Repeat Monitoring of Seagrass Beds for Project Next Generation: Summer 2013/2014

Prepared by

Ryder Consulting

February 2014

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environment + planning + project management

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Cover Photo: Seagrass beds off Harwood, Otago Harbour – Brian Stewart

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Executive Summary

Port Otago Ltd has been granted consents to carry out dredging and disposal work that will deepen the approaches to Port Chalmers. Conditions of the consent stipulate that environmental monitoring of seagrass beds be carried out before work commences. Seagrass beds are recognised as being ecologically significant in providing nursery grounds for a wide variety of intertidal invertebrates and fish, and as feeding areas for birds and fish. Seagrass beds were surveyed in winter 2013, spring 2013 and summer of 2013/2014 by Ryder Consulting Ltd. This report presents the findings of the third (summer) survey.

There has been a significant reduction in the mean length of *Zostera* blades since the winter survey at both the control sites (Papanui Inlet) and the potential impact sites (Harwood), but this is not unexpected as growth varies with season.

For other parameters measured there has been a significant change to percentage cover if one considers treatment (impact vs control), in conjunction with season. There has also been a change in biomass, with the biomass of plants at the control site being significantly less than those at the impact site (Harwood) this summer. All other parameters, including substrate composition and thickness of the RDL, show no significant changes.

Bearing in mind there had been no capital works dredging carried out prior to this latest survey, any changes are attributed to natural variability. Such variability needs to be considered when dredging does commence.

The survey will be repeated in autumn.

1 Introduction

The approaches to Port Chalmers are considered to be inadequate to accommodate the passage of large container vessels that may visit the port in future years (Plunket 2011). To address this concern Port Otago Ltd (POL) applied for and has been granted consents enabling dredging of the channel between Port Chalmers and the entrance to Otago Harbour at Taiaroa Head. Dredging will ultimately result in the disposal of up to 7.2 million cubic metres of dredged material at a site known as A0, some 6.3 km north-east of Taiaroa Head. It is proposed that the dredging will be carried out at two intensities; incremental capital works dredging (ICW), which is relatively small scale, and major capital works dredging (MCW), which is at a larger scale.

As part of the resource consent application process POL engaged various consultants to carry out a raft of investigations, including comprehensive assessments of the ecology of the lower Otago Harbour (e.g. James *et al*. 2007, Paavo and Probert 2005, Paavo *et al.* 2008, Paavo 2009).

A condition of the resource consent granted to carry out the proposed dredging work specifies that POL must carry out appropriate biological monitoring of seagrass beds to gauge any effects that might be attributable to the works. The surveys are to occur quarterly for a period of one year. Should adverse effects be found modifications may be made to the dredging regime, if necessary. Seagrass (*Zostera muelleri* subsp. *capricorni*) beds, are considered important due to their significance as vital shelter, feeding, spawning and nursery habitat for a number of epifaunal species and fish (Reed and Hovel 2006, Mills 2006).

POL has engaged Ryder Consulting Ltd (RCL) to carry out quarterly monitoring of seagrass beds within Otago Harbour and at a control site in Papanui Inlet. The following report presents the findings of the third (summer) survey carried out by RCL and compares them with the findings presented in the initial baseline report (winter) commissioned by POL, and the spring survey.

2 Methods

On each occasion four randomly placed transects across the seagrass beds at Harwood were surveyed. Harwood was selected as a suitable site as it is a possible impact site where, due to lower tidal current speeds, fine sediments generated from the dredging operation may settle out and affect the habitat (Figure 2.1). Two additional transects

were surveyed at Papanui Inlet as control sites (Figure 2.2).

Figure 2.1 *Location of transects across seagrass beds off Harwood, Otago Harbour.*

Figure 2.2 *Seagrass bed transect locations at Papanui Inlet.*

Being outside the Harbour, Papanui Inlet is not an ideal control site. However, it is believed to be the best control site available within reasonable travelling distance as it has a similar low-current regime to the Harwood site and will be affected by weather events that may also affect the Harbour at Harwood. It may be best thought of as a "reference" site.

Each transect was 100 m long with a $1m^2$ quadrat photographed at 20 m intervals. At each quadrat a randomly located 75 mm diameter core was taken to a depth that ensured collection of *Zostera* plant stems and root systems (i.e. 200 mm). Cores were labelled and returned to the laboratory where they were rinsed using a 1 mm sieve to separate plant material from substrate.

It was assumed that only the parts of *Zostera* plants that appeared above the substrate contained chlorophyll and, as such, individual *Zostera* blades were measured from the point at which they became distinctly green (Figure 2.3). Shoots were counted as a 'set' of blades obviously grouped together, regardless of whether or not they arose on the same stolon (Figure 2.4) and shoots per square metre calculated.

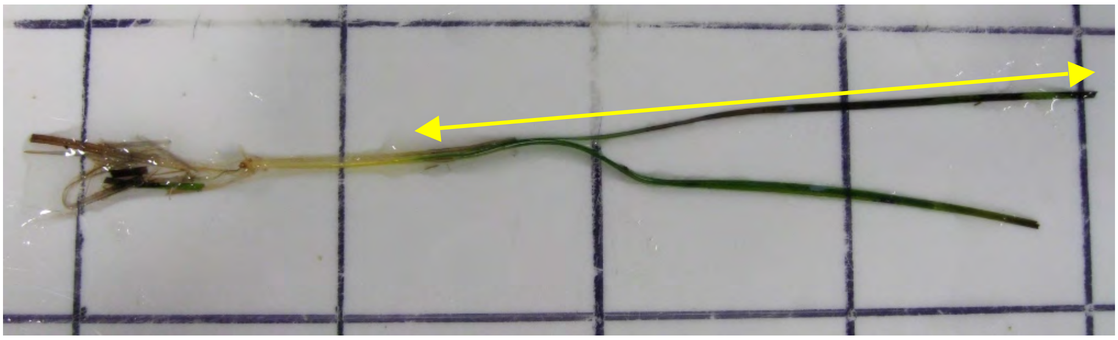

Figure 2.3 Zostera *blade length measured as length of yellow arrow.*

Percentage cover was calculated for each quadrat using a methods similar to the "Dots on Rocks" technique, in which fifty randomly placed dots are overlain on each image and whether or not seagrass blades are present under the dot is recorded (e.g. Figure 2.5).

Finally all *Zostera* plant material, including blades, stolons and root system was gently squeezed to remove excess water and weighed to give biomass per core, from which biomass per square metre was calculated.

