Macrophyte monitoring of Waituna Lagoon 2011

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1 Introduction

Waituna Lagoon is a large shallow coastal lagoon impounded between a low shallow gravel bar and surrounding peat bog. The lagoon is artificially opened to the sea usually on an annual basis, and is estuarine when the lagoon is open. Openings occur when the water level is above 2.2 m asl and sea conditions are suitable but closings occur naturally. The trigger for lagoon opening is currently based on land drainage criteria.

The lagoon forms part of the Awarua complex and is recognised as a wetland of international importance under the RAMSAR Convention on wetlands. It is significant because of the important diverse habitats in the area that support a wide range of fauna. It is a nationally significant natural feature and landscape. The lagoon provides important habitat for waterfowl, migratory birds, coastal birds and native fish. Over 81 species of birds have been recorded in the area, including paradise shelduck, grey duck, black swan and shoveler. The lagoon provides a safe moulting area for large numbers of these waterfowl. The Waituna catchment contains marine, estuarine and freshwater fish species. These include a national stronghold for the threatened giant kokopu as well as inanga, short fin eels and the threatened long fin eel (Atkinson 2008).

It is a place of great significance to Ngai Tahu and was traditionally an important mahika kai area. The Lagoon is also an important recreational area for fishing and duck hunting but has limited tourist usage at present.

Waituna Lagoon has historically been a macrophyte dominated system. Dense beds of *Ruppia* were present in the lagoon in the 1960's (Roger McNaughton pers comm. Johnson and Partridge 1998). Dominant beds of *Ruppia megacarpa* (horse's mane weed) along with *Myriophyllum triphyllum* (milfoil) were present throughout the lagoon, particularly in deeper water in 1995 (Johnson and Partridge 1998). Increased land-use intensification in the catchment has resulted in a decline in water quality, in particular increased ammonium concentrations entering the lagoon (Thompson and Ryder 2003). Waituna Lagoon is described as meso-eutrophic on the Trophic Level Index, a measure of the life supporting capacity of a lake or lagoon (Schallenberg et al. 2010). This means that the Lagoon has high nutrients, high phytoplankton biomass and poor water quality. Increased nutrient run-off has been linked to increased phytoplankton biomass and turbidity in the lagoon, which may pose a threat to the macrophyte beds.

Lagoons exist in two states. They are either clear and macrophyte dominated or turbid and phytoplankton dominated. Clear and macrophyte dominated has high values for biodiversity, aesthetic, recreational and tourist needs and is typically the desired state. The process which a lagoon moves from one state to the next can be quite rapid and is termed "flipping". Once a lagoon flips from macrophyte dominated to phytoplankton dominated it is often difficult to reverse.

Department of Conservation (DoC), as part of their responsibility for managing the lagoon under their biodiversity conservation role, initiated macrophyte surveys in Waituna Lagoon in 2007. Surveys were repeated in 2009 and 2010. DoC has commissioned NIWA to undertake the 2011 macrophyte survey to document the

status of the lagoon vegetation using the methodology adopted by Robertson and Stevens (2009) and Stevens and Robertson (2010) to provide an inter-annual comparison of its condition. This report summarises the results of this survey.

2 Methods

Methodology was carried out in accordance to Robertson and Stevens (2009) and Stevens and Robertson (2010). Methodology is not entire in either report and the reader is directed to both reports for background methodology.

Survey sites

Forty-eight sites were re-surveyed in Waituna Lagoon (Figure 1) situated on 10 transects across the lagoon as established by Robertson and Stevens (2009). Sites were positioned near the edge of the lagoon to sample shallow water habitats and mid-lagoon to sample deeper water habitats. On longer transects, additional sites were included for spatial coverage (Robertson and Stevens 2009). Sites were re-located using GPS co-ordinates provided by DoC.

Figure 1: Geo-referenced survey sites in Waituna Lagoon. Transects are numbered 1 to 10 East to West and numbered on each transect in ascending order from north.

Survey methods

At each site, 4 replicate sediment samples 15 x 15 cm and 6 cm deep were carefully lifted to the surface using a flat based garden hoe. Each sample was then assessed for:

- Macrophyte, macroalgae and / or microalgal species present.
- Percent cover[1] of each species.

[1] Percent cover groupings were based on the categories established by Robertson and Stevens (2009). These categories were 1 = 1-5%, 2 = 5-10%, 3 = 10-20%, 4= 20-50%, 5 = 50-80%, 6 = 80-100%.

- Mean height of each species.
- Life stage[2] of ruppia (where applicable).
- Sediment type.
- Depth to blackened sulphide layer.

Water quality parameters were measured at each site. These parameters were:

- Temperature
- Salinity
- Turbidity
- Secchi depth[3]
- Dissolved oxygen

The survey was carried out from 15-17 March 2011, with the remaining six sites surveyed on 11 April 2011. The lagoon was open to the sea for at least 2 months prior to the surveys. Lagoon water levels were low making boating impractical. A variety of modes of transport were utilised, including wading, quad bike, kayak and boat.

