

Frentz Reef 2013

Fine Scale Rocky Shore Monitoring



Prepared for
Environment
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Cover Photo: Frentz Reef - Terrestrial margin and rocky shore south of Monkey Island.



Frentz Reef - looking towards Monkey Island and Orepuki Beach.

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**Prepared for
Environment Southland**

By

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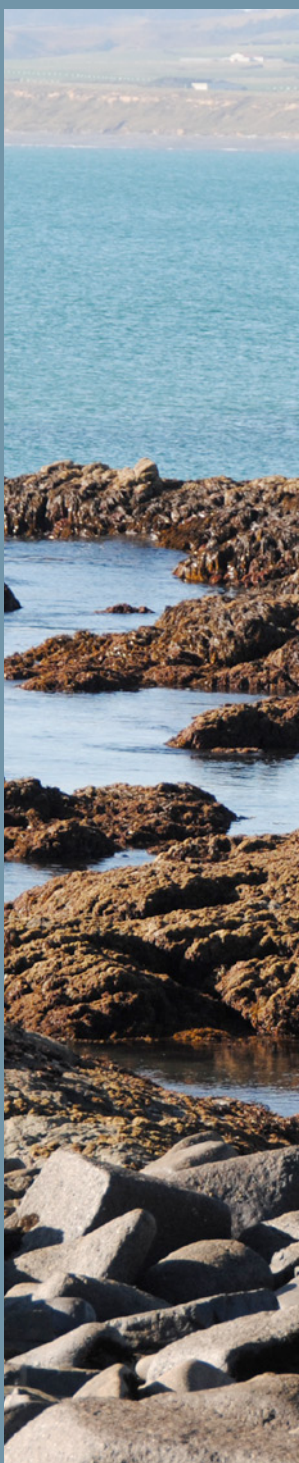
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All photos by Wriggle except where noted otherwise.

ROCKY SHORE - EXECUTIVE SUMMARY



This report summarises results of the first year of fine scale monitoring of the rocky shore community at Frentz Reef, Southland, a southern coast site exposed to moderate-high wave energy, southerly and westerly winds, and bathed by the relatively warm but often nutrient depleted waters of the Southland Current. It is a key site in Environment Southland's (ES's) long-term coastal monitoring programme. This report describes:

- Fine scale semi-quantitative monitoring of the abundance and diversity of conspicuous rocky shore plants and animals, and
- Fine scale quantitative monitoring of the abundance and diversity of plants and animals in 18 x 0.25m² fixed quadrats at high, mid, and low eulittoral (intertidal) levels at three sites.

FINE SCALE MONITORING RESULTS

The semi-quantitative monitoring identified 30 attached or sessile rocky shore species, excluding those in heavily fissured areas and rock pools. In total, 13 algae, 4 limpets, 4 topshells, 4 lichens, 1 chiton, 2 barnacles, 1 bivalve and 1 polychaete species were observed.

The supralittoral (splash) zone was predominantly bare rock. Lichens (4), were frequent/occasional, and brown and blue-banded periwinkles common/abundant.

The high eulittoral zone [8 species] was characterised by a dense cover of 3 red algae - moss weed (superabundant), rubber weed (abundant), and nori (rare), 2 column and ridged surf barnacles (abundant/rare), the speckled whelk (abundant), and 2 limpet species (occasional/rare).

The mid shore [10 species] was dominated by column barnacles (superabundant) and limpets (3 species rated abundant/frequent). Also present were two red algae - moss weed (frequent) and rubber weed (abundant), the speckled whelk, snakeskin chiton (frequent), a brown algae (tar spot) and a polychaete tube worm (rare).

The lower shore [16 species] was most diverse and was dominated by a superabundant cover of turfing, crustose red algae, and an abundant cover of 2 brown algal species (sea bladders and fan weed). The algal canopy provided shelter and refuge to a range of other species, including: limpets (2), barnacles (1), chitons (1), topshells (1) bivalves (1), and subdominant brown (4), red (3) and green (1) algae.

Nineteen of the 30 species recorded in the semi-quantitative monitoring were also recorded in the first baseline year of quantitative fixed quadrat sampling.

ROCKY SHORE ISSUES AND CONDITION

The low-moderate risk to rocky shore ecology on the Southland coast is primarily due to predicted accelerated sea level rise and temperature change and, to a lesser extent, over-collection of living resources and introduction of invasive species. The risk from pathogens, sedimentation, eutrophication, and toxins was considered low.

The first year of baseline monitoring found the coastline in a healthy and unpolluted condition. No introduced invasive species were seen, and there was no indication of excessive nutrient or sediment inputs.

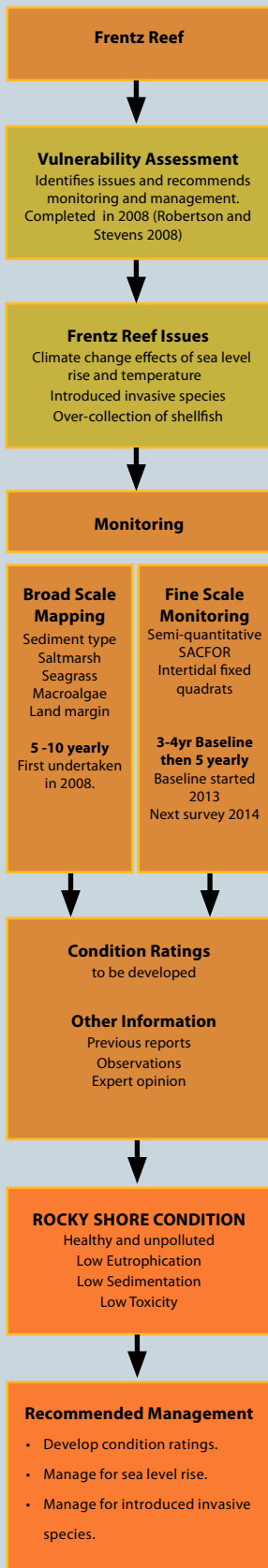
RECOMMENDED MONITORING AND MANAGEMENT

To provide a robust baseline of rocky shore conditions (particularly to enable monitoring of changes from predicted accelerated sea level rise and increased temperatures), it is recommended that fine scale monitoring continue annually for the next 2-3 years (to provide a baseline), with the next monitoring undertaken in February 2014.

While the rocky shore baseline is established, it is proposed that condition ratings be developed to characterise the status of the shore. It is proposed that these ratings focus on measuring shifts in community composition, the presence or absence of key indicator species (including introduced plants and animals), and indicators of nutrient enrichment and sedimentation.

1. INTRODUCTION

OVERVIEW



Developing an understanding of the condition and risks to coastal habitats is critical to the management of biological resources. Importantly, the “Southland Coast - Te Waewae to the Catlins - Mapping, Risk Assessment and Monitoring” report (Robertson and Stevens 2008) identified a low-moderate risk to rocky shore ecology on the Southland coast. This was primarily from predicted climate change effects of accelerated sea level rise and elevated temperatures, the over-collection of living resources, and the introduction of invasive species. The primary ecological responses to such pressures are considered to be habitat change, and effects on biodiversity. Due to the generally high clarity, low nutrients, and low disease risk of water that bathes the Southland rocky shoreline, the risk from pathogens, sedimentation, eutrophication, and toxins was considered low. Because of this, the number of monitoring indicators can be kept small, although this may change if catchment land use intensifies.

