Trout and Native Fish Species Interactions Resource

This resource is a condensed version of the thesis ‘Risk Assessment and Mitigations of the Potential Impacts of trout Predation on New Zealand’s Indigenous Fish Species’ (2022) by Ami Coughlan[1]. It is primarily for resource managers to support them to implement the National Policy Statement for Freshwater Management 2020 (NPS-FM), specifically policies 9 and 10.

This resource provides a list of indigenous fish species that have been assessed against a Risk Assessment Matrix (RAM) criteria (Appendix 2) to determine the likely risk of trout species interaction having a negative impact on their population. This resource also includes strategies on what to do about it, and how to minimise any risks (Appendix 1).

Each species table details the risks of trout predation having a negative impact on native freshwater fish populations based on available biological and ecological research in flowing water. Each table gives a ranking of either high, moderate, or minor risk. Each table is ordered from the most endangered species down to species that are not threatened[2].

At a high level, the response to each level of risk is set out in the table below. This is high level advice, as a difference response may be appropriate in specific contexts, depending on the local information and circumstances. You should discuss the local response in detail with the Department of Conservation and Fish & Game.

High risk of negative interactions with trout	- Talk to the statutory authorities (F&G and DoC) and tangata whenua about the specific species interaction - Refer to Appendix 1 on the tools to minimise possible impacts of trout predation on indigenous freshwater fish species in rivers
Moderate risk of negative interactions with trout	- Talk to the statutory authorities (F&G and DoC) and tangata whenua about the specific species interaction - Refer to Appendix 1 on the tools to minimise possible impacts of trout predation on indigenous freshwater fish species in rivers
Minor risk of negative interactions with trout	- Record the species present. No management response is generally required, but recording allows monitoring to ensure risk remains minor.

[1] https://mro.massey.ac.nz/items/3e53432f-3ceb-42f3-bdb8-61f664500541
[2] Link to: DOC website: Conservation status of plants and animals https://www.doc.govt.nz/nature/conservation-status/

- Refer to Appendix 1 on the tools to minimise possible impacts of trout predation on indigenous freshwater fish species in rivers

Negative interactions between any freshwater fish species and any predator / competitor will become worse when the environment they both live in is degraded. The best way to minimise negative interactions between trout and salmon and indigenous species is to provide an abundance of diverse, good quality habitat. This means lots of clean, clear, cool water, and plenty of instream pools, runs and riffles.

Appendix 1 provides tools to help mitigate possible trout predation impacts on indigenous freshwater species. The strategies outlined in Appendix 1 are anticipated to help reduce their level of risk in the ecosystem and lower their status as a threatened species. All species will require monitoring, but the tools set out in Appendix 1 provide direction on how to respond to identified negative species interaction.

Where species are at a minor risk of negative population level impacts from trout predation, efforts to protect and enhance their habitat should still be encouraged, as this will ensure biological interactions remain low risk.

The RAM risk factors and weightings are transparent. These tables and the framework designed to deliver the risk results (vulnerability rating in Appendix 2) will need to be updated as any species risk status changes, and as future information regarding the biological and ecological needs of freshwater species becomes available, as necessary. This will help ensure efforts continue to refocus on the most critical species according to the RAM.

Species marked with an asterix (*) are species we are aware of that may be identified by tangata whenua as mahinga kai species. Management responses that are necessary to address any impacts on these species must be informed by engagement with tangata whenua in these locations.

Smelt*

Using the RAM, it is considered the risk of negative interactions with trout to be harmful to either smelt species populations is minor.

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Common smelt *Retropinna retropinna*	Not threatened	They grow to a maximum size of 125 mm and live for a maximum of two years. They are diadromous and typically constrained to slow velocity, lowland areas, though they can travel further inland if low gradients and velocities permit.	Minor	Migrating smelt have pelagic shoaling movements through the centre of waterways, potentially increasing the risk of predation by trout, however, trout and smelt often co-exist, likely due to their high fecundity, early maturation, widespread dispersal, and the generalist habitat preferences of smelt.
Stokell's smelt *Stokellia anisodon*	Naturally uncommon	They are a predominantly marine species which can only be found in coastal freshwater areas of the eastern South Island during spawning; they do not eat in freshwater and die after breeding.	Minor	

Eel*

Using the RAM, it is considered the risk of negative interactions with trout in causing harm to either eel populations is minor.

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Longfin eel *Anguilla dieffenbachii*,	Declining	Both species are catadromous, migrating to sea to breed as fully grown adults, with the larval eels returning to freshwater systems to grow to maturity. Eels are widely distributed across New Zealand and are slow growing (males migrate to breed >25 years old and females >40 years), long lived, nocturnal and carnivorous. Longfin eels are New Zealand's largest native freshwater fish: females can obtain sizes of 2 m long and exceed 25 kg. Large eels are the apex freshwater predator of any given area and support a significant commercial fishery despite their vulnerability status. Elvers inhabit shallow lowland habitats with loose cobble substrate, while larger eels (>500	Minor	Differences in feeding times may reduce the likelihood of interaction, although during summer both trout and eels are most active during twilight. While juvenile eels can migrate in shoals, their consumption by trout is likely to be low due to their nocturnal and refuge seeking behaviours. Adult eels typically reside in undercut banks and backwaters during the day and are generally avoided by trout due to eels' status as apex predators.
Shortfin eel *Anguilla australis*	Not threatened		Minor	

		mm) seek deep, slow flowing water and are strongly associated with undercut banks and debris. Eels prefer low flows but can tolerate a variety of velocities.		Large eels are piscivorous and aggressive hunters that frequently consume trout.

