New Zealand Freshwater Fish Sampling Protocols

PART 1 WADEABLE RIVERS & STREAMS

- Electrofishing
- Spotlighting
- Trapping
- Data Management

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First published in New Zealand in 2013 by
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Design & Production by EOS Ecology
www.eosecology.co.nz

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ISBN 978-0-473-23437-9

preface

In 2004 a group of freshwater fish survey practitioners from across New Zealand met in Wellington to discuss the creation of a set of protocols to standardise fish surveys nationwide. Although all participants agreed a protocol was needed, funding was not found to take this process forward until 2010. In the intervening years more Regional Councils undertook and commissioned fishery surveys for use in State of the Environment (SOE) monitoring and environmental flow studies.

Due to the absence of a set of standardised protocols and guidance in their appropriate use, various techniques have been used by various agencies and institutions over the intervening years. As the compounding effects of human pressures on aquatic fish communities continue to increase, the need for a standardised data collection approach to clearly demonstrate, report and address these impacts is now urgent. The process to date largely resembles the previous developmental pathway that led to improved standardisation of aquatic macroinvertebrate sampling for SOE monitoring and subsequently the range of indices used to report effects (Stark *et al.*, 2001; Stark & Maxted, 2007). At the time of writing the development of useful fish indicators for evaluating effects in New Zealand wadeable streams is still in its infancy but would be expected to develop rapidly once data collection becomes standardised across the country. This document incorporates the combination of many years' experience of the authors and the suggestions and reviews of many freshwater scientists who gave their time to bring this project to its current state.

acknowledgements

The development of these protocols has been greatly improved by feedback from various colleagues from regional councils, the Department of Conservation, consultants, research institutes, and universities. The protocols were developed under the Envirolink tools program funded through the Foundation for Science Research and Technology Project number MAUX0912. We thank the Envirolink staff for the short extension granted to enable this document to be improved by the incorporatation and alignment with other related projects. The Hauraki District Council is also thanked for providing survey data from the Waitakaruru Stream.

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1 introduction

Photo: Longfin eel © EOS Ecology / Bronwyn Gay

1.1 Overview

The inclusion of fish (and associated metrics) for assessing and monitoring the state of running waters is a relatively recent initiative compared to the long running use of macroinvertebrates and chemical measures of water quality internationally. In the early 1980s bioassessment that used fish communities was made popular in the USA by James Karr with the development of the fish Index of Biotic Integrity (IBI). Originally it was developed for fish assemblages in small streams in the northern United States (Karr *et al.*, 1986) and since then the IBI has been modified for use in most of the world including Canada, Mexico, France, Australia, Africa, Belgium, and India (Hughes *et al.*, 1998). Until 2004 when an IBI was developed in New Zealand (Joy & Death, 2004) fish were only occasionally used in bioassessment as there was no real way to compare sites because of the influence of diadromy on natural distributions (McDowall & Taylor, 2000). The New Zealand IBI overcomes this limitation by having a scoring system that takes into account natural changes due to altitude and distance from the sea. Using fish in freshwater assessment in New Zealand is not limited to using the IBI but it has the advantage of taking into account the natural changes when comparisons are made at different elevations.

An extensive body of data on the spatial distribution of freshwater fish throughout New Zealand is stored in the New Zealand Freshwater Fish Database (NZFFD*), a digital archive administered by the National Institute of Water and Atmospheric Research (NIWA). Use of the data to date, particularly for evaluating national and regional aspects of fish distribution, has mostly been limited to basic information on the presence or absence of species. Although records often contain other information such as relative abundance estimates and fish size data, these data are of limited use for regional or national evaluations due to the historical absence of a consistent collection methodology. While impressive predictive

* McDowall, R. M., & J. Richardson, (1983). *The New Zealand freshwater fish survey – a guide to input and output*. (Fisheries Research Division Information leaflet No. 12). Wellington: Ministry of agriculture and Fisheries.

models of fish distribution have been developed using the presence and absence information from this database, (Joy & Death, 2003; Leathwick *et al.*, 2005; Leathwick *et al.*, 2008) further developments have been limited by a lack of data collection consistency and detail. Detailed information such as fish relative abundance and population structure is patchy and consistent sampling is at best sporadic. As well as limiting modelling ability, this lack of consistency and detail also means that trends and changes to fish communities cannot be accurately quantified over local, regional and/or national scales.

The New Zealand Ministry for the Environment is currently revising the use of indicators for water quality reporting. This revision is one of three tasks defined for the development of tools and methodologies designed to improve water quality assessment and reporting, referred to as "National Environmental Monitoring and Reporting" (NEMAR). The use of fish is integral to this water quality reporting and consistent, comparable data is critical for its effective implementation.

The use of consistent and appropriate sampling methods will allow regional councils to robustly report on freshwater fish diversity and recruitment patterns within river systems especially in poorly surveyed lowland habitats. Such data is critically needed to inform policy and management given that a recent evaluation of the fish fauna resulted in two thirds of the native fauna being currently ranked with a threat status of 'declining' or worse (Allibone *et al.*, 2010). Furthermore, approximately one third of New Zealand's native fish fauna is capable of diadromy. Genetic evidence indicates that there is sufficient gene exchange occurring through offshore mixing that many of these diadromous species can, and should be considered to be, national populations or stocks (Waters, 1999; Waters *et al.*, 2000). Thus, a coordinated approach to assessing changes in populations will require consistency in collection of data both locally and nationally.

The adoption of standardised sampling protocols will provide the framework for building long-term data sets containing a large number of replicated sites. Such datasets will provide a more statistically powerful means of identifying ecological patterns and detecting change over time (Bonar *et al.*, 2009). Standardised protocols can also facilitate data sharing and greater co-operation between different organisations involved in freshwater resource management and research (Bonar *et al.*, 2009).

Regional councils have for some time sought a standardised sampling protocol for surveying fish communities in New Zealand wadeable streams. While individual regional councils and the Department of Conservation have developed regional and species specific systems (Allibone 1999, Ling *et al.*, 2009; David & Hamer, 2010), there has been a consensus that an overriding, national, all species protocol is required. To this end the protocols described in this document are designed to meet these requirements.

1.2 Scope

This document is designed as a self-contained guide to surveying freshwater fish communities in New Zealand wadeable streams. It introduces key principles for effective and comparable surveying of freshwater fish communities, and for recording basic, but important, population parameters such as relative abundance estimates and size class structure. The information provided here will assist practitioners with effectively characterising freshwater fish communities by providing guidance on:

- How to select the most appropriate sampling method to use.
- How to implement each sampling method.
- How to record the data that is collected.

1.3 Guiding Principles

It is crucial for the future of freshwater management in New Zealand that accurate decisions regarding freshwater environments are made. For these decisions to be robust they must be underpinned by accurate fishery survey data. Spatial information that describes the distribution of species across New Zealand will become more accurate when survey data is collected using a consistent level of effort. Furthermore, it is envisaged that in many instances, consent related surveys and assessments would utilise the same standardised methodologies to ensure a minimum standard of data collection that practitioners are required to meet but are welcome to exceed. Such a strategy has the potential to not only provide additional knowledge to support comparable State of the Environment (SOE) survey information, but in many cases is likely to result in a more streamlined consenting process as protocols for assessment will be agreed prior to consent application. The presence of these national protocols will mean that stakeholders can collect information encouraging national databases to present a hierarchy of data identifying how "accurate" the information is and whether information could be used for national scale analyses.

These protocols are designed to provide guidance of the **absolute minimum** amount of sampling effort required to give:

- An effective description of reach scale fish diversity, population structure and relative abundance in wadeable New Zealand streams.
- A robust and repeatable method for long-term sampling (e.g., SOE reporting, reference site benchmarking, long-term trend analysis, etc.).

These protocols will cover the sampling of freshwater fish in wadeable streams using backpack electrofishing, spotlighting and trapping methods. A range of other potential sampling methods, while not adopted, were initially considered and these are described in Appendix 1. Wadeable streams (for the use of methods described in this document) are defined as locations where at least 90% of site is ≤0.6 m deep and mean wetted width is ≤12 m. This definition takes into consideration issues relating to health and safety, method effectiveness, and the time and resources required to complete a site. The protocols are not designed for sampling wide braided rivers, non-wadeable streams, or lakes and wetlands.

The protocols described in this document have not been designed to be used in every situation where freshwater fish will be sampled. Researchers are likely to want to consider and utilise a greater range of sampling methods than those outlined in these protocols when seeking to answer specific research questions. Those involved in species-specific work, such as Fish & Game New Zealand or the Department of Conservation, are likely to select methods which are biased towards the species they are working on and will be less concerned about community composition as a whole. A range of species specific protocols for use in flowing habitats may be accessed through the Department of Conservation or Fish & Game New Zealand.

It is acknowledged that no single method can meet every need in every situation and it is accepted that certain methods are more or less effective at capturing particular species within a given assemblage at a given site. Nevertheless, the underlying premise for adopting these protocols is to improve our general understanding of national and regional patterns of fish community attributes through the standardisation of data collection and sampling effort.

1.4 Survey of Freshwater Ecologists

Early in the protocol development process the need for an end-user survey to identify existing techniques used by freshwater ecologists to assess freshwater fish populations was recognised. This process provided an opportunity to understand different organisations aims and requirements for fish surveys, as well the skills and knowledge of the end-users of this project. The full results are given in Appendix 2 but can be summarised as follows:

- All but one of the respondents regularly survey fish in wadeable streams.
- All respondents used electrofishing, 87% used spotlighting, 67% used Gee minnow traps (GMTs) and 53% used fyke nets.
- Less than half of the respondents used any written guidelines to standardise results.
- All respondents said they added information to the New Zealand Freshwater Fish Database (NZFFD).
- Pasture sites were the primary landuse type monitored.
- Ten of the fifteen respondents sampled some long-term monitoring sites.
- The reasons for surveys were many and varied.
- Most respondents would like to have some spreadsheet to enter data into and calculate IBI scores.

2

general considerations

Photo: Redfin bully © EOS Ecology / Shelley McMurtie

2.1 Timing of Surveys

To ensure that most migratory species are present in streams and can thus be captured in surveys the timing of surveys is crucial. The recommendation is that in general surveys for SOE type monitoring should not take place between May 1 and November 30. The reason for this is that generally fish become less active and less susceptible to capture when temperatures are low. For instance eels may remain inactive for extended periods once stream temperatures fall below 11–12°C (Chisnal, 1987; Graynoth & Taylor, 2000). While sampling during winter months could be justified for other objectives such as investigation of spawning behaviour and activity or larval emergence and drift, such objectives are not the target of these methods. In addition to season, other climatic effects should also be considered prior to sampling. For instance, avoid fishing during or immediately after rainfall events or bed moving high flows. During such periods fish can either be displaced from the survey area or may burrow further into cover reducing fish capture efficiency and causing unnecessary data variability. To minimise such variability in data collection, the Waikato Regional Council imposes a two week stand-down period for any biological sampling following bed disturbing flows (David & Hamer, 2010). Bed moving flows are determined from a network of gauged sites spread across the region, each with an established trigger level informing when bed movement is likely to have occurred. Generally, the optimal time for fishing and minimising variance is when flows are at or close to base flow and stable. Avoid sampling during full moon phases when spotlighting as fish tend to become more skittish. Do not deploy any nets or traps if heavy rain is forecast for the catchment over the following 24 hours.

2.1 Site Selection

Site selection depends on the aims and objectives of a study or monitoring programme. However to minimise the influence of localised human impacts sites should not be located within 100 m of a bridge or vehicle ford, unless you are assessing the influence of these impacts, if unavoidable make note of it on datasheets. Also ensure that there are no major migration barriers or tributary confluences within the entire sample reach (150 m) as this may also increase within-site variance. For an unbiased evaluation of current regional fish community attributes we recommend using probabilistic site selection methods, (Ator *et al.*, 2003) in association with a network of 'least impacted' reference sites to serve as independent controls. For the specific purposes of SOE monitoring, regional site selection methodology, monitoring and reporting is likely to be guided by National Environmental Monitoring and Reporting (NEMAR) – a central government led process driven by the Ministry for the Environment (MfE).

These methods can also be used to assess fish community responses to various impacts such as land-use development or point source discharges. Although the methods described in this document may not be suitable for every possible situation, for impact assessments we highly recommend the use of before, after, control, impact or treatment, (BACI, BACT) type designs.

3 the fish sampling protocols

Photo: Fyke net © EOS Ecology / Bronwyn Gay

From the many options available for sampling fish (see Appendix 1 for details) three existing techniques were chosen for these protocols:

- Backpack electrofishing
- Trapping using a combination of fyke nets and Gee minnow traps (GMTs)
- Spotlighting

The selection of these three techniques was based on their widespread use by organisations sampling wadeable streams across New Zealand (see respondents survey results in Appendix 2).

3.1 Sample Reach Length

Spatial scale is a critical consideration in any sampling protocol. Development and testing of methods for describing the relative abundance and diversity of fish communities at the reach scale has received limited attention in New Zealand (David *et al.*, 2010) but significant attention overseas. For instance, it has previously been established that fish species richness increases with the number of geomorphic units sampled (Gorman & Karr, 1978; Angermeier & Schlosser, 1989). Additionally, effort, stream length, and stream area can also influence species richness and relative abundance at the reach-segment scale (Lyons, 1992; Simonson & Lyons, 1995; Patton *et al.*, 2000; Hughes *et al.*, 2002; Blocksom *et al.*, 2009; Fischer & Paukert, 2009). This knowledge has resulted in the United States Environmental Protection Agency (US EPA) adopting standardised fishing protocols specifying that sampled reach lengths should be 40 x the mean wetted channel width with a minimum distance of 150 m. A study across 73 wadeable New Zealand streams that used similar protocols to those employed by the US EPA, concluded that irrespective of locality, that continuous sampling of 150 m of stream is required to detect >90% of the fish species likely to be present at a reach scale (David *et al.*, 2010). Consequently the protocols outlined in this document recommend a standard 150 m sample reach length. While 150 m is a substantial length of stream to sample, there are two justifications for the adoption of this length:

① Irrespective of where sampling will occur it appears that the vast majority of species likely to be present at a reach scale will be captured within this length of stream. Indicators relating to fish diversity (e.g., Observed/Expected, native versus exotic) are frequently used overseas for evaluating human related environmental effects. Therefore using a method that ensures a high probability of detecting the majority of species likely to be present is crucial for developing effective indicators.

② Long-term sites are important part of SOE monitoring. Consequently, it is prudent to consider the potential for natural changes to stream geomorphology (e.g., as a

result of floods) and the subsequent establishment or repositioning of geomorphic units (e.g., pools, riffles, runs). Fish species, particularly those with more specific habitat requirements, will move and adapt to these changes. To minimise unnecessary variability in data collection over time (that may occur in response to such events), it is important to sample at a scale that will be less influenced by sub-reach scale shifts in habitat availability.

Where possible it is encouraged to collect habitat, water quality, and invertebrate data at the same sites to provide multiple layers of information, particularly for SOE monitoring.

3.2 Choosing the Appropriate Sampling Protocol

The first task is to decide which sampling technique or techniques to employ at a given site to maximise the chance of accurately assessing the fish community present. It is important to note that using one technique is the minimum requirement and often two or all three techniques would have to be employed at one site to maximise catch rates and the probability of collecting all species present. It is also important to be aware that the design of the survey programme may strongly influence method selection at specific sites. For example if you want to directly compare sites within the programme then it might be better to use the same method even if it doesn't score highest at some of your sites. Similarly, if habitat characteristics at a site change over time (e.g., turbidity decreases) you may want to switch to a more effective method because this will affect your ability to detect change over time.

The Method Decision Table (Figure 1) can be used to decide the optimal sampling methods. For each parameter, select the condition that best describes the site. Transfer the numbers for that box to the columns on the right hand side of the table and then aggregate the scores to give a total at the bottom. The method with the highest total score is the most appropriate method to use at that site. However, if scores are close (0–3 points difference) then Table 1 may assist with making a final decision. This decision table was developed after undertaking the lowland stream method comparison that is documented in Section 4.1.

Site name Whareroa DS — Method decision table — Method

Trap = Fyke nets and Gee minnow traps combined, Spot = Spotlight, EFM = backpack electrofishing machine(see protocols for details)

Parameter	Condition				Trap	Spot	EFM
Water velocity	Low → High						
	Still Trap 3, Spot 3, EFM 1	Slow Trap 3, Spot 3, EFM 2	Medium Trap 2, Spot 3, EFM 3	High Trap 1, Spot 1, EFM 3	3	3	2
Conductivity	Low → High						
	< 30 µS/cm Trap 3, Spot 3, EFM 0	30-300 µS/cm Trap 1, Spot 1, EFM 3	300-450 µS/cm Trap 3, Spot 3, EFM 2	>450 µS/cm Trap 3, Spot 3, EFM 0	3	3	0
Turbidity	Clear → Turbid						
	Clear (bed visible* > 80% of reach) Trap 1, Spot 3, EFM 3	Slightly discoloured (bed visible* 50 -80% of reach) Trap 2, Spot 2, EFM 3	Moderate turbidity soft bottom (bed visible* 20 - 50% of reach) Trap 3, Spot 1, EFM 1	Very turbid soft bottom (bed visible* <20% of reach) Trap 3, Spot 0, EFM 1	3	1	1
Vegetation or anything that obscures vision of bed	High visibility → Low visibility						
	80 - 100% bed visible Trap 3, Spot 3, EFM 3	Bed visible over 50 - 80% of reach Trap 3, Spot 2, EFM 3	Bed visible over 20 - 50% of reach Trap 3, Spot 1, EFM 2	Bed visible over <20% of reach Trap 3, Spot 1, EFM 0	3	1	0
Depth	Shallow → Deep						
	100% of reach < 0.4m Trap 1, Spot 3, EFM 3	>75% of reach < 0.4m Trap 2, Spot 3, EFM 2	75 - 25% of reach < 0.4m Trap 3, Spot 2, EFM 2	< 25% of reach < 0.4m Trap 3, Spot 2, EFM 0	3	2	0
				TOTAL	15	10	3

*when not obscured by other structures (eg. macrophytes, large woody debris)

FIGURE 1. Example of a completed Method Decision Table to guide the selection of which protocol method to use. For each parameter identify the most appropriate 'Condition' that describes your site and enter the corresponding score for each method in three boxes on the right hand side. Once all parameters are completed sum the three columns in the bottom right hand corner. The method with the highest score is the optimal one to use at the site. Note that for the "vegetation or anything that obscures vision of bed" parameter the potential to mobilise sediment by walking on the stream bed while undertaking electrofishing or spotlighting must also be considered. A blank copy of the table is provided in Appendix 5.

3.3 Species Biases

All three techniques are species selective which means that they are more effective at capturing some species than others. To some degree effectiveness is also influenced by a range of other factors such as habitat complexity and various environmental factors. Operators need to be aware of these biases and take them into account when selecting methods and interpreting data.

Table 2 provides a general guide to the species specific biases inherent in each of the methods covered in these protocols. In general terms backpack electrofishing is more effective for species that utilise fast flowing habitats, and spotlighting is selective for species that utilise slow flowing habitats. Fyke nets are selective for cover-seeking mobile species (Hubert, 1996; Portt *et al.*, 2006), although this may be less of a factor in wadeable streams where the entire water column can be sampled. Gee minnow traps (GMTs)are also selective for mobile and cover seeking species and will only capture small fish that are able fit through the trap entrances. The depth at which GMTs are set can also influence catches because they tend to sample a limited depth of water. For example, surface specialists such as *Gambusia* will be less frequently caught if traps are set at depths greater than about 20 cm.

