Habitat preference of Manuherikia River alpine galaxias

(*Galaxias* affinis *paucispondylus* “Manuherikia")

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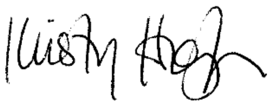	Reviewed by:	Kristy Hogsden
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Executive summary

Habitat suitability curves (HSCs) are commonly used to describe preferences of freshwater biota for water velocity, water depth, substrate, and other relevant habitat characteristics. Changes in flow affect these physical habitat characteristics, potentially altering habitat suitability for different biota. By generating quantified habitat suitability criteria these relationships can then be used to apply physical habitat models under different flow scenarios. The results from these scenarios help guide flow management decisions. HSCs have been developed for many of New Zealand's freshwater fishes, including alpine galaxias (*Galaxias paucispondylus*) has had HSCs developed, but there are no specific HSCs for the Manuherikia River alpine galaxias (*Galaxias* affinis *paucispondylus* "Manuherikia"). *G.* affinis *paucispondylus* "Manuherikia" has high intrinsic biodiversity value and is currently classified as 'Nationally Endangered' in New Zealand. The aim of the present study was to calculate HSCs for *G.* affinis *paucispondylus* "Manuherikia". Habitat and fish abundance data collected by the Department of Conservation were used to generate HSCs that could be applied to future flow assessments that use physical habitat models such as the commonly used RHYHABSIM software.

G. affinis *paucispondylus* "Manuherikia" displayed weak patterns of habitat preference for all variables, due to low sample replication. Results should be interpreted and used very cautiously as there were large standard errors associated with all categories for all variables, especially those with the highest preference values. It was difficult to reliably infer water velocity and substrate preference of *Galaxias* affinis *paucispondylus* "Manuherikia", but they may prefer habitats in shallower water (depths up to 0.1 m).

Low levels of replication within habitat categories contributed to the large level of uncertainty observed in the present study. To reduce the uncertainty associated with these HSCs and further improve understanding of the habitat preferences for *G*. affinis *paucispondylus* "Manuherikia", future habitat surveys should target the habitat categories with low sample replication and high standard errors.

1 Background

Information on habitat requirements of freshwater fishes is used to guide the management of Aotearoa New Zealand's freshwater resources. Studies on physical habitat requirements aim to identify the important flow-driven factors used, and/or preferentially selected, by target fish species (Jowett and Richardson 2008). Data on habitat can then be used by managers during flow assessments by examining how the availability of important habitat factors changes with differing flows. The relationships between habitat preference and flows can then be used to ensure fish habitat is maintained or enhanced under changing flow regimes or could help avoid situations where the availability of suitable habitat may become limiting (Jowett and Richardson 2008).

Habitat suitability curves (HSCs) are used to describe preferences of freshwater biota across environmental gradients (e.g., water velocity, water depth, substrate). HSCs have been developed for many New Zealand freshwater fishes (Jowett and Richardson 2008), including alpine galaxias (*Galaxias paucispondylus*), but there are no specific HSCs for the 'Nationally Endangered' (Dunn et al. 2018) Manuherikia River alpine galaxias (*Galaxias* affinis *paucispondylus* "Manuherikia"). Habitat requirements of this species could be inferred from *G*. *paucispondylus*; however, this could be misleading given the different habitat requirements found between other similar non-diadromous *Galaxias* species (Crow et al. 2010; 2014).

The aim of the present study was to calculate HSC for *G*. affinis *paucispondylus* "Manuherikia" for water velocity, water depth and substrate index. Data collected by the Department of Conservation (DOC) were used to calculate HSCs that could be applied to future flow assessments using the software package RHYHABSIM or SEFA (http://www.jowettconsulting.co.nz or www.sefa.co.nz, respectively).

