

**BEFORE THE ENVIRONMENT COURT  
AT CHRISTCHURCH**

**ENV-2010-CHC-115, 123, 124 AND 135**

**IN THE MATTER** of Appeals pursuant to Section 120 of the  
Resource Management Act 1991

**BETWEEN** WEST COAST ENT INC  
Appellant

**AND** ROYAL FOREST AND BIRD  
PROTECTION SOCIETY OF  
NEW ZEALAND INC  
Appellant

**AND** WHITE WATER NEW  
ZEALAND INC  
Appellant

**AND** DIRECTOR GENERAL OF  
CONSERVATION  
Appellant

**AND** WEST COAST REGIONAL  
COUNCIL AND BULLER  
DISTRICT COUNCIL  
Respondents

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STATEMENT OF EVIDENCE OF  
**RICHARD MARK ALLIBONE**  
FOR DIRECTOR-GENERAL OF CONSERVATION  
Dated: 16 May 2012

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**AND**                    **MERIDIAN ENERGY LIMITED**  
**Applicant**

**AND**                    **FRIDA INTA**  
**Section 274 Party**

**AND**                    **WHANAU PIHAWAI WEST – RICHARD**  
**WAYNE BARBER AND IRI MAY BARBER**  
**MILNER**  
**Section 274 Party**

**AND**                    **J MacTAGGART**  
**Section 274 Party**

**AND**                    **ORION ENERGY NZ LTD,**  
**ALPINE ENERGY LTD, MAIN**  
**POWER NZ LTD AND**  
**ELECTRICITY ASHBURTON**  
**LTD**  
**Section 274 Party**

**AND**                    **NZ RAFTING INC**  
**Section 274 Party**

**AND**                    **ANN SHERIDAN**  
**Section 274 Party**

**AND**                    **BULLER ELECTRICITY**  
**Section 274 Party**

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## **1. QUALIFICATIONS AND EXPERIENCE**

- 1.1. My full name is Richard Mark Allibone
- 1.2. I am a senior freshwater ecologist at Golder Associates (NZ) Ltd. I have been in practice as a freshwater and terrestrial scientist and manager for 20 years.
- 1.3. I have previously been employed as the National Services Manager for the Queen Elizabeth the Second (QEII) National Trust; Species Protection Officer at the Biodiversity Recovery Unit of the Department of Conservation; Fisheries Scientist and Post Doctoral Fellow at the National Institute of Water and Atmospheric Research (NIWA) and a Freshwater Fisheries Specialist for the Department of Conservation in the Nelson/Marlborough and Otago Conservancies.
- 1.4. I have a BSc (Geology and Zoology), an MSc (Zoology) and a PhD (Zoology) from the University of Otago. My University research centred on the biology, taxonomy and population structure of New Zealand's migratory galaxiids (whitebait) and non-migratory galaxiids. For my Masters thesis I carried out one of the first investigations of the population structure of whitebait and non-migratory galaxiids in the South Island and Stewart Island. My PhD study investigated the biology and distribution of non-migratory galaxiids in the Taieri River system. This was the first research to study the biology of four species of non-migratory galaxiid found in the Taieri River. The research included determining their distribution, diet, spawning ecology, growth and populations structure and determining the conservation status and threats to the populations remaining today.

- 1.5. Over the past 20 years I have been involved in research that has led to the recognition of six new non-migratory galaxiids and another three possible species. I was the project leader for the initial NIWA FRST freshwater fish biodiversity and whitebait research programmes from 1998 to 2001. The biodiversity research included the continuation of work I commenced on non-migratory galaxiid taxonomy and investigations into the distribution and biology of galaxiids. My research at NIWA included research on the whitebait catch by whitebaiters concentrating on an assessment of catch in the Mokau River, Taranaki. In conjunction with the Department of Conservation I set up the first monitoring programmes for adult koaro and shortjaw kokopu (whitebait species). This work included electric fishing and spotlight surveys for the monitoring, individual tagging programmes at monitoring sites, the first successful investigations for spawning sites of koaro and shortjaw kokopu, which also confirmed banded kokopu spawning behaviour.
- 1.6. As a Department of Conservation staff member I was a co-author of the Department of Conservation's three freshwater fish recovery plans (large galaxiids, non-migratory galaxiids, and mudfish recovery plans) and was the recovery group leader for the non-migratory galaxiid recovery group and a member of the other two freshwater fish recovery groups from 2001 to 2003. I am currently the chair of the Department of Conservation's freshwater fish threat ranking group and led the threat ranking classification process for 2009.
- 1.7. Previously I have assessed the effects of hydro-electric schemes on native fish for the Department of Conservation for the Clutha River hydro-electric power stations consent process in 2001 and a hydro-electric station on the upper

Waipa River (Waikato); for Environment Canterbury for the North Bank Tunnel Concept; and I was part of the Department of Conservation's technical team assessing the effects of Project Aqua. I have conducted fish passage assessments for the Patea Dam, the Mararoa Weir (Waiau River, Southland) and lead a monitoring programme for a trap and transfer operation on the Waihopai River Dam in Marlborough. I am currently one member of the three person independent expert panel that oversees the consent monitoring for Patea Dam and I lead the panel's review on matters relating to native fish.

- 1.8. I have undertaken freshwater fish surveys throughout New Zealand in urban, rural and wilderness areas. Much of this survey effort has been in Stewart Island, Chatham Islands and other part of the country that are in remote regions accessible only by foot or helicopter. These areas are generally unmodified areas with limited terrestrial or aquatic habitat alteration and few if any introduced species present.
- 1.9. I have been a contributing author to two books and 25 peer reviewed papers and reports.
- 1.10. I am familiar with the Mokihinui River, its whitebait fishery, and the hydro-electric dam proposal to which these proceedings relate.
- 1.11. I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. I confirm that the issues addressed in this brief of evidence are within my area of expertise.
- 1.12. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed. I have specified where my opinion is based on limited or

partial information and identified any assumptions I have made in forming my opinions.

1.13. My opinions rely in part on the evidence presented by

- Dr Marc Shallenberg
- Dr Russell Death
- Dr Henry Hudson (draft in preparation)

## **2. SCOPE OF EVIDENCE**

2.1. My evidence will deal with the following:

- The native fish of the Mokihinui River catchment;
- The whitebait fishery of the Mokihinui River
- The effects of flow fluctuations downstream of the proposed dam on the native fish of the Mokihinui;
- The effects of the proposed dam on upstream fish migration;
- The effects of the proposed dam on downstream fish migration;
- Cumulative effects of the proposed dam and mitigation; and
- Comment on the proposed consent conditions and mitigation.

### **3. KEY FACTS AND OPINIONS**

- 3.1. The native fish community of the Mokihinui River is a diverse diadromous fauna that includes nine threatened species. All fish species must migrate to and from the sea to complete their life cycles. The biodiversity value of the catchment includes the intact native fish fauna and limited if any current and historic commercial eel fishing activity. Adjacent catchments to the south contain more restricted fish fauna due to Acid Mine Drainage and migration barriers whereas the Mokihinui River native fish are only impacted by the presence of brown trout.
  
- 3.2. The whitebait fishery of the Mokihinui River is a popular fishery drawing fishers from as far afield as Canterbury and Nelson. The fishing is undertaken using scoop nets and is most effective when water turbidity is low. Mark recapture trials during the 2010 whitebait season found the maximum catch rate was 40% and average catch rate is in the order of 30%. Total catch for the 2010 season was estimated to be 2-2.5 tonnes that equates to approximately 3 million whitebait. The escapement rate for whitebait was estimated to be on average 70% leading to an estimate of 7 million whitebait escaping to migrate upstream. The catch estimate is substantially lower than the catch reported from the 1990s and may indicate substantial decline in the fishery or be the result of yearly variation.
  
- 3.3. The construction of the Mokihinui Dam is confirmed to prevent the upstream migration of six native fish species, longfin eel, redfin bully, common bully, koaro, shortjaw kokopu and torrentfish. The dam is also likely to prevent the upstream passage of shortfin eel, banded kokopu, giant kokopu, bluegill bully, inanga and lamprey. Distributional data for common smelt is too sparse (a single record) to

estimate its upstream penetration and possible occurrence at the dam site.

- 3.4. Downstream of the dam the proposed hydro electric flow fluctuations will impact on the lower river fish fauna. I expect that the fish in the lower river will be subjected to the effects of flow fluctuations, fish stranding and possibly gas bubble disease, deoxygenated water and toxic water discharges from the Mokihinui dam. I expect these effects will have significant detrimental effects on the resident and upstream migrating native fish.
- 3.5. Upstream fish passage using a trap and transfer system at the dam is untested for a number of the fish species that migrate upstream to the dam. The proposal to use a trap and transfer system also fails to provide any indication of the likely effectiveness of the trap and transfer. Nor does it provide any assessment of the likely limitations on success posed by the dam and associated structures. It is my expectation that fish communities above the dam will decline in abundance and their distribution will shrink as recruitment via the proposed trap and transfer process will fail to sustain present diversity and abundance.
- 3.6. Upstream transfer of the majority of native fish species that are likely to migrate upstream to the dam will transfer fish into areas of the Mokihinui catchment where they are not currently present. This transfer represents an additional environmental and ecological impact on the Mokihinui catchment. The alternative of not transferring a range of native fish will be that their upstream distribution is truncated at the dam.
- 3.7. Downstream fish passage for all fish species is problematic and there is significant doubt whether any fish species that migrate downstream as small larval fish will be able to

complete a journey through the upstream reservoir. Furthermore, if common smelt establish landlocked populations in the reservoir downstream passage of larval fish maybe further compromised as smelt are pelagic planktivores that will prey upon larval fish.

- 3.8. Eels and lamprey will be able to migrate downstream to the dam but will need to be diverted away from the spillway to avoid mortalities associated with the 80 m fall over the dam.
- 3.9. The proposed consent conditions provide mixed guidance with regard to the fish passage objectives and require a consistent and logical approach to determining which species require transfer. This assessment must include the likely success of downstream passage and any additional impacts of upstream transfer to areas outside the natural range of fish species.
- 3.10. The lack of any monitoring of fish populations downstream of the hydro-electric dam means the proposed conditions cannot detect the effects of flow fluctuations, determine the level of fish stranding or detect any effects of gas supersaturation, deoxygenated water and toxic water discharges from the dam on native fish communities and this in my opinion is a major omission.
- 3.11. Mitigation of the impacts of the hydro-electric dam is currently restricted to the provision of upstream fish passage via trap and transfer system and by less specific downstream actions for longfin eel. Additional mitigation involving the enhancement of inanga spawning sites is proposed in the event that monitoring of upstream fish communities indicates they are declining due to the Mokihinui dam and operations. This spawning

enhancement will not offset any declines in the koaro, kokopu, bully, eel and torrentfish populations.

- 3.12. In my opinion the assessment of effects conducted by Meridian witnesses fails to recognise these issues and has failed to fully assess the effects of the dam and its operations.
- 3.13. The range of impacts I expect to occur will impact severely on torrentfish, a unique component of New Zealand's freshwater biota.
- 3.14. In my opinion the consent conditions proposed by Meridian are insufficient for monitoring and addressing the effects of the given the effects of the proposed dam.
- 3.15. In my opinion even with the fish passage mitigation proposed, the full effects of the dam on native fish are significant, unavoidable and will lead to significant declines in native fish in the Mokihinui catchment. Given the connectivity between catchments due to the oceanic dispersal of larval fish if declines in the Mokihinui catchment are large native fish will also decline in adjacent catchments.

#### **4. NATIVE FISH OF THE MOHIKINUI RIVER CATCHMENT**

- 4.1. Mr Bonnett in his evidence in chief provides some distribution maps (Appendix 2 of his evidence) for native fish in the Mokihinui River catchment. In my opinion these figures provide a general idea of distribution of the various fish species in the Mokihinui River catchment. However, there is a noticeable bias in the sampling effort for tributaries of the Mokihinui River in the gorge. Fish

sampling sites upstream of the gorge are more limited and this does lead to some difficulties assessing the fish occurrence and abundance outside of the inundation zone. Sampling in the Mokihinui River itself in the gorge is also limited and this leads to some difficulty in determining the upstream limits for some of the native fish, which I describe below. Finally, I note that at least some of the fisheries data collected by myself on behalf of the Department of Conservation is not shown on these figures. Also Mr Bonnett in his evidence provides only limited if any descriptions of the distribution of fish species against which the fish passage requirements can be assessed. Therefore, in the section below I provided additional details of the distribution of native fish in the Mokihinui River and a summary of the potential loss of fish passage for each species.

- 4.2. I would also note that as the majority of the survey work undertaken by Meridian witnesses has been done by electric fishing. I have some concerns about the quality of data for the three kokopu species, inanga, common smelt brown mudfish and juvenile lamprey that are difficult to capture using electric fishing. A further caveat on the survey methodology adopted by NIWA is the short lengths of stream fished at each site. David et al. (2010) found that to have a 90 % capture probability for all the fish species present in a reach then 150 m of stream needs to be electric fished. I have estimated the length of stream fished at each of the NIWA survey sites by dividing area fished by average width of the waterway (data provided by NIWA and Meridian). I do expect these estimates to underestimate length of stream fished when the fish survey team has fished the edge zones of wide channels. However the estimates of stream length fished ranged between 0.33 metres to 100 metres in length, with an average of 21

metres. I would readily accept that my estimates here are crude but it is my opinion that the survey reaches are unlikely to have captured the full diversity of fish species present at all sites and in particular rare species will be under represented in the survey results. Therefore, I would consider the distributional data to be incomplete and the known ranges and abundances of the rarer native fish to be poorly understood.

- 4.3. In September and October 2010 I conducted Gee minnow trapping sampling at sites immediately below and immediately above the proposed dam site and a spotlight survey of a small un-named stream on the lower river. I returned in March 2011 and conducted an electric fishing operation at two sites on the Mokihinui River, one at the Burkes Creek confluence and the other in the first riffle downstream from the dam site. The aim of this work was to gain some understanding of the juvenile bully and torrentfish populations and the extent of their migration upstream. I conducted electric fishing operations in Rough & Tumble Creek in the vicinity of the confluence with Hodges Creek, at the confluence of the Mokihinui River and Rough & Tumble Creek, conducted Gee minnow trapping on small un-named tributaries of the Mokihinui that enter the river approximately 300-500 m downstream of the Rough & Tumble confluence. I also conducted spotlighting surveys of Burkes Creek, Welcome Creek and Rough & Tumble Creek in March 2011. All my survey sites are shown in Figure 1. I have used this information along with that provided by Mr Bonnett, that available in NZFFD and observation of the river and its environs to gain an understanding of the river and the likely distribution of the native freshwater fish.

- 4.4. The thirteen native fish found in the Mokihinui River are all diadromous species that require access to and from the sea to complete their lifecycles (McDowall 1990). The native fish include five galaxias species (all whitebait), two eels, lamprey, three bullies, common smelt and torrentfish (see table 1, Appendix 1 for photographs and site locations since 2000). One additional introduced fish occurs in the Mokihinui River, namely brown trout.
- 4.5. The following five galaxias species; koaro, inanga, banded kokopu, giant kokopu, and shortjaw kokopu, all contribute to the national whitebait fishery although the proportion of each species in the catch varies among rivers. Spawning for the diadromous galaxiids (whitebait) is generally thought to occur on the river banks, either at high tide or during floods. The larvae upon hatching during subsequent high tides or floods drift downstream to sea where they remain for up to six months before returning back upstream as whitebait to complete their lifecycle as adults.
- 4.6. Shortjaw kokopu is one of the rarest whitebait species. In 1994 this fish was thought to be one of the most threatened native freshwater fishes, being classified as a category A threatened species at the time by Molloy & Davis (1994). In more recent years survey techniques have progressed from electric fishing to night time spotlighting for this fish. This has resulted in the discovery of relatively large populations of shortjaw kokopu (e.g., Jack & Barrier 2000, Jack et al 2001). These discoveries resulted in the threat status of this species being revised to sparse by 2005 (Hitchmough et al. 2007). The “sparse” status indicated that the species is thought to be uncommon and occurs at low densities, but is not in decline. More recently Allibone et al (2010) classified shortjaw kokopu as declining as

declines were reported in areas such as West Coast of the North Island.

- 4.7. Shortjaw kokopu whitebait, as noted by Mr Bonnett in his evidence in chief (Section 5.11) are difficult to distinguish from koaro whitebait and because of this difficulty, I agree with Mr Bonnett that the koaro catches in the Mokihinui River should be considered to be a combination of koaro and shortjaw kokopu and the proportions of the two species in the whitebait run is unknown.
- 4.8. Shortjaw kokopu are also a long-lived fish (Allibone et al. 2003) and may live for up to 20 years. Once mature at age three or four the fish spawn once a year. Eggs are laid on the river bank and the larvae go to sea and return as whitebait. Spawning sites for this species occur on banks of streams (Charteris et al. 2003). It has been indicated that spawning and hatching is dependent on increased flow during autumn, therefore maintaining the natural flow of the river where shortjaw kokopu reside is important (Charteris et al. 2003). In the Mokihinui catchment shortjaw kokopu have been recorded in tributaries downstream of the proposed dam such as Chasm Creek and Burke Creek, but also at a site well upstream of the proposed dam in Stern Creek (49 km inland).
- 4.9. Inanga is the most common whitebait and is widespread around New Zealand in the lower reaches of rivers and lowland lakes and wetlands. Of all the whitebait species inanga is a relatively poor climber and therefore does not have the same ability as other whitebait species to penetrate far inland, especially up steep gradients. To date, the records of inanga in the Mokihinui River have been limited to river sections below the proposed dam site (NZFFD, Golder unpublished data, Bonnett and Crow 2011).

However, in my opinion this is based on relatively few observations and limited targeted fishing for inanga.

- 4.10. My personal observations of the lower gorge area leads me to the opinion that inanga would be capable of penetrating at least into the lower reaches of the Mokihinui Gorge. Bonnett & Crow (2011) note catching post-whitebait stage inanga at their ecolodge site that is upstream of Burkes Creek, and only 1.5 km downstream of the proposed dam site. As there are no physical barriers to inanga migration between the ecolodge site and the dam site, inanga will, in my opinion, have access to the lower reaches of the Mokihinui Gorge.
- 4.11. Inanga spawn in autumn, with the majority of inanga spawning only once in their lifecycle (McDowall 1990). Spawning inanga migrate downstream as adults during late summer/early autumn forming shoals that search for spawning habitat. Spawning occurs amongst submerged intertidal vegetation at or just after the peak of spring tides (Benzie 1968) and the eggs are left on the bank as the tide recedes. Spawning is a critical part of the lifecycle and must occur in the tidal zone of a river.
- 4.12. Mr Bonnett in section 11 of his evidence notes no inanga spawning habitat has been located and the natural events such as floods and far infra gravity waves (FIG waves, see Mr Derek Goring's evidence section 6.2) will have detrimental effects. He concludes that the Mokihinui hydro dam effects will be less than minor. I expect inanga will spawn at some locations in the Mokihinui estuary even if the conditions are suboptimal. For an annual species such as inanga to forgo spawning is highly unlikely. It is not possible to review Mr Bonnett's inanga survey data and sites as none are presented but I would note that I caught

numerous inanga in Brewery Stream (the stream that runs through Mokihinui village). This stream is tidal in the lower reaches, is well vegetated and could provide good protected spawning habitat for inanga.

4.13. Giant kokopu is the largest whitebait. Adult fish are thought to be long lived. Spawning habitat is unknown although some evidence indicates this fish undertakes downstream spawning migrations. In the Mokihinui River this fish has only been recorded downstream of the proposed dam site and for the most part in tributaries (NZFFD, Bonnett & Crow 2011, Golder unpublished data). Mr Bonnett in his evidence in chief provides no comment on the distribution of giant kokopu although he provides a distribution map (page 75). The distribution map and my observations of giant kokopu in Burkes Creek indicate that giant kokopu do migrate upstream at least as far as Burkes Creek and what Mr Bonnett describes as the ecolodge site. In my opinion as no migration barriers exist between the Burkes Creek/ecolodge sites and the proposed dam site, giant kokopu will be entering the Mokihinui Gorge. However, the steep tributaries are unlikely to provide significant amounts of habitat for giant kokopu, although some areas of suitable habitat are present.

4.14. Banded kokopu is the third most common whitebait and has been recorded in the whitebait catch in the Mokihinui River and as far upstream as the ecolodge site (Bonnett & Crow 2011). In September 2010 I located adult and post-whitebait banded kokopu in first tributary upstream from the river mouth on the true right of the lower Mokihinui River. I have subsequently located banded kokopu in this stream again in December 2011, and on both occasions this was done rapidly by spotlight survey. To date these are the

only records of adult banded kokopu in the Mokihinui catchment.

4.15. Mr Bonnett's whitebait survey work (Bonnett & Crow 2010) captured post-whitebait kokopu at the ecolodge site and I would expect adult populations to be present upstream of this site. Baker & Montgomery (2001) found that banded kokopu are attracted upstream by the scent (pheromones) released by adult banded kokopu upstream. Using this scent cue juvenile (post whitebait) banded kokopu are thought to migrate upstream to locate adult habitat. The presence of post-whitebait banded kokopu at the ecolodge site indicates that adult banded kokopu do occur upstream. The NZMS topographic map 50 series (BR22 Lyell map sheet) shows only one tributary of the Mokihinui between the ecolodge site and the proposed dam site and that is Podge Creek. Mr Bonnett (survey data provided to DOC) electro-fished four sites in Podge Creek in February 2011 and no banded kokopu were collected. In my opinion three possible conclusions can be drawn from this: either banded kokopu are migrating upstream past the proposed dam site into the Mokihinui Gorge where adult banded kokopu are present most likely in small forest tributaries or the post-whitebait banded kokopu juveniles are entering Podge Creek and the electric fishing surveys failed to locate adult or juvenile banded kokopu; or combination of the two.

4.16. The Mokihinui River holds a large population of longfin eels that are widely distributed around the catchment (Dr Jellyman evidence in chief). Eels spawn only once during their lifecycle, at sea after their downstream migration. Individual eels can be very long-lived with a life span of up to 100 years (Jellyman 1997). The downstream migration to sea for spawning is vital as this occurs towards the end

of their lifecycle and occurs as part of the eel's migration to ocean spawning habitat. If downstream fish passage is not available or the eels die during the migration they do not contribute to the species spawning. The Dr Jellyman also confirms this critical fish passage issue and that the dam will block the upstream and downstream migration of eels.

- 4.17. Shortfin eels are widespread within New Zealand and can be found well inland. However, to date this species has not been located in any significant numbers in the Mokihinui River (Dr Jellyman evidence in chief). This finding is not surprising given the nature of the river system that provides little in the way of suitable low gradient stream, wetland and shallow lake habitat for shortfin eels.
- 4.18. I would note with respect to both eels, aside from incidental captures of elvers, no attempt has been made by Meridian to assess the size of the elver migration or the species composition of elvers entering the Mokihinui River mouth. Dr Jellyman (sections 10.6-10.8) has developed a desktop assessment of the likely elver run based on his population model and data from other sites and indicates a run of 100,000 elvers per annum, but no elver data from the Mokihinui River has been collected.
- 4.19. Lampreys are one of the more poorly understood fish species in New Zealand. Surveys often fail to locate this species as the adult and juveniles can be rare or cryptic. Adult lamprey enter freshwater and migrate inland, upstream to breed. Like eels the lamprey spawns once and dies. Juvenile lamprey rear in freshwater for several years, residing in burrows in fine sediments. The 8-10 cm long eel-like juveniles then migrate downstream to sea.
- 4.20. In the Mokihinui River lamprey have been located at two sites below the proposed dam (NZFFD, Golder

unpublished data). The most upstream record is in the mainstem of the Mokihinui River at its confluence with Burkes Creek, where I collected a single adult male lamprey in March 2011. Mr Bonnett's fish surveys of Podge Creek did not locate adult or juvenile lamprey so in my opinion the adult male lamprey was proceeding upstream to spawning habitat upstream of the dam site.

4.21. There are three species of bullies present in the Mokihinui River: common, bluegill and redfin bullies. All are small fishes with relatively short life spans of a few years. The three species display varying abilities to migrate inland, with common bully and bluegill bully being the more limited in the Mokihinui River. Mr Bonnett in Section 5.7 of his evidence notes common bullies are present in the lower Mokihinui gorge although later in Section 9.2 states they have not been recorded upstream of the dam site. This is not correct as I have collected adult common bullies immediately upstream of Welcome Creek when Gee minnow trapping the area in September and October 2010. This location is upstream of the proposed dam site. Thus it is clear that common bully do enter the Mokihinui Gorge. However, the upstream limit of the common bully has not been determined.

4.22. Bluegill bullies occur in the lower Mokihinui River downstream of the proposed dam site. Mr Bonnett's sampling and my own have collected bluegill bullies from mainstem sites below the dam and Mr Bonnett has recorded bluegill bully in Coal Creek and Podge Creek. I have collected bluegill bullies at the sampling riffle immediately downstream of the dam where small numbers of juvenile bluegill bullies (20-40 mm in length) were present in March 2011. It is highly likely, in my opinion that these

fish ascend the next riffle upstream and enter the Mokihinui Gorge.

