Freshwater fish: electrofishing—fixed reach

Version 1.1

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Contents

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Te Papa Atawhai

Synopsis

Fixed-reach backpack electrofishing is a tool for determining fish community diversity in wadeable freshwater streams. The method provides estimates of taxa richness and relative abundances but does not allow any estimation of actual abundances or density. Other measures of population structure (e.g. size/age class representation) can also be obtained if adequate numbers of fish are collected and fish length data is recorded. Fixed-reach electrofishing provides a suitable tool for both inventory and monitoring of freshwater fish. It is one of the best methods to assess community composition.

The fixed-reach method broadly refers to fishing a set length of stream, either with a single upstream or downstream pass (multi-pass electrofishing is described in 'Freshwater fish: electrofishing—multi-pass'—docdm-755838). David et al. (2010) have proposed a new standardised method for fixed-reach electrofishing based on a method developed by the United States Environmental Protection Agency (US EPA) (Peck et al. 2006) and this is the method that is provided in this Toolbox description. The David et al. (2010) method has been tested in 73 New Zealand streams and has been shown to confidently estimate actual taxa richness. It is therefore strongly recommended that the David et al. (2010) method be used for fixed-reach backpack electrofishing where the objective is to measure fish community diversity. Variations on the method, such as shorter sample reach lengths, may be appropriate where the objective is to measure the relative abundances of key species rather than overall community diversity. However, varying the method will result in data that is not compatible with that collected by other operators (e.g. many regional councils) who use the standard method described here.

The fixed-reach method uses catch per unit effort (CPUE) as an index of relative abundance. The accuracy of CPUE as an index is primarily determined by whether catch efficiency, or 'catchability', remains constant and unaffected by other factors (Hubert & Fabrizio 2007). Unvarying catchability is one of the key assumptions made when assessing differences in relative abundance. However, in reality, it is well known that a wide range of factors influence catch efficiency when using a backpack electrofishing machine so it is important to take a cautious approach and consider changes in catch efficiency when comparing results over time and especially when reporting differences between sites.

All backpack electrofishing should comply with DOC's standard operating procedure (SOP) for the safe use of electrofishing machines (see 'Electric fishing: one page SOP'—docdm-676678, and 'Electric fishing technical document—health and safety'—docdm-752861).

Assumptions

Where the data are used to determine presence/absence:

- *Methodology is standardised to account for variation in detection probability*. It is important to use a consistent and legitimate spatial sampling framework. That is, that each sample unit should be large enough to contain the range of fish that are present in the area the sample represents. David et al. (2010) have shown that freshwater fish taxa richness can be confidently estimated in New Zealand streams if a survey reach of at least 150 m is sampled. This is the minimum sampling unit for this method. This assumption may be violated if shorter sections of stream are sampled. Similarly, if the method is applied to collect population demographic information about a single species, each sample reach should be large enough to contain the full range of size classes present in the area.

- *Species of interest are truly absent from the reach when none are detected*. This assumption will be violated when species are present but at a level that is undetectable by electrofishing methods.
- *All species are equally observable*, i.e. rare or cryptic species are able to be recorded.

Where the data are used to compare relative abundance:

- The relationship between number of individuals collected (index) and number of individuals present (density) is linear.
- Capture efficiency is independent of sample timing, site conditions, fish species present and operator proficiency. This assumption should be carefully considered when making comparisons over time or between sites, as some site characteristics (stream width, turbidity, macrophyte cover) are known to influence catch efficiency (Temple & Pearsons 2007).
- There is no movement into or out of the sample reach or any sub-reaches during sampling.
- Where fish length data is collected the size structure of fish in the sample is the same as the size structure of the population present within the sample reach. This assumption may be frequently violated in certain stream habitats as electrofishing tends to be more effective on large fish (Reynolds 1996); however, when sampling braided river fish species (e.g. pencil galaxiids) a representative sample can often be achieved.

Advantages

Generally provides a full representation of fish species present in the study area.

