Department of Conservation
Te Papa Atawhai

NIWA
Taihoro Nukurangi

Vegetation Status in Waituna Lagoon: Summer 2021

Climate, Freshwater & Ocean Science

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This report was commissioned by The Department of Conservation (DOC) and based on work under Project DOC20203.

Authors:

Mary de Winton

Susie Elcock

Published by:

NIWA – National Institute of Water & Atmospheric Research Ltd

PO Box 11115

Hamilton 3251

Phone +64-7-856 7026

Web: www.niwa.co.nz

For more information please contact: mary.dewinton@niwa.co.nz

Acknowledgements:

NIWA staff who have contributed to monitoring events include Aleki Taumoepeau, Rohan Wells, Donna Sutherland, Neil Blair, Eric Stevens and Derek Kater. We especially thank Chris Owen (Southern Waterways Boat Contracting) for his knowledge of Waituna Lagoon and skipper expertise. Many thanks to Sarah Crump and Sarah Thorne (DOC) for local orientation and Health & Safety briefings. Hugh Robertson, Emily Funnell, Sarah Crump and Jane Bowen (DOC) contributed to the look and content of this report. Also appreciated is provision of environmental data from the Environment Southland team – thank you.

Layout design: Aarti Wadhwa

Contents

DOC commissioned NIWA to undertake the 2021 summer-time Waituna Lagoon survey to document the health of submerged vegetation and to provide an inter-annual comparison of its condition. This report summarises the key findings to guide further ecological management of the lagoon.

Key findings

In 2021, none of six ecological targets were achieved for Waituna Lagoon;

- The lagoon was open to the sea over the critical spring-summer period for *Ruppia* growth (for >3 months before monitoring) for the second consecutive year and this is likely responsible for the poor performance of submerged plants in 2021,
- There has been a further large reduction in the distribution and abundance (biomass) of submerged plants (mainly *Ruppia* species) since reductions were recorded in the 2020 survey,
- *Ruppia* (and other submerged plants) were not recorded from the south-western sector (approximately half of the lagoon area),
- In 2021, results measuring lagoon-wide *Ruppia* cover, biomass index and *Ruppia* reproductive success were only 1/10th of the ecological targets,
- *Ruppia megacarpa* was limited to only three sites, which was 1/3rd of the ecological target,
- Macroalgal development exceeded the maximum acceptable threshold of <10% cover.

Based on all six ecological targets:

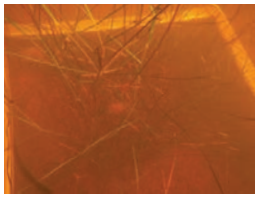
- 2021 is the third monitoring year that fails to achieve any targets, with 2013 and 2017 also not meeting any ecological targets.
- Surveys that achieved only one or no targets were also years where when the target for lagoon closure (closed >3 months before survey) was not met.
- Current evidence indicates that having a closed lagoon for at least two consecutive growing seasons is important.

Purpose of this report

This report presents the 2021 annual summer monitoring data for submerged vegetation in Waituna Lagoon in relation to ecological targets that have been identified by the Lagoon Technical Group to guide ecological management. Results are compared to annual monitoring results since 2009.

The document is supported by a technical report[1] that describes the water level regime, water quality (physico-chemical) and substrate conditions, submerged vegetation abundance and composition and *Ruppia* life-stage.

[1] de Winton, M., Elcock, S.R. (2021) Technical Report on Vegetation Status in Waituna Lagoon: 2009–2021. *NIWA Publication*.



Waituna Lagoon is an internationally important example of a coastal waterbody that remains in good ecological condition.

Background

The importance of Waituna Lagoon

Waituna Lagoon on the south coast of New Zealand is included within a Ramsar Wetland of International Importance. The Lagoon is of cultural significance to Ngāi Tahu recognised by a Statutory Acknowledgement under the Ngāi Tahu Claims Settlement Act 1998[2]. It is also significant for conservation of biological diversity and as a key recreational site.