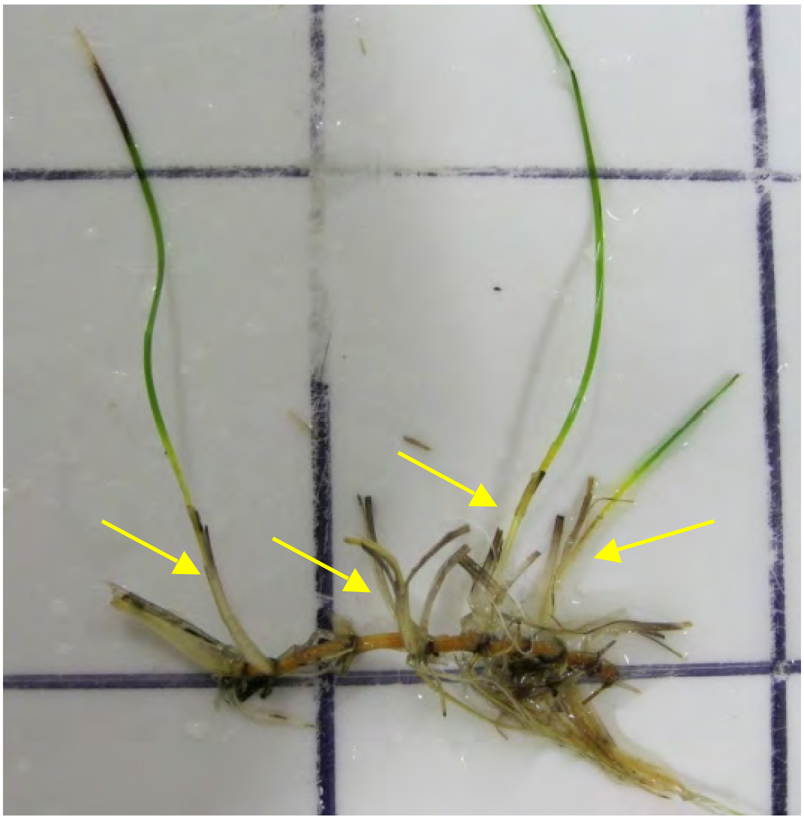

Figure 2.4 *Four* Zostera *'shoots' (arrows) arising from a single stolon.*

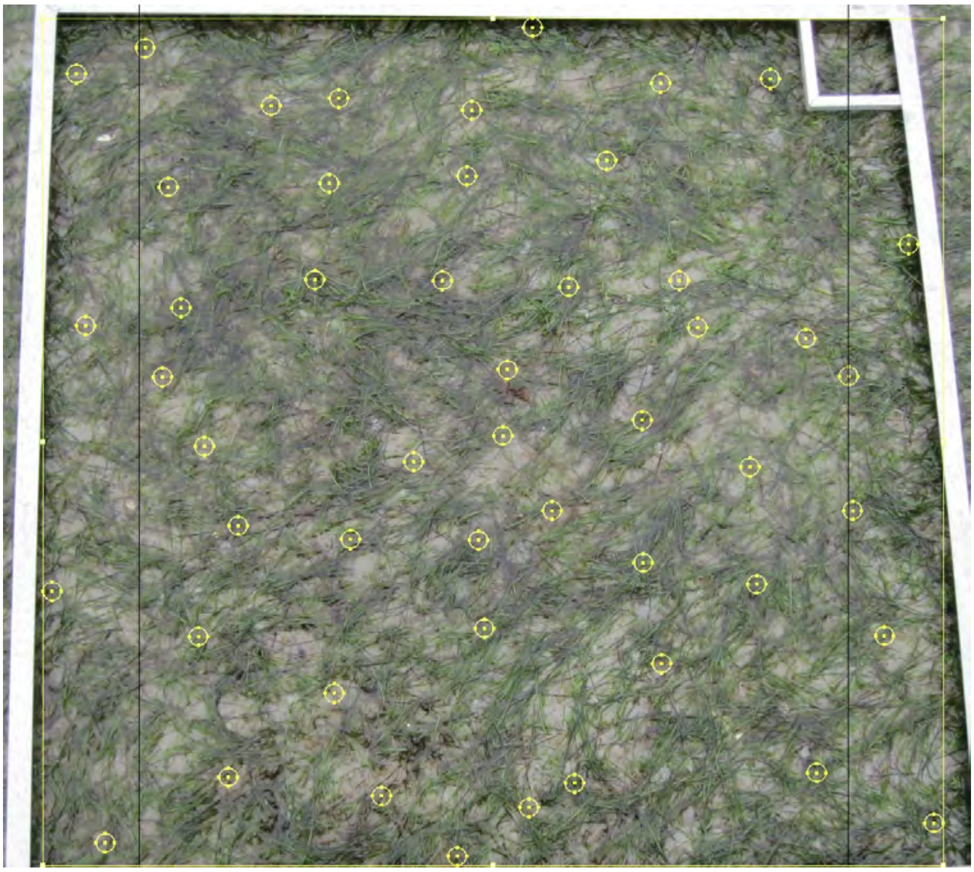

Figure 2.5 *Random points used to determine percentage cover for a quadrat.*

To gauge impacts on substrate, a single core was taken at the seaward end of each transect and photographed for determination of the depth of the redox discontinuity layer (RDL). A subsample was then removed from the top 20 mm of each core and returned to the laboratory for particle size analysis.

3. Results

Seagrass beds were visited at low tide on 3rd December 2013. GPS co-ordinates (NZMG) for all transects and quadrat locations are presented in Table 3.1 to facilitate revisits to the sites in future surveys. Examples of photographs of individual quadrats assessed are presented in Appendix 1.

Cover by seagrass was generally moderately high along transects, with very few quadrats falling on sparsely vegetated areas (Appendix 1). As in the winter (July) survey however (Stewart 2013), there were frequent patches of bare sand scattered throughout the seagrass beds beyond the transects (Figure 3.1).

Table 3.1 *GPS locations of seagrass assessment sites. Co-ordinates are expressed as NZMG.*

Harwood	Transect 1					
	QA	QB	QC	QD	QE	QF
	E2328600	E2328580	E2328559	E2328540	E2328521	E2328502
	N5484829	N5484836	N5484841	N5484845	N5484848	N5484855
	Transect 2					
	QA	QB	QC	QD	QE	QF
	E2328577	E2328558	E2328540	E2328521	E2328502	E2328480
	N5485157	N5485162	N5485167	N5485170	N5485175	N5485179
	Transect 3					
	QA	QB	QC	QD	QE	QF
	E2328630	E2328613	E2328596	E2328580	E2328562	E2328545
	N5485474	N5485483	N5485494	N5485506	N5485517	N5485528
	Transect 4					
	QA	QB	QC	QD	QE	QF
	E2329367	E2329374	E2329382	E2329389	E2329397	E2329406
	N5485828	N5485843	N5485864	N5485881	N5485899	N5485920
Papanui Inlet	Control 1					
	QA	QB	QC	QD	QE	QF
	E2330260	E2330267	E2330278	E2330291	E2330304	E2330315
	N5482688	N5482671	N5482658	N5482640	N5482627	N5482606
	Control 2					
	QA	QB	QC	QD	QE	QF
	E2330278	E2330296	E2330312	E2330330	E2330347	E2330365
	N5482708	N5482700	N5482690	N5482680	N5482673	N5482663

Blade length was once again variable among transects and also along the length of each transect (Figure 3.2).

Figure 3.1 Zostera *bed at Harwood showing patchy nature of cover.*

The greatest mean blade length was observed along Transect 4, Harwood (c.f. greatest at Papanui Inlet Transect 2 in spring), with next mean longest being along Transect 3 at Harwood. T3 at Harwood also had the most consistent blade lengths. The shortest overall blade lengths were found along Transect 1 at Papanui Inlet (Figure 3.3). Overall *Zostera* blade length in summer was significantly less than in the winter survey, but similar to the spring survey ($F_{2,12} = 1.26$; $p = 0.319$) (Figures 3.2, 3.3 and 3.4).

