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Flat Point 2017

Fine Scale Rocky Shore Monitoring

Prepared for

Greater Wellington Regional Council

May 2017

Cover Photo: Flat Point - looking south toward Glenburn headland and showing low shore sea lettuce bloom.

Flat Point 2017

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By

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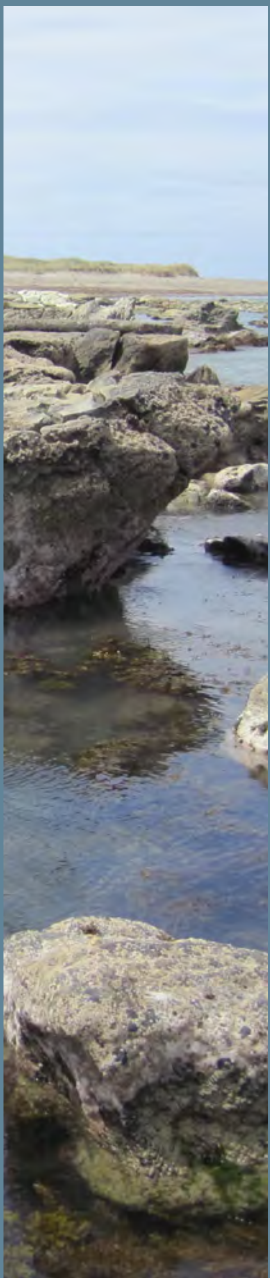
ROCKY SHORE - EXECUTIVE SUMMARY



This report summarises results of the second year of fine scale monitoring of the rocky shore community at Flat Point, Wairarapa, an eastern coast site exposed to moderate-high wave energy, northerly, easterly and southerly winds, and bathed by the relatively cool waters of the Wairarapa Coastal Current. It is a key site in Greater Wellington Regional Council's (GWRC's) long-term coastal monitoring programme. This report describes:

- Fine scale semi-quantitative monitoring of the abundance and diversity of conspicuous rocky shore plants and animals, and
- Fine scale quantitative monitoring of the abundance and diversity of plants and animals in 18 x 0.25m^2 fixed quadrats at high, mid, and low eulittoral (intertidal) levels at three sites.

FINE SCALE MONITORING RESULTS

The 2016 and 2017 semi-quantitative monitoring recorded 28 attached or sessile rocky shore species, excluding those in heavily fissured areas and rock pools. In total, 12 algae, 3 limpet, 7 topshell, 1 chiton, 3 barnacle and 2 bivalve species were observed.

The uppermost supralittoral (splash zone) rocky reef habitat was limited to the tops of large rocks/bedrock exposed above the beach sands. Present on the rocks were topshells (3), including the brown and blue-banded periwinkles (superabundant/rare), 2 limpets (common/rare), 3 barnacles (superabundant/rare), the black mussel (rare), and the red algae *Porphyra* sp. (frequent).

The high eulittoral (intertidal) zone [10 species] was characterised by a dense cover of barnacles - column barnacles (superabundant), 2 limpet species (abundant/frequent), 3 topshell species (common/rare), snakeskin chiton (common), *Porphyra* sp. (occasional), and blue and black mussels (frequent/rare).

The mid shore [10 species] was largely dominated by column barnacles (abundant). Also present were 2 limpet species (common/occasional), 4 topshells (common/rare), snakeskin chiton (common), and 2 bivalves (rare).

The lower shore [18 species] was most diverse and was dominated by a superabundant cover of turfing, crustose red algae, and an abundant cover of brown algae (Neptune's necklace) and, in 2017, an abundant bloom of sea lettuce. The algal canopy provided shelter and refuge to a range of other species, including: limpets (3), barnacles (1), chitons (1), topshells (2), and subdominant brown (5), red (2) and green (1) algae.

Twenty of the 28 species recorded in the semi-quantitative monitoring were also recorded in the quantitative fixed quadrat sampling and no significant change was observed in the species presence, abundance or distribution from 2016 to 2017.

ROCKY SHORE ISSUES AND CONDITION

Rocky shore ecology on the Wairarapa coast has been assessed as having a low-moderate risk, primarily due to predicted climate change pressures including accelerated sea level rise, temperature change, ocean acidification and, to a lesser extent, over-collection of living resources and introduction of invasive species. The risk from pathogens, sedimentation, eutrophication, and toxins was considered low.

Baseline monitoring in 2016 and 2017 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

The two years of baseline rocky shore monitoring (particularly to detect changes from predicted accelerated sea level rise and increased temperatures) showed a stable community with little variation between years. It is therefore recommended that monitoring be extended to a 5 yearly cycle (next scheduled for January 2022) to enable the establishment of monitoring sites in higher risk areas on the Wellington south coast

It is further recommended that condition ratings be developed to characterise rocky shore status e.g. shifts in community composition, the presence or absence of key indicator species (including introduced plants and animals), and indicators of nutrient enrichment and sedimentation.

1. INTRODUCTION

OVERVIEW

Flat Point

↓

Vulnerability Assessment
Identifies issues and recommends monitoring and management. Completed in 2007 (Robertson and Stevens 2007)

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Flat 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 2007

Fine Scale Monitoring
Semi-quantitative SACFOR
Intertidal fixed quadrats

Baseline then 5 yearly
2016
2017
Next survey 2022

↓

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. Importantly, the "Wairarapa Coastal Habitats - Mapping, Risk Assessment and Monitoring" report (Robertson and Stevens 2007) identified a low-moderate risk to rocky shore ecology on the Wairarapa coast. This was primarily from predicted climate change effects of accelerated sea level rise and elevated temperatures, the over-collection of living resources, and the introduction of invasive species. The primary ecological responses to such pressures are considered to be habitat change, and effects on biodiversity. Due to the generally high clarity, low nutrients, and low disease risk of water that bathes the Wairarapa rocky shoreline, the risk from pathogens, sedimentation, eutrophication, and toxins was considered low. Because of this, the number of monitoring indicators can be kept small, although this may change if catchment land use intensifies.

