BEFORE THE HEARING PANEL APPOINTED BY THE CHIEF FRESHWATER COMMISSIONER FOR THE FRESHWATER PARTS OF THE PROPOSED OTAGO REGIONAL POLICY STATEMENT

Under	**the Resource Management Act 1991**
And	
In the matter of	**the parts of the proposed Otago Regional Policy Statement considered to be a Freshwater Planning Instrument**

Evidence of Dr Nicholas Rex Dunn on behalf of the Director-General of Conservation *Tumuaki Ahurei* (Freshwater)

Dated: 28 June 2023

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Executive Summary

1. The Otago region houses a suite of highly threatened indigenous non-diadromous galaxiid fishes.

2. Policies and methods addressing both hydrological environment alteration and the negative effects of salmonids over the term of the proposed Regional Policy Statement are required to enable appropriate planning provisions to support the presence, abundance, survival, and recovery of these threatened species.

3. Mapping the distributions of threatened freshwater fish species and description of their habitats is important in the development of planning instruments and provisions assessing and managing the effects of activities.

Introduction

1. My full name is Nicholas Rex Dunn.

2. I have been asked by the Director-General of Conservation *Tumuaki Ahurei* (Director-General, D-G) to provide expert evidence on her submission and further submission on the parts of the proposed Otago Regional Policy Statement (pORPS) to be considered as a Freshwater Planning Instrument.

Qualifications and experience

3. I am employed by the Department of Conservation *Te Papa Atawhai* (DOC, Department) as a Freshwater Science Advisor in the Biodiversity Systems and Aquatic Unit of the Biodiversity, Heritage and Visitor Group. I have held this role since September 2012. I was employed by DOC as a Technical Support Officer Freshwater in the Canterbury Conservancy between December 2010 and September 2012.

4. I hold a Bachelor of Science (Earth Sciences) degree from the University of Waikato (2001) where I majored in hydrology and soil science. During this degree I studied freshwater ecology at Karlstad University in Sweden as an exchange student, completing a third year level dissertation on the effect of drift availability on diet composition of stream resident brown trout.

5. I hold a Master of Science (Environmental Science) (First Class Honours) degree from the University of Canterbury (2004), majoring in freshwater ecology and hydrology. My MSc thesis investigated aspects of the influences of extremes in flow variations on the ecology and dynamics of populations of non-diadromous galaxias fishes.

6. I hold a Doctor of Philosophy degree from the University of Otago (2012). My PhD thesis investigated aspects of the influences of hydrological environments on the morphology, ecology, and spawning biology of non-diadromous galaxias fishes.

7. I am a professional member of the Royal Society of New Zealand (MRSNZ) and a member of the New Zealand Freshwater Sciences Society.

8. I worked with Te Uru Rākau/Forestry New Zealand (Ministry for Primary Industries) in developing the Fish Spawning Indicator component of the Resource Management

(National Environmental Standards for Plantation Forestry) Regulations 2017 (NES-PF).

9. In my role as Freshwater Science Advisor for DOC, I lead the New Zealand Threat Classification System freshwater fishes expert panel which undertook the most recent (Dunn et al. 2018) conservation status assessment for these species.

10. I am currently undertaking research to formally describe fishes within the *Galaxias vulgaris* species complex, including *Galaxias* "Nevis" (Nevis galaxias), *Galaxias* "southern" (southern flathead galaxias), *Galaxias* "species D" (Clutha flathead galaxias), and *Galaxias* "Teviot" (Teviot flathead galaxias). I am also describing fishes in the *Galaxias paucispondylus* species complex including *Galaxias* affinis *paucispondylus* "Manuherikia" (alpine galaxias (Manuherikia River)).

11. I have led research projects investigating instream habitat suitability preferences of non-diadromous galaxias fishes, including *Galaxias* affinis *paucispondylus* "Manuherikia", *Galaxias gollumoides* (Gollum galaxias), *Galaxias* "Nevis", *Galaxias* "southern", *Galaxias* "Teviot", and *Galaxias* "species D" which occur in the Otago Region.

12. I am familiar with a number of non-diadromous galaxias and their habitats in the Otago region, and have previously represented the Department on the Otago Regional Council convened Manuherikia Technical Advisory Group.

