Littoral macrophytes in Manapōuri Power Scheme

3-year consents monitoring baseline 2026



Prepared for Meridian Energy Ltd.

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Contents

Executive summary **9**

1 Introduction **11**

2 Methods **14**

2.1 Lake levels 14

2.2 Inter-decile range 14

2.3 Macrophyte community composition survey 15

2.4 Statistical analysis 22

3 Results **23**

3.1 Lake levels 23

3.2 Inter-decile range 26

3.3 Macrophyte community composition survey 27

3.4 Low mixed, turf community 29

3.5 Tall submerged species 36

4 Discussion **44**

5 Acknowledgements **46**

6 References **47**

Appendix A Resource consent monitoring conditions **49**

Appendix B Lake level fluctuations and inter-decile range **53**

Appendix C Turf species **62**

Appendix D Tall vascular plants **97**

Appendix E Characeans **118**

Tables

Table 3-1: Frequency and duration (days) where lake level is less than the median lake level for the 12 months (365 days) prior to each macrophyte survey. 25

Table 3-2: Mean monthly inter-decile range (m) for the 12-month period (365 days) prior to each macrophyte survey. 26

Table 3-3: Comparison of the number of species within each defined macrophyte assemblage recorded within each lake during the surveys from 1993 to 2026. 28

Table 3-4: List of low mixed, turf species recorded in Lakes Te Anau, Manapōuri and Hauroko during the 2026 survey. 29
Table 3-5: Significant changes in upper and lower elevation limits of common turf species between 2012 and 2026 in Lakes Te Anau, Manapōuri and Hauroko. 35
Table 3-6: Tall submerged (vascular and characean) species recorded in Lakes Te Anau, Manapōuri and Hauroko in 2026. 38
Table 3-7: Significant changes in upper and lower elevation limits of submerged species between 2022 and 2026 in Lakes Te Anau, Manapōuri and Hauroko. 42
Table 3-8: Median maximum depth of vegetation in Lakes Te Anau, Manapōuri and Hauroko 2017 - 2026. 43

Table C-1: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Centrolepis pallida* in the three lakes from 1993-2026. 66
Table C-2: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Elatine gratioloides* in the three lakes from 1993-2026. 71
Table C-3: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Glossostigma* in the three lakes from 1993-2026. 76
Table C-4: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Lilaeopsis ruthiana* in the three lakes from 1993-2026. 81
Table C-5: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Pilularia novae-hollandiae* in the three lakes from 1993-2026. 86
Table C-6: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Ranunculus limosella* in three lakes from 1993-2026. 91
Table C-7: Frequency of occurrence (expressed as % of sites for each lake) for each turf species in the three lakes from 2008-2026 93
Table D-1: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Elodea canadensis* in Lakes Te Anau and Manapōuri from 1993-2026. 100
Table D-2: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Isoetes alpina* in all three lakes from 1993-2026 105
Table D-3: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Myriophyllum propinquum* in the three lakes form 1993-2026. 110
Table D-4: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Myriophyllum triphyllum* in the three lakes from 1993-2026. 111
Table D-5: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Potamogeton cheesemanii* in the three lakes from 1993-2026 116

Table D-6: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Potamogeton ochreatus* in the three lakes from 1993-2026 117
Table E-1: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Chara australis* in the three surveyed lakes from 1993-2026. 122
Table E-2: Frequency of occurrence (% sites), lake-wide average and maximum median cover of *Chara acanthopitys* and *C. globularis* in Lakes Te Anau, Manapōuri and Hauroko recorded during the 2026 survey. 124

Figures

Figure 2-1: Lake Te Anau survey site locations. 16
Figure 2-2: Lake Manapōuri survey site locations. 17
Figure 2-3: Lake Hauroko survey site locations. 18
Figure 2-4: Diver recording a submerged vegetation profile in Lake Hauroko (23 March 2026). 19
Figure 2-5: Transect to sample emersed turf vegetation in Lake Te Anau (21 March 2026). 19
Figure 2-6: Emersed turf vegetation on the margin of Lake Manapōuri (25 March 2026). 21
Figure 2-7: Zone 1 turf vegetation on the margin of Lake Manapōuri (26 March 2026). 21
Figure 2-8: Zone 3 turf vegetation on the margin of Lake Hauroko (23 March 2026). 22
Figure 3-1: Median lake level for the 12 months prior to each macrophyte survey from 1993 to 2026 in Lake Te Anau, Lake Manapōuri and Lake Hauroko. 24
Figure 3-2: Lake-wide elevation ranges of amphibious turf species in Lake Te Anau 2026. 32
Figure 3-3: Lake-wide elevation ranges of amphibious turf species in Lake Manapōuri 2026. 33
Figure 3-4: Lake-wide elevation ranges of amphibious turf species in Lake Hauroko 2026. 34
Figure 3-5: Dense shallow water beds *of Isoetes alpina* in Lake Hauroko (23 March 2026). 36
Figure 3-6: The non-native *Elodea canadensis* in Lake Manapōuri (25 March 2026). 37
Figure 3-7: Deep water charophyte meadows in Lake Hauroko (23 March 2026). 38
Figure 3-8: Elevation ranges of tall submerged plants in Lake Te Anau in 2026. 39
Figure 3-9: Elevation ranges of tall, submerged plants in Lake Manapōuri in 2026. 40
Figure 3-10: Elevation ranges of tall submerged plants in Lake Hauroko in 2026. 41

Figure A-1: Lake Te Anau. 51
Figure A-2: Lake Manapōuri. 52
Figure B-1: Lake level fluctuations in Lake Te Anau for the year preceding the 2026 macrophyte survey. 53
Figure B-2: Lake level fluctuations preceding each macrophyte survey in Lake Te Anau since 1993. 54

Figure B-3: Lake level fluctuations in Lake Manapōuri for the year preceding the 2026 macrophyte survey. 55
Figure B-4: Lake level fluctuations preceding each macrophyte survey in Lake Manapōuri since 1993. 56
Figure B-5: Lake level fluctuations in Lake Hauroko for the year preceding the 2026 macrophyte survey. 57
Figure B-6: Lake level fluctuations preceding each macrophyte survey in Lake Hauroko since 1993. 58
Figure B-7: Monthly inter-decile variance from the 34-year median lake level (zero) for the 12-month period prior to each survey in Lake Te Anau. 59
Figure B-8: Monthly inter-decile variance from the 34-year median lake level (zero) for the 12-month period prior to each survey in Lake Manapōuri. 60
Figure B-9: Monthly inter-decile variance from the 34-year median lake level (zero) for the 12-month period prior to each survey in Lake Hauroko. 61
Figure C-1: Female flowers (left) and turf dominated by *Centrolepis pallida* (right). 62
Figure C-2: Lake-wide elevation ranges of *Centrolepis pallida* in Lake Te Anau 1993-2026. 63
Figure C-3: Lake-wide elevation ranges of *Centrolepis pallida* in Lake Manapōuri 1993-2026. 64
Figure C-4: Lake-wide elevation ranges of *Centrolepis pallida* in Lake Hauroko 1993-2017. 65
Figure C-5: *Elatine gratioloides*. 67
Figure C-6: Lake-wide elevation ranges of *Elatine gratioloides* in Lake Te Anau 1993-2026. 68
Figure C-7: Lake-wide elevation ranges of *Elatine gratioloides* in Lake Manapōuri 1993-2026. 69
Figure C-8: Lake-wide elevation ranges of *Elatine gratioloides* in Lake Hauroko 1993-2026. 70
Figure C-9: *Glossostigma diandrum* and *G. cleistanthum* (left and right). 72
Figure C-10: Lake-wide elevation ranges of *Glossostigma* in Lake Te Anau 1993-2026. 73
Figure C-11: Lake-wide elevation ranges of *Glossostigma* in Lake Manapōuri 1993-2026. 74
Figure C-12: Lake-wide elevation ranges of *Glossostigma* in Lake Hauroko 1993-2026. 75
Figure C-13:*Lilaeopsis ruthiana*. 77
Figure C-14: Lake-wide elevation ranges of *Lilaeopsis ruthiana* in Lake Te Anau 1993-2026. 78
Figure C-15: Lake-wide elevation ranges of *Lilaeopsis ruthiana* in Lake Manapōuri 1993-2026. 79
Figure C-16: Lake-wide elevation ranges of *Lilaeopsis ruthiana* in Lake Hauroko 1993-2026. 80
Figure C-17: *Pilularia novae-hollandiae*. 82
Figure C-18: Lake-wide elevation ranges of *Pilularia novae-hollandiae* in Lake Te Anau 1993-2026. 83
Figure C-19: Lake-wide elevation ranges of *Pilularia novae-hollandiae* in Lake Manapōuri 1993-2026. 84

Figure C-20: Lake-wide elevation ranges of *Pilularia novae-hollandiae* in Lake Hauroko 1993-2026. 85
Figure C-21: *Ranunculus limosella*. 87
Figure C-22: Lake-wide elevation ranges of *Ranunculus limosella* in Lake Te Anau 1993-2026. 88
Figure C-23: Lake-wide elevation ranges of *Ranunculus limosella* in Lake Manapōuri 1993-2026. 89
Figure C-24: Lake-wide elevation ranges of *Ranunculus limosella* in Lake Hauroko 1993-2026. 90
Figure D-1: *Elodea canadensis*. 97
Figure D-2: Lake-wide elevation ranges of *Elodea canadensis* in Lake Te Anau 1993-2026. 98
Figure D-3: Lake-wide elevation ranges of *Elodea canadensis* in Lake Manapōuri 1993-2026. 99
Figure D-4: *Isoetes alpina*. 101
Figure D-5: Lake-wide elevation ranges of *Isoetes alpina* in Lake Te Anau 1993-2026. 102
Figure D-6: Lake-wide elevation ranges of *Isoetes alpina* in Lake Manapōuri 1993-2026. 103
Figure D-7: Lake-wide elevation ranges of *Isoetes alpina* in Lake Hauroko 1993-2026. 104
Figure D-8: *Myriophyllum triphyllum*. 106
Figure D-9: Lake-wide elevation range of the native milfoils (*Myriophyllum propinquum* and *M. triphyllum*) in Lake Te Anau 1993-2026. 107
Figure D-10: Lake-wide elevation range of the native milfoils (*Myriophyllum propinquum* and *M. triphyllum*) in Lake Manapōuri 1993-2026. 108
Figure D-11: Lake-wide elevation ranges of the native milfoils (*Myriophyllum propinquum* and *M. triphyllum*) in Lake Hauroko 1993-2026. 109
Figure D-12: *Potamogeton* in Lake Hauroko. 112
Figure D-13: Lake-wide elevation range of the native pondweed (*Potamogeton cheesemanii*) in Lake Te Anau 1993-2026. 113
Figure D-14: Lake-wide elevation range of the native pondweeds (*Potamogeton cheesemanii* and *P. ochreatus*) in Lake Manapōuri 1993-2026. 114
Figure D-15: Lake-wide elevation ranges of the native pondweeds (*Potamogeton cheesemanii* and *P. ochreatus*) in Lake Hauroko 1993-2026. 115
Figure E-1: *Chara australis*. 118
Figure E-2: Lake-wide elevation range of *Chara australis* in Lake Te Anau 1993-2026. 119
Figure E-3: Lake-wide elevation range of *Chara australis* in Lake Manapōuri 1993-2026. 120
Figure E-4: Lake-wide elevation ranges of *Chara australis* in Lake Hauroko 1993-2026. 121
Figure E-5: *Chara acanthopitys* (previously known as *Chara fibrosa*) 123
Figure E-6: Diver swimming above a mixed meadow of *Nitella* species. 125
Figure E-7: Lake-wide elevation range of *Nitella* species in Lake Te Anau 2017 to 2026. 126

Figure E-8: Lake-wide elevation range of *Nitella* species in Lake Manapōuri 2017 to 2026. 127
Figure E-9: Lake-wide elevation range of Nitella species in Lake Hauroko 2017-2026. 128

Executive summary

The littoral margins of Lakes Te Anau and Manapōuri, situated in the Fiordland National Park, support possibly the highest diversity of amphibious (turf) and aquatic plants in New Zealand. These include species that are endemic (essentially restricted) to these lakes, other nationally threatened species, and increasingly rare native plant community types. Unlike many other New Zealand lakes, the relatively low number of weed species that have established in these lakes means that the native flora has not been outcompeted and displaced. This assumes great significance on a national scale, in terms of lake flora biodiversity.

The lake levels of Lakes Te Anau and Manapōuri are controlled for the purpose of hydro-electric generation. The lake levels are operated within their natural range according to the Gazetted Operating Guidelines for the levels of Lakes Manapōuri and Te Anau, recommended by the Guardians of the Lakes. Under Appendix 1 to the 1996 resource consents for the operation of the Manapōuri Power Scheme (CN 96019-V4, CN 96020-V5, CN 96021-V5, CN 96022-V6 and CN96023-V5), Meridian Energy Limited (Meridian) are required to undertake surveys of the macrophyte community within Lakes Te Anau and Manapōuri every five years to compare with Lake Hauroko, which is not controlled for hydro-electric purposes and where the lake level fluctuates naturally. Recently, Meridian has explored options for more flexible operations and additional lake storage opportunities. Subsequent changes to the operating guidelines for Lakes Te Anau and Manapōuri were agreed with the Guardians of Lakes Manapōuri, Monowai and Te Anau (the Guardians) and came into force on 30 May 2025 (Gazette Notice Number 2015-go2889). These changes include increased flexibility to enable more effective use of the Low Operating Range (LOR) of Lakes Te Anau and Manapōuri. Gazetted Operating Guidelines for the low operating and high operating ranges of Lakes Manapōuri and Te Anau remain unchanged. Earth Sciences New Zealand were engaged to provide a baseline macrophyte survey of Lakes Te Anau, Manapōuri and Hauroko applying the same methodology used previously and against which any effects of the new lake level regime could be gauged.

Turf and aquatic plants monitoring was repeated over 21-27 March 2026. A highly diverse turf community was recorded, although species richness was lower than that recorded in 2022. Compared to 2022, the twelve-month period prior to the 2026 survey had higher-than-average lake levels, higher annual lake level fluctuation and higher than normal monthly inter-decile ranges, all of which would be less favourable for maximum turf species richness and development.

There were few statistically significant differences in the upper and lower elevation limit of submerged species between 2022 and 2026. Despite higher lake water levels, the median maximum depth of vegetation with cover ≥10% had increased markedly in Te Anau and Manapōuri, but not in Lake Hauroko, and absolute minimum elevation (maximum depth) increased in Te Anau and Hauroko but slightly reduced in Lake Manapōuri. These changes may indicate higher water transparency in the lakes during the last survey.

However, over time, elevation ranges, percent occurrence and cover of the common species in the turf, tall vascular macrophyte and characean communities have remained relatively stable since the commencement of monitoring surveys in 1993, with apparent (statistically significant) migration of species up or down the profile noted between sampling occasions, but without any recognisable trend over the entire monitoring period.

The previous 2018 and 2022 reports documented a significant decline in the native *Isoetes alpina* in Lakes Te Anau and Manapōuri. This pattern appears to be reversed in 2026, with an apparent but not statistically significant increase in elevation range, number of sites and percentage covers of this species.

Overall, there appears to be no significant impact on the macrophyte communities from the existing management regime compared to fluctuations that are driven by climatic-influenced factors (e.g., rainfall, storm events and air temperature variations), based on the comparison with uncontrolled Lake Hauroko. Provided that lake level fluctuation and inter-decile variance regimes continue, it is likely that the highly diverse littoral vegetation of these lakes will persist in Lakes Te Anau and Manapōuri.

Six additional vegetation profiles were selected in the 2026 survey to substitute for various sites that had been impacted by landslides or other disturbance events over the past 33 years since the monitoring programme was instigated in 1993. The inclusion of these sites in 2026 has provided the requisite number of vegetated sites to preserve the robustness of our analysis.

The extensive dataset from previous surveys, augmented by additional sites, provides a robust long-term baseline to detect possible vegetation changes resulting from more frequent use of the LOR. Sensitivity to change will be enhanced by the planned three- year interval for a 12-year period.

1 Introduction

Meridian Energy Limited (Meridian) operate the Manapōuri Power Scheme (MPS), which harnesses water from Lakes Manapōuri and Te Anau, and the Mararoa River to generate electricity in New Zealand's largest single hydroelectric power station at Manapōuri Power Station.

As part of the compliance monitoring programme for the operation of the MPS, long-term surveys of aquatic macrophytes (including amphibious turf species and tall submerged species) have been undertaken in Lakes Te Anau and Manapōuri, and in Lake Hauroko as a control. Surveys had been undertaken at a 5-yearly interval since 1993[1], with the last survey completed in 2022 (Champion et al. 2022).

Recently, Meridian has explored options for more flexible operations and additional lake storage opportunities. Subsequent changes to the operating guidelines for Lakes Te Anau and Manapōuri were agreed with the Guardians of Lakes Manapōuri, Monowai and Te Anau (the Guardians) and came into force on 30 May 2025. These are anticipated to result in an increased use of the Low Operating Range (LOR) of Lakes Te Anau and Manapōuri.

Monitoring of the potential effects of the proposed changes on aquatic ecology has been considered and recommendations made on the frequency, timing and methods for monitoring (James and Schwarz 2025). These recommendations stated:

- A ‘baseline’ aquatic macrophyte survey should be carried out in February/March 2026.
- All sampling protocols should remain the same as for the previous 5-yearly surveys.
- The elevation range of turf species should be resurveyed in the 2026 aquatic macrophyte baseline survey.
- The focus of aquatic macrophytes monitoring should be as indictors of change in aquatic ecology more broadly.
- There should be a change to 3-yearly monitoring, in place of the current 5-yearly monitoring cycle, for a suggested 12-year period, with review after 6 years and 12 years.
- Event driven surveys (including departures from the (revised) guidelines) should be retained.

Meridian applied to Environment Southland under section 127 of the RMA for a change of conditions. The application sought to amend Appendix 1 to five of its 1996 core operating permits for the Manapōuri Power Scheme (CN 96019-V4, CN 96020-V5, CN 96021-V5, CN 96022-V6 and CN96023-V5), with an increase in the frequency of scheduled aquatic macrophyte monitoring from 5-yearly to 3-yearly, and to bring forward the next survey due in

[1] Prior to 2007, turf plants were only recorded if they were found as submerged species. From 2007 onwards, surveys have included emersed turf species

2027 so that it was instead due in 2026. Environment Southland granted this application in March 2026.

The purpose of the monitoring is to identify any long-term changes in the aquatic macrophyte communities within the controlled lakes, Te Anau and Manapōuri, compared with natural variability in the uncontrolled Lake Hauroko, and to provide a baseline to compare this (and previous surveys) against future vegetation changes. This is to ensure that the operating regime of the MPS is sustaining the aquatic macrophytes within the lakes used for hydro-electricity generation.

Aquatic macrophytes are used as an indicator of system integrity as they are responsive to lake level fluctuations, the key variable altered during hydro-power scheme operations (Schwarz and Hawes 1997, Riis and Hawes 2002). Plant communities that grow in shallow water around the lake margin may become de-watered at times of low water level thereby favouring species that can withstand both exposure to the air and flooding dependant on lake level.

These communities are also exposed to erosion and/or physical damage resulting from wave effects. Turf vegetation growing in this zone is usually of short stature (< 5 cm tall), but is comprised of a very diverse, species-rich community. During prolonged periods of low water level, this community is threatened by competition from taller, more terrestrial vegetation, whereas long periods of submersion promote the ingress of taller, obligate submerged species.

Changes in lake level can also affect deeper vegetation communities as the amount of light reaching the community changes. Prolonged periods of low light (because of high lake levels) may reduce the depth to which plants can grow, while the reverse is true during a period of low lake levels (Schwarz and Hawes 1997). The effects of both wave action and a fluctuating light environment can affect the growth and loss processes of vegetation, thus impacting the overall biomass in the littoral zone (Schwarz and Hawes 1997).

Several aspects of lake level fluctuation have been identified as important for defining these plant distributions (Rorslett 1991, Riis and Hawes 2002, Hawes et al. 2003). The most important of these are: (1) the amplitude of lake level fluctuation, which defines the overall area available to each zone of macrophyte community; (2) the frequency of submersion and emersion, which defines the degree of desiccation; and (3) the duration of high and low lake level events, which determines the time available for sensitive life-history stages (e.g., reproduction and seedling establishment) to be completed (Jansson et al. 2000, Riis and Hawes 2002, Hawes et al. 2003).

New Zealand Institute for Earth Science Limited (Earth Sciences New Zealand) was contracted by Meridian to undertake a new baseline survey of aquatic macrophytes in Lakes Te Anau, Manapōuri and Hauroko in 2026. As required by the consent monitoring programme (Resource Consents 96019-V4, 96020-V5, 96021-V5, 96022-V6 and 96023-V5 (1996 MPS Operating Consents)), Meridian requested that we:

- Use the methodology based on Sutherland et al. (2010) which comprises field surveys of shoreline transects for amphibious turf plant species, their cover and elevation range, and submerged macrophyte profiles recording species depth range, cover and height.
- Add new turf transects or submerged macrophyte profiles to substitute for sites that no longer support vegetation as a result of landslides or erosion etc, to

preserve sufficient site numbers to ensure the robustness of the analysis following the methodology of Sutherland et al. (2010).

- Undertake data analysis (including analysis of inter-decile water level ranges) following the established methodology of Sutherland et al. (2010).
- Deliver an Earth Sciences New Zealand peer-reviewed client report following the same format as Champion et al. (2022).

Previous investigations provide historic data for comparison (see Wells et al. 1994, Schwarz et al. 1997, Hawes et al. 2003, Sutherland et al. 2007, 2012, Champion et al. 2018, 2022), along with additional relevant reports (Sutherland and Graynoth 2009, Sutherland et al. 2010, 2013, 2014).

2 Methods

2.1 Lake levels

Water level records from fixed gauges in each lake were used in all lake level analyses. Lake Manapōuri data was taken from the Supply Bay gauge. Mean daily lake levels were calculated. Plant elevations and depths were measured relative to ambient lake level at the time of the survey. Additional water level records taken at 5-minute intervals over the field trip (21-27 March 2026) were used to normalise all measured elevations and depths to m.a.s.l.

We calculated the median lake level and low-level events for the 12 months prior to the survey. The low-level event frequency was determined as the mean number of events that are >1 day when the lake level recessed through the median level. The average duration of these events was then calculated and expressed as number of days (following Sutherland et al. 2010).

2.2 Inter-decile range

One of the first challenges when attempting to understand the effects of lake level variation on plants is to parameterise lake level fluctuations in a way that is ecologically relevant. An extensive study of the relationship between amphibious turf plants and lake level fluctuations of 21 lakes in New Zealand was carried out by Riis and Hawes (2002). They found that using the inter-quartile range statistic (the range (m) between levels that occur more than 25% of the time and less than 75% of the time) for lake level data was significantly correlated with species richness of the turf community.

The use of inter-quartile or inter-decile (levels that occur more than 10% and less than 90% of the time) range statistics have the effect of buffering extremes in lake levels. This avoids the short-duration extremes in lake levels which amphibious and aquatic turf plants in this zone can tolerate but which have less ecological effect than fluctuations that are less extreme but are of longer duration (months to years). An inter-decile approach was adopted by Sutherland and Graynoth (2009) in Lakes Te Anau and Manapōuri. To satisfy consent monitoring conditions (see Methods in Appendix A), calculation of inter-decile range statistics has been used for all reports following this (Sutherland et al. 2010, 2012, 2013, 2014; Champion et al. 2018, 2022).

Three water level statistics related to the inter-decile range were calculated from daily mean lake level data following Sutherland and Graynoth (2009).

Monthly inter-decile range: The inter-decile range values (m) over which the lake level varied within a given month were determined for each of the twelve months prior to each survey.

Annual inter-decile range: The mean annual amplitude (range) was calculated by averaging the twelve-monthly inter-decile range values.

Monthly inter-decile variance: Monthly inter-decile values were estimated by calculating the trimmed mean of monthly lake levels and subtracting the long-term (34 year) median. The trimmed mean calculation excludes values below 10th percentile and above 90th percentile within a given month.

Long-term median lake level: Long-term median lake levels are calculated over the period of lake vegetation monitoring by NIWA/Earth Sciences New Zealand (beginning in 1992); therefore,

the time period included in the long-term median calculation increases incrementally with each monitoring occasion.

2.3 Macrophyte community composition survey

The 2026 monitoring survey was undertaken from 21- 27 March, at a four-year interval since the previous 2022 monitoring.

The macrophyte profile sites were established during the first consent monitoring survey in 1993 (see Wells et al. 1994). The sites were chosen at representative locations around each lake where the maximum depth of macrophyte growth was not solely determined by the steepness of the lakeshore, nor influenced by lake inflows, or other shoreline modifications such as human settlement. Fifteen sites were surveyed in both Lakes Te Anau (T) and Manapōuri (M) (Figure 2-1 and Figure 2-2) and thirteen sites in the control lake, Lake Hauroko (H) (Figure 2-3).

Additional sites were selected for surveying as part of the assessment of effects of the Manapōuri Tailrace Amended Discharge (MTAD) (Sutherland et al. 2010, 2013, 2014), where more transects supporting amphibious low growing turfs (Section 3.4) were required. These additional sites, six in Lakes Te Anau (TE) and Manapōuri (MAN), and four in Hauroko (HA) (Figure 2-1 to Figure 2-3), were also included in the 2012, 2017, 2022 and current (2026) monitoring surveys.

In 2026, two additional turf transects (HA4a and MAN2a) and four submerged macrophyte profiles (T14a, M4a, M9a and M15a) were selected in order to provide the requisite number of vegetated sites to preserve the robustness of the analysis. Locations of all sample sites are in Figure 2-1 to Figure 2-3.

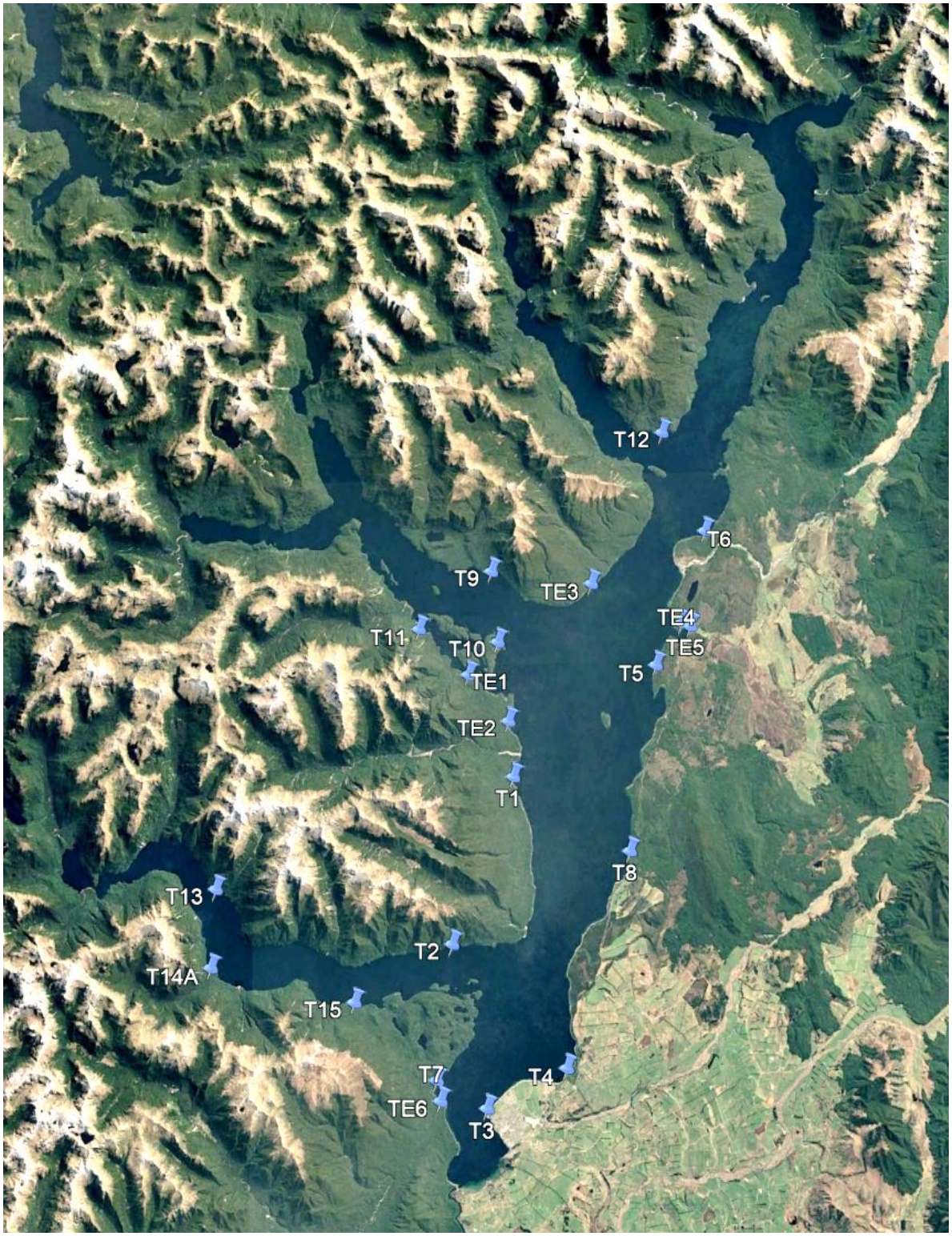


Figure 2-1: Lake Te Anau survey site locations. Sites with the notation T were surveyed for submerged and turf vegetation, TE were supplementary sites surveyed for emersed turf only. Google Earth Pro image.

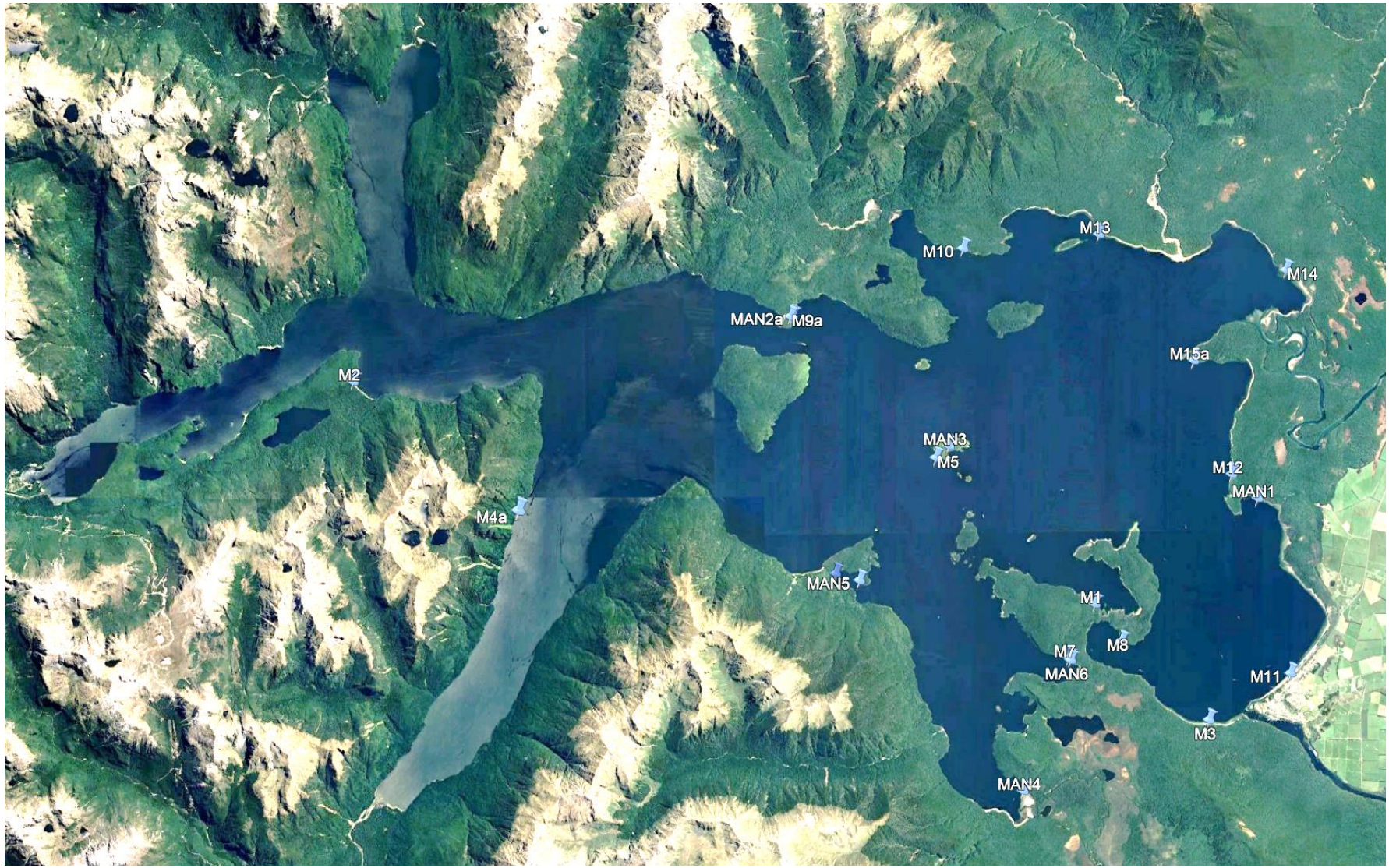


Figure 2-2: Lake Manapōuri survey site locations. Sites with the notation M were surveyed for submerged and turf vegetation, MAN were supplementary sites surveyed for emersed turf only. Google Earth Pro image



Figure 2-3: Lake Hauroko survey site locations. Sites with the notation H were surveyed for submerged and turf vegetation, HA were supplementary sites surveyed for emersed turf only. Google Earth Pro image.

At each site, the macrophyte community was surveyed in a 2 m wide band from the shore to the deepest extent (absolute minimum elevation) of the macrophytes (for the full macrophyte profiles) by SCUBA divers or from the upper elevation limits of the turfs, bordering taller woody or dense rush communities, to the deepest extent of the aquatic turfs (at turf assessment profiles), along a profile at right angles to the shoreline. Figure 2-4 and Figure 2-5 illustrate submerged vegetation assessed by SCUBA diver and a transect to sample emersed vegetation.



Figure 2-4: Diver recording a submerged vegetation profile in Lake Hauroko (23 March 2026).



Figure 2-5: Transect to sample emersed turf vegetation in Lake Te Anau (21 March 2026).

At each site the following data were recorded:

- Species present.
- Ambient elevation range of each species encountered (either using a depth gauge for submerged plants or surveying the elevation of emersed species using a surveyor's level and level rod to measure the height above the lake level). Both values were then normalised to elevation (m.a.s.l.) based on lake level data (Section 2.1).
- Average and maximum cover of each species across its elevation range:
  - Submerged species covers were recorded using a modified Braun-Blanquet scale (Clayton 1983).
  - Emergent species were recorded as percentage cover.
- Bottom limit of vegetation, i.e., the lower elevation limit where cover was ≥10%.
- Absolute minimum elevation species, i.e., the deepest recorded plant

Turf communities were divided into three zones, based on their elevation range in vegetation profiles. In Lakes Te Anau and Manapōuri, Zone 1 plants would only be submerged when the lake level approaches or exceeds the High Operating Range (HOR). Zone 3 plants are submerged for much of their elevation range even when lake level is in the LOR. Zone 2 plants occupy elevations intermediate between the other zones. In Lake Hauroko, these zones are assigned based on the similar vegetation groupings discerned in Lakes Te Anau and Manapōuri. Figure 2-6 to Figure 2-8 show turf vegetation and representative species from Zones 1 to 3.



Figure 2-6: Emersed turf vegetation on the margin of Lake Manapōuri (25 March 2026).



Figure 2-7: Zone 1 turf vegetation on the margin of Lake Manapōuri (26 March 2026). Left: flowering *Ranunculus ranceorum*, *Hydrocotyle hydrophila* and *Cardamine lacustris*, Right: flowering *Lobelia ionantha* and *Myriophyllum propinquum*.

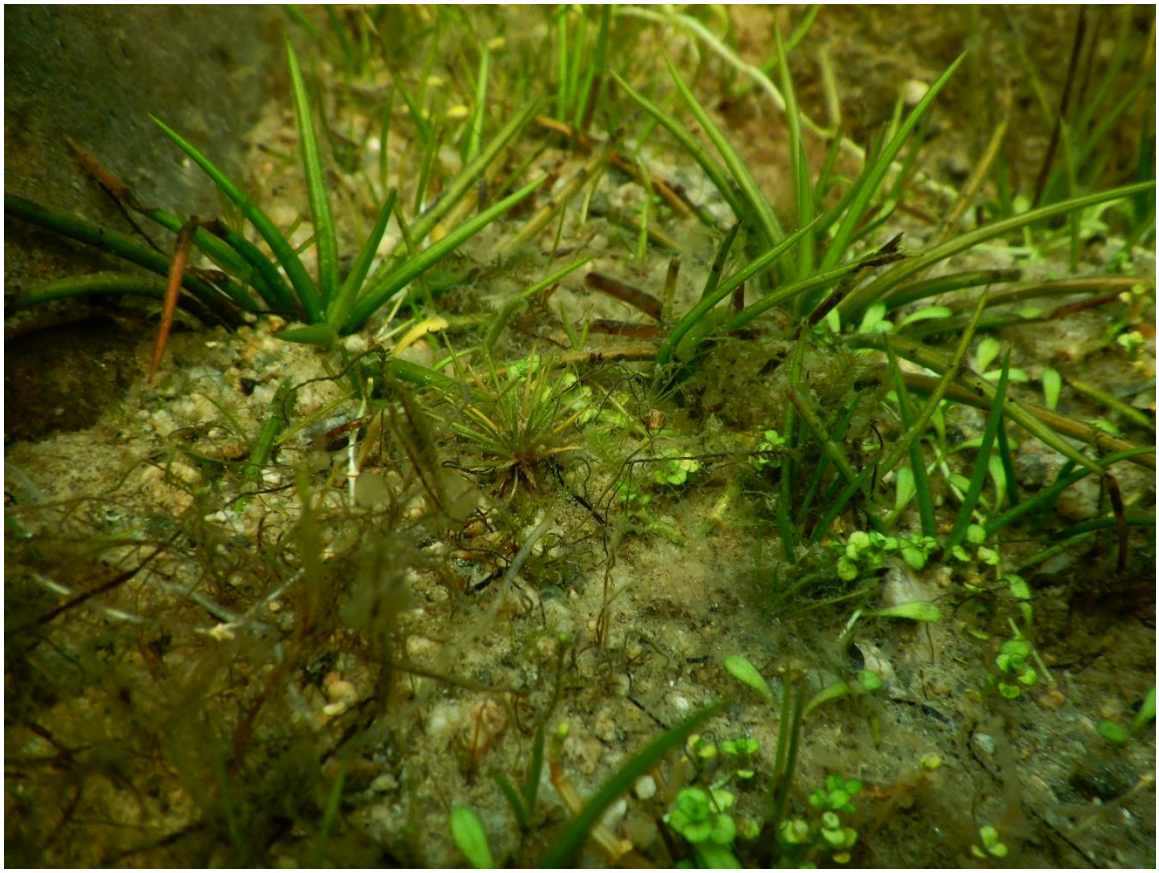


Figure 2-8: Zone 3 turf vegetation on the margin of Lake Hauroko (23 March 2026). Plants include *Trithuria brevistyla* (centre), *Isoetes alpina*, *Elatine gratioloides* and *Glossstigma diandrum*.

