Before the Independent Hearing Panel

Under	the Resource Management Act 1991
In the matter of	the Proposed Otago Regional Policy Statement 2021

Statement of Evidence of Jayde Edward Malthus Couper on behalf of Otago Fish and Game Council (#0321)

28 November 2022

Submitter's solicitors:
Maree Baker-Galloway | Rosie Hill
Anderson Lloyd
Level 2, 13 Camp Street, Queenstown 9300
PO Box 201, Queenstown 9348

p + 64 3 450 0700
maree.baker-galloway@al.nz | rosie.hill@al.nz

anderson lloyd.

Qualifications and experience

1 My full name is Jayde Edward Malthus Couper.

2 I am employed as a Fish and Game Officer / Ecologist by the Otago Fish and Game Council. I have been employed by the Otago Fish and Game Council since September 2021, prior to that I was employed as a Fish and Game Officer by the Central South Island Fish and Game Council from December 2013 to September 2021. As part of the roles mentioned above, I have gained experience on ecological and fishery monitoring and how those factors affect angling amenity.

3 I hold a Bachelor of Science in Environmental Science and Water Science and Technology from Lincoln University.

Code of conduct for expert witnesses

4 I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2014 and that I have complied with it when preparing my evidence. Other than when I state I am relying on the advice of another person, this 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.

Scope of evidence

5 I have been asked to prepare evidence on the following matters by the Otago and Central South Island Fish and Game councils' (referred to collectively in this evidence as **Fish and Game**)

(a) Water Quality in Otago

(b) Water Quantity in Otago

(c) Anthropogenic physical alterations to water bodies

(d) Important aquatic species in the Otago region and their interactions

(e) Pressures on Otago's water bodies

(f) The benefits of Fish and Games protection and restoration work

(g) Native/ indigenous ecosystems

(h) Freshwater recreation

(i) A review of APP1

(j) In preparing this evidence I have reviewed:

(k) the section 32 report;

(l) the section 42A reports for chapters relevant to Fish and Game's submission, including supplementary briefs of evidence; and

(m) the 21 October 2022 tracked changes version of the PORPS.

6 I am aware that because of my expertise in freshwater ecology and monitoring, my evidence will be relevant to the freshwater planning instrument. However due to the relationships between the provisions in the non-freshwater planning instrument and the freshwater domain, my evidence is also relevant to the non-freshwater planning instrument. It is intended that much of this evidence will be replicated for the freshwater planning instrument with additional detail as required.

Executive Summary

7 I have been asked to provide a summary on the general state of Otago's aquatic ecosystems. In order to do that I have carried out a review of the available monitoring and reporting. My views have also been informed by my understanding of the ecology of these waterways particularly factors affecting populations and resilience of the Fish & Game managed species.

8 Due to the numerous waterways and extent of the Otago Region it is not possible to investigate or describe the state of every water body in the region.

9 To help describe the general state of Otago's aquatic ecosystems I have broken my analysis down into four components that together, broadly describe the health of Otago's waterways. These components are, water quality, water quantity, the species that are present in the waterways and the interactions between them, and the physical alteration of waterbodies. These components can be thought of as the foundations of stream health and indicate anthropogenic degradation of the waterways.

10 In general, I have found that a large proportion of the region is showing signs of poor water quality. This poor water quality, however, is not consistent geographically across the region.

11 The monitoring results I found suggested that water quality is lower in coastal Otago, particularly the lower Clutha, Dunedin coast and North Otago FMU/ rohe.

12 In contrast there are more issues around water quantity and abstraction issues in the Central Otago area, particularly the Manuherekia rohe. A bulk of abstraction occurs in the Dunstan, Manuherekia and Roxburgh rohe and Taieri FMU.

13 There is strong evidence that a large proportion of Otago's wetlands have been drained and that there is a high amount of physical alteration of Otago's rivers and streams.

14 There are multiple stressors and pressures on freshwater ecosystems in Otago, including land use changes, climate change and introduced species. These factors cannot be looked at in isolation as they can compound together.

15 To show how I came to these conclusions I will first describe the components I mentioned above and how they affect the ecology of waterbodies.

Water Quality - Background

The effects of water quality on ecosystems

16 Water quality is an umbrella term that covers many interacting factors, the generalised factors are: water chemistry including nutrients and toxicants, physical factors including temperature, substrate composition and suspended sediment and biological factors such as the presence of pathogens.

Nutrient enrichment

17 Elevated levels of nutrients in waterways (eutrophication) causes significant negative ecological effects. The most problematic nutrients are nitrogen and phosphorus. Nitrogen levels in waterways are of particular concern as some forms including ammoniacal nitrogen and nitrates at high enough levels they can be directly toxic to invertebrates[1], fish species[2], and humans[3].

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[1] Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. *Chemosphere*, *58*(9), 1255–1267.

[2] Hickey, C. W., & Martin, M. L. (2009). *A review of nitrate toxicity to freshwater aquatic species Prepared for Environment Canterbury.*

[3] Richards, J., Chambers, T., Hales, S., Joy, M., Radu, T., Woodward, A., Humphrey, A., Randal, E., & Baker, M. G. (2022). Nitrate contamination in drinking water and colorectal cancer: Exposure assessment and estimated health burden in New Zealand. *Environmental Research*, *204*

18 Elevated levels of nutrients become an issue to waterways, their inhabitants and their users as they encourage the prolific growth of algae and similar organisms. High densities of algae from eutrophication have serious negative effects on recreational values as they cover the substrate, making it aesthetically unpleasant and in some circumstances dangerously slippery.[4]

19 In sufficiently eutrophic streams, algae concentrations can reach levels that their night-time respiration process as well as the rotting of this algae can reduce oxygen levels in waterways[5].

20 A further side effect of elevated nitrate concentrations is that it favours the growth of organisms in the phormidum genus[6]. Some phormidium species release chemicals that make the water toxic to humans and animals. When these species are abundant the waterway becomes unsafe for contact recreation[7].

21 The negative effect of this algae has further ecological downsides as it leads to small, non-drifting invertebrates becoming proportionately more prevalent[8] which has a negative effect on the fish that rely on these species for food.

22 The outcomes of eutrophication are typically most obvious in flowing water however, lakes, wetlands and ponds are not immune to the effects. In still water systems a similar process occurs which at high concentrations is referred to as an algal "bloom". Blooms drastically reduce the clarity and aesthetic value of a waterway, with the water often described as "pea-soup" Blooms can have similar toxic effects as in rivers. Algal blooms can lead to

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[4] Suplee, M. W., Watson, V., Teply, M., & McKee, H. (2009). How Green is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams. *JAWRA Journal of the American Water Resources Association*, *45*(1), 123–140.

[5] Canning, A. D., & Death, R. G. (2021). The influence of nutrient enrichment on riverine food web function and stability. *Ecology and Evolution*, *11*(2), 942–954.

[6] McAllister, T. G., Wood, S. A., & Hawes, I. (2016). The rise of toxic benthic Phormidium proliferations: A review of their taxonomy, distribution, toxin content and factors regulating prevalence and increased severity. In *Harmful Algae* (Vol. 55, pp. 282–294). Elsevier B.V.

[7] https://www.lawa.org.nz/learn/factsheets/potentially-toxic-algae/

[8] Hayes, J., Hay, J., Gabrielsson, R., Goodwin, E., Jellyman, P., Booker, D., Wilding, T., & Thompson, M. (2018). *Review of the rationale for assessing fish flow requirements and setting ecological flow and allocation limits for them in new Zealand-with particular reference to trout*.

dangerously low oxygen levels[9]. The Otago Regional Council suggest that people avoid contact with the water in the case of a bloom.[10]

23 In severe cases a lake can undergo a regime change known as a 'flip" which means it shifts from a state where the ecology is dominated by plants to being dominated by algae[11]. A lake flipping has serious and long-term effects on the ecology and biodiversity of the lake and can be permanent[12].

Toxicants

24 The introduction of toxicants to a water body can have varying negative effects of the system. Toxicants include pesticides and other agricultural and industrial chemicals and heavy metals. These toxicants can have severe effects on waterways[13] [14].

