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Stirling Point 2012

Fine Scale Rocky Shore Monitoring

Prepared for
Environment Southland
December 2012

Cover Photo: Stirling Point - Ben Robertson sampling on the low shore at Site 2.
Inside cover: Stirling Point foreshore west of Site 1.

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By

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Contents

List of Figures

List of Tables

ROCKY SHORE - EXECUTIVE SUMMARY

This report summarises the results of the third year of fine scale baseline monitoring of the rocky shore community at Stirling Point near Bluff. The site is located on the southern coast and is 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 receives occasional flood flows from the Oreti and Aparima Rivers. 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, 2 quadrats each at High, Mid, and Low eulittoral (intertidal) levels at three sites.

FINE SCALE MONITORING RESULTS

A total of 25 species were recorded from quadrats in 2012, the fewest from the high shore (10), and the most in the middle (15) and lower shore (15).

In 2012, high shore quadrats were dominated by the red algae *Stictosiphonia arbuscula* (43% cover) and small brown periwinkles. Since 2010, algal cover had declined while periwinkle abundance had increased, indicating a likely grazing effect.

Mid shore quadrats generally had the highest diversity, dominated by barnacles (56% cover in 2012) but with relatively high abundances of mobile invertebrates (limpets, chitons, topshells), and small macroalgae. Macroalgal cover was patchy, with a low (8%) percentage cover.

The low shore was dominated by a superabundant (~70%) cover of bull kelp (*Durvillaea antarctica),* providing shelter and refuge to a range of other species including limpets, chitons, and 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 three 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, sedimentation, eutrophication, and toxins is considered low.

The three 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. The sampling has established a robust measure of natural variation against which any future changes can be assessed.

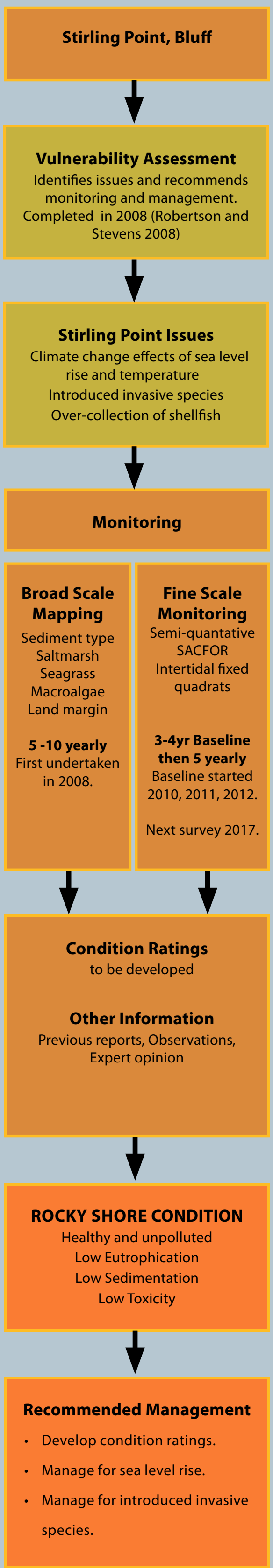
RECOMMENDED MONITORING AND MANAGEMENT

Following completion of the three year baseline it is recommended that rocky shore monitoring continue on a 5 yearly cycle, with the next monitoring scheduled for February 2017. When combined with the linked monitoring being undertaken at Waipapa 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



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.

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 year baseline of annual monitoring near Stirling Point, (Bluff) in February 2010, and 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. This includes 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 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 Stirling Point fine scale rocky shore intertidal monitoring site is located approximately 1km southwest of Stirling Point (Figure 1). The area is representative of the rocky shoreline on this part of the southern coast, and is characterised by the following:

- Hard igneous rocky shores comprising bluffs, cliffs, rock stacks and rocky bays.
- 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, the more nutrient rich Foveaux current, and occasional flood flows from the Oreti and Aparima Rivers.
- Dominated near low water by the giant southern bull kelp (*Durvillaea antarctica*) with mussels and barnacles common above the bull kelp zone.

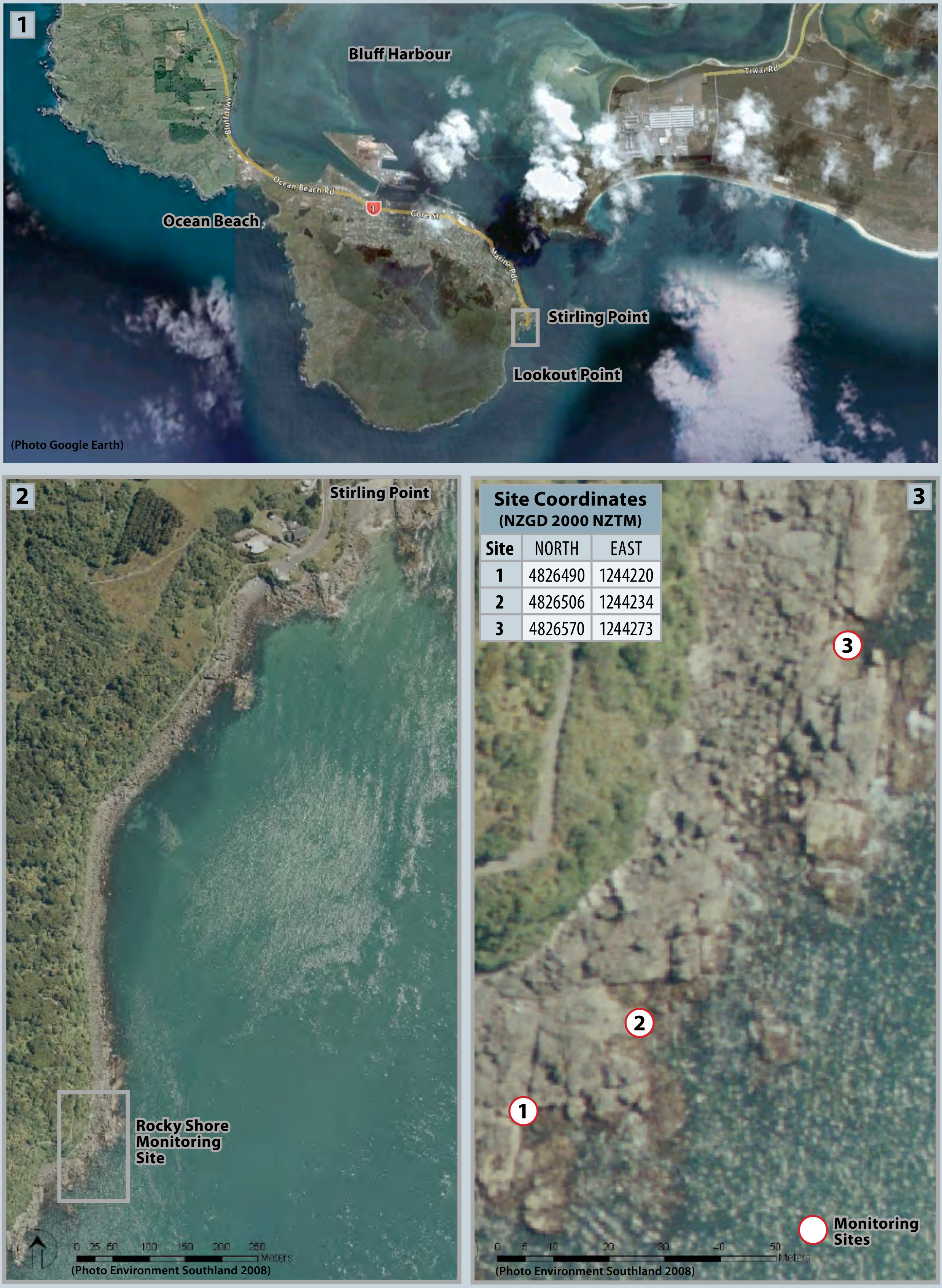
The site, which extends along ~100m of shore, has three separate areas with similar substrate, aspect, wave exposure, and tidal height. In these areas the abundance and diversity of conspicuous plants and animals in the supralittoral zone (the area regularly splashed, but not submerged, by seawater) and the eulittoral (intertidal) zone have been described (Stevens and Robertson 2010), and fixed replicate quadrats have been established at three intertidal shore heights. 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).