[2] V – Vegetative, F – Flowering, PF – Post flowering, Nil – nothing,
[3] Due to the low water level in the lagoon at the time of the survey, black disc measurements were used in substitution to Secchi depth measurements. Black disk is measured horizontally so that useful measurements can be made in shallow waters (Davies-Colley 1994).

3 Results

At the time of the survey only 28 of the 48 sampling sites were submerged (Figure 2).

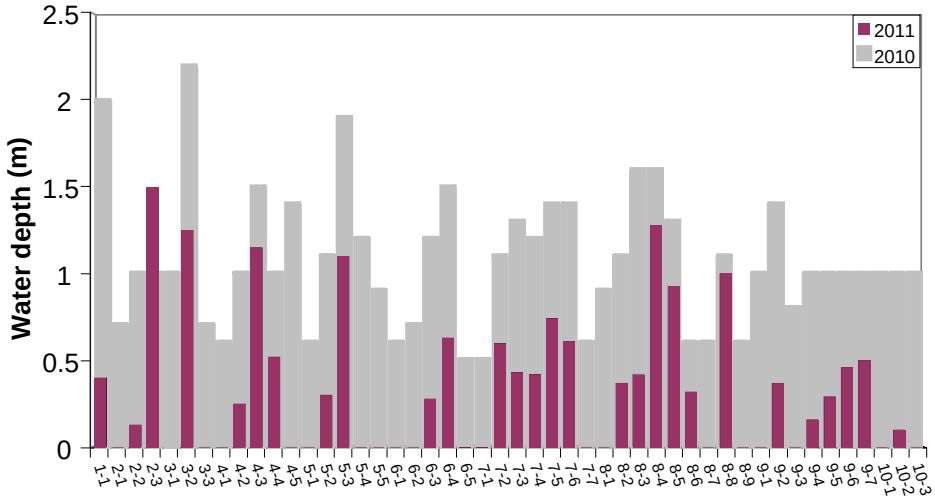

Figure 2: Water depth at 48 sampling sites, compared to depths recorded in the 2010 survey (Stevens and Robertson 2010).

3.1 Water quality parameters

Dissolved oxygen (DO) was close to or above saturation in both surface and bottom waters at all sites at the time of sampling (Figure 3). Day-time DO reached as low as 92%, close to the 90% desirable minimum for freshwater-bodies adopted by many councils, including Environment Southland. Temperature was relatively constant throughout the lagoon on each sampling date. Temperature was cooler during the April monitoring date (11.7 ^{o}C) compared to March (19.5 ^{o}C). Water depth was the main contributor to variance in temperature across the lagoon with warmer temperatures at shallower sites (Appendix 1). Weak stratification was present at some sites with stratified temperature ranging from 0.5 to 1^{o}C cooler in bottom than surface waters.

Salinity was moderate across the lagoon with most sites between 12 and 25 ppt (Figure 4). At several sites, a freshwater layer (salinity < 4 ppt) was overlying a denser saline layer, resulting in both temperature and saline stratification (Appendix 1).

Turbidity was highly variable in the lagoon at the time of the survey. Turbidity, measured in NTU units, ranged from 8.7 to 390 (Appendix 1). High readings were recorded at shallower sites suggesting re-suspended sediment was a main contributor to turbidity. Similarly, water clarity (black disc measurements) reflected the turbidity results with low clarity at shallower sites (Appendix 2). Based on these measurements, overall light was not currently limiting macrophyte growth in Waituna Lagoon due to the shallow water depth. Occasionally sites, such as Site 9.4, had turbidity and Secchi measurements that would indicate light limitation. These localised low clarity are likely to be driven by either wind disturbance events, or local run-off inputs.

