Freshwater fish: passive nets—fyke nets

Version 1.1

This specification was prepared by Michael Lake in 2013.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

Fyke nets are essentially a type of cylindrical fish trap which contain a series of funnel-shaped openings which make it easy for fish to enter the trap but very difficult to for them to make their way out. One or more vertical sections of netting, called leaders, extend from the mouth of the fyke net and guide swimming fish into the net. Fyke nets are considered a type of passive sampling gear because they rely on fish to willingly encounter and enter the net (Hubert 1996). They can be used to sample freshwater fish in a wide range of environments including lakes, wetlands, rivers and streams.

The efficiency and selectivity of fyke nets is influenced by the probability that fish will encounter, enter and be retained within the net until it is retrieved (Portt et al. 2006). Fyke net catches tend to be biased towards mobile bottom-dwelling species but a wide range of species can be caught when they are set in shallow water. Fyke nets are highly effective for capturing freshwater eels, particularly when baited. The species and habitat decision trees in the 'Introduction to monitoring freshwater fish' (docdm-1008026) should be used to identify whether fyke netting is the appropriate method for sampling your species or communities of interest.

Unlike with gill nets, most fish can be released alive after being captured in fyke nets and the capture of non-target species, such as diving birds, is relatively rare. Fyke nets can also be set amongst complex habitat including dense beds of aquatic vegetation. Predation within fyke nets, particularly when baited, can be a significant issue for the survival of captured fish and can interfere with the collection of accurate data.

The capture efficiency of fyke nets is influenced by a number of net characteristics including mesh size, net dimensions, and the size of the mouth and funnel openings. Standardisation of sampling gear within a survey or monitoring programme is therefore important for obtaining relative abundance data that can be compared spatially and temporally. The type of fyke net selected for use in a survey should be determined by the survey objectives but where possible should be standardised with those used in other surveys with which the data may be compared.

Fyke nets can be used for inventory surveys where the objective is to estimate taxa richness or the presence/absence of fish species at a location. Fyke nets are biased towards cover-seeking benthic species and are less effective at capturing open-water species, especially when set in deep water. It is therefore recommended that other methods be used in combination with fyke nets when undertaking inventory surveys in deep, open-water environments.

Fyke nets can also be used to collect relative abundance data based on calculations of catch per unit effort (CPUE). Fyke net CPUE, as with other passive netting methods, is usually expressed as number of fish caught per net per unit of time (e.g. hours or nights). The accuracy of CPUE as an index of abundance is primarily determined by whether catch efficiency, or 'catchability', remains constant and unaffected by other factors (Hubert & Fabrizio 2007). Unvarying catch efficiency is one of the key assumptions made when assessing differences in relative abundance. In reality, however, a wide range of factors can influence catch efficiency when using fyke nets. It is important to take a cautious approach and consider potential differences in catch efficiency when comparing relative abundance data over time and space.

Standardising net types and sampling protocols is critical for obtaining reliable relative abundance data. At the time of writing, standardised national protocols for using a combination of fyke nets and Gee's minnow traps in New Zealand wadeable streams is under development (Joy et al. 2003). It is recommended that, where appropriate, those protocols be adopted by DOC staff when sampling stream environments using fyke nets.

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 the number of nets used is large enough to capture the range of fish that are present in the area that is represented by the sample.
- *Species of interest are truly absent from the sample area when none are detected*. This assumption will be violated when species are present but inactive or occur at densities that are undetectable by fyke netting methods. For example, eel activity is very low at temperatures less than about 10°C so fyke net samples collected in winter may fail to detect these species. Similarly, at very low densities fish may fail to encounter any fyke nets during the sampling period and therefore evade capture and detection. Because fyke nets are species-selective, only those species known to be susceptible to capture using this method should be considered as being sampled.