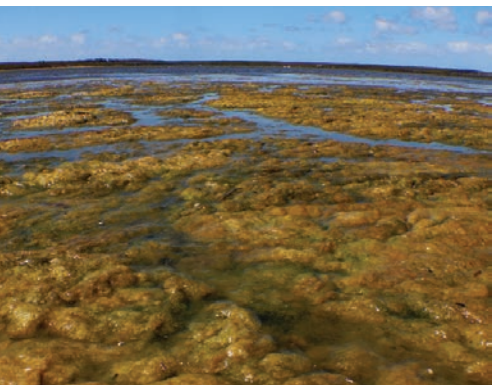
The Department of Conservation has been monitoring submerged aquatic plants (including *Ruppia* spp.) in Waituna Lagoon since 2007 under the Arawai Kākāriki Wetland Restoration Programme.

Coastal lowland lakes like Waituna Lagoon are impacted by changes in land use in the catchment including sediment and nutrient loads from upstream run-off. It is now rare to find coastal lowland lakes in intact ecological condition, but Waituna Lagoon remains highly valued for its associated plant, wetland, fish and birdlife.

Ruppia safeguards the lagoon

When *Ruppia* grows densely in Waituna Lagoon it protects water quality, dampens wave action and stops the bed being stirred up.

[2] Ngai Tahu Claims Settlement Act 1998 No. 97 (as at 23 May 2008), Public Act Schedule 73 Statutory acknowledgement for Waituna Wetland – New Zealand Legislation.



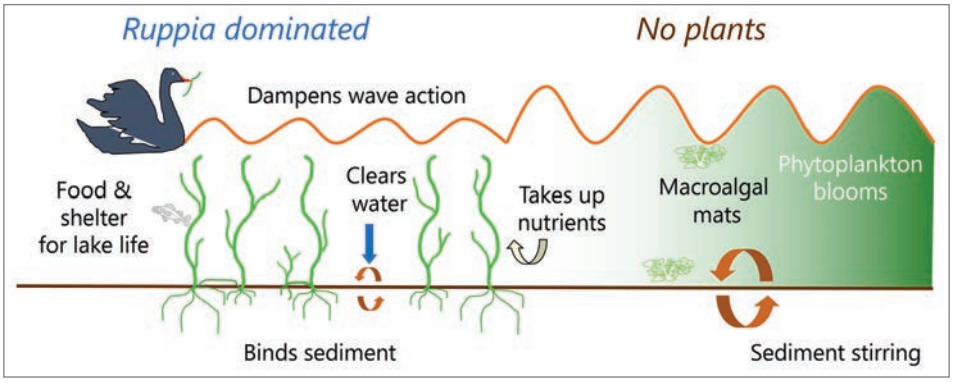
Ruppia safeguards the lagoon

When *Ruppia* grows densely in Waituna Lagoon it protects water quality, dampens wave action and stops the bed being stirred up.

Risk of Waituna Lagoon shifting to a poor ecological condition

Submerged plants have an important role in keeping shallow lakes and lagoons clean and healthy (Figure 1). If submerged plant communities become too stressed, they can collapse. The lake or lagoon then enters a new, dirty water state, with high resuspended sediment and macroalgal mats or phytoplankton blooms instead of plants. The submerged native plant species of *Ruppia* (horse's mane) safeguard water quality in Waituna Lagoon. *Ruppia* tolerates fluctuating levels of saltwater in lagoons better than other submerged plants, but does not occur in the sea. Other plants, including a nationally rare, salinity-tolerant charophyte, also occur at Waituna Lagoon.

Figure 1: *Ruppia* vegetation can safeguard water quality in the lagoon compared to a system with no plants.



Management of water level at Waituna Lagoon

Agencies, community and iwi are working together to manage and protect Waituna Lagoon. When water levels in the lagoon rise too high for land drainage, the management response has been to mechanically open the lagoon to the sea. Lagoon openings are usually undertaken once or twice a year to prevent catchment flooding and to flush nutrients from the lagoon, but lagoon closing only occurs naturally under certain sea conditions. Management of these artificial openings is increasingly taking into account the Lagoon's ecology. The timing and length of openings should ideally not negatively impact on the survival of *Ruppia* and other vegetation. This requires managing openings to avoid key times in the life-history of *Ruppia* including critical spring to summer growth and seed production.

At present, the lagoon can be opened to the sea once the water level of Waituna Lagoon reaches a certain trigger level noted in the resource consent[3], which varies at different times of the year and has associated conditions.

