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coastalmanagement

Waipapa Point 2012

Fine Scale Rocky Shore Monitoring

Prepared for **Environment Southland**
December 2012

Cover Photo: Waipapa Point - Rock and boulder reef north of the lighthouse.
Inside cover: Waipapa Point - Coastal dune and seagrass beds between the rocky reef and the sandy shore north of the lighthouse.

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By

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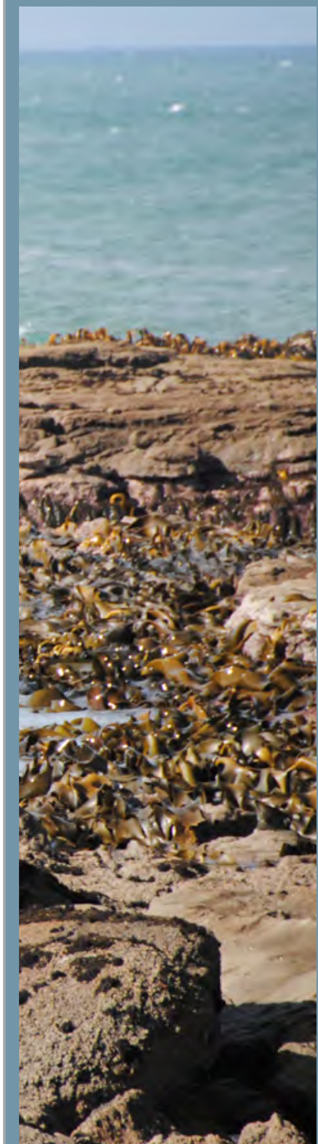
ROCKY SHORE - EXECUTIVE SUMMARY



This report summarises results of the second 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 the 2012 results of:

- 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

A total of 27 species were recorded from quadrats in 2011 and 2012, the fewest from the mid shore (8), then the high shore (12) and the most from the lower shore (17).

In 2012, high shore quadrats were dominated by the red algae *Stictosiphonia arbuscula* (40% cover), a 10% decrease since 2011 that is attributed to grazing.

Mid shore quadrats generally had low diversity, dominated by barnacles (87% cover in 2012). Mobile invertebrates (limpets, chitons) common to abundant, but there were no topshells present. Macroalgal cover was very low (<1% cover).

The low shore quadrats were dominated by a superabundant (~90%) cover of bull kelp (*Durvillaea antarctica),* providing shelter and refuge to a range of other species including limpets, chitons, calcareous red algae, and pink/white paint. Total algal cover exceeded 100% because of overlapping algal growth. Apart from *Durvillaea,* most other algae were relatively small, growing in the shelter of the bull kelp canopy and on kelp holdfasts. Topshells were not recorded from low shore quadrats, most likely due to the high wave exposure.

Few differences were observed between the two years of quadrat data indicating relatively stable conditions. Minor changes included increased high shore grazing of *S. arbuscula,* and the loss of a single *Durvillaea* plant from one low shore quadrat.

ROCKY SHORE ISSUES AND CONDITION

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

The first two years 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

Continue annual sampling at Waipapa Point to establish a 3-4 year baseline (next scheduled monitoring is Jan/Feb 2013), then at 5 yearly intervals, or as deemed necessary based on rocky shore condition ratings (to be developed).

When combined with the linked monitoring being undertaken at Stirling Point and the proposed site west of Cosy Nook, this will enable large scale changes to rocky shore conditions, particularly those associated with predicted accelerated sea level rise and temperature and pH changes, to be assessed.

To help ES interpret future changes it is also intended to develop condition ratings to characterise the status of the shore once the rocky shore baselines are completed. The development of condition ratings that focus 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, is an essential part of effective management, and particularly as any landuse intensification will increase the current low risk.

1. INTRODUCTION

OVERVIEW

Waipapa Point

↓

Vulnerability Assessment
Identifies issues and recommends monitoring and management. Completed in 2008 (Robertson and Stevens 2008)

↓

Waipapa Point Issues
Climate change effects of sea level rise and temperature
Introduced invasive species
Over-collection of shellfish

↓

Monitoring

Broad Scale Mapping
Sediment type
Saltmarsh
Seagrass
Macroalgae
Land margin

5 -10 yearly
First undertaken in 2008.

Fine Scale Monitoring
Semi-quantative SACFOR
Intertidal fixed quadrats

3-4yr Baseline then 5 yearly
Baseline started 2011, 2012.
Next survey 2013.

↓

Condition Ratings
to be developed

Other Information
Previous reports,
Observations,
Expert opinion

↓

ROCKY SHORE CONDITION
Healthy and unpolluted
Low Eutrophication
Low Sedimentation
Low Toxicity

↓

Recommended Management

- Develop condition ratings.
- Manage for sea level rise.
- Manage for introduced invasive species.

