NIWA
Taihoro Nukurangi

Potential options for regulation changes to the NZ whitebait fishery

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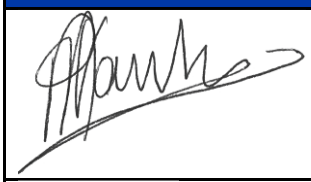
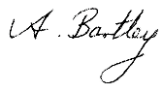
	Reviewed by:	Paul Franklin
	Formatting checked by:	Alison Bartley
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Executive Summary

New Zealand's whitebait fishery is based on the harvest of the juveniles of five galaxiid species. Four of these five galaxiid species are ranked as threatened (shortjaw kokopu) or in decline (inanga, koaro, giant kokopu) under the Department of Conservation Threat Classification System, with banded kokopu the only non-threatened whitebait species. These species face a suite of cumulative and interacting pressures including habitat loss, invasive species, climate change, pollution and harvest in the whitebait fishery. The whitebait fishery itself is perceived to be in decline, which parallels declines in adult fresh water fish populations and their habitats.

Since the enactment of the whitebait fishery management legislation in 1994, no review of the legislation governing the whitebait fishery for New Zealand has been undertaken. A lack of knowledge of the biology and ecology of the five galaxiid species has largely been responsible for limiting further management actions by the appropriate regulatory authorities. However, since 1994, scientific knowledge about galaxiid whitebait species has increased considerably and a review of the regulations pertaining to the whitebait fishery is now warranted. In this regard, NIWA was contracted to present options for changes to the regulation of the nationwide whitebait fishery based on the scientific knowledge discovered since 1994. The assessment does not cover Matauranga Maori, social, cultural, legal or economic perspectives on the regulatory options presented, but we recognise the process of managing the whitebait fishery requires stakeholder engagement at all levels and this is critical to implementing a sustainable whitebait fishery management strategy.

Based on the current scientific knowledge of the galaxiid whitebait species, and international approaches to fishery management, a number of potential regulatory changes to reduce harvest impacts on the whitebait fishery were identified. Of these options, we would strongly recommend greater regulation of the whitebait fishery as a priority. However, initially we do not recommend setting catch limits or banning commercial fishing (the sale of whitebait). Instead, we recommend implementing a licencing system where provision of a catch diary is required to renew a licence. This will provide a baseline of catch per unit effort for whitebait across New Zealand that can be used to monitor the response of the fishery to future management initiatives. This also allows for an adaptive management strategy where regulations can be changed/modified as scientific knowledge of the whitebait species advances.

Other options recommended for further consideration at a national level are:

- Reducing the total length of the fishing season by 4 weeks by either: bringing the end of the season forward to 31st October, or implementing two fortnight long "stand-down" periods covering two spring-tide migration peaks. This is to protect kokopu and koaro species that have different life histories to inanga. This option will also protect the variable life history characteristics of inanga over the fishing season.
- Banning the use of screens or guidance devices between the set net and the river bank. These changes will improve whitebait escapement.
- Banning whitebait fishing from a boat to prevent fishers following large whitebait runs and accessing some areas, which will improve escapement.

Regulatory changes that would be effective at a regional level but would require additional knowledge of stock structure and species composition for each river include:

- Reducing areas of key rivers that can be fished.
- Rotational harvesting.
- Closed river systems.

In addition to regulating the fishery, complementary measures supporting the populations of the fishery species in other ways are important to achieving conservation targets. These measures include, but are not limited to, mitigating barriers to upstream and downstream migration, restoration and conservation of aquatic habitats including water quality, and support for alternatives to the wild fishery such as aquaculture.

Overall, ecological knowledge of the whitebait species underpins successful conservation of the species and sustainability of the whitebait fishery. Therefore, further research on whitebait species is imperative to achieving these goals. Should the whitebait fishery be licenced, we would recommend investing some of the licence fees paid by fishers into further research to support the fishery.