2 Methods

2.1 Field sampling

G. affinis *paucispondylus* “Manuherikia” only occurs in the Manuherikia River above Falls Dam in Otago. A reach of the Manuherikia River above Falls Dam (reach midpoint NZTM Easting 1356007, Northing 5037073) was sampled in November 2020. Reach selection was based on the taxon being previously known at the location, and: (1) an understanding of the abundance of the taxon; (2) the presence of few other non-target species; and (3) access permission from landowners/managers. The timing of sampling was designed to measure habitat preferences during higher flow conditions in spring.

The sampling reach selected contained a variety of instream habitat types. Starting at the downstream end of this reach, 30 transects were marked at 3 m intervals. A discharge gauging was conducted at the most downstream transect. Current velocity was measured at 0.6 x depth using a Marsh McBirney Flo-Mate 2000 electromagnetic current meter.

At each transect, a 0.75 x 0.75 m quadrat was carefully placed within the stream so as to cover the dominant flow, water depth, and substratum conditions. A 1 m wide push net was placed at the downstream edge of the quadrat. Three-pass electrofishing of the quadrat was then conducted using a Kainga EFM 300 backpack electrofishing machine (NIWA Instrument Systems) in a downstream direction. Each pass consisted of 5 seconds of electrofishing machine current time, separated by a minimum electrofishing stoppage of 5 seconds between subsequent passes. After electrofishing, captured fish were anaesthetised with 2-phenoxyethanol, and identified to species using the keys of McDowall (1990; 2000), if required, or knowledge of the taxa. Fish were measured to the nearest 0.5 mm maximum total length (TL). Fish were then placed in an aerated bucket of water to recover, before being released back into quiet areas of the stream.

Following electrofishing, the mid-point of the quadrat was recorded using a handheld GPS (Garmin 64s) and the distance from each bank to the mid-point of the quadrat was measured. Water depth and water velocity (at 0.6 x depth) at the midpoint of the quadrat were measured. Percentage substratum composition within the quadrat was estimated using the following size classes: bedrock (>4096 mm), boulder (256–4096 mm), cobble (64–256 mm), large gravel (8–64 mm), fine gravel (2–8 mm), sand (0.06–2 mm) and silt/mud (<0.06 mm). Percentage cover of all algal and macrophyte types were also estimated within the quadrat. Once measurements were complete, the next transect upstream was sampled for fish and habitat in the same manner.

2.2 Fish density estimates

The total number of fish in each quadrat (summed from the three passes) was used as a measure of fish density, rather than a calculated population estimate (e.g., the Carle and Strub (1978) method). With fish catches being low (i.e., numerical average of 0.63 fish per quadrat) population estimates were unable to be generated due to insufficient data.

2.3 Substrate index

A substrate index (SI) was calculated for each quadrat from estimates of percent substrate composition using the relationship:

SI= %Bedrock*0.08 + %Boulder*0.07 + %Cobble*0.06 + %Gravel*0.05 + %Fine Gravel*0.04 + %Sand*0.03 + %Silt*0.02 (Jowett and Richardson 1990).

Vegetation has previously been included in SI calculations (Jowett and Richardson 2008) but was excluded from this analysis as vegetation was absent from all quadrats and would have no effect on the SI.

2.4 Habitat suitability curve calculations

The programme HABSEL (Jowett 2011) was used to calculate HSCs for water velocity, water depth and substrate index using density data of *G*. affinis *paucispondylus* "Manuherikia". This software uses an approach consistent with that suggested in Jowett and Richardson (2008), which has previously been the method used to calculate HSCs for many New Zealand fishes. The developed suitability curves are forage ratios where habitat use is adjusted for habitat availability, which is consistent with the category III curves described in Bovee (1986). The forage ratio is an index that measures preference for a particular habitat category and is calculated as the average abundance of the target organism in a given habitat category divided by the average abundance in all habitats. A forage ratio greater than 1.0 indicates preferential habitat selection, where habitat use is greater than expected by chance, a forage ratio less than 1.0 are indicates habitat use is less common than expected by chance, and a value equal to 1.0 indicates neutral selection (Jowett and Davey 2007).

