Freshwater fish: electrofishing—spotfishing

Version 1.1

This specification was prepared by Michael Lake in 2013.

Contents

Disclaimer
This document contains supporting material for the Inventory and Monitoring Toolbox, which contains DOC's biodiversity inventory and monitoring standards. It is being made available to external groups and organisations to demonstrate current departmental best practice. DOC has used its best endeavours to ensure the accuracy of the information at the date of publication. As these standards have been prepared for the use of DOC staff, other users may require authorisation or caveats may apply. Any use by members of the public is at their own risk and DOC disclaims any liability that may arise from its use. For further information, please email biodiversitymonitoring@doc.govt.nz

Department of Conservation
Te Papa Atawhai

Synopsis

'Electrofishing: spotfishing' is the term given to a suite of approaches that can be used to collect freshwater fish from specific habitat or habitats using a backpack electrofishing machine. The spotfishing method outlined here is not as prescriptive as other electrofishing methods in the Toolbox. This is because there is large variation in the way it can be undertaken depending on the survey objectives.

Spotfishing will primarily be used to collect freshwater fish presence/absence, species distribution data, and obtain samples for morphological and genetic analysis. However, because spotfishing can target specific habitat it may not be a suitable method for determining fish community composition at the reach scale and is probably best used to supplement other methods that are appropriate for this task (e.g. 'Freshwater fish: electrofishing—fixed reach'—docdm-755847). If fishing effort is quantified, spotfishing can be used to determine relative abundances by collecting catch per unit effort data (CPUE). However, these relative abundances can only be applied to the habitat or habitats that were sampled and not to fish communities at the stream section or reach-scale. Note also that effort may be harder to standardise or quantify compared to other electrofishing methods because it is at least partly determined by the skill of the individual observers and their familiarity with both the habits of the target species and the geography of the sampled streams. Spotfishing is also an efficient means of collecting other forms of data from freshwater fish populations such as length-frequency, fish health and condition factor as well as data for detecting pest fish invasions and assessing the effect of fish passage barriers.

The main advantage of spotfishing is that it is significantly less time-consuming than other methods of backpack electrofishing. This allows larger areas of a catchment to be covered with limited resources. The flexibility of spotfishing is also ideally suited to detecting fish species and/or life-stages with specific habitat requirements and very patchy distributions within a stream or river (e.g. torrentfish, juvenile lamprey).

The critical step prior to undertaking any sampling using the spotfishing method is the selection of habitats that will be targeted. The selection of target habitat will depend on the survey objectives and habitat preferences of the fish species that are to be found and perhaps collected. Useful resources for identifying habitat preferences of target species are provided in 'Full details of technique and best practice'.

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

Spotfishing—presence/absence indices:

- Species of interest are truly absent from the sample area when none are detected.

- Methodology is standardised to account for variation in detection probability, i.e. based on a legitimate spatial sampling framework. For instance, if a particular habitat (e.g. woody debris in pools less than 1 m deep) is targeted at one site in the study, the same habitat should be targeted at all sites.

The following assumptions only apply when fishing effort is recorded to determine a CPUE of 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 (Temple & Pearsons 2007); or these factors can be accurately quantified and incorporated into analysis (e.g. using a generalised linear model). This assumption should be considered carefully when making comparisons over time or between sites.
- There is no movement into or out of the sample area during the sampling period.

In addition to the assumptions related to use of data, it is important to note that backpack electrofishing of any kind also makes some assumptions which may not hold:

- Where fish length data are 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

- Less labour-intensive than other electrofishing methods. Time savings can be used to sample more sites or larger areas of preferred habitat for target species.
- Can be conducted in larger rivers provided there is enough wadeable preferred habitat that can be sampled.
- More efficient at capturing target species than fixed-reach or multi-pass electrofishing.

In addition, be aware that backpack electrofishing has the following advantages:

- All wadeable habitat types within the stream can be sampled including fast-flowing riffle and run habitats.
- Allows CPUE 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 than other sampling methods.

- Can be carried out during normal working hours (rather than after dark).

Disadvantages

- Higher probability of failure to detect species that have a low preference for the habitat that is being targeted. Spotfishing is therefore not an appropriate method for collecting information on freshwater fish community composition at a reach scale.
- Difficult to standardise effort, so that it is not possible to use data collected to compare fish relative abundance over time and between sites.

