Regional Guidelines for Ecological Assessments of Freshwater Environments

Standardised Fish Monitoring for Wadeable Streams

Environment Waikato

REGIONAL COUNCIL

Based on a modification of the US EPA Environmental Monitoring and Assessment Program – Field operations manual for wadeable streams (2006) Section 12 Aquatic Vertebrates by Frank H. McCormick and Robert M. Hughes. Original link:
http://www.epa.gov/emap/html/pubs/docs/groupdocs/surfwatr/field/ewwsm_s12.pdf
revised by Peck, D et al. 2006.

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February 2010

Document #: 1576121

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Executive summary

Environment Waikato is currently developing a series of protocols to assist those involved in assessment and monitoring of freshwater ecosystems. The fish monitoring protocols for wadeable streams are intended to establish a regionally consistent set of approaches for sample collection, analysis and reporting, and to set a minimum level of effort that workers are required to meet and welcome to exceed. The primary objective of using a standardised fish monitoring protocol is to collect quantitative, repeatable and transparent data that include a representative sample of the majority of fish species in the assemblage.   The methods are designed to be useful for a variety of purposes from regional fish State of the Environment (SOE) monitoring and assessment of environmental effects, to effective evaluation of stream rehabilitation initiatives. These methods are based on USEPA protocols which were tested across a variety of stream types throughout the Waikato region. Slight modifications to these methods and additional development in other areas to suit New Zealand conditions and species assemblages were made. These include; a modified prescriptive backpack electrofishing procedure, and the development of a prescriptive spotlight sampling procedure for nocturnally active native fish species. The longitudinal sampling distance of a reach is set at 150m irrespective of wadeable stream width or procedure used. This length is based on the likelihood of detecting maximum reach scale diversity informed from testing across a variety of stream types within the Waikato region and elsewhere around New Zealand. A separate but related procedure for standardised processing and recording of catches is also provided. Where appropriate, these protocols may be used across the Waikato region in conjunction with other standardised methods for evaluating other biological (e.g. Macroinvertebrate sampling in wadeable streams - Collier & Kelly 2005) and physical (e.g. Standardised Habitat Assessment Protocols – Harding et al. 2009) elements in wadeable stream environments.

1　Introduction

Environment Waikato is currently developing a series of protocols to assist those involved in assessment and monitoring of freshwater ecosystems. The assessment protocols are intended to establish a regionally consistent set of approaches for sample collection, analysis and reporting, and to set a minimum level of effort that workers are required to meet and welcome to exceed. We recognise that each study will have its own set of questions and requirements, and that variation to any protocols or recommended methods may be necessary to address specific questions. These protocols should not constrain the scope of work that is carried out but should be used to ensure that, where appropriate, the approaches applied are consistent with recommended methods and meet or exceed the minimum level of effort.　The guidelines discussed in this document relate to the monitoring of fish communities within the Waikato region.

The use of a standardised sampling protocol for monitoring fish communities in New Zealand wadeable streams has been needed for some time.　The primary advantage of having a standardised regional protocol is that information is collected in a consistent manner enabling trends in fish populations to be monitored across larger spatial and temporal scales.　Approximately one third of New Zealand's native fish species are capable of diadromy. Consequently many of the same species can be found throughout both the North and South Islands particularly in catchments close to the coast.　Because of this life-history strategy, juveniles born in one region may disperse at sea and facilitate recruitment to other regions. To confidently establish the state of these stocks, a coordinated approach to assessing their populations at both regional and national scales is needed.

One such protocol developed by the United States Environment Protection Agency (USEPA) as part of their Environmental Monitoring and Assessment Programme (EMAP) has been in operation for almost a decade now. The consistency of data collection across the Western US has enabled robust assessment of the state of native and exotic fish communities over a wide geographic area ($205,000km^2$).　The proven utility and adoption of this method in the US prompted a trial to determine its utility in New Zealand wadeable streams in 2008/2009. Following permission of the original developers, data sheet templates and protocols were modified slightly to enable reach scale evaluation of species accumulation for stream distance sampled, and to accommodate New Zealand specific databases and methodological details.　The primary objective of using a standardised fish monitoring protocol is to collect quantitative, repeatable and transparent data that include a representative sample of the majority of fish species in the assemblage.　These protocols represent the minimum level of sampling that should be conducted where the primary goal is to assess the diversity and relative abundance of a fish community at a particular elevation and distance inland.　There is significant scope to extend data collection using these protocols where warranted or appropriate (e.g. undertaking multiple pass rather than single pass electrofishing or spotlighting) and incorporating other standardised protocols such as the Stream Habitat Assessment Protocols (Harding et al. 2009).　It is expected that the protocols outlined herein would be suitable for a variety of purposes including Assessment of Environmental Effects (AEE's) for consent purposes, State of the Environment (SoE) reporting and evaluating the effectiveness of restoration/rehabilitation initiatives on fish communities.

Because many fish often require access throughout river basin networks and the sea, their abundance and diversity is often strongly influenced by factors such as gradient, altitude and distance inland from the coast (Jowett & Richardson 1996).　Thus, it may be necessary to sample multiple sites along a streams length (from headwaters to the sea) to capture this diversity.　In terms of reporting on the state of these communities through time, strategic selection of sites may be worthwhile.　For instance, known diadromous communities present well inland may be more vulnerable or susceptible to

anthropogenic changes as recruitment sources are further away than communities closer to the coast (except in cases where localised 'lake derived' recruitment may be occurring). Reduction in densities or species diversity from these inland sites over time may be useful as early indicators of recruitment reduction for other sites where such effects may take much longer to manifest themselves (i.e. where recruitment supply can often exceed a stream's carrying capacity). Alternatively, if localised rather than large-scale recruitment effects are of interest at the same site (e.g. effects of sedimentation on local fish communities) it may make more sense to focus on an indicator species that is able to recruit locally. For instance the density (fish/m^2) of non-migratory species such as Crans or upland bullies or any of the non-migratory galaxiids may better represent local effects than densities of diadromous species whose numbers and recruitment could be influenced by factors well beyond the monitoring area (e.g. unfavourable conditions for larval rearing at sea, construction of a barrier downstream preventing or reducing annual recruitment from marine environments)

2   Site selection

Site selection depends on the intended purpose of the investigation. For standard SOE monitoring a completely random computer generated allocation of wadeable stream locations may be applicable (e.g. Stein & Bernstein 2008, Peck et al. 2006). This approach is incorporated with targeted monitoring of impact and reference sites and is the current model adopted at Environment Waikato for SOE invertebrate monitoring.