Importantly, 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 very popular for its scenic beauty and recreational activities. Although recreational fishers use the area (it is a highly valued recreational paua fishery), the monitoring sites are considered unlikely to be appreciably affected because quadrat locations are discretely marked (unlikely to be noticed), and are in areas on the shore where direct impacts are unlikely.

The wider area is an important tourist destination, while the coastline, and the seabed offshore forms part of the local rock lobster, oyster, and blue cod fishery. Occasional fur-seals may been seen on rock promontories or outcrops, along with yellow-eyed penguins at Lookout Point. Access to this part of coast is by foot (a popular walkway runs along the hillside between Stirling Point and Lookout Point), but access to the shoreline is generally difficult.

The current report describes the methods and results of the third year of rocky shore monitoring of fixed quadrats at Stirling Point, and includes recommendations on monitoring and management.

1. Introduction (Continued)



Site	NORTH	EAST
1	4826490	1244220
2	4826506	1244234
3	4826570	1244273

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

2. METHODS

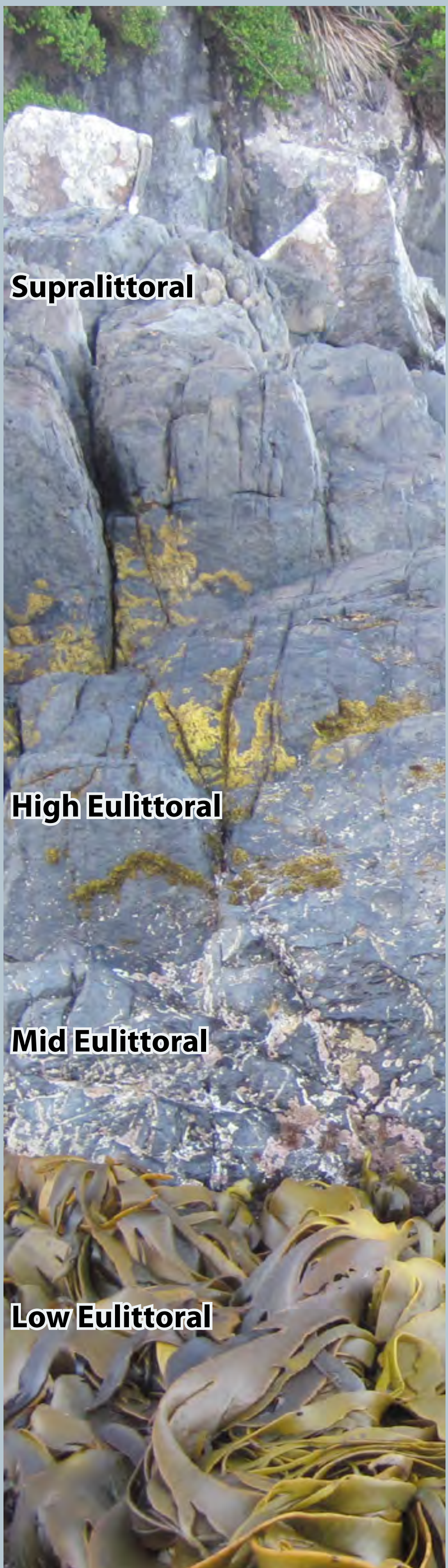


Figure 2. Example of general rocky shore zonation at Stirling Point.

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 Stirling Point in 2010 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 2010 sampling are presented in Stevens and Robertson (2010), and the 2011 sampling results in Stevens and Robertson (2011). In 2012, two scientists re-sampled the fixed quadrats in the final year of the three year baseline monitoring period during relatively calm sea conditions on 26/27 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	Growth Form	
	i. Crust/Meadow	ii. Massive/Turf
>80	S	-
40-79	A	S
20-39	C	A
10-19	F	C
5-9	O	F
1-4	R	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 of individuals/colonies			
i	ii	iii	iv				
<1cm	1-3cm	3-15cm	>15cm	No	Area Assessed	No/m^2	No/0.25m^2
S	-	-	-	>1	1x1cm (0.0001m^2)	>10,000	>2500
A	S	-	-	1-9	3.16x3.16cm (0.001m^2)	1000-9999	250-2500
C	A	S	-	1-9	10x10cm (0.01m^2)	100-999	25-249
F	C	A	S	1-9	31.6x31.6cm (0.1m^2)	10-99	1-9
O	F	C	A	1-9	100x100cm (1.0m^2)	1-9	-
R	O	F	C	1-9	3.16x3.16m (10m^2)	-	-
-	R	O	F	1-9	10x10m (100m^2)	-	-
-	-	R	O	1-9	31.6x31.6m (1,000m^2)	-	-
-	-	-	R	>1	100x100m (10,000m^2)	-	-

Figure 3. Shoreline position of the fixed intertidal quadrats at Site 2 .

3. RESULTS AND DISCUSSION

Figure 4. ***Stictosiphonia arbuscula*** **growing in the high eulittoral zone.**

Figure 5. The limpets ***Cellana radians*** **(top) and** ***C. strigilis redmiculum*** **(bottom).**

Figure 6. The barnacles ***Chamaeosipho columna*** **and the larger** ***Elminius plicatus*** **on bare rock in the high eulittoral zone.**

*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 26/27 January 2012 Stirling Point rocky shore monitoring are summarised in the following section (see Tables 3 and 4, Figure 11), 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, and from infrequent risks such as oil spills.

Table 3 summarises richness, abundance and diversity measures for the three shore heights in 2010, 2011 and 2012. A total of 31 species have been recorded over 3 years from the fixed quadrat sites, the fewest from the high shore (14), and the most in the middle (23) and lower shore (18) (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.

As with previously monitoring (see Stevens and Robertson 2010 and 2011), the high shore quadrats in 2012 were characterised by a relatively low diversity community, dominated by a ~40% cover of the red algae *Stictosiphonia arbuscula* (Figure 4). This algae forms dense bushy bands with often curled short hairy branchlets that helps it minimise dessication. Nestled within it, brown periwinkles were common-abundant, with relatively high numbers of small individuals. The larger herbivorous limpets *Cellana radians* and *C. strigilis redmiculum* (Figure 5) were occasional/frequent, (Table 4, Figure 11), with distinctive home patches carved into the rock where they can seal themselves in to protect against dessication when the tide is out during the heat of the day.

In the mid shore quadrats, the dominance shifts from algae to barnacles (50-60% cover) which filter-feed from the water column at high tide. The dominant species was *Chamaeosipho columna*, frequent in extensive sheets across the rock, while *Elminius plicatus* was common and comprised smaller colonies often nestled among the *Chamaeosipho* (Figure 6).

Table 3. Summary of richness, abundance and diversity indices for mobile invertebrates, sessile invertebrates, and macroalgae present in high, mid, and low shore quadrats, Stirling Point, 2010, 2011, and 2012.

