coastalmanagement

Waipapa Point 2011

Fine Scale Rocky Shore Monitoring

Prepared
for
Environment Southland
August 2011

Cover Photo: Waipapa Point - Wave swept rocky platform adjacent to the lighthouse.
Inside cover: Waipapa Point - Intertidal seagrass beds between the rocky reef and the sandy shore north of the lighthouse.

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By

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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 Waipapa Point, Southland, a southern coast site exposed to 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 0.25m^2 fixed quadrats at High, Mid, and Low eulittoral (intertidal) levels at three sites.

FINE SCALE MONITORING RESULTS

The semi-quantitive monitoring identified 30 attached or sessile rocky shore species, excluding those present in heavily fissured areas and rock pools. In total, 11 algae, 5 limpets, 5 topshells, 4 lichens, 3 chitons, and 2 barnacle species were observed.

The supralittoral (splash) zone [9 species] was dominated by bare rock and lichens (4 species). Periwinkles (2 species) were common, and other species (1 topshell, 1 algae and 1 limpet) were rare. Coastal herbfields were present adjacent to the upper shore.

The high eulittoral zone [10 species] was dominated by the red algae *Stictosiphonia arbuscula* (80% cover). Small brown periwinkles were rated frequent, limpets (3 species) common/occasional, the grooved topshell - occasional, and 2 barnacles and 2 red algae, rated rare.

The mid shore [15 species] was dominated by barnacles (~80% cover, 2 species) and limpets (4 species rated common/frequent). Six species of red algae, generally small and patchy, were present - all rated rare, with 3 topshells (occasional/rare).

The lower shore [17 species] was most diverse and was dominated by a superabundant (90%) cover of bull kelp (*Durvillaea antarctica),* providing shelter and refuge to a range of other species including limpets (4), chitons (3), and calcareous red algae and pink/white paint (3). Two subdominant brown and 1 green algae were also observed.

Of the 30 species observed, 24 were recorded in the quantitative fixed quadrats.

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

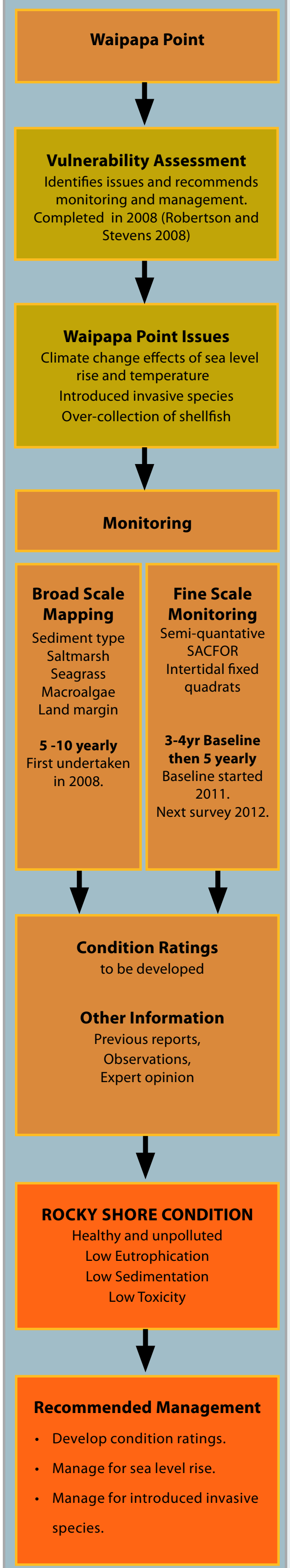
To provide a robust baseline of rocky shore conditions (particularly to enable monitoring of changes from predicted accelerated sea level rise and increased temperatures), it is recommended fine scale monitoring continue annually for the next 2-3 years (to provide a baseline) with the next monitoring undertaken in February 2012.

It is also recommended that one additional site on the Southland coast be identified (e.g. West of Cosy Nook), and baseline monitoring be initiated in February 2012.

While the rocky shore baseline is established, it is proposed condition ratings be developed to characterise the status of the shore. It is proposed that the condition 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. The recent "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, 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 Waipapa Point in 2011. After establishment of the baseline, monitoring will be undertaken 5 yearly and the results will help 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, including 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 plays 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.

The key stressors of rocky shores are; climate change and sea level rise, over collection of living resources, introduction of invasive species, and pollution which can all be linked to a decline in the dominant canopy species of fucoids and kelps, on which many other species depend for food or habitat.

