly been introduced by shipping (Hay & Luckens 1987). Undaria has a very short-range natural dispersal capacity (Forrest et al. 2000), hence its apparent absence from the Makara site may reflect that it has not been spread there by human activities. It is doubtful that Undaria would establish at the Baring Head site given the harsh physical conditions there.

5. CONSIDERATIONS FOR MONITORING

5.1 UTILITY AND MONITORING OF EXISTING SITES

The fixed quadrats installed at Scorching Bay provide a basis for repeated long-term monitoring. A common approach with baseline monitoring is to undertake several surveys initially (e.g. annually, seasonally) to characterise a baseline of natural temporal variability. In the present situation, such an approach would arguably be of limited benefit. A key reason is that the fixed quadrats are positioned at the neap tide zone and above. This positioning enables tracking of changes in vertical zonation patterns of sessile taxa like barnacles; in particular, in response to long-term change (e.g. in response to global warming). However, except perhaps due to major disturbance events (e.g. an oil spill, introduction of an invasive species), significant year-to-year changes are unlikely. This scenario was evident in the results of the Flat Point surveys, which revealed little change over two summer surveys conducted in consecutive years.

Based on the above situation, it is suggested that full repeat surveys at Scorching Bay, conducted at 5 yearly intervals, would likely be sufficient to capture long-term trends. This is the interval recommended for Flat Point. A hybrid option would be to photograph the quadrats annually and archive the photographs. Quantitative analysis could be conducted at any time; for example, if a significant change was obvious. This option would be relatively low cost and would also allow the fixed quadrat markers to be checked and maintained (or replaced) as necessary. If such an approach was implemented at Scorching Bay, it would ideally be implemented at Flat Point as well.

In terms of the other two sites surveyed in 2018, there is probably limited value in repeating the Baring Head survey, on the basis that access to the wave-exposed low shore is too difficult for the purpose of reliable sampling. However, the Makara site provides an example of a relatively high-diversity rocky shore that is easily accessible and has a different wave-climate and geographic position to either Flat Point or Scorching Bay. In terms of regional representation, it would therefore be of value to set up a monitoring programme at Makara as well.

5.2 ADDITIONAL SITES FOR BASELINE ASSESSMENT AND MONITORING?

It is worthwhile to consider the merit in establishing baselines at additional locations in the greater Wellington region in order that the programme overall captures locations that are regionally representative, or significant in terms of the biota present and the pressures the locations may be subjected to. A related concept is to establish baselines for ongoing monitoring in reference locations that are subjected to little or no direct human pressure. For example, although the biota at Scorching Bay and Makara are typical of healthy rocky shores, these high-use areas have probably been impacted by human activities already. Without reference sites against which to assess current condition, it is difficult to place the present results in context with respect to the stressors in Appendix 1. For example, if these areas have been impacted by direct disturbance or seafood harvesting (e.g. of Karengo, mussels, topshells), there is no way of gauging the significance of that disturbance. The harvested species may be less abundant or smaller in size than a relatively undisturbed site, which may in turn have other cascading effects on the rocky shore assemblage.

5.3 ADEQUACY OF PRESENT MONITORING METHODS

In the context of the range of pressures discussed in Appendix 1, it is relevant to consider whether the present monitoring methodology is adequate. While the combined SACFOR and fixed quadrat approach enables sampling in most tidal states and weather conditions, a downside is that the relatively high-diversity low shore subtidal fringe is not well represented. This fringing habitat is arguably the area of greatest ecological value on the shore (e.g. it is where canopy-forming algae are found), which would ideally be subject to quantitative monitoring as well, but on a scale similar to the SACFOR assessment (i.e. across tens of metres of shore, rather than in a small quadrat). One approach would be to lay horizontal transect lines (e.g. 50m length) between fixed markers and record the sessile biota (invertebrates and macroalgae) beneath random points along the transect. In this way, the percent cover of the different biota could be calculated, reducing the subjectivity inherent in the broad-scale SACFOR approach.