TABLE 1. Relative advantages and disadvantages of protocol methods; if the Method Decision Table gives an equivocal result (method scores are within 0–3 points) then this table can be used to help make a final decision.

Parameter	Spotlighting	Electrofishing	Trapping
Time taken to sample	Fast	Moderate	Moderate
Return trip required	No	No	Yes
Amount of equipment	Low	High	High
Expense of equipment	Low	High	Moderate
Impaired by broken water	Yes	No	No
Sampling done during normal working hours	No	Yes	Yes
Ease of identification of fish	Low	High	High
Potential harm to fish	Low	Moderate	High
Reliability of relative abundance estimates	High	High	Low
Effectiveness for collecting size class data	Low	High	High

TABLE 2. Species biases of the three protocol methods for fish species commonly encountered in wadeable streams. The X denotes species which are underestimated using that method. (Note: some biases may vary depending on site conditions but it is assumed that the correct technique is being selected using Tables 1 & 2).

	Species Underestimated By:		
Common name	Electrofishing	Spotlighting	Trapping
Banded kokopu	X		
Giant kokopu	X		
Shortjaw kokopu	X		
Giant bully	X		
Common smelt	X		
Inanga	X		
Mullet	X		X
Black flounder			X
Redfin bully			X
Common bully		X	
Non-migratory bullies		X	X
Longfin & Shortfin eel		X	X
Non-migratory galaxiids		X*	X
Koaro		X	X
Bluegill bully		X	X
Torrentfish		X	X
Lamprey		X	X
Salmonids		X	X

* Juveniles will be readily observed but adults will be underestimated.

Photo: Electrofishing wand © EOS Ecology / Bronwyn Gay

3.4 Backpack Electrofishing Method

The backpack electrofishing method uses a single-pass method over 150 m of stream and is based on a standardised US EPA protocol (Peck *et al.*, 2006) adapted by David & Hamer (2010). The machine settings described in this method relate specifically to NIWA Kainga EFM300 backpack machines, which at the time of writing were the only electrofishing machines in common use in New Zealand. These protocols have been developed and designed specifically for long-term monitoring of reach scale fish community attributes across a wide range of wadeable stream types. Wadeable for the purposes of these protocols is defined as sites where 90% of the reach being sampled is 0.6 m deep or less and has an average wetted width of 12 m or less. Attributes and data that can be obtained from these protocols over time include; reach scale fish diversity (e.g., native vs. exotic), relative abundance (fish/100 m^2), and size structure. Additionally, distributions of fish within each sample reach can be tracked through time because each sample reach is split into ten continuous 15 m subreaches. These data may for instance be useful for determining habitat stability within a sample reach and/or whether certain parts of the reach consistently support more or less fish than others.

Lists of equipment required to carry out the backpack electrofishing method are provided in Appendix 3.

3.4.1 Sampling Procedures

① Walk the reach to be sampled (150 m) to ensure that there are no major tributaries joining or major impediments within the reach to be sampled. If possible do this without walking in the stream. While doing this use a tape measure or hip chain to divide the sample reach into ten 15 m subreaches and mark with flagging tape. Obtain GPS points for the top and bottom of the site and fill this in along with the date on the Fish Collection Form.

② At least 50% of the reach upstream and at least 50% of the area downstream of the midpoint must be 'fishable' by electrofishing for this method to be used. If at least 50% the reach either side of the midpoint cannot be

electrofished the reach will be deemed 'unfishable' using the electrofishing protocols. The reason for imposing this 'rule' is to ensure that if the reach is electrofished, that sufficient spatial area within the recommended lineal distance is covered by the method. If not, an alternative method or combination of methods is likely to be required to confidently obtain diversity and relative abundance measures at the reach scale.

③ Measure and record water clarity, dissolved oxygen, temperature, and conductivity on the form. If it is not possible to undertake step one without entering the stream channel, ensure that these measures are upstream of any streambed disturbance.

④ Once the settings on the electrofishing machine are adjusted properly to sample effectively and minimise injury and mortality (see Section 3.4.2 for details), record these settings and the anode ring size used (big/small). Following this, reset the 'elapsed time' (using the 'clear' button) on the back of the machine so it reads zero (Figure 2). Also remember to record the 'start' time and begin sampling at the downstream end of the reach (subreach A).

⑤ The person holding the pole net downstream of the electrofisher captures any stunned or fleeing fish, and places them in a bucket. The fisher may also use hand nets to capture any stunned fish. Stopnets to block the upstream and downstream end of the reach are **not** used. The fisher starts on the edge of either bank and should be positioned 2–4 m above the pole netter. The fisher then fishes down towards the pole netter sweeping the wand from side to side but in line with the pole net. Generally this means a rectangular area or 'lane' of approximately 6–8 m^2 is fished on each pass. It is important that the machines cathode ('tail') is always between the fisher and the pole netter but that the anode ring does not make contact with it. This is important because fishing in this way concentrates the field to the area being fished thus reducing electrical charge to water beyond the immediate area. Fish through the lane quickly and consistently. After fishing a 'lane' both the pole netter and fisher move a 'pole net width' across the channel to fish another 'lane'. The fisher must remember to reposition the cathode between him/herself and the pole netter after each move across the channel. Once the other side of the channel is reached, both the pole netter and fisher move upstream approximately 3 m to repeat the process continuing upstream and from bank to bank.

⑥ Search and sample for fish (including koura (crayfish) and shrimp) even if the stream is extremely small, and it appears that sampling may produce no specimens. Sample all available habitats without bias including shallow margins that may appear to be devoid of fish. Place collected fish into a bucket with fresh stream water. Move the anode wand into cover with the electric current on then remove the wand quickly to draw fish out. In stretches with deep pools, fish the margins of the pool as much as possible, being extremely careful not to step or slide into deep water. If more than a 2 m^2 area can't be fished (e.g., a large, deep pool) estimate or preferably measure the area that can't be fished and record this on the form. This area will later be subtracted from the total reach area fished. Do this by creating a 'flag' and comment (e.g., F1 – deep pool in subreach B, fished edge, 3 m^2 area not fished).

⑦ If wearing a hip chain keep an eye on the distance travelled or search stream banks for marked flagging tape (placed earlier) denoting the end of a subreach. At the end of a subreach (15 m) process fish and/or change water to stop mortality, and track sampling effort. See Section 3.4.3 for guidance on how to process fish. Once fish have been processed, remember to measure the stream wetted width at that end of the subreach and record this in the 'wetted width' space provided for each subreach. This is important as these widths will be averaged later on and used to calculate the stream area sampled.

⑧ Repeat steps 4–7 until all subreaches are completed. Record the number of subreaches sampled (e.g., all 10, 5–9 or <5) on the collection form by filling in the appropriate 'bubble'; note which subreaches (if any) were not sampled and why. Sample distance is the total reach length actually fished (i.e., it will be equal to or less than the target 150 m reach length). Record the total shocking time ('elapsed time' on the back of the electrofishing machine) in the 'total shock (button) time' and actual 'finish' time. This is important because it provides information on the effort expended and the time taken to complete a site. This information is useful if repeat visits to the site are planned.

3.4.2 Electrofishing Machine Settings

The ambient conductivity will determine the initial voltage setting selected. If conductivities are suitable for electrofishing, select initial voltage setting (1–4* for high conductivity [>300 µS/cm]; 2–5 for medium conductivity [100 to 300 µS/cm]; 3–6 for low conductivity [<100 µS/cm] waters). In waters with primarily larger fish (length >200 mm), use a pulse rate frequency of 30 pps with a pulse width of 2 msec. If mostly small fish are expected, use a pulse rate of 60–70 pps. It is well worth testing these settings immediately below the selected site to check their effectiveness – adjust if necessary. If final settings result in all six lights showing on the wand drop the voltage first until five lights or less appear. If fish response is poor, increase the pulse width first and then the voltage. Increase the pulse rate last to minimise mortality or injury to large fish. If mortalities occur, first decrease pulse rate, then voltage, then pulse width.

* These are the values used by the Kainga EFM300 electrofishing machine. Multiply by 100 to calculate actual voltage.

3.4.3 Recording Procedure

The following steps should be followed when processing the fish caught using this method.

① An example of a completed electrofishing Fish Collection Form is provided in Figure 3 and blank collection forms are provided in Appendix 5. If no fish, koura or shrimp were collected after fishing the 10 subreaches, fill in the 'Fished none collected' bubble on the collection form.

② Identify and measure each individual at the end of each subreach, ideally handling each fish only once. If a species cannot be positively identified, assign it as "unidentified" followed by its common family name (e.g., "unidentified bully"). Keep up to 20 sample specimens (see step 4) for later identification back at the laboratory. Note every subreach where a species is collected by listing it under the appropriate subreach column on the form. Koura and shrimp are not measured. Record koura as number of individuals captured and place shrimp into one of the following four categories: 1–10, 10–100, 100–1000, 1000+.

③ Process any species with a 'threatened' conservation status first and return individuals immediately to the stream. Photograph specimens for voucher purposes if conditions permit and if stress to individuals is minimal. Indicate if photographed on Fish Collection Form. If individuals have died, prepare them as voucher specimens and preserve in formalin or ethanol and add them to the mortality column on the form (see step 7).

④ If a species is encountered that cannot be identified, keep voucher specimens (up to 20 from throughout the reach) of smaller individuals. If no small individuals are collected, photograph each species and indicate so on the form. Retaining 20 smaller specimens can be used to later adjust count data when one apparent species turns out to be more than one. For example, if you collect 20 voucher individuals of species A and 5 turn out to be species B then total number of individuals can be adjusted so that 75% of the total is assigned to species A and 25% to species B (e.g., if juvenile Cran's and common bullies are encountered).

⑤ It is strongly recommended that all fish captured are counted and that fish total length (nose to distal end of the caudal fin) is measured for the first 50 fish of each species captured. No lengths for koura or shrimp need to be recorded. If more than 50 of a particular fish species are captured, it is recommended that an additional 10 individuals (the first 10 captured) of that species per subsequent sub-reach are also measured. The maximum number of measures per species possible for a site is 140 (i.e., 50 in subreach A + 10 x 9 subreaches = 140) even though many more may have been captured. All age 0+ fish † collected will need to be counted as they may need to be removed during analysis. Examine each individual for external anomalies and tally those observed. Readily identified external anomalies include missing organs

† Fish in their first year of life. Also known as YOY (young of year) or age-0 fish.

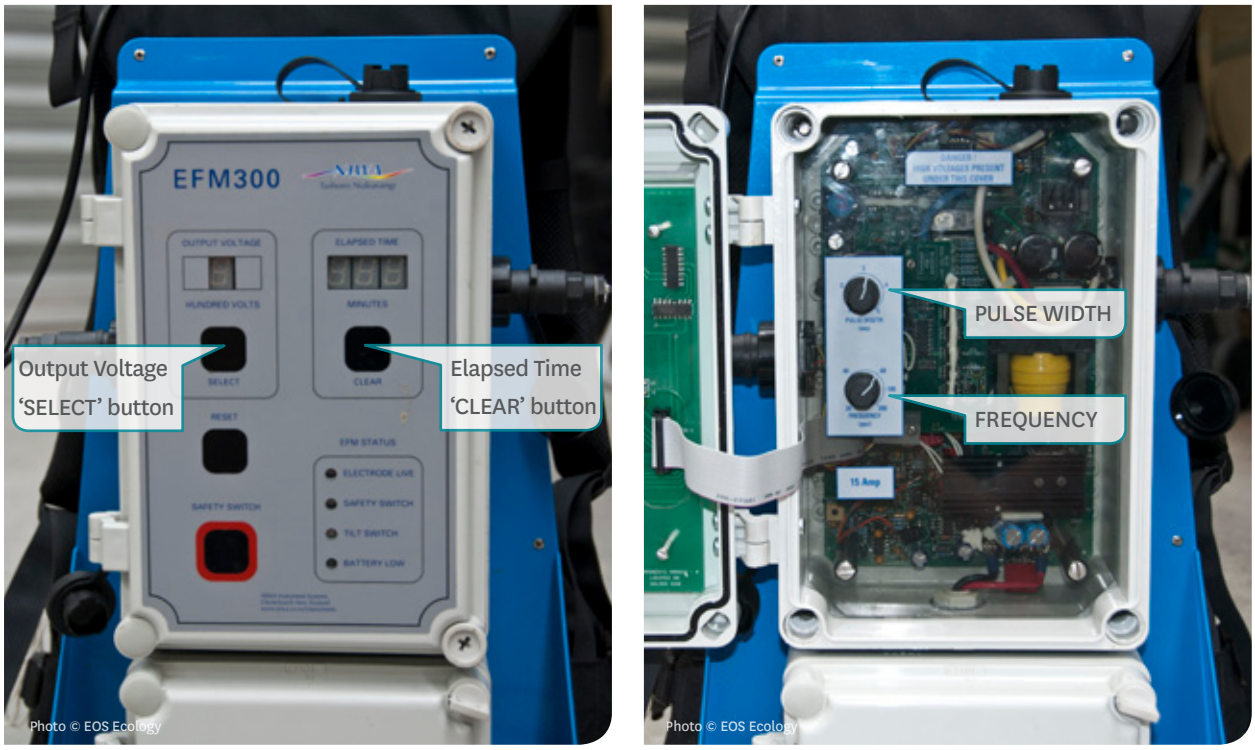
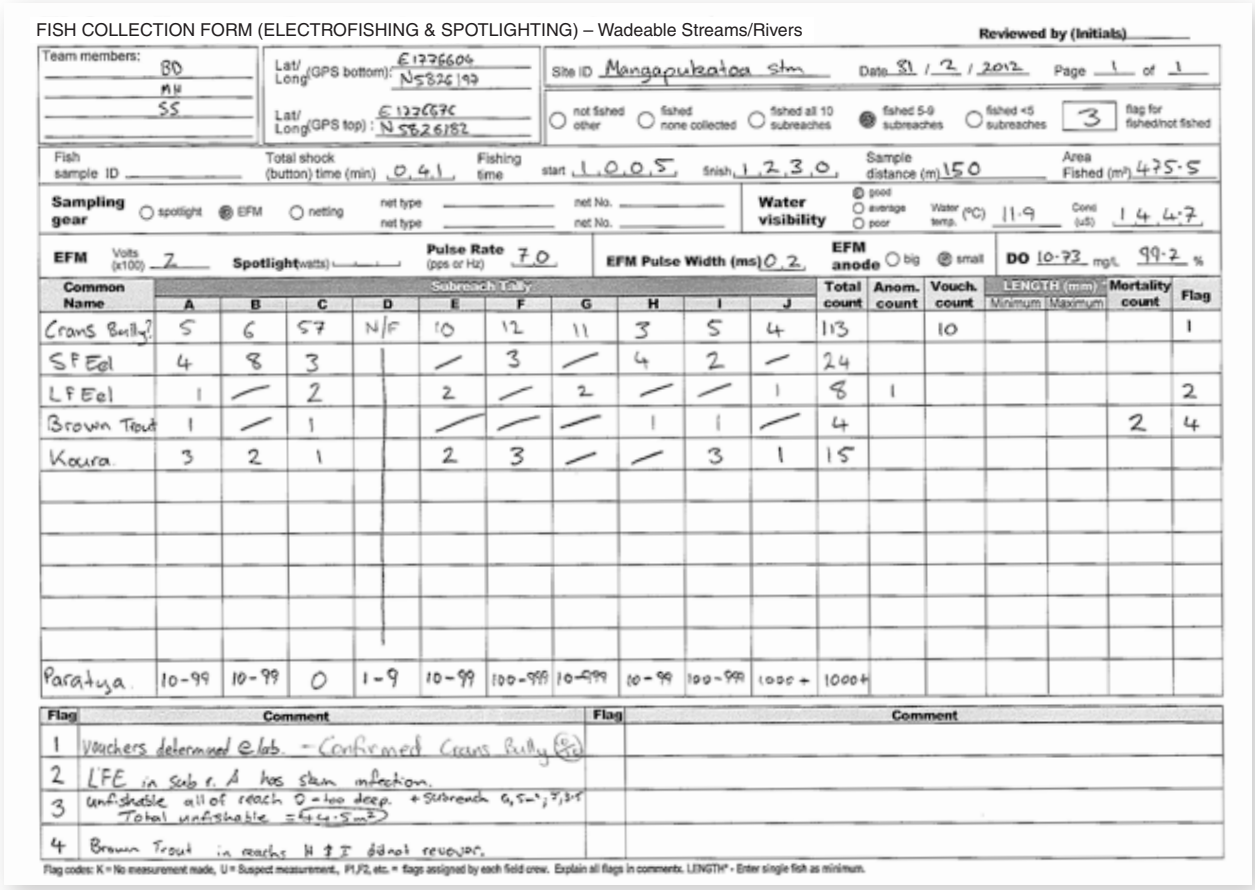


FIGURE 2. NIWA Kainga EFM300 electrofishing machine.