Therefore, to address the identified risks, and to provide baseline information on rocky shore ecology at key representative locations, Robertson and Stevens (2007) recommended long term monitoring of the abundance and diversity of plants and animals at regionally representative high diversity rocky shores (e.g. Flat Point and Cape Palliser) using rapid assessment methods developed under the Marine Biodiversity and Climate Change Project (Hiscock 1996). Wriggle Coastal Management was contracted by Greater Wellington Regional Council (GWRC) to undertake a proposed 3 year baseline of annual monitoring at Flat Point in 2016. After establishment of the baseline, monitoring is scheduled to be undertaken 5 yearly with the results used to 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 Wairarapa coastline. They reflect the erosive effect of waves where softer rocks are worn down, leaving harder rocks exposed. The habitat is physically complex, with rock pools, gullies, crevices and boulders providing a diverse range of habitats supporting a variety of different species. The harsh and variable physical conditions, including light availability, degree of exposure, large shifts in temperature and salinity, aspect, substrate, and biotic features, lead to the development of a characteristic zonation of species on stable shoreline substrate. These include zones dominated by lichens, periwinkles, barnacles, limpets, mussels, and canopy forming algae - the dominant biogenic habitat along temperate rocky shores worldwide (e.g. Tomanek and Helmuth 2002).

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

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

As such, monitoring representative rocky shore sites provides a robust and effective way of detecting changes to this important and highly valued coastal community, and provides an invaluable benchmark for assessing the possible impacts from infrequent events such as oil spills or toxic algal blooms should they occur.

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 that ingest toxic fish or shellfish poisoned by TABs. Significant effort and cost may be needed to remove or prevent the spread of unwanted species e.g. *Undaria* - an introduced golden brown seaweed that has been a prominent marine pest in New Zealand with extensive effort put into both minimising its spread removing it from certain locations e.g. Fiordland, Stewart Island.

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 on NZ's exposed outer coasts but if present, will reduce biodiversity and human values and uses.

1. Introduction (Continued)

The Flat Point fine scale rocky shore intertidal monitoring site is located approximately 500m south of the main swimming and boat launching beach at Flat Point, and directly south of the airstrip (Figures 1a and 1b). The area is representative of the rocky shoreline on this exposed region of the eastern coast, and is characterised by the following:

- Predominantly exposed rugged reefs, composed of generally soft, easily erodible sandstones and mudstones.
- Exposure to moderate-high wave energy and southerly, northerly and easterly winds.
- Bathed by the relatively cool, and often nutrient depleted, waters of the Wairarapa Coastal Current that flows northeast along the Wairarapa coast. However, inshore waters are influenced by elevated nutrient, sediment and pathogen loadings from Wairarapa river plumes.
- Dominated beneath low water by the branching, brown macroaglae *Carpophyllum flexuosum* and *Cystophora torlosa* (zig-zag weed), and directly above low water by the beaded, brown macroalga *Hormosira banksii* (Neptune's necklace), with barnacles and limpets common above the algal zone.

The sampling area was located on a rough, irregular intertidal reef (~100m x 50m) which was seaward of a relatively wide strip of sandy beach, and part of a wider sequence of connected intertidal and subtidal reefs present on this section of coast (see photo below). Several submerged reefs are present offshore. Although the area is semi-exposed, and is periodically subject to high wind and wave action from the southeast, the sampling site itself is relatively well protected from direct wave-action, with the sloping and undulating shoreline further helping to dissipate wave energy. Consequently, it supports a relatively diverse rocky shore community and exhibits strong shoreline zonation (Figure 2). The shoreline zones are relatively narrow (each ~1 vertical metre) reflecting the tidal range at the site (~1.2-2.1m).

The site is not directly or significantly influenced by river plumes, terrestrial discharges (e.g. stormwater, sewage), or structures (e.g. seawalls, wharfs, marine farms). Human use is moderate-high. It is a popular tourist destination, a highly valued recreational paua fishery, and is valued for diving, fishing, and its scenic beauty and bird life. The monitoring sites are considered unlikely to be appreciably affected by recreational fishers or visitors because quadrat locations are discreetly marked (unlikely to be noticed), are positioned where direct impacts are unlikely, and do not support species commonly targeted for recreational harvesting e.g. paua and mussels.

The current report describes the methods and results of the first and second years of baseline rocky shore monitoring at Flat Point undertaken in January 2016 and 2017.

View south over the Flat Point rocky shore sampling site.