Key Environmental Rocky Shore Issues		Likely Response
Habitat Loss or Modification	**Climate Change and Sea level Rise.** Accelerated global change in temperature, sea-level rise, and increases in the frequency of storms will affect rocky shores throughout the world, with effects occurring over a long time scale. Warmer temperatures will alter nitrate concentrations and with this, planktonic and kelp production, species ranges, and the capacity of introduced species to become established.	In the long term, loss of rare species, reduction in species diversity, reduced habitat area, and the loss of entire communities of organisms in some situations.
	Over-collection of Living Resources and Recreation. Direct removal of living resources can have major effects on coastlines (e.g. Airoldi et al. 2005) at both local and regional scales, and is likely to increase as expanding human populations put further pressure on resources. Impacts from recreational activities (e.g. trampling) are likely to increase with greater leisure time in wealthier regions of the world. 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).	Over collection of key species will lead to community level changes from disruption to natural predator-prey balances or loss of habitat maintaining species. Macroalgal harvesting can remove protective habitat resulting in subsequent species loss and greater exposure to natural disturbances.
	Introduction of Invasive Species. Increased global transport (hull fouling and ballast water discharges) is responsible for the introduction of invasive plants and animals to our rocky shores which can cause damage to local rocky shore communities. *Undaria* (a golden brown seaweed introduced to NZ in the 1980s) is a prominent marine pest in Southland (Paterson Inlet and Bluff Harbour) that has had extensive effort put into preventing its spread and removing it from the region. Introduced toxic microalgae, while harmless enough at low levels, can reproduce explosively when conditions are right, giving rise to toxic algal blooms (TABs).	Displacement of native species particularly following disturbance events (e.g. canopy loss). A shift to less diverse communities and possibly increased ephemeral blooms. Illness and/or mortality of humans, fish, sea birds and marine mammals who ingest toxic fish or shellfish poisoned by TABs.
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 increases to unacceptable levels. High flushing and dilution mean disease risk from bathing, wading or eating shellfish 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.
Sedimentation	If sediment inputs are 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). More sheltered rocky shore habitats such as rockpools are also susceptible to direct deposition, and impacts through 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.
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 (e.g. Fong 2008). 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.
Toxins	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 Waipapa Point fine scale rocky shore intertidal monitoring site is located approximately 500m northwest of the Waipapa Point lighthouse (Figure 1) near the southern most point of NZ's South Island. The area is representative of the rocky shoreline on this part of the southern coast, and is characterised by the following:

- Predominantly exposed sandstone, mudstone and siltstone reefs and platforms, mixed with dunes and sandy beaches.
- Exposure to 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 near low water by the giant southern bull kelp (*Durvillaea antarctica*) with barnacles common above the bull kelp zone.

The sampling area was located on an extensive but relatively gently sloping intertidal platform (~300m x 150m) which was seaward of a coarse sand beach, and part of a wider sequence of intermittent platforms and subtidal reefs present on this section of coast (Figure 1, photo below). Because of the relatively low slope, the bull kelp zone was often wide (50-100m in places), providing significant dissipation of wave energy, but with the most exposed seaward edges characterised by vertical rock faces and limited algal cover. The mid-tide barnacle zone was relatively narrow, with the high eulittoral zone restricted to the top of eroding rock (e.g. Figure 2). The entire reef area is at times wave swept and is regularly sprayed. Between the rocky reef and the beach, a sheltered narrow intertidal inlet running northwest of the lighthouse supports healthy seagrass beds.

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, being a popular tourist destination, it is a highly valued recreational paua fishery, and is valued for diving, fishing, and its scenic beauty. The area is an important local bird roost (white fronted terns, red billed gulls, black shags). 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 rocky shore monitoring at Waipapa Point, and includes recommendations on monitoring and management.

View north of Waipapa Point Lighthouse to the rocky shore sampling site.