FISH COLLECTION FORM (ELECTROFISHING & SPOTLIGHTING) – Wadeable Streams/Rivers

Reviewed by (Initials) _____

Team members: BD, MH, SS

Lat/Long (GPS bottom): E 1776604 N 5826197

Lat/Long (GPS top): E 1776675 N 5826182

Site ID: Mangapukatea stm Date: 31 / 2 / 2012 Page 1 of 1

not fished other ○ | fished none collected ○ | fished all 10 subreaches ○ | fished 5-9 subreaches ● | fished <5 subreaches ○ | flag for fished/not fished: 3

Fish sample ID: _____ Total shock (button) time (min): 0,4,1 Fishing time: start 1,0,0,5 finish 1,2,3,0 Sample distance (m) 150 Area Fished (m²) 475.5

Sampling gear: ○ spotlight ● EFM ○ netting net type _____ net No. _____ net type _____ net No. _____

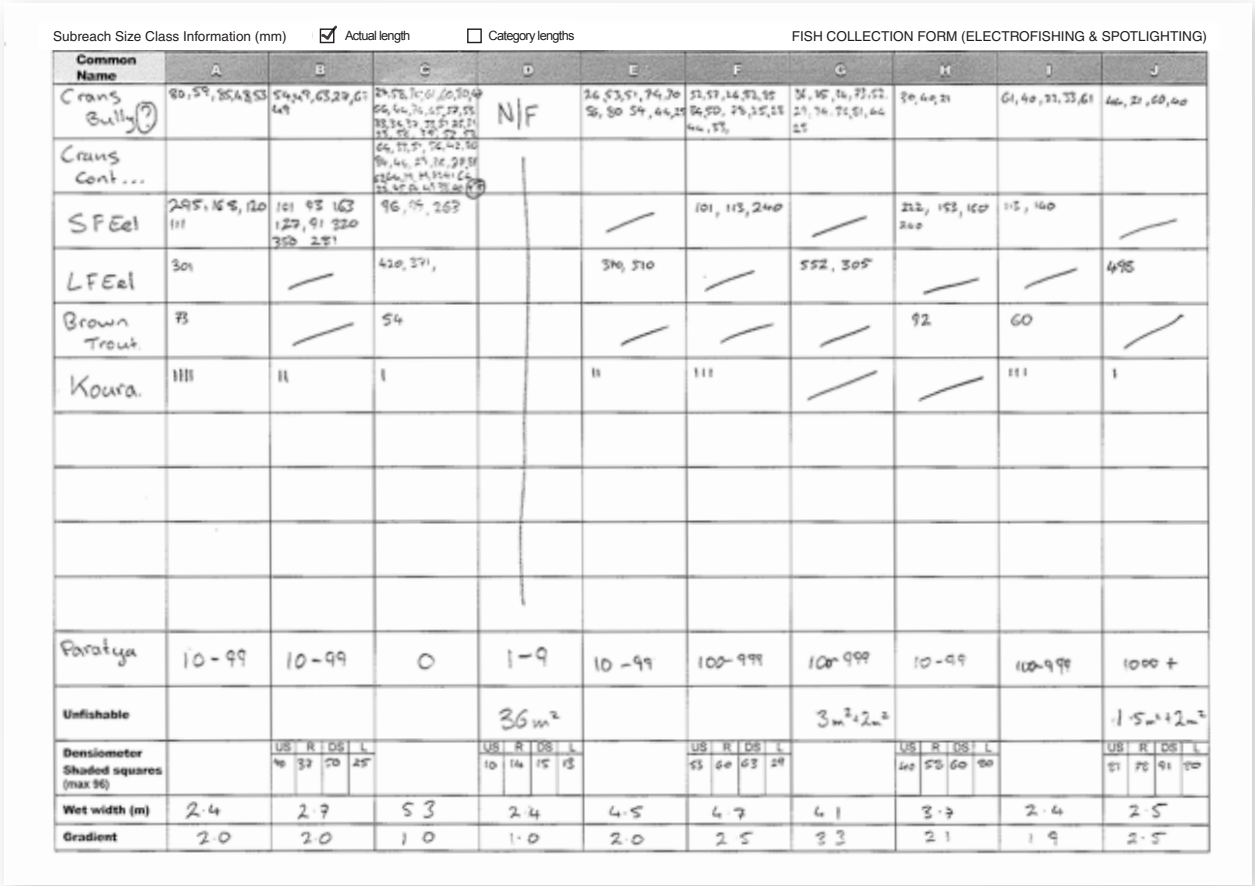
Water visibility: ● good ○ average ○ poor Water temp. (°C) 11.9 Cond. (uS) 144.7

EFM: Volts (x100) 2 Spotlight (watts) _____ Pulse Rate (pps or Hz) 70 EFM Pulse Width (ms) 0.2 EFM anode ○ big ● small DO 10.73 mg/L 99.2 %

Common Name	Subreach Tally A	B	C	D	E	F	G	H	I	J	Total count	Anom. count	Vouch. count	LENGTH (mm) Minimum	Maximum	Mortality count	Flag
Crans Bully?	5	6	57	N/F	10	12	11	3	5	4	113		10				1
SF Eel	4	8	3	|	/	3	/	4	2	/	24						
LF Eel	1	/	2	|	2	/	2	/	/	1	8	1					2
Brown Trout	1	/	1	|	/	/	/	1	1	/	4					2	4
Koura	3	2	1	|	2	3	/	/	3	1	15						
				|													
				|													
				|													
				|													
				|													
				|													
Paratya	10-99	10-99	0	1-9	10-99	100-999	10-99	10-99	100-999	1000+	1000+						

Flag	Comment	Flag	Comment
1	Vouchers determined @ lab - Confirmed Crans Bully (Gc)		
2	LFE in Subr. A has stem infection.		
3	Unfishable all of reach 0 - 100 deep. + Subreach A, 5-10; 75-85 Total unfishable = 44.5 m²		
4	Brown Trout in reaches H & I did not recover.		

Flag codes: K = No measurement made, U = Suspect measurement, F1,F2, etc. = flags assigned by each field crew. Explain all flags in comments. LENGTH* - Enter single fish as minimum.



Subreach Size Class Information (mm) ☑ Actual length ☐ Category lengths FISH COLLECTION FORM (ELECTROFISHING & SPOTLIGHTING)

Common Name	A	B	C	D	E	F	G	H	I	J
Crans Bully?	80,59,85,48,53	54,49,63,29,67	29,58,[illegible]	N/F	26,53,51,74,30	32,57,46,52,95	36,45,14,77,52	80,40,21	61,40,23,33,61	46,21,60,40
Crans Cont...										
SF Eel	295,168,120	101 93 163 129,91 320 350 251	96,[illegible],263			101, 113, 240		212, 153, 160 260	113, 140	
LF Eel	301		420, 371,		390, 310		552, 305			498
Brown Trout	78		54					92	60	
Koura	IIII	II	I		II	III			III	I
Paratya	10-99	10-99	0	1-9	10-99	100-999	100-999	10-99	100-999	1000+
Unfishable				36 m²			3 m² + 2 m²			1.5 m² + 2 m²
Densiometer Shaded squares (max 96)		US 40 R 32 DS 20 L 25		US 10 R 14 DS 15 L 13		US 53 R 60 DS 63 L 29		US 40 R 55 DS 60 L 80		US 51 R 75 DS 91 L 90
Wet width (m)	2.4	2.7	5.3	2.4	4.5	4.7	4.1	3.7	2.4	2.5
Gradient	2.0	2.0	1.0	1.0	2.0	2.5	3.3	2.1	1.9	2.5

FIGURE 3. Example of a completed electrofishing Fish Collection Form.

(eye, fin), skeletal deformities, shortened operculum, eroded fins, irregular fin rays or scales, tumours, lesions, ulcerous sores, blisters, cysts, blackening, white spots, bleeding or reddening, excessive mucus, and fungus. After all of the individuals of a species have been processed, record the total number of individuals affected. Photograph specimens with extreme anomalies.

⑥ Record the total number of mortalities due to electrofishing or handling.

⑦ Follow the appropriate procedure to prepare voucher specimens and/or to select specimens for tissue samples. Release all remaining individuals so as to avoid their recapture (i.e., at least one pool riffle sequence downstream or in their absence 20 m downstream).

⑧ For any line with a fish name, ensure that all spaces on that line are filled in with a number, even if it is zero.

⑨ Tally the number of individuals of each species collected in the 'Total count' box on the Fish Collection Form after the 10 subreaches have been fished.

⑩ Repeat Steps 1–9 for all other species.

3.4.4 Recording Procedure if Parts of Reach are Unfishable

In areas within the site where electrofishing is unsafe or ineffective (e.g., too deep or fast), measure or estimate the area that is 'unfishable' and record this on the Fish Collection Form under the appropriate subreach column (e.g., Row: 'Unfishable', Column: 'B', 3 m^2). The total unfishable area for the site will be summed and subtracted from total wetted area of the site calculated from average stream widths.

3.4.5 Fish Seen but Not Caught

While fishing a reach, record the number of any other fish stunned or seen in the subreach but not captured. Additionally small shoaling species (e.g., inanga, smelt) may be seen in a reach but may avoid the operators and/or electric current. These fish are not included in the total tally but can be recorded as missed fish (e.g., "missed eel", "missed bully") on the Fish Collection Form. If the species cannot be clearly identified record as "missed fish". Do not guess or assume what the species is if it cannot be clearly identified.

3.4.6 Electrofishing Tips

- Fishing teams of at least three people are recommended to allow sampling to proceed smoothly. To maintain a standardised level of effort it is recommended that only two people, including the machine operator, should be actively collecting fish. If only two people are available, a catch bucket can be strapped to the fishing machine or fishing machine operator.
- Avoid contact between the anode and cathode but if possible, fish with the cathode between the fisher and the pole netter. Fishing with the anode and cathode close together keeps a tighter and arguably more controlled electrical field.
- It is often useful for both the pole netter and fisher to use bankside or instream objects as a marker or point of reference to maintain a constant line as they move across the channel. This increases sampling efficiency and minimises the potential for fishing areas that has already been fished.
- Consider your position relative to surface glare to maximise visibility and fish capture. Wear polarised sunglasses and sunhats to aid vision. In some situations (e.g., under thick canopy cover or when there is humic coloration) better visibility may be experienced without wearing polarised glasses.
- Mark the flagging tape with letters corresponding to the subreach name in the Fish Collection Form so that fish records are not placed in the wrong subreach. Labelling each subreach also makes retracing your steps much easier if for any reason data entry becomes out of step with the electrofishing.
- Ensure the pole net base forms a tight seal with the stream bed and is positioned so that any immobilised and or dislodged fish are more likely to be carried up and into the net by the current rather than down and under it.
- When fishing down a 'lane', and when reaching the pole netter, hover with the anode near the pole net opening for 3 seconds before directing the pole netter to lift his catch. These few seconds often allow some fish that have been immobilised but caught up on the bottom or in weed to be carried through by the current and into the net, whilst preventing any already within the net (and that may have already recovered) escaping out the front.
- Record elapsed time at end of each subreach if possible so that if the machine fails at some point during sampling and elapsed time is lost it will still be possible to record fishing effort for all the previous subreaches.

3.5 Spotlighting Method

Spotlighting is a sampling technique particularly suitable for wadeable streams in New Zealand. This is because many freshwater fish species are benthic (and sub-benthic) and nocturnal. As with any technique there are advantages and disadvantages with its use. Although some conflicting studies exist, in general one pass spotlighting under appropriate conditions (see method selection Tables 1 and 2) tends to be most effective for detecting many of New Zealand's larger primarily nocturnal galaxiids. If good visibility exists (e.g., minimal surface turbulence), typically diurnal species can also be clearly observed and counted by experienced operators. In contrast, juvenile eels and lamprey in particular tend to be underrepresented by spotlighting as they often live and move within the streambed even at night. Perhaps the greatest advantage of spotlighting is that it is a fairly rapid and largely non-invasive technique that requires very little equipment. When used in appropriate situations, the greatest disadvantage is that catching fish to obtain accurate length measures is very time consuming. We recommend experienced operators visually estimate fish size by placing them in defined species size categories and regularly capture and measure some fish during surveys to 'calibrate' and record their 'visual estimate error'.

Lists of equipment required to carry out the spotlighting method are provided in Appendix 3.

3.5.1 Sampling Procedures

(specifically for Lightforce 30w spotlight beams, Figure 4)

① After arriving at a site walk the reach to be sampled (150 m) during daylight hours to ensure that there are no major tributaries joining or major impediments within the reach to be sampled. As this is being done (and providing water clarity/surface is sufficient for spotlighting) use a tape measure or hip chain to split the site into 10 equidistant subreaches with marked flagging tape. Since 150 m will be sampled, each subreach will be 15 m long. Obtain GPS points for the top and bottom of the site and fill this in along with the date on the Fish Collection Form.

② Measure and record the stream temperature and conductivity on the form. Following this, fill in the 'spotlight' bubble and indicate the bulb strength (30 watt recommended).

③ Do not begin sampling until at least 45 minutes after sunset. Record the 'start' time in the 'fishing time' slot on the collection form and begin spotlighting at the downstream end of the reach (subreach A). Commence walking in an upstream direction scanning the spotlight beam from bank to bank approximately 1–2 m upstream. Do not scan the beam more than 4 m ahead. This will prevent frightening fish that are further upstream. If possible keep out of the water as this will reduce wave-induced refraction and maintain good visibility. Make a conscious effort to look for small benthic as well as larger fish. Call out species identified to a following team member assigning fish to a size category outlined in Appendix 4. Make an effort to catch any fish that cannot be identified from the bank. Move quietly and at a constant pace. This will generally prevent fish moving in an upstream direction and being double counted. Many New Zealand native fish are very sensitive to vibrations at night and heavy footsteps can frighten fish well upstream. If you need to stop while spotlighting, do so at a riffle where the chances of fish moving upstream is reduced. If a species is seen but not identified, identify it to closest confident taxonomic level (e.g., "unidentified kokopu"). Capture a few different fish species early on in the sampling using two dip nets and estimate and record their length prior to measuring them (this is done to calibrate length estimations, see Section 3.5.2). To capture fish at night keep the spotlight beam focussed directly on the fish. Move very slowly though the water and very gently place one net at the tail end of a fish being careful not to touch the tail. Gently bring the second net toward the head end. Resist the temptation to 'snatch' at fish as in most cases this will result in a failed capture attempt with a reduced chance of an additional attempt. Often it is possible to very gently nudge fish toward the other net. If the fish darts away, generally it will dive straight into the net placed behind it at which point the net should be raised rapidly. Measure and record any captured fish noting this as a 'flag' on the form (e.g., F1 banded kokopu visual estimate 125 mm, actual 133 mm). These values can be used later to record an observers 'visual length estimate error'.

④ Search and sample for fish (including koura and shrimp) even if the stream is extremely small, and it appears that sampling may produce no specimens. Sample all available habitats without bias including shallow margins that may appear to be devoid of fish. In stretches where visibility is precluded by an area exceeding 2 m^2 (continuous), measure the area that can't be fished and record this on the form. This area will later be subtracted from the total reach area fished to indicate the 'spotlightable' area that was surveyed.

⑤ If wearing a hip chain keep an eye on the distance travelled or search stream banks for flagging tape (placed earlier) denoting the end of a subreach. Once fish have been collated after each subreach and recorded under the appropriate column, remember to record the stream wetted width at that point in the 'wetted width' space provided for each subreach. This is important as these widths will be averaged later along with total stream length fished to provide the stream area sampled.

⑥ Continue through the following subreaches. To ensure the size ranges of different species are recorded, try to capture or estimate the sizes of any species which appear smaller or larger than any seen previously. Record maximum and minimum fish lengths for each species. If fish are definitely seen but cannot be identified to any taxonomic level list them as "missed fish". Eels are often difficult to catch without large dip nets at night and identifying them can be difficult particularly when they are small. Record eels that can't be confidently identified as "unidentified eel" otherwise record them next to their relevant species name. In most cases it is likely that some will be identifiable and others will not so record both. At a coarser level it will be possible to tally up all 'eels' for a site. This same problem may apply to some of the bully species. Be sure to spotlight all habitats where possible (deep, shallow, fast, slow, complex, and simple).

⑦ Repeat steps 5 and 6 until all subreaches are completed. Record the number of subreaches sampled (all 10, 5–9 or <5) on the collection form by filling in the appropriate 'bubble'; note which subreaches (if any) were not sampled and why in the comments section of the form. Sample distance is the total reach length actually fished (i.e., it will be equal to or less than the 150 m reach length). Don't forget to record the spotlighting start and finish time in the 'Fishing time' location on the form as this represents the 'effort' expended.

FIGURE 4. Lightforce 30 watt spotlight and battery.

3.5.2 Recording Procedure

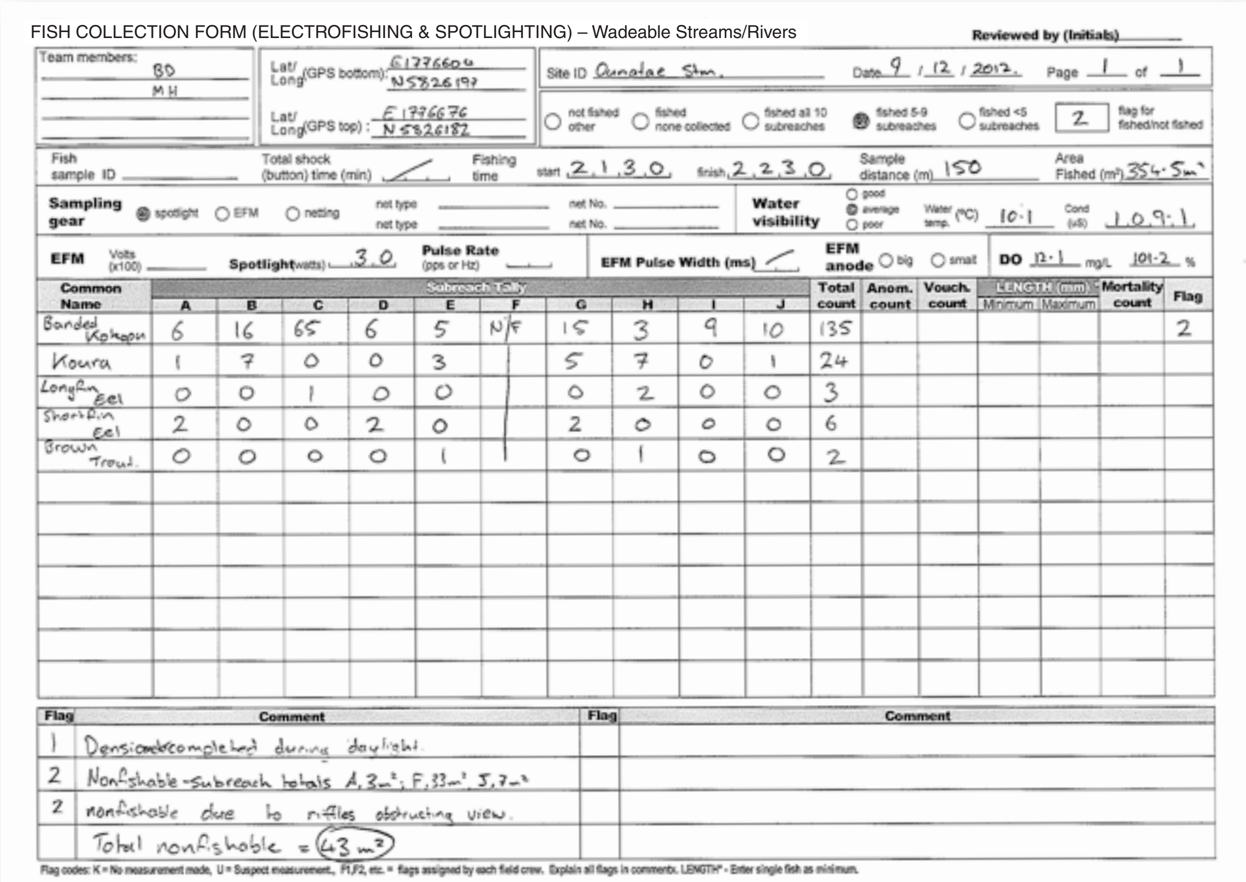
The following steps should be followed when processing the fish caught using the spotlighting method.

① Complete all header information accurately and completely on the Fish Collection Form. An example of a completed spotlighting Fish Collection Form is provided in Figure 5 and blank forms are provided in Appendix 5. If no fish, koura or shrimp were collected after fishing the 10 subreaches, fill in the 'Fished none collected' bubble on the collection form.

② Identify and record each fish species observed and estimate its total length. Record the common name on the first blank line in the 'Common Name' section of the Fish Collection Form. Assign size class codes based on those recommended in Table 3 or a pre-defined size class table specifically designed for the survey or monitoring programme. Alternatively estimate the length of fish to the nearest centimetre and assign to size classes during the analysis stage.

TABLE 3. Suggested size class categories for use in recording fish lengths estimated using the spotlighting method. Because growth rates of fish populations may vary nationally there may be value in developing size class categories tailored to specific survey or monitoring programmes.