1 Background

In New Zealand, around one third of the freshwater fish fauna are diadromous (Goodman et al. 2014), which means they migrate between freshwater and marine environments during their lifecycle. There are five species of diadromous galaxiids: inanga (*Galaxias maculatus*), koaro (*G. brevipinnis*), giant kokopu (*G. argenteus*), banded kokopu (*G. fasciatus*) and shortjaw kokopu (*G. postvectis*). 'Whitebait' is the common name for the juvenile stage of these five galaxiid species and collectively they form the basis of New Zealand's nationwide cultural, recreational and commercial whitebait fishery. Smelt (*Retropinna retropinna*) are another species that can form an important component of the whitebait fishery in some parts of the country.

Although much of the data on whitebait population trends is anecdotal, whitebait catches and adult populations have undoubtedly declined over the last 50 years. As such, four of these five galaxiid species are ranked as threatened (shortjaw kokopu) or in decline (inanga, koaro, giant kokopu) in New Zealand under the Department of Conservation Threat Classification System. The cause of these declines remains unclear because these species face a suite of cumulative and interacting pressures including habitat loss, invasive species, climate change, pollution, and harvest in the whitebait fishery. However, the degradation and loss of habitat for juveniles and adults, as well as spawning habitat, is thought to be a primary factor in the decline of our whitebait species (Goodman et al. 2014).

Recently, there has been increasing uncertainty about the fate of whitebait populations and the status of the fishery in both the scientific community and general public[1],[2],[3]. Whitebaiters and non-whitebaiters alike are increasingly dissatisfied with the management of the whitebait fishery and the conservation of the galaxiid species that make up the fishery.

Since the enactment of the whitebait fishery management legislation and subsequent revisions in 1994 (NZSR 1994/65; NZSR 1994/66), no review of the legislation governing the whitebait fishery for New Zealand has been undertaken. A lack of knowledge of the biology and ecology of the five galaxiid species has largely been responsible for limiting further management actions by the appropriate regulatory authorities. However, since 1994, scientific knowledge about galaxiid whitebait species has increased considerably, and a review of the regulations pertaining to the whitebait fishery is now warranted. The following section provides a brief overview of new scientific knowledge and how this could help guide regulation changes in the whitebait fishery. Goodman et al. (2018) provides a more detailed summary of the current state of knowledge and research gaps related to conservation of the whitebait fishery.

1.1 Scientific knowledge post-1994

Since 1994, scientific knowledge of the whitebait species' biology and ecology has advanced in four key areas – species composition of the harvest, inward migrations of juvenile whitebait, stock structure, and life history (Table 1-1).

[1] https://www.stuff.co.nz/science/100195336/whitebait-decline-likely-overstated-say-nz-scientists

[2] https://www.newshub.co.nz/home/new-zealand/2017/09/whitebaiters-could-face-season-of-declining-catches.html

[3] https://www.stuff.co.nz/environment/103274252/whitebait-facing-extinction-within-a-generation-government-warned

Table 1-1: A summary of key knowledge about whitebait gained since 1994. This information was used to give scientific backing for the regulation changes proposed in this report.

Topic	New knowledge about whitebait since 1994
Species composition	1. Inanga are the dominant species in the whitebait fishery nationwide. 2. Species composition changes through the season, with kokopu and koaro species increasing their contribution in October and November. 3. Little variation in species composition is seen between years.
Inward migrations	1. Inanga size, age and body condition declines from September–November. 2. Inanga caught in September are from autumn spawning events, while November captured fish are from winter-spawning events. 3. Largest catches typically occur on spring tides.
Stock structure & life histories	1. Several stocks of inanga in NZ have been identified from reconstructing marine growth rates. 2. No evidence for genetically distinct stocks, but studies underway. 3. There is no specific information on stock structure of koaro and kokopu species, but based on spatial differences in size and age, and recent investigations of dispersal in koaro, there are likely several stocks in NZ. 4. Life history differences exist between the five whitebait species.
Fishing practices	1. "Black-bait" or juvenile whitebait are caught later in the season (November). 2. By-catch of non-target species (i.e., glass eels) tends to occur later in the season.