Sedimentation

25 One of the most consequential negative human effects is the sedimentation of our waterways. The introduction of fine sediments to waterways can have immediate and severe repercussions on the health of the water body. Sediment causes issues both as it is in the water column (suspended) and when it settles out, typically in slower parts of the waterway (deposited).

26 Sediment deposited in the stream bed is recognised as one of, if not, the most influential negative water quality factors. A study that adjusted amounts of sediment, nitrates and phosphorus in test streams showed that

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[9] Paerl, H. W., Fulton, R. S., Moisander, P. H., & Dyble, J. (2001). Harmful Freshwater Algal Blooms, With an Emphasis on Cyanobacteria. *The Scientific World Journal*, *1*, 76–113.

[10]https://www.orc.govt.nz/news-and-events/news-and-media-releases/2022/november/stay-clear-toxic-cyanobacteria-in-butchers-dam

[11] Schallenberg, M., & Sorrell, B. (2009). Regime shifts between clear and turbid water in New Zealand lakes: Environmental correlates and implications for management and restoration. *New Zealand Journal of Marine and Freshwater Research*, *43*(3), 701–712

[12] Gibbs, M. M., Roygard, J., Patterson, M., Brown, L., & Brown, D. (2022). Factors influencing cyanobacteria blooms: review of the historical monitoring data to assess management options for Lake Horowhenua. *New Zealand Journal of Marine and Freshwater Research*, 1–27

[13] Champeau, O., Tremblay, L., & Strickland, R. (2013). *Ecotoxicity review of 26 pesticides,New Zealand*

[14] McRae, N. K., Gaw, S., & Glover, C. N. (2016). Mechanisms of zinc toxicity in the galaxiid fish, Galaxias maculatus. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *179*, 184–190.

sediment had the most pervasive effects on macroinvertebrate production and composition[15]. Sediment has a negative effect on waterway ecology by clogging the interstitial space in the substrate of streams.

27 Deposited sediment is highly detrimental to salmonid spawning as they spawn in gravel riffles where free flowing gravels and clean, cold, oxygenated water is available. Increased sediment presence in streams can prevent salmonids from being able to dig a redd (nest) due to concretion of the gravels. If spawning occurs sedimentation can kill the eggs buried in the gravels by not allowing water flow past them which leads to a decrease in oxygen availability and a build-up of respiration by-products. Deposited sediment is a particular issue in spring fed streams as they do not receive high flows to flush out sediment[16]. Spring fed streams are uncommon and are recognised as often having high biodiversity values.[17]

28 Sediment that is suspended in the water column reduces the clarity of the water and negatively effects invertebrates through smothering and abrasion, causing a reduction in amount of quality and supply of invertebrate food sources.[18]

29 Suspended sediment also affects the feeding of species that feed largely using their vision, including drift feeding species. A reduction in water clarity can lead to these fish spending more time and energy foraging which causes reductions in growth rates, general health and potentially reproductive fitness.[19]

30 In my experience sediment that is both suspended or deposited on the bed of a waterway also reduces the aesthetic values of the streams.

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[15] Davis, S. J., Ó hUallacháin, D., Mellander, P. E., Kelly, A. M., Matthaei, C. D., Piggott, J. J., & Kelly-Quinn, M. (2018). Multiple-stressor effects of sediment, phosphorus and nitrogen on stream macroinvertebrate communities. *Science of the Total Environment*, *637–638*, 577–587

[16] Scarsbrook, M., McIntosh, A., Wilcock, B., & Matthaei, C. (2016). Effects of agriculture on water quality. *Advances in New Zealand Freshwater Science. NZ Freshwater Sci. Soc. & NZ Hydrol. Soc*, 483-503.

[17] Barquín, P. (2008). *Management and conservation strategies for coldwater springs Looking into the main BIOphysical MEchanisms that confer resilience to freshwater and adjacent terrestrial ecosystems.*

[18] Suren, A. M., & Jowett, I. G. (2010). *New Zealand Journal of Marine and Freshwater Research Effects of deposited sediment on invertebrate drift: An experimental study*.

[19] Dr. Russel Death, evidence for ENV-2018-CHC-000037

Pathogens

31 There are multiple pathogens of concern that enter our water, notably campylobacter, giardia and cryptosporidium. However, the presence of E. Coli is usually used in testing to indicate the presence of pathogens from the faeces of warm-blooded animals[20]. Contact recreation with water that has elevated levels of pathogens can cause illness. The pathogens in waterways are sourced from both farmed and wild species.

Water Quality in the Otago Region

32 Above I have given an explanation on the main components that make up the umbrella term of water quality. To give an overall analysis on the state of water bodies in the Otago Region, I have undertaken a review of available reports on water in the Otago Region.

33 I found the state of Otago's water quality is not consistent across all water bodies however there is strong evidence of degradation in multiple waterways around the region and a general trend of degrading water quality over time.

34 To inform my views of water quality issues in the Otago Region, I have relied heavily on the "State and Trends of River and Lake Water Quality in the Otago Region 2000-2020"[21] paper produced by the ORC, as it gives an up-to-date analysis on the long-term water quality data in the region.

35 The report is based on long-term data on water quality from 124 sites around the Otago Region, mostly at Otago Regional Council (ORC) monitored river sites. ORC staff report that the sites for analysis were selected to provide a regional picture and are representative of different land cover types.

36 Fish and Game staff have collated the information in the report and found that for the region overall, water quality fell below one or more National

[20] https://www.stats.govt.nz/indicators/river-water-quality-escherichia-coli

[21] Ozanne R - *State and Trends of River and Lake Water Quality in the* Otago Region 2000-2020.

Policy Statement for Freshwater Management 2020 (NPS-FM) bottom lines at 63% of sites[22] [23], with many sites falling below multiple bottom lines.

37 Falling below the NPS-FM bottom line on any of the water quality parameters suggests a high level of degradation. To give an indication of the level of degradation required to fall below the NPS-FM bottom lines I have included the descriptions of the effects for some of the water quality parameters that have been breached in the Otago region:

38 E. Coli – There is not strict bottom line for E. Coli however contact recreation is classified as a predicted average infection risk of 3% or below.

39 Suspended fine sediment - High impact of suspended sediment on instream biota. Ecological communities are significantly altered and sensitive fish and macroinvertebrate species are lost or at high risk of being lost.

40 Ammoniacal Nitrogen - Starts approaching acute impact level (that is, risk of death) for sensitive species.

41 Phytoplankton - Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes

42 Nitrates (Based on toxicity) - Impacts on growth of multiple species, and starts approaching acute impact level (that is, risk of death) for sensitive species at higher concentrations (>20 mg/L).

43 DRP (D Band) - Ecological communities impacted by substantial DRP elevation above natural reference conditions. In combination with other conditions favouring eutrophication, DRP enrichment drives excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia are lost.

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[22] . Please note that wherever these calculations are discussed they carry over the assumptions by the author of the above citation. These are:

1. The author notes that there is no NPS-FM bottom line for Dissolved Reactive Phosphorous, the “D” band was used as a substitute.
2. The author lists an E. coli national bottom line; however, it does not appear that there is one in the NPS-FM. I assume that the thresholds for primary contact are used (exceeds A, B or C bands)

[23] Fish and Game calculation based on the ORC *State and Trends of River and Lake Water Quality in the* Otago Region 2000-2020 report.