Category	High Shore			Mid Shore			Low Shore		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Total number of species	11	10	10	22	17	15	18	15	14
MOBILE INVERTEBRATES (topshells, limpets, chitons)									
Richness (Number of species)	4	4	4	7	5	6	6	4	5
Abundance (Mean number of individuals)	236	807	1084	224	23	563	11	14	11
Diversity (Shannon Index)*	0.1	0.02	0.03	0.6	0.6	0.2	1.3	1.0	1.2
SESSILE INVERTEBRATES (barnacles, mussels)									
Richness (Number of species)	2	2	3	3	3	3	3	3	2
Abundance (Mean percentage cover)	2	2	3	53	53	57	6	6	6
Diversity (Shannon Index)*	0.7	0.7	0.9	0.7	0.7	0.7	0.6	0.5	0.5
MACROALGAE									
Richness (Number of species)	5	4	3	12	9	6	9	8	8
Abundance (Mean percentage cover)	72	65	45	13	15	8	153	132	123
Diversity (Shannon Index)*	0.1	0.2	0.1	1.5	1.4	0.9	1.1	1.2	1.3

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

Table 4. 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, Stirling Point, 2010, 2011, 2012.

Shore	Group	Scientific name	Common Name	Unit	2010		2011		2012		2010	2011	2012
					Mean	SE	Mean	SE	Mean	SE	SACFOR RATING		
HIGH SHORE	Topshells	*Austrolittorina antipodum*	Blue banded periwinkle	#	-	-	-	-	0.3	0.3	-	-	R
		Austrolittorina cincta	Brown periwinkle	#	230.0	65.4	804.2	464.0	1080.2	532.3	C	A	A
		Haustrum lacunosum	Rock whelk	#	2.3	0.5	-	-	0.2	0.2	O	-	R
	Limpets	*Cellana radians*	Tortoiseshell limpet	#	0.8	0.2	0.2	-	-	-	O	O	-
		Cellana strigilis redmiculum	Striated limpet	#	2.8	0.9	2.3	0.8	3.7	1.1	F	F	C
		Patellodia corticata	Encrusted slit limpet	#	-	-	0.2	-	-	-	-	O	-
	Barnacles	*Chamaesipho columna*	Column barnacle	%	0.8	0.5	1.1	0.9	1.9	1.0	R	R	R
		Elminius plicatus	Ridged surf barnacle	%	0.8	0.3	1.0	0.3	0.9	0.3	R	R	R
	Mussels	*Mytilus galloprovincialis*	Blue mussel	%	-		-	-	0.3	0.3	-	-	O
	Brown Algae	*Ralfsia verrucosa*	Tar spot/blood crust	%	0.5	-	1.0	0.0	-	-	R	R	-
		Scytosiphon lomentaria	Whip tube	%	0.1	-	-	-	-	-	R	-	-
	Red Algae	*Apophlaea lyallii*	Rubber weed	%	0.4	0.4	0.1	-	0.5	0.3	R	R	R
		Gracilaria sp. ?secundata	Gracilaria weed	%	0.2	-	1.0	1.2	0.7	0.5	R	R	R
		Stictosiphonia arbuscula	Moss weed	%	70.8	10.5	62.5	9.7	43.3	13.1	S	S	S
MID SHORE	Topshells	*Austrolittorina antipodum*	Blue periwinkle	#	0.5	-	-	-	-	-	R	-	-
		Austrolittorina cincta	Brown periwinkle	#	201.0	108.8	0.5	0.0	540.0	154.1	C	R	A
		Haustrum lacunosum	Rock whelk	#	0.5	-	-	-	0.5	0.3	R	-	R
	Limpets	*Cellana radians*	Tortoiseshell limpet	#	2.0	0.7	0.8	0.5	4.3	2.8	F	O	C
		Cellana strigilis redmiculum	Striated limpet	#	36.2	9.5	19.7	0.8	16.7	3.0	A	C	C
		Patellodia corticata	Encrusted slit limpet	#	2.0	1.1	1.7	0.0	2.0	1.6	F	F	F
	Chitons	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	0.5	0.0	0.7	0.0	0.2	0.2	O	O	O
	Barnacles	*Chamaesipho columna*	Column barnacle	%	19.5	9.7	19.5	9.7	22.8	10.4	F	F	C
		Elminius plicatus	Ridged surf barnacle	%	33.3	7.6	33.3	7.6	34.2	8.8	C	C	C
	Mussels	*Mytilus galloprovincialis*	Blue mussel	%	0.6	0.3	0.3	0.0	0.1	0.1	R	R	O
	Brown Algae	*Adenocystis utricularis*	Sea bladder/ Sea sack	%	0.0	-	-	-	-	-	R	-	-
		Ralfsia verrucosa	Tar spot/blood crust	%	0.5	-	0.8	0.3	-	-	R	R	-
		Scytosiphon lomentaria	Whip tube	%	0.3	0.1	0.1	-	-	-	R	R	-
		Splachnidium rugosum	Gummy weed	%	0.1	0.1	0.3	0.1	0.1	0.1	R	R	R
	Green Algae	*Bryopsis sp.*	Green fern	%	0.2	0.3	-	-	-	-	R	-	-
		Codium convolutum	Encrusting velvet	%	0.1	-	-	-	-	-	R	-	-
		Ulva lactuca	Sea lettuce	%	-	-	0.1	-	0.1	0.1	-	R	R
	Red Algae	*Corallina officinalis*	Pink turf	%	6.8	4.6	5.1	4.0	1.0	0.8	F	F	R
		Gracilaria sp. ?secundata	Gracilaria weed	%	0.2	-	0.2	-	0.3	0.3	R	R	R
		Lithothamnion sp.	Pink/white paint	%	3.0	3.5	1.7	0.0	-	-	R	R	-
		Pachymenia lusoria	Red weed	%	0.8	-	0.6	0.7	0.5	0.5	R	R	R
		Porphyra sp.	Karengo, Nori	%	0.1	-	-	-	-	-	R	-	-
		Stictosiphonia arbuscula	Moss weed	%	1.0	1.0	6.3	3.8	5.8	3.2	R	F	F
LOW SHORE	Limpets	*Benhamina obliquata*	Large siphon limpet	#	0.3	0.0	0.3	0.0	1.2	0.4	O	O	F
		Cellana ornata	Ornate limpet	#	0.3	-	-	-	-	-	O	-	-
		Cellana radians	Tortoiseshell limpet	#	3.2	1.5	4.5	1.3	2.3	1.2	C	C	F
		Patellodia corticata	Encrusted slit limpet	#	5.3	0.9	7.3	1.5	6.3	3.0	C	C	C
	Chitons	*Eudoxochiton nobilis*	Noble chiton	#	0.3	0.0	-	-	0.2	0.2	F	-	F
		Sypharochiton pelliserpentis	Snake's skin chiton	#	1.7	0.4	1.3	0.8	1.2	0.5	F	F	F
	Barnacles	*Chamaesipho columna*	Column barnacle	%	4.6	3.6	4.8	3.3	4.7	3.1	R	R	R
		Elminius plicatus	Ridged surf barnacle	%	0.8	0.0	1.0	0.4	1.2	0.5	R	R	R
	Mussels	*Mytilus galloprovincialis*	Blue mussel	%	0.2	0.0	0.1	-	-	-	R	R	-
	Brown Algae	*Durvillaea antarctica*	Bull kelp	%	83.3	3.3	70.2	14.2	66.8	15.9	S	S	S
		Ralfsia verrucosa	Tar spot/blood crust	%	0.4	-	0.6	0.4	2.2	0.9	R	R	R
		Xiphophora gladiata	Strap weed	%	2.1	0.5	2.9	1.5	2.0	1.0	O	O	O
	Green Algae	*Codium convolutum*	Encrusting velvet	%	0.4	0.1	0.1	-	0.2	0.2	R	R	R
	Red Algae	*Corallina officinalis*	Pink turf	%	10.8	2.0	10.8	2.0	13.3	2.8	C	C	C
		Corallina polymorphum	Pink globules	%	1.7	0.0	4.5	3.7	9.2	3.5	R	R	O
		Gigartina spp.	Agar weed	%	2.3	0.8	-	-	-	-	O	-	-
		Lithothamnion sp.	Pink/white paint	%	51.7	10.1	40.0	9.3	27.5	6.0	A	C	C
		Pachymenia lusoria	Red weed	%	0.4	-	3.1	1.6	2.1	1.6	R	O	O

The abundance of mobile invertebrates decreased on the mid shore in 2012, particularly the limpet *C. strigilis redmiculum,* as did the range of algae present (6 species). which were generally small in size, patchy in their distribution, and had a relatively low percentage cover (10-15% in total). The calcareous red algal turf *Corallina officinalis* was the only species rated as frequent in 2012, all other algal species being classed as rare (Table 4).