[3] Resource Consent 20146407-01, 14 February 2017.

Natural lagoon level

Once, Waituna Lagoon would have naturally breached to the sea after several years of filling with freshwater. Today it is regularly opened and infiltrated by the sea.

What do openings mean for conditions in Waituna Lagoon?

Monitoring of the waters of Waituna Lagoon over time[4] has built up a picture of the key changes caused by opening events[5]. Water level is lower and salinity higher when the lagoon is open and temperature and nutrient concentrations are both reduced with flushing by the sea (Figure 2). These changes and their duration influence the vegetation of Waituna Lagoon.

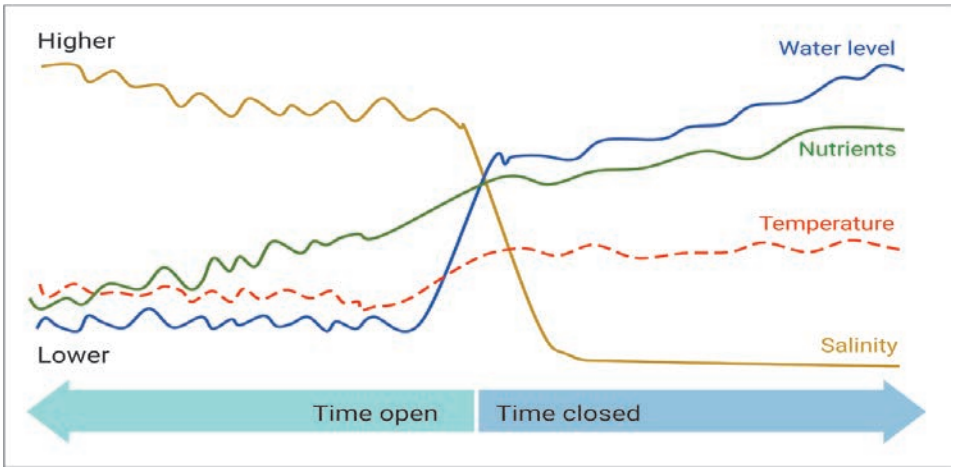


Figure 2: Key changes in the waters of Waituna Lagoon with time after opening or closing to the sea.

Catchment management

Agencies and the community aim to reduce sediment and nutrient inputs to Waituna Lagoon, focusing on strategies and initiatives for catchment management of contaminants, increasing biological processing of run-off and improving freshwater habitat. It is essential that these efforts meet the nutrient load reduction targets developed by the Lagoon Technical Group in 2013 to ensure the long-term persistence of *Ruppia* vegetation and safeguard the lagoon ecosystem. However, opening the lagoon to disrupt algal blooms provides a short-term solution for the ecological health of the lagoon.

[4] https://www.lawa.org.nz/explore-data/southland-region/lakes/waituna-lagoon/

What do we monitor?

Ruppia

Ruppia acts as an ecological sentinel in Waituna Lagoon, providing an early-warning system to detect deterioration. Department of Conservation oversee the monitoring of *Ruppia* and other aquatic plants and algae to determine status and trends in ecological health of the Lagoon. Monitoring also supports the resource consent for lagoon opening, contributing to opening decisions at a lower water level where vegetation has been stable (key ecological targets met for a number of years), or where poor water clarity is likely to have an adverse ecological effect if the lagoon isn't opened and flushed.

Results of annual monitoring are compared with target conditions sought under the Ecological Guidelines[5] for Waituna Lagoon. Two additional targets were suggested by an analysis of all monitoring data in 2018[6]. These ecological targets are listed in Box 1.