- 4.23. The redfin bully is most widespread with its distribution extending right through the Mokihinui Gorge to the Mokihinui Forks. Mr Bonnett in his evidence in chief (Section 5.7) notes their widespread distribution.
- 4.24. Torrentfish are a native fish found in the lower to mid reaches of rivers around the country. However, the biology of the species is not so well understood, and this is particularly true of its migratory behaviour. Juvenile torrentfish have been found entering freshwater in late winter and spring (Scrimgeour & Eldon 1989) although McDowall (1994) reports torrentfish as small as 17-18 mm obtained in April and May (1980-81) at Canterbury river mouths. Given the timing of torrentfish arrival in freshwater is uncertain the speed of their upstream migration is unknown and fish may migrate to their upstream limits in a single year or over a number of years.
- 4.25. The distribution of males and females is also distinctive, with some reports (e.g., Scrimgeour & Eldon 1989) that torrentfish populations in the upper reaches of a river being dominated by female fish. Trap data from the Rangitata River indicates that torrentfish migrate downstream and it is thought this is for spawning (Webb 1999) although spawning habitat is unknown and the adult migrations are very poorly understood. Mr Bonnett in his evidence in chief (Section 5.8) also notes that the upstream migration of torrentfish is likely to be progressive rather than rapid.
- 4.26. One key consideration with respect to torrentfish, not commented on by any Meridian witness is the uniqueness of the species. This fish stems from a marine group of fishes including blue cod. It is the only freshwater

dwelling species of fish in a whole family of fish (the Cheimarrichthyidae, McDowall 1973). Unlike all other native and endemic freshwater fish in New Zealand it has no closely related fish species in New Zealand (compared with longfin and short fin eels or the many galaxiids) nor does it occur elsewhere in the world (compared with lamprey). It is a unique and highly distinct endemic component of New Zealand's biodiversity.

- 4.27. Common smelt is the final native fish species confirmed to be present in the Mokihnu River. A single specimen was collected by Mr Bonnett at the ecolodge site. Common smelt enter freshwater to feed and spawn and the majority are present in freshwater in spring and summer. Inland penetration in low gradient rivers is 100s of kilometres but they are restricted by high gradient sections. This species has been found to readily landlock and has been introduced to a number of lakes as forage food for salmonids.
- 4.28. The fisheries surveys to date have not located any non-migratory fish in the Mokihinui River catchment. The Ngakawau River (i.e. the catchment immediately south of the Mokihinui) has records of both brown mudfish (DOC survey 2009 NZFFD, Golder unpublished data 2012) and upland bully (Harding et al 2006, Golder 2011). It is possible that the Ngakawau River is the northern most extension for upland bully, but as brown mudfish occur in coastal regions to the north (e.g., Karamea) brown mudfish are now, in my opinion either extinct or yet to be located in the Mokihinui catchment.

## **5. NATIVE FISH THREAT STATUS, BIODIVERSITY VALUE AND ASSESSMENT OF IMPACTS**

- 5.1. The Department of Conservation reviews the threat ranking for native species on a three yearly basis and the threat rankings for native fish were last reviewed in June 2009. The threat ranking process of 2009 adopted the method set out in Townsend et al. (2008) and the terminology for the threat rankings was altered from the previous two ranking processes conducted in 2002 (Hitchmough 2002) and 2005 (Hitchmough et al 2007).
- 5.2. I have participated, as an expert on native fish, in the threat rankings process in 2002 and 2005 and chaired the process in 2009. As the chair person of the expert panel I had a role in selecting other expert panel members and had to ensure the ranking process was followed. Other expert panel members on the freshwater fish expert panel were, Dr Donald Jellyman (NIWA), Dr Nicholas Ling (University of Waikato), Associate Professor John Waters (University of Otago), Mr Pete Ravenscroft (DOC) and Dr Bruno David (Environment Waikato). The panel members were selected so that the panel had expertise in fish taxonomy, native fish biology, and their combined experience covered the full geographic extent of New Zealand and individuals had good knowledge of current and historic fish communities in New Zealand.
- 5.3. The threat ranking process in 2009 ranked more New Zealand freshwater fish as threatened or at risk than in any previous threat ranking process. The result of this process is that the number of threatened species in the Mokihinui catchment has risen from four (Hitchmough et al 2007), longfin eel, giant kokopu, shortjaw kokopu and lamprey to

nine as redfin bully, koaro, bluegill bully, torrentfish and inanga have all been classified as declining by the expert panel (Allibone et al 2010). The expert panel concluded:

*In summary it is apparent from this threat ranking process that no genera of freshwater fish in New Zealand is immune from the processes of decline and furthermore; since the last review of the status of freshwater fish in 2005, both the abundance and distribution of an additional seven established species have declined, resulting in these species being added to various threat categories. An additional five indeterminate taxa have been added to the list, four of which are in the Threatened group. It is apparent that more serious effort is now required to reverse the decline in native freshwater fishes and to manage the instrumental causes of their decline that are ongoing, and in some cases increasing, if the extinction of further freshwater fish is to be prevented*

- 5.4. All the threatened species now listed in the Mokihinui catchment have been shown to occur in the lower river and use the main stem as habitat or as a migration pathway to adult habitat. All will be subjected to the downstream effects of the hydro-electric operations such as flow fluctuation, habitat modification and gas bubble disease.
- 5.5. In my opinion the lower Mokihinui River supports a diverse range of native fish and provides the all-important migratory route for fish to and from the sea and the river and its tributaries. Impacts of the hydro-electric scheme on this lower 11 km of the river has the potential, in my opinion, to directly impact on the diverse fish communities of the main stem and on fish communities throughout the whole catchment if migratory pathways are disrupted.

- 5.6. Six species, longfin eel, koaro, shortjaw kokopu, redfin bully, torrentfish and common bully are all confirmed to occur upstream of the dam and will lose habitat to inundation. Bluegill bully, lamprey and giant kokopu and juvenile banded kokopu are all recorded in close proximity to the dam and in my opinion, are also likely to penetrate into the Mokihinui Gorge and be subject to some habitat loss.
- 5.7. The biodiversity value of the Mokihinui River catchment with regard to native fish is, in my opinion significant. Appendix 1 of my evidence displays the distribution maps of the 13 native fish species using NZFFD records for surveys conducted since 1 January 2000. I have restricted the mapping to records since 2000 as the use of historic records from before this date can misrepresent the current distribution if the species have undergone range contraction in the last decade. One of the key findings of Allibone et al. (2010) was that a number of migratory species (koaro, torrentfish, bluegill bully and redfin bully) have declined by approximately 50% in the frequency that they are reported in the NZFFD records since 2000. The distribution maps and the number of fish records show that torrentfish, bluegill bully, giant kokopu, shortjaw kokopu, lamprey and common smelt are all recorded in between 1% and 3% of the records. Whereas longfin eel, the most commonly recorded native fish occurs in 30% of the records.
- 5.8. I note when all the data used is mapped (Appendix 1 Figure 1) there are some obvious areas with no sampling in the last 12 years, Kahurangi, Fiordland and Rakiura National Parks, in particular have little sampling. However, it is my opinion that the NZFFD does provide a good overview of

the approximate distributions of the thirteen native fish confirmed to be present in the Mokihinui River catchment.

- 5.9. The Mokihinui River as noted by many witness has thirteen native fish and aside from the lower river estuarine species, black flounder and giant bully (that are likely to be present) the community present represent the full suite of migratory native freshwater fish on the West Coast. When the national distributions of native fish are considered, this West Coast freshwater fish fauna includes all the migratory fish (which despite generally being thought of as widespread, includes many species that are not (e.g. bluegill bully, torrentfish)). In this respect in my opinion the river has significant value as it harbours the full diversity of migratory West Coast native fish in a single community.
- 5.10. Additional value for the river is provided by Dr Jellyman who notes the longfin eel population appears to be unfished and DOC records indicate no commercial fishing is currently undertaken on DOC administered areas within the catchment. Therefore aside from the whitebait fishing and invasion by brown trout, the river is in its natural state. In a local context the Mokihinui River provides a diverse and intact native fish fauna. The adjacent Ngakawau and Waimangaroa River are subject to acid mine drainage (AMD) impacts from past and present coal mining. Both the Ngakawau and Waimangaroa Rivers have steep gorges a short distance inland that prevent fish passage to upper catchments and clean water tributaries. Fisheries surveys of these two catchments (NZFFD, Harding et al 2006, Golder 2011) have found the majority of the streams to either have few fish or no fish life at survey sites. In contrast, the Mokihinui River provides habitat for broad range of native fish and is far less limited by any human

induced or natural restrictions to fish recruitment in the catchment.

- 5.11. The creation of the Mokihinui Dam will in my opinion extend the region impacted, low diversity fish communities northwards. In my opinion the cumulative adverse effect on freshwater habitats of multiple developments in the region north of the Buller River should be considered because the migratory native fish of this region are all sourced from the same pool of ocean reared juvenile fish. Increasing the human induced impact with the Mokihinui dam on the available habitat for these fish risks further decline for a number of fish species that are now in significant decline nationally.
- 5.12. I would also note that Golder (2011) in a recent survey of the Ngakawau River catchment found that since Solid Energy (NZ) Limited (SENZ) began treatment of AMD waters at the Stockton mine site the pH and turbidity of the Ngakawau River has improved. The Golder (2011) survey found, in contrast to Harding et al (2006), that koaro recruitment appears to be significantly higher indicating the SENZ mitigation is working to improve conditions for native fish with koaro currently benefiting from the improved conditions. In my opinion the Mokihinui dam, with its impacts on a broad range of native fish, will more than counteract the local improvements achieved by SENZ and lead to further decline of native fish in the region north of Westport.
- 5.13. I would note in my assessment of the fisheries values I differ from Mr N Norton (his evidence in chief sections 5.6, 8.4 9.6) regarding the assessment of biodiversity impacts with regard to native fish. Mr Norton states five threatened species, koaro, longfin eel, bluegill bully, redfin

bully and torrentfish, will be subject to habitat loss when the Mokihinui Gorge is inundated. Mr Norton has ignored the impact on common bully that is also resident in the Mokihinui Gorge as he has only considered threatened species. I do not consider this correct as cumulative loss of habitat for any species leads to decline and eventually species can then become threatened. It is not appropriate to simply ignore species because they are not threatened.

5.14. In addition Mr Norton has ignored a number of important fish survey findings. Shortjaw kokopu has been confirmed to occur in areas upstream of the inundation zone, hence this migratory species certainly uses the Mokihinui Gorge. I have found a mature male lamprey downstream of the proposed dam site and in my opinion lamprey will enter the gorge and spawn in the gorge, its tributaries or in the upper Mokihinui. Banded kokopu whitebait have been collected by Mr Bonnett (Bonnett and Crow 2011) at the ecolodge site and as I have stated above are likely to be migrating upstream into the gorge and its tributaries. I have also caught giant kokopu in Burkes Creek and would expect this species to be migrating into the gorge. These species should all be considered in the assessment of loss due to the creation of the reservoir.

5.15. Therefore, in my opinion, when considering the effect of the dam on upstream fish communities this should not be restricted to loss of habitat for five threatened species, but should consider all species that enter and occupy the gorge. Any assessment should acknowledge the uncertainty associated with the fish distribution data available for the assessment, something Mr Norton does not do. An implicit assumption or omission in Mr Norton's assessment is that any artificial provisions for upstream fish passage migration will be successful and maintain the present

communities in their present state upstream of the inundation zone. Later in my evidence I have set out the limitations and risks with the artificial upstream fish passage provisions proposed. In my opinion Mr Norton cannot assume that fish passage will be successful. In summary, it is my opinion that the geographic range over which the fish communities will be altered is much greater than just the inundation zone and this alteration affects more species than Mr Norton considers.

- 5.16. Finally Mr Norton makes no mention of the impact of the hydro-electric operations on downstream fish communities. As I set out below in my evidence I have major misgivings with regard to the assessment of effects for the lower river. As such it is my opinion that any assessment of the change in biodiversity values should include recognition of significant detrimental effects on the native fish community of the Mokihinui River below the proposed dam site.

## **6. THE WHITEBAIT FISHERY OF THE MOHIKINUI RIVER**

- 6.1. During the 2010 whitebait season I spent three weeks (13 - 17 September, 4-8 October, 1-5 November) at the Mokihinui River assessing the whitebait catch. This time on the river allowed me to gain a very good understanding of the nature of the fishery and the river conditions that influence the catch.
- 6.2. A small majority of the fishers I met were people who came to visit the Mokihinui River for the whitebait season and some had been fishing the river for decades. Visitors generally came from the Nelson and Canterbury regions. The more local people came from Westport and the area

between Westport and Mokihinui. It was also apparent that some fishers were on the river for the full season and the majority of these fishers were experienced fishers who understood the fishery and had their favourite fishing sites or were stand owners. It was also common to find stands (a platform or wharf like structure that extends out over the river from which people fish) fished by different people on different visits because stand holders shared their stands with friends; all of whom could only visit the river for a week or two during the season. Therefore, the fishers represent a range of skill levels and fishing effort. The total catch for any person reflecting the amount of time they spent on the river, their skill at fishing (scooping) and the size of the whitebait run during their fishing period.

- 6.3. The fishery as noted by Mr Greenway (sections 4.27) has 69 registered fishing stands and these are situated on both banks of the river but do not extend to the river mouth. However, Mr Greenway's assessment of the whitebait fishery is then limited to noting it is a river of potential national significance (section 4.27). No witness for Meridian provides any evidence regarding the nature of the fishing activity nor any assessment of potential effects of the hydro-electric operations apart from noting that the flow regime will be *as far as practicable run of the river*.
- 6.4. For the benefit of the Court I have set out below my observations on the fishery for the 2010 whitebait season and I consider the potential effects of the proposed dam. As noted above there are a series of fishing stands on the lower tidal section of the Mokihinui River. Additional fishing is conducted closer to the river mouth by whitebaiters walking the shoreline with scoop nets (photograph below). This activity is concentrated on the Mokihinui village side of the river as the sand bar at the

river mouth provides a good riverbed over which to conduct scoop fishing. On the Gentle Annie side of the river the scooping activity is more restricted due to the rocky nature of the river bed. Here shoreline and scoopers generally fish from fixed points (photograph below). These fishers although remaining in a fixed place are not registered stand holders.

- 6.5. I would note that long-term reduction in sediment supply to the coast will change the composition of the river mouth sediments with the potential to reduce whitebaiting at the river mouth. Dr Hicks notes in his evidence that the gravel bar at the river mouth will slowly erode away as gravel supply declines. Dr Goring in sections 6.8 of his evidence notes that swell waves currently break on the gravel bar and do not penetrate far into the lagoon. He goes on to say as the gravel bar reduces in size due to reduced sediment transport to the river mouth swell waves will penetrate further into the lagoon. From my personal experience and observations of scooping in swell waves it is much more physically demanding than in calm water. Therefore, I would expect a reduction in the gravel bar to reduce the fishing activity at the river mouth as swell waves penetrate further upstream. If the swell waves penetrate upstream to fixed position scoopers or stands the desirability and fishability of these lower lagoon sites will decrease. I do accept this effect unlike other more immediate effects may occur over a number of decades.



Whitebaiters scoop fishing the Mokihinui River mouth.



Whitebaiters scoop fishing from fixed sites at Gentle Annie, Mokihinui River mouth.

- 6.6. Fishing from stands is conducted along the mid-tidal reaches of the river. Some stands can be fished at all times as they are situated over the river channel. Others stands can only be fished when the tide is half in or fuller. Therefore activity on individual stands varies according to the water level in the estuary.
- 6.7. During October when fishing pressure peaks the number of fishers on the river would have been close to 100, with all the stands occupied, scoopers at the river mouth and at fixed spots upstream from the mouth, and set netters fishing the area near the back markers<sup>1</sup>. In early September and November the fishing pressure was less. In November the scooping activity at the river mouth had declined markedly as fishers had finished early for the year because catches were considered poor.
- 6.8. Meridian's proposal to operate the Mokihinui hydro scheme as far as practicable as run of the river during the whitebait season appears a reasonable option to maintain the river flows in a fishable state. However, I would note the caveat *as far as practicable* lacks specificity which may be of concern to fishers.
- 6.9. One aspect of the Mokihinui River whitebaiting not noted by witnesses appearing for Meridian is the nature of the fishing activity. There is a very strong local custom on the river that the fishing is conducted by scoop netting. No stand holder that I visited in 2010 fished with screens and nets with traps. When I have previously conducted research on whitebait catches in the North Island and on the Hokitika River the whitebaiters on stands used screens and

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<sup>1</sup> Markers that indicate the upstream limit of whitebait fishing

whitebait nets with traps rather than scoop nets. Thus the Mokihinui fishing practices are, in my opinion somewhat unusual.

6.10. Fishing with whitebait traps from stands requires less effort as the traps catch and hold fish in the nets until such time as the whitebaiter lifts the net. The fish practice in the Mokihinui of using a scoop net on a stand requires the whitebaiter to watch for whitebait and to actively scoop them in order to catch them. Some stands did have screens and all had a series of white spotting boards on or just above the river bed. The catching of whitebait was done on all stands using a scoop net. The success of the fishing was very much related to the visual clarity of the water. Only the scoopers at the river mouth are fishing “blind” although in clear water, even the walking scoopers can, on occasion, see schools of whitebait. Therefore, it was my experience, that the turbidity of the river was a key factor governing the catch of whitebait.

6.11. My three visits to the Mokihinui River were conducted to assess the whitebait catch and to provide the Court with an estimate of the catch rate and possible run size of whitebait in the Mokihinui River. To do this we captured whitebait early in the morning with the assistance of some of the whitebaiters. The number of fish caught was determined by counting all individuals as they were collected. The whitebait were then dyed using neutral red (red and pink coloured fish or Bismarck brown (orange coloured fish) so they could be identified for at least two days. Once dyed the majority of fish were released back into the river downstream of all whitebaiters on the Gentle Annie side of the river. A sample of whitebait was kept from each dye batch to monitor for mortalities due to dyeing and handling stress. Over the subsequent three days after each release

we visited all the whitebaiters on the river at least once and most each day to determine how many dyed bait were caught, the locations they were caught the time(s) they were caught and if possible information on the total catch of whitebait.



Whitebait dye red with neutral red dye, September 2010, Mokihinui River.

- 6.12. The releases were conducted during weeks with fine weather and we avoided times of the year when floods and heavy rain occurred. The week in September was relatively cool and the whitebaiters on the river considered the water too cool for a good run to happen and the water was also turbid and difficult to fish. The week in October was considered to be good fishing conditions with reasonable water clarity and warm temperatures. The final week in November was also warm and the river was relatively low and very clear. In November the experienced whitebaiters I spoke to considered the river too clear for good fishing and the whitebait I observed were reluctant to swim over the white spotting boards.

- 6.13. The catch of dyed whitebait varied from 3.1 % to 40.7 % percent. The recapture rate for fish dyed with neutral red was always lower than that for the fish dyed with Bismarck brown. The monitoring of the whitebait retained in live boxes found that the activity of fish dyed with neutral red dropped markedly four hours after the fish had been dyed. However, mortality for the retained neutral red dyed fish was low at less than 10%. No mortality or changes in activity were noted with the fish stained orange with the Bismarck brown dye. Bearing these differences in mind and from the results in Table 2, it is my opinion, that the red dye marked trials can be compared to one another to assess fishing success and the orange dyed fish trials provide the best data to assess the total catch rate as well as to compare the catch rates between the survey weeks.
- 6.14. In all trials the whitebait were counted as they were caught before they were dyed. The dyed whitebait was weighed (in batches) and an average weight for whitebait of 0.66 g was obtained by dividing the number caught by the weight. This average weight was used to convert estimated catches given to me in kilograms or pounds by whitebaiters into the number of fish caught for each escapement trial.
- 6.15. It is apparent from the capture data that the catch rate through the season increased and that the catch rate was highest in November when the whitebaiters indicated the river was too clear for good fishing. I did observe whitebaiters catch bait on all visits to the river and I would conclude that in November fishing for the schools of whitebait seen required more care as the whitebait did move to avoid the net and the spotting boards. However, most schools of fish dispersed and dropped back downstream when avoiding the scoop net and would attempt to swim past whitebaiters again once the school

had reformed, so individual fishers would generally have more than one opportunity to catch the passing whitebait.

- 6.16. One factor that would influence the catch was fishing effort and while we were unable to quantify effort completely we did make some observations of fishing activity. The activity was highest in October and on the other two visits effort was less. Therefore, in my opinion fishing effort did not explain the trend of increasing catch rate through the season.
- 6.17. Therefore, in my opinion with respect to the effect of the proposed dam and reservoir on the whitebait fishing at the Mokihinui mouth there is one aspect that has not been considered. The fishery becomes more efficient as water clarity increases and fine substrate material (silt and clay particles) remains on the river bed rather than in suspension. I note that the reservoir has the potential to decrease turbidity by allowing a proportion of the finer material to settle out rather than being transported downstream to the river mouth (Hicks evidence in chief sections 6.2-6.3). I cannot quantify this effect as we do not have a relationship established between turbidity and fishing success aside from the initial assessment I have conducted. This conclusion is, I note, at odds with the perception of the whitebaiters that fishing was less successful when the water was very clear in November. In my opinion, after observing the fishing effort (see Sections 6.3 - 6.11), the capture rate was high as the whitebait shoals were making several attempts to pass each stand if disturbed by the scooping activity and were therefore exposed to greater fishing effort.
- 6.18. Considering Dr Goring's assessment that swell waves are likely to penetrate further into the lagoon, this will increase

turbidity as the waves suspend fine river bed sediments. Therefore, scoop fishing in the lower part of the river lagoon will become more difficult as the ability to see whitebait crossing the spotting boards will be reduced.

6.19. I would conclude from the evidence of Dr Hicks and Dr Goring that the changes to sediment transport and wave action in the lagoon will alter fishing activity. Whitebaiting is likely to be more successful in the upper areas of the lagoon but less successful in the lower section of the lagoon.

6.20. Based on my experience with dyed whitebait releases on the Awakino, Mokau and Waikato Rivers and small West Coast streams the 30 to 40 % catch rate in the Mokihinui fishery is very high and raises concerns about how sustainable this fishery is and whether the catch rate is too high. There is potential that the Mokihinui catchment is a sink population for various whitebait species. By this I mean more fish enter the river (as whitebait) from the general pool of juvenile fish in the ocean than adults fish resident in the river contribute to the general pool of oceanic rearing juveniles. The adult pool is therefore sustained by reproduction and larval fish that originate from other catchment. Any increase in the catch rate is, in my opinion, a cause for concern as the net loss effect increases.

6.21. While I was conducting the whitebait escapement trials I also questioned the whitebaiters regarding their opinion of the whitebait season and about their catch for the year. Also fishers were given stamped addressed envelopes to send in catch weights for the season. The intent was to gather enough catch information to estimate the whitebait

catch for the 2010 season and to then estimate the total run size.

- 6.22. Nine fishers sent in catches for the season, some with details of the location and effort some with just the catch weight. The highest total weight for the season for the nine fishers that responded was 50 lbs (c 22.5 kg) and the lowest 2.5 lbs (c. 1 kg). From the data provided it is apparent that the number of days fishing and the time of year the fishing was done influenced the catch.
- 6.23. Verbal estimates of fishers' catches were also noted while on the river. Two of the regular fishers who fished the full season indicated that while their catches were poor they were in the order of 200-300 kgs for the season. These season catch rates may sound large but are well within the range of individual season long whitebait catches reported for West Coast rivers.
- 6.24. Given the catch reported to me, the comments made by fishers on the river and my observations on the river in 2010 I would expect the total catch for the season was in the order of 2 to 2.5 tonnes. This figure is substantially less than the catch noted by Mr Wightwick (2008) and the West Coast Whitebaiters Association of 8-10 tonnes in the 1990s. The low catch would be consistent with the fishers' comments that the season was poor and that the experienced long term fishers had had much more successful seasons in the past.
- 6.25. The low catch rate for whitebait in the Mokihinui River may also indicate that the long-term trend for whitebait catches is in decline. The 20 year gap between the early 1990s assessment of 10 tonnes and my estimate of 2-2.5 tonnes indicates a decline in the order of 75% to 80%. There is certainly some degree of uncertainty with such a

decline as yearly variation will play an important part in the observed annual catches. However, if the data is accepted as correct and indicative of the general trend then, in my opinion, a substantial decline in the whitebait catch has occurred in the last 20 years.

- 6.26. Alternatively, the low catch may be the result of extreme variation in the size of the whitebait run between years. In this case, assessment of the state of the fishery is handicapped by the lack of long-term monitoring data. If the yearly variation is accepted as the cause of the low catch rate observed, then in my opinion, all catch estimates in the river, those I have produced and those produced by Mr Bonnett should be considered as estimates of catch and upstream post-whitebait run strength in a poor whitebait year.
- 6.27. An estimate of the escapement can be made from the catch data I have gathered. Using the data from the Bismark brown mark and recapture trials the average catch rate is 30%. The average weight of whitebait was determined as 0.66 g per fish. Therefore, the 2 tonnes estimated catch equates to 3 million whitebait caught. Using the mean 30% capture rate the total run can be estimated to be approximately 10 million fish and the number of fish that escape fishery is approximately 7 million. If we accept that the 2010 whitebait season was a poor season and a good season is as reported by Wightwick (2008) a catch of 10 tonnes (a fivefold increase) then we could expect, if all things are equal, a upriver run of 35 million fish.
- 6.28. Mr Bonnett in section 12.12 of his evidence in chief has reported the results of post-whitebait trapping at the ecolodge site and estimates the run of post-whitebait was between 39,657 to 498,375 individuals at this site in 2010.