The low shore is where the brown algae have their stronghold. It was again dominated in 2012 by an almost exclusive (superabundant) cover of bull kelp *Durvillaea antarctica* (67%) which spread over the low intertidal and shallow subtidal fringe (Figure 7). 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, C. radians, Patelloida corticata*) and chitons (e.g. *Eudoxochiton nobilis, Sypharochiton pelliserpentis*) with a strong ability to cling to the rocks were common/frequent. These species graze on the abundant cover of the calcareous red algae *Corallina officinalis*, pink/white paint *Lithothamnion* sp. ,and other algae present beneath the bull kelp canopy.

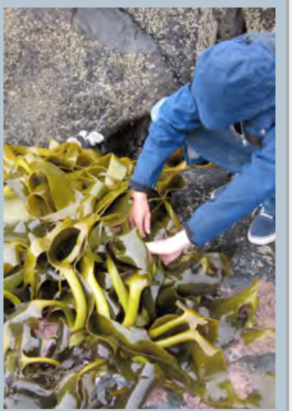


Figure 7. Lower shore quadrat sampling among the bull kelp *Durvillaea antarctica.*

Topshells were not seen in the low tide quadrats sampled, most likely due to the high wave exposure. Other algal species present on the low shore (Table 4) were generally relatively small in size, and primarily limited to growing beneath the dominant cover of *Durvillaea*.

Figure 8 presents the results of a multivariate analysis which shows the relationship between all the individual quadrats sampled over the three year baseline. The results, as expected, show the quadrats group into three very obvious shore height associations. Within these groupings, minor changes in community structure are evident from 2010 to 2012 reflecting small shifts in the abundance of mobile species, combined with changes in algal cover, primarily through grazing (e.g. Figure 10).

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.

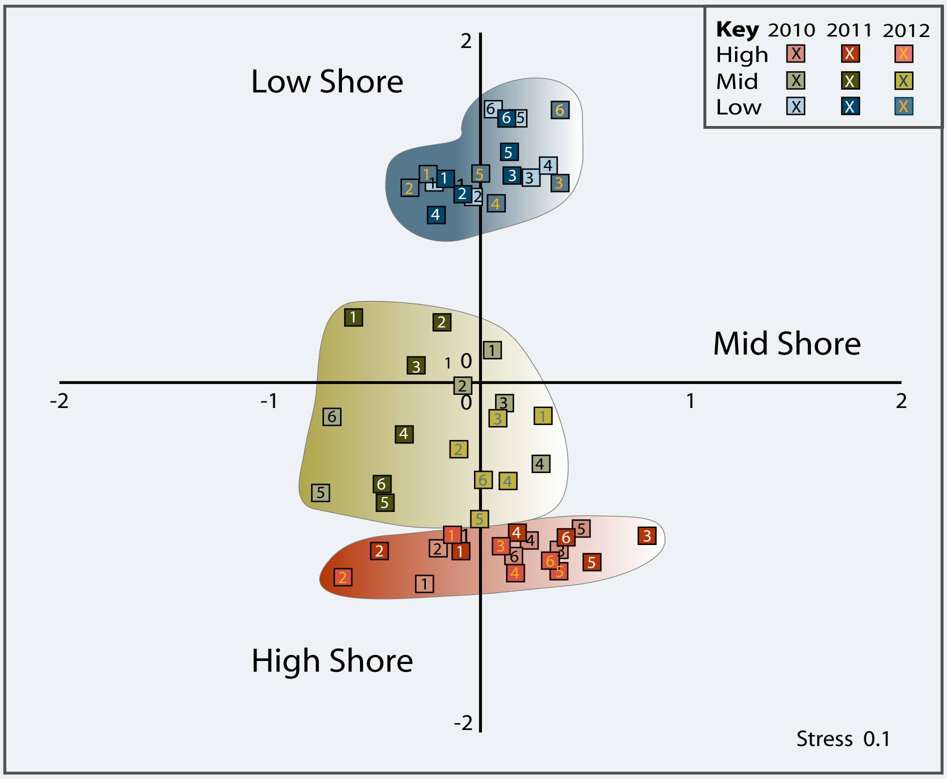


Figure 8. NMDS plot showing the relationship among samples in terms of similarity in community composition for Stirling Point rocky shore quadrats in Feb 2010 and 2011, and Jan 2012.

On the low shore, the NMDS plot (Figure 8) shows all the quadrats remain tightly grouped, reflecting the very similar community composition between bull kelp (*Durvillaea)* dominated replicates. The adaptation of the bull kelp assemblage to the high energy of the lower shore is reflected in the wider separation of these sites from the mid and high shore sites which have a different composition and a greater species overlap (and therefore align more closely with each other.)

On the mid shore, the wider spread between sites is due to the presence of mobile species represented by only one or two individuals, or mobile species that are commonly present in large clumped assemblages e.g. periwinkles (sidebar photo). Their presence/absence can cause rapid density changes in quadrat counts on the mid shore as a consequence of prevailing weather that either allows a temporary reprieve to otherwise harsh conditions, allowing them to migrate down the shore, or high energy conditions forcing them to seek refuge up the shore. This often short lived temporal variation has likely been reflected in the periwinkles which were rare on the mid shore in 2011 (sampling followed a period of large swells), but common/ abundant on the mid shore in 2010 and 2012 (when there were calmer conditions).

As noted in 2011, quadrat 4 had lost its bull kelp cover, most likely as a consequence of storm effects. The newly opened up space has remained largely bare, (Figure 9) with the algae present in 2012 different to those present in 2012. This highlights the potential significance of any loss of the dominant fucoid algal cover, and the likely slow recovery period from change.

Figure 9. Low tide quadrat 4 in 2010 (left), 2011 (centre) and 2012 (right) showing loss of dominant bull kelp cover.

On the high shore, no significant differences were observed between quadrat composition across the three years of monitoring. However, algal grazing effects remain visually apparent in the photo quadrats (e.g. Figure 10, Appendix 1). The decreased algal cover from 2010 (71%), 2011 (63%) and 2012 (43%) corresponded to an increase in mean periwinkle abundance 230 to 804 to 1080 per quadrat. As such, grazing is the dominant cause of the observed change.

Notwithstanding these relatively minor changes, overall there was a high degree of concordance between the three years of quadrat data collected, as evident by the similarity of the 2010, 2011 and 2012 SACFOR scores summarised in Table 4 and Figure 11.

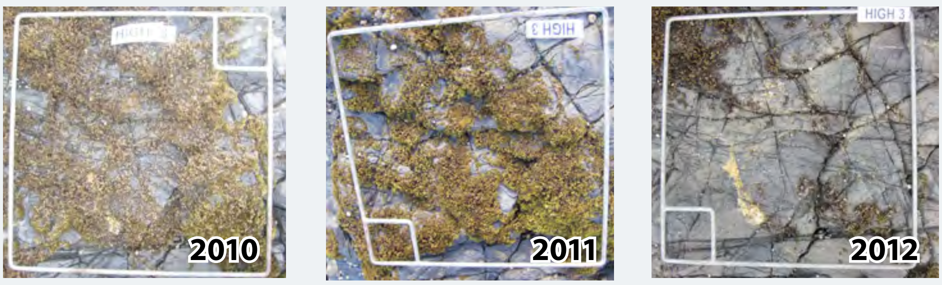


Figure 10. High tide quadrat 3 in 2010 (left), 2011 (centre) and 2012 (right) showing reduced cover of *Stictosiphonia arbuscula* as a result of grazing.