Species composition studies have been carrired out in several parts of New Zealand (Hanchet & Hayes 1989; Boubée et al. 1992; Rowe et al. 1992; McDowall 1999; Yungnickel 2017). These show that for the past few decades inanga have been the dominant whitebait species in most rivers nationwide (50-99%). Banded kokopu can contribute up to 20% of catches at specific times of the season, with koaro, giant kokopu and shortjaw kokopu contributing a smaller proportion of the catches. The kokopu and koaro species show temporal trends in abundance, and tend to be present between October and November. Spatial variation in species composition is related to a suite of complex factors including the distribution of adult populations, the availability of adult habitat, pheromone and other migration cues, ocean currents and river flows. However, the contribution of each species to the fishery, and the temporal trends in abundance, must be considered when assessing the management options for protecting all five whitebait species. The prevalence of kokopu and koaro species in October and November was a key driver in restricting the whitebait fishing season on the West Coast and should now be considered nationwide.

Recently, there have been substantial developments in our understanding of the marine growth phase of inanga which was previously a "black box" (Rowe & Kelly 2009; Neilson 2016; Egan 2017; Yungnickel 2017). New knowledge about the inward migrations of whitebait indicates that the current open season of the fishery could be exploiting earlier spawned, better conditioned, larger whitebait rather than the later spawned, smaller, less well conditioned individuals that arrive later in the season. This exploitation could skew the traits of individuals in the adult populations over time,

and regulatory changes could seek to more evenly exploit individuals with a variety of traits to mitigate this impact.

Significant evidence has emerged of stock structure in koaro and inanga – i.e., the existence of spatially distinct sub-populations, which have some genetic mixing, but overall have limited dispersal and tend to return to rivers within the same region where they were spawned (Hickford & Schiel 2016; Augspurger 2017; Egan 2017). This suggests that within regions, the way the whitebait fishery is managed and regulated could directly affect the sustainability of that region's whitebait fishery into the future. This is an important finding that supports regionalised regulation and management.

Scientific understanding of the life histories of the large galaxiids remains rudimentary and largely unhelpful to decisions about regulation of the fishery. Nonetheless, we do know that inanga have a very different life history compared to koaro and the kokopu species (they grow faster, they have an extensive spawning season, a smaller body size and smaller eggs). The management review in the 1990s led to regulations based on the life history of inanga, but the widely different life histories should be considered when developing management strategies for whitebait species collectively.

1.2 Tasmanian whitebait fishery

In addition to new scientific knowledge on New Zealand galaxiid species, lessons can be learnt from management strategies employed in the Tasmanian whitebait fishery. The Tasmanian whitebait fishery is similar to the New Zealand whitebait fishery in terms of species composition, as it includes two of the same species; inanga and koaro. It also comprises a mix of species with different life histories, including annual species (those that usually only live for a single year), such as inanga. The 2006 management plan for the Tasmanian whitebait fishery (IFS 2006) lists five issues that must be addressed to ensure the sustainability of the fishery:

- Impact on threatened species.
- Maintenance of healthy populations of native fish.
- Avoidance of over-exploitation.
- Protection and rehabilitation of habitat.
- Community support for habitat protection.

The management plan also recognises that improvements in the understanding of the whitebait species' biology will be key to improving fishery management practices and ensuring the sustainability of the fishery. The main regulations employed in the fishery are: timing the season to avoid over-exploitation of stocks, river closures operating on a seasonal rotation, fishing equipment restrictions to increase escapement of whitebait, licences are required, catch limits are imposed, and the sale or trade of whitebait is forbidden (IFS 2006; Tasmanian Government 2009). Overall, key learnings that could be applied to the New Zealand whitebait fishery are:

- A sustainable fishery is underpinned by conservation principles.
- Temporal controls underlaid by understanding of the species composition of the fishery and timing of migration runs can help sustainably manage the fishery.
- A moratorium can be a useful tool if there are specific tasks to be achieved before the fishery can be re-opened.