5.4 A REVISED APPROACH TO MONITORING?

The above discussion highlights ways in which the GWRC rocky shore monitoring could be optimised, in terms of the range of sites assessed, and the sampling design and methodology. However, the merit of making changes depends on GWRC's specific monitoring needs and goals, and on monitoring priorities for locations not already assessed. In addition, before making any changes to the present methodology, it would be worthwhile reviewing approaches used by other regional councils. Ideally, a standard or comparable methodology would be applied across rocky shores, to provide nationally consistent datasets similar to those developed through implementation of protocols such as the NZ estuary Monitoring Protocol (Robertson et al. 2002) or the NZ Estuary Trophic Index (Robertson et al. 2016a,b).

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APPENDIX 1. A SUMMARY OF COMMON ENVIRONMENTAL STRESSORS AFFECTING NEW ZEALAND ROCKY SHORES

There are five main environmental issues that affect NZ rocky shores, with the main stressors being climate change and sea level rise, over-collection of living resources, introduction of invasive species, and pollution. All these can be linked to a decline in the dominant algal canopy species, on which many other species depend for food or habitat.

1. HABITAT LOSS OR MODIFICATION

i. Climate Change and Sea level Rise

Predicted climate change impacts (e.g. warmer temperatures, ocean acidification, sea-level rise, increased storm frequency) are expected to alter species ranges (e.g. increased sub-tropical introductions and/or establishment of pest species), alter planktonic and kelp production, and interfere with the formation of shells and skeletons by corals, crabs, marine snails, and bivalves. Long term predictions are the loss of rare species, a reduction in species diversity, and the loss of entire communities of organisms in some situations.

ii. Over-collection of Living Resources and Recreation

Direct removal of living resources (e.g. fish, mussels, paua, crayfish, algae) can cause major community level changes (e.g. Airoldi et al. 2005) from disruption to natural predator-prey balances or loss of habitat-maintaining species. For example, some popular recreational fish species (e.g. greenbone, red moki) play an important role in maintaining algal habitat and depletion of these species can cause significant changes in community structure (e.g. Taylor and Schiel 2010). Macroalgal harvesting can remove protective habitat, resulting in species loss and greater exposure to natural disturbances. Impacts are expected from recreational activities (e.g. algal trampling) and over-collection at both local and regional scales, and is likely to intensify as expanding human populations put further pressure on resources.

iii. Introduction of Invasive Species.

Increased global transport (hull fouling and ballast water discharges) is a major vector in the introduction of invasive or pest plants and animals. Displacement of native species, particularly following disturbance events (e.g. canopy loss), can result in less diverse communities and possibly increased ephemeral blooms. Introduced toxic microalgae, while harmless enough at low levels, can reproduce explosively when conditions are right, giving rise to toxic algal blooms (TABs), and resultant illness and/or mortality of humans, fish, sea birds and marine mammals that ingest toxic fish or shellfish poisoned by TABs. Significant effort and cost may be needed to remove or prevent the spread of unwanted species e.g. Undaria - an introduced golden brown seaweed that has been a prominent marine pest in New Zealand with extensive effort put into both minimising its spread and removing it from certain locations e.g. Fiordland, Stewart Island.

2. HUMAN DISEASE RISK

If pathogen inputs to the coastal area are excessive (e.g. from coastal wastewater discharges or proximity to a contaminated river plume), the disease risk from bathing, wading or eating shellfish can increase to unacceptable levels. High flushing and dilution mean disease risk is unlikely to be significant away from point source discharges. Public health reports of illness are likely to be the first indication of faecal bacterial issues directly impacting on human values and uses.