1. Introduction (Continued)

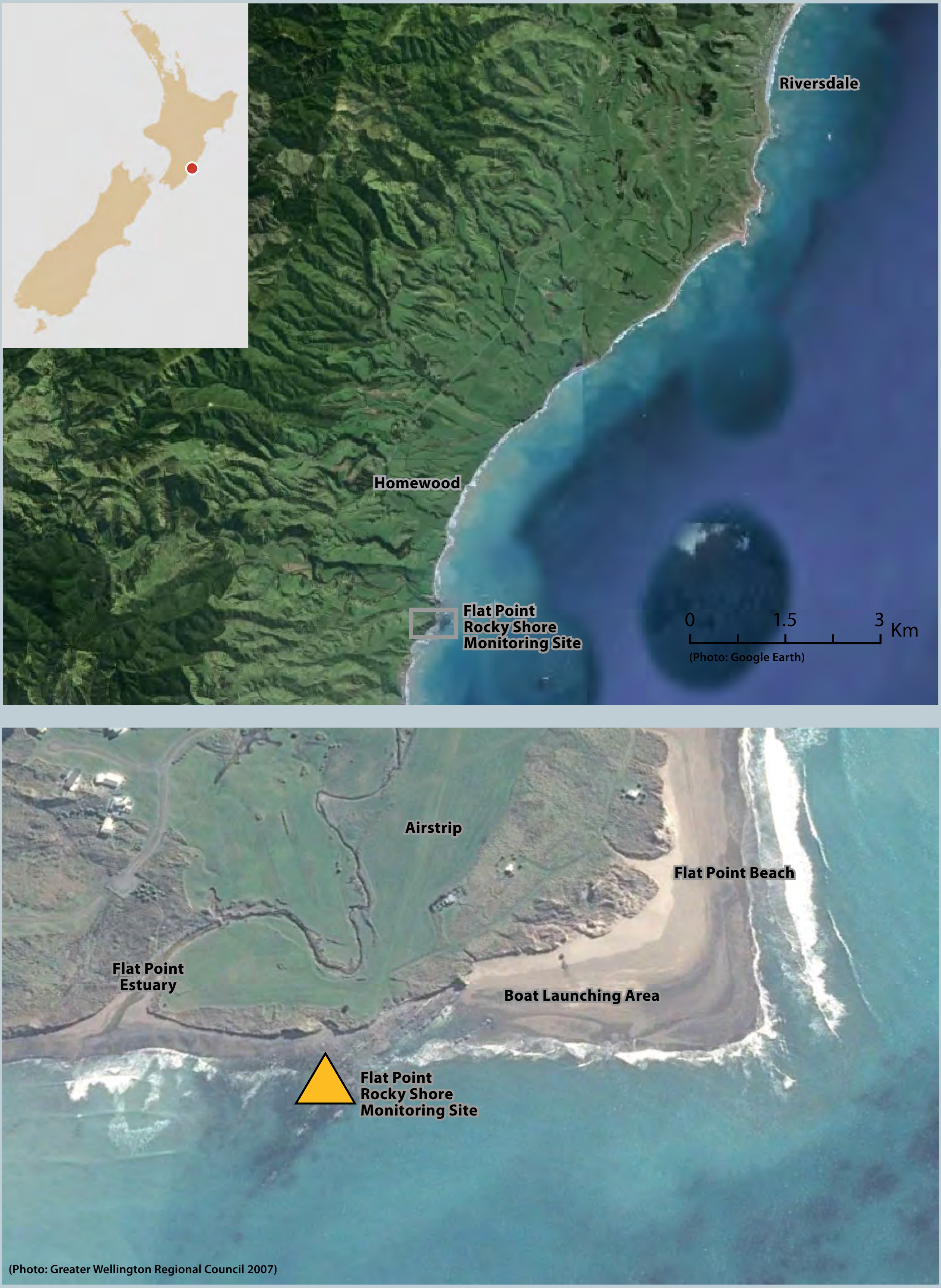


Figure 1. Location of the rocky shore sampling area at Flat Point.

2. METHODS

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

Sampling was undertaken by two scientists during calm sea conditions on 30 January 2017 when estuary monitoring was being undertaken in the region.

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

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

The semi-quantitative assessment was applied by walking over and photographing the wider sampling area, and identifying and recording the relative abundance of all the conspicuous species present from the supralittoral zone to mean low water. For the repeat of the 2016 survey a time limit of 60 minutes was used to guide the sampling effort, with extensively shaded areas, rock pools or heavily fissured areas excluded from the assessment. Details were recorded on pre-prepared data sheets that included the range of species likely to be found at the site. In addition, a photographic field guide was used to assist with field identifications.

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

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

Figure 2. General shoreline zonation present at Flat Point (note supratidal zone limited to very top of bedrock reef).

2. Methods (Continued)

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

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

High Eulittoral Quadrats
(6 quadrats located ~1m below the top of the barnacle zone)

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

Mid Eulittoral Quadrats
(6 quadrats in the middle of the barnacle zone)

- Percent cover of all barnacles, mussels, and algae.
- Number of each limpet or chiton (individuals >10mm) in each 0.25m^2 quadrat.
- Number of each species of snail >5mm in each 0.25m^2 quadrat.

Low Eulittoral Quadrats
(6 quadrats ~1m above the bottom of the barnacle zone)

- Percent cover of all barnacles, mussels, and algae.
- Number of each limpet or chiton (individuals >10mm) in each 0.25m^2 quadrat.
- Number of each species of snail >5mm in each 0.25m^2 quadrat.

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

A. PERCENTAGE COVER

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

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

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

B. DENSITY SCALES

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

3. RESULTS AND DISCUSSION

Results of the 30 January 2017 fine scale rocky shore monitoring at Flat Point are summarised below in two sections: the semi-quantitative assessment, followed by the fixed quadrat sampling. Overall there was very little change from the 2016 results.

The semi-quantitative assessment in 2017 identified 28 species (Table 3), excluding creviced areas and rock pools. Algae were dominant (12 species), but a wide range of common rocky shore organisms able to withstand the physical rigours of the exposed wave environment including barnacles, limpets, chitons, topshells and bivalve shellfish were also observed.

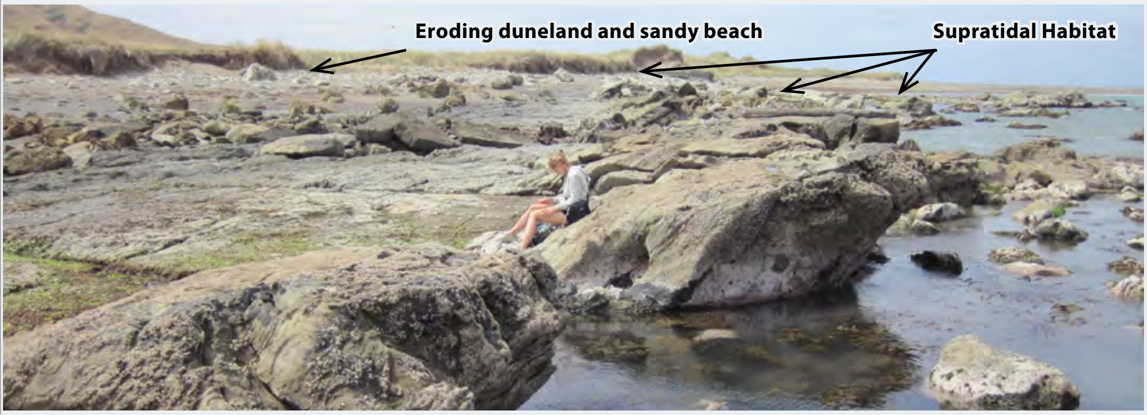
Changes from 2016 were the inclusion of the green alga *Codium convolutum* (rare) on the low shore, an increased cover of sea lettuce on the mid shore (occasional) and low shore (abundant), periwinkles previously only seen in the supralittoral zone also recorded on the high shore (rare or common), and a small increase in the cover of the brown alga *Ralfsia verrucosa* (from rare to common), and the red alga *Stictosiphonia arbuscula* (rare on the mid shore).