44 MCI - Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to inorganic pollution/nutrient enrichment.

45 These descriptions above show the severity of water issues in some parts of the region however the issues were not ubiquitous across all sites, the ORC monitoring report states that water quality data showed "obvious spatial patterns associated with the variation in grades, with water quality being best at river and stream reaches located at high or mountainous elevations under predominantly native cover. These sites tend to be associated with the upper catchments of larger rivers (e.g. Clutha River/Matau- Au [sic]) and the outlets from large lakes (e.g. Hawea, Wakatipu and Wanaka). Water quality is generally poorer at sites located on smaller, low-elevation streams that drain pastoral or urban catchments."[24]

46 This variation is shown further by the large variation between FMU/rohe, the percent of sites falling below at least one national bottom line varied between the FMU/rohe as follows[25]:

(a) Upper Lakes 36%

(b) Dunstan 44%

(c) Manuherekia 75%

(d) Roxburgh 40%

(e) Lower Clutha 100%

(f) Taieri 55%

(g) Dunedin Coast 88%

(h) North Otago 87%

(i) Catlins 75%

47 The lower Clutha rohe showed the highest levels of degradation. In this rohe every site breached at least one bottom line, three of the sites, the

[24] Plan Change 7 Decision - Annexure 4

[25] Fish and Game calculations based on - Ozanne R - *State and Trends of River and Lake Water Quality in the* Otago Region 2000-2020.

Wairuna, the Heriot Burn and the Crookston Burn were below the NPS bottom line in ten of the fourteen variables measured.

48 The Upper Lakes have the highest quality levels, particularly the large southern lakes, Wanaka, Hawea and Wakatipu, reflecting their relatively pristine unmodified states, however there was evidence of a long-term degradation in some of the measured factors.

49 I was only able to find limited information on toxicants. The ORC has good information on ammoniacal nitrogen which suggests it is only an issue at a few sites and is showing a decreasing trend across the region. I believe that heavy metals are measured at a number of sites by the Otago Regional Council, however I am not aware of any publicly available reporting, consequently I am unable to comment on the scale and severity of the issue.

50 ORC data suggest that levels of deposited sediment are at healthy levels with almost all sites receiving an "A" grade[26].. I still have concern for the lower order tributaries which are above the monitoring sites, particularly spring-fed streams which are an uncommon and important ecosystem.

51 Suspended sediment as outlined above is likely to be one of the major stressors on aquatic ecosystems. McDowell et al found that low-order small streams (<1 m wide, 30 cm deep and in flat catchments dominated by pasture) exempt from potential fencing regulations" accounted for 84% of catchment sediment loading. The Otago Regional Council monitoring shows that suspended sediment levels failed to meet the NPS bottom line at 40 of 78 sites.

52 These summaries show that there is a significant level of improvement needed to meet even the bottom-line values. Unfortunately, there is strong long-term evidence that this is not happening, concerningly, across the region the 20-year trends were predominantly degrading for all variables apart from ammoniacal nitrogen.[27]

53 ORC monitoring has also shown major issues with ground water quality. In their groundwater SOE report for 2021[28], they found that e. coli levels exceeded the Drinking Water Standards for NZ (DWSNZ) thresholds in

[26] Otago regional Council – Water Quality Ecological Assessments, SOE report card 2016 – 2021

[27] Plan Change 7 Decision - Annexure 4

[28] Levy, A. (Groundwater S., Ettema, M., Xiaofeng, L., & Otago (N.Z.). Regional Council. (2021). State of the environment groundwater quality in Otago.

75% of the monitored bores at some point and that "potential faecal contamination is a significant water quality issue across Otago". The monitoring also found varying levels of nutrient enrichment across the region but concluded that "most groundwater nitrate and DRP concentrations exceed the surface water limits". Nitrates in particular were extremely high in some cases; with 80th percentile nitrate concentrations exceeding the Schedule 15 in the Regional Plan: Water for Otago limit by up to a factor of 369 times.

54 I found good information to show that ammoniacal nitrogen levels around the region are low at most of the monitored sites and dropping over time[29].

55 Apart from for ammoniacal nitrogen and for groundwater I was unable to find region wide reporting on other toxicants in surface water. For groundwater there is elevated levels of arsenic in parts of the region, thought to be mostly a natural consequence of the schist geology.[30]

56 The E. coli NPS-FM bottom line[31] was the most breached in the region. E. coli levels did not meet the NPS-FM bottom lines in many sites all around the region including in the upper Clutha rohe. Levels are particularly bad in the lower Clutha rohe where, 13 out of 15 sites did not meet the NPS-FM bottom line[32]

57 Taking in to account the number of water quality factors that do not meet minimum standards and the long-term trends, there strong evidence that the health of Otago's aquatic ecosystems is heavily degraded and getting worse.

Water Quantity in the Otago region

58 There are also significant issues around water quantity in the Otago Region. Large abstraction regimes have significantly altered the ecological values and health of a number of waterways throughout the region. The Skelton Report refers to this as "the high level of water abstraction and the

[29] Ozanne R - *State and Trends of River and Lake Water Quality in the* Otago Region 2000-2020.

[30] Levy, A. (Groundwater S., Ettema, M., Xiaofeng, L., & Otago (N.Z.). Regional Council. (2021). State of the environment groundwater quality in Otago.

[31] Information gathered from tables in; Ozanne R - *State and Trends of River and Lake Water Quality in the* Otago Region 2000-2020 - The author lists an E. coli national bottom line; however, it does not appear that there is one in the NPS-FM. I assume that the thresholds for primary contact are used (exceeds A, B or C bands)

[32] Ozanne R - *State and Trends of River and Lake Water Quality in the* Otago Region 2000-2020.

significant alteration of natural flows, ecosystems and habitat for indigenous flora and fauna"[33]

59 Abstraction of water particularly when waterways are at the low levels often found in summer has significant negative effects on the health of the waterway and its inhabitants.

60 In general, a reduction in flow reduces the production of invertebrates, this is mostly due to a decrease in the wetted area of the waterway and reduction in the amount of detritus that invertebrates eat, moving down the river. There is also a reduction in the concentration of invertebrates that drift and are more vulnerable to fish[34]. This reduction in invertebrate numbers and vulnerability to predation as well as a reduction in physical space means that waterways in general are less productive and less resilient at reduced flows.

61 In some cases, abstraction can dewater entire sections of a waterway. This disrupts the migration of fish species. These events lead to the death of fish via; increased predation in the reduced area of water[35], high temperatures[36] and suffocation. A study of the Lindis River showed only a small proportion of trout survived a summer of low flows.[37]

62 In its 2021 decision on Plan Change 7, limiting terms for surface water abstraction consents, the Environment Court commented on the scale of abstraction in Otago.[38, 39]

> "Over the next five years a significant proportion of permits authorising the take and use of water in Otago will expire. Included among these are hundreds of deemed permits, many of which originated during Otago's goldrush. They authorise the taking of water in quantities large enough to

[33] Skelton, Peter (2019) Investigation of Freshwater Management and Allocation Functions at Otago Regional Council - Report to the Minister for the Environment. Wellington: Ministry for the Environment.

[34] John Hayes Plan Change 7 evidence – para 23

[35] Trotter, M. J. (2016). Juvenile trout survival and movement during the summer low flow abstraction period in the Lindis River, Central Otago (Thesis, Master of Science). University of Otago.

[36] : BRIAN S. CARUSO (2001) Regional river flow, water quality, aquatic ecological impacts and recovery from drought, Hydrological Sciences Journal, 46:5, 677-699

[37] Trotter, M. J. (2016). Juvenile trout survival and movement during the summer low flow abstraction period in the Lindis River, Central Otago (Thesis, Master of Science). University of Otago.

[38] Plan Change 7 Decision – Para 1

[39] Plan Change 7 Decision - Annexure 5, Paras 2 – 4

> sluice a goldfield and few, if any, conditions are attached as to the use of water."
>
> …
>
> "The region has been subdivided into nine FMUs/rohe based on major and minor catchment boundaries. The largest of these is the Clutha/Mata-Au FMU which covers 67% of the region with 88% of its mean flows coming from major sources in the Southern Alps. The mean flows in the five rohe which make up this FMU (as percentages of the total) are Upper Lakes 72%, Dunstan 15%, Roxburgh 4%, Manuherekia 3% and Lower Clutha 6%.
>
> The significantly drier Roxburgh and Manuherekia rohe have a combined area about the same as the Upper Lakes rohe but with a combined mean flow of about one-tenth of the mean flow of the Upper Lakes rohe.
>
> Water use across the region as indicated from the ORC consents database has a total maximum rate of 155 m3/s from 1638 consents. This total includes 309 deemed permits totalling 41.3 m3/s mostly concentrated in the Dunstan, Manuherekia and Roxburgh rohe and Taieri FMU."