Pouched Lamprey*

Using the RAM, it is considered the risk of negative interactions with trout to be harmful to pouched lamprey populations is minor.

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Pouched lamprey *Geotria australis*	Nationally vulnerable	They are a strictly nocturnal anadromous species whose adults reach a maximum of 700 mm long, spawn in freshwater and die after protecting and aerating their eggs. The juveniles (ammocoetes) live in shaded, shallow, slow water with fine substrate into which they burrow if disturbed and filter feed on algae and organic detritus for approximately four years before migrating to sea to parasitise marine animals. They are located in Australia, South America and New Zealand where, although widely distributed, they are threatened due to fish passage	Minor	The pool or under boulder habitat usage of adult lamprey may provide refuge from all predators except for large longfin eels; adult lamprey are too large to be eaten by even the largest trout. As trout move upwards into the water column to feed, and allowing that there is no overlap of diet, it is unlikely that the benthic ammocoetes would be exposed to predation by trout. The cryptic nature of

		barriers and loss of freshwater spawning habitat. Adult lamprey congregate under boulders, are rarely found above the substrate and do not feed in freshwater.		lamprey makes assessing their population abundance and distribution, difficult.

Black Flounder*

Using the RAM, it is considered the risk of negative interactions with trout to be harmful to black flounder populations is minor.

Species	**Threat status**	**Habitat and behaviour**	**Risk of negative interactions with trout**	**Species interaction**
Black flounder *Rhombosolea retiarii*	Not threatened	They are a diadromous flatfish species which grow to 350 mm, predominantly inhabit freshwater systems and spawn large numbers of small eggs at sea. They consume benthic invertebrates and have been observed consuming whitebait. Flounder are widespread in coastal waterways where they inhabit slow flowing sandy pools, estuaries, and lakes. Adults can be found up to 250km inland along low gradient, large rivers and can occasionally be found in faster flowing,	Minor	Studies examining interactions between trout and black flounder have not been found, however predation risks from trout are likely to be restricted to the migration of juvenile black flounder from the sea into estuarine and backwater systems during. The limited information on flounder abundance and late onset of breeding age (as predation

		cobbled rivers. Their life expectancy is unknown.		may occur before reproduction) of flounder may increase the vulnerability of the species to negative impacts of any type. A study in one coastal lagoon found many flounder bones in the stomachs of trout; however, the report concluded the bones were flounder carcasses discarded by fishers and solely consumed by trout due to scarcity of other food. Adult black flounder may interact with trout in lowland waterways during the migrations of whitebait as both species prey on juvenile whitebait, though predation of adult flounder by trout is unlikely due to the large body

				size and strict benthic positioning of flounder.

Diadromous galaxiids (whitebait species)*

Using the RAM, it is considered the risk of negative interactions with trout to be harmful to inanga and banded kokopu populations is minor, and shortjaw kokopu, giant kokopu and kōaro populations is moderate.

Giant kokopu, kōaro, inanga and banded kokopu populations can preferentially recruit within freshwater or estuarine systems. Shortjaw kokopu does not appear capable of forming landlocked populations.

Populations which preferentially breed in freshwater are at greater risk of negative impacts from anthropogenic activities than those who incorporate a marine life phase. The large bodied diadromous galaxiid species (giant kokopu, shortjaw kokopu, banded kokopu, and kōaro) are slow growing and strongly favour habitat with riparian vegetation.

The increased moderate risk to shortjaw kokopu, giant kokopu and koaro reflects broad dietary, habitat and feeding habits that overlaps with trout, as well as the increased vulnerability to predation encountered by migrating galaxiids (especially juveniles), and the potential for competitive exclusion. This may partially explain limited co-occurrence patterns between the species. Habitat preferences and environmental variables will impact on spatial distributions of the species also. Populations of diadromous galaxiid species have also suffered major declines in areas where river channelisation, deforestation, wetland drainage and conversion of land to pasture have occurred.

If trout and diadromous galaxiids species are found to interact within the same freshwater body, these vulnerabilities may be offset by differences in microhabitat (i.e. the finer details of habitats used by different species such as pools or riffles, where there is a variety of quality habitat more species can coexist) and diel feeding preferences (i.e. the time of day that species typically undertake activities such as feeding, sleeping etc); the four large diadromous galaxiids species are likely to grow too big to be consumed by trout and have been observed excluding trout from preferred habitat.