Where the data are used to compare relative abundances:

- *The relationship between number of individuals collected (index) and number of individuals present (density) is linear*. This is unlikely to be the case in many instances with passive netting techniques because of their dependence on fish behaviour, which may be highly variable, and the effects of gear saturation (Hubert & Fabrizio 2007).
- *Capture efficiency is independent of environmental conditions, fish species, population structure and operator proficiency*. These assumptions should be carefully considered when making comparisons over time or between sites, as many of these factors are known to strongly influence catch efficiency (Hubert 1996; Breen & Ruetz 2006; Portt et al. 2006).
- *There is no movement into or out of the sample reach or any sub-reaches during sampling (i.e. the population is demographically closed).* This assumption is less likely to hold if the sampling period is extended, or if the area of the body of water being sampled greatly exceeds the area in which nets are deployed. This particularly applies to highly mobile species, which are often targeted by this sampling method.

Advantages

Advantages of fyke netting:

- Can be relatively easily set in complex habitat types such as dense aquatic vegetation or amongst coarse woody debris. In this respect fyke nets are better than gill nets but not as good as minnow traps.
- Is less selective for fish species and sizes than gill nets or minnow traps (Hubert 1996). However, the size of mesh and funnel openings will determine the minimum and maximum sizes of fish caught.
- Large net and capture capacity, which collapses to small, flat, compact size.
- Results in far less fish mortality and injury compared with gill nets and most fish can be released.
- Presents less risk to diving birds than gill nets (see 'Set nets and diving birds: best practice guidance'—docdm-1470778).
- Is a highly efficient method for sampling eel species, particularly if baited (Jellyman & Graynoth 2005).
- Is effective for catching fish during migratory movements. Double-winged fykes can also be used to determine the direction of movement; for example, between a river and associated floodplain wetlands (Lyon et al. 2010).

Advantages of passive netting in general:

- Sampling is relatively unaffected by turbidity or electrical conductivity which can limit the use of methods like spotlighting or electrofishing.
- Samples are taken continuously over a long time period. This has the advantage of dampening the effects of any diurnal variations in fish behaviour (Hayes 1989).
- It allows sampling in habitats that are not wadeable because water depth or sediment depth is too great.
- Does not require a high level of technical expertise or specialist training (although the experience of field staff will influence catch efficiency).
- It causes less disturbance in shallow habitats than some active methods such as seining or electrofishing.

Disadvantages

Disadvantages of fyke nets:

- They can be difficult to set in deep water or at sites with uneven or steeply sloping substrates.
- Predation can occur inside the nets and this is likely to be a significant issue with eels in New Zealand. Predation can affect recorded capture rates of smaller fish which are either eaten or actively avoid entering nets containing predators (Breen & Ruetz 2006). Predation will also

influence the contents of predators' stomachs and this should be taken into account if fyke net catches are used in diet studies.

- They can be difficult to set in strong currents as they tend to accumulate debris or will not set properly (Portt et al. 2006). However, fyke netting is more conducive to sampling in currents than gill nets.
- There is a bias towards cover-seeking mobile species, benthic species and larger fish species (Hubert 1996; Breen & Ruetz 2006; Portt et al. 2006).
- Catch rates are generally lower than those for gill nets (Hubert 1996).
- Catch rate variability is often high, which means that relatively large numbers of sets are required to detect changes in relative abundance (Portt et al. 2006).

Disadvantages of passive netting in general:

- It provides a less accurately defined unit of effort compared with active techniques because no spatial measure is included (Hayes et al. 1996).
- It is biased towards more active fish species. The more active a fish is the more likely it is to encounter the net.
- Catch rates and taxa richness can vary with time of day depending on diurnal patterns of fish behaviour (Portt et al. 2006). This can be overcome by setting gear over a 24-hr period.
- It requires a return trip to retrieve gear, which may increase the level of resources required to collect data, particularly for remote sites.

Suitability for inventory

This method is appropriate for inventory:

- Where active fishing methods cannot be implemented or resourced (e.g. in non-wadeable, turbid or structurally complex habitats)
- When combined with other sampling methods which overcome some of the species biases inherent in fyke net samples. When sampling in lakes or large rivers, fyke nets should be combined with either gill nets and/or boat electrofishing to ensure open water species are adequately sampled.