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.
- 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

- As a simple, cost-effective method for scoping distribution patterns, e.g. prior to planning a more intensive monitoring project.
- Where the fixed-reach electrofishing method cannot be used because large areas of the sample reach are unwadeable. This will often be the case in larger rivers where pools are too deep to wade but riffle and run habitats can be safely electrofished.
- To complement more comprehensive methods for sampling freshwater fish community composition. Spotfishing can be used to detect rare or very patchy species that may not be picked up by other sampling methods such as fixed-reach electrofishing. Spotfishing will only provide additional information of the presence/absence and distribution of these species and potentially their relative abundances within the targeted habitat.

Suitability for monitoring

This method should only be considered appropriate for monitoring where absolute abundance or relative abundance (at the reach scale) of fish are not considered to be important variables of interest in the monitoring programme, e.g. if population structure or presence/absence are the primary variables of interest. Most fish monitoring programmes will need to include some measure of abundance, so the scope for using the spotfishing method for monitoring is likely to be limited.

Skills

Design and analysis

Staff involved in the design of survey programmes for spotfishing need to be familiar with or source information about species distributions in the study area in question, and about the habitat preferences of target species' or life stages. This will enable efficient targeting of sample effort.

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 a biometrician is obtained during both the design and analysis stages to ensure that the data collected are 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

- 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 (optional). 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.
- Measuring tape to measure area fished.
- Wading rod for measuring stream depths (optional).
- Freshwater fish identification book, e.g. *The Reed Field Guide to New Zealand Freshwater Fishes* (McDowall 2000).

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'.

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

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

The minimum requirements for a fish survey will be largely 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 location of sampling sites must be recorded using an accurate hand-held GPS, or known point from an NZTopo50 1:50 000 map. If sampling reaches are sufficiently long then the upstream and downstream ends should both be recorded.
- The name of the observers who collected the data.
- The date and time of sampling.
- Electrofishing machine settings.
- 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 type of habitat that is being targeted by spotfishing should be recorded. If CPUE data are required, measure or estimate the area of each habitat that is sampled. Alternative but less useful measures of CPUE 'effort' can be based on shock time (recorded as 'elapsed time' on Kainga EFM300), total fishing time, or number of habitats fished (e.g. number of pools).
- Measurement of fish length is optional depending on whether population structure is a key variable of interest; however, the recording of juvenile and adult age classes should be a bare minimum.

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 are also useful when it comes time to analyse data as many habitat variables will help explain why certain results were observed. However, where the purpose of spotfishing is to collect the maximum number of fish records with the least amount of effort, relatively little time should be spent collecting other data. Habitat attributes that should be recorded are:

- Electrical conductivity
- Water temperature
- Water visibility (using a simple scale, e.g. good, average or poor)
- Substrate composition (measured or 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. 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 data loss.

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely, also 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, site designation, species identity, etc.) in columns, with each row representing a single observation (typically each fish 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. Storage tools can be either manual or electronic systems (or both, preferably). Data may be entered into an appropriate file format such as .xls, .txt, .dbf for specific analyses. 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. For instance, copies of field data could be stored in both Area and Conservancy Office filing systems.

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] DOC staff can request this software to be loaded using a 'Move, add, change' (MAC) request form.

Analysis, interpretation and reporting

Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis.

Datasets obtained from spotfishing will primarily be used to provide information on species presence/absence within the targeted habitat. Species diversity can also be easily expressed as the

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

total number of species (taxa richness) recorded at a site. This information is best presented spatially to demonstrate the distribution of species across a catchment or catchments.

If fishing effort was recorded then CPUE data can be generated to provide estimates of relative abundance. It is important to note that these relative abundances only apply to the habitat types that were targeted for fishing (e.g. relative abundance of shortfin and longfin eels within shallow riffles) rather than relative abundances within the stream at the reach scale.

CPUE data can be 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 or between surveys made by different observers as the assumption that catch efficiency remains constant is likely to be violated (refer to 'Disadvantages' section). If making between-site comparisons, it is important to mindful of differences in variables that affect catch efficiency such as electrical conductivity and habitat complexity.

Depending on the survey objectives it may be useful to assess population structure using fish length data. Length data are typically used to generate length-frequency histograms, which allow the structure of a fish population to be assessed. Length-frequency histograms can provide an insight into factors that may be affecting fish population dynamics, such as high mortality or recruitment failure (Anderson & Neumann 1996). When interpreting length-frequency histograms it is important to consider potential size biases in sampling and whether sample size is adequate. 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: spotfishing for dwarf galaxias in the Mangahao River, Tararua Range

This case study is taken from unpublished material provided by Logan Brown, Horizons Regional Council, April 2011.