2.4 Statistical analysis

Median average cover and median maximum cover were determined lake-wide based on the average and maximum percent cover scores across the elevation range for each species at each site.

Plant elevation ranges were graphed using box and whisker plots using TidyVerse (Wickham et al. 2019). The upper boundary of the box plot indicates the 75th percentile, the black line within the box marks the median, the pale line marks the mean value, and the lower boundary of the box indicates the 25th percentile. Whiskers (error bars) above and below the box represents 1.5 times the interquartile range (distance between the 25th and 75th percentiles), while outlying points are represented by solid dots.

Individual species upper and lower elevation limits were examined using Analysis of Variance (ANOVA). Significant differences indicated by ANOVA were interpreted as statistical difference between 2022 and 2026 surveys. All data analyses were conducted using R version 4.2.2 (R Development Core Team 2022).

3 Results

3.1 Lake levels

Lake level fluctuations varied in both magnitude and frequency throughout the 12-month period prior to the March 2026 macrophyte surveys. Graphs of water level for each lake are presented in Appendix B (Figure B-1, Figure B-3 and Figure B-5).

During the twelve months prior to the 2026 survey, the lake level was above the gazetted guideline for the main operating range lake level (202.7 m.a.s.l.) in the High Operating Range (HOR) on three occasions in Lake Te Anau. Lake level was in the HOR (above 178.6 m.a.s.l.) for 122 consecutive days between mid-September and early January (median height 0.64 (0.58 SD) m). Lake level was in the HOR on two occasions in Lake Manapōuri, for over 88 consecutive days between late September and mid-December (median height 0.71 (0.49 SD) m). This compares with 2022 (Te Anau; 8 occasions, 23 days total and Lake Manapōuri; 8 occasions, 23 days total). In 2012, lake level was below the HOR for most of the 12-months prior to the survey.

In the year prior to the 2026 survey, the lake level was in the Low Operating Range (LOR) in Lake Te Anau (below 201.5 m.a.s.l.) on one occasion (August 2025) for 16 days and in Lake Manapōuri (below 176.8 m.a.s.l.) on two occasions (April and August 2025) for 5 and 2 days respectively. In the year prior to the last (2022) survey, the lake level was in the LOR on four and three occasions in Lakes Te Anau and Manapōuri respectively, with a total of 27 days below this level in each lake. This compares with 2017, when lake level stayed above the LOR for the 12-months prior to the survey in Lake Manapōuri and was only in the LOR of Lake Te Anau on the 25 days prior to turf survey in April 2017.

The 12-month median lake level has varied in each lake over time (Figure 3-1). Median lake levels for the 12-months preceding the 2026 survey were higher than the 34-year median (1992-2022) in Lakes Te Anau and Manapōuri and lower for Lake Hauroko (Figure 3-1). This compared with 2022 where levels were lower than the long-term median in all three lakes, whereas in 2017, all lakes exceeded the long-term median.

In the year prior to the 2026 vegetation monitoring, there were four events in Lake Te Anau where the lake level receded below the 12-month median, with a mean duration of 45.8 days. Lakes Manapōuri and Hauroko had seven events, with a mean duration 26.1 and 26.0 days respectively (Table 3-1).

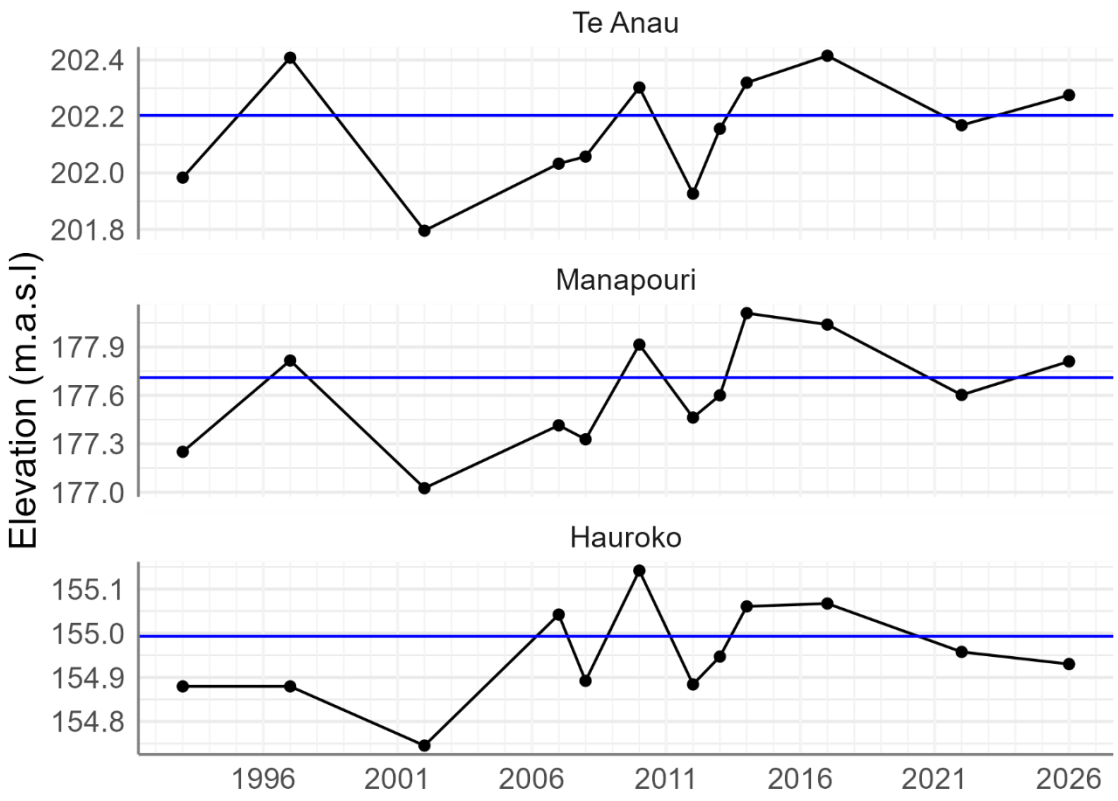


Figure 3-1: Median lake level for the 12 months prior to each macrophyte survey from 1993 to 2026 in Lake Te Anau, Lake Manapōuri and Lake Hauroko. Blue line indicates 34-year median lake level prior to this year's survey.

Table 3-1: Frequency and duration (days) where lake level is less than the median lake level for the 12 months (365 days) prior to each macrophyte survey. The 2008 and 2017 values were calculated using lake level measurements over 442 and 443 days respectively to accommodate both the aquatic macrophyte and turf surveys undertaken in those years.

Year of survey	Lake Te Anau		Lake Manapōuri		Lake Hauroko	
	Freq.	Mean duration	Freq.	Mean duration	Freq.	Mean duration
1993	5	36.6	4	45.8	6	30.5
1997	4	45.5	7	26.1	4	45.8
2002	10	18.3	9	20.3	11	16.6
2007	5	36.4	5	36.6	7	26.0
2008	9	24.3	10	21.9	5	43.6
2010	7	26.1	8	22.9	10	18.3
2012	7	29.4	9	22.8	6	34.2
2013	9	23.6	5	42.4	7	30.3
2014	6	30.5	9	20.2	8	22.9
2017	8	22.9	7	26.1	10	18.3
2022	9	20.3	9	20.3	7	26.1
2026	4	45.8	7	26.1	7	26.0

3.2 Inter-decile range

The mean monthly inter-decile range over the 12-month period prior to the 2026 survey was 0.64 m in Lake Te Anau, 0.79 m in Lake Manapōuri and 0.52 m in Lake Hauroko (Table 3-2). The 2025-2026 values are higher than the median value for all sampling occasions, with Lake Manapōuri value being the greatest inter-decile range recorded to date. This compared with lower than usual mean monthly inter-decile ranges reported in 2021-2022 but higher than usual ranges in 2016-2017. Monthly inter-decile variance from the 34-year median lake level for the 12-month period prior to each survey from 1993 to 2026 are shown for Lakes Te Anau, Manapōuri and Hauroko (Figure B-7 to Figure B-9).

Table 3-2: Mean monthly inter-decile range (m) for the 12-month period (365 days) prior to each macrophyte survey. The 2007-2008 and 2016-2017 values were calculated using lake level measurements over 442 and 445 days respectively to accommodate both the aquatic and turf surveys undertaken in those years.

Sampling period	Te Anau	Manapōuri	Hauroko
1992-1993	0.75	0.67	0.48
1996-1997	0.57	0.67	0.39
2001-2002	0.49	0.56	0.45
2006-2007	0.59	0.61	0.42
2007-2008	0.67	0.65	0.49
2009-2010	0.54	0.68	0.46
2011-2012	0.47	0.49	0.42
2012-2013	0.67	0.67	0.52
2013-2014	0.64	0.72	0.54
2016-2017	0.69	0.69	0.54
2021-2022	0.54	0.58	0.44
2025-2026	0.64	0.79	0.52

3.3 Macrophyte community composition survey

The macrophytes present in Lakes Te Anau, Manapōuri and Hauroko are divided into three distinct assemblages according to the elevation range of the littoral zone[2] that they occupy. These are:

- Low mixed, or turf community. This assemblage is comprised of amphibious and aquatic plants that typically grow < 5 cm in stature, extending along the inundation zone to ~ 1 m depth, when the lake level was in the LOR. Lake levels were just above the LOR during the 2026 vegetation monitoring.
- Submerged vascular macrophytes. This assemblage is comprised of macrophytes that are typically > 5 cm in height and usually occupy the permanently submerged littoral zone, from ~ 2-8 m depth below ambient lake levels.
- Characeans. These are macroscopic algae with vascular plant-like appearance, which usually dominate in deeper waters (with a maximum depth of 14.5 m (187.2 m.a.s.l.) in Lake Te Anau in 2026).

The numbers of species present in each assemblage recorded in the lakes during the 2026 survey are presented in Table 3-3, compared with earlier surveys. Prior to 2007, turf plants were only recorded if they were found as submerged species. From 2007 onwards, surveys have included emersed turf species occurring in the zone extending from the lake edge to (but not including) vegetation dominated by tall rush-like vegetation (e.g., oioi – *Apodasmia similis*) or where mature woody vegetation (e.g., mānuka – *Leptospermum scoparium*) is present. Turf species, including some species not recorded within the survey, frequently extend into those taller vegetation types but are outside the scope of this study.

[2] Littoral zone is defined as the near shore area of the lake influenced by lake waters but with sufficient penetration of light to allow plant growth

Table 3-3: Comparison of the number of species within each defined macrophyte assemblage recorded within each lake during the surveys from 1993 to 2026. [a] indicates turf surveys of submerged species, [b] indicates turf surveys that include emersed species. Low mixed turf records include an adjustment of previous years to include *Isoetes alpina* and *Myriophyllum propinquum*.

	2026	2022	2017	2012	2010	2008	2007	2002	1997	1993
Lake Te Anau										
Low mixed turfs	47[b]	58[b]	35[b]	42[b]	36[b]	34[b]	44[b]	11[a]	10[a]	12[a]
Tall vascular	6	5	6	5	6		7	6	5	6
Characeans	10	8	12	10	9		6	7	6	7
Lake Manapōuri										
Low mixed turfs	39[b]	55[b]	30[b]	37[b]	32[b]	25[b]	41[b]	12[a]	16[a]	14[a]
Tall vascular	7	6	5	7	7		7	7	6	6
Characeans	10	9	10	10	8		6	7	6	6
Lake Hauroko										
Low mixed turfs	30[b]	28[b]	18[b]	17[b]	20[b]	14[b]	23[b]	13[a]	12[a]	12[a]
Tall vascular	5	7	5	6	6		7	6	5	5
Characeans	9	10	10	10	10		8	7	6	6

3.4 Low mixed, turf community

3.4.1 Distribution of species

A diverse assemblage of predominantly native turf species was present in each lake, with the greatest diversity present in Lake Te Anau (47 species), 39 species in Lake Manapōuri and the lowest in Lake Hauroko (30 species) in 2026. Species recorded in each lake during the 2026 survey are presented in Table 3-4, together with their elevation zone from 1 (highest) to 3 (lowest).

Three turf species have had a name change since the 2022 report, *Goodenia radicans* (was *Selliera radicans*), *Limosella australis* (was *Limosella lineata*) and *Trithuria brevistyla* (was *Trithuria inconspicua* subsp. *brevistyla*). Two upper turf buttercups were recorded in previous surveys. Records of *Ranunculus maculatus* on the margins of Lake Te Anau and Manapōuri were made in error. They were based on misidentification of juvenile *R. ranceorum* plants.

Table 3-4: List of low mixed, turf species recorded in Lakes Te Anau, Manapōuri and Hauroko during the 2026 survey. Three zones of turf species are described in Section 2.3. * also a component of the tall vascular submerged vegetation. § non-indigenous species. ¥ threatened or at-risk species[3]

Taxa	Habitat (Zone 1, 2 or 3)		
	Te Anau	Manapōuri	Hauroko
Azorella cockaynei	1	1	
**Callitriche petriei*		3	3*
¥*Cardamine lacustris*	2	2	
Carex gaudichaudiana	1	1	1
¥*Carex talbotii*	1	1	
Centella uniflora	1		
Centrolepis pallida	2	2	2
Crassula sinclairii		2	
Elatine gratioloides	3	3	3
Eleocharis acuta	2	2	2
Eleocharis gracilis		2	
Eleocharis pusilla	3	3	3
Epilobium komarovianum			1
Galium perpusillum	1	1	
Gentianella grisebachii	1		
Glossostigma cleistanthum	3	3	3
Glossostigma diandrum	3	3	3
Glossostigma elatinoides	3		
Gonocarpus micranthus	1		
Goodenia radicans	1		
Gratiola sexdentata	2	2	2

[3] After de Lange et al. (2024)

Taxa	Habitat (Zone 1, 2 or 3)		
	Te Anau	Manapōuri	Hauroko
Gunnera dentata	1		
Hydrocotyle hydrophila	1	2	2
Hydrocotyle novae-zelandiae var. *montana*	1	1	
§*Hypochaeris radicata*	1		
**Isoetes alpina*	3	3	3
Isolepis aucklandicus	2	2	2
§*Juncus articulatus*	1		
§*Juncus bufonius*		2	
§*Juncus bulbosus*		2	3
Juncus novae-zelandiae			1
¥*Juncus pusillus*	2	2	2
Lachnagrostis striata	2	2	2
§*Leontodon saxatilis*		1	1
Leptinella maniototo	2	2	
Leptinella squalida subsp. *medianus*	1	1	
Lilaeopsis ruthiana	3	3	3
Limosella australis	2	2	2
Lobelia angulata			1
¥*Lobelia ionantha*	2	2	
Lobelia perpusilla	1	2	
§*Lotus pedunculatus*			1
§*Myosotis laxa* subsp. *caespitosa*	2		
Myriophyllum pedunculatum subsp. *novae-zelandiae*	2	2	2
**Myriophyllum propinquum*	2/3	2/3	2/3
Myriophyllum votschii			3
Pilularia novae-hollandiae	3	3	3
Plantago triandra	2	2	
§*Prunella vulgaris*			1
Ranunculus limosella	3	3	3
¥*Ranunculus ranceorum*	2	2	
Schoenus maschalinus		2	
Triglochin striata	2	2	2
¥*Trithuria brevistyla*		3	3
Utricularia dichotoma	2	2	
Viola filicaulis	1		1

The elevation range of turf species recorded in 2026 is presented in box and whisker plots (Figure 3-2 to Figure 3-4).

Generally, the commonest Zone 1 species include the sedge species *Carex gaudichaudiana, C. talbotii*, *Isolepis aucklandicus* and herbs *Plantago triandra*, *Gunnera dentata*, *Hydrocotyle novae-zelandiae var. montana* (previously referred to as *H. microphylla*), *H. hydrophila, Azorella cockaynei*, *Leptinella squalida* subsp. *medianus* and *Lobelia angulata*. Near-threatened species found in this zone included the 'At-Risk, Naturally Uncommon' buttercup *Ranunculus ranceorum* and *Cardamine lacustris,* with the 'At-Risk, Declining' *Carex talbotii* (de Lange et al. 2024). The landward edge of this zone was characterised by the occurrence of the indigenous *Viola filicaulis* and *Centella uniflora*. Several non-native herbs including catsear (*Hypochaeris radicata*), lotus major (*Lotus pedunculatus*), *Leontodon saxatilis* and selfheal (*Prunella vulgaris*) were sparse within this zone.

Several species found in Zone 1 extend into Zone 2, including *Plantago triandra and Hydrocotyle hydrophila*. Additional species, characteristic of the intermediate Zone 2, are the sedges *Eleocharis acuta, E. gracilis,* the rushes *Juncus pusillus, J. bulbosus* (introduced and also a component of the submerged vegetation), the grass *Lachnagrostis striata* and herbs *Callitriche petriei* (also a submerged plant in Lake Hauroko), *Centrolepis pallida*, *Gratiola sexdentata*, *Leptinella maniototo, Lobelia ionantha, Limosella lineata, Myriophyllum pedunculatum* subsp. *novae-zelandiae, Myriophyllum propinquum*, *Triglochin striata* and *Utricularia dichotoma*. Near-threatened species found in Zone 2 included *Lobelia ionantha* ranked as 'At-Risk, Declining' (de Lange et al. 2024). *Juncus pusillus* is regarded as 'At-Risk, Naturally Uncommon'. Apart from bulbous rush (*J. bulbosus*), the only other introduced plants recorded from this zone was the herb water forget-me-not (*Myosotis laxa* subsp. *caespitosa*) and the rushes *Juncus articulatus* and *J. bufonius*, all rarely occurring.

Zone 3 species are also referred to as aquatic turf plants, as they are most frequently found in shallow water most of the year. *Centrolepis pallida* frequently extended into this zone, often forming dense mats in shallow water. The commonest species found were *Elatine gratioloides*, *Eleocharis pusilla, Glossostigma diandrum*, *Glossostigma cleistanthum, Lilaeopsis ruthiana*, *Pilularia novae-hollandiae* and *Ranunculus limosella*. The nationally threatened *Trithuria brevistyla* ranked as Nationally Vulnerable (de Lange et al. 2024), was found in Zone 3 of Lakes Manapōuri and Hauroko in the 2026 survey. In 2022, *T. brevistyla* was found in all three lakes but it was rare in Lakes Te Anau and Manapōuri. No non-native species were recorded in this zone.

We have included data for deeper water records of the Zone 3 turf species and also two species that are conspicuous in the turf communities, but which also form tall, submerged vegetation (see Section 3.5); *Isoetes alpina* and *Myriophyllum propinquum*. The latter species is often dominant in Zone 3 and lower Zone 2 exposed turfs.

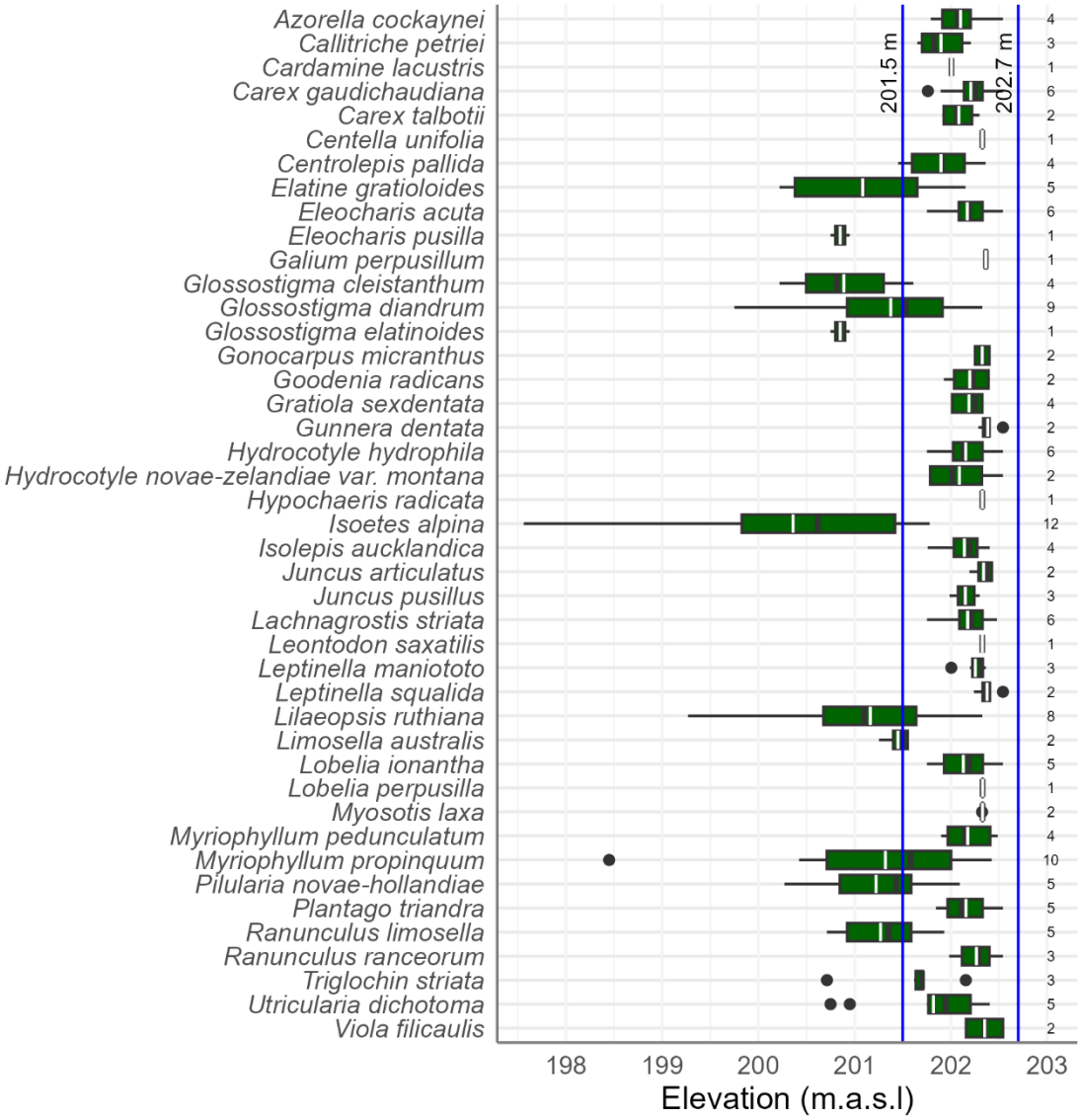


Figure 3-2: Lake-wide elevation ranges of amphibious turf species in Lake Te Anau 2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Numbers on the right-hand side of the diagram detail the number of sites where the species was recorded.

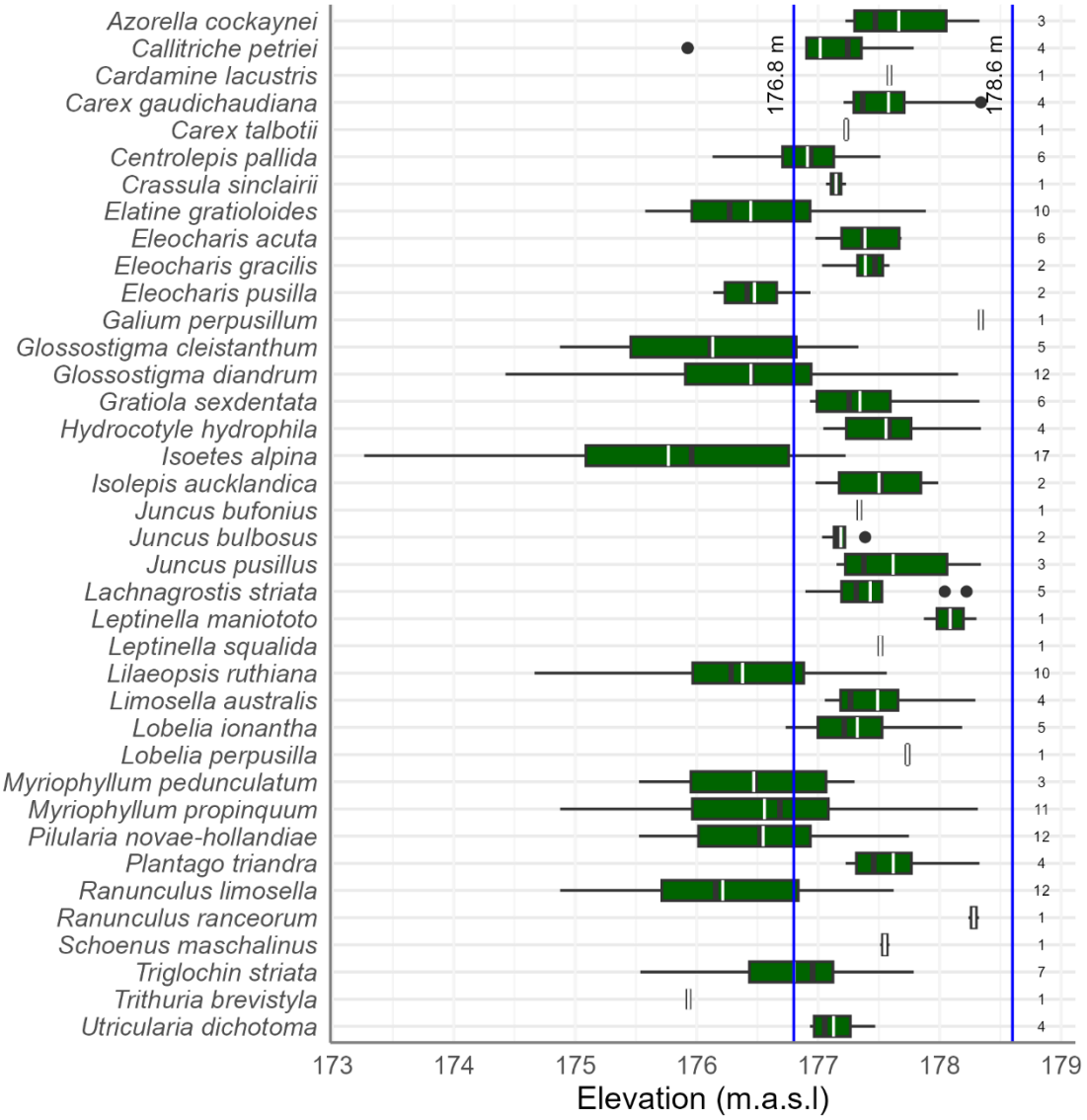


Figure 3-3: Lake-wide elevation ranges of amphibious turf species in Lake Manapōuri 2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Numbers on the right-hand side of the diagram detail the number of sites where the species was recorded.

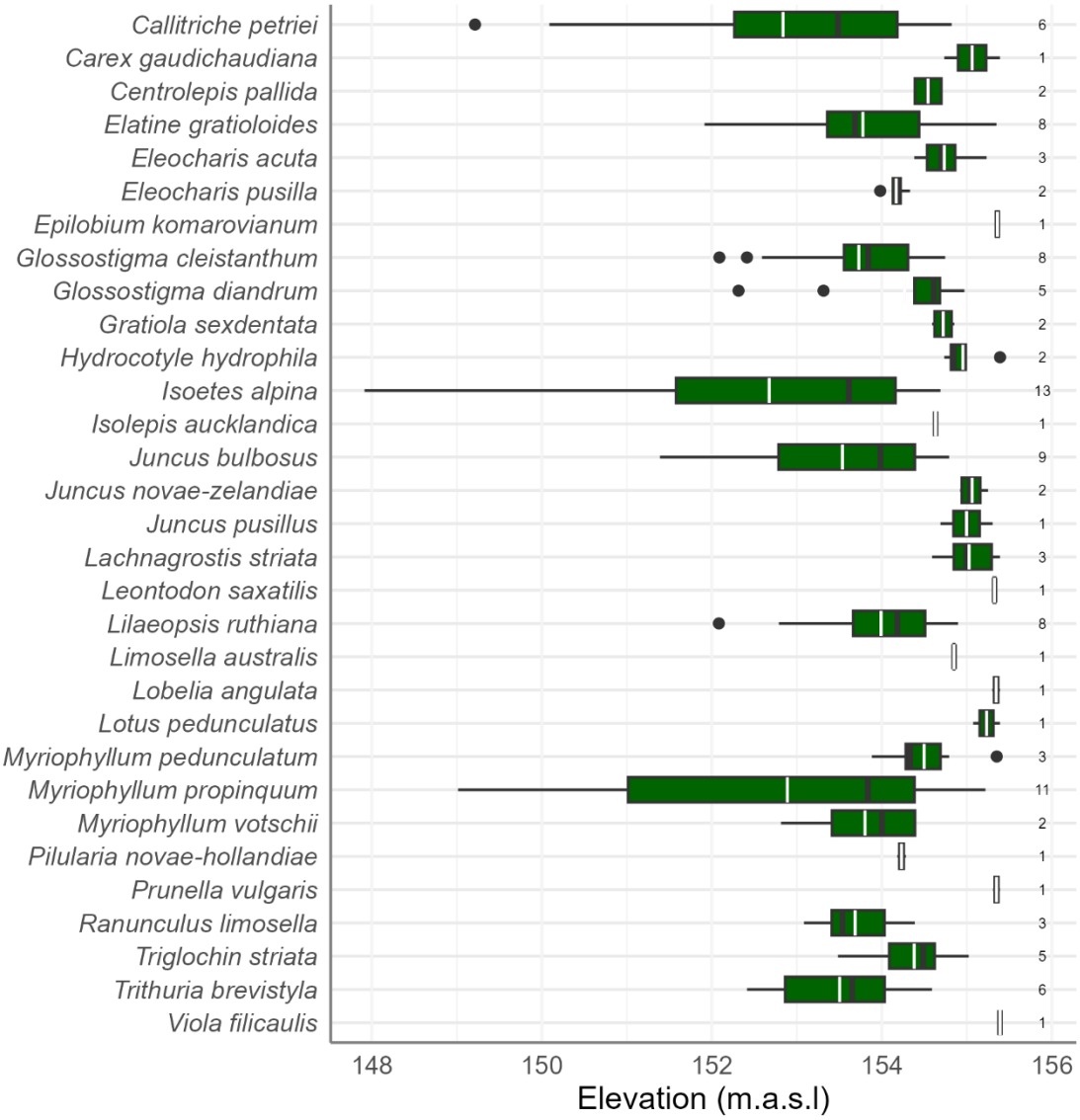


Figure 3-4: Lake-wide elevation ranges of amphibious turf species in Lake Hauroko 2026. Numbers on the right-hand side of the diagram detail the number of sites where the species was present.

3.4.2 Comparison with earlier surveys

Previous reports (e.g., Champion et al. 2022) compared data for the monitoring events including elevation ranges, percentage occurrence at sites where turf communities were recorded and median and maximum covers of the widespread cushion-forming *Centrolepis pallida* and the commonest aquatic turf species (*Elatine gratioloides*, *Glossostigma* (*G. diandrum* and *G. cleistanthum*), *Lilaeopsis ruthiana*, *Pilularia novae-hollandiae* and *Ranunculus limosella*) within Lakes Te Anau, Manapōuri and Hauroko. Appendix C presents a comparison of these same six species from previous surveys with 2026 data.

The Analysis of Variance (ANOVA) performed on upper and lower elevation limits of these species between 2022 and 2026 showed few significant differences in upper and lower elevation limits (Table 3-5), with reduced lower depth limit in 2026 for *Glossostigma* in Lake Hauroko and a deeper lower limit for *Centrolepis pallida* in Lake Manapōuri.

For other species, significant differences between 2022 and 2026 data (all decreasing elevation) were calculated for *Eleocharis pusilla* and *Utricularia dichotoma* (lower elevation limits) and *Lachnagrostis striata* (upper elevation limit) in Lake Manapōuri.

Table 3-5: Significant changes in upper and lower elevation limits of common turf species between 2012 and 2026 in Lakes Te Anau, Manapōuri and Hauroko. using Analysis of Variance (ANOVA), significance level (p) was set at <0.05.

Lake	Species	Upper or lower limit	F statistic	p value
Manapōuri	*Centrolepis pallida*	Upper	10.154	0.009
Manapōuri	*Eleocharis pusilla*	Lower	25.397	0.015
Hauroko	*Glossostigma*	Lower	7.467	0.023
Manapōuri	*Lachnagrostis striata*	Upper	5.149	0.047
Manapōuri	*Utricularia dichotoma*	Lower	5.375	0.049

The 2022 survey recorded the highest species richness of turf species found at the three lakes to date. A lower number of species were found in 2026, with *Carex flaviformis, Centrolepis glabra, Coprosma petriei, Crassula ruamahanga, Epilobium angustum, Isolepis basilaris, Isolepis habra, *Lagenophora petiolata, *Lythrum portula, Montia angustifolia, Muehlenbeckia axillaris, Nertera depressa, Ophioglossum coriaceum, *Persicaria hydropiper, *Ranunculus glabrifolius* and *Rorippa palustre* not recorded on the transects. However, the species marked with an asterisk were recorded in 2026 in the vicinity of the transects, often at higher elevation than the upper end of transects. The species not recorded from transects in 2026 are mostly Zone 1 species with the exception of *Centrolepis glabra, Isolepis basilaris, Montia angustifolia* and *Rorippa palustre*.

Three species were recorded in 2026 but not in 2022 including *Eleocharis gracilis, Schoenus maschalinus* and the non-native hawkbit *Leontodon saxatilis*; with the two native species found in Zone 2 and hawkbit occurring at a single location in Zone 1 of Lake Te Anau. However, hawkbit is not a new record for this lake, having been recorded on three previous surveys from 2008 to 2012.

3.5 Tall submerged species

The submerged vegetation, excluding turf species, was comprised of 14 indigenous species and the introduced elodea (*Elodea canadensis*) in Lake Te Anau, 15 indigenous species and also elodea in Lake Manapōuri and 15 indigenous species in Lake Hauroko. The invasive elodea has not been detected in Lake Hauroko, but the introduced *Juncus bulbosus* was found as a tall submerged vascular species in this lake. Species recorded in each lake during the 2026 survey are presented in Table 3-6. Figure 3-5 shows shallow water vegetation dominated by *Isoetes alpina*, Figure 3-6 shows vegetation dominated by elodea and Figure 3-7 shows deeper water charophyte meadows.

Chara fibrosa has had a name change since the 2022 report, now known as *Chara acanthopitys*. The identity of the various *Nitella* species found in these lakes now appears resolved, with *Nitella claytonii*, *N.* sp. aff. *cristata, N. hyalina, N. leonhardii, N. masonae, N. subtilissima* and *N. tricellularis* distinguished. Two recently recognised taxa *N. conformis* and *N. mucosa* (Champion et al. 2021) were difficult to confidently identify without fertile material and have been amalgamated as *Nitella pseudoflabellata* in this report.



Figure 3-5: Dense shallow water beds *of Isoetes alpina* in Lake Hauroko (23 March 2026).



Figure 3-6: The non-native *Elodea canadensis* in Lake Manapōuri (25 March 2026).



Figure 3-7: Deep water charophyte meadows in Lake Hauroko (23 March 2026).

Box and whisker plots indicating the elevation range of tall submerged species recorded in 2026 are shown in Figure 3-8 to Figure 3-10.

Table 3-6: Tall submerged (vascular and characean) species recorded in Lakes Te Anau, Manapōuri and Hauroko in 2026. § non-indigenous species.