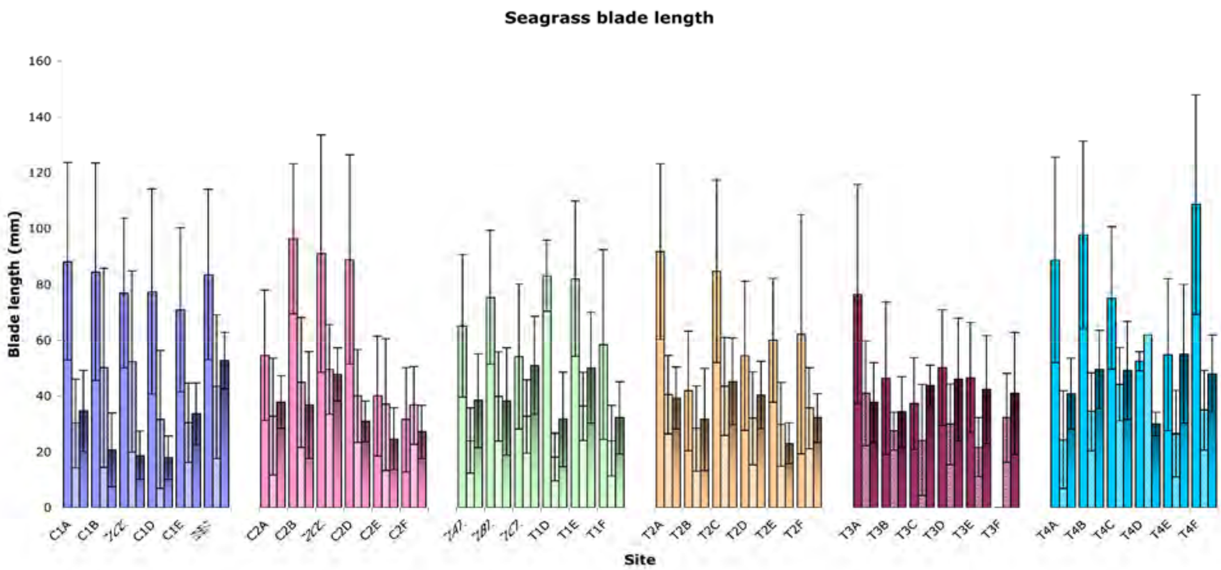

Figure 3.2 Zostera *mean blade lengths in quadrats at Papanui Inlet (C) and Harwood (T) in July 2013 (winter), October 2013 (spring) and December 2013 (summer). Solid bars are winter, patterned bars are spring and shaded bars are summer. Error bars are +/- one standard deviation.*

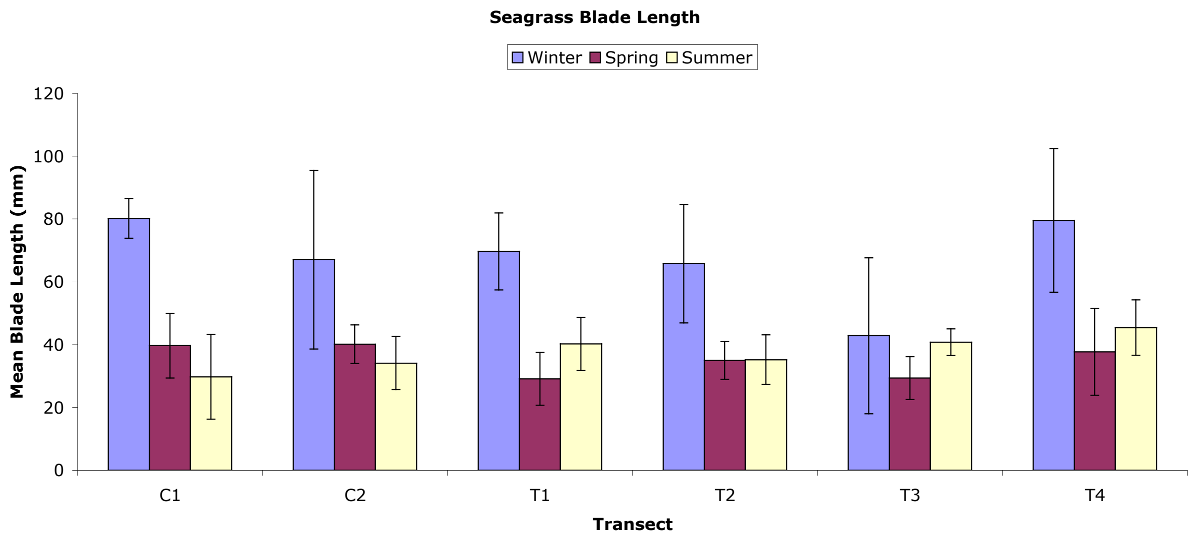

Figure 3.3 *Mean* Zostera *blade length along transects Papanui Inlet (C) and Harwood (T) in July 2013 (winter), October 2013 (spring) and December 2013 (summer). Error bars are +/- one standard deviation.*

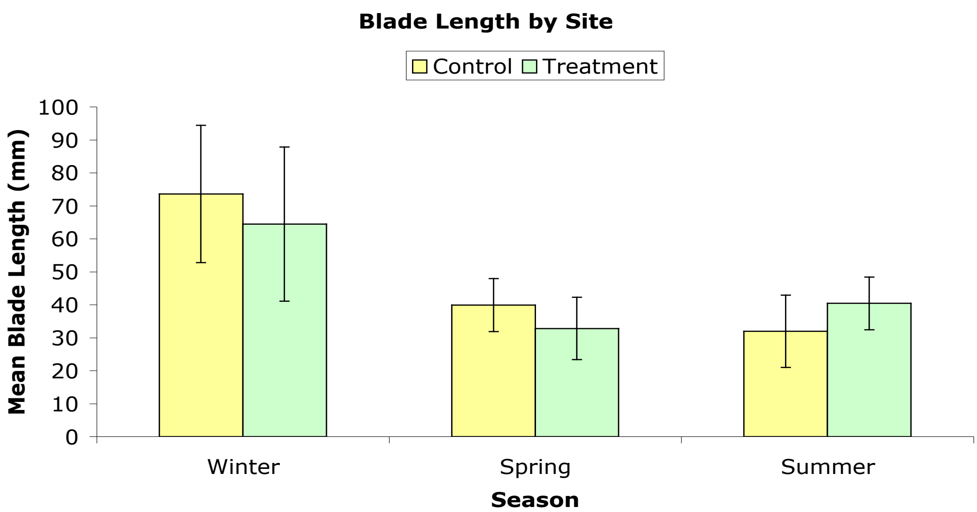

Figure 3.4 *Mean* Zostera *blade length at control and treatment sites through the seasons. Error bars are +/- one standard deviation.*

When blade length at treatment and control areas is analysed with season using 2-way ANOVA, we find that there is a significant difference in blade length with season, but not for treatment. The interaction between treatment and season is also significant (Table 3.2). Note that p values of less than 0.05 indicate significant differences.

Table 3.2 *Results for 2-way ANOVA testing effect of season and treatment with respect to blade length.*

	$F_{1,35}$	p
Treatment	0.719	0.398
Season	51.05	0.0001
Treatment/Season Interaction	3.311	0.0404

As in the winter and spring surveys, the density of *Zostera* shoots was reasonably consistent among transects at both Harwood and Papanui Inlet (Figure 3.5) and also when control and treatment sites are compared (Figure 3.6). Density appears greatest along Transect 2 at Harwood, as it was in winter.

Likewise, percentage cover of *Zostera* is not significantly different from season to season or from treatment and control areas (Figures 3.7 and 3.8).