Therefore, to address the identified risks, and to provide baseline information on rocky shore ecology at key representative locations, Robertson and Stevens (2008) recommended long term monitoring of the abundance and diversity of plants and animals at three high diversity rocky shores (e.g. West of Cosy Nook, Stirling Point, and Waipapa Point) using rapid assessment methods developed under the Marine Biodiversity and Climate Change Project (Hiscock 1996). Wriggle Coastal Management was contracted by Environment Southland (ES) to undertake the first year of a 3-4 year baseline of annual monitoring near Stirling Point, (Bluff) in February 2010, and at Waipapa Point in 2011. Sampling at Frentz Reef in Te Waewae Bay commenced in 2013. After establishment of the baseline, monitoring will be undertaken 5 yearly and the results will help to determine the extent to which the coast is affected by major environmental pressures (Table 1), both in the short and long term.

Rocky shores are a dominant and visually dramatic part of the Southland coastline. They reflect the erosive effect of waves where softer rocks are worn down, leaving harder rocks exposed. The habitat is physically complex, with rockpools, gullies, crevices and boulders providing a diverse range of habitats supporting a variety of different species. The harsh and variable physical conditions, including light availability, degree of exposure, large shifts in temperature and salinity, aspect, substrate, and biotic features, lead to the development of a characteristic zonation of species on stable shoreline substrate. These include zones dominated by lichens, periwinkles, barnacles, limpets, mussels, and canopy forming algae - the dominant biogenic habitat along temperate rocky shores worldwide (e.g. Tomanek and Helmuth 2002).

Canopy forming algae play a vital role on the rocky shore by providing food and shelter to a wide range of species. Consequently, any change or loss of this canopy habitat is likely to result in a cascade of related effects. For example, canopy loss will increase heat stress, desiccation of understory species, and wave exposure, likely resulting in a simplified cover dominated by resilient species e.g. coralline algae, which in turn may preclude the re-establishment of canopy species. Changes in canopy cover may also result in secondary impacts altering existing ecosystem dynamics, with bare space colonised by new species (possibly invasive or nuisance species), food shortages altering grazing dynamics or predation, or changed susceptibility to other stressors such as sedimentation and eutrophication.

The relationship between stressors (both natural and human influenced) and changes to rocky shore communities is complex and can be highly variable. However, there are clear links between the degradation of rocky shore habitat and the combined effects of elevated nutrient, sediment, pathogen, and toxin inputs, harvesting, trampling, coastal development, introduced species, as well as broader stressors such as changes to sea temperature, sea level, wave exposure, and storm frequency and intensity (directly influenced by global climate change) - see Table 1.

As such, monitoring representative rocky shore sites provides a robust and effective way of detecting changes to this important and highly valued coastal community.

1. Introduction (Continued)

Table 1. Summary of the major environmental issues affecting NZ 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.

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.

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. Airoidi 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.

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 who 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 Southland (Paterson Inlet and Bluff Harbour) with extensive effort put into minimising its spread and removing it from the region.

2. 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. Airoidi 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 in Southland but, if present, will reduce biodiversity and human values and uses.

1. Introduction (Continued)

The Frentz Reef fine scale rocky shore intertidal monitoring site is located approximately 500m southeast of Monkey Island (Figure 1), a popular tourist destination in Te Waewae Bay near the western Southland coastal town of Riverton. The area is representative of the rocky shoreline on this semi-exposed region of the southern coast, and is characterised by the following:

- Predominantly exposed, rugged reefs, composed of 150-200 million year old relatively soft, crystalline granite, diorite and gabbro volcanic rock.
- Exposure to moderate-high wave energy and southerly and westerly winds.
- Bathed by the relatively warm, and often nutrient depleted, waters of the Southland Current that flows from the south-western end of the South Island, northwards up the east coast. However, inshore waters are influenced by elevated nutrient, sediment and pathogen loadings from Southland river plumes.
- Dominated beneath low water by the fan-shaped, brown macroalgae *Xiphophora gladiata*, and directly above low water by the crustose coralline macroalga *Corallina officinalis*, with barnacles common above the crustose algal zone.

The sampling area was located on a rough, irregular intertidal reef (~100m x 50m) which was seaward of a relatively narrow strip of variably sized, cobble and boulder beach, and part of a wider sequence of connected intertidal and subtidal reefs present on this section of coast (Figure 1, photo below). Several submerged reefs are present offshore. Although the area is semi-exposed, and is periodically subject to high wind and wave action from the southwest, the sampling site itself is relatively well protected from direct wave-action, with the sloping and undulating shoreline further helping to dissipate wave energy. Consequently, it supports a relatively diverse rocky shore community and exhibits strong shoreline zonation (Figure 2). The shoreline zones are relatively narrow (each ~1 vertical metre) reflecting the tidal range at the site (~1.4-2.3m).

The site is not directly or significantly influenced by river plumes, terrestrial discharges (e.g. stormwater, sewage), or structures (e.g. seawalls, wharfs, marine farms). Human use is moderate-high. It is a popular tourist destination, a highly valued recreational paua fishery, and is valued for diving, fishing, and its scenic beauty and bird life. The monitoring sites are considered unlikely to be appreciably affected by recreational fishers or visitors because quadrat locations are discretely marked (unlikely to be noticed), are in areas on the shore that require some effort to get to, and are positioned where direct impacts are unlikely.

The current report describes the methods and results of the first year of the proposed 3-4 year baseline of rocky shore monitoring at Frentz Reef.



View north to the Frentz Reef rocky shore sampling site.

1. Introduction (Continued)



Figure 1. Location of the rocky shore sampling area at Frenztown Reef.

2. METHODS

The fine scale rocky shore monitoring programme involves measuring the abundance and diversity of conspicuous plants and animals. Monitoring targets the supralittoral zone (the area regularly splashed, but not submerged, by seawater) and the eulittoral (intertidal) zone that extends from the rarely inundated spring high water tide line, to the almost always inundated neap low tide line. Results will be used to evaluate any vertical shift in the zonation pattern associated with climate change, or impacts from introduced species, over-collection of shellfish (e.g. paua, mussels), excessive sediment and nutrient inputs, as well as to provide a baseline for infrequent risks such as oil spills.

Sampling was undertaken by three scientists during relatively calm sea conditions on 23-24 February 2013 when estuary monitoring was being undertaken in the region.

The methodology is based on that used in the UK MarClim - Marine Biodiversity and Climate Change Project (MNCR 1990, Hiscock 1996, 1998), and consists of two parts,

1. A semi-quantitative assessment to develop a checklist of the species present and record their relative abundance across a representative sampling area.
2. Recording the abundance and diversity of plants and animals in 0.25 m² fixed quadrats positioned in the spatially largest strata at the site, and stratified within 3 eulittoral tide levels (High, Mid, and Low).

The semi-quantitative assessment was applied by walking over and photographing the wider sampling area, and identifying and recording the relative abundance of all the conspicuous species present from the supralittoral zone to mean low water. At each shore zone 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 field guide was used to assist with field identifications (see Table 2 photo inset).