3. Results and Discussion (Continued)

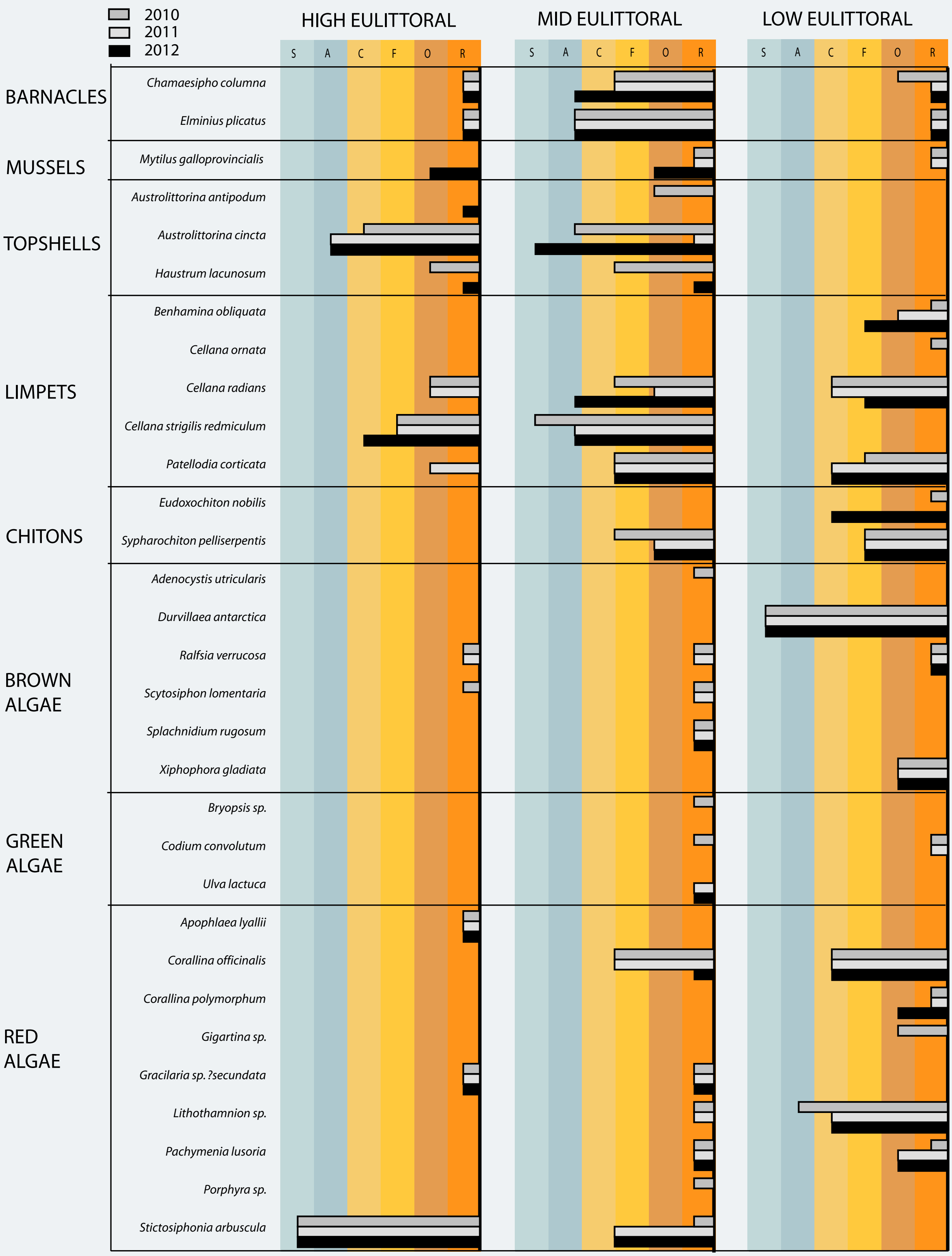


Figure 11. Mean SACFOR rating for species present in 6 fixed quadrats in high, mid and low eulittoral zones.

3. Results and Discussion (Continued)

Splachnidium rugosum

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 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 three years of baseline monitoring indicate Stirling 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 established, in conjunction with rocky shore monitoring at the Waipapa Point and Cosy Nook sites, 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.

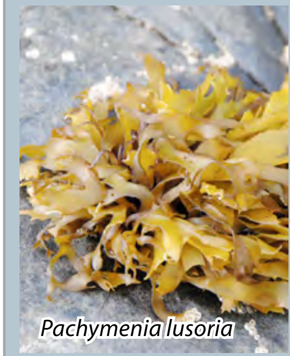
To help ES interpret future changes it is also intended to develop condition ratings to characterise the status of the shore once the rocky shore baselines are completed. This is something not previously attempted in NZ because current scientific knowledge of many NZ rocky shore species is scarce or 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, sedimentation, eutrophication, and toxins is considered low.

The three 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. The sampling has established a robust measure of natural variation against which any future changes can be assessed.

5. MONITORING



Pachymenia lusoria

Stirling 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* in Bluff Harbour), and impacts from excessive sediment, eutrophication, pathogens and toxins. Following completion of the three year baseline it is recommended that monitoring continue as outlined below:

Rocky Shore Monitoring:

- Monitor rocky shore ecology at Stirling Point at 5 yearly intervals, or as deemed necessary based on rocky shore condition ratings (to be developed). The next scheduled monitoring is February 2017.
- 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