Density data were available for *G*. affinis *paucispondylus* "Manuherikia" in the present study and it was assumed that higher fish densities were present in higher quality habitat areas (Jowett and Richardson 2008). To account for differences in fish densities between streams, fish data at each stream were standardised by dividing observed fish densities by the maximum density observed from the stream (Jowett and Richardson 2008). This converts all density data to a value between 0–1 for each stream.

Forage ratios were calculated with observations binned by habitat values (e.g., bin 1= water velocity observations from 0 to <0.3 m/s, bin 2= water velocity observations from 0.3 to <0. m/s, etc.; Appendix B). All binned groups were adjusted for each forage ratio such that each bin contained a minimum of three observations. Forage ratio values (+ standard error) for binned habitat values were displayed for all habitat variables as bar charts. Forage ratio values (+ standard error) for binned habitat values were displayed for all habitat variables as bar charts. Kernel smoothed curves were used to display trends across the habitat categories for the calculated forage ratios. Kernel smoothed curves were also overlaid on each bar chart that showed the relative abundance of used and available data.

Forage ratio values for habitat categories were then converted to a table for use in RHYHABSIM. To enable the data to be compatible with RHYHABSIM, each habitat variable required information linking a range of habitat values (e.g., velocity 0.15, 0.45, 0.75, 1.05 m/s) to a weighting value that indicates habitat preference. The habitat values were calculated from the median of the binned habitat categories on the forage ratios. The weightings were calculated by converting the forage ratio scores for each habitat category to a value ranging between 0 and 1. Habitat values for depth and velocity in the RHYHABSIM table started at 0 while SI values started at 1, despite no observations for these habitat values. This was done because a preliminary analysis in RHYHABSIM showed misleading results occurred if these variables had no data for these habitat values. A forage weighting value of 0 was set for SI index of 1.25–5.25 because no observations were completed for this habitat value and it was considered conservative to underestimate habitat quality in these areas. A depth of 0 was assigned a weighting value of 0 because fish cannot live in dry areas.

3 Results

Eleven of the 30 quadrats sampled contained *G*. affinis *paucispondylus* “Manuherikia”, with a total of 19 individuals captured and a mean fish density of 0.63 fish/m^2. With so few data, standard errors for most habitat categories were relatively large and data must be interpreted very cautiously (Appendix B). Additionally, the ranges of water depths and substrate (characterised with an index) over which samples were taken were small (0 to 0.3 m and 5.9 to 6.7 respectively).

G. affinis *paucispondylus* “Manuherikia” showed the highest forage ratios for water velocity in categories 0 to <0.3 m/s and 0.6 to <0.9 m/s, with forage ratio values above 1.0 for both categories (indicating habitat preference) (Figure 3-1). No fish were caught in the three samples representing the highest velocity category (0.9 to <1.2 m/s).

For water depth, the highest forage ratio was for the 0 to <0.1 m category (preference value 2.03) with a lower forage ratio for depths of 0.1 to <0.2 m (Figure 3-2). No fish were caught in the five samples in the highest depth category (0.2 to <0.3 m/s). While the category with the highest forage ratio for both water velocity and depth did not have a standard error that crossed below 1.0, it must be noted that these categories also had very few samples (5 and 7 respectively) and large standard errors (note also the large relative standard errors for most categories; Appendix B).

For substrate, the greatest preference was for an index value range of 5.5 to <6, but there were only three samples in this category and the standard error, which was very large, also crossed below 1.0. A neutral preference was found for a substrate index of 6 to <6.5. No fish were caught in the three samples in the highest category (6 to <6.5; Figure 3-3).