Species common name	0+ (mm)	Small (mm)	Med (mm)	Large (mm)
Bluegill bully	≤20	21-30	31-40	41+
Redfin bully	≤20	21-40	41-60	61+
Common bully	≤20	21-40	41-60	61+
Cran's bully	≤20	21-40	41-60	61+
Upland bully	≤20	21-40	41-60	61+
Tarndale bully	≤20	21-40	41-60	61+
Giant bully	≤20	21-60	61-150	151+
Torrentfish	≤40	41-60	61-90	91+
Common smelt	≤40	41-60	61-80	81+
Stokell's smelt	≤40	41-60	61-80	81+
Inanga	≤40	41-60	61-80	81+
Koaro	≤50	51-100	101-150	151+
Banded kokopu	≤50	51-100	101-200	201+
Shortjaw kokopu	≤50	51-100	101-200	201+
Giant kokopu	≤50	51-100	101-200	201+
Longfin eel	≤100	101-300	301-500	501+
Shortfin eel	≤100	101-300	301-500	501+
Spotted eel	≤100	101-300	301-500	501+
Lamprey	Ammocoete	Macrophthalmia	NA	Adult
Clutha flathead galaxias	≤25	26-50	51-90	90+
Alpine galaxias	≤25	26-50	51-90	90+
Dusky galaxias	≤25	26-50	51-100	100+
Eldon's galaxias	≤25	26-50	51-100	100+
Flathead galaxias	≤25	26-50	51-90	90+
Gollum galaxias	≤25	26-50	51-90	90+
Longjaw galaxias	≤20	21-30	30-50	50+
Canterbury galaxias	≤40	41-60	60-100	100+
Central Otago roundhead galaxias	≤25	26-50	51-90	90+
Yellow eye mullet	≤50	51-100	101-150	151+
Grey mullet	≤50	51-100	101-300	301+
Black flounder	≤50	51-100	101-200	201+
Tench	≤50	51-180	181-250	251+
Gambusia	≤5	6 to 15	16-25	26+
Guppy	≤5	6 to 15	16-25	26+
Rainbow trout	≤80	81-220	221-500	501+
Brown trout	≤80	81-220	221-500	501+
Atlantic salmon	≤80	81-200	201-350	351+
Brook char	≤50	51-100	100-200	200+
European perch	≤50	51-100	101-250	251+



FISH COLLECTION FORM (ELECTROFISHING & SPOTLIGHTING) – Wadeable Streams/Rivers   **Reviewed by (Initials)** ______

Team members: BD, MH

Lat/Long (GPS bottom): E1776604 N5826197

Lat/Long (GPS top): E1776676 N5826182

Site ID: Ounatae Stm.   Date: 9 / 12 / 2012.   Page 1 of 1

○ not fished other ○ fished none collected ○ fished all 10 subreaches ● fished 5-9 subreaches ○ fished <5 subreaches   2 flag for fished/not fished

Fish sample ID ______   Total shock (button) time (min) /   Fishing time start 2130 finish 2230   Sample distance (m) 150   Area Fished (m²) 354·5m²

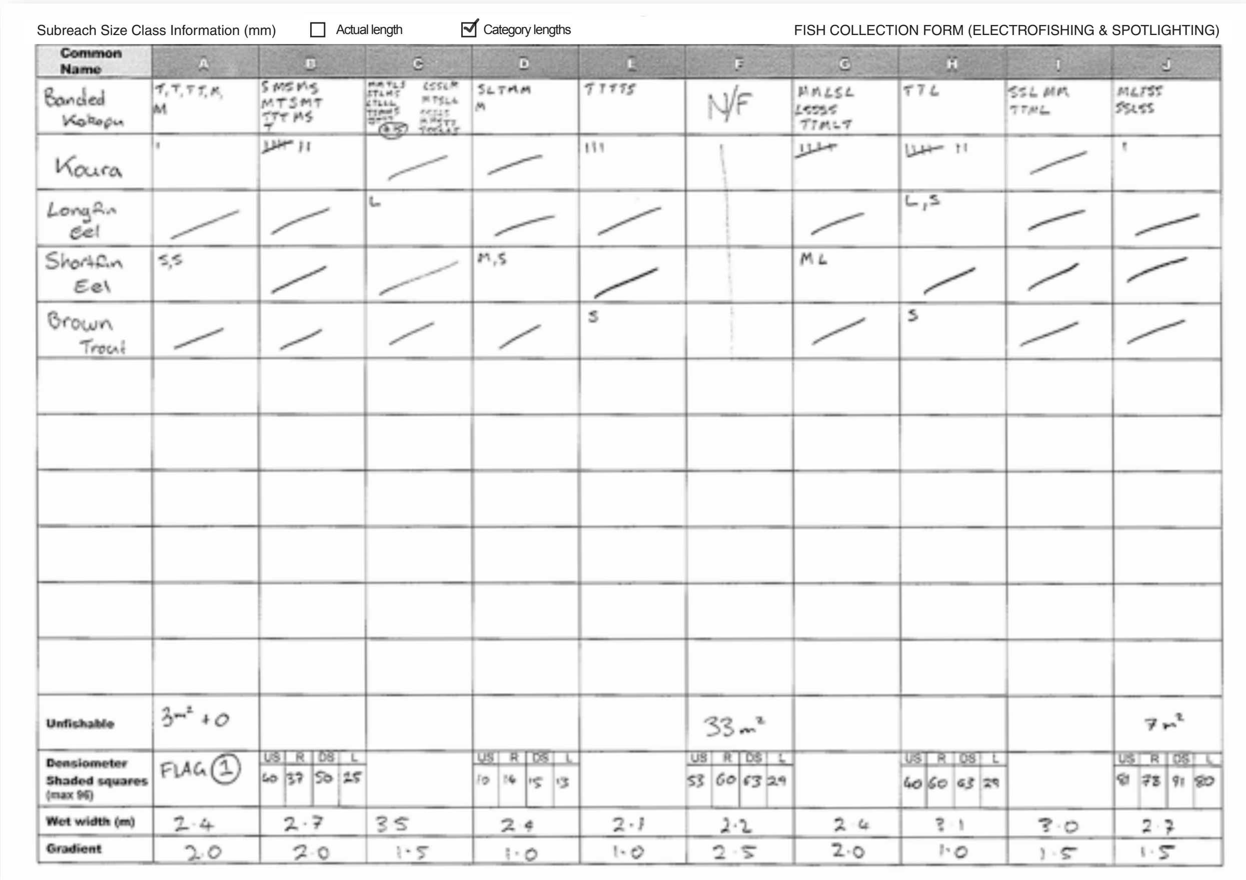
Sampling gear ● spotlight ○ EFM ○ netting   net type ______ net No. ______   **Water visibility** ○ good ● average ○ poor   Water temp. (°C) 10·1   Cond (uS) 109·1

EFM Volts (x100) ______   **Spotlight** (watts) 30   **Pulse Rate** (pps or Hz) ______   **EFM Pulse Width (ms)** /   **EFM anode** ○ big ○ small   **DO** 12·1 mg/L 101·2 %

Common Name	A	B	C	D	E	F	G	H	I	J	Total count	Anom. count	Vouch. count	LENGTH (mm) Minimum	LENGTH (mm) Maximum	Mortality count	Flag
Banded Kokopu	6	16	65	6	5	N/F	15	3	9	10	135						2
Koura	1	7	0	0	3		5	7	0	1	24						
Longfin Eel	0	0	1	0	0		0	2	0	0	3						
Shortfin Eel	2	0	0	2	0		2	0	0	0	6						
Brown Trout	0	0	0	0	1		0	1	0	0	2						

Flag	Comment	Flag	Comment
1	Densiometer completed during daylight.		
2	Nonfishable subreach totals A, 3m²; F, 33m², J, 7m²		
2	nonfishable due to riffles obstructing view.		
	Total nonfishable = 43 m²		

Flag codes: K = No measurement made, U = Suspect measurement, F1,F2, etc. = flags assigned by each field crew. Explain all flags in comments. LENGTH* - Enter single fish as minimum.



Subreach Size Class Information (mm)   ☐ Actual length   ☑ Category lengths   FISH COLLECTION FORM (ELECTROFISHING & SPOTLIGHTING)

Common Name	A	B	C	D	E	F	G	H	I	J
Banded Kokopu	T,T,TT,M, M	SMSMS MTSMT TTTMS T	[illegible]	SLTMM M	TTTTS	N/F	MMLSL LSSSS TTMLT	TTL	SSLMM TTML	MLTSS SSLSS
Koura	I	HHT II	/	/	III		HHT	HHT II	/	I
Longfin Eel	/	/	L	/	/		/	L,S	/	/
Shortfin Eel	S,S	/	/	M,S	/		ML	/	/	/
Brown Trout	/	/	/	/	S		/	S	/	/
Unfishable	3m² + 0					33m²				7m²
Densiometer Shaded squares (max 96)	FLAG (1)	US 60, R 37, DS 50, L 25		US 10, R 14, DS 15, L 13		US 53, R 60, DS 63, L 29		US 60, R 60, DS 63, L 29		US 81, R 78, DS 91, L 80
Wet width (m)	2·4	2·7	3·5	2·4	2·1	2·2	2·4	3·1	3·0	2·7
Gradient	2·0	2·0	1·5	1·0	1·0	2·5	2·0	1·0	1·5	1·5

FIGURE 5. Example of a completed spotlighting Fish Collection Form.

③ If a species cannot be positively identified, assign it as "unidentified" followed by its common family name (e.g., "unidentified bully"). Keep up to 20 sample specimens (see step 4) for later identification back at the laboratory. If no small individuals are collected, photograph each species and indicate so on the data form. Retaining 20 smaller specimens can be used to later adjust count data when one apparent species turns out to be more than one. For example if you collect 20 voucher individuals of species A and 5 turn out to be species B then total number of individuals can be adjusted so that 75% of the total is assigned to species A and 25% to species B (e.g., if juvenile Cran's and common bullies are encountered).

④ Note every subreach where a species is collected by listing it under the appropriate subreach column on the form. The length of koura and shrimp are not estimated. Record koura as number of individuals captured and place shrimp into one of the following four categories 1–10, 10–100, 100–1000, 1000+.

⑤ Follow the appropriate procedure to prepare voucher specimens and/or to select specimens for tissue samples. Release all remaining individuals so as to avoid their recapture (i.e., at least one pool riffle sequence downstream or in their absence 20 m downstream).

⑥ For any line with a fish name, ensure that all spaces on that line are filled in with a number, even if it is zero.

⑦ Tally the number of individuals of each species collected in the 'Total count' box on the Fish Collection Form after the 10 subreaches have been fished.

To verify that fish species are being accurately identified and to calibrate visual estimates of fish length it is important that a number of fish species from each site are captured, preferably at the beginning of the sample reach. This verification should be carried out for each sampling reach, particularly when training up new team members. The person with the spotlight should call out the species and estimated length of the fish to fellow team members before attempting to capture the fish. Keep the spotlight beam trained on or to the side of the fish while attempting to catch it. If the fish is captured, confirm the species and measure the fish length before recording next to the estimated length for that individual.

3.5.3 Recording Procedure if Parts of Reach are Unfishable

In areas within the site where spotlighting is unsafe or ineffective (e.g., visibility reduced), measure or estimate the area that is 'unfishable' and record this on the Fish Collection Form under the appropriate subreach column (e.g., Row: 'Unfishable', Column: 'B', 3 m^2). The total unfishable area for the site will be summed and subtracted from total wetted area of the site calculated from average stream widths.

3.5.4 Spotlighting Tips

- Spotlighting drains batteries much faster than backpack electrofishing. Avoid draining lead-acid batteries too far as this will decrease their life span. Change batteries as soon as the spotlight has noticeably dimmed. As a guide, for a 12v 7 Ah sealed lead-acid battery change after 1 hour of continuous use.
- Wear a belt/holster to hang the primary spotlight and swap to a LED based head lamp (e.g., Led Lenser) to free up another hand when attempting to catch fish. This is invaluable when using two dipnets to catch fish.
- Avoid spotlighting on bright full moon nights when fish tend to be more skittish.
- If a fish is seen but it darts away before being able to clearly identify it, switch off all lights (including headlamps) and wait in the dark for around two minutes. In most cases fish will re-emerge from cover over this time allowing a second chance for identification.

Photo: Gee minnow trap © EOS Ecology / Bronwyn Gay

3.6 Trapping Method

In some situations the use of traps (fyke nets and Gee minnow traps (GMTs)) rather than more active methods such as spotlighting and electrofishing may be more appropriate for evaluating reach scale fish communities. As with the selection of other methods, Figure 1 provides an indication of the conditions where netting and trapping may be the more appropriate sampling method.

There are a number of potential issues or unknowns related to the deployment of traps. At times significant mortality, predation and/or escapement can occur and this can vary between equipment types and within and between species. Furthermore very few studies have investigated how many traps and over what time period and spatial scale are required to effectively assess reach scale fish faunas. The results of trials that were undertaken to fill some of these knowledge gaps are presented in the Supporting Information section. The results of the investigation of the effectiveness of exclusion chambers to reduce predation by eels on other fish caught in fyke nets is discussed. Additionally species accumulation curves determine how many nets (GMTs and fyke nets) should be set to obtain a reasonable assessment of the fish community present. Results of the trials showed 6 fyke nets (with internal exclusion pipes) and 12 GMTs (6.4 mm or ¼ inch mesh) spread over 150 m of stream should be sufficient to describe the reach scale community present. The section below describes the sampling procedure.

In establishing a consistent methodology a range of other variables also need to be considered. For instance standardising net and trap dimensions (e.g., mesh size, lead length, net mouth/funnel diameter, etc.) is likely to be important for minimising variability in catch data. It is recognised that a wide range of traps and nets are currently in use by various organisations. It is recommended that for the purposes of SOE monitoring that a consistent set of gear is used*. A recommended standard fyke net design was developed through the field trials and is

* For many organisations with limited resources it may be appropriate to update/upgrade their equipment over time as older gear needs replacing.

described in Section 4.1.3. It is also recommended that the 6.4 mm mesh GMTs (Memphis Net & Twine Co., Inc., model G40M) be used when carrying out the trapping method. While these traps will not work as effectively on very small fish compared to the 3.2 mm mesh traps used for mudfish surveys they are considerably cheaper to purchase. The collection of very small fish is also not seen as critical information and indeed it is sometimes recommended that they are not included in data analysis (see Section 3.10.4.2).

Lists of equipment required to carry out the trapping method are provided in Appendix 3.

3.6.1 Sampling Procedures

① Check the weather forecast. If there is any chance of significant rainfall in the catchment in following 24 hours do not deploy traps.

② If there is potential for dissolved oxygen levels to be low (<4 mg/L, or lots of macrophytes, warm water and sluggish flow are present) overnight then make sure traps are deployed with an air gap† (a space within the trap where fish can gulp air from the surface).

③ After arriving at a site walk the reach to be sampled (150 m) to ensure that there are no major tributaries joining or major impediments within the reach to be sampled. If possible do this without walking in the stream.

④ Obtain GPS points for the top and bottom of the site and fill this in along with the date on the Fish Collection Form.

⑤ Select the reach suitable to be surveyed, mark out the centre point and then place 3 fykes upstream and 3 downstream of this point to the upstream and downstream end of sample reach. Try to stagger the nets over the 75 m above and below the centre point but keeping to deep pools if they exist.

⑥ Place the fyke nets with openings facing downstream to avoid debris being trapped and remember to tie off the cod end to retain fish. Use stakes (or some other type of anchor) at either end to keep the lead and main body of the net taut.

⑦ If stream flow permits place at angle across the stream as much as possible, and the tie cod end close to bank (the idea is to maximise the chance of moving fish up or downstream entering trap.

⑧ Place two GMTs within 5 m of every fyke and tie off to bank vegetation or to a stake in the bank.

⑨ Mark all traps with flagging tape or similar and GPS each fyke net location (total of six fyke GPS coordinates per site).

⑩ Use laminated cards attached to traps giving the name of organisation, phone number and permit numbers so if the public or fisheries officers encounter the traps they can contact someone to get details.

⑪ Record the time that the traps were set and leave in overnight.

⑫ Retrieve all nets and traps one at a time and process the catch. Record the time that traps were retrieved.

3.6.2 Recording Procedure

The following steps should be followed when processing the fish caught using the trapping method.

① All data should be recorded onto the trapping Fish Collection Form. An example of a completed collection form is provided in Figure 6 and blank forms are provided in Appendix 5.

② In the collection form enter the GPS points (top and bottom of the sample reach plus the six fyke nets), water quality data, initials of field team members, and time and dates for setting and retrieving the traps.

③ Empty the contents of the fyke nets or traps into buckets or fish bins containing fresh stream water. Catches containing large eels will need to be emptied into fish bins containing the appropriate concentration of anaesthetic if they are to be measured. Immediately place the lid on the fish bin to prevent them escaping.

④ Enter the trap type and number into the 'Gear Type and Number' column. Record each individual fish collected on a separate row. If no fish are caught in a net or trap enter "no fish" in the species column. It is strongly recommended that total length (nose to distal end of the caudal fin) of each fish is measured until at least 50 individuals of species have been measured at a site. If more than 50 are captured, it is recommended that at least a subsample of an additional 10 individuals (the first 10 removed) of that species for subsequent net/trap is also measured. Record these values in the 'Length/# of fish' column on the Fish Collection Form. Record any mortalities due to injury/predation within the traps or subsequent handling in the 'Comments' column.

⑤ If fish are not or cannot be measured (e.g., escaped while measuring) then record the number of additional fish not measured in the 'Length/# of fish' column of a single row (e.g., +5).

⑥ Freshwater shrimp and koura lengths do not need to be recorded as part of the protocols, however if koura size is a variable of interest then orbit-carapace length can be measured.

† Significant mortalities can occur in low oxygen environments where large numbers of fish may be trapped.

FISH COLLECTION FORM (TRAPPING)

Page 1 of 2

Site: Nukuhia 1

Date: 9/10/2012

	Easting	Northing
Upstream end	1804398	5809286
Downstream end	1809416	5809375
Fyke 1:	1804416	5809375
Fyke 2:	1804428	5809363
Fyke 3:	1804403	5809330
Fyke 4:	1804402	5809311
Fyke 5:	1804402	5809306
Fyke 6:	1804398	5809286

Water quality

pH	6.9
Water temp (°C)	13.4
DO (%)	74
DO (mg/L)	7.3
Conductivity (µS/cm)	240

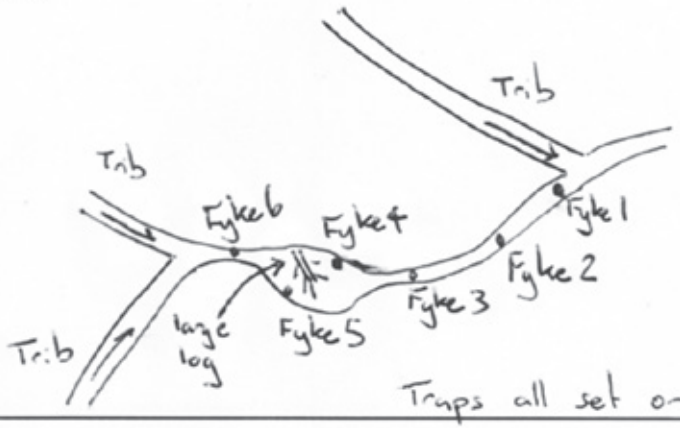
☐ specific ✓ ambient

Team members: MDL, FFA

Nets set @ 1.00 pm 8/10/2012

Nets retrieved @ 10.00 am 9/10/2012

Notes:



- Dense beds of macrophytes
- Willow dominated riparian zones

Gal.mac = inanga
LFE = longfin eel
SFE = shortfin eel
Gam.aff = gambusia

Traps all set on bottom

Gear Type & Number	Species	Length / # of fish	Comment
Fyke 1	Gal.mac	76	
	"	68	
	"	67	
	"	88	many cysts
	"	79	
	"	92	
	"	76	
	"	74	
	"	+3	Partially eaten
	LFE	600	
	SFE	470	
Fyke 2	SFE	320	
	"	640	
	"	400	
	"	410	
Fyke 3	Gal.mac	69	
	"	63	
	"	65	
	"	64	
	SFE	510	
	"	400	
	"	430	

Gear Type & Number	Species	Length / # of fish	Comment
Fyke 3 cont.	SFE	460	
	LFE	760	
	"	810	
	Gam.aff	32	
	"	32	
	"	37	
	"	31	
GMT 1	"	40	
	"	42	
	"	36	
	"	34	
	"	+5	escaped
GMT 2	Gal.mac	74	
	"	76	
	"	92	
	"	88	
	"	68	
	"	70	
	"	76	
	"	76	
	"	80	
	SFE	290	

FIGURE 6. Example of a completed trapping Fish Collection Form.