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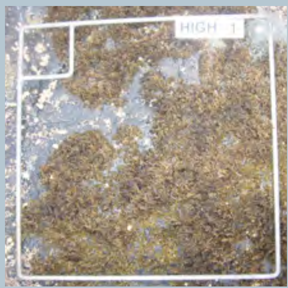
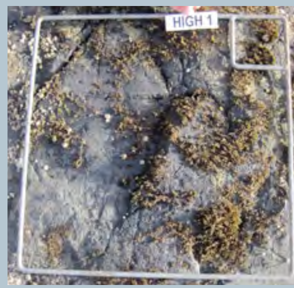
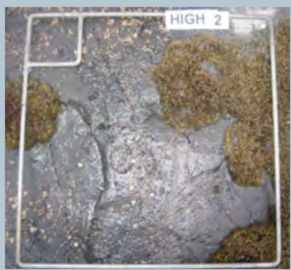
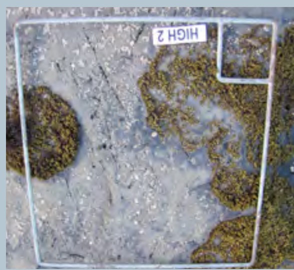
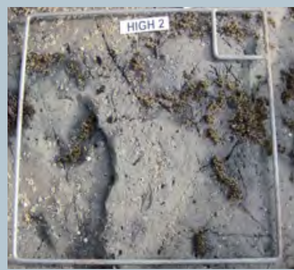
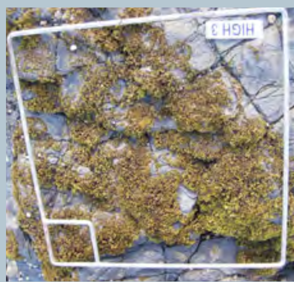
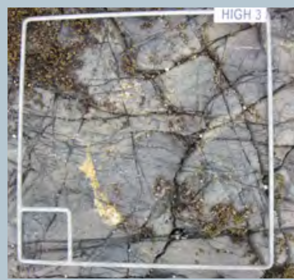
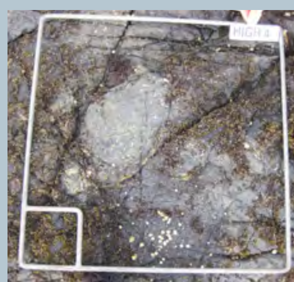
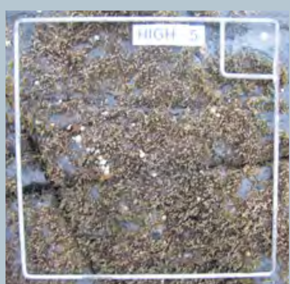
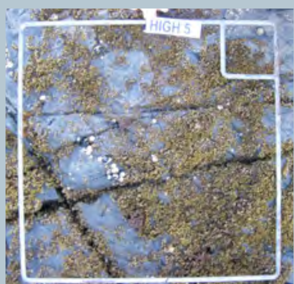
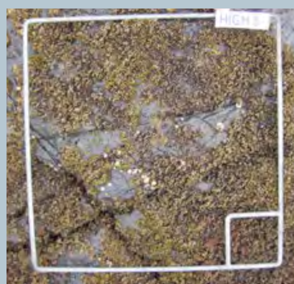
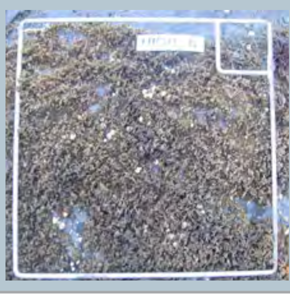
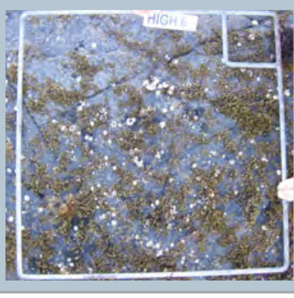
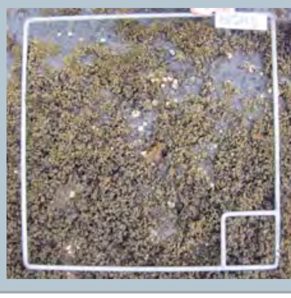
APPENDIX 1. DETAILED RESULTS

High Eulittoral	2010	2011	2012
QUADRAT 1 NZTM 1244219 East NZTM 4826493 North			
QUADRAT 2 NZTM 1244220 East NZTM 4826491 North			
QUADRAT 3 NZTM 1244229 East NZTM 4826504 North			
QUADRAT 4 NZTM 1244231 East NZTM 4826507 North			
QUADRAT 5 NZTM 1244269 East NZTM 4826565 North			
QUADRAT 6 NZTM 1244270 East NZTM 4826567 North			

APPENDIX 1. DETAILED RESULTS (CONT.)

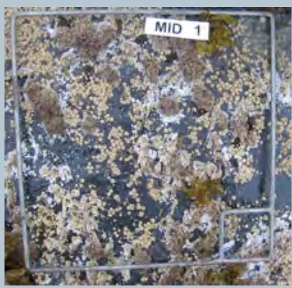
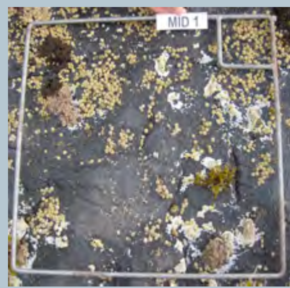
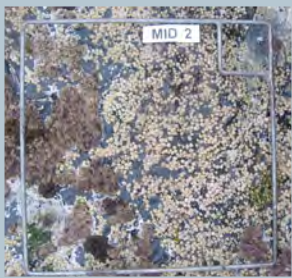
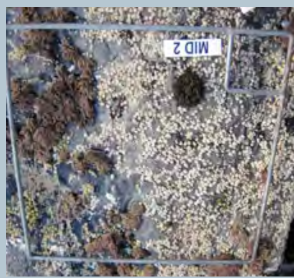
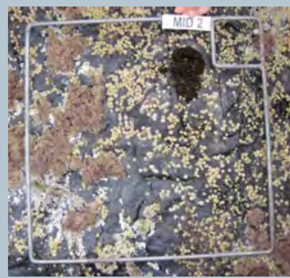
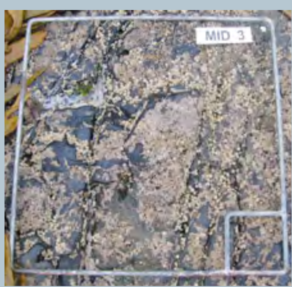
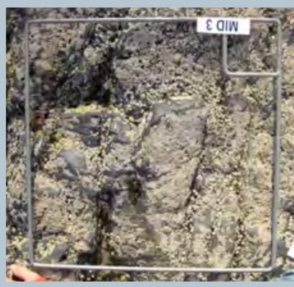
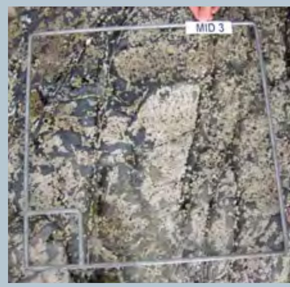
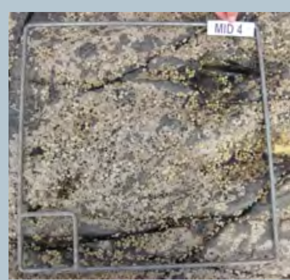
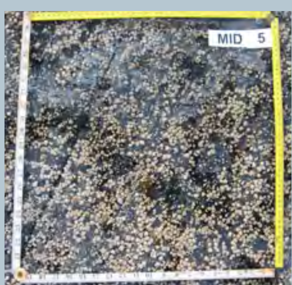
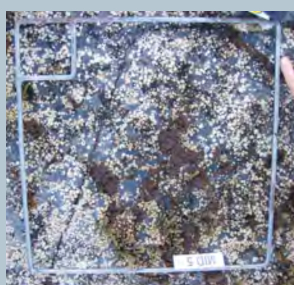
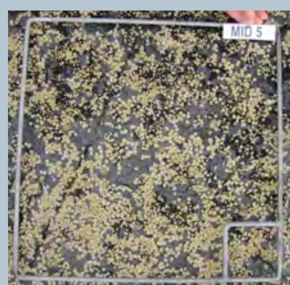
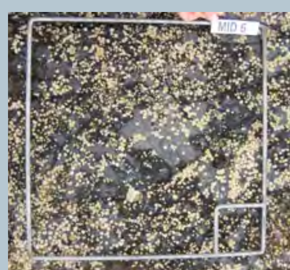
High Shore Quadrat Data 2010, 2011, 2012.