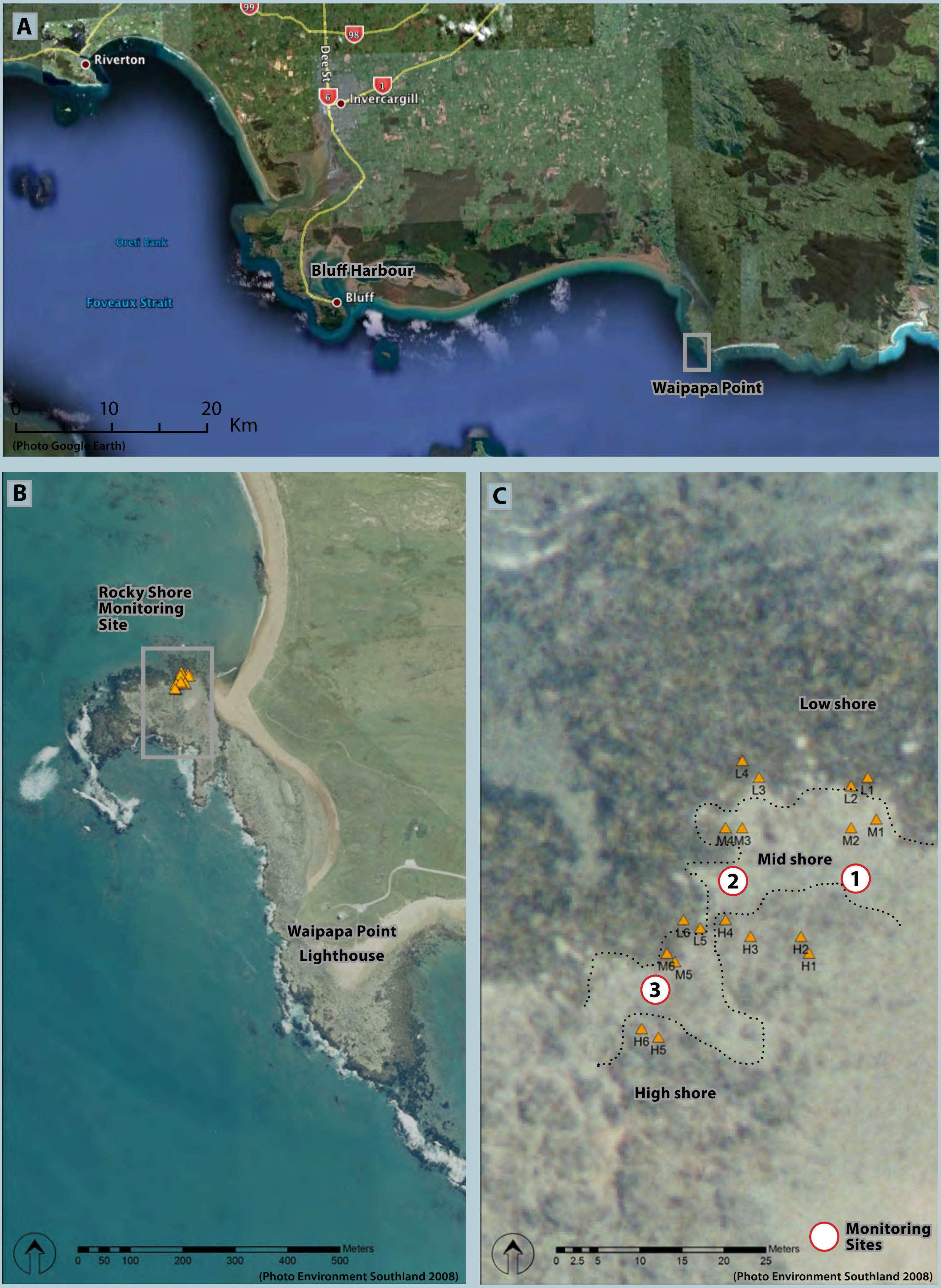


Figure 1. Location of rocky shore sampling sites at Waipapa Point.

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 provide a baseline for infrequent risks such as oil spills.

Sampling was undertaken by two scientists during relatively calm sea conditions on 16 February 2011 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 0.25m^2 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 (~100m x 40m - see Figure 1), and identifying and recording the relative abundance of all the species present from the supralittoral zone to mean low water. 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). At each site 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.

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 gently sloping 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 1c).

Figure 2. Position of fixed intertidal quadrats at Site 1.

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 0.25m^2 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 0.25m^2 quadrat.
- Number of each species of snail >5mm in each 0.25m^2 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 0.25m^2 quadrat.
- Number of each species of snail >5mm in each 0.25m^2 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	1.0m^2	10m^2	100m^2	1,000m^2
<1cm	1-3cm	3-15cm	>15cm	(50x50cm)	(100x100cm)	(3.16x3.16m)	(10x10m)	(31.6x31.6m)
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	1-9	10-99	100-999	1000-9999	>10,000
O	F	C	A		1-9	10-99	100-999	1000-9999
R	O	F	C			1-9	10-99	100-999
-	R	O	F				1-9	10-99
-	-	R	O					1-9
-	-	-	R					<1

3. RESULTS AND DISCUSSION

Results of the 16 February 2011 fine scale rocky shore monitoring at Waipapa Point are summarised below in two sections - the semi-quantitive assessment, followed by the fixed quadrat sampling.

The semi-quantitive assessment identified 30 species (Table 3), excluding creviced areas and rock pools. Algae were dominant (11 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 and bivalve shellfish. 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 good way of tracking long-term climate change effects such as predicted accelerated sea level rise or increased temperatures.

Supralittoral Zone

At Waipapa Point, the supralittoral zone adjacent to the lighthouse was assessed where the rocky shore transitioned from marine to terrestrial habitat, a feature not present adjacent to the fine scale quadrat sites. The supralittoral zone was dominated by bare rock, with a relatively high cover of lichens on the near-vertical rock and boulders present above the intertidal platform. Four species of lichen were recorded, all firmly attached as thin crustose sheets within the spray zone. Most abundant was the white *Pertusaria*, present in relatively large patches and often closely associated with frequent grey-green *Ramalina*, and the strikingly coloured orange *Xanthoria* (see photo below). The black *Verrucaria* was common along the lower supralittoral fringe.

Also appearing at the lower edge of the supralittoral fringe, the brown and banded periwinkles *Austrolittorina cincta* (below) and *A. antipodum* were classified as common. 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. Only one other topshell was observed in this zone, the grooved topshell *Diloma aethiops*, but was rare, as was the limpet *Cellana ornata*.