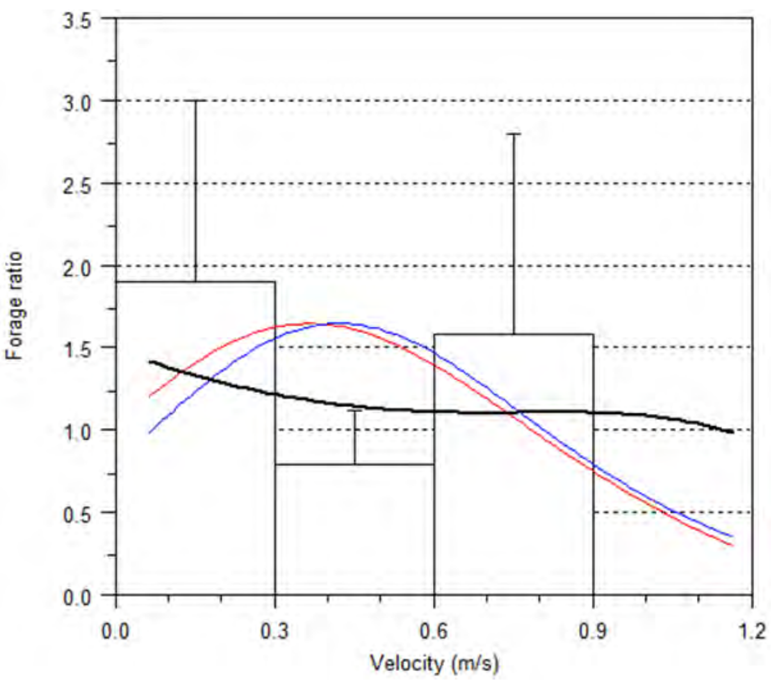

Figure 3-1: Water velocity preference by *Galaxias* affinis *paucispondylus* “Manuherikia”. Data displayed as forage ratio values (+ standard error) for binned water velocity values. Kernel smoothed curves overlaid show the relative abundance of used habitat (red line), available habitat (blue line) and the selected habitat (i.e., habitat suitability curve (HSC); black line). The HSC is the ratio of the used habitat curve divided by the corresponding available habitat curve. A forage ratio of >1.0 indicates a water velocity preference while <1.0 indicates water velocity avoidance.

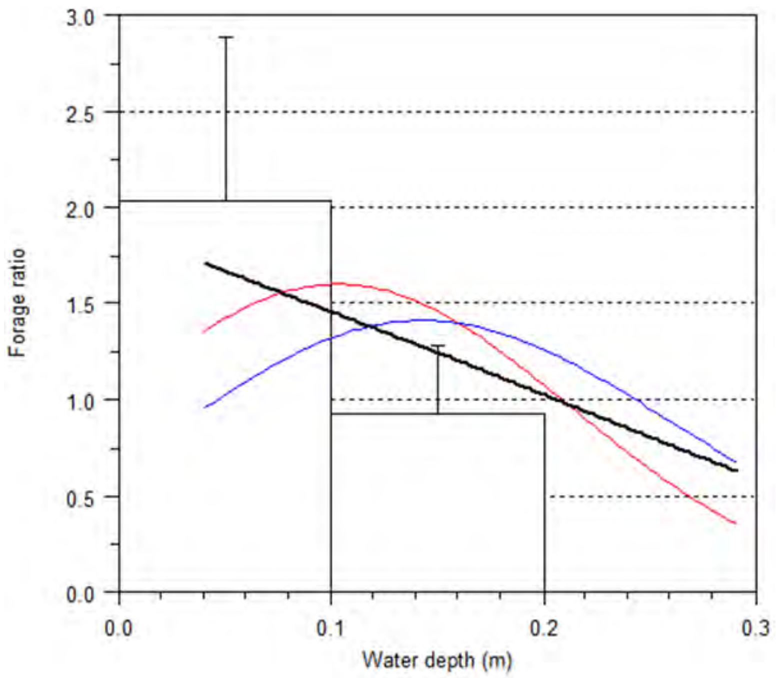

Figure 3-2: Water depth preference by *Galaxias* affinis *paucispondylus* "Manuherikia". Data displayed as forage ratio values (+ standard error) for binned water depth values. Kernel smoothed curves overlaid show the relative abundance of used habitat (red line), available habitat (blue line) and the selected habitat (i.e., habitat suitability curve (HSC); black line). The HSC is the ratio of the used habitat curve divided by the corresponding available habitat curve. A forage ratio of >1.0 indicates a depth preference while <1.0 indicates avoidance.