The abundance of each species was rated using SACFOR categories described in Table 2. The SACFOR assessment preferentially uses percentage cover of two growth types of attached organisms - Crust/ Meadow (e.g. lichen, barnacles, coralline paint), or Massive/Turf (e.g. bull kelp, coralline turf) - Table 2, A. All other individual organisms >5mm in size were counted, with the largest individual organism size used to determine the relevant SACFOR size class rating for each species as detailed in Table 2, B.

The semi-quantitative assessment guided the selection of 18 stratified fixed intertidal quadrats, because true random sampling approaches are not appropriate on a broken rocky shore. The use of fixed quadrats reduces the need for extensive sample replication and minimises spatial variation, while seasonal variation is minimised by scheduling monitoring for the same period each year (January to March). Within the wider sampling area, 3 sites were identified with predominantly irregular bedrock that was sheltered from the direct effect of prevailing wind and waves to facilitate safe sampling (Figure 2). At each site, 6 quadrats were located, 2 each at high, mid and low water.

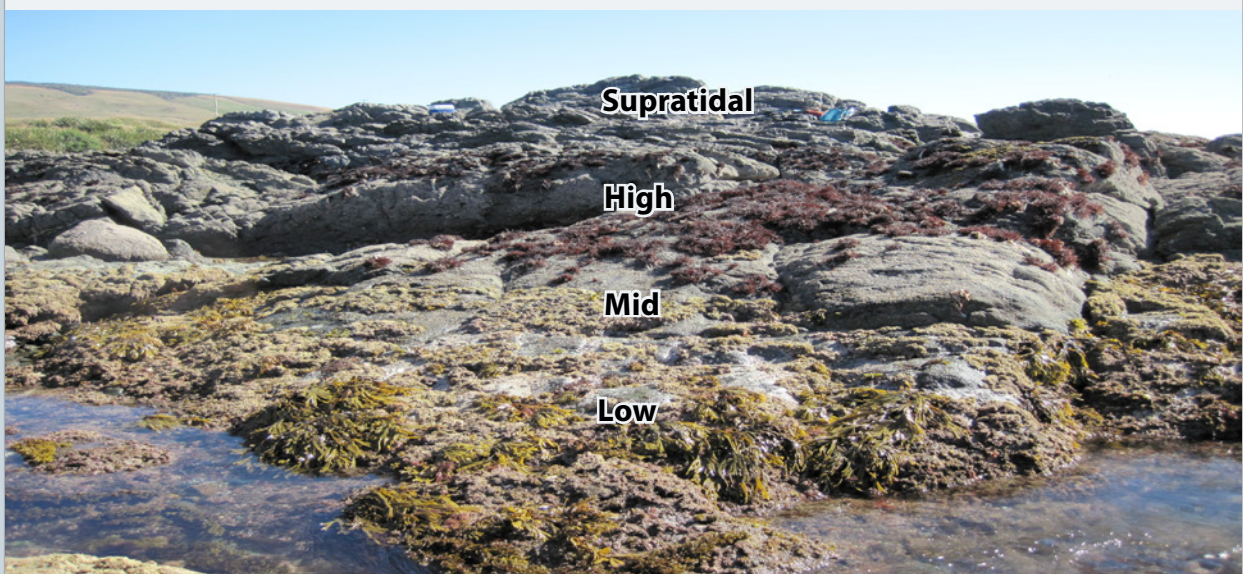


Figure 2. Site 2 showing general shoreline zonation.

2. Methods (Continued)



Quadrats at each shore height had similar physical characteristics (slope, aspect, wave exposure), and were positioned in areas with attached plants or animals as the change to these features is the primary focus of the monitoring. The upper shore true left hand corner of each quadrat was marked for repeat sampling by drilling and fixing a stainless steel bolt in the rock, the site location photographed, and GPS position recorded.

After selecting and marking each quadrat, the following information was recorded:

High Eulittoral Quadrats

(6 quadrats located 1m below the top of the barnacle zone)

- Percent cover of all barnacles, mussels, and algae.
- Number of each periwinkle species present (counted from a representative 2cm x 2cm section within each quadrat).
- Number of each limpet or chiton (individuals >10mm) in each 0.25m² quadrat.

Mid Eulittoral Quadrats

(6 quadrats in the middle of the barnacle zone)

- Percent cover of all barnacles, mussels, and algae.
- Number of each limpet or chiton (individuals >10mm) in each 0.25m² quadrat.
- Number of each species of snail >5mm in each 0.25m² quadrat.

Low Eulittoral Quadrats

(6 quadrats 1m above the bottom of the barnacle zone)

- Percent cover of all barnacles, mussels, and algae.
- Number of each limpet or chiton (individuals >10mm) in each 0.25m² quadrat.
- Number of each species of snail >5mm in each 0.25m² quadrat.

Table 2. SACFOR Percentage Cover and Density Scales (after Marine Nature Conservation Review - MNCR).

A. PERCENTAGE COVER		
i. Crust/Meadow	% cover	ii. Massive/Turf
S	>80	-
A	40-79	S
C	20-39	A
F	10-19	C
O	5-9	F
R	1-4	O
-	<1	R

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

- Whenever percentage cover can be estimated for an attached species, it should be used in preference to the density scale.
- The massive/turf percentage cover scale should be used for all species except those classified under crust/meadow.
- Where two or more layers exist, for instance foliose algae overgrowing crustose algae, total percentage cover can be over 100%.

B. DENSITY SCALES								
SACFOR size class				Density				
i	ii	iii	iv	0.25m ² (50x50cm)	1.0m ² (100x100cm)	10m ² (3.16x3.16m)	100m ² (10x10m)	1,000m ² (31.6x31.6m)
<1cm	1-3cm	3-15cm	>15cm					
S	-	-	-	>2500	>10,000			
A	S	-	-	250-2500	1000-9999	>10,000		
C	A	S	-	25-249	100-999	1000-9999	>10,000	
F	C	A	S	3-24	10-99	100-999	1000-9999	>10,000
O	F	C	A	1-2	1-9	10-99	100-999	1000-9999
R	O	F	C	0-<1	0-<1	1-9	10-99	100-999
-	R	O	F			0-<1	1-9	10-99
-	-	R	O				0-<1	1-9
-	-	-	R					0-<1



3. RESULTS AND DISCUSSION

Results of the 23-24 February 2013 fine scale rocky shore monitoring at Frentz Reef are summarised below in two sections: the semi-quantitative assessment, followed by the fixed quadrat sampling.

The semi-quantitative assessment identified 30 species (Table 3), excluding creviced areas and rock pools. Algae were dominant (12 species), but a wide range of common rocky shore organisms able to withstand the physical rigours of the exposed wave environment were present in a predictable zonation across the shoreline. These included barnacles, limpets, chitons, topshells, polychaetes and bivalve shellfish. Notably, no introduced invasive species were identified.

The zonation fell into four key zones, the spray zone of the upper shore (supralittoral), and high, mid, and low intertidal (eulittoral) zones. Within these broad zones, most species comprised two broad categories, those either directly attached to the rock (e.g. lichens, barnacles, seaweeds), or sessile species such as limpets and chitons, that are physically adapted to high energy wave conditions (they have a broad base and the ability to cling strongly to the rock), or utilise cracks and depressions in the rock for shelter.

Because this regular zonation of attached and sessile organisms is primarily governed by tidal inundation, monitoring changes to the shore composition provides a very effective way of tracking long-term climate change effects such as predicted accelerated sea level rise or increased temperatures.