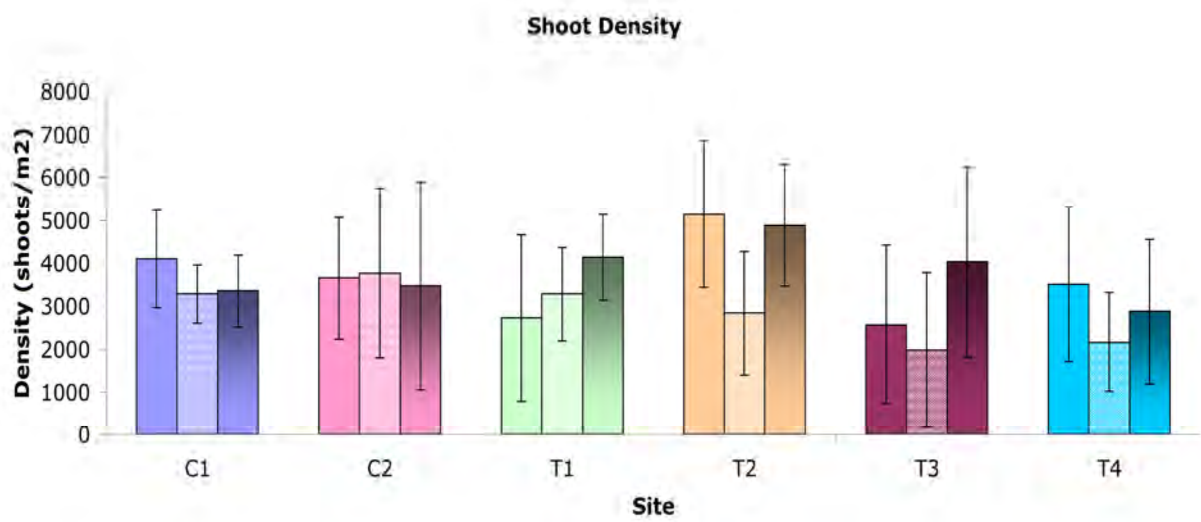

Figure 3.5 *Mean* Zostera *shoot density along transects Papanui Inlet (C) and Harwood (T) in July 2013 (winter), October 2013 (spring) and December 2013 (summer). Solid bars are winter, patterned bars are spring and shaded bars are summer. Error bars are +/- one standard deviation.*

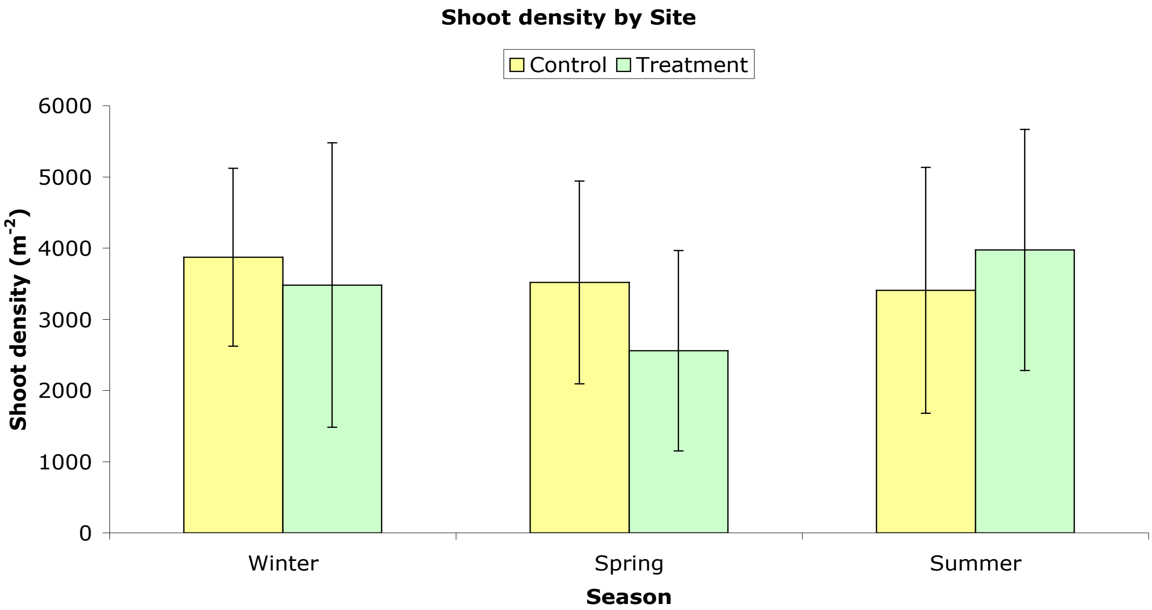

Figure 3.6 *Mean* Zostera *shoot density length at control and treatment sites through the seasons. Error bars are +/- one standard deviation.*

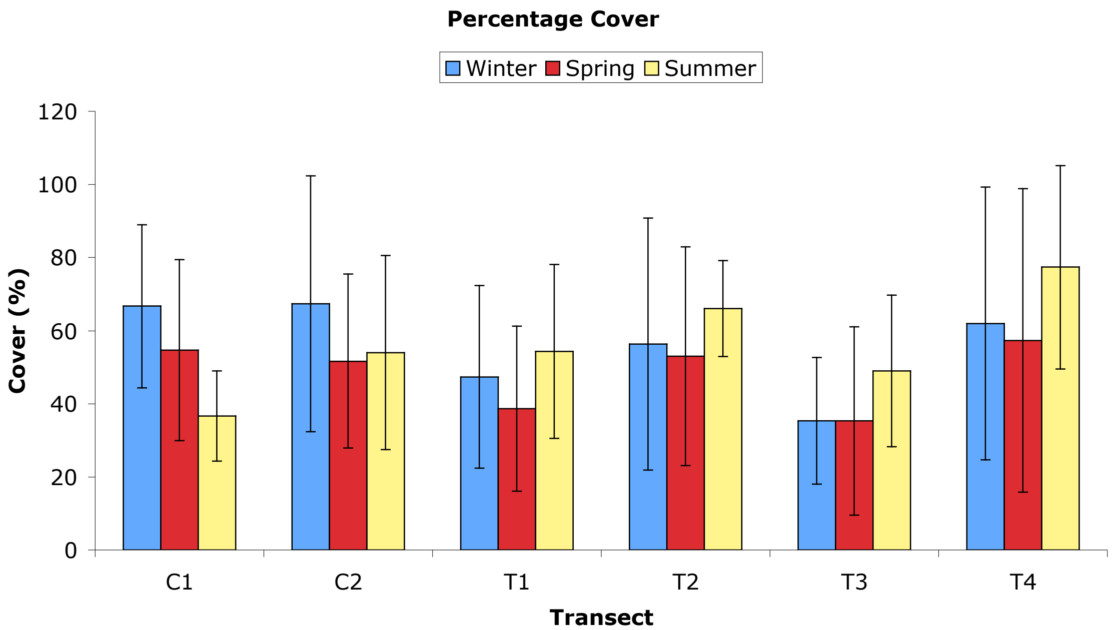

Figure 3.7 *Mean percentage cover of* Zostera *in quadrats along transects in control (C) and treatment (T) areas. Error bars are +/- one standard deviation.*

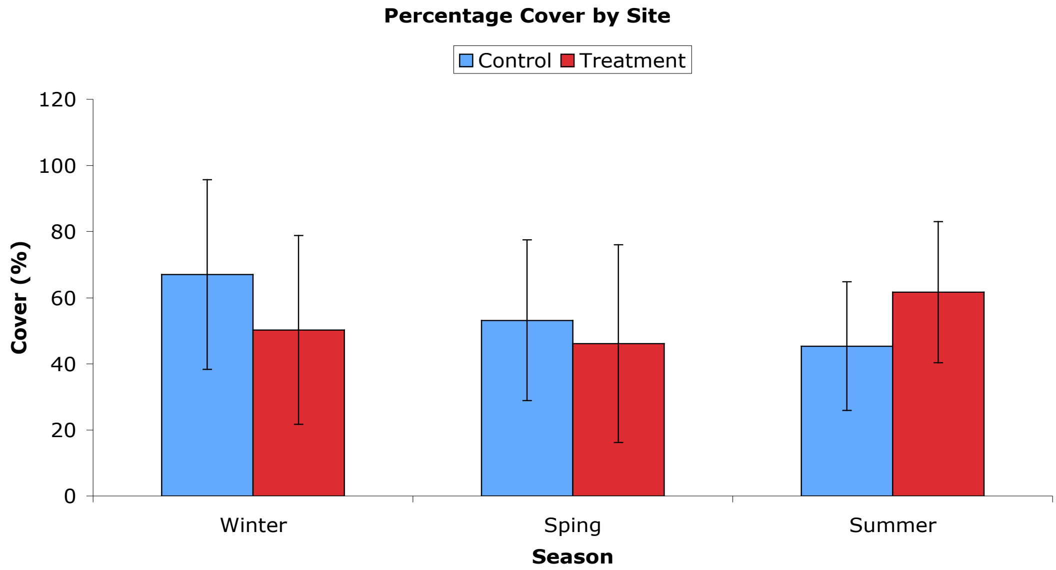

Figure 3.8 *Mean percentage cover of* Zostera *at treatment and control sites through the seasons. Error bars are +/- one standard deviation.*

Two-way analysis of variance (ANOVA) reveals no significant difference in shoot density among transects from season to season, or among treatments (Table 3.3). Neither is the interaction between treatment and season significant (Table 3.3).