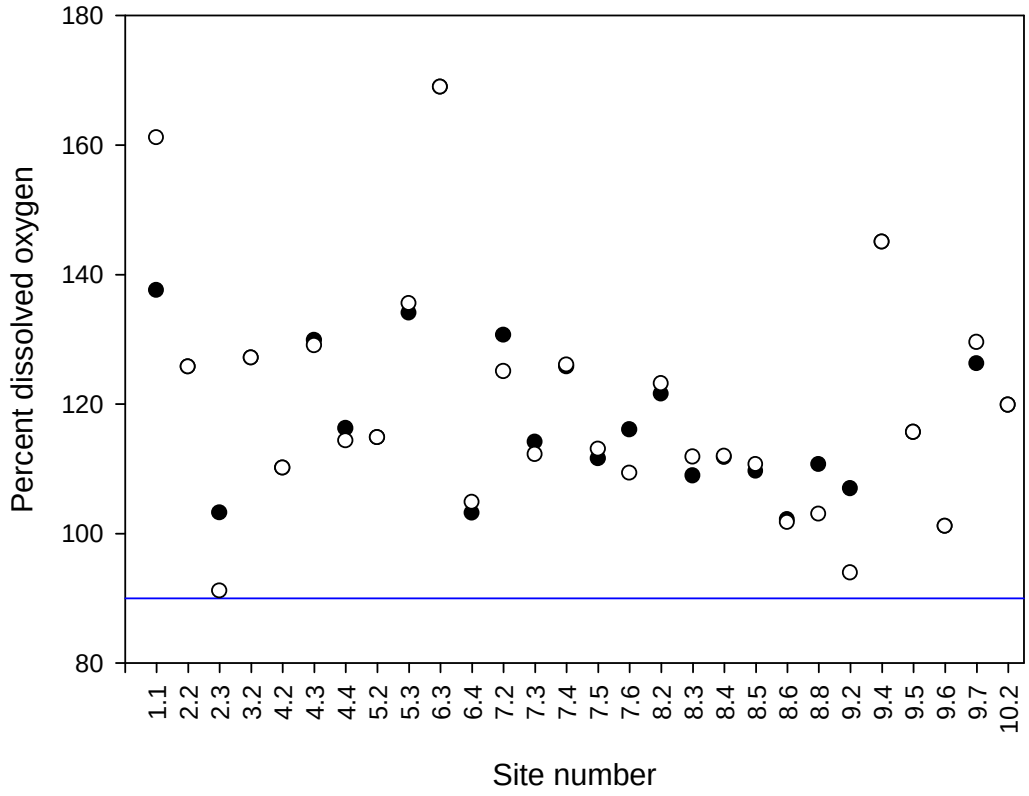

Figure 3: Percent dissolved oxygen at all sites in Waituna Lagoon during the 2011 survey period. Black dots = surface water, white dots = bottom water. Blue line indicates 90% saturation. The site number is given as the transect number then the site number on the transect.

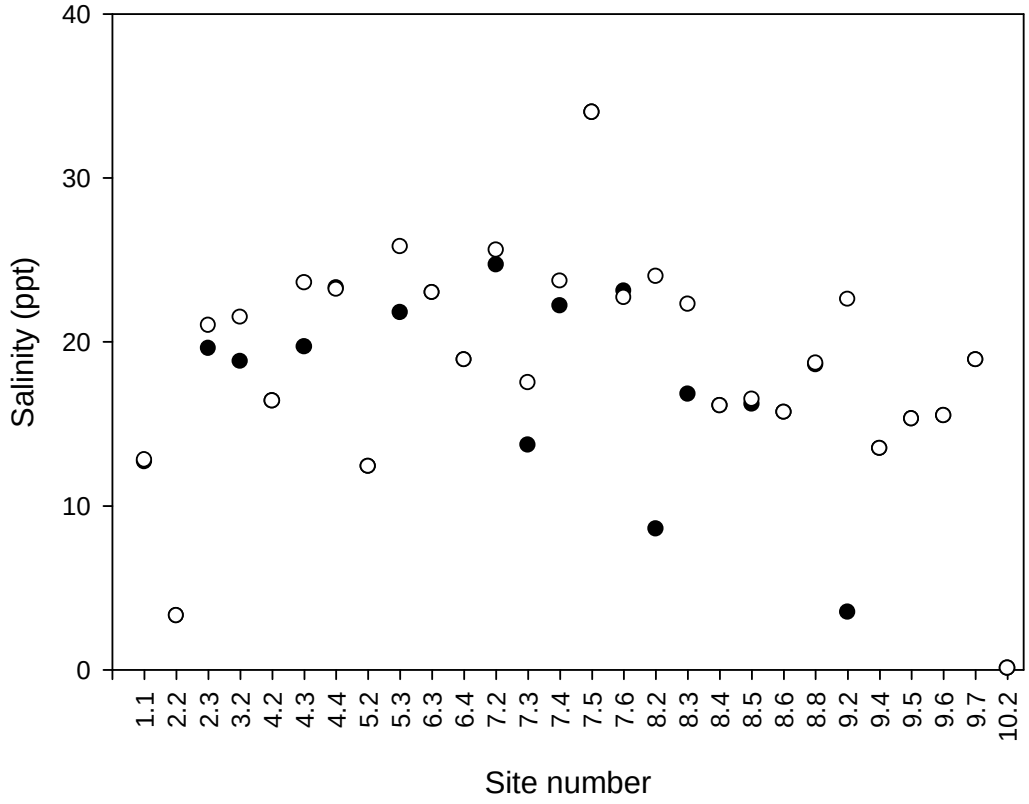

Figure 4: Salinity measurements in surface water (black dots) and bottom water (white dots) at all submerged sampling points in March/April 2011. The site number is given as the transect number then the site number on the transect.