Suitability for monitoring

This method is appropriate for monitoring:

- When monitoring mobile, benthic, cover-seeking fish species (e.g. eels)
- Where active fishing methods cannot be implemented or resourced (e.g. in non-wadeable, turbid or structurally complex habitats)
- Where it is important to have low rates of injury and mortality (e.g. where both pest fish and threatened native fish may be present)

Skills

Field operations

The setting of fyke nets does not require any specialist skills or training; however, it is recommended that at least one team member has some prior experience with setting these types of nets. In large rivers and lakes a boat may be required to set fyke nets. Appropriate training and certification in the operation of boats will therefore be required (refer to the standard operating procedure: 'Boat competency SOP'—docdm-346005). Survey teams should contain at least one person able to identify freshwater fish to species level and who has experience in handling fish to minimise any unnecessary injury or mortality and speed up fish processing.

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 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 fyke netting when undertaking their analyses and cautious of the level of inference derived from any results.

Resources

- Survey team. In wadeable habitats, standard fyke nets can easily be set by one person. In deeper habitats, however, a boat is usually required and a minimum of two team members will be needed to safely set fyke nets. In some instances it will be advisable to have larger teams, particularly if significant numbers of fish are caught or the fyke net is particularly big.
- Fyke nets.
- Personal flotation devices and any other boat safety equipment if a boat is being used. Personal flotation devices may also be necessary at wadeable sites that are deep, swift or soft-bottomed.
- Anchor weights or poles for anchoring the ends of nets. Better sets are usually achieved with poles but their use is limited to shallow habitats.
- Shark clips for quickly attaching and detaching anchors and floats.

- Fish bins. At least one bin is required for holding captured fish for processing. For fykes incorporating a separation grid (a mesh panel which segregates fish by size) a second bin or large bucket is required.
- Aerator if captured fish are to be kept alive for long periods.
- Measuring board (if fish are to be measured).
- Voucher jars for fish samples / fin clips filled with 70% ethanol.
- GPS unit.
- Water quality field meter(s). As a minimum, water temperature should be recorded but dissolved oxygen is also a useful parameter to measure, especially in lakes that stratify.
- 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).
- Waders are optional but recommended where water temperatures are cold or where water quality is poor. If waders are used then staff should be trained in wader safety; see 'Wading safely' (olddm-566603) for guidance.[1]

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on the 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 (including time set and time retrieved).
- The location of each sampling site using a GPS.
- Net types (including physical dimensions and mesh sizes).
- Number of nets set at the site.
- Depth of water the net was set at.
- 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.

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

- The number of each fish species captured.

Measurement of fish length is optional depending on whether information about population structure is part of the survey objectives.

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:

- Water depth
- Water temperature
- Habitat description including presence of any macrophytes or other structure and substrate type.

Data storage

Data should be recorded on rain-proof field data sheets to ensure that they remain intact and legible. 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, net type, number caught, identity, etc.) in columns, with each row representing the occasion on which a given survey site was sampled. An example of a data entry template for fish data collected using passive netting methods is provided in Appendix B.

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

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

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.

There are several texts available to assist with the analysis of fisheries data. Murphy & Willis (1996) provides a useful introduction into most types of analyses but a more in-depth and up to date text is provided by Guy & Brown (2007).

Datasets obtained from fyke netting can be used to 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. Because fyke net catches are biased towards benthic fish species it is recommended that additional sampling methods that target open water species (e.g. gill nets) be used when undertaking inventory surveys at deep open-water sites.

The key variable that will be used to assess relative abundances using fyke nets is catch per unit effort (CPUE), which provides an index of abundance rather than a measure of density. As with all passive netting methods, fishing effort is measured in terms of soak time—the time period over which nets are set. CPUE for fyke nets is usually expressed as the number of fish caught per trap per night but different time periods can be used (e.g. hours).