- Banning sales of whitebait can reduce pressure on the fishery, however, it may drive up illegal sales and the social problems associated with illegal activities.
- Quotas and diaries generate useful information for managing the fishery, however, they are best combined with a licensing system to incentivise fishers to complete and submit diaries.
- Gear restrictions can form part of a suite of conservation-focused regulations.
- Where evidence of a stock structure exists, rotational harvesting between the stocks can help balance the pressure for equitable access to local fishing areas, with conservation of part of the population each year. This approach works best for species that survive spawning rather than inanga, which is mostly an annual species.

1.3 Scope

The scope of this report was to outline of a suite of potential regulatory management options for the New Zealand whitebait fishery that are informed by the improved scientific understanding since 1994. The science supporting each option will be briefly discussed. This report does not include the extensive Matauranga Maori pertaining to the whitebait species, or how Maori communities historically utilised and managed these fisheries.

2 New Zealand whitebait fishery management options

Based on our understanding of the whitebait species' ecology, and considering the successful management strategies employed in conservation of the Tasmanian whitebait fishery, the following section outlines a suite of regulatory management options that can be broadly categorised as:

- Temporal controls.
- Harvest controls.
- Spatial controls.

Although the options provided below were developed from scientific information and do not consider cultural, social, political and economic aspects, we recognise the process of managing the whitebait fishery requires stakeholder engagement at all levels and this is critical to implementing a sustainable whitebait fishery management strategy.

2.1 Temporal controls

The New Zealand wide legislation permits whitebait fishing for 15 weeks a year between 15 August to 30 November. For the West Coast of the South Island, fishing is permitted between 1 September to 14 November (11 weeks). We recommend considering one national season and suggest the following two options for reducing the total length of the national fishing season by four weeks:

- **Reduce the length of the fishing season from the 15th August to the 31st October**. This option has the advantage of increasing escapement of the rarer kokopu species and of the larger/older inanga that spawn later in the season and are captured as by-catch.
- **Two fortnight long "stand-down" periods**. This option has the advantage of increasing escapement of different cohorts of inanga, the main whitebait species, and in particular increasing the recruitment of larger inanga migrating earlier in the season. It also reduces fishing pressure on koaro and kokopu species that migrate at various times throughout the fishing season.

As implementing both options would considerably reduce the season length, we recommend implementing only one of these options, contingent upon the desired outcomes and values.

A further temporal control that we do not currently recommend is:

- Restrict daily fishing hours.

2.1.1 Reduce length of fishing season to 31st October (from 30th Nov)

For fisheries that exploit multiple species like the whitebait fishery, one way to minimise potential adverse effects of mixed-species harvesting is to limit fishing to periods when maximum separation among species occurs (Murawski & Finn 1988). A reduced season length from 30 November to 15 November was previously adopted on the West Coast of the South Island. This was undertaken to reduce the vulnerability of giant kokopu to fishing pressure as their migration timings coincided with the whitebait fishing season. However, in the initial West Coast whitebait management review it was proposed that season length be reduced by one month from 30 November to 31 October (Department of Conservation 1993). This was because studies showed giant kokopu also migrate in late October and early November and are harvested in the fishery. Based on updated ecological

knowledge since 1994 and the current threat rankings of four whitebait species, we recommend reducing the season length one full month to 31 October to protect the rarer kokopu and koaro species.

An additional benefit to reducing fishing season length is that a portion of the inanga population are protected from fishing pressure. Inanga migrating later in the season are derived from winter spawning events and have different early life history characteristics to inanga migrating earlier in the season. A further driver for restricting whitebaiting during November comes from whitebaiters themselves, as they tend to catch "black bait" more frequently in November, which is less desirable and not of commercial grade. Black bait refers to inanga that are not fresh run from the ocean but have started feeding and pigmentation is evident. As such, some regular or full-time fishers reduce effort during November or don't fish at all (authors' personal communication with whitebaiters).