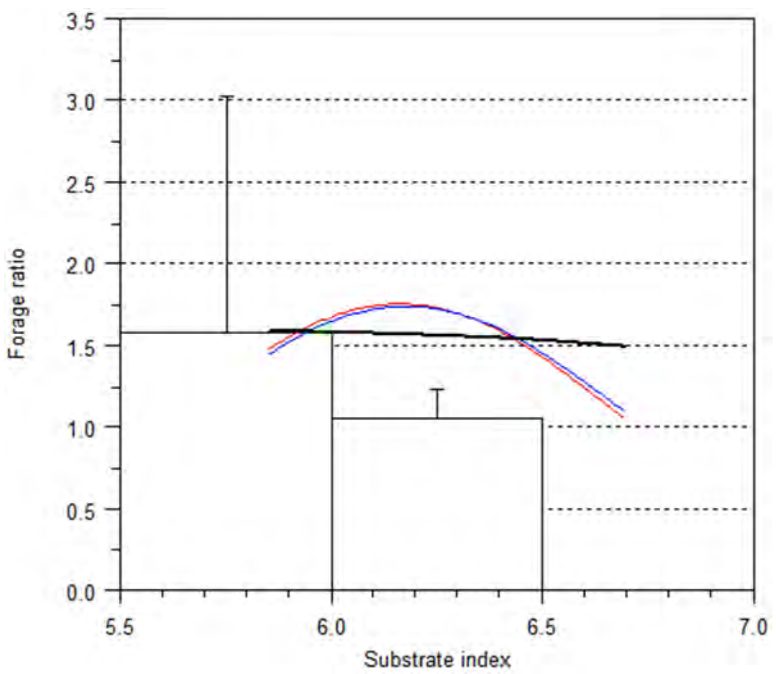

Figure 3-3: Substrate index preference by *Galaxias* affinis *paucispondylus* "Manuherikia". Data displayed as forage ratio values (+ standard error) for binned substrate index values. Kernel smoothed curves overlaid show the relative abundance of used habitat (red line), available habitat (blue line) and the selected habitat (i.e., habitat suitability curve (HSC); black line). The HSC is the ratio of the used habitat curve divided by the corresponding available habitat curve. A forage ratio of >1.0 indicates a substrate index preference while <1.0 indicates substrate index avoidance.

4 Discussion and future considerations

4.1 Habitat preference of *Galaxias* affinis *paucispondylus* “Manuherikia”

All water velocity, depth, and substrate index categories with the highest values of preference also had a very low number of samples and large standard errors. It was difficult to reliably infer habitat preference of *G*. affinis *paucispondylus* “Manuherikia” from the data due to this high degree of uncertainty. *G*. affinis *paucispondylus* “Manuherikia” may prefer shallower water (depths up to 0.1 m), but patterns of water velocity preference were not clear. Samples were only collected within a narrow range of substrate types (resulting in index values within a range of <1) so commenting on potential patterns of preference is not possible.

Low levels of replication within habitat categories contributed to the high degree of uncertainty observed in the present study. A study of *G*. “southern” habitat preferences (Sinton et al. 2021a) noted that only habitat categories containing 100 or more samples were likely to generate reliable estimates based on a relative standard error (RSE) of 20% or below. Only one habitat category in this study had a RSE less than 20%, the rest were all much larger (see Appendix B). Additionally, if fish densities are low (e.g., <1 fish per m^2, as found in the river in this study) there is an increased chance that no fish will be caught in samples of “preferred” habitats, further adding to the variability of results. Collinearity between habitat variables could further complicate interpretations of individual habitat variables, but this was not explored due to limitations in the HABSEL software.

