**BEFORE THE ENVIRONMENT COURT**
**I MUA I TE KOOTI TAIAO O AOTEAROA**

| | |
|---|---|
| **UNDER** | the Resource Management Act 1991 |
| **IN THE MATTER** | of appeals under Clause 14 of the First Schedule of the Act |
| **BETWEEN** | **TRANSPOWER NEW ZEALAND LIMITED** (ENV-2018-CHC-26) |
| | **FONTERRA CO-OPERATIVE GROUP** (ENV-2018-CHC-27) |
| | **HORTICULTURE NEW ZEALAND** (ENV-2018-CHC-28) |

# EVIDENCE OF ZANE NIGEL MOSS FOR SOUTHLAND FISH AND GAME COUNCIL AS A SECTION 274 PARTY

## TOPIC B3 - RELATING TO MANAPOURI POWER SCHEME

**19 AUGUST 2022**

Judicial officer: Judge Borthwick

Counsel: Sally Gepp
Level 1, 189 Hardy Street,
Nelson 7010
Email: sally@sallygepp.co.nz
Telephone: 021 558 241

**ARATIATIA LIVESTOCK LIMITED**
(ENV-2018-CHC-29)

**WILKINS FARMING CO**
(ENV-2018-CHC-30)

**GORE DISTRICT COUNCIL, SOUTHLAND DISTRICT COUNCIL & INVERCARGILL CITY COUNCIL**
(ENV-2018-CHC-31)

**DAIRYNZ LIMITED**
(ENV-2018-CHC-32)

**H W RICHARDSON GROUP**
(ENV-2018-CHC-33)

**BEEF + LAMB NEW ZEALAND**
(ENV-2018-CHC-34 & 35)

**DIRECTOR-GENERAL OF CONSERVATION**
(ENV-2018-CHC-36)

**SOUTHLAND FISH AND GAME COUNCIL**
(ENV-2018-CHC-37)

**MERIDIAN ENERGY LIMITED**
(ENV-2018-CHC-38)

**ALLIANCE GROUP LIMITED**
(ENV-2018-CHC-39)

**FEDERATED FARMERS OF NEW ZEALAND**
(ENV-2018-CHC-40)

**HERITAGE NEW ZEALAND POUHERE TAONGA**
(ENV-2018-CHC-41)

**STONEY CREEK STATION LIMITED**
(ENV-2018-CHC-42)

**THE TERRACES LIMITED**
(ENV-2018-CHC-43)

**CAMPBELL'S BLOCK LIMITED**
(ENV-2018-CHC-44)

**ROBERT GRANT**
(ENV-2018-CHC-45)

**SOUTHWOOD EXPORT LIMITED, KODANSHA TREEFARM NEW ZEALAND LIMITED, SOUTHLAND PLANTATION FOREST COMPANY OF NEW ZEALAND**

(ENV-2018-CHC-46)

**TE RUNANGA O NGAI TAHU, HOKONUI RUNAKA, WAIHOPAI RUNAKA, TE RUNANGA O AWARUA & TE RUNANGA O ORAKA APARIMA**
(ENV-2018-CHC-47)

**PETER CHARTRES**
(ENV-2018-CHC-48)

**RAYONIER NEW ZEALAND LIMITED**
(ENV-2018-CHC-49)

**ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND**
(ENV-2018-CHC-50)

**Appellants**

**AND** **SOUTHLAND REGIONAL COUNCIL**

**Respondent**

## Introduction, qualifications, and experience

1. My name is Zane Moss. I am the Manager of Southland Fish and Game Council ("Fish & Game"). I am authorised by Fish & Game to provide this affidavit.

2. I hold the qualifications of Bachelor of Science majoring in Applied Biology (1993) and Master of Science with Honours in Wildlife Management (1997), both from Lincoln University.

3. I have been employed Fish & Game since 1997, initially as a Field Officer and subsequently as the Operations Manager. I have been employed as the Regional Manager since 2016.

4. My main areas of expertise are freshwater and fish ecology and recreational fisheries management. I have knowledge of the responses of fish populations to freshwater abstraction and land use intensification, fish bioenergetics, instream habitat modelling and habitat suitability analyses. This evidence draws on my knowledge, including various published scientific papers and reports.