If the season was as the whitebaiter's reported a poor season and the catch as I have estimated is about a quarter of a good season's catch then the upstream run of post-whitebait stage fish could be four times what Mr Bonnett has estimated.

- 6.29. There is a clear discrepancy between the estimate of the whitebait run I have obtained from the mark and recapture trials during the whitebait season and the estimates of the run at the ecolodge site Mr Bonnett has calculated. Mr Bonnett has attempted to determine the catch efficiency of the Southland sock nets he used and retention rate of the whitebait in the nets once caught (Bonnett & Crow 2011). Both these trials, as Mr Bonnet notes, utilised low numbers of fish and the conclusions are limited due to the low sample size. However, Mr Bonnett has provided a range of potential whitebait run sizes based on possible catch and retention rates to account for this.
- 6.30. In my opinion the available data cannot explain the discrepancy between the two sites. There are three factors that are not accounted for that will reduce the whitebait run at the ecolodge site. Mortality of whitebait due to predators as they migrate upstream and some whitebait choosing to enter tributaries such as Coal and Chasm Creeks rather than progressing up the Mokihinui River will reduce the upstream run size at the ecolodge site. However, to date, there are no estimates of either of these two factors. A final factor that may contribute is that the whitebait migrated past the ecolodge site at times when no netting was being conducted. This would either be in late December or in periods when the river could not be fished due to floods.
- 6.31. In summary I would conclude there is considerable uncertainty with regarded to the current state of the

whitebait fishery in the Mokihinui River, but indicators are that it is in decline. The size of the runs in the tidal zone and the ecolodge site are substantially different and cannot be fully reconciled. The likely run size at the dam site, in my opinion cannot be credibly estimated and may vary considerably from year to year.

## **7. THE EFFECTS OF IMPOUNDMENT AND RESERVOIR CREATION ON NATIVE FISH AND THEIR HABITAT**

- 7.1. Prior to determining fish passage requirements, in my opinion, it is important to consider the effects of the creation of the reservoir, and objectives for native fish management upstream of the dam. I have been unable to find in any Meridian witnesses evidence or the AEMP any specification of objectives for native fish management or of mitigation goals to be achieved in order to compensate for the loss of riverine habitat in the gorge. Rather only fish passage mitigation is proposed. Therefore, below I have set out the effects of the reservoir creation.
- 7.2. Dr James (section 6.3) and Mr Bonnett (section 8.1) state that the creation of the Mokihinui Dam will inundate approximately 14 km of riverine habitat. Mr Bonnett then notes in section 8.3 of his evidence that the inundation will also flood the lower reaches of the Mokihinui River tributaries in the Gorge and in section 8.6 he reports the result of the LiDar analysis of stream length. This analysis shows that an additional 7.22 km of tributary habitat will be inundated. This indicates that the actual distance of riverine habitat to be flooded is over 21 km, a distance not reported in Dr James evidence. Dr Leathwick in his

evidence in chief has also addressed this issue and provided an estimate of the total loss of habitat to inundation.

- 7.3. No analysis has been conducted to estimate total area of habitat lost. This in my opinion is a more informative estimate of the impact on fish species as area of habitat loss can also be related to fish density and inferences drawn on the total decline in fish abundance due to the creation of the reservoir.
- 7.4. Mr Bonnett in sections 8.6 also presents analysis of the areas of tributaries that become available to brown trout as barriers to upstream movement are submerged by the creation of the reservoir. This analysis indicates another 1.7 km of tributary habitat currently habitat only for native fish will become accessible to brown trout. Further Mr Bonnett notes that this is a 50% reduction in trout-free habitat for tributaries in the gorge area. Therefore, nearly 23 km of riverine habitat is either completely lost or subject to the introduction of a significant introduced predator known to adversely affect native fish populations.
- 7.5. Mr N Norton in his assessment of effect on biodiversity ignores the effect of the range extension by brown trout. This is in my opinion a significant omission with regard to the assessment of biodiversity loss as brown trout are a leading cause of decline for native fish (McDowall 2006) and are also recognised for their impacts on invertebrates (McIntosh 2000). Therefore in my opinion Mr Norton's assessment of indigenous biodiversity loss is understated.
- 7.6. Mr Bonnett, also in section 8.6, notes that the River Classification System (REC) shows that the Mokihinui catchment contains more than 900 km of first, second, and third order tributaries. A key factor not commented on by Mr Bonnett is that the habitat inundated is the lower

reaches of streams that are known habitats for koaro, torrentfish, redfin bully and longfin eels. The fish distribution maps (Mr Bonnett's appendix 2) indicate all the torrentfish habitat and the majority of the redfin bully habitat is inundated upstream of the dam site. Therefore, while by far the majority of the catchment upstream of the dam site remains as riverine habitat this is not used by redfin bully and torrentfish. The remaining habitat for these two species occurs downstream of the dam and for torrentfish the majority is in the main-stem of the river and subject to the impacts of the dam operations.

- 7.7. Koaro exist outside the inundation zone in the reaches upstream of the proposed reservoir. The distribution maps in appendix 2 of Mr Bonnett's evidence in chief show the location of all sampling sites (page 70) and the location of all the sites with koaro (page 77). It is clear from a comparison of these maps that koaro occurred at only three sites upstream of the Mokihinui Forks and the majority of the koaro sites are in tributaries of the gorge. Therefore, in my opinion, as with torrentfish and redfin bully, the inundation of the gorge will impact on a very significant proportion of the koaro streams and hence the koaro population. This impact will be the combined effect of inundation and loss of habitat and the introduction of brown trout to additional riverine areas.
- 7.8. I have previously noted the inundation of the gorge also truncates the upper reaches of the distribution of common bully (Table 1) and also most likely truncates bluegill bully distribution.
- 7.9. In my opinion the impact of the inundation on inanga, shortjaw kokopu, banded kokopu, giant kokopu and lamprey is unknown as the distribution of these species in

the Mokihinui catchment has not been determined. Notwithstanding, I expect there will be some loss of habitat for these species. The available distribution and occurrence data shows all five species are present immediately below the dam site (and shortjaw kokopu upstream of the gorge) and in my opinion all are capable of migrating upstream into the gorge. However, the location and area of habitat these species use is unknown and therefore it is not possible to quantify the effect of the creation of the reservoir.

7.10. In summary the creation of the reservoir without mitigation would lead to:

- The loss of all torrentfish upstream of the dam
- The loss of almost all the redfin bully habitat upstream of the gorge
- The loss of a major proportion of the koaro habitat
- Invasion by brown trout into additional areas of koaro habitat
- Truncation of the upstream range of inanga, common bully, bluegill bully, shortjaw kokopu, banded kokopu, giant kokopu, inanga and lamprey.

My conclusion differs significantly from that used by Mr Norton in his assessment of biodiversity effects. I conclude the loss of habitat is a highly significant effect of the flooding of the Mokihinui gorge.

## **8. THE EFFECTS OF FLOW FLUCTUATIONS DOWNSTREAM OF THE PROPOSED DAM**

8.1. There are several potential effects of the proposed dam on the downstream fish communities:

- Fish stranding due to flow fluctuations
- Disruption of fish spawning
- Loss of habitat due to flow fluctuations
- Loss of food resources due to flow fluctuations
- Effects of gas bubble disease
- Effect of any discharges of anoxic water from the reservoir.

8.2. Investigation of stranding for native fish in New Zealand have rarely been conducted so limited information exists on the risk presented by fluctuation flows that result from hydro-electric generation. Mr Bonnett in his evidence (Section 7) makes no mention of stranding as an issue in his assessment of the impacts on native fish in the lower Mokihinui River. Dr Jellyman in his evidence in chief also does not mention fish stranding in the lower Mokihinui River. Mr Jowett in his evidence in chief notes stranding (section 6.13) is an issue that is frequently reported for juvenile salmonids. However in section 6.27 Mr Jowett notes with regard to a stranding investigation on the Waitaki River:

Observation of the effect of a sudden flow change below the Waitaki Power stations indicated that fish did not become stranded by a sudden reduction in flow, although they can become isolated in pockets of water (Strickland et al. 2002).

Following this note Mr Jowett concludes there is no risk of stranding in the Mokihinui River due to flow fluctuations.

- 8.3. Dr James in his summary of the effects of the fluctuating flows does not mention fish stranding and the Aquatic Ecology Management Plan does not mention monitoring for native fish stranding.
- 8.4. Meridian Energy Ltd commissioned the study of Strickland et al. (2003) on stranding as a result of flow fluctuations of the Waitaki River as part of the Project Aqua investigations. I have reviewed a copy of this report provided to DOC and myself by Meridian Energy (Strickland et al. 2003). The study targeted salmonid fish but also investigated native fish stranding as the flow was decreased in a series of steps from 351 m<sup>3</sup>/s, to 152 m<sup>3</sup>/s, to 119 m<sup>3</sup>/s to 90 m<sup>3</sup>/s over four days. After each drop in flow selected reaches of the river were surveyed to assess the numbers of salmonids trapped in isolated pools or stranded (and dead). NIWA staff, commercial eelers and a DOC observer also conducted searches for native fish stranding during this trial.
- 8.5. Appendix 2 of Strickland et al (2002) provides the notes the NIWA/DOC team made during the stranding trial. I have attached this appendix (and appendix 1 of Strickland et al 2002) as Appendix 2 to my evidence. The notes include comments on birds feeding in recently dewatered areas, numerous dead bullies found in scour holes, lamprey stranded but still alive, several bullies stranded but still alive, and at least 50 dead bullies counted in one dried pool. Having read Strickland et al (2003) I do not agree with Mr Jowett's statement that native fish did not become stranded, and I believe the report indicated significant mortalities of bullies occurred during the Project Aqua stranding trial.

- 8.6. I have also conducted stranding searches in small streams and a river in Otago to investigate native fish losses as a result of droughts. Despite the rivers and streams having good to high pre-drought fish densities of small native fish such as bullies and non-migratory galaxiids searches for dead fish in recently dried river beds often, in my experience, has had little success. Bodies of small fish desiccate quickly and are difficult to recognise and predators and scavengers also remove bodies quickly (photograph below). I also found, as noted by Strickland et al (2003) that birds and in the case of my observations, mammals often prey upon fish before the pools are completely dry so fish mortalities occur via predation before stranding and subsequent desiccation occurs.



A desiccated galaxiid at the bottom of a pool dried during a Central Otago drought. Note the fish died before the bed of the stream has dried.

- 8.7. The Waitaki River, where Strickland et al (2003) conducted their study has populations of bullies, mainly upland bullies, and torrentfish at the sites selected for the

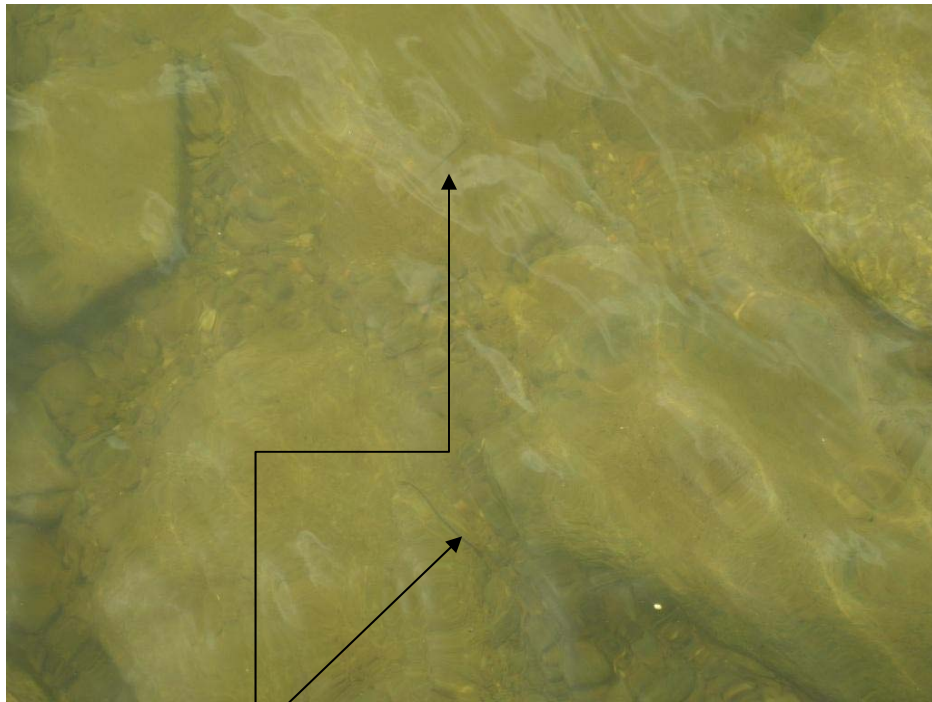
investigation. Eels and lamprey are also present but numerically the areas fish community is dominated by bullies. A key factor, in my opinion, is that the Waitaki River does not have a whitebait run of any note and whitebait would not have been present in the areas the stranding trial was conducted along. Therefore, while this study shows bullies are readily stranded no investigation of stranding has been conducted on a river with a significant whitebait run. In my opinion while the Waitaki River study demonstrates mortalities do occur the applicability of this result to the whitebait run in the Mokihinui River is unknown and Mr Jowett's conclusion that there is no risk is made without any data to support it with respect to whitebait.

- 8.8. I have reviewed Bonnett & Crow (2011) that reports the results of their study on whitebait migration in the Mokihinui River. With respect to the stranding issue there are several important results that Mr Bonnett and Mr Jowett, have in my opinion failed to assess. Bonnett & Crow (2011) report the catch from Southland sock whitebait nets set across the river from the river bank as far out as was safely wadeable. The report on page 43 notes that there was an "edge effect" with the catch of whitebait being significantly greater at the river edge than in nets further from the river edge. I also noted that the catches of whitebait at the ecolodge site peaked in late November and early December.
- 8.9. Bonnett & Crow (2011) also report their observations of dyed whitebait migration and catch rates of whitebait with nets set at different heights in the water. Their observations and catch results indicate that whitebait were migrating upstream near to the bed of the river rather than high in the water column. In my opinion this makes good ecological

sense as the water velocities are low near the river bed and it requires less energy expenditure by the fish to move upstream.

- 8.10. Bonnett & Crow's (2011) study provides three very important pieces of information relevant to the assessment of whitebait stranding. Firstly, the whitebait are most common at the river edge, the area of the river that will expose the fish to much greater stranding risk than if they were migrating in the middle of the river channel. Secondly, the whitebait's preferred position in the water column when migrating upstream is near the riverbed amongst the substrate. Thirdly, the post whitebait stage juveniles were moving upriver towards the proposed dam site after the whitebait fishing season had finished. After 14 November each year Meridian intend to use the summer ramping rates and the river will be exposed to large daily flow fluctuations. Therefore, in my opinion the data shows that whitebait are at risk to stranding due to their preference for migrating upstream at the river edge and near the river bed and as the timing of their migration means they will be subject to the full daily range of flow fluctuations. These are all conditions that promote stranding of fish.
- 8.11. The whitebait run of giant kokopu has been shown to occur later than other whitebait with the majority of this species entering rivers in November and often after the whitebait season finishes (McDowall 1999, McDowall & Kelly 1999). The late run of this threatened fish will subject the giant kokopu whitebait to a proportionally greater risk of stranding than other species that at least commence their upstream migration in the whitebait season.

- 8.12. Bonnett & Crow (2011) indicate that their Southland sock catch rates for bullies increased significantly in late November. They also report the November bully run at the ecolodge site was dominated by the threatened redfin bully. The implication, in my opinion, is that fluctuating flows will impact on the more threatened bully species.
- 8.13. In addition to the effect of the fluctuating flows after the whitebait season there is potential for adverse effects on upstream migrating whitebait prior to the whitebait season and “run of the river” operations commencing on 1 September each year. Early (and late) run whitebait do occur (McDowall & Eldon 1980 ) and will also be exposed to the effects of fluctuating flows and the risk of stranding prior to 1 September and after 14 November each year.
- 8.14. On the 7 December 2011 I had the opportunity to visit the lower Mokihinui River and walked a 100 m reach on the true left bank of the river downstream from Coal Creek. The river was turbid but clear enough to see to the bottom in the shallow edge water. As I walked the 100 m section of river edge I observed whitebait in the shallows less than 1 m from the river’s edge in water less than 10 cm deep (photograph below). I also observed a small number of common bullies in this edge water.



Whitebait (arrowed) in edge water habitat in the Mokihinui River

- 8.15. Strickland et al (2003) in their background comments on fish stranding state the following:

*Stranding is a problem mainly in streams and rivers where there are gently sloping shores or bars (Cushman, 1985; Hunter 1992). Bauersfeld (178a) and Beck Assoc. (1980) determined that stranding of juvenile salmon and steelhead (sea-run rainbow trout) occurred primarily on bars (e.g. riffles) with slopes less than 4-5 percent. Juvenile salmonids are more likely to become stranded over cobble and boulder, rather than finer substrates (Monk 1988).*

- 8.16. Below the proposed dam site, the Mokihinui River widens with meanders, multiple channels in places and a boulder-cobble bed (photographs below). This open river bed has extensive areas of shallow riffle and gentle sloping banks. In addition Dr Hicks (sections 6.14 a) and Dr Hudson's evidence note that the proposed dam will trap finer sediments, sand and gravel behind the dam. Consequently, the bed of the lower river will become progressively

dominated by cobble and boulder. This will then in my opinion increase the risk of stranding over time.



A multiple channel section of the lower Mokihinui River between Coal Creek and Burkes Creek confluences (photo Dr Henry Hudson).

- 8.17. Mr Jowett in section 6.27 of his evidence states that ramping rates are only required for public safety as the study in the Waitaki River found no stranding. As I have already shown the Waitaki River stranding study did find native fish stranded and the conditions in sections of the lower Mokihinui present a high risk of stranding due to river bed morphology. Therefore in my opinion Mr Jowett is not justified in ignoring fish stranding when assessing ramping rates and the current proposed ramping rates represent an unknown but potentially significant risk.
- 8.18. It is my conclusion that the risk of whitebait and bullies becoming stranded has not been assessed by the witness' appearing for Meridian Energy. The Waitaki River study indicates native fish do become stranded and my observations also found that mortality via predation can occur prior to death by stranding. The Mokihinui whitebait

investigations provide good data to indicate that there is a stranding risk for edge migrating whitebait and edge dwelling bullies. My personal observation supports the fact the whitebait use the edge habitat as do bullies. Furthermore, international studies indicate that the key aspects of river morphology that promote stranding are present in the lower Mokihinui River. Furthermore, the increasing proportion of coarse substrate will increase the risk of stranding over time. In addition the river ramping rates have been set without any consideration of fish stranding because Mr Jowett states there is no risk, a proposition I do not accept.

- 8.19. The next consideration with regard to stranding and flow fluctuations is the effect of flow fluctuation on native fish spawning. The adult kokopu and koaro have only been very rarely reported in the lower river and spawning for these species is unlikely to be affected by flow fluctuations in the lower river due to their rarity in this area.
- 8.20. However, all the witnesses for Meridian have ignored the effects of flow fluctuation on bullies and torrentfish spawning. Torrentfish spawning biology is unknown (as previously discussed) so the possible impact on torrentfish is unknown, but in my opinion this should be acknowledged. If the population of torrentfish from upstream of the proposed dam is lost due to inundation then production of torrentfish larvae in the Mokihinui River is reliant on the spawning habitat downstream of the dam and the effect of flow fluctuations on this spawning is unknown.
- 8.21. Recent investigations by Mr Manna Warburton (personal comment) at the University of Otago have found that torrentfish eggs are about 0.5 mm in diameter and

McDowall (1973) reports a diameter of up to 0.6 mm. I have previously conducted desiccation tests on inanga eggs that are 1 mm in diameter and once the humidity around the eggs drops below 100 % desiccation and death occurs rapidly. The rate is dependent on the humidity level with low humidity promoting rapid desiccation. For the smaller torrentfish eggs the risk of desiccation will be high for any nests laid in the varial zone. This risk cannot be quantified at present as the torrentfish spawning is not understood, but in my opinion the risk should be acknowledged.

- 8.22. For bully species it is known that redfin and common bullies spawn under rocks often near the river edge where water velocity is moderate. Male fish guard the nest. It is likely that bluegill bullies have a similar spawning strategy. Once spawned, the eggs cannot move and the male bullies will be reluctant to leave the nest sites they guard so both the fish and the nest are vulnerable to stranding or to being exposed to unsuitable habitat in deep water. Bullies that live and spawn at the river margins and in the riffles are in my opinion likely to be affected by the flow fluctuations and resulting changes in water level.
- 8.23. Mr Jowett (sections 6.9 – 6.26) of his evidence has indicated that while flow fluctuations will occur and habitat for fish may change in its distribution in the lower Mokihinui River there will be no impact on native fish. He justifies this by noting native fish can swim to new locations as the river flow fluctuates.
- 8.24. In my opinion Mr Jowett's assessment is simplistic and ignores behavioural and energetics issues that artificial flow fluctuations will impose on the fish community. In very simple terms if fish are to remain in preferred water depths and water velocities as the flow fluctuates the fish

are going to have to move. Moving imposes an energy cost on individual fish. For fish that have individual territories this movement then requires them to either stay in suboptimal territories or to move and re-establish new territories. To do this twice a day as flows rise and fall with electricity demand has the potential to be disruptive and increase the energy requirements of the fish.

- 8.25. Fish, particularly eels, that take refuge under cover during the day can find that the cover they selected during high flow periods becomes dewatered as the flow declines. The fish are then forced to make un-natural movements or risk death if stranded. In addition, small fish that are resting under cover that are forced to move are then exposed to additional predation pressure either from larger fish or birds.
- 8.26. Mr Jowett does note in his evidence that invertebrate communities will decline due to flow fluctuations and indicates this may reduce food for brown trout (section 6.16 of his evidence). However, he concludes that a reduction in food will not affect native fish and that brown trout can make up their invertebrate diet lost by eating native fish. Dr Death in his evidence (sections 6.11 -6.14) also states a reduction in invertebrates will occur and indicates that he expects the reduction to be greater than Mr Jowett.
- 8.27. Mr Jowett bases his conclusion that there will be no effect on native fish (Section 6.16 of his evidence in chief) on the research of Jowett et al. (1996). However, he does not present any data on the diet of native fish to support his conclusion. Jowett et al. (1996) studied the fish fauna of Red Jacks Creek in the Grey River catchment. The sampling sites in this study were situated between 26 and

41 km from the coast and at altitudes from 30 to 190 m. Therefore, all sample sites in this study are located further upstream and at higher altitude than the lower Mokihinui River. Jowett et al. (1996) comment in their discussion that inland distance and altitude are major factor controlling the abundance of diadromous fishes. In my opinion the comparison between the Red Jacks Creek sites and the lower Mokihinui River has to be treated with caution as fish abundance at Red Jacks Creek will be more limited by the altitude and distance inland than in the Mokihinui River. Therefore, we should expect stronger relationships between food availability and diadromous fish abundance at low altitudes where recruitment limitations do not occur.

- 8.28. In the second year of Jowett et al.'s (2011) study an assessment of the relationship between fish density to the Ash Free Dry Mass (AFDM) of invertebrates was conducted. This study found a significant positive relationship between ASFDM of invertebrates and the abundance of bluegill bully (and brown trout) indicating that the abundance of bluegill bully was at least correlated with the abundance of invertebrates.
- 8.29. Jowett et al (1996) caught only one torrentfish in the second year, indicating in my opinion either recruit limitation or a decline in abundance due to mortalities caused by the first year's electric fishing. Common bully and inanga, other species common in the lower Mokihinui River, were not found at their study sites. Therefore, for these three species, in my opinion, the study of Jowett et al. (1996) does not provide any useful data on the relationship between food abundance and fish density that can be applied to the Mokihinui River.

- 8.30. Diet studies of torrentfish and bullies in riverine habitats have found that the diet is composed of aquatic invertebrates (e.g., Sagar & Eldon 1983) such as *Deleatidium* mayfly nymphs and chironomids (larval dipterans). Mr Jowett's analysis of habitat loss shows a 20-30% decline in *Deleatidium* in the 16-46 cumecs range he assessed. Given the full range of the flow fluctuations is 16-126 cumecs I would expect a greater loss of *Deleatidium* habitat. In addition, Mr Jowett has not assessed the impact of the flow fluctuations on chironomids. Therefore, in my opinion Mr Jowett has not provided an assessment of the effects on invertebrate food items and his conclusion of no effect is based on a very limited and incomplete analysis.
- 8.31. In my opinion, any reduction of invertebrate abundance that impacts brown trout will also, affect native fish. The effect of flow fluctuations is to create a varial zone on the river margin that is variously wetted and dried as the flow fluctuates. It is common that this varial zone has few invertebrates as the wetting and drying regime is too hostile and the duration of the each wet phase is too short to allow recolonisation of the varial zone by aquatic invertebrates (Dr R Death evidence in chief). Mr Jowett proposes that native fish will move into the varial zone as the flow increases so they can maintain their position in their preferred physical habitat. However, as the fish move out into the varial zone they move into areas with little if any invertebrate food. Therefore, feeding is disrupted as there is no invertebrate prey present in the varial zone.
- 8.32. The energetic cost and behavioural changes that are necessary if fish move in order to remain in their preferred range of water depth and velocity present individual fish with foraging and habitat selection choices. If fish stay in

the permanent wetted zones of the river invertebrate food will be available. However, this will require fish that prefer shallow water habitat to instead occupy deeper water when the power station is operating. The fish may also make compromise habitat selections staying in deeper water as flows increase until water velocities exceed the velocities the fish are capable of feeding in. At this point they progressively move to shallow water trading off feeding opportunities against energy expenditure and declining foraging success. This foraging trade off is often termed optimal foraging – animals will seek to maximise their energy gain while minimising their energy expenditure. However, in the Mokihinui with fluctuating flows this strategy breaks down because invertebrate food is scarce in the varial zone where preferred habitat for shallow water fish is located. Habitat selection is then the result of a balance between feeding opportunity and physical ability of fish. When Mr Jowett uses habitat preference curves developed from fish surveys in stable rivers for his RHYHABSIM analysis (i.e. those without hydro electric flow fluctuations) he is using data from fish that are not forced to make these daily choices in foraging strategy. In my opinion these differing foraging strategies will enforce different habitat preferences and the habitat preference curves used by Mr Jowett are not valid for use in a fluctuating flow situation. Furthermore, in the Mokihinui habitat preference will vary with flows in response to this trade off between feeding opportunity and physical ability. I would also note that Dr Leathwick in his evidence addresses this issue from the modelling perspective and we share the same concerns about the RHYHABSIM modelling and preference curves used.