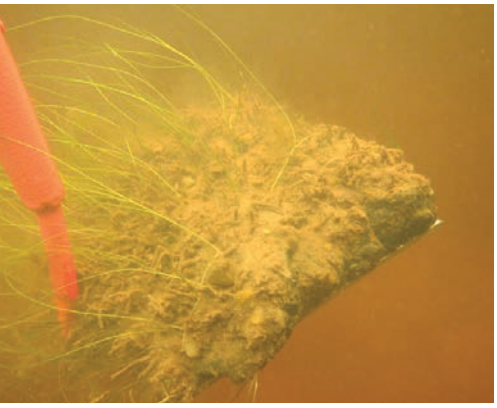
Box 1: Ecological targets for *Ruppia* in Waituna Lagoon:

- Lagoon closed during *Ruppia* growing season (spring and summer).
- >30–60% for average % cover of *Ruppia* (and other native macrophytes[7]).
- <10% cover of benthic and epiphytic filamentous algae (macroalgae).
- >1000 average for *Ruppia* 'biomass index' (% cover x cm height).
- ≥40% of *Ruppia* samples in a flowering or post-flowering life-stage.
- ≥20% of the sites record *Ruppia megacarpa*.

[5] Lagoon Technical Group (2013). Ecological Guidelines for Waituna Lagoon. Report prepared for Environment Southland.

[6] de Winton, M., Mouton, T. (2018) Technical Report on Vegetation Status in Waituna Lagoon: 2009–2018.

[7] Other native macrophytes comprised <35% of all occurrence records for all surveys.



Monitoring methods

The lagoon is monitored each year in late summer at 47-48 sites (Figure 3a). At each site, an assessment of environmental quality includes depth and water quality measurements (Figure 3b). Substrate characteristics are measured in four samples of the lagoon bed retrieved using a garden hoe, and the composition and abundance of vegetation is also described, including *Ruppia* life-stage as flowering or vegetative. Submerged native plants and dominant macroalgae are shown in (Figure 4).

Figure 3a: Map showing the location of sampling sites (47-48).

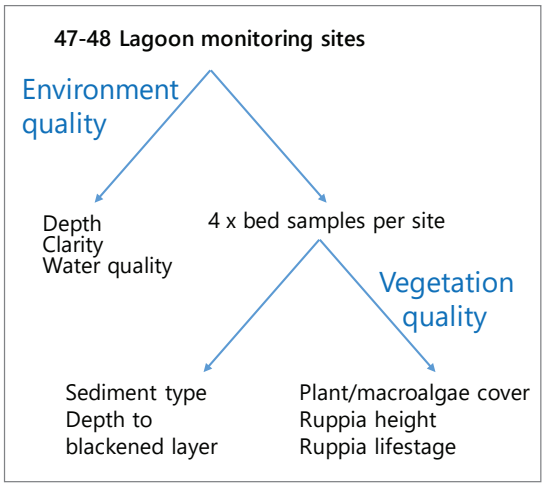


Figure 3b: Sampling design diagram.

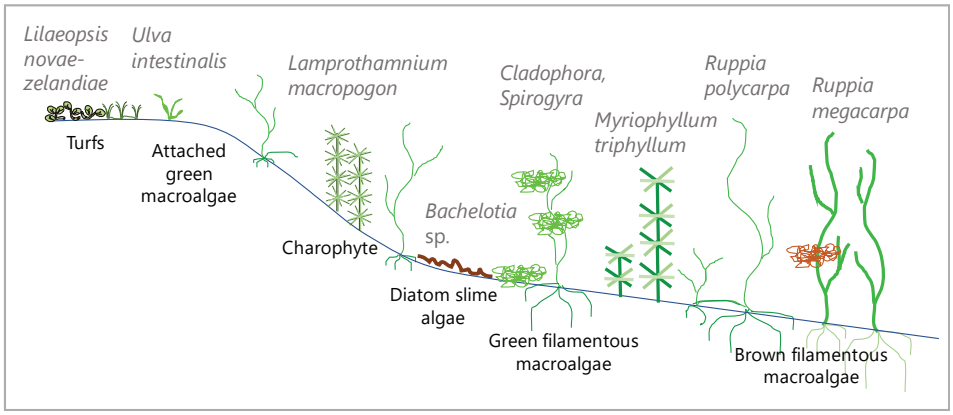


Figure 4: Common submerged plants and macroalgae types in Waituna Lagoon.

Did 2021 results achieve ecological targets for Waituna Lagoon?

The results of annual summer monitoring of the submerged vegetation in Waituna Lagoon are analysed and compared to the six ecological targets to track the health of the *Ruppia* community.

Target lagoon closure was not achieved in 2021, but was in 2009, 2010, 2012, 2015, 2016, 2018 and 2019.