63 This aligns with my understanding that relative to the amount of water available, there is a large amount of water consented to be taken. Water bodies in Central Otago are particularly affected, likely because they are often situated in dry and very dry catchments with low summer base flows.

64 Other key issues identified by this decision are:

> "… the levels of allocation for some freshwater bodies in the region are high in comparison with the current primary allocation limits…"[40];
>
> "… both water demand and water availability would be impacted by climate change…"[41]; and
>
> "… there are a range of issues affecting the current coverage and continuity of flow recording in the region"[42]

[40] Plan Change 7 Decision – Para 6

[41] Plan Change 7 Decision – Para 8

[42] Plan Change 7 Decision – Para 9

65 A concerning example of the extent of allocation in the Otago Region is the Manuherekia Catchment. The Skelton report notes that "it is estimated that 75% of the available flow in the Manuherekia River is taken for irrigation and stock water. This compares with about 25% in other regions of New Zealand"[43]. I assume here that Professor Skelton is referring generally to takes at low flows where there is a voluntary 900l/s minimum flow that water users adhere to.

66 This extremely high allocation and use, means that abstraction can hold the Manuherekia at its minimum flow for significant periods of time, this is referred to as "flat-lining[44]. Flow variability is important to the ecological health of a waterway and holding the river at a low flow for long periods of time reduces the health and productivity of the waterway. Small floods known as freshes are most affected by this time at minimum flow, these freshes remove built up algae and sediment, maintaining the productivity of macroinvertebrates as well as providing cues and sufficient water depth for fish migration.[45]

67 Structures like Falls Dam on the Manuherekia attenuate and store flood flows which also contributes to reduced flows downstream for parts of the year. It's important to note that they can also increase flow in the dryer parts of the year under the right management regime.

68 When a waterway is held at a low flow for a long period there is an increase in the biomass of algae species. Alongside this general increase, there is also a change over time in the species composition. If a waterway is held at a low flow for an extended period of time, there is a change from a thin coating of light brown algae species to thicker layers of darker species and often leading to often brightly coloured long filamentous algae that spread out throughout the water column[46].

69 The species that accumulate over time become more intrusive and have an increasingly negative effect on recreation values.

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[43] Skelton report

[44] Snelder, T. H., Rouse, H. L., Franklin, P. A., Booker, D. J., Norton, N., & Diettrich, J. (2014). The role of science in setting water resource use limits: case studies from New Zealand. *Hydrological Sciences Journal*, *59*(3–4), 844–859.

[45] John Hayes- Plan Change 7 evidence – para 63

[46] Barry J. F. Biggs & Geoff M. Price (1987) A survey of filamentous algal proliferations in New Zealand rivers, New Zealand Journal of Marine and Freshwater Research, 21:2, 175-191

70 As outlined in the 'water quality' section above, the proliferation of algae also leads to small, non-drifting invertebrates becoming proportionately more prevalent[47].

71 In summary I found the availability of data on natural flows and abstraction is very poor for the Otago region. The Plan Change 7 decision found "a high degree of uncertainty in the reliability of the existing water quantity information held by the Regional Council"[48].

Anthropogenic physical alterations of waterbodies

72 In addition to affecting the quality and quantity of water, human activity can affect the physical structure of the bed which can have negative ecological consequences.

73 Extraction of bed material removes the gravel which is crucial for invertebrate production and the spawning of many fish species.

74 I have read some reports supplied by the Otago Regional Council for individual rivers, however the reports are relatively out of date, the most recent published in 2014 although there are some strategies published more recently. I was unable to find a cumulative assessment of the region as a whole. Anecdotally some rivers have abundant gravel while others are gravel limited. In parts of the region, rivers are down to bedrock and a moratorium on issuing gravel extraction consents was recommended by the ORC Chief Executive [49], although I was unable to determine if this moratorium is in place.

75 There are also significant mechanical efforts to "tame" rivers to protect infrastructure. Otago Fish & Game has received over fifty notifications of works already in 2022, this number underestimates the total as it does not include notifications regarding waterways north of the Shag River.

76 These works include the straightening or waterways, the creation of reinforced gravel banks and the removal of woody debris[50]. While these

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[47] Hayes, J., Hay, J., Gabrielsson, R., Goodwin, E., Jellyman, P., Booker, D., Wilding, T., & Thompson, M. (2018). *Review of the rationale for assessing fish flow requirements and setting ecological flow and allocation limits for them in New Zealand-with particular reference to trout*.

[48] Plan Change 7 Decision - Annexure 5

[49] Otago regional Council - *Channel morphology of the Shag River, North Otago*. (2009).

[50] Activities outlined in notifications of work to Otago Fish and Game.

activities are sometimes necessary, they have significant long-term ecological effects.

77 In my opinion, rivers are healthiest, most natural and best for recreation when allowed to move about within a larger bed and to follow natural meanders and contain a variety of mesohabitats i.e., pools, runs and riffles.

78 One of the major anthropogenically caused issues for freshwater species is the creation of fish migration barriers, these can be in the form of large hydro dams and weirs, all the way down to small culverts. A number of fish species require migration to carry out their life cycle and preventing their movement can disrupt this or exclude them from entire habitats. There is no comprehensive data on fish barriers in the region, I believe progress is being made with NIWA's fish passage assessment tool[51], it is however, far from comprehensive.

79 Dams cause further ecological issues by altering flow regimes and flooding river and wetland habitat The altered flow regimes can lead to increased temperature, bed armouring, an increase in problem algae growth and changes to the aquatic community below the dam[52].

80 Above I mentioned weirs are an issue for fish passage, but there are further effects associated with weirs. Weirs are typically used to provide enough water height (or head) to allow the abstraction of water. If these abstraction points are not effectively screened, fish can be lost to the system. There is no screening requirement for small takes as a permitted activity[53]. In the last few years, the ORC has developed standard conditions for consents including fish screening conditions. These can be applied to resource consents; however, I was unable to find good information on the number of screened vs unscreened takes in Otago nor the efficacy of the screens that are in place.

81 In my experience the physical manipulation of streams is most pronounced in urban environments. Urban intensification can lead to larger more

[51] https://fishpassage.niwa.co.nz/

[52] Lessard, J., Murray Hicks, D., Snelder, T. H., Arscott, D. B., Larned, S. T., Booker, D., & Suren, A. M. (2012). Dam Design can Impede Adaptive Management of Environmental Flows: A Case Study from the Opuha Dam, New Zealand. *Environmental Management 2012 51:2*, *51*(2), 459–473.

[53] NIWA - *Status report summarising fish screening issues across New Zealand*. (2020)

intense floods as the land is converted to non-permeable surfaces.[54] A good example of this urban intensification and physical manipulation is the Water of Leith that runs through Dunedin City, the Leith's natural morphology has been almost totally destroyed by straightening and channelising, in my opinion removing most natural character values. I would expect that there are significantly reduced ecological values compared with the natural state of the river. Perhaps even worse is the Toitū stream, the "stream where Dunedin began"[55], now flows underground through a series of stormwater tunnels before discharging directly to the Harbour.

82 There are also large flood schemes around the region, notably on the lower Taieri, these schemes alter the natural environment and allow the development of wetlands and river margins.

Wetland Alteration

83 Wetlands are an important ecosystem that provide important ecological benefits and habitats for a diverse range of species. They also maintain and improve downstream aquatic ecosystems by filtering out nutrients and sediment, preventing erosion of adjacent slopes and hillsides and may mitigate the severity of flooding[56].

84 However, most wetlands in Otago have been drained. Forest and Bird have calculated that relative to pre-human occupation, only 24% of the wetlands in Otago remain[57].