- 8.33. Mr Jowett in section 6.23 of his evidence in chief states that cover for native fish will be present in the river

amongst cobble/boulder habitat. I agree that this cobble boulder substrate will be present and as Dr Hicks notes this substrate will actually increase in abundance as fine sediments are removed from the lower river. However, as the references in Strickland et al (2003) note cobble-boulder substrates promote stranding. In my opinion that is because small fish take refuge amongst the large substrate particles and may remain there as flows drop until they cannot escape from small pockets of water back to the river channel and have become stranded.

- 8.34. In conclusion it is my opinion that the fluctuating flows downstream of the proposed dam present a significant risk to native fish. The upstream migrating whitebait, edge dwelling bully species are vulnerable to stranding, and there is an unknown, but possibly significant risk, to native fish spawning in the lower river as a result of the proposed flow fluctuations. The fluctuating flows will have energetic costs for resident fish and will reduce the feeding opportunities for native fish. The fluctuating flows will also lead to changes in habitat preferences. If, as Mr Jowett suggests, brown trout will feed move heavily on native fish to compensate for a decline in their invertebrate resource this represent an additional source of mortality. In addition, the enforced movements native fish will have to undertake to remain in their preferred habitats will expose them to additional predation pressure as they cannot remain under cover as flows drop or they will be stranded.
- 8.35. All of the witness' appearing for Meridian Energy have failed to consider the impact of gas supersaturation and gas bubble disease (GBD) (or trauma) occurring in aquatic organisms downstream of the proposed dam. Gas supersaturation arises from a variety of man-made (e.g., spillway flows at dams) and natural sources (e.g.,

waterfalls). Gas supersaturation occurs when water and atmospheric gasses (oxygen, nitrogen etc) are forced together under pressure (Schisler & Bergersen 1999). Fish and other aquatic organisms when respiring breathe in supersaturated gas that is absorbed into the blood. Subsequent degassing occurs in the fish as the supersaturated gas leaves the blood and forms gas bubbles in blood stream and tissues of the fish. Gas bubble disease is equivalent to the “bends” in human divers and causes minor tissue damage through to death depending on the exposure to supersaturated gasses, the sensitivity of the fish, and fish behaviour. The most severe effects of gas supersaturation and gas bubble disease are found when fish absorb supersaturated gasses in deep water, and then rise to the surface or when supersaturated water rises to the surface and is absorbed by surface dwelling fish.

- 8.36. At hydro-electric dam sites two activities can give rise to gas supersaturation. Zhong & Power (2012) note that atmospheric gasses can be forced in solution with water during passage through the turbines especially when turbines are operating at low load levels. A second more commonly recognised phenomena is gas supersaturation as a result of spillway discharges. During spillway discharges, water falling from the top of dam entrains gasses and the mix of water and gas plunges into the plunge-pool below the dam. Gasses entrained in the spillway water are then forced into solution as the hydrostatic pressure in water increases with depth and more gas can be held in solution in deep water. As water rises from the depths of the plunge pool gasses in solution leave the solution (degas), but over a much slower time period than it takes water to rise to the surface. Therefore the water becomes supersaturated with atmospheric gasses. The risk of the occurrence of gas supersaturation is

especially high if a plunge pool exists at the dam and downstream of the dam the river becomes wider and shallow. This is exactly the scenario for the Mokihinui River (see Figure 4 of Mr Watts evidence reproduced below).



Figure 4 – Schematic diagram of proposed dam and associated facilities

- 8.37. Gas supersaturation can be avoided at dams if energy dissipation structures at the foot of the dam break up the spillway flow or flow deflectors spread the spillway flow over a wide area. A flip bucket will achieve this, but I note in Dr Jellyman's evidence (section 7.18) the flip bucket at the Mokihinui dam will only operate on declining flows from  $1200 \text{ m}^3/\text{s}$  to  $150 \text{ m}^3/\text{s}$ . Mr Henderson states in his evidence (section 7.8) that the dam is expected to spill water approximately 35% of the time. Mr Henderson notes in section 7.10 that the volume of water spilled is often small, at less than  $0.5 \text{ m}^3/\text{s}$ . From my literature search I would not expect these low flows to create a noticeable gas supersaturation effect. However, Mr Henderson notes that on average years and wet years the high flows (greater than  $16 \text{ m}^3/\text{s}$ ) occur between 10% and 18% of the time. These

flows have greater potential to create gas supersaturation conditions.

- 8.38. The effects on fish are most acute for fish resident in water less than 1 m deep (Weikamp 2008). This is a critical consideration with respect to the Mokihinui River and the habitat use by bullies, torrentfish and whitebait. Jowett & Richardson (1995) showed that bully species, torrentfish and eels are resident most frequently in shallow water less than 0.5 m deep. Mr Jowett (sections 5.7 to 5.10) of his evidence confirms these shallow water preferences. Bonnett & Crow (2011) have also demonstrated that whitebait prefer to migrate in the shallow edge water. Therefore, in my opinion at times when the spill or hydro electric operations supersaturate the water with atmospheric gasses there is a risk of gas bubble disease occurring in the majority of native fish species in lower Mokihinui River.
- 8.39. Conversely fish such as adult eels when residing at the bottom of deep pools are very unlikely to be exposed to supersaturated gasses or suffer gas bubble disease.
- 8.40. Weitamp (2008) has reviewed the effect of gas bubble disease in fish (and invertebrates) and summarised the observations and experimental studies. Injuries observed include burst swim bladders, deformities were growth occurs around gas bubbles, gas bubbles in the eyes, jaws and mouth, eye popping, loss of buoyancy control and mortality. Recovery is possible and fish exposed to supersaturated gasses and gas bubble disease can continue to grow and behave normally after exposure. The experimental and in river studies found that symptoms were most severe when fish were present in shallow water and when gas supersaturation levels were over 120% total

dissolved gas (100% in the normal saturation level and in equilibrium with the atmosphere).

- 8.41. For whitebait and bullies in shallow water I would expect incidents of gas bubble disease to cause additional effects. Any of these small fishes when distressed by the gas bubble disease is more likely to be vulnerable to predators. For instance a loss of buoyancy control when gas bubbles form will prevent bullies and whitebait taking refuge in the substrate to avoid predators such as brown trout.
- 8.42. In summary, the assessment of effects has not considered gas bubble disease. The Mokihinui Dam will at times have the potential to create the precursor conditions, gas supersaturation. The frequency of flood events will control the frequency of gas supersaturation events which on average may occur 10% of the time. Gas bubble disease disproportionately affects shallow water dwelling fish and this includes the majority of native fish in the Mokihinui River.
- 8.43. A final factor given limited attention in the assessment of downstream effects is the discharge of deoxygenated water from the dam. This could occur as noted by Dr James (Evidence in Chief section 6.14) and Dr Schallenberg when deoxygenated water from the depths of the Mokihinui reservoir is brought to the surface. This occurs when thermal stratification breaks down at the end of summer or when strong winds create seiches in the stratified reservoir. Such events are reported to occur in the Patea Dam with discharges of deoxygenated water released downstream into the lower Patea River. Events that force deep deoxygenated water upwards to the height of penstock intakes will lead to the release of deoxygenated water downstream. I note mitigation for such an event is

proposed in the evidence of (Dr James 6.14, AEMP) but for this to be effective the release of deoxygenated water has to be detected so that mitigation can commence. There will inevitably be adverse effects on the fish (and invertebrates) downstream of the dam.

- 8.44. Therefore, in conclusion I do not agree with the statement in the AEMP (page 18) that:

*The proposed flow regime of the scheme will have little or no effect on native fish habitat or their invertebrate food production in the lower river.*

Nor do I agree Mr Bonnett, Dr Jellyman, Mr Jowett and Dr James that the effects on native fish in the lower Mokihinui River will be minor, or will be mitigated. In my opinion their assessments of effects for the lower river have not considered all the potential impacts nor have they considered the implications of their own studies and other studies such as Dr Hicks' in their assessments. In my opinion significant effects will occur leading to a decline in the abundance of native fish downstream of the Mokihinui Dam and a reduction in the abundance of migratory fish reaching the dam.

## **9. THE EFFECTS OF THE PROPOSED DAM ON UPSTREAM FISH MIGRATION**

- 9.1. In Table 1 I outlined the native fish species that will have the upstream range of their distribution truncated by the proposed dam. The other significant effect as acknowledged by Mr Bonnett and Dr Jellyman is that the dam is a fish passage barrier. This barrier effect can be partially mitigated with the provision of structures that promote fish passage or the transfer of fish by manual or

mechanical means. However, as I set out below, in my opinion the impact on upstream fish passage cannot be fully mitigated.

- 9.2. Mr Bonnett in sections 12.2-12.6 of his evidence in chief very briefly outlines various methods that are used to provide fish passage at dams. His opinion is that for the small native fish present in the Mokihinui River there is only one option, a trap and transfer system to provide upstream fish passage. Dr Jellyman in sections 10.2-10.12 of his evidence discusses a trap and transfer programme for eels in more detail. A key omission, in my opinion, in the two statements is an assessment of the effectiveness of the proposed trap and transfer operation for all the native fish; koaro, shortjaw kokopu, common bully, redfin bully, torrentfish that are known to be at the dam site and upstream, and other species, bluegill bully, banded kokopu, inanga, lamprey and possibly giant kokopu that are also likely to migrate upstream at least to the dam and probably beyond.
- 9.3. Furthermore, an assessment of fish passage should, in my opinion, clearly state which species are targeted for transfer and which are not. For instance, the Patea Dam consents (Taranaki Regional Council consent 0489-2 condition 19) now list seven target species, lamprey, koaro, banded, shortjaw and giant kokopu and longfin and shortfin eel. This consent also specifies in condition 21 (vi) that measures must be undertaken to avoid the transfer of smelt (common smelt). These consent conditions are designed so that species that did occur upstream are transferred, but other species (common smelt) that may establish landlocked populations that are detrimental to the survival of the target species are excluded from the upstream reaches.

- 9.4. For the Mokihinui dam there has been no assessment of the target species or any assessment of species that may be detrimental to transfer. As such there is considerable uncertainty with regard to which species are subject to the proposed trap and transfer programme and which species should be excluded.
- 9.5. The evidence provided by Mr Bonnett and Dr Jellyman provides nothing in the way of assessment of the effectiveness of any upstream fish passage operation at the Mokihinui Dam or indeed at any other dam in New Zealand. This is due to the lack of research on fish passage facilities for the majority of native fish and secondly to the absence of any monitoring of the success or failure of fish passage at dams in New Zealand. The recommendations by Mr Bonnett and Dr Jellyman are therefore made without any reference to success rate of any type of fish passage operation. That is they cannot indicate what percentage of fish, of any species, are likely to be transferred upstream of the dam and what percentage will remain stranded below the dam.
- 9.6. Dr Jellyman in sections 10.2, 10.6-10.8 does note the numbers of elvers caught in other trap and transfer operations. However, key information regarding the success of other operations is lacking as monitoring only reports the numbers of elver (and other fish) transferred. There is no reporting of the delay to migration, the numbers of fish that do not successfully enter the trap and the additional mortality caused by delay and predation.
- 9.7. I have conducted a literature review of the studies assessing the effectiveness of fish passage facilities at sites around the world. The most recent relevant review by Noonan et al. (2011) reported the results of fish passage mitigation at

61 dams around the world. This review included only one trap and transfer operation as this method is rarely used overseas. This is in part due to the concentration of effort on salmonid fishes that are generally provided with fish ladders of some form. Noonan et al. (2011) report that 77% of fish passage operations for salmonid fish operate with some success, whereas only 50% of the operations for non-salmonids actually work. They conclude that this is due to the use of methods appropriate for salmonids for other fish species for which they are not appropriate and that limited effort has been applied to developing appropriate methods for non-salmonids.

- 9.8. Agostinho et al. (2002) discuss the development of fish passage requirements in Brazil. They note the fish passes became a legal requirement at dams in 1927 however assessments of the effectiveness of passage facilities (both upstream and downstream) has only recently (in 1990s) commenced. In the discussion Agostinho et al. (2002) note that many fish passage facilities have been constructed using designs for North American salmonids and these fish passage constructions are not appropriate for a broad range of South American fishes.
- 9.9. These studies reflect the New Zealand situation where considerable effort has been invested in the development of upstream passage methods for elvers, but very little for other native fish. It is, in my opinion, simplistic to assume a one stop shop approach will work at the Mokihinui Dam. Therefore, in my opinion, it cannot be stated with confidence that a trap and transfer operation will provide passage for all native fish species.
- 9.10. For the benefit of the Court I have set out below factors that are considered to cause mortality or disruption to fish

during the provision of fish passage or fish traps at dams. In my opinion it is important that all these factors are considered when the assessment of potential methods is being conducted and their likely success and passage related mortalities are considered. This has not yet been done for the Mokihinui dam. In fact it is highly likely that we have insufficient information for many of the native fish to be in a position to assess the various fish passage options.

- **Passage delay:** the additional time migrating fish are required to spend in the vicinity of the dam as they attempt to gain up or downstream passage. Delay can be caused by behavioural issues, an inability to locate the fish passage pathway provided or physical difficulty entering a fish passage pathway.
- **Attraction efficiency:** the likelihood that migrating fish are able to detect the fish passage pathway. For any method there is a likelihood that fish will fail to locate the entrance to the fish pass.
- **Entrance efficiency:** the percentage of fish that having detected the fish passage pathway will actually enter the fish pass.
- **Passage efficiency:** the percentage of fish that enter the pass and successfully negotiate the pass, or are successfully transferred.
- **Fallback:** the number of fish that enter an upstream fish passage pathway but drop back to the downstream end and are unable to negotiate the pass to the end or trap.

9.11. I have also read parts of the US Department of the Interior (Bureau of Reclamation) guide to small dam building particularly the fish passage requirements. The most

important factor noted, in my opinion, with respect to ecological considerations such as fish passage is that every dam is unique and requires site specific solutions to fish passage issues as the unique features of each dam site and dam design provide site specific issues. With respect to the Mokihinui Dam this is a critical consideration as the coastal location of this dam means many of the migratory native fish are present at this dam site. For the majority of major hydro-electric dams, such as Roxburgh, Waitaki, and Karapiro the number of species is fewer and/or only elvers are targeted for upstream transfer. Therefore, there is little knowledge to draw upon to design the fish passage facilities.

- 9.12. Furthermore, the Mokihnui dam presents some unusual design features that make fish passage mitigation more difficult than at dams I have visited. Firstly, there is no access to the dam face on the true right bank of the river. Here the dam is built against a steep rock face and at present there appears no way to build fish passage facilities on this bank. Secondly, the spillway flows are essentially uncontrolled and for both upstream and downstream passage there is very little ability to manage spillway flows to promote fish passage. Dams with multiple spillway gate systems can provide controlled spill flows of various sizes that can allow climbing fish to ascend or descend.
- 9.13. The study of Bonnett & Crow (2011) provides good evidence that a migration delay will occur for whitebait. The Southland sock nets were used during both night and day. Bonnett & Crow (2011) report the catches were much greater by day than by night. This accords with my personal experience with the whitebait fishery, the dyed whitebait releases we have conducted and McDowall & Eldon (1980) reports on the whitebait run being very much

a day-time phenomena and night-time movements are small if they occur.

- 9.14. Bonnett & Crow (2011) also report the results of the “closed circuit” fish passage trials where post whitebait individuals were tested on their ability to move up fish ramps. By far the majority of movement up the ramps was reported to occur by night. Therefore in my opinion Bonnett & Crow (2011) have demonstrated that migration delay exists for whitebait. They have shown that day-time moving whitebait will wait for night before moving up the fish ramp to a trap. As the migration occurs in November and December when daylight hours are longest this delay can be in the order of 15 hours or more.
- 9.15. I do not expect that a day-long delay in itself to be a cause of mortality. Rather, the presence of whitebait searching for passage and/or waiting until dark to move up a fish ramp does present predators such as trout, eels and birds an opportunity to prey upon the fish delayed and concentrated at the dam. The concentration of predators at dams is a frequently reported effect of dam that leads to increased mortality of migratory fish.
- 9.16. I have undertaken fish trap and transfer observations at the Waihopai Dam for three years as part of the consent monitoring requirements. The Waihopai Dam is on the Waihopai River, a tributary of the Wairau River in Marlborough. Colleagues and I from Golder undertook night-time spotlight surveys of the fish ascending the attractant flow path to the trap and also assessed fish climbing the spillway (photo to determine the proportion of the elvers moving upstream via the trap verses the spillway (photos below) .



Waihopai Power station trap (blue box).



Waihopai Dam spillway with minor flood flow.

- 9.17. Summer rainfall is uncommon at the Waihopai Dam. However, one night in February 2008 we undertook the nightly monitoring during light rain. Runoff from the

powerhouse, and associated structures and natural runoff from the hillside around the powerstation lead to water flowing down to the river all around the powerhouse discharge point. On this night elvers were observed to be seeking passage up all damp faces, some moving up the attractant flow to the trap and others climbing the dam rock face anywhere small trickles of water came down. It was evident that many elvers were moving up flow paths that would lead them to be stranded and subsequently desiccated when the rain stopped. Brief observations around the trap the following morning found a number of stranded elvers but the majority I expect were stranded in the grass and other vegetation around the powerhouse. At the Waihopai Dam where summer rainfall is rare this effect of attraction to the wrong flows is also rare. However, at the Mokihinui dam rainfall will be much greater and the likelihood of the attraction efficiency being lower than hoped for or false attraction flows to divert the fish is, in my opinion, a significant concern.

- 9.18. The Waihopai HEPS also demonstrates a second attraction efficiency issue, a small residual flow comes over the dam spillway and down the natural river channel to join the tail race discharge at the powerhouse. During each night-time observation at the Waihopai Dam we undertook counts of elvers on the spillway. On each night elvers were present on the spillway. These fish are ones that therefore failed to find the attractant flow at the powerhouse and moved up the residual flow path instead. Therefore, in my opinion in the Mokihinui there is potential for an unknown percentage of fish (elvers, bullies, torrentfish and whitebait) to fail to detect the attractant flow to a trap at the powerhouse and instead to be attracted to flows from the turbine discharge or the spillway or any other flows entering the river in the vicinity of a dam.

- 9.19. The design of the Mokihinui Dam and configuration of the river channels below gives rise to a number of fish migration pathways and locations where they will congregate. I have used the diagram (Figure 4) provided by Mr Watts in his evidence in chief to describe these (see above). Following on from the results of Bonnett & Crow (2011) it can be expected that whitebait moving up the river will do so with the majority moving along either bank of the river and few in the centre of the river. The fish moving up the true left will move naturally up into the tail race and powerhouse area, however those moving up the true right will move into the plunge pool area. Once in the plunge pool area two possibilities exist: (1) the fish cross the river channel towards the tailrace and powerhouse or (2) they are attracted to the spillway. During low flow conditions the spillway will be dry and there will be no attractant flow towards the spillway. Whitebait will then have to search for flow cues that take them across the river channel. If the plunge pool acts as a backwater area this searching behaviour may require the fish to undertake unnatural downstream movements in order to locate the tailrace. To date, to my knowledge, no investigation of the rheotactic behaviour of the migrating whitebait has been undertaken. If whitebait behave in the same way as other upstream migrating fish such as salmon (that become entrained in powerstation tailraces), then downstream movements are extremely unlikely.
- 9.20. In the event that whitebait move into the plunge pool area during flows over  $150 \text{ m}^3/\text{s}$  then the spillway is likely to be flowing (if storage is unavailable) and an attractant flow will exist in the plunge pool leading fish to the spillway. Given my observations at the spillway at Waihopai Dam it is my opinion that both elvers and whitebait will attempt to climb the spillway. Whether the elvers and whitebait can

successfully climb the 80 m dam, I do not know, but it will require considerable energy expenditure and time. Changes in flow conditions during an ascent will also create difficulties and will lead to fish being swept down again or being stranded as flows increase or decrease over the spillway. Of critical concern is whether any fish ascending the spillway can successfully negotiate the crest of the dam. Here the water velocity will be high and the surface may be smoothed by the passage of water making it difficult for fish to maintain adhesion to the dam face. For bullies and torrentfish that succeed in reaching the dam face passage will be impossible because they will not be able to climb the spillway.

- 9.21. An additional factor we observed at the Waihopai Dam spillway was that only small elvers (around 10 cm or less in length) successfully ascended the spillway. Larger elvers failed to climb the spillway and this has been noted at other dams. Larger elvers struggle to climb long distances or negotiate irregularities that smaller fish can negotiate.
- 9.22. It is also possible that fish that begin to ascend the Mokihinui Dam spillway do so during a period of increasing flow. These fish will start the ascent in a gentle flow but find that as the flow and velocity on the spillway increases they are displaced from the spillway to fall back to the plunge pool. Alternatively fish that begin an ascent of the spillway on a declining flow could be stranded part way up as the flow drops below 150 m<sup>3</sup>/s. Therefore it is my opinion that the plunge pool area represents an area where fish will fail to locate the attractant flow, fish will be subject to additional migration delay, fish that attempt to climb the spillway are likely to suffer a significant level of fallback and additional mortality is likely due to the delay

and fallback as predators feed on the whitebait and elvers accumulating in the plunge pool.

- 9.23. It is also my opinion that on rainy nights the flow of rain water down the dam face will provide an attractant flow and fish will attempt to gain passage by ascending the dam face even when the river is below  $150 \text{ m}^3/\text{s}$  and no high flow spill is occurring. Attempts to climb the dam face during rainy nights will have additional risks associated with them. If the rainfall stops during the ascent fish, will be stranded on a drying surface. Larger fish that commence the ascent are likely to fail to complete the climb and increasing rainfall may flush the climbing fish off the dam face.
- 9.24. If fish successfully climb to the top of the dam, an additional migration issue is present. Fish that negotiate the crest of the dam will drop off the dam face into an 80 m deep lake and face potential predation by large resident fish.
- 9.25. I have one further concern regarding the dam design as shown in Mr Watts' Figure 4. The true left bank downstream of the powerhouse is shown as a smooth (concrete) channel. As the river channel in this area is also narrow and will be subject to flows up to  $150 \text{ m}^3/\text{s}$  I would expect the water velocity to be high. The narrow channel here provides little if any of the shallow edge water that Bonnett & Crow (2011) have shown whitebait to prefer to migrate in. It is possible that for the weak swimming whitebait (and other species) that the river channel itself becomes a velocity barrier (and behavioural barrier) to migration and fish do not even reach the powerhouse and any traps in place at the powerhouse.

- 9.26. In my opinion it is highly unlikely that the proposed trap and transfer operation at the Mokihinui Dam will be successful. The trap and transfer method has not been specifically designed for whitebait species, bullies and torrentfish. Therefore, with very limited design knowledge it is extremely unlikely that fish passage provision will be successful for all species. The complexities of the dam site with multiple flow paths and the potential effect of rainfall means the attraction of migrating fish to any trap location will be highly problematic. It is my expectation that fish communities above the dam will decline in abundance and their distribution will shrink as recruitment via the proposed trap and transfer process fails to sustain present diversity and abundance. I believe there is a significant risk associated with the proposal that the failure to provide fish passage short term can be countered by long term by adaptive management. There will be limitations imposed by the biology of the fish species and the physical structure of the dam that will limit the range of options available to adaptatively manage fish passage.
- 9.27. As noted above (section 34), all the native fish in the Mokihinui River are diadromous and therefore all undertake an upstream and downstream migration to complete their life cycle. For three species in the Mokihinui, koaro, common bully and common smelt, landlocking often occurs where the fish complete their migratory life cycle using a lake or reservoir instead of the ocean. Two other species, the banded kokopu, and giant kokopu can also landlock although this is far less common than for koaro and common bully.
- 9.28. In my current role on the Expert Panel for the Patea Dam consents, the issue of fish passage for native fish has been a key area of concern. One factor that was apparent is that

no trials had been conducted at the Patea Dam or any other dam elsewhere in New Zealand on the attraction efficiency, entrance efficiency, passage efficiency or fallback for elvers or indeed any other native fish. Catch rates are routinely reported but it is unknown what is not successfully trapped and transferred at any dam in New Zealand. Dr Jellyman correctly reports that trap and transfers move several million elvers a year but he makes no reference to the fish that do not obtain passage and in my opinion the success or not of trap and transfer operations is not fully understood. Of critical importance with respect to the proposed Mokihinui Dam is that fish passage could be required not just for elvers but for a range of whitebait species, bullies and torrentfish for which no previous fish passage operations have been specifically tasked. The success rate of transfer is unknown for all of these species.