To put such sites into context, however, a selection of wadeable sites with minimal human impairment ("reference" sites) if they exist should also be regularly monitored. When assessing the state of fish communities, it is important to have a subset of sites that are monitored repeatedly through time. This is necessary to differentiate between natural variability in fish communities (e.g. inter-annual variation in relative abundances) and actual trends (e.g. a consistent decline in species richness and or relative abundance at a particular site). If the same sampling methodology is applied regionally and nationally, for many species and communities (particularly diadromous fish communities), it will soon become apparent if particular trends are occurring at a local, regional or national scale.

When using these methods for AEE purposes, the inclusion of physically comparable sites that are un-impacted by the disturbance(s) under investigation is very important. In the context of monitoring; an "impact" site refers to the stream reach likely to be disturbed/affected by an activity; a "control" site refers to a location that is very similar (as close as can be obtained) to a disturbed site (excluding the disturbance factor) to isolate the effect of the particular disturbance(s). This is not to be confused with a "reference" site that reflects undisturbed or minimally disturbed conditions in the area prior to human development.

"Control" or "reference" sites may be on the same stream but above the impact site where comparable reaches are available nearby, or on nearby streams that are physically similar (e.g., similar size, gradient, substrate type etc) but un-impacted by the disturbance(s) under investigation. Where an impact is anticipated in the future, both control sites and "impact" sites can be sampled prior to the onset of effects to establish baseline comparability between sites. Sampling of "control" and "impact" sites before and after the onset of disturbance (BACI design) is viewed as one of the most robust sampling designs for assessing environmental effects (Collier & Kelly 2005).

Prior to undertaking sampling, it is possible to utilise predictive desktop models (e.g. Joy & Death 2004, Leathwick et al. 2009) to gain some indication of the fish community likely to be present at a site. These models have been built from extensive distributional presence absence data contained within the New Zealand Freshwater Fish database. A probability of occurrence for various species is provided for every River Environment Classification (REC) segment based on the similarity of local conditions (within an REC segment) to segment conditions elsewhere known to contain

each of the species. Any REC segment containing any fish species with a probability value greater than 0.5 represents a 50% likelihood that that species will be detected. It is important to recognise, however, that while these models may be useful for providing an indication of presence or absence, observed data are critical for validation and or evaluating relative species abundance.

Sampling times – The timing and frequency of sample collection will depend in part on the objectives and urgency of the study. Being clear about the objectives of the study will help define appropriate sampling times and frequencies. Typically, evaluation of fish populations is best undertaken between December and April when fish are most active and responsive to the techniques described. Possible exceptions include surveys to specifically target whitebait arrivals to lowland coastal streams which tend to occur outside the typical summer sampling period. It should be noted, however, that many species become less active and much more difficult to capture in colder months. For instance, eel capture rates are known to drop at temperatures below 14^0C (Chisnall 1987), with the effect being more dramatic when water temperatures fall below $10\text{-}11^0$ C. (B. David unpubl. data).

Flood disturbance - The occurrence of major floods can compromise the validity of bioassessments, particularly where quantitative data are used, as the results tend to reflect the effects of flow disturbance rather than the stressor being investigated.

Doug Stewart (Environment Waikato) has calculated the maximum levels and flows of rivers (monitored by Hydrological sites) able to be sampled. These rivers represent key catchments within the Waikato region. If levels are exceeded then sampling must not occur within the following two week period. This allows a recovery time for macroinvertebrates (see Collier & Kelly 2005) and fish within each catchment. Flows can be viewed using HydroTel (Environment Waikato's telemetry system). As these catchments are representative of areas throughout the region, the information must be used to infer levels within streams not individually represented by geographical location. Rainfall data can also be used to help elaborate on areas not listed below. Rainfall can also be accessed using HydroTel.

Table 1:   **Invertebrate and fish Disturbance Levels**

River	Site	Catchment area	Bed disturbing flow (m3s-1)	Level – stage (m)
Awakino	Gorge	226.0	100	3.5
Kaueranga	Smiths	122.0	80	7.4
Mangaokewa	Te Kuiti PS	173.2	60	51.2
Mangatangi	SH2	196.0	30	10.9
Mangawara	Jefferis	98.0	20	19
Ohinemuri	Karangahake	287.5	133	13.8
Piako	Kiwitahi	105.0	15	2.4
Tairua	Broken Hills	117.0	70	2.4
Tauranga/Taupo	Te Kono	199.5	75	1.3
Waipa	Otewa	317.0	90	77.222
Whakapipi	SH22	44.4	10	8.7

3   Sample collection

For most wadeable streams, backpack electrofishing equipment is used as the principal sampling gear but spotlighting can also be used at suitable sites. Depending on species present and the purpose of the work it may also be worthwhile to use both methods at the same site. The use of other techniques (e.g. fyke nets, minnow traps)

is currently being evaluated as part of an Envirolink Foundation for Research Science and Technology (FRST) project aimed at standardising the use of these methods across wadeable stream environments. In the interim Environment Waikato supports and advocates the use of 'standardised mudfish monitoring guidelines' (Ling et al. 2009) for fish sampling in wetlands within the region.