2012	Scientific name	Common Name	Unit	Class	Quadrat						Mean	SACFOR RATING
					1	2	3	4	5	6		
Topshells	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	0	2	0	0	0	0	0.3	R
	Austrolittorina cincta	Brown periwinkle	#	i	31	46	651	751	1501	3501	1080	A
	Haustrum lacunosum	Rock whelk	#	i	0	0	0	1	0	0	0.2	R
Limpets	*Cellana strigilis redmiculum*	Striated limpet	#	ii	5	0	7	3	6	1	3.7	C
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	5	5	0.5	0.1	0	1	1.9	R
	Elminius plicatus	Ridged surf barnacle	%	i	1	0	1	0.5	1	2	0.9	R
Mussels	*Mytilus galloprovincialis*	Blue mussel	%	i	0	2	0	0	0	0	0.3	O
Red Algae	*Apophlaea lyallii*	Rubber weed	%	ii	0	1	0	2	0	0	0.5	R
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii	0	0	0	0	3	1	0.7	R
	Stictosiphonia arbuscula	Moss weed	%	ii	30	10	15	40	80	85	43.3	S

2011	Scientific name	Common Name	Unit	Class	Quadrat						Mean	SACFOR RATING
					1	2	3	4	5	6		
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	15	5	5	300	2000	2500	804	A
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	0	0	1	0	0	0	0.2	O
	Cellana strigilis redmiculum	Striated limpet	#	ii	4	0	0	6	2	2	2.3	F
	Patellodia corticata	Encrusted slit limpet	#	ii	0	0	0	1	0	0	0.2	O
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	1	5	0	0.1	0	0.5	1.1	R
	Elminius plicatus	Ridged surf barnacle	%	i	1.5	0.75	0.5	0.5	0.5	2	1.0	R
Brown Algae	*Ralfsia verrucosa*	Tar spot/blood crust	%	i	0	0	0	0	3	3	1.0	R
Red Algae	*Apophlaea lyallii*	Rubber weed	%	ii	0	0.5	0	0	0	0	0.1	R
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii	0	0	0	0	5	1	1.0	R
	Stictosiphonia arbuscula	Moss weed	%	ii	70	15	80	65	75	70	62.5	S

2010	Scientific name	Common Name	Unit	Class	Quadrat						Mean	SACFOR RATING
					1	2	3	4	5	6		
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	0	30	350	200	400	400	230	C
	Haustrum lacunosum	Rock whelk	#	i	4	0	3	5	2	0	2.3	O
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	0	0	2	2	1	0	0.8	O
	Cellana strigilis redmiculum	Striated limpet	#	ii	2	2	3	7	2	1	2.8	F
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	1	3	0	0.1	0	0.5	0.8	R
	Elminius plicatus	Ridged surf barnacle	%	i	1	0.5	0.1	0.2	1	2	0.8	R
Brown Algae	*Ralfsia verrucosa*	Tar spot/blood crust	%	i	0	0	0	0	3	0	0.5	R
	Scytosiphon lomentaria	Whip tube	%	ii	0	0	0	0	0	0.5	0.1	R
Red Algae	*Apophlaea lyallii*	Rubber weed	%	ii	0	0.5	0	2	0	0	0.4	R
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii	0	0	0	0	1	0	0.2	R
	Stictosiphonia arbuscula	Moss weed	%	ii	80	20	80	70	85	90	70.8	S

APPENDIX 1. DETAILED RESULTS (CONT.)

Mid Eulittoral	2010	2011	2012
QUADRAT 1 NZTM 1244216 East NZTM 4826490 North			
QUADRAT 2 NZTM 1244219 East NZTM 4826489 North			
QUADRAT 3 NZTM 1244234 East NZTM 4826502 North			
QUADRAT 4 NZTM 1244235 East NZTM 4826506 North			
QUADRAT 5 NZTM 1244274 East NZTM 4826565 North			
QUADRAT 6 NZTM 1244274 East NZTM 4826572 North			

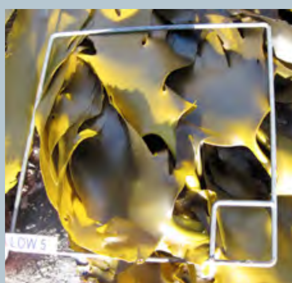
APPENDIX 1. DETAILED RESULTS (CONT.)

Mid Shore Quadrat Data 2011, 2012.

2012	Scientific name	Common Name	Unit	Class	Quadrat 1	2	3	4	5	6	Mean	SACFOR RATING
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	400	40	500	600	1200	500	540	A
	Haustrum lacunosum	Rock whelk	#	i	0	0	0	2	1	0	0.5	R
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	18	2	2	3	0	1	4.3	C
	Cellana strigilis redmiculum	Striated limpet	#	ii	21	6	16	10	24	23	16.7	C
	Patellodia corticata	Encrusted slit limpet	#	ii	0	2	10	0	0	0	2.0	F
Chitons	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	ii	0	0	0	0	0	1	0.2	O
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	2	15	60	50	5	5	22.8	C
	Elminius plicatus	Ridged surf barnacle	%	i	15	50	10	20	60	50	34.2	C
Mussels	*Mytilus galloprovincialis*	Blue mussel	%	i	0	0	0.5	0	0	0	0.1	O
	Splachnidium rugosum	Gummy weed	%	ii	0	0	0.5	0	0	0	0.1	R
Green Algae	*Ulva lactuca*	Sea lettuce	%	ii	0	0	0.5	0	0	0	0.1	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	5	0	1	0	0	0	1.0	R
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii	2	0	0	0	0	0	0.3	R
	Pachymenia lusoria	Red weed	%	ii	3	0	0	0	0	0	0.5	R
	Stictosiphonia arbuscula	Moss weed	%	ii	0	3	0.5	1	10	20	5.8	F

2011	Scientific name	Common Name	Unit	Class	Quadrat 1	2	3	4	5	6	Mean	SACFOR RATING
Topshells	*Austrolittorina cincta*	Brown periwinkle	#	i	0	0	0	1	1	1	0.5	R
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	0	1	3	1	0	0	0.8	O
	Cellana strigilis redmiculum	Striated limpet	#	ii	22	20	18	17	22	19	19.7	C
	Patellodia corticata	Encrusted slit limpet	#	ii	0	5	5	0	0	0	1.7	F
Chitons	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	ii	0	1	1	1	0	1	0.7	O
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	2	5	50	50	5	5	19.5	F
	Elminius plicatus	Ridged surf barnacle	%	i	20	50	10	20	50	50	33.3	C
Mussels	*Mytilus galloprovincialis*	Blue mussel	%	i	0.5	0.5	0.5	0	0	0	0.3	R
Brown Algae	*Ralfsia verrucosa*	Tar spot/blood crust	%	i	3	2	0	0	0	0	0.8	R
	Scytosiphon lomentaria	Whip tube	%	ii	0	0	0	0	0	0.5	0.1	R
	Splachnidium rugosum	Gummy weed	%	ii	0	0	0	0	1	0.5	0.3	R
Green Algae	*Ulva lactuca*	Sea lettuce	%	ii	0	0	0.5	0	0	0	0.1	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	10	20	0.5	0	0	0	5.1	F
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii	0	0	1	0	0	0	0.2	R
	Lithothamnion sp.	Pink/white paint	%	i	5	5	0	0	0	0	1.7	R
	Pachymenia lusoria	Red weed	%	ii	3	0.5	0	0	0	0	0.6	R
	Stictosiphonia arbuscula	Moss weed	%	ii	0	1	1	0.5	15	20	6.3	F

APPENDIX 1. DETAILED RESULTS (CONT.)

Low Eulittoral	2010	2011	2012
QUADRAT 1 NZTM 1244220 East NZTM 4826492 North			
QUADRAT 2 NZTM 1244221 East NZTM 4826491 North			
QUADRAT 3 NZTM 1244237 East NZTM 4826502 North			
QUADRAT 4 NZTM 1244238 East NZTM 4826514 North			
QUADRAT 5 NZTM 1244277 East NZTM 4826569 North			
QUADRAT 6 NZTM 1244276 East NZTM 4826575 North			

APPENDIX 1. DETAILED RESULTS (CONT.)

Mid Shore Quadrat Data 2010.