9.29. Whitebait, bullies and other native fish have been reported in fish traps at dams such as Patea Dam (Martin et al. 2006) and in my personal experience the Waihopai Dam, in the Wairau River catchment. However, these fish are considered bycatch and had not been specifically targeted for transfer. In both cases there has been no research to determine the number of fish that fail to enter the traps or even fail to reach the dam due to the downstream effects of the dams.

9.30. For whitebait, bullies and torrentfish it is now necessary to consider the possible effects of any proposed fish passage mitigation. None of the witnesses for Meridian have presented any evidence that discusses the possible deleterious effects of the proposed trap and transfer programme and therefore, in my opinion, Meridian has

conducted a very limited assessment of the possible effects on upstream fish migration.

9.31. Mr Bonnett discusses upstream fish passage in sections 12.1 to 12.16 of his evidence in chief. Nowhere in this evidence does he explicitly state which species the proposed trap and transfer system provide passage for. Mr Bonnett's and Dr Jellyman's general evidence indicates that elvers and koaro are certainly target fish species for upstream trap and transfer and in sections 12.14, 12.15 EIC Mr Bonnett indicates that banded kokopu and shortjaw kokopu are also expected to use a trap and transfer system. It is not clear from either Dr Jellyman's evidence or Mr Bonnett's whether the other migratory species, common bully, redfin bully, torrentfish, and bluegill bully will be catered for in the trap and transfer system.

9.32. Mr Kyle's draft consent conditions are also limited with respect to fish species requiring fish passage. For the proposed pre-construction consent conditions condition 53 refers to the AEMP and outlines a requirement for research on potential methods for netting, box trapping and upstream transfer of juvenile galaxiids and eels. This limits investigation of potential upstream fish passage methods to a small suite of options. No mention is made of any requirement for bully species, lamprey or torrentfish to be included in this research, all of which will, in my opinion occur upstream of the dam site. Consent condition 123 refers to the implementation of measures to maintain passage for galaxiids, trout and eels, again with no mention of bullies, torrentfish and lamprey.

9.33. Mr Kyle's proposed consent conditions for the operational phase of the dam include condition 179 that states the consent holder shall maintain a trap and transfer system to

ensure upstream migration and survival of juvenile native fish (galaxiids, bullies and eels). This last consent condition has, in my opinion, two interesting aspects; first it has predetermined the outcome of research under condition 53 in that it requires a trap and transfer system to be implemented. Secondly once again torrentfish and lamprey are not provided for and bullies will have to use whatever system has been developed for galaxiids and eels.

- 9.34. I do accept that the draft consent condition will have some omissions and errors and also are subject to the Court's final decision so these proposed consent conditions do not have to apply. However, I would note that no witness from Meridian Energy has provided a clear account of the fish that require passage and which fish Meridian Energy actually intends to provide passage for.
- 9.35. The bullies and torrentfish, as noted by Mr Bonnett (Section 12.2c EIC) and Dr Jellyman (section 11.3e EIC) have lesser climbing abilities and the ramp structure will need to be of a low gradient for them. Furthermore, there is no understanding of the attractant flow requirements for these species or their tolerance to the stress of remaining in the holding tank. Lamprey also present difficulties as they are very much larger than all the other fish migrating upstream and will need facilities that cater for their larger body size.
- 9.36. There is no discussion by Meridian's witnesses about how the trap and transfer operation should be managed to cater for species for which the entire known upstream habitat will be inundated by the reservoir. Koaro, redfin bully and longfin eel can all be transferred upstream of the reservoir to streams with existing populations. Shortjaw kokopu could also be transferred upstream although only one

stream (some 30 km further upstream) is known habitat for this species upstream of the reservoir. The distribution of lamprey is so poorly understood it is not currently known if individuals occur above the proposed reservoir area and any transfer would proceed, or not, with that current lack of knowledge. Any other species collected in the trap and transferred upstream of the reservoir to the dam tributaries or to the Mokhinui Forks is being transferred upstream beyond its natural range.

9.37. In my opinion the transfer of shortfin eel, torrentfish, bluegill bully, common bully and possibly giant kokopu and banded kokopu will introduce all these species outside their natural range. There has been no consideration as to whether this is ecologically or environmentally appropriate and what effect this may have on upstream resident communities of fish and invertebrates (nor whether this is legally allowed<sup>2</sup>). The alternative is to ensure that none of these species are included in the upstream fish passage operation and the loss of habitat and subsequent decline in the abundance and distribution of these fish upstream of the dam is then an impact that cannot be avoided.

9.38. I have not considered common smelt as a fish that requires transfer at the dam and I am uncertain as to whether this species migrates upstream to the dam site. Mr Bonnett caught a single individual during his whitebait run assessment at the ecolodge site but the general occurrence and abundance of common smelt is unknown.

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<sup>2</sup> I am aware that Section 26ZM of the Conservation Act 1987 prohibits the transfer of live aquatic life or release of live aquatic life into fresh water other than with appropriate ministerial approvals, however, I do not comment further on this legal requirement.

- 9.39. This migratory species has been commonly introduced to lakes as forage food for trout (e.g., Lake Taupo) and readily establishes landlocked populations. The establishment of common smelt in lakes has been shown to have led to major declines in the abundance of landlocked koaro populations in the North Island (Rowe 1990, Rowe 1993). Common smelt are planktivores that will consume larval fish and if they establish in the Mokihinui reservoir downstream migrating larval fish will be subject to predation.
- 9.40. I am uncertain as to the likelihood that common smelt may reach the dam and in what numbers as the data is too sparse. However, I am certain the establishment of a landlocked population of common smelt in the reservoir has a high risk of significant impacts on other native fish. I would strongly recommend that (like Patea Dam) all measures are taken to ensure common smelt are NOT transferred upstream of the Mokihinui dam.

## **10. THE EFFECTS OF THE PROPOSED DAM ON DOWNSTREAM FISH MIGRATION**

- 10.1. In table 1 I outlined (1) the species currently confirmed present upstream of the dam, (2) those that are also most likely to occur upstream of the dam and (3) those that are unlikely to occur upstream of the proposed dam.
- 10.2. Mr Bonnett' evidence in chief sections 9.6 – 9.22 provides an assessment of the likely passage of larval koaro downstream through the reservoir and past the proposed dam. In more general terms he also discusses larval fish movement over the dam or through the turbines in sections 9.23 – 9.28. Finally in sections 9.27 -9.28 Mr Bonnett

mentions torrentfish, bluegill bully and common bully. Below I have addressed the downstream passage assessment and likely effects for each fish species currently present above the proposed dam site.

- 10.3. The downstream passage of larval koaro has been assessed by Mr Bonnett (sections 9.6 – 9.21) of his evidence in chief. He briefly describes the spawning behaviour of koaro based on the studies of Allibone & Caskey (2000) and O'Connor & Koehn (1998). There are however, reasons to take a precautionary approach to the analysis conducted by Mr Bonnett based on these studies.
- 10.4. The study reported in O'Connor & Koehn (1998) was conducted in Australia on the broad finned galaxiid. This is currently given the scientific name *Galaxias brevipinnis* after a revision of the galaxiid taxonomy by Dr Robert McDowall in 1970 (McDowall 1970) when he synonymised *G. weedoni*, and *G. parkeri* in Australia with *G. brevipinnis* (koaro) in New Zealand based on a morphological assessment.
- 10.5. However, the galaxiids in Australia and New Zealand have been subject to considerable research effort in the last twenty years with particular attention to their taxonomy and the relationship among species. The majority of these investigations are based on genetic studies and these have provided much insight into the species' relationships. A number of studies have demonstrated (e.g., Waters and Wallis 2001, Burridge et al. 2011) that the *G. brevipinnis* in New Zealand and Australia are genetically distinct at a level that would support them being separate species (e.g., Figure 2). In my opinion the reliance of the study of Koehn & O'Connor (1998) to describe the spawning biology of *G. brevipinnis* should be treated with some caution as the

taxonomic work of the 1970s has now been superceded by more recent studies that indicate *Galaxias brevipinnis* on either side of the Tasman Sea are in fact distinct and should be treated as separate species.

- 10.6. The assessment of Mr Bonnett also relies on my study on Mt Taranaki where we found a single koaro spawning site. This study has been taken by Mr Bonnett to indicate that koaro spawn on floods, however some real care needs to be taken when interpreting my finding. The photograph below shows the koaro spawning site we found and in the photograph the nest is present at the stream edge. The paper notes the eggs are still in a 1-2 mm layer of water. This spawning site is very different to the shortjaw and banded kokopu spawning sites myself and others found in following years (Charteris 2002, photographs below) which were 10-50 cm above the water level and certainly require floods for the fish to spawn at these locations. In comparison the scale of water level rise to allow the koaro to spawn while the fish are fully submerged (at the site we found) is less than 5 cm. Charteris (2002) found 16 galaxiids spawning sites in 2001 and all were kokopu nests in the flood zone. Given koaro were present in the reach with the kokopu, the lack of koaro spawning sites amongst the kokopu sites, and the presence of the koaro spawning site at the waters edge indicates koaro spawn differently to the two kokopu species present.



The koaro spawning site in Katikara Stream, immediately downstream of the large boulder in the centre of the photo.



A banded kokopu spawning site indicated by orange arrow, Katikara Stream



A shortjaw kokopu spawning site indicated by orange arrow, Katikara Stream

- 10.7. Charteris (2002) did however find that koaro larvae were only drifting downstream during flood events in the Mt Taranaki stream studied. This would indicate that while the nests are in the water, hatching may be triggered by floods and freshes although the size of the flood required to stimulate hatching is unknown. One factor of relevance on Mt Taranaki was the high rainfall, and frequent freshes in May,, so hatching could be associated with floods and freshes as they are very frequent. Therefore I would note that the paper of Allibone & Caskey (2000) describes a single spawning site of koaro and Charteris (2002) report hatching of koaro from the same stream on a single year. In my opinion this is a very limited pool of studies to base the assessment of spawning on.
- 10.8. Further data regarding koaro spawning and hatching behaviour has been reported that provides additional reasons for concern regarding our understanding of koaro

spawning. McDowall & Suren (1994) report the capture of koaro larvae in the Otira River in March 1994. These larvae were captured near Arthurs Pass during an invertebrate drift study. McDowall & Suren (1994) note the larvae are about 8 mm long, and conclude due to yolk sac size and the small size of the larvae that they were freshly hatched. The paper then notes that no freshes were likely to have occurred in the Otira River for the previous eight days and that if spawning had occurred on the river banks there was no way for the koaro larvae to hatch. Therefore, for the larvae to be freshly hatched the spawning site had to be in the Otira River and submerged during normal flows.

- 10.9. I have one further observation of fish spawning that is also relevant to the possible spawning habitat of koaro. In March 1988 I was collecting koaro from Maori River, Stewart Island. I was sampling in riffle habitat, rolling over rocks to collect fish that were swept downstream into a stop net. While working in one riffle in water about 20-30 cm deep I found of patch of fish eggs adhering to the underside of a boulder. The eggs were round, colourless eggs, with fish larvae apparent in the eggs. The only fish I was catching in the stream was koaro, and galaxiid eggs are round and colourless. Therefore, while I have never had the eggs identified, the characteristics of the eggs and the presence of only koaro in the stream would in my opinion indicate that koaro do, at least at times, spawn in the wetted channel of a stream.
- 10.10. A further final issue to consider is the timing of all the spawning observation that have been made for koaro. My observation on Stewart Island and McDowall & Suren (1995) both are from the month of March. Allibone & Caskey (2000) report koaro spawning in May and Charteris

reports larval hatching in May and June. The controls on spawning timing and egg hatching are uncertain and therefore in my opinion any assessment should consider the time frame for spawning to extend from February (to get larval fish in March in the Otira River) through to June for the end of larval fish hatching, a five month period.

- 10.11. Mr Bonnett in Sections 9.6 – 9.21 EIC has conducted his assessment of the spawning and hatching of koaro based on koaro only spawning on the river bank in floods during April and May. As stated above it is my opinion a period from February to June should be used for the spawning and hatching period. It should also be acknowledged that our current understanding of the spawning behaviour is based on very little knowledge and some of the data utilised by Mr Bonnett - the spawning of an Australian galaxiid - is from another species. In addition there is good reason to expect that koaro spawning is at the stream margin or in the stream itself rather than on the flooded margins. Therefore in my opinion the assessment of downstream transport is inappropriately limited to the flood flow periods and should include the transport of larvae on the full range of flows including low flow periods, not just floods as has been undertaken by the Meridian witnesses.
- 10.12. Mr Bonnett in sections 9.16 to 9.20 describes the work of Mr Charles Mitchell who attempted to rear koaro larvae for larval migration trials. Due to the inability to gain koaro eggs the larval trials were conducted with banded kokopu. I would note that koaro are thought to be common and abundant in the North Island and the failure to obtain a sample of mature koaro is surprising. For instance, while I worked at NIWA Hamilton I conducted a long-term life history project on koaro at Omanawa Stream a tributary of the Oparau River that Mr Mitchell's included in his search

for koaro. I would note that the population I studied at Omanawa Stream was composed of large relatively old individuals and I did not observe any juvenile recruits reaching the site in the four year study. Therefore, it could be speculated that the failure to collect koaro is due to their decline in recent years as reflected in their current DOC threat status of declining.

10.13. In general terms I accept Mr Bonnett's assessment that the eggs and larvae of the two species are similar especially when compared with the smaller inanga eggs. I do have reservations regarding the trial using banded kokopu. My reservation is that the yolk sac resources in the two species may be dissimilar. The bank spawning (see photo) banded kokopu will have to retain enough yolk sac reserves to allow for a period on the river bank awaiting a flood event and then transport downstream. Koaro spawning at the waters edge or in the water would have less risk associated with hatching and smaller yolk reserves could suffice if hatching time is more certain. However, yolk sac reserves are the important factor for sustaining the fish during the downstream drift period and duration of the drift to sea during low flow periods will be longer than during flood events.

10.14. Mr Bonnett in section 9.27 EIC comments briefly on the potential for torrentfish, either adults or larvae, to achieve passage downstream through the reservoir and over or through the dam. This assessment is restricted due to the very limited knowledge of the spawning behaviour of torrentfish and the complete lack of knowledge of the larval stage of the torrentfish. If adult fish are moving downstream to the lower reaches of the river to spawn below the dam, adult torrentfish have to survive passage through the turbines or over the spillway. To date the

mortality rate for torrentfish passing through or over high dams is unknown. Furthermore, if adult torrentfish move downstream then upstream fish passage facilities will be required for adult torrentfish to return to their upper river habitat.

- 10.15. Current PhD studies being undertaken by Manna Warburton at the University of Otago has found that torrentfish and bluegill bullies have very small eggs in the order of 0.5 mm in diameter. No larval torrentfish or bluegill bullies have ever been found but given the size of the eggs it is reasonable to assume that larvae will be in the order of 2-3 mm in length and they will have very limited yolk sac reserves. Nothing is known of the time taken for these eggs to develop and hatch. However, the small size of the eggs and yolk sac resources means that larval torrentfish and bluegill bullies will have short survival times before starvation occurs. There is also no evidence that these two species spawn during fresh or flood events and that larval transport occurs during floods.
- 10.16. Therefore, in my opinion downstream transport of these larval torrentfish and bluegill bullies through the lake is much more unlikely than koaro. Alternatively, if adult torrentfish migrate downstream to spawn then, in my opinion we can expect the dam to cause mortalities during the downstream passage to spawn and the upstream passage to return to adult habitat.
- 10.17. No assessment of the downstream fish passage possibilities for redfin bully are provided by Dr Jellyman or Mr Bonnett. This bully spawns under rocks in its stream habitat from late winter to early summer and the larval fish that are approximately 3-4 mm in length when first hatched (McDowall 1965) drift downstream to the sea. McDowall

(1965) conducted studies of the spawning behaviour of redfin bullies and makes no mention of spawning being linked to flood flows. As such it is most likely that larval redfin bullies drift downstream on all flows from early spring to mid –summer as batches of eggs hatch. For any redfin bullies spawning upstream of the reservoir, the larval bullies will have to drift through the reservoir. No assessment of this extension of migration time has been conducted, but given that redfin bully larvae are also smaller than galaxiid larvae, the yolk sac reserves are smaller and the time to starvation is likely to be shorter. In my opinion the effect of the reservoir will be to restrict or eliminate downstream movement by larval redfin bullies.

- 10.18. No assessment of the downstream passage for shortjaw kokopu, giant kokopu, banded kokopu or juvenile lamprey is provided by either Dr Jellyman or Mr Bonnett. The experimental data provided by Mr Mitchell would be appropriate to use for banded kokopu and most likely also for shortjaw and giant kokopu as the three species are most closely related. For lamprey, the downstream migration is so poorly understood that design of a fish passage pathway is not possible. Passage will rely on the survival of the lampreys as they pass through the turbines or over the spillway. As lamprey juveniles are significantly larger than the larval bullies and galaxiids the risk of mortality presented by either pathway is much greater.
- 10.19. Dr Jellyman notes that common bully may landlock in the reservoir and in that case downstream or upstream passage of common bully will not be required to maintain the population above the dam. I would accept this as possible although it should be acknowledged that any landlocked population will be restricted by the poor quality habitat in the reservoir where the steep sided nature of the gorge

provides very little shallow water habitat and this will be subject to water level variations according to electric generation demands.

- 10.20. Dr Shallenberg has identified a series of water quality issues that the proposed reservoir will present. The presence of a deoxygenated hypolimnion for approximately seven months of the year will restrict the fish present in the reservoir to the shallow epilimnion.
- 10.21. Dr Jellyman does provide an assessment of the downstream passage possibilities for longfin eel. This assessment in sections 10.13-10.21 of his evidence in chief represents the current state of our ability to provide downstream passage for adult eels. The key aspect of the downstream options is that passage methods are still being developed and in my opinion, there will be an increase in mortality and delays to eel migration.
- 10.22. I note that Dr Jellyman provides a series of potential methods for the downstream passage of eels but is also uncertain just what method or methods will be applied (section 10.21 of his evidence in chief) at the Mokihinui dam. Despite this he believes downstream passage will be achieved with no significant adverse effects. His evidence provides examples of methods used at other dams in New Zealand but provides no data on how successful these operations are and notes finally in section 10.18e that providing passage for downstream migrating eels is a problem that is still unresolved at hydro-electric dams worldwide.
- 10.23. It is worth noting that some of the downstream passage methods for eels described by Dr Jellyman cannot be used at the Mokihinui dam due to the dam design. In section 10.18c EIC Dr Jellyman describes the use of spillway

discharges at the Patea Dam (photos below) being used to provide fish passage. This is done by opening the spillway gates at the top of the dam, something that cannot be done at Mokihinui as there are no control gates on the dam.

- 10.24. At this point, for benefit of the Court, I have set out the potential impacts on fish that passage through hydro-electric turbines or over spillways can have. Fish passage through the penstocks and turbines subject fish to changes in water pressure and supersaturated gas levels (Becker et al. 2003). Physical damage will result from contact with the turbine blades and shear stress in the turbine chamber as the fish pass around the turbine blades can cause internal injuries. Passage over the spillway can lead to skin damage, that in turn leads to osmotic regulation difficulties (the flooding of the internal tissues with water), the liberation of toxic materials from injured tissues and infection by pathogens of abrasion sites (Hoar 1956). There are also effects related to the flow of water over the dam and spillway structures including rapid pressure changes, rapid decelerations, shearing effects, turbulence, and the striking force of fish on the water when free falling (Ruggles & Murray 1983). Ruggles & Murray (1983) in their review note the impact related injuries above increased with fish size and height of the fall. Finally, biotic interactions are also noted where predators accumulate either immediately upstream of dams preying upon fish that have delayed downstream passage as they seek passage through the dam or downstream of the dam where they feed on disorientated or injured fish.
- 10.25. The ranges of effects vary depending on fish size and species. Larval fish may pass through the turbines unharmed but can be vulnerable to predators in the reservoir upstream of the dam or immediately downstream of the dam if disorientated by the passage through the

turbine. Similarly, free falling larval fish are too small to achieve the high fall velocities that can injure fish. Conversely larger fish are less vulnerable to predators but are more likely to suffer injuries during passage through the turbines or over the spillway.

- 10.26. There is no mention in the Meridian witness evidence of eels passing over the dam crest during flood flows and falling to the plunge pool below. Dr Jellyman does not suggest the spillway is a pathway that eels may take. He restricts his discussion of potential downstream passage methods to methods that divert eels to bypasses or traps rather than passing over the spillway.
- 10.27. The spillway is a potential downstream pathway for eels, and represents a series of risks to them and these risks are not presented by any of Meridian's witnesses. These risks will vary with the flow over the dam at the time any eels pass over the crest.
- 10.28. Eels passing over the dam will be subject to abrasion when in contact with the concrete surface and shear stress due to differential accelerations on the body. Mr Watt's diagram of the dam indicates the dam face is inclined and therefore at low flows eels will slide down the face and hit the flip bucket. Alternatively, during higher flows eels may free fall from the dam crest or become entrained in the falling column of water. In these scenarios they have to survive the impact either on the dam face or the water below. In my opinion downstream passage over the spillway has to be prevented otherwise downstream migrant eels will suffer significant mortalities passing over the spillway. Any diversion methods proposed need to actually work as many behavioural avoidance methods such as lights and bubble screens are far less successful than hoped.



Patea Dam with spillway gates on the true left of the dam. Note also the plunge pool area below the spillway is downstream of the powerhouse and powerstation discharge. This configuration avoids entrainment of migrant fish in a plunge pool area as shown in Mr Watt's diagram of Mokihinui dam.



Patea Dam spillway.

- 10.29. Similar issues will be faced by all fish that pass over the spillway and the impact of the fall will vary among species and with the size of the fish. To my knowledge no-one in New Zealand has attempted to assess the effects of a fall comparable to the 80 m fall at the Mokihinui dam. Therefore, any assessment is necessarily speculative and relies on research conducted on fish other than New Zealand native fish.
- 10.30. In conclusion, in my opinion the success of downstream passage for all the native fish in the Mokihinui River upstream of the dam is uncertain. For eels our current knowledge is improving but passage is still problematic and significant mortality is likely unless passage over the spillway is prevented. For the other fish species there is so little knowledge of the spawning and larval fish ecology that we cannot even assess the likely effects of the delay in downstream movement and the likely mortality due to passage through or over the dam.

## **11. POTENTIAL COMBINED EFFECTS OF THE DAM AND PROPOSED FISH PASSAGE MITIGATION POTENTIAL**

- 11.1. As noted in section 149 of my evidence it is my opinion that the majority if not all the habitat used by torrentfish, redfin bully, common bully, bluegill bully and inanga upstream of the proposed dam site will be inundated. In addition giant kokopu, banded kokopu, shortjaw kokopu, lamprey and possibly shortfin eel have unknown distributions above the dam site but are likely to be subject to habitat loss.

- 11.2. The lack of detail with regard to the proposed trap and transfer operation provides some difficulty in assessing the biodiversity impacts of the proposal. However, if we assume that all species that are currently present upstream of the dam site are transferred above the dam and placed in tributaries or at the Mokihinui Forks then bluegill bully, redfin bully torrentfish, inanga and common bully will be placed upstream of their natural range in the Mokihinui catchment. Therefore, in my opinion the mitigation has an impact in terms of a modification to the biodiversity of the Mokihinui catchment. Currently as Dr Leathwick has demonstrated, the distribution of its native freshwater fish is in a natural state throughout the Mokihinui catchment. The placement of fish outside that natural range is a modification and in my opinion further degrades the river ecosystem. Unlike other proposals where the transfer of fish is considered appropriate as it seeks to maintain or restore the upstream ecology (e.g., Patea Dam trap and transfer objectives), in this case it is my opinion the transfer is an additional modification and would be an additional impact that degrades the natural aquatic environment of the catchment.
- 11.3. I also note that Mr Norton in his assessment of biodiversity impacts does not consider the introduction of fish outside their natural range in his assessment. In my opinion his assessment is only valid if fish passage is provided for koaro, longfin eel, redfin bully and shortjaw kokopu, the only species recorded upstream of the dam.
- 11.4. In addition to the biodiversity impact of the introduction of fish outside their natural range, there is a second issue that should be considered in conjunction with this. For torrentfish, redfin bully, inanga and bluegill bully there are no data to indicate that successful downstream passage of

the larval fish can be achieved. Therefore, upstream transfer has an environmental cost in terms of the out-of-range introduction of a species (to mitigate habitat loss). If no larval fish survive passage through the reservoir, then fish introduced upstream of the dam do not contribute to the recruitment of further generations of fish and populations (and the upper Mokihinui catchment) would become a “sink population” where fish go in but nothing comes out.