2.1.2 Two fortnight long "stand down" periods

Over the 15-week fishing period, there are temporal changes in the characteristics of inanga associated with larval hatch dates. Earlier migrating autumn-hatched inanga are larger, older, in better condition, with slower marine growth rates than later-migrating winter-hatched inanga that are smaller, younger, in poorer condition, but are faster growing (Egan 2017). Therefore, it is apparent that harvesting is largely selective on the larger better conditioned inanga that spawned in autumn and winter as their migration aligns with the fishing season.

Although the peak migration of inanga can vary within the season, there is usually a strong association between catches and spring tides. An option to minimise fishing pressure on inanga is, therefore, to prohibit fishing on selected spring tide sequences. Spring tides occur twice each lunar month and typically coincide with peak whitebait catches. Because spring tides are well defined and can be predicted, a "stand down period" can be easily defined each year. Until further knowledge comes to hand, one option is to close a spring tide in September (to protect autumn spawned fish) and one in late October (to protect winter spawned fish). We recommend each "stand down" period encompass a two-week period starting three days prior to the peak spring tide. This is because Baker and Smith (2015) found whitebait required up to four days to pass the 22 km reach of the Mōkau River where fishing pressure is concentrated. A two-week window would, therefore, protect fish in both small and large river systems. To implement this option, the current start and end dates of the fishing season would need to be retained. Although this option would provide less protection for koaro and kokopu species, in many rivers, the spring tide in late October often aligns with a pulse of banded kokopu migrants (authors' unpublished data).

2.1.3 Restrict fishable hours

At present there is no scientific evidence to support changing the fishable hours. It may be argued that whitebait are not subjected to consistent fishing pressure over the season length as day-length varies, and that night time migrations allow sufficient escapement of whitebait. However, it has not been clearly demonstrated that whitebait migrate at night time. Baker and Smith (2015) found some evidence for movement of fish on the overnight tidal cycle, but this was still limited compared to diurnal movements. Although current fishing hours coincide with the main diurnal hours whitebait are thought to migrate, we do not recommend changing the fishable hours until empirical evidence shows this will be an effective means of increasing escapement.

2.2 Harvest controls

The effects of fishing pressure on whitebait populations are unknown. The fishery is typified by a high annual variability in catch rates, but the underlying causes are poorly understood. A lack of data on fishing pressure and fishery induced mortality rates, and differences in catch rates between different gear types, combined with limited knowledge of each species' life histories, the productivity of populations and stock structure, suggests a conservative approach to harvest controls is initially warranted. Therefore, potential management options we recommend are:

- Introduction of quotas and diaries.
- Gear restrictions.
- Fishing licenses.

Harvest controls that we do not currently recommend are:

- Moratorium.
- Ban commercial fishing (sale of whitebait).

2.2.1 Introduction of quotas and diaries

One option for fisheries management is a quota system (weight limit/daily bag limit) that restricts whitebait catches. Such a system is appealing because it has a determinate effect on the level of fishing pressure from an individual fisher. Quotas can apply to daily catch, total seasonal catch, or possession of whitebait. A quota system can also use an adaptive management strategy. This approach allows the quota to be adjusted as the ability of the fishery to sustain that quota is demonstrated over the years.

Quota systems can require the concurrent application of a diary system. However, a diary system does not need to be accompanied by quotas, and can be used alone. Aside from their use in enforcement of quotas, diaries are useful to build knowledge of catch per unit effort and to corroborate temporal trends in whitebait numbers. A useful diary would require the fisher to record the length of time spent fishing on any one day and the total catch over that time. Unwin (1983) cited such a diary as an acceptable standard of information on the variation in effort expended and catch of whitebait. Boubée et al. (1992) and Smith and Baker (2010) also recommended diaries should be kept to ascertain whether catches of whitebait are declining over time.

At present, we don't recommend introducing a quota system to the whitebait fishery and recommend monitoring whitebait recruitment nationwide through a diary system. This is because a baseline of catches needs to be determined in order to develop an appropriate quota that balances the desire to maintain whitebait harvest with the conservation of the species. Fisher's catches relative to effort provide a simple and effective means of documenting temporal trends in whitebait abundance and would benefit all whitebaiters by potentially enabling a reduction in fishing regulations over time should whitebait numbers increase. In addition, diaries can benefit harvesting as they can be used to disentangle the impact of fishing from other anthropogenic effects. For example, Smith and Baker (2010) commented that "reduced entry of whitebait should be reflected in adult population numbers", therefore, if whitebait catches are stable over time, reductions in adult population size may reflect variables other than declines induced through harvesting. Such a finding

would suggest that conservation efforts focus not on reducing fishing effort, but on other measures to support the population.