3. SEDIMENT

Excessive suspended sediments can lower water clarity and cause ecological damage at the shoreline through reduced plant and algal production, clogging of respiratory and suspension feeding organs of sensitive organisms, and can variously affect the ability of recruits to settle and establish (e.g. Airoldi 2003, Foster and Schiel 2010). Sheltered rocky shore habitats, e.g. rockpools, are more susceptible to direct deposition and reduced sediment oxygenation. Generally high wave energy on the open coast will favour offshore sediment settlement over intertidal deposition. Increased sedimentation is likely to reduce biodiversity through lowered productivity and recruitment success, and reduced ability to recover from disturbances. Human values and uses will be reduced directly by poor clarity (swimming/diving), and indirectly through biodiversity changes.

4. EUTROPHICATION

Eutrophication occurs when nutrient inputs are excessive, and can have chronic broad scale impacts over whole coastlines. High nutrients support increased localised nuisance macroalgal growth, and with this, opportunistic grazers. Where dominant, they decrease diversity by excluding or out-competing other species, and can be particularly influential in the colonisation of bare space following disturbance events. Elevated nutrients have also been implicated in a trend of increasing frequency of harmful algal blooms (HABs) which can cause illness in humans and close down shellfish gathering and aquaculture operations. High flushing and dilution on relatively remote exposed rocky shores mean the most likely indicators of eutrophication effects will be increases in nuisance macroalgal growths (e.g. Ulva) and phytoplankton blooms, and a subsequent reduction in diversity.

5. TOXIC CONTAMINATION.

If potentially toxic contaminant inputs (e.g. heavy metals, pesticides) are excessive, shoreline biodiversity is threatened and shellfish may be unsuitable for eating. Except for large-scale infrequent discharges such as oil spills, pollution tends mainly to influence embayed coastlines or areas immediately adjacent to outfalls. Increased toxins are unlikely to be a significant issue on NZ's exposed outer coasts but if present, will reduce biodiversity and human values and uses.

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APPENDIX 2. SAMPLING STATION DATA AND COORDINATES

LINZ tidal information for Wellington		Height (m)
Mean High Water Springs	MHWS	1.85
Mean High Water Neap	MHWN	1.49
Mean Low Water Neap	MLWN	0.73
Mean Low Water Springs	MLWS	0.46
Spring Range	SpringRange	1.39
Neap Range	NeapRange	0.76
Mean Sea Level	MSL	1.12
Highest Astronomical Tide	HAT	1.89
Lowest Astronomical Tide	LAT	0.4

LINZ tidal information for Makara		Height (m)
Mean High Water Springs	MHWS	1.3
Mean High Water Neap	MHWN	0.9
Mean Low Water Neap	MLWN	0.7
Mean Low Water Springs	MLWS	0.3
Spring Range	SpringRange	1.0
Neap Range	NeapRange	0.2
Mean Sea Level	MSL	0.8

Date	Site	High Water	Low Water	Height (m) Low-High (range)
24/1/18	Scorching Bay	11.15h	17.38h	0.7-1.6 (0.9)
26/1/18	Makara	04.24h	10.43h	0.65-0.95 (0.3)
26/1/18	Baring Head	12.49h	19.04h	0.6 -1.6 (1.0)

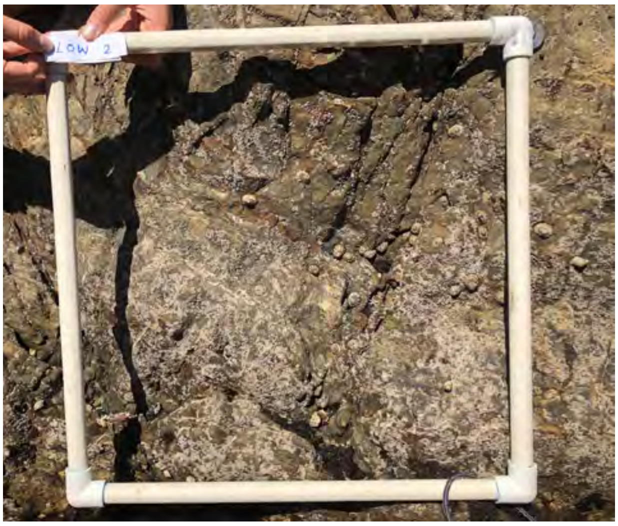
Date	Location	Site	NZTM East*	NZTM North*
25/01/2018	Scorching Bay	1	1753586	5427524
25/01/2018	Scorching Bay	2	1753588	5427515
25/01/2018	Scorching Bay	3	1753793	5426770
25/01/2018	Scorching Bay	4	1753794	5426767
25/01/2018	Scorching Bay	5	1753451	5426403
25/01/2018	Scorching Bay	6	1753449	5426402
25/01/2018	Makara	-	1743687	5435670
25/01/2018	Baring Head	-	1756108	5414193
			*NZGD2000	*NZGD2000