Table 3. Results of the semi-quantative SACFOR assessment at Waipapa Point, 16 February 2011.

Group and Family		Species	Common name	Scale	Class	Supra	High	Mid	Low
Lichens	*Pertusariaceae*	*Pertusaria spp.*	White pore lichen	%	i	A			
	Ramalinaceae	*Ramalina spp. scopulorum*	Grey/green lichen	%	i	O			
	Verrucariaceae	*Verrucaria spp. maura*	Black lichen	%	i	O			
	Teloschistaceae	*Xanthoria spp. parietina*	Yellow/orange lichen	%	i	F			
Topshells	*Littorinidae*	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	C			
	Littorinidae	*Austrolittorina cincta*	Brown periwinkle	#	i	C	F	O	
	Buccinidae	*Buccinulum lineum*	Lined whelk	#	ii				R
	Trochidae	*Diloma aethiops*	Grooved topshell	#	ii	R	O	R	R
	Turbinidae	*Turbo smaragdus*	Cats eye	#	ii			R	F
Limpets	*Siphonarridae*	*Benhamina obliquata*	Large siphon limpet	#	ii				O
	Nacellidae	*Cellana ornata*	Ornate limpet	#	ii	R	O	F	O
	Nacellidae	*Cellana radians*	Tortoiseshell limpet	#	ii		O	C	O
	Nacellidae	*Cellana strigilis redmiculum*	Striated limpet	#	ii		C	F	
	Lottiidae	*Patelloida corticata*	Encrusted slit limpet	#	ii			C	C
Chitons	*Chitonidae*	*Amaurochiton glaucus*	Blue-green chiton	#	ii				O
	Mopaliidae	*Maorichiton caelata*	Kelp chiton	#	ii				F
	Chitonidae	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	ii				F
Barnacles	*Catophragmidae*	*Chamaesipho columna*	Column barnacles	%	i		R	S	
	Balanidae	*Elminius plicatus*	Ridged surf barnacle	%	i		R	R	
Red Algae	*Hildenbrandiaceae*	*Apophlaea lyallii*	Rubber weed	%	ii	R	R	R	
	Corallinaceae	*Corallina officinalis*	Pink turf	%	ii			R	S
	Corallinaceae	*Corallina polymorphum*	Pink globules	%	i				F
	Gracilariaceae	*Gracilaria sp. ?secundata*	Gracilaria weed	%	ii		R	R	
	Corallinaceae	*Lithothamnion sp.*	Pink/white paint	%	i			R	C
	Halymeniaceae	*Pachymenia lusoria*		%	ii			R	
	Rhodomelaceae	*Stictosiphonia arbuscula*	Moss weed	%	ii		S	R	
Green	*Codiaceae*	*Codium convolutum*	Encrusting velvet	%	i				R
Brown Algae	*Durvillaeaceae*	*Durvillaea antarctica*	Bull kelp	%	ii				S
	Ralfsiaceae	*Ralfsia verrucosa*	Tar spot/blood crust	%	i				O
	Fucaceae	*Xiphophora gladiata*	Strap weed	%	ii				O

3. Results and Discussion (Continued)

Figure 3. Coastal herbfield above the high eulittoral zone.

In a narrow band between the upper reaches of the rocky shore and the marram grass that fringed the surrounding pasture, the salt sprayed shoreline supported a low turfing herbfield (Figure 3) dominated by *Selliera radicans*, *Leptinella dioica,* and *Crassula moschata*. Also common were the wetland/aquatic fern *Azolla filiculoides*, the slender clubrush *Isolepis curnea*, and the tussock *Poa astonii*. Many of the herbfield species were also evident among the grazed pasture on the surrounding hills.

High Eulittoral Zone

The high eulittoral zone is submerged for short periods on each tide and is also frequently doused by waves and spray. This high energy zone was characterised by extensive patches of bare rock that supported a relatively sparse community. The dominant species was the red algae *Stictosiphonia arbuscula* (photo below), which forms dense bushy bands with often curled short hairy branchlets that helps it minimise dessication. Also present as a low cover were *Gracilaria sp.? secundata,* and *Apoplea lyallii*. Nestled among algae, the herbivorous limpets *Cellana radians* and *C. strigilis redmiculum*, were occasional/common and widespread. Brown periwinkles were frequent, and the barnacles *Chamaeosipho columna* and *Elminius plicatus* were starting to appear at the lower fringe of the zone - rated rare.

Mid Eulittoral Zone

Although still containing bare patches, the mid eulittoral zone was dominated by barnacles which filter-feed from the water column at high tide. *Chamaeosipho* was superabundant (80% cover), present in extensive sheets across the rock (see photo below), while *Elminius plicatus* was rated rare, often nestled among the *Chamaeosipho*.