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

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

Supralittoral Zone

At Flat Point, the extent of the supralittoral zone above the high tide line was restricted to the upper portion of the rocky reef habitat and did not extend further landward because the uppermost shore comprised a sandy beach and eroding dune system (see photo below). Because of this, there was only a small area of supratidal rocky substrata present, and this appears to be relatively frequently inundated by seawater. Consequently, it precluded the presence of lichens, a type of plant that typically inhabits rock and boulders at the upper edge of the spray zone.



However, at the lower edge of the supralittoral fringe, where rock substrata was present, were the brown and blue-banded periwinkles *Austrolittorina cincta* and *Austrolittorina antipodum,* classified as common and super-abundant, respectively. These small topshells, while extremely tolerant of the sun, tend to congregate in cracks and fissures in the rock that provide some protection from the elements during the day. Other invertebrate species observed were the column and ridged-surf barnacles *Chamaesipho columna* (super-abundant) and *Elminius placatus* (rare), the ornate and tortoise-shell limpets *Cellana ornata* (common) and *Cellana radians* (rare), and the black bivalve mussel *Xenostrobus zelanicus* (rare). Also present was the red macroalgae *Porphyra sp.,* with an overall abundance rating of frequent.

Table 3. Results of the semi-quantitative SACFOR assessment at Flat Point, 30 January 2017.

Group and Family		Species	Common name	Scale	Class	Supra	High	Mid	Low
Topshells	Littorinidae	*Austrolittorina antipodum*	Blue banded periwinkle	#	i	S	R		
	Littorinidae	*Austrolittorina cincta*	Brown periwinkle	#	i	C	R		
	Littorinidae	*Risellopsis varia*	Periwinkle	#	ii		C	R	
	Turbinidae	*Turbo smaragdus*	Cats eye	#	ii			R	C
	Muricidae	*Haustrum scobina*	Oyster borer	#	ii	R	R	R	
	Trochidae	*Diloma aethiops*	Grooved topshell	#	ii		F	C	C
	Muricidae	*Haustrum haustorium*	Black rock shell	#	ii		O		
Limpets	Nacellidae	*Cellana ornata*	Ornate limpet	#	ii	C	A	C	F
	Nacellidae	*Cellana radians*	Tortoiseshell limpet	#	ii	R	F	O	O
	Siphonariidae	*Siphonaria zelandica*		#	ii				O
Chitons	Chitonidae	*Sypharochiton pelliserpentis*	Snakeskin chiton	#	ii		C	C	C
Barnacles	Catophragmidae	*Chamaesipho columna*	Column barnacles	%	i	S	S	A	R
	Balanidae	*Elminius plicatus*	Ridged surf barnacle	%	i	R			
	Balanidae	*Epopella plicata*	Plicate barnacle	%	i	R			
Bivalves	Mytilidae	*Mytilus galloprovincialis*	Blue mussel	%	i		R	R	
	Mytilidae	*Xenostrobus neozelanicus*	Black mussel	%	i	R	F	R	
Red Algae	Bangiaceae	*Porphyra* sp.	Karengo, Nori	%	ii	F	O		
	Corallinaceae	*Corallina officinalis*	Pink turf	%	ii				S
	Gelidiaceae	*Gelidium caulacantheum*		%	ii				C
	Rhodomelaceae	*Stictosiphonia arbuscula*	Moss weed	%	ii			R	R
Brown Algae	Adenocystaceae	*Adenocystis utricularis*	Sea bladders	%	ii				R
	Hormosiraceae	*Hormosira banksii*	Neptune's necklace	%	ii				A
	Splachnidiaceae	*Splachnidium rugosum*	Gummy weed	%	ii				F
	Scytothamnaceae	*Scytothamnus australis*		%	ii				C
	Ralfsiaceae	*Ralfsia verrucosa*	Tar spot/blood crust	%	ii				R
	Scytosiphonaceae	*Colpomenia sinuosa*	Oyster thief	%	ii				O
Green Algae	Codiaceae	*Codium convolutum*	Encrusting velvet	%	i				R
	Ulvaceae	*Ulva lactuca*	Sea lettuce	%	i			O	A

3. Results and Discussion (Continued)

Figure 3. ***Chamaeosipho columna, Cellana ornata,*** **and** ***Risellopsis varia*** **on the high shore.**

High Eulittoral Zone

The high eulittoral zone is submerged for short periods on each tide, and although relatively sheltered, is also exposed to seawater via waves and spray depending on swell and wind angle. Because of its exposed nature, the high shore zone was characterised by extensive patches of bare rock that supported a relatively sparse animal and plant community. Dominating this zone was the sessile, filter-feeding column barnacle *Chamaeosipho columna,* which filter-feeds from the water column at high tide. *C. columna* was superabundant (>80% cover), present in extensive sheets across the rock (see photo below). Other dominant invertebrate species included the highly mobile, herbivorous limpets *Cellana ornata* (abundant) and *Cellana radians* (frequent), and the snakeskin chiton *Sypharochiton pelliserpentis* (listed as common). The blue and black bivalve mussels *Mytilus galloprovincialis* and *Xenostrobus neozelanicus,* which formed patchy colonies amongst the barnacles, were rated as rare/frequent. Also present was the red algae, *Porphyra* sp. - occasional. The only changes identified from the 2016 survey were the presence of the periwinkles (*A. cincta, A. antipodum, Risellopsis varia*) in the high eulittoral zone. These small and highly mobile species commonly migrate up and down the shoreline, their distribution governed largely by physical constraints, in particular prevailing wave energy and temperature. The broader distribution of these species in 2017 is thought to reflect more overcast and noticeably cooler conditions whilst sampling compared to 2016's hot, dry conditions.

3. Results and Discussion (Continued)

Figure 4. ***S. pelliserpentis* and *C. radians* and *C. ornata* on the mid shore.**

Mid Eulittoral Zone

Although still containing bare patches, the mid eulittoral zone was dominated by the barnacle *Chamaeosipho columna,* classified as abundant.