Developing an understanding of the condition and risks to coastal habitats is critical to the management of biological resources. 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, elevated temperature and pH, 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, sediment, 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 Cosy Nook will commence in 2013. 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 sediment 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 and pH, 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. Airoldi et al. 2005) from disruption to natural predator-prey balances or loss of habitat-maintaining species. For example, some popular recreational fish species (e.g. greenbone, red moki) play an important role in maintaining algal habitat and depletion of these species can cause significant changes in community structure (e.g. Taylor and Schiel 2010). Macroalgal harvesting can remove protective habitat, resulting in species loss and greater exposure to natural disturbances. Impacts are expected from recreational activities (e.g. algal trampling) and over-collection at both local and regional scales, and is likely to intensify as expanding human populations put further pressure on resources.

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. Airoldi 2003, Foster and Schiel 2010). Sheltered rocky shore habitats, e.g. rockpools, are more susceptible to direct deposition and reduced sediment oxygenation. Generally high wave energy on the open coast will favour offshore sediment settlement over intertidal deposition. Increased sedimentation is likely to reduce biodiversity through lowered productivity and recruitment success, and reduced ability to recover from disturbances. Human values and uses will be reduced directly by poor clarity (swimming/diving), and indirectly through biodiversity changes.

4. Eutrophication.

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

5. Toxic Contamination.

If potentially toxic contaminant inputs (e.g. heavy metals, pesticides) are excessive, shoreline biodiversity is threatened and shellfish may be unsuitable for eating. Except for large-scale infrequent discharges such as oil spills, pollution tends mainly to influence embayed coastlines or areas immediately adjacent to outfalls. Increased toxins are unlikely to be a significant issue 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, 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 second 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.