SCORCHING BAY NORTH

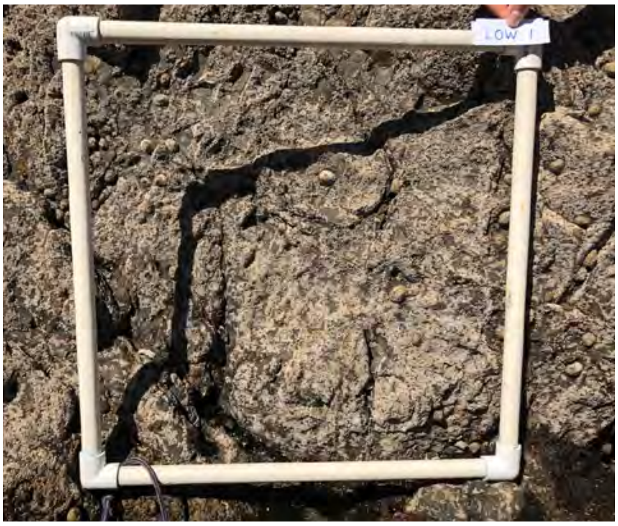
High Quadrat 1

High Quadrat 2

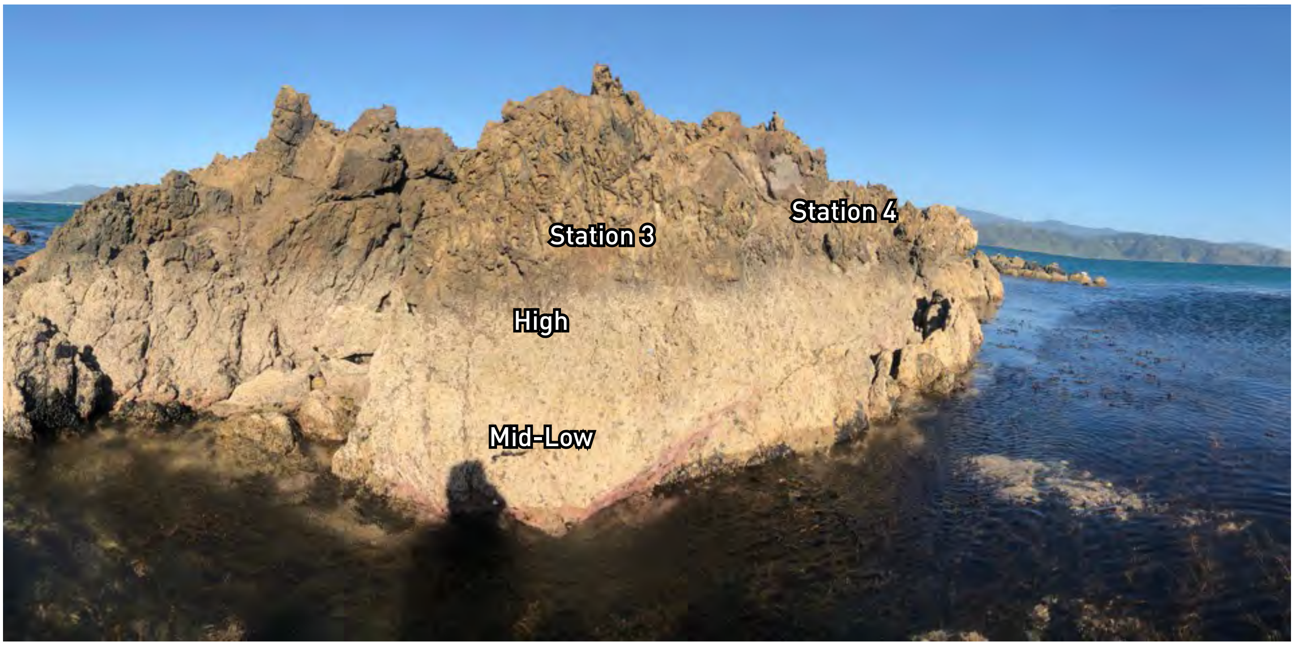
Mid-Low Quadrat 1



Mid-Low Quadrat 2



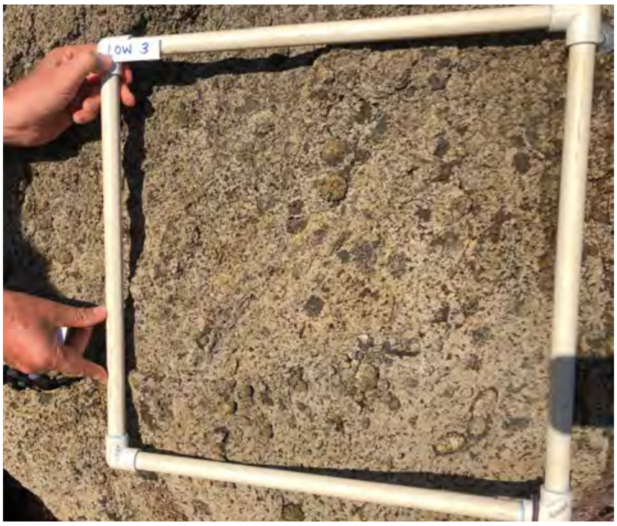
SCORCHING BAY MIDDLE



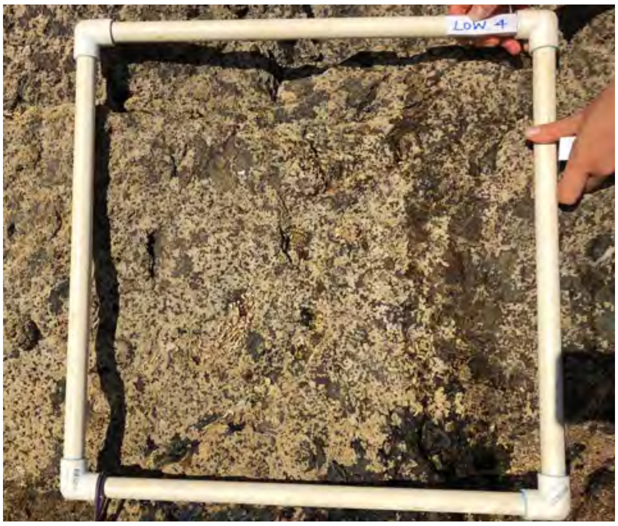
High Quadrat 3

High Quadrat 4

Mid-Low Quadrat 3



Mid-Low Quadrat 4



SCORCHING BAY SOUTH

High Quadrat 5

High Quadrat 6

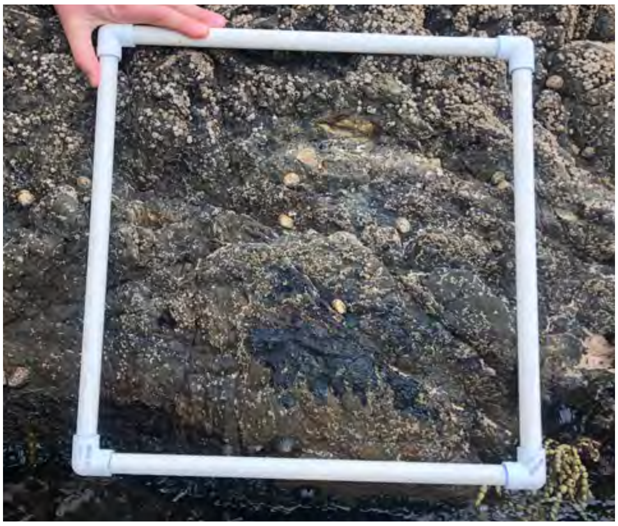
Mid-Low Quadrat 5

Mid-Low Quadrat 6

MAKARA

High Quadrat 1

Mid-Low Quadrat 1



APPENDIX 3. SCIENTIFIC AND COMMON NAMES

Main group	Species	Common name
Anemone	Actinia tenebrosa	Red waratah
	Anthothoe albocincta	White-striped anemone
	Isactinia olivacea	Olive anemone
	Oulactis muscosa	Sand anemone
Barnacle	Calantica spinosa	Spiny goose neck barnacle
	Chamaesipho brunnea	Brown surf barnacle
	Chamaesipho columna	Column barnacles
	Epopella plicata	Plicate barnacle