- Provides a robust estimate of relative abundances within a site. Comparisons of relative abundances between sites are also possible provided the factors that affect catch efficiency, such as substrate composition and electrical conductivity are taken into account.
- Less likely to injure fish compared with multiple-pass electrofishing because fish are generally only exposed to electricity once.
- The standardised method proposed by David et al. (2010) is increasingly providing the potential to directly compare data with that collected for other wadeable streams regionally and nationally.

In addition, backpack electrofishing has the following advantages:

- All wadeable habitat types within the stream can be sampled including fast-flowing riffle and run habitats.
- Allows catch per unit effort data to be calculated on an accurately defined area basis, e.g. fish captured per 100 m^2 (Hayes et al. 1996).

- Less affected by water temperatures and turbidity compared with some other sampling methods.
- Relatively low impacts on fish and other instream biota compared with some other sampling methods.
- Samples a greater diversity of fish species compared with other sampling methods.
- Can be carried out during normal working hours (does not require staff to work at night).

Disadvantages

- Does not measure actual abundance of target species.
- Is more time consuming than other electrofishing methods described in the Toolbox. It is generally not practical to sample streams larger than 10 m wide because they cannot be completed within one day with just one team.
- Limited to sampling reaches of stream where at least 80% of available habitat can be safely fished.
- The ability to detect locally rare species may decrease if specific habitat types are rare within the fixed reach. For example, if riffle habitats are small or infrequent within the sample reach, the potential to detect riffle-dwelling species such as torrentfish will be reduced.

In addition, be aware that backpack electrofishing of any type has the following limitations:

- Requires specialist equipment and completion of an electrofishing training course.
- Specific fish species capture can require operator and poll net holder experience.
- Limited to sampling in wadeable habitats.
- Potentially size-selective and therefore caution must be used when interpreting length-frequency data.
- Capture efficiency is reduced in habitats with complex structure such as woody debris and dense macrophytes (Portt et al. 2006).
- Capture efficiency is reduced as stream width increases (Portt et al. 2006).
- Capture efficiency is reduced as turbidity increases (Portt et al. 2006).
- Equipment is reasonably bulky and may not be appropriate for remote areas with poor access.
- Capture efficiency is low for nocturnal pool-dwelling species such as kōkopu.
- Capture efficiency is known to vary widely between different species (Portt et al. 2006). This means that relative abundances in electrofishing samples may not reflect actual relative abundances of different species in the sampling reach.
- Capture efficiency is reduced in very low or very high electrical conductivities. The Kainga EFM 300 is designed to work in conductivities between 10 and 400 µS/cm (NIWA Instrument Systems n.d.).

Suitability for inventory

Fixed-reach backpack electrofishing is ideally suited to acquiring inventories of freshwater fish species in wadeable streams. The probability that fish species will not be detected is low if a 150 m long reach if sampled using this method (David et al. 2010). Reducing the length of sample reaches increases the probability that species will be missed and is not recommended for inventory surveys.

Suitability for monitoring

This method is suitable where the objective of monitoring is to detect changes in:

- Community composition, including taxa richness and relative abundances of freshwater fish in wadeable streams. This application requires a minimum sample length of 150 m.
- The population structure, recruitment or health of specific fish species that are of interest (e.g. threatened species). This application may require an alternative sample length that is sufficient to capture all the different size classes present in the reach characterised by this sample.

Skills

Design and analysis

Staff involved in the development of survey programmes should be familiar with basic principles of good sampling design. 'A guideline to monitoring populations' (docdm-870579) will assist with understanding these principles. It is important that input from statisticians is obtained during both the design and analysis stages to ensure that the data collected is scientifically robust. Good statistical design is especially critical when developing monitoring programmes as they tend to be complex and have high ongoing running costs. It is much harder to improve design after data collection has started or been underway for some time than it is to put time into the initial planning. Putting effort into designing a programme well at the outset ensures that the running costs are justified and will result in useful information that meets the monitoring objectives.