Limpets were the most common of the mobile invertebrates with *Cellana radians* and *C. ornata,* both common/occasional. Other invertebrates included the chiton *Sypharochiton pelliserpentis* and the grooved topshell *Diloma aethiops,* both common, while the other topshells present (*R. varia, T. smaragdus* and *H. scobina*) were rated rare - most present sheltering in shaded cracks and crevices on the vertical rock faces (Figure 4). Also present among the barnacles, were the two species of mussel *M. galloprovincialis* and *X. neozelanicus,* both listed as rare. Recorded for the first time on the mid shore were the red alga *Stictosiphonia arbuscula* (rare) and the green alga *Ulva lactuca* (occasional).

Figure 5. ***Hormosira banksii* and *Corallina officinalis* on the low shore.**

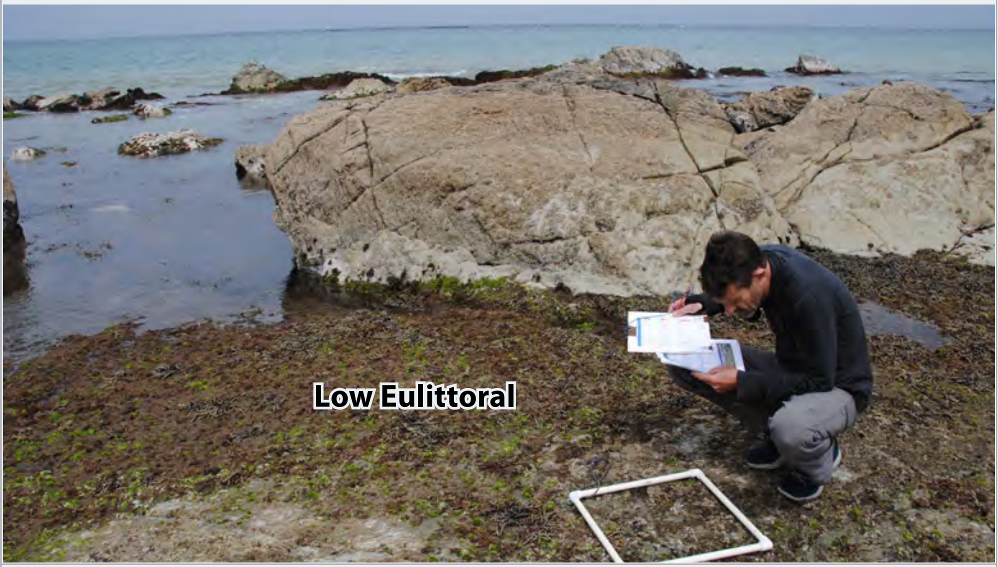
Low Eulittoral Zone

The lower eulittoral zone is exposed to the air for only a short period on each tidal cycle and is where algae of various forms have their stronghold on the shore. It was dominated by an extensive (superabundant) close turf of the calcareous red alga *Corallina officinalis*. Among this turf, a variety of subdominant brown macroalgae (i.e. *Adenocystis utricularis, Hormosira banksii, Splachnidium rugosum, Scytothamnus australis, Ralfsia verrucosa, Colpomenia sinuosa, Gelidium caulacantheum, Stictosiphonia arbuscula* and foliose green alga *Ulva* sp. were rated abundant to rare in cover (Table 3). The only appreciable change in algal abundance was *Ulva lactuca* which had increased from occasional to abundant. The presence of opportunistic macroalgal species like *Ulva* is a strong indicator of nutrient enrichment of coastal habitat.

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

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

These species graze on the calcareous red algae *Corallina officinalis*. Two topshells (*Turbo smaragdus, Diloma aethiops*) were commonly observed, although many mobile topshells seek refuge from the sun in crevices during the day and are therefore not common on the open shore when the tide is out. Also among the algal turf, other invertebrate species present included *Chamaeosipho columna* - rare.



Fixed Quadrats

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

3. Results and Discussion (Continued)

Example of topshells rapidly moving from low tide refuges onto exposed rock after being covered by water on the incoming tide.

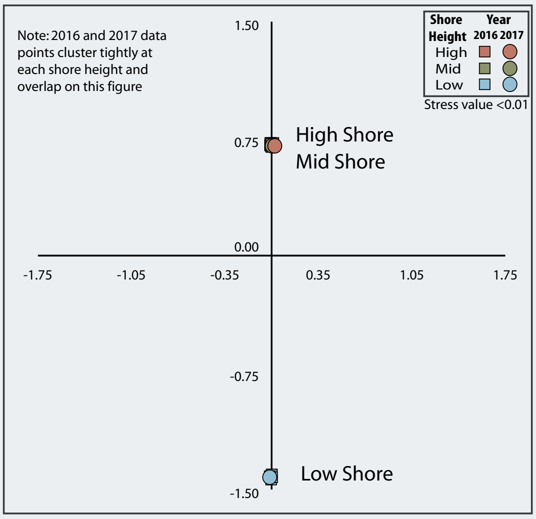
Table 4 summarises richness, abundance and diversity measures for the three shore heights. A total of 19 species were recorded from quadrats in 2017, 9 on the high shore, 8 on the mid shore, and 7 the lower shore. Combined with the 2016 data a total of 20 species have been recorded from quadrats, 9 on the high shore, 8 on the mid shore and 11 the lower shore. Note that this result only reflects species within the quadrats, and not the shore overall, as quadrat sampling excludes habitats such as crevices and rock pools which will support many additional species, while many mobile species move into shelter while the tide is out (see sidebar photo).

Table 4. Summary of richness, abundance, and diversity indices for mobile invertebrates, sessile invertebrates, and macroalgae present in quadrats, Flat Point, 2016 and 2017.