Bivalve	Aulacomya maoriana	Ribbed mussel
	Mytilus galloprovincialis	Blue mussel
	Perna canaliculus	Green lipped mussel
Brown algae	Carpophyllum flexuosum	Flapjack
	Carpophyllum maschalocarpum	Flapjack
	Colpomenia sinuosa	Oyster thief
	Cystophora retroflexa	Slender zig-zag weed
	Cystophora scalaris	Ladder zigzag seaweed
	Dictyota kunthii	na
	Durvillaea antarctica	Bull kelp
	Hormosira banksii	Neptune's necklace
	Lessonia variegata	na
	Petalonia binghamiae	na
	Ralfsia spp	Tar spot/brown crust
	Scytothamnus spp	na
	Splachnidium rugosum	Gummy weed
	Undaria pinnatifida	Wakame
	Zonaria aureomarginata	na
Chiton	Sypharochiton pelliserpentis	Snakeskin chiton
Green algae	Chaetomorpha coliformis	Sea emerald
	Codium convolutum	Encrusting velvet
	Ulva lactuca	Sea lettuce
	Ulva spp	na
Lichen	Pertusaria sp.	White pore lichen
	Xanthoria sp. ?parietina	Yellow/orange lichen
Limpet	Cellana denticulata	Denticulate limpet
	Cellana ornata	Ornate limpet
	Cellana radians	Tortoiseshell limpet
	Notoacmea pileopsis	Black-edged limpet
	Onchidella nigracans	Leathery sea slug
	Patelloida corticata	Encrusted slit limpet
Red algae	Chondria spp	na
	Corallina paint	Pink paint
	Corallina turf	Pink turf
	Gelidium spp	na
	Gigartina spp	na
	Laurencia thyrsifera	na
	Pyropia sp.	Porphyra, Karengo, Nori
	Sarcothalia livida	na
Sea squirt	Cnemidocarpa bicornuta	Saddle sea squirt
Sea star	Patiriella regularis	Cushion star
Topshell	Buccinulum linea	Lined whelk
	Diloma aethiops	Grooved topshell
	Diloma aridum	Sparse spotted black top shell/maihi
	Diloma nigerrima	Bluish top shell
	Haustrum haustorium	Brown rock shell
	Haustrum lacunosum	White whelk
	Haustrum scobina	Oyster borer
	Turbo smaragdus	Cats eye
Topshell (periwinkle)	Austrolittorina antipodum	Blue banded periwinkle
	Austrolittorina cincta	Brown periwinkle
	Risellopsis varia	Periwinkle
Tube worm	Spirobranchus cariniferus	Blue tubeworm