The ability to use a spreadsheet software package such as Microsoft Excel is a minimum skill required for data entry, data checking and analyses. The ability to use statistical software packages is desirable but not mandatory provided support from statisticians is available. Staff involved in data analysis must be conscious of the underlying assumptions of electrofishing when undertaking their analyses.

Survey teams

The training required for undertaking electrofishing is outlined in DOC's 'Electric fishing: one page SOP' (docdm-676678) and 'Electric fishing technical document—health and safety' (docdm-752861). A minimum of two certified operators are required to use a backpack electrofishing machine. To be certified, an operator must have completed an 'Electric Fishing for Machine

Operators' training course and attended refresher courses at required intervals (contact the DOC Science & Capability Group to find out about these courses). All team members must hold a current first aid certificate and be trained in wader safety.

The survey team should contain at least one person able to identify freshwater fish to species level and one who has experience in handling fish to minimise unnecessary injury or mortality.

Resources

Backpack electrofishing:

- Survey team—a minimum of two certified operators are required to undertake backpack electrofishing (see 'Electric fishing: one page SOP'—docdm-676678, and 'Electric fishing technical document—health and safety'—docdm-752861). In many instances it will be advisable to use three-person teams so there is always someone available to handle fish and record any missed fish. Three-person teams may be needed when time-frames are tight or at sites that are overgrown, deeply incised or have uneven stream beds.
- Backpack electrofishing machine. The battery powered NIWA Kainga EFM 300 is the standard machine used in New Zealand.
- Waders for all team members. All waders should be checked for leaks prior to fishing. Staff should be trained in wader safety; see 'Wading safely' (olddm-566603) for guidance.[1]
- Pole net.
- Dip nets. Typically at least one dip net is used by the operator. In a team of three it is possible for a second or even third team member to also use dip nets.
- Polarised sunglasses for all team members (optional).
- Buckets to hold fish for brief periods during sampling. Two buckets are typically used, one for eels and one for other fish species.
- Measuring board (if fish are to be measured).
- Voucher jars for fish samples / fin clips filled with 70% ethanol.
- Linesman gloves for each team member. These must be rated to 1000 V and waterproof.
- GPS unit / NZTopo50 1:50 000 map.
- Water quality field meter(s).
- Rain-proof data sheets with clipboard and pencils, including New Zealand Freshwater Fish Database forms.
- Freshwater fish identification book, e.g. *The Reed Field Guide to New Zealand Freshwater Fishes* (McDowall 2000).

Fixed-reach equipment:

[1] http://www.doc.govt.nz/Documents/parks-and-recreation/places-to-visit/tongariro-taupo/wade-safely-brochure.pdf

- Hip-chain and/or measuring tape. Either can be used to mark out sub-reaches and measuring tape can also be used to measure stream widths.
- Wading rod for measuring stream depths.
- Markers to delineate sub-reaches (flagging tape, plastic cones or spray paint/dazzle) can be used.
- Watch—to record start and finishing times.

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to ‘Full details of technique and best practice’.

DOC staff must complete a ‘Standard inventory and monitoring project plan’ (docdm-146272).

The minimum requirements for a fish survey will largely be determined by the objectives of the study or monitoring programme. Careful consideration of these objectives should be made prior to collecting data. However, for any study the following minimum attributes should be recorded:

- The name of the observers who collected the data.
- The date and time of sampling.
- The upstream and downstream ends of the sampling reach must be recorded using an accurate hand-held GPS.
- All fish collected should be identified to species level. If this cannot be done in the field then a voucher sample may be collected and preserved, or a series of detailed photographs taken for further assessment by a qualified expert. A fin clip preserved in ethanol may be taken for mitochondrial analysis.
- The number of each fish species captured. Any species that are directly observed but not captured can be recorded as ‘missed’. Often it is possible to partially identify species of fish that are ‘missed’ (e.g. recorded as *Anguilla* sp.). Kōura or freshwater crayfish should be recorded and counted in the same way as fin-fish species. The number of freshwater shrimp captured should also be recorded but if large numbers are encountered then it will probably be necessary to assign abundance categories (e.g. 1–10, 10–100, 100–1000 and 1000+ individuals).
- The number of each species that are in juvenile or adult age classes should always be recorded. Measurement of fish length is optional depending on whether information about population structure is part of the survey objectives.
- Shock time (measured as ‘elapsed time’ on the Kainga EFM300 machine) and total fishing time should be recorded as additional estimates of the fishing effort.
- Electrofishing machine settings including output voltage, pulse width and pulse frequency.