3.6.3 Trapping Tips

- It is recommended that traps are left unbaited unless specific species are being targeted (e.g., shortfin and longfin eels).
- Long poles are usually the best way of setting fyke nets in soft substrates while anchor weights are best for setting nets in hard substrates.
- Aquarium nets are useful for extracting small fish from buckets and bins for further handling/measuring.
- If large numbers of eels are captured, submerse the entire fyke net in a fish bin containing anaesthetic for a short period to relax the captured fish prior to emptying the net.
- The design of nets and traps can have a strong influence on the catches that are obtained. Ensure that the same design of nets and traps are used to collect all samples that you wish to later compare. Consider adopting the recommended fyke net design (Section 4.1.3) for new survey or monitoring programmes or when purchasing new gear.
- It is usually best to use process the two fyke compartments separately to avoid unnecessarily anaesthetising fish or unduly injuring/stressing them by leaving them in a bin full of large (and usually slimy by that stage) eels. Separate processing will also allow the catches obtained from the two different compartments to be recorded separately as they are likely to yield quite different species and size classes.

Photo: Drying fyke nets © EOS Ecology / Shelley McMurtie

3.7 Health and Safety

All personnel undertaking electrofishing must have completed an EFM training course and have current workplace first aid certificates. Avoid electrofishing near unprotected people, pets, or livestock. Discontinue activity during thunderstorms or heavy rain and maintain frequent communication with other sampling personnel while electrofishing.

For each site, know the location of the nearest emergency care facility. Although the team leader has authority, each team member has the responsibility to question and modify an operation or decline participation if it is unsafe.

- If electrofishing, ensure all team members are wearing waders, and electrical gloves are also recommended.
- Wear polarised sunglasses and sun hats to aid vision.
- In stretches with deep pools, fish the margins of the pool as much as possible, being extremely careful not to step or slide into deep water.

3.8 Biosecurity

Invasive organisms can have significant adverse effects on freshwater environments and the New Zealand economy. The control of invasive organisms is usually expensive and complete eradication rarely possible. It is therefore important the fish sampling does not facilitate the spread of invasive aquatic organisms.

Freshwater fish sampling programmes carry a high risk of spreading invasive organisms because people and equipment are frequently moving between sites and catchments. Biosecurity measures for controlling the spread of invasive organisms are wide and varied depending on the organisms and the equipment being used. The development of a comprehensive set of biosecurity measures for sampling freshwater fish is outside of the scope of these protocols and it is the responsibility of each individual organisation to develop and update the most appropriate biosecurity measures for their work. However, some general points about reducing the risk of spreading invasive organisms when undertaking fish surveys are outlined below.

The best method to prevent the spread of invasive organisms is to avoid moving gear and equipment between sites. While it is not practical to have different sets of equipment for each sampling site there may be particularly high-risk or high-value sites where it would be prudent to use a separate set of equipment. Extra special care should be taken when borrowing gear used in other regions, especially where invasive species are known to be present.

Equipment can be decontaminated but most decontamination solutions or procedures will not be effective on all types of invasive species. For example the dishwashing and salt solutions recommended for use on Didymo are unlikely to be effective on the propagules of higher plant weeds (de Winton *et al.*, 2010). A suite of decontamination procedures may be necessary to manage all of the biosecurity risks associated with a fish sampling programme. Some decontamination procedures may also damage some types or equipment or influence how well they work (e.g., repel fish from traps). Salt solutions are not recommended for decontaminating GMTs because they will accelerate corrosion.

3.9 Fish Welfare

The following recommendations are made to reduce the risk of injury or stress to captured fish:

- Do not handle any fish with dry hands. Ensure hands are wet first to minimise damage to fish.
- If individual fish in buckets show signs of stress (loss of righting response, gaping, gulping air, exuding excessive mucus), change water or stop fishing and process them. This should only be necessary on very warm days, in long transects, or if large numbers or biomasses of fish are collected. Under extreme conditions a battery operated aerator attached to a bucket may help to minimise stress caused by low oxygen.
- Cease electrofishing to process and release fish species with conservation status listings of threatened or endangered, or large sports fish as they are netted. If periodic processing is required, be sure to release individuals well downstream to reduce the likelihood of collecting them again.
- Testing of this method in New Zealand has highlighted the need to keep larger eels (>500 mm) isolated from other captured fish. These can be either kept in an additional bucket until processing at the end of a subreach or processed immediately and released well downstream.
- Avoid holding koura in the catch buckets as they are capable of injuring small fish and they do not need to be measured as part of the protocols.
- Upon reaching the end of each subreach, one person can process fish from one bucket while the other team members continue fishing the next subreach. It is also advised to use an anaesthetic to aid in the handling and correct identification of fish, particularly eels smaller than 200 mm.

Photo: Measuring trout © EOS Ecology / Bronwyn Gay

3.10 Recording and Interpreting Data

3.10.1 Recording Procedure for Fish that are Captured but Unable to be Identified

In most cases all fish older than 1 year (1+) should be identifiable to species in the field. Exceptions to this may include female Cran's, upland, and common bullies, and various non-migratory galaxiids, particularly in areas of range overlap. Identification problems with other species are more likely to occur with new fresh-run recruits of various whitebait galaxiid, eel, and bully species. In situations where this occurs, a voucher sample should be taken and fish preserved in formalin or ethanol. When taking the sample, and if the unidentifiable fish are abundant (10's–100's) a random sub-sample of up to 20 individuals total should be taken from throughout the fished reach. List these fish as "unidentified – galaxiid, eel, or bully" along with their length on the Fish Collection Form. Based on later identification (either genetic or microscopic), proportions of any different species present in the sample can later be used to adjust totals detected from the reach.

3.10.2 Data Entry

A central repository for assembling data is required to realise the full benefit of adopting these protocols nationally. At present the New Zealand Freshwater Fish Database (NZFFD) is not capable of handling the structure or size class information collected using the protocols. The Waikato Regional Council has developed a MS Excel™ data capture tool* that will significantly improve the speed and accuracy of entering data collected using the protocols. The data capture tool will also facilitate the future collation of data sets by providing a single database structure. Future development of the data capture tool will include the inclusion of simple export functions that

* At the time of writing this tool can only be used for the electrofishing and spotlighting methods

will allow data to be exported in a structure that can be readily summarised and analysed. To get a copy of this data capture tool contact Waikato Regional Council, Senior Technical Lead, Environmental Monitoring – who will provide you with the spreadsheet and a personalised password (as of January 2012 Mark Hamer: mark.hamer@waikatoregion.govt.nz).

At the time of writing, the structure of the NZFFD is undergoing redevelopment. Once the structure and variables list of the NZFFD has been finalised it is envisaged that an NZFFD export function will be added to the data capture tool. This export function will provide a quick and easy means of submitting data to the NZFFD while only having to electronically enter data once. In the meantime it is recommended that all relevant fish data be entered into the existing NZFFD cards and submitted to the database administrator.

3.10.3 External Examination of Fish

During the tallying procedure for each species, examine each individual for the presence of external anomalies and record the number of individuals affected in the relevant Fish Collection Form. Blackening and exophthalmia (pop-eye) may occasionally result from electrofishing. Injuries due to sampling are not included in the tally of external anomalies, but should be noted in the comments section of the form. Blackening from electrofishing usually follows the myomeres or looks like a bruise. If fish die due to the effects of sampling or processing, record the number for each species on the Fish Collection Form.

3.10.4 Data Analysis and Interpretation

A number of different analyses can be conducted using the data collected using these protocols. Which analyses are carried out will depend largely on the objectives of the survey or monitoring programme. The following sections provide guidance on the types of analyses that are likely to be carried out for any fish sampling programme.

3.10.4.1 Species Diversity

Species diversity is the simplest form of data that can be derived from freshwater fish surveys. Because of the low diversity of fish species in New Zealand it is usually easy enough to list the species present but species diversity can also be expressed simply as taxa richness. Species diversity data is the only fish data required to calculate IBI scores.

The use of a 150 m sampling reaches provides some confidence that most of the fish species present at a site will be collected using the protocols (David *et al.*, 2010). However, it is still important to remember that the absence of a species from a sample is not proof that a species is absent from a site. The species selectivity of each of the different protocol methods also needs to be considered when interpreting species diversity (see Section 3.3).

3.10.4.2 Relative Abundance Estimates

Relative abundance estimates provide a greater level of information about freshwater fish communities than species composition and are therefore potentially more sensitive to change over time and space.

For the three protocol methods relative abundances are based on catch per unit effort (CPUE) which is basically a measure of the number of individuals from each species caught for a given level of effort. Backpack electrofishing and spotlighting are both active fishing techniques and effort is best defined as the area of stream bed fished. The time taken to sample a site or total shock (button) time could also be used as a measure of effort although they have no spatial basis and therefore do not provide an indication of abundance. The shock time can be useful for repeat visits to a site to ensure a similar shock time is expended. The area fished is calculated as the;

Length of the site fished x average stream width - estimated unfishable area.

The length of the site fished will be 150 m and average stream width can be calculated from the mean of the ten subreach widths recorded as part of the electrofishing and spotlighting protocols. CPUE for the electrofishing and spotlighting protocols is normally reported as fish per 100 m^2.

Trapping using fyke nets and GMTs is a passive fishing technique that relies on fish movement which means the area actually sampled cannot be accurately defined (Hubert 1996, Hayes *et al.*, 1996). Effort is therefore usually based on 'soak time' (the time that sampling gear is left in the water). CPUE for traps is normally reported as fish/net/hour or fish/net/night. We recommend using fish/net/night.

Using CPUE as an index of relative abundance is reliant on a number of assumptions and these should be taken into consideration when interpreting the data. The key assumption is that there is a positive linear relationship between CPUE and the actual abundance of fish present. This is not always likely to be the case, especially when using the trapping method, because catches are so influenced by fish behaviour and the effects of gear saturation and escapement (Hubert & Fabrizio, 2007). It is also assumed that there is no movement of fish into or out of a site during sampling. Some fish will almost always enter or leave a site during sampling but this is likely to be a much bigger issue for trapping because sampling takes place over a much longer period of time.

Another key assumption is that catch efficiency remains constant over time and space. This assumption is also unlikely to hold completely true given the raft of factors that influence catch efficiency including operator proficiency, environmental conditions, fish size and fish species (Hubert & Fabrizio, 2007). This is an important assumption to consider when comparing samples because high catch efficiencies will give the impression of greater abundance of fish than low catch efficiencies.

There are also some key assumptions underlying the use of soak time as measure of fishing effort for passive sampling

techniques like the trapping protocol. The key assumption is that soak time is a proportional measure of effort, or put simply, that the longer a net or trap is left in the water the more fish it will contain when retrieved. In reality this is known not to be the case because, for various reasons, passive trapping gear tends to become 'saturated' over time with catch rates declining to an asymptotic level (Hubert & Fabrizio, 2007). Fish are also known to be able to escape traps after being caught as was observed during the field trials of the sampling methods. Predation within the traps will also influence the number and diversity of species recorded. All of these factors compromise the ability of soak time to provide an accurate measure of effort and as a consequence, the sensitivity of relative abundance estimates obtained from trapping data is likely to be less than that obtained using the other two protocol methods.

The presence of new recruits (0+ fish) at a site can create substantial variance in relative abundance estimates of fish at a site over time. Such variation may be driven by good or poor recruitment years for various species. It is important to record and measure these fish if they are captured to enable the investigation of regional recruitment patterns over time. Additionally, inanga and smelt are two typically annual species that are highly mobile, shoaling and pelagic. The numerical abundance of these species can also be highly variable at a reach scale through time and be difficult to catch consistently using the standardised methodologies. As with other 0+ fish, these species should also be recorded and measured if captured.

Since work will typically be carried out from December-April inclusive, any 0+ fish including highly mobile and shoaling pelagic species (smelt and inanga) within the population may be justifiably removed from analyses for calculating relative abundance between years to minimise this variance.

3.10.4.3 Size Structure Analysis

Analysis of the size structure of fish samples can provide useful information characterising fish populations. Size structures that lack any small 0+ may be indicative of recent recruitment failure and provide forewarning of potential species decline. The absence of older size classes may also indicate that adult habitat is impaired or that the site represents a population sink for a diadromous species.

Length data is typically used to generate length-frequency histograms, which allow the structure of a fish population to be assessed. Length-frequency histograms can provide an insight into factors that may be affecting fish population dynamics, such as high mortality or recruitment failure (Anderson & Neumann, 1996). When interpreting length-frequency histograms it is important to consider potential size biases in sampling and whether sample size is adequate. Density plots are sometimes used as an alternative to histograms because their appearance is less influenced by the arbitrary selection of length class intervals.

4 supporting information

Photo: Gee minnow traps © EOS Ecology / Bronwyn Gay

4.1 Field Trials of Sampling Methods in Lowland Streams

A series of field trials were run in the lower North Island over the summer of 2011–2012 to assess the relative efficiencies of each of the sampling methods described in Section 3 and refine the trapping method. The field trials were designed to achieve three objectives;

① Compare the relative catch efficiencies of each of the three methods.

② Determine the amount of trapping effort (i.e., number of nets and traps) required to adequately characterise fish community composition.

③ Identify an optimal fyke net design.

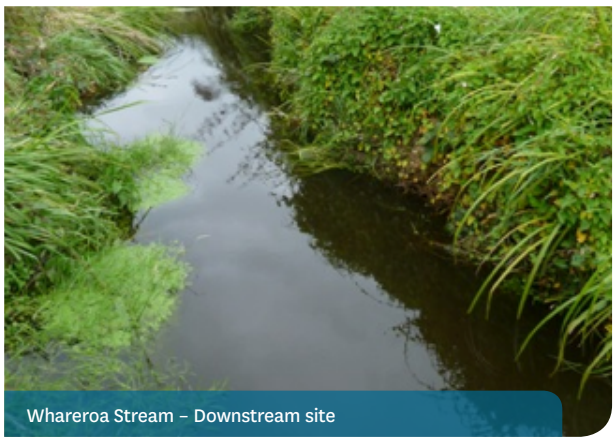
4.1.1 Comparison of Sampling Methods

While there is general agreement that electrofishing is usually the most suitable method for sampling fish communities in clean, upland wadeable streams, the best method for lowland and degraded streams is less clear. This knowledge gap was reflected in the questionnaire results where 89% of respondents requested information on how best to sample lowland pastoral sites. The emphasis of this evaluation project was therefore on the performance of each of the sampling methods in lowland stream habitats.

Two lowland streams in Kapiti (Wellington Region), the Whareroa and the Ngarara, and one low-mid elevation stream, the Turitea (Manawatu Region), were sampled to compare the efficiency of different fish sampling methods at the same site. Two sites were used on the Whareroa Stream but only one site on each of the Ngarara and Turitea streams.

All of the sampling sites consisted of 150 m long reaches of stream as this had been identified as an optimal distance for characterising fish species diversity at the reach scale in New Zealand streams (see Section 3.1).

Each site was sampled using all three of the techniques described in Section 3 so that the relative efficiencies of each method could be assessed. Electrofishing was carried out first and then nets and traps were set. Spotlighting was carried out while the nets were deployed.


Whareroa Stream – Downstream site


Whareroa Stream – Upstream site


Turitea Stream


Ngarara Stream

FIGURE 7. Photographs of the four sites used to compare the protocol methods.

4.1.1.1 Backpack Electrofishing

Streams were sampled using the Waikato Regional Council protocols (David & Hamer, 2010), which form the basis of the backpack electrofishing protocol described in Section 3.4. None of these streams were conducive to electrofishing because of issues with bank access, dense vegetation, deep water, slow flow velocities and poor visibility (Figure 8). These constraints meant that not all subreaches could be fished at many of the sample reaches.

Dense overhanging and aquatic vegetation obstructed the movement of the electrofishing wand, stop net and hand nets which impacted on capture efficiencies. Some areas were so deep that field staff could not safely or effectively fish these habitats, particularly where deep soft sediments were present.

Where it was possible to electrofish, water clarity was average at best and once field operators had entered the stream soft sediment became dislodged and visibility was further reduced. Overhanging and instream vegetation also reduced visibility and as a consequence there was a heavy reliance on 'blind fishing', where most captured fish are swept into the stop net unseen rather than spotted and collected using hand nets. While blind fishing can be effective in fast flowing streams where the stop nets can be firmly set against the bed and banks of the stream it is not so effective in the soft-bottomed lowland streams sampled in this study. Low flow velocities, particularly in the deeper pools, meant that the potential for fish to be swept into the stop net was low and poor visibility meant that 'missed fish' were often not detected.

4.1.1.2 Spotlighting

Streams were sampled following the Waikato Regional Council spotlighting protocols (David & Hamer, 2010), which form the basis of the spotlighting protocol described in Section 3.5. However, these streams were not conducive to spotlighting for many of the same reasons that backpack electrofishing of those sites difficult (see above). Limited bank access, instream and

FIGURE 8. Subreach in Whareroa Stream, note poor visibility, overhanging vegetation and deep pool.

overhanging vegetation, deep water depths and poor visibility were the main difficulties encountered.

High turbidity in the streams meant that light penetration into the water was very limited. Water depth in some reaches was shallow enough for spotlights to penetrate to the streambed in some areas but otherwise only the top 15%–20% of the water column could be illuminated. Walking through the sites to electrofish and place traps during the day may also have contributed to reduced clarity during spotlighting the following night and this should be kept in mind when planning to use spotlighting in combination with other sampling techniques in soft-bottomed streams.

As a consequence field staff could only spotlight from one side of the stream, which increased the potential for fish to be misidentified from a distance or fail to be detected under overhanging and in-stream vegetation. However, when field staff entered the stream to spotlight it stirred up the soft streambed, further reducing visibility, and disturbing fish with inanga seen 'jumping' ahead of the spotlight.

4.1.1.3 Trapping

Fish sampling using fyke nets and GMTs was undertaken more or less in line with the trapping protocols described in Section 3.6. A total of 10 fyke nets and 20 GMTs were set overnight at each site. This trapping effort was considered to be much higher than would normally be deployed at wadeable stream sites but was necessary to provide data that could be used to identify the optimal trapping effort for determining species richness. This information could then be incorporated into the protocols (see Section 4.1.2).