Supralittoral Zone

At Frentz Reef, the supralittoral zone was dominated by bare rock. Lichens were present on the near-vertical rock and boulders at the upper edge of the spray zone with four species recorded, all firmly attached as thin crustose sheets. Most abundant were the strikingly coloured orange *Xanthoria* (see photo below) and black *Verrucaria*, both present in relatively large patches and often closely associated with two less abundant taxa, the grey-green *Ramalina* and white *Pertusaria*.



Also present at the lower edge of the supralittoral fringe were the brown and blue-banded periwinkles *Austrolittorina cincta* (below) and *Austrolittorina antipodum*, classified as common and abundant, respectively. These small topshells graze on the attached lichens and, while extremely tolerant of the sun, tend to congregate in cracks and fissures in the rock that provide some protection from the elements during the day.



Table 3. Results of the semi-quantitative SACFOR assessment at Frentz Reef, 24 February 2013.

Group and Family		Species	Common name	Scale	Class	Supra	High	Mid	Low
Lichens	Pertusariaceae	<i>Pertusaria</i> spp.	White pore lichen	%	i	O			
	Ramalinaceae	<i>Ramalina</i> spp. <i>scopulorum</i>	Grey/green lichen	%	i	O			
	Verrucariaceae	<i>Verrucaria</i> spp. <i>maura</i>	Black lichen	%	i	F			
	Teloschistaceae	<i>Xanthoria</i> spp. <i>parietina</i>	Yellow/orange lichen	%	i	F			
Topshells	Littorinidae	<i>Austrolittorina antipodum</i>	Blue banded periwinkle	#	i	A			
	Littorinidae	<i>Austrolittorina cincta</i>	Brown periwinkle	#	i	C			
	Turbinidae	<i>Turbo smaragdus</i>	Cats eye	#	ii				C
	Muricidae	<i>Lepsithais lacunosus</i>	Speckled whelk	#	ii		A	F	
Limpets	Nacellidae	<i>Cellana ornata</i>	Ornate limpet	#	ii		R	C	
	Nacellidae	<i>Cellana radians</i>	Tortoiseshell limpet	#	ii			F	
	Nacellidae	<i>Cellana strigilis redmiculum</i>	Striated limpet	#	ii		O	A	R
	Lottiidae	<i>Patelloida corticata</i>	Encrusted slit limpet	#	ii				O
Chitons	Chitonidae	<i>Sypharochiton pelliserpentis</i>	Snakeskin chiton	#	ii			F	R
Barnacles	Catophragmidae	<i>Chamaesipho columna</i>	Column barnacles	%	i		A	S	O
	Balanidae	<i>Elminius plicatus</i>	Ridged surf barnacle	%	i		R		
Red Algae	Hildenbrandiaceae	<i>Apophlaea lyallii</i>	Rubber weed	%	ii		A	A	
	Corallinaceae	<i>Corallina officinalis</i>	Pink turf	%	ii				S
	Corallinaceae	<i>Lithothamnion</i> sp.	Pink/white paint	%	i				O
	Bangiaceae	<i>Porphyra</i> sp.	Karengo, Nori	%	ii		R		
		Red Alga (unidentified)		%	ii				F
Brown Algae	Ralfsiaceae	<i>Ralfsia verrucosa</i>	Tar spot	%	ii			R	R
	Adenocystaceae	<i>Adenocystis utricularis</i>	Sea bladders	%	ii				A
	Splachnidiaceae	<i>Splachnidium rugosum</i>	Gummy weed	%	ii				F
	Dictyotaceae	<i>Dictyota dichotoma</i>	Brown fan weed	%	ii				A
	Stypocaulaceae	<i>Halopteris</i> sp.		%	ii				C
	Cystoseriraceae	<i>Cystophora torulosa</i>	Zig-zag weed	%	ii				O
Green Algae	Ulvophyceae	<i>Ulva lactuca</i>	Wakame	%	ii				R
Bivalves	Mytilidae	<i>Perca canaliculus</i>	Green lipped mussel	#	iii				R
Polychaetes	Serpulidae	<i>Pomatoceros</i> sp.		%	i			R	



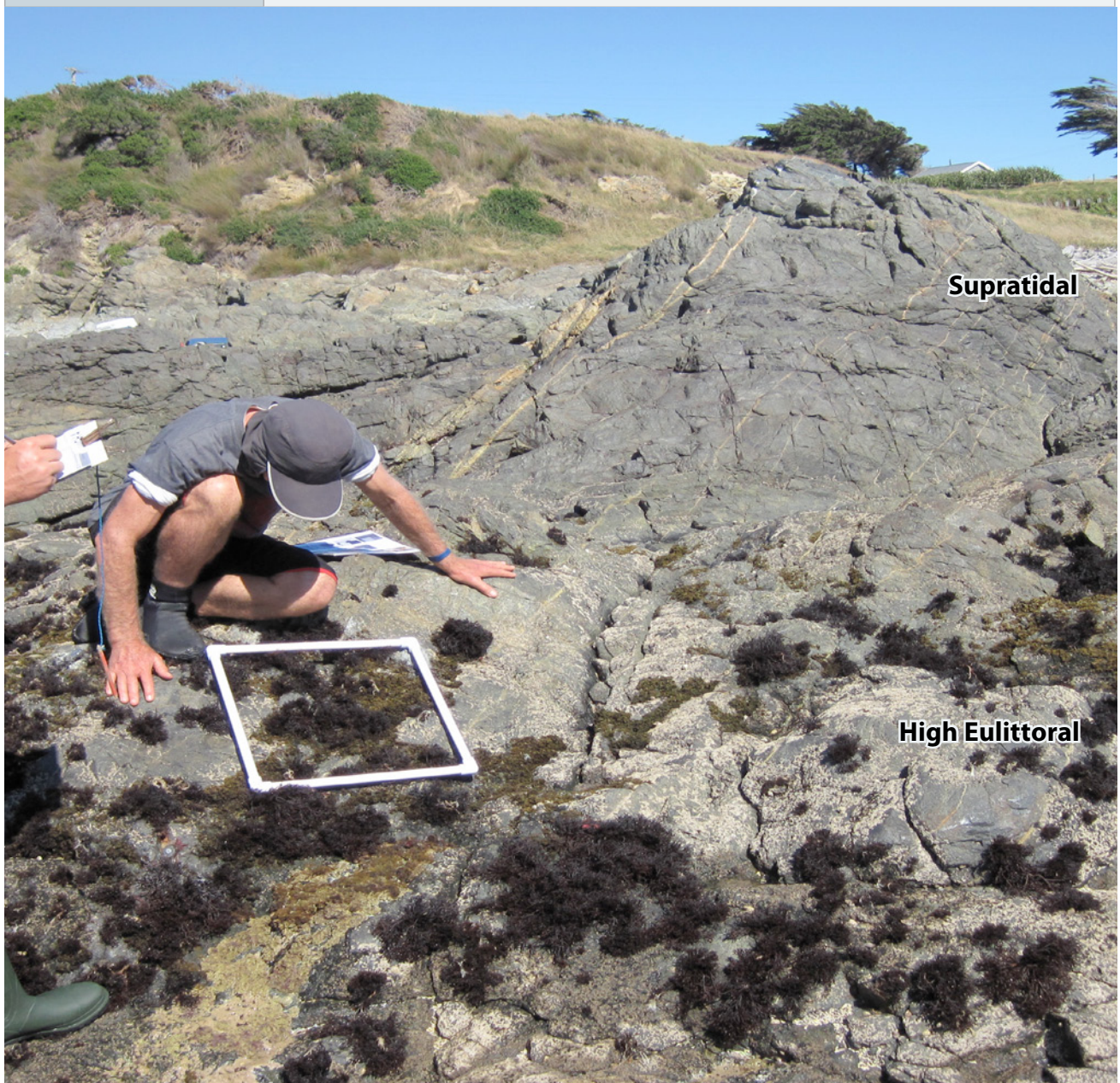
3. Results and Discussion (Continued)