It is important to collect habitat data to describe factors that may influence catch efficiency and therefore the key underlying assumptions of the method. Habitat data is also useful when it comes time to analyse data as many habitat variables will help explain why certain results were observed.

The minimum habitat variables that need to be recorded are included in the field data sheets developed by David & Hamer (2010) and are provided in 'Full details of technique and best practice'. These are:

- Electrical conductivity
- Water temperature
- Stream width (calculated from 10 widths recorded at the end of each subreach)
- Total length of sample reaches (if different to 150 m)
- Water visibility (good, average or poor)

The collection of the following additional habitat variables is optional but recommended.

- Substrate composition (preferably measured and not visually estimated)
- Stream shading
- Average water depth
- Stream gradient

There are a number of guidelines and protocols available for collecting habitat data. A set of standard national guidelines has been recently developed by Harding et al. (2009).

Data storage

Data should be recorded on rain-proof field data sheets. A copy of field data sheets developed by David & Hamer (2010) is provided in 'Appendix B'. All data sheets should be reviewed by the team leader before leaving a site to ensure all fields have been entered properly. Avoid carrying multiple completed field data sheets between sites as this increases the potential for significant data loss. Once the data from the field data sheets has been electronically entered, the sheets should be stored in the appropriate file.

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and securely store survey information as soon as possible, and preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, followed by copying and data backup for security.

Summarise the results in a spreadsheet or equivalent. Arrange data as 'column variables', i.e. arrange data from each field on the data sheet (date, time, location, plot designation, number seen, identity, etc.) in columns, with each row representing the occasion on which a given survey site was sampled.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

Summaries of all fish survey data should also be entered into the New Zealand Freshwater Fish Database (NZFFD) administered by the National Institute of Water and Atmospheric Research (NIWA). The NZFFD is an important national repository for presence/absence data and represents a valuable resource for a range of different applications including research, impact assessments and threatened species monitoring. As a minimum, site location, fishing method and species collected should be recorded in the database forms. Data can be entered electronically using the Freshwater Fish Database Assistant software, which is freely available from the NIWA website.[2]

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. Copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions, preferably offline if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

Analysis, interpretation and reporting

Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis. Statistical advice should preferably be sought during the design stage of any proposed monitoring programme.

Datasets obtained from fixed-reach electrofishing provide estimates of species diversity and relative abundances. Species diversity can be easily expressed as the total number of species, or taxa richness, recorded at a site. The key variable that will be used to assess relative abundances is catch per unit effort (CPUE). This is normally best expressed as fish/100 m^2 but it is important to remember that this is not a measure of density but rather an index of abundance. Catch per unit effort can be calculated for each species collected as well as any groups of unidentified/uncaptured fish that are of interest (e.g. missed eels (*Anguilla* sp.)).

Catch per unit effort data can be readily used to assess changes in relative abundances at a site over time provided that all sampling events occur under similar environmental conditions. It is therefore important to repeat sampling at the same time of year and avoid extreme flow conditions that may influence catch efficiency. Caution should be used when making comparisons of CPUE between sites as the assumption that catch efficiency remains constant is likely to be violated in many situations. If between-site comparisons are made it is important to be mindful of differences in variables that affect catch efficiency such as electrical conductivity and habitat complexity.

Depending on the objectives of the survey it may be useful to assess population structure using any fish length data that has been collected. 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 & Neuman 1996). When interpreting length-frequency histograms it is important to consider potential size biases in sampling and whether

[2] http://www.niwa.co.nz/our-services/databases/freshwater-fish-database

sample size is adequate. Many statisticians now recommend density plots as an alternative to histograms because the selection of length category boundaries (i.e. minimum and maximum values) can have a large influence on the appearance of histograms.