- 11.5. In my opinion there is no obvious way to mitigate the inundation of habitat by the Mokihinui reservoir on fish habitat and fish passage for (in decreasing order of impact) torrentfish, redfin bully, and bluegill bully. The inundation will cause habitat loss and the transfer of fish upstream of the reservoir will have a negative biodiversity impact. This impact has the potential to provide no benefit to the upper river ecosystem nor to the sustainability of these fish, all of which are threatened species. It is likely to create sink populations rather than sustain these species.
- 11.6. For banded kokopu, giant kokopu, shortjaw kokopu, inanga and shortfin eel the sparse distributional data means the occurrence of these species above the inundation zone is not known. Any trap and transfer operation has the same potential effects as the transfer of torrentfish and bullies and is likely to create further biodiversity impacts.
- 11.7. If any trap and transfer operation is designed to transfer only a selected suite of target species that occur naturally above the reservoir – koaro, longfin eel, and redfin bully, then a sorting method is required to remove the other unwanted species at the dam. The problem with such an approach is that the sorting of target species from other similar species is difficult and time consuming. In the case

of elvers and bullies it is possible with time and care to sort species. However, for the kokopu species and koaro this is more difficult and probably not possible. Any such sorting process is also likely to cause additional mortality due to stress and handling of the fish.

- 11.8. In conclusion, it is my opinion that the success of any artificial up and downstream fish passage programme is uncertain. A successful upstream passage programme for many species entails further biodiversity impacts in the upstream riverine environment. I expect that whatever course of action is taken regarding fish passage, there will be significant reductions in the abundance of torrentfish, redfin bullies and bluegill bullies. These are all listed threatened species.

## **12. PROPOSED CONSENT CONDITIONS**

- 12.1. Below I have provided some comments for the benefit of the Court on the proposed consent conditions provided by Mr Kyle. I have made these comments with the intent of providing consent conditions that might lead to a better understanding of the impacts of the Mokihinui Dam in the event that Court decides to consent the dam.
- 12.2. Condition 48 requires the formation of an independent expert panel to review work undertaken under the AEMP. I wonder whether there are sufficient independent experts left in New Zealand to meet the requirements of this condition. In my experience as an expert panel member on the Patea Dam I have found that local knowledge of the catchment and its history is important. It is also my experience that an expert panel of three members requires very broad knowledge of aquatic ecology to cover the

entire task as stated in 48b(i) to (iv). For the Mokihinui River the majority of experts, if not all, are currently engaged in this consent process. Valuable knowledge of the river is likely to be excluded and or will have to be learnt again if new independent experts are sought.

- 12.3. Condition 51 sets out pre-construction monitoring sites for native fish. During my fish surveys of Rough and Tumble Creek I noted that a natural fish passage barrier exists in the lower reaches of the stream about 500 m from the confluence with the Mokihinui River. Monitoring in this stream upstream of this point will only provide data on koaro and longfin eel and as such provide a limited and inadequate baseline data set. I recommend additional streams for monitoring are included with Welcome Creek, Anderson Flat Stream and Specimen Creek being priorities. It is important that the monitoring sites are spread throughout the reservoir area as the effects of the dam may initially appear in only one or two tributaries.
- 12.4. As I have noted above, the proposed consent conditions present a confused picture of the proposed upstream fish passage conditions. Different proposed conditions include different suites of fish species and some species are omitted entirely. In my opinion, all the consent condition that relate to fish passage should clearly state a list of target species and not general groups of fish. Any omission from the list of target species should be recognised and if not mitigated should be counted as an ecological cost of the scheme.
- 12.5. The consent conditions should in my opinion clearly state that no upstream transfer of common smelt is to be conducted and that there is a clear and achievable method

at fish passage facilities at the dam to ensure this consent condition is achieved.

- 12.6. The pre-construction consent requirements set out in condition 53 include a requirement that AEMP determine the effect of the dam on downstream migration of galaxiid larvae. This condition does not have any requirement for downstream larval fish assessment for the bully species or torrentfish nor for juvenile lamprey. If upstream transfer is to be provided then downstream transport is also required if transferred fish are to contribute to the reproductive output of their species.
- 12.7. I note Condition 53 (c) includes a requirement for *recommendation for mitigation including optimization of spillway design to facilitate fish passage .... for galaxiid populations*. I note again this condition is only directed at one group of native fish rather than all species. There are likely to be different requirements for different species and an optimization of the spillway for any one species can have detrimental effects on others. I recommend that spillway design is optimized to maximise downstream passage for all native fish species transferred upstream of the dam. Prior to accepting this condition I would also recommend that Meridian provide information on the ability to optimize the spillway. What features can be modified to what extent is important. Adaptive management or optimization of fish passage will have to be conducted within the design constraints of the dam. These design constraints are not apparent to me at this stage and could preclude meaningful optimization.
- 12.8. Consent condition 56 presents a series of conditions that propose the enhancement of inanga spawning habitat. At this stage no-one has located inanga spawning sites in the

Mokihinui River and any enhancement remains uncertain until habitat can be located. I expect that inanga will spawn at some sites although spawning sites may be localised, small and difficult to find. I would also note that consent conditions cannot require Meridian to undertake work on land belonging to other parties. Therefore if inanga spawn on private land the condition cannot necessarily be enforced.

- 12.9. Consent condition 56 also sets out that inanga spawning enhancement will be used to offset the effects of the scheme on galaxiid spawning. By this I take it to mean enhancement of inanga spawning (if possible) can be used to offset declines in kokopu and/or koaro spawning. I do not see this as suitable mitigation as any enhancement of inanga is as yet unknown and the increase of one species does not offset the decline in other species.
- 12.10. Condition 124 requires the placement of removable screens in front of the penstocks to exclude adult eels. I recommended the expert panel set the date range for the placement of this screen. I also note that given the majority of fish reaching the dam for downstream passage will be larval fish, unless a screen with a mesh size of 1 mm is used there will be no effective screening of larval fish.
- 12.11. Consent condition 178 requires the monitoring of juvenile galaxiid and juvenile eel populations above and below the dam. This condition makes no mention of monitoring bully species or torrentfish that are also impacted by the proposed dam. Furthermore, it only requires the assessment of juvenile fish. This is not assessing the full potential impacts of the dam as impacts may be apparent in the adult populations of all the native fish. This consent condition needs, in my opinion to include populations of

fish downstream of the dam and include adult and juvenile fish. It must include sites in the Mokihinui River below the dam so that the effects of fluctuating flows, fish stranding and water quality can be determined.

12.12. Consent condition 179 does not include a requirement for torrentfish transfer.

12.13. It is my opinion that for consent condition 180 to be complied with, the monitoring of native fish will be required in adjacent catchments to determine if any declines are regional or river specific. However, there is a risk in this approach as a decline in the abundance of native fish in the Mokihinui River may drive a regional decline as all the native fish (aside from eels) will draw their recruits from the same oceanic pool of larval fish off the west coast. I would also recommend that a statistical power test is undertaken with initial datasets to determine what level of sampling is required to detect what level of effect (i.e. how much fish monitoring would be required to prove statistically a 10%, 20% or 30% etc decline). It is common in ecological sampling that intensive monitoring at many sites is required to collect sufficient data to robustly test for significant differences. Even a 50% decline in abundance can be difficult to detect when the annual variation is high. Therefore, I would note detecting decline is difficult and attributing to a single cause or not is even more challenging. Linking the mitigation work in consent condition 181 to this condition requires in my opinion very stringent monitoring to ensure real trends are actually detected. Finally I would also note that the monitoring and analysis should include all native fish, not just an arbitrary subset.

- 12.14. Consent condition 181 only applies to galaxiids and eels and makes no mention of bullies and torrentfish. In my opinion the omission of three threatened species, redfin bully, bluegill bully and torrentfish is unsatisfactory. I have shown (Appendix 1) that these species are all of limited distribution and declining (Allibone et al 2010). This omission is significant because it allows the proposed scheme to impact further on these threatened species.
- 12.15. The consent conditions provide no requirement for the monitoring of fish stranding below the dam. In my opinion monitoring is required at a number of sites throughout the migration period of galaxiids, bullies, torrentfish and eels to determine the effect of the fluctuating flows. If stranding is found to occur an assessment of ramping rates should be required to determine if stranding can be reduced by lower ramping rates. The outcome of the assessment of ramping rates should then lead to a review of the consent conditions that authorise ramping rates.
- 12.16. Monitoring in the lower river should also be conducted for water quality effects including dissolved oxygen levels and the total gas saturation percentage. In the event that supersaturation events are detected, monitoring of the fish populations downstream of the dam should commence to investigate the whether GDB is present in the fish. In the event that GBD is detected, mortality and chronic effects should be assessed for all fish species affected along with the frequency of the occurrence of GDB and distance downstream symptoms are observed.
- 12.17. In line with Dr Shallenberg's concerns regarding the discharge of water with toxic sulphides monitoring of the power station discharge for sulphides is required in addition to the monitoring proposed in conditions 155. In

the event that toxic discharges are detected then investigations of the effect on downstream communities should be instigated as rapidly as possible.

- 12.18. In the event that stranding, GDB or toxic water discharges cause mortality in the downstream fish populations I would recommend a consent condition that then requires mitigation to offset the effects and seeks methods to reduce or prevent further occurrences of these effects.
- 12.19. The consent conditions are silent with regard to the whitebait fishery in the lower Mokihinui River. In my opinion monitoring of the fishery is required with pre-construction monitoring designed to link catch rates to river turbidity. Monitoring once the dam becomes operation will seek to determine if any change in river turbidity and wave action in the lagoon over time results in increased whitebait catches or changes to the fishability of the lagoon, and seek to maintain a sustainable whitebait fishery. The monitoring can also assess the proportion of each whitebait species in the run to determine if the proportions of individual species vary over time. This monitoring can be linked the galaxiid population monitoring at the dam and at adult fish sites to see if any declines in adult fish are followed by declines in the whitebait run of particular species.
- 12.20. In summary, in my opinion the proposed consent conditions are incomplete and fail to encompass the monitoring of a number of potential effects. The fish passage requirements are limited and fail to address all the species for which the dam will present a fish passage barrier. Monitoring of the effects downstream of the dam on fish and fisheries is a key requirement missing from the consent conditions and is in my opinion required. In my opinion even with the fish passage mitigation proposed, the

full effects of the dam on native fish are significant, unavoidable and will lead to significant declines in native fish in the Mokihinui catchment.

### **13. MITIGATION**

13.1. The Meridian witnesses provide no mitigation proposals for the effects on native fish aside from fish passage. Fish passage, in my opinion, has yet to be proven and it carries significant risk especially with the:

- potential failure to attract fish to the traps
- to the downstream passage of larval fish through the reservoir, and
- passage of adult eels over the spillway.

13.2. There is no mitigation and very limited acknowledgement of the loss of habitat due to the inundation of the river and creation of the reservoir. There is no mitigation for the impacts on the lower river as all the Meridian witness' claim there will be no effects. As I have explained above, in my opinion, effects in the lower river are to be expected and with no mitigation, these effects are currently an ecological cost of the proposed scheme.

13.3. I would also reiterate that for torrentfish, in particular, as upstream transfer at the dam is not proposed and the majority of its downstream habitat will be impacted by the dam and its operations this unique, distinctive endemic threatened species, stands to lose the most as none of the impacts on it are considered, and none are mitigated.

- 13.4. In my opinion the proposed mitigation for galaxiids using inanga spawning enhancement is also of limited value and will not address the effects of decline suffered by other galaxiids.

## **14. CONCLUSIONS**

- 14.1. The Mokihinui River supports a diverse range of native fish including nine threatened fish species.
- 14.2. In the local region, the Mokihinui River supports more species and provides more habitat for native freshwater fish than neighbouring river systems. It is not impacted by human induced effects apart from invasive species.
- 14.3. The Mokihinui whitebait fishery is a significant fishery that catches between 2 and 10 tonnes of whitebait a year and a catch rate of 30-40% of the whitebait run. However, this fishery may be in decline and unsustainable if fishing pressure increases.
- 14.4. The Mokihinui whitebait fishery is based on scoop fishing and visual clarity of the water is a key factor in fishing success. Changes to water turbidity and wave action in the lagoon as a result of the dam are likely to increase fishing success in the upper lagoon, but reduce fishing success in the lower lagoon.
- 14.5. Fluctuating flows by hydro electric operations at the Mokihinui dam will cause stranding, enforce behavioural changes on fish, reduce food available for native fish and subject the native fish to increased predation pressure from brown trout.

- 14.6. Additional effects downstream of the Mokihinui dam include gas bubble disease and the effects of deoxygenated water and toxic water discharges from the reservoir.
- 14.7. Upstream fish passage will be prevented by the dam. The proposed trap and transfer system is untried for the majority of native fish. The impediment to fish passage will subject the fish to migration delays, additional predation, and additional energy expenditure. No research has been conducted on native fish in New Zealand to determine the effectiveness of the trap and transfer fish passage operations and effectiveness of the proposed trap and transfer system is unknown. It is my expectation that fish communities above the dam will decline in abundance and their distribution will shrink as recruitment via the proposed trap and transfer process fails to sustain present diversity and abundance.
- 14.8. Upstream fish transfer to the upper Mokihinui River and tributaries of torrentfish, redfin bully and other species that normally only penetrate to the lower reaches of the Mokihinui Gorge creates an additional set of ecological impacts.
- 14.9. The distribution of common smelt is poorly understood and therefore the potential for this species to reach the dam is uncertain. However, any transfer of this fish upstream of the dam should be avoided to ensure a landlocked stock does not establish in the reservoir.
- 14.10. Downstream fish passage is problematic for all the native fish species and especially so for larval fish. There are no data to demonstrate downstream passage will be successful for any species. I do expect a proportion of the longfin eels can be transferred but the proportion successfully transferred is uncertain.

- 14.11. The mitigation proposed for adverse effects on freshwater fishes of the Mokihinui is grossly insufficient and some aspects are inappropriate.

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## TABLES

Table 1. Native fish distributions in the Mokihinui River with respect to the proposed dam site.

<b>Common name</b>	<b>Downstream of dam</b>	<b>Upstream of dam</b>	<b>Capable of entering Mokihinui Gorge</b>	<b>Existing habitat remaining after inundation</b>	<b>Capable of utilising trap and transfer system</b>
Shortfin eel	Y		Y	n/a	Y
Longfin eel	Y	Y	Y	Y	Y
Koaro	Y	Y	Y	Y	Y
Banded kokopu	Y		Y	Unknown	Y
Shortjaw kokopu	Y	Y	Y	Y	Y
Giant kokopu	Y		Y	Unknown	Expected
Inanga	Y		Y	N	N
Common bully	Y	Y	Y	N	N
Bluegill bully	Y		Y	N	N
Redfin bully	Y	Y	Y	Y	Possibly
Torrentfish	Y	Y	Y	N	N
Lamprey	Y		Y	Unknown	
Common smelt	Y		Y	N	

Table 2. Dyed whitebait release results for the mark recapture studies on the Mokihinui River, September to November 2010.

<b>Date of release</b>	<b>Colour</b>	<b>Number released</b>	<b>Recapture rate N and %</b>
14 Sept	Brown	96	20, 20.8%
15 Sept	Red	220	7, 3.1%
5 Oct	Brown	399	123, 30.8%
6 Oct	Red	401	39, 9.7%
2 Nov	Brown	300	122, 40.7%
3 Nov	Red	305	32, 10.5%

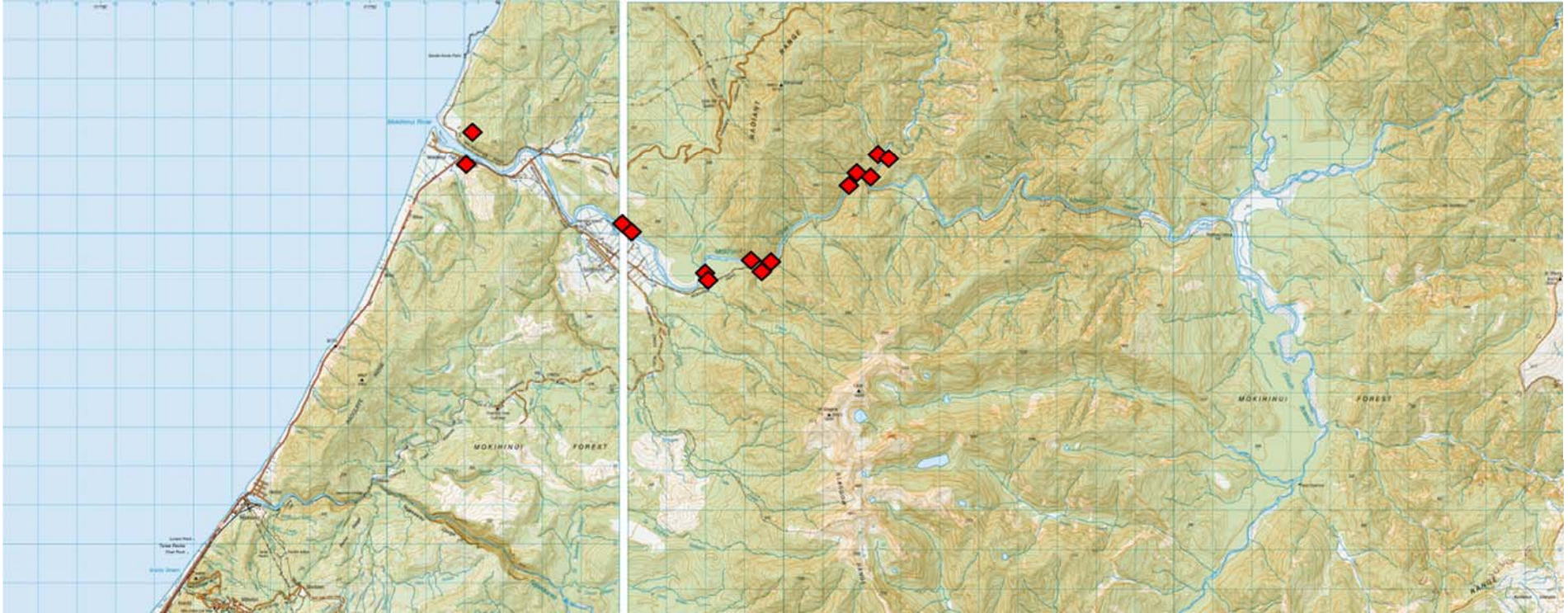
**FIGURES**

Figure 1. Fish sampling sites that I visited in September 2010, October 2010, November 2010, March 2011, November 2011.

## SPECIATION AND LOSS OF DIADROMY IN FISHES

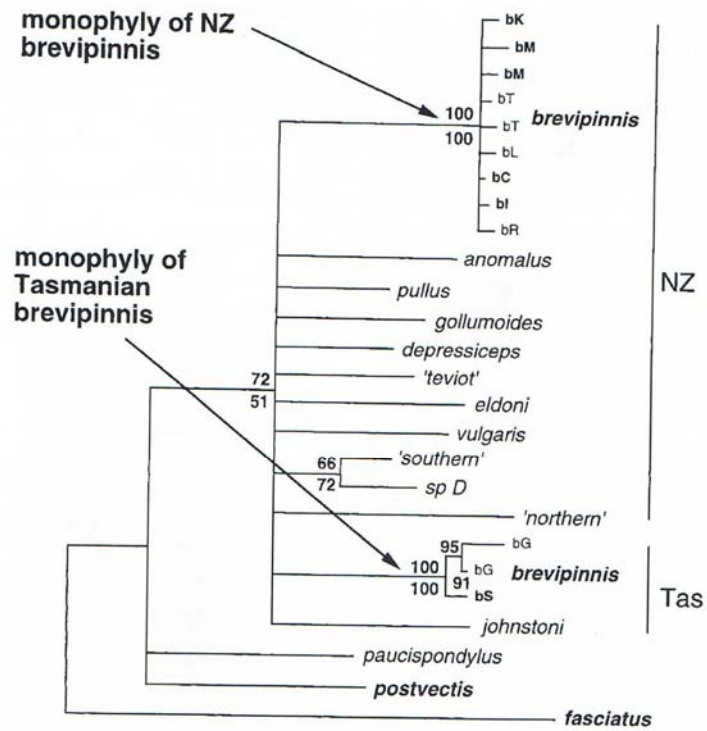


Figure 2. Analysis of relationship among some galaxiid species in New Zealand and Australia showing the distinction between *G. brevipinnis* in Australia and New Zealand (from Waters & Wallis 2001).

## **APPENDIX 1**

### **Native fresh water fish of the Mokihinui River**

The distribution maps utilise data downloaded from the New Zealand Freshwater Fish database 8 May 2012.

The total number of records available for the period from 1 January 2000 was 15909. The database has a total of 31619 records as of the 8 May 2012.

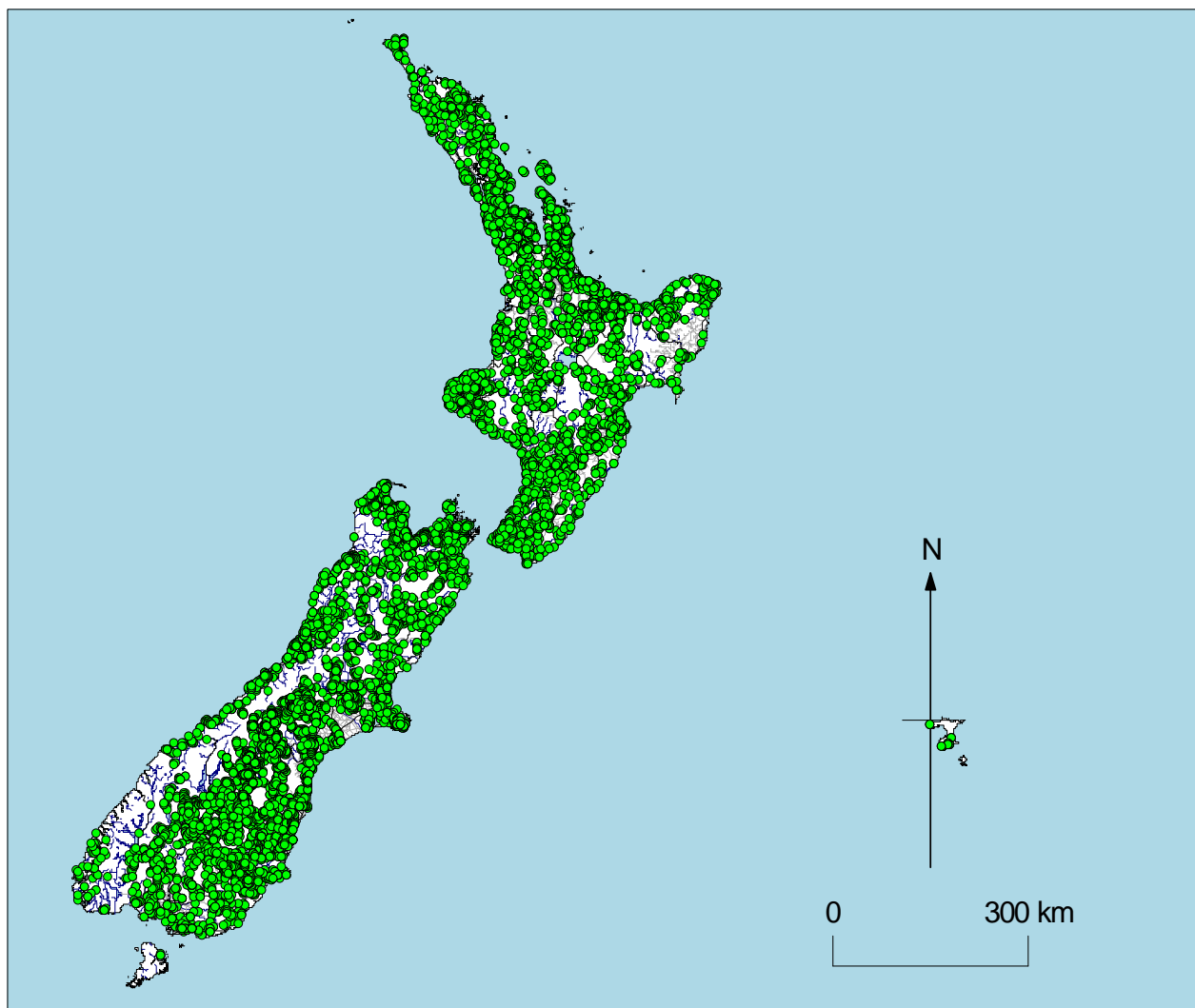


Figure 1 NZFFD record locations for all fishing records since 1 January 2000.