Table 3.3 *Results for 2-way ANOVA testing effect of season and treatment with respect to shoot density.*

	$F_{1,35}$	p
Treatment	0.604	0.439
Season	1.642	0.199
Treatment/Season Interaction	1.764	0.177

When percentage cover is analysed using to-way analysis of variance (ANOVA) there is no significant difference in cover among transects from season to season, nor among treatments (Table 3.4). However, the interaction between treatment and season is significant (Table 3.4).

Table 3.4 *Results for 2-way ANOVA testing effect of season and treatment with respect to percentage cover.*

	$F_{1,35}$	p
Treatment	0.209	0.648
Season	0.909	0.406
Treatment/Season Interaction	3.226	0.044

Biomass in summer was greatest along Transect 1 at Harwood (c.f. greatest at Transect 2 at Harwood in previous surveys) (Figures 3.9). As in the winter survey, highest biomass relates to the highest density (Figure 3.5). There is, however, little change in biomass from season to season (Figure 3.10). When tested using two way ANOVA there is a significant difference among treatment and control areas (Table 3.5). However, there is no significant difference in biomass from season to season, or for season/treatment interaction (Table 3.5).

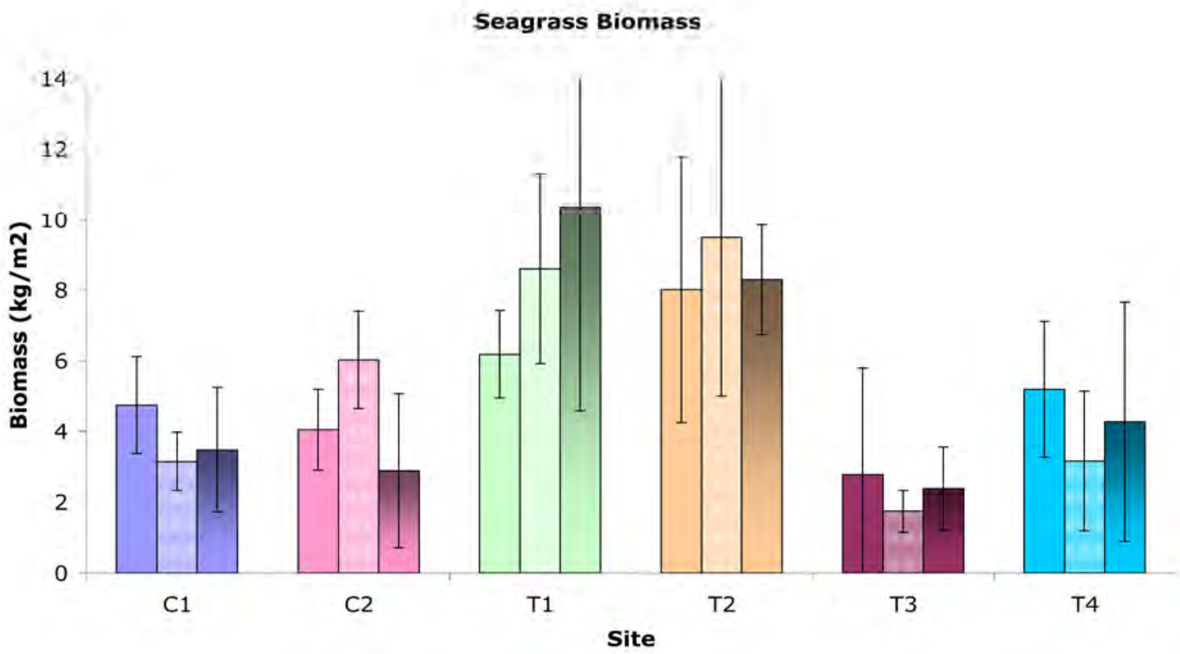

Figure 3.9 *Mean* Zostera *biomass along transects at Papanui Inlet (C) and Harwood (T) in July 2013 (winter), October 2013 (spring) and December 2013 (summer). Solid bars are winter, patterned bars are spring and shaded bars are summer. Error bars are +/- one standard deviation.*

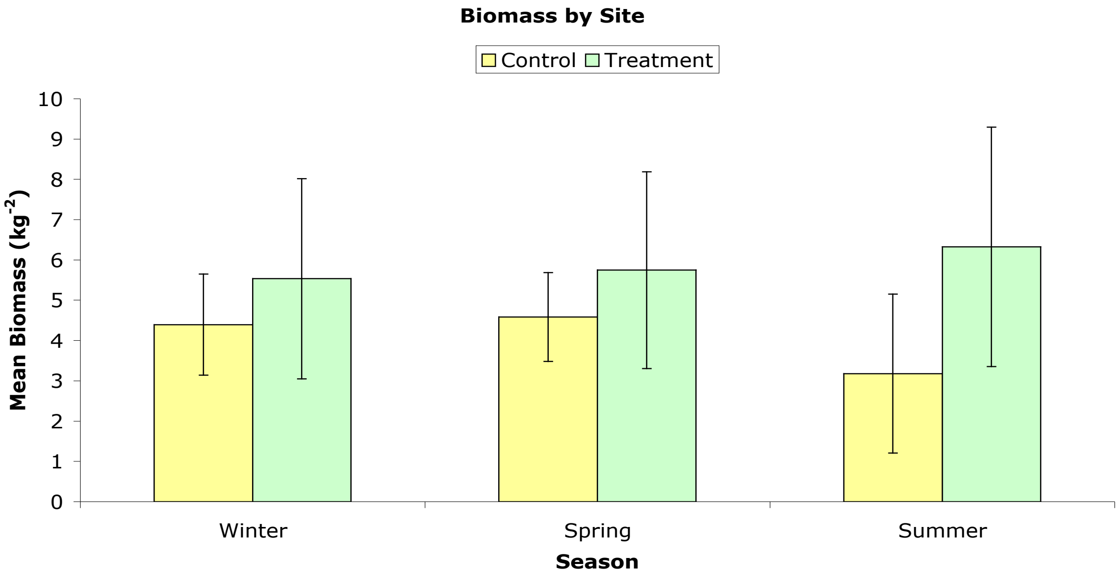

Figure 3.10 *Mean* Zostera *biomass at control and treatment sites through the seasons. Error bars are +/- one standard deviation.*

Table 3.5 *Results for 2-way ANOVA testing effect of season and treatment with respect to biomass.*

	$F_{1,35}$	p
Treatment	6.551	0.012
Season	0.114	0.892
Treatment/Season Interaction	0.876	0.419

Examination of cores taken at each transect revealed that the redox discontinuity layer (RDL) is well defined and deep at both Transects in Papanui Inlet (Appendix 2). At Harwood, the RDL is very ill defined at Transects 1 and 2 (Appendix 2), and at Transect 3 it is absent in the winter core, but more well defined in the summer core, lying from 25-65 mm deep (Appendix 2). At Transect 4 there is an ill-defined anoxic layer extending from 40 mm to 130 mm depth.