2010	Scientific name	Common Name	Unit	Class	Quadrat						Mean	SACFOR RATING
					1	2	3	4	5	6		
Topshells	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	0	0	0	0	3	0	0.5	R
	Austrolittorina cincta	Brown periwinkle	#	i	100	50	450	600	6	0	201	C
	Haustrum lacunosum	Rock whelk	#	i	0	0	0	0	3	0	0.5	R
Limpets	*Cellana radians*	Tortoiseshell limpet	#	ii	5	2	4	1	0	0	2.0	F
	Cellana strigilis redmiculum	Striated limpet	#	ii	20	22	27	23	80	45	36.2	A
	Patellodia corticata	Encrusted slit limpet	#	ii	2	3	7	0	0	0	2.0	F
Chitons	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	ii	0	1	1	0	0	1	0.5	O
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	2	5	50	50	5	5	19.5	F
	Elminius plicatus	Ridged surf barnacle	%	i	20	50	10	20	50	50	33.3	C
Mussels	*Mytilus galloprovincialis*	Blue mussel	%	i	1	0	0	2	0	0.5	0.6	R
Brown Algae	*Adenocystis utricularis*	Sea bladder/ Sea sack	%	ii	0.1	0	0	0	0	0	0.0	R
	Ralfsia verrucosa	Tar spot/blood crust	%	i	3	0	0	0	0	0	0.5	R
	Scytosiphon lomentaria	Whip tube	%	ii	0	0	0	1	0	0.5	0.3	R
	Splachnidium rugosum	Gummy weed	%	ii	0.1	0	0	0	0	0.5	0.1	R
Green Algae	*Bryopsis sp.*	Green fern	%	ii	0.1	1	0	0	0	0	0.2	R
	Codium convolutum	Encrusting velvet	%	i	0	0	0	0	0	0.5	0.1	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	20	20	0	0	0	0.5	6.8	F
	Gracilaria sp. ?secundata	Gracilaria weed	%	ii	0	0	0	1	0	0	0.2	R
	Lithothamnion sp.	Pink/white paint	%	i	15	0	3	0	0	0	3.0	R
	Pachymenia lusoria	Red weed	%	ii	5	0	0	0	0	0	0.8	R
	Porphyra sp.	Karengo, Nori	%	ii	0	0	0.5	0	0	0	0.1	R
	Stictosiphonia arbuscula	Moss weed	%	ii	0.1	0.2	0.5	0	0	5	1.0	R

Low Shore Quadrat Data 2012.

2012	Scientific name	Common Name	Unit	Class	Quadrat						Mean	SACFOR RATING
					1	2	3	4	5	6		
Limpets	*Benhamina obliquata*	Large siphon limpet	#	ii	2	2	0	1	2	0	1.2	F
	Cellana radians	Tortoiseshell limpet	#	ii	0	0	5	7	1	1	2.3	F
	Patellodia corticata	Encrusted slit limpet	#	ii	12	18	0	2	6	0	6.3	C
Chitons	*Eudoxochiton nobilis*	Noble chiton	#	iii	0	0	0	0	0	1	0.2	F
	Sypharochiton pelliserpentis	Snake's skin chiton	#	ii	0	1	3	0	1	2	1.2	F
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	2.5	2.5	20	2.5	0.5	0	4.7	R
	Elminius plicatus	Ridged surf barnacle	%	i	2.5	2.5	0	1	1	0	1.2	R
Brown Algae	*Durvillaea antarctica*	Bull kelp	%	ii	80	100	100	1	80	40	66.8	S
	Ralfsia verrucosa	Tar spot/blood crust	%	i	1	2	5	0	0	5	2.2	R
	Xiphophora gladiata	Strap weed	%	ii	1	0	0	5	5	1	2.0	O
Green Algae	*Codium convolutum*	Encrusting velvet	%	i	1	0	0	0	0	0	0.2	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	15	25	10	5	15	10	13.3	C
	Corallina polymorphum	Pink globules	%	i	10	5	0	5	10	25	9.2	O
	Lithothamnion sp.	Pink/white paint	%	i	20	5	40	40	40	20	27.5	C
	Pachymenia lusoria	Red weed	%	ii	2.5	10	0	0	0	0	2.1	O

APPENDIX 1. DETAILED RESULTS (CONT.)

Low Shore Quadrat Data 2010, 2011.

2011	Scientific name	Common Name	Unit	Class	Quadrat 1	2	3	4	5	6	Mean	SACFOR RATING
Limpets	*Benhamina obliquata*	Large siphon limpet	#	ii	1	1	0	0	0	0	0.3	O
	Cellana radians	Tortoiseshell limpet	#	ii	0	10	6	6	2	3	4.5	C
	Patellodia corticata	Encrusted slit limpet	#	ii	9	8	2	5	13	7	7.3	C
Chitons	*Sypharochiton pelliserpentis*	Snake's skin chiton	#	ii	2	0	1	0	0	5	1.3	F
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	2.5	2.5	20	2.5	1	0	4.8	R
	Elminius plicatus	Ridged surf barnacle	%	i	2.5	2.5	0	1	0	0	1.0	R
Mussels	*Mytilus galloprovincialis*	Blue mussel	%	i	0	0	0	0.5	0	0	0.1	R
Brown Algae	*Durvillaea antarctica*	Bull kelp	%	ii	80	80	100	1	80	80	70.2	S
	Ralfsia verrucosa	Tar spot/blood crust	%	i	1	2.5	0	0	0	0	0.6	R
	Xiphophora gladiata	Strap weed	%	ii	2.5	2.5	0	0	2.5	10	2.9	O
Green Algae	*Codium convolutum*	Encrusting velvet	%	i	0.5	0	0	0	0	0	0.1	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	15	15	15	5	10	5	10.8	C
	Corallina polymorphum	Pink globules	%	i	1	0	1	5	0	20	4.5	R
	Lithothamnion sp.	Pink/white paint	%	i	30	20	50	40	80	20	40.0	C
	Pachymenia lusoria	Red weed	%	ii	2.5	10	1	5	0	0	3.1	O

2010	Scientific name	Common Name	Unit	Class	Quadrat 1	2	3	4	5	6	Mean	SACFOR RATING
Limpets	*Benhamina obliquata*	Large siphon limpet	#	ii	1	0	0	0	0	1	0.3	O
	Cellana ornata	Ornate limpet	#	ii	0	0	0	2	0	0	0.3	O
	Cellana radians	Tortoiseshell limpet	#	ii	0	3	10	2	3	1	3.2	C
	Patellodia corticata	Encrusted slit limpet	#	ii	9	7	5	4	4	3	5.3	C
Chitons	*Eudoxochiton nobilis*	Noble chiton	#	iii	0	0	0	0	1	1	0.3	F
	Sypharochiton pelliserpentis	Snake's skin chiton	#	ii	2	0	1	3	1	3	1.7	F
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	2.5	2.5	20	2.5	0	0	4.6	R
	Elminius plicatus	Ridged surf barnacle	%	i	2.5	2.5	0	0	0	0	0.8	R
Mussels	*Mytilus galloprovincialis*	Blue mussel	%	i	0.5	0.5	0	0	0	0	0.2	R
Brown Algae	*Durvillaea antarctica*	Bull kelp	%	ii	80	80	100	80	80	80	83.3	S
	Ralfsia verrucosa	Tar spot/blood crust	%	i	0	2.5	0	0	0	0	0.4	R
	Xiphophora gladiata	Strap weed	%	ii	2.5	2.5	0	0	2.5	5	2.1	O
Green Algae	*Codium convolutum*	Encrusting velvet	%	i	0.5	1	0	0	0.5	0.5	0.4	R
Red Algae	*Corallina officinalis*	Pink turf	%	ii	15	15	15	5	10	5	10.8	C
	Corallina polymorphum	Pink globules	%	i	0	0	0	0	5	5	1.7	R
	Gigartina spp.	Agar weed	%	ii	1	5	1	5	1	1	2.3	O
	Lithothamnion sp.	Pink/white paint	%	i	30	20	50	80	80	50	51.7	A
	Pachymenia lusoria	Red weed	%	ii	2.5	0	0	0	0	0	0.4	R