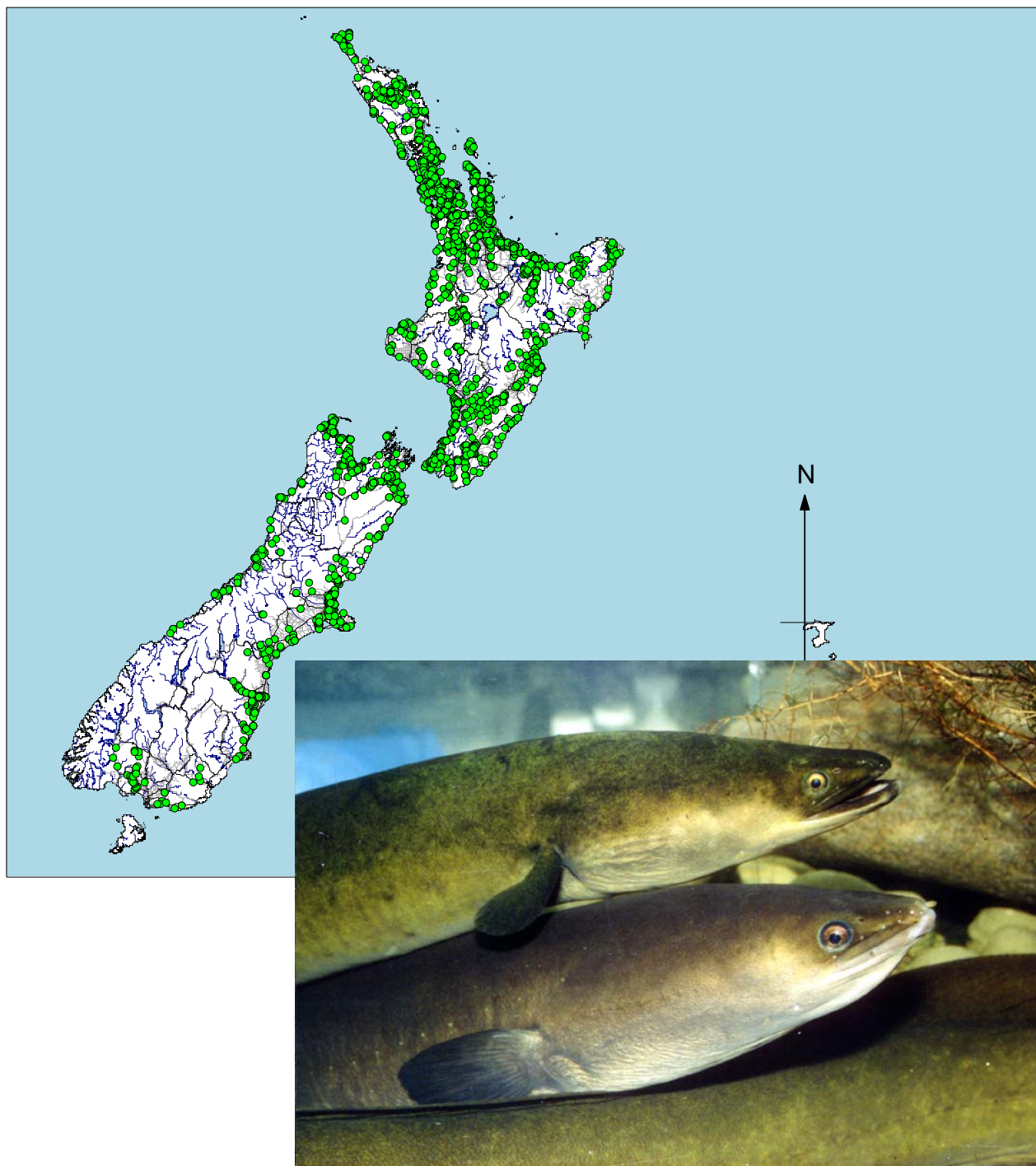


Figure 2. Shortfin eel (*Anguilla australis*), NZFFD records from 2000 onwards (N =3194).



Figure 3. Longfin eel (*Anguilla dieffenbachii*), NZFFD records from 2000 onwards (N =4805).

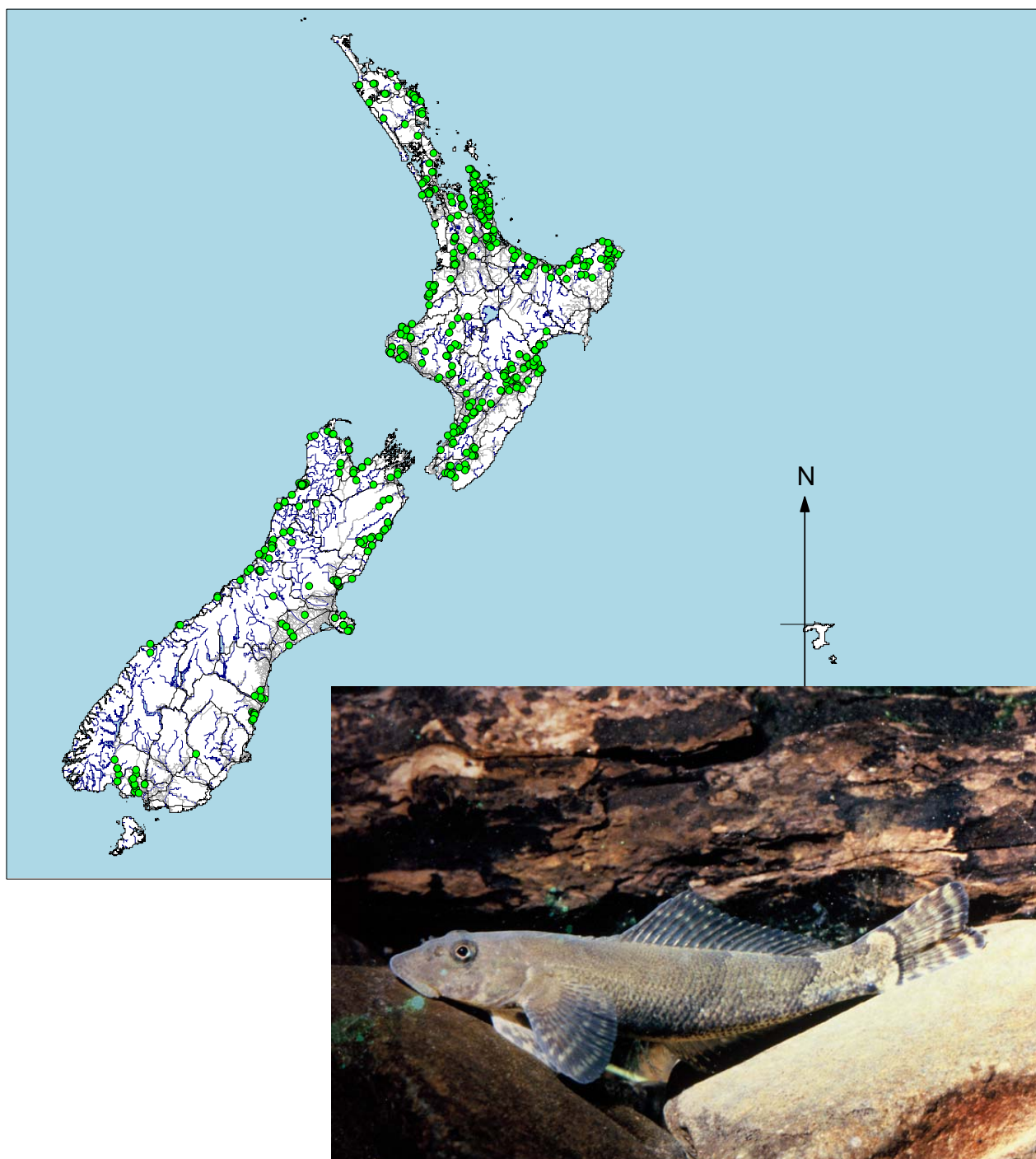


Figure 4. Torrentfish (*Chiemarrichtys fosteri*), NZFFD records from 2000 onwards (N =677).

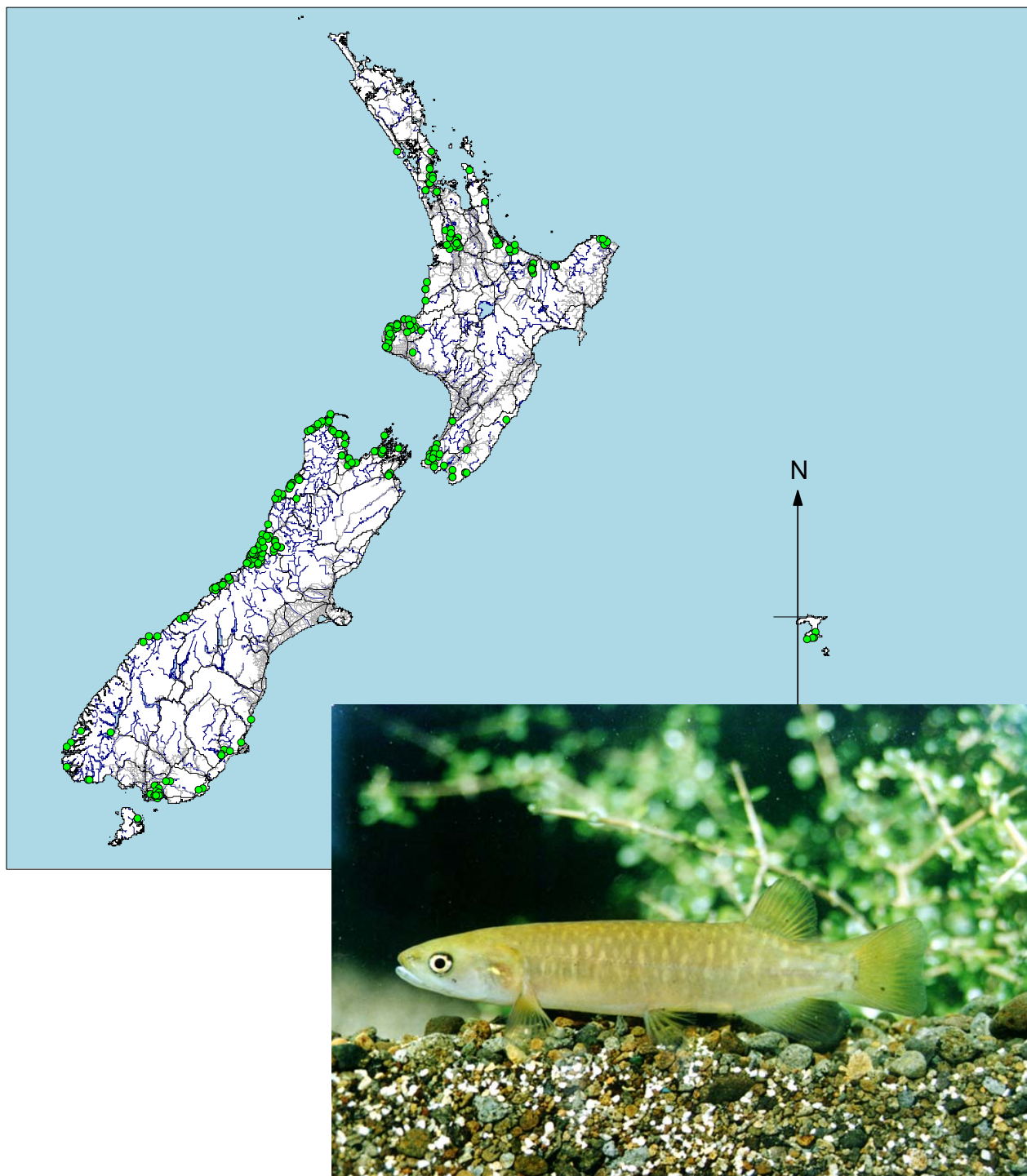


Figure 5. Giant kokopu (*Galaxias argenteus*), NZFFD records from 2000 onwards (N =365).

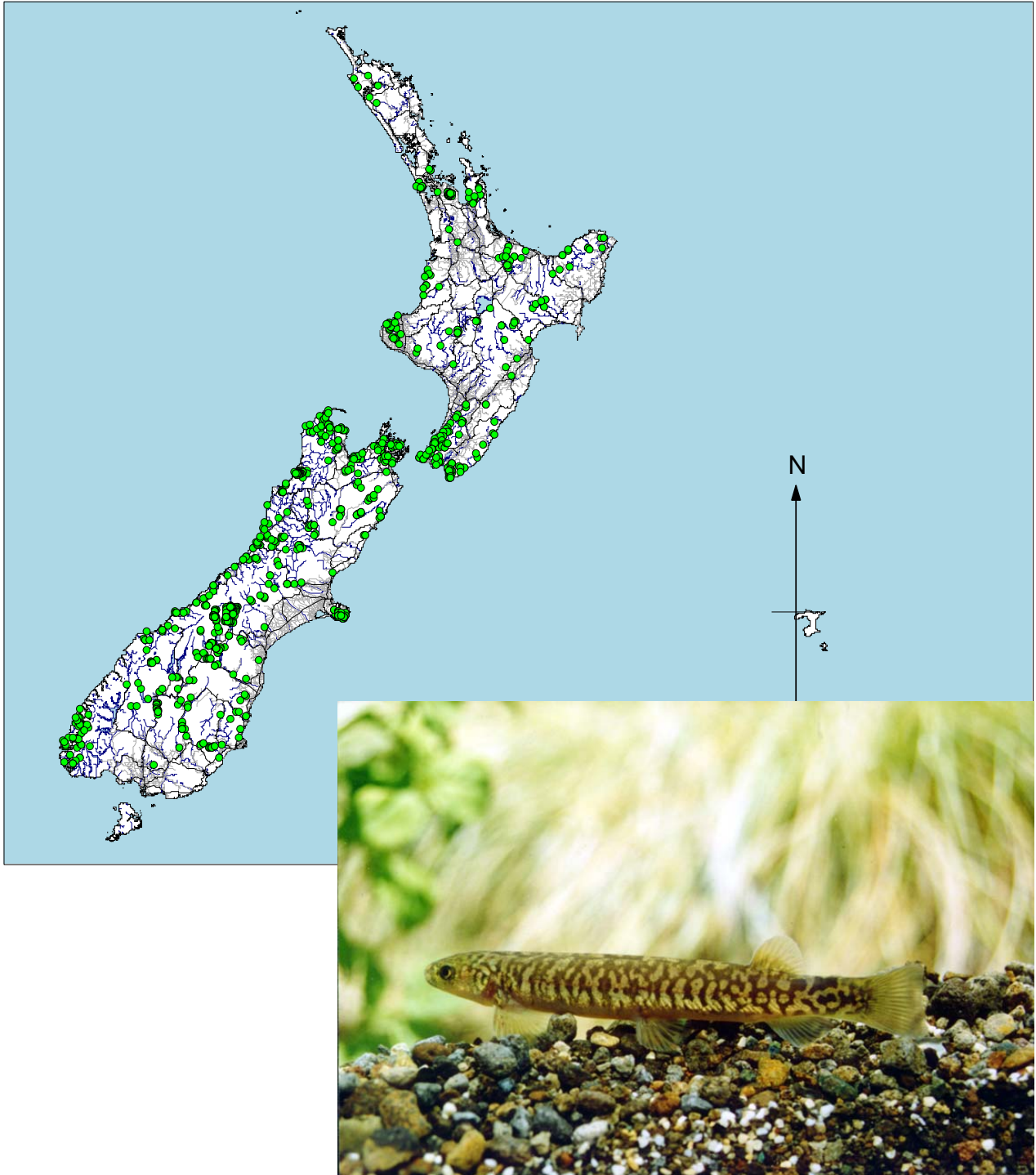


Figure 6. Koaro (*Galaxias brevipinnis*), NZFFD records from 2000 onwards (N =1083).

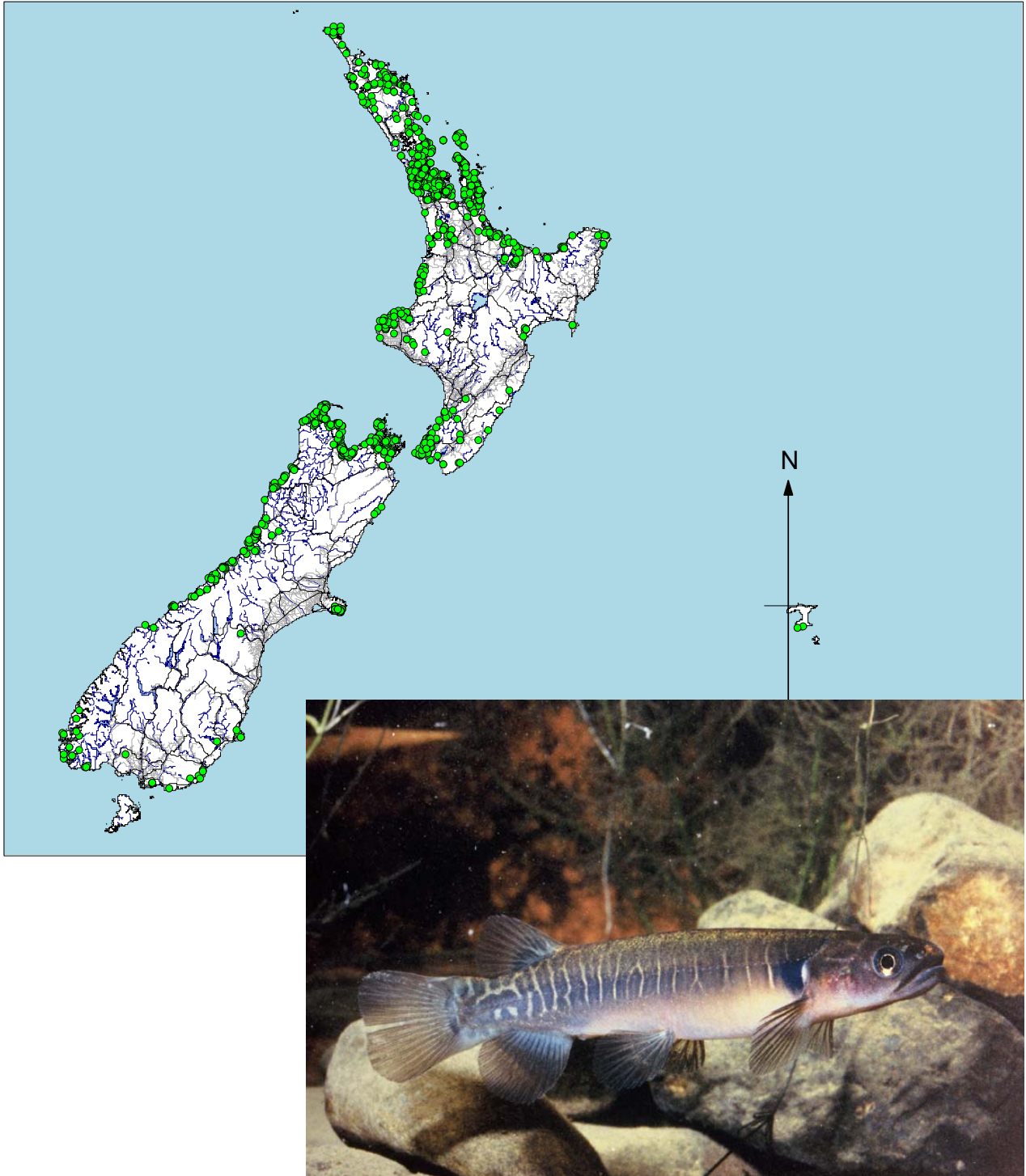


Figure 7. Banded kokopu (*Galaxias fasciatus*), NZFFD records from 2000 onwards (N =1962).

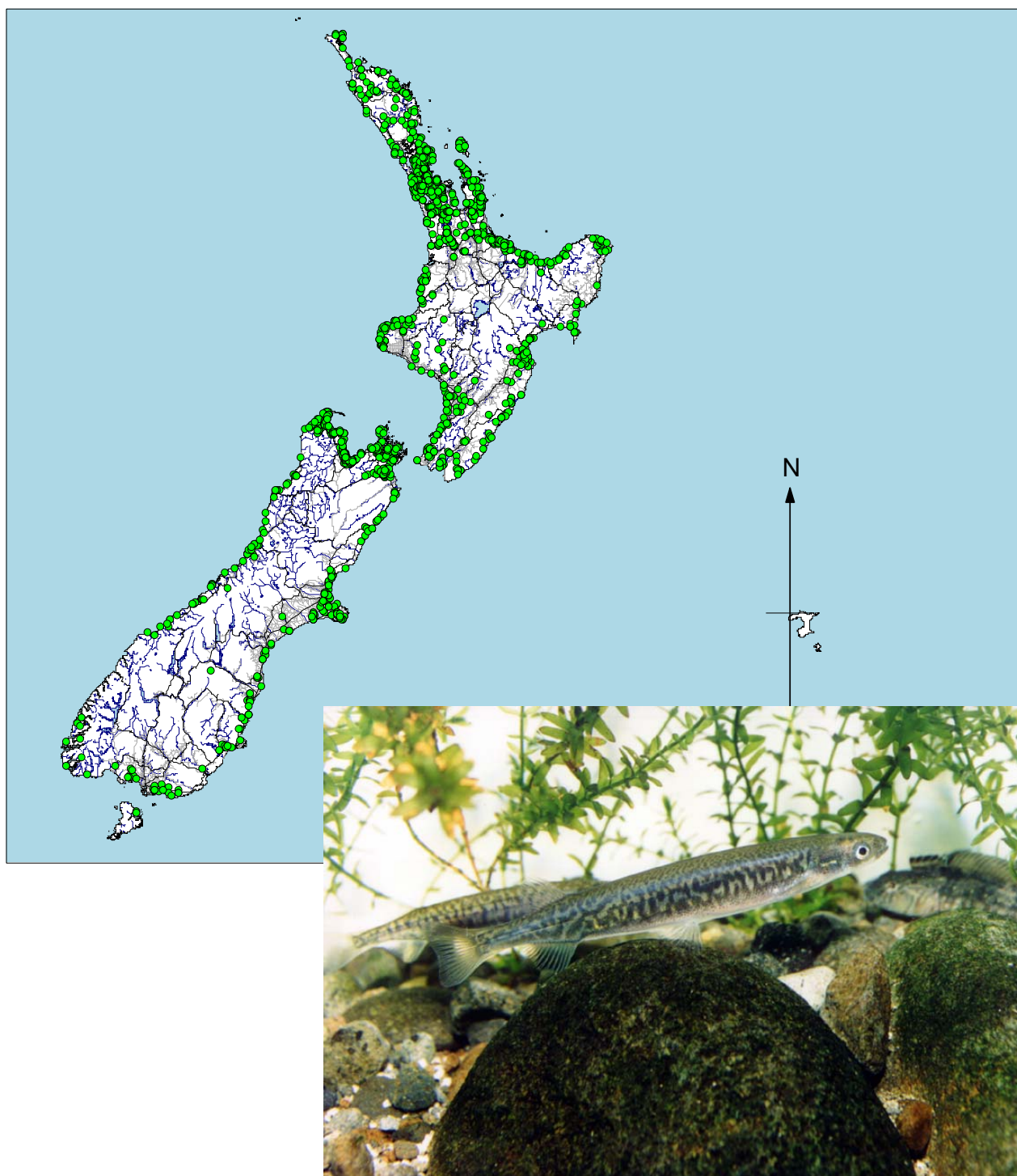


Figure 8. *Inanga* (*Galaxias maculatus*), NZFFD records from 2000 onwards (N =1878).

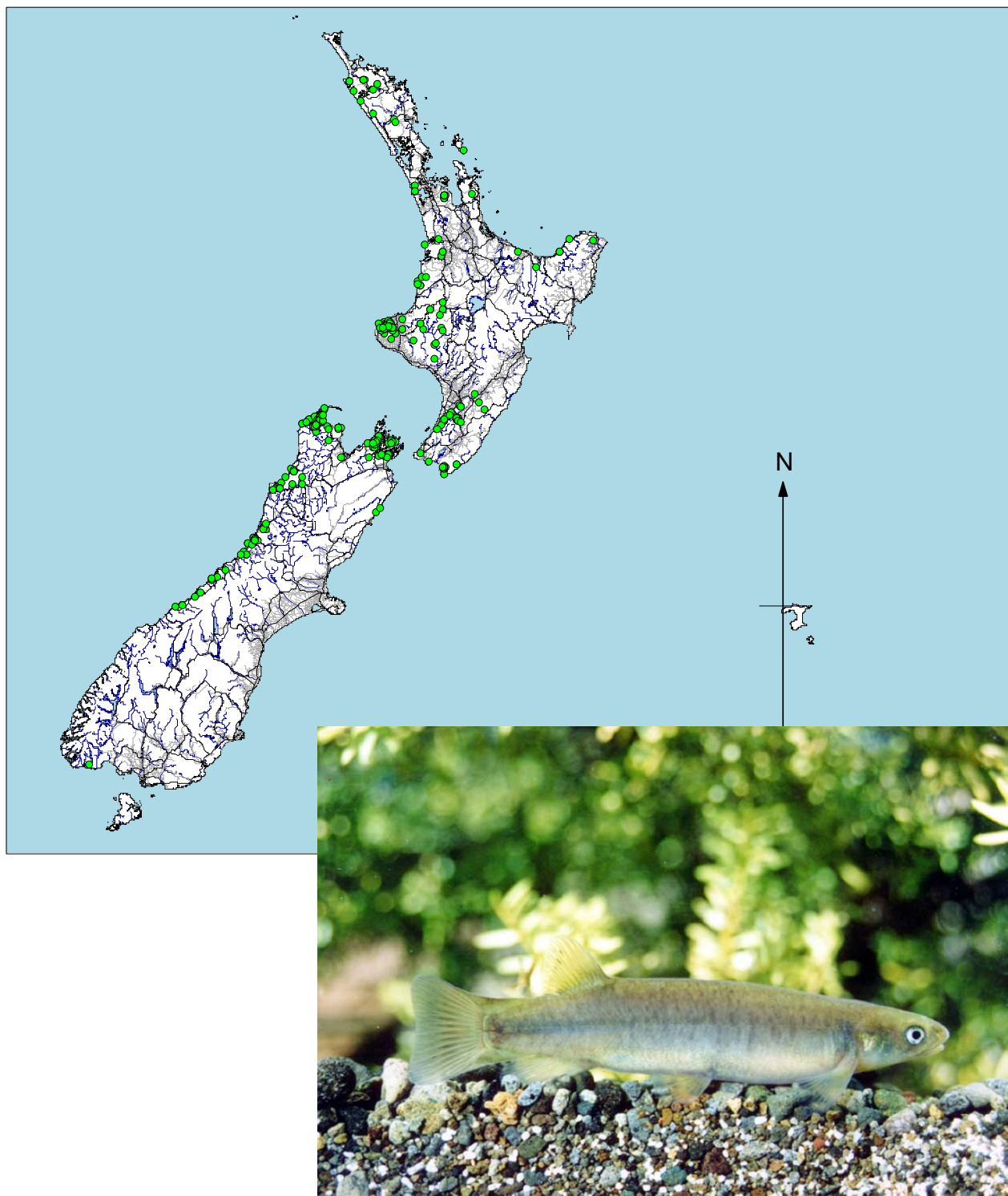


Figure 9. Shortjaw kokopu (*Galaxias postvectis*), NZFFD records from 2000 onwards (N =304).