5. The Southland Fish & Game region encompasses the lower South Island, extending from the Mataura catchment west to Fiordland and south to Stewart Island. This largely overlaps with the area of the Southland Regional Council, commonly known as Environment Southland. I have been involved in Environment Southland-led processes relating to the development of the Proposed Southland Water and Land Plan (the Proposed Plan) and its predecessor, the Operative Regional Water Plan for Southland (2010) (the Operative Plan), which was notified in 2000. I have participated in Environment Court facilitated mediation in relation to appeals on the Proposed Plan.

## Code of conduct

6. I confirm that I have read the Code of Conduct for expert witnesses as contained in the Environment Court Practice Note 2014. I have complied with the Code of Conduct when preparing my written statement of evidence and will do so when I give oral evidence.

7. The data, information, facts, and assumptions I have considered in forming my opinions are set out in my evidence. The reasons for the opinions expressed are also set out in my evidence.

8. Other than where I state I am relying on the evidence of another person; my evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

9. I confirm I have read and agree to comply with the Code of Conduct of Expert Witnesses in the Environment Court Practice Note. This evidence is within my area of expertise, except where I state that I am

relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

10. I advise that I am married to Dr Jane Kitson who has provided evidence in these proceedings for Nga Runanga o Ngāi Tahu. I do not consider that any conflict of interest arises out of this.

**Scope of evidence**

11. My evidence will, from an ecological perspective, cover the following matters so far as they relate to sports fishing and habitat values associated with the Waiau catchment:

    a. Overview of the Waiau catchment;

    b. Sports fish values of the Waiau catchment;

    c. Observed changes in the Waiau River fishery; and

    d. Angling usage of the Waiau River fishery and the effect of didymo

**Overview of the Waiau Catchment**

12. The Waiau catchment lies on the eastern edge of Fiordland and is Southland's largest catchment. The Waiau River drains Lake Te Anau into Lake Manapouri, from where most flow is diverted through the West Arm of Lake Manapouri to create electricity through the Manapouri Power Scheme (MPS). The MPS is currently operated by Meridian Energy.

13. Prior to 1970 the full flow of the Waiau River, over 450m³/s, flowed from Lake Manapouri to the sea near Tuatapere.[1] In 1970 a temporary rock weir was constructed across the Waiau River, and a large proportion of the river's flow was diverted through the Manapouri Power Station and into Doubtful Sound. In 1976, the Manapouri Control Structure (commonly known as the Mararoa Weir or MLC) was completed and most of the water of the Mararoa and Waiau Rivers diverted with only a very small flow (0.29m³/s) released through a fish pass for much of the time.[2]

14. Between the MPS commencing operation in the early 1970's - 1996 no minimum flow below MLC into the lower Waiau River was provided for. It was subsequently recognised that the very small flow from the Mararoa Weir provided very little instream habitat for fish and benthic invertebrate communities in the section of river immediately downstream.[3] Since 1996 a seasonally variable minimum flow regime

[1] Jowett, I. G., (May 1993). *Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn*. NIWA Freshwater – NZ Freshwater Miscellaneous Report No. 46.
[2] Ibid.
[3] Ibid.

of 12, 14 and 16m³/s has been provided, and the Mararoa Weir is used to governs flows to achieve this.

**Sports fish values of the Waiau catchment**

15. The Waiau catchment, including its tributaries, supports an extensive range of aquatic habitats from its mountainous headwaters to the tidal / estuarine habitat in its lower reaches. These habitats combine to support an extensive range of fish fauna.

16. Four sports fish species[4] are found in the Waiau catchment: Brown trout (*Salmo trutta*), Rainbow trout (*Oncorhynchus mykiss*) Chinook salmon (*Oncorhynchus tshawytscha*) and Perch (*Perca fluviatilis*). Brown and rainbow trout are, however, the major sports fish in the Waiau catchment and are spread throughout its lakes, rivers, and streams.

17. The Waiau fishery is wild and self-sustaining, through natural spawning, rearing and the recruitment of juvenile trout into the adult trout population. Fishery productivity is related to habitat quality, quantity (with respect to flow) and ecosystem health.

18. Management of trout fisheries by Fish & Game is largely to sustain suitable habitat to enable thriving populations of these species, and where necessary, to regulate harvest to ensure sustainability.

**Observed changes in the Waiau River fishery**

19. The diversion of the waters out of Lake Manapouri to Deep Cove via the MPS is the largest single diversion of water out of one catchment and into another in New Zealand. Up to 550m³/sec is currently permitted to be taken. This has had significant large-scale adverse effects on the lower Waiau from MLC to the sea.