1. Introduction (Continued)

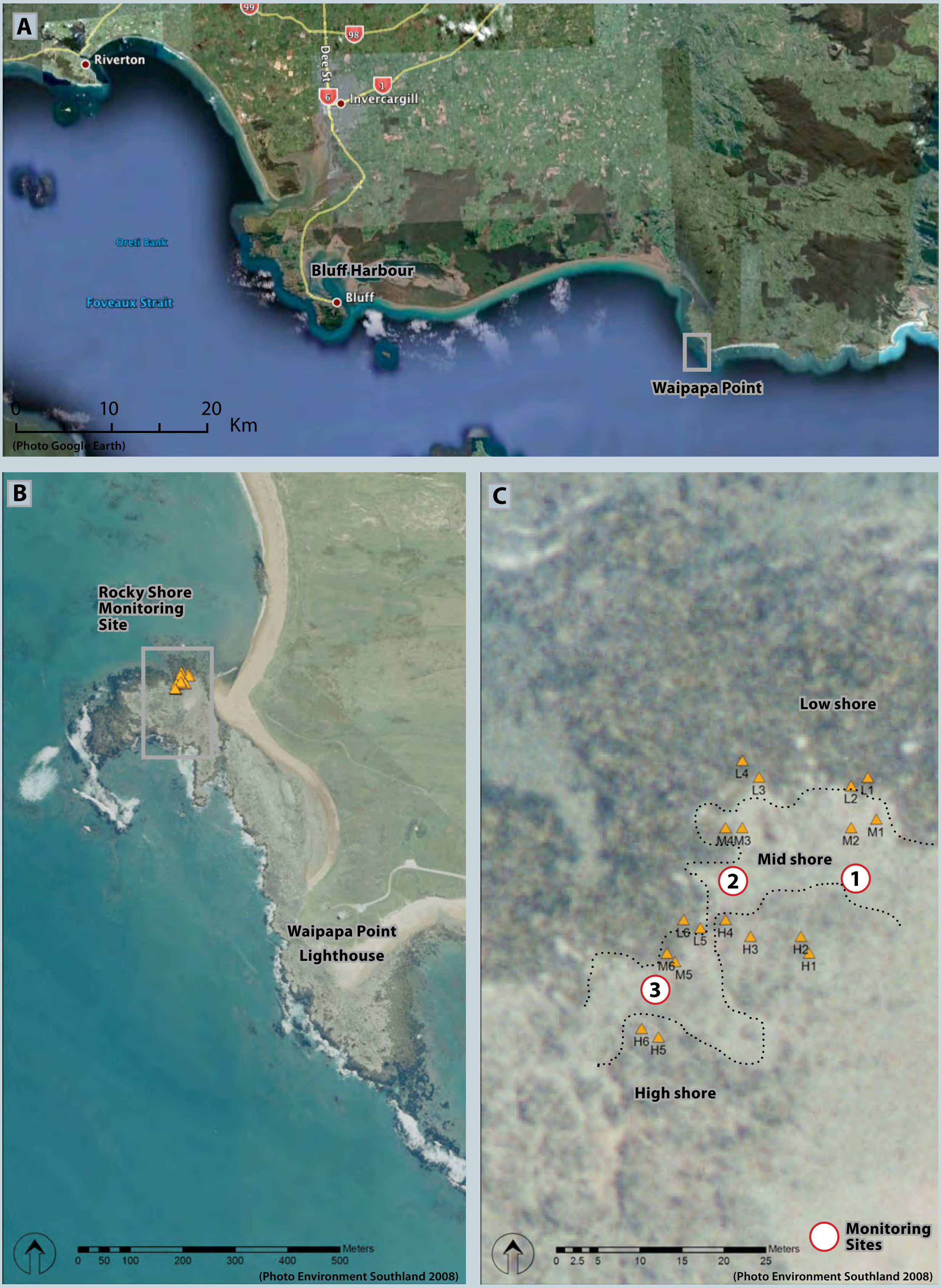


Figure 1. Location of rocky shore sampling sites at Waipapa Point.

2. METHODS

Figure 2. Position of fixed intertidal quadrats at Site 1 showing general shoreline zonation.

The methodology is based on a two part approach used in the UK MarClim - Marine Biodiversity and Climate Change Project (MNCR 1990, Hiscock 1996, 1998). At Waipapa Point in 2011 this involved:

1. A semi-quantitative assessment to develop a checklist of the species present, record their relative abundance across a representative sampling area, and guide the selection of 18 fixed intertidal quadrats within 3 eulittoral tide levels (High, Mid, and Low) in the spatially largest strata at the site (moderately sloping bedrock).
2. Establishment of 18 fixed 0.25m^2 quadrats in areas with attached plants or animals, and recording the abundance and diversity of plants and animals within each (the change to these features being the primary focus of the monitoring). Quadrats were located at sites sheltered from the direct effect of prevailing wind and waves to facilitate safe sampling.

Full details of the methods and results of the 2011 sampling are presented in Stevens and Robertson (2011). In 2012, two scientists re-sampled the fixed quadrats in the second year of the 3-4 year baseline monitoring period during relatively calm sea conditions on 24/25 January 2012.

After relocation of each marked quadrat, information was recorded on the following:

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 greater than 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 greater than 10mm) in each 0.25m^2 quadrat.
- Number of each species of snail >5mm in the 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 limpets or chiton (individuals greater than 10mm) in each 0.25m^2 quadrat.
- Number of each species of snail >5mm in the 0.25m^2 quadrat.

SACFOR rating categories were derived as described in Table 2 based on the percentage cover or density of plants or animals. The SACFOR assessment preferentially uses the 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.

2. Methods (Continued)

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

Figure 3. Shoreline position of the fixed mid tide and low tide quadrats at Site 3.

3. RESULTS AND DISCUSSION

Figure 4. *Stictosiphonia arbuscula* near the high tide line.

*The Shannon index is widely used for comparing diversity by relating the number and evenness of the species present - the more species and the greater the evenness, the higher the index. If practically all abundance is present in one species, and the other species are very rare (even if there are many of them), Shannon index values approach zero. Index values typically fall between 1.5 and 3.5, and only rarely surpass 4.5

Results of the 24/25 January 2012 Waipapa Point rocky shore monitoring are summarised in the following section (see Tables 3 and 4, Figures 5 and 7), with raw data and 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, pH or clarity) associated with climate change, and to evaluate impacts from introduced species, over-collection of shellfish (e.g. paua, mussels), and from infrequent risks such as oil spills.

Table 3 summarises richness, abundance and diversity measures for the three shore heights in 2011 and 2012. A total of 27 species have been recorded over 2 years from the fixed quadrat sites, the fewest from the mid shore (8), then the high shore (12) and the most from the lower shore (17) (Table 4). This only reflects species richness 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 3. 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, 2012.

Category	High Shore			Mid Shore			Low Shore		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
Total number of species	8	10		8	6		15	10	
MOBILE INVERTEBRATES (topshells, limpets, chitons)									
Richness (Number of species)	4	4		4	4		7	3	
Abundance (Mean number of individuals)	15.2	17.7		19.3	39.7		8.7	6.8	
Diversity (Shannon Index)*	0.63	1.07		0.69	0.56		0.87	0.76	
SESSILE INVERTEBRATES (barnacles, mussels)									
Richness (Number of species)	1	2		1	1		1	1	
Abundance (Mean percentage cover)	0.2	5.3		88.5	86.7		2.5	0.2	
Diversity (Shannon Index)*	0.00	0.00		0.00	0.00		0.00	0.00	
MACROALGAE									
Richness (Number of species)	3	4		3	1		7	8	
Abundance (Mean percentage cover)	51.8	41.8		5.8	0.3		187.0	176.4	
Diversity (Shannon Index)*	0.18	0.21		0.48	0.00		1.25	1.37	
UNVEGETATED									
Bare Rock (Mean percentage cover)	48.3	61.7		11.5	11.5		5.0	8.3	

Note: Low shore macroalgal percent cover values exceed 100% because of overlapping algal growth. The Shannon Index values of zero for sessile invertebrates above arise because of the low number of species present, indicating the community composition is highly predictable.