For wadeable streams, (typically stream orders 1-3 and >90% of the sample reach <0.7 m deep), standard site length is set at **150 m**. This is the minimum sampling length used in the USEPA protocols. In New Zealand streams, this length has been set based on the likelihood of detecting maximum diversity at a site using one pass electric fishing methods irrespective of stream size, distance inland and geographic position. For data showing this point and an explanation refer to Appendix 1 - Figures 1, 2. For data indicating approximate sampling time by area fished see Figure 3 and for additional comments and suggestions on method selection and use see Appendix 2.

If the site has not been visited before it is recommended to undertake a desktop exercise using GIS, aerials and the River Environment Classification data layer (if available) to assess landowner information and suitability and access to the site. At this time it is also possible to determine other useful information including the stream's distance inland (note this is measured at the downstream end of the REC segment), altitude, segment gradient, REC segment identification number and possibly Fish Index of Biological Integrity (Fish IBI score).

Once at a selected site, follow the step by step procedures as outlined in Tables 1, 2 and 3 below. Total collection time for a site should be 1 to 6 hours to obtain a representative sample. An average sized stream typically takes 3-3.5 hrs to complete but if a stream is very wide (>10 m) and contains high densities of fish, two separate crews may be required to complete the site within a day. As a guide, if it appears that the reach is so wide that three - four hours of sampling will only allow you to sample 50% or less of the available surface area an additional crew may be necessary.

4   Permits

Permits for taking Aquatic life, capturing sportsfish and sample collection in DOC reserve areas are required from DOC, Fish and Game and Ministry of Fisheries. Ensure familiarity with the relevant regulations and legislative requirements pertaining to your sampling location.

4.1   Backpack electrofishing procedure

Table 2:   **Backpack electrofishing procedures (Specifically for NIWA Kianga 300 EFM backpack machines)**

1. After arriving at a site visually assess water visibility and record the stream's temperature and conductivity on the form using an appropriate calibrated meter. Ensure these measures are taken in clear undisturbed water. The conductivity will determine the initial voltage setting selected. If conductivity or depth preclude backpack electrofishing, sample by spotlighting if possible. Once readings have been taken, walk the reach to be sampled (150 m) to ensure that there are no major tributaries joining or major impediments to passage within the reach to be sampled. **If possible do this from the bank without walking in the stream.** As this is being done, use a tape measure or hip chain to split the site into 10 equidistant subreaches marked with flagging tape. Clearly mark the relevant subreach letter (A-J) on the flagging tape or marker as this will be a useful reminder of the subreach being fished during sampling. (Appendix 1, Figure 4). If the site is to be used for long-term monitoring, permanent labelled markers positioned above flood height but still visible from the stream may be appropriate. 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 and site name on the fish collection form (Appendix 1, Figure 5).
2. If conductivities are suitable for electrofishing (10 – 400 µS/cm), 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 of most fish >200 mm), use a pulse rate of 30 Hz with a pulse width of 2 msec. If mostly small fish are expected (most cases), use a pulse rate of 60-70 Hz. Test these settings immediately below the selected site. **If these settings result in all six lights showing on the wand drop the voltage first until 5 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.

3. Remember to run through your pre-operational safety checks (checking the safety switches, connections etc). Once the settings on the electrofishing machine are adjusted properly to sample effectively and minimise injury and mortality, record these settings and the anode ring size used (big/small) in the spaces provided on the sheet. Following this, reset the total shock (button) time in the back of the machine to zero. Also remember to record the 'start' time in the 'fishing time' slot on the collection form and begin sampling at the downstream end of the reach (subreach A). A pole netter positioned below the fisher captures any stunned fish and places them in a bucket. The fisher (and in larger rivers a third person) 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 2-3 m above the pole netter. The fisher then fishes down towards the pole netter sweeping the wand from side to side but inline with the pole net. Generally this means a rectangular area or 'lane' of approximately 6 m^2 is fished on each pass. **It is important that the machine's cathode ('tail') is always upstream of the pole netter and between the fisher and the pole netter** but that the anode ring does not make contact with it. Fish through 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**. 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. 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. Note: It is often useful for both the pole netter and fisher to use bankside or instream objects as a marker to maintain a constant line as they move across the channel. This increases sampling efficiency and minimises the potential for fishing water that has already been fished.

4. Search and sample for fish (including crayfish and shrimps) 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 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) 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 (calculated later). Do this by creating a 'flag' and comment e.g. 'F1 - deep pool in subreach B, fished edge, 3 m^2 area not fished' (see example Fig. 5).

5. If wearing a hipchain 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 reduce mortality and track sampling effort (for processing fish see details in Table 3 – procedure to identify, tally and examine fish). **Once fish have been processed after each subreach, remember to record the stream wetted width at that point and record this in the 'wetted width' space provided for each subreach** (Appendix 1 Fig. 5). This is important as these widths will be averaged later along with total stream length fished to provide the stream area sampled. The first width measurement is made at the end of subreach A. Remember to fill out the 'Habitat Type %' assessment on the back of the sheet at the end of each subreach (see Harding et al. 2009, p 34 for habitat type definitions if unfamiliar).

6. Repeat steps 3-5 until subreach J is finished. 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. Ensure the number or letter you use in the "Flag for fished/not fished" box and comment "flag" (explaining why), correspond. Sample distance is the total reach length actually fished (i.e. it will be equal to or less than the 'support' reach length – Appendix 1, Figure 4). **Don't forget to record the total shocking time (back of the EF machine) in the "total shock (button)**

time (min)' location and actual 'finish' time on the form. This must be done before you turn the machine off after fishing and is important because it provides information of the effort expended and the time taken to complete a site. This information is useful if repeat visits to the site are planned

Record any other general comments such as perceived fishing efficiency (e.g. general fish reaction to electric current), missed fish (you may want to assign a row to missed fish to record missed fish per subreach), gear operation, deep pools, suggestions on the Fish Collection Form.