13. I have appeared before Councils in both plan change (e.g., Canterbury Regional Council Land and Water Regional Plan 2012, and a number of the Plan Changes (1, 2, 3, 4, 5, and 7), and Hurunui Waiau Regional Plan) and resource consent (e.g., Hurunui Water Project Limited) hearings to give expert evidence for the D-G on freshwater ecology and ecohydrology matters.

14. I appeared before the Environment Court to give expert evidence for the D-G in the directly referred proposed Plan Change 7 (Water Permits) to the Regional Plan: Water for Otago. My evidence addressed non-diadromous galaxias in Otago, their importance, the influence of hydrological environments on their life history, and the use of planning instruments in their management. I similarly appeared in the Lindis (Plan Change 5A (Lindis: Integrated water management) and Lindis Catchment Group resource consents) consolidated proceedings Environment Court hearing. My evidence addressed the influence of water flow on and habitat requirements of *Galaxias* "species D" (Clutha flathead galaxias), and the application of residual flows in tributary streams containing that taxon's habitat. I also assisted the D-G during

Environment Court mediation with Mt Campbell Station that related to proposed alteration of *Galaxias* "species D" habitat for irrigation infrastructure in Bickerstaffe Creek, southeast of Alexandra.

Code of Conduct

15. I confirm that I have read the code of conduct for expert witnesses as contained in the Chief Freshwater Commissioner and Freshwater Hearings Panels Practice and Procedures Note 2020. I have complied with the Practice Note when preparing my written statement of evidence and will do so when I give oral evidence before the hearing.

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

17. Unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope

18. I have been asked to provide evidence in relation to the notified Freshwater Planning Instrument parts of the pORPS, the D-G's submission[1] and further submission[2], and relevant parts of the section 42A report.

19. In her submissions, the D-G supported notified provisions, particularly the matter of LF-VM-02 (7)(b)(iii) and sought inclusion of additional provisions and matters to develop a planning framework to better enable protection of indigenous freshwater species and freshwater habitats from adverse effects, for inclusion in LF-FW-O1A.

20. My evidence covers the area of threatened indigenous non-diadromous galaxiids and their habitat specifically, being divided into the following parts:

[1] Submission on pORPS 2021 – Freshwater Planning Instrument Part, dated 5 December 2022, submission: fpi044
[2] Submission on pORPS 2021 – Freshwater Planning Instrument – Further Submission, dated 3 February 2023, submission: fsfpi044

(a) Non-diadromous galaxiids in Otago and their importance,

(b) Habitats of non-diadromous galaxiids in Otago,

(c) Life history of non-diadromous galaxiids in Otago,

(d) Threats to non-diadromous galaxiids in Otago,

(e) The influence of hydrological environments on the life history of non-diadromous galaxiids,

(f) The use of planning instruments in the management of non-diadromous galaxiids:

  (i) Provisions to manage activities affecting the hydrological environments of non-diadromous galaxiids.

  (ii) The importance of mapping and defining of the habitats of non-diadromous galaxiids,

Material considered

21. In preparing my evidence I have read and relied upon the following documents:

(a) Relevant freshwater planning instrument parts of the proposed Otago Regional Policy Statement 2021.

Non-diadromous galaxiids in Otago and their importance

22. The Otago region houses a suite of Threatened non-diadromous[3] galaxiid[4] fishes (Family Galaxiidæ; Dunn et al. 2018; Table 1; Figure 1). Many of these indigenous taxa[5] are endemic to, or predominantly occur in the Otago region. Further taxa predominating in either the Canterbury or Southland regions, also have subpopulations[6] of equal importance in the Otago region. A further taxon, the At

[3] See explanation in paragraph 29.
[4] The term galaxiid covers the seven genera within Family Galaxiidæ. I use the term here to refer to the genera *Galaxias* and *Neochanna*, being the only two genera present within Galaxiidæ in New Zealand, rather than the more common, and less precise usage where it is used to refer to members of *Galaxias* alone.
[5] For the purposes of this evidence, taxon (plural taxa) describes both a formally described species and a biological entity as yet without a formal name (Townsend et al. 2008**)**.
[6] Hitchmough et al. (2007) define subpopulation as: "geographically or otherwise distinct groups in the population between which there is little exchange (typically one successful migrant individual of gamete per year or less)". For non-diadromous

Risk: Declining *Galaxias vulgaris* (Canterbury galaxias) also has subpopulations occurring in Otago.

