

Assessment of Brown Trout Diet in the Lower Hokitika River

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November - December 2023



Summary

In November 2023, a pilot study was conducted to investigate the dietary composition of brown trout in the lower Hokitika River, with a particular focus on the contribution of whitebait. The study combined gut content analysis with stable isotope analysis (SIA) to provide a more robust understanding of trout feeding behaviour. Gut content data indicated a diet dominated by crabs, bullies, and snails, with no significant presence of whitebait. In contrast, isotope mixing models suggested that the “mullet” prey category, likely representative of various marine fish, accounted for approximately 48% of the assimilated diet. The combined prey category of whitebait and bullies contributed around 26%.

Because whitebait and bullies displayed similar $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values, they could not be isotopically separated, limiting the ability to quantify whitebait consumption independently. When these findings are considered alongside the seasonal availability of whitebait and the gut content results, it is unlikely that whitebait play a significant role in the diet of brown trout in this area. These results challenge the commonly held belief that whitebait are a dominant food source for trout in West Coast river systems

and highlight the limitations of SIA in estuarine environments where prey species may be isotopically indistinct.

Introduction

Understanding trout diet is important for managing freshwater ecosystems, particularly where introduced trout coexist with native species. In New Zealand, trout are occasionally assumed to impact whitebait (*Galaxiidae*) populations during seasonal migrations, though such claims remain largely anecdotal and lack strong empirical support. In November 2023, a pilot study was undertaken to evaluate the contribution of whitebait to the diet of brown trout in the lower Hokitika River, using both gut content analysis and stable isotope analysis (SIA). These methods offer complementary insights: gut content analysis provides a snapshot of recent feeding activity, while SIA, based on $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope ratios in liver and muscle tissues, reflects longer-term assimilated diet. The study aimed to provide evidence-based insight into the relative importance of whitebait in trout diet and to assess whether concerns over predation are supported by dietary data.

Methods

Collection of trout tissue

Trout were collected on 7 December 2023 in the lower tidal reaches of the Hokitika River, below the State Highway 6 bridge. Fish were captured using fishing rods and nets. The timing of capture was specifically chosen to coincide with the end of the spring whitebait run, allowing sufficient time for predation and isotopic assimilation of whitebait into trout tissues. This timing helps ensure that stable isotope ratios in liver and muscle reflect dietary inputs from the whitebait migration period.

Collection of Prey Samples

Potential prey samples were collected prior to trout sampling in the same locations trout were captured. Whitebait and smelt were collected on 24 October 2024 using a whitebait net, then placed on ice and frozen for later analysis. Crabs were hand-collected by searching under rocks on 8 November 2024. Bullies were captured via electrofishing, and mullet were caught by rod fishing at the same time.

Sample preparation

After thawing, all samples were oven-dried at 60°C for 48 hours and homogenised using a mortar and pestle. For crabs, soft tissue was carefully removed from the carapace prior to drying. Approximately 0.8 mg of each dried, ground sample was weighed into tin capsules for stable isotope analysis.

Stable isotope ratios of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) were measured at the NIWA Wellington Laboratory using a continuous-flow isotope ratio mass spectrometer (IRMS)

coupled with an elemental analyser. Isotope values are reported in delta (δ) notation in parts per thousand (‰) relative to international standards. Two-point normalisation was performed using certified reference materials. Arithmetic lipid correction was applied to all $\delta^{13}\text{C}$ values (trout and prey) when C:N mass ratios exceeded 3.5, following the equations of Fry (2002) and the recommendations of Post et al. (2007).

Data Exploration

Prior to developing mixing models, we generated isospace plots and visually inspected them to (1) confirm that trout liver and muscle $\delta^{15}\text{N}$ and lipid-corrected $\delta^{13}\text{C}$ values fell within the prey polygon; (2) identify and exclude outliers that did not fall within the prey polygon; (3) assess whether prey and consumer sampling was sufficient and biologically reasonable; and (4) determine whether isotopic values of prey groupings were sufficiently distinct, a requirement for robust mixing model outcomes (Phillips et al., 2014). To confirm whether $\delta^{15}\text{N}$ and/or lipid-corrected $\delta^{13}\text{C}$ values differed among prey sources, we used Student's t-tests. When prey items were not significantly different in isospace, they were grouped following best practice guidelines (Phillips et al., 2014).