Please note: As best practice to avoid inadvertent transfer of pest species (macrophyte fragments, fish eggs, didymo etc) when moving between streams or catchments, we recommend that nets and boots/waders are soaked in a concentrated saltwater solution (1 part salt to 14 parts water) for two hours or a bleach solution (2% or 20 ml per litre). The bleach solution is fast acting and nets only need to be sprayed or dipped in this solution for it to be effective. However, the bleach solution will not remain effective for longer than a day. Alternatively 5% detergent may also be used.

Table 3: Procedure to identify, tally, and examine fish collected using backpack electric fishing gear

1. Complete all header information accurately and completely on the Fish collection form. If no fish, crayfish or shrimps were collected after fishing the 10 subreaches, fill in the "Fished none collected" bubble on the collection form.

2. Identify each individual at the **end of each subreach**, ideally handling it only once. Record the common name on the first blank line in the "Common Name" section of the Fish collection form. Record the tally of fish species caught from each subreach in the relevant subreach column on the form. **See step 4 if a species cannot be positively identified**. Koura and shrimp are not measured. Count koura as individuals captured and place paratya into one of the following four categories 1-10,10-100, 100-1000, 1000+.

3. Process any species listed as threatened first and return individuals immediately to the stream (one riffle downstream). 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 and add them to the mortality column on the form (see step 6).

4. Measure the total length (nose to distal end of the caudal fin, no lengths for crayfish or shrimps) of the largest and smallest individual to provide a size range for the species. Record these values under the "LENGTH" column on the Fish collection form. If more detailed fish size information is warranted, individual fish can be measured and or assigned to a size category (see Table 5). Individual lengths or size categories (T=tiny, S=small M=medium L=large) can be recorded on the back of the fish collection forms where more space is available.

5. Examine each individual for external anomalies and tally those observed. Readily identified external anomalies include missing organs (eye, fin), skeletal deformities, shortened operculum, eroded fins, irregular fin rays or scales, tumors, 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 under the anomolies column ('Anom. count') and describe the anomaly type using a flag on the Fish collection form. Photograph specimens with especially extreme anomalies.

6. Record the total number of mortalities due to electrofishing or handling on the Fish collection form in the mortality column ('Mortality count'). Depending on site location and fish species captured, a permit may be required to capture and/or kill and remove fish. Permits may be required from the Department of Conservation, Fish and Game and/or the Ministry of Fisheries. Please ensure familiarity with the relevant regulations and legislative requirements pertaining to your sampling location.

7. Follow the appropriate procedure to prepare voucher specimens (i.e. fix in formalin/ethanol or put on ice) and/or to select specimens for tissue samples. Release all remaining

individuals so as to avoid their recapture (ie at least one pool riffle sequence downstream or in their absence 20m downstream). Record the name given to this voucher specimen sample in the "Fish sample ID" section of the form.

8. If a species is encountered that cannot be identified, assign it as "unknown" followed by its common family name (e.g., unknown bully A). Keep up to 20 sample specimens for later identification back at the laboratory. Record the subreach they were from and also record the number collected in the voucher count column. If no small individuals are collected, photograph each species and indicate so on the data form. Large, questionable species may be placed on ice and then frozen. 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 voucher 20 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 crans and common bullies are encountered).

9. At the end of each subreach ensure that for any row with a fish name, that all spaces on that row are filled in with a number or a dash (if zero).

10. 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.

11. Repeat Steps 1 through 10 for all other species.

Table 4:   Spotlight fishing procedures (Specifically for Lightforce 30W spotlight beams)

1. After arriving at a site walk the reach to be sampled (150 m) <u>during daylight hours</u> 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 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. Once this is done, measure and record the stream's temperature and conductivity on the form. Following this, fill in the 'spotlight' bubble and indicate the bulb strength (30 watt recommended) on the form.

3. **<u>Do not begin sampling until at least 45 minutes after sunset.</u>** Remember to 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. <u>Do not scan the beam more than 4m ahead, as this</u> will frighten fish 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 who will record as you move upstream. <u>Make an effort to catch any fish that cannot be identified from the bank</u>. Move quietly and at a constant pace. This will generally prevent fish moving in an upstream direction and double counting them. 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 eg. 'Unidentified kokopu'. Estimate the length of individual fish early on during sampling and then attempt to capture and measure them to calibrate your visual estimates. Do this for a few different species. Measure and record any captured fish noting this as a 'flag' on the form (e.g F1 banded kokopu visual estimate 125mm, actual 133mm). These values can be used later to record an observers 'visual length estimate error'. Use <u>two dipnets</u> to capture fish at night keeping the spotlight beam focussed directly on the fish. Move <u>very slowly</u> 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. <u>Resist the temptation to 'snatch' at fish</u> 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 bolts, generally it will dive straight into the net placed behind it at which point the net should be raised rapidly.

4. Search and sample for fish (including crayfish and shrimps) 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 2m² (continuous), measure the area that can't be fished and record this on the form. Do this with a flag or the bottom row of the form can be used to keep track of 'unfishable area' per subreach. This area will later be subtracted from the total reach area fished to indicate the 'spotlightable' area that was surveyed.

5. If wearing a hipchain keep an eye on the distance travelled or search stream banks for marked 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 and record this in the 'wetted width' space provided for each subreach**. (Note: when using the spotlighting method, fish should be recorded as you go by calling out species and sizes to a following scribe). If more detailed fish size information is warranted, individual fish can be measured and or assigned to a size category (see Table 5). Estimated individual lengths or size categories (T=tiny, S=small M=medium L=large) can be recorded on the back of the fish collection forms where more space is available.

It is important that widths are measured as these will be averaged later along with total stream length fished to provide the stream area sampled. Remember to fill out the 'Habitat Assessment %' on the back of the sheet at the end of each subreach

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 dipnets 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. If a species is encountered that cannot be identified, assign it as 'unknown' followed by its common family name (e.g., unknown bully A). Keep up to 20 sample specimens for later identification back at the laboratory. Be sure to spotlight all habitats where possible (deep, shallow, fast, slow, complex, and simple).

7. Repeat steps 5 and 6 until subreach J is finished. 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 'support' reach length – Fig. 1). 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.