85 Unfortunately, the issue is not entirely historical, wetlands have continued to be drained in recent times. In the period of 1996 to 2018 there been over 400 hectares of wetlands lost in the Otago Region[58]. 95% of that loss was conversion to cropping, exotic forest and exotic grassland.[59]

86 A lot of this drainage is carried out on small scales as part of on farm drainage schemes. There is a large number of mole and tile drains however

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[54] Birkland, T. A., Burby, R. J., Conrad, D., Cortner, H., & Michener, W. K. (2003). River Ecology and Flood Hazard Mitigation. *Natural Hazards Review*, *4*(1), 46–54. https://doi.org/10.1061/(asce)1527-6988(2003)4:1(46)

[55] http://www.toituosm.com/collections/staff-picks/toit-where-dunedin-began

[56] Sorrell, B., Reeves, P., & Clarkson, B. (2004). Wetland management and restoration. *Freshwaters of New Zealand*, *40*.

[57] https://www.forestandbird.org.nz/resources/world-wetlands-day-forest-bird-release-maps-showing-extent-wetlands-crisis (data sourced from the Ministry for the Environment.)

[58] OCR Section 42a report Para 1055

[59] Stats NZ / Manaaki Whenua Landcare Research – Wetland area dataset

in my experience the true number and scale of these systems is unknown. Although they are usually on the paddock scale and typically only drain small areas, small wetlands can have high ecological values[60] and draining them can have cumulative effects. These drains can also provide pathways for nutrients to reach larger waterbodies.[61]

Important aquatic/ wetland species in the Otago Region

87 Otago has a high number of species that live in and rely on the health of freshwater ecosystems, many of these are restricted only to the Otago Region and in some case very small geographical areas. Otago is nationally regarded as a "biodiversity hotspot" for freshwater fishes[62].

88 Dr Alibone puts it succinctly in his Plan Change 7 Evidence:

> "The number of recognised native freshwater fish species and indeterminate taxa in Otago is thirty-one taxa. The present-day taxa can be split into fifteen diadromous species that migrate to and from the sea and sixteen taxa that complete their full life history in freshwater. Fifteen of the taxa are also classified as threatened, and this includes thirteen non-migratory galaxiids and one closely related mudfish."[63]

89 The above shows the rarity and importance of the native fish that live in Otago waterways, as well as being varying and rare, a number of these species only exist in Otago waterways[64].

90 In addition to the native species listed above there are six species of valued introduced fish referred to as sports fish. This includes four species of salmonid: brown trout, rainbow trout, Chinook salmon and brook char, and two coarse fish: perch and tench. To my knowledge tench in the Otago

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[60] Stewart, C., Garrick, E., McDougall, M., & Moss, Z. (2021). Waterfowl hunting wetlands as habitat for two New Zealand eel species.

[61] Scarsbrook, M., McIntosh, A., Wilcock, B., & Matthaei, C. (2016). Effects of agriculture on water quality. *Advances in New Zealand Freshwater Science. NZ Freshwater Sci. Soc. & NZ Hydrol. Soc*, 483-503.

[62] Galaxiids – Otago's unique freshwater fish – DOC information pamphlet.

[63] Richard Alibone PC7 evidence para 4

[64] McQueen, S. (2013). *Freshwater Fishes of New Zealand.* Auckland NZ: New Holland Publishers

Region are limited to the lower Kakanui River, its tributaries[65] [66] and some ponds in the area[67].

91 Chinook salmon have two distinct life histories. They exist as an anadromous form that is born in freshwater, lives at sea for 1-4 years and then returns to freshwater to spawn. In Otago this life history is largely limited to the lower Waitaki and Clutha catchments. Due to their size, palatability and fighting characteristics, sea run salmon are favoured by many anglers, some of whom do not target any other species. The sea run salmon fishery is currently in a poor state with record low returns occurring. There is a volunteer run Chinook salmon hatchery on Welcome Stream in the lower Waitaki. Fish passage is key to this life history with dams severely limiting the productivity of this fishery. Chinook salmon can also live in lake systems and their tributaries, these fisheries make up a large part of the significant southern lakes fisheries.

92 Brown trout are widespread in the Otago region. Some brown trout spend time in the ocean and are sought after by anglers due to their size and palatability. Brown trout generally migrate upstream to spawn so are vulnerable to fish barriers including areas of low flow.

93 Rainbow trout are generally considered by anglers to be easier to catch than brown trout. They are present in the Clutha and Waitaki catchments and a number of still waters, including around the Dunedin City area where they provide important recreation opportunities in an urban environment. Fish & Game Otago stock these waters with rainbow trout from our Macraes based hatchery. The large southern lakes make up a significant proportion of angling activity in Otago and are heavily sustained by rainbow trout. Rainbow trout migrate upstream in spring to spawn which makes them particularly sensitive to low flows and water abstraction.

94 Introduced goldfish are present in the region[68] and are recognised in the Otago Pest Management plan 2019- 2029 as “organisms of interest” which means they are watch-listed for further surveillance but are not accorded pest status[69].

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[65] Stoffels R (2022). New Zealand Freshwater Fish Database (extended). The National Institute of Water and Atmospheric Research (NIWA). Sampling event dataset

[66] McQueen, S. (2013). *Freshwater Fishes of New Zealand.* Auckland NZ: New Holland Publishers

[67] Personal communications with anglers.

[68] Wilderlab – eDNA records

[69] Otago regional council - Otago Pest Management plan 2019- 2029

95 There are a large number of species of aquatic invertebrates present in New Zealand waterways with new discoveries and reclassifications commonplace[70]. National research suggest that the vast majority of aquatic invertebrate are endemic[71]. I am unaware of any definitive list of the species present in Otago.

96 I am unable to comment in depth on the range and distribution of aquatic plant species in Otago, however I am familiar with their importance as shelter and food for aquatic and wetland species.

97 A number of aquatic, riparian and wetland plants are registered in the Otago as pests, species that are particularly invasive to these habitats include; broom, false tamarisk, gorse, hornwort, nassella, old mans beard and spartina. Not all these species are currently present in Otago, however they present substantial risk. Despite providing significant habitat for fish species, lagarosiphon is on the pest schedule due to its ability to rapidly spread[72].

98 There are six species of waterfowl that are managed by Fish & Game. Waterfowl are heavily associated with aquatic habitats particularly wetlands. The species we manage are: kakīānau/black swan, pārera/grey duck, rakiraki/mallard duck, pūtakitaki/paradise shelduck, kuruwhengi/New Zealand shoveler and pukeko. Of these species, the mallard and black swans are the only introduced species.[73]

99 There are also a number of native species associated with water and wetlands, including many that are highly threatened. With a couple of exceptions these birds are protected under the Wildlife Act[74].

100 In summary, the Otago Region contains numerous valuable aquatic species both native and introduced. A number of these species are only found in the Otago Region, and many are endangered. Most of the major threats are outlined in above sections, however there are also interactions between the species that can cause issues.

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[70] Jellyman, P. G., Davie, T., Pearson, C. P., & Harding, J. S. (2016). *Advances in New Zealand freshwater science*. New Zealand Hydrological Society Incorporated, New Zealand Limnological Society Incorporated.

[71] Jellyman, P. G., Davie, T., Pearson, C. P., & Harding, J. S. (2016). *Advances in New Zealand freshwater science*. New Zealand Hydrological Society Incorporated, New Zealand Limnological Society Incorporated.

[72] https://www.orc.govt.nz/managing-our-environment/pest-hub/aquatic/lagarosiphon

[73] The science is mixed but It's likely that black swan have naturally flown to New Zealand as well as deliberate introductions.

[74] Wildlife act 1953

Species interactions

101 The factors I have outlined above, water quality, quantity and physical manipulations have severe negative effects on native fish populations. Joy et al. found strong links between fish biodiversity declines and pasture farming. They attributed this to increasing in-stream nutrients, deposited fine sediment, increasing macrophyte and algal abundance, increasing water temperatures, and decreasing water velocity[75].

102 Alongside those crucial factors, there are negative effects associated with competition with, and predation by other fish species. Competition and predation are a natural part of an unaltered ecosystem but become a problem when they are influenced by the action of humans either by physically manipulating the habitat or introducing species that previously weren't present.