Mixing Model Analysis

Stable isotope data were analysed using the Bayesian mixing model package MixSIAR (Stock & Semmens, 2016) in R (R Core Team, 2017). Models were run for trout individuals ($n = 4$) whose isotopic values fell within the prey polygon. Each model was run using a chain length of 300,000 iterations, a burn-in of 200,000 iterations, and thinning every 100th iteration across three chains. An uninformative 'generalist' prior was applied.

Species-specific trophic discrimination factors (TDFs) were not available, so we applied mean TDFs for aquatic organisms from McCutchan et al. (2003): 2.3‰ (± 1.61 SD) for $\delta^{15}\text{N}$ and 0.4‰ (± 1.20 SD) for lipid-corrected $\delta^{13}\text{C}$.

Results

A total of seven trout were captured, ranging in size from 229 mm to 584 mm (mean 412 mm \pm 58 mm SE).

Gut content analysis

Analysis of gut contents revealed that crabs, bullies, and snails were common components of the trout diet. Of the seven trout captured, six had identifiable prey in their stomachs. Stomach content analysis showed crabs and snails were present in five individuals, bullies in three, and caddis larvae in two. Snails were the most numerous prey item, with 42 individuals accounting for 70% of the total prey count, followed by 12 bullies (20%), 9 crabs (15%), and 2 caddis larvae (3%). However, due to the small size of the snails, crabs and bullies contributed the majority of the prey biomass and volume.

Isotope Mixing model

Data exploration indicated that the stable isotope signatures of bullies and whitebait were isotopically similar, making it necessary to combine them into a single prey source category for the mixing model (Figure 1a,b). Furthermore, three of the smallest trout sampled, ranging in size from 229 mm to 339 mm, exhibited $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values that fell outside the isotopic mixing polygon. This discrepancy suggests the presence of a missing prey source not accounted for in the model. After correcting for trophic enrichment, the $\delta^{15}\text{N}$ values of these small trout were consistently lower than those of crabs, implying their diet included prey from a lower trophic level. Given that snails, organisms typically found at lower trophic positions, were detected in the stomach contents of these trout, it is likely that snails represent the missing prey source contributing to their isotopic signatures.