Taxa	Lake Te Anau	Lake Manapōuri	Lake Hauroko
Callitriche petriei		✓	✓
Chara acanthopitys	✓	✓	✓
Chara australis	✓	✓	✓
§*Elodea canadensis*	✓	✓	
Isoetes alpina	✓	✓	✓
§*Juncus bulbosus*			✓
Myriophyllum propinquum	✓	✓	✓
Myriophyllum triphyllum	✓	✓	✓
Nitella claytonii	✓	✓	✓
Nitella sp. aff. *cristata*	✓	✓	✓
Nitella hyalina	✓		
Nitella leonhardii	✓	✓	✓
Nitella masonae	✓	✓	

Taxa	Lake Te Anau	Lake Manapōuri	Lake Hauroko
Callitriche petriei		✓	✓
Nitella pseudoflabellata	✓	✓	✓
Nitella subtilissima	✓	✓	✓
Nitella tricellularis	✓	✓	✓
Potamogeton cheesemanii	✓	✓	✓
Potamogeton ochreatus		✓	✓

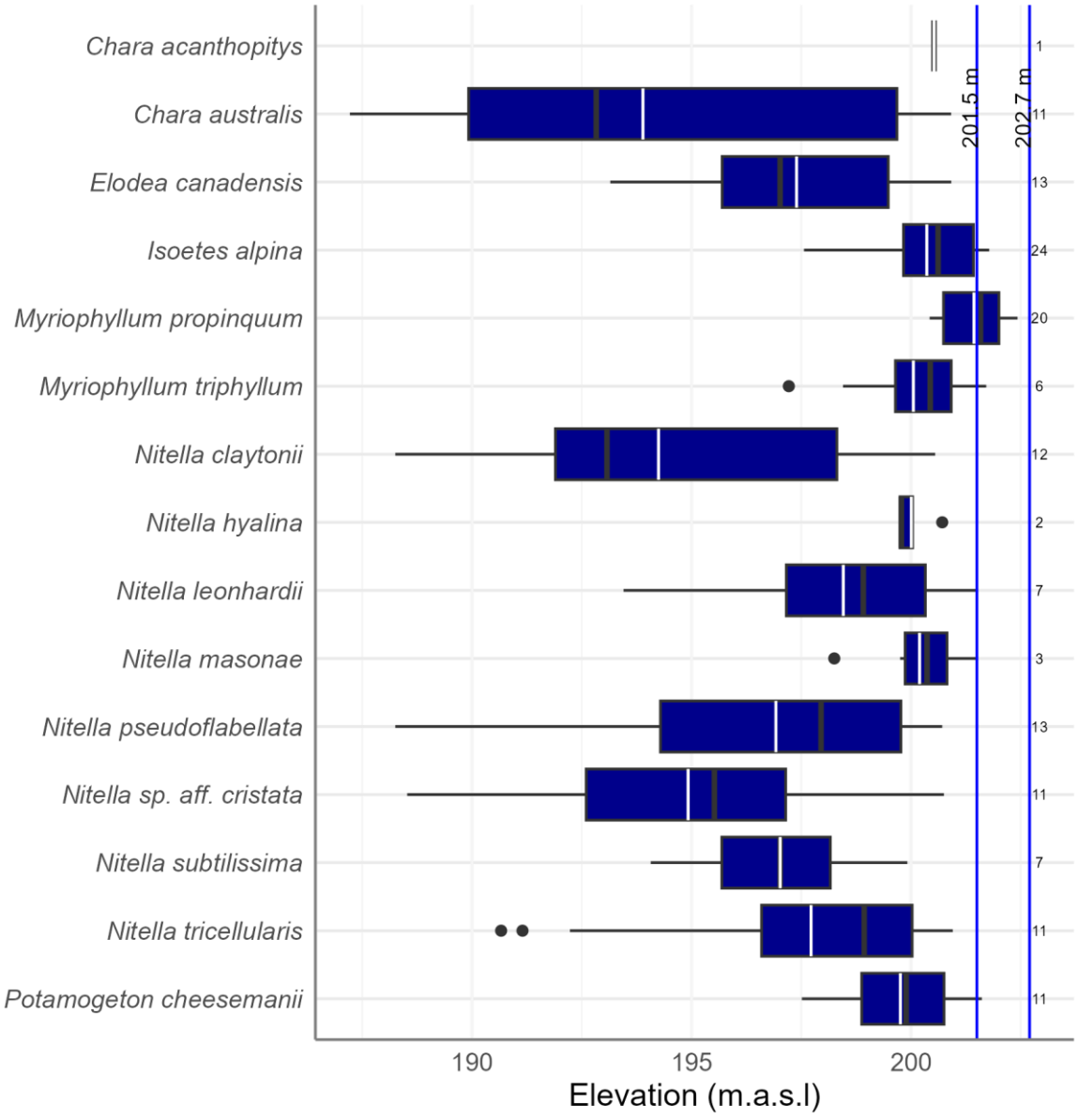


Figure 3-8: Elevation ranges of tall submerged plants in Lake Te Anau in 2026. Numbers on the right-hand side of the diagram detail the number of sites where the species was recorded.

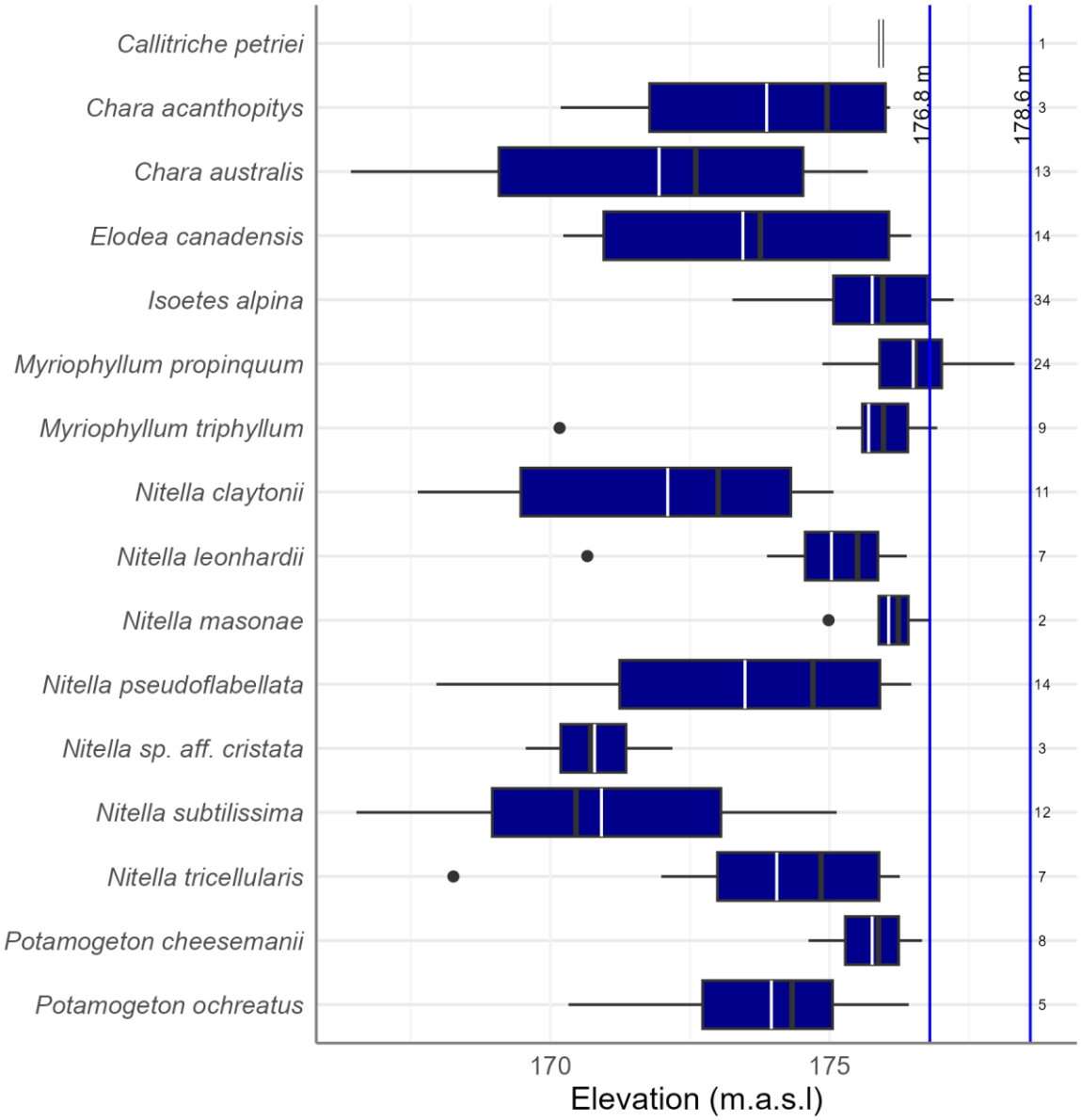


Figure 3-9: Elevation ranges of tall, submerged plants in Lake Manapōuri in 2026. Numbers on the right-hand side of the diagram detail the number of sites where the species was recorded.

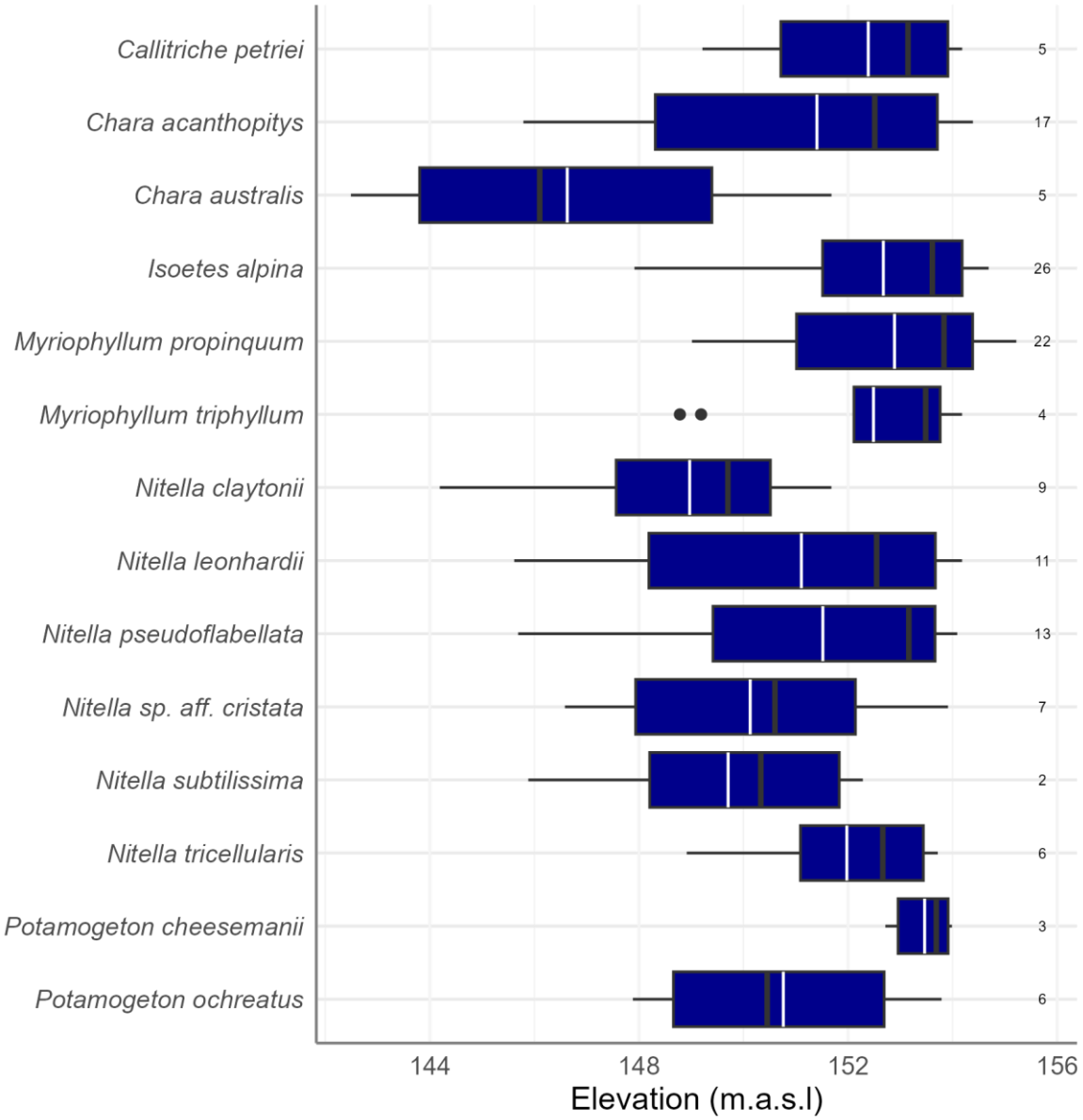


Figure 3-10: Elevation ranges of tall submerged plants in Lake Hauroko in 2026. Numbers on the right-hand side of the diagram detail the number of sites where the species was recorded.

In 2026, the deepest growing (absolute minimum elevation) vegetation was sampled in Lake Te Anau (14.5 m depth; 187.2 m.a.s.l.), with slightly shallower bottom limits in Lakes Hauroko (12.2 m deep – 142.5 m.a.s.l.) and Manapōuri (10.5 m deep– 166.4 m.a.s.l.). In each case the deepest growing species was *Chara australis* (Figure 2-8 to Figure 3-10). The deepest growing vascular species was elodea in Lakes Te Anau and Manapōuri (Figure 3-8 and Figure 3-9), growing to 8.6 m and 6.7 m (193.2 and 170.2 m.a.s.l.) respectively. In Lake Hauroko, the deepest vascular species were *Potamogeton ochreatus* and *Isoetes alpina*, both growing to a maximum depth of 6.8 m depth (147.9 m.a.s.l.). *Isoetes alpina* was also present in all three lakes usually forming a dense vegetation in a zone between the turf and other submerged species growing to a maximum depth of 3.6 and 3.5 m (197.6 m.a.s.l. and 173.3 m.a.s.l.) in Lakes Te Anau and Manapōuri respectively.

3.5.1 Comparison with earlier surveys

Previous monitoring reports (e.g., Champion et al. 2018) compared data for the monitoring events including elevation ranges, number of sites occupied and median and maximum covers of selected tall submerged species within Lakes Te Anau, Manapōuri and Hauroko. These included the vascular species *Elodea canadensis, Isoetes alpina*, milfoil (*Myriophyllum* spp.), pondweed (*Potamogeton* spp.) and the characeans *Chara australis* and two *Nitella* species. Appendix D and Appendix E present a comparison of the same species/species group from previous (1993 to 2022) surveys with 2026 data.

Despite the resolution of *Nitella* species occurring in Lakes Te Anau, Manapōuri and Hauroko, we have amalgamated data of all *Nitella* species depth ranges for comparison between 2017, 2022 and 2026 (Appendix E). Data collected prior to 2017 was processed with a different software package, and we only have high confidence to compare data from 2017 to 2026. We suggest that future analyses of *Nitella* data are undertaken for all species individually, with 2026 data forming the baseline to compare these.

The Analysis of Variance (ANOVA) performed on elevation limits of these species between 2022 and 2026 showed some significant differences in both upper and lower elevation limits (Table 3-7), with a shallower lower elevation limits in 2026 for *E. canadensis* in Lake Manapōuri, and deeper elevation limits in 2026 for *C. australis* (lower limit) in Lake Te Anau and *Nitella* spp. (upper and lower limit) in Lake Hauroko.

Table 3-7: Significant changes in upper and lower elevation limits of submerged species between 2022 and 2026 in Lakes Te Anau, Manapōuri and Hauroko. using Analysis of Variance (ANOVA).

Lake	Species	Upper or lower limit	F statistic	p value
Te Anau	*Chara australis*	Lower	5.898	0.024
Manapōuri	*Elodea canadensis*	Lower	5.599	0.027
Hauroko	*Nitella* spp.	Lower	29.995	0
Hauroko	*Nitella* spp.	Upper	6.594	0.017

Deepest plant records (characeans) where vegetation was ≥10% cover were compared from 2017 to 2026 (Table 3-8). The 10% minimum threshold was chosen based on the LakeSPI methodology (Clayton and Edwards 2006, de Winton et al. 2012).

The median of this bottom limit (lower elevation limit in m.a.s.l) has been decreasing (becoming deeper) over this time interval in Lakes Te Anau and Manapōuri, with a median increase of 2.2 m depth in these lakes comparing 2026 with 2017. The median bottom limit for Lake Hauroko was similar between years.

Table 3-8: Median maximum depth of vegetation in Lakes Te Anau, Manapōuri and Hauroko 2017 - 2026. Depths expressed as elevation (meters above sea level) with standard deviation in parentheses.

Lake	median bottom limit (m.a.s.l) (±SD)		
	2017	2022	2026
Te Anau	194.4 (3.0)	193.6 (1.8)	192.2 (3.8)
Manapōuri	171.7 (3.0)	170.2 (2.8)	169.5 (2.2)
Hauroko	148.1 (1.6)	148.0 (1.8)	148.2 (1.9)

4 Discussion

The littoral margins of Lakes Te Anau and Manapōuri support possibly the highest diversity of amphibious and aquatic plants in New Zealand (Johnson and Rogers 2002; NIWA Aquatic Plants Database). These include species that are endemic (essentially restricted) to these lakes, including the buttercup (*Ranunculus ranceorum*) and the cress iti (*Cardamine lacustris*) (Garnock-Jones and Johnson 1987; de Lange and Murray 2008), and other nationally threatened species (de Lange et al. 2024) and increasingly rare native plant community types (Holdaway et al. 2012).

Unlike many other New Zealand lakes, the relatively few numbers of weed species that have established in these lakes means that the native flora has not been outcompeted and displaced. This assumes great significance on a national scale, in terms of lake flora biodiversity and intact examples of native aquatic plant assemblages.

Extensive suitable shoreline habitats and the long-term lake level regimes considered ideal for maintaining high turf diversity (Riis and Hawes 2002) are likely to be the driving factors behind the greater diversity in Lakes Te Anau and Manapōuri compared to Lake Hauroko. In Lakes Te Anau and Manapōuri, lake levels typically fluctuate over a 3 m range (with a consented operational range of 3.44 and 4.64 m respectively as set out by the Gazetted Operating Guidelines for the Levels of Lakes Manapōuri and Te Anau) throughout the year, while for Lake Hauroko, lake levels typically fluctuate over a 2 m range throughout the year. Lake Hauroko consistently had lower monthly inter-decile ranges than the other two lakes (Table 3-2) and Riis and Hawes (2002) consider this range to be important for defining diversity in turf communities.

The most important aspects of level variation are the range of water level fluctuation, which defines the overall area of the amphibious zone, the frequency of submersion / emersion, which defines the degree of desiccation, and the duration of high and low water events, which determine the time available for sensitive life-history stages to be completed.

Lower than typical inter-decile variance and lake levels experienced during the 2011-12 summer period (Sutherland et al. 2012), extending until September 2012, was a result of the dry climate and low inflows. Water level had the lowest fluctuations and monthly inter-decile variation since the start of monitoring surveys in 1993. As a consequence of these climate-influenced factors, turf communities were reduced in percentage occurrence and cover for a number of the dominant aquatic turf species and especially the high % cover vegetation in Zone 2 dominated by *Centrolepis pallida*.

The 2017 survey occurred in a period where water levels were higher than median levels. The 2016/17 water level remained in the High Operating range for 130 days for Lake Te Anau (>202.7 m.a.s.l.) and Lake Manapōuri (>178.6 m.a.s.l.). Higher than normal lake levels also affected the Lake Te Anau turf survey, with level only dropping below the long-term median level 25 days prior to this. Consequently, the 2017 turf survey recorded fewer species than earlier, with 16 species that were formerly recorded being absent, mostly those species that occurred in the higher elevation turf (Zone 1).

A record number of turf species were recorded in the 2022 survey, with 24 additional turf species not recorded in 2017 present at the surveyed sites. The combination of lower-than-average lake levels over the 12 months prior to survey, with several months below 30-year median lake level, annual fluctuation of 2.7 m in Lake Te Anau, 2.9 m in Lake Manapōuri

and 2.2 m in Lake Hauroko and slightly lower than normal monthly inter-decile ranges were all favourable for maximum turf species richness and development.

The year prior to the 2026 survey was wetter than in 2022, with higher water levels and level fluctuations similar to 2016/17. The combination of higher-than-average lake levels over the 12 months prior to survey, higher annual fluctuation of 3.4 m in Lake Te Anau, 4.4 m in Lake Manapōuri and 2.9 m in Lake Hauroko and higher than normal monthly inter-decile ranges would be less favourable for maximum turf species richness and development than in 2022. In 2026, turf species richness was lower, with 16 species found in 2022 not recorded in transects. The majority of the missing species occurred in Zone 1, apart from four species in Zone 2 or 3, and are reliant on long periods of low water level to enable their germination and flowering. However, number of turf species in 2026 was greater than 2017, with five additional species recorded. All surveys were undertaken by the same personnel, with the same amount of search effort (Sutherland et al. 2010).

The inclusion of six additional vegetated sites in 2026 was to substitute for various sites that had been impacted by landslides or other natural disturbance events over the past 33 years since the monitoring programme was instigated in 1993. These additional sites have provided the requisite number of vegetated sites to preserve the robustness of the analysis.

There were few significant differences in the upper and lower elevation limit of submerged species between 2022 and 2026, with the introduced weed elodea (*Elodea canadensis*) having a shallower maximum depth in Lake Manapōuri and the native characean *Chara australis* growing deeper in Lake Te Anau. The range of combined *Nitella* species showed a shallower maximum and minimum elevation for Lake Hauroko in 2026 compared to 2022 and was more similar to the range recorded in 2017. The lower elevation limit of vegetation occurrence in these lakes is determined by the amount of photosynthetically available radiation (Schwarz et al. 1996) which is related, in part, to water level. In Lakes Te Anau and Manapōuri, the median lower elevation limit was higher (shallower) in 2017 than in 2022 and 2026, consistent with a slightly higher median water level over the year preceding the 2017 survey (Figure B-2, Figure B-4).

Previous reports highlighted a potential decline of the native *Isoetes alpina* in Lakes Te Anau and Manapōuri but not Hauroko. There was an apparent retraction in lower elevation limit, lower frequency of occurrence in lake profiles and a decrease in cover (Champion et al. 2022). This trend appears to be reversed in 2026, with an apparent but not statistically significant increase in elevation range between 25th and 75th percentiles of 0.4 m in Lake Te Anau, 0.6 m in Lake Manapōuri but a decrease of 1.0 m in Lake Hauroko compared to 2022. Additionally, *I. alpina* was recorded at an additional 4 sites in Lake Manapōuri and median average and median maximum covers increased in all three lakes. Thus, there is apparent increase of this species in Lakes Te Anau and Manapōuri between 2022 and 2026, although further monitoring is recommended.

The decline and recovery of *Centrolepis pallida* and *Isoetes alpina* has been documented over the monitoring programme since 1993, illustrating the value of this long-term monitoring approach and the dynamic nature of vegetation responses to climatic variability. Over time, elevation ranges, percent occurrence and cover of the common species in the turf, tall vascular macrophyte and characean communities have remained relatively stable since the commencement of monitoring surveys in 1993, with apparent (statistically significant) migration of species up or down the profile noted between sampling occasions and some changes in the

abundance of individual species, but without any recognisable trend over the entire monitoring period.

Overall, there appears to be no significant impact on the macrophyte communities from the existing management regime compared to fluctuations that are driven by climatic-influenced factors (e.g., rainfall, storm events and air temperature variations), based on the comparison with uncontrolled Lake Hauroko. Provided that lake level fluctuation and inter-decile variance regimes continue, it is likely that the highly diverse littoral vegetation will persist in Lakes Te Anau and Manapōuri. The establishment of a robust long-term baseline and more frequent monitoring planned at every 3 years for a 12-year period will provide a good basis to detect any possible vegetation changes resulting from more frequent use of the LOR.

5 Acknowledgements

We wish to thank Dr Anne-Maree Schwarz and Jason Holland (Environmental Manager, Meridian) for helping scope out this project. We also thank them for their thorough review of the report along with Dr Jo Hoyle (Earth Sciences New Zealand).

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Appendix A Resource consent monitoring conditions

The monitoring requirements in Appendix 1 and Appendix A relating to Littoral Macrophytes and Lake Macrophytes are:

Appendix 1 to Resource Consents 96019-V5, 96020-V6, 96021-V6, 96022-V7 and 96023-V6 (1996 MPS Operating Consents)

A) Lakes Te Anau and Manapouri.
3) Littoral Macrophytes.

Objective: To assess the effects of the lake level management regime on the aquatic macrophytes of Lakes Manapouri and Te Anau.

Methods: Monitoring will be undertaken using transects and photo points as set out by the most recent monitoring report for Lakes Te Anau, Manapouri and Lake Hauroko (NIWA, 2010[4]). Methods of data collection and analysis (including analysis of inter-decile ranges) are to be the same as set out in the NIWA, 2010, monitoring report, so that the results are directly comparable. Lake Hauroko shall be used as the control site to identify any observed changes that may be due to a regional climatic phenomenon, rather than lake management. Any alterations to the transects, photo points, methods of data collection or analysis shall be discussed with the Guardians of Lakes Manapouri, Te Anau and Monowai, and shall require approval from Environment Southland prior to implementation.

Re-measurement of the transects in Lakes Manapouri, Te Anau and Hauroko will occur at three-yearly intervals, with the next monitoring being undertaken in 2026. Re-measurement of the transects may also occur if the low-level guidelines have been breached ("event driven" monitoring).

For "event driven" monitoring surveys, the number of transects and/or photo points may vary from those required for the three-yearly monitoring, depending on the nature and extent of the "event", as agreed with Environment Southland and following consultation by the consent holder with the Guardians of Lakes Manapouri, Te Anau and Monowai. The timing of an "event driven" monitoring survey may also be varied by Environment Southland and following consultation by the consent holder with the Guardians of Lakes Manapouri, Te Anau and Monowai, taking into account the timing of the next three-yearly monitoring survey.

References:

NIWA. 2010. Monitoring the potential effects of MTAD on Lakes Te Anau and Manapouri macrophytes: baseline survey.

[4] Sutherland et al. (2010)

Appendix A to MTAD Resource Consents 2061546-V4, 2061547-V3 and 206158

B Lakes Manapouri and Te Anau.

(i) Lake Macrophytes.

Lakes Te Anau and Manapouri Macrophytes.

5. The consent holder shall undertake a macrophyte monitoring survey using the existing approach described in Appendix 1 of existing consent CN96022 [Manapouri Power Scheme: Water Permit to Dam and Divert Water from Lake Manapouri and Mararoa River for Hydroelectricity Generation] for each of the first two summers after this consent is first exercised.

   (Note 1: This annual monitoring is additional to the existing and event-driven MPS monitoring requirements contained in Appendix 1 of the existing MPS consents. At those times when the survey required under the programme coincides with monitoring required under Appendix 1 of the existing MPS consents, only one integrated survey need be undertaken.
   Note2: An initial macrophyte monitoring survey was carried out during the 2009/2010 summer[5]).

   Operating Guidelines for Levels of Lakes Te Anau and Manapouri (Gazetted 21 November 2002) are represented in Figure A-1 and Figure A-2 respectively.

[5] The monitoring surveys required under 5 were undertaken for two summers following the exercise of MTAD consents and completed by 2014. No further monitoring is required under MTAD Appendix A.

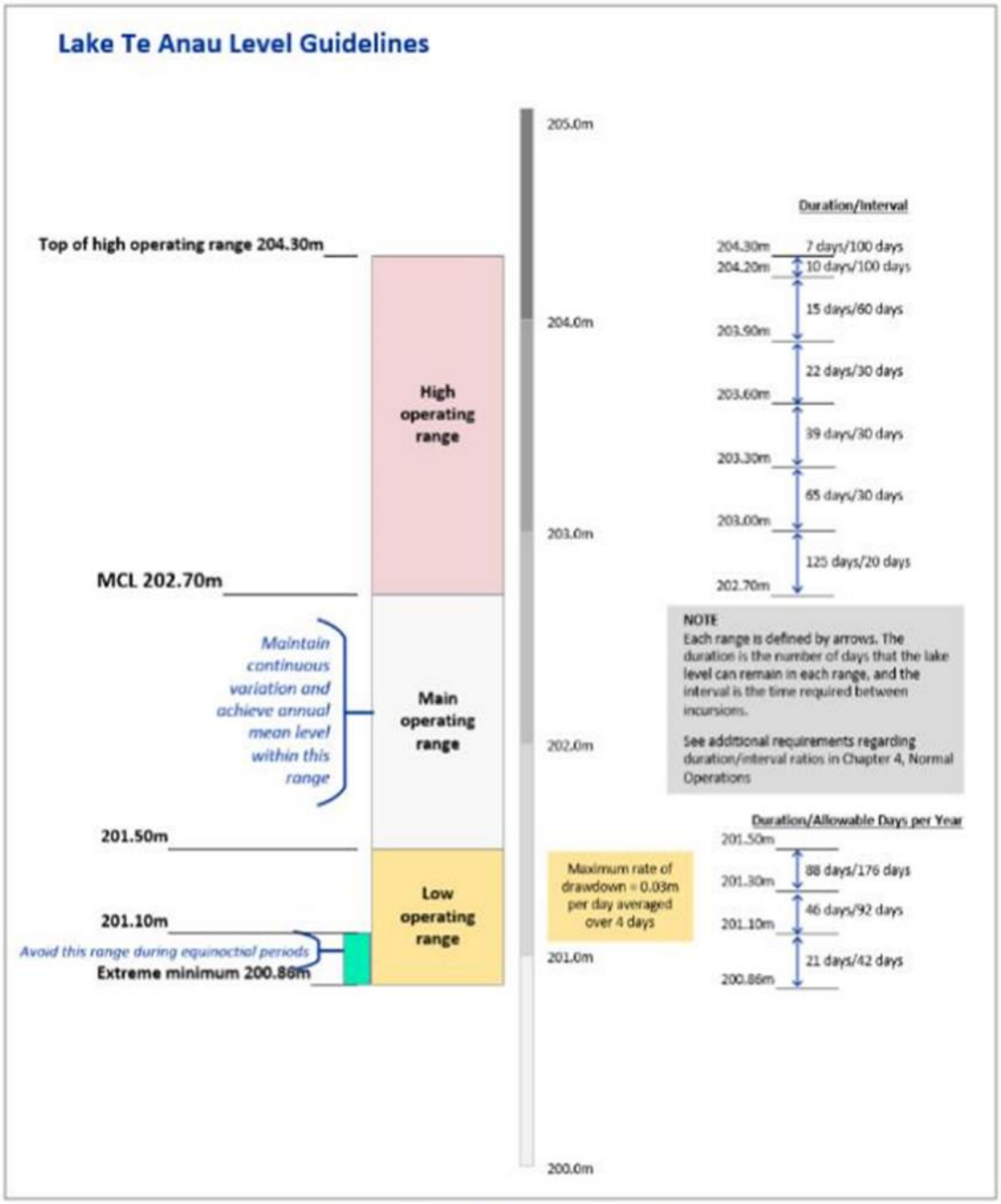


Figure A-1: Lake Te Anau. Gazetted guidelines (m.a.s.l.).

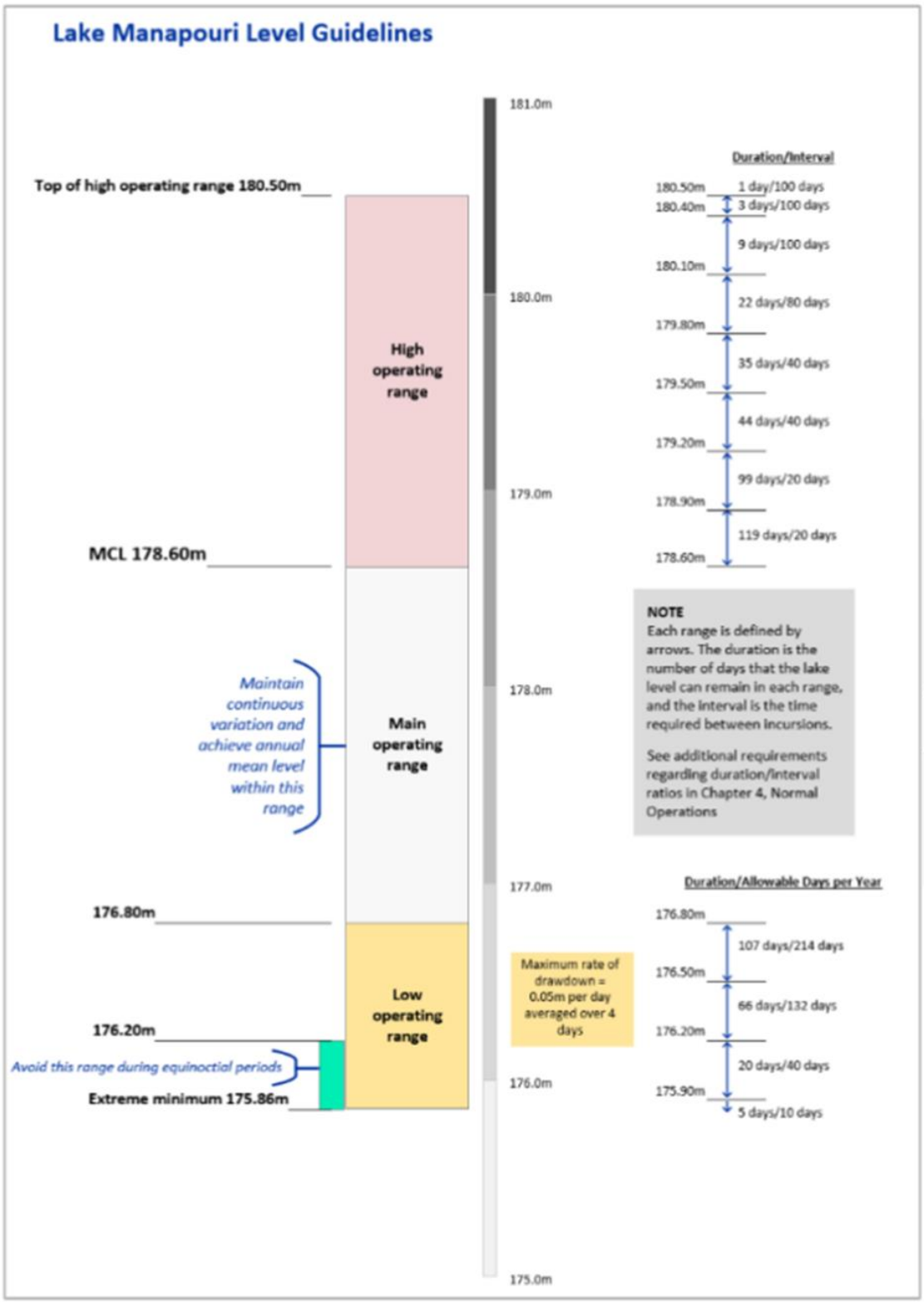


Figure A-2: Lake Manapōuri. Gazetted guidelines (m.a.s.l.).

Appendix B Lake level fluctuations and inter-decile range



Figure B-1: Lake level fluctuations in Lake Te Anau for the year preceding the 2026 macrophyte survey. The timing of the survey is indicated by the red line; the blue lines indicate the gazetted guidelines main operating range for lake level (between 202.7 and 201.5 m.a.s.l.) and the dashed grey line indicates the median level over the preceding 12 months.

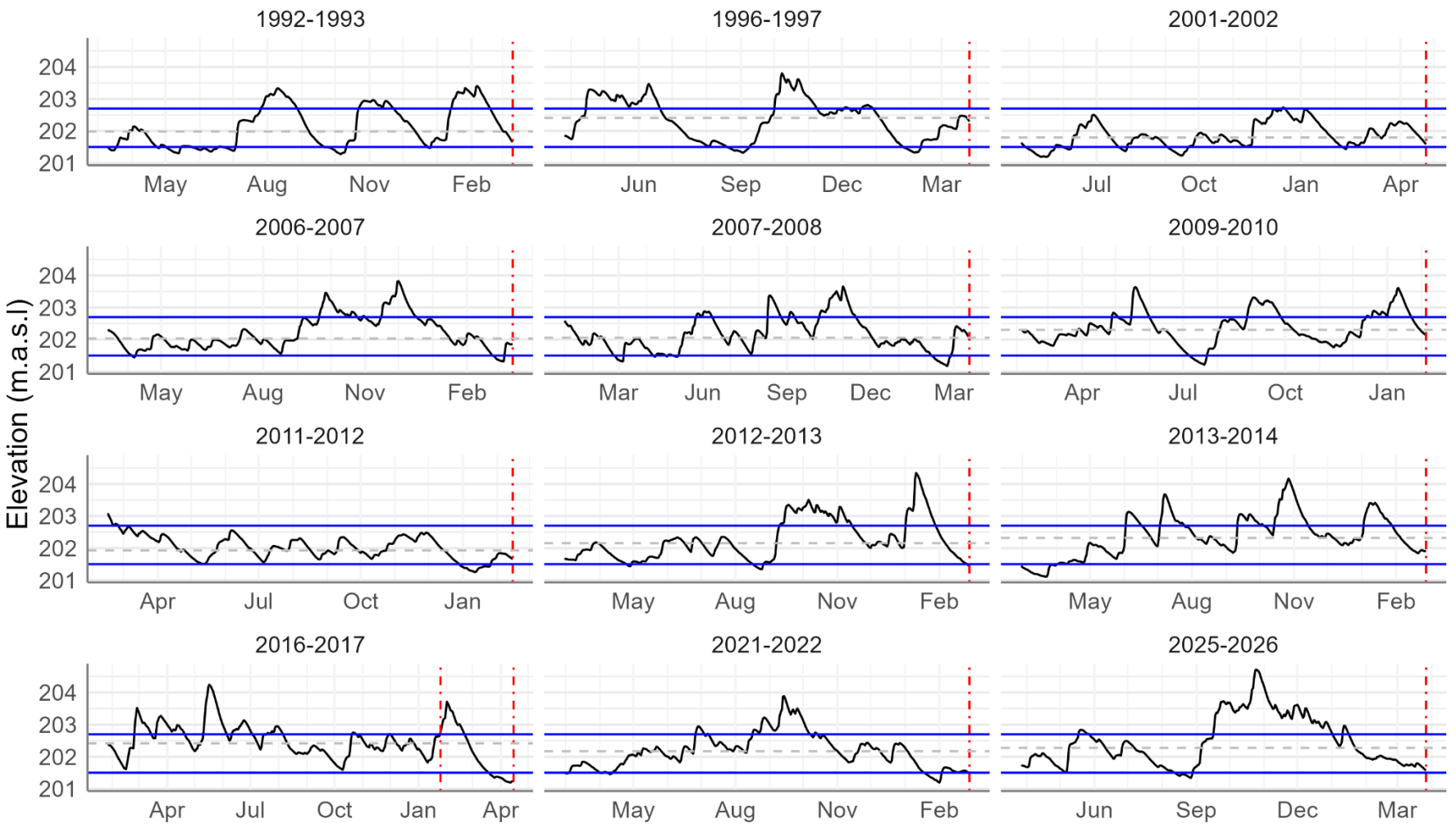


Figure B-2: Lake level fluctuations preceding each macrophyte survey in Lake Te Anau since 1993. The blue lines indicate the gazetted guidelines main operating range for lake level, timing of each survey is indicated by the red lines, and the dashed grey lines indicate the median level over the preceding 12 months.



Figure B-3: Lake level fluctuations in Lake Manapōuri for the year preceding the 2026 macrophyte survey. The timing of the survey is indicated by the red line; the blue lines indicate the gazetted guidelines main operating range (between 178.6 and 176.8 m.a.s.l.) for lake level and the dashed grey line indicates the median level over the preceding 12 months.