103 Most of the NZ research on fish interactions has been performed on introduced salmonids. The effect of salmonids is varying and is strongly affected by location and the species involved, Jones and Closs found coexistence with salmonids was improved in species with "fast" life history traits (e.g. high fecundity, small eggs)[76]. Salmonids can have serious deleterious effects on populations of non-migratory galaxiids[77] and have caused local extinctions in areas where they have accessed previous non-migratory strongholds. Atkinson and Joy summarised that non- migratory galaxiids are "particularly vulnerable due to their small geographical range as well as being very similar to salmonids in terms of feeding behaviour, food and habitat preference."[78]

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[75] Joy, M. K., Foote, K. J., McNie, P. & Piria, M. (2018). Decline in New Zealand' s freshwater fish fauna: effect of land use. Marine and Freshwater Research,70(1), 114–124

[76] Jones, P. E., & Closs, G. P. (2015). Life history influences the vulnerability of New Zealand galaxiids to invasive salmonids. *Freshwater Biology*, *60*(10), 2127–2141.

[77] Evidence of Dr Nicholas Dunn on behalf of Director-General of Conservation for Otago Regional Council Plan Change 7 - para 33

[78] Atkinson, N., & Joy, M. (2012). *Salmonids and Native Fish in New Zealand Are Trout to Blame for the Decline in Native Fish? A report prepared for Fish and Game New Zealand*.

104 There are places that salmonids and some species of native fish co-exist well [79] [80]. In my experience this is largely in waterways with high levels of habitat diversity particularly instream cover.

105 The best way to protect non migratory galaxiids from salmonids is to keep them geologically separated. Maintaining separation of salmonids and non-migratory galaxiid's has difficulties as salmonids tend to migrate on freshes and floods and are proficient at jumping small barriers relative to native fish. This shapes my opinion that the long-term survival and restoration of non-migratory galaxiid populations depends heavily on the installation and maintenance of physical barriers that prevent salmonid migration at differing flows. It is valuable to note that the method is only possible in smaller waterways and not in mainstem rivers.

106 The Otago Fish and Game Council has a species interaction policy that seeks to manage the effects of salmonids on native fish by implementing a multi-agency approach to the management of species interactions with Ngai Tahu, DOC and ORC. Fish & Game has supported galaxiid conservation and trout removal projects in the past.

107 It is important to note that Otago Fish & Game have no intention to extend the range of salmonids in the region and to do so would require the approval of the Minister of Conservation. The Otago Fish and Game hatchery operation I mentioned in an earlier section only releases trout to sites that are recruitment limited, often these are semi-isolated from other water bodies. The program does not currently release trout to rivers. I know of one private hatchery in the region that releases Chinook salmon in to the Waitaki river.

108 Species interaction issues are not, however, limited, to introduced fish. Human alteration of ecosystems can allow native fish to access waterways they didn't previous exist which in some cases appear to be able to predate on or compete with the original occupants. An example of this is the creation

[79] McDowall, R.M., Richardson, J. (1983) The New Zealand freshwater fish survey: a guide to input and output. New Zealand Ministry of Agriculture and Fisheries, Fisheries Research Division Information Leaflet, 12: 1-15.

[80] Atkinson, N., & Joy, M. (2012). *Salmonids and Native Fish in New Zealand Are Trout to Blame for the Decline in Native Fish? A report prepared for Fish and Game New Zealand*.

of lakes by damming and new water races appears to allow koaro to reach areas they previously were not and exclude other species.[81]

109 Due to the varying causes and scales of native fish decline there is a need for a tailored approach for identifying specific areas where issues need to be resolved. Fish & Game's submission has proposed a framework to deal with species interaction issues. Mr Paragreen has provided more detail in his evidence.

110 Fish and Game will elaborate further on species interactions in the freshwater part of the PORPS and outline their strategy for working with affected parties.

Pressures on Otago's water bodies

111 Table 1 outlines the key pressured facing Otago's freshwater ecosystems. For the avoidance of doubt, this list is not exhaustive.

Table 1: Pressures on Otago aquatic ecosystems

Pressure	**Impacts**
Agriculture	• Agriculture adds significant amounts of nitrogen, phosphorus, faecal matter and sediment to New Zealand waterways.[82] [83] • Linked to increased nitrates in groundwater.[84] • Correlated with regime shifts in downstream lakes (flipping)[85]

[81] McDowall, R. M., & Allibone, R. M. (1994). Possible competitive exclusion of common river galaxias (Galaxias vulgaris) by koaro (G. brevipinnis) following impoundment of the Waipori River, Otago, New Zealand. Journal of the Royal Society of New Zealand, 24(2), 161–168

[82] Howard-Williams, C., Davies-Colley, R., Rutherford, K., & Wilcock, R. (2010). Diffuse pollution and freshwater degradation: New Zealand perspectives. Issues and solutions to diffuse pollution, 126-140.

83 McDowell, R., & Wilcock, R. (2008). Water quality and the effects of different pastoral animals. New Zealand Veterinary Journal, 56(6), 289–296. https://doi.org/10.1080/00480169.2008.36849

84 Morgenstern, U., & Daughney, C. J. (2012). Groundwater age for identification of baseline groundwater quality and impacts of land-use intensification – The National Groundwater Monitoring Programme of New Zealand. Journal of Hydrology, 456–457, 79–93

85 Schallenberg, M., & Sorrell, B. (2009). Regime shifts between clear and turbid water in New Zealand lakes: Environmental correlates and implications for management and restoration. New Zealand Journal of Marine and Freshwater Research, 43(3), 701–712

	• The conversion of tussock land to pasture can reduce catchment water yield[86]. • Agricultural intensification degrades aquatic biodiversity.[87] • Has further effects due to irrigation demand, outlined below.
Irrigation	• Reduces water flow in rivers causing significant ecological issues, outlined above in the "water quantity" section. • Allows for intensification of agriculture[88] • Irrigation by wash can carry nutrients to surface and ground water.[89]
Forestry	• Conversion of tussock or pasture land to forestry reduces catchment water yield[90] • Harvest can increase organic matter in waters leading to reduced oxygen.[91] • Causes sedimentation of streams, particularly at establishment and harvest time[92] • An increase in nutrients relative to expected natural values for downstream waterways.[93]

86 Davie, T. J. A., Fahey, B. D., Stewart, M. K., & Nz, D. C. (2006). Tussock grasslands and high water yield: a review of the evidence.

87 Moller, H., MacLeod, C. J., Haggerty, J., Rosin, C., Blackwell, G., Perley, C., Meadows, S., Weller, F., & Gradwohl, M. (2010). Intensification of New Zealand agriculture: Implications for biodiversity.

88 Houlbrooke, D. J., Paton, R. J., Littlejohn, R. P., & Morton, J. D. (2011). Land-use intensification in New Zealand: Effects on soil properties and pasture production. *Journal of Agricultural Science*, *149*(3), 337–349.

89 Duncan, M. J., & Woods, R. A. (2004). Flow regimes of New Zealand rivers: Freshwaters of New Zealand. In *Freshwaters of New Zealand* (pp. 7-1). New Zealand Hydrological Society.

90 Fahey, B; Duncan, M.; Quinn, J. 2004a: Impacts of forestry. Pp. 33.133.16 in Harding, J.; Mosley, P.; Pearson, C.; Sorrell, B. (Eds) Freshwaters of New Zealand. New Zealand Hydrological Society, Wellington

91 Fahey, B; Duncan, M.; Quinn, J. 2004a: Impacts of forestry. Pp. 33.133.16 in Harding, J.; Mosley, P.; Pearson, C.; Sorrell, B. (Eds) Freshwaters of New Zealand. New Zealand Hydrological Society, Wellington

92 Fahey, B.D. & Marden, Michael & Phillips, Christopher. (2003). Sediment yields from plantation forestry and pastoral farming, coastal Hawke's Bay, North Island, New Zealand. Journal of Hydrology New Zealand. 42. 27-38.

93 Ministry for the Environment & Stats NZ (2020). New Zealand's Environmental Reporting Series: Our freshwater 2020. Available from environment.govt.nz and www.stats.govt.nz.