High Eulittoral Zone

The high eulittoral zone is submerged for short periods on each tide, and although relatively sheltered, is also exposed to seawater via waves and spray depending on swell and wind angle. Because of its exposed nature, the high shore zone was characterised by extensive patches of bare rock that supported a relatively sparse community. The dominant species were the brittle red algae *Stictosiphonia arbuscula* and *Apoplea lyallii* (see Figure 3), which form dense, bushy bands often exhibiting curled, short, hairy branchlets that help minimise desiccation. Another red algae, *Porphyra* sp., was present but classified as rare. Nestled among algae, the herbivorous limpets *Cellana ornata* and *C. strigilis redmiculum* were present, but rated occasional in terms of their overall abundance. Additionally, the sessile column barnacle *Chamaeosiphon columna* and the speckled whelk *Lepsithais lacunosus* also appeared among algae and on bare rock, particularly at the lower fringe of the zone, and both were rated as abundant.



Figure 3. *Stictosiphonia arbuscula* and *Apoplea lyallii* on the high shore.



3. Results and Discussion (Continued)

Mid Eulittoral Zone

Although still containing bare patches, the mid eulittoral zone was dominated by the barnacle *Chamaeosipho columna* which filter-feeds from the water column at high tide. *C. columna* was superabundant (>80% cover), present in extensive sheets across the rock (see photo below).

Limpets were the most common of the mobile invertebrates with *Cellana radians* and *C. ornata*, both frequent/common, and *C. strigilis redmiculum* abundant. Other invertebrates included the chiton *Sypharochiton pelliserpentis* and the whelk *Lepsithais lacunosus*, both frequent, while the tube-dwelling polychaete worm *Potamocerus* sp. was rated rare - preferring to populate cracks of vertical rock faces (Figure 4). Also present among the barnacles, were the red macroalgae *Apoplea lyallii* (abundant) and *Stictosiphonia arbuscula* (frequent), as well as the crustose brown *Ralfsia verrucosa* (rare), which all became sparse towards the mid shore's lower fringe.



Figure 4. *Potamocerus* sp. on the mid shore.



Low Eulittoral Zone

The lower eulittoral zone is exposed to the air for only a short period on each tidal cycle and is where algae of various forms have their stronghold on the shore. It is dominated by an extensive (i.e. superabundant) close turf of the calcareous red algae *Corallina officinalis*. Among this turf, a variety of subdominant brown macroalgae (i.e. *Adenocystis utricularis*, *Dictyota dichotoma*, *Halopteris* sp., *Splachnidium rugosum* (Figure 5), *Cystophora toralosa*, *Ralfsia verrucosa*), crustose pink/white paint *Lithothamnion* sp. and foliose, green alga *Ulva* sp. were rated abundant to rare in cover (Table 3).

Although less abundant than both middle and high tidal elevations, a variety of sessile animals take advantage of the shelter and refuge provided from waves, heat, and predation by the algal canopy. In particular, limpets (i.e. *Patelloida corticata*, *Cellana strigilis redmiculum*) and the snakeskin chiton *Sypharochiton pelliserpentis* with a strong ability to cling to the rocks, were rated occasional to rare, many returning to a home spot where their shell has adapted to fit the rock and provide a snug fit that offers protection from the elements (see Figure 6, bottom right). These species



Figure 5. *Splachnidium rugosum* on the low shore.

3. Results and Discussion (Continued)

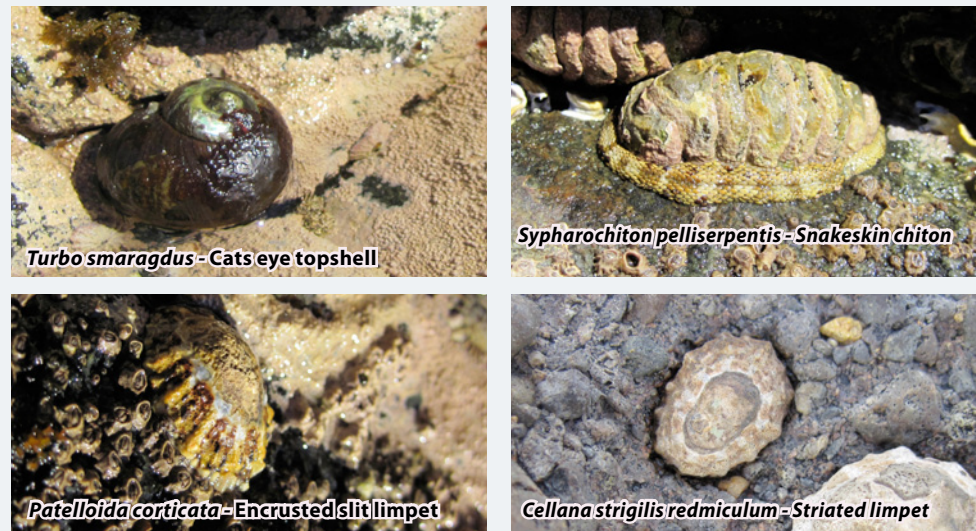


Figure 6. Topshells, limpets and chitons from the mid and low eulittoral zones.

graze on the calcareous red algae *Corallina officinalis* and pink/white paint *Lithothamnion* sp. (see Figure 6 top left). Only one topshell species *Turbo smaragdus* was commonly observed, although many mobile topshells seek refuge from the sun in crevices during the day and are thus not common on the open shore. Also among the algal turf, other invertebrate species present included *Chamaeosiphon columna* - occasional, and the green lipped mussel *Perna canaliculus* - rare.



Fixed Quadrats

Results from the fixed quadrats at Frentz Reef are summarised in Tables 4 and 5, and Figures 6 and 7, with photos of each quadrat presented in Appendix 1. The principle purpose of repeat sampling fixed quadrats over time is to collect information on the stability of the mobile invertebrate and attached invertebrate and algal communities at representative shore heights. Because of the dynamic and often harsh rocky shore coastal environment, establishing a baseline of natural variability is vital if future changes are to be detected and interpreted. The baseline is designed to detect any long term vertical shift in the zonation pattern caused by sea level rise or changes in water quality (e.g. sea temperature or clarity) associated with climate change, and to evaluate impacts from introduced species, over-collection of shellfish, and from infrequent risks such as oil spills.