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Shortjaw kokopu *Galaxias postvectis*	Nationally vulnerable	They have a life span of up to 15 years, maturing at 3 years, and spawning many, large eggs. It is the rarest of the large galaxiids, inhabiting small, clear streams in native forests with logs or boulders as instream cover. A survey found that shortjaw kokopu had irregular recruitment patterns and were widely but sparsely distributed, and often found in low abundance. However, the species is cryptic and difficult to sample, and may more abundant than currently recorded. During the study, one reach was cleared of riparian vegetation and the resident kokopu emigrated, despite previously displaying high site fidelity. This response demonstrates the importance of vegetated cover to the species.	Moderate	A spotlight survey of fish assemblages in 148 streams across northern parts of the South Island observed trout co-occurrence with shortjaw kokopu at over the half the sites trout were present. It is, however, unknown which factors, or combinations thereof, explain the lack of co-occurrence at the remaining sites. The increased risk for shortjaw kokopu is linked to its low abundance.
Kōaro *Galaxias brevipinnis*	Declining	They have a life span of 15+ years, females spawn large numbers of small eggs. This	Moderate	Two surveys have noted pool dwelling populations of kōaro

		species has excellent climbing ability which allows for their widespread distribution. They inhabit riffles and pools, are often found under large boulders, are rarely found where riparian cover has been removed, and rise from the riverbed to feed in a manner similar to trout.		in waterways where trout are rare or absent, and it has been suggested that trout may exclude kōaro from preferred habitats. It has been noted that feeding time differences in Lake Taupō tributaries reduced competitive pressure between rainbow trout and kōaro, but trout presence may have led to some exclusion of kōaro in rivers with low habitat heterogeneity. In a series of experiments it was found that the presence of medium sized trout (up to 140 mm) had no significant effect on the growth rate of small, medium, or large kōaro over a one-month period, but that small kōaro avoided both medium trout and large kōaro suggesting

				predator avoidance may be of more importance to juvenile kōaro than competition factors regardless of species.
Giant kokopu *Galaxias argenteus*	Declining	They are highly fecund, live up to 30 years and reach maturation after three years. Juveniles inhabit backwaters adjacent to fast flowing water, adults prefer pool habitat in slow flowing, clean, lowland waterways with abundant riparian vegetation.	Moderate	Giant kokopu are regularly found with brown trout in the same waterway but cohabit less frequently at finer spatial scales, potentially due the large size, aggressive territorial behaviour, and predatory nature of both species, or fine scale habitat preferences. They are more likely to be absent where trout abundance is high although both species were observed in the same pools in one stream. Giant kokopu have also been noted excluding trout from prime riverine habitat.

				The increased risk for giant kokopu is considered more vulnerable due to its late maturation time and almost identical habitat and feeding preferences to trout.
Īnanga *Galaxias maculatus*	Declining	They are associated with pasture sites, slow, deep water, fine substrate within a gentle upstream gradient from the river mouth and are unable to progress past instream barriers. Inanga habitat criteria is dictated by swimming ability and bio-energetic requirements rather than the river and surrounding environment as most individuals spend only a short time (~ seven months) in freshwater. The short life span of inanga indicates that populations could suffer serious declines should year class recruitment falter or fail.	Minor	Experiments on habitat use by inanga when trout are present show conflicting results, although inanga showed behavioural changes only when large trout were present. Inanga show no response to trout odour, but actively avoid eel odour (chemicals in water). This may be because inanga recognise eel as a more significant predator, however the behaviour is likely to expose inanga to higher predation risks by trout. One experiment showed predation

				by large trout on adult inanga at between 0-40% (mean 14.5%).
Banded kokopu *Galaxias fasciatus*	Not threatened	They live up to 10 years, males mature in two years, females in four – spawning large quantities of small eggs. This species often inhabits small pools with fine substrate and undercut banks in first and second order streams. Banded kokopu are highly sensitive to suspended sediment and avoid rivers with turbid lower reaches, limiting or excluding juvenile migration to less degraded upstream habitats.	Minor	Trout and banded kokopu have been observed acting aggressively towards each other (trout keep territories, banded kokopu swam in a loose shoal). Territorial and aggressive behaviours were also noted among banded kokopu where the density of the fish was highest. It is possible that banded kokopu could be excluded from some habitat by large trout in reaches where both could co-occur, or alternatively that trout may be excluded by banded kokopu.

Mudfish species

The RAM considers that due to the threatened nature of mudfish species, and their small and fragmented populations, vulnerability of the species to trout (or any other) predation must be assumed to be high.

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Canterbury mudfish *Neochanna burrowsius*	Nationally critical	The major driver of decline in species abundance and distribution in mudfish species is loss of their wetland habitat, with the exception of Chatham Island mudfish.	High	Trout have been recorded consuming mudfish in one study, impact of such predation has not been assessed, however due to the threatened nature of mudfish species, and their small and fragmented populations, vulnerability of the species to trout (or any other) predation must be assumed to be high.
Northland mudfish *Neochanna heleosis*	Nationally vulnerable		High	
Black mudfish *Neochanna diversus*	Declining		High	
Brown mudfish *Neochanna apoda*	Declining		High	
Chatham Island mudfish *Neochanna rekohua*	Naturally uncommon		High	

Torrentfish

Using the RAM, it is considered the risk of negative interactions with trout to be harmful to torrentfish populations is minor.