20. Mitigation has been implemented, particularly after consents were granted in 1996. There has been some regaining of ecosystem function since then, but the lower Waiau remains a significantly adversely affected ecosystem.

21. Fish and Game has monitored trout populations in the upper and lower Waiau, and other Southland rivers, such as the Oreti and Mataura Rivers, since 1990 via 'drift diving'. In response, Fish and Game has recorded changes in trout populations that reflect changes in habitat conditions and management initiatives.

22. Drift diving has been used extensively in New Zealand since the '100 Rivers' investigations throughout the country in the late 1980's.[5] The technique involves teams of divers drifting down set reaches of a river

---

[4] "Sports fish" mean those freshwater fish described in the First Schedule of the Freshwater Fisheries Regulations 1983.
[5] Tierney, L. D. and Jowett, I. G. (1990). *Trout Abundance in New Zealand Rivers: An assessment by Drift Diving*. NZ Freshwater Fisheries Report No. 118 MAF Fisheries Christchurch ISSN 0113 – 2504.

(river transects) in wetsuits and snorkeling equipment and counting the fish they see including species and size class.

23. Trout populations have declined in the lower Waiau and in the Mararoa Rivers in a pattern consistent with the hypothesis that excessive periphyton (*Didymosphenia geminata* (didymo)) growth is a contributor to the observed decline. Conversely, trout populations in surveyed rainfed rivers, such as the Oreti and Mataura Rivers with high flow variability, that have not been adversely affected by excessive didymo have not declined in a similar way.

24. The trout population in two 1 km reaches of the lower Waiau (downstream of MLC) has changed since 1996 (**Figure 1**). Two significant events have occurred over this period:

    a. In late 1996 the new seasonal minimum flow of 12, 14 and 16m³/s was implemented. Other than flood flows the only flow in the lower Waiau was from small tributary inflows and the 0.29m³/s released through a fish pass at the Mararoa Weir.

    b. Following this new flow regime, juvenile trout first reached a size recorded by drift diving in 1997, and their abundance dramatically increased (**Figure 1**).

    c. In 2004 the invasive alga didymo was discovered and since then large blooms have occurred whenever there has been a sustained period of low flow or only minor freshes (<100m³/s) occurring. This has coincided with a decline in trout numbers overall (**Figure 1**).

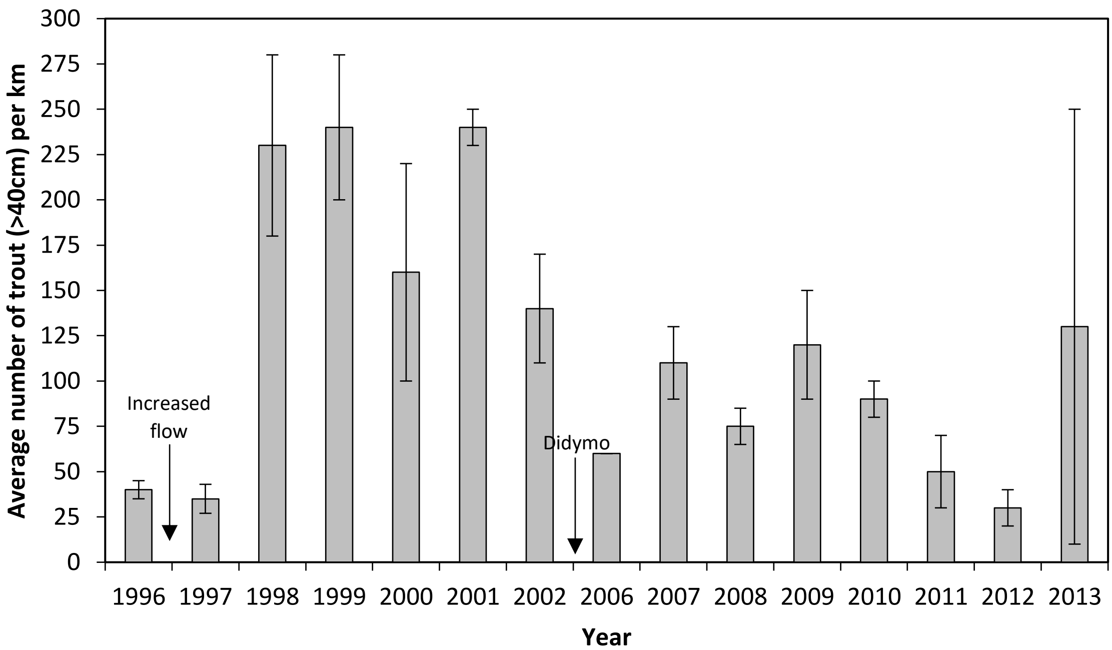


**Figure 1**: Average number of brown and rainbow trout (>40cm) in two one km reaches in the lower Waiau River between Excelsior and Redcliff. Error bars show 1 SD.