Substrate composition was reasonably consistent across transects (Table 3.6, Figures 3.11 and 3.12). Only two cores were collected from the seagrass beds during the initial baseline survey. Composition at Transect 1 is very similar from winter to summer, but at Transect 3 there is a much higher percentage of grains in the 125-250 µm size range in winter than in summer (Figure 3.11).

Table 3.6 *Percentage composition of particle sizes of substrate at each transect in summer. C = Control; T = Treatment. Two winter cores are included for comparison.*

	Percentage Composition					
Site	<63µm	>63µm	>125µm	>250µm	>500µm	>2mm
C1	2.71	4.48	23.45	61.03	5.09	3.23
C2	1.67	5.72	31.88	52.88	5.31	2.54
T1 (winter)	0.06	0.06	9.08	78.07	9.20	3.53
T1	0.12	0.04	17.43	75.52	2.53	4.37
T2	0.04	0.31	15.90	76.55	3.72	3.47
T3 (winter)	0.48	0.06	43.26	48.75	4.32	3.14
T3	0.11	0.14	17.00	72.89	3.44	6.42
T4	0.66	0.79	25.82	58.24	9.90	4.60

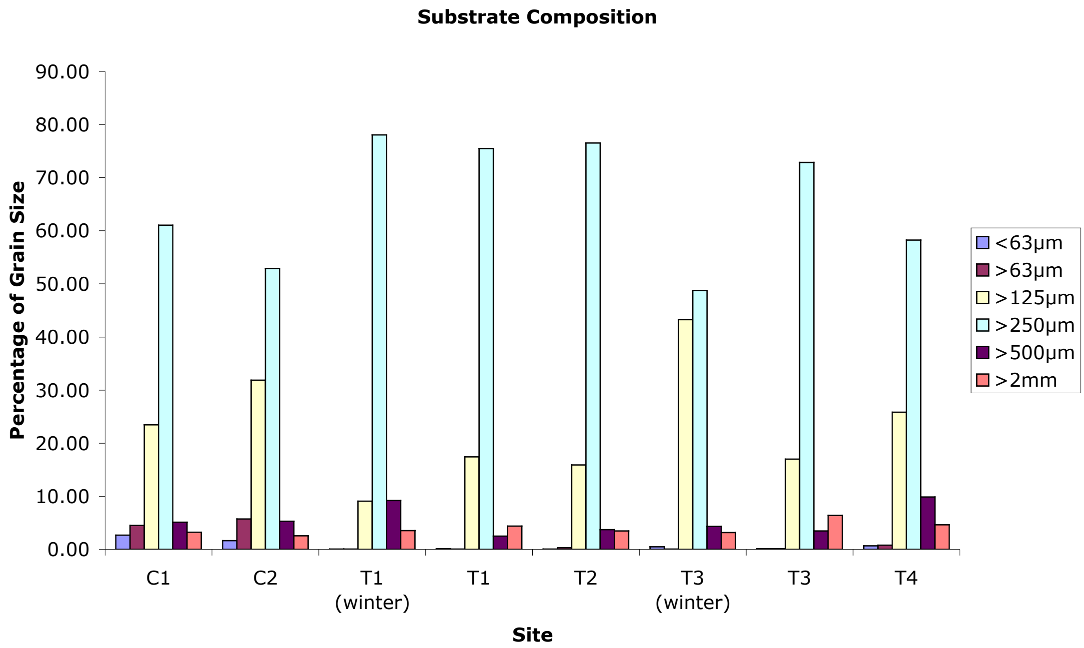

Figure 3.11 *Composition of substrate at each transect. C = Control; T = Treatment. Two winter cores are included for comparison.*

Substrate composition is also quite consistent among treatment and control sites (Figure 3.13), with there being no significant difference when results are examined using one-way analysis of variance ($F_{1,10} = 3.38$; $p = 0.999$).

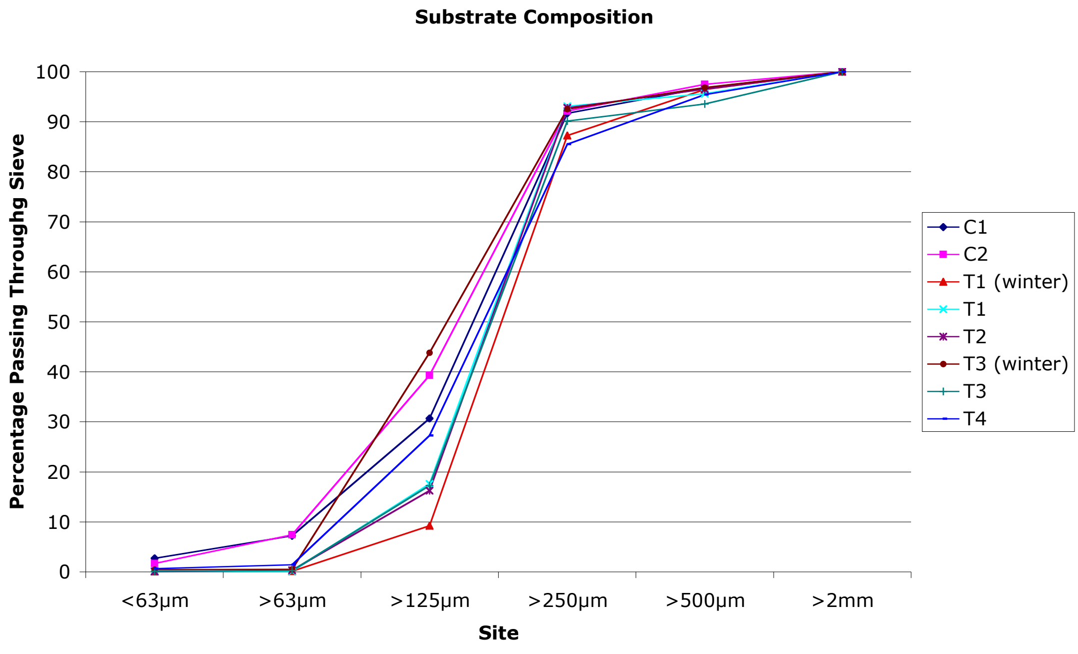

Figure 3.12 *Composition of substrate at each transect expressed as percentage of grains passing through specific mesh sizes.*