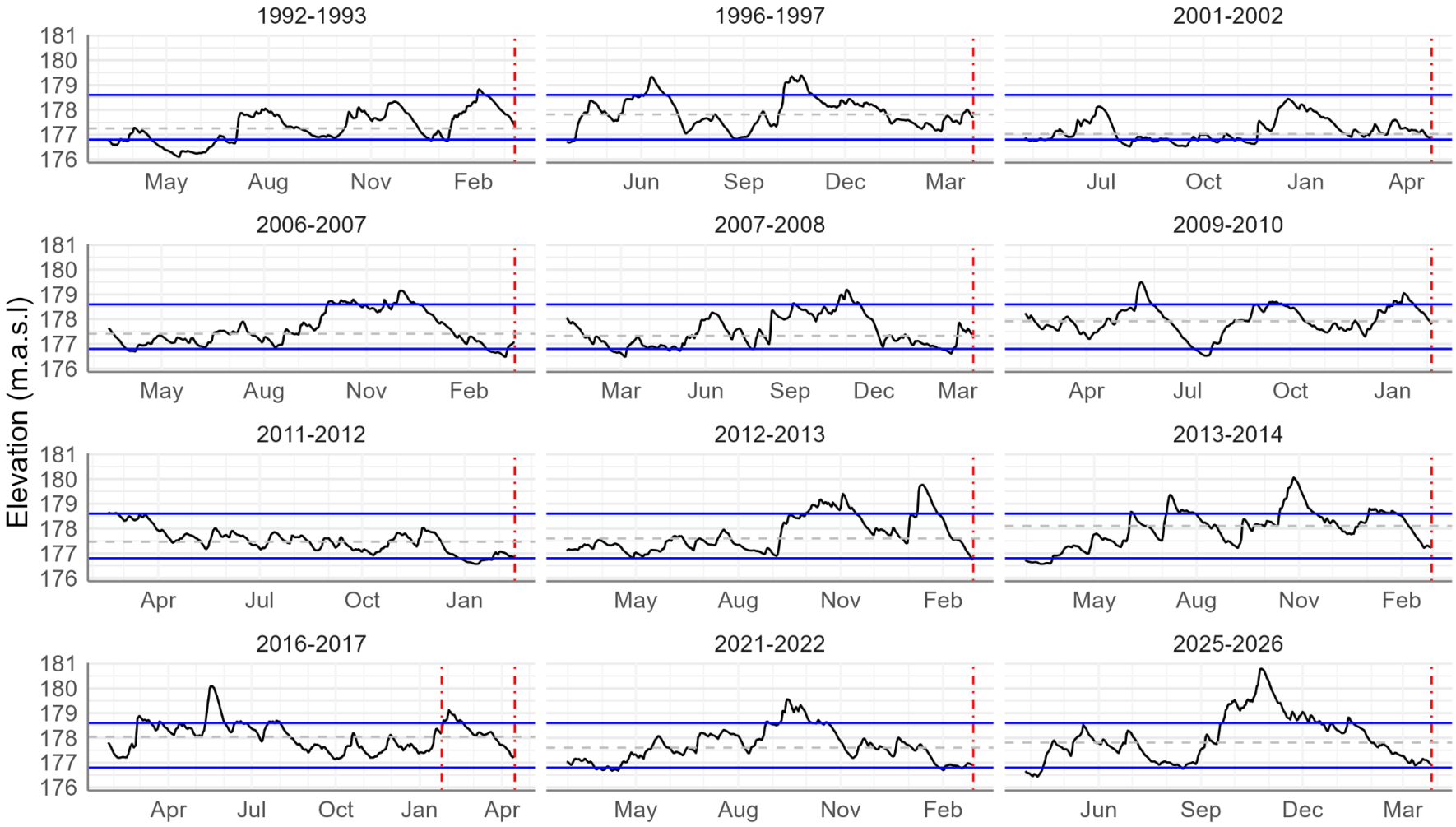


Figure B-4: Lake level fluctuations preceding each macrophyte survey in Lake Manapōuri since 1993. The blue lines indicate the gazetted guidelines main operating range for lake level, timing of each survey is indicated by the red lines, and the dashed grey lines indicate the median level over the preceding 12 months.



Figure B-5: Lake level fluctuations in Lake Hauroko for the year preceding the 2026 macrophyte survey. The timing of the survey is indicated by the red line, and the dashed grey line indicates the median level over the preceding 12 months.

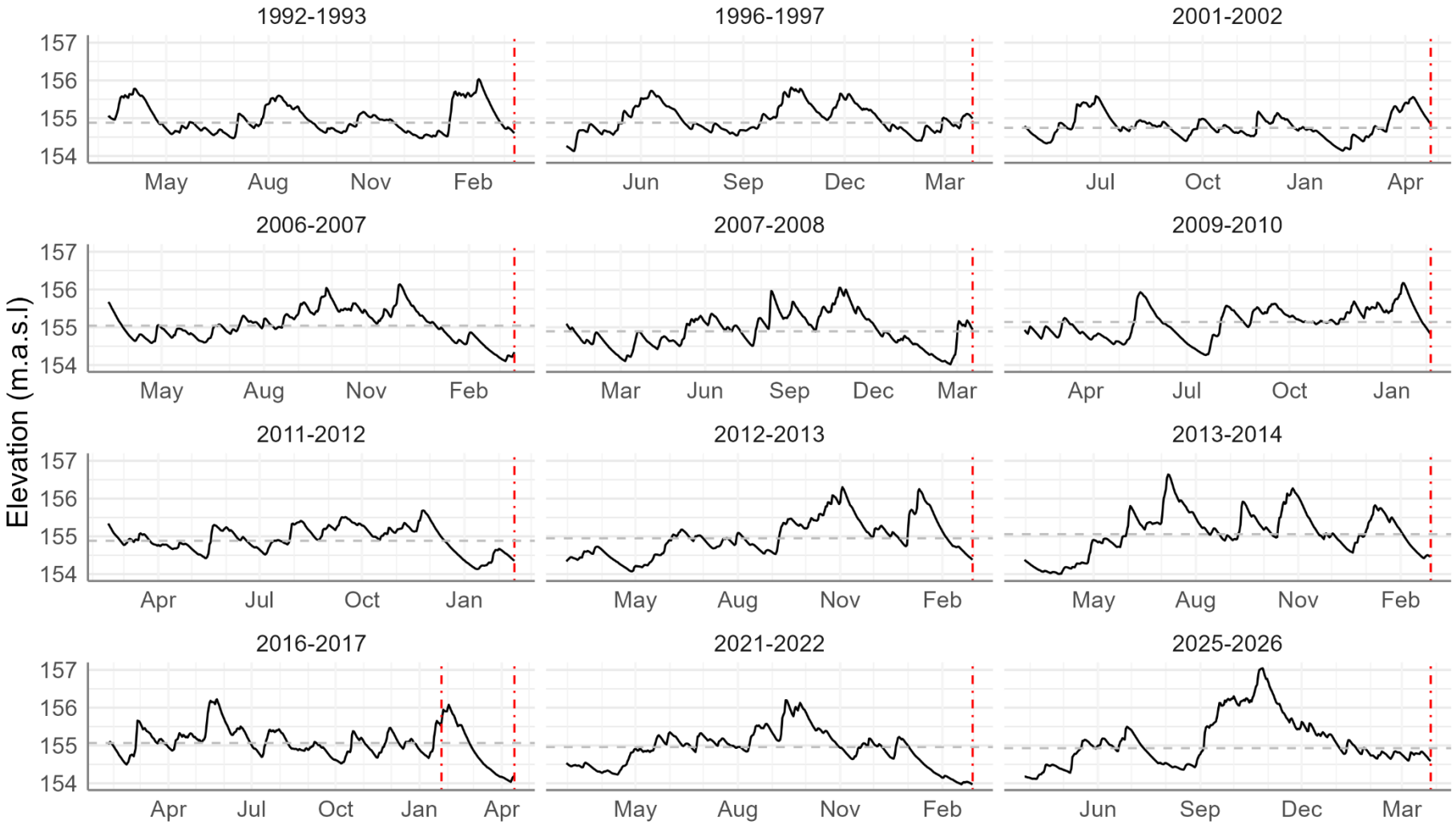


Figure B-6: Lake level fluctuations preceding each macrophyte survey in Lake Hauroko since 1993. Timing of each survey is indicated by the red lines, and the dashed grey lines indicate the median level over the preceding 12 months.

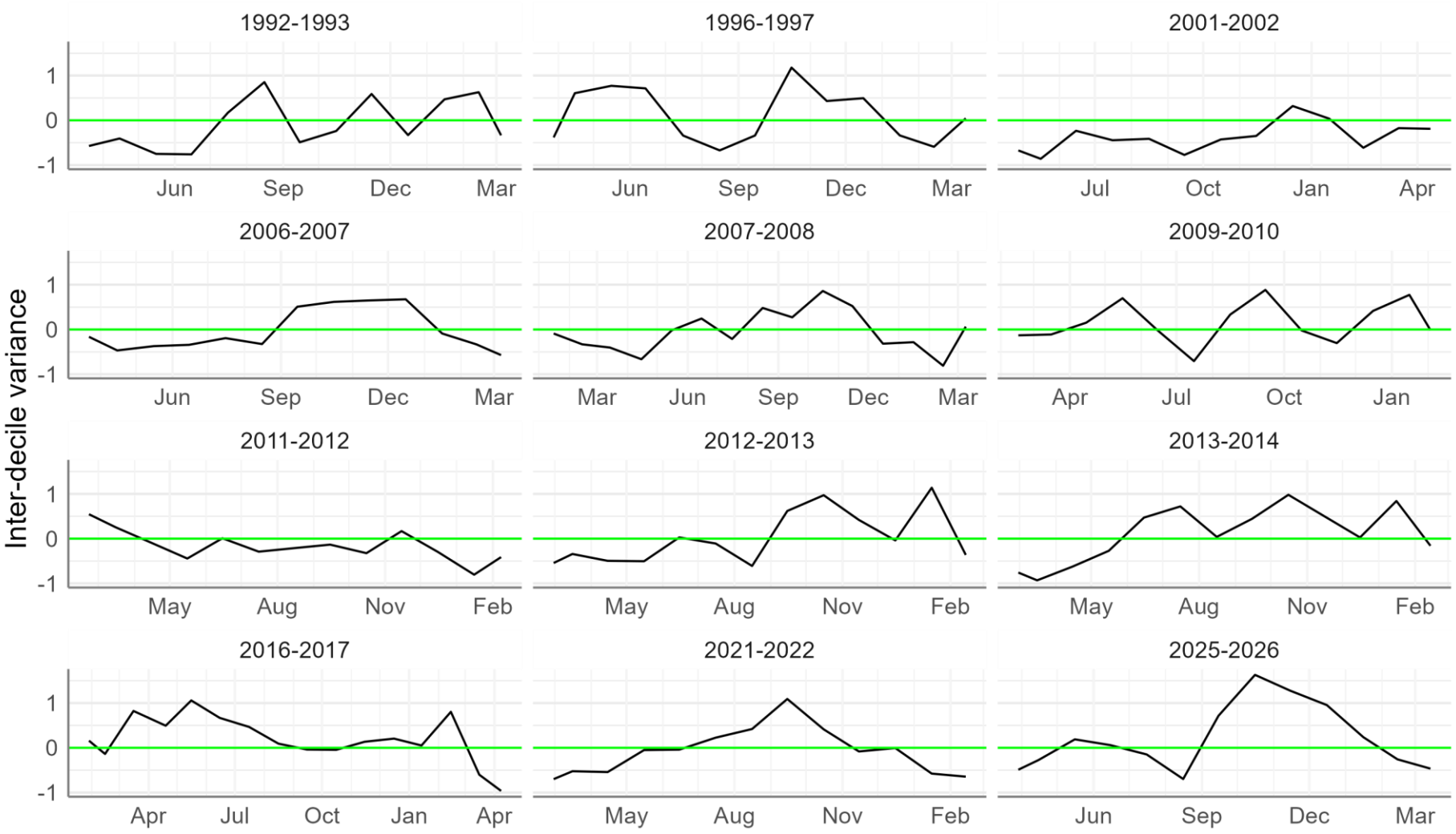


Figure B-7: Monthly inter-decile variance from the 34-year median lake level (zero) for the 12-month period prior to each survey in Lake Te Anau.

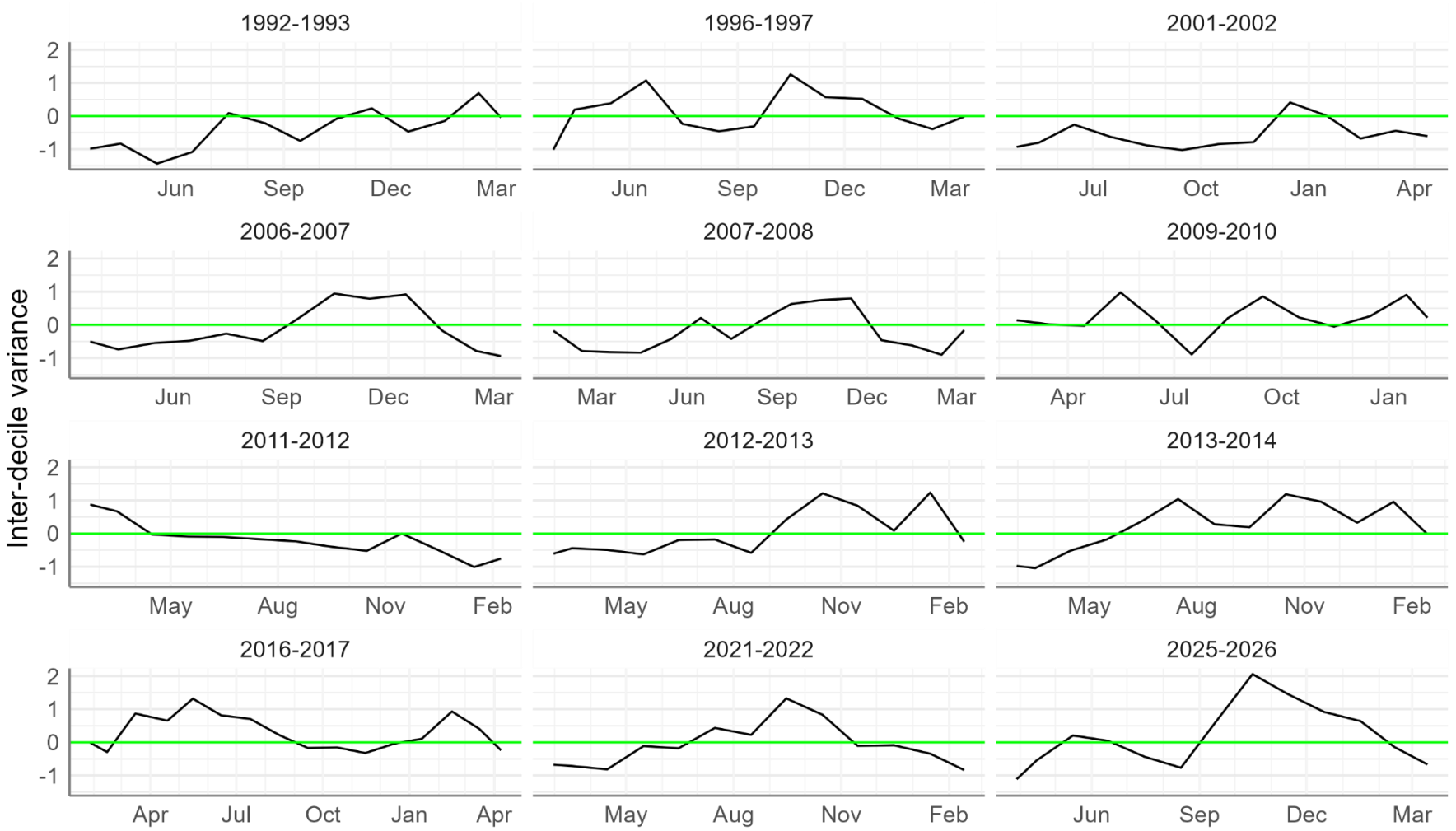


Figure B-8: Monthly inter-decile variance from the 34-year median lake level (zero) for the 12-month period prior to each survey in Lake Manapōuri.

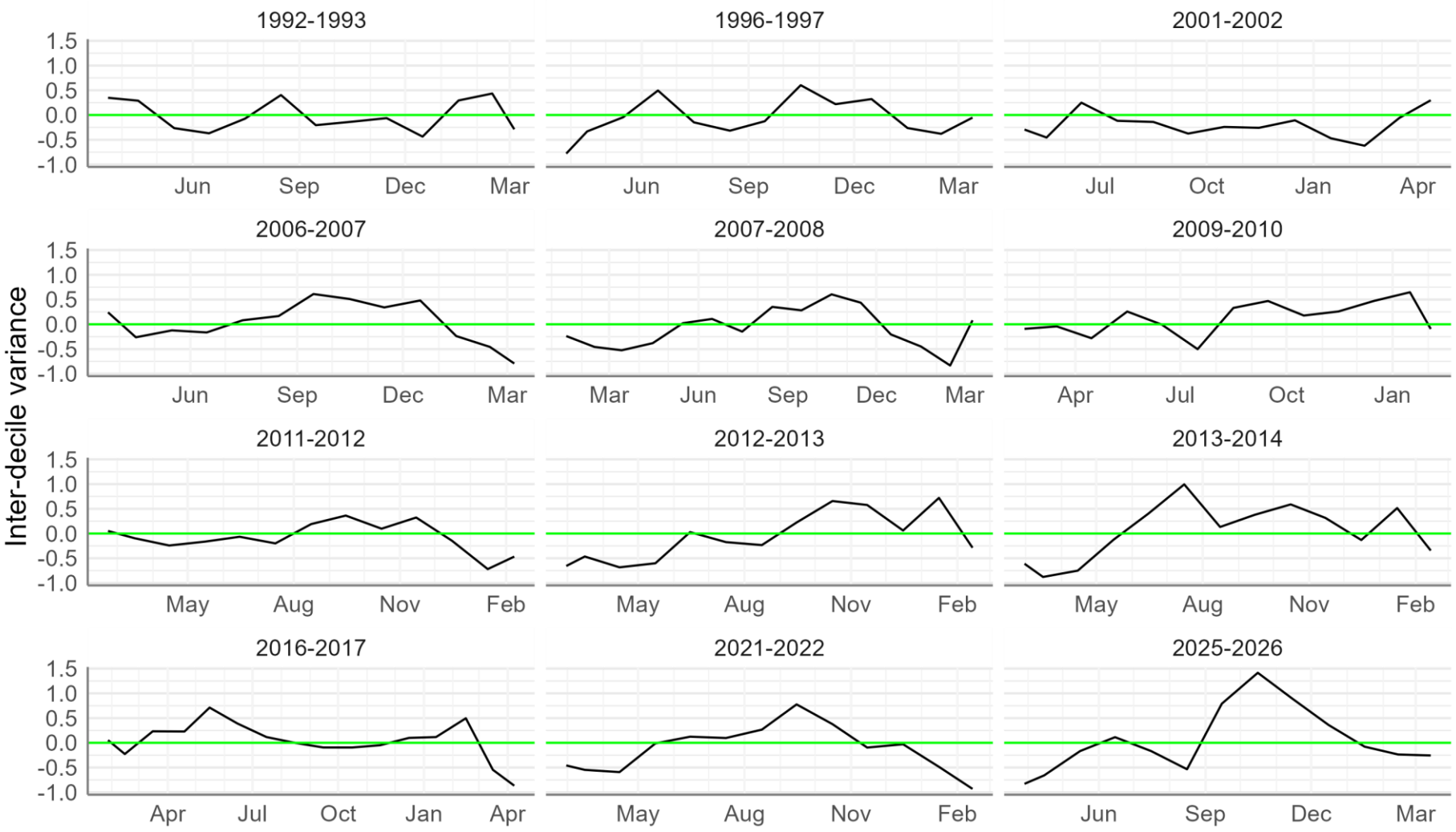


Figure B-9: Monthly inter-decile variance from the 34-year median lake level (zero) for the 12-month period prior to each survey in Lake Hauroko.

Appendix C Turf species

In 2026, two new turf sites (one each in Lakes Manapōuri and Hauroko) were included in the survey to substitute for sites that had been impacted by natural disturbance events over the life of our monitoring programme. Turf species were recorded at sites numbering 12, 14 (13 excluding the new site) and 10 (9 excluding the new site) in Lakes Te Anau, Manapōuri and Hauroko respectively. This compared with the 2022 survey when turfs were recorded in 13, 12 and 9 sites in Lakes Te Anau, Manapōuri and Hauroko respectively.

Below we provide detailed results for six common turf species. To interpret the graphs in this and the following two sections; the upper boundary of the box plot indicates the 75th percentile, the black line within the box marks the median, the pale line marks the mean value, and the lower boundary of the box indicates the 25th percentile. Whiskers (error bars) above and below the box represents 1.5 times the interquartile range (distance between the 25th and 75th percentiles), while outlying points are represented by solid dots.

Centrolepis pallida

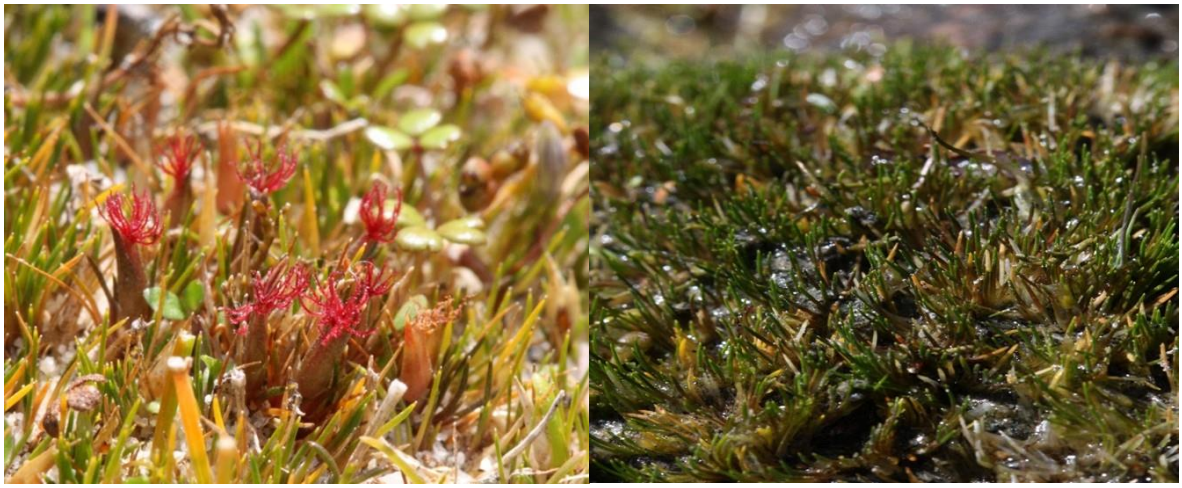


Figure C-1: Female flowers (left) and turf dominated by *Centrolepis pallida* (right).

Centrolepis pallida (Figure C-1) occupied an elevation range of 0.6 m in Lake Te Anau, 0.4 m in Lake Manapōuri and 0.1 m in Lake Hauroko (between 25th and 75th percentiles) (Figure C-2 to Figure C-4).

There was a significant difference in the lower elevation limit of *C. pallida* in Lake Manapōuri between 2022 and 2026, with this plant growing at lower elevations in 2026. There were no other significant differences in the upper or lower elevation limits of *C. pallida* in other lakes between 2022 and 2026.

In Lake Manapōuri, *C. pallida* was found at 6 (5 excluding the new turf site) sites in 2026, two less than in 2022, but greater than previous surveys in 2014 (3 sites) and 2017 (4 sites). Conversely, in Lake Te Anau this species was found at three sites in 2026, one more than in 2022. *Centrolepis pallida* was restricted to two sites in Lake Hauroko (Figure C-2 to Figure C-4).

Median average and median maximum cover of *C. pallida* declined between 2022 and 2026 in Lakes Te Anau and Manapōuri but was similar in Lake Hauroko with low covers on both occasions (Table C-1).

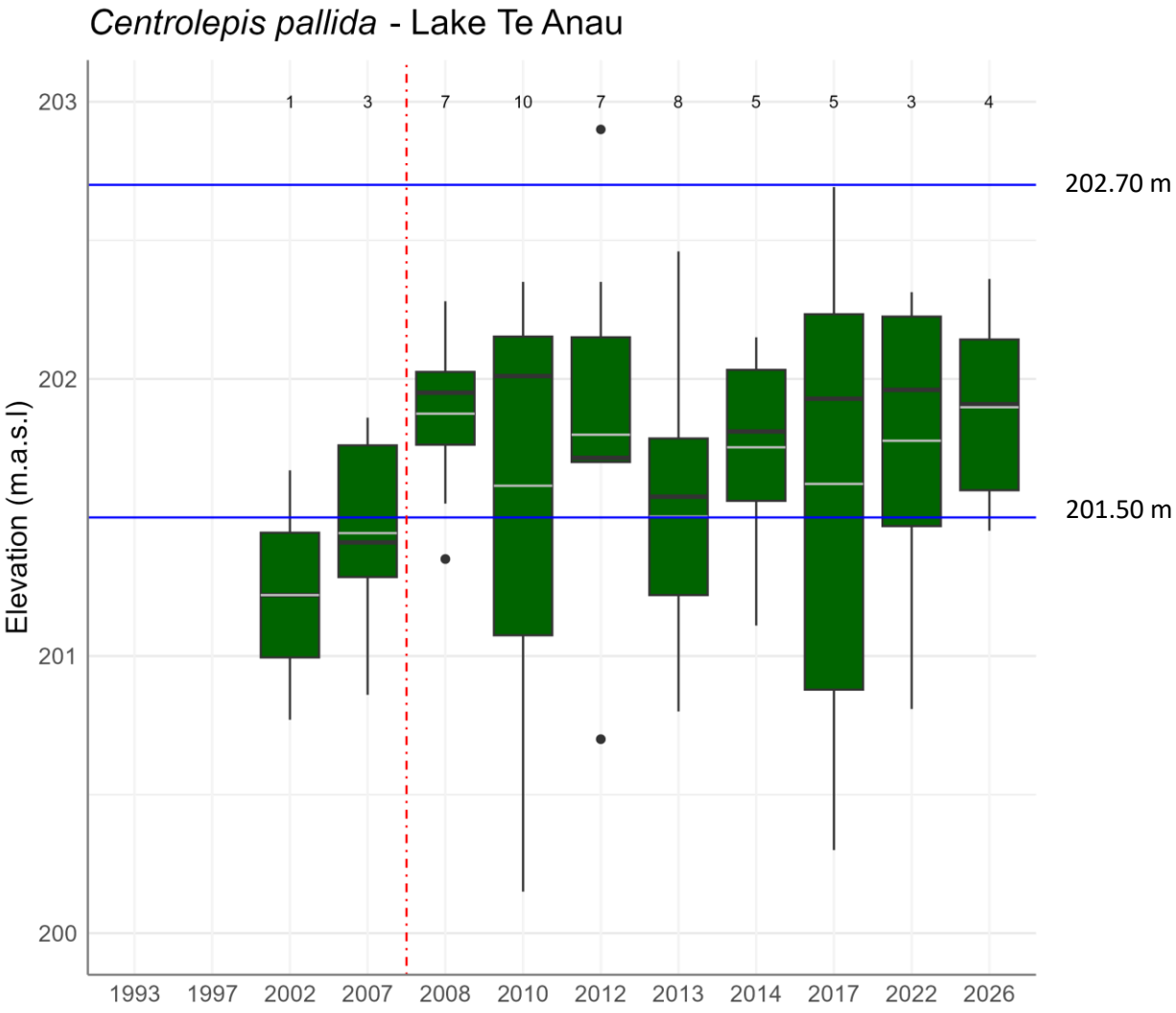


Figure C-2: Lake-wide elevation ranges of *Centrolepis pallida* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

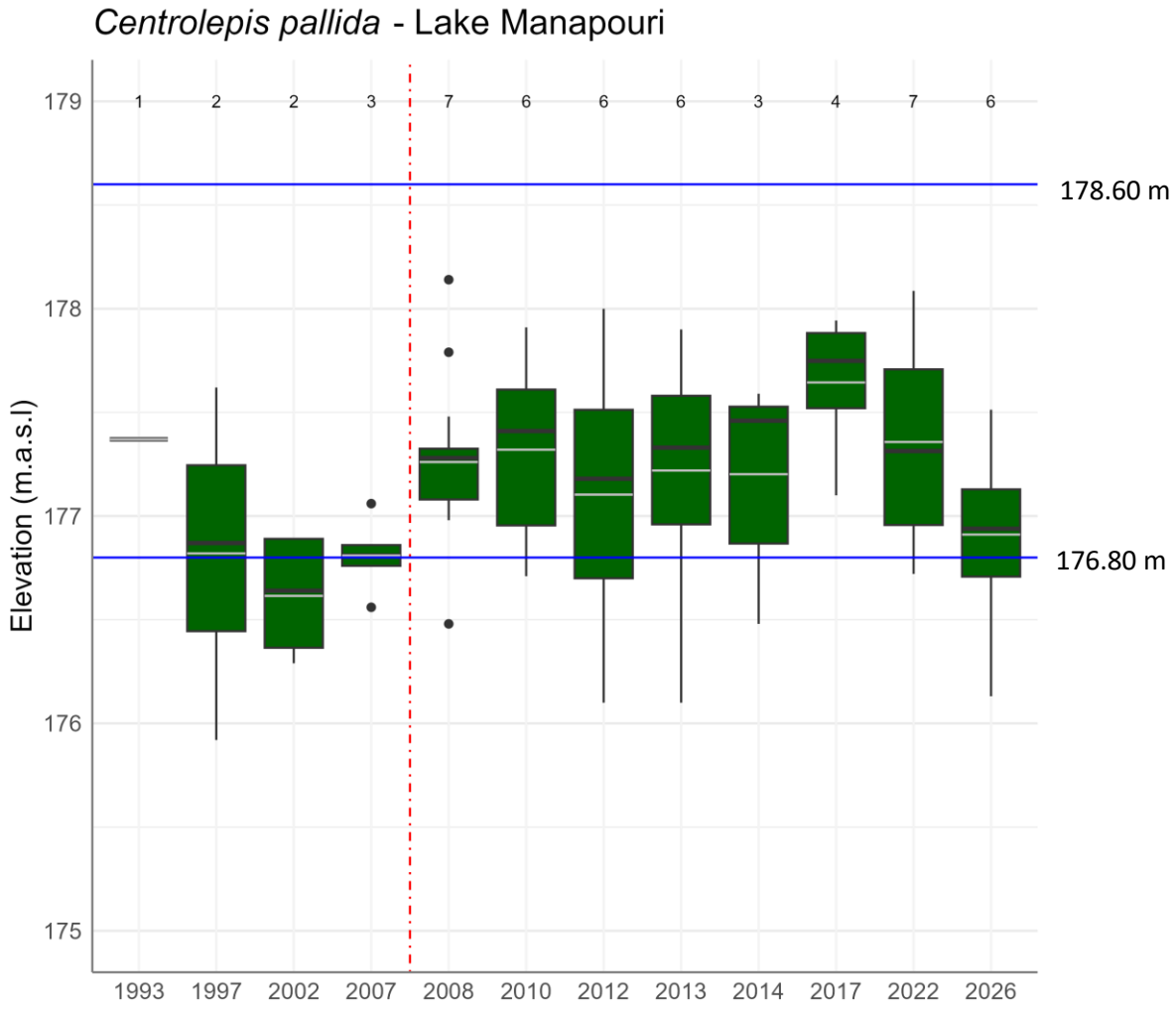


Figure C-3: Lake-wide elevation ranges of *Centrolepis pallida* in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

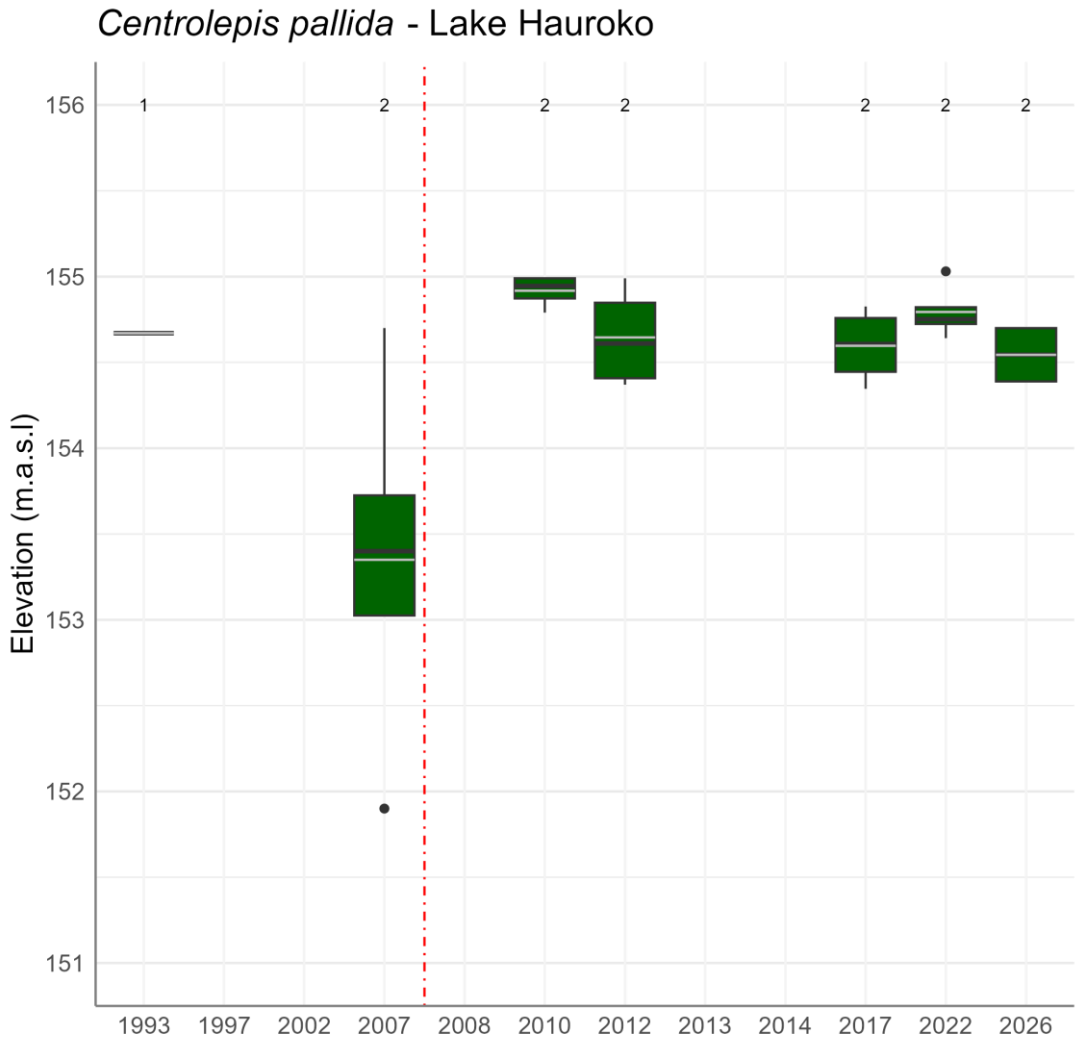


Figure C-4: Lake-wide elevation ranges of *Centrolepis pallida* in Lake Hauroko 1993-2017. Red dotted line indicates where surveys changed to include plants above water line.

Table C-1: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Centrolepis pallida* in the three lakes from 1993-2026. Cover ranges are - = not recorded, 1 = 1-5%, 2 = 5-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	-	-	-	-
1997	-	-	-	-
2002	10	1	1	1
2007	30	1	1	2
2008	67	1	2	2
2010	100	2	3	6
2012	40	3	3	5
2017	36	3	4	5
2022	46	3	5	5
2026	67	2	3	3
Lake Manapōuri				
1993	10	1	1	1
1997	20	2	3	3
2002	20	1	2	3
2007	30	1	1	1
2008	67	2	3	5
2010	60	2	3	5
2012	46	1	3	6
2017	33	3	3	4
2022	58	3	4	5
2026	67	2	3	5
Lake Hauroko				
1993	11	1	1	1
1997	-	-	-	-
2002	11	1	1	1
2007	22	1	1	1
2008	-	-	-	-
2010	40	1	2	3
2012	40	2	3	4
2017	17	2	3	3
2022	22	1	1	1
2026	25	1	1	1

Elatine gratioloides



Figure C-5: *Elatine gratioloides*. Emergent form with three pink petaled flowers.

Elatine gratioloides (Figure C-5) occupied an elevation range of 1.3 m in Lake Te Anau and 1.1 m in Lakes Manapōuri and Hauroko (between 25th and 75th percentiles) (Figure C-6 to Figure C-8).

There were no significant differences in the upper or lower elevation limits of *E. gratioloides* in the three lakes between 2022 and 2026.

Frequency of *E. gratioloides* occurrence halved in Lake Te Anau (five sites in 2026 compared with 10 sites in 2022) but had the same frequency in the other lakes (Figure C-6 to Figure C-8).

Median maximum cover of *E. gratioloides* reduced from cover class 2 to 1 between 2022 and 2026 for Lakes Te Anau and Hauroko (Table C-2).