25. Fish & Game surveyed five other sites in the lower Waiau between 2006 – 2013 and the counts there (average number of trout (>40cm

per km) are similar, suggesting that the trout population in the lower Waiau has been adversely affected by didymo (**Figure 2**).

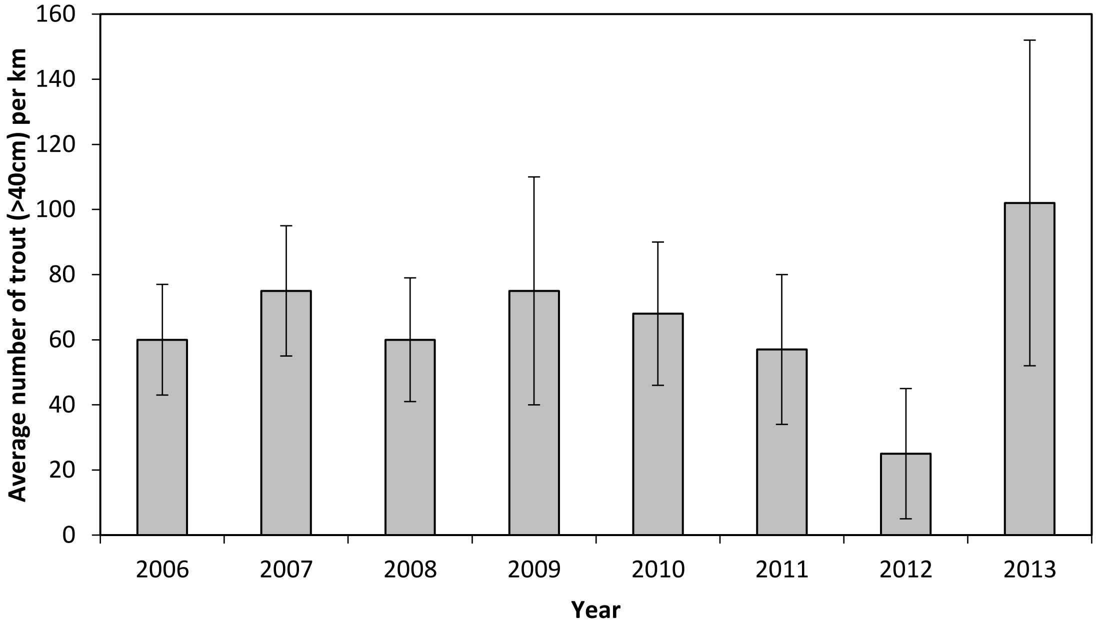


**Figure 2**: Average number of brown and rainbow trout (>40cm) in seven one km reaches in the lower Waiau River between Duncraigen and Redcliff. Error bars show 1 SD.

26. Fish & Game has also counted trout in the upper Waiau (between Te Anau Lake Control and Balloon Loop) on a number of occasions between 2006 - 2021 (**Figure 3**). In contrast to the lower Waiau, the upper Waiau does not have depleted flows. Its mean flow is approximately 350m³/s with a low flow of approximately 100m³/s.

27. Also, in contrast to the lower Waiau River, the upper Waiau has a large population of trout, and the average size is larger than those found in the lower Waiau River.

28. Didymo was first observed in the upper Waiau in 2015 (pers. obs.), at which time it was only in isolated growths of approximately 20mm diameter, and not influencing the ecosystem. It started to bloom the following year, and yet despite its excessive growth, there was no significant decline in the trout population (**Figure 3**).

29. In my opinion, the difference in adult trout abundance between the upper and lower Waiau is likely due to the size of the rivers. The size, water quality and/or flow characteristics of the upper Waiau continues to provide a healthy ecosystem for trout, despite the presence of didymo.