The dimensions of the nets and traps used in the trial were as follows:

- Fyke nets: Each fyke net consisted of three compartments with the last two separated by an exclusion grid consisting of six 60 mm long PVC tubes with an inside diameter of 32 mm. The first hoop at the mouth was 600 mm in diameter with the other hoops reducing in diameter towards the cod-end of the net, mesh size 19 mm.
- Gee minnow traps (GMTs): Model G40M. These were 42cm long with a maximum diameter of 23cm. The traps consisted of a 6.4 mm square wire galvanised steel mesh. The entrance holes were 22 mm in diameter.

Trapping effectiveness was not as constrained by the same issues that made electrofishing and spotlighting so difficult at the same sites. While bank access and dense aquatic and marginal vegetation sometime made it difficult to set fyke nets and GMTs, this did not prevent nets and traps from being successfully deployed although these factors may have had some influence on catch efficiency.

4.1.1.4 Results

Overall, the streams used in the method comparison trial were not optimal for electrofishing and spotlighting methods because of poor visibility, deep water and limited access to sections of stream. However electrofishing and spotlighting still scored highest at some sites using the method suitability scores calculated using the Method Decision Table (Figure 1). Based on these scores trapping was the optimal method at Whareroa Downstream and Ngarara sites but was the lowest scoring method at Whareroa Upstream and Turitea sites (Table 4). Electrofishing was the highest scoring method at Turitea but lowest scoring site at Whareroa Downstream and Ngara. Spotlighting did not score highest or lowest scoring at any of the sites.

The different sampling methods were compared by looking at the numbers of fish taxa caught using each method. Because not all of the eels could be identified to species level (especially when spotlighting) they were combined to allow a more accurate comparison of the methods. Unidentified bullies were excluded from the comparison because of the risk of artificially inflating taxa richness.

Trapping was the most effective fish sampling method used at the Whareroa Downstream site (Table 5). The combination of GMTs and fyke nets resulted in the capture of 100% of the species that were detected using all protocol methods combined and was also the method that caught the greatest

TABLE 4. Method suitability scores for each of the sites used in the method comparison trials. Scores calculated using the method selection table provided in Figure 1. Green = scored highest (optimal method), orange = scored second, red = scored third.

Site	Electrofishing	Spotlighting	Trapping
Whareroa Downstream	2	10	15
Whareroa Upstream	13	12	12
Turitea	15	13	8
Ngarara	7	10	15

number of fish. Trapping methods also caught four species that were not detected using either electrofishing or spotlighting methods and caught a much greater total number of fish. On their own, GMTs were far less effective and only detected half of the all the species caught. Electrofishing was not a very effective method at this site and only succeeded in detecting a small number of the fish taxa present. Spotlighting was slightly more effective and detected large numbers of inanga. Only a small proportion of the site could be effectively sampled using electrofishing and spotlighting methods because of high turbidity, deep water, soft bed substrates and dense macrophyte beds. The results achieved for the different methods correspond well with the suitability scores calculated for the site in Table 4.

While no single method detected all of the fish taxa present at the Whareroa Upstream site, electrofishing was the most effective method. Electrofishing only failed to detect one species, giant bully, which appeared to only be present in very low numbers anyway (Table 6). Electrofishing also caught the greatest total number of fish and was the only method that captured koura. Trapping was the second most effective method, detecting four out of the six species found at the site. Spotlighting was hampered by poor visibility and only resulted in the detection of two individuals from two species. All three methods scored equally using the Method Decision Table (results shown in Table 4), which may suggest that backpack electrofishing is the optimal method to use for sampling wadeable streams when habitat conditions are such that there is no signficant advantage in using any one method.

TABLE 5. Comparison of the total numbers of fish collected from Whareroa Downstream site on 14/03/2012 using different sampling methods. Eel species are combined but unidentified bullies are excluded.

	Sampling Method					Site
Fish Taxa	**Electrofishing**	**Spotlighting**	**Fyke Nets**	**GMTs**	**Fyke Nets + GMTs**	**Total**
Eels	1	3	47	1	48	52
Giant kokopu		5	19		19	24
Inanga		51		15	15	66
Common bully			4		4	4
Giant bully	1	1	17	7	24	26
Redfin bully	7			30	30	37
Black flounder			1		1	1
Method Total	9	60	88	53	141	210
% of All Species Caught	43	57	71	57	100	100

TABLE 6. Comparison of the total numbers of fish collected from Whareroa Upstream site on 30/03/2011 using different sampling methods. Records for unidentified eels and bullies are not included.

	Sampling Method					Site
Fish Taxa	**Electrofishing**	**Spotlighting**	**Fyke Nets**	**GMTs**	**Fyke Nets + GMTs**	**Total**
Eels	53		11		11	64
Inanga	1	1				2
Giant bully			1		1	1
Redfin bully	4	1		2	2	7
Koura	2					2
Method Total	60	2	12	2	14	76
% of All Species Caught	80	40	40	20	60	100

Spotlighting was found to be the most effective method for recording fish taxa richness at the Turitea site with 100% of taxa detected (Table 7). Spotlighting only scored second using the Method Decision Table but it was within two points of electrofishing, which was the highest scoring method. Trapping detected only 57% of taxa and GMTs on their own only collected one species, common bullies. Electrofishing scored the highest suitability score but only detected only 57% of taxa, however electrofishing was a particularly effective method for collecting upland bullies and this meant the method collected the highest total number of fish from the site.

Electrofishing detected all of the fish taxa found at the Ngarara Stream Site (Table 8). This was somewhat surprising given that it had a low suitability score because many sections of the site too deep or obscured by vegetation. However, all three methods collected over 75% of taxa present and could therefore be considered effective at the site. Trapping failed to detect redfin bullies or koura but caught similar overall fish numbers to electrofishing. On their own, neither fyke nets nor GMTs were particularly effective on their characterising taxa richness. Spotlighting failed to detect giant and common bullies but overall collected the same proportion of fish taxa as the trapping method. Large numbers of inanga were recorded using the spotlighting method.

The results of the method comparison trial also provided useful insights into the biases of each of the methods. The fyke nets were effective at capturing a range of larger fish species such as eels and giant kokopu but smaller fish like juvenile eels, bullies and small galaxiids would have been able to escape through the 19 mm mesh. Using a finer mesh would probably have resulted in more small fish being caught in the fyke nets (see Section 4.1.3). As expected the GMTs only collected small

TABLE 7. Comparison of the total numbers of fish collected from Turitea site on 04/03/2011 using different sampling methods. Records for unidentified eels and bullies are not included.

	Sampling Method					Site
Fish Taxa	**Electrofishing**	**Spotlighting**	**Fyke Nets**	**GMTs**	**Fyke Nets + GMTs**	**Total**
Eels	6	5	22		22	33
Cran's bully		1				1
Upland bully	24	6				30
Common bully	5	8		2	2	15
Koura	1	1				2
Perch		1	1		1	2
Trout		3	1		1	4
Method Total	36	25	24	2	26	87
% of All Species Caught	57	100	43	14	57	100

TABLE 8. Comparison of the total numbers of fish collected from Ngarara site on 12/03/2011 using different sampling methods. Records for unidentified eels and bullies are not included.

	Sampling Method					Site
Fish Taxa	**Electrofishing**	**Spotlighting**	**Fyke Nets**	**GMTs**	**Fyke Nets + GMTs**	**Total**
Eels	58	4	36		36	98
Giant kokopu	2	1	3		3	6
Banded kokopu	3	2	5		5	10
Inanga	47	142		23	23	212
Common bully	7		1	1	2	9
Giant bully	1			1	1	2
Redfin bully	1	1				2
Koura	3	1				4
Method Total	74	147	45	25	70	343
% of All Species Caught	100	75	50	38	75	100

fish and the method was therefore biased against large bodied species. The effectiveness of the GMTs was also likely to have been reduced by high rates of escapement by inanga that were observed after 2 and 6 hours of being set.

The effectiveness of electrofishing at capturing eels was quite variable between sites, which would indicate that habitat can strongly affect capture rates for these species using this method. Electrofishing collected a much wider range of eel sizes compared with other methods and this should be taken into account if eel population structure is a key variable in any survey or monitoring programme.

Spotlighting consistently underestimated the numbers of eels present, and where they were detected, spotlighting samples tended to be biased towards large individuals. However, spotlighting was the most effective method at detecting inanga and giant kokopu and this is most likely to be due to the tendency for both species to use open water habitat at night. Water clarity was poor at most of the trial sites, which limited penetration of the spotlight beam. This meant that spotlighting would have been much less effective at sampling benthic species such as bullies.

4.1.2 Determining Optimal Trapping Effort

When sampling using traps there is usually a trade-off between maximising the catch and minimising the level of effort. The more traps that are set the more fish that are likely to be caught but time and resources constraints will usually always be limited. There will also be diminishing returns from each additional trap that is set because even though more fish are potentially caught the amount of additional information describing species richness and relative abundances tends to decline. An optimal level of effort for describing fish community composition can therefore be thought of as the minimum number of traps required to confidently collect the maximum number of fish species present at a site.

To calculate the optimal number of GMTs and fyke nets to set at wadeable stream sites a repeated subsampling approach was carried out using a Microsoft Excel™ macro written in Visual Basic™. The program repeatedly sub-sampled from the dataset collected from lowland stream sites using 20 GMTs and 10 fyke nets. Trials were run to subsample 100 times random combinations of 2, 3, 4, 5, 6, 7, 8, 9, and 10 fyke nets and similarly all combinations of GMTs from 2 to 20. The results were graphed as species accumulation curves and visually assessed to identify the inflection or flattening point where catch data from additional traps did not substantially increase the probability of finding more species.

The simulated species accumulation curves plotted for the fyke nets, shown in Figure 9, show that the inflection point is around 6 fyke nets, where adding further traps on average added very little chance of finding more fish species. For the GMTs the inflection point is higher at approximately 12 traps (Figure 10). These data were used to identify the trapping effort of 6 fyke nets and 12 GMTs recommended in the trapping method.

4.1.3 Assessment of Fyke Net Design

The design of fyke nets is known to have a strong influence on how efficient they are at capturing different species of fish. The size of the mesh used in the leader and around the trap will determine the minimum size of fish that will be caught and retained in the net. The diameter of the mouth and funnel throats will also determine the maximum size of fish that can be caught in a fyke net.

One of the potential issues with using fyke nets is that when predatory fish are caught they can reduce catches of prey species by predating on them or discouraging them from entering the net (Breen and Ruetz, 2006). In New Zealand waters the most widespread and abundant predators are eels and these species have been identified as causing potential biases in fyke net catches (Hayes & Rutledge, 1991).

A new fyke net design was developed as part of the field trials to maximise the range of fish species and size classes of fish that would be captured using the trapping method. Two design features were identified as being critical to achieving this aim. The first was the adoption of a fine mesh size that would retain small fish. Fyke nets used by recreational and commercial fisherman typically use a mesh size of around 15 mm* (knot to knot or square mesh). The second was the need for a device that would reduce predation effects within the trap and allow more 'prey' species to be collected.

Two approaches have previously been used to reduce predation within fyke nets in New Zealand. Luminous glow sticks placed in the first two funnels of fyke nets have been found to reduce eel predation in surveys carried out in Southland (Andy Hicks, Environment Southland pers. comm.). Large predatory eels have also been physically separated from smaller fish by fitting a coarse mesh material between trap compartments (Hayes, 1989; Chisnall & West, 1996).

Some form of separation mesh or grill was considered preferable to using glow sticks because it was important that eels could enter the trap and be captured when they were present. There was some uncertainty as to how well the sticks might work in very turbid habitats where trapping may be only sampling method that can be used. The effectiveness of glow sticks could potentially vary with water clarity and introduce more variance to fyke net samples. The costs associated with using glow sticks was also considered potentially cost prohibitive, particularly if large sticks were required to overcome poor water clarity.

For the method comparison trials a metal grid was initially used to separate the last two compartments and thereby exclude

* Fyke nets used by recreational fishers must be no smaller than 12 mm under the Fisheries (Amateur Fishing) Regulations 1986

large predatory eels from the third compartment. However, a pilot study revealed that giant kokopu and eels sustained injuries when attempting to force themselves through the metal grid (Figure 11 and Figure 12). This problem was rectified by gluing PVC tubes (32 mm inside diameter) into the grid (Figure 13). The addition of PVC tubes not only prevented injuries but also further reduced the maximum size of eels that could enter the third compartment from 700 mm to about 520 mm in length because the larger eels could no longer squeeze through.

While the PVC separation tubes were effective there were some concerns that the tubes would be too awkward and therefore expensive to incorporate into a standardised fyke net design and that they would not be sufficiently robust to last through any extended field sampling programmes. It was therefore decided to switch back to using a separation grill but use smoothed plastic rather than wire to minimise injuries to fish. The size of the grill was also reduced to 25 mm to ensure that larger predatory eels were excluded from the third chamber of the net (Figure 14). Additionally, a zip was installed to aid the removal of fish from the third (middle) chamber (Figure 15).

The fyke net design recommended in these protocols incorporates a 4 mm woven mesh that was considered to be an optimal balance between capturing as small a fish as possible while still allowing sufficient water flow to maintain water quality inside the trap (Figure 15). Maintaining water quality within fyke nets can be particularly critical in productive lowland habitats that experience dissolved oxygen sags at night and/or when large catches of fish are expected†. A woven mesh is recommended for

† Where dissolved oxygen sags are expected it may be advisable to set fykes and GMTs with an air space at the top to allow fish access to the surface.

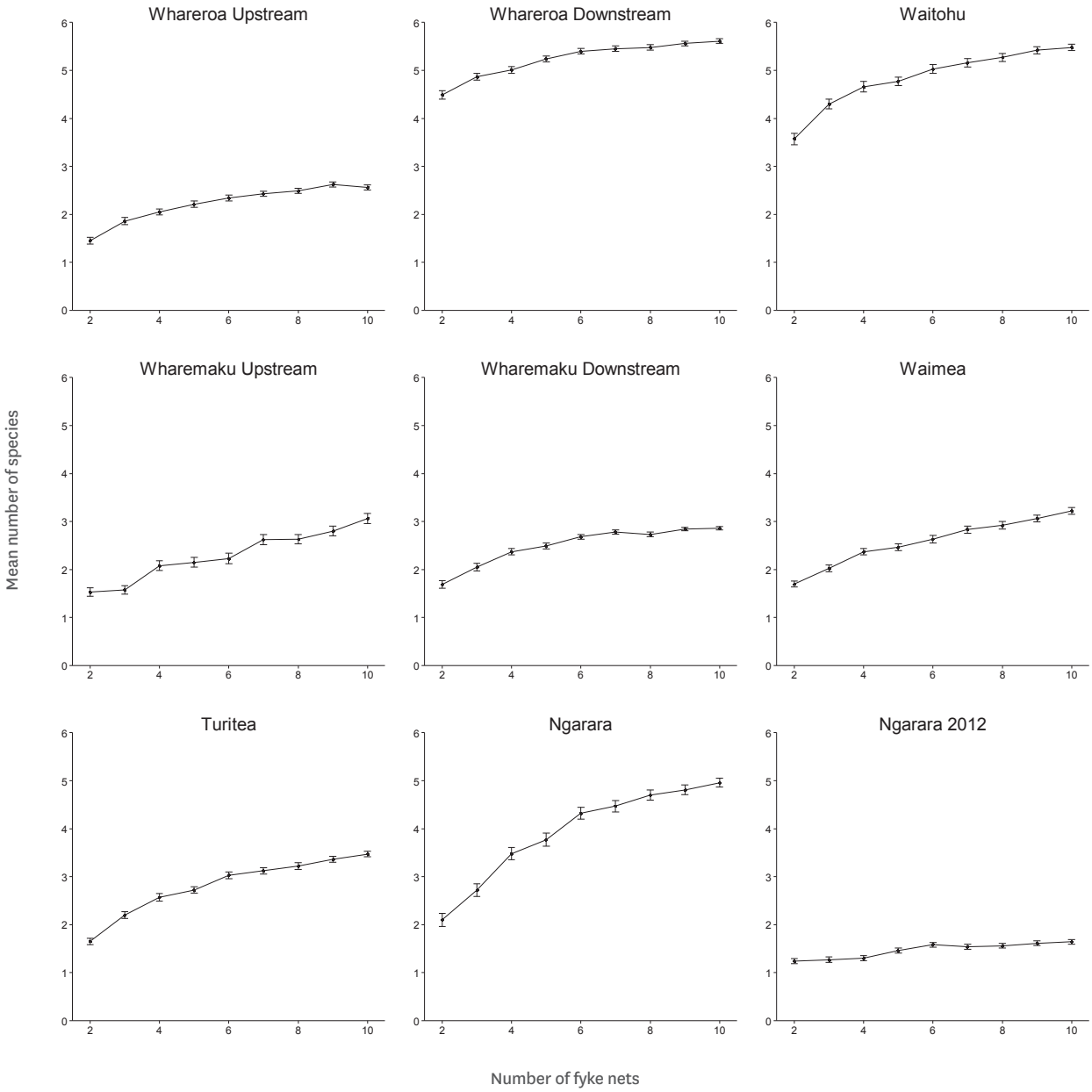


FIGURE 9. Simulated species accumulation curves derived from fyke net data collected from nine sites.