Category	High Shore			Mid Shore			Low Shore		
	2016	2017	2022	2016	2017	2022	2016	2017	2022
Total number of species	5	9		6	8		10	7	
MOBILE INVERTEBRATES (topshells, limpets, chitons)									
Richness (Number of species)	2	6		5	5		2	0	
Abundance (Mean number of individuals)	28.0	59.2		12.8	19.5		0.3	-	
Diversity (Shannon Index)	0.04	0.39		0.77	0.64		0.35	-	
SESSILE INVERTEBRATES (barnacles, mussels)									
Richness (Number of species)	3	3		1	2		0	0	
Abundance (Mean percentage cover)	94.3	93.5		31.7	29.0		-	-	
Diversity (Shannon Index)	0.10	0.09		-	0.02		-	-	
MACROALGAE									
Richness (Number of species)	0	0		0	1		8	7	
Abundance (Mean percentage cover)	-	-		-	0.33		66.2	88.2	
Diversity (Shannon Index)	-	-		-	-		0.45	0.85	

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

Figure 7 shows that the biotic community present predictably and strongly groups quadrats based on shore height. Such groupings also confirm that the individual sampling locations selected at each shore height are representative of each other and have not changed from 2016 to 2017. The similarity between the high and middle shore communities among quadrats (i.e. lack of distance between high and mid shore zones) reflects the relatively narrow tidal range with these sites being very similar in appearance and located close together on the shore.



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

Figure 7. n-MDS plot showing the relationship among samples in terms of similarity in macroalgal and macroinvertebrate community composition for Flat Point rocky shore quadrats, Jan. 2016 and 2017.

3. Results and Discussion (Continued)

Table 5. Raw data, mean number or percentage cover (±SE) and SACFOR rating of mobile invertebrates, sessile invertebrates, and macroalgae present in high, mid, and low shore quadrats, Flat Point, 2017.

High Shore Quadrat Data

H2017	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	*Austrolittorina cincta*	Periwinkle	#	i						2	0.3		R
	Haustrum scobina	Oyster borer	#	ii					1		0.2		R
	Risellopsis varia	Periwinkle	#	i					42	79	20.2	10.7	F
Limpets	*Cellana ornata*	Ornate limpet	#	ii	9	24	19	35	72	67	37.7	10.7	A
	Cellana radians	Tortoiseshell limpet	#	ii	1			1		1	0.5	0.0	O
Chitons	*Sypharochiton pelliserpentis*	Snakeskin chiton	#	ii		1					0.3	0.0	O
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	50	90	95	95	90	90	85.0	7.1	S
	Epopella placata	Ridged barnacle	%	i					1		0.2		R
Bivalves	*Xenostrobus neozelanicus*	Black mussel	%	i	10	10	5	10	5	10	8.3	1.1	O

Mid Shore Quadrat Data

M2017	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Topshells	*Haustrum scobina*	Oyster borer	#	ii			1				0.2		R
	Risellopsis varia	Ridged periwinkle	#	ii				10			1.7		O
Limpets	*Cellana ornata*	Ornate limpet	#	ii	3	18	16	13	17	19	14.3	2.4	C
	Cellana radians	Tortoiseshell limpet	#	ii		2	4	6			2.0	0.8	F
Chitons	*Sypharochiton pelliserpentis*	Snakeskin chiton	#	ii			8				1.3		F
Barnacles	*Chamaesipho columna*	Column barnacle	%	i	40	30	30	35	20	15	28.3	3.8	C
Bivalves	*Xenostrobus neozelanicus*	Black mussel	%	i				1	2	1	0.7	0.2	R
Red Algae	*Stictosiphonia arbuscula*	Moss weed	%	ii	1		1				0.3	0.0	R

Low Shore Quadrat Data

L2017	Scientific name	Common Name	Unit	Class	Quadrat						Total		
					1	2	3	4	5	6	Mean	SE	SACFOR
Brown Algae	*Adenocystis utricularis*	Sea bladder	%	ii	2	3	1	5	3		2.3	0.6	O
	Ralfsia verrucosa	Tar spot/blood crust	%	i	10	1	20	5	5	5	7.7	2.7	O
	Hormosira banksii	Neptunes necklace	%	ii		2	1	1	5	10	3.2	1.6	O
Green Algae	*Codium convulutum*	Encrusting velvet	%	i		2	1				0.5	0.3	R
	Ulva lactuca	Sea lettuce	%	ii	2	25	5		5	5	7.0	3.8	F
Red Algae	*Corallina officinalis*	Pink turf	%	ii	85	50	45	65	35	35	52.5	7.9	S
	Gelidium caulacantheum		%	ii		10		20	20	40	15.0	5.1	C