Please note: As best practice to avoid inadvertent transfer of pest species (macrophyte fragments, fish eggs, didymo etc.) when moving between streams or catchments, we recommend that nets and boots/waders are soaked in a concentrated saltwater solution (1 part salt to 14 parts water) for two hours or a bleach solution (2% or 20 ml per litre). The bleach solution is fast acting and nets only need to be sprayed or dipped in this solution for it to be effective. However, the bleach solution will not remain effective for longer than a day. Alternatively 5% detergent may also be used.

5   Reporting and data entry

A central repository for assembling these data is required. It is envisaged that a common interface will be developed enabling organisations to easily upload and retrieve raw data. It is acknowledged that different software packages may be used by different organisations to undertake region-specific analyses. As a minimum, reach scale fish diversity (total number of species) and density (e.g. number of fish/100m²) should be recorded. For density measures it is important to omit any area of a reach that was not fished.

Note: these data should still be submitted to the New Zealand Freshwater Fish Database. As such, fish records and NZFFD cards should still be completed for each site.

6 Fish common names and species code

Use McDowall's New Zealand Freshwater Fishes field guide (2000) to record fish names. E.g. Common name: Giant kokopu, Species name: *Galaxias argenteus*, species code = Galarg

Table 5: Waikato region fish size class table

Species common name	Tiny (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+
Crans bully	≤20	21-40	41-60	61+
Upland bully	≤20	21-40	41-60	61+
Torrentfish	≤40	41-60	61-80	81+
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	51-140	141-250	251+
Longfin eel	≤100	101-300	301-500	501+
Shortfin eel	≤100	101-300	301-500	501+
Lamprey	Ammocoete	Macrophthalmia	NA	Adult
Gambusia*	≤5	6-15	16-25	26+
Rainbow trout*	≤110	111-220	221-500	501+
Brown trout*	≤110	111-220	221-500	501+
European perch*	≤50	51-80	81-150	151+

* Denotes non-native species

6.1 Concluding remarks

Each site should take on average about 2-3 h to complete but may take up to 8 h in very wide (>10m) wadeable streams. 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.

With sufficient national coverage, it is expected that a more realistic assessment of the state of fish communities across New Zealand can be made. It is likely that in time identification of any national issues (e.g. recruitment failure of diadromous species) will be possible not only regionally but nationally. Consistency and comparability are essential if the full potential of the method is to be realised.

7 Literature cited

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7.1 Gear checklist for freshwater fish sampling

- Electric fishing machine
- Flathead screwdriver (to attach anode and open EFM and change/check settings)
- 2 sets (4) 7amp hr batteries for electric fishing machine or spotlight (charged) (12v)
- Calibrated conductivity/temperature/dissolved oxygen meter
- Heavy-duty rubber gloves
- Chest/thigh waders with patch kit
- Polarized sunglasses
- Flagging tape
- GPS unit (plus spare batteries)
- Measuring tape (1x 20m, 1x 100m)
- Hipchain (plus biodegradable cotton replacement roles)
- Long-handled dip nets (0.6 cm mesh) with insulated handles
- Watch or stopwatch to track elapsed fishing time
- Buckets for holding and processing fish
- Pole net (2-3 mm mesh, chain on bottom)
- Aquarium net
- Taxonomic reference books and keys for fishes of the region
- Digital camera with macro capability for photographing
- Fish measuring board and small plastic rulers (2)
- Screw-top plastic jars (leakproof) for voucher samples
- 2 L 10% (buffered) formalin or voucher sample jar half full of 10% formalin or 70% EtOH
- Clipboard
- Headlamp (plus spare batteries)
- Spotlight (30watt)
- Fish anaesthetic (Aqui S)
- Sheet of pre-printed jar labels
- Scissors for cutting jar labels
- Electrical tape
- Lead pencils for recording data
- Permanent marker
- Fish Collection Forms printed on waterproof paper
- Habitat assessment forms printed on waterproof paper
- Fish monitoring methods document
- Laminated sheets of fish procedure tables
- Fish collection permits if required (DoC, Iwi, Fish&Game)
- Decontamination equipment

Appendix 1:
Species diversity (how much stream length to sample) graphs

Below are data plotted from 73 New Zealand river sites using modified US EPA protocol methods. Streams varied from 1st to 3rd order and from right on the coast to 160 km inland. Geographically they include sites from Auckland, Waikato, Manawatu, Wellington and Otago. From the species accumulation curves (Figure 1) it can be seen that if you sample 150m of stream irrespective of size or location the majority of species likely to be present at a reach scale will be detected. This general pattern probably reflects the higher probability of sampling the full variety of habitats available at a reach scale. While total diversity at some sites was detected after 20-30 m, at other sites 2-3 species could be added beyond 90m, but sampling beyond 150m did not add much despite significant extra effort (Figure 2). This is a justifiable guide for SOE monitoring where diversity and relative abundance through time (once/yr) using standard one pass methods is the primary goal.