4.2 Comparison to other studies

Alpine galaxias (*G*. *paucispondylus*) have been shown to prefer water with velocities of 0.4 to 0.6 m/s in depths of 0.15 m or less, and coarse substrates (substrate index of at least 6; Jowett and Richardson 2008). Similarly, Sinton et al. (2021b) found data suggested that *G*. affinis *paucispondylus* “Southland” also preferred shallow water depths (up to 0.1 m). These studies support the potential that *G*. affinis *paucispondylus* “Manuherikia” would also prefer shallower habitats.

4.3 Future considerations

Patterns of habitat preference were weak when compared with those observed for other species (e.g., torrentfish (*Cheimarrichthys fosteri*), Canterbury galaxias (*G. vulgaris*) or kōaro (*G. brevipinnis*) from Jowett and Richardson (2008)). To further improve understanding of the habitat preferences for *G*. affinis *paucispondylus* “Manuherikia”, the following options could be considered.

- Sample across a wider range of substrate types and water depths, as well as increase the number of samples in all habitat categories (see Appendix B). As many as 100 samples per category may be required to reduce uncertainty and provide meaningful results.
- Test the statistical significance of each preference curve using bootstrap re-sampling, which would further quantify the level of uncertainty in the HSCs.
- Explore collinearity between habitat variables, as there could be interactions between the variables which complicate interpretation. We recognise that this will not assist with RHYHABSIM analyses, which is unable to address collinearity, but would assist with management decisions.

- Investigate nocturnal habitat use. All data collected in the present study were sampled during the day but other studies have shown some native fish species may be more susceptible to capture during the evening (Crow et al. 2010; Graynoth et al. 2012). Shifts in habitat use between day and night have also been observed in other freshwater fishes in New Zealand, which has been shown to influence assessments of flow requirements (Davey et al. 2011). Consideration of nocturnal habitat requirements may produce more defensible flow recommendations for these species (Davey et al. 2011).

5 Acknowledgements

We appreciate the permission from landowners and managers to access streams on their properties.

6 References

Bovee K.D. (1986) Development and evaluation of habitat suitability criteria for use in the instream flow incremental methodology. United States Fish and Wildlife Service, Cooperative Instream Flow Group. Instream Flow Information Paper 21: 231 p.

Carle F.L., Strub M.R. (1978) A new method for estimating population size from removal data. Biometrics 34: 621-830.

Crow S.K., Closs G.P., Waters J.M., Booker D.J., Wallis G.P. (2010) Niche partitioning and the effect of interspecific competition on microhabitat use of two sympatric galaxiid stream fishes. Freshwater Biology 55: 967-982.

Crow S.K., Booker D.J., Dunn N.R., Jack D. (2014) Habitat preference of Gollum galaxias (*Galaxias gollumoides*) and Clutha flathead galaxias (*G.* 'species D'). NIWA Client Report CHC2015-061. 19p.

Davey A.J.H., Booker D.J., Kelly D.J. (2011) Diel variation in stream fish habitat suitability criteria: implications for instream flow assessment. Aquatic Conservation: Marine and Freshwater Ecosystems 21: 132-145.

Dunn, N.R., Allibone, R.M., Closs, G.P., Crow, S.K., David, B.O., Goodman, J.M., Griffiths, M., Jack, D.C., Ling, N., Waters, J.M., Rolfe, J.R. (2018) Conservation status of New Zealand freshwater fishes, 2017. Department of Conservation, Wellington, New Zealand. 11 p.

Graynoth E., Bonnett M.L., Jellyman D.J. (2012) Estimation of native fish density in lowland streams by repeated electric fishing during the day and following night. New Zealand Journal of Marine and Freshwater Research 46: 243-261.

Jowett I.G. (2011) Analysis of habitat suitability data. Version 3. © Ian Jowett Consulting. http://www.jowettconsulting.co.nz/home/habprf.