3. Results and Discussion (Continued)

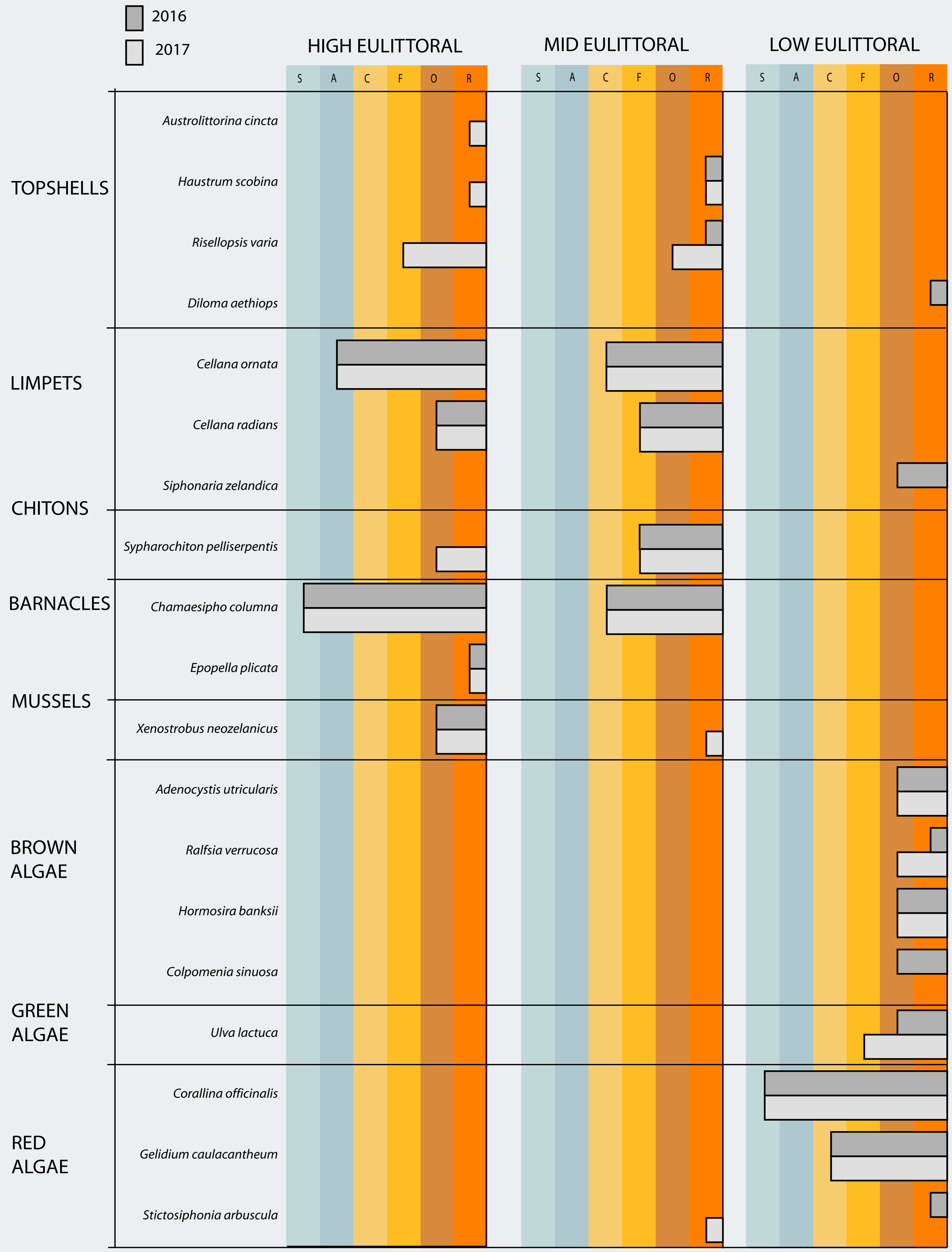


Figure 8. Mean SACFOR rating for species present in 6 fixed quadrats in high, mid and low eulittoral zones, 2016 and 2017.

3. Results and Discussion (Continued)

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

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

Two years of baseline monitoring at Flat Point indicate a diverse rocky shore community, typical of temperate rocky shores worldwide (e.g. Tomanek and Helmuth 2002), with very little change between years and no obvious presence of pollution. While there is a low-moderate risk based on predicted sea level rise and temperature change, the risk from pathogens, sedimentation, eutrophication, and toxins is currently considered relatively low in a regional context. Consequently GWRC has proposed that the 3 year monitoring baseline be shortened to 2 years, to allow monitoring effort to switch to higher priority sites on the Wellington south coast.

Ongoing monitoring at Flat Point is recommended on a 5 yearly cycle with detailed data analysis undertaken after the next round of monitoring (scheduled for 2022. This is likely to include a combination of PRIMER-e based analyses (Clarke & Gorley 2006), analysis of similarity (ANOSIM) to test for statistical differences in biotic assemblages among quadrats over time, and similarity percentage analysis (SIMPER) to identify taxa contributing most to multivariate differences among quadrats over time. SIMPER analysis will also enable identification of key indicator species, which will aid the intended development of condition ratings to characterise the status of the shore. Such ratings have not previously been attempted because current scientific knowledge of many NZ rocky shore species is scarce or incomplete. However, by focusing on measuring shifts in community composition, the presence or absence of key indicator species (including introduced plants and animals), as well as indicators of nutrient enrichment and sedimentation, it will be possible to develop appropriate condition ratings once the baseline monitoring is completed.

4. SUMMARY

The first two years of baseline rocky shore monitoring at Flat Point showed a healthy and unpolluted coastline supporting a diverse community of rocky shore organisms present in a predictable shoreline zonation.

The zonation extended from a relatively low diversity, high shore intertidal community dominated by barnacles, limpets and mussels, through the mid shore barnacle dominated zone where topshells, limpets and chitons were also common, to the highest diversity low shore algal zone dominated by the extensively turfing, crustose red algae *Corallina officinalis,* and beneath low water by several fleshy brown macroalgae (e.g. *Carpophyllum flexuosum, Carpophyllum plumosum and Cystophora torulosa*).

5. MONITORING

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

Rocky Shore Monitoring:

- Because pressures on the rocky shore at Flat Point are considered only low-moderate, and the community appears stable with very little variation evident over the first 2 years of monitoring, it is recommended that the originally proposed 3 year baseline be shortened to 2 years. This will allow the establishment of rocky shore monitoring sites on the Wellington south coast that have been identified as a higher priority by GWRC.
- Continue the scheduled monitoring at Flat Point at 5 yearly intervals (next due 2022) or as deemed necessary based on rocky shore condition ratings (to be developed).

6. ACKNOWLEDGEMENTS

Thanks to Megan Oliver (GWRC) for her support and feedback on the draft report.

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APPENDIX 1. DETAILED RESULTS