Figure 5 presents the results of a multivariate analysis which shows the relationship between all the individual quadrats sampled over the first two years of baseline monitoring. The results, show the quadrats group strongly by shore height, and the groupings confirm that the individual sampling locations selected at each shore height are representative of each other. Within these groupings, minor changes in community structure are evident from 2011 to 2012 reflecting both small shifts in the abundance of mobile species, combined with changes in algal cover, primarily by grazing (e.g. Figures 6 and 7).

3. Results and Discussion (Continued)

Table 4. Summary 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, 2012.

HIGH	Scientific name	Common Name	Unit	2011		2012		2013		2011	2012	2013
				Mean	SE	Mean	SE	Mean	SE	SACFOR RATING		
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	1.7	1.3	-	-			O		
	Dicthais orbita	White rock shell	#	-	-	1.3	0.8				O	
	Diloma aethiops	Grooved topshell	#	2.2	3.2	-	-			O		
Limpets	*Cellana radians*	Tortoiseshell limpet	#	0.7	0.0	6.3	3.0			O	C	
	Cellana strigilis redmiculum	Striated limpet	#	10.7	2.7	7.2	3.2			C	C	
	Patellodia corticata	Encrusted slit limpet	#	-	-	2.8	0.7				O	
Chitons	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	-	-	0.2	-				O	
Barnacles	*Elminius plicatus*	Ridged surf barnacle	%	0.2		5.2	1.8			R	O	
Brown Algae	*Splachnidium rugosum*	Gummy weed	%	-	-	0.2	-				R	
Red Algae	*Apophlaea lyallii*	Rubber weed	%	1.0	1.2	0.3	0.0			R	R	
	Gracilaria sp. ?secundata	Gracilaria weed	%	0.8	-	1.3	0.8			R	O	
	Stictosiphonia arbuscula	Moss weed	%	50.0	9.3	40.0	6.8			S	A	

MID	Scientific name	Common Name	Unit	2011		2012		2013		2011	2012	2013
				Mean	SE	Mean	SE	Mean	SE	SACFOR RATING		
Limpets	*Cellana ornata*	Ornate limpet	#	0.2		0.2	-			O	O	
	Cellana radians	Tortoiseshell limpet	#	2.5	2.5	8.2	4.5			F	C	
	Cellana strigilis redmiculum	Striated limpet	#	1.5	1.1	0.2	-			F	O	
	Patellodia corticata	Encrusted slit limpet	#	15.2	6.9	31.2	16.2			C	A	
Barnacles	*Chamaesipho columna*	Column barnacle	%	88.5	7.7	86.7	7.4			S	S	
Red Algae	*Apophlaea lyallii*	Rubber weed	%	0.2	-	0.3	0.0			R	R	
	Corallina officinalis	Pink turf	%	0.7	0.6	-	-			R		
	Lithothamnion sp.	Pink/white paint	%	5.0	-	-	-			R		

LOW	Scientific name	Common Name	Unit	2011		2012		2013		2011	2012	2013
				Mean	SE	Mean	SE	Mean	SE	SACFOR RATING		
Topshells	*Buccinulum lineum*	Lined whelk	#	0.2	-	-	-			R		
	Diloma aethiops	Grooved topshell	#	0.7	-	-	-			R		
	Turbo smaragdus	Cats eye	#	0.2	-	-	-			R		
Limpets	*Benhamina obliquata*	Large siphon limpet	#	0.7	0.2	-	-			O		
	Cellana radians	Tortoiseshell limpet	#	-	-	2.0	0.6				F	
	Patellodia corticata	Encrusted slit limpet	#	6.7	3.1	4.2	1.5			C	C	
Chitons	*Amaurochiton glaucus*	Blue-green chiton	#	0.2	-	-	-			O		
	Plaxiphora caelata	Kelp chiton	#	0.2	-	0.7	0.0			F	F	
	Sypharochiton pelliserpentis	Snake's skin chiton	#	2.5	2.5	0.2	-			F	O	
Brown Algae	*Durvillaea antarctica*	Bull kelp	%	86.7	7.7	89.2	8.2			S	S	
	Ralfsia verrucosa	Tar spot/blood crust	%	0.1		0.3	--			R	R	
	Xiphophora gladiata	Strap weed	%	1.8	0.5	5.1	1.2			O	F	
Green Algae	*Codium convolutum*	Encrusting velvet	%	1.9	0.8	3.5	1.5			R	R	
Red Algae	*Corallina officinalis*	Pink turf	%	60.8	7.4	45.8	11.6			S	S	
	Corallina polymorphum	Pink globules	%	10.3	3.1	14.2	7.2			F	F	
	Gigartina spp.	Agar weed	%	-	-	3.3	0.8				O	
	Lithothamnion sp.	Pink/white paint	%	25.3	5.3	15.0	5.5			C	F	

3. Results and Discussion (Continued)

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.