Jowett I.G., Davey A.J.H. (2007) A comparison of composite habitat suitability indices and generalized additive models of invertebrate abundance and fish presence-habitat availability. Transactions of the American Fisheries Society 136: 428-444.

Jowett I.G., Richardson J. (1990) Microhabitat preferences of benthic invertebrates in a New Zealand river and the development of in-stream flow-habitat models for *Deleatidium* spp. New Zealand Journal of Marine and Freshwater Research 24: 19-30.

Jowett I.G., Richardson J. (2008) Habitat use by New Zealand fish and habitat suitability models. National Institute of Water and Atmospheric Research Science and Technology Series No. 55 148 p.

McDowall R.M. (1990) New Zealand freshwater fishes: a natural history and guide. Auckland, Heinemann Reed. 553 p.

McDowall R.M. (2000) The Reed field guide to New Zealand freshwater fishes. Auckland, Reed Publishing. 224 p.

Sinton, A.M.R., Crow, S.K., Dunn, N.R., Boddy, N. (2021a) Habitat preference of southern flathead galaxias (*Galaxias* “southern”). *NIWA Client Report* 2021155CH. 19p.

Sinton, A.M.R., Crow, S.K., Dunn, N.R., Boddy, N. (2021b) Habitat preference of Southland alpine galaxias (*Galaxias* affinis *paucispondylus* “Southland”). *NIWA Client Report* 2021154CH. 17p.

Appendix A Forage ratios for RHYHABSIM

Table A-1: *Galaxias* affinis *paucispondylus* "Manuherikia" forage ratios prepared for RHYHABSIM analysis. The category rows contain the median of the binned habitat categories and corresponding weighting rows contain the weighted forage ratio score for each habitat category (calculated by converting the forage ratio scores for each habitat category to a value ranging between 0 and 1).

Index	Values													
Water velocity category (m/s)	0	0.15	0.45	0.75	1.05									
Water velocity weighting	0	1.00	0.42	0.84	0									
Water depth value (m)	0	0.05	0.15	0.25										
Water depth weighting	0	1.00	0.43	0										
Substrate index value	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75	7.25	7.75
Substrate index weighting	0	0	0	0	0	0	0	0	0	1.00	0.66	0	0	0

Appendix B HABSEL category and selectivity value tables

Table B-1: Water velocity HABSEL categories and associated forage ratio values for *Galaxias* affinis *paucispondylus* "Manuherikia". A forage ratio of >1.0 indicates a water velocity preference while <1.0 indicates water velocity avoidance.

Water velocity (m/s) category	Number of samples	Forage Ratio	Forage Ratio standard error (SE)	Forage Ratio relative SE (%)
0–<0.3	5	1.89	1.11	59
0.3–<0.6	18	0.79	0.33	42
0.6–<0.9	4	1.58	1.21	77
0.9–<1.2	3	0	0	0

Table B-2: Water depth HABSEL categories and associated forage ratio values for *Galaxias* affinis *paucispondylus* "Manuherikia". A forage ratio of >1.0 indicates a water depth preference while <1.0 indicates water depth avoidance.

Water depth (m) category	Number of samples	Forage Ratio	Forage Ratio standard error (SE)	Forage Ratio relative SE (%)
0–<0.1	7	2.03	0.85	42
0.1–<0.2	18	0.88	0.33	38
0.2–<0.3	5	0	0	0

Table B-3: Substrate index HABSEL categories and associated forage ratio values for *Galaxias* affinis *paucispondylus* "Manuherikia". A forage ratio of >1.0 indicates a substrate index preference while <1.0 indicates substrate index avoidance.

Substrate index category	Number of samples	Forage Ratio	Forage Ratio standard error (SE)	Forage Ratio relative SE (%)
5.5–<6.0	3	1.58	1.45	92
6.0–<6.5	24	1.05	0.18	17
6.5–<7.0	3	0	0	0