3. Results and Discussion (Continued)

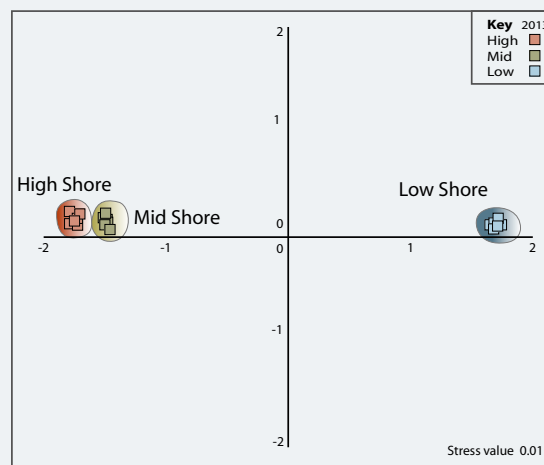
Table 4 summarises richness, abundance and diversity measures for the three shore heights. A total of 19 species were recorded from quadrats, with fewer found at high and mid shore (10 and 7, respectively), compared to the lower shore (12). The diversity of both algae and mobile invertebrates was highest at the low shore, and the lowest on the upper shore. Note that this result only reflects species within the quadrats, and not the shore overall, as quadrat sampling excludes habitats such as crevices and rock pools which will support many additional species.

Table 4. Summary of richness, abundance, and diversity indices for mobile invertebrates, sessile invertebrates, and macroalgae present in high, mid, and low shore quadrats, Frentz Reef, 2013.

Category	High Shore			Mid Shore			Low Shore		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
Total number of species	7			10			12		
MOBILE INVERTEBRATES (topshells, limpets, chitons)									
RICHNESS (Number of species)	2			6			4		
ABUNDANCE (Mean number of individuals)	5.0			9.8			5.7		
DIVERSITY (Shannon Index)	0.63			0.98			1.04		
SESSILE INVERTEBRATES (barnacles, mussels)									
RICHNESS (Number of species)	3			1			1		
ABUNDANCE (Mean percentage cover)	24.5			74.2			5.5		
DIVERSITY (Shannon Index)	0.08			-			-		
MACROALGAE									
RICHNESS (Number of species)	2			3			7		
ABUNDANCE (Mean percentage cover)	75.0			21.2			127.8		
DIVERSITY (Shannon Index)	0.54			0.35			1.09		

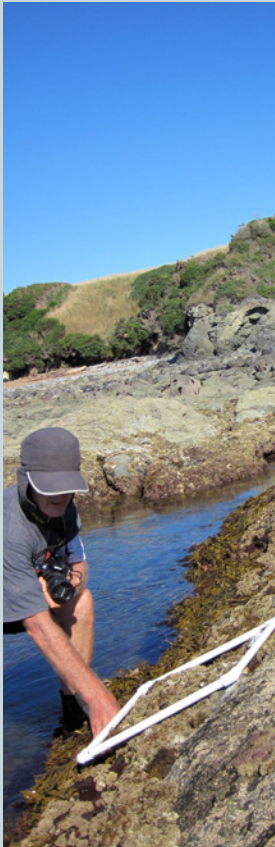
Note: Low shore macroalgal percent cover values exceed 100% because of overlapping algal growth.

Figure 6 shows that the biotic community present predictably groups quadrats relatively strongly, based on shore height. The apparent similarity between the high and middle shore communities among quadrats (i.e. lack of distance between high and mid shore zones) is likely attributable to the site's semi-sheltered nature, allowing similar species to populate a range of tidal elevations. Nevertheless, such groupings also confirm that the individual sampling locations selected at each shore height are representative of each other.



The n-MDS plot (left) shows the 6 replicate samples at each of three shore heights, based on Bray Curtis dissimilarity and square root transformed data. The approach involves multivariate data analysis methods, in this case non-metric multidimensional scaling (n-MDS) using PRIMER-e version 6.1.16. The analysis basically plots the site and abundance data for each species as points on a distance-based matrix (a scatterplot ordination diagram). Points clustered together are considered similar, with the distance between points and clusters reflecting the extent of the differences. The interpretation of the ordination diagram depends on how well it represents actual dissimilarities (i.e. how low the calculated stress value is). Stress values greater than 0.3 indicate that the configuration is no better than arbitrary, and we should not try and interpret configurations unless stress values are less than 0.2.

Figure 6. n-MDS plot showing the relationship among samples in terms of similarity in community composition for Frentz Reef rocky shore quadrats, Feb. 2013.



3. Results and Discussion (Continued)

Table 5. Raw data, mean number or percentage cover (\pm SE) and SACFOR rating of mobile invertebrates, sessile invertebrates, and macroalgae present in high, mid, and low shore quadrats, Frentz Reef, 2013.

High Shore Quadrat Data

H2013	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	<i>Lepsithais lacunosus</i>	Speckled whelk	#	ii	6	2	3		4		2.2	0.6	O
Limpets	<i>Cellana strigilis redmiculum</i>	Striated limpet	#	ii	4	2		1	6	4	2.8	0.8	F
Barnacles	<i>Elminius plicatus</i>	Ridged surf barnacle	%	i		1					0.2		R
	<i>Chamaesipho columna</i>	Column barnacle	%	i	20	5	20	10	70	20	24.2	9.5	C
Red Algae	<i>Apophlaea lyallii</i>	Rubber weed	%	ii		15	20	45	5	20	17.5	6	C
	<i>Stictosiphonia arbuscula</i>	Moss weed	%	ii	65	75	50	60	25	70	57.5	7.4	S
Polychaetes	<i>Potamoceros</i> sp.		%	i						1	0.2		R

Mid Shore Quadrat Data

M2013	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	<i>Lepsithais lacunosus</i>	Speckled whelk	#	ii	2	2		2	1		1.2	0.2	O
	<i>Turbo smaragdus</i>	Cats eye	#	ii				1			0.2		R
Limpets	<i>Cellana ornata</i>	Ornate limpet	#	ii	1			1			0.3		O
	<i>Cellana radians</i>	Tortoiseshell limpet	#	ii		3	1		1	1	1	0.4	O
	<i>Cellana strigilis redmiculum</i>	Striated limpet	#	ii				1	6	2	7	1.4	C
Chitons	<i>Sypharochiton pelliserpentis</i>	Snakeskin chiton	#	ii				1			0.2		O
Barnacles	<i>Chamaesipho columna</i>	Column barnacle	%	i	80	90	50	40	95	90	74	9.5	A
Brown algae	<i>Ralfsia verrucosa</i>	Tar spot/blood crust	%	i		1	5				1	1.2	R
Red Algae	<i>Apophlaea lyallii</i>	Rubber weed	%	ii	10	5	30	50	1	20	19.3	7.5	C
	<i>Stictosiphonia arbuscula</i>	Moss weed	%	ii				5			0.8		R

Low Shore Quadrat Data

L2013	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	<i>Turbo smaragdus</i>	Cats eye	#	ii		6		2	3	4	2.5	0.7	O
Limpets	<i>Cellana strigilis redmiculum</i>	Striated limpet	#	ii			3				0.5		O
	<i>Patelloidia corticata</i>	Encrusted slit limpet	#	ii			12	3			2.5	2.6	F
Chitons	<i>Sypharochiton pelliserpentis</i>	Snakeskin chiton	#	ii		1					0.2		O
Barnacles	<i>Chamaesipho columna</i>	Column barnacle	%	i	5	1	5	2	10	10	5.5	1.6	O
Brown Algae	<i>Adenocystis utricularis</i>	Sea bladder	%	ii	30	20	15	20	10	30	20.1	3.3	A
	<i>Ralfsia verrucosa</i>	Tar spot/blood crust	%	i		30					5		R
	<i>Splachnidium rugosum</i>	Gummy weed	%	ii		2	2	5	10	3	3.7	1.4	O
	<i>Dictyota dichotoma</i>		%	ii	1	5	5	3	5	2	3.5	0.7	O
Red Algae	<i>Corallina officinalis</i>	Pink turf	%	ii	95	90	70	90	90	90	87.5	3.6	S
	Red algae (unid)		%	ii	10		5	5		4	4	1.1	O
	<i>Lithothamnion</i> sp.	Pink/white paint	%	i	2		5	5	3	5	3.3	0.6	R