1. Lagoon closure

A closed lagoon over spring and summer (defined as three months before monitoring) is an ecological target that provides stable conditions for the *Ruppia* growing season (Box 1). Whether the lagoon is closed or open has a strong influence on conditions that affect plants, such as depth, salinity and temperature. In 2021, Waituna Lagoon had been open for the duration of the *Ruppia* growing season, being opened 4.8 months before the annual summer monitoring (Table 1). This is the second consecutive year that the lagoon has been open for most of the *Ruppia* growing season, with 2020 also having an extended opening prior to monitoring (Table 1).

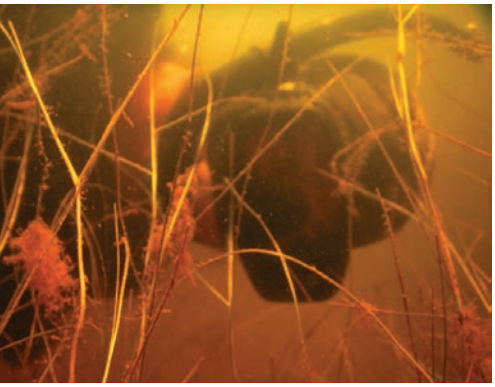


Table 1: Months that the lagoon has been closed (positive numbers) or open (negative numbers) prior to each monitoring event. Occasions the target is met are shown as bold, in highlighted cells.

Year	Months closed before monitoring
2009	**4.7**
2010	**4.6**
2011	-5.6
2012	**4.6**
2013	-3.9
2014	-6.2
2015	**6.2**
2016	**3.2**
2017	1.0
2018	**13.7**
2019	**3.5**
2020	-4.1
2021	-4.8

2. *Ruppia* cover

A healthy *Ruppia* community occupies a large habitat area in Waituna Lagoon. This is measured by calculating the percentage cover of *Ruppia* across all sites in the Lagoon. In 2021, the lagoon-wide average cover did not meet the ecological target (Box 1) of >30–60% (Table 2, Figure 5). Lagoon-wide cover in 2021 was amongst the three lowest values recorded, with *Ruppia* present in only limited sites (Table 2, Figure 5). This low *Ruppia* cover value is the second recorded in consecutive years, with low cover also recorded in 2020.

Target lagoon-wide *Ruppia* cover was achieved in 2019 and 2016.

Note: both these years the lagoon had been closed for two consecutive growing seasons for >3 months.

Table 2: *Ruppia* measurements including % sites, average cover at sites and % sites where >30% cover, and overall averaged lagoon-wide cover. Occasions the target is met are shown as bold, in highlighted cells.

Year	% sites where *Ruppia* present	Average cover (sites where present)	% sites with >30% cover	Lagoon-wide average cover
2009	73	33	23	24
2010	52	31	21	16
2011	25	7	2	2
2012	60	14	8	9
2013	33	22	13	7
2014	19	16	2	3
2015	70	29	23	21
2016	87	46	53	**40**
2017	74	12	6	9
2018	100	26	12	26
2019	96	37	43	**36**
2020	68	8	4	5
2021	30	9	0	3

Figure 5: Lagoon-wide cover of *Ruppia* is shown as green bars and percentage of sites at which *Ruppia* was present as a blue line.

3. *Ruppia* biomass index

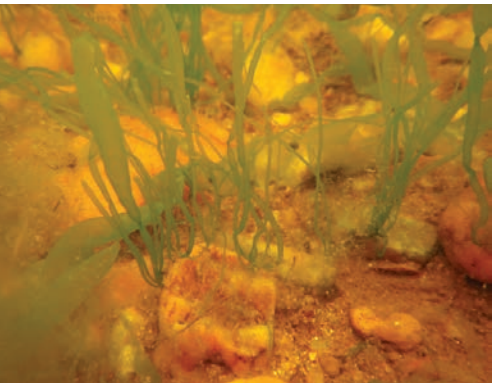
Target lagoon-wide *Ruppia* biomass index was not achieved in 2021, but was achieved in 2015, 2016, 2018 and 2019.

Target lagoon-wide *Ruppia* biomass index was achieved in 2015, 2016, 2018 and 2019.