23. These endemic taxa are highly significant within the New Zealand indigenous freshwater fish fauna. Analysis of taxa listed in Table 3 of the conservation status assessment of Dunn et al. (2018) gives a total of 22 threatened taxa. Of these, 20 (or 91%) are non-diadromous galaxiids, 14 (or 70 %) of which occur in the Otago region.

24. The significance of these threatened taxa means that planning instruments, such as the proposed Otago Regional Policy Statement 2021, relating to them or their habitats are of importance in providing for their continued persistence and management, giving effect to the National Policy Statement for Freshwater Management 2020 (NPSFM 2020) which requires that threatened species[7] be managed for as a compulsory value; and in meeting New Zealand's obligations under the United Nations Convention on Biological Diversity 1992.

Habitats of non-diadromous galaxiids in Otago

25. Non-diadromous galaxiids occupy a diverse range of habitats across a hydrological continuum from no-slow flowing wetlands through to steep fast flowing streams and rivers (O'Brien & Dunn 2007 a; Dunn et al. 2020).

26. The non-diadromous galaxias in Otago are typically considered to be stream dwellers (DOC 2004), whereas Canterbury mudfish (*Neochanna burrowsius*) is a wetland specialist (O'Brien & Dunn 2007a). Non-diadromous galaxias are not typically considered to occupy lacustrine (pond or lake habitat; Stokell 1949; McDowall 2010).

27. Non-diadromous galaxias in Otago typically, albeit with exceptions, occupy smaller (low Strahler Stream Order), narrower, lower discharge tributary streams that may be associated with wetlands (Crow et al. 2015; Sinton et al. 2016, 2021 a, b, c; Daly et al. 2022; Gerbeaux et al. 2022), with local populations separated by larger river (higher Strahler Stream Order) reaches containing piscivorous[8] salmonids (Family Salmonidæ – trouts, salmons, and chars; based on examination of non-diadromous

freshwater fish, a subpopulation is considered to be contained within a single catchment, e.g., the Clutha River/ Mata Au catchment or Taieri River catchment. A sub-population consists of one or more local populations.

[7] NPS-FM 2020: page 39, Section 3 – Threatened species – "This refers to the extent to which an FMU or part of an FMU that supports a population of threatened species has the critical habitats and conditions necessary to support the presence, abundance, survival, and recovery of the threatened species. All the components of ecosystem health must be managed, as well as (if appropriate) specialised habitat or conditions needed for only part of the life cycle of the threatened species."

[8] Piscivorous means fish-eating. From http://www.briancoad.com/Dictionary/Complete%20Dictionary.htm accessed 20 September 2018.

Galaxias distributions and New Zealand Freshwater Fish Database (NZFFD) records).

28. In Otago, Canterbury mudfish (*N. burrowsius*) are known from four small wetlands and associated slow flowing stream sites, three of which are wholly or partly within the Otago Regional Council boundary on the south bank of the Waitaki River (O'Brien & Dunn 2008).

Life history of non-diadromous galaxiids in Otago

29. The term non-diadromous is applied to those fishes that do not migrate between freshwater and marine environments, completing their entire life-history in freshwater. As proposed by Myers (1949) those fish which migrate wholly within freshwater environments are termed potamodromous. Northcote (1997, page 1032) summarises four types of potamodromous migrations between spawning, feeding and survival habitats:

    a) fluvial potamodromy – spawning, feeding, and survival habitats are in main-stem streams and rivers only.

    b) fluvial-adfluvial potamodromy - spawning habitat is in stream or river tributaries, and feeding and survival habitats are in streams, rivers, and tributaries.

    c) lacustrine-adfluvial potamodromy - spawning habitat is in lake tributaries and feeding and survival habitats are mainly in lakes.

    d) allacustrine potamodromy - spawning habitat is in lake outlet streams or rivers and feeding and survival habitats are mainly in lakes.