Given the current reluctance of fishers to share information on their catches (McDowall and Eldon 1980, Unwin 1983, Smith and Baker 2010), a diary system would probably only be effective as a regulatory tool attached to a licensing system, which requires submission of the diary to qualify for a license. Even then, the diary and license system relies on the honesty of fishers as no agency could resource reliability checks of diary entries versus actual catches. The implementation of diaries could be supported by a campaign to build social license for catch diaries by communicating to fishers the benefits to them of providing accurate catch data.

2.2.2 Gear restrictions/fishing methods

Gear restrictions will provide an effective means to increase whitebait escapement and reduce harvesting impacts. Some options for gear restrictions that could help regulate catches in the whitebait fishery includes:

- Reductions in the net size/circumference.
- Restrictions on the use of screens, nets and other guidance tools.
- Changes in the types of nets that can be used.
- Restrictions on the use of other fishing tools such as boats.

Currently, set nets are allowed for whitebaiting and they are very effective at capturing whitebait. Options for regulatory change around the use of set nets include decreasing the allowable size of set nets, or the distance that a set net may protrude into the river. Regulations currently permit an internal circumference of 4.5 m and the net can protrude 6 m or one third of the river width (whichever is less) into the river channel. In contrast, the Tasmanian regulations restrict net circumference to 1.2 m with no ability to block one third or 6 m of the channel. Hence, reducing the allowable circumference of set nets by half, to 2.25 m is a feasible option for considerably reducing fishing pressure.

A further measure for enhancing escapement is through prohibiting the use of wings, leaders, screens or structures of any kind capable of diverting fish into the net, and ensuring the net is not constructed in such a way as to act in this manner. In addition, restricting the use of any screen, valve, or device that impedes fish escaping from the net could be implemented. Guidance devices push whitebait further into the river channel, subjecting them to faster water velocities, which results in higher catch rates. For example, Baker and Smith (2015) found that recapture rates of whitebait were positively correlated with increasing water velocities around the edge of the whitebait trap. Juvenile galaxiids prefer low velocity waters for migration (<0.1 m s^{-1}; McDowall and Eldon 1980), and fish often move upstream in the low velocity surface waters (≤1.0 m deep) along riverbank margins (Stancliff et al. 1988b). Therefore, escapement of whitebait will increase if nets are restricted to being closer to the river bank.

Another option to increase escapement by ensuring nets remain close to the bank would be to ban set nets and only allow scoop nets. This, however, may affect some people such as the elderly or injured more than others, and is also less practical along the banks of large rivers that are typically steep or otherwise ill-suited to scoop netting.

Overall, we would recommend retaining the use of set nets nationwide but banning the use of screens or guidance devices between the set net and the river bank. This is because the guidance devices create an impediment to whitebait migrations, forcing fish into the faster water velocities and hence increasing the likelihood of capture in the set net. Although this option could be implemented in conjunction with a reduction in size of the set net (from 4.5 m to 2.25 m), this level of change is deemed too severe based on current scientific knowledge and is also more likely to promote illegal fishing.

In addition to removing guidance devices, another regulatory possibility would be to prohibit the use of boats for whitebaiting for any reason. Boat use has a particularly high impact on escapement because the fisher can stay upstream of a migration run as it moves up river and have multiple opportunities to target each run compared to a set net from a stand that can only target the migration run from one position.

If licenses for whitebaiting were put into regulation, then it would be possible to require that gear is tagged with the fisher's license number. This would be helpful to identify owners of non-regulation gear, and also to identify unlicensed fishers.