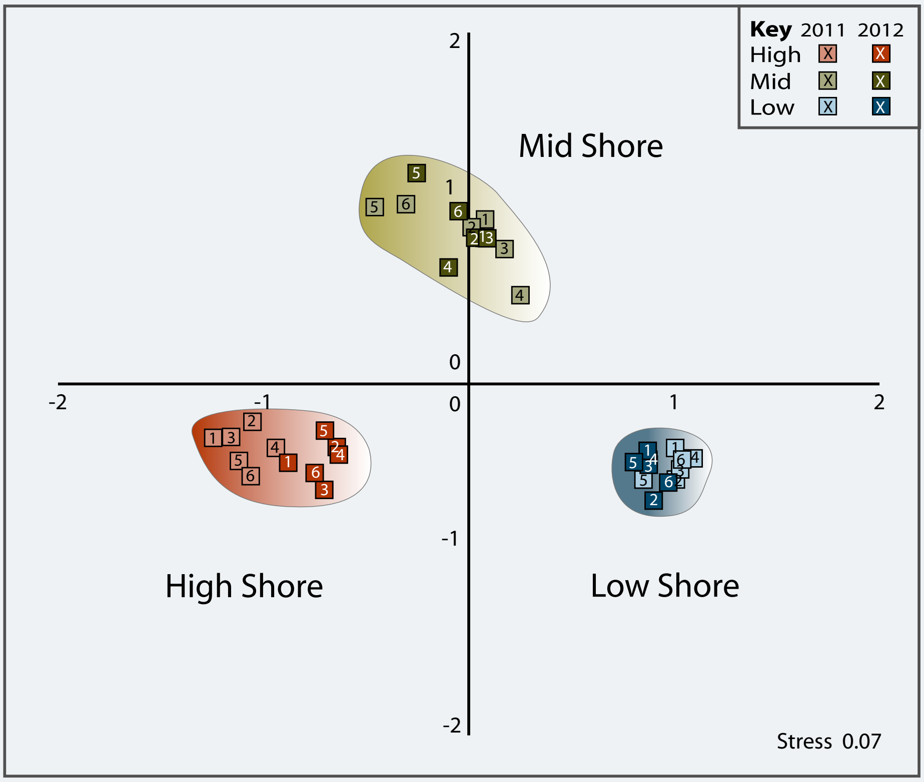


Figure 5. NMDS plot showing the relationship among samples in terms of similarity in community composition for Waipapa Point rocky shore quadrats, Feb. 2011 and Jan. 2012.

As found in the inaugural year of monitoring (see Stevens and Robertson 2011), the high shore quadrats in 2012 were characterised by extensive patches of bare rock that supported a relatively sparse community. The dominant species remained the red algae *Stictosiphonia arbuscula* (Figures 4 and 6), 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 common and the barnacle *Elminius plicatus* was rated occasional/rare. The small differences in quadrats from 2011 to 2012 are due to the reduced cover of *Stictosiphonia arbuscula* from grazing (see Figure 5), and a minor change in the composition of topshells and limpets present.

Cellana strigilis redmiculum
Striated limpet

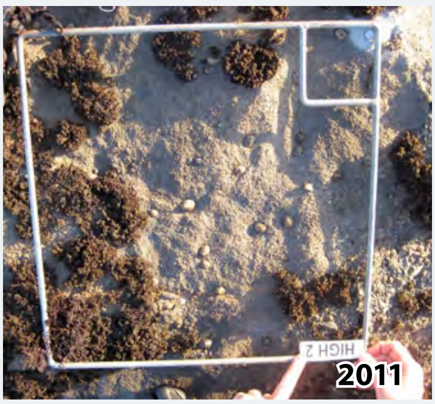


Figure 6. High tide quadrat 2 in 2011 (left), and 2012 (right) showing reduced cover of *Stictosiphonia arbuscula* as a result of grazing.