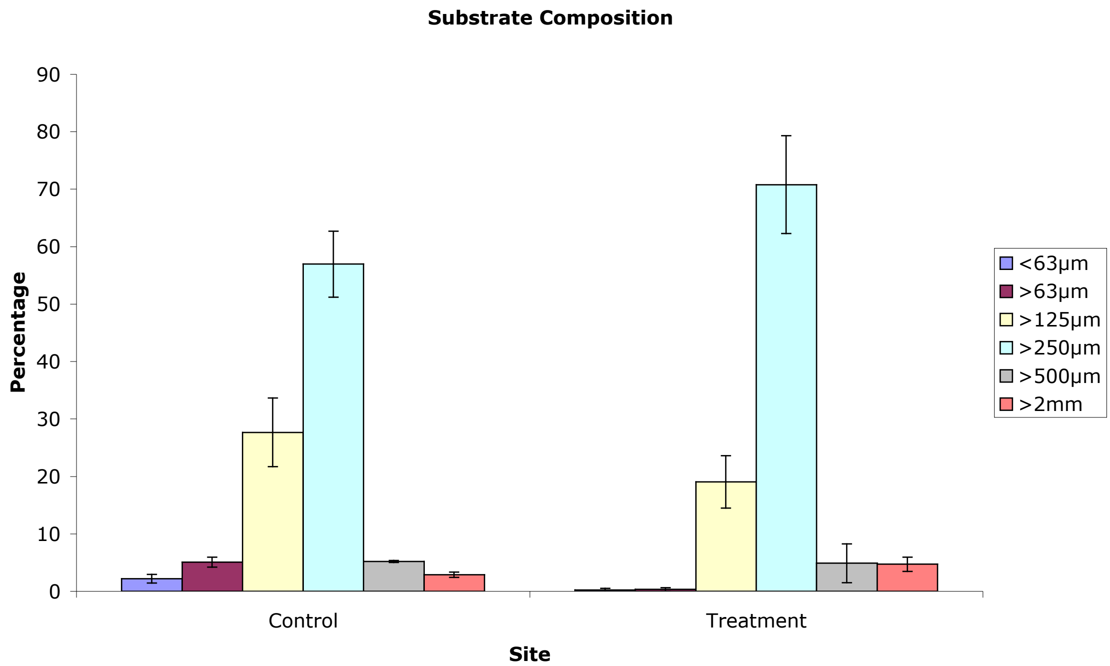

Figure 3.13 *Mean composition of substrate at each site. Error bars are +/- one standard deviation.*

Areas that were originally aerial photographed on 28 July 2013 were re-photographed on 3 February 2014. Actual spatial area covered by seagrass varied very little from winter to

summer for both Papanui Inlet and Harwood (Figures 3.14 and 3.15). Seagrass density appears to be less in the summer photographs, with cover appearing to be more sparse. However, this is not borne out by actual measurement of shoot density nor percentage cover and is more likely a reflection of blade length, which does show a significant difference with season.

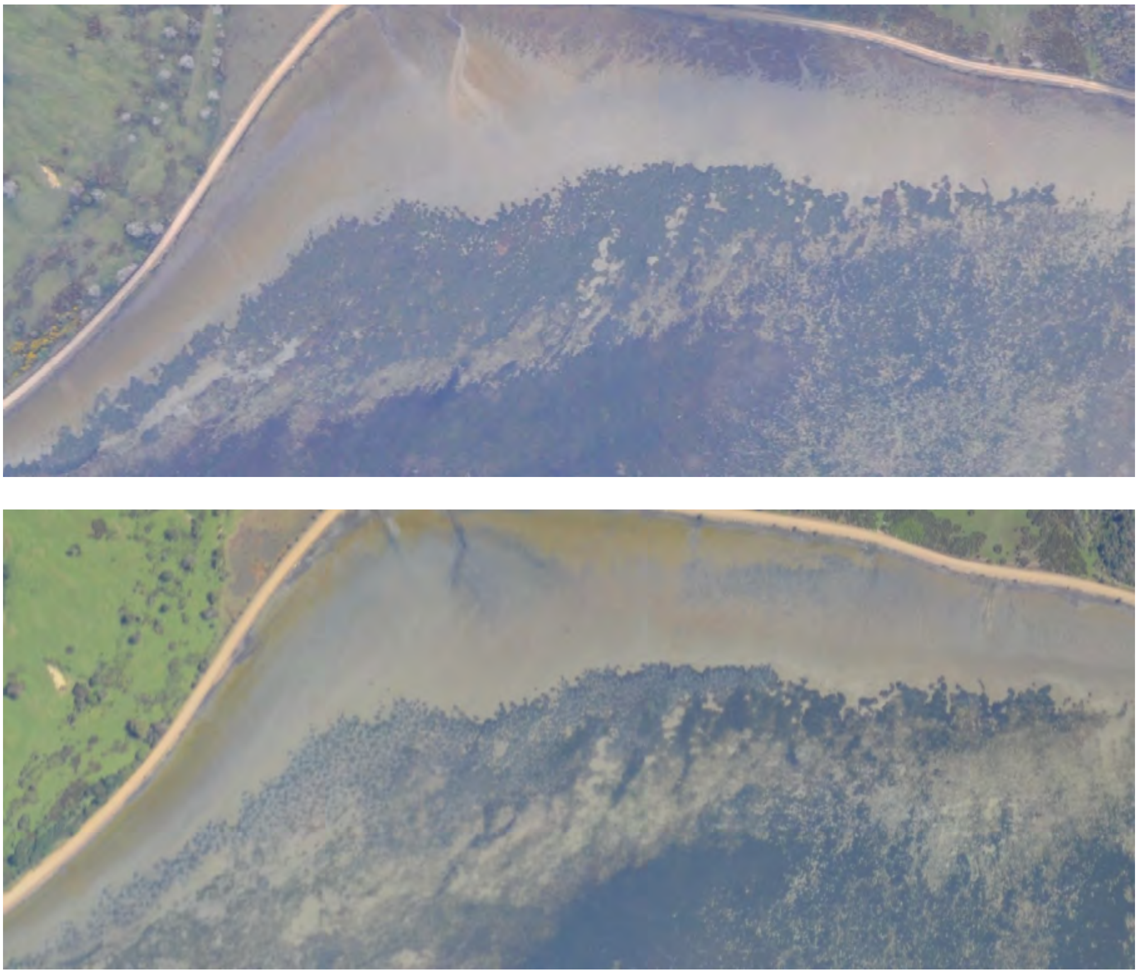

Figure 3.14 *Aerial photographs of seagrass study area, Papanui Inlet. Top = winter 2013, bottom = summer 2013-2014.*

Figure 3.15 *Aerial photographs of seagrass study area, Harwood. Top = winter 2013, bottom = summer 2013-2014.*

4. Discussion

There has been a significant reduction in the mean length of *Zostera* blades since the winter survey. However, this has occurred at both the Papanui Inlet (control) sites and the Harwood sites and is not unexpected. Ismail (2001) found that cover by *Zostera* can change markedly with season due largely to growth parameters (biomass, leaf length, leaf area) being typically higher in summer and lower in winter. Further, Ismail (2001) found that mean leaf growth rate was much higher during the summer season. This latest survey was conducted at the beginning of summer and it is expected that blade length will increase through the warmer months. *Zostera* is a perennial plant and the change in blade length is largely the result of die-back during late winter and spring and regrowth in summer.

For other parameters measured (shoot density, percentage cover and biomass) there

has been a significant change to percentage cover if one considers treatment (impact vs control) in conjunction with season. There has also been a change in biomass, with the biomass of plants at the control site being significantly less than those at the impact site (Harwood) this summer. All other parameters, including substrate composition and thickness of the RDL, show no significant changes.

Bearing in mind there had been no major capital works dredging carried out prior to this latest survey, any changes must be put down to natural variability. Such variability needs to be considered when analysing results obtained after dredging does commence.

The survey will be repeated in autumn and results will be compared with winter, spring and summer survey results.