3.2 Blackened 'sulphide' layer

Depth to blackened 'sulphide' layer at submerged sites varied across the lagoon ranging from just below surface to absent in the surface 6 cm (Figure 5). Compared to 2010, there has been an improvement in the depth to blackened layer at 19 sites (i.e., positioned at greater sediment depth), while only 4 sites had shallower layers relative to 2010 (Figure 5).

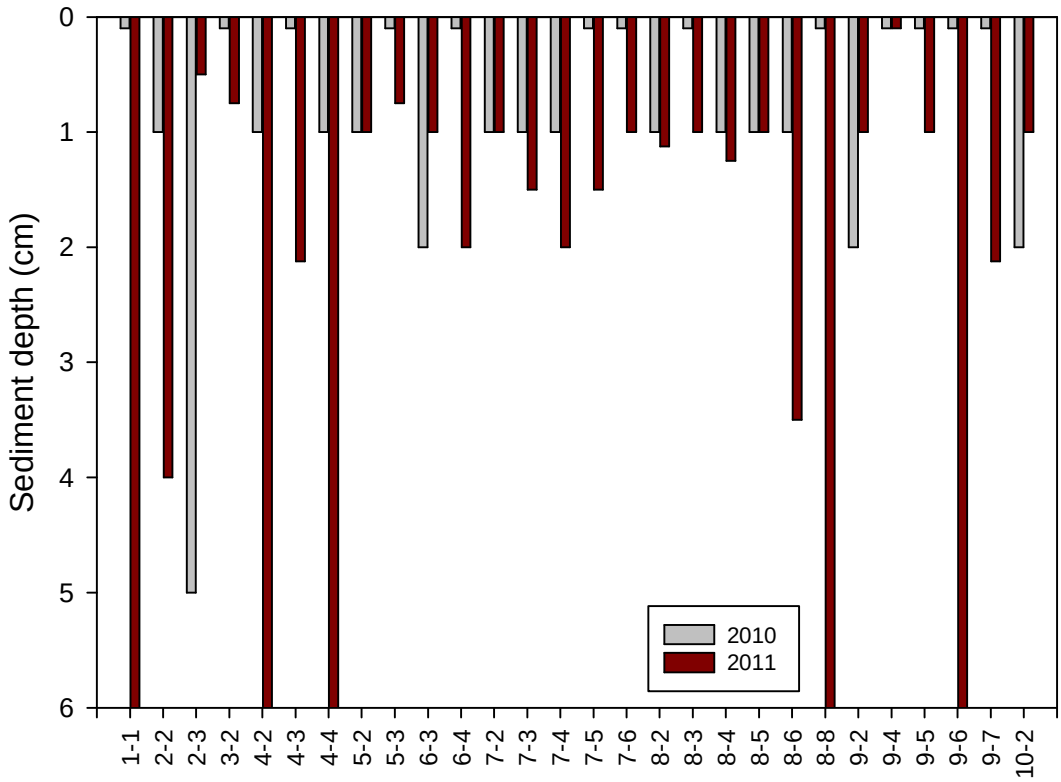

Figure 5: Depth (cm) to the blackened 'sulphide' layer at submerged sites in 2011 compared to depths recorded in the 2010 survey (Stevens and Robertson 2010). Note sites that were dry during the 2011 survey have been excluded from this graph for ease of viewing regardless if there were measurements taken during the 2010 survey.

3.3 Macrophyte survey

Both *Ruppia megacarpa* and *R. polycarpa* were present in Waituna Lagoon, recorded from eleven sites overall (Figure 6). Cover of *Ruppia* spp. was low with most vegetated sites having an average cover of 1-5% (Figure 6). *R. megacarpa* and the marine macroalgae *Ulva intestinales* were the most frequently occurring species, both occurring at 6 sites. *Gracilaria chilensis*, also a marine macroalgae, was present at one site. No other macrophyte was present in the lagoon at the time of survey, however, fragments of *Myriophyllum triphyllum* and *Potamogeton ochreatus* were arriving from freshwater stream inputs.

Mean height (4 replicates) of ruppia beds at each site ranged from 2 to 12 cm across the lagoon and all plants were in vegetative state (no flowering or fruiting evident).

Figure 6: Cover of Ruppia spp. at survey sites (Figure 1) in Waituna Lagoon during the 2011 survey. Cover shown as average (foreground) and maximum (background) according to the cover categories of Robertson and Stevens (2009).