Survey results should be reported on in a timely manner to ensure that they are available for future users. Extending the time between data collection and reporting increases the potential for useful information gathered during sampling to be forgotten and lost.

Case study A

Case study A: backpack electrofishing—fixed reach in Ōmāhu Stream

Synopsis

The fixed-reach method of backpack electrofishing was used to compare fish communities upstream and downstream of an abstraction weir and natural waterfall in the Ōmāhu Stream, Waikato Region (Lake et al. 2010). Two sites on the stream were sampled using the method recommended by David & Hamer (2010). Results were used to assess the potential ecological effects of a water take on freshwater fish.

Objectives

- To compare fish communities above and below fish passage barriers and a water take on the Ōmāhu Stream.

Sampling design and methods

- The Ōmāhu Stream is a small tributary of the Waihou River in the Waikato Region. The upper catchment flows through regenerating native forest on the western flanks of the Coromandel Ranges south of Thames. The lower reaches flow through relatively flat farmland.
- Two sites were located within the forested section of the Ōmāhu Stream catchment. The upstream site was positioned approximately 300 m upstream of a water abstraction weir. The downstream site was positioned about 150 m downstream of the same weir and immediately downstream of a 3 m natural waterfall.

Data collection

- Electrofishing was carried out at each site according to the guidelines developed by David & Hamer (2010).
- Habitat was visually assessed at each site using standardised habitat criteria developed by the Waikato Regional Council.

Results

The number of fish species, or taxa richness, observed at the upstream site was considerably lower than that recorded at the downstream site. Only three fish species and kōura (freshwater crayfish) were collected from the upstream site (Table 1). A total of nine fish species were collected from the downstream site (Table 2). None of the diadromous 'non-climbing' species found at the downstream site (e.g. īnanga, redfin bully, torrentfish) were found at the upstream site.

Table 1. Numbers, distribution and catch per unit effort (CPUE) for freshwater fish collected from the upstream site in Ōmāhu Stream, March 2010.

	Subreach												
	A	B	C	D	E	F	G	H	I	J	Total number	CPUE (fish/100m²)	% of subreaches
Longfin eel	1	3	1	1		1	1	1	3		12	1.87	80
Shortfin eel	1			1							2	0.31	20
Unidentified eel		2		1			2		1	1	7	1.09	50
Banded kōkopu									1		1	0.16	10
Kōura	2		2			1	1	3	5	2	16	2.49	70
TOTAL	4	5	3	3		2	4	4	10	3	38	5.92	90

Catch per unit effort (CPUE) data was derived by dividing the total number of fish by the area fished at each site. Overall catch rates for fish were much higher at the downstream site with approximately five times more fish caught there compared with the upstream site. Kōura (*Paranephrops planifrons*) were the dominant species collected from the upstream site, while Cran's bullies (*Gobiomorphus basalis*) were the dominant species in the downstream site. Some species such as banded kōkopu (*Galaxias fasciatus*), redfin bullies (*Gobiomorphus huttoni*) and īnanga (*Galaxias maculatus*) were relatively rare and/or only caught in a few of the 10 subreaches that were fished. The catch rates for eels and banded kōkopu, species that were found in both sites, were very similar.

Table 2. Numbers, distribution and catch per unit effort (CPUE) for freshwater fish collected from the downstream site in Ōmāhu Stream, March 2010.