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Torrentfish Cheimarrichthys fosteri	Declining	They preferentially inhabit torrents and fast flowing riffles. The females migrate downstream to spawn and then return to their earlier habitat; the distance migrated is likely to be river specific.	Minor	The torrentfish generally occupy different microhabitats, and have widespread distribution and low threat ranking. One study found a large trout with eight torrentfish in its stomach, so predation can occur. This predation is most likely during the spawning migrations, as large trout seldom inhabit torrent environments.

Non-diadromous galaxiids

The RAM considers risk of trout predation to populations of Central Otago roundhead, Gollum, Canterbury and alpine galaxiids to be moderate, and the risk to dwarf, upland longjaw, lowland longjaw, Eldon's, dusky, and the bignose and Taieri flathead galaxiids to be high.

These are galaxiid species which spend their entire life cycles in freshwater systems, and often have larger eggs and fry in comparison with diadromous galaxiids. They are generally cryptic and relatively unstudied, with many species only described recently based on genetic analysis (past research talks about certain species which are found later to be separate species, further confounding results of the studies).

Trout and non-diadromous galaxiids have been found coexisting in some sites particularly in locations with higher level of disturbance size and frequency, interstitial or vegetation refuges, and those sites of a size which excludes large trout. While some studies discuss the predominance of some non-diadromous galaxiid species presence above barriers to trout, non-overlapping distributions of non-diadromous species have also been noted to occur due to geomorphological changes brought about by geological and glacial processes which have isolated populations and led to the speciation noted.

There are broad diet and habitat overlaps between non diadromous galaxiids and trout, the small size of these indigenous species increases risk of predation. Those species with slower life strategies, delayed maturation, and high threat ranking are at an increased risk to any form of disturbance (biological or habitat based). While the literature is not clear on the impact trout can have, habitat preservation and restoration, and reduction of all threats to these species are of utmost importance.

If trout and galaxiid species are found to interact within the same freshwater body, the precautionary principle should be used where species are highly threatened, fragmented, or have slow life strategies and late maturation which can lead to unrecoverable population impacts by any means (predation by fish or birds, or loss of habitat).

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Lowland longjaw galaxiid *Galaxias cobinitis*	Nationally critical	have a life span of one year, and spawn very few eggs, though in stable flow years the population can increase in abundance rapidly. The species is only found in two river systems in northern Otago in gently flowing shallow water riffle margins with plentiful interstitial spaces. Adults are adept at burrowing through substrate, making it difficult to assess actual population numbers.	High	It has been stated that lowland longjaw galaxiids are rapidly becoming restricted to areas behind barriers which exclude large trout. Lowland longjaw also show a significant preference for groundwater upwellings, reductions to these via abstractions or groundwater changes pose a significant extinction threat.
Dusky galaxiid *Galaxias pullus*	Nationally endangered	They are found in small, fragmented reaches in eastern Otago, South Island, and can live up to 15 years (maturing in their 4th year). They spawn few, very large eggs in stream edges, survival of eggs highly vulnerable to any reduction in water height.	High	A survey of 14 sites where dusky galaxiids were present found only one site where the species co-occurred with trout or koaro, no information on habitat variables given, the lack of eels at any dusky galaxiid site was thought to allow

				predation pressure from koaro or trout on dusky galaxiids.
Eldon's galaxiid *Galaxias eldoni*	Nationally endangered	They are found only in eastern Otago, South Island, and has a highly fragmented populations with very restricted distribution, occupying high altitude, tussockland or forest streams with stony substrates. This species can live for 15 years, and spawn few, large eggs with the fry being large with very restricted dispersal ability. Abundance and distribution of Eldon's galaxiid has substantially declined since 2000, rendering them more vulnerable to any threats.	High	
Bignose galaxiid *Galaxias macronasus*	Nationally vulnerable	They are a cryptic, mostly sub-alpine species currently found in 13 sites within the Waitaki River catchment, Canterbury, South Island. Bignose galaxiids can be very abundant in low discharge environments lacking other species, so may actively avoid other species.	High	Water abstraction has been noted as a threat to this species, as it reduces habitat availability and potentially removes juveniles with the pumped water.
Upland longjaw galaxiid *Galaxias prognathous*	Nationally vulnerable	They inhabits braided mainstems, tributaries and springs at high elevations in central South Island. Species spawns few, small eggs	High	A study has shown that upland longjaw has been noted where quinnat salmon, rainbow trout

