Department of Conservation
Te Papa Atawhai

NIWA
Taihoro Nukurangi

Vegetation Status in Waituna Lagoon: Summer 2022

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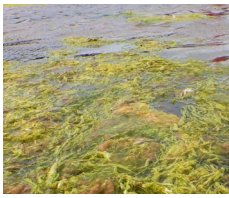

This report was commissioned by The Department of Conservation (DOC) and based on work under Project DOC20203.

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Acknowledgements:

NIWA staff who have contributed to monitoring events include Aleki Taumoepeau, Susie Elcock, 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 Johlene Kelly, 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 2022 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 2022, two of six ecological targets were achieved for Waituna Lagoon;

- The lagoon was closed to the sea for most of the spring-summer growing season for *Ruppia*, achieving the target for **lagoon closure.**
- *Ruppia megacarpa* recolonised most of the sites it had been lost from over the previous two years that had long periods open to the sea, achieving the target for **status of *Ruppia megacarpa***.
- Although targets for lagoon-wide ***Ruppia* cover, *Ruppia* biomass index** and ***Ruppia* reproductive success** were not achieved, measurements increased substantially compared to the previous year.
- This *Ruppia* recovery occured despite the fact that drought conditions in Southland and a low water level had impacted on *Ruppia* habitat (i.e., 15% of monitored sites were dry) and growth conditions (average salinity was equivalent to 23% seawater).
- The target of <10% for **macroalgae cover** was again not achieved, making it the seventh year since 2015 that macroalgal development has exceeded this target.
- This trend of higher macroalgal abundance includes years of both open and closed lagoon status and suggests other drivers (e.g., temperature, sediment nutrients) are also important.
- Overall, vegetation monitoring results for Waituna Lagoon from 2022 continue to support the need for closed lagoon conditions during the key growing season, preferably for consecutive years, as a means of protecting widespread *Ruppia* vegetation and the ecological benefits that submerged plants provide.

Purpose of this report

This report presents the 2022 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. (2022) Technical Report on Vegetation Status in Waituna Lagoon: 2009–2022. *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 with an intact ecological condition, but Waituna Lagoon remains highly valued for its associated plant, wetland, fish and birdlife.

[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.

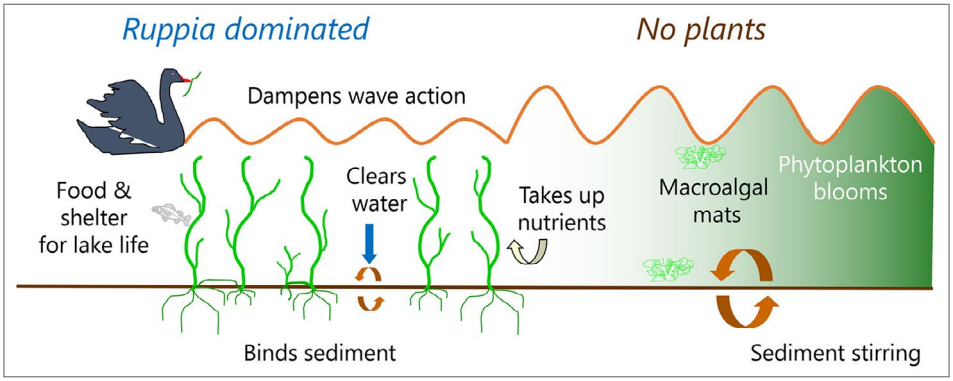
Ruppia safeguards the lagoon

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 levels of resuspended sediment and development of 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 flush nutrients from the lagoon. Lagoon closing only occurs naturally reliant on certain sea conditions. Management of these artificial openings is increasingly taking into account the Lagoon's ecology. The timing and length of openings ideally should not negatively impact on the survival of *Ruppia* and other vegetation. This requires managing openings to avoid critical periods in the life-history of *Ruppia* including 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 an interim resource consent[3]. The trigger level varies at different times of the year and the consented opening has associated conditions. More recently, the optimal Resource Consent conditions for the ecological and cultural health of the lagoon ecosystem were assessed by an expert technical panel[4] as a step towards better management of lagoon openings.