3. Results and Discussion (Continued)

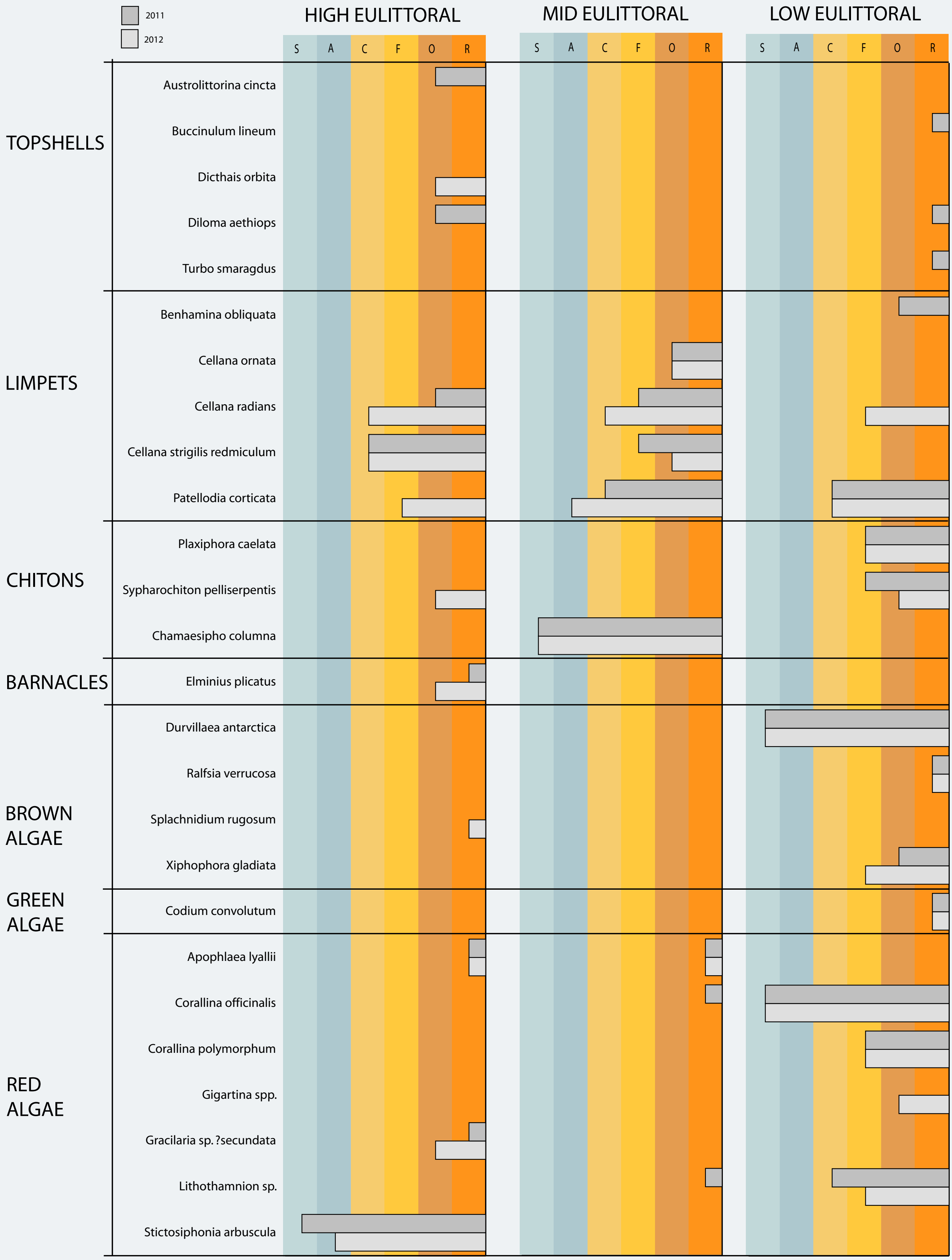


Figure 7. Mean SACFOR rating for species present in 6 fixed quadrats in high, mid and low eulittoral zones.

3. Results and Discussion (Continued)

Chamaesipho columna* and *Cellana strigilis redmiculum

The mid shore sites were 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 sidebar photo).

Limpets were the most common of the mobile invertebrates with *Cellana radians, C. ornata* and *C. strigilis redmiculum* common/occasional and *Patellodia corticata* abundant. No topshells were recorded from the midshore quadrats but were evident on the shore at this height sheltering in crevices and under boulders. Macroalgae were rare and only represented by *Apoplea lyallii* in 2012.

Mid shore quadrats 1, 2, and 3 remain very tightly grouped (Figure 5), with minor separation evident in quadrats 4, 5 and 6. This is not significant and reflects differences in barnacle cover combined with the low diversity within the quadrats. There was no significant change between quadrats over the first 2 years of monitoring.

At the low shore, all sites and quadrats were very tightly grouped (Figure 5) and have changed very little from 2011 to 2012 (Figure 7). Sites are 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. Despite the loss of a *D. antarctica* plant from quadrat 5 (see Appendix 1 photos) there was no appreciable change in the canopy due the overlapping cover of surrounding plants. There was an increase in the bare rock exposed following the loss of the holdfast but this is expected to be quickly recolonised.

Several other algal species (e.g Figure 8) were also present beneath the dominant canopy e.g. *Lithothamnion, Corallina polymorphum* and *Xiphophora gladiata* - frequent, *Gigatina* - occasional, and *Ralfsia verrucosa* and *Codium convolutum* - rare.

In 2012, topshells were absent from the quadrats, but present on the shoreline, with the dominant grazers being limpets (e.g. *Cellana radians, Patelloida corticata*) and chitons (e.g. *Sypharochiton pelliserpentis, Plaxiphora (Maorichiton) caelata, Amaurochiton glaucus*) that have a strong ability to cling to the rocks. These were rated common to occasional (Figure 7).