30. Non-diadromous galaxias are known (e.g., Cadwallader 1976; Dunn 2003, 2011) to actively move between habitats within the stream environment, which could be categorised as fluvial potamodromy if it constituted a migration. The extent of this movement is not well understood, but can be up to several hundred metres (Cadwallader 1976; Dunn 2003). Observations have also been made of non-diadromous galaxias active movement in situations considered to be spawning migrations (Cadwallader 1976; Allibone & Townsend 1997; Moore et al. 1999). But again, the extent and prevalence of such behaviour is not well understood.

31. The life history phases (phenologies) of non-diadromous galaxiids in Otago can be summarised as having a spring spawning period (Allibone & Townsend 1997; Moore et al. 1999; O'Brien & Dunn 2007 a; Dunn 2011; Jones et al. 2016; Te Uru Rākau/Forestry New Zealand 2018; Dunn et al. 2022), a late spring larval hatching, a late spring – late summer rapid juvenile growth period, a spring – late summer gain in adult condition and development of reproductive cells, the latter of which continues albeit at a slower rate over autumn and winter, and a late winter reproductive cell readiness for spawning (Dunn 2003, 2011).

Table 1. Summarised distribution of threatened non-diadromous galaxiids[9] in the Otago region[10], the number of natural sub-populations[10], estimated area occupied[9], population trend[9], and distribution relative to the Otago region.

Taxa	Common name	Distribution in Otago	Number of sub-populations	Area occupied (ha)	Population trend	Distribution
Nationally Critical						
Galaxias "species D"	Clutha flathead galaxias (Clutha River)	Cardrona River, Lindis River, Clutha tributaries above Lake Dunstan, Bannock Burn, Manor Burn, Pool Burn, Benger Burn, lower Clutha tributaries, Catlins, Purakanui, and Tahakopa rivers, Karoro Creek	8	<100	Declining >70%	Predominantly Otago
Galaxias "Teviot"	Teviot flathead galaxias (Teviot River)	Teviot River tributaries and Taieri River tributary	2	1	Declining 50-70%	Endemic to Otago
Galaxias cobitinis	Lowland longjaw galaxias	Kauru and Kakanui Rivers	1	<100	Stable +/-10%	Endemic to Otago
Neochanna burrowsius	Canterbury mudfish	Waitaki River south bank tributaries	18	<100	Declining >70%	Predominantly Canterbury

[9] Dunn et al. (2018)
[10] NZFFD (New Zealand Freshwater Fish Database) data accessed on 1 March 2023

Table 1. Continued

Taxa	Common name	Distribution in Otago	Number of sub-populations	Area occupied (ha)	Population trend	Distribution
Nationally Endangered						
Galaxias anomalus	Central Otago roundhead galaxias	Taieri and Manuherikia tributaries	2	<100	Declining 50-70%	Endemic to Otago
Galaxias eldoni	Eldon's galaxias	Taieri and Tokomairiro River tributaries	2	<10	Declining 10-50%	Endemic to Otago
Galaxias pullus	dusky galaxias	Lower Clutha and Taieri River tributaries	2	<10	Declining 10-50%	Endemic to Otago
Galaxias "Nevis"	Nevis galaxias (Nevis River)	Nevis River	1	<10	Declining 10-30%	Endemic to Otago
Galaxias affinis *paucispondylus* "Manuherikia"	alpine galaxias (Manuherikia River)	Manuherikia River above Falls Dam	1	<10	Declining 30-50%	Endemic to Otago
Nationally Vulnerable						
Galaxias depressiceps	Taieri flathead galaxias	Shag/ Waihemo, Waikouaiti, Taieri, Tokomairiro river tributaries, Akatore Creek	5	<100	Declining 10-30%	Endemic to Otago
Galaxias gollumoides	Gollum galaxias	Clutha, Catlins, Purakaunui, Tahakopa, Fleming, Tautuku, Mataura river tributaries	17	<100	Declining 10-30%	Predominantly Southland
Galaxias "Pomahaka"	Pomahaka galaxias (Pomahaka River)	Pomahaka River and other lower Clutha, Tokomairaro river tributaries	2	<100	Declining 30-50%	Predominantly Otago
Galaxias "southern"	southern flathead galaxias (Southland, Otago)	Von River (Clutha), Mataura rivers	7	<100	Declining 10-30%	Predominantly Southland
Galaxias affinis *paucispondylus* "Southland"	alpine galaxias (Southland)	Von and Lochy Rivers	4	<1000	Declining 30-50%	Predominantly Southland