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

[4] Robertson, H.A., Ryder, G., Atkinson, N., Ward, N., Jenkins, C., de Winton, M., Kitson, J., Schallenberg, M., Holmes R. (2021) Review of conditions for opening Waituna Lagoon. Supporting Information. Prepared for Whakamana Te Waituna. 29 pp. *Technical Assessment – Review of conditions for opening Waituna Lagoon (2021)*.

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[5] has built up a picture of the key changes caused by opening events[6]. 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.

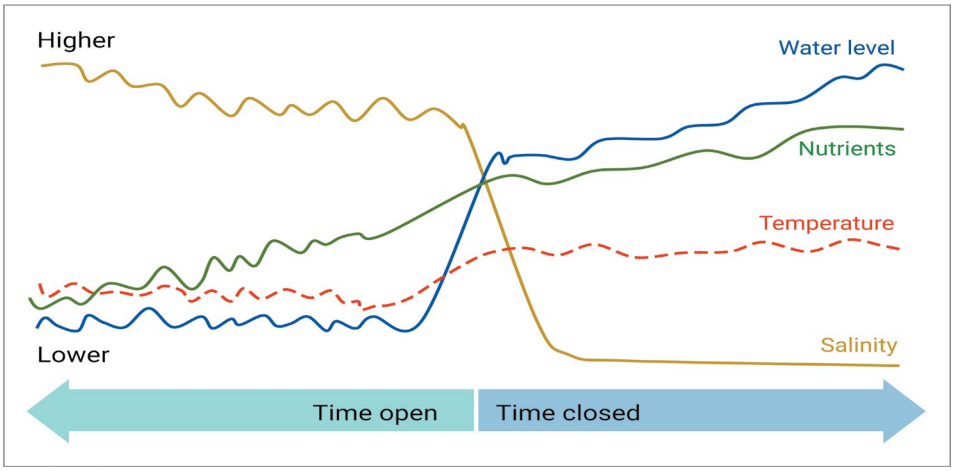


Figure 2: Key changes in the waters of Waituna Lagoon with time after opening or closing to the sea.

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.

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

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

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 interim 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[7] for Waituna Lagoon. Two additional targets were suggested by an analysis of all monitoring data in 2018[8]. These ecological targets are listed in Box 1.

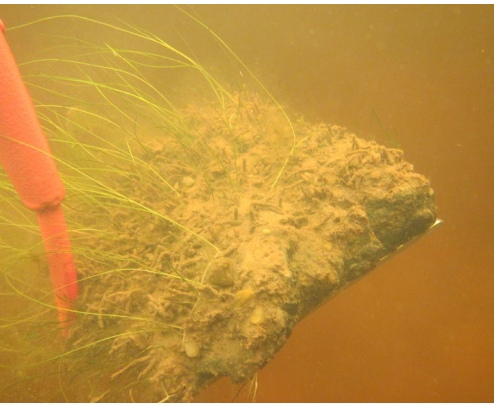
Box 1: Ecological targets for *Ruppia* in Waituna Lagoon:

- Lagoon closed during *Ruppia* growing season (spring and summer).
- >30–60% for average % cover of *Ruppia* (and other native macrophytes[9]).
- <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*.

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

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

[9] 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).

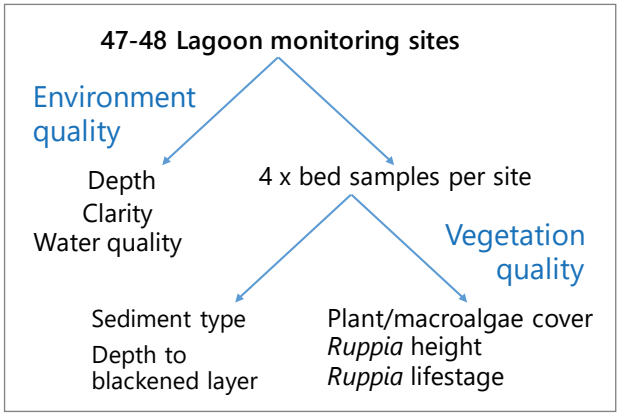


Figure 3b: Sampling design diagram.