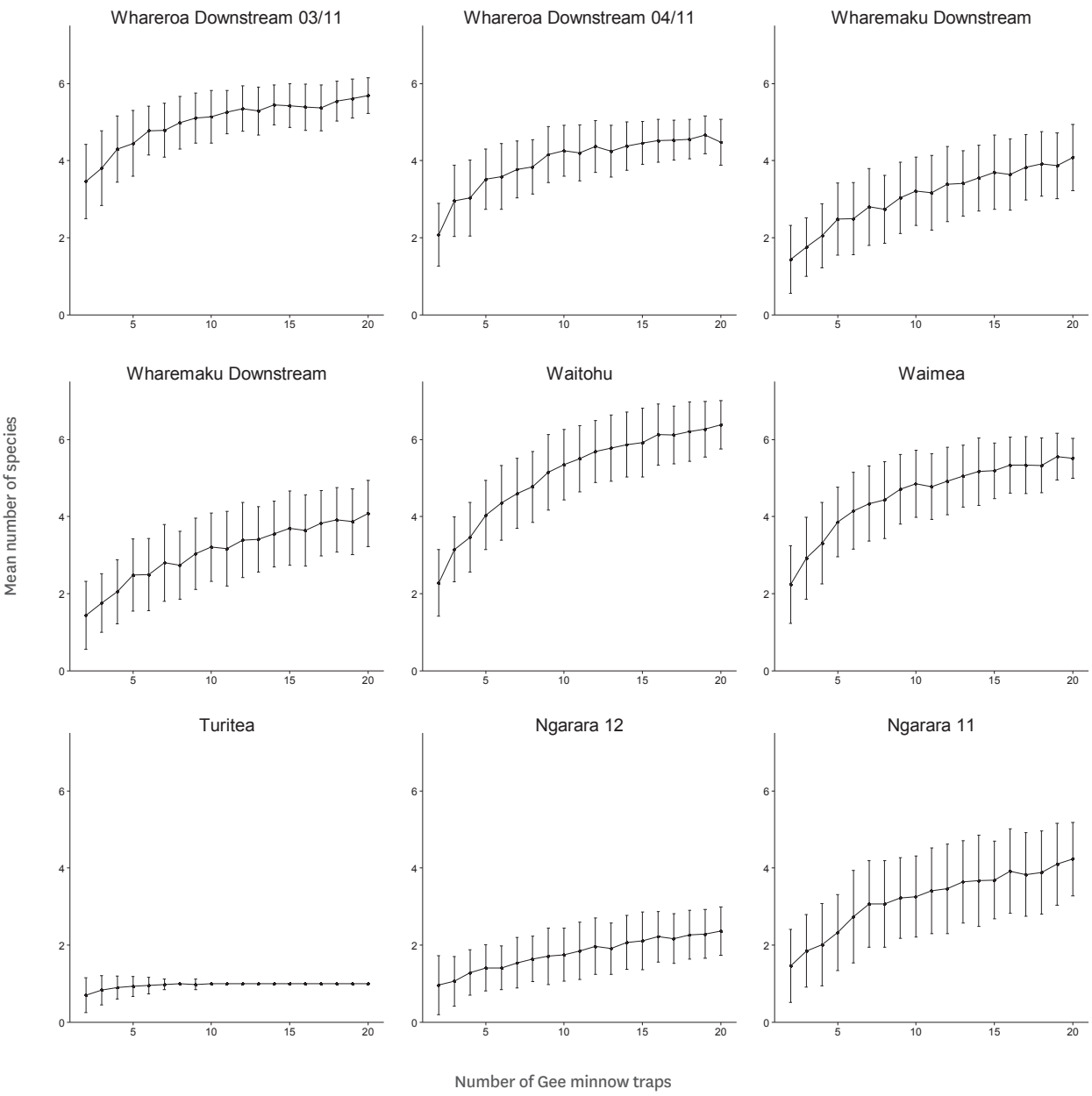


FIGURE 10. Simulated species accumulation curves derived from Gee minnow trap data collected from nine sites.

FIGURE 11. Metal grid between second and third compartment of fyke, showing residue from eels forcing themselves through grid.

FIGURE 12. Abrasion injury on giant kokopu from trying to force through the metal grid.

fyke nets because it is considered less likely to 'gill' any small fish attempting to escape (Figure 16).

A standard fyke net design is not prescribed as part of the fishing protocols for a number of reasons. Firstly, many organisations will already have a set of fyke nets and will be reluctant to purchase a whole new set of gear before undertaking fish sampling using the trapping method. It is hoped, however, that as existing sets of fyke nets wear out or new monitoring programmes are initiated that organisations will be prepared to invest in a new set of fyke nets that match the design recommended in these protocols. Secondly, there is a need for organisations to retain some flexibility over fyke net design because the design recommended here will not be suitable for all types of habitats (e.g., very shallow or narrow streams).

While adoption of the following standard fyke design is not a critical component of using the trapping protocols it is strongly recommended that the design described below is copied as much as possible when purchasing new fyke nets (Figure 17). In this way it is hoped that a standardised fyke net design will be progressively adopted for sampling wadeable streams in New Zealand. The parameters of the recommended fyke net design are as follows:

Leader

- 4 mm drab coloured woven mesh.
- 2.8 m long and 0.6 m deep.

Trap

- 4 mm coloured woven mesh. Dark drab coloured material is best.
- 3 m overall length.
- Trap is supported by a D-ring (0.6 m high x 0.7 m wide) followed by a series of six hoops decreasing from 0.5 m to 0.35 m in diameter from the mouth to the cod-end.
- Three compartments with the first and second compartments separated by a 200 mm throat and the second and third compartments separated by a 25 mm plastic separation grill.
- A zip in the middle compartment to aid fish removal.
- The mouth of fyke net should extend 0.9 m into the trap and have an opening of 0.2 x 0.2 m^2.

FIGURE 13. PVC separation tubes used in fyke nets during the field trials.

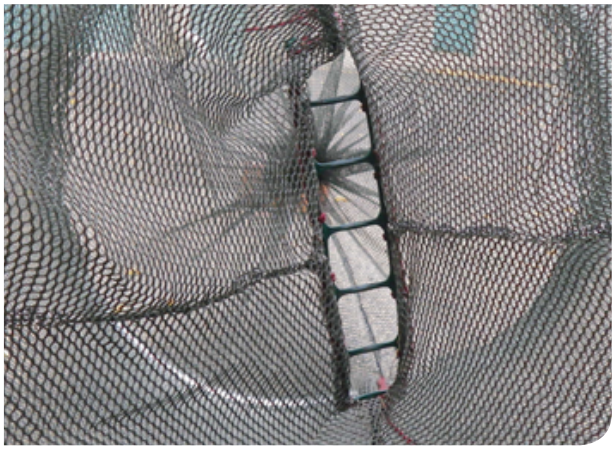


FIGURE 14. Design of the separation grill for use in the recommend fyke net design.

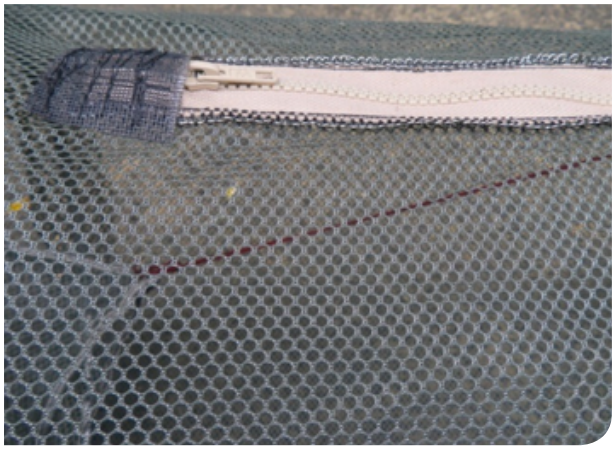


FIGURE 15. Middle compartment zip and mesh material used in the recommended fyke net design.

FIGURE 16. Inanga injury caused by becoming gilled in 19 mm stretched (10 mm relaxed) fyke net mesh.

- The leader should extend into the mouth of the trap as far as the mouth which is set back 0.9 m from the first D-hoop.

At the time of writing this recommended fyke net design has only had limited use under field conditions but preliminary results are promising. The new fine-mesh fyke nets were deployed alongside standard commercial fyke nets in Waitakaruru River and Te Puaeharuri Stream, which flow into the south west corner of the Firth of Thames. Two nets of each type were set at each site along with four GMTs.

Both types of fyke net were more or less equally effective on both eel species present with almost all of the eels caught in the fine-mesh fyke recovered from the 2nd compartment (Table 9). Only one eel made it through the separation grill into the 3rd compartment, it was a 402 mm long shortfin eel. Large numbers of inanga were also caught in the fine-mesh fyke nets with most collected from the 3rd compartment. No inanga were found in the standard eel fykes, although it should be noted that most of the inanga would have been able to pass through the wider (15 mm) mesh of those nets. Cran's bullies were another small bodied fish species that were collected in greater numbers in the fine-mesh fykes and were mostly recovered from the 3rd compartment. Torrentfish and common smelt were only collected in the 3rd compartment of the fine mesh fykes, however these species were only found at one site. Overall the fine mesh fykes caught 100% of the species detected at the three sites combined while the eel fykes and GMTs only caught 50%.

FIGURE 17. Recommended standard fyke net for use in fish sampling of New Zealand wadeable streams.

TABLE 9. Summary of catch data collected from the Waitakaruru River and Te Puaeharuri Stream in March, 2012. Data supplied by the Hauraki District Council.

		Fine Mesh Fyke *(n=5)*			
Species	**Eel Fyke *(n=6)***	**2nd Compartment**	**3rd Compartment**	**GMT *(n=12)***	**Total**
Shortfin eel	12	19	1		32
Longfin eel	29	34		1	64
Torrentfish			3		3
Inanga		9	92	79	180
Cran's bully	1	1	18	19	39
Common smelt			12		12
Total	42	63	126	100	331

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APPENDIX 1:

review of potential sampling techniques

A literature search was undertaken to search for all available suitable sampling techniques so that all could be considered for developing protocols. These methods are listed and pros and cons discussed below

New Zealand's freshwater fish fauna have many unique features which means that the applicability of techniques used internationally cannot necessarily be applied. The unique features include the fact the majority of species encountered are small bodied, nocturnal, benthic, and live down within the substrate where interstitial spaces are available.

Methods discussed below:

① Fyke nets

② Gill nets

③ Seine nets

④ Minnow traps

⑤ Enclosure traps

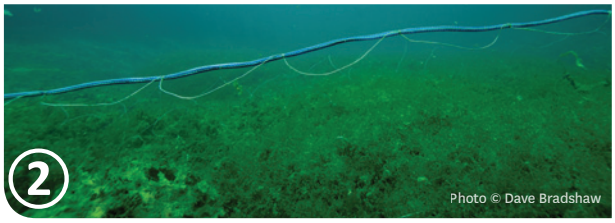
⑥ Electrofishing

⑦ Spotlighting

⑧ Underwater observation – including snorkelling, SCUBA, video cameras

Other methods (not discussed here as more relevant to lakes, reservoirs or ocean habitats)

- Rotary screw traps
- Tagging (fish detection)
- Hydro acoustics
- Bongo nets
- Pound netting



① FYKE NETS

Advantages:

- Fish caught in this way are not normally injured or killed.
- Can be set and lifted by one person.
- Can be set in water that is deeper or shallower than the height of the hoops, as long as the tunnels are submerged.
- Catches fish that are moving and is therefore well suited to intercepting fish moving along known migration routes, such as during spawning migrations (Portt *et al*., 2006).
- Fyke nets have been show to collect more fish and produced greater species richness and diversity measures when compared with seining (Clark *et al*., 2007).

Disadvantages:

- Can trap a variety of creatures other than fish, (e.g., waterfowl) but probability of this reduced if front hoop is fully submerged.
- Difficult to set where the substrate is uneven, such as among boulders, and where there is dense vegetation or an abundance of other obstructions such as logs or stumps.
- Predation upon small fish by larger fish can occur.
- Behavioural and seasonal factors affect catch.
- They are size and species selective and catches are often highly variable. The maximum size of fish that can enter these nets is determined by the size of the throat and the minimum size of fish retained is determined by the perimeter of the openings in the mesh in relation to a fish's maximum girth (Portt *et al.*, 2006).
- Can result in mortality of species requiring constant movement for respiration (e.g., yellow-eyed mullet).
- Requires visiting site twice.
- Gear left our over night may be prone to theft and vandalism.

Notes:

- Efficiency is directly related to the probability that a fish will encounter the net, then that it will enter and be retained.
- Need to report the length, height and mesh size and material of the wings and lead when using fyke nets.
- Has been shown to be a highly effective method of capturing lake dwelling galaxiids in Tasmania, Australia (Hardie *et al.*, 2006).
- Fyke netting is a convenient and effective technique for capturing freshwater eels (Jellyman & Graynoth, 2005).
- Can be baited to increase catch rates for some species although this is not recommended unless targeting specific species.

② GILL NETS

Advantages:

- Can be set anywhere where there is sufficient depth for the lead and float-lines to fully separate and remain unobstructed.
- Can be set over any substrate (e.g., boulders) although their efficiency will be reduced when substrate is uneven.
- Simple to use (Portt *et al.*, 2006).

Disadvantages:

- Will tangle on any rough object, so not suitable for use in areas where there is a lot of floating vegetation, wood or other debris.
- Cannot be set perpendicular to strong currents.
- Can accumulate debris even in gentle currents decreasing their fishing efficiency.
- Light, turbidity and net colour will affect efficiency.
- Not effective at catching sedentary fish.
- Whether or not fish encounter nets may be dependent on seasonal migrations.
- Selective with respect to fish size.
- Fish mortality is typically high, although does vary with species and habitat conditions (Portt *et al.*, 2006).

Notes:

- The amount of fish caught with gill nets changes with the mesh size, mesh shape, filament width, colour and hanging ratio (Duman *et al.*, 2006).

③ SEINE NETS

Advantages:

- Has been shown to produce samples containing higher species richness, abundances and more unique species records than other gear types (Lapointe 2006).
- Fish are not usually injured.
- Simple method of surveying large area in a relatively short time (Portt *et al.*, 2006).
- Catch per unit effort can be calculated on an area basis (e.g., fish captured per x m^2 of streambed).

Disadvantages:

- Lead line has to remain on bottom of substrate to prevent fish from escaping.
- Fish can also escape when snagging occurs or when trying to release snagging.
- Accumulations of macrophytes and debris can make net heavy and difficult to pull forward.
- Size of mesh will determine size of fish caught.
- Difficult to drag in strong currents, particularly when using fine mesh sizes (Portt *et al.*, 2006).

Notes:

- Normally used in water depths that is less than one half or two thirds the depth of the seine, so that the lead line remains on the bottom and the float line remains at the surface as the net is pulled forward.
- Catch efficiency highest for surface and mid-water schooling species, intermediate for territorial and cover-seeking species and lowest for demersal and eel-like species.
- Electric seines are a variation on the standard seine but are much less commonly used. They include a series of electrodes spaced along cables that are stretched between two operators in a seine like fashion (Portt *et al.*, 2006).

④ MINNOW TRAPS

Advantages:

- Traps are small, light and easily transported, deployed and retrieved by one person.
- Can be used in highly vegetated areas or habitats with woody debris.
- Fish caught are usually injury free (Portt *et al.*, 2006).

Disadvantages:

- Maximum size of fish that can be caught is determined by size of the funnel opening.
- Minimum size of fish is determined by size of mesh used.
- Fish are known to escape from these traps (Portt *et al.*, 2006).
- Fish can get stuck in funnel opening.
- Requires visiting site twice.
- Gear left our over night may be prone to theft and vandalism.

Notes:

- Good for use in low velocity streams or littoral habitat but can be anchored in riffle habitat.

⑤ ENCLOSURE TRAPS (Includes Pop, Drop and Throw traps)

Advantages:

- Designed for use in streams with little or no current.
- Can be used in highly vegetated areas or habitats with woody debris.
- Most effective for sampling relatively abundant fishes.
- Fish caught are usually injury free (Portt *et al.*, 2006).

Disadvantages:

- Fast swimming species able to avoid falling traps.
- Collect instantaneous samples from relatively small areas (Portt *et al.*, 2006).
- Not suitable for collecting fish in fast flowing waters.

⑥ ELECTROFISHING

Advantages:

- Can be used in wide range of habitats where safe wading or boating possible.
- All but very small fish may be caught but catch ability varies among species and is higher for larger fish (Portt *et al.*, 2006).
- Catch per unit effort can be calculated on an area basis (e.g., fish captured per 100 m^2 of streambed).
- Only requires a single site visit.

Disadvantages:

- Efficiency lower in larger streams.
- Poor visibility due to suspension of sediment can be an issue in soft-bottomed waterways.
- Dependent on habitat conditions especially conductivity.
- Requires a minimum of two operators.
- Safety training required for operators.
- Spinal damage and haemorrhaging in eels can be high (Reynolds & Holliman, 2004).

Notes:

- Netting (pole net and dip net) efficiency can be affected by habitat characteristics such as current velocity, substrate, underwater obstructions, and aquatic and bank vegetation (Portt *et al.*, 2006).

⑦ SPOTLIGHTING

Advantages:

- Can be used in wide range of habitats.
- Non-invasive technique that may not even require fish to be captured in some instances.
- Rapid, enabling greater distances to be covered (approx. 4–6 x faster than electrofishing).
- Not affected by salinity or conductivity.
- Works well in deep pools provided there is good water clarity.
- Only requires teams of two people.

Disadvantages:

- Capturing fish may be more time consuming relative to electrofishing.
- Not effective in turbid conditions.
- Is conducted outside normal working hours.
- Identification of species may be more difficult without experience.
- More difficult to collect a representative sample of fish for size class analysis.

⑧ UNDERWATER OBSERVATION (Includes snorkelling, SCUBA, underwater videos, underwater visual censuses, remote underwater videoing)

Advantages:

- Useful for determining species-habitat relationships.
- No harm or injury to fish (Portt *et al.*, 2006).

Disadvantages:

- Must be able to identify fish without having them in hand.
- Not possible in extremely small or shallow streams, or in extremely high velocity habitats.
- Factors affecting visibility affect observation efficiency.
- Accurate counts difficult if fish abundance high.
- Observations dependent on fish behaviour (e.g., to presence of divers or camera) and activity patterns (Portt *et al.*, 2006).

Notes:

- More efficient in smaller streams (Orell & Erkinaro, 2007).
- Visibility and cover are both considerations (Portt *et al.*, 2006).
- Use of remote underwater videoing techniques are being developed (Colton & Swearer, 2010).

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APPENDIX 2:

results of national protocol for monitoring freshwater fish survey of freshwater ecologists

PRE-SURVEY INFORMATION

Below is the list of people and their organisations who responded to the email questionnaire sent on the 23/02/2010:

Name	Organisation	Name	Organisation
Alex James	EOS Ecology	Mike Lake	DOC
Matthew Dale	Otago Regional Council	Don Jellyman	NIWA
Steve Ledington	Environment Southland	Dean Olsen	Cawthron
Bart Jansma	Taranaki Regional Council	Corina Jordan	Fish and Game
Peter Hamill	Marlborough District Council	Andy Hicks	Otago University
Trevor James	Tasman District Council	Gerry Closs	Otago University
Graham Surrey	Auckland Regional Council	Jane Goodman	DOC
Carol Nicholson	Horizons Regional Council	Matt Bloxham	Environment Bay of Plenty

PROJECT OUTLINE

Does your organisation currently monitor freshwater fish in wadeable streams and rivers? *(n=16)*

Yes ..... 94% *(15)*
No ..... 6% *(1)*

If so, what methods are employed? *(n=15)*

EFM ..... 100% *(15)*
Spotlighting ..... 87% *(13)*
Gee minnow traps ..... 67% *(10)*
Fyke nets ..... 53% *(8)*
Seines ..... 27% *(4)*
Drift diving ..... 20% *(3)*
Gill nets 0%
Trammel nets 0%

Does your organisation use any written guidelines or protocols to guide staff on how to monitor fish communities? *(n=16)*

Yes ..... 37.5% *(6)*
No ..... 43.75% *(7)*
Sometimes ..... 18.75% *(3)*

If yes, what?

Four organisations are trialling the draft national electrofishing protocol. Some organisations have inhouse guidelines. However, most organisations use the 'standard electrofishing guidelines' driven mostly by health and safety regulations.

Does your organisation use any tools/indices (e.g., Fish IBI) to assess the results of fish monitoring? *(n=16)*

Yes ..... 37.5% *(6)*
No ..... 62.5% *(10)*

There was no consistent answer to this, the tools/indices mentioned were: Fish IBI; model developed by Leathwick *et al.*, 2008; Predictive modelling (Joy and Death (2004)); Population estimates based on the removal method; Indices of abundance and diversity; Diversity index developed by Jody Richardson (NIWA) *et al.*

Is the fish monitoring done by your organisation qualitative or quantitative i.e., just presence/absence or abundance data collected? *(n=15)*

Qualitative 0%
Quantitative ..... 37.5% *(6)*
Both ..... 56% *(9)*

If quantitative, what aspects are measured?