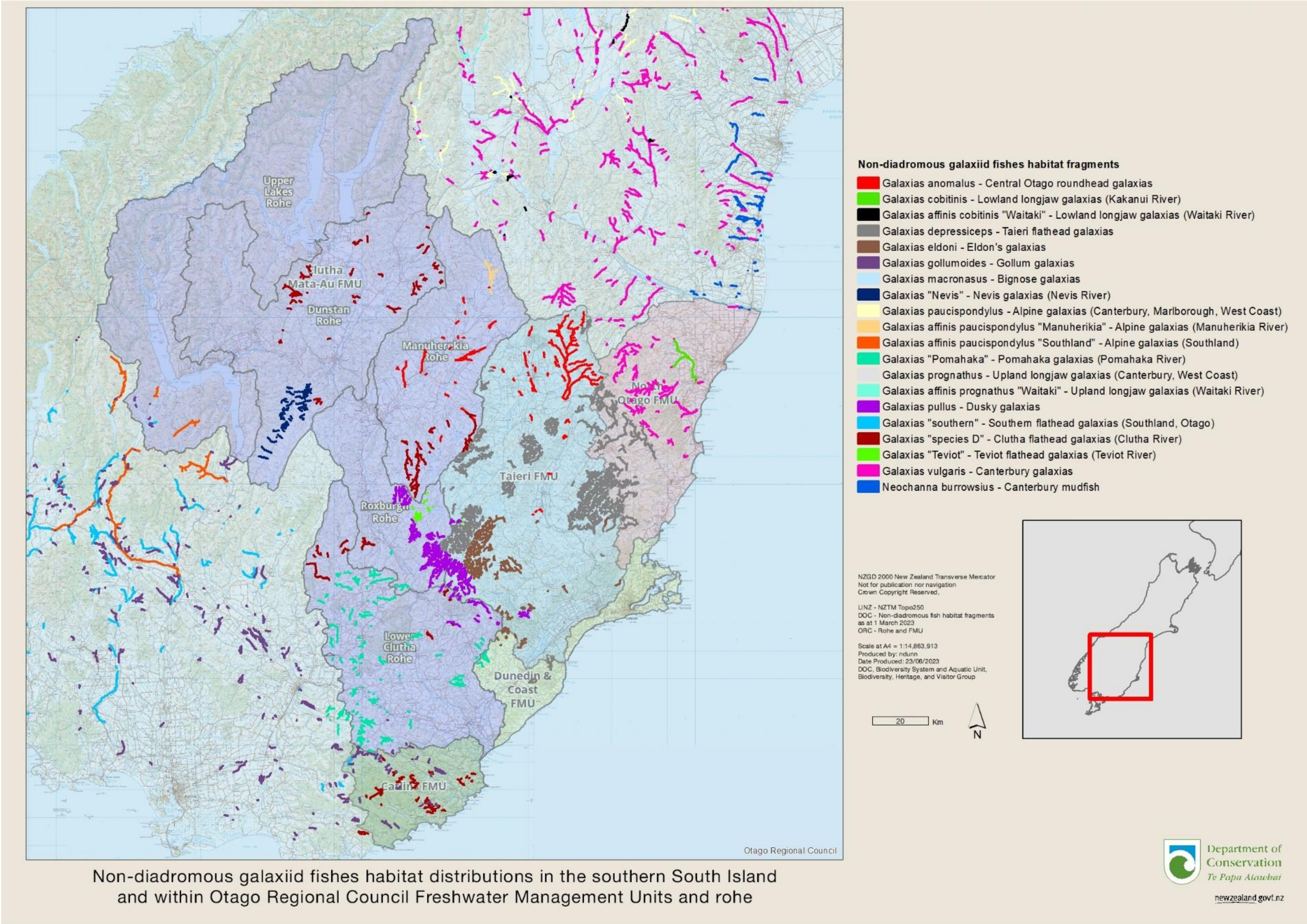

Figure 1. Non-diadromous galaxiid fishes habitat distributions in the Southern South Island and within Otago Regional Council Freshwater Management Units and rohe.