5. References

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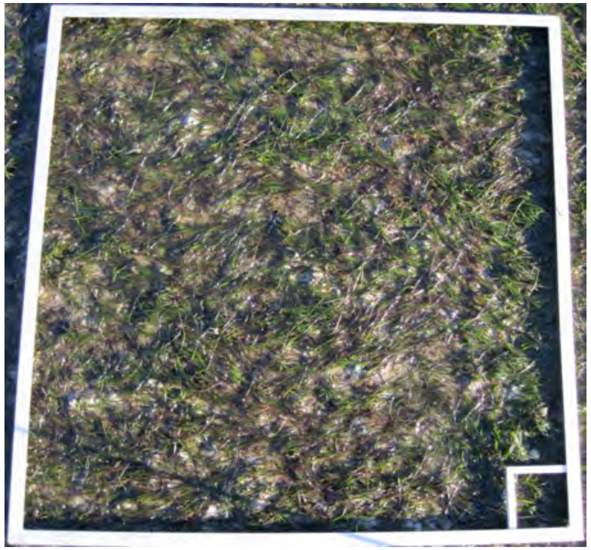
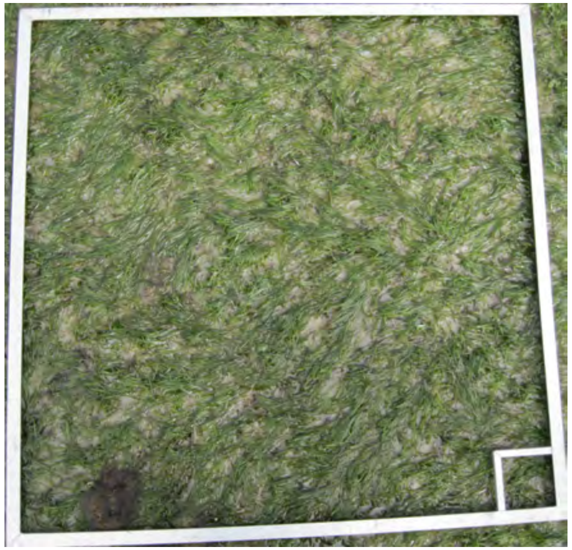
Appendix 1 – Example Seagrass Quadrats

Harwood: Transect 1 (Quadrats are 1 m x 1 m. Small square is 10 cm x 10 cm)



Quadrat A, July 2013

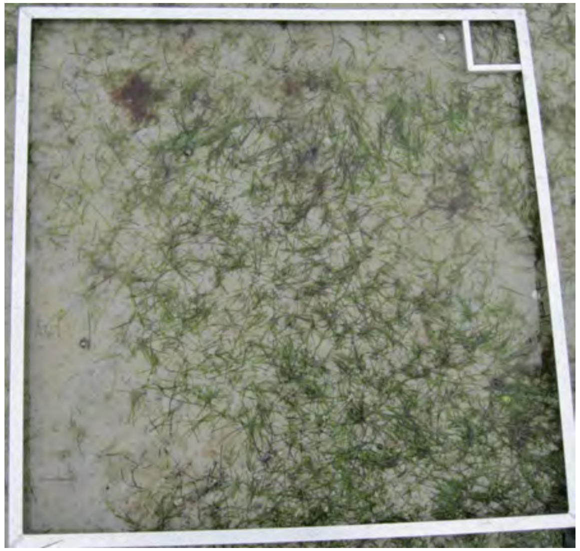
Quadrat A, October 2013



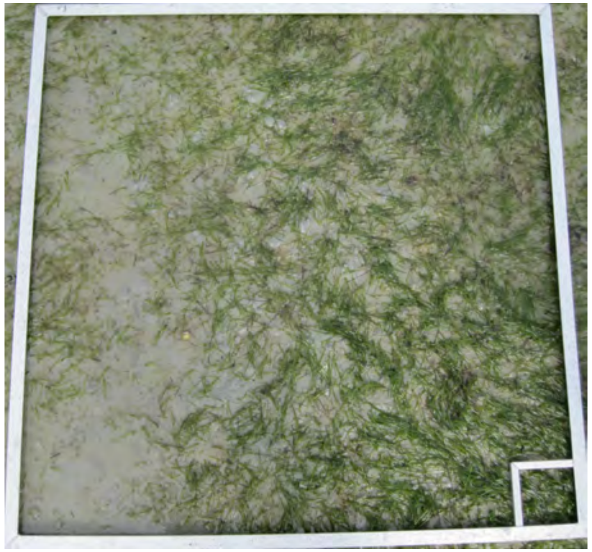
Quadrat A, December 2013

Harwood: Transect 1

Quadrat B, July 2013

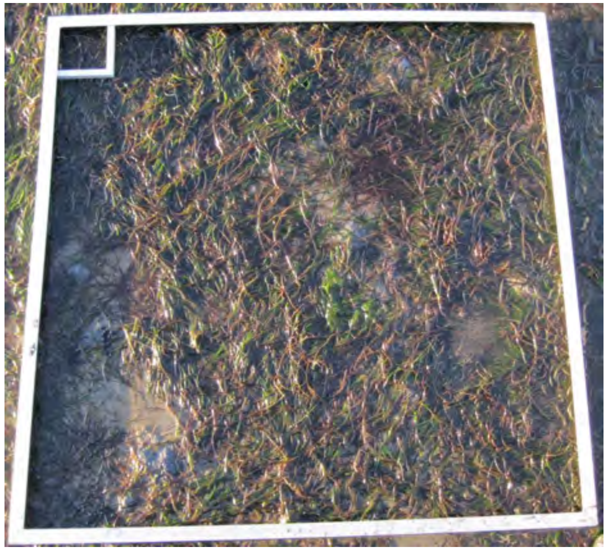


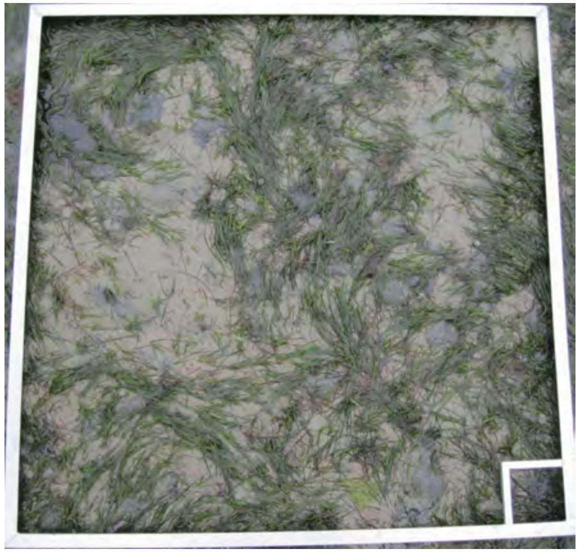
Quadrat B, October 2013

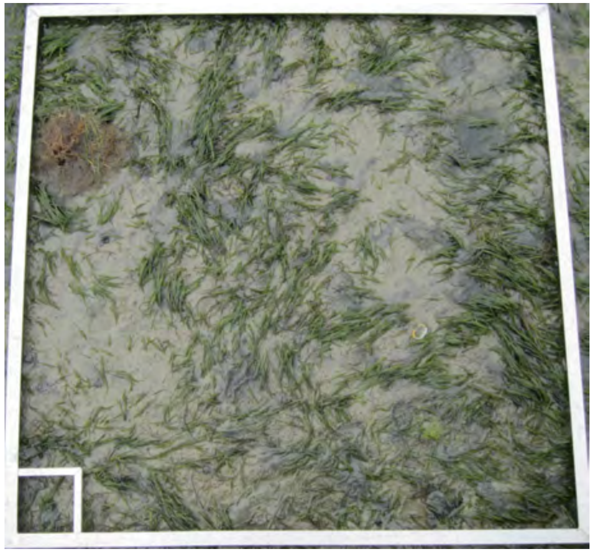


Quadrat B, December 2013

Papanui Inlet: Transect 1


Quadrat A, July 2013


Quadrat A, October 2013


Quadrat A, December 2013

Appendix 2 – Cores

Control Transect 1 (summer)

Control Transect 2 (summer)

Treatment Transect 1 (winter)

Treatment Transect 1 (summer)

Treatment Transect 2 (summer)

Treatment Transect 3 (winter) Treatment Transect 3 (summer)

Treatment Transect 4 (summer)