	Subreach												
	A	B	C	D	E	F	G	H	I	J	Total Number	CPUE (fish/100m²)	% of subreaches
Longfin eel	3	1		1		1	2			2	10	1.46	60
Shortfin eel						1		1	1	1	4	0.58	40
Unidentified eel		2		2		1		1			6	0.87	40
Banded kōkopu		1								1	2	0.29	20
Īnanga	1					1	2				4	0.58	30
Redfin bully		1							1	1	3	0.44	30
Cran's bully	6	10	9	8	16	6	8	13	9	5	90	13.12	100
Smelt	1				16	30	2	2			51	7.43	50

Torrentfish	1	4	2	4	5	4	1	2		6	29	4.23	90
Brown trout	2	2						1	1	2	8	1.17	50
Kōura											0	0.00	0
TOTAL	14	21	11	15	37	44	15	20	12	18	207	30.17	100

Aquatic and riparian habitat was assessed as being similar at both sites, although the upstream site had a boulder-dominated substrate while the downstream site had a cobble-dominated substrate. The total area fished at both sites was comparable with 642 m^2 fished at the upstream site and 686 m^2 fished at the downstream site.

Limitations and points to consider

- The results of the backpack electrofishing survey showed large differences in the composition of fish communities at the upstream and downstream sites. It was concluded that the presence of a natural waterfall immediately below the location of the water abstraction weir was preventing the upstream movement of fish and that the weir itself was having little additional effect.
- Taxa richness and relative abundance data collected from the two sites could be compared with confidence because habitat, and therefore expected catch efficiencies, were similar at both sites.
- The patchy distribution of several rare species in the electrofishing samples illustrates the value of sampling 150 m sections of stream. If shorter reaches had been fished at either site there would have been a high probability that taxa richness would have been underestimated.

References for case study A

David, B.O.; Hamer, M. 2010: Regional guidelines for ecological assessments of freshwater environments: standardised fish monitoring for wadeable streams. *Environment Waikato Technical Report (2010/09)*. 21 p.

Lake, M.; Robb, M.; Aldridge, B.; Stewart, P. 2010: Matatoki and Omahu stream abstraction August 2010. Report prepared for the Thames Coromandel District Council by Kessels & Associates Limited. 64 p.

Full details of technique and best practice

The procedure outlined below is a summarised version of that developed by David & Hamer (2010), which in turn, is an adaptation of a method developed for the US EPA by Peck et al. (2006). It is recommended that the full description of the method be read and understood prior to undertaking any fixed-reach sampling.[3]

[3] available at http://www.waikatoregion.govt.nz/Publications/Technical-Reports/TR-201009/

1. Select a 150 m sample reach that does not contain any inflowing tributaries, major fish barriers or unfishable habitat that constitutes more than 20% of available habitat. Measure out 10 equidistant subreaches of 15 m in length using a hip chain or measuring tape, these are labelled A–J. Mark the upstream end of each subreach using flagging tape or some other type of markers. Avoid walking in the stream and disturbing any fish while measuring out the reach.
2. Record electrical conductivity and water temperature on the field sheet. If machine settings (voltage, pulse width and pulse frequency) have not already been determined in previous surveys or as part of a wider monitoring programme then select the appropriate settings using the following guidelines.
    - Set voltage based on electrical conductivity: 100–400 V for high conductivity (> 300 µS/cm); 200–500 V for medium conductivity (100–300 µS/cm); 300–600 V for low conductivity (< 100 µS/cm).
    - Where mostly small fish are expected (most cases in New Zealand streams) use a pulse frequency of 60–70 Hz and pulse width of 2 msec. If larger fish > 200 mm are expected, use a pulse rate of 30 Hz.
3. Run through pre-operational safety checks and then test settings in a section of stream *below* the sample reach. If six or more lights are showing on the wand, reduce the voltage until five lights or less appear (be aware that the number of lights showing will vary depending on how close the two fishing electrodes are). If fish response is poor, increase the pulse width before increasing the voltage. Increase pulse frequency last to minimise mortality or injury of large fish. If injuries or mortality occur, first decrease pulse frequency, then voltage, then pulse width.
4. Prior to initiating electrofishing reset the ‘elapsed time’ counter, record the start time and note down the GPS coordinates for the start of the reach.
5. Start backpack electrofishing. The machine operator starts on the edge of either bank and should be positioned 2–3 m upstream of the pole netter but closer if water velocity is low. The pole netter sets the pole net flush with the bed of the stream and perpendicular to the flow. The machine operator then sweeps the anode ring in a downstream direction and from side to side but always in line with the pole net. In this way a ‘lane’ of stream is sampled. The cathode or earth strap should be kept upstream of the pole net within the lane being fished or occupying area that has already been fished to avoid disturbing an unfished area. In flowing habitats, stunned fish within the lane will tend to be swept into the pole net but a dip net can be used to gently dislodge stunned fish caught between rocks. The machine operator and/or third team member should collect other stunned fish as they are spotted using dip nets.
   If slow-flowing pool habitat is being targeted, then the pole net becomes less effective and most fish will be caught in dip nets held by the operator or assistants. When fishing undercut banks or log jams, fish can be drawn out by placing the uncharged anode on the edge of the fish cover, then switching it on and then pulling the anode out and away as the partially stunned fish emerges.
6. Once a lane has been fished, move across the stream to an unfished lane and repeat the process. When the opposite bank is reached both the machine operator and pole netter move upstream or downstream (depending on the direction of fishing selected) 2–3 m and begin fishing again. The objective is to systematically fish each subreach by sampling all available habitat once.