Although *Ruppia* biomass is not sampled annually, a proxy for biomass can be derived by multiplying *Ruppia* cover by height as a 'biomass index'. In a healthy *Ruppia* community a biomass index >1000 is expected (Box 1). This might be visualised as a 10% cover of plants that are 100 cm tall or by a 100% cover of plants that are 10 cm tall, and other combinations. In 2021, lagoon-wide biomass index was 103, so this target was not met (Table 3). This is the second consecutive year that the average biomass index has been well short of the target.

Table 3: *Ruppia* presence at sites, number of sites where target biomass index was achieved and average biomass index calculated lagoon-wide. Occasions the target is met are shown as bold, in highlighted cells.

Year	% sites where *Ruppia* present	% sites with >1000 biomass index	Lagoon-wide average biomass index
2009	73	25	734
2010	52	21	899
2011	25	0	9
2012	60	4	177
2013	33	2	98
2014	19	2	114
2015	70	23	**1252**
2016	87	32	**1362**
2017	75	6	697
2018	100	19	**1324**
2019	96	45	**1872**
2020	68	4	199
2021	30	4	103



Limits for lagoon-wide macroalgae cover were not met in 2021, but had been met from 2009 to 2012, 2014 and 2018.

4. Macroalgae cover

Nutrient enrichment of waterbodies may result in excessive macroalgae growth that smothers the lake bed and shades *Ruppia* plants. One ecological target (Box 1) recognises that macroalgae on the lagoon bed (benthic), on plants (epiphytic) and floating mats should be no more than minor (<10% cover). Lagoon-wide average macroalgae cover in 2021 was 15% and exceeded this limit (Table 4 and Figure 6). This follows generally higher macroalgae cover that have been recorded since 2015 (Table 4).

Table 4: Percentage of sites recording macroalgae, their average cover, percentage of sites achieving <10% cover and average lagoon-wide cover. Occasions the target is met are shown as bold, in highlighted cells.

Year	% sites where macroalgae present	Average % cover (sites where present)	Sites with >10% cover (%)	Lagoon-wide average cover (%)
2009	19	17	6	**3**
2010	8	29	6	**2**
2011	17	3	0	**<1**
2012	23	16	8	**4**
2013	27	52	19	14
2014	27	17	11	**4**
2015	89	50	70	45
2016	79	36	49	28
2017	64	27	26	17
2018	11	2	0	**<1**
2019	89	73	85	66
2020	79	31	32	25
2021	25	28	12	15

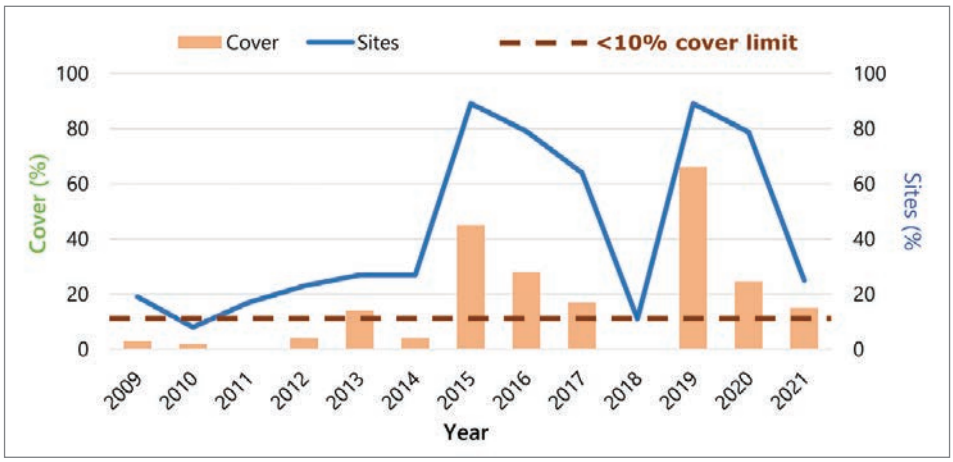


Figure 6: Lagoon-wide cover of macroalgae is shown as orange bars and percentage of sites at which macroalgae was present as a blue line.

The target for *Ruppia* reproductive success was achieved in 2012, 2015, 2016, 2018 and 2019.