Mean diversity index variability (+/- SD) for distance sampled
n=73 sites
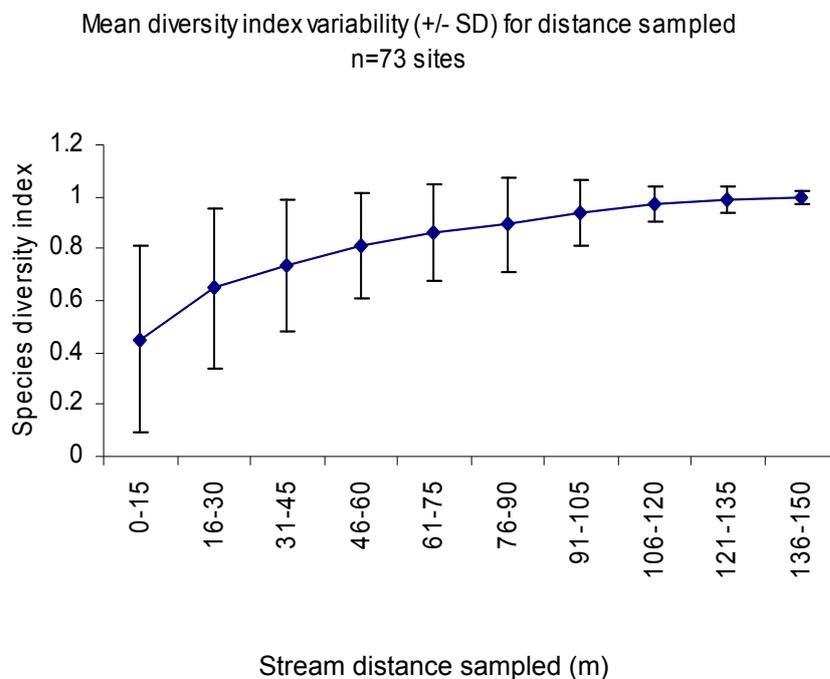
Figure 1: **Diversity index (species accumulation) curve for 73 sites across New Zealand. Likelihood of detecting previously undetected species becomes lower with increasing stream distance sampled. Error bars are expressed as (+/- 1 SD around the mean).**

Fish diversity for stream distance sampled n=73 sites
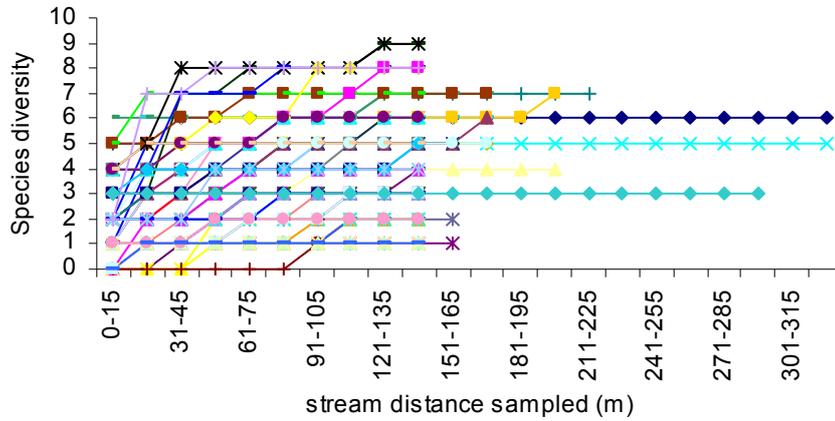
Figure 2: Range of fish species diversity detected at 73 sites across New Zealand by stream distance sampled. Reach scale species diversity ranged from 1-9.

Shock time V area fished n=73 sites

$R^2 = 0.4843$
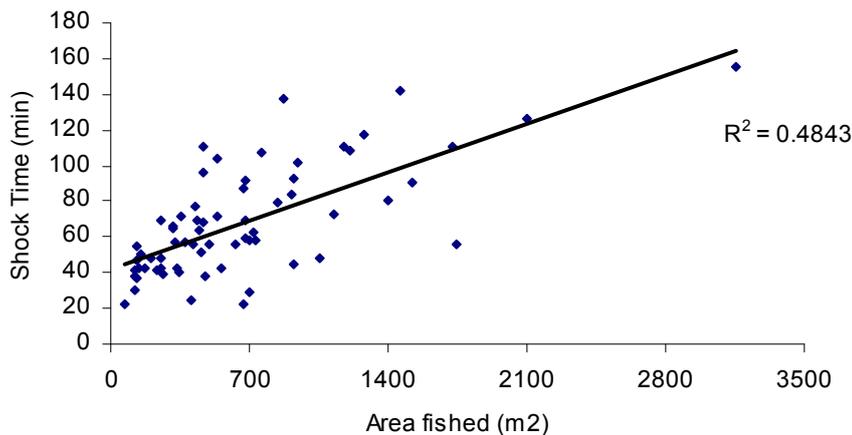
Figure 3: Relationship between shock time and area fished for 73 sites across New Zealand. A positive linear trend indicates that irrespective of operator that effort expended is generally proportional to the area fished.

While 150m is a substantial length of stream to sample, there are three main reasons for justifying 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 at this length (diversity of habitat available and hence diverse species will be captured).

2. If sampling is to occur at the same sites through time (e.g. annually or 3-yearly), then even if there are major stream bed disturbances (e.g. flood) the redistribution of those diverse habitat types are still likely to be represented even if their position within the 150m reach may have changed