Numbers ..... 87% *(13)*
Abundance ..... 73% *(11)*
Size class ..... 73% *(11)*
Biomass ..... 27% *(4)*

Comments:
A number of organisations commented that what they measure depends largely on the client/project requirements. Other aspects that are measured are size range and catch per unit effort

Does your organisation enter fish monitoring data into the freshwater fish database? *(n=15)*

Always ..... 60% *(9)*
Sometimes ..... 40% *(6)*
Never 0%

Comments:
Many of the organisations that said they always enter their fish data onto the NZFFD but also commented that they often get behind in doing so. Most organisations also enter their fish monitoring data into internal databases.

Does your organisation, or do you, consider any one landcover type to be the primary wadeable stream habitat fished? *(n=13)*

Pasture ..... 46% *(6)*
Indigenous forest 0%
Other..... 54% *(7)*

Comments:
Most of the organisations commented that they do not primarily monitor fish in one habitat type but rather a variety of landcover types, e.g., exotic forest, indigenous forest, pasture, urban, etc.

Does your organisation or do you collect any long term monitoring data from the same location? *(n=15)*

Yes ..... 67% *(10)*
No..... 33% *(5)*

If yes, is it for long-term monitoring to evaluate temporal changes or shifts in population/species metrics?
All ten organisations that collect long term monitoring data do so to evaluate temporal changes in population/species metrics.

At what scale does your organisation mostly collect freshwater fish data? *(n=15)*

Catchment ..... 7% *(1)*
Sub-catchment ..... 33% *(5)*
Segment ..... 73% *(11)*
Other..... 27% *(4)*

Comments:
Again, many organisations have said the scale at which they survey freshwater fish varies depending on the purpose. Four organisations collect data on a 'regional' scale.

Does your organisation usually collect general fish community data or target particular species? *(n=15)*

Community ..... 47% *(7)*
Species..... 0%
Both ..... 53% *(8)*

What does your organisation primarily collect data on fish for? *(n =15)*

Specific consents ..... 40% *(6)*
AEEs..... 33% *(5)*
Pest fish management..... 20% *(3)*
Native fish management..... 47% *(7)*
Rehabilitation ..... 33% *(5)*
SOE ..... 33% *(5)*
Pure research ..... 27% *(4)*
Other..... 7% *(1)*

Does your organisation have the time and resources available to include a trial on a limited number of already developed fishing protocols in 2011 (e.g., SOE) monitoring to provide data to aid in the development of guidelines for fish protocols? This may involve up to 1 day per site depending on resource availability. *(n=15)*

Yes ..... 73% *(11)*
No..... 27% *(4)*

Comments:
Many organisations are very interested in such a project but suggested their involvement may be limited due to financial pressures.

Where would you like to see most effort for these protocols go? *(n=9)*

Sampling wadeable lowland sites ..... 89% *(8)*
Highly modified farm drains and streams ..... 11% *(1)*
Other..... 0% *(0)*

Comments:
Most organisations suggested they would like the protocols to be applicable to as many stream types as possible, particularly both of the above, plus urban streams and coastal catchments. It was also suggested that a generic protocol that shows how to select sites (e.g., impacted vs. reference), detect impacts to different types of fish, information of sampling frequency and timing would be very useful for regional water managers.

Do you think some way of entering data into a computer program that would calculate a score e.g., an index such as a Fish IBI be useful? *(n=16)*

Yes ..... 94% *(15)*
No..... 6% *(1)*

If yes, what?
There was no consistent answer to this question. Some responses were: habitat value scores (e.g., riparian veg, instream habitat); basic information such as number of species, abundance, and density estimates (e.g., based on removal method), and ideally O/E ratio; a 'recruitment index' of some kind (species specific), to give an indication of the long term viability of populations; some index that integrates abundance and diversity (maybe like MCI with weightings for sensitivity?)

Where would you like to see the raw data housed? *(n=15)*

Most organisations suggested a national database or modification of the NZFFD.

What attributes would you like to see?
Density ..... 93% *(14)*
Diversity..... 93% *(14)*
Size-class..... 100% *(15)*
Assemblage balance..... 60% *(9)*
Other..... 26% *(4)*

Comments:
Other suggestions were: catch per unit effort; habitat measures; methodology; electrofishing machine settings.

Do you have specialist knowledge/tips on any particular techniques that you would like to share? *(n=15)*

Yes..... 53% *(8)*
No..... 47% *(7)*

If yes, what?
Most organisations have skill and experience they are willing to share if asked. Some additional comments were:

- An observation from carrying out the electrofishing protocols last year in soft-bottomed streams would be that it's very difficult to effectively fish those streams, as any disturbance of the substrate means that the water becomes so turbid that you can't see the fish you're trying to catch.
- Urban systems are very different to pasture and forest and may well require specific methods. Because of all the stormwater pipe inputs and bridges, segment lengths are constrained (e.g., over say a 200 m long reach, there may be multiple inputs, structures, and changes in riparian characteristics, all of which may influence fish distribution and abundance). Also, often the substrate has additional composition classes, such as plastic bags, bottles, cans, shopping trolleys, cell phones, cutlery, umbrellas, etc. Some of these provide novel habitats that don't exist in forest and pasture streams.

Do you see a requirement to evaluate the efficiency of specific techniques deployed in New Zealand streams? E.g., how would you rank the list below in order of importance? Any other suggestions not listed below? *(n=14, results presented are averages ± sd)*

Comparison of different trap meshes and types e.g., Killwell vs. Gee minnow ..... 7.1 ± 1.0
Comparison of baited vs. non baited traps..... 6.8 ± 1.3
Rate of escapement and/or predation in traps (e.g., fyke nets) ..... 6.0 ±1.7
Trap capture rate over time (e.g., optimum soak time) ..... 5.1 ± 0.9
Specificity of traps to different species ..... 3.7 ± 1.2
Different techniques specificity – e.g., electrofishing vs. spotlighting which species more likely to be found ..... 2.4 ± 1.4
Accuracy of fish density estimates ..... 2.3 ± 1.5
Optimum number and variety of traps to effectively characterise local diversity and relative abundance..... 2.3 ± 0.9

Other suggestions were:

- Protocols regarding the use of anaesthetics on fish.
- Whether Gee minnow traps can be modified to cause less damage to fish.
- Optimum electrofishing machines settings for various species and habitats.

REFERENCE

Joy, M.K., and R.G. Death 2004. Application of the index of biotic integrity methodology to New Zealand freshwater fish communities. *Environmental Management* 34: 415–428.

APPENDIX 3:

field equipment checklists

EQUIPMENT CHECKLIST FOR ALL PROTOCOLS

Gear	Comments	Packed
Fish Sampling Protocols Field Guide		○
Copies of any previous data sheets for the site	Will assist with standardising effort with previous sampling events.	○
GPS		○
Watch or other timepiece		○
Water quality field meter	To record conductivity and water temperature.	○
Measuring board(s)	30 cm boards are long enough for most situations. Measuring tapes can be used for measuring large eels and sports fish.	○
Digital camera	Select robust models with a macro capability for photographing fish.	○
Voucher jars	Leak-proof, screw-top designs are recommended.	○
Preservative	70% ethanol can be used for preserving fish specimens.	○
Waterproof labels	For labelling in voucher specimen jars.	○
Anaesthetic		○
Pencils		○
Clipboard and field sheets	Including Fish Collection Forms and any habitat assessment forms used.	○
Permits	– Ministry of Primary Industries – Department of Conservation – Fish & Game New Zealand – Iwi	○
Measuring tape(s)	– For measuring reach lengths, habitat data and large fish. – Use long measuring tapes (50–100 m) if using them to mark out sites (hipchains are a good option for quickly measuring out sites).	○
Small aquarium net	For retrieving fish from buckets for measuring and capturing very small fish during spotlighting.	○
Aerator (battery powered)	Optional requirement if sensitive fish are being collected and held for long periods of time or where water quality is very poor.	○
Taxonomic identification books and keys		○

EQUIPMENT CHECKLIST FOR BACKPACK ELECTROFISHING

Gear	Comments	Packed
Electrofishing machine (EFM)	NIWA Kainga EFM 300 is the standard model.	○
EFM batteries	Including spare batteries.	○
Electrical tape	For protecting battery terminals.	○
Heavy-duty rubber gloves		○
Waders	One pair for each team member.	○
Wader repair kit		○
Polarized sunglasses and hat	Set for each team member.	○
Long-handled dip nets with insulated handles	Recommend either of the following nets depending on the size of fish encountered (or combination if >2 people fishing): 1. 300 mm diameter, 500 mm deep and 6 mm mesh size. 2. 150 mm diameter, 150 mm deep and 4 mm mesh size.	○
Buckets with tight fitting lids for holding fish.	Minimum of two buckets recommended. One containing anaesthetic for holding eels and another for other fish species. A third bucket can be useful for processing large numbers of fish. Lids are useful for containing large angry eels. Fish bins with lids may be useful if numerous large eels are expected to be caught.	○
Pole net	Width = 1.4 m, height = 1.1 m, and mesh size of 4 mm.	○
Flagging tape/permanent markers	For marking out and labelling subreaches.	○

EQUIPMENT CHECKLIST FOR SPOTLIGHTING

Gear	Comments	Packed
Spotlight (recommend 30 watt)	At least one spotlight per team.	○
Batteries (12 V)	Including spare batteries.	○
Headlamps	One per team member.	○
Long-handled dip nets	Recommend combination of the following nets: 1. 300 mm diameter, 500 mm deep and 6 mm mesh size. 2. 150 mm diameter, 150 mm deep and 4 mm mesh size.	○
Buckets for holding fish	Only one bucket is normally needed.	○
Electrical tape	For protecting battery terminals.	○
Fish size category table	See Table 3.	○
Flagging tape/permanent markers	For marking out and labelling subreaches.	○

EQUIPMENT CHECKLIST FOR TRAPPING

Gear	Comments	Packed
Fyke nets x 6	See specifications listed in main protocols document.	○
Gee minnow traps x 12	See specifications listed in main protocols document.	○
Anchor weights or poles	12 (two per fyke net).	○
Clips and lengths of cord	– To join trap halves and set traps. – One set per minnow trap.	○
Fish bins and lids	– A minimum of two bins for processing fyke net catches. – One bin for anaesthetising fish and one for recovery of fish.	○
Buckets	For processing minnow trap catches and the catches from the cod-end compartment of fyke nets.	○
Flagging tape	To mark locations of traps.	○

APPENDIX 4:

size class categories for new zealand freshwater fish

The table below lists all of the freshwater fish species currently known to occur in New Zealand along with their corresponding NZFFD six character code. Also included are preliminary maximum length limits for identifying individuals less than one year old (0+ fish). These limits are based on the high degree of confidence that fish of a given species will be less than one year old during the typical field sampling season in New Zealand (December–April inclusive). The limits are not exhaustive and should be considered a 'living document' that can be updated as more supporting data is accumulated.

The limits do not match the juvenile-adult sizes identified in the NZFFD user documentation because those are based on reproductive maturity rather than age.

Common Name	Scientific Name	Code	0+ Maximum (mm)
Alpine galaxias	*Galaxias paucispondylus*	galpau	
Atlantic salmon	*Salmo salar*	salsal	80
Banded kokopu	*Galaxias fasciatus*	galfas	50
Bignose galaxias	*Galaxias macronasus*	galmar	
Black flounder	*Rhombosolea retiaria*	rhoret	50
Black mudfish	*Neochanna diversus*	neodiv	
Bluegill bully	*Gobiomorphus hubbsi*	gobhub	20
Brook char	*Salvelinus fontinalis*	salfon	50
Brown mudfish	*Neochanna apoda*	neoapo	
Brown trout	*Salmo trutta*	saltru	80
Canterbury galaxias	*Galaxias vulgaris*	galvul	40
Canterbury mudfish	*Neochanna burrowsius*	neobur	
Catfish	*Ameiurus nebulosus*	ameneb	
Chatham mudfish	*Neochanna rekohua*	neorek	
Chinook salmon	*Oncorhynchus tshawytscha*	onctsh	
Clutha flathead galaxias	*Galaxias* sp. 'D'		25
Common bully	*Gobiomorphus cotidianus*	gobcot	20
Common smelt	*Retropinna retropinna*	retret	40
Cran's bully	*Gobiomorphus basalis*	gobbas	20
Dart goby	*Parioglossus marginalis*	parmar	
Dusky galaxias	*Galaxias pullus*	galpul	25
Dwarf galaxias	*Galaxias divergens*	galdiv	
Dwarf inanga	*Galaxias gracilis*	galgra	
Eldons galaxias	*Galaxias eldoni*	galeld	25
Estuarine triplefin	*Grahamina* sp.	graham	
Flathead galaxias	*Galaxias depressiceps*	galdep	25
Gambusia	*Gambusia affinis*	gamaff	5
Giant bully	*Gobiomorphus gobioides*	gobgob	20
Giant kokopu	*Galaxias argenteus*	galarg	50
Golden orfe	*Leuciscus idus*	leuidu	

Common Name	Scientific Name	Code	0+ Maximum (mm)
Goldfish	*Carassius auratus*	caraur	
Gollum galaxias	*Galaxias gollumoides*	galgol	25
Grass carp	*Ctenopharyngodon idella*	cteide	
Grayling	*Prototroctes oxyrhynchus*	prooxy	
Grey mullet	*Mugil cephalus*	mugcep	50
Guppy	*Poecilia reticulata*	poeret	5
Inanga	*Galaxias maculatus*	galmac	40
Koaro	*Galaxias brevipinnis*	galbre	50
Koi carp	*Cyprinus carpio*	cypcar	
Koura	*Paranephrops* spp.	parane	
Lamprey	*Geotria australis*	geoaus	
Longfin eel	*Anguilla dieffenbachii*	angdie	100
Lowland longjaw galaxias	*Galaxias cobitinis*	galcob	20
Marine species	Marine	marine	
No species recorded	Nil	nospec	
Northern flathead galaxias	*Galaxias* sp.	galspn	
Otago flathead galaxias	*Galaxias* sp.	galspd	
Perch	*Perca fluviatilis*	perflu	50
Rainbow trout	*Oncorhynchus mykiss*	oncmyk	80
Redfin bully	*Gobiomorphus huttoni*	gobhut	20
Roundhead galaxias	*Galaxias anomalus*	galano	25
Rudd	*Scardinius erythrophthalmus*	scaery	
Sailfin molly	*Poecilia latipinna*	poelat	
Shortfin eel	*Anguilla australis*	angaus	100
Shortjaw kokopu	*Galaxias postvectis*	galpos	50
Silver carp	*Hypophthalmichthys molitrix*	hypmol	
Sockeye salmon	*Oncorhynchus nerka*	oncner	
Southern flathead galaxias	*Galaxias* sp.	galsps	
Spotted eel	*Anguilla reinhardtii*	angrei	100
Stokells smelt	*Stokellia anisodon*	stoani	40
Tarndale bully	*Gobiomorphus alpinus*	gobalp	20
Tench	*Tinca tinca*	tintin	50
Teviot flathead galaxias	*Galaxias* sp.	galspt	
Torrentfish	*Cheimarrichthys fosteri*	chefos	40
Unidentified bully	*Gobiomorphus* spp.	gobiom	
Unidentified eel	*Anguilla* spp.	anguil	
Unidentified flounder	*Rhombosolea* spp.	rhombo	
Unidentified galaxiid	*Galaxias* spp.	galaxi	
Unidentified mullet	*Mugil*	mugil	
Unidentified salmonid	*Salmo*	salmo	
Upland bully	*Gobiomorphus breviceps*	gobbre	20
Upland longjaw galaxias	*Galaxias prognathus*	galpro	20
Yelloweye mullet	*Aldrichetta forsteri*	aldfor	50

APPENDIX 5:
blank fish collection forms

Photo: Electrofishing © EOS Ecology / Shelley McMurtrie

FISH COLLECTION FORM (ELECTROFISHING & SPOTLIGHTING) – Wadeable Streams/Rivers

Reviewed by (Initials) _____

Team members: _____ _____ _____ _____

Lat/Long (GPS bottom): _____ _____

Lat/Long (GPS top) : _____ _____

Site ID _____ Date ____ / ____ / _____ Page _____ of _____

◯ not fished other ◯ fished none collected ◯ fished all 10 subreaches ◯ fished 5-9 subreaches ◯ fished <5 subreaches ☐ flag for fished/not fished

Fish sample ID _____ Total shock (button) time (min) _____ Fishing time start _____ finish _____ Sample distance (m) _____ Area Fished (m^2) _____

Sampling gear ◯ spotlight ◯ EFM ◯ netting net type _____ net No. _____ net type _____ net No. _____

Water visibility ◯ good ◯ average ◯ poor Water temp. (°C) _____ Cond (uS) _____

EFM Volts (x100) _____ **Spotlight** (watts) _____ **Pulse Rate** (pps or Hz) _____ **EFM Pulse Width (ms)** _____ **EFM anode** ◯ big ◯ small **DO** _____ mg/L _____ %

Common Name	Subreach Tally										Total count	Anom. count	Vouch. count	LENGTH (mm) *		Mortality count	Flag
	A	B	C	D	E	F	G	H	I	J				Minimum	Maximum		

Flag	Comment	Flag	Comment

Flag codes: K = No measurement made, U = Suspect measurement., F1,F2, etc. = flags assigned by each field crew. Explain all flags in commentx. LENGTH* - Enter single fish as minimum.

Subreach Size Class Information (mm) ☐ Actual length ☐ Category lengths

FISH COLLECTION FORM (ELECTROFISHING & SPOTLIGHTING)

Common Name	A	B	C	D	E	F	G	H	I	J
Unfishable										
Densiometer Shaded squares (max 96)		US R DS L		US R DS L		US R DS L		US R DS L		US R DS L
Wet width (m)										
Gradient										

FISH COLLECTION FORM (TRAPPING) Page ____ of ____

Site: _____ Date: _____

	Easting	Northing	Water quality		
Upstream end	_____	_____	**Water temp (°C)**	_____	
Downstream end	_____	_____	**DO (%)**	_____	
Fyke 1:	_____	_____	**DO (mg/L)**	_____	
Fyke 2:	_____	_____	**Conductivity (µS/cm)**	_____	☐ specific ☐ ambient
Fyke 3:	_____	_____			
Fyke 4:	_____	_____			
Fyke 5:	_____	_____	**Team members**	_____	
Fyke 6:	_____	_____		_____	
				_____	
Nets set @ _____			**Nets retrieved @** _____		

Mesh Sizes (mm)		**Fyke dimensions**	
Fyke Leader	_____	**Leader height (cm):**	_____
Fyke Trap	_____	**Fyke mouth entrance diameter (cm):**	_____
Gee minnow trap	_____	**Fyke exclusion grid size (mm):**	_____
		No. of funnels (baffles)	_____

Notes:

Gear Type & Number	Species	Length / # of fish	Comment	Gear Type & Number	Species	Length / # of fish	Comment

FISH COLLECTION FORM (TRAPPING) Page ____ of ____

Site: ____ Date: ____________________

Gear Type & Number	Species	Length / # of fish	Comment	Gear Type & Number	Species	Length / # of fish	Comment

ISBN 978-0-473-23437-9

Photo: Setting fyke net © EOS Ecology / Amber Sinton