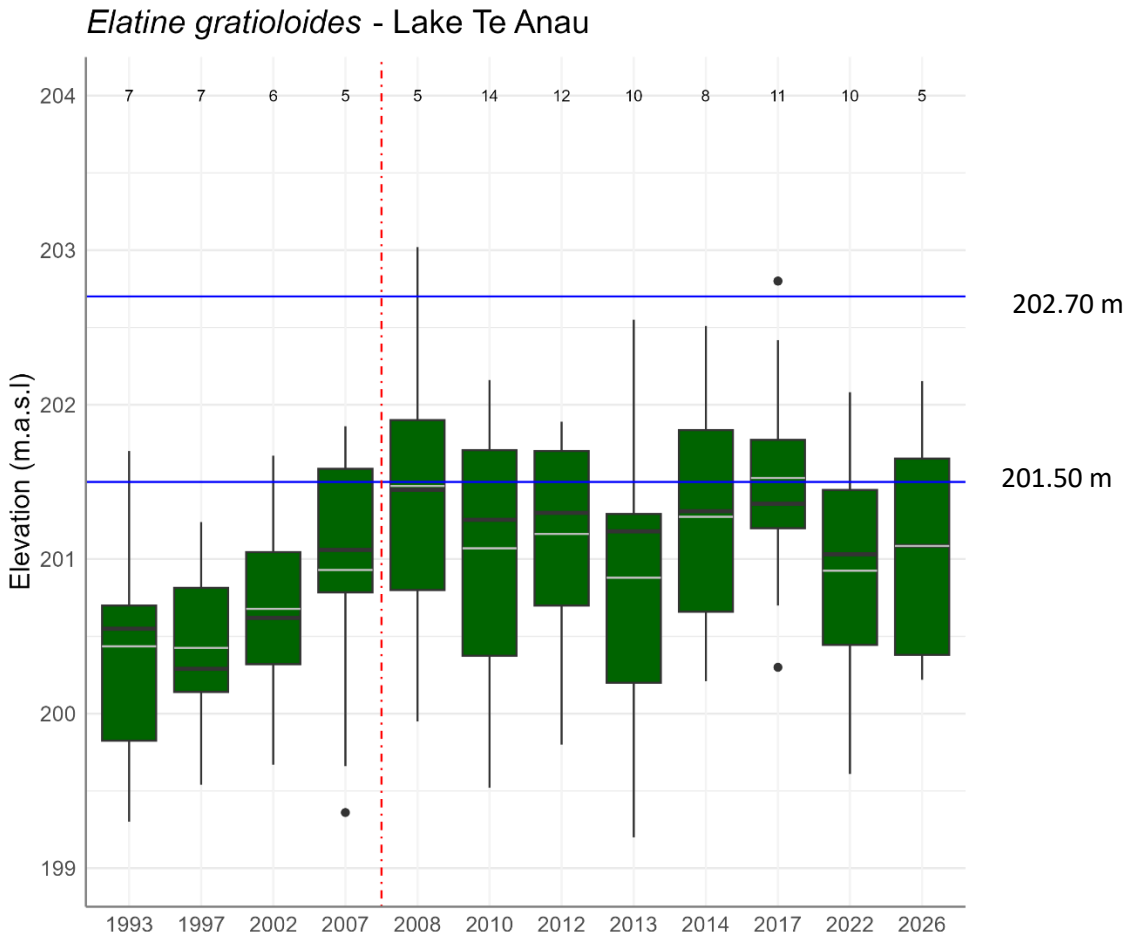


Figure C-6: Lake-wide elevation ranges of *Elatine gratioloides* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

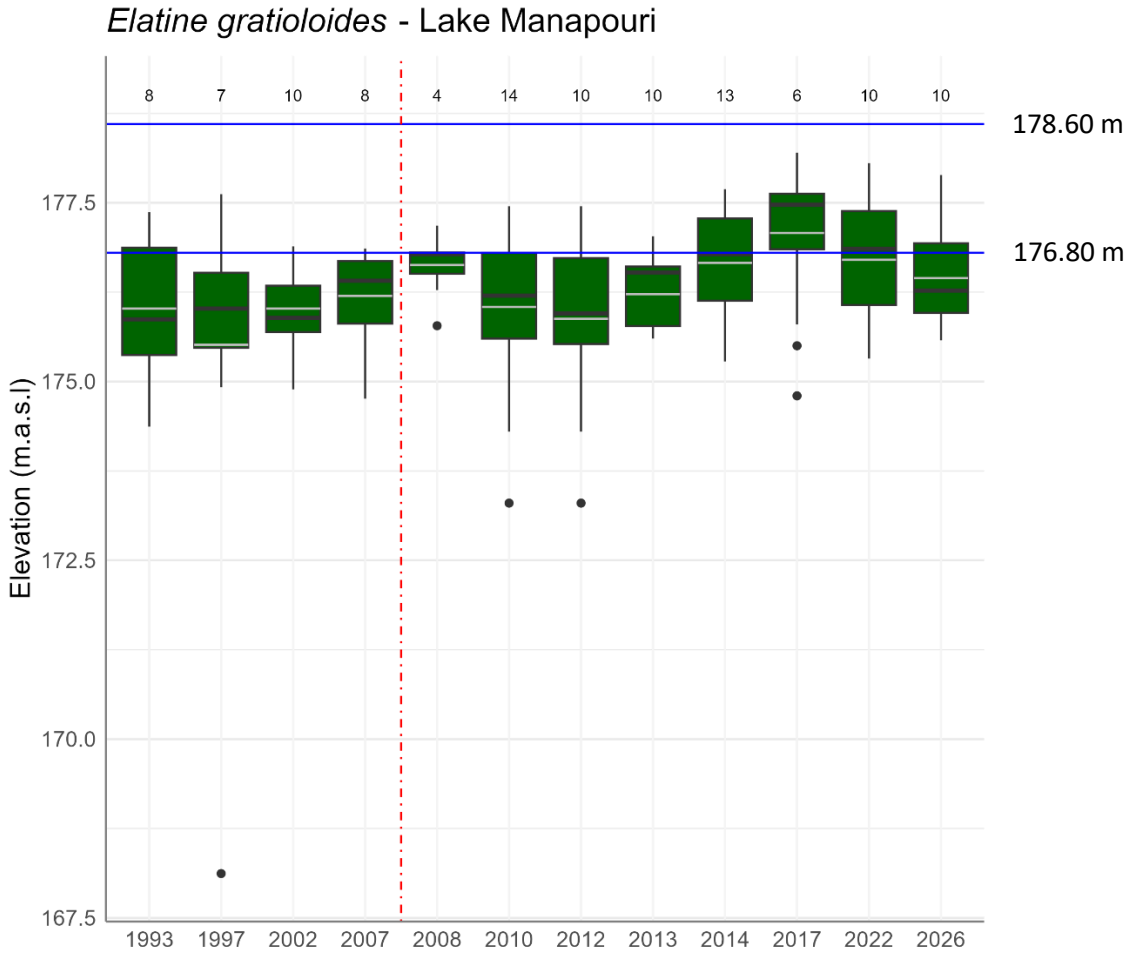


Figure C-7: Lake-wide elevation ranges of *Elatine gratioloides* in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

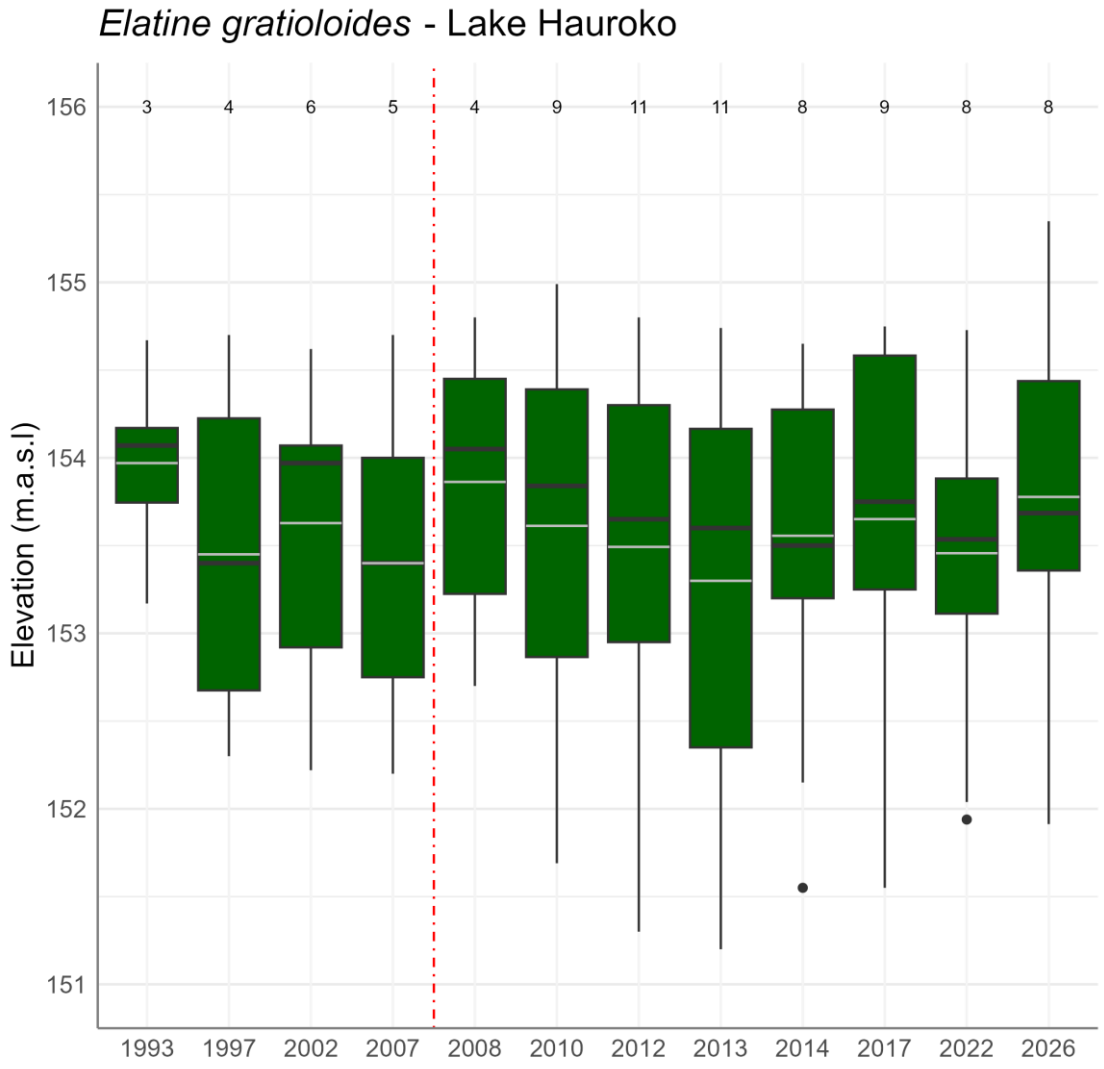


Figure C-8: Lake-wide elevation ranges of *Elatine gratioloides* in Lake Hauroko 1993-2026. Red dotted line indicates where surveys changed to include plants above water line.

Table C-2: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Elatine gratioloides* in the three lakes from 1993-2026. Cover ranges are; 1 = 1-5%, 2 = 6-25%, 3 = 256-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	70	1	1	3
1997	70	1	3	4
2002	60	1	2	2
2007	50	1	1	2
2008	67	2	2	3
2010	100	1	1	2
2012	80	1	2	3
2017	64	1	2	3
2022	77	1	2	3
2026	50	1	1	3
Lake Manapōuri				
1993	80	1	2	3
1997	70	1	2	3
2002	100	1	1	6
2007	80	1	2	5
2008	67	2	2	3
2010	100	1	2	4
2012	67	1	1	2
2017	50	1	1	3
2022	83	1	1	3
2026	50	1	1	2
Lake Hauroko				
1993	33	1	1	1
1997	44	1	1	2
2002	67	1	1	2
2007	56	1	1	6
2008	100	2	2	5
2010	100	1	2	2
2012	20	2	2	3
2017	75	1	2	2
2022	89	1	2	3
2026	75	1	1	2

Glossostigma diandrum and *G. cleistanthum*



Figure C-9: *Glossostigma diandrum* and *G. cleistanthum* (left and right). Note the five lobed flower of *G. diandrum* and underwater flower (unopened) of *G. cleistanthum,* both species have narrow spathulate leaves.

Glossostigma cleistanthum (Figure C-9) was recorded for the first time in Zone 3 of each lake but its distribution data is likely to have been previously included in that of *G. submersum* (name used in the reports prior to 2007) or *G. diandrum* (used in reports from 2007 onwards). All 2022 and 2026 data combined records of both *G. diandrum* (Figure C-9) and *G. cleistanthum* as *Glossostigma*.

Glossostigma occupied an elevation range of 1.0 m in Lake Te Anau, 1.1 m in Lake Manapōuri and 0.3 m in Lake Hauroko (between 25th and 75th percentiles) (Figure C-10 to Figure C-12).

The lower elevation limit of *Glossostigma* was reduced from 2022 to 2026 in Lake Hauroko. There were no other significant differences in the upper elevation limit in the three lakes or lower elevation limit Lakes Te Anau and Manapōuri between 2022 and 2026.

Frequency of *Glossostigma* occurrence was less in 2026 than 2022 in Lakes Te Anau (9 sites in 2026 compared with 11 sites in 2022) and Hauroko (5 and 6), whereas there were more sites in Lake Manapōuri (12 (11 excluding the new turf site) and 9) (Figure C-10 to Figure C-12).

There was a similar pattern in median maximum cover of *Glossostigma* which declined between surveys in Lakes Te Anau and Hauroko but increased in Lake Manapōuri (Table C-3). However, fluctuations in frequency and abundance have been noted on previous sampling occasions (Table C-3) and, unless consistent declines over several sampling occasions are recorded, these are likely to reflect natural variability of this turf species.

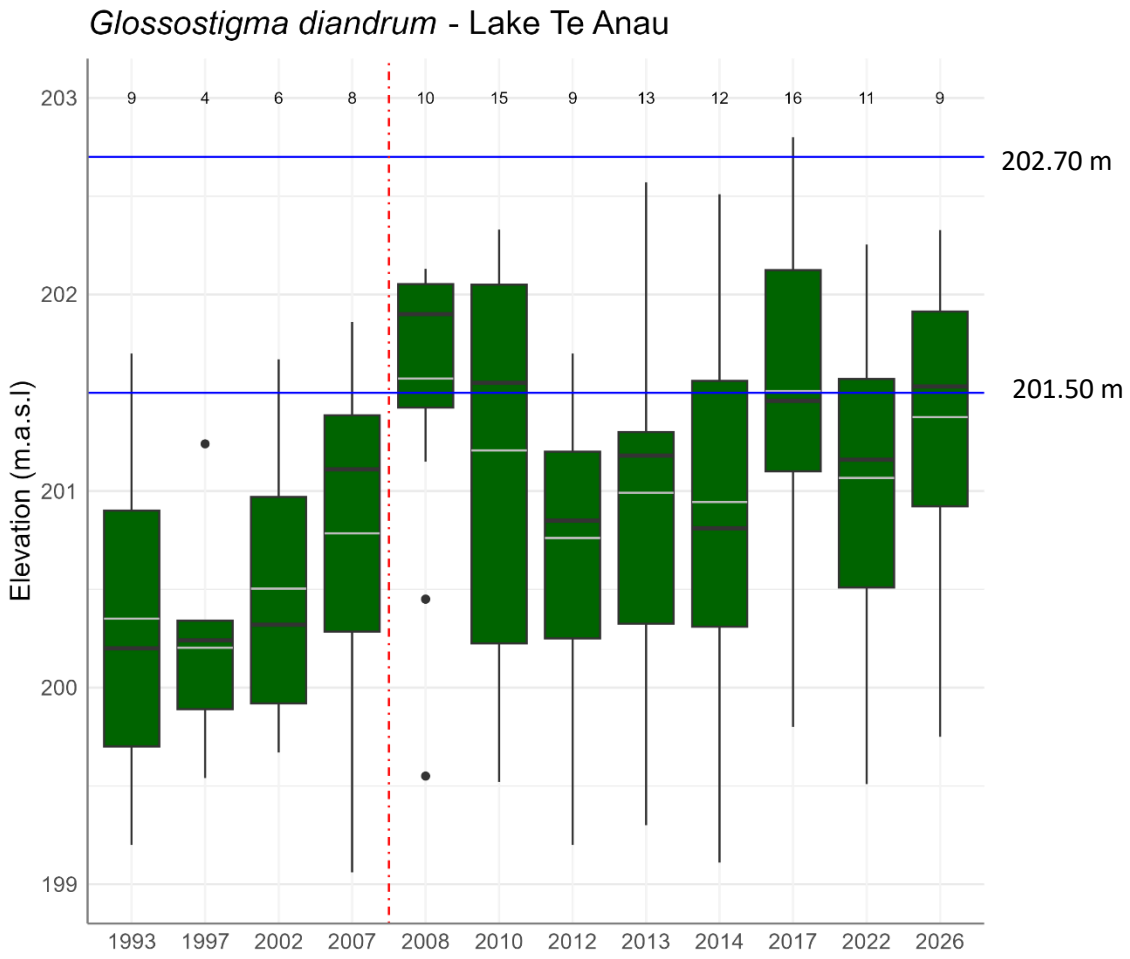


Figure C-10: Lake-wide elevation ranges of *Glossostigma* in Lake Te Anau 1993-2026. *G. cleistanthum* records from 2026 were combined with those of *G. diandrum*. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

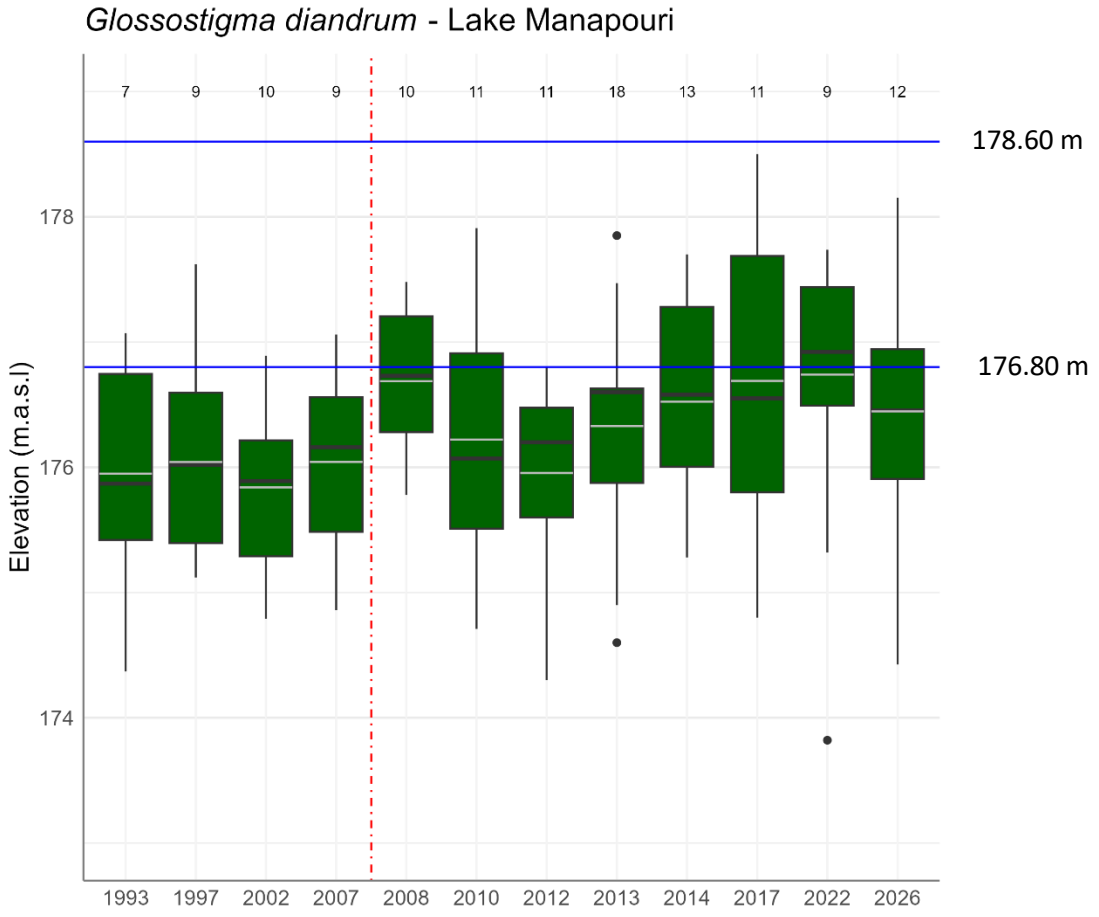


Figure C-11: Lake-wide elevation ranges of *Glossostigma* in Lake Manapōuri 1993-2026. *G. cleistanthum* records from 2026 were combined with those of *G. diandrum*. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

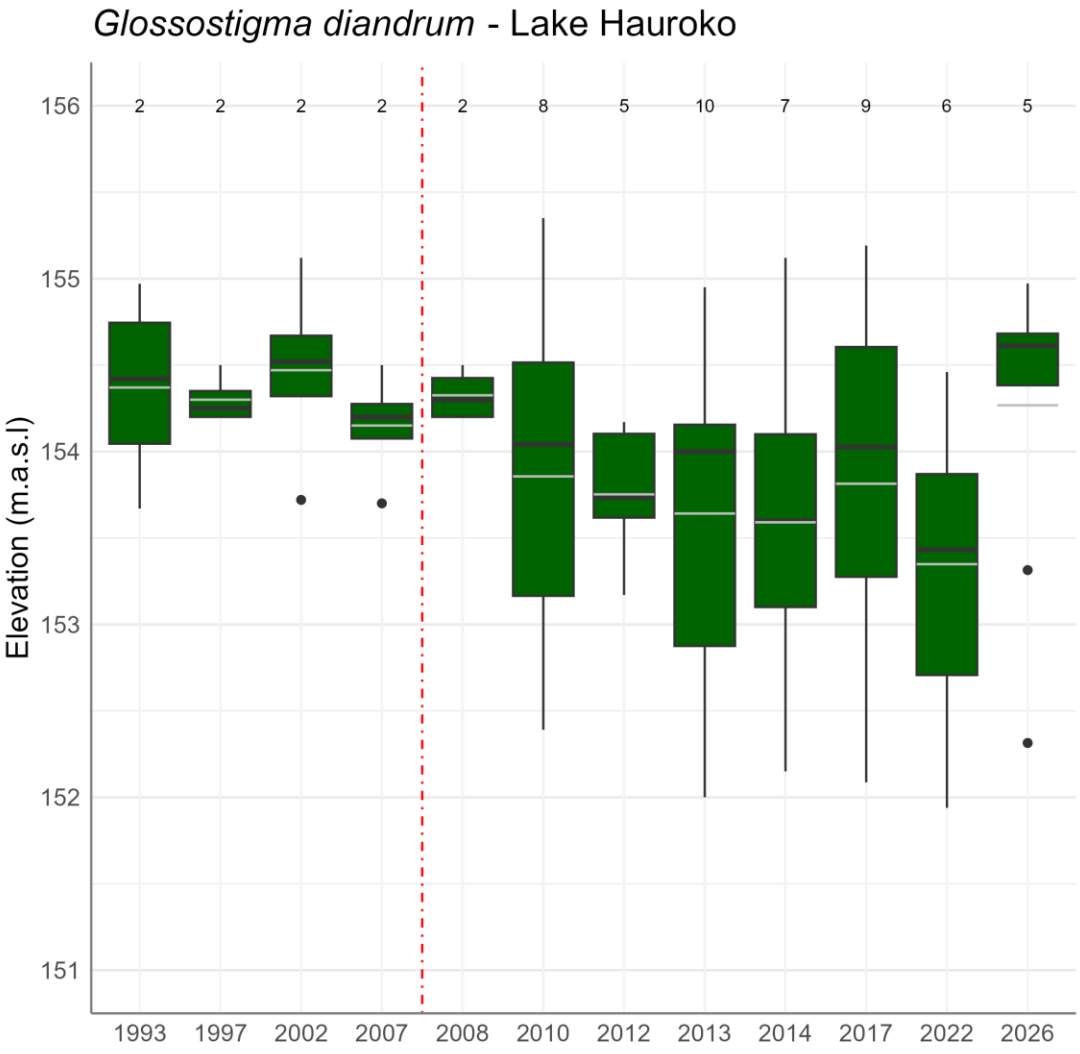


Figure C-12: Lake-wide elevation ranges of *Glossostigma* in Lake Hauroko 1993-2026. *G. cleistanthum* records from 2022 were combined with those of *G. diandrum*. Red dotted line indicates where surveys changed to include plants above water line.

Table C-3: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Glossostigma* in the three lakes from 1993-2026. *Glossostigma cleistanthum* records from 2022 were combined with those of *G. diandrum*: Cover ranges are 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	90	1	1	3
1997	40	1	1	1
2002	60	2	3	6
2007	80	1	2	5
2008	100	2	3	4
2010	100	1	2	4
2012	47	1	2	2
2017	100	1	2	3
2022	85	1	2	4
2026	100	1	1	3
Lake Manapōuri				
1993	70	1	2	5
1997	90	1	2	2
2002	100	1	2	5
2007	90	1	2	4
2008	100	2	3	5
2010	100	1	2	2
2012	60	2	3	5
2017	92	2	3	5
2022	75	1	2	4
2026	83	2	3	4
Lake Hauroko				
1993	56	1	1	3
1997	56	1	1	2
2002	56	1	1	2
2007	56	1	2	2
2008	75	1	1	3
2010	78	1	2	2
2012	33	1	2	3
2017	75	1	2	4
2022	67	1	2	3
2026	100	1	1	1

Lilaeopsis ruthiana



Figure C-13: *Lilaeopsis ruthiana*. Note the five lobed flowers (left) and underwater foliage (right).

Lilaeopsis ruthiana (Figure C-13) occupied an elevation range of 1.0 m in Lake Te Anau, 0.8 m in Lakes Manapōuri and Hauroko (between 25th and 75th percentiles) (Figure C-14 to Figure C-16).

There were no significant differences in the upper or lower elevation limits of *L. ruthiana* in the three lakes between 2022 and 2026.

Frequency of *L. ruthiana* occurrence was less in Lake Te Anau (8 sites in 2026 compared with 10 sites in 2022) but more than 2022 in Lake Hauroko (8 and 5) and the same frequency in Lake Manapōuri (10 sites) (Figure C-14 to Figure C-16).

Median maximum cover of *L. ruthiana* reduced from a class 2 cover to a class 1 cover in all lakes between 2022 and 2026 (Table C-4).

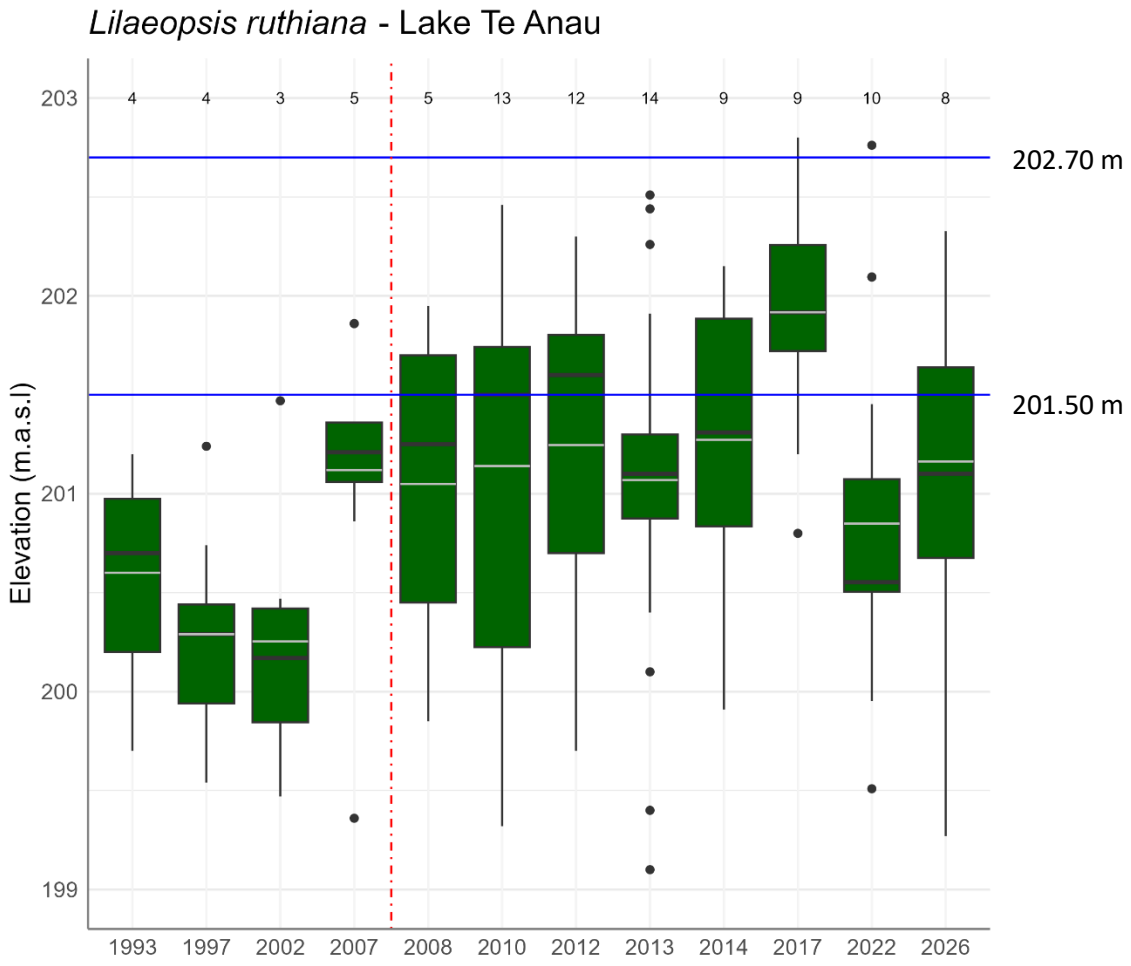


Figure C-14: Lake-wide elevation ranges of *Lilaeopsis ruthiana* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

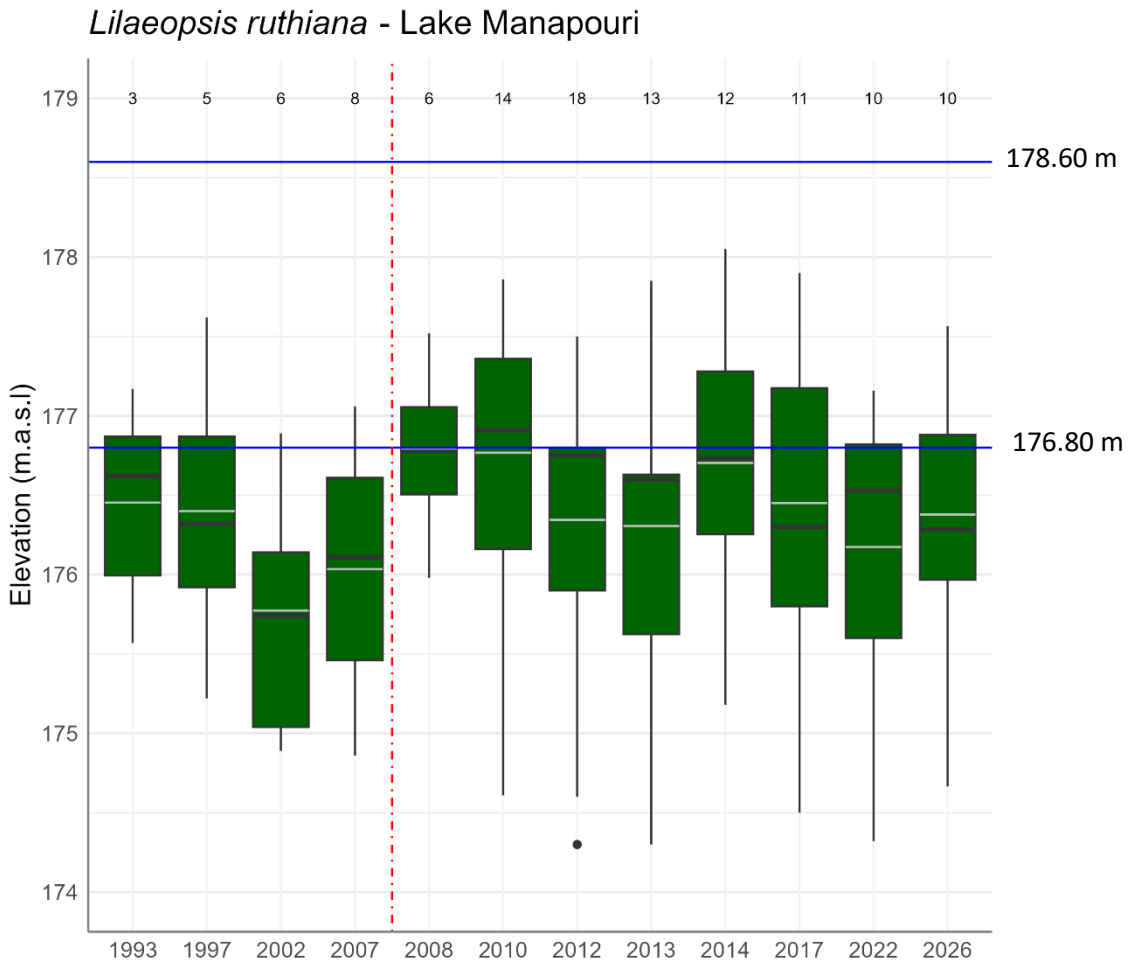


Figure C-15: Lake-wide elevation ranges of *Lilaeopsis ruthiana* in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

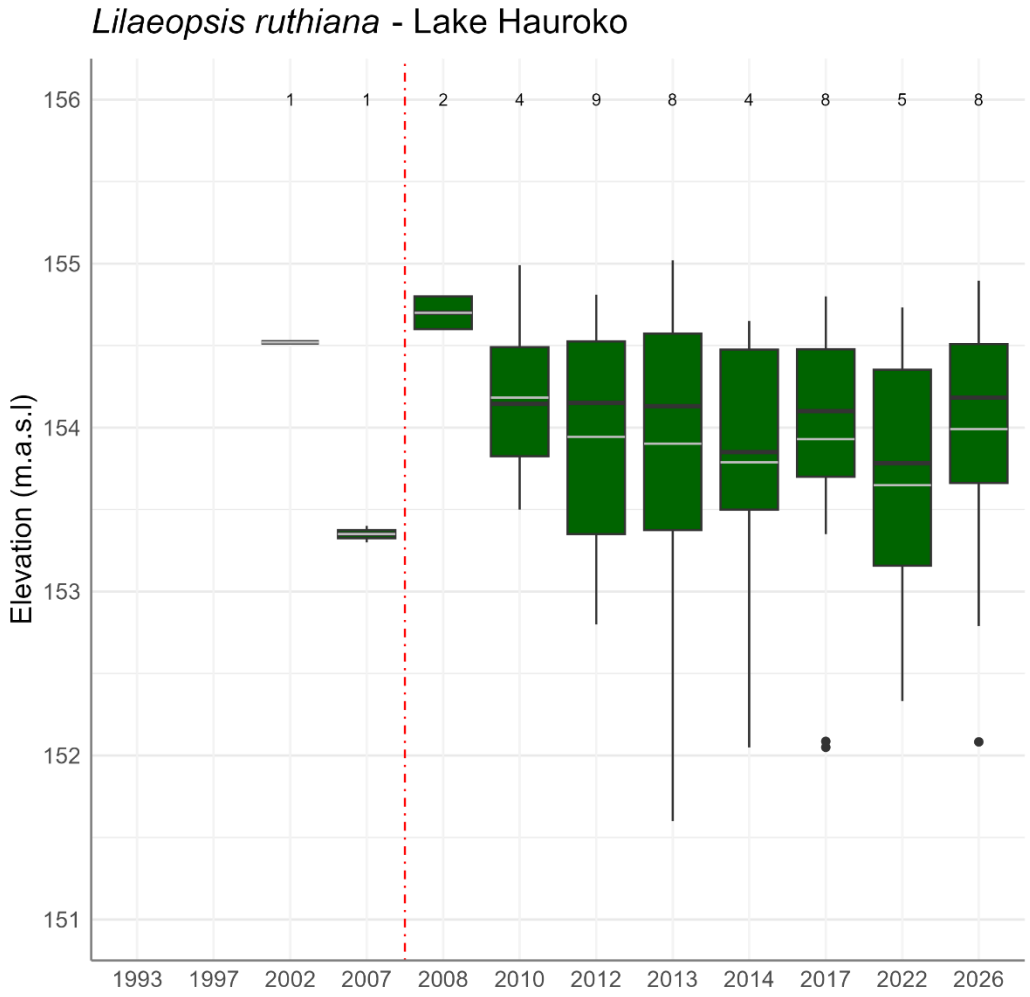


Figure C-16: Lake-wide elevation ranges of *Lilaeopsis ruthiana* in Lake Hauroko 1993-2026. Red dotted line indicates where surveys changed to include plants above water line.

Table C-4: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Lilaeopsis ruthiana* in the three lakes from 1993-2026. Cover ranges are - = not recorded, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	40	1	2	2
1997	30	1	1	3
2002	30	1	1	3
2007	50	1	1	3
2008	83	1	1	2
2010	100	1	2	4
2012	73	1	2	2
2017	50	1	2	2
2022	77	1	2	3
2026	67	1	1	4
Lake Manapōuri				
1993	20	1	2	2
1997	50	1	1	3
2002	60	1	1	2
2007	80	1	2	3
2008	83	1	1	2
2010	100	1	2	3
2012	93	1	2	3
2017	92	1	2	5
2022	83	1	2	4
2026	100	1	1	2
Lake Hauroko				
1993	-			
1997	-			
2002	11	1	1	1
2007	11	1	1	1
2008	50	1	1	1
2010	89	1	1	3
2012	53	1	2	2
2017	58	1	2	3
2022	56	1	2	3
2026	100	1	1	2

Pilularia novae-hollandiae



Figure C-17: *Pilularia novae-hollandiae*. Note the sporangia at the base of fronds (left) and dense sward on Holmwood Island, Lake Manapōuri (right).

Pilularia novae-hollandiae (Figure C-17) occupied an elevation range of 0.8 m in Lake Te Anau, 1.0 m in Lake Manapōuri and 0.1 m in Lake Hauroko (between 25th and 75th percentiles) (Figure C-18 to Figure C-20).

There were no significant differences in the upper or lower elevation limits of *P. novae-hollandiae* in the three lakes between 2022 and 2026.

Frequency of *P. novae-hollandiae* occurrence had increased in Lake Manapōuri (12 sites in 2026 compared with 9 sites in 2022) but reduced in Lakes Hauroko (1 and 3) and Te Anau (5 and 9) (Figure C-18 to Figure C-20).