3. Data collected over time will be comparable.
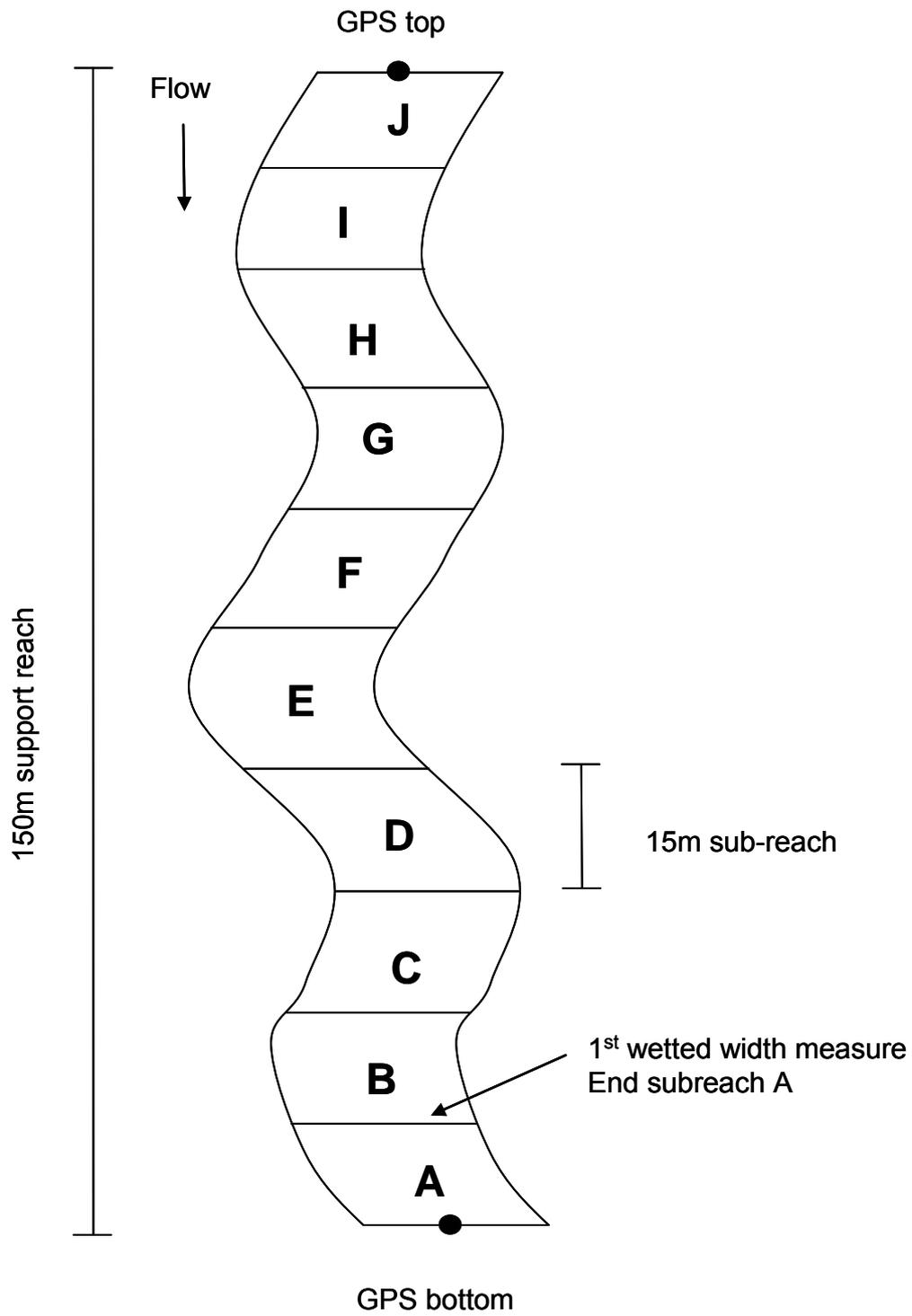
Figure 4: **Reach layout (150m) showing 15m subreaches**

Fish collection form - Wadeable streams / rivers

Reviewed by (Initials) _MH_

Team members: _Bruno David_, _Mark Hamer_

Lat/Long (GPS bottom): E 2747247 / N 6468890
Lat/Long (GPS top): E 2747108 / N 646 8933

Site ID _Waiwawa Trib us box culvert_ Date 12 /3 / 09 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

Fish sample ID _____

Total shock (button) time (min) _0.57_

Fishing time start _11:29_ finish _15:00_

Sample distance (m) _150_ Area Fished (m²) _463.5_

Wetted width (m) A _2.3_ B _3.3_ C _1.2_ D _2.4_ E _4.1_ F _2.0_ G _2.8_ H _2.0_ I _3.1_ J _7.7_

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

Water visibility ● good ○ average ○ poor
Water temp. (°C) _13.8_ Cond (uS) _73.5_

EFM anode ○ big ● small distance inland (km) _10.9_ altitude (m) _40_ gradient (°) _0-12_ REC seg ID(s) _2468_

[F1] FLAG for other Sampling Information

EFM Volts (x100) _3_ Spotlight (watts) _____ Pulse Rate (pps or Hz) _65_ EFM Pulse Width (ms) _0.2_ FISH QIBI Score _60_

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
Paratya	100-1000	100-1000	100-1000	100-1000	100-1000	100-1000	100-1000	100-1000	100-1000	100-1000	1000+	—	—	—	—	—	
Unid. Eel	I	—	—	—	—	II	—	—	I	—	4	—	—	—	—	—	
Longfin eel	III	HHT II	I	I	—	II	—	—	—	I	15	—	—	150	600	—	F2
Redfin bully	HHT IIII	HHT II	II	III	HHT III	HHT HHT II	HHT II	HHT IIII	II	HHT HHT II	74	—	—	30	85	I	
Koura	II	III	I	II	I	I	—	—	II	—	12	—	—	—	—	—	
Shortfin eel	—	I	I	I	—	—	—	I	—	—	4	—	—	—	—	—	
Banded Kokopu	—	—	II	—	II	—	I	III	—	I	9	—	—	55	105	—	
Missed fish	—	—	—	II	—	—	—	I	—	—	3	—	—	—	—	—	

Flag	Comment	Flag	Comment
F1	last subreach only fished shallow front edge of waterfall pool	—	7m² not fished.
F2	large longfin in migratory phase (last subreach - J)		

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

Figure 5:   Fish collection form

Subreach size class information (mm) ☐ Actual length ☒ Category lengths

Common Name	A	B	C	D	E	F	G	H	I	J
Longfin eel	S,M,M	m,m,S,S,S,S,S	m	m	—	M,S	—	—	—	L
Redfin bully	L,L,m,m,m,m,L,S,S	m,L,L,M,S,L,L	L,m	L,L,m	m,L,L,L,L,m,S,S	m,m,L,L,L,L,L,m,m,m,m,S	S,m,m,L,L,L,M,S	L,L,L,L,L,m,m,m,S	L,L	L,L,L,L,m,m,m,L,L,L,L,m,m,M
banded Kokopu	—	—	S,M	—	S,S	—	m	S,S,m	—	S
Shortfin eel	—	s	s	T	—	—	—	s	—	—

Habitat type %	A	B	C	D	E	F	G	H	I	J	Total
Still	5	5	5	5	5	5	5	—	—	—	
Backwater	—	—	—	—	—	—	—	—	—	—	
Pool	25	45	40	35	40	20	45	50	10	45	
Run	30	25	45	45	30	40	30	10	10	30	
Riffle	40	25	5	5	10	30	5	—	—	—	
Rapid	—	—	—	—	—	—	—	—	—	—	
Cascade	—	—	5	10	15	5	15	40	80	25	

Common name	T	S	M	L
Redfin Bully	0-20	21-40	41-60	61+
Banded Kokopu	0-50	51-100	101-200	201+
Eels	0-100	101-300	301-500	500+

Appendix 2: General notes and comments

General notes relating to backpack electric fishing procedure

Avoid contact with the anode and cathode but if possible fish with the anode and the cathode on the same side of the stream. As you move across the channel reposition the cathode accordingly. Fishing with the anode and cathode close together keeps a tighter and arguably more controlled electrical field.