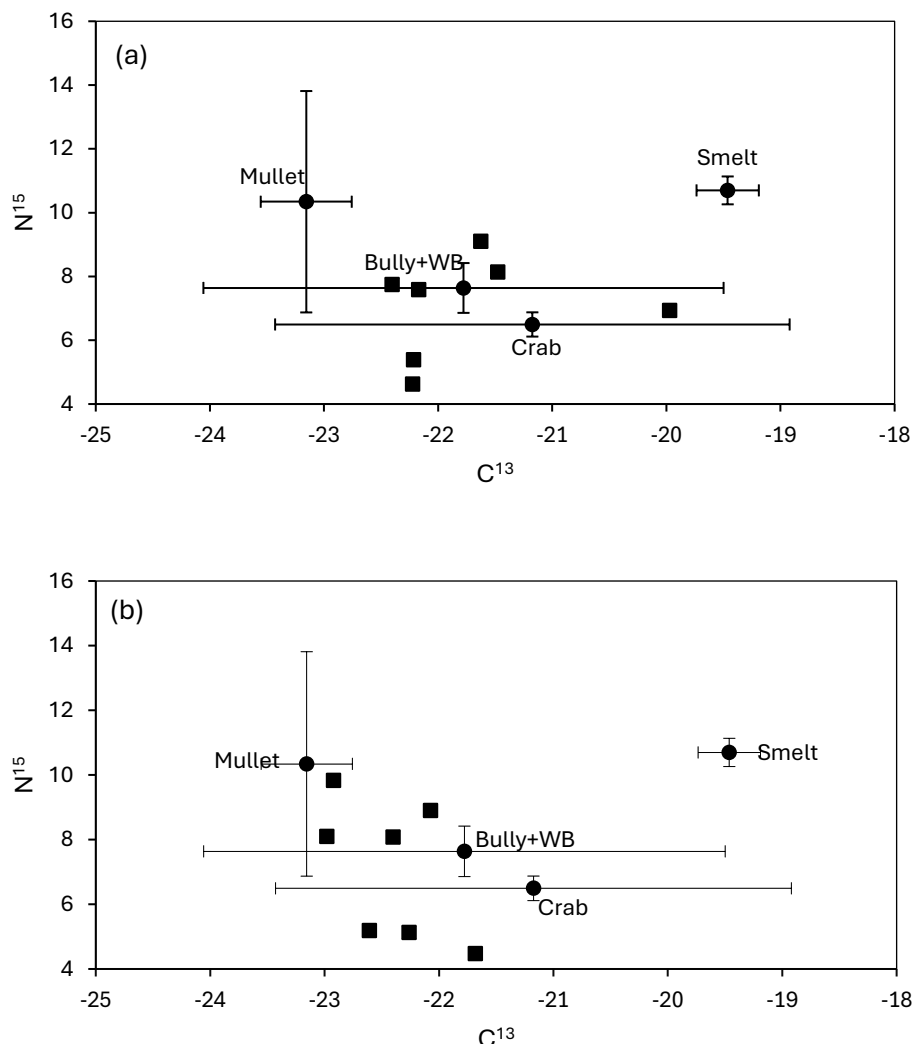


Figure 1: Isospace plots showing the $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values of (a) brown trout liver (■) and (b) brown trout muscle tissue (■) relative to potential prey (●). Prey values are

means \pm 1 standard deviation. Brown trout tissue has been corrected using trophic enrichment factors.

Table 1: Estimated dietary proportion contributions of different food items in the diet of brown trout from the Hokitika River. Dietary proportion estimates were generated using MixSIAR models, with uninformative (generalist) priors.

Prey	Mean proportion of diet	Standard deviation
Muscle Samples		
Crab	0.175	0.154
Mullet	0.475	0.226
Smelt	0.087	0.078
Bully+whitebait	0.263	0.218
Liver Samples		
Crab	0.254	0.154
Mullet	0.309	0.153
Smelt	0.142	0.093
Bully+whitebait	0.295	0.183

The stable isotope mixing model using trout muscle tissue suggests mullet was the most important prey item comprising on average 48% of large trout diet. However, it is likely that this "mullet" signal reflects marine-derived fish in general, rather than mullet exclusively. The bully+whitebait prey item was also important comprising 26% of diet. Bullies are likely to make up a large portion of combined bully+whitebait prey item given their confirmed high occurrence in the stomach content of trout. The stable isotope mixing model using trout liver tissue suggests three prey categories: mullet, crabs and bully+whitebait all contributed around 30% of large trout diet.

Discussion and conclusion

Stomach content analysis identified a diverse diet in brown trout from the Hokitika River, with snails, crabs, and bullies the most frequently encountered prey items. Stable isotope mixing models revealed that, depending on tissue type, an average of 26–30% of their assimilated diet consisted of the combined bully and whitebait prey category. However, mullet and crabs also comprised a significant proportion of their assimilated diet (approximately 18–48%). This finding aligns with the opportunistic feeding nature of brown trout, which are well known to exploit a wide range of prey items depending on availability (Elliott, 1994). Considering results from both gut content and stable isotope analyses, we infer that whitebait do not constitute a significant component of brown trout diet in the Hokitika River. This conclusion is consistent with the findings of Kleyzen (2023), who reported that bullies, crabs, and snails dominate the estuarine trout diet, while whitebait were absent within the tidal reaches of the Oreti River in Southland. The scarcity of whitebait in the trout diet likely reflects their limited seasonal availability and

the relatively high energy costs associated with capturing them. In contrast, crabs and bullies provide a more consistent, year-round food source with potentially lower energy demands for predation.

Acknowledgements

Thank you to Cohen Stewart (Southland Fish & Game) for support and guidance throughout the project, and to Jayde Couper (Otago Fish & Game) for assistance with data exploration and isotope mixing models.

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