Median maximum cover of *P. novae-hollandiae* was lower in 2026 compared with 2022 (Table C-5).

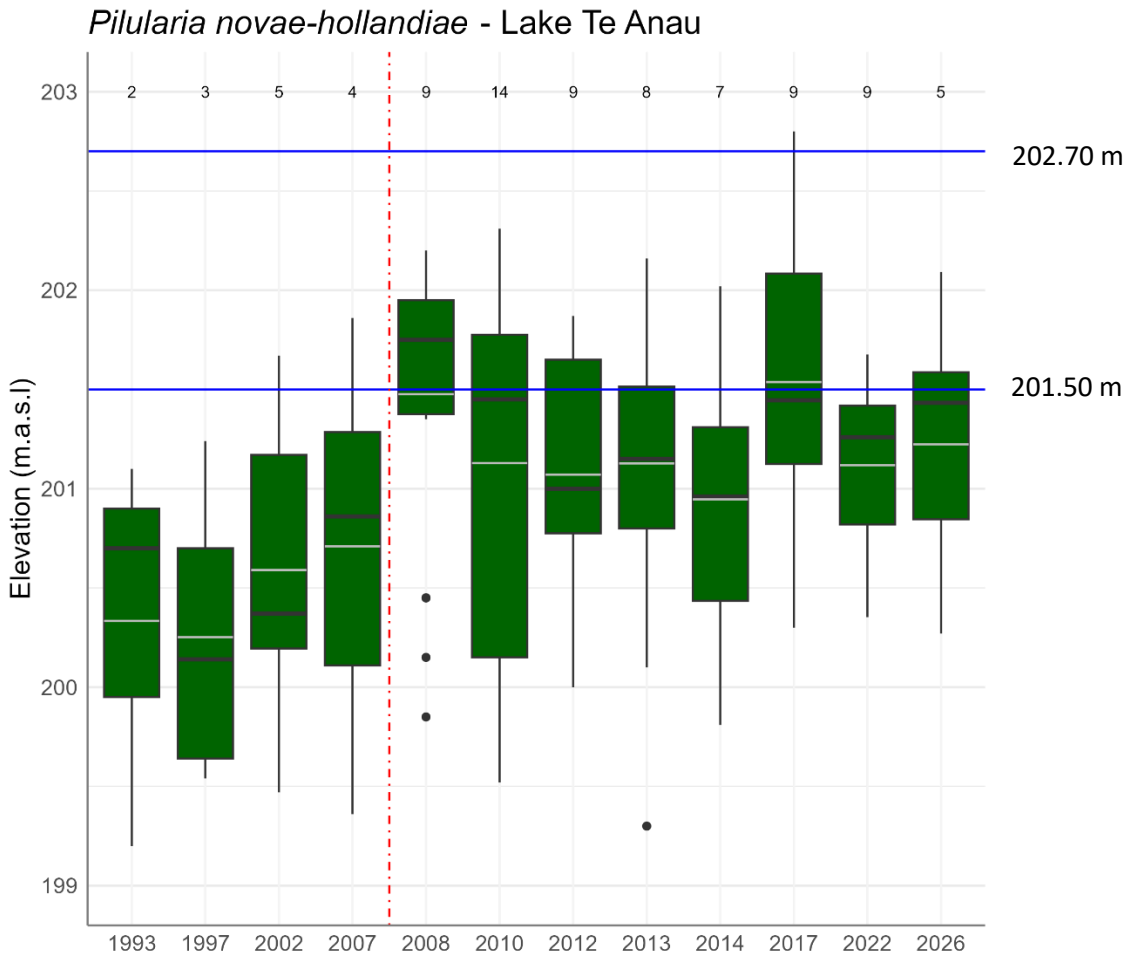


Figure C-18: Lake-wide elevation ranges of *Pilularia novae-hollandiae* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

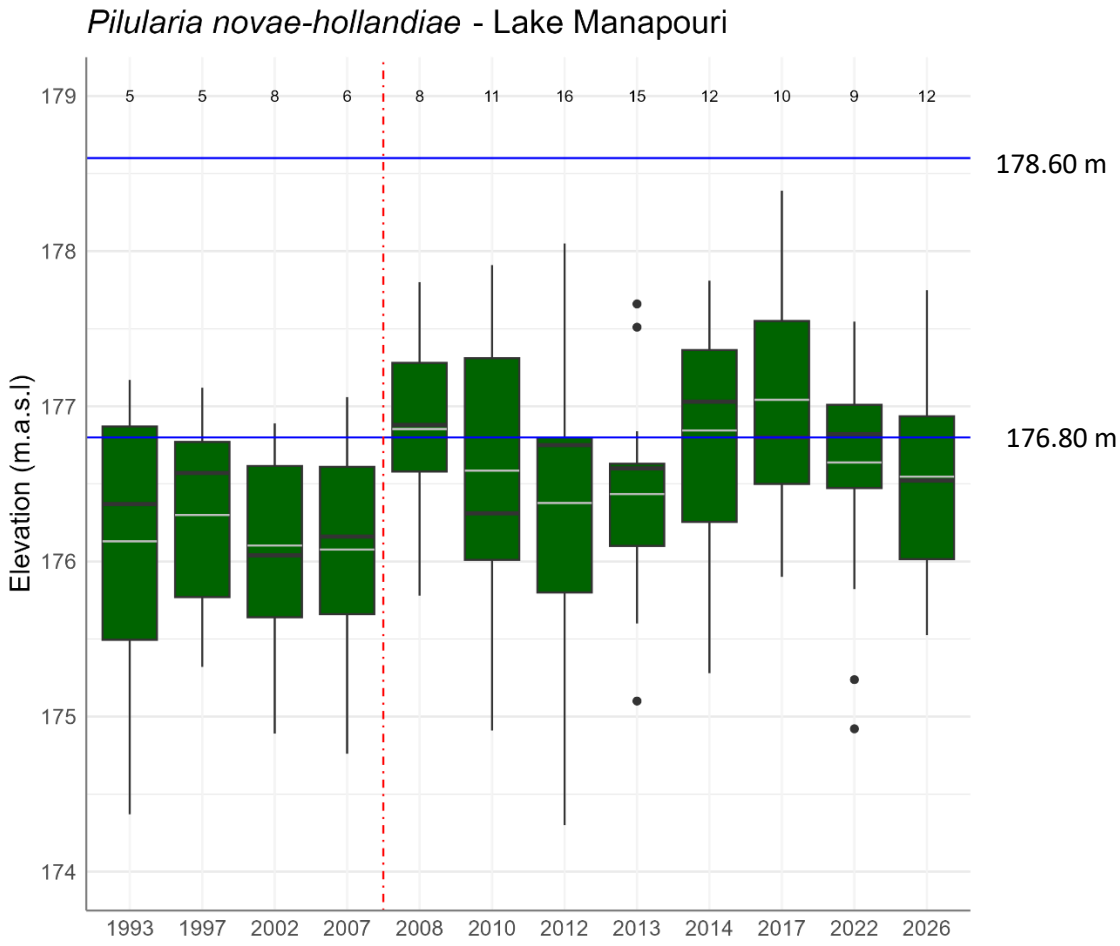


Figure C-19: Lake-wide elevation ranges of *Pilularia novae-hollandiae* in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

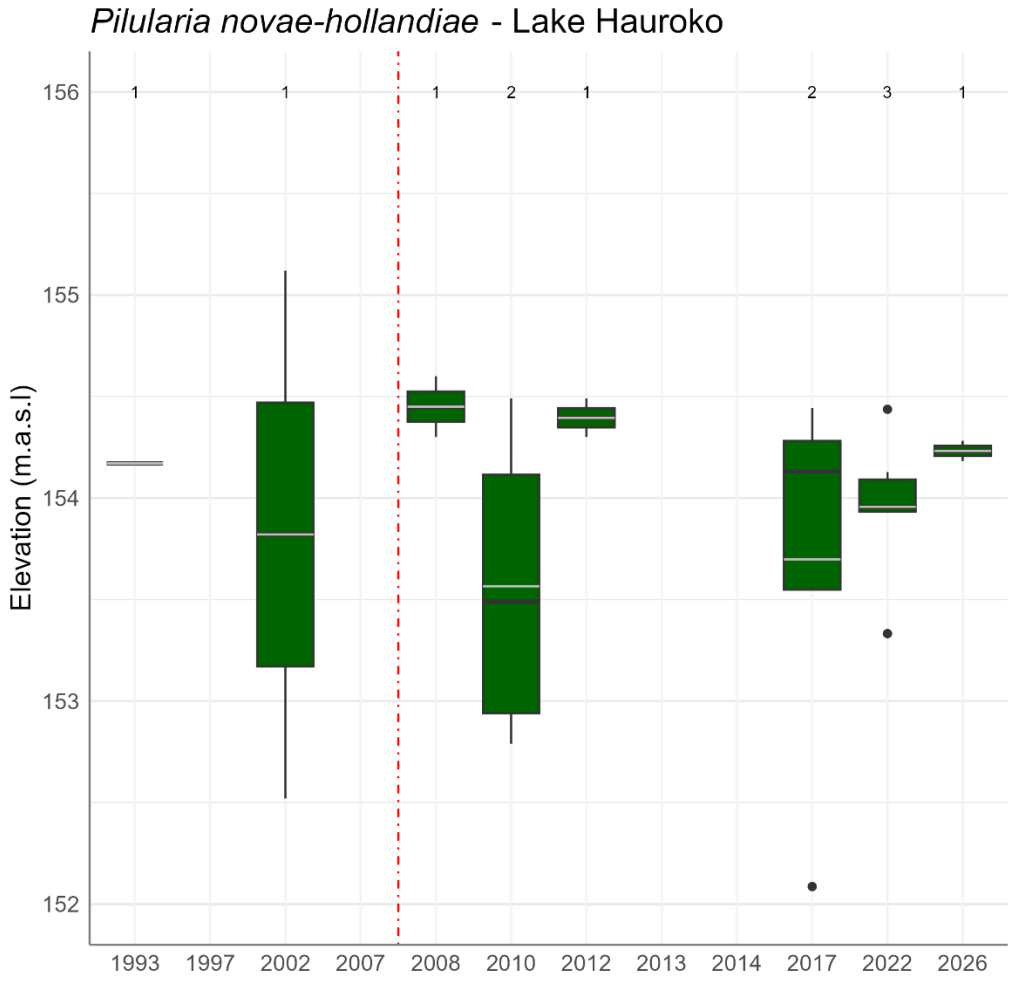


Figure C-20: Lake-wide elevation ranges of *Pilularia novae-hollandiae* in Lake Hauroko 1993-2026. Red dotted line indicates where surveys changed to include plants above water line.

Table C-5: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Pilularia novae-hollandiae* in the three lakes from 1993-2026. Cover ranges are - = not recorded, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	20	1	1	4
1997	20	1	1	4
2002	50	1	3	4
2007	40	2	2	3
2008	100	1	2	3
2010	100	1	2	5
2012	47	2	3	6
2017	57	1	2	4
2022	69	1	2	5
2026	50	1	1	5
Lake Manapōuri				
1993	50	3	3	3
1997	50	1	2	3
2002	80	1	3	5
2007	60	1	2	5
2008	100	2	3	4
2010	100	2	3	5
2012	87	2	3	3
2017	83	2	3	6
2022	75	2	3	5
2026	83	1	1	2
Lake Hauroko				
1993	11	1	1	1
1997	-			
2002	-			
2007	-			
2008	25	1	1	1
2010	44.4	1	1	2
2012	7	2	2	2
2017	17	1	2	2
2022	33	1	2	3
2026	25	1	1	1

Ranunculus limosella



Figure C-21: *Ranunculus limosella*. Note the four-petalled flower on an emergent plant (left) and the typical submerged form (right).

Ranunculus limosella (Figure C-21) occupied an elevation range of 0.76 m in Lake Te Anau, 1.2 m in Lake Manapōuri and 0.6 m in Lake Hauroko (between 25th and 75th percentiles) (Figure C-22 to Figure C-24).

There were no significant differences in the upper or lower elevation limits of *R. limosella* in the three lakes between 2022 and 2026.

Frequency of *R. limosella* occurrence was greater in 2026 than 2022 in Lakes Manapōuri (12 sites in 2026 compared with 6 sites in 2022) and Hauroko (3 and 2), whereas there were 5 occurrences on both occasions in Lake Te Anau (Figure C-22 to Figure C-24).

Median average cover of *R. limosella* did not vary between 2026 and 2022, but median maximum cover decreased in Lakes Te Anau and Manapōuri from cover class 2 in 2022 to cover class 1 in 2026 but was the same cover in Lake Hauroko (Table C-6).

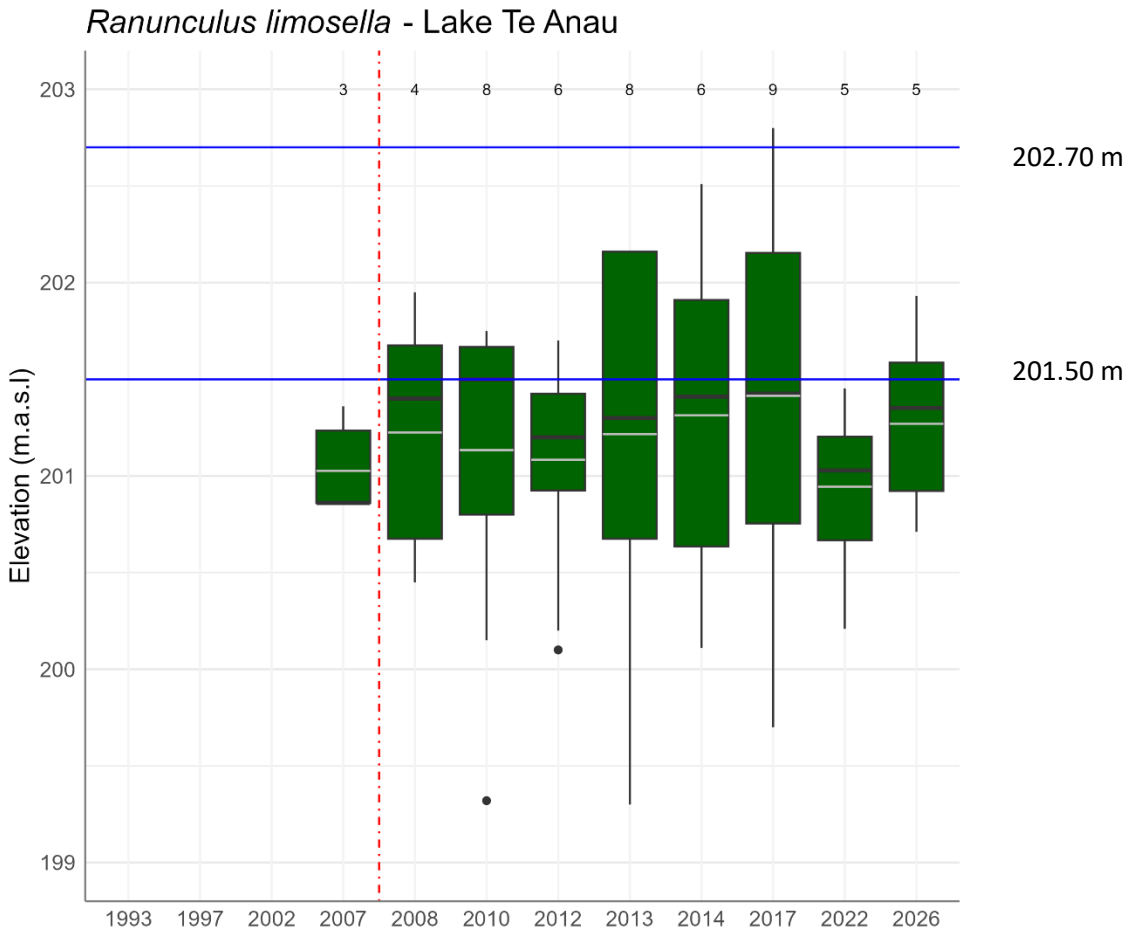


Figure C-22: Lake-wide elevation ranges of *Ranunculus limosella* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

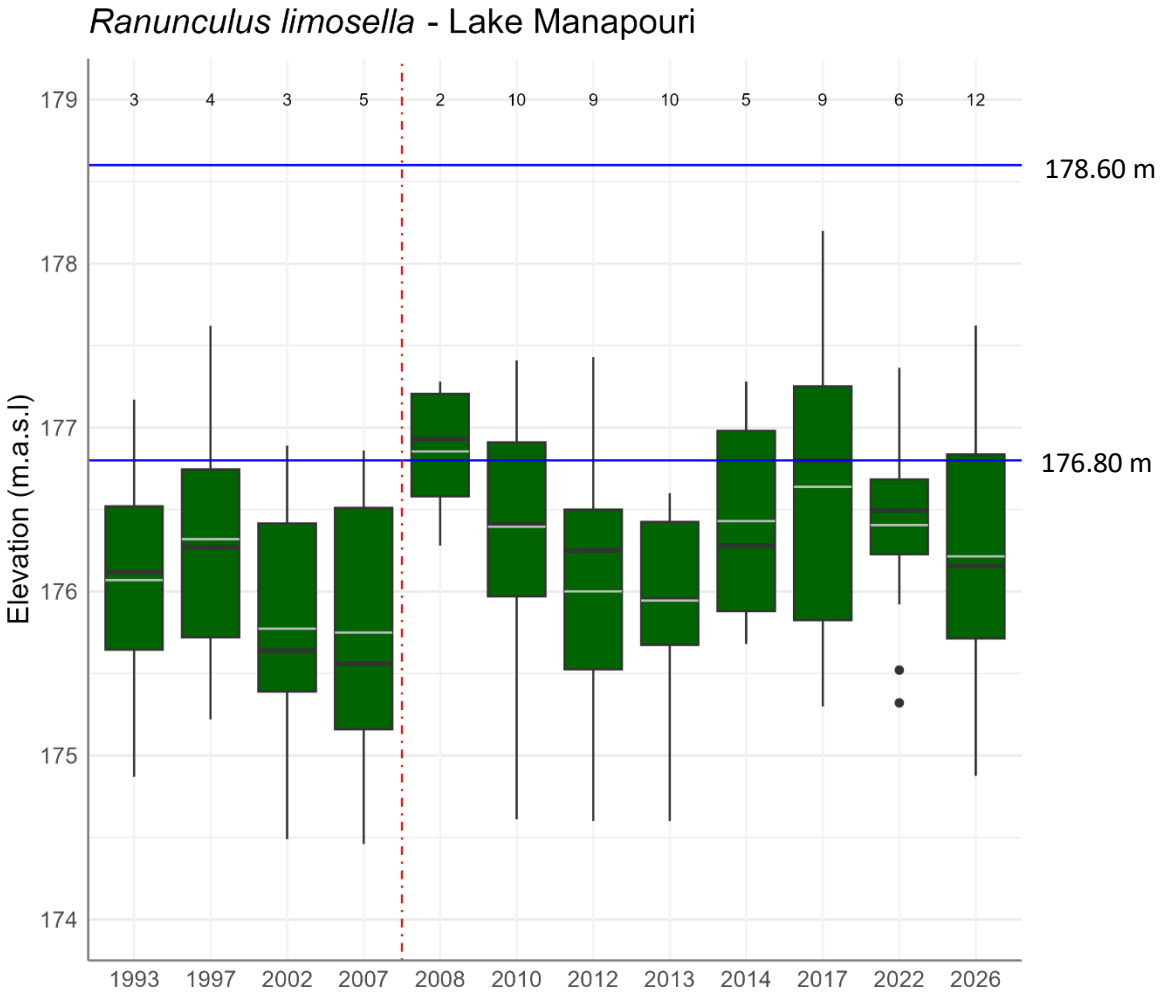


Figure C-23: Lake-wide elevation ranges of *Ranunculus limosella* in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines. Red dotted line indicates where surveys changed to include plants above water line.

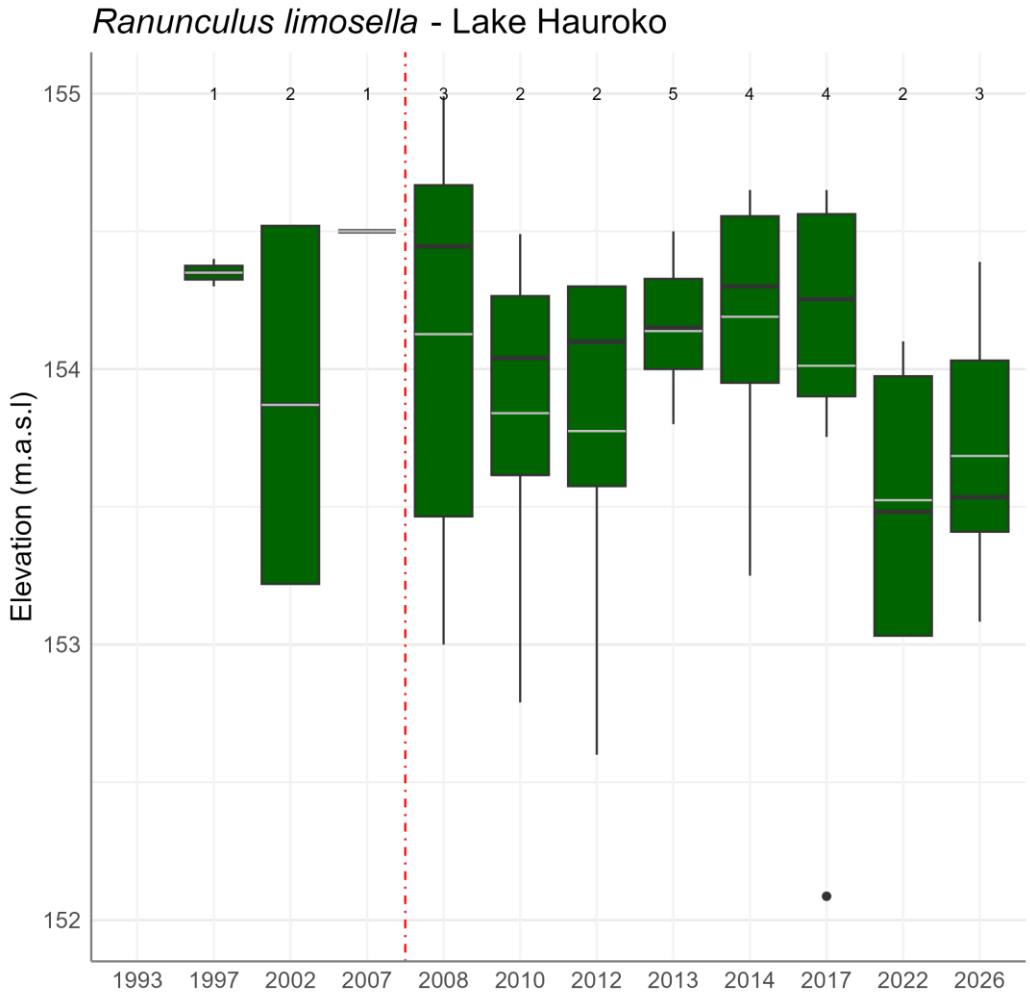


Figure C-24: Lake-wide elevation ranges of *Ranunculus limosella* in Lake Hauroko 1993-2026. Red dotted line indicates where surveys changed to include plants above water line.

Table C-6: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Ranunculus limosella* in three lakes from 1993-2026. Cover ranges are - = not recorded, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	-			
1997	-			
2002	-			
2007	30	1	1	1
2008	67	1	1	2
2010	80	1	1	2
2012	33	1	2	2
2017	36	1	1	2
2022	38	1	2	3
2026	50	1	1	3
Lake Manapōuri				
1993	30	1	2	2
1997	40	1	1	2
2002	30	1	1	2
2007	50	1	1	2
2008	17	2	2	2
2010	100	1	2	3
2012	47	1	1	5
2017	83	1	1	2
2022	50	1	2	2
2026	83	1	1	2
Lake Hauroko				
1993	-			
1997	11	1	1	1
2002	22	1	1	1
2007	11	1	1	1
2008	25	1	1	1
2010	67	1	1	1
2012	20	1	2	3
2017	33	1	2	2
2022	22	1	1	1
2026	27	1	1	2

Other turf species

Frequency of occurrence data for all turf species are presented in Table C-7, expressed as percentage of sites where turf species were recorded in each of the three lakes from 2008-2026.

Table C-7: Frequency of occurrence (expressed as % of sites for each lake) for each turf species in the three lakes from 2008-2026 In 2008 only six turf sites were surveyed in Lakes Te Anau and Manapōuri and 4 turf sites in Lake Hauroko. + - present just outside of one transect. Total number of species includes those dealt with earlier in Appendix C. § non-indigenous species. ¥ threatened or at-risk species[6]. *Isoetes alpina* and *Myriophyllum propinquum* are excluded from the turf data in this table. Blanks indicate a species that has never been recorded from transects in that lake, 0 is used when a species was not recorded on that date but had been found on at least one occasion in that lake.

Species	Lake Te Anau						Lake Manapōuri						Lake Hauroko					
Year	08	10	12	17	22	26	08	10	12	17	22	26	08	10	12	17	22	26
Azorella cockaynei	50	50	50	43	31	33	50	10	60	17	42	16	0	0	0	8	0	0
¥*Cardamine lacustris*	0	20	0	0	23	8	0	0	0	0	0	5						
Carex gaudichaudiana	83	70	80	43	46	50	83	30	70	17	58	33	25	11	0	17	11	13
Carex flaviformis							0	0	0	0	8	0						
¥*Carex talbotii*	17	30	30	14	15	17	67	40	50	8	33	5						
Centella uniflora	0	0	0	0	8	8	0	20	20	0	0	0						
¥*Centrolepis glabra*	17	20	20	14	8	0	0	10	0	0	8	0						
Coprosma petriei	0	0	0	0	8	0	0	0	0	0	8	0						
¥*Crassula ruamahanga*	0	0	0	0	8	0												
Crassula sinclairii	17	40	40	14	31	0	0	30	30	0	25	5	0	0	0	0	11	0
Eleocharis acuta	83	100	80	36	46	50	0	0	0	25	75	32	0	11	22	8	11	9
Eleocharis gracilis							0	0	0	0	0	16						
Eleocharis pusilla	0	30	20	14	15	8	67	20	20	17	25	11	50	11	30	17	22	25
¥*Epilobium angustum*							0	0	0	0	8	0						
Epilobium komarovianum							0	10	20	+	0	0	0	0	0	0	11	13
Epilobium brunnescens	0	0	10	0	0	0												
Galium perpusillum	17	20	0	0	8	8	0	0	0	0	25	5						

[6] After de Lange et al. (2024)

Species	Lake Te Anau						Lake Manapōuri						Lake Hauroko					
Year	08	10	12	17	22	26	08	10	12	17	22	26	08	10	12	17	22	26
Gentianella grisebachii	17	10	10	0	8	+												
Glossostigma cleistanthum	0	0	0	0	8	33	0	0	0	0	8	26	0	0	0	0	33	75
Glossostigma elatinoides	0	0	0	21	0	8	0	0	0	25	8	0						
Gonocarpus incana	0	0	20	0	0	0												
Gonocarpus micrantha	0	0	10	0	15	17												
Goodenia radicata	50	20	60	29	38	17	17	20	40	8	8	0						
Gratiola sexdentata	50	70	80	29	31	33	100	60	80	33	58	32	25	22	22	8	11	25
Gunnera dentata	33	20	20	14	15	17	50	10	20	8	25	0						
Hydrocotyle hydrophila	50	70	80	43	46	50	67	40	90	25	58	21	25	11	11	17	22	25
Hydrocotyle novae-zelandiae var. *montana*	17	10	30	29	15	17	0	0	0	0	17	0						
§*Hypochaeris radicata*	0	0	10	7	8	8												
Isolepis aucklandicus	0	0	30	43	31	33	0	0	30	25	25	11	0	0	10	17	11	13
¥*Isolepis basilaris*							0	0	20	0	8	0						
Isolepis habra	0	0	0	0	8	0							0	0	20	0	11	0
§*Juncus articulatus*	0	0	0	0	38	17	0	0	0	0	25	0	0	0	0	0	11	+
§*Juncus bufonius*							0	0	0	0	8	5						
Juncus novae-zelandiae	0	0	20	0	15	0	0	0	0	0	17	0	0	0	20	0	0	25
¥*Juncus pusillus*	67	50	30	43	23	25	67	40	50	8	16	16	0	11	0	8	0	13
Lachnagrostis striata	100	60	80	43	46	50	17	30	80	17	58	26	25	22	33	17	22	38
Lagenophora petiolata	0	0	10	0	0	0	0	0	0	0	8	0						
§*Leontodon saxatilis*	17	20	20	0	0	8							25	11	0	0	11	13
¥*Leptinella maniototo*	50	20	30	14	8	25	67	10	70	17	33	5						
Leptinella squalida subsp. *medianus*	83	40	30	29	15	17	67	30	40	17	58	11						

Species	Lake Te Anau						Lake Manapōuri						Lake Hauroko					
Year	08	10	12	17	22	26	08	10	12	17	22	26	08	10	12	17	22	26
Limosella australis	50	50	0	14	23	17	11	44	0	27	25	16	41	41	0	25	22	13
Lobelia angulata	17	20	10	14	15	0	0	10	30	0	25	0	25	11	0	8	11	13
¥*Lobelia ionantha*	33	70	10	36	38	42	50	50	80	25	58	26	25	11	0	0	0	0
Lobelia perpusilla	0	0	0	0	38	8	33	30	20	0	33	5	0	11	0	0	0	0
§*Lotus pedunculatus*	33	20	30	14	23	+	0	0	0	0	25	0	0	11	11	8	22	13
§*Lythrum portula*							0	0	20	0	8	+						
¥*Montia angustifolia*	0	0	10	0	8	0	0	0	20	0	0	0	0	0	10	0	0	0
Myosotis laxa subsp. *caespitosa*	0	0	0	0	8	17	0	0	0	0	8	0						
Myriophyllum pedunculatum subsp. *novae-zelandiae*	17	10	20	14	54	33	0	30	60	8	67	16	0	11	22	17	44	38
Myriophyllum votschii	17	22	40	7	15	0	33	20	20	17	25	0	25	11	11	0	0	25
Nertera depressa	0	0	0	0	8	0												
Ophioglossum coriaceum							33	10	10	8	8	0						
Oxalis exilis							0	0	10	0	0	0						
Persicaria hydropiper							0	0	0	0	8	0						
Plantago triandra	83	80	60	43	38	42	17	40	70	33	50	26						
§*Prunella vulgaris*	17	10	10	0	15	+	0	0	0	0	8	0	25	11	0	0	0	13
Ranunculus glabrifolius	0	0	0	0	8	+												
¥*Ranunculus ranceorum*	0	0	0	43	8	25	17	10	50	17	33	5						
Rorippa palustris							0	0	0	0	8	0						
Sagina procumbens	0	0	10	0	0	0												
Schoenus maschalinus							0	0	10	0	0	5						
¥*Tetrachondra hamiltonii*	0	0	10	0	0	0												
Triglochin striata	33	50	60	43	46	25	83	70	80	17	50	37	25	44	44	8	11	63

Species		Lake Te Anau						Lake Manapōuri						Lake Hauroko					
	Year	08	10	12	17	22	26	08	10	12	17	22	26	08	10	12	17	22	26
¥*Trithuria brevistyla*		0	40	30	21	15	0	0	0	0	8	17	5	50	89	22	83	67	75
Utricularia dichotoma		17	70	80	43	31	42	0	70	20	25	50	21						
Viola filicaulis		50	20	40	14	31	13	33	10	30	0	25	0	0	0	0	0	0	13
Total number of turf spp.		**36**	**39**	**45**	**40**	**56**	**45**	**29**	**36**	**41**	**34**	**53**	**37**	**17**	**23**	**20**	**22**	**26**	**28**

Appendix D Tall vascular plants

Previous consent monitoring reports presented data comparing elevation ranges, number of sites occupied and median and maximum covers of the invasive elodea, the native *Isoetes alpina*, and aggregated data for milfoils (*Myriophyllum* spp.) and pondweeds (*Potamogeton* spp.) and the same approach is followed here. The following sections outline these data for each species.

Elodea canadensis



Figure D-1: *Elodea canadensis*. Lake Manapōuri at 4.9 m depth.

Elodea (*Elodea canadensis,* Figure D-1) was not found in Lake Hauroko.

Elodea remains the dominant introduced weed in the submerged vegetation of Lakes Te Anau and Manapōuri. It occupied an elevation range of 3.8 m in Lake Te Anau and 5.0 m in Lake Manapōuri (between 25th and 75th percentiles).

The lower (maximum depth) elevation limit of elodea differed significantly (becoming shallower) in Lake Manapōuri between 2022 and 2026 (Table 3-7, Figure D-3). There were no significant differences in the upper or lower elevation limits of elodea Lake Te Anau between 2022 and 2026 (Table 3-7).

Frequency of elodea occurrence was similar in Lake Te Anau (13 sites in 2026 compared with 12 sites in 2022) and Lake Manapōuri (14 and 10) (Figure D-2 and Figure D-3).

Median maximum cover of elodea had declined from a class 4 to class 3 cover in Lake Manapōuri but did not vary between 2026 and 2022 in Lake Te Anau (Table D-1).

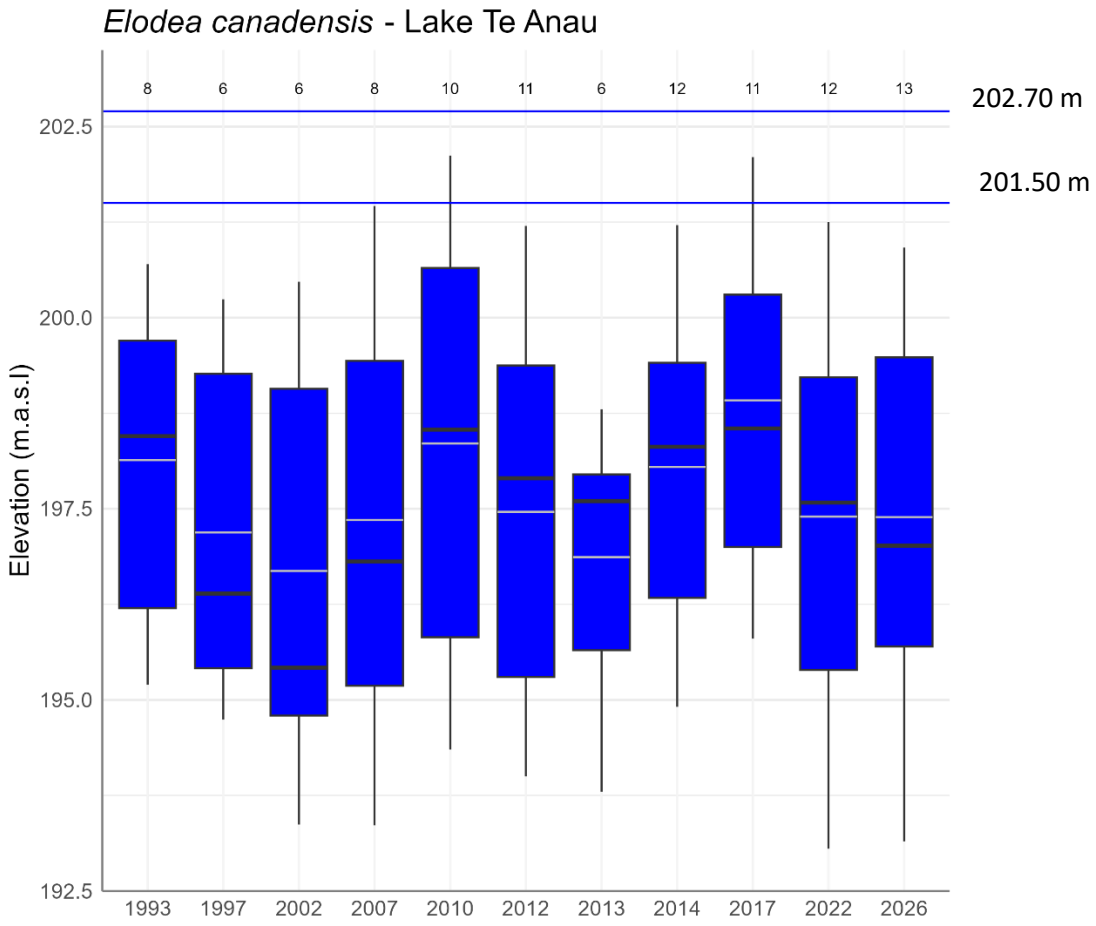


Figure D-2: Lake-wide elevation ranges of *Elodea canadensis* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines.