4 Discussion and Recommendations

Care must be exercised when making direct comparisons between the 2011 and previous surveys. Lagoon openings had occurred during the spring prior to the 2009 and 2010 surveys but the lagoon had been closed for approximately 3 – 4 months prior to both surveys. This contrasts to the 2011 survey when the lagoon was open at the time of survey and had been open for at least 2 months prior. While the growth of ruppia was lower than previous years care must be taken in interpreting the data and ascribing this change to deteriorating water quality. Other factors can be implicated. Increased exposure to wave action and grazing pressure (herbivorous waterfowl) also negatively affect submerged macrophytes (Gerbeaux, 1993). Changes in the abundance of ruppia have been shown to be strongly related to water level in the preceding 2 months (Carruthers et al. 1999; Riddin and Adams 2008). Desiccation events, such as rapid dewatering after mouth breaching, can result in partial or complete loss of ruppia biomass within hours (Adams and Bates 1994; Tyler-Walters 2001). In plot experiments, Brock (1982) found that *R. megacarpa* grew in salinities between 12 and 50% total dissolved solids, but remained vegetative at extreme salinities and its seeds required lowered salinities in order to germinate.

In the past, ruppia has recovered from openings in the Waituna Lagoon. When openings occur at the start of the growth season, there is still sufficient time for the ruppia biomass to recover, as seen in 2009 and 2010 surveys. However, the ability of ruppia to recover from openings during the later part of the growth season is unknown. In order to effectively manage lagoon openings, and to ensure that ruppia is able to recover rapidly, a better understanding of the parameters that control ruppia growth in Waituna Lagoon is needed. While managing the lagoon nutrient

levels are important to prevent 'flipping' to phytoplankton dominance, it is equally important to ensure that ruppia is capable of recovering after opening events to ensure that openings are not the cause of a 'flipping' event.

The current methodology is a good measure of patch dynamics of ruppia over time. However, the limited survey area at each sampling site on a transect meant that important information was missed. During the 2011 survey it was often noted that large patches of high cover (80-100%) ruppia were present between sampling sites yet cover was low (1-5%) to absent at marked sites. The results are therefore limiting in the following ways:

- The spatial scale of sampling can misrepresent overall average covers and not record significant large patches of vegetation.
- It also constrains biodiversity information because uncommon species are unlikely to be encountered in small samples.
- There is limited data on ecological limits (such as minimum and maximum depth extent) on a spatial or temporal basis.

To overcome these limitations and identify better indicators that will assist DoC with managing the lagoon, we suggest increasing both the temporal and spatial scale of the macrophyte surveys. This need not necessarily involve more cost as the current methodology is very intense on the fine scale.

5 Acknowledgments

Neil Blair and Andy Hicks assisted with fieldwork.

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7 Appendix 1: Water quality parameters measured at sites along ten transects in Waituna Lagoon during the 2011 survey.

DATE	NZMG EAST	NZMG NORTH	Transect	SITE	Depth m	Sample	Temp (℃)	DO (mg/l)	Turbidity (NTU)	Sal_ppt
15/03/2011	2177865	5395520	1	1	0.4	Top	13.57	12.86	24	12.7
						Bottom	13.62	15.05	43.3	12.8
15/03/2011	2177014	5395517	2	1	Dry					
15/03/2011	2177033	5395373	2	2	0.13	Top	12.28	12.79	156	3.3
						Bottom	12.28	12.79	156	3.3
15/03/2011	2177067	5395234	2	3	1.5	Top	14.2	9.13	11	19.6
						Bottom	14.93	7.87	164	21
15/03/2011	2176005	5395562	3	1	Dry					
15/03/2011	2176009	5395432	3	2	1.25	Top	14.27	11.29	10.6	18.8
						Bottom	14.48	10.43	49.6	21.5
15/03/2011	2176048	5395245	3	3	Dry					
16/03/2011	2175050	5396183	4	1	Dry					
16/03/2011	2175047	5396001	4	2	0.25	Top	18.72	9.08	26.6	16.4
						Bottom	18.72	9.08	26.6	16.4
15/03/2011	2175050	5395363	4	3	1.15	Top	14.82	11.33	11.2	19.7
						Bottom	14.09	11.15	51.2	23.6
15/03/2011	2174994	5394989	4	4	0.52	Top	15.16	9.85	15	23.3
						Bottom	15.17	9.69	17.2	23.2
15/03/2011	2175035	5394643	4	5	Dry					
16/03/2011	2174118	5395889	5	1	Dry					
16/03/2011	2174129	5395817	5	2	0.3	Top	16.75	10.07	16.6	12.4
						Bottom	16.75	10.07	16.6	12.4
15/03/2011	2174104	5395284	5	3	1.1	Top	14.88	11.54	15.5	21.8
						Bottom	13.95	11.59	71.7	25.8
15/03/2011	2174060	5394866	5	4	Dry					
15/03/2011	2174017	5394771	5	5	Dry					
16/03/2011	2173090	5396803	6	1	Dry					
16/03/2011	2173085	5396617	6	2	Dry					
16/03/2011	2173087	5396013	6	3	0.28	Top	19.45	13.21	14.9	23
						Bottom	19.45	13.21	14.9	23
17/03/2011	2173102	5395536	6	4	0.63	Top	14.11	9.18	8.7	18.9
						Bottom	14.13	9.33	11.6	18.9
17/03/2011	2173134	5395398	6	5	Dry					
16/03/2011	2172004	5397069	7	1	Dry					
16/03/2011	2172017	5396657	7	2	0.6	Top	15.03	11	9.2	24.7
						Bottom	14.55	10.57	10.8	25.6
17/03/2011	2172050	5395872	7	3	0.43	Top	14.02	10.51	12.4	13.7
						Bottom	14.03	10.08	10.2	17.5
17/03/2011	2172047	5395297	7	4	0.42	Top	15.15	10.73	9.6	22.2
						Bottom	15.2	10.64	54	23.7
17/03/2011	2172012	5394838	7	5	0.74	Top	14.94	8.85	24.7	34
						Bottom	14.95	8.96	25.6	34
17/03/2011	2172010	5394041	7	6	0.61	Top	13.78	10.13	10.8	23.1
						Bottom	13.78	9.57	11.6	22.7
17/03/2011	2172000	5393900	7	7	Dry					
16/03/2011	2171028	5396501	8	1	Dry					
16/03/2011	2171042	5396368	8	2	0.37	Top	14.63	11.41	17.4	8.6
						Bottom	14.03	10.63	13.1	24
16/03/2011	2171049	5396071	8	3	0.42	Top	14.18	9.81	15.6	16.8
						Bottom	13	9.96	14.7	22.3
11/04/2011	2171048	5395470	8	4	1.28	Top	11.74	8.28	22.3	16.1
						Bottom	11.72	10.69	22.2	16.1