5. *Ruppia* reproductive success

This ecological target focuses on the reproductive success of *Ruppia* and the likely replenishment of the seed bank which is vital for vegetation recovery after any major disturbance (e.g., extended lagoon opening). The target is ≥40% of *Ruppia* samples in a flowering or post-flowering life-stage, to incorporate sites with both *Ruppia* species (*R. polycarpa* and *R. megacarpa*). In 2021, only 4% of sites recorded flowering *Ruppia*. The reproductive success target was not achieved (Table 5). This is the second consecutive year that *Ruppia* has had a low reproductive success.

Table 5: Percentage of sites recording reproductive success for *Ruppia* as either flowering or post-flowering status. Occasions the target is met are shown as bold, in highlighted cells.

Year	% sites recording reproduction
2009	18
2010	32
2011	0
2012	**53**
2013	9
2014	10
2015	**59**
2016	**71**
2017	3
2018	**44**
2019	**46**
2020	6
2021	4

The target for status of *Ruppia megacarpa* was achieved in 2010, 2018 2019 and 2020.

6. Status of *Ruppia megacarpa*

Ruppia megacarpa is associated with taller, denser submerged vegetation in Waituna Lagoon. It acts as a strong 'ecosystem engineer', which subsequently supports the local environment that promote further vegetation development. The target states ≥20% of the sites should record *R. megacarpa*. A threshold of 20% of sites is recommended because this represents known sampled areas that are favourable for this species[8]. Only 6% of sites recorded *R. megacarpa* in 2021. This is the first time in four consecutive years that the target has not been met (Table 6).

Table 6: Percentage of sites recording *Ruppia megacarpa*. Occasions the target is met are shown as bold, in highlighted cells.

Year	% sites recording *Ruppia megacarpa*
2009	10
2010	**23**
2011	17
2012	2
2013	6
2014	0
2015	4
2016	9
2017	6
2018	**30**
2019	**32**
2020	**21**
2021	6

[8] de Winton, M. (2019) Vegetation Status in Waituna Lagoon: Summer 2019. *NIWA Publication*.

None of the six ecological targets were achieved in 2021.

Conclusions

Ecological targets in 2021

In 2021, none of the six ecological targets were met (Table 7). This result follow the achievement of just 1 target in the previous 2020 year. The pronounced reduction in *Ruppia* abundance and health in 2021 follows the second consecutive year of a sustained open lagoon over the main vegetation growth period. Notably, we saw a retraction in the distribution of *Ruppia*, with no submerged plants recorded over an estimated half of the lagoon area (south-western sector). This means that recovery of *Ruppia* in these areas will be initially dependent on seed banks and their successful germination and establishment. Recovery may not occur if there is insufficient seed bank, with poor reproductive success seen in 2020 and 2021.

Table 7: Summary of 2021 results for all ecological targets.

Ecological target	Targets met?	Comment
Lagoon closure	×	Lagoon was open for the entire *Ruppia* growing season.
Ruppia cover	×	Lagoon-wide *Ruppia* cover was only 1/10th of the target (>30% cover).
Ruppia biomass index	×	*Ruppia* biomass index was only 1/10th of the target (>1000).
Macroalgae cover	×	Macroalgae development exceeded the acceptable threshold of 10% cover.
Ruppia reproductive success	×	Reproductive success was 1/10th of the target (≥40% of samples flowered).
Status of *Ruppia megacarpa*	×	*Ruppia megacarpa* was limited to 1/3rd of the target sites (≥20% sites).

Ecological targets over all monitoring years

- No single monitoring year has achieved all six ecological targets for submerged vegetation in Waituna Lagoon (Table 8).
- Years that met fewest targets (one or none) were those that also did not meet the lagoon closure target.
- 2021 represents a second consecutive year that achieved one or no targets.
- There are no strong trends in target results over time indicating the system is highly dynamic, although:
  - biomass index was achieved more recently (four out of last seven years), and
  - excessive macroalgae were recorded during six out of the previous seven years, a sign of nutrient enrichment.

Table 8: Summary of results for six ecological targets over all monitoring years. Darker rows indicate greater numbers of targets were met.