Threats to non-diadromous galaxiids in Otago

32. In her submissions, the D-G sought a planning framework which will enable greater protection of indigenous freshwater species and their habitats where activities may adversely them, both on public and privately owned/managed land.

33. I support the inclusion of provisions into policies and methods which seek to restrict and manage activities affecting threatened non-diadromous galaxiids and their habitats in particular.

34. Activities that are considered to affect freshwater fishes and their habitats leading to negative effects on population demographics and the reduction in quality of loss of habitat include water abstraction (Crow et al. 2013) and the drawdown of ground water (O'Brien & Dunn 2007 a), placement of structures in (Jellyman & Harding 2012), and disturbance of the beds of rivers and lakes, and adjacent to wetlands; vegetation clearance in beds of waterbodies and in adjacent riparian areas (Collier 1995; Reeves et al. 2004; Greer et al. 2012), and gravel extraction (Dunn & O'Brien 2006). Further pressures on the habitats of freshwater fishes arise from water quality issues and sedimentation (Rowe et al. 2009; Larnard et al. 2019; MfE & StatsNZ 2023).

35. Furthermore, for threatened non-diadromous galaxiids, the presence of predatory salmonids has been identified as a cause of decline in Otago (Townsend & Crowl 1991), Canterbury (McIntosh et al. 2010), and across their Southern Hemisphere distribution (McDowall 2006).

36. The effects of these activities and the presence of salmonids are implicated in the fragmentation of non-diadromous galaxiid populations, and could be used as a framework in which to view the multiple threats facing these taxa. This term "fragmentation" has long standing (Townsend & Crowl 1991) in non-diadromous galaxiid thinking in Otago. It refers to both fragmentation of habitat through:

(a) alteration of the hydrological environment,

(b) decline in quality and complete loss of habitat,

(c) the decline and loss of viability of localised populations (population fragments) due to decline and loss of habitat for critical life stages and,

(d) negative interactions and population decline and loss due to the presence of predatory salmonids.

37. For those non-diadromous taxa that have a small number of fragmented local populations (Table 1), addressing both hydrological environment alteration and the negative effects of salmonids, by way of planning instrument provisions, is required to support the presence, abundance, survival, and recovery of these threatened species.

The influence of hydrological environments on the life history of non-diadromous galaxiids

38. Environmental variables, particularly those associated with the hydrological environment of a habitat can have a modifying influence on the reproductive biology of fishes (Bye 1984; Jobling 1995). The hydrological environment controls the availability and structure of spawning locations required by freshwater fish (Jobling 1995; Matthews 1998; Wootton 1998), and can moderate cues such as water temperature, important for timing of reproductive readiness, and in initiating spawning activity (Bye 1984).

39. Alteration of the hydrological environment and the thermal regime before and during the spawning period by water abstraction for out of stream use or augmentation to convey water for use elsewhere, can have a profound influence on survival of critical life stages, subsequent recruitment, and hence stream dwelling non-diadromous galaxiid local population viability and persistence (Dunn 2003, 2011; Jellyman & McIntosh 2008; Dunn et al. 2022).

40. Changes to physical habitat due to alteration of the hydrological environment potentially influences availability of spawning locations within streams. Higher and faster flows could lead to fewer low velocity areas on the underside of boulders and cobbles and around submerged riparian vegetation, the considered (Allibone & Townsend 1997; Moore et al. 1999; Dunn 2011) spawning location of stream dwelling non-diadromous galaxias (Dunn et al. 2022).

41. This situation could reduce the likelihood of eggs being fertilised and attaching to suitable substrates, as galaxiid fertilisation is external (Breder & Rosen 1966), with both eggs and milt being discharged into the water column (Benzie 1961). Lower, slower flows could result in eggs not receiving enough oxygen and/or removal of

metabolic waste products, and adults could become more susceptible to infection from parasite metacercaria.