Limpets were the most common of the mobile invertebrates with *Cellana radians, C. ornata* and *C. strigilis redmiculum* all frequent/common. Periwinkles were again present, but fewer compared to higher on the shore, while the larger gastropods (e.g. *Diloma aethiops, Turbo smaragdus*) were uncommon - sparse on exposed surfaces and preferring to shelter in crevices and under boulders. Large macroalgae were rare but included the red algae *Apoplea lyallii, Corallina officinalis , Gracilaria sp.? secundata, Lithothamnion sp., Stictosiphonia arbuscula,* and *Pachymenia lusoria*.

Low Eulittoral Zone

The lower eulittoral is exposed to the air for only a short period on each tidal cycle and is the where the brown algae have their stronghold on the shore. It is dominated by an almost exclusive (superabundant) 90% cover of bull kelp *Durvillaea antarctica* which spreads over the low intertidal and shallow subtidal fringe, and underneath this, the calcareous red algae *Corallina officinalis* also has a superabundant cover.

A variety of sessile animals and algae take advantage of the shelter and refuge provided from waves, heat, and predation by the overlying fronds. In particular, limpets (e.g. *Benhamina obliquata, Cellana radians, C. ornata, Patelloida corticata*) and chitons (e.g. *Sypharochiton pelliserpentis, Maorichiton caelata, Amaurochiton glaucus*) with a strong ability to cling to the rocks were rated common to occasional, 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 4, bottom right).

3. Results and Discussion (Continued)

Figure 4. Topshells, limpet and chitons from the mid and low eulittoral zones.

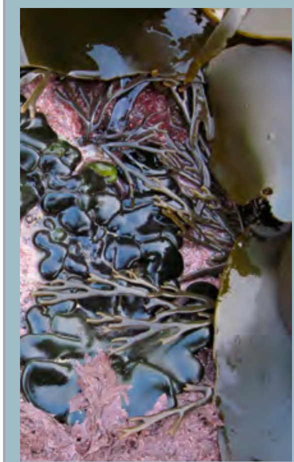


Figure 5. ***Codium convolutum*** **on the low shore.**

These species graze on the calcareous red algae *Corallina officinalis* and pink/white paint *Lithothamnion* sp. on the rock (see Figure 4 middle top). Topshells were generally uncommon, most likely due to the high wave exposure, but included frequent *Turbo smaragdus* and rare *Buccinulum lineum*. Among the *Durvillaea* other algal species present included *Lithothamnion* and *Ralfsia verrucosa* - common, *Corallina polymorphum* frequent, *Xiphophora gladiata* occasional, and *Codium convolutum* - rare.

Fixed Quadrats

Results from the fixed quadrats at Waipapa Point 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 community at representative shore heights. Because of the dynamic and often harsh rocky shore coastal environments, 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)

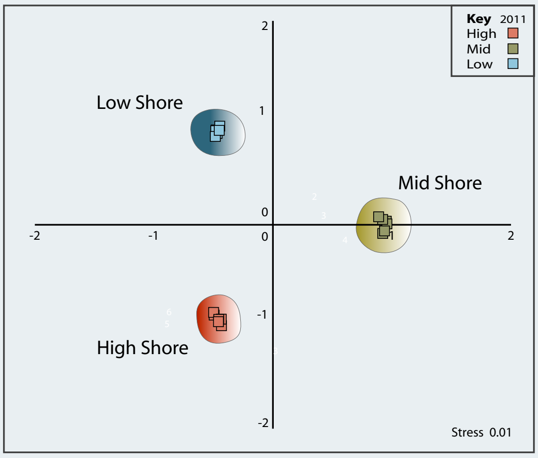
Table 4 summarises richness, abundance and diversity measures for the three shore heights. A total of 24 species have been recorded from quadrats, the fewest from the high and mid shore (8 each), and the most in the lower shore (15). The highest diversity of both algae and mobile invertebrates was present at the low shore, and the least on the upper shore. Note that this 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, Waipapa Point, 2011.

Category	High Shore			Mid Shore			Low Shore		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
Total number of species	8			8			15		
MOBILE INVERTEBRATES (topshells, limpets, chitons)									
Richness (Number of species)	4			4			8		
Abundance (Mean number of individuals)	15.2			0.0			11.2		
Diversity (Shannon Index)	0.63			0.69			0.87		
SESSILE INVERTEBRATES (barnacles, mussels)									
Richness (Number of species)	1			1			0		
Abundance (Mean percentage cover)	0.2			88.5			0		
Diversity (Shannon Index)	-			-			0		
MACROALGAE									
Richness (Number of species)	3			3			7		
Abundance (Mean percentage cover)	51.8			5.8			187.0		
Diversity (Shannon Index)	0.18			0.48			1.25		

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

Figure 6 below shows that the community present predictably groups quadrats very strongly by shore height, and the groupings confirm that the individual sampling locations selected at each shore height are representative of each other.