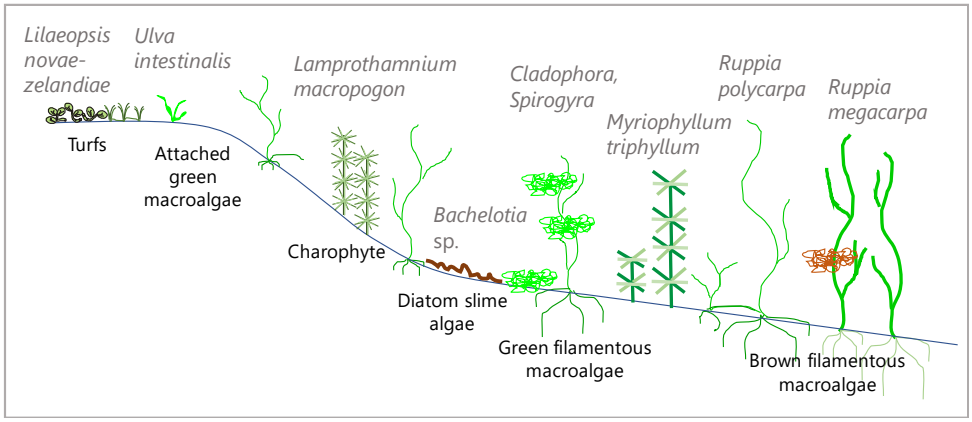


Figure 4: Common submerged plants and macroalgae types in Waituna Lagoon.

Did 2022 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 achieved in 2022, as it was in 2009, 2010, 2012, 2015, 2016, 2018 and 2019.

1. Lagoon closure

A closed lagoon over spring and summer (defined as the 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.

The lagoon had been closed for 4.5 months prior to the summer 2022 monitoring (Table 1), meeting the target for closure of the lagoon (>3 months) and providing favourable conditions over the key spring-summer growth period for *Ruppia*. Achievement of this target follows two consecutive years where Waituna Lagoon was open to the sea for the majority of the growth season for *Ruppia* (Table 1). Although the lagoon was closed at the time of the summer 2022 monitoring, a drought in Southland resulted in a much lower lagoon water level than normal and approximately 15% of monitored sites were dry or nearly dry.

Table 1: Months that the lagoon has been closed (positive numbers) or open (negative numbers) prior to each monitoring event. Occasions that 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
2022	**4.5**

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.

Lagoon-wide average cover in 2022 did not meet the ecological target (Box 1) of >30–60% (Table 2, Figure 5). However, all *Ruppia* measurements for 2022 (Table 2) showed substantial increases compared with the previous two years when the lagoon closure target was not met (Table 1).

Target lagoon-wide *Ruppia* cover has only been 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
2022	72	19	19	13

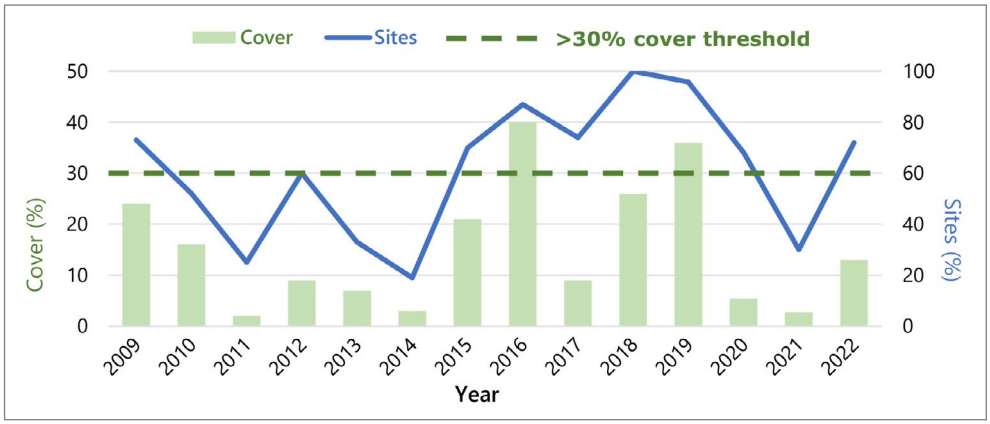


Figure 5: Lagoon-wide cover of *Ruppia* is shown as green bars and percentage of sites at which *Ruppia* was present as a blue line.