		in their first year and can live for more than 3 years.		and brown trout where found, although scale of cohabitation (river, reach, or site) was not stated. Water abstraction causing loss of critical spring fed high altitude streams is heavily implicated in their declining population abundance and distribution.
Taieri flathead galaxiid Galaxias *depressiceps*	Nationally vulnerable	They inhabit riffles and runs in small – medium swiftly flowing tussockland streams. They live up to 8 years, and spawn few, large eggs on the underneath of boulders.	High	Of the other flathead galaxiid species (e.g., *Galaxias 'species' D*; *Galaxias southern*, and *Galaxias Teviot*) little is known about their biology, ecology, or interactions with trout. Studies found presence of trout altered the depths at which adult flatheads were found in Otago streams, and juveniles were more common in gravel substrate when trout were present. However gravel was

				only found in pools at trout sites, and juvenile Taieri flathead galaxiids preferentially inhabit pools, indicating again the complexities in determining impacts of trout against habitat variables and preferences of native fish species.
Dwarf galaxiid *Galaxias divergens*	Declining	They are widespread throughout New Zealand, adults are benthic inhabiting edged and riffles in shallow cobbled streams and utilise interstitial spaces in low flows. Juveniles shoal in stream margins and backwaters.	High	Trout have been implicated in fragmenting the range of this species, however dwarf galaxiids have been found cohabiting with trout of any size in many parts of their range.
Alpine galaxiid *Galaxias pauscipondylus*	Nationally vulnerable	They generally inhabits high altitude, fast flowing streams of the central South Island, and spawn few, large eggs in their second year. Juvenile recruitment is highest in permanent upwellings in small, shallow sites with plentiful substrate interstitial spaces.	Moderate	Alpine galaxiids have been noted co-occurring with quinnat salmon, rainbow trout, and brown trout, and presence of absence of trout did not appear to change the

				occurrence of this species or alter juvenile recruitment.
Canterbury galaxiid *Galaxias vulgaris*	Declining	They are widespread throughout Canterbury, Otago, and Southland rivers. Adults become diurnal and highly aggressive during the breeding season. Females spawn large numbers of large eggs in riffles, and juveniles inhabit slow moving backwaters and river margins near to adult habitat. Initially thought to be one species, genetic testing has indicated there are at least 10 taxa under the umbrella name, speciation is likely caused by geographical history of the regions. Egg size and fecundity vary greatly across the different species, those species with the lowest fecundity and delayed maturation rates associated with stable headwater creeks, those with the fastest life strategies are found in disturbed lower catchment waterways.	Moderate	High fecundity and widespread larval dispersal of many Canterbury galaxiid species may assist the noted co-occurrence with trout, however differing species biology and life strategies complicated historical research and knowledge.
Central Otago roundhead galaxiid	Nationally endangered	are found in swift, shallow gravel streams or small, slow, deep gravel creeks in Central	Moderate	Brown trout and roundhead galaxiids co-occurred in some

Galaxias anomalus		Otago. The species has a moderate climbing ability, often utilises instream or bankside cover and spawns moderate numbers of large eggs under boulders.		reaches with low slow, high risk of intermittent waterway drying, and good representation of riffles and runs close to the mainstem of the Manuherikia River, so disturbance may potentially create positive conditions for cohabitation.
Gollum galaxiid *Galaxias gollumoides*	Nationally vulnerable	They are found in Southland, South Otago, and on Stewart Island. This species inhabits lowland, low velocity streams and swamps with silty substrate and emergent vegetation, adults likely spawn large numbers of small eggs after their first year.	Moderate	Research into interactions between trout and Gollum galaxiid was not found, other research suggests water abstraction, stream channelisation, nutrient and sediment loading are the primary threats to the species.

Diadromous bully species

The RAM considers the risk of trout predation to be deleterious to common, giant, and redfin bully populations to be minor, and for bluegill bullies to be moderate. Bully species have high fecundity, multiple spawning events in a year, early maturation, wide larvae dispersal, and nest guarding behaviours which contribute to abundance and distribution of the species.

Like the diadromous galaxiids, diadromous bullies migrate between freshwater and marine environments at different stages of their life cycles. Adult bullies are benthic and occupy a wide range of habitats, the female bullies lay eggs on or under any hard surface.

Species	**Threat status**	**Habitat and behaviour**	**Risk of negative interactions with trout**	**Species interaction**
Bluegill bullies *Gobiomorphus hubbsi*	Declining	They inhabit the heads of rapids and avoid pools, and generally migrate further inland over their lifespan, so the oldest bullies are found further up the catchment.	Moderate	The patchy distribution of bluegill bullies increases the risk to the species from impacts from any sources, including trout predation. Threats to this species is primarily sediment infill of interstitial spaces in substrate.
Giant bully *Gobiomorphus gobiodes*	Naturally uncommon	They are a highly fecund, slow growing species which can live for 10 years, often found in low elevations close to the sea. Juveniles are likely misidentified as common	Minor	

		bullies, and are highly cryptic, leading to scarcity of information around their biology, ecology, and population trends.		
Common bully *Gobiomorphus cotidianus*	Not threatened	They spawn large numbers of eggs, potentially several times a year. They are widespread and abundant across their ranges, however, there has been a noted decline (~25%) in riverine populations between 2003 and 2015.	Minor	Common bullies co-occur with trout of all sizes.
Redfin bully *Gobiomorphus huttoni*	Not threatened	They inhabit riffles, runs, and pools in fast flowing, bouldery streams. This species preferentially inhabits interstitial spaces, and infill of this may partially explain steady rate of population decline.	Minor	They are nocturnal and will co-occur with trout, interactions have not been studied, however the species remains locally abundant where conditions allow.