	• Spreads wilding pines[94] • Often leads to recreation access being denied or made more difficult.
Mining	• The mining of waterways can cause suspended sediment plumes.[95] • Can introduce sediment and heavy metals into waterways.[96] [97]
Damming/ Hydro power generation	• Flooding of upstream habitats causing loss of riverine habitat, wetlands and potentially allowing the spread of species that cause compete with or predate on threatened species[98]. • Manipulate flow regimes which can lead to increased temperature, bed armouring, an increase in problem algae growth and changes to the aquatic community below the dam[99]. • Can physically prevent fish migration disrupting lifecycles[100] • Can affect water quality downstream.[101]

[94] Peltzer, D. A. (2018). Ecology and consequences of invasion by non-native (wilding) conifers in New Zealand. *Journal of New Zealand Grasslands*, 39–46.

[95] Ryan, P. A. (2010). *New Zealand Journal of Marine and Freshwater Research Environmental effects of sediment on New Zealand streams: A review*.

[96] Black, A., Craw, D., Youngson, J. H., & Karubaba, J. (2004). Natural recovery rates of a river system impacted by mine tailing discharge: Shag River, East Otago, New Zealand. *Journal of Geochemical Exploration*, *84*(1), 21–34.

[97] Harding, J. S. (2005). *Impacts of metals and mining on stream communities*.

[98] McDowall, R. M., & Allibone, R. M. (1994). Possible competitive exclusion of common river galaxias *(Galaxias vulgaris)* by koaro *(G. brevipinnis) f*ollowing impoundment of the Waipori River, Otago, New Zealand. *Journal of the Royal Society of New Zealand*, *24*(2), 161–168

[99] Lessard, J., Murray Hicks, D., Snelder, T. H., Arscott, D. B., Larned, S. T., Booker, D., & Suren, A. M. (2012). Dam Design can Impede Adaptive Management of Environmental Flows: A Case Study from the Opuha Dam, New Zealand. Environmental Management 2012 51:2, 51(2), 459–473.

[100] Young, R. G., Smart, G., Harding, J., & Young, R. *Impacts of hydro-dams, irrigation schemes and river control works*

[101] Young, Roger & Smart, Graeme & Harding, Jon. (2022). Chapter 37 Impacts of hydro-dams, irrigation schemes and river control works.

	• Manipulate flow regimes which can lead to increased temperature, bed armouring, an increase in problem algae growth and changes to the aquatic community below the dam[102]. • Can physically prevent fish migration disrupting lifecycles[103] • Can affect water quality downstream.[104]
Urban Development	• Removes permeable land increasing the magnitude of floods[105] and how quickly they appear • Urban land is strongly associated with negative effects on water quality, particularly e coli and heavy metal toxicants.[106]
Gravel Extraction	• Reduces natural character • Removes substrate important to fish spawning and invertebrate production.
Climate change	• Has many effects on aquatic ecosystems (Outlined below).
Wetland drainage	• Outlined above.
Introduced species	• Introduced plants can make access for recreation more difficult • Introduced plants, notably gorse contribute to nitrate leaching.[107]

[102] Lessard, J., Murray Hicks, D., Snelder, T. H., Arscott, D. B., Larned, S. T., Booker, D., & Suren, A. M. (2012). Dam Design can Impede Adaptive Management of Environmental Flows: A Case Study from the Opuha Dam, New Zealand. Environmental Management 2012 51:2, 51(2), 459–473.

[103] Young, R. G., Smart, G., Harding, J., & Young, R. *Impacts of hydro-dams, irrigation schemes and river control works*

[104] Young, Roger & Smart, Graeme & Harding, Jon. (2022). Chapter 37 Impacts of hydro-dams, irrigation schemes and river control works.

[105] Birkland, T. A., Burby, R. J., Conrad, D., Cortner, H., & Michener, W. K. (2003). River Ecology and Flood Hazard Mitigation. *Natural Hazards Review*, *4*(1), 46–54. https://doi.org/10.1061/(asce)1527-6988(2003)4:1(46)

[106] Ministry for the Environment & Stats NZ (2020). New Zealand's Environmental Reporting Series: Our freshwater 2020. Available from environment.govt.nz and www.stats.govt.nz.

[107] Dyck, W. J., Gosz, J. R., & Hodgkiss, P. D. (1983). Nitrate losses from disturbed ecosystems in New Zealand. A comparative analysis. *New Zealand journal of forestry science*, *13*(1), 14-24.

	• Negative interactions between fish species can occur (Outlined further above.)

The effects of climate change on freshwater ecosystems and species

112 The effects of climate change are uncertain as they are based on uncertain models and future emission behaviour of humans . The level of uncertainty in predicting national and, especially, more localised outcomes of these future climate patterns is very high.

113 The Ministry for the Environment's overall assessment of the effects of climate change on ecosystems is that "Climate change is likely to cause major changes in ecological communities and interactions between species. The extent of these changes is unknown. Climate change could also make ecosystems and organisms more susceptible to other stresses like pollution, fire , invasive species and disease .

114 One of the most likely outcomes resulting from climate change is a shift in when and where rain falls. Large alpine catchments like the Clutha are predicted to receive more rainfall. There is also expected to be a change in annual patterns as "earlier snowmelt for snow-affected rivers increases winter flows at the expense of spring flows" .

115 There is also expected to be a significant reduction in snow accumulation , There is a possibility of larger floods in catchments that currently receive most of their winter precipitation as snow.

116 More frequent and intense droughts will increase demands on the freshwater resource.

117 Overall flows in rivers are expected to increase in most areas with the exception being in the upper Taieri Catchment. Larger floods are predicted with increases up to 100% in some locations by the end of the century

118 Lakes will be negatively affected by climate change as they are expected to have more frequent and longer stratification events . Stratification is when the warmer top layers of water in a lake sits on top of a cooler layer at the bottom and leads to increased algae growth near the surface and reduced oxygen levels near the bed of the lake.

Cumulative effects

119 I have outlined above the many factors affecting waterways, however its pertinent that none of these factors can be looked at in isolation, all these factors can interact and compound together to create larger issues .

120 A good example of this is the effects of sedimentation, Scarsbrook et al have talked about the effects of deposited fine sediment in particular saying that “Besides having pervasive and often detrimental effects on stream communities when added on its own, elevated levels of deposited fine sediment make the effects of several other stressors (e.g. nutrient enrichment, flow reduction and increased temperature) on ecosystem health worse.”

121 These factors are not limited to water quality, they also compound with quantity factors. Waterways with high level of abstraction and modification are affected more strongly by a decline in water quality.

The benefits of Fish and Games protection and restoration work.

122 The outcomes of Fish and Game advocacy has significant ecological benefits for the ecosystem of Otago. Atkinson and Joy summarised that “The protection of habitat for trout has many positive outcomes for native fish and their habitats. This is because Fish and Game New Zealand is able to advocate for water quality with greater authority than many other freshwater advocacy groups due to the fact that salmonids, as game fish, are protected under both the Resource Management Act (1991) and Freshwater Fisheries Act (1983).”

123 Apart from situations where there are species interactions issues, for example of the type I have outlined above, the ecological values sought by Fish and Game can also provide for the needs of indigenous species. Salmonids in particular, require high water quality and flow to provide valuable recreation. In my opinion, waterways with sufficient quality, flow and physical structure contain the highest natural values and provide high levels of ecological values even when they contain introduced species.

124 Fish and Game also carries out significant work that protects and restores wetlands which has benefits for recreational hunting values as well as important habitat for introduced and indigenous species.

125 A good recent example of Fish and Game enhancement work is the restoration of the Takitakitoa wetland near the mouth of the Taieri River. Takitakitoa wetland was drained for grazing, most likely in 1950’s. Using income derived from licence sales, compliance work and the Gamebird

Habitat Trust , Fish and Game was able to create a 350m long bund and reflood and create approximately 42 hectares of shallow water habitat . Many native species frequent the wetland including inanga, shoveler, grey teal, scaup, royal spoonbills and pied stilts. The wetland is an important part of the chain of coastal Otago wetlands. The wetland has been planted with native plants with the help of local schools and business. These planting days alongside other wetland visits have allowed Fish & Game to communicate to community members the values of wetlands and the species that inhabit them.