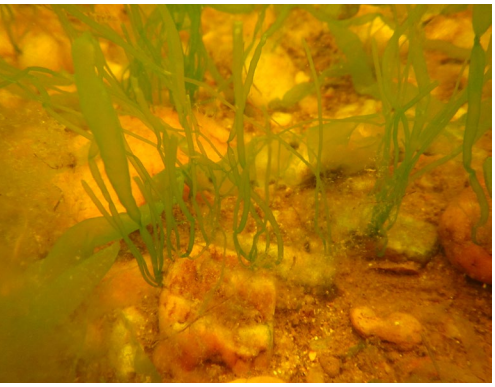
3. *Ruppia* biomass index

Target lagoon-wide *Ruppia* biomass index was achieved in 2015, 2016, 2018 and 2019, but not achieved in 2022.

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. Lagoon-wide biomass index in 2022 did not meet the target (Table 3) but shows a substantial increase over the previous two years when the lagoon closure target was not met (Table 1). Years where the target lagoon-wide *Ruppia* biomass index was achieved in 2015, 2016, 2018 and 2019 were years when the lagoon closure target was met (Table 1), and a successive year of closure resulted in the higher biomass index value (i.e., 2016 and 2019).

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
2022	72	4	462



Limits for lagoon-wide macroalgae cover were not met in 2022, 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). In 2022, the lagoon-wide average macroalgae cover substantially exceeded the 10% cover limit and was the second highest value recorded (Table 4 and Figure 6). This result continues a general trend of greater macroalgal growth for years since 2015, (Table 4 and Figure 6) regardless of whether the lagoon closure target was not met (Table 1).

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
2022	85	63	66	54

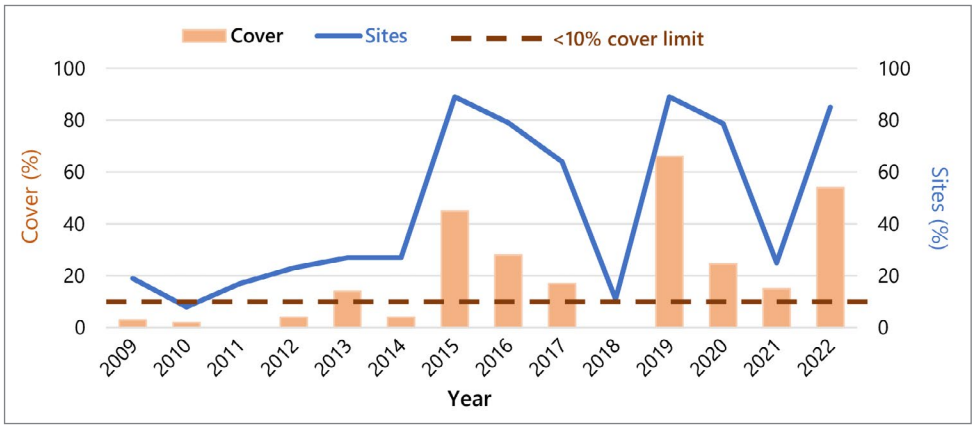


Figure 6: Lagoon-wide cover of macroalgae is shown as orange bars and percentage of sites at which macroalgae was present as a blue line.

The target for *Ruppia* reproductive success was not achieved in 2022, but was 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 at sites in a flowering or post-flowering life-stage. Although the target for reproductive success of *Ruppia* was not met in 2022 (Table 5), a large increase in fertile *Ruppia* samples was recorded relative to the previous two years when the lagoon closure target was not met (Table 1).