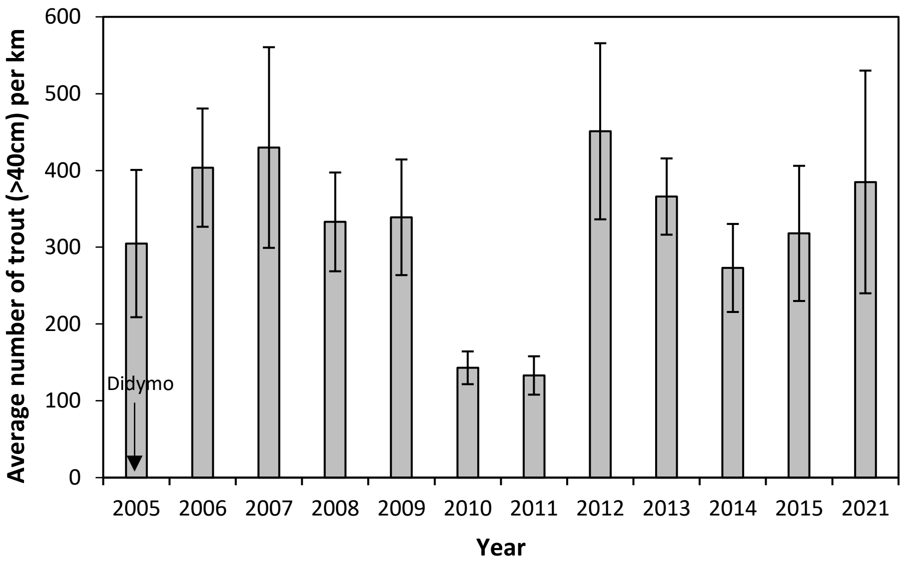


**Figure 3:** Average number of brown and rainbow trout (>40cm) in nine one km reaches on the upper Waiau River between the Te Anau Lake Control and Balloon Loop. Error bars show 1 SE.

30. The abundance of trout in the upper Waiau is shown in the chart (**Figure 3**) above. The average number Fish and Game have counted per km in the upper Waiau has varied from 140 – 450/km. In comparison, the number of trout counted per km in the lower Waiau, post didymo has varied from 40 - 100/km (**Figure 2**).

31. The abundance in the lower Waiau increased dramatically after the increase in minimum flows post 1996. Since 2004 (when didymo was first detected) the size of the lower Waiau river has not changed, however, the previously observed abundance of adult trout has. In my opinion, this is likely related to a reduction in the availability and quality of food due to didymo colonisation and accrual in the lower Waiau River.

32. Thick mats of periphyton are known to alter the composition of the macroinvertebrate community by increasing the abundance of pollution tolerant invertebrates such as chironomids and worms and decreasing the abundance and/or size of macroinvertebrates that are more available, primarily through their behaviour, to trout.[6]

33. Pollution-tolerant invertebrates live in amongst the algae and fine muddy sediment it traps and are less inclined to ‘drift’ with the current as part of their lifecycle. Consequently, they are less accessible to fish than mayflies, caddis flies and stoneflies that do all drift in the water column. Additionally, those pollution-tolerant species that do drift tend to be relatively small and therefore provide poorer nutrition.

34. Thick mats of periphyton also alter the chemical characteristics of the water it occupies, especially close to the stone surfaces and amongst

---

[6] Kilroy, C., Biggs, B., Blair, N., Lambert, P., Jarvie, B., Dey, K., Robinson, K., and Smale, D. (January 2006). Ecological studies on *Didymosphenia geminata* 2005. NIWA Client Report: CHC2005-12330.

the stones which the algae grows on. Because periphyton comprises growing algae, large changes in pH and dissolved oxygen occur daily.[7] This can adversely affect stream insects such as mayflies and stoneflies which have a high demand for good water quality.

35. If the periphyton biomass of a stream remains at low to moderate levels a diverse population of stream macroinvertebrates survives, and this leads to a healthy population of fish which have the potential to grow to large sizes.

36. In rivers with long periods of low or steady flows a large biomass of periphyton usually grows. In the lower Waiau the situation is made worse by didymo, which can grow to produce mats up to 30mm thick. After a time, parts of these thick mats of didymo break off and drift in the water column making the river look visibly polluted and making fishing difficult and frustrating because the long stands of didymo can become entangled on fishing line and lures.

37. This has occurred in the lower Waiau, especially since didymo arrived but also prior to that. This is because the flow into the lower Waiau river is artificially controlled – this means many of the floods have not occurred because the water has been captured in Lake Manapouri and reserved for hydro power generation.