2.2.3 Fishing licenses

Fishing licenses are a regulatory tool that can be used for a number of purposes. They can be used to collect information on the number of fishers operating in a given region and the variability in that number between seasons and over many years. There is a positive relationship between the number of fishers operating in an area and the amount of whitebait caught per day and requiring fishers to be licensed provides a method of quantifying the number of fishers operating in a given area. Licensing can be a useful regulatory strategy to facilitate the enforcement of other types of regulations, such as diaries, quotas and some types of gear restrictions. Fishing licenses would, therefore, be an effective nationwide regulation change with each fisher needing to keep and submit a catch diary as a requirement to renewing their licence.

2.2.4 Moratorium

A moratorium (of a sort) on the whitebait fishery was used quite effectively in Tasmania from the mid-late 1980s through to 1990 when the fishery re-opened. The "moratorium" in this case was the delay in re-opening the fishery until after a review of the current state of knowledge on the ecology and status of the species comprising the fishery had been undertaken by Fulton and Pavuk (1988). The benefit of this moratorium was that it allowed time for collection of information on species composition and migration times of the species comprising the fishery and this information was used to create regulations for the new fishery based on conservation principles. Without the moratorium, the regulations would not have been informed by the scientific understanding that now underpins them. This example illustrates the kind of situation in which a moratorium is a useful and effective strategy – i.e., when there is a well-defined, short-term objective that must be met prior to the fishery re-opening and there are immediate steps taken to meet that objective. In the absence of a defined objective, a moratorium can work against those seeking regulatory change as the indefinite length or indeterminate reason for the moratorium can generate ill-will from interested parties.

At this point in the management of the whitebait fishery, there is a sizeable body of knowledge on the ecology and status of the five whitebait species and, while there are also large knowledge gaps, gaps in current knowledge will take a considerable amount of time and other resources to fill. As

such, a moratorium on whitebait fishing based on the gaps in our knowledge of the species is not recommended as it would be unlikely to have a well-defined, short-term objective.

2.2.5 Ban commercial fishing (sale of whitebait)

The whitebait fishery currently includes a commercial component, that the Inland Revenue Department recognises as a taxable income. A ban on commercial fishing would entail identification of whitebaiters who are selling their catch for financial gain. This is difficult because differentiation between recreational and commercial fishers is impossible unless this information is given voluntarily. In addition, at this stage, the impact of commercial fishing is undetermined. It remains unclear due to a lack of catch records from both recreational and commercial fishers whether the smaller number of commercial fishers catch and sell more than the total amount of whitebait caught by recreational fishers nationwide. This could, however, be addressed in time by licensing the fishery and requiring all fishers, both recreational and commercial, to keep and submit catch diaries. Therefore, determining the appropriate regulation measures for commercial fishing should be carried out after establishing a baseline of catches across New Zealand.

It should be noted that the banning of whitebait sales has the potential to affect our tourism industry by restaurants not being able to serve the iconic kiwi whitebait fritter. Here, the aquaculture of whitebait provides a means to supply restaurateurs. Presently, aquaculture of our whitebait species is in its infancy, with Manāki New Zealand Premium Whitebait, New Zealand's first and only aquaculture venture for our whitebait species, recently entering receivership. However, moving forward this type of sustainably produced whitebait should be considered as an alternative to commercial sale of wild stock.

2.3 Spatial controls

Spatial controls are used in the Tasmanian whitebait fishery where they are based on an understanding of the stock structure within the fishery. Recent studies have also pointed to stock structure within whitebait populations in New Zealand and this evidence of stock structure supports spatial variation in regulations as a management tool. Potential spatial controls that we recommend considering are:

- Reducing areas of rivers that can be fished.
- Rotational harvesting.
- Closed river systems.

However, based on the recent evidence of regional stocks existing, spatial controls will be most effective if they are developed at a regional level. In this regard, a good understanding of both stock structure and species composition for each individual river within each region would be required. Therefore, some regions may have enough knowledge to apply the spatial controls outlined below to key rivers, but for other regions, these measures may not be appropriate until further research is undertaken.