DATE	NZMG EAST	NZMG NORTH	Transect	SITE	Depth m	Sample	Temp (℃)	DO (mg/l)	Turbidity (NTU)	Sal_ppt
11/04/2011	2171120	5394893	8	5	0.93	Top	11.84	10.42	21.3	16.2
						Bottom	11.78	8.32	21.1	16.5
11/04/2011	2171195	5394495	8	6	0.32	Top	11.85	9.74	36	15.7
						Bottom	11.85	9.7	32.6	15.7
11/04/2011	2170958	5393126	8	7	Dry					
11/04/2011	2170989	5393047	8	8	1	Top	11.94	10.34	21.3	18.6
						Bottom	11.89	9.63	45.6	18.7
11/04/2011	2171015	5392974	8	9	Dry					
16/03/2011	2170021	5396268	9	1	Dry					
16/03/2011	2169973	5395831	9	2	0.37	Top	11.46	11.1	17.1	3.5
						Bottom	14.28	8.14	10.9	22.6
17/03/2011	2169946	5395338	9	3	Dry					
17/03/2011	2169832	5395189	9	4	0.16	Top	17.47	12.5	390	13.5
						Bottom	17.47	12.5	390	13.5
17/03/2011	2169946	5394950	9	5	0.29	Top	17.28	9.87	97.3	15.3
						Bottom	17.28	9.87	97.3	15.3
11/04/2011	2170245	5394350	9	6	0.46	Top	11.94	9.63	26.3	15.5
						Bottom	11.94	9.63	26.3	15.5
11/04/2011	2170280	5392766	9	7	0.5	Top	11.88	11.79	18.4	18.9
						Bottom	11.82	12.12	18.5	18.9
16/03/2011	2169042	5396141	10	1	Dry					
16/03/2011	2169028	5395949	10	2	0.1	Top	15.43	11.58	39.1	0.1
						Bottom	15.43	11.58	39.1	0.1
16/03/2011	2169050	5395759	10	3	Dry					

8 Appendix 2: Aquatic plant species present at each sampling site in Waituna Lagoon during 2011 survey. Substrate, temperature, salinity and water depth are recorded.

Date	NZMG East	NZMG North	Transect	Site	Rep	Depth m	Temp (℃) Top	Temp (℃) Bottom	Sal_ppt (top)	Sal_ppt (bottom)	Secchi (cm)	Substrate	Sulphide depth (cm)	Species	Height (cm)	Stage	% Cover
15/03/2011	2177865	5395520	1	1	1	0.4	13.57	13.62	12.7	12.8	57	SM/S/G	6	nil			
					2							SM/S/G	6	nil			
					3							SM/S/G	6	nil			
					4							SM/S/G	6	nil			
15/03/2011	2177014	5395517	2	1	1	Dry											
15/03/2011	2177033	5395373	2	2	1	0.13	12.28	12.28	3.3	3.3	15	SM/S/G	1	Rm	7	v	5-10
					2							SM/S/G	1	Rm	8	v	10-20
					3							SM/S/G	nil	Rm	8	v	20-50
					4							SM/S/G	nil	Rm	8	v	20-50
15/03/2011	2177067	5395234	2	3	1	1.5	14.2	14.93	19.6	21	81	VSM/S	0.5	nil			
					2							VSM/S	0.5	Rm	12	v	1-5
					3							VSM/S	0.5	Rm	10	v	1-5
					4							VSM/S	0.5	Rm	12	v	1-5
15/03/2011	2176005	5395562	3	1	1	Dry											
15/03/2011	2176009	5395432	3	2	1	1.25	14.27	14.48	18.8	21.5	67	VSM/S	0.5	nil			
					2							VSM/S	1	nil			
					3							VSM/S	0.5	nil			
					4							VSM/S	1	nil			
15/03/2011	2176048	5395245	3	3	1	Dry											
16/03/2011	2175050	5396183	4	1	1	Dry											