38. Levels (biomass) of periphyton that allow the survival of mayflies, stoneflies and caddis flies have been determined by many studies in a range of rivers in New Zealand and these are measured using an index called Standing Crop Index, commonly known as SCI. Based on the information currently available an index of 220 for mat forming colonial algae is considered to be the maximum to maintain a healthy macroinvertebrate community and to provide for angling amenity values. This index equates to all surfaces covered with a 2.2 mm mat on average.

39. In the mid 2000's, Fish and Game and NIWA with the funding support of Meridian, studied flushing flows required to keep the SCI below 220. This work established that four sustained flows of around or over 400$m^3$/s at Sunnyside (Environment Southland flow recording gauge near Monowai in the middle of the lower Waiau) in October, December, February, and March would reduce the SCI to close to zero at monitoring sites immediately following these flows.

40. The time of the year when flushing flows are most needed is in the summer period because periphyton grows fastest then, which is when natural high flows occur less frequently on average. That said, flushing flows are only required when they are not delivered naturally during the accrual period.

**Angling usage of the Waiau River fishery and the effect of didymo**

[7] Ibid.

41. Fish and Game nationally coordinates and funds a National Angler Survey (NAS) at seven-year intervals, designed by NIWA.

42. The most recent NAS was undertaken during the 2014 / 2015 fishing season[8] and is the fourth to be undertaken since 1994 / 1995.[9] The NAS provides a reliable and comparable long term reference point for angler use. Changes in angling use between surveys can be noted for some waters and not others.

43. Angler use of the Waiau River trout fishery has been variable over the last 25 years. However, there has been a general trend of increasing / sustained angler use of the upper Waiau trout fishery and decreasing use of the lower Waiau trout fishery. In my opinion, this is likely due to angler experience with didymo; the lower Waiau is greatly affected by didymo whereas the upper Waiau is less affected – principally due to higher flows.

44. Didymo affects the angling experience because hooks, flies and lures can become covered or entangled in didymo. This is particularly the case when the didymo accrues to such an extent that mats become heavy and break apart. The dislodged didymo fragments become suspended in the water column and are easily caught up in fishing equipment. The mats are also visually unappealing, looking like floating pieces of toilet paper when detached.

45. The negative effects of didymo on recreational anglers in New Zealand was well documented in a study by Beville et al. (2012).[10] Beville et al. (2012) assessed the impact of Didymo on nonmarket values of recreational angling and found that overall, didymo reduced fishing values by about NZ$44 per visit. Anglers were sensitive to the scale of didymo infestation, suffering significantly higher costs when more water bodies are affected. In their conclusion, Beville et al. (2012) state:

> *"We find that Didymo has a significant negative effect on most anglers, either by reducing the benefits obtained from fishing experiences on Didymo-affected sites, transferring fishing effort to currently lower valued sites, or reduction in fishing effort*."

A reduction in fishing effort has been clearly observed on the lower Waiau and it can be concluded that this is due primarily to didymo (**Table 1**).

**Table 1**: National Angler Survey data (Unwin 2016) for different reaches of the Waiau River (Southland). Estimates are angler days ± 1 SE.

---

[8] Unwin M. (2016). *Angler usage of New Zealand Lake and River Fisheries - Results from the 20014 / 15 National Angling Survey*. NIWA – report prepared for Fish & Game New Zealand.

[9] Data for the 2020 / 2021 national angling survey is currently being analysed by NIWA.

[10] Beville, S. T., Kerr, G. N., & Hughey, K. F. (2012). Valuing impacts of the invasive alga Didymosphenia geminata on recreational angling. *Ecological Economics*, *82*, 1-10.

| River reach | 2014/15 | 2007/08 | 2001/2 | 1995/6 |
|---|---|---|---|---|
| **Te Anau Lake Control to Manapouri (upper Waiau)** | 7,550 ± 1,340 | 7,200 ± 1,180 | 5,920 ± 1,120 | Not available* |
| **Mararoa Weir to the sea (lower Waiau)** | 2,230 ± 570 | 6,480 ± 1,560 | 7,890 ± 940 | Not available* |
| **Unspecified reach** | | 3,620 ± 1,140 | 850 ± 320 | 7,720 ± 840 |
| **Total use of Waiau River** | 9,780 ± 1,460 | 17,300 ± 2,270 | 14,660 ± 1,500 | 7,720 ± 840 |

*There was no river reach demarcation during the 1995/6 survey.

Zane Moss

19 August 2022