The NMDS plot (right) shows the 6 replicate samples at each of three shore heights and is based on Bray Curtis dissimilarity and square root transformed data. The approach involves multivariate data analysis methods, in this case non-metric multidimensional scaling (NMDS) using PRIMER version 6.1.10. The analysis basically plots the site, year 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 good a representation it is of 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. NMDS plot showing the relationship among samples in terms of similarity in community composition for Waipapa Point rocky shore quadrats, Feb. 2011.

3. Results and Discussion (Continued)

Table 5. Raw data, mean number or percentage cover, standard error, and SACFOR rating of mobile invertebrates, sessile invertebrates, and macroalgae present in high, mid, and low shore quadrats, Waipapa Point, 2011.

High Shore Quadrat Data

H 2011	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	1	2	7				1.7	1.3	O
	Diloma aethiops	Grooved topshell	#	ii	1	12					2.2	3.2	O
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii		2		2			0.7	0.0	O
	Cellana strigilis redmiculum	Striated limpet	#	ii	10	23	13	7	5	6	10.7	2.7	C
Barnacles	*Elminius plicatus*	Ridged surf barnacle	%	i			1				0.2		R
Red Algae	*Apophlaea lyallii*	Rubber weed	%	ii		5	1				1.0	1.2	R
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii						5	0.8		R
	Stictosiphonia arbuscula	Moss weed	%	ii	30	30	60	90	50	40	50.0	9.3	S

Mid Shore Quadrat Data

M 2011	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Limpets	*Cellana ornata*	Ornate limpet	#	ii		1					0.2		O
	Cellana radians	Tortoiseshell limpet	#	ii		1	2	12			2.5	2.5	F
	Cellana strigilis redmiculum	Striated limpet	#	ii				1	6	2	1.5	1.1	F
	Patellodia corticata	Encrusted slit limpet	#	ii	18	2	42	29			15.2	6.9	C
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	95	95	95	50	98	98	88.5	7.7	S
Red Algae	*Apophlaea lyallii*	Rubber weed	%	ii					1		0.2		R
	Corallina officinalis	Pink turf	%	ii			3	1			0.7	0.6	R
	Lithothamnion sp.	Pink/white paint	%	i				30			5.0		R

Low Shore Quadrat Data

L 2011	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	*Buccinulum lineum*	Lined whelk	#	i				1			0.2		R
	Diloma aethiops	Grooved topshell	#	ii					4		0.7		R
	Turbo smaragdus	Cats eye	#	ii			1				0.2		R
Limpets	*Benhamina obliquata*	Large siphon limpet	#	ii			1	2		1	0.7	0.2	O
	Patellodia corticata	Encrusted slit limpet	#	ii	22	3	5	3	4	3	6.7	3.1	C
Chitons	*Amaurochiton glaucus*	Blue-green chiton	#	ii		1					0.2		O
	Maorichiton caelata	Kelp chiton	#	ii	1						0.2		F
	Sypharochiton pelliserpentis	Snake's skin chiton	#	ii	12	1				2	2.5	2.5	F
Brown Algae	*Durvillaea antarctica*	Bull kelp	%	ii	50	100	100	85	90	95	86.7	7.7	S
	Ralfsia verrucosa	Tar spot/blood crust	%	i			0.5				0.1		R
	Xiphophora gladiata	Strap weed	%	ii		3	5	3			1.8	0.5	O
Green Algae	*Codium convolutum*	Encrusting velvet	%	i	5	3	0.5	3			1.9	0.8	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	50	50	60	80	40	85	60.8	7.4	S
	Corallina polymorphum	Pink globules	%	i	20	20	10		10	2	10.3	3.1	F
	Lithothamnion sp.	Pink/white paint	%	i	30	30	30	2	40	20	25.3	5.3	C