Synopsis

This case study demonstrates the use of the backpack electrofishing spotfishing method to gather information on the presence of 'Declining' dwarf galaxias (*Galaxias divergens*) within two unnamed tributaries of the Mangahao River. The survey was part of a larger study carried out by Horizons Regional Council staff in order to gain an understanding of the distribution of significant fish species within the Tararua and Ruahine ranges. This information may then be applied by the Council while assessing the values of freshwater management zones, and the potential adverse effect of management actions such as gravel extraction, discharges into water and water extraction in those zones.

Dwarf galaxias were known to occur higher up and lower down in the Mangahao Catchment but records were sparse. Spotfishing was used to sample specific habitats within sections of stream to maximise the probability of catching dwarf galaxias within the time frame available.

Objectives

- To detect the presence of dwarf galaxias within two small tributaries of the Mangahao River.

Sampling design and methods

The overarching study aims to map distributions of a wide variety of fish species over an extensive and rugged landscape. Resources were limited, so the sample design reflected the need to maximise information collected with minimal effort. Existing information about fish distributions (taken from the NZFFD) was used to target streams thought likely to support particular fish species. Search methods within those areas were tailored to the species thought most likely to be present.

Dwarf galaxias are known to prefer relatively shallow and fast-flowing water (Jowett & Richardson 2008). A backpack electrofishing machine was used to sample shallow riffle and run habitat in the two tributaries. Special focus was given to sampling stream edges. Habitats that were slow and deep, such as pools, were bypassed by the electrofishing team.

Data collection

Electrofishing was carried out over sample reaches that were approximately 75–100 m in each of the unnamed tributaries. One site was constrained by a waterfall at the upstream end. Both sample reaches were considered to be representative of the habitat present within the tributaries as a whole.

All species captured were identified and counted. Fish length was not measured.

Results

No dwarf galaxias were collected from either of the tributary streams during the survey. Longfin eels (*Anguilla dieffenbachii*) and kōura (*Paranephrops planifrons*) were the dominant species found and one kōaro (*Galaxias brevipinnis*) was also captured.

All data were recorded onto MS Excel spreadsheets for basic data analysis and long-term storage on the Horizons Regional Council servers. Data were also entered onto NZFFD cards and will be submitted to the NIWA online database. For those sites where fish species met the rare and threatened specifications in the Proposed One Plan it is planned to create a GIS layer that can be used to assess future resource consent applications. The results of the survey were included in a report documenting the results of fish surveys carried out across the Tararua and Ruahine ranges (Patterson & Brown 2011).

Limitations and points to consider

Horizons Regional Council staff concluded that dwarf galaxias were unlikely to be present in either of the tributary streams. It is unclear why this was the case as the species had been found in similar habitat at sites upstream and downstream of the survey sites. However, the detection of kōaro was considered significant as the species had not been collected previously and is very rare in the Manawatū River catchment. Kōaro have a conservation status of 'Declining' and are used by Horizons Regional Council to identify high-value sites within the region.

While one-off surveys cannot prove that dwarf galaxias were absent (see 'Assumptions' section) they did provide strong evidence that neither stream supported a sizeable population of the species. Spotfishing was therefore a very efficient method of meeting the objectives of the survey.

The advantage of the spotfishing method in this instance was that the key information was collected very quickly. Field observers estimated that each of the sites took approximately 40 minutes to sample. It would not be possible to complete even one site within the same time frame using other electrofishing methods described in the Toolbox.

The surveys were very tightly focused and little additional information was collected. No measurements of the total area or length of stream sampled were made so relative abundances could not be estimated on a spatial basis.

The data could not be used to describe the freshwater fish community as a whole. This was due to decisions in sampling design (e.g. pool habitat was not sampled and therefore the probability that pool-dwelling fish would be detected was low) and in the sampling method.

Further surveying using spotlighting methods was conducted in order to make up for these deficiencies.

In the context of the wider study aim (to understand fish distribution in the Ruahine and Tararua ranges), the size and bulk of the electrofishing machine means the people carrying out the surveys have to be committed to get into some of the more remote waterways. This can mean that remote locations may be under-surveyed. As is typical for a large-scale inventory project, a range of complementary sampling methods will be applied to ensure that all habitats and locations can be adequately surveyed.

References for case study A

Jowett, I.G.; Richardson, J. 2008: Habitat use by New Zealand fish and habitat suitability models. *NIWA Science and Technology Series No. 55*. National Institute of Water and Atmospheric Research, Wellington.