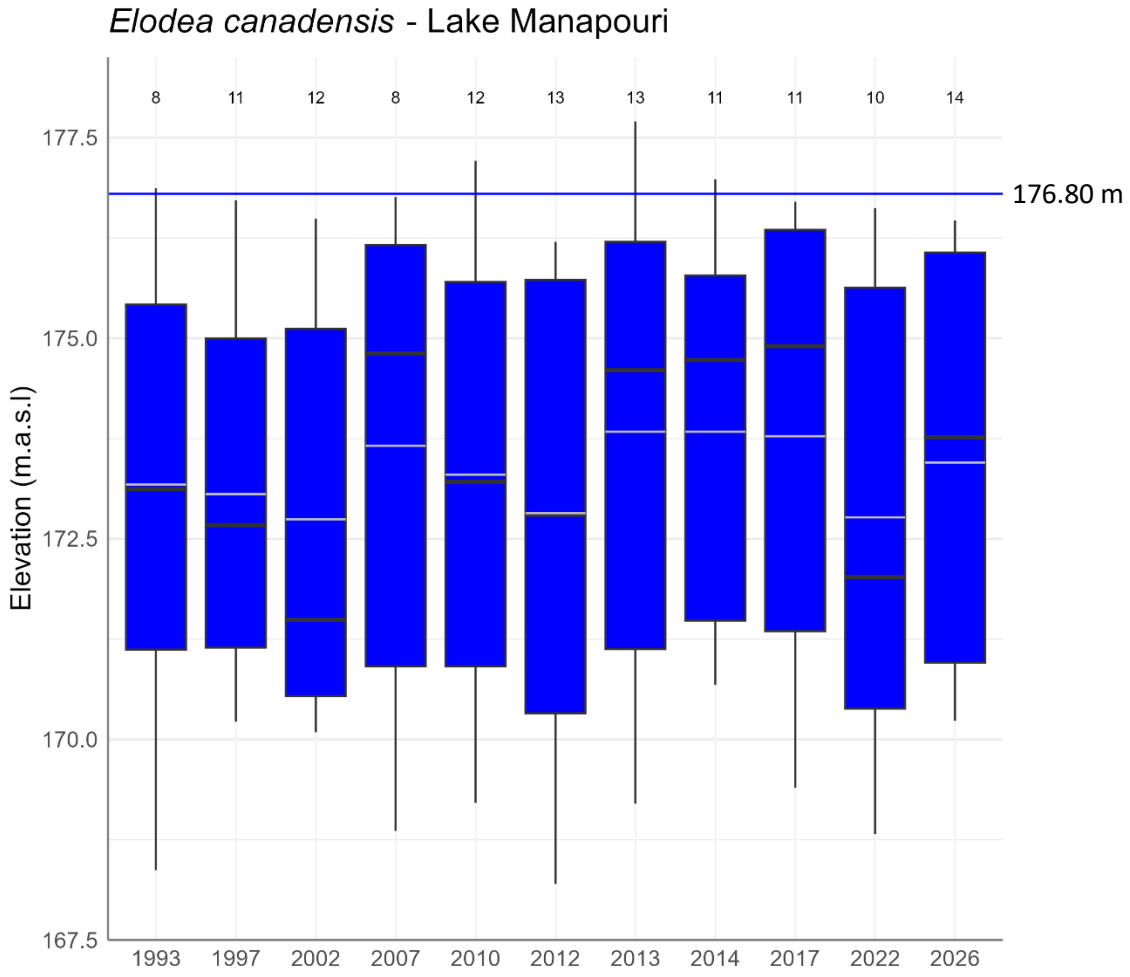


Figure D-3: Lake-wide elevation ranges of *Elodea canadensis* in Lake Manapōuri 1993-2026.
Gazetted guidelines main lake level operating range (lower range) is indicated by a horizontal blue line.

Table D-1: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Elodea canadensis* in Lakes Te Anau and Manapōuri from 1993-2026. Cover ranges are - 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	47	4	5	6
1997	40	2	4	6
2002	53	3	4	5
2007	54	1	2	5
2010	67	3	4	6
2012	73	3	3	5
2017	79	2	3	6
2022	80	2	3	6
2026	87	2	3	5
Lake Manapōuri				
1993	62	1	2	6
1997	73	2	5	6
2002	93	2	3	6
2007	62	1	4	5
2010	86	2	5	6
2012	87	3	4	6
2017	79	2	4	6
2022	67	2	4	6
2026	93	2	3	5

Isoetes alpina



Figure D-4: *Isoetes alpina*. Forming a dense turf at 2 m depth in Lake Hauroko.

Isoetes alpina (Figure D-4) formed a distinct band of vegetation at several transects in each lake, between the lower extent of shorter turf vegetation and taller vascular or characean species. It occupied an elevation range of 1.5 m in Lake Te Anau, 1.7 m in Lake Manapōuri and 2.5 m in Lake Hauroko (between 25th and 75th percentiles) In 2022, *I. alpina* occupied an elevation range of 1.1 m in Lakes Te Anau and Manapōuri and 3.5 m in Lake Hauroko (Figure D-5 to Figure D-7).

There were no significant differences in the upper or lower elevation limits of *I. alpina* in the three lakes between 2022 and 2026 (Figure D-5 to Figure D-7).

Frequency of *I. alpina* occurrence was higher in 2026 compared with 2022 in all three lakes: Lake Te Anau (12 sites in 2026 compared with 8 sites in 2022), Lake Manapōuri (17 (15 excluding new submerged sites) and 7) and Lake Hauroko (13 and 10) (Figure D-5 to Figure D-7).

Median average and median maximum cover of *I. alpina* increased between 2022 and 2026 in all lakes. Median average cover increased from cover class 1 to 2 and median maximum cover from class 1 to 3 in Lake Te Anau, median average cover increased from class 1 to 3 and median maximum cover from class 2 to 4 in Lake Manapōuri and median average cover increased from class 2 to 3 and median maximum cover from class 4 to 5 in Lake Hauroko (Table D-2).

Thus, frequency of occurrence and cover of *I. alpina* had increased in all of the monitored lakes.

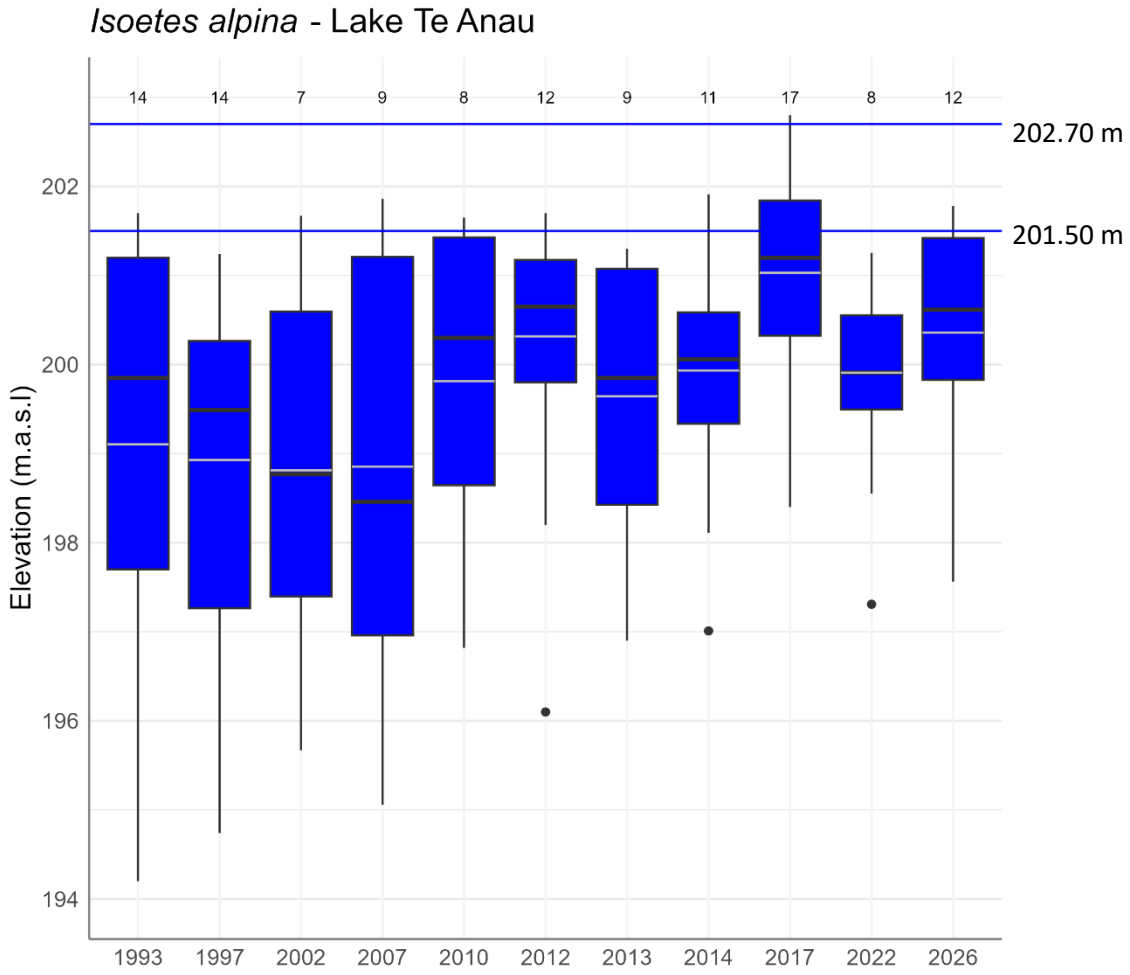


Figure D-5: Lake-wide elevation ranges of *Isoetes alpina* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines.

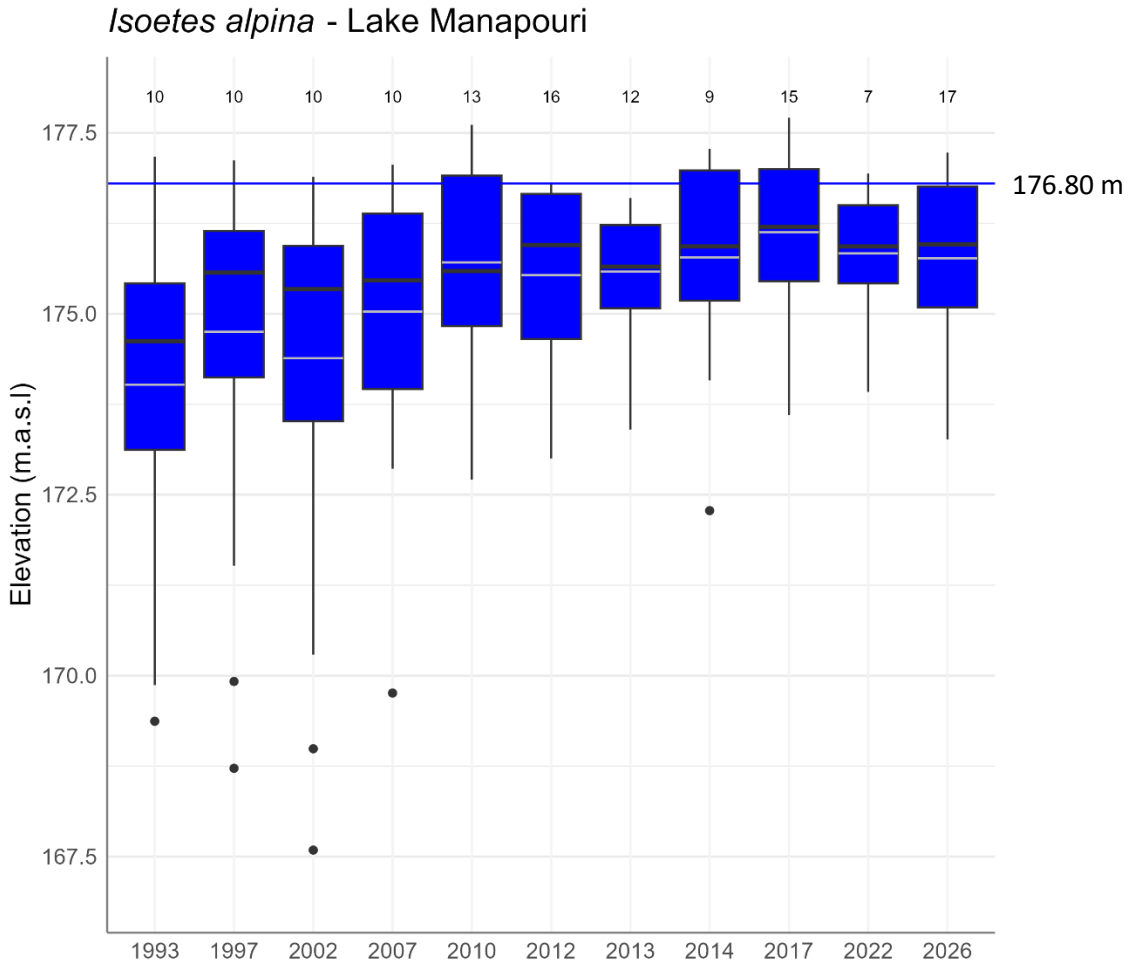


Figure D-6: Lake-wide elevation ranges of *Isoetes alpina* in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range (lower range) is indicated by a horizontal blue line.

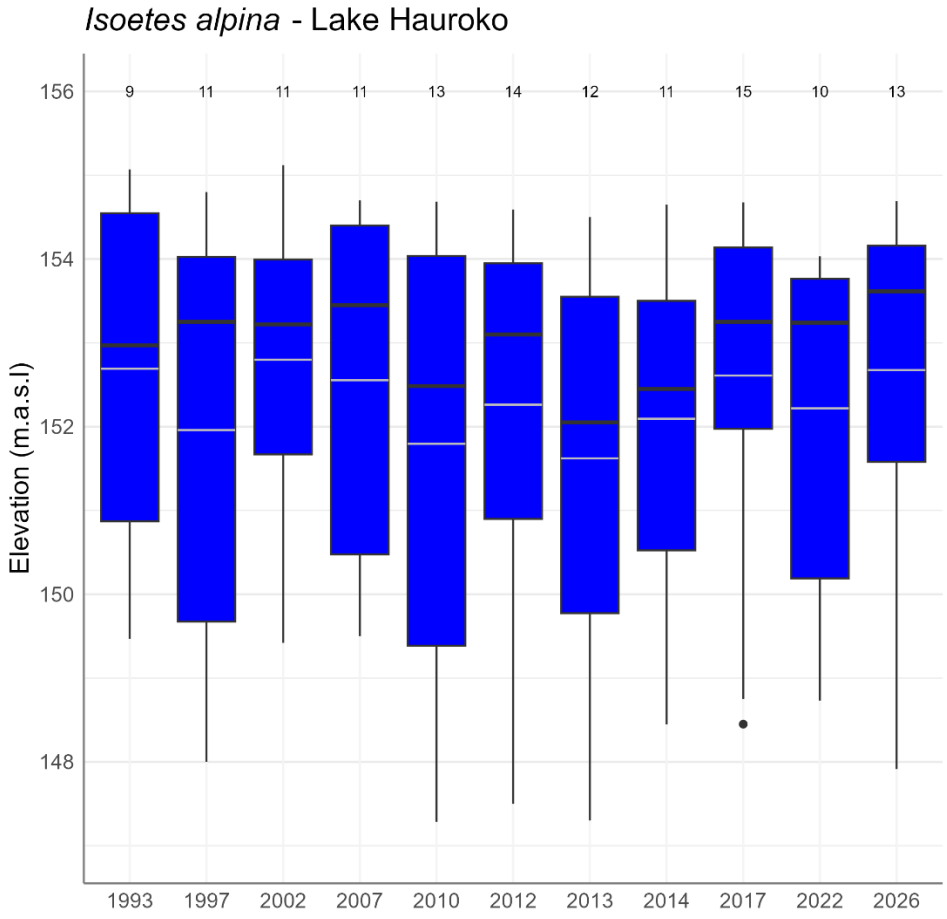


Figure D-7: Lake-wide elevation ranges of *Isoetes alpina* in Lake Hauroko 1993-2026.

Table D-2: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Isoetes alpina* in all three lakes from 1993-2026 . Cover ranges are; 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	80	3	5	6
1997	87	1	2	6
2002	53	2	3	6
2007	69	1	3	5
2010	53	1	2	2
2012	67	1	2	5
2017	71	2	3	6
2022	53	1	1	5
2026	53	2	3	5
Lake Manapōuri				
1993	76	3	3	6
1997	67	1	2	5
2002	80	1	1	3
2007	85	1	2	4
2010	93	1	2	6
2012	80	2	3	5
2017	71	2	2	6
2022	47	1	2	6
2026	73	3	4	6
Lake Hauroko				
1993	69	4	6	6
1997	77	4	5	6
2002	85	2	5	6
2007	85	2	6	6
2010	100	5	6	6
2012	73	4	5	6
2017	85	4	5	6
2022	77	2	4	6
2026	77	3	5	6

Myriophyllum species

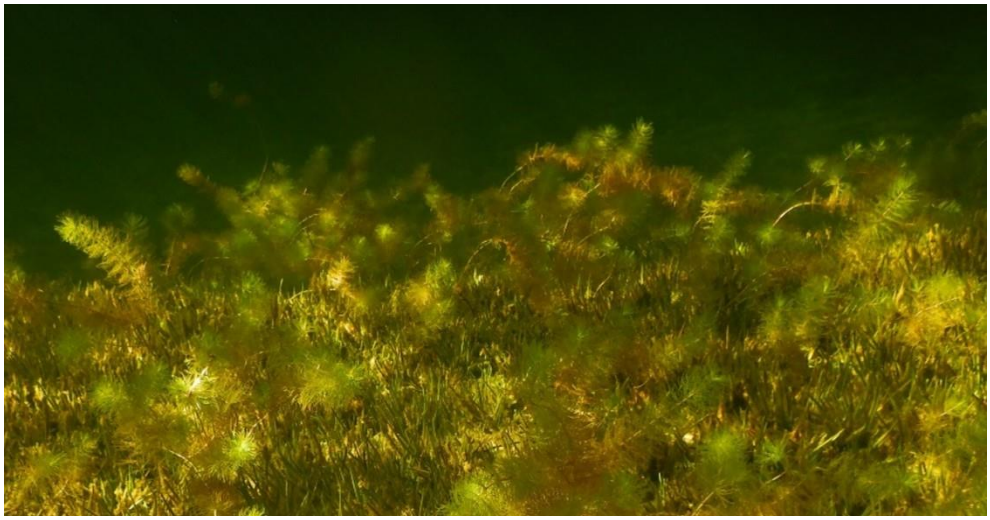


Figure D-8: *Myriophyllum triphyllum*. Growing associated with *Isoetes alpina* at 1 m depth in Lake Hauroko.

Milfoils (*Myriophyllum* spp.) (Figure D-8) were found mainly in shallow water in many transects in each lake. They occupied an elevation range of 1.1 m in Lake Te Anau, 1.2 m in Lake Manapōuri and 2.8 m in Lake Hauroko (between 25th and 75th percentiles) (Figure D-9 to Figure D-11).

There were no significant differences in the upper or lower elevation limits of *I. alpina* in the three lakes between 2022 and 2026 (Figure D-5 to Figure D-7).

Frequency of milfoils occurrence was lower in 2026 compared with 2022 in Lake Te Anau (6 sites in 2026 compared with 7 sites in 2022), but higher in Lakes Manapōuri (10 and 7) and Lake Hauroko (8 and 5).

Median and median maximum cover of milfoils were similar between 2022 and 2026, with both species (*M. propinquum* and *M. triphyllum*) occurring at low cover values (Table D-3 and Table D-4).

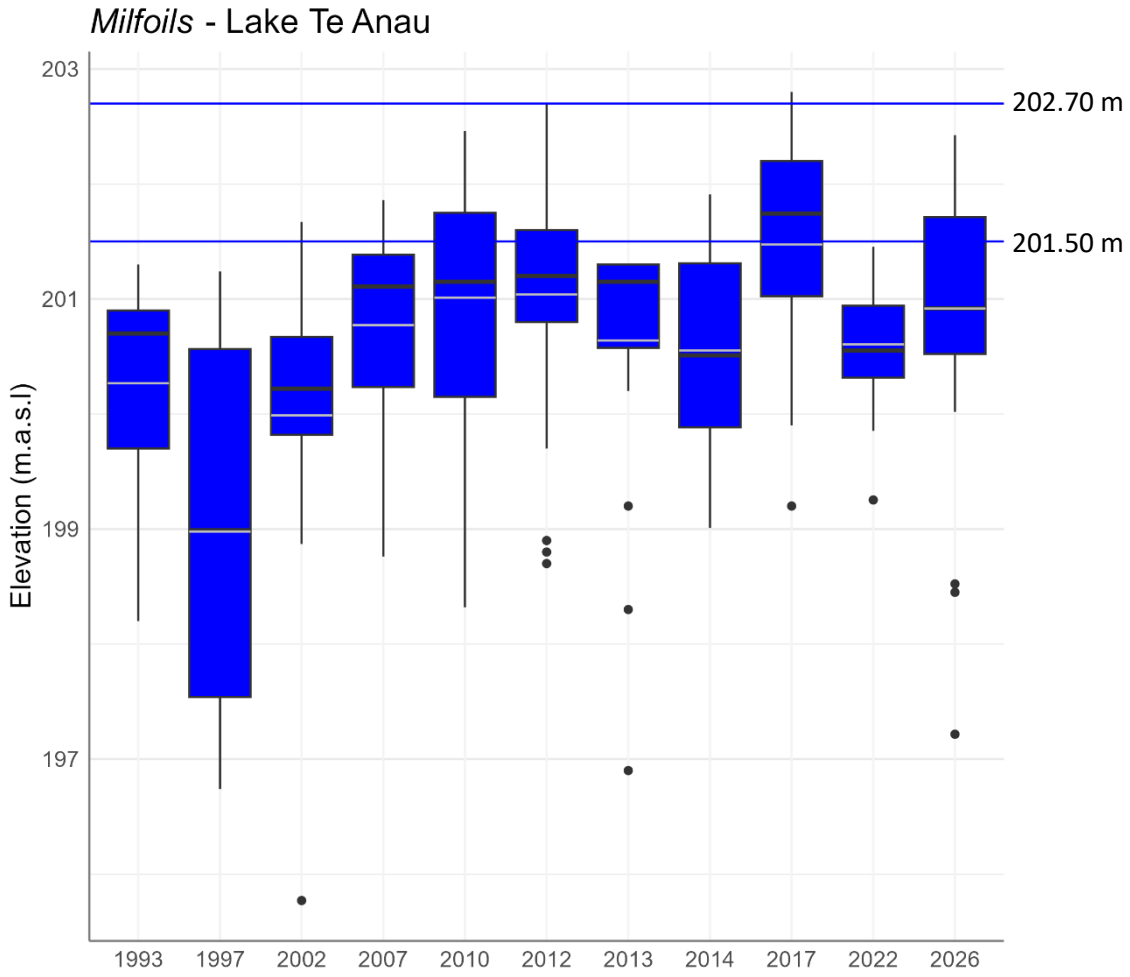


Figure D-9: Lake-wide elevation range of the native milfoils (*Myriophyllum propinquum* and *M. triphyllum*) in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines.

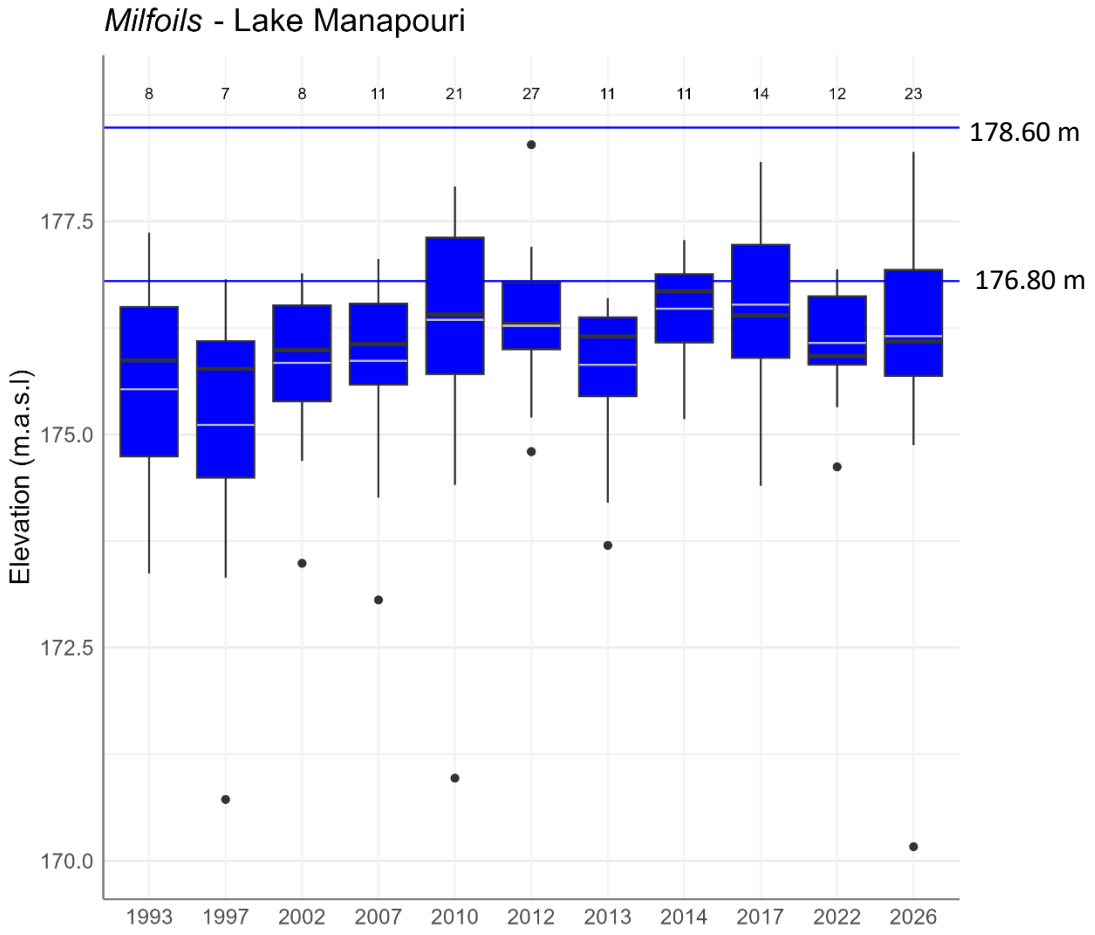


Figure D-10: Lake-wide elevation range of the native milfoils (*Myriophyllum propinquum* and *M. triphyllum*) in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines.

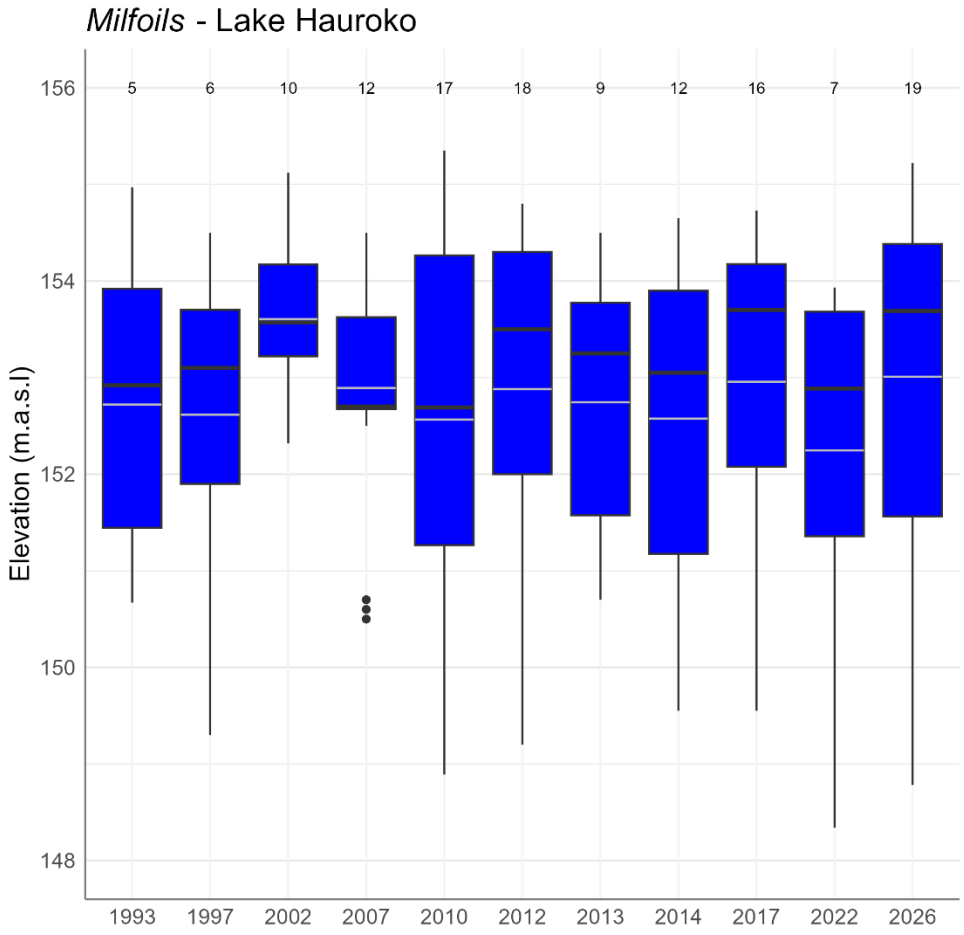


Figure D-11: Lake-wide elevation ranges of the native milfoils (*Myriophyllum propinquum* and *M. triphyllum*) in Lake Hauroko 1993-2026.

Table D-3: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Myriophyllum propinquum* in the three lakes form 1993-2026. Cover ranges are - = not recorded, 1 = 1-5%, 2 = 6-25%. 3 = 26-50%, 4 = 51-75%, 5 = 76-96%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	-	-	-	-
1997	-	-	-	-
2002	-	-	-	-
2007	31	1	2	3
2010	93	2	3	5
2012	33	1	2	2
2017	21	1	2	4
2022	13	1	2	2
2026	26	2	2	4
Lake Manapōuri				
1993	7	1	2	2
1997	-	-	-	-
2002	-	-	-	-
2007	43	1	2	3
2010	86	1	2	3
2012	47	1	1	3
2017	-	-	-	-
2022	33	1	2	3
2026	40	1	2	3
Lake Hauroko				
1993	23	1	2	3
1997	46	1	3	4
2002	54	1	1	3
2007	54	1	1	2
2010	92	1	2	3
2012	47	1	2	2
2017	38	1	1	3
2022	31	1	2	4
2026	62	1	2	4

Table D-4: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Myriophyllum triphyllum* in the three lakes from 1993-2026. Cover ranges are; 1 = 1.5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	53	1	2	4
1997	53	2	2	4
2002	53	1	2	3
2007	62	1	3	6
2010	73	1	2	3
2012	60	1	2	3
2017	64	1	2	3
2022	47	1	1	2
2026	40	2	2	5
Lake Manapōuri				
1993	54	1	2	5
1997	60	1	2	3
2002	62	1	2	5
2007	38	1	1	3
2010	64	1	2	4
2012	47	1	2	3
2017	64	2	2	4
2022	47	1	1	3
2026	60	1	2	3
Lake Hauroko				
1993	23	1	1	2
1997	31	1	1	3
2002	46	1	2	3
2007	38	1	2	2
2010	38	1	1	2
2012	27	1	2	3
2017	54	1	3	4
2022	23	1	2	2
2026	31	2	3	3

Potamogeton species

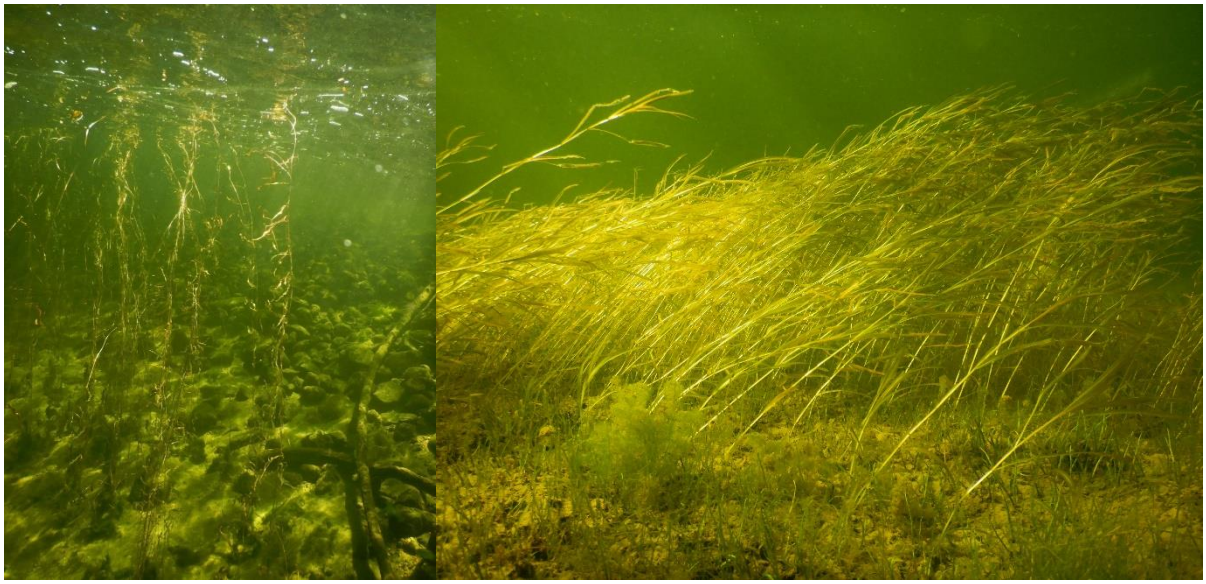


Figure D-12: *Potamogeton* in Lake Hauroko. Left: *Potamogeton cheesemanii* forming surface reaching growths (1.5 m tall), Right: *P. ochreatus* forming a shallow bed.

Pondweeds (*Potamogeton* spp.) (Figure D-12) were found mainly in shallow water in many transects in each lake. They occupied an elevation range of 1.3 m in Lake Te Anau, 1.0 m in Lake Manapōuri and 4.0 m in Lake Hauroko (between 25th and 75th percentiles) (Figure D-13 to Figure D-15).

There were no significant differences in the upper (minimum depth) and lower (maximum depth) elevation limits of pondweeds in any of the lakes in 2026 compared with 2022.

Frequency of pondweed occurrence was the same in 2026 as 2022 in Lake Te Anau (11 sites in 2026 and 2022), but higher in Lakes Manapōuri (13 and 9) and Lake Hauroko (9 and 7).

The median average and median maximum cover of pondweed species were very similar between 2026 and 2022 (Table D-5 and Table D-6). *Potamogeton ochreatus* was unrecorded from Lake Te Anau in 2022 and 2026.

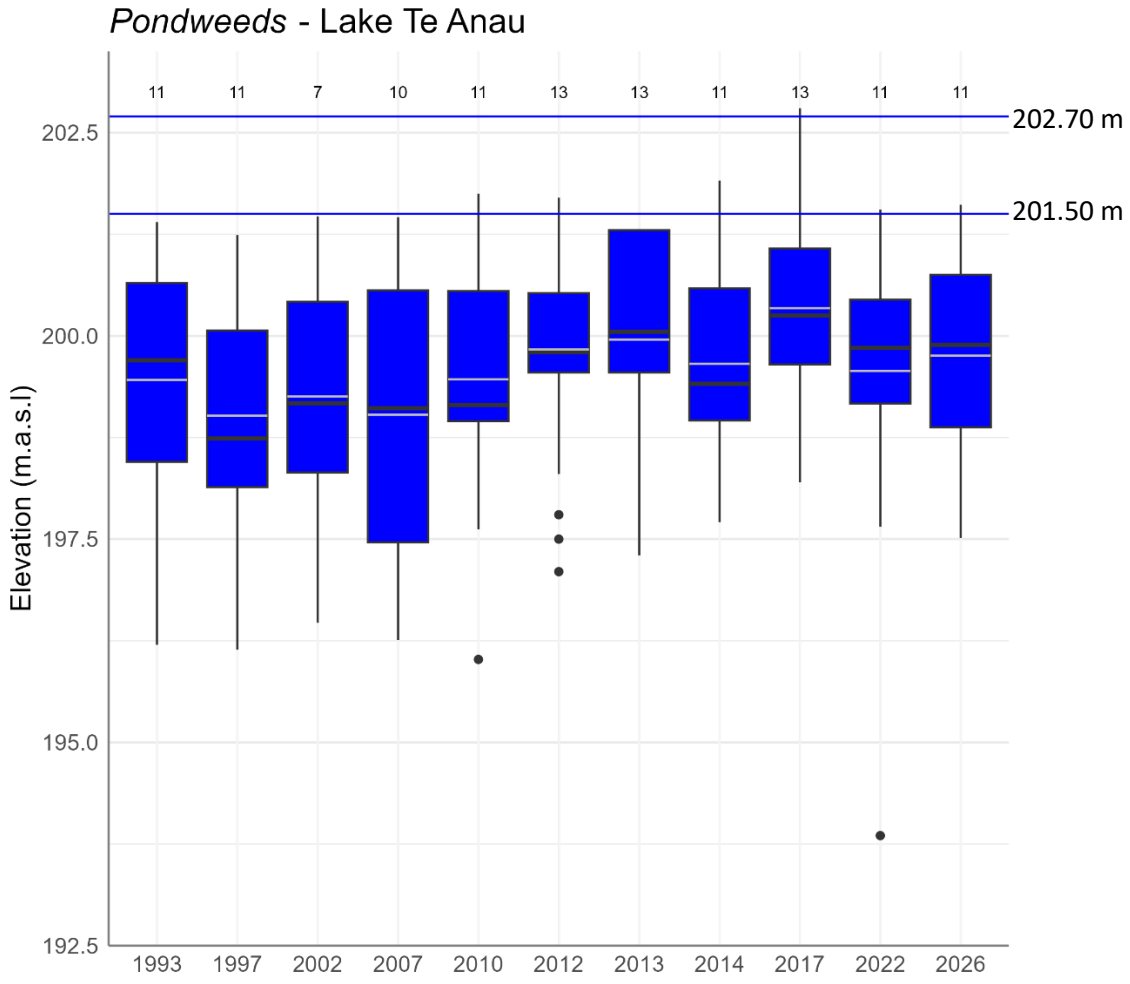


Figure D-13: Lake-wide elevation range of the native pondweed (*Potamogeton cheesemanii*) in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines.