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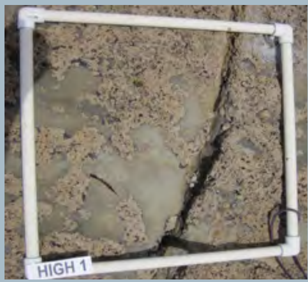
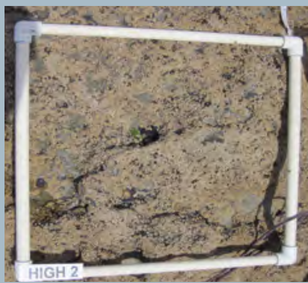
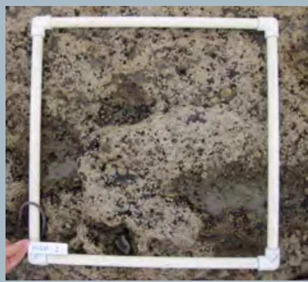
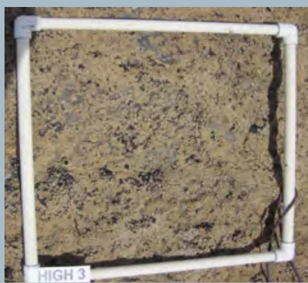
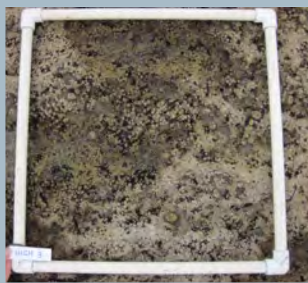
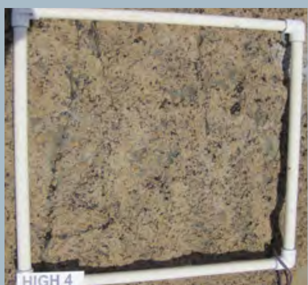
QUADRAT 1 NZTM 1847960 East NZTM 5429657 North			
QUADRAT 2 NZTM 1847960 East NZTM 5429657 North			
QUADRAT 3 NZTM 1847958 East NZTM 5429655 North			
QUADRAT 4 NZTM 1847951 East NZTM 5429653 North			
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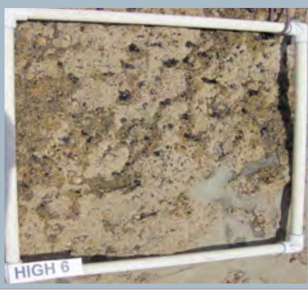
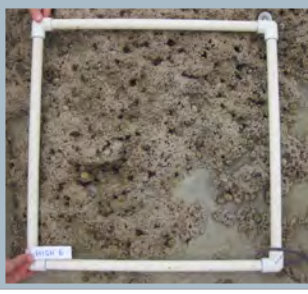
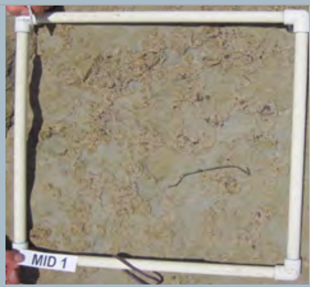
QUADRAT 6 NZTM 1847949 East NZTM 5429648 North			

APPENDIX 1. DETAILED RESULTS (CONT.)

Mid Eulittoral	2016	2017	2022
QUADRAT 1 NZTM 1847960 East NZTM 5429657 North			
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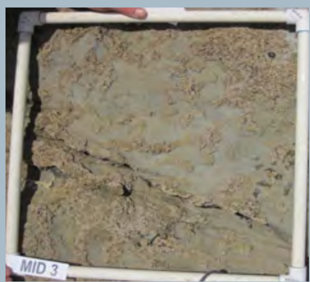
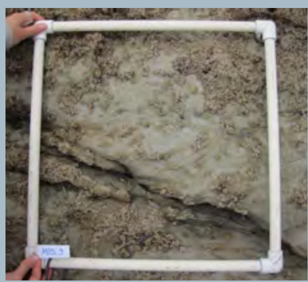
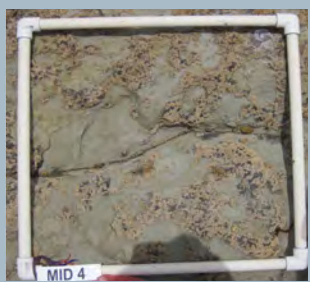
QUADRAT 3 NZTM 1847957 East NZTM 5429654 North			
QUADRAT 4 NZTM 1847951 East NZTM 5429655 North			
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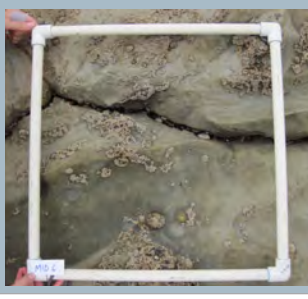
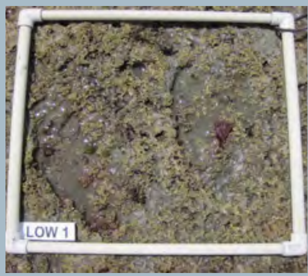
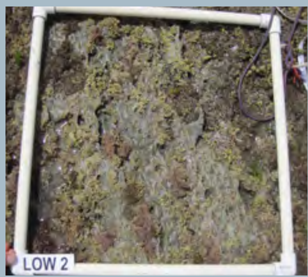
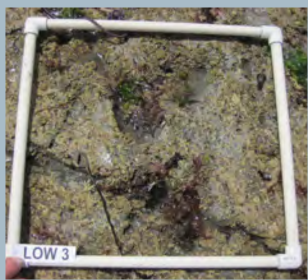
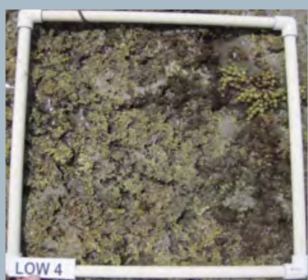
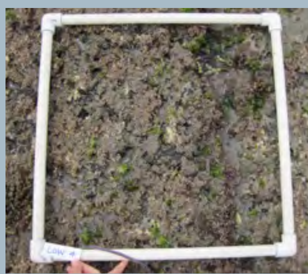
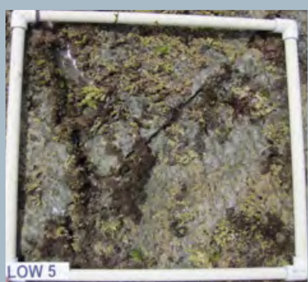
QUADRAT 6 NZTM 1847948 East NZTM 5429649 North			

Appendix 1. DETAILED RESULTS (CONT.)

Low Eulittoral	2016	2017	2022
QUADRAT 1 NZTM 1847948 East NZTM 5429663 North			
QUADRAT 2 NZTM 1847949 East NZTM 5429661 North			
QUADRAT 3 NZTM 1847946 East NZTM 5429662 North			
QUADRAT 4 NZTM 1847947 East NZTM 5429659 North			
QUADRAT 5 NZTM 1847948 East NZTM 5429657 North			
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