2.3.1 Reduce areas of rivers that can be fished

A reduction in fishing area was proposed by Baker and Smith (2015) as a means to reduce fishing pressure on diadromous galaxiids. Such a reduction could be regulated as a distance upstream beyond which whitebait fishing is prohibited. Particular areas can also be delineated in which fishing is prohibited. This has been undertaken in the regulation of the Tasmanian whitebait fishery, where 100 m sections of the Duck and Mersey rivers are permanently closed downstream of a weir on each river which leads to high concentrations of whitebait and little chance of escapement.

Reduction of the area where fishing is allowed is supported by research showing that the distance fished upstream is related to species diversity. Rowe et al. (1992) found that most of the koaro captured in Bay of Plenty rivers were from fishers fishing 102 km upstream from the river mouth. Likewise, Stancliff et al. (1988a) showed that more galaxiids were caught further upstream from the river mouth compared to smelt. On the west coast of the South Island the fishable area is restricted and is physically demarcated on the river.

Another possibility for reducing the area allowed for whitebaiting would be to increase the required distance between fishers. This would also likely reduce numbers of fishers in areas where fishing pressure is currently high. As whitebait are not concentrated at the mouth but migrate upstream in a dispersed run, this would increase the rate of escapement of whitebait. This regulatory measure would have the added benefit of reducing the risk of capture of spawning inanga, which use habitat along the banks in the areas where whitebait fishing occurs, and would decrease trampling of inanga spawning habitat.

Both of these measures could unfairly impact some fishers over others as stands will either need to be moved upstream a set distance or cease to exist. As such, determining the most effective way to reduce fishing areas for any given river will need to be assessed regionally.

2.3.2 Rotational harvesting and closed river systems

Rotational harvesting involves the closure of some rivers or parts of a river system each year, with the rivers that are closed being rotated yearly so that some are always open and so that each river is closed some years. As a conservation measure, rotational harvesting is helpful when there is stock structure, because it affords complete protection to a part of a stock every few years. As a regulatory tool, rotational harvesting is relatively easy to implement and to monitor. Information about which rivers are open any given season can easily be made available, and enforcement only requires visiting closed rivers to observe whether there are fishers active where they should not be.

As an alternative to rotational harvesting, a regulatory option that also protects stocks on a regional basis is to close river systems. This would preferentially impact communities close to those river systems, and may be seen as unfair to those living in particular areas. Currently, there are already river systems in the West Coast that are permanently closed to whitebaiting. Therefore, the precedence for this type of approach has already been set. However, determining further river systems where rotational harvesting will benefit the conservation of the whitebait fishery will require detailed regional knowledge of whitebait stocks and ecology. In addition, both these approaches are likely to benefit the four large galaxiid species more so than inanga (an annual species) as they survive spawning for multiple years.

2.4 Conclusions

A series of options for regulating the whitebait fishery have been provided above. Based on the current state of knowledge, we would strongly recommend greater regulation of the whitebait fishery as a priority. However, initially we do not recommend setting catch limits or banning commercial fishing (the sale of whitebait). Instead we recommend implementing a licencing system where provision of a catch diary is required to renew a licence. This will provide a baseline of catch per unit effort for whitebait across New Zealand that can be used to monitor the response of the fishery to future management initiatives. This also allows for an adaptive management strategy where regulations can be changed/modified as scientific knowledge of the whitebait species advances. We further recommend that a reduction in the total length of the fishing season by four weeks be considered as well as restrictions on whitebait fishing gear.

In addition to regulating the fishery, complementary measures supporting the populations of the fishery species in other ways are important to achieving conservation targets. These measures include, but are not limited to, mitigating barriers to upstream and downstream migration, restoration and conservation of aquatic habitats including water quality, and support for alternatives to the wild fishery such as aquaculture.

Overall, ecological knowledge of the whitebait species underpins successful conservation of the species and sustainability of the whitebait fishery. Therefore, further research on whitebait species is imperative to achieving these goals. Should the whitebait fishery be licenced, we would recommend investing some of the licence fees paid by fishers into further research to support the fishery.

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