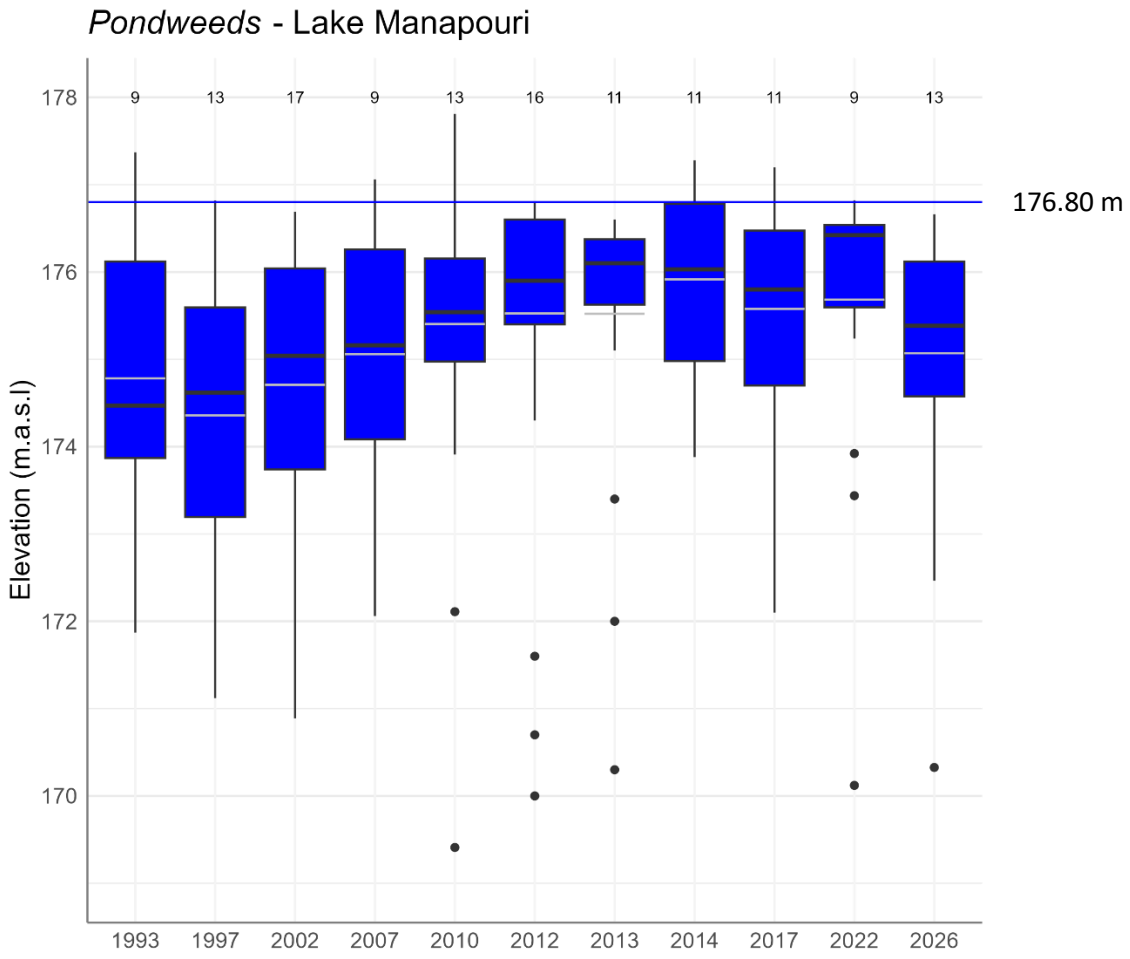


Figure D-14: Lake-wide elevation range of the native pondweeds (*Potamogeton cheesemanii* and *P. ochreatus*) in Lake Manapōuri 1993-2026. Gazetted guidelines main lower lake level operating range is indicated by a horizontal blue line.

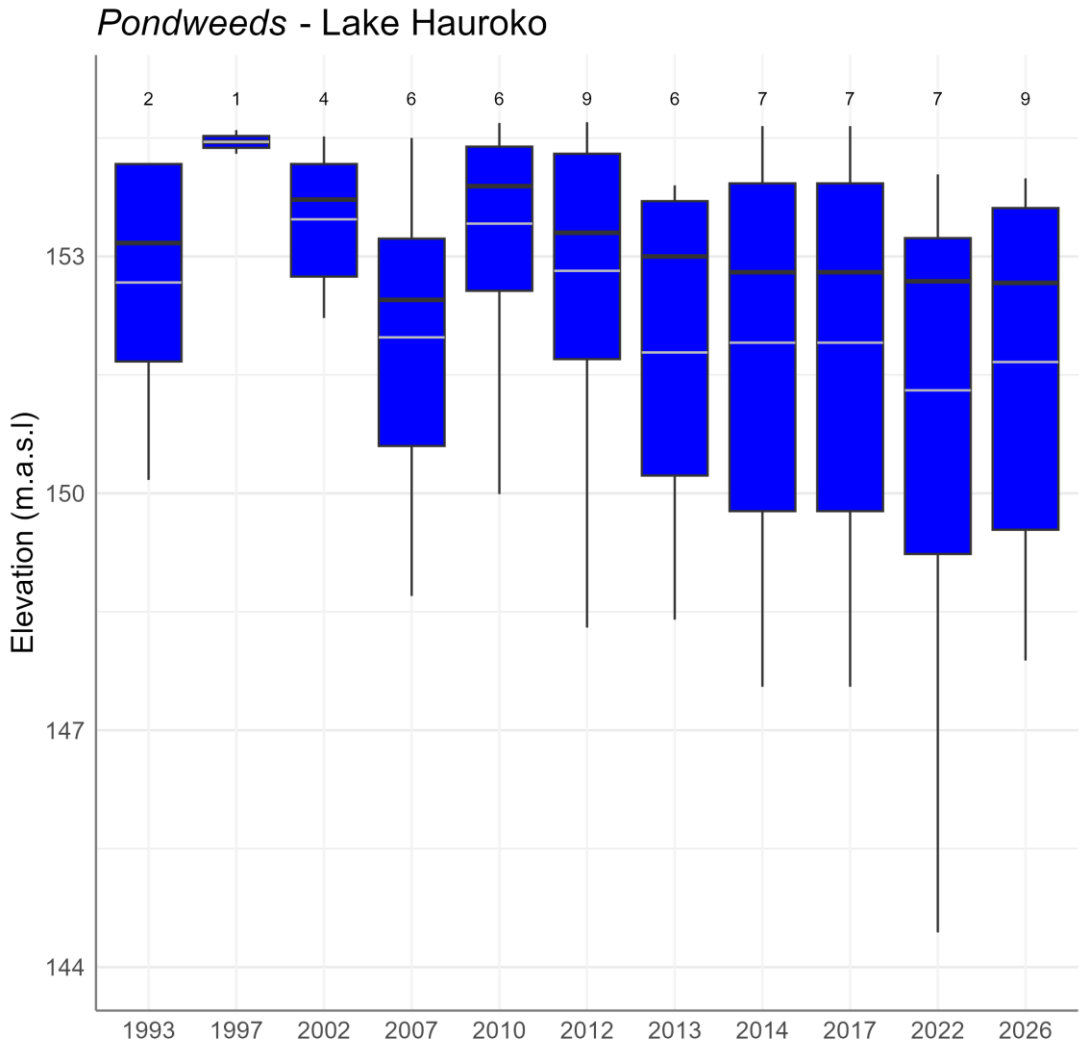


Figure D-15: Lake-wide elevation ranges of the native pondweeds (*Potamogeton cheesemanii* and *P. ochreatus*) in Lake Hauroko 1993-2026.

Table D-5: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Potamogeton cheesemanii* in the three lakes from 1993-2026. Cover ranges are; 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	60	1	2	3
1997	60	1	2	3
2002	53	2	3	4
2007	69	2	3	4
2010	67	1	3	3
2012	73	1	2	4
2017	15	1	2	4
2022	73	1	2	2
2026	73	1	2	4
Lake Manapōuri				
1993	54	1	2	4
1997	53	1	2	2
2002	87	1	2	3
2007	54	1	2	4
2010	64	1	2	3
2012	73	1	3	5
2017	64	1	2	3
2022	53	1	2	3
2026	53	1	1	3
Lake Hauroko				
1993	15	1	1	1
1997	8	1	2	2
2002	8	1	1	1
2007	15	1	1	1
2010	31	1	2	3
2012	13	1	2	2
2017	86	1	2	2
2022	23	1	2	3
2026	62	1	1	1

Table D-6: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Potamogeton ochreatus* in the three lakes from 1993-2026. Cover ranges are - = not recorded, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	7	1	1	1
1997	7	1	2	2
2002	7	2	2	2
2007	7	1	1	1
2010	7	2	2	2
2012	-	-	-	-
2017	7	1	2	2
2022	-	-	-	-
2026	-	-	-	-
Lake Manapōuri				
1993	7	1	1	1
1997	20	1	3	4
2002	40	1	3	5
2007	15	1	1	3
2010	29	1	1	2
2012	13	1	1	2
2017	14	1	2	2
2022	7	1	1	1
2026	33	1	1	3
Lake Hauroko				
1993	-	-	-	-
1997	-	-	-	-
2002	23	1	3	3
2007	23	1	3	3
2010	15	1	1	2
2012	27	1	2	3
2017	38	1	3	3
2022	31	1	2	2
2026	31	1	2	3

Appendix E Characeans

Chara australis



Figure E-1: ***Chara australis*.**With orange antheridia, forming open covers with elodea at 3 m deep, Lake Te Anau.

Chara australis (Figure E-1)) was the deepest growing species sampled in the three lakes. It occupied a wide elevation range throughout the submerged vegetation with a range of 9.8 m in Lake Te Anau, and 5.5 m in Lakes Manapōuri and Hauroko (between 25th and 75th percentiles) (Figure E-2 to Figure E-4).

The lower (maximum depth) elevation limits of *C. australis* differed significantly in Lake Te Anau between 2022 and 2026 and was growing at lower (deeper) elevations in 2026 (Table 3-7). There were no other significant differences comparing upper and lower elevation limits in the three lakes between sampling occasions (Figure E-2 to Figure E-4).

Frequency of *C. australis* occurrence was lower in 2026 compared with 2022 in Lake Te Anau (11 sites in 2026 compared with 13 sites in 2022), whereas frequencies increased in Lakes Manapōuri (13 and 10) and Hauroko (5 and 4) (Figure E-2 to Figure E-4).

The median average cover of *C. australis* increased in Lake Te Anau from cover class 2 to 3 but decreased in Lake Manapōuri (2 to 1) and remained the same in Lake Hauroko. Median maximum cover showed the same pattern (Table E-1).

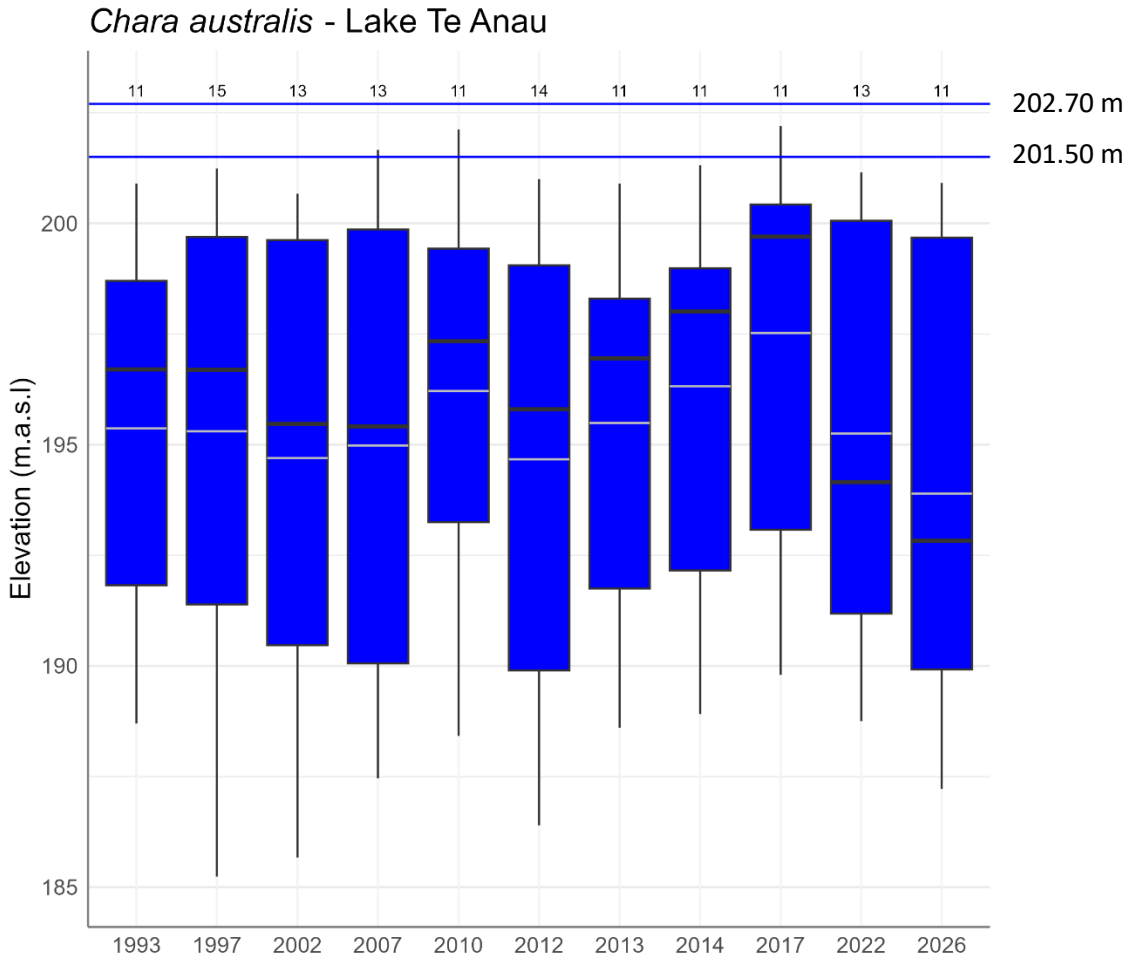


Figure E-2: Lake-wide elevation range of *Chara australis* in Lake Te Anau 1993-2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines.

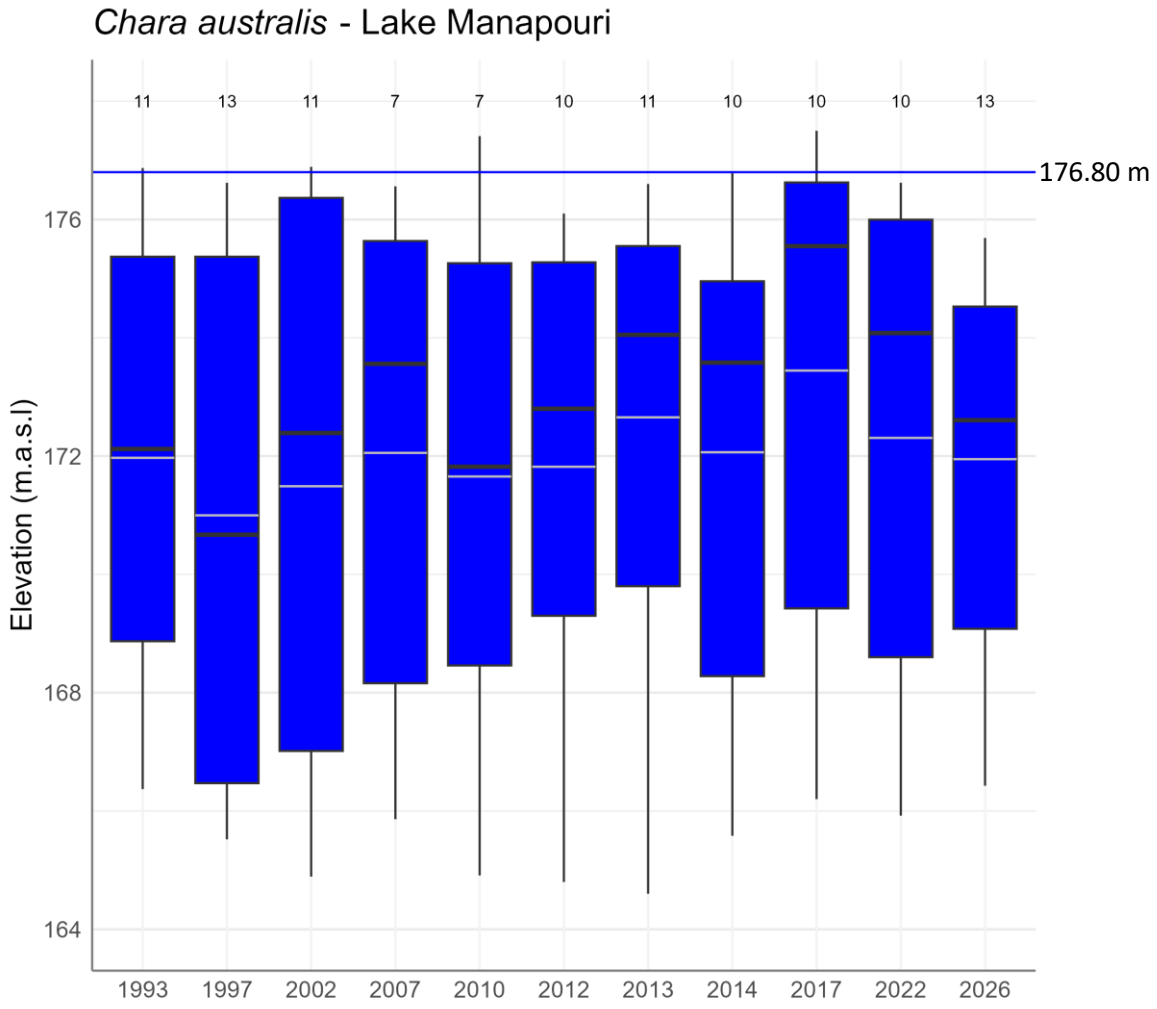


Figure E-3: Lake-wide elevation range of *Chara australis* in Lake Manapōuri 1993-2026. Gazetted guidelines main lake level operating range is indicated by a horizontal blue line.

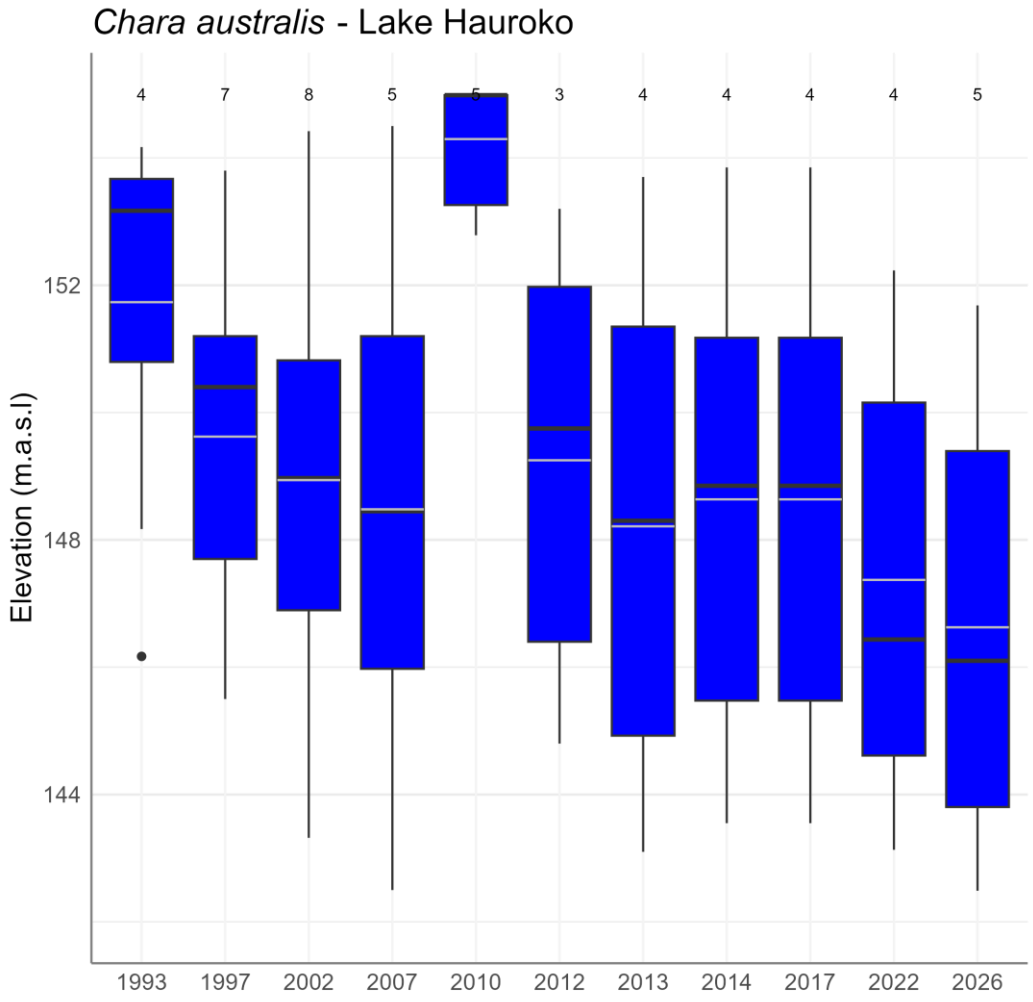


Figure E-4: Lake-wide elevation ranges of *Chara australis* in Lake Hauroko 1993-2026[7].

[7] In 2010, the elevation range was significantly lower ($p < 0.01$) in Lake Hauroko compared to previous years (Sutherland et al. 2010) and subsequent surveys.

Table E-1: Frequency of occurrence (% sites), lake-wide average and maximum median cover and absolute maximum cover of *Chara australis* in the three surveyed lakes from 1993-2026. Cover ranges are; 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau				
1993	100	3	5	6
1997	100	2	3	6
2002	80	3	5	6
2007	87	2	4	6
2010	73	1	3	6
2012	93	2	3	6
2017	71	1	3	5
2022	87	2	3	6
2026	73	3	5	6
Lake Manapōuri				
1993	79	2	3	6
1997	93	3	5	6
2002	79	2	5	6
2007	50	1	3	6
2010	50	2	4	6
2012	67	1	3	6
2017	71	2	4	6
2022	67	2	3	6
2026	87	1	2	6
Lake Hauroko				
1993	30	1	2	3
1997	54	1	1	5
2002	62	1	3	5
2007	39	1	2	4
2010	38	1	1	6
2012	20	2	3	5
2017	31	2	3	6
2022	31	2	3	5
2026	38	2	3	5

Other *Chara* species

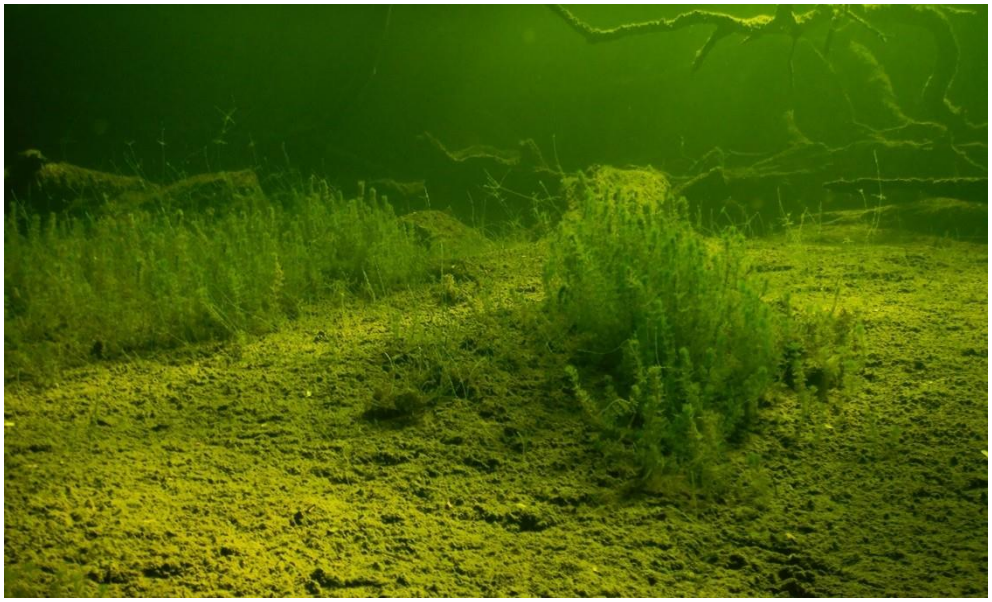


Figure E-5: *Chara acanthopitys* (previously known as *Chara fibrosa*) Forming open vegetation at 3 m in Lake Hauroko.

Chara acanthopitys (previously known as *Chara fibrosa*) (Figure E-5) was present in a wide elevation range throughout the submerged vegetation in Lake Hauroko (5.8 m between 25th and 75th percentiles) and Lake Manapōuri with an elevation range of 4.0 m. *C. acanthopitys* was found on one Lake Te Anau transect in 2026 while it was not recorded there in 2022.

Frequency of *C. acanthopitys* occurrence was lower in 2026 compared with 2022 in Lake Hauroko (11 sites in 2026 compared with 12 sites in 2022) and Lake Manapōuri (2 sites in 2026 compared with 3 sites in 2022).

The median average cover and median maximum cover values of *C. acanthopitys* were generally higher in 2026 compared to 2022 for all the lakes. (Table E-2).

Chara globularis was first found at one transect in Lake Te Anau in 2017 but was not found in 2022 or 2026.

Table E-2: Frequency of occurrence (% sites), lake-wide average and maximum median cover of *Chara acanthopitys* and *C. globularis* in Lakes Te Anau, Manapōuri and Hauroko recorded during the 2026 survey. Data from 2010, 2012, 2017 and 2022 surveys (where available) are included for comparison. Cover ranges are - = not recorded, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%.

Year	Species	% of sites	Cover Lake median average	Cover Lake median maximum	Cover Absolute maximum
Lake Te Anau					
2010	*Chara acanthopitys*	20	1	1	1
2012		13	1	1	1
2017		21	1	1	0
2022		-	-	-	1
2026		7	1	1	1
2017	*Chara globularis*	7	1	1	1
2022		-	-	-	-
2026		-	-	-	-
Lake Manapōuri					
2010	*Chara acanthopitys*	13	1	1	1
2012		7	1	1	1
2017		13	1	1	2
2022		20	1	1	1
2026		13	2	3	3
Lake Hauroko					
2010	*Chara acanthopitys*	77	2	3	5
2012		80	2	3	5
2017		77	1	2	6
2022		92	2	3	5
2026		85	2	4	5

Nitella species



Figure E-6: Diver swimming above a mixed meadow of *Nitella* species. Lake Manapōuri at 6 m depth.

Eight different *Nitella* (Figure E-6) taxa were recognised in the 2026 survey. Amalgamated records for all these characeans occupied an elevation range of 9.1 m in Lake Te Anau, 7.5 m in Lake Manapōuri and 6.7 m in Lake Hauroko (between 25th and 75th percentiles) (Figure E-7 to Figure E-9). At least one *Nitella* species was present on every profile at all three lakes.

As discussed in Section 3.5, due to past taxonomic uncertainty, amalgamated data of all *Nitella* species depth ranges have been compared previously between 2017 and 2022 and now between 2022 and 2026.

The upper (minimum depth) and lower (maximum depth) elevation limits of *Nitella* species differed significantly in Lake Hauroko between 2026 and 2022 (Table 3-7, Figure E-9) resulting in an overall shallower depth range in 2026.

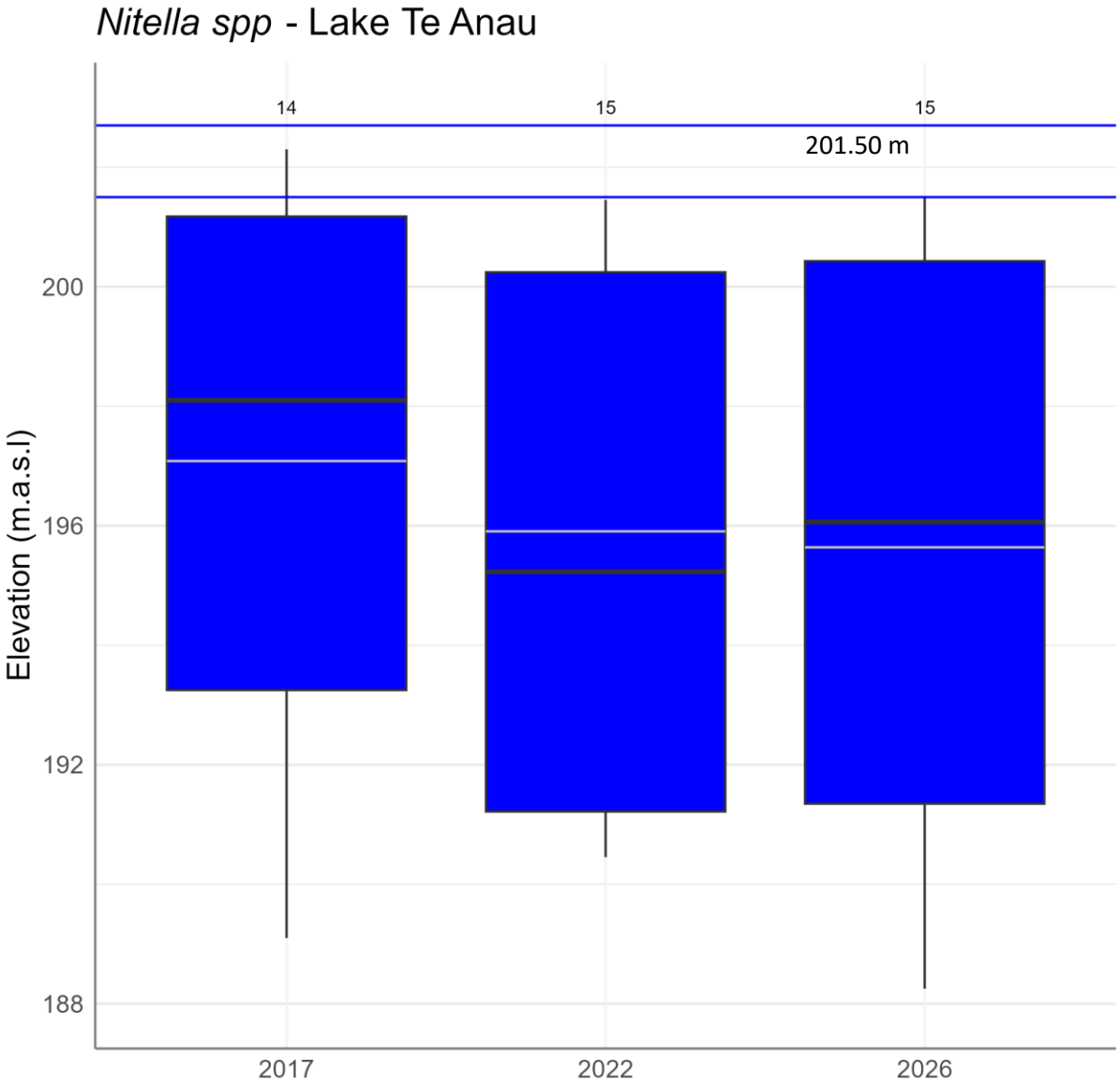


Figure E-7: Lake-wide elevation range of *Nitella* species in Lake Te Anau 2017 to 2026. Gazetted guidelines main lake level operating range is indicated by horizontal blue lines.

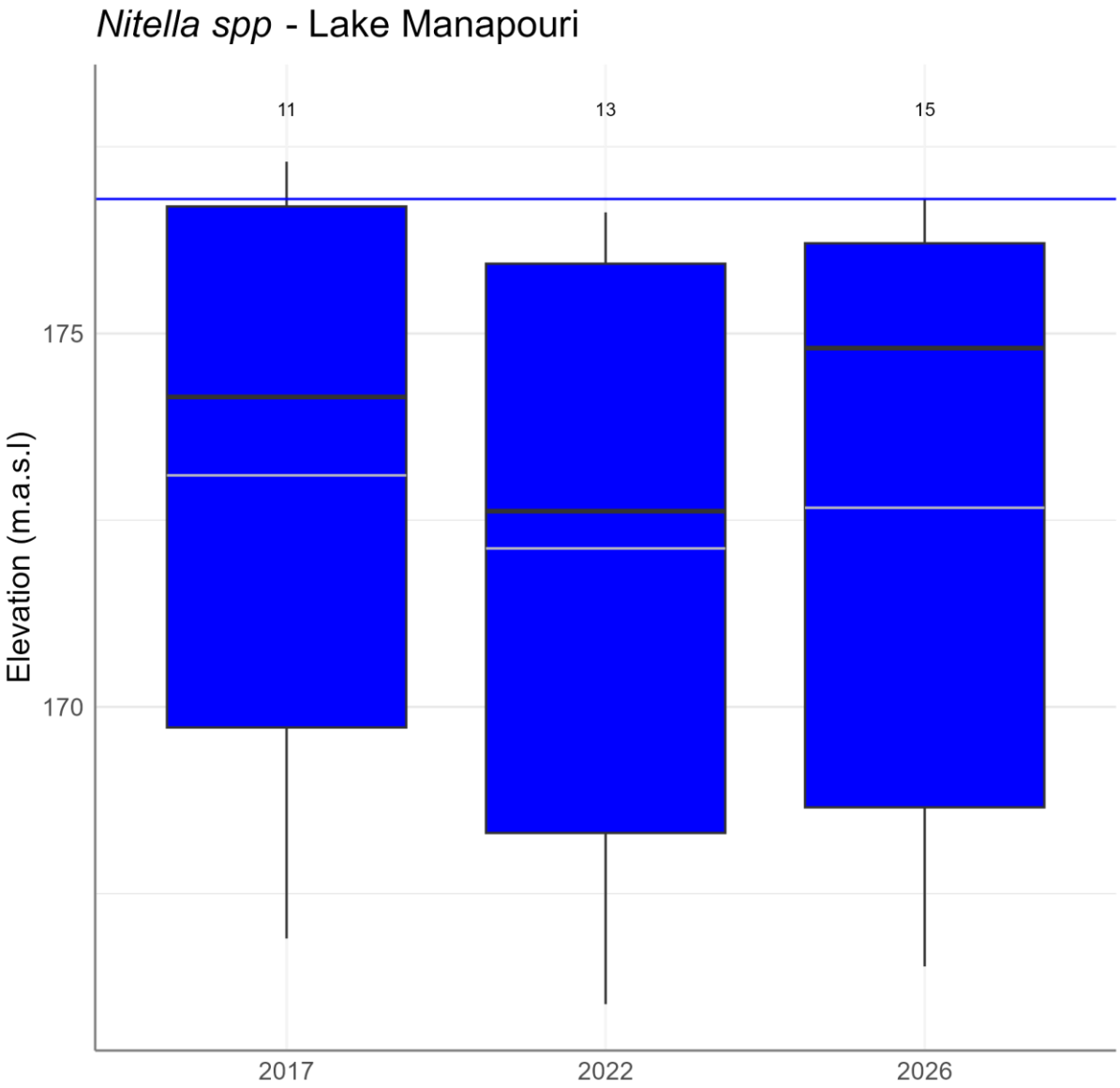


Figure E-8: Lake-wide elevation range of *Nitella* species in Lake Manapōuri 2017 to 2026. Gazetted guidelines main lake level operating range is indicated by a horizontal blue line.

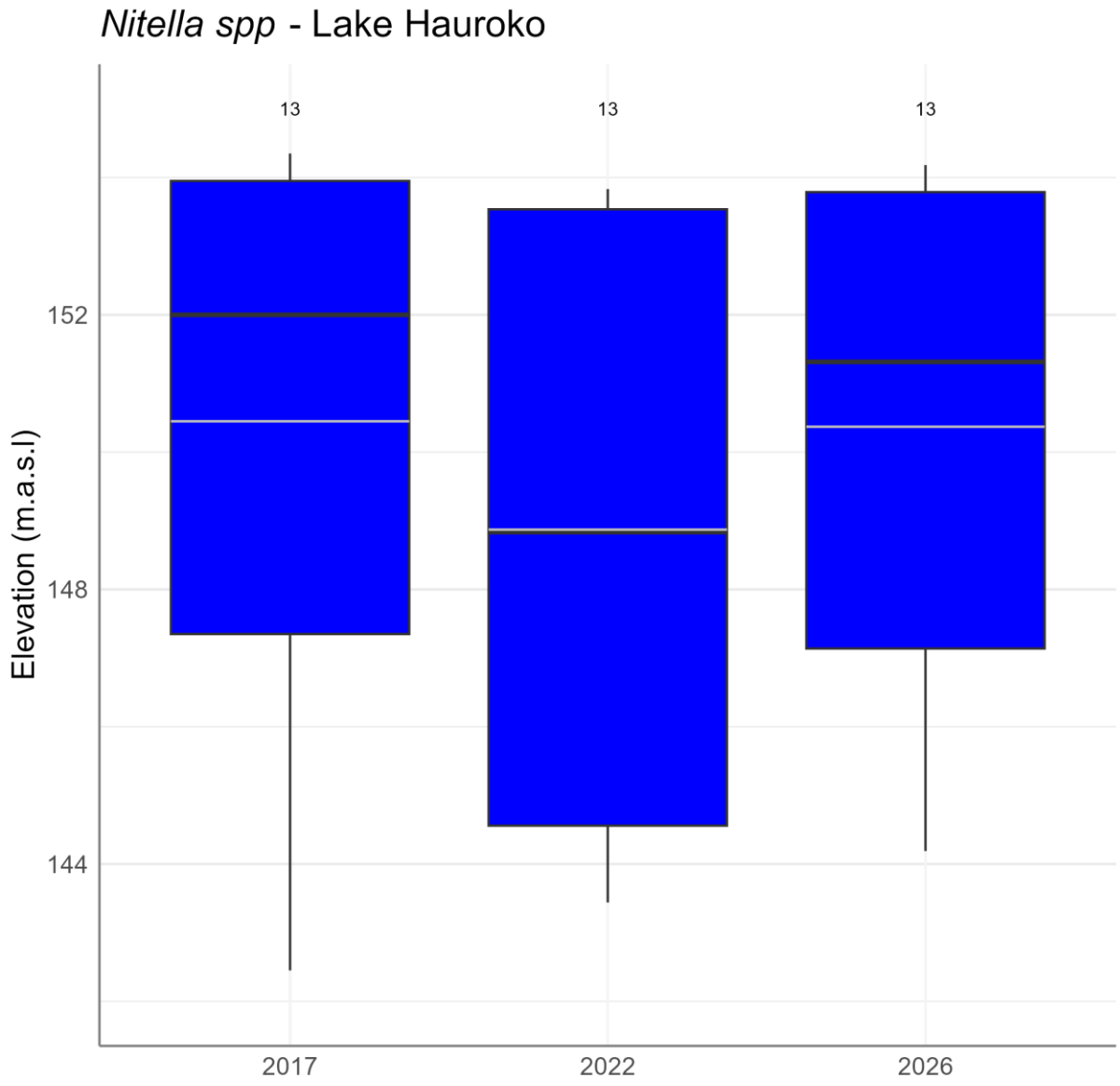


Figure E-9: Lake-wide elevation range of Nitella species in Lake Hauroko 2017-2026.