42. Larval and juvenile stream dwelling non-diadromous galaxiids utilise backwater and pool areas as rearing habitat where they swim in the water column (Benzie 1961; Cadwallader 1973; Dunn 2003, 2011; Jellyman & McIntosh 2008). These habitats tend to reduce in size and number as flow magnitudes increase, and small larvæ are readily washed out due to their limited locomotory (swimming) abilities. If these larvæ cannot enter suitable habitat downstream or are carried to reaches that subsequently dry and they perish, this could lead to recruitment failure and reduced viability of a local population (Dunn 2003).

43. Alteration of the thermal regime and spawning timing could mean food items for adults to regain condition, or juveniles to begin feeding on, become unsynchronised, which could potentially influence long term population persistence if individuals are unable to respond to changes in environmental conditions.

44. Thus, the timing of these different life stages and their habitat requirements needs to be taken into consideration when assessing the wider cumulative catchment effects of water abstraction on both ground and surface water and hence the hydrological habitat of non-diadromous galaxiids, and the effects of its modification on the biological parameters discussed in my paragraphs 38-43 above.

The use of planning instruments in the management non-diadromous galaxiids

Provisions to manage activities affecting the hydrological environment

45. Development of a planning framework enabling provision of appropriate hydrological environments, particularly in the tributary habitats of non-diadromous galaxiids underlies aspects of the D-G’s submissions on the freshwater planning instrument parts of the proposed Otago Regional Policy Statement 2021.

46. Given the threatened status of non-diadromous galaxiids, and their small, fragmented subpopulations and habitats, there is an acute need for planning provisions to support the presence, abundance, survival, and recovery of these threatened taxa.

47. It is acknowledged that there are gaps in the state of knowledge on the fundamental biology and habitat conditions required by non-diadromous galaxiids and for their critical life stages, specifically, a number of studies have been conducted on many of

the Otago taxa, but these have not been adequately reported on, or the knowledge synthesised.

48. Despite these gaps in specific knowledge, precautionary management decisions can be made by using inferences from what is known of a taxon or knowledge of similar taxa, such as done in the NES-PF 2017 Fish Spawning Indicator (Allibone 2017; Te Uru Rākau/Forestry New Zealand 2018) which seeks to protect spawning habitat from plantation forestry activities. However, it needs to be acknowledged that this literature and knowledge does not necessarily cover all known habitats or conditions a taxon is considered to occur in.

49. Non-diadromous galaxiids and the hydrological environment of their habitats, particularly where the latter is modified or removed for or by use of water out of stream, can be influenced by a number of activities that can be managed through planning provisions. These activities include, but are not limited to water quantity allocations, flow regimes including reduced or no flows, residual flows, augmented flows through the artificial conveyance of water through natural and modified natural channels, online damming creating inappropriate lacustrine habitat, and the design and operation of intake structures. Moreover, these activities can create conditions for negative interactions between salmonids and galaxiids to occur.

50. Where practicable, avoidance of water abstraction and the associated activities listed in paragraph 49, in the tributary habitats of non-diadromous galaxiids could be considered. However, any attempt to change from the current hydrological environment regime requires consideration of the consequences of changes on local non-diadromous galaxiid populations. Where avoidance of abstraction and associated activities in tributaries is not practicable, mitigating measures should be considered.

51. Mitigations could include the application of biologically meaningful residual flows at abstraction points to mitigate localised deleterious effects, such as the creation of drying reaches, on the hydrological environment and freshwater species. These residual flows could be tied, through restrictions on rate of take, to catchment minimum flows or interim minimum flows. They should also be measured in terms of flow volume, as without this it is difficult to know if they are being complied with, or whether the volume abstracted is not having a negative effect on non-diadromous galaxiids or the ecosystem and conditions that constitutes the habitat that supports them.

52. The design and operation of intake structures should mitigate the entrainment of non-diadromous galaxiids into water infrastructure. This is because non-diadromous galaxiids move within habitats and possibly undertake fluvial potadromous migrations (see paragraphs 29-30), although this is an area requiring further research. However, non-diadromous galaxias larvæ are known to passively move within streams (e.g., Cadwallader 1976; Bonnett 1990; Dunn 2003, 2011), both at high and reduced flows (Dunn 2003). Thus, the limited locomotory abilities of this critical life stage means it is appropriate to minimise loss or mortality of fish and the subsequent effects on local populations by use of well-designed intake structures and fish screens.