Patterson, M.; Brown, L. 2011: Ruahine and Tararua ranges freshwater fish survey. Horizons Regional Council and the Department of Conservation. Report number 2011/ET/1217.

Full details of technique and best practice

Before undertaking any sampling it is important to spend time determining the habitats that will be targeted. The target habitat that should be selected will depend on the survey objectives and fish species of interest. Information on catchment and reach-scale habitat preferences of New Zealand freshwater fish species is provided in Leathwick et al. (2008). Micro- and meso-scale habitat preferences for depth, velocity and substrate can be found in Jowett & Richardson (2008).

The following steps[3] should be followed when undertaking spotfishing in the field:

1. Record electrical conductivity and water temperature on the field sheet. If machine settings (voltage, pulse width and pulse rate) 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 then use a pulse frequency of 30 Hz.

2. Run through pre-operational safety checks and then test settings in a section of stream *below* the sample area. 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 from fish being too severely shocked, first decrease pulse rate, then voltage, then pulse width.

3. 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.

4. 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

[3] Sections of this procedure are modified from David & Hamer (2010).

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.

5. 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).

6. Identify, count, and if required, measure all fish that are of interest. Fish should be measured to the nearest mm using a purpose-built measuring board.

7. Once the target habitat has been sampled:
    - Measure or estimate the area sampled if CPUE data are being collected.
    - Record any other relevant habitat variables (e.g. substrate composition, meso-habitat composition).

Tips and recommendations

If fish species cannot be identified in the field, take photographs or retain and preserve a voucher specimen for closer examination under a stereo microscope by a qualified expert.

If large numbers of fish are being captured and lengths are being recorded it is recommended that subsamples of abundant species be measured to save time. A minimum sample size of 100 fish is recommended for generating length frequency distributions (Anderson & Neumann 1996).

References and further reading

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

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), Environment Waikato. 21 p.

Harding, J.S.; Clapcott, J.E.; Quinn, J.M.; Hayes, J.W.; Joy, M.K.; Storey, R.G.; Greig, H.S.; Hay, J.; James, T.; Beech, M.A.; Ozane, R.; Meredith, A.S.; Boothroyd, I.K.G. 2009: Stream habitat assessment protocols for wadeable rivers and streams of New Zealand. School of Biological Sciences, University of Canterbury, Christchurch. http://www.cawthron.org.nz/coastal-freshwater-resources/downloads/stream-habitat-assessment-protocols.pdf

Hayes, D.B.; Ferreri, C.P.; Taylor, W.W. 1996: Active fish capture methods. In Murphy, B.; Willis, D.W. (Eds): Fisheries techniques. 2nd edition. American Fisheries Society, Bethesda, Maryland.

Jowett, I.G.; Richardson, J. 2008: Habitat use by New Zealand fish and habitat suitability models. *NIWA Science and Technology Series No. 55*. National Institute of Water and Atmospheric Research, Wellington. 148 p.

Leathwick, J.; Julian, K.; Elith, R.; Rowe, D.K. 2008: Predicting the distributions of freshwater fish species for all New Zealand's rivers and streams. NIWA Client Report (HAM2008-005), National Institute of Water and Atmospheric Research, Hamilton. 56 p.

McDowall, R.M. 2000: The Reed field guide to New Zealand freshwater fishes. Reed Books, Auckland. 224 p.

NIWA Instrument Systems. n.d.: Electric fishing machine (EFM300) operator's manual v1.00. National Institute of Water and Atmospheric Research Ltd (unpublished).

Patterson, M.; Brown, L. 2011: Ruahine and Tararua ranges freshwater fish survey. Horizons Regional Council and the Department of Conservation. Report number 2011/ET/1217.

Portt, C.B.; Coker, G.A.; Ming, D.L.; Randall, R.G. 2006: A review of fish sampling methods commonly used in Canadian freshwater habitats. Canadian Technical Report of Fisheries and Aquatic Sciences 2604.

Reynolds, J.B. 1996: Electrofishing. In Murphy, B.; Willis, D.W. (Eds): Fisheries techniques. 2nd edition. American Fisheries Society, Bethesda, Maryland.

Temple, G.M.; Pearsons, T.N. 2007: Electrofishing: backpack and drift boat. In Johnson, D.H.; Shrier, B.M.; O'Neal, J.S.; Knutzen, J.A.; Augerot, X.; O'Neil, T.A.; Pearsons, T.N. (Eds): Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society in association with State of the Salmon. 478 p.

Appendix A

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

docdm-755847	Freshwater fish: electrofishing—fixed reach
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