3. Results and Discussion (Continued)

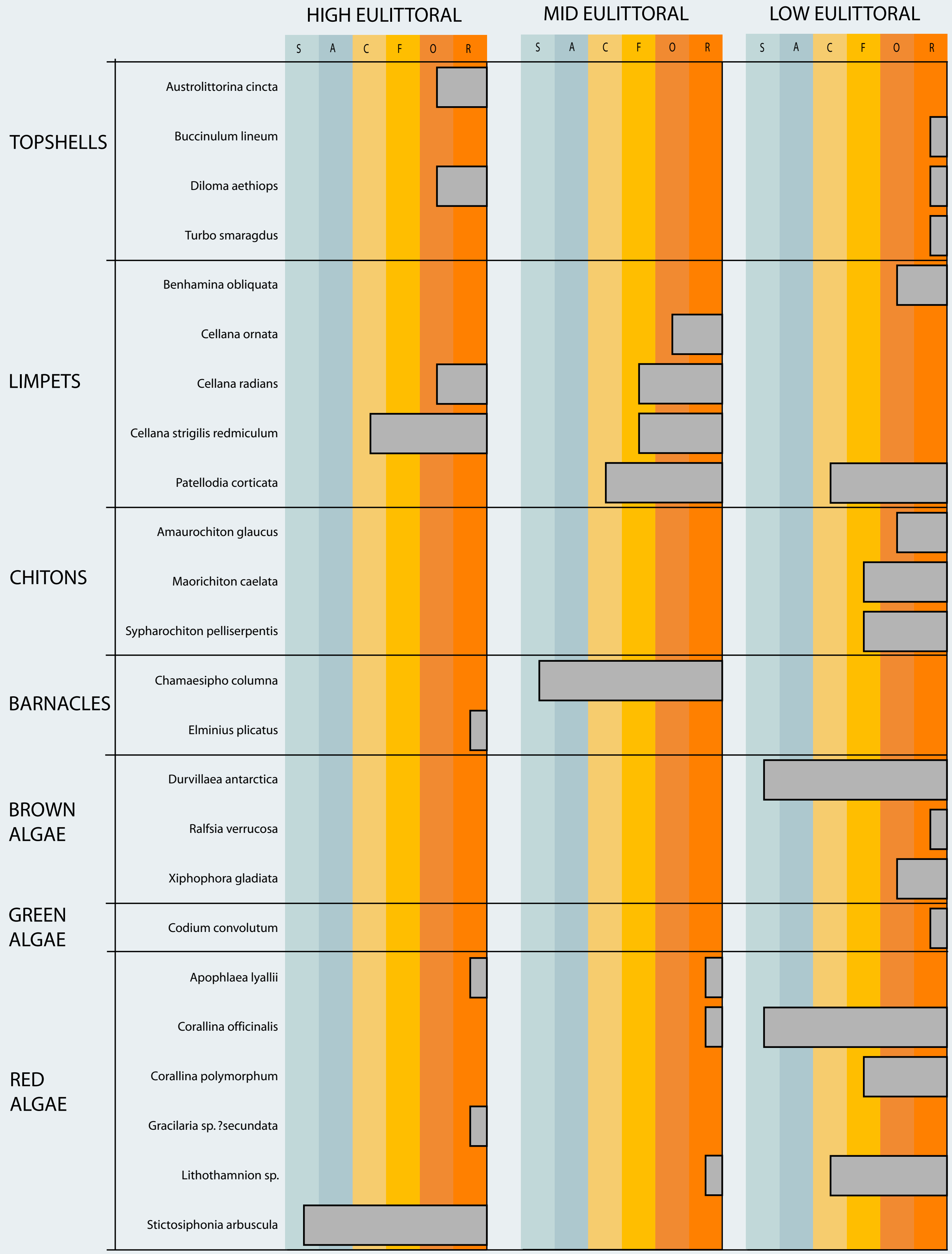
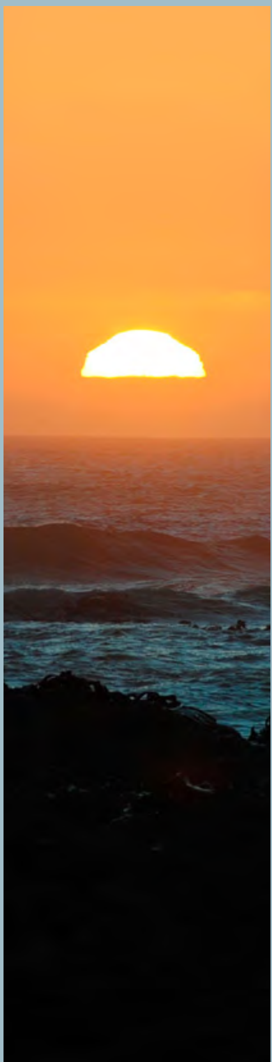


Figure 7. Mean SACFOR rating for species present in 6 fixed quadrats in high, mid and low eulittoral zones.

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, 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 Waipapa Point 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.

As the baseline monitoring continues it is intended to use the monitoring results to develop condition ratings to characterise the status of the shore, something not previously 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 in 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 Waipapa Point 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 intertidal high shore community, dominated by the red algae *Stictosiphonia arbuscula*, 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 giant southern bull kelp *Durvillaea antarctica.*

Over the scheduled 3-4 years of baseline monitoring, condition ratings will be developed to characterise the status of the shore.

5. MONITORING

Waipapa Point has been identified by Environment Southland as a priority for monitoring the effects of predicted accelerated sea level rise and temperature change, 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 Waipapa Point in February 2012. After the 3-4 year baseline is established, reduce monitoring to 5 yearly intervals or as deemed necessary based on rocky shore condition ratings (to be developed).
- Identify monitoring sites at one other representative location on the Southland coast (e.g. West of Cosy Nook), and initiate baseline monitoring in 2012.

6. ACKNOWLEDGEMENTS

This survey and report has been undertaken with the help and support of Greg Larkin (Coastal Scientist, Environment Southland).