3. Results and Discussion (Continued)

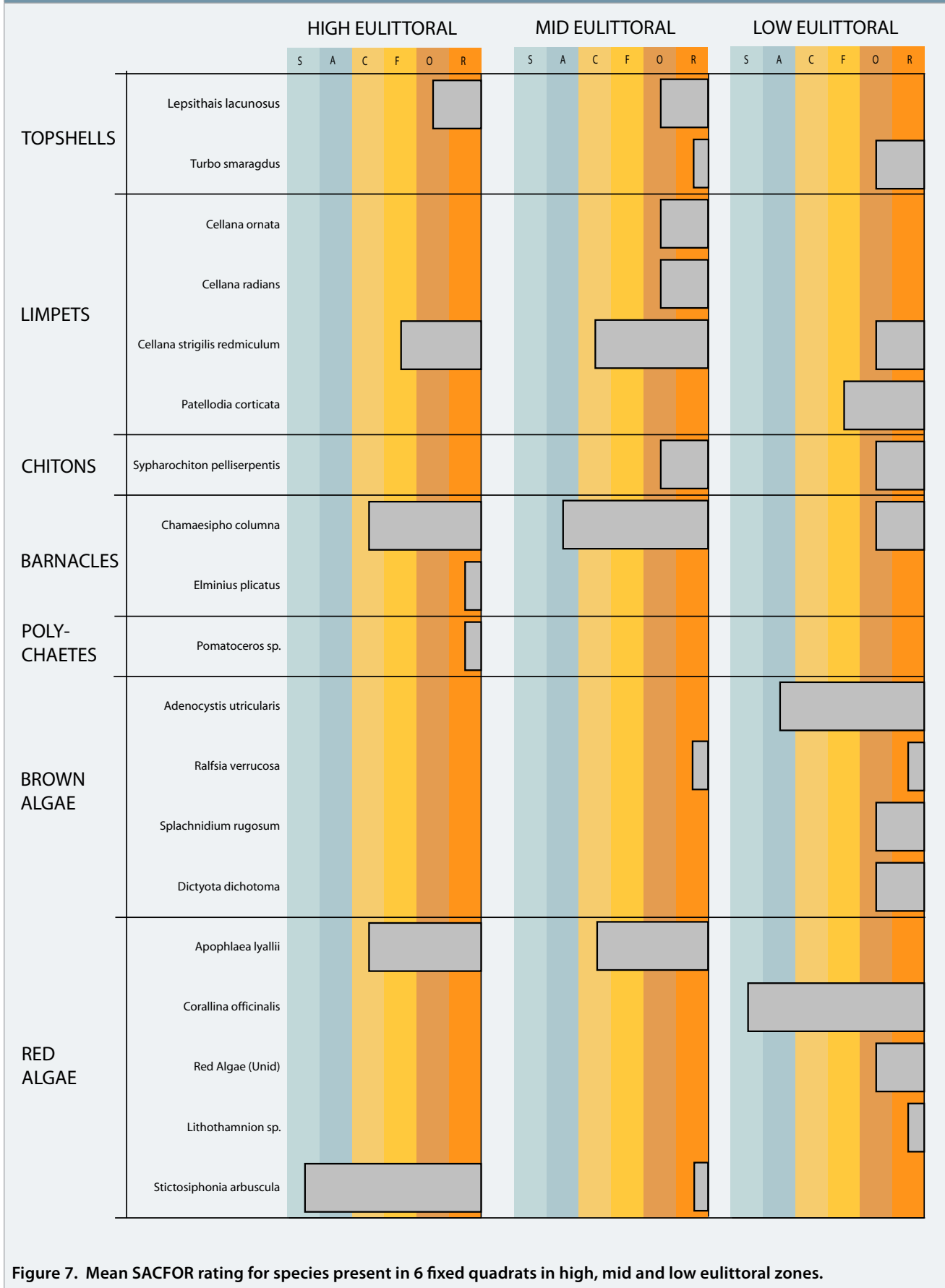


Figure 7. Mean SACFOR rating for species present in 6 fixed quadrats in high, mid and low eulittoral zones.

3. Results and Discussion (Continued)



The monitoring of representative rocky shore habitats in Southland is vital if these highly valued and ecologically important ecosystems are to be managed effectively. Key physical variables such as sea temperature and wave forces can underpin a wide range of physiological and ecological processes, including altered species interactions, predation intensity, and dispersal and tolerances to thermal stress (Schiel 2011). These can be driven by natural changes in large scale events such as the El Niño/La Niña-Southern Oscillation, or by human impacts on global climate systems. In addition, coastal ecosystems are directly and often significantly affected by human use and development (over-collection of living resources and introduction of invasive species), as well as changes in land-use practices that in particular alter sediment and nutrient loadings.

Kelp communities comprise the dominant biogenic habitat along temperate rocky shores and loss of the three-dimensional algal community will likely result in a cascade of effects trending towards lower value, two-dimensional habitat, dominated by low-lying crusts and turfs, with subsequent adverse impacts on fish, invertebrate and algal sub-canopy communities. Because declines in algal habitat have been linked to degradation of water quality, increased sedimentation, increased nutrients, and contaminant discharges (e.g. Foster and Schiel 2010, Fong 2008), ensuring these stressors remain at a level the coastal environment can assimilate is clearly very important.

The initial monitoring results from Frentz Reef indicate a healthy and unpolluted rocky shore community. The risk from pathogens, sedimentation, eutrophication, and toxins is currently considered low, while a low-moderate risk is present, based on predicted accelerated sea level rise and temperature change.

Once the baseline monitoring is complete, analysis will include a combination of PRIMER-e based analyses (Clarke & Gorley 2006), analysis of similarity (ANOSIM) to test for statistical differences in biotic assemblages among quadrats over time, and similarity percentage analysis (SIMPER) to identify taxa contributing most to multivariate differences among quadrats over time. SIMPER analysis will also enable identification of key indicator species, which will aid the intended development of condition ratings to characterise the status of the shore. Such ratings have not previously been attempted because current scientific knowledge of many NZ rocky shore species is scarce or incomplete. However, by focusing on measuring shifts in community composition, the presence or absence of key indicator species (including introduced plants and animals), as well as indicators of nutrient enrichment and sedimentation, it will be possible to develop appropriate condition ratings once the baseline monitoring is completed.

In addition, the scheduled 3-4 years of baseline monitoring will provide a robust measure of natural variation against which any future shift in vertical zonation on the shoreline or community composition can be assessed. It will also provide an invaluable benchmark for assessing the possible impacts from infrequent events such as oil spills or toxic algal blooms should they occur.

4. SUMMARY

The inaugural year of baseline rocky shore monitoring at Frentz Reef showed a healthy and unpolluted coastline supporting a collection of common rocky shore organisms present in a predictable shoreline zonation.