Year	Lagoon closure	*Ruppia* cover	*Ruppia* biomass index	Macroalgae cover	*Ruppia* reproductive success	Status of *Ruppia megacarpa*	Targets met
2009	✓	×	×	✓	×	×	2
2010	✓	×	×	✓	×	✓	3
2011	×	×	×	✓	×	×	1
2012	✓	×	×	✓	✓	×	3
2013	×	×	×	×	×	×	0
2014	×	×	×	✓	×	×	1
2015	✓	×	✓	×	✓	×	3
2016	✓	✓	✓	×	✓	×	4
2017	×	×	×	×	×	×	0
2018	✓	×	✓	✓	✓	✓	5
2019	✓	✓	✓	×	✓	✓	5
2020	×	×	×	×	×	✓	1
2021	×	×	×	×	×	×	0

Implications for lagoon health

- Ecological targets for Waituna Lagoon are not met when lagoon openings occur over late spring to summer.
- Two or more consecutive years of openings during the main vegetation growth period should be avoided to ensure *Ruppia* can regenerate successfully.
- At least two consecutive years of a favourable closed lagoon appear to allow better *Ruppia* development.
- There are trade-offs between a stable closed lagoon for good *Ruppia* development and risk of nutrient build-up fuelling macroalgae and phytoplankton blooms.
- Ecological targets for lagoon-wide *Ruppia* cover and biomass index are likely to be met when *Ruppia megacarpa* is more prevalent, due to its ability to form tall, high cover beds.

Summary of technical findings

The accompanying technical report[9] to this summary document outlines that:

- Mouth status of Waituna Lagoon strongly influences water conditions.
  - The 2021 vegetation monitoring was undertaken during an open lagoon with strong tidal influences.
  - Lagoon waters were highly saline at the time of monitoring (average 82% of sea water levels) and had low water levels (average <0.3 m) at sampling sites.
  - 34% of sites were dry during this monitoring.
- *Ruppia* had retracted to the eastern half of the lagoon.
- *R. megacarpa* has had a greater proportional distribution decrease than *R. polycarpa*.
- For the second consecutive year of prior open lagoon conditions, macroalgae remained relatively abundant, suggesting other drivers than lagoon mouth status (e.g., temperature, sediment nutrients) are also important.

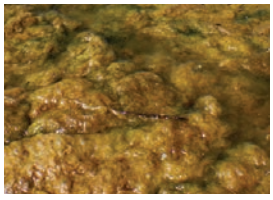
Overall, vegetation monitoring results for Waituna Lagoon from 2021 continue to support the need for closed conditions during the key growing seasons, often for consecutive years as a means of protecting widespread *Ruppia* vegetation and the ecological benefits that submerged plants provide.

[9] de Winton, M., Elcock, S.R. (2021) Technical Report on Vegetation Status in Waituna Lagoon: 2009–2021. *NIWA Publication.*

Glossary

Term	Definition
Benthic	Relating to, or occurring at the bottom of a body of water.
Biomass index	An indicator of biomass for *Ruppia* species that is based on multiplying measured cover (%) by height (cm).
Catchment	The area of land bounded by watersheds draining into a basin.
Charophyte	A group of freshwater algae that superficially resemble higher submerged plants in that they are anchored to the substrate and have stems and whorls of 'branchlets'.
Ecosystem engineer	An organism that creates, significantly modifies, maintains or destroys a habitat.
Ecosystem health	A way to describe the state of a system relative to a desired management target or reference condition.
Epiphytic	Living on the surface of plants.
Life-stage	Stages in form and function through which an organism passes during its lifespan that include reproductive status.
Macroalgae	Collective term used for seaweeds and other benthic marine or freshwater algae that are generally visible to the naked eye.
Resource consent	Official permission to carry out an operation that has an environmental impact.
Run-off	The draining away of water (or substances carried in it) from the surface of an area of land.
Submerged vegetation	Plants that grow entirely beneath the surface of the water, except for flowering parts in some species, including charophytes but excluding macroalgae.




Referral links

- Awarua-Waituna Wetlands: (doc.govt.nz)
- Land, Air, Water Aotearoa (LAWA) – Waituna Lagoon
- Waituna Lagoon • Living Water
- Home – Whakamana te Waituna
- Awarua Waituna Lagoon – National Wetland Trust | Learn More