53. The installation of barriers to physically impede upstream movement of salmonids into indigenous fish habitat is an example of a tool to manage this adverse species interaction (Closs et al. 2016). At times, barriers have also been used to manage koaro (*Galaxias brevipinnis*) that can proliferate in, and move from man-made lakes into threatened non-migratory fish habitat (McDowall & Allibone 1994; Allibone 2008). At other times, barriers have been installed to exclude salmonids from koaro spawning habitat, such as in Hamurana Stream, a tributary of Lake Rotorua. The use of barriers has been trialled in a small number of non-diadromous galaxiid habitats, with varying success, highlighting the experimental state of this management tool.

54. Many factors are taken into account when proposing the installation of a physical barrier (Closs et al. 2016), including but not limited to the needs of the indigenous fish community (and not solely restricted to select threatened species), the value of a water body for salmonid spawning and angling, and the physical nature of the waterway. Thus, appropriate placement of a barrier is important, to address these various considerations and situations.

55. In the absence of physical barriers, the creation of drying reaches below abstraction points, by not applying residual flows, has been put forward as a way to mediate the adverse interaction of salmonids and galaxiids. I do not however consider there is a robust technical argument to support this (see also the cautionary discussion of Leprieur et al. 2006), due to the unpredictability of precipitation events having the ability to raise flows and reconnect stream reaches allowing movement of fish. Thus, it leaves the effectiveness of drying reaches as management tool to chance, and only operates during the irrigation season. Such species interactions may be better managed by the use of barriers incorporated into the design of intake and residual flow measuring structures.

The importance of mapping and defining of habitats

56. The mapping of freshwater fish habitat is critical, as knowledge of, and identification of the distribution of species and communities provides a basis for effective conservation (Leathwick et al. 2008).

57. The identification of habitats in planning instruments is important given the number and nature of activities (see paragraphs 34-36) that can occur in the habitats of threatened freshwater fishes, the effects of which can be assessed and managed through planning provisions.

58. To assist Canterbury Regional Council, a geospatial dataset was originally developed as part of the package restricting activities in mapped Canterbury mudfish habitat as part of the Canterbury Regional Council Natural Resources Regional Plan - Water Quantity (Canterbury Regional Council 2011). Over the last 19 years, I have progressively expanded on the original Canterbury mudfish habitat geospatial dataset incorporating new information and data, based on O'Brien & Dunn (2007 b, c) and recent NZFFD records.

59. I have also extended this work to create a national geospatial dataset of the distributions of habitats of indigenous non-diadromous freshwater fishes, including those in Otago (see Figure 1), primarily to inform the New Zealand Threat Classification System freshwater fish conservation status assessment, and as part of a system for DOC to manage non-diadromous galaxiids, as detailed in Dunn & O'Brien (2022).

60. This national geospatial dataset has also been made available to other agencies including Ministry for the Environment, and Forestry New Zealand (Ministry for Primary Industries) as well as regional councils including Otago Regional Council[11].

61. This geospatial dataset can be used to identify the habitat of threatened non-diadromous galaxiids in Freshwater Management Units (FMUs) and is being expanded to cover all indigenous freshwater fishes.

62. This geospatial dataset is frequently updated as new data becomes available in the NZFFD, and information on the status of subpopulation fragments is obtained. When used in a planning context, it is important to understand that this data also needs to be updated as not committing to keeping a dataset up-to-date does not allow for the protection of newly recognised habitats and populations. This is a real issue as the

[11] https://doc-deptconservation.opendata.arcgis.com/datasets/0a8fe178906944a08a9d3ef3e0d133d5_0/about

majority of threatened non-diadromous galaxiid habitats, are on private property, with sites typically only being discovered during consenting processes, or after works have been undertaken.

Conclusion

63. The Otago region houses a suite of highly threatened indigenous non-diadromous galaxiid fishes.

64. Policies and methods addressing both hydrological environment alteration and the negative effects of salmonids over the term of the proposed Regional Policy Statement are required to enable appropriate planning provisions to support the presence, abundance, survival, and recovery of these threatened species.

65. Mapping the distributions of threatened freshwater fish species and description of their habitats is important in the development of planning provisions assessing and managing the effects of activities.

Dr Nicholas Rex Dunn

Date: 28 June 2023

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