Figure 8. Example of the range of algal species present under the dominant bull kelp canopy in the low tide quadrats.

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, pH, 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 (e.g. 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 are a key environmental indicator. They 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 sediment, 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 first two years of baseline monitoring indicate Waipapa Point supports a healthy and unpolluted rocky shore community. The risk from pathogens, sediment, eutrophication, and toxins is considered low, while a low-moderate risk is present based on predicted accelerated sea level rise and temperature/pH change. Because global stressors such as climate change will place the entire coastal community under increasing pressure (IPCC 2007), and will increase vulnerability to other stressors such as landuse intensification, ongoing monitoring of change is essential. The baseline being established, in conjunction with rocky shore monitoring at the Stirling Point and Cosy Nook sites, will provide a pragmatic and robust way of monitoring such changes.

In addition, the scheduled 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, and it will provide an invaluable benchmark for assessing the possible impacts from infrequent events such as oil spills or toxic algal blooms should they occur.

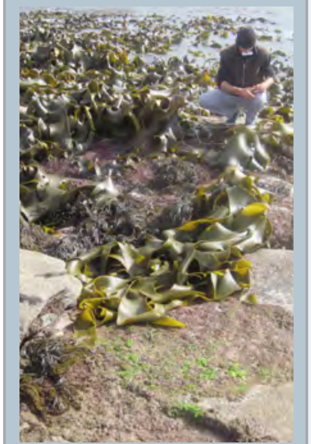
To help ES interpret future changes it is also intended to develop condition ratings to characterise the status of the shore once the rocky shore baselines are completed. This is something not previously attempted in NZ because current scientific knowledge of many NZ rocky shore species is scarce or incomplete. However, the development of condition ratings that focus 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, is an essential part of effective management, particularly as any landuse intensification will increase the current low risk.

4. CONCLUSION

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

The first two years of baseline monitoring indicates the Waipapa Point coastline is in a healthy and unpolluted condition. No introduced invasive species were seen, and there was no indication of excessive nutrient or sediment inputs. Completion of the baseline will establish a robust measure of natural variation against which any future changes can be assessed.

5. MONITORING



Waipapa Point has been identified by Environment Southland as a priority for monitoring the effects of predicted accelerated sea level rise, temperature and pH change, over-collection of living resources, the introduction of invasive species (such as *Undaria*), and impacts from excessive sediment, eutrophication, pathogens and toxins. It is recommended that monitoring continue as outlined below:

Rocky Shore Monitoring:

- Continue annual sampling at Waipapa Point to establish a 3-4 year baseline. The next scheduled monitoring is Jan/Feb 2013. After the baseline is established, monitor rocky shore ecology at 5 yearly intervals, or as deemed necessary based on rocky shore condition ratings (to be developed).
- Develop rocky shore condition ratings to assist in management decisions following completion of the baseline sampling at Waipapa Point and Cosy Nook (baseline sampling scheduled for completion in 2015).

6. ACKNOWLEDGEMENTS

Many thanks to Nick Ward (Coastal Scientist, Environment Southland), and to Greg Larkin (Technical Consultant to Environment Southland) for their review of this report.