126 Overall, the work and finances provided by Fish and Game and their licence holders restore and protect the ecological values of a large portion of the region.

Native/ indigenous ecosystems

127 I have been asked to comment on the term “indigenous ecosystem” in the PORPS. To inform my decision I reviewed dictionaries to find a standard meaning, most referred to the original people of the land which does not appear to apply in this case, others referred only to plants and animals which are only a small subset of organisms that occur in an ecosystem. I have adopted the Merriam-Webster definition “produced, growing, living, or occurring natively or naturally in a particular region or environment”.

128 Taking in to account the above definition (or any other definition I found) I believe that “indigenous ecosystems” in the Otago Region are incredibly rare and geographically limited if not non-existent. The closest to non-anthropogenically influenced ecosystems is likely to be at very top of first order streams in very steep catchments, however I would expect that these probably contain some species of invertebrates.

129 The above analysis only looks at the species present however ecosystems are not limited to species present and instead includes more broad scale variables such as weather and climate. Using this definition, I cannot picture that any indigenous ecosystems exist in the Otago Region.

130 In my opinion the adaption of a more general term i.e. habitat or ecosystem is preferable to the term “indigenous ecosystem”. In cases where the intention is to refer to only native flora or fauna then they should be referred to as “indigenous species”

Freshwater recreation

Popularity of sports fishing and game bird hunting

131 The recreational resource under Fish & Game New Zealand is immense. The 2013/2014 Active NZ Survey conducted by Sport and Recreation New Zealand reported that 19.5% of respondents had been fishing (including both marine and freshwater angling) in the past 12 months . The survey found fishing had a higher rate of participation than rugby, tramping, football, cricket and basketball for men; and that fishing had a higher participation rate than netball, tennis, snow sports and tramping for women.

132 Within Otago, fishing license sales have exceeded 24,000 licenses in all categories with over 12,500 being whole season licences.

133 One of the best long-term data sets on the popularity of freshwater fishing is the National Angling Survey. Fish and Game contracts NIWA to conduct a National Angling Survey every 7-8 years. The surveys estimate angler usage of freshwater fisheries in angler days as well as breaking down the information in multiple ways such as, by region, by waterway or by water type .

134 The National Angling survey briefly looks at overall participation regionally, it showed that 12.5% of adult males in the Otago Fish and Game Region hold a Fish and Game fishing licence, the third highest region in the country behind the Central South Island Region and the Southland Region. This shows that freshwater angling is important to a large part of the population although it's worth noting that currently female participation is much lower.

135 Participation rates estimated from the four completed National Angling Surveys between 1994 and 2015 show that total freshwater fishing effort in the Otago Fish & Game Region ranged from 180,860 ±8,330 to 218,710 ± 8,660 angler-days over the fishing season, one of the highest levels of effort in the country. Otago Regional Council waters in the Central South Island Fish and Game Region probably account for a further 5000 angler days per annum although some use statistics are difficult to separate.

136 Angling use of specific water types in the Otago Region showed few obvious trends across the surveys, Unwin states that there was an "absence of any consistent trends for most types of fishery, the main exception being a marked decline for lowland rivers (from 22,300 ± 2,650 angler-days in 1994/95 to 8,870 ± 1,360 angler-days in 2014/15)" . This data aligns with the anecdotal shift noted in Mr Paragreen's evidence.

137 Fishing activity in the Upper Clutha rohe is particularly high with on average over a third of angling activity in Otago based on lakes Wanaka, Hawea and Wakatipu .

138 Although catch and release fishing is becoming more popular, fishing for the table is still a common practice and provides a huge food resource. Fish and Game carried out a study on trout fishing activity on the lower Waitaki River for the 2018/19 season and found that for the approximately 13,000 trout caught for the season, almost 4,000 were kept by anglers. More recent surveys on Lake Wanaka showed around half of the fish caught were kept for the table.

139 Fish & Game also manages gamebird hunting and administers hunting licences. The number of licenced hunters in the Otago Fish and Game Region has increased over time from an average of 3,100 in the nineties to around 4,200 since 2010 . These figures do not take account of Central South Island's licence sales in North Otago. In reality we manage and represent significantly more hunters as landowners are entitled to hunt their own properties without a licence.

140 Gamebird hunting is a huge recreation asset with up to 82,000 ± 4,000 hours spent hunting waterfowl and 8,800 ±2,000 spent hunting upland game annually in the Otago Region. The food supplied is also immense, in some seasons, over 100,000 gamebirds are harvested in the region, which makes them a huge resource. It is important to note that these figures underestimate the total harvest as they do not include the activity on landowners hunting without the need for a licence who make up a considerable proportion of hunters .

141 In summary, angling and hunting participation by the public in Otago is high and there is a quantifiable value derived as a result. This occurs despite negative pressures on freshwater ecosystems but that does not mean the resource declines due to habitat degradation should not be addressed.

The importance of access to waterways

142 Alongside all the factors mentioned above, hunting and fishing requires good access to the resource. While a proportion of these activities occur on private land, often by the good will of landowners, the majority occurs on, and is access by, public land. This public land consists mostly of DOC, council or LINZ managed lands as well as marginal strips and public roads. Very often, enduring access is only available due to unformed legal roads (paper roads). To maintain the recreation resource, it is crucial that access to and across these lands is maintained or improved.

APP1

143 Based on my experience, I have the following thoughts about the habitat for trout and salmon; angling amenity; and natural character topics of APP1

Habitat for trout and salmon

144 List A point a- Doesn't recognise that in the case of spawning and rearing, many streams could contribute to an outstanding fishery and be critical in aggregate but not individually.

145 List A point b- Discounts fisheries supplemented by hatcheries, this discount the sea-run salmon fishery of the Waitaki and potentially the Clutha both of which I consider outstanding despite depleted runs. Supplementation only contributes a small percent of these fisheries.

Angling amenity

146 List A - Does not recognise that non-trout species can be outstanding, sea-run salmon fisheries as well as the Southern Lakes salmon fisheries would be discounted.

147 List A- Also discounts a number of back country fisheries which are outstanding but do not contain high numbers or especially large trout but offer a very high level of angling experience.

148 List A point a- fish over 4kg are exceedingly rare, most anglers will fish their whole life without catching one. There is no strict definition of trophy but in my opinion 3.5kg would be considered an outstanding and still uncommon salmonid in the Otago context.

149 List A point b – The brackets do not add clarification and restrict to one fishery.

150 List A point c – The brackets do not add clarification and restrict to one fishery.

151 List A point c –The term biomass is not a good indicator of an outstanding fishery and is difficult to accurately assess. If the term is used as total biomass, its likely to only cover fisheries with an exceptionally large area. If the term is used on a rate i.e. the weight of fish per hectare of lake or per km of river, it's possible that the highest trout biomass is for at least part of the year in small spawning streams running into large waterbodies. These small high biomass spawning streams are vital for the surrounding fisheries are unlikely to be directly outstanding as a fishery.

152 List B - Does not recognise that non-trout species can be significant, sea-run salmon fisheries as well as the Southern Lakes salmon fisheries would be discounted.

153 List B point b – The use of “challenging” is good, many anglers seek out challenging fisheries, however challenging fisheries are unlikely to have high numbers of fish. High catch rate covers the outstanding cicada-based fisheries.

154 List C point a – Discounts sea-run salmon fisheries.

155 List C point b – I think the bracketed section should be removed, an outstanding fishery can exist where there isn’t high water quality but it is less common.

156 Not included in any of the above - One aspect of the criteria that is missing is the way in which people connect with fisheries. Not all connections are based on bio-physical characterises and people may view angling opportunities as outstanding when the bio-physical characteristics are not.

Natural Character

157 List A point a- I am concerned this would make a waterbody like Lake Hawea not outstanding due to the damming and level fluctuations. While it has been dammed, it still possesses very high natural character characteristics, much of which would have still been present prior to damming.

Jayde Edward Malthus Couper
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