7. All captured fish should be transferred to collection buckets. It is recommended that eels be collected in a separate bucket to other fish to prevent injury to other fish species. Eels should be lightly anaesthetised so that they can be measured and small individuals can be accurately identified to species level. Where it is planned to use anaesthetics or collected voucher specimens there will be specific ethical considerations that should be first discussed with suitably qualified technical staff or other experts. Very large eels are often best processed immediately following capture and while they are still stunned. Also record any fish that are shocked but not captured as missed fish. It will often be possible to partially identify species of fish that are 'missed' (e.g. missed eel).
8. Identify, count and measure all fish captured at the end of each subreach. Tallies and lengths should be recorded on the back of the field data sheet where there is more space. Total counts can then be entered on the front of the sheet. Return fish well downstream of where fishing will recommence in the next subreach. Count kōura as individuals collected but only estimate the abundance of freshwater shrimp using the following categories; 1–10, 10–100, 100–1000, and 1000+.
9. At the end of each sub-reach:
    - Estimate the area of any unfishable habitat within the subreach and record in the field data sheet
    - Measure stream width
    - Record any other relevant habitat variables (e.g. substrate composition, meso-habitat composition)
10. Repeat steps 6–9 and at the end of subreach J record:
    - Total elapsed time (shock time)
    - Time finished
    - GPS coordinates for the top of the reach
    - Electrofishing machine settings and anode ring size.

Tips and recommendations

If information on population structure is not required to meet the study objectives, consider only recording minimum and maximum lengths for each species to save time. If large numbers of fish are being captured and lengths are being recorded it is recommended that subsamples of abundant species be measured. Measure the first 10 individuals of the abundant species captured from each subreach while ensuring a total sample size of at least 100 fish is measured within the sample reach. Assigning length categories rather than actual lengths can also help reduce fish processing time. Recommended length categories for different species are provided in David & Hamer (2010).

If fish species cannot be identified in the field, retain and preserve a sub-sample as a voucher collection for closer examination under a stereo microscope or by a qualified expert.

References and further reading

Anderson, R.O.; Neumann, R.M. 1996: Length, weight, and associated structural indices. In Murphy, B.R.; Willis, D.W. (Eds.): Fisheries techniques. 2nd edition. American Fisheries Society, Bethesda, Maryland.

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Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-755838	Freshwater fish: electrofishing—multi-pass
docdm-676678	Electric fishing: one page SOP
docdm-752861	Electric fishing technical document—health and safety
docdm-870579	A guideline to monitoring populations
docdm-146272	Standard inventory and monitoring project plan
olddm-566603	Wading safely

Appendix B: Field data sheet developed by David & Hamer (2010)

Fish collection form - 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) ______ Wetted width(m) **A**____ **B**____ **C**____ **D**____ **E**____ **F**____ **G**____ **H**____ **I**____ **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

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																