Avoid electrofishing near unprotected people, pets, or livestock. Discontinue activity during thunderstorms or heavy rain and maintain frequent communication 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 gloves, and follow safe standard operating procedures.

Wear polarized sunglasses and caps to aid vision.

If fish show signs of stress (loss of righting response, gaping, gulping air, excessive mucus), change water or stop fishing and process them. This should only be necessary on very warm days, in long reaches, or if large numbers or biomasses of fish are collected.

Cease electrofishing to process and release listed threatened or endangered species or large game 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.

While fishing a reach record the number of any other fish stunned or seen in the subreach but not captured. If they can be clearly identified, add them to the appropriate species list otherwise record them in a separate row to the closest taxamonic level (e.g. 3 missed 'bully', 1 missed 'kokopu' sp). Do not guess or assume what the species is if it cannot be clearly identified.

Testing of this method in New Zealand has highlighted the need to keep larger eels (>500mm) 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.

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 any eels smaller than (200mm).

If time allows, record the size category of short and longfin eels. Because eels are long-lived, only breed once and are considered a national stock, it is important to identify any long term trends and/or any recruitment issues as early as possible.

Taxonomic identification and tally

It is important to note all subreaches from where a species is collected, as this provides information on longitudinal distribution and gives an estimate of sampling efficiency.

Where there are many individuals of easily identified species, processing is facilitated by keeping a tally count of the number of individuals of each species and totalling the tally once processing is complete.

If threatened fish have died, voucher them being sure to label location and date of capture.

External examination and length measurements

During the tallying procedure for each species (Table 3), examine each individual for the presence of external anomalies. Record the number of individuals affected on the Fish collection form (Figure 5). Blackening and exopthalmia (popeye) 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 (Figure 1). For each species, use a measuring board or ruler to determine the length of the largest and smallest individuals collected at a site. Measure the total length for fish (nose to distal end of caudal fin). No length measurements are taken for crayfish or shrimps. For crayfish count numbers captured and or missed and for shrimps (paratya) indicate abundance using a coarse scale of 0-100, 100-1000 or 1000+ for each subreach.

Some notes on method selection: Pro's and cons of spotlighting vs electrofishing.

Certain sites will be more conducive to either method but at some sites the use of both methods may be valid. Comparing sites where the two methods have been used suggest that there are some consistent species differences with regards to detection.

Eels – tend to detect higher numbers with EFM than spotlight (particularly smaller eels). Note, generally detection of eels with either method appears to decline rapidly once water temperatures fall below 12.0 degrees C for North Island streams.

Kokopu - tend to detect lower numbers with EFM than spotlight (Bowie & Henderson 2002)

Bullies - tend to detect higher numbers with EFM than spotlight (results more similar when few riffles are present)

Koura - tend to detect higher numbers with EFM than spotlight (results more similar in fishless streams)

Trout – spotlighting vs electric fishing – can vary probably depending on reach habitat (e.g. slightly higher with EFM Hickey & Closs 2006, lower with EFM Bowie & Henderson 2002)

Hickey M and Closs G 2006. Evaluating the potential of night spotlighting as a method for assessing species composition and brown trout abundance: a comparison with electrofishing in small streams. Journal of Fish Biology 69: 1513-1523

Bowie S and Henderson I 2002. Shortjaw kokopu (*Galaxias postvectis*) in the northern Tararua Ranges: Distribution and habitat selection. DOC Science Internal Series 30. Department of Conservation, Wellington. 21 p.

Spotlighting

<u>Advantages</u>
Non invasive
Rapid, enabling greater distances to be covered (approx 4-6X faster than electrofishing)
Not effected by salinity or conductivity
Works well in deep pools providing good water clarity
Only requires 2 people
Minimal equipment required

<u>Disadvantages</u>
Not effective in streams with abundant riffles (suggest electrofishing if 'unspottable' riffle habitat >50%)
Capturing fish may be more time consuming relative to electric fishing
Not effective in turbid conditions
Is conducted outside normal working hours
Identification of species may be more difficult without experience

Electro fishing

<u>Advantages</u>
Comparable data
Effective in slightly turbid water / windy days
During normal working hours
Effective in riffle/shallow habitats.

<u>Disadvantages</u>
Requires specialist equipment
Deep areas not sampled effectively
Can be time consuming
Ineffective if water conductivity is very high or very low

Fish collection form - Wadeable streams / rivers

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 (m²) _____   Wetted width(m) A_____ C_____ E_____ G_____ I_____ B_____ D_____ F_____ H_____ J_____

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

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

EFM anode   ○ big   ○ small   distance inland (km) _____   altitude (m) _____   gradient(°) _____   REC seg ID(s) _____   [ ] FLAG for other Sampling Information

EFM   Volts (x100) _____   **Spotlight** (watts) |___|___| **Pulse Rate** (pps or Hz) |___|___| **EFM Pulse Width (ms)** |___|___| **FISH QIBI** Score

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

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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

Common Name	A	B	C	D	E	F	G	H	I	J

Habitat type %	A	B	C	D	E	F	G	H	I	J	Total	Common name	T	S	M	L
Still																
Backwater																
Pool																
Run																
Riffle																
Rapid																
Cascade																