Date	NZMG East	NZMG North	Transect	Site	Rep	Depth m	Temp (℃) Top	Temp (℃) Bottom	Sal_ppt (top)	Sal_ppt (bottom)	Secchi (cm)	Substrate	Sulphide depth (cm)	Species	Height (cm)	Stage	% Cover
16/03/2011	2175047	5396001	4	2	1	0.25	18.72	18.72	16.4	16.4	100	SM/S	nil	Ui			5-10
					2							SM/S	nil	Ui			5-10
					3							SM/S	nil	Ui			5-10
					4							SM/S	nil	Ui			5-10
15/03/2011	2175050	5395363	4	3	1	1.15	14.82	14.09	19.7	23.6	90	VSM/S	5	nil			5-10
					2							VSM/S	0.5	Rm	5	v	1-5
					3							VSM/S	2	nil			
					4							VSM/S	1	nil			
15/03/2011	2174994	5394989	4	4	1	0.52	15.16	15.17	23.3	23.2	83	SM/S/G	nil	nil			
					2							SM/S/G	nil	Rm	5	v	10-20
					2							SM/S/G	nil	Ui			5-10
					3							SM/S/G	1	Rm	10	v	10-20
					4							SM/S/G	nil	nil			
15/03/2011	2175035	5394643	4	5	1	Dry											
16/03/2011	2174118	5395889	5	1	1	Dry											
16/03/2011	2174129	5395817	5	2	1	0.3	16.75	16.75	12.4	12.4	90	SM/S	1	Rp	2	v	1-5
					2							SM/S	1	Rp	3	v	1-5
					3							SM/S	1	Rp	2	v	1-5
					4							SM/S	1	Rp	2	v	5-10
15/03/2011	2174104	5395284	5	3	1	1.1	14.88	13.95	21.8	25.8	72	VSM/S	1	Clad.			1-5
					2							VSM/S	0.5	Clad.			1-5
					3							VSM/S	1	nil			
					4							VSM/S	0.5	nil			
15/03/2011	2174060	5394866	5	4	1	Dry											
15/03/2011	2174017	5394771	5	5	1	Dry											
16/03/2011	2173090	5396803	6	1	1	Dry											

16/03/2011	2173085	5396617	6	2	1	Dry											
Date	**NZMG East**	**NZMG North**	**Transect**	**Site**	**Rep**	**Depth m**	**Temp (℃) Top**	**Temp (℃) Bottom**	**Sal_ppt (top)**	**Sal_ppt (bottom)**	**Secchi (cm)**	**Substrate**	**Sulphide depth (cm)**	**Species**	**Height (cm)**	**Stage**	**% Cover**
16/03/2011	2173087	5396013	6	3	1	0.28	19.45	19.45	23	23	90	SM/S	1	Rp	4	v	1-5
					2							SM/S	1	Rp	4	v	5-10
					3							SM/S	1	Rp	4	v	1-5
					4							SM/S	1	Rp	4	v	1-5
17/03/2011	2173102	5395536	6	4	1	0.63	14.11	14.13	18.9	18.9	96	SM/S/G	2	Clad.			
					2							SM/S/G	2	Clad.			
					3							SM/S/G	2	nil			
					4							SM/S/G	2	nil			
17/03/2011	2173134	5395398	6	5	1	Dry											
16/03/2011	2172004	5397069	7	1	1	Dry											
16/03/2011	2172017	5396657	7	2	1	0.6	15.03	14.55	24.7	25.6	100	FS	1	nil			
					2							FS	1	decay			5-10
					3							FS	1	nil			
					4							FS	1	nil			
17/03/2011	2172050	5395872	7	3	1	0.43	14.02	14.03	13.7	17.5		S/GR	1.5	Clad.			5-10
					2							S/GR	1.5	Rsp			1-5
					3							S/GR	1.5	Clad.			1-5
					4							S/GR	1.5	Clad.			5-10
17/03/2011	2172047	5395297	7	4	1	0.42	15.15	15.2	22.2	23.7		SM/S	2	Rm	3	v	5-10
					2							SM/S	2	Rm	3	v	50-80
					3							SM/S	2	Rm	3	v	20-50
					4							SM/S	2	Rm	3	v	20-50
17/03/2011	2172012	5394838	7	5	1	0.74	14.94	14.95	34	34	70	FS	1.5	nil			
					2							FS	1.5	nil			
					3							FS	1.5	nil			
					4							FS	1.5	nil			