Non-diadromous bully species

The RAM considers the risk of trout predation to be deleterious to Cran's bully populations to be minor, and for upland and Tarndale bully populations to be moderate. All species have been noted to co-occur with trout, however upland and Tarndale bullies are geographically isolated with fewer recruitment opportunities, and thus more vulnerable to any negative impacts.

Non migratory bully species live their life cycles in freshwater, and generally spawn larger eggs than diadromous bully species.

Species	Threat status	Habitat and behaviour	Risk of negative interactions with trout	Species interaction
Tarndale bully *Gobiomorphus alpinus*	Naturally uncommon	They inhabit the shores of five small lakes in the Tarndale Hills, South Island.	Moderate	Brown trout are present in several of the lakes, no research has been found on impacts of the trout on the bully population or distribution. Predominant threats to the species are sedimentation and weed growth.
Upland bully *Gobiomorphus breviceps*	Not threatened	They are highly productive, with 8 or more spawning events a year. Juveniles inhabit very slow river margins and backwaters, adults inhabit a wide range of environments, but strongly avoid areas where substrate is infilled.	Moderate	Surveys have noted widespread coexistence between upland bully and trout species.
Cran's bully *Gobiomorphus basalis*	Not threatened	They inhabit rocky streams in native forest, spawn a moderate abundance of large eggs with juveniles maturing rapidly in river margin habitat. This species tolerates a wide	Minor	It is considered that this species was introduced to several North Island lakes as food for trout, however no

		range of conditions and can be locally abundant.		research on interactions or impacts of trout predation has been found.

Grayling

The New Zealand grayling are the only native fish species known to become extinct. As outlined in the table below, while there has been speculation that extinction was from trout, there is no evidence of this as trout were not present in many of the locations where grayling became extinct. This example is included as a reminder that evidence of species interaction and the implication of a negative risk to indigenous freshwater species is critical to understand in each particular reach before mitigation measures are decided at the local water body level. Speculative, and historical assumptions must be questioned and decisions based on best information available.

Species	**Threat status**	**Habitat and behaviour**	**Risk of negative interactions with trout**	**Species interaction**
New Zealand grayling *Prototroctes oxyrhynchus*	Extinct	They were a small, shoaling, species found in abundance throughout much of the country, and was the sole native herbivorous freshwater fish species. Abundance of grayling was noted to have declined considerably by 1870, and the last recorded grayling sighting was in 1920.	-	While trout have been implicated in their extinction, grayling also disappeared from isolated streams where trout were not present, and it is considered more likely that over-harvesting of the species and overwhelming habitat modification by European settlers, alongside source-sink

				population dynamics, caused the sad loss of this unique species.

Appendix 1: Tools to moderate possible impacts of trout predation on indigenous freshwater fish species in rivers

Environmental risk factors	Actions required	Rationale
Flow variability	Advocate for a natural flow regime, reduce water abstraction for any use, and allow a return to a natural cycle of drought and flood.	Streamflow major variable affecting abundance and distribution of freshwater species. Trout only linked to significant negative impacts on native species in stable streams. Natural flow peaks and droughts assists cohabitation with native species and native species spawning and recruitment.
Stream morphology and size	Advocate for variety and variability of natural stream processes to positively influence biological diversity by providing for species specific habitat and life history needs. Discourage and find alternatives to channelisation and water abstraction where possible.	Habitat heterogeneity allows cohabitation of many species, including trout and native fish species across differing life stages. Edgewater habitats increases recruitment potential to bolster populations. Dynamic river structure vital for fish species
Sediment and substrate size	Advocate for reduced sediment and a range of substrate sizes, minimise sediment inputs into waterways, and allow riparian overhanging structures and wood inputs.	Interstitial space provides habitat, access to food, and refuge for many native fish species and is thus necessary for multi-species communities. Sediment infills substrate, reduces waterway depth, and homogenizes habitat, which may preclude cohabitation.
Nutrients and pollutants	Advocate for minimised inputs of nutrients and pollutants from any source.	Nutrient inputs can infill waterways and interstitial spaces with aquatic flora and cause hypoxic conditions overnight. Metal and chemical pollutants impair fish species greatly decreasing predator avoidance ability.