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
2022	30

The target for status of *Ruppia megacarpa* was achieved in 2010, 2018 2019, 2020 and 2022.

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 promotes 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[10].

In 2022, *R. megacarpa* had recovered to occupy 23% of sites (Table 6) and so meets the target for status of this plant species.

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
2022	**23**

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

Two of the six ecological targets were achieved in 2022.

Conclusions

Ecological targets in 2022

Six ecological targets are considered compatible with a stable and self-sustaining native submerged plant population (Box 1). Only two of these six ecological targets were met in 2022 (Table 7). However, one or no targets were met in the previous two years (2020 and 2021). The target of a closed lagoon for >3 months prior to monitoring was achieved in 2022 and reestablishment by *Ruppia megacarpa* proceeded to over 20% of sites.

Restrictions on meeting several targets may have resulted from a drought in southern Southland over the 2021/22 summer that meant approximately 15% of the monitored lagoon sites were dry at the time of the 2022 survey. Nevertheless, progress towards meeting three additional targets was apparent under closed lagoon conditions (Table 7). In contrast, macroalgal cover exceeded acceptable levels despite the reduction in underwater habitat due to low lagoon levels in 2022.

Table 7: Summary of 2022 results for all ecological targets.

Ecological target	Targets met?	Comment
Lagoon closure	✓	Lagoon was closed for the *Ruppia* growing season prior to monitoring.
Ruppia cover	×	Lagoon-wide *Ruppia* cover was just under half of the (target >30% cover).
Ruppia biomass index	×	*Ruppia* biomass index was almost half of the (target >1000).
Macroalgae cover	×	Macroalgae development exceeded the acceptable threshold of 10% cover by a considerable margin.
Ruppia reproductive success	×	Reproductive success, with 30% of sites recording fertile plants in 2022, did not meet the (target ≥40% of samples flowered).
Status of *Ruppia megacarpa*	✓	*Ruppia megacarpa* contributed significantly to lagoon vegetation.

Ecological targets over all monitoring years

- Two targets were met in 2022, representing the lower range for number of targets achieved at times when the lagoon closure target was achieved (Table 8).
- 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.
- There are no strong trends in target results over time indicating the system is highly dynamic, although more recently:
  - biomass index was achieved (four out of last eight years), and
  - excessive macroalgae (target not achieved) were recorded during seven out of the previous eight years, a possible 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
2022	✓	✗	✗	✗	✗	✓	2

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[11] to this summary document outlines that:

- At the time of the 2022 monitoring, the lagoon had been closed to the sea for most of the spring-summer growing season for *Ruppia*.
- During the 2022 monitoring, Waituna Lagoon had a low water level (0.57 m below normal) due to local drought, 15% of monitored sites were dry and this limited the habitat available for *Ruppia*.
- Water salinity at the time of the 2022 monitoring was higher than usual (23% seawater) for a closed lagoon because of limited freshwater dilution under drought conditions.
- Despite impacts of drought in 2022, the *Ruppia* population had expanded under the closed lagoon conditions compared to the previous two years that had long periods open to the sea.
- Flowering and fruiting of *Ruppia* increased in 2022, following two years of limited fertility. Successful fruiting is important to replenish seed banks that contribute to plant recovery following lagoon openings.
- Macroalgae in 2022 were again relatively abundant, continuing a trend of higher macroalgal abundance since 2015 and suggesting drivers other than lagoon mouth status (e.g., temperature, sediment nutrients) are also important.

Overall, vegetation monitoring results for Waituna Lagoon from 2022 continue to support the need for closed lagoon conditions during the key growing season, preferably for consecutive years, as a means of protecting widespread *Ruppia* vegetation and the ecological benefits that submerged plants provide.

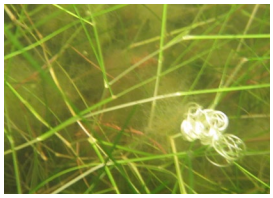
[11] de Winton, M. (2022) Technical Report on Vegetation Status in Waituna Lagoon: 2009–2022. *NIWA Publication*.

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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