Date	NZMG East	NZMG North	Transect	Site	Rep	Depth m	Temp (℃) Top	Temp (℃) Bottom	Sal_ppt (top)	Sal_ppt (bottom)	Secchi (cm)	Substrate	Sulphide depth (cm)	Species	Height (cm)	Stage	% Cover
17/03/2011	2172010	5394041	7	6	1	0.61	13.78	13.78	23.1	22.7	119	SM/S	1	nil			
					2							SM/S	1	nil			
					3							SM/S	1	nil			
					4							SM/S	1	nil			
17/03/2011	2172000	5393900	7	7	1	Dry											
16/03/2011	2171028	5396501	8	1	1	Dry											
16/03/2011	2171042	5396368	8	2	1	0.37	14.63	14.03	8.6	24	93	FS	1	nil			
					2							FS	1	nil			
					3							FS	1.5	Rp	4	v	1-5
					4							FS	1	nil			
16/03/2011	2171049	5396071	8	3	1	0.42	14.18	13	16.8	22.3	95	FS	1	nil			
					2							FS	1	nil			
					3							FS	1	nil			
					4							FS	1	nil			
11/04/2011	2171048	5395470	8	4	1	1.28	11.74	11.72	16.1	16.1	90	FS	1.5	nil			
					2							FS	1.5	nil			
					3							FS	nil	nil			
					4							FS	2	nil			
11/04/2011	2171120	5394893	8	5	1	0.93	11.84	11.78	16.2	16.5	90	FS	1.5	nil			
					2							FS	0	nil			
					3							FS	0.5	nil			
					4							FS	2	nil			
11/04/2011	2171195	5394495	8	6	1	0.32	11.85	11.85	15.7	15.7	92	S/GR	nil	nil			
					2							S/GR	0.5	nil			
					3							S/GR	nil	nil			
					4							S/GR	1.5	nil			

Date	NZMG East	NZMG North	Transect	Site	Rep	Depth m	Temp (℃) Top	Temp (℃) Bottom	Sal_ppt (top)	Sal_ppt (bottom)	Secchi (cm)	Substrate	Sulphide depth (cm)	Species	Height (cm)	Stage	% Cover
11/04/2011	2170958	5393126	8	7	1	Dry											
11/04/2011	2170989	5393047	8	8	1	1	11.94	11.89	18.6	18.7	90	SM/S/G	0	Gc			1-5
					2							SM/S/G	nil	Clad.			1-5
					3							SM/S/G	nil	nil			
					4							SM/S/G	nil	Ui			1-5
11/04/2011	2171015	5392974	8	9	1	Dry											
16/03/2011	2170021	5396268	9	1	1	Dry											
16/03/2011	2169973	5395831	9	2	1	0.37	11.46	14.28	3.5	22.6	62	SM/S/G	1	nil			
					2							SM/S/G	1	nil			
					3							SM/S/G	1	nil			
					4							SM/S/G	1	nil			
17/03/2011	2169946	5395338	9	3	1	Dry											
17/03/2011	2169832	5395189	9	4	1	0.16	17.47	17.47	13.5	13.5	15	SM/S	0	Ui			1-5
					2							SM/S	0	Ui			1-5
					3							SM/S	0	nil			
					4							SM/S	0	nil			
17/03/2011	2169946	5394950	9	5	1	0.29	17.28	17.28	15.3	15.3	5	SM/S	1	Rm	5	v	1-5
					2							SM/S	1	Rm	4	v	1-5
					3							SM/S	1	Rm	5	v	1-5
					4							SM/S	1	Rm	5	v	1-5
11/04/2011	2170245	5394350	9	6	1	0.46	11.94	11.94	15.5	15.5	60	SM/S	nil	nil			
					2							SM/S	nil	Rm	2	v	1-5
					3							SM/S	nil	nil			
					4							SM/S	nil	nil			

Date	NZMG East	NZMG North	Transect	Site	Rep	Depth m	Temp (℃) Top	Temp (℃) Bottom	Sal_ppt (top)	Sal_ppt (bottom)	Secchi (cm)	Substrate	Sulphide depth (cm)	Species	Height (cm)	Stage	% Cover
11/04/2011	2170280	5392766	9	7	1	0.5	11.88	11.82	18.9	18.9	65	SM/S	1.5	nil			
					2							SM/S	2	Rm	1	v	1-5
					3							SM/S	2	nil			
					4							SM/S	3	Rm	1	v	1-5
16/03/2011	2169042	5396141	10	1	1	Dry											
16/03/2011	2169028	5395949	10	2	1	0.1	15.43	15.43	0.1	0.1	too shallow	VSM/S	1	Ui			1-5
					2							VSM/S	1	nil			
					3							VSM/S	1	nil			
					4							VSM/S	1	nil			
16/03/2011	2169050	5395759	10	3	1	Dry											