Environmental risk factors	Actions required	Rationale
Source and sink populations	Tools: Correctly identify source vs sink populations and connectivity between them, maintain source populations and work to bolster recruitment for sink populations. Ensure fish abundance alone isn't the metric for population health, analyse age groups and site fecundity.	Sink populations of species lose more individuals than they create, and therefore must be bolstered by immigration from healthier populations (source populations). Sink populations are highly vulnerable to extirpation from any threat, including trout or other predator. Source populations may sustain other populations in the face of pressures.
Marine - freshwater connectivity	Advocate for increased marine - freshwater connectivity in both upstream and downstream directions and remove fish passage barriers where possible	The high incidence of diadromy in freshwater fish indicates the importance of access between marine and freshwater environments in replenishing freshwater communities in the face of biological and environmental pressures.
Riparian vegetation	Advocate for appropriate riparian vegetation extending throughout as much as the catchment as is practicable.	Many fish species require robust riparian vegetation, inputs of food and woody debris as shelter can sustain inter-species cohabitation as well as partially mitigate other environmental impacts.
Temperature	Advocate for natural temperature fluctuations, reduce or remove anthropogenic sources of thermal pollutants into waterways, ensure water abstraction does not interfere with the riverine ecosystem.	Water temperature outside any species preferred range overrides any biological interactions by changing all species behaviours (including feeding and breeding), and negative impacts of these unfavourable conditions will increase any impact of predation.
Trout size	While environment plays a larger role in mediating cohabitation between trout and native species, large trout (>150mm FL) in deep, stable rivers may pose a threat to threatened native fish if any such are inhabiting the same	Trout can become piscivorous once over 150mm FL. After this size, fish remain a small portion of trout diet (<10%, on average), and this proportion is governed primarily by the abundance of small fish and the availability of refuge for the prey. Non-diadromous species with highly

Environmental risk factors	Actions required	Rationale
	waterbody. Therefore, removal of large trout may be occasionally required if these circumstances occur.	fragmented and impacted habitats need to be protected from introductions of any large piscivorous fish, including trout.

Appendix 2: Risk Assessment Matrix

This RAM gives an objectively derived numeric score for each species based on an assessment of specific traits. The impact trout predation has on the population of each native species depends on frequency and extent of interactions with trout, population dynamics, and behaviour. Literature on species life history (how rapidly species re-populate), biology, and ecology information were used to populate this RAM. Certain risk factors were seen as more likely to cause species to be more vulnerable than others, and these were given a weighting to show this. The scores derived from this information where then grouped into highly vulnerable, moderate, and minor risk groups. This ranking shows how vulnerable each species is likely to be to population level detrimental impacts of trout predation. Those threatened, fragmented, species are highly vulnerable to extinction or extirpation from any source and need to be protected from all threats. Where adults of a species remain small, they are more likely to be able to be eaten by trout or a larger fish. Species with a slow life strategy (spawning few, large, eggs, having a low dispersion rate of individuals or breeding maturity reached after many years) are more vulnerable to losses which contribute to smaller, fragmented, or less resilient populations. Species which mature quickly, spawn many small and mobile young, and/or disperse widely, tend to have populations which are more resilient to threats, including that of predation by trout.

	Risk factors and weightings									
Species	**Overlapping mesohabitat / niche with trout**	**Diet similarities**	**Diel activity patterns**	**Fecundity and egg size**	**Age at maturity**	**Larval dispersal (recolonisation)**	**Threat ranking**	**Adult size**	**Score**	**Vulnerability rating**
	1	**1**	**1**	**2**	**1**	**2**	**2**	**2**		
Dusky galaxiid (*Galaxias pullus*)	2	2	2	3	3	3	3	2	31	High
Lowland longjaw galaxiid (*Galaxias cobinitis*)	2	2	2	3	1	3	3	3	31	High
Eldon's galaxiid (*Galaxias eldoni*)	2	2	2	3	2	3	3	2	30	High
Bignose galaxiid (*Galaxias macronasus*)	2	2	2	3	2	3	2	3	30	High
Upland longjaw galaxiid (*Galaxias prognathus*)	2	2	2	3	1	3	2	3	29	High
Canterbury mudfish (*Neochanna burrowsius*)	2	2	1	3	2	3	3	2	29	High
Brown mudfish (*Neochanna apoda*)	2	2	1	3	2	3	2	2	27	High