The zonation extended from a relatively low diversity, high shore intertidal community, dominated by the red algae *Stictosiphonia arbuscula* and *Apophlaea lyllii*, through the mid shore barnacle dominated zone where topshells, limpets and chitons were also common, to the highest diversity low shore algal zone dominated by the extensively turfing, crustose red algae *Corallina officinalis*, and beneath low water by the fan-shaped, brown macroalgae *Xiphophora gladiata*.

5. MONITORING

Frentz Reef has been identified by Environment Southland as a priority for monitoring the effects of predicted accelerated sea level rise and temperature change, the over-collection of living resources, the introduction of invasive species, and impacts from excessive sedimentation, eutrophication, pathogens and toxins. It is recommended that monitoring continue as outlined below:

Rocky Shore Monitoring:

- Continue the scheduled baseline monitoring at Frentz Reef in February 2014. After the 3-4 year baseline is completed, reduce monitoring to 5 yearly intervals or as deemed necessary based on rocky shore condition ratings (to be developed).

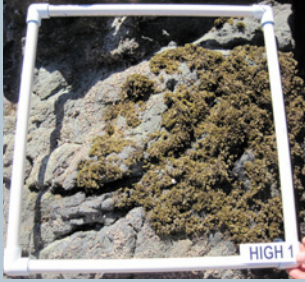
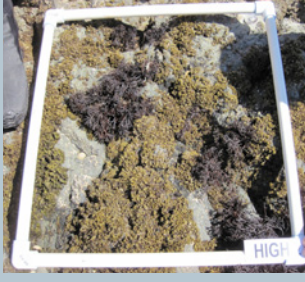
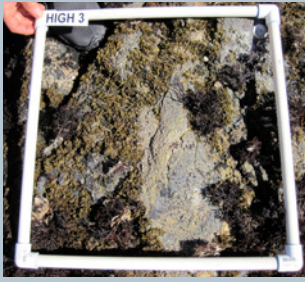
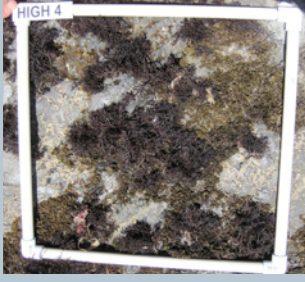
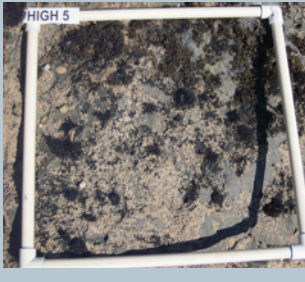

6. ACKNOWLEDGEMENTS

We thank Nick Ward (Coastal Scientist, Environment Southland) for his help and support during the surveying and reporting stages.



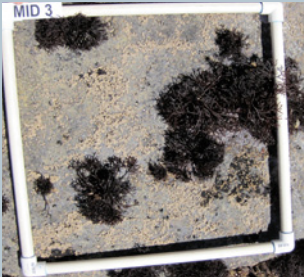
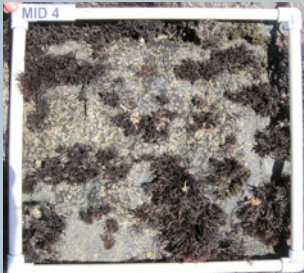

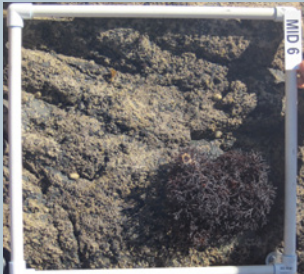
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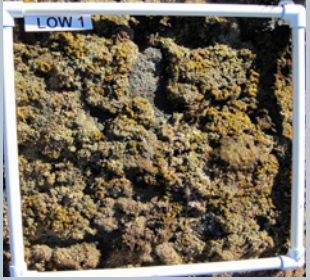
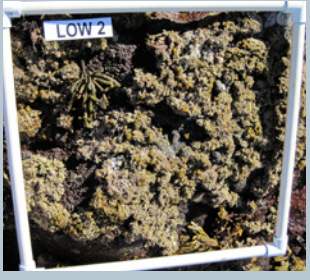
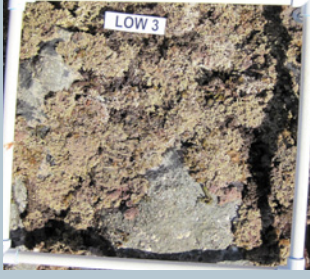
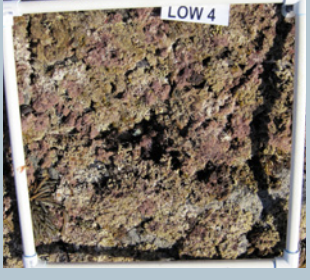
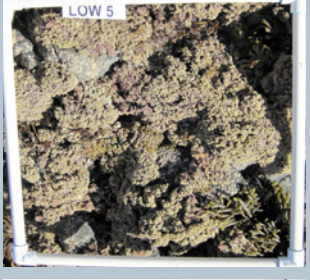
APPENDIX 1. DETAILED RESULTS

High Eulittoral	2013	2014	2015
<p>QUADRAT 1</p> <p>NZTM 1193189 East NZTM 4858650 North</p>			
<p>QUADRAT 2</p> <p>NZTM 1193187 East NZTM 4858655 North</p>			
<p>QUADRAT 3</p> <p>NZTM 1193183 East NZTM 4858655 North</p>			
<p>QUADRAT 4</p> <p>NZTM 1193182 East NZTM 4858654 North</p>			
<p>QUADRAT 5</p> <p>NZTM 1193162 East NZTM 4858648 North</p>			
<p>QUADRAT 6</p> <p>NZTM 1193163 East NZTM 4858647 North</p>			

APPENDIX 1. DETAILED RESULTS (CONT.)

Mid Eulittoral	2013	2014	2015
<p>QUADRAT 1</p> <p>NZTM 1193191 East NZTM 4858655 North</p>			
<p>QUADRAT 2</p> <p>NZTM 1193191 East NZTM 4858657 North</p>			
<p>QUADRAT 3</p> <p>NZTM 1193184 East NZTM 4858654 North</p>			
<p>QUADRAT 4</p> <p>NZTM 1193183 East NZTM 4858656 North</p>			
<p>QUADRAT 5</p> <p>NZTM 1193166 East NZTM 4858650 North</p>			
<p>QUADRAT 6</p> <p>NZTM 1193164 East NZTM 4858650 North</p>			

Appendix 1. DETAILED RESULTS (CONT.)

Low Eulittoral	2011	2012	2013
<p>QUADRAT 1</p> <p>NZTM 1193197 East NZTM 4858656 North</p>			
<p>QUADRAT 2</p> <p>NZTM 1193196 East NZTM 4858667 North</p>			
<p>QUADRAT 3</p> <p>NZTM 1193189 East NZTM 4858665 North</p>			
<p>QUADRAT 4</p> <p>NZTM 1193181 East NZTM 4858663 North</p>			
<p>QUADRAT 5</p> <p>NZTM 1193166 East NZTM 4858655 North</p>			
<p>QUADRAT 6</p> <p>NZTM 1193166 East NZTM 4858654 North</p>	