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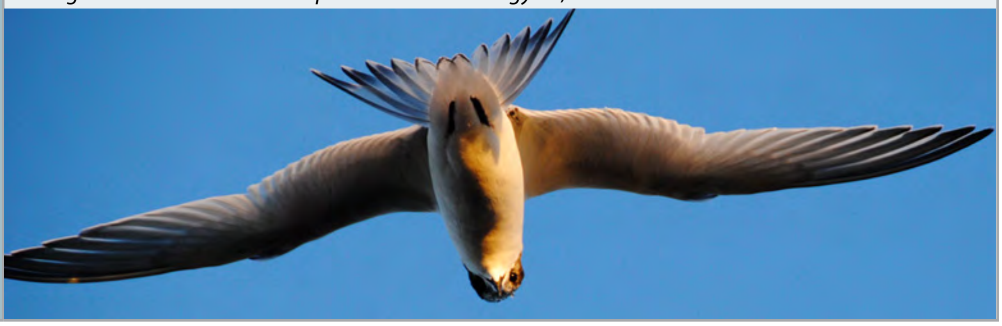
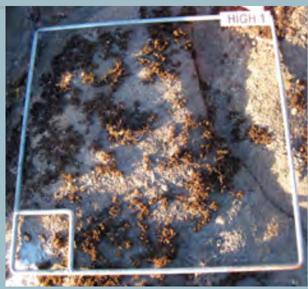
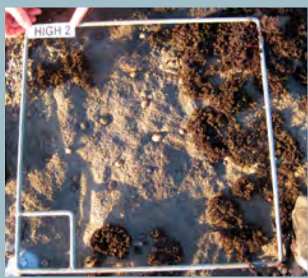
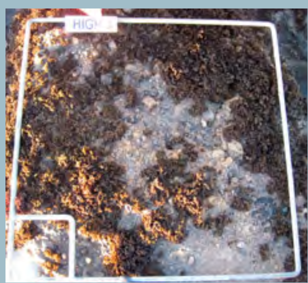
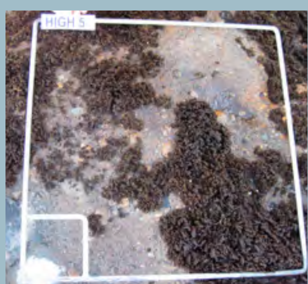
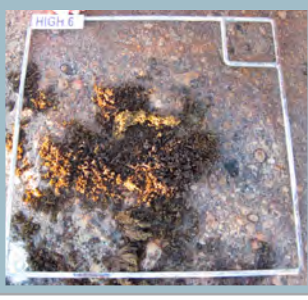
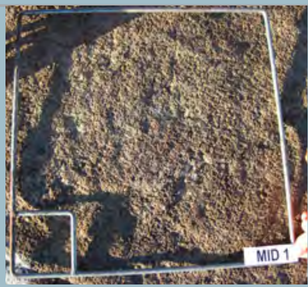
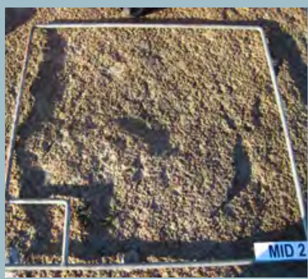
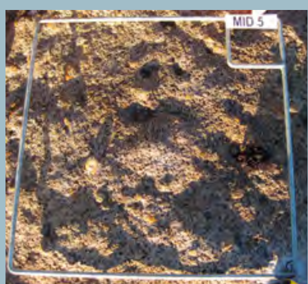


APPENDIX 1. DETAILED RESULTS

High Eulittoral	2011	2012	2013
QUADRAT 1 NZTM 1281993 East NZTM 4824673 North			
QUADRAT 2 NZTM 1281992 East NZTM 4824675 North			
QUADRAT 3 NZTM 1281986 East NZTM 4824675 North			
QUADRAT 4 NZTM 1281983 East NZTM 4824677 North			
QUADRAT 5 NZTM 1281975 East NZTM 4824663 North			
QUADRAT 6 NZTM 1281973 East NZTM 4824664 North			

APPENDIX 1. DETAILED RESULTS (CONT.)

Mid Eulittoral	2011	2012	2013
QUADRAT 1 NZTM 1282001 East NZTM 4824688 North			
QUADRAT 2 NZTM 1281998 East NZTM 4824688 North			
QUADRAT 3 NZTM 1281985 East NZTM 4824688 North			
QUADRAT 4 NZTM 1281983 East NZTM 4824688 North			
QUADRAT 5 NZTM 1281977 East NZTM 4824672 North			
QUADRAT 6 NZTM 1281976 East NZTM 4824673 North			

Appendix 1. DETAILED RESULTS (CONT.)

Low Eulittoral	2011	2012	2013
QUADRAT 1 NZTM 1282000 East NZTM 4824694 North			
QUADRAT 2 NZTM 1281998 East NZTM 4824694 North			
QUADRAT 3 NZTM 1281987 East NZTM 4824694 North			
QUADRAT 4 NZTM 1281985 East NZTM 4824696 North			
QUADRAT 5 NZTM 1281980 East NZTM 4824676 North			
QUADRAT 6 NZTM 1281980 East NZTM 4824676 North