Species	Risk factors and weightings								Score	Vulnerability rating
	Overlapping mesohabitat / niche with trout	Diet similarities	Diel activity patterns	Fecundity and egg size	Age at maturity	Larval dispersal (recolonisation)	Threat ranking	Adult size		
	1	**1**	**1**	**2**	**1**	**2**	**2**	**2**		
Black mudfish (*Neochanna diversus*)	2	2	1	3	2	3	2	2	27	High
Northland mudfish (*Neochanna heleosis*)	2	2	1	3	2	3	2	2	27	High
Chatham Island mudfish (*Neochanna rekohua*)	2	2	1	3	2	3	2	2	27	High
Taieri Flathead galaxiid (*Galaxias depressiceps*)	2	2	2	2	2	3	2	2	26	High
Dwarf galaxiid (*Galaxias divergens*)	2	2	2	1	2	3	2	3	26	High
Roundhead galaxiid (*Galaxias anomalus*)	2	2	1	1	2	3	3	2	25	Moderate
Gollum galaxiid (*Galaxias gollumoides*)	2	2	2	1	1	3	2	3	25	Moderate
Tarndale bully (*Gobiomorphus alpinus*)	2	2	2	1	1	3	2	3	25	Moderate
Canterbury galaxiid (*Galaxias vulgaris*)	2	2	2	1	2	2	2	3	24	Moderate
Alpine galaxiid (*Galaxias paucispondylus*)	2	2	2	1	2	3	2	2	24	Moderate
Upland bully (*Gobiomorphus breviceps*)	2	2	2	3	1	2	1	2	23	Moderate
Koaro (*Galaxias brevipinnis*)	3	3	2	1	2	1	2	2	22	Moderate
Giant kokopu (*Galaxias argenteus*)	3	3	3	1	3	1	2	1	22	Moderate
Shortjaw kokopu (*Galaxias postvectis*)	3	3	2	1	3	1	2	1	21	Moderate
Bluegill bully (*Gobiomorphus hubbsi*)	2	2	2	1	1	1	2	3	21	Moderate
Inanga (*Galaxias maculatus*)	3	2	2	1	1	1	2	2	20	Minor
Torrentfish (*Cheimarrichthys fosteri*)	2	2	2	1	2	1	2	2	20	Minor
Stokell's smelt (*Stokellia anisodon*)	3	1	3	1	1	1	2	2	20	Minor
Banded kokopu (*Galaxias fasciatus*)	3	3	2	1	3	1	1	1	19	Minor
Cran's bully (*Gobiomorphus basalis*)	2	2	2	1	1	2	1	2	19	Minor
Common smelt (*Retropinna retropinna*)	3	2	3	1	1	1	1	2	19	Minor
Longfin eel (*Anguilla dieffenbachii*)	2	3	1	1	3	1	2	1	19	Minor

Species	Risk factors and weightings								Score	Vulnerability rating
	Overlapping mesohabitat / niche with trout	Diet similarities	Diel activity patterns	Fecundity and egg size	Age at maturity	Larval dispersal (recolonisation)	Threat ranking	Adult size		
	1	**1**	**1**	**2**	**1**	**2**	**2**	**2**		
Giant bully (*Gobiomorphus gobiodes*)	2	2	2	1	2	1	2	1	18	Minor
Redfin bully (*Gobiomorphus huttoni*)	2	2	2	1	2	1	1	2	18	Minor
Shortfin eel (*Anguilla australis*)	2	3	1	1	3	1	1	1	17	Minor
Common bully (*Gobiomorphus cotidianus*)	2	2	2	1	1	1	1	2	17	Minor
Black flounder (*Rhombosolea retiarii*)	1	3	2	1	2	1	1	1	16	Minor
Pouched lamprey (*Geotria australis*)	1	1	1	1	3	1	2	1	16	Minor

Appendix 3: Current legislation under which Fish and Game advocate for the habitat of trout and salmon

The table below has bold text to emphasis the specific direction to protect trout and salmon habitat and ecosystem conditions.

Resource Management Act 1991	Section 7 (h)	Persons exercising functions and powers under the Act must have particular regard to the protection of the habitat of trout and salmon.
Conservation Act 1987	Section 26 B (1)	New Zealand Fish and Game Council to represent nationally the interests of anglers and hunters and provide co-ordination of the management, enhancement, and maintenance of sports fish and game.
	Section 26 P (1)	There is hereby established for the purposes of the management, maintenance, and enhancement of sports fish and game a Fish and Game Council for each region defined by the Minister under section 26A(1)(c).
	Section 26 Q (1)	The functions of each F&G council shall be to manage, maintain, and enhance the sports fish and game resource in the recreational interests of anglers and hunters, and, in particular; a) To assess and monitor: i) Sports fish and game populations; and ii) The success rate and degree of satisfaction of users of the sports fish and game resource; and **iii) The condition and trend of ecosystems as habitats for sports fish and game** c) to promote and educate iii) by keeping anglers and hunters informed on matters affecting their interests e) in relation to planning i) to represent the interests and aspirations of anglers and hunters in the statutory planning process vi) to liaise with local Conservation Boards, and vii) **to advocate in the interests of the Council, including its interest in habitats**

National Policy Statement - Freshwater Management 2020	Section 2.1.1	The objective of this NPS is to ensure that natural and physical resources are managed in a way that prioritises: a) First, the health and well-being of water bodies and freshwater ecosystems b) Second, the health needs of people (such as drinking water) c) Third, the ability of people and communities to provide for their social, economic, and cultural well-being, now and in the future.
	Section 2.2	Policies 9. The habitats of indigenous freshwater species are protected. 10**. The habitat of trout and salmon is protected**, insofar as this is consistent with Policy 9.
	3.26 Fish Passage (3)	When developing the policies required by subclause (2) a regional council MUST a) take into account any Freshwater Fisheries Management Plants and **Sports Fish and Game Management Plans** approved by the Minister of Conservation under the Conservation Act 1987; and b) seek advice from the Department of Conservation or **statutory fisheries managers** regarding fish habitat and population management.
Natural and Built Environment Bill (draft)	6AB	The **habitat of trout and salmon is protected**, so far as is consistent with the protection of indigenous species.