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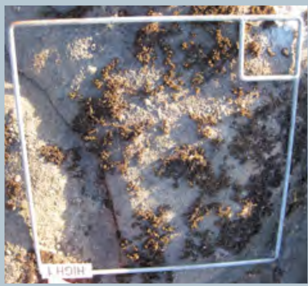
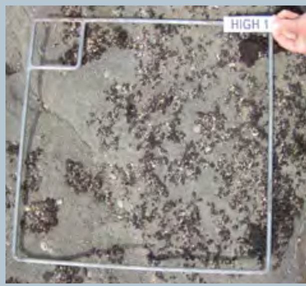
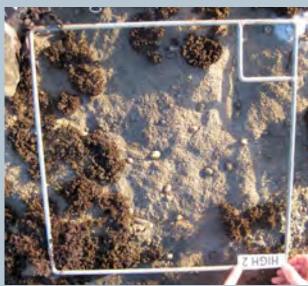
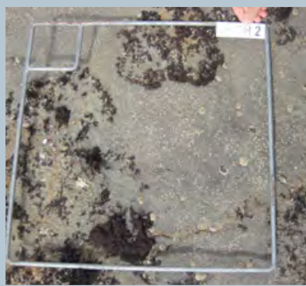
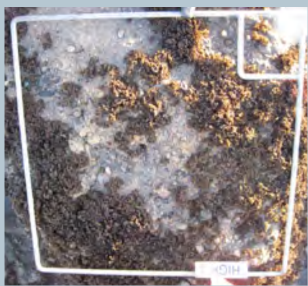
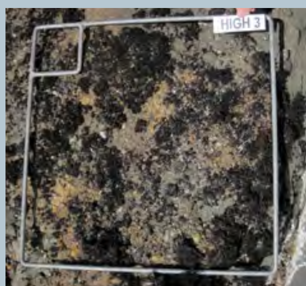
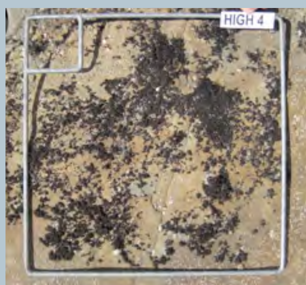
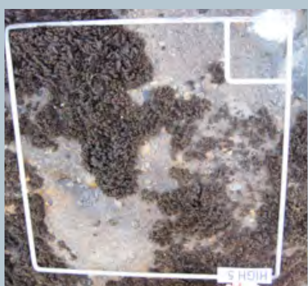
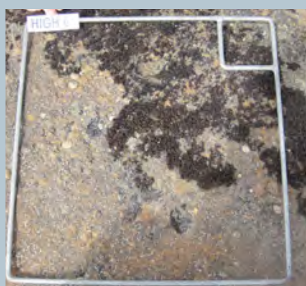
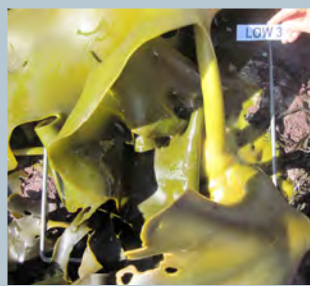
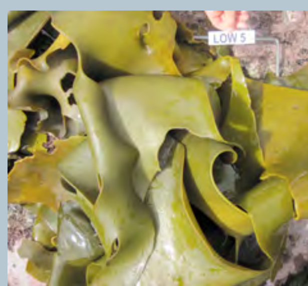
APPENDIX 1. DETAILED RESULTS

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 understory	2012 canopy
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			

APPENDIX 1. DETAILED RESULTS (CONT.)

2012 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.

High Shore Quadrat Data

H 2012	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	*Dicthais orbita*	White rock shell	#	ii	1		5	1		1	1.3	0.8	O
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	4	18		13	3		6.3	3.0	C
	Cellana strigilis redmiculum	Striated limpet	#	ii	9	22	3	2	1	6	7.2	3.2	C
	Patellodia corticata	Encrusted slit limpet	#	ii		4	2	6	2	3	2.8	0.7	O
Chitons	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	ii			1				0.2	-	O
Barnacles	*Elminius plicatus*	Ridged surf barnacle	%	i		10	1	10		10	5.2	1.8	O
Brown Algae	*Splachnidium rugosum*	Gummy weed	%	ii				1			0.2	-	R
Red Algae	*Apophlaea lyallii*	Rubber weed	%	ii		1	1				0.3	0.0	R
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii	1	5	2				1.3	0.8	O
	Stictosiphonia arbuscula	Moss weed	%	ii	40	10	60	50	40	40	40.0	6.8	A

Mid Shore Quadrat Data

M 2012	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	4	6	11	28			8.2	4.5	C
	Cellana strigilis redmiculum	Striated limpet	#	ii				1			0.2	-	O
	Patellodia corticata	Encrusted slit limpet	#	ii	45	7	101	32		2	31.2	16.2	A
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	95	95	90	50	95	95	86.7	7.4	S
Red Algae	*Apophlaea lyallii*	Rubber weed	%	ii					1	1	0.3	0.0	R

Low Shore Quadrat Data

L 2012	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	2	2	1	2	5		2.0	0.6	F
	Patellodia corticata	Encrusted slit limpet	#	ii	2		6	11	3	3	4.2	1.5	C
Chitons	*Plaxiphora caelata*	Kelp chiton	#	ii		2				2	0.7	0.0	F
	Sypharochiton pelliserpentis	Snake's skin chiton	#	ii			1				0.2		O
Brown Algae	*Durvillaea antarctica*	Bull kelp	%	ii	50	100	100	85	100	100	89.2	8.2	S
	Ralfsia verrucosa	Tar spot/blood crust	%	i					2		0.3		R
	Xiphophora gladiata	Strap weed	%	ii	5	10	5	5	0.5	5	5.1	1.2	F
Green Algae	*Codium convolutum*	Encrusting velvet	%	i	10	5	5	1			3.5	1.5	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	40	20	40	80	15	80	45.8	11.6	S
	Corallina polymorphum	Pink globules	%	i	5	50	10	5	5	10	14.2	7.2	F
	Gigartina spp.	Agar weed	%	ii	5	2	5	1	2	5	3.3	0.8	O
	Lithothamnion sp.	Pink/white paint	%	i	20	10	5	10	40	5	15.0	5.5	F

APPENDIX 1. DETAILED RESULTS (CONT.)

2011 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.

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
	Plaxiphora 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

APPENDIX 1. DETAILED RESULTS (CONT.)

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