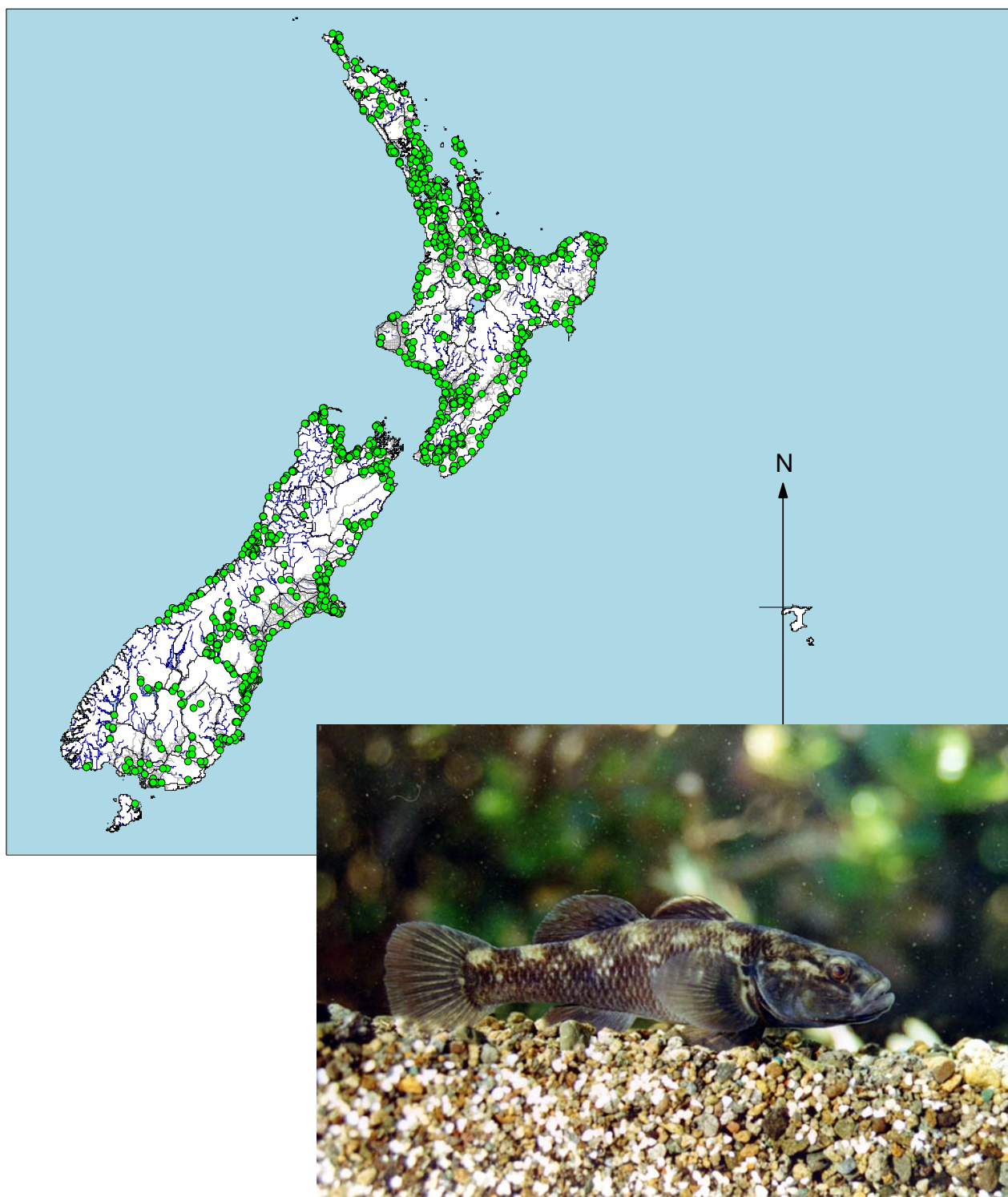


Figure 10. Common bully (*Gobiomorphus cotidianus*) NZFFD records from 2000 onwards (N =2101).



Figure 11. Bluegill bully (*Gobiomorphus hubbsi*) NZFFD records from 2000 onwards (N =265).

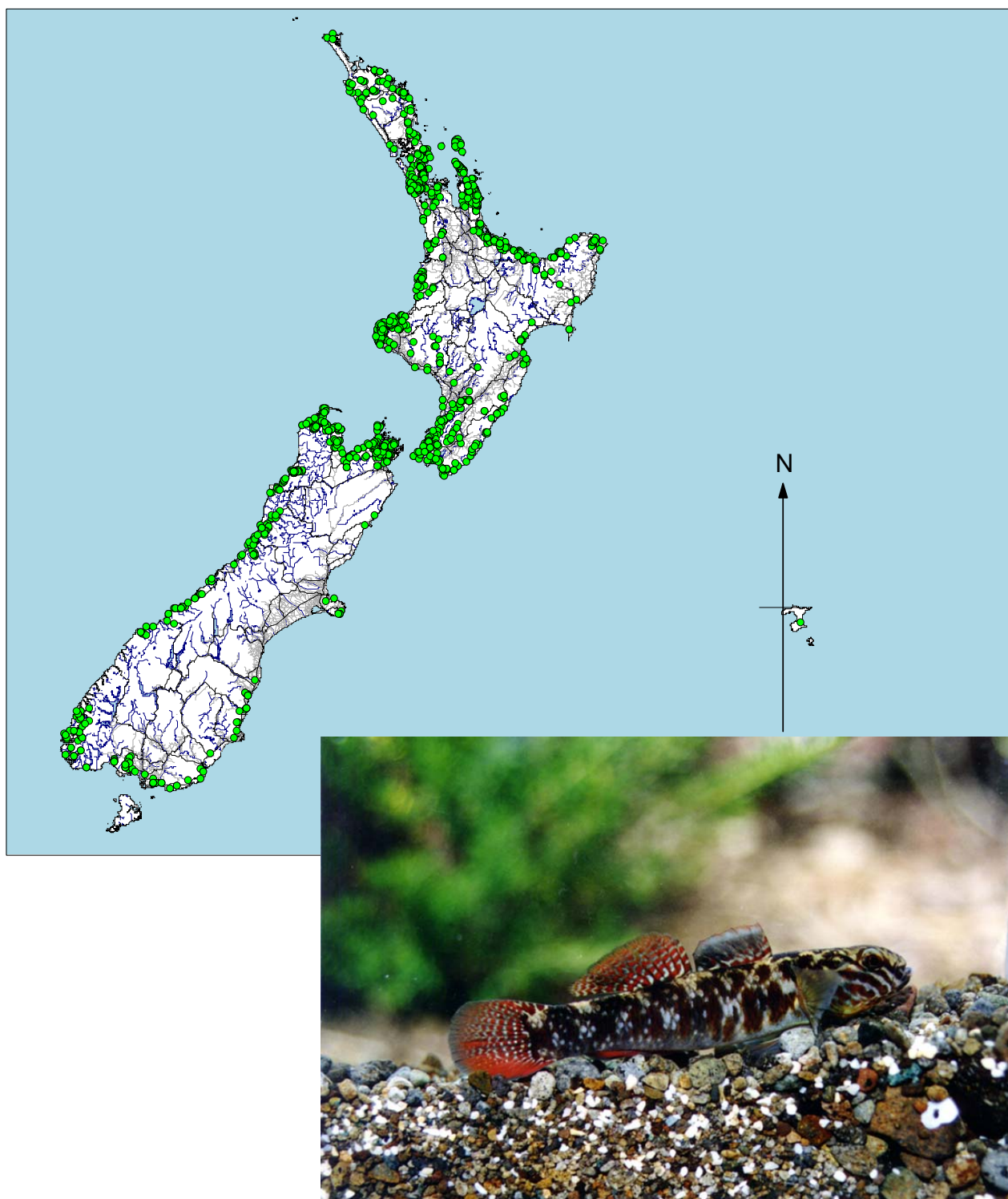


Figure 12. Redfin bully (*Gobiomorphus huttoni*), NZFFD records from 2000 onwards (N =1622).

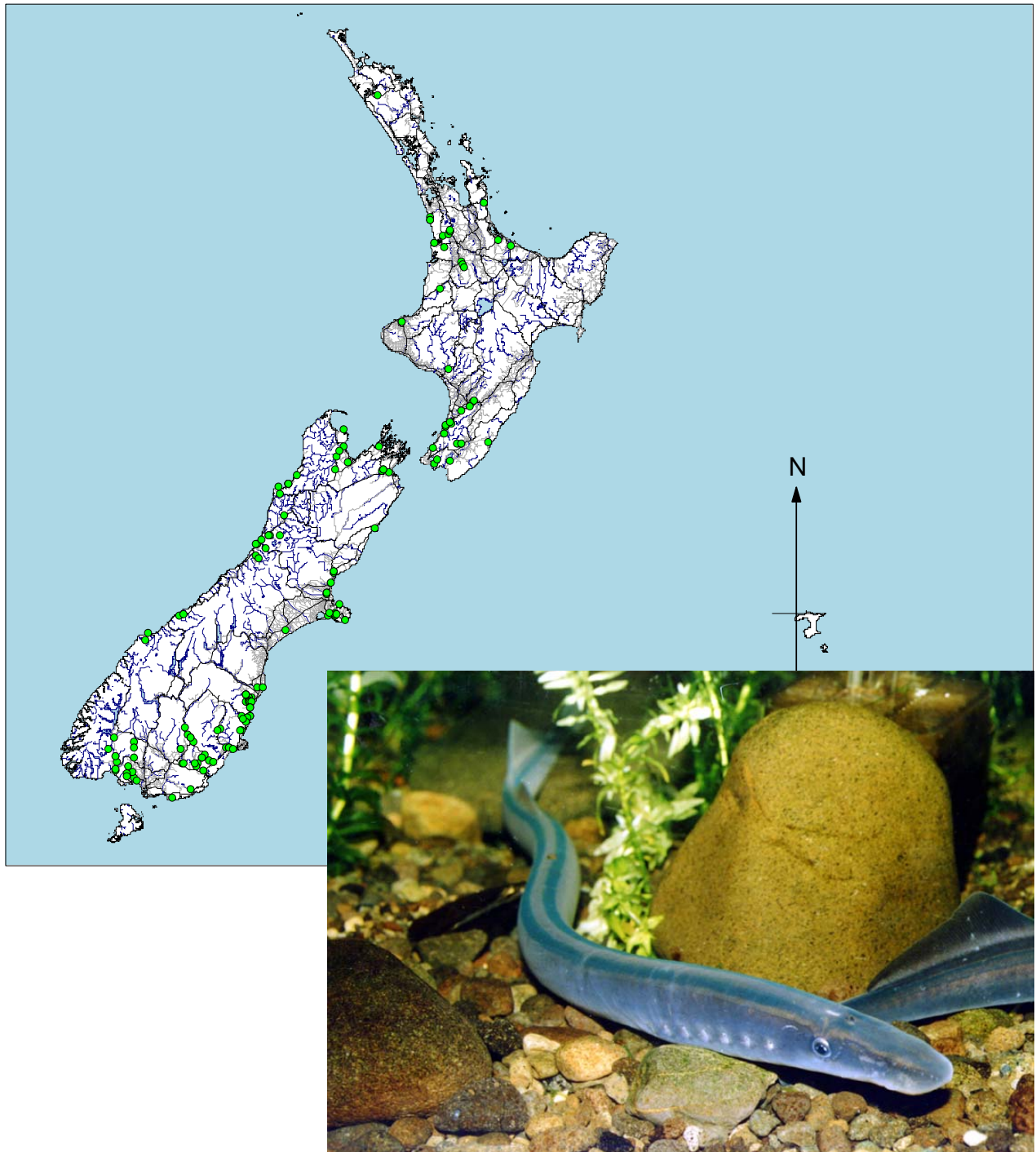


Figure 13 Lamprey (*Goetria australis*), NZFFD records from 2000 onwards (N =160).

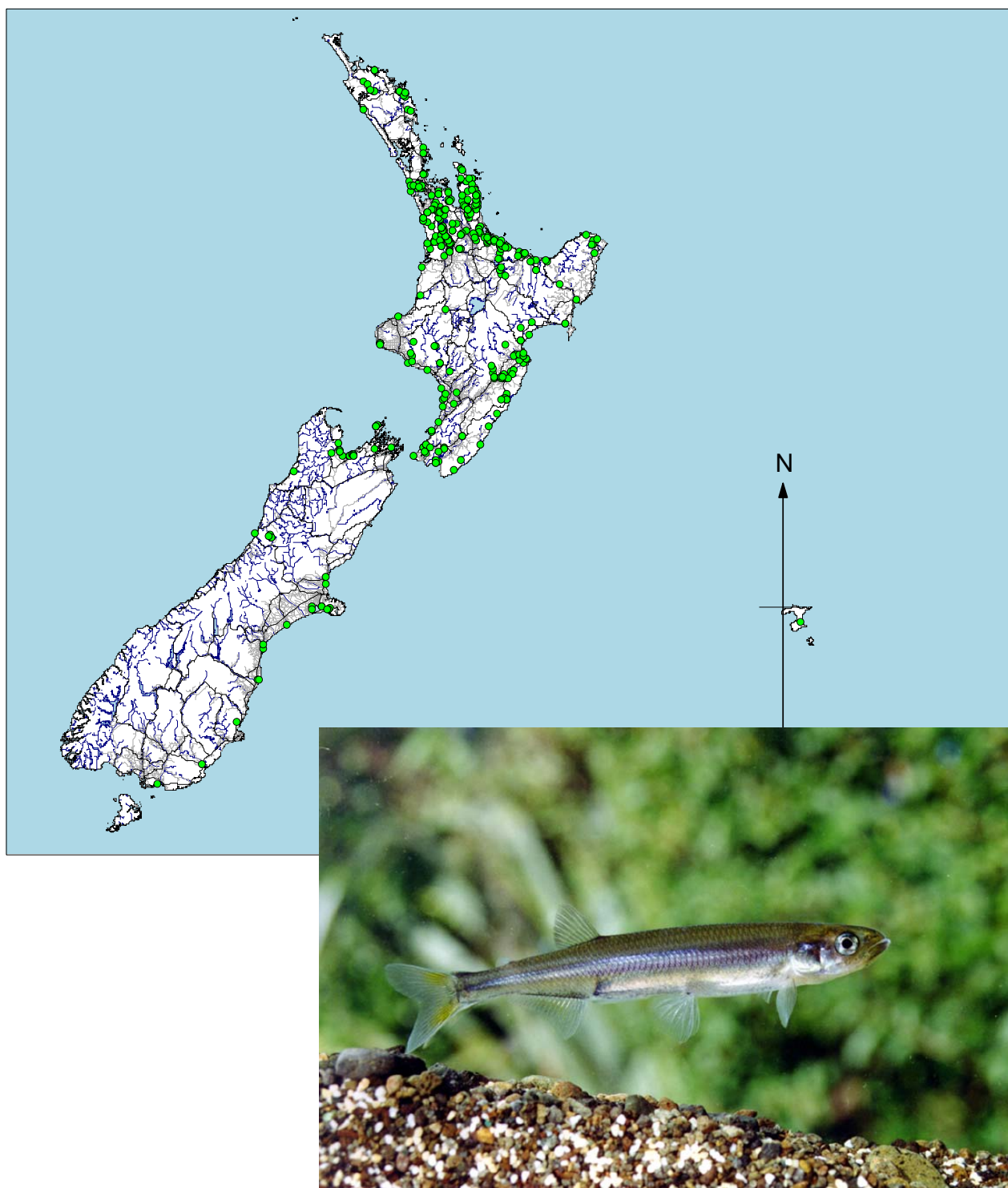


Figure 14. Common smelt (*Retropinna retropinna*), NZFFD records from 2000 onwards (N =471).

Appendix 2 Appendices 1 and 2 from Strickland et al (2003) Project Aqua stranding report.

## **APPENDIX 2**

**Project Aqua: Environmental Study: *Stranding***

**APPENDIX 1: CSIF&G observer records of stranded fish and redds during the low flow trial. (See definitions of “safe” and “at risk” in Section 2.3)**

**152 m<sup>3</sup>/s**

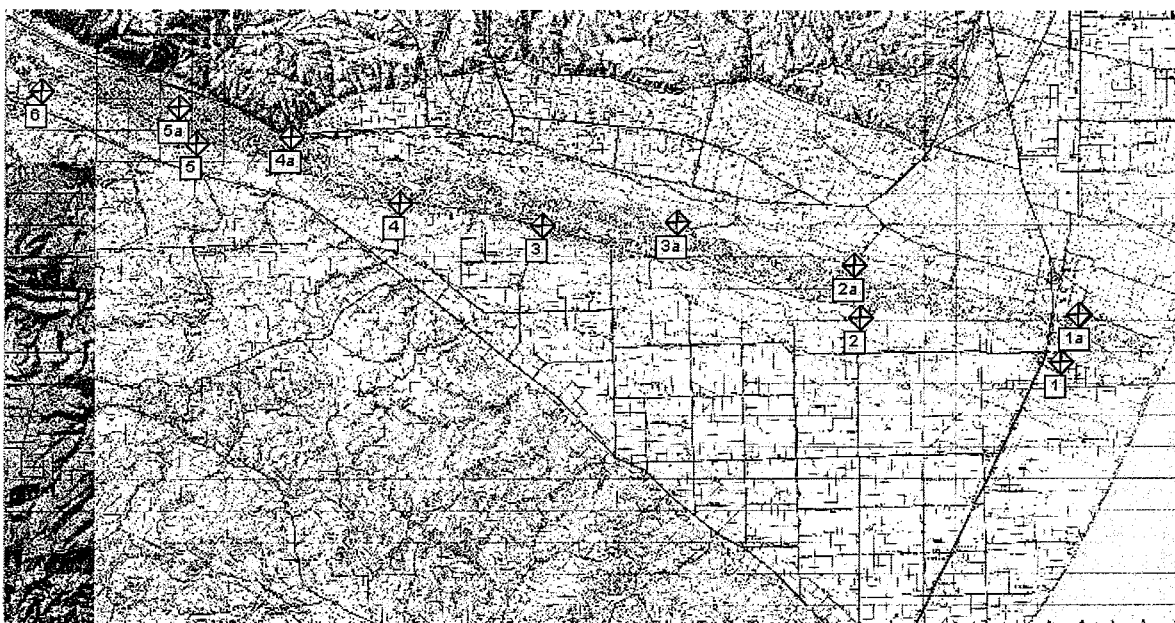
Number of trout found stranded	<b><u>29 total.</u></b>	
	23 “at risk”	[ 12(s), 11(l) ]
	6 “safe”	[ 1(s),1(m), 4(l) ]
Number of trout found dead	<b><u>4 total</u></b>	[ 2(s), 2(m) ]
Number of redds observed	<b><u>23 total</u></b>	
	23 “safe”	[ 21 trout, 2 salmon ]

**119 m<sup>3</sup>/s**

Number of trout found stranded	<b><u>55 total.</u></b>	
	22 “at risk”	[ 19(s), 3(l) ]
	33 “safe”	[ 8(s), 13(m),12(l) ]
Number of trout found dead	<b><u>9 total.</u></b>	
Number of redds observed	<b><u>21 total.</u></b>	
	11 “safe”	[ 5 trout, 6 salmon. ]
	10 “at risk”	[ 4 trout, 6 salmon. ]

**90 m<sup>3</sup>/s**

Number of trout found stranded	<b><u>52 total.</u></b>	
	24 “at risk”	[ 22(s), 1(m), 1(l) ]
	28 “safe”	[ 18(s), 1(m), 9(l) ]
Number of trout found dead	<b><u>13 total</u></b>	[ 10(s), 2(m), 1(l) ]
Number of redds observed	<b><u>13 total</u></b>	
	12 “at risk”	[ 2 trout, 10 salmon. ]
	1 “safe”	[ 1 trout. ]



Lower reaches of the Waitaki River covered by CSIF&G fish stranding observers. 1 & 1a SH1 bridge to mouth, 2 & 2a Ferry Rd, 3a Bells Pond, 3 Wilsons Rd, 4 Goulding Rd, 4a Redcliffs irrigation intake, 5 Black Point, 5a Grassy Hills, 6 Duntroon.

**APPENDIX 2: NIWA field notes from the low flow trial fish stranding surveys**

Date and flow	Access and boat launching	Habitat	Access for fishing and observed strandings
<b>Ferry Road (Site 1, J41 546 854 to 548 857 and site 2, J41 520 860)</b>			
10/7/01 152 m <sup>3</sup> /s	Usual boat launching point at end of access track was dry so drove across river bed to find deep water.	The deep pools close to the banks with fallen trees and branches are productive habitats for eels.	Access to "normal" eel fishing habitat in this reach no longer possible even at current levels.
11/7/01 119 m <sup>3</sup> /s	Vehicle track to J41 520 860.	In this area there are numerous hollows in the river bed. Where tree trunks are present, there is always an associated scour hole. In these depressions, numerous bullies and juvenile salmonids were seen.	Little change from yesterday. Much higher density of bullies (common and upland) found than further upstream.  One fyke net set in outlet to side channel.
12/7/01 90 m <sup>3</sup> /s			Level change minimal from previous day particularly in side braid. One brown trout juvenile (120 mm) and 2 longfin eels (400 mm) captured in fyke net.  Three brown trout juveniles and numerous bullies found dead in scour holes associated with log jams. Also several dead bullies seen, particularly under large stones.
<b>Duntroon boat ramp (I40 270 931)</b>			
10/7/01 152 m <sup>3</sup> /s	Marginal despite removal of concrete blocks by Meridian.	The habitat opposite Duntroon is the most productive for eel fishers. As expected, little sign of productive habitat exposure at today's levels (these being just above low levels occurring in the past few weeks).	Travelled by jet boat down to about J40 318 916 and up true right channel to about I40 300 927 before grounding. Under "normal" flow, fishers are able to access considerably more habitat upstream but still significant areas accessible by jet boat and some "new" fishing sites created at today's levels.
11/7/01 119 m <sup>3</sup> /s	Marginal.	Numerous birds observed feeding on recently dewatered areas.	Main channels still passable and most backwaters with plenty of water. Numerous log jams and rooted island still able to be fished.  Productive habitat opposite Duntroon no longer accessible, however new fishable habitat created. Willow encroachment likely to destroy existing shallow habitats.
12/7/01 90 m <sup>3</sup> /s	Boat ramp un-usable.	Major change in water level from yesterday with bank habitat now exposed.	5 lamprey ammocoetes (still alive). Several bullies stranded but still alive. Three brown trout juveniles and at least 50 dead bullies counted in one dried pool.
<b>Waitaki Lodge (I40 273 946)</b>			
10/7/01 152 m <sup>3</sup> /s	Access from road by foot. No boat launching possible from here.	Very productive habitat throughout. There is a stable side channel here that is full of macrophytes and invertebrates.	Normally this site is accessible by jet boat from downstream, but the water level today too low to allow passage. Access to this area is also possible via an upstream channel at I40 205 964.

Date and flow	Access and boat launching	Habitat	Access for fishing and observed strandings
11/7/01 119 m <sup>3</sup> /s		Very little change from yesterday.  Trout spawning redds now visible but still submerged	Pools with frozen water surface collapsing with change in water level.
12/7/01 90 m <sup>3</sup> /s		Little change but potential salmonid migration barriers now forming in riffles.	
<b>Otekaieke River Mouth (I40 184 963)</b>			
10/7/01 152 m <sup>3</sup> /s	By vehicle across the Otekaieke River (normally dry but with some water during present visits).	There is a large backwater here which is partly fed by springs and surplus irrigation water. Important to ensure that such backwaters remain with Project Aqua.  A fyke net was set at the outlet of the backwater to determine if any eels would emerge as water receded overnight.	A few metres from the stream mouth there is a small willow island which always yields several eels.  Jet boat passage through the right bank channel is normally possible and passage would not have been an issue at the present flows.
11/7/01 119 m <sup>3</sup> /s		Three longfinned eels (~ 400 mm) in very good condition were captured in the fyke net. The colour of the fish indicated that they came from shallow wetland.  Very little change in water level in the backwater, possibly indicating that flows arise from a spring or similar much further upstream.	Jet boat passage through the channel no longer possible.
12/7/01 90 m <sup>3</sup> /s		No change from yesterday. No stranding noted.	
<b>Kurow Bridge (I40 102 957)</b>			
10/7/01 152 m <sup>3</sup> /s	From rest area near bridge.	Shallow side channels drying out. Numerous amphipods present. Dobsonfly larvae under just about every large rock. Numerous <i>Potamopyrgus</i> sp. (snails) and planarians. Thick brown algal mat over most stones. These shallow side channels are extremely productive and likely to be important for bullies, elvers and juvenile salmonids.	
11/7/01 119 m <sup>3</sup> /s		Channels now almost dry. Remnant pools frozen. Few bullies found in pool. Live invertebrates under rocks. Plants frozen so die back expected.	
12/7/01 90 m <sup>3</sup> /s		Little change from yesterday.	