When calculating CPUE the catch obtained from each net should be recorded as individual sub-samples. The mean (or median) CPUE and associated variance can then be calculated for each sampling site. Catch per unit effort data tend not to be normally distributed so care should be taken with applying parametric tests (Hubert & Fabrizio 2007). Some researchers recommend using the median rather than the mean as a measure of central tendency for CPUE data (Hubert 1996; Hubert & Fabrizio 2007).

When calculating CPUE for passive capture gear it is important to be aware that soak time (the time period over which nets are set) is not a proportional measure of fishing effort. This is because catch efficiency is known to decline as more and more fish are caught in a net through a process called gear saturation. For entrapment-type nets, including fyke nets, escapement can also be an issue which affects capture efficiency over time. Some fish species are better at escaping than others and net saturation can also affect rates of escapement (Breen & Ruetz 2006; Portt et al. 2006; Hubert & Fabrizio 2007). This means that setting a net over 48 hours may produce a different catch rate to the same net set over two 24-hr periods. Direct comparisons of CPUE data obtained using different soak times are therefore not recommended unless the relationship between catch efficiency and soak time is well understood.

To use CPUE as an index of abundance it is assumed that there is a positive linear relationship between CPUE and density. This relationship is known to be different for different species and influenced by a wide range of factors including the mouth diameter, mesh size, and leader arrangement of the fyke nets being used. All of these variables can influence the ability of CPUE to reflect the relative abundance of species present at a site. It is therefore critical that fyke net sampling be standardised by using the same sampling design, sampling gear (e.g. net types) and deployment procedures across the sites and time periods of interest. Fyke nets tend to produce highly variable catch data and large numbers of net sets are often required to detect statistically significant differences (Portt et al. 2006).

When interpreting data obtained from fyke net catches it is necessary to consider the method-specific biases outlined in the ‘Disadvantages’ section. When using CPUE data as an index of relative abundance the variables that can affect the relationship between CPUE and actual fish density should always be considered. For example, care should be taken when comparing the CPUE of two species caught at a site if one of those species is known to be more susceptible than the other to capture in fyke nets. Ideally, the ability of CPUE to reflect actual fish density should be validated before reaching any firm conclusions about observed differences in CPUE. Validation would require fish density estimates to be made using mark-recapture or depletion model approaches.

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 & 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. A detailed description of the net types used should be included in the report so the survey can be replicated at a future date.

Case study A

Case study A: Waituna Lagoon giant kōkopu survey

Synopsis

Waituna Lagoon is a shallow lake located near Invercargill which forms part of the Awarua Wetlands Ramsar-listed site. The lagoon catchment is known to support giant kōkopu (*Galaxias argenteus*), a facultative diadromous fish species with a conservation status of ‘At Risk—Declining’

(Allibone et al. 2010). A combination of fyke nets and minnow traps were used to compare giant kōkopu populations the Waituna Lagoon and neighbouring catchments and to collect samples for otolith microchemistry analysis. This case study is based on analysis of some of the catch data collected during that study to look at the potential of fyke nets as a tool for monitoring fish populations and giant kōkopu in particular.

Fyke net catch data on its own was found to underestimate both taxa richness and the presence of giant kōkopu. However, when combined with Gee's minnow traps, overall taxa richness and detection rates for giant kōkopu were enhanced. Fyke net data were not found to be very sensitive to detecting differences in giant kōkopu abundance between sites.

Objectives

- Determine if the Waituna Lagoon catchment supported large numbers of giant kōkopu. This objective is the focus of this case study.
- Determine the importance of any non-diadromous recruitment within the lagoon and the potential effects of artificial lagoon mouth opening. While a key objective of the project, this objective is not included in this case study.

Sampling design and methods

Sampling was undertaken at a total of 42 sites across six different catchments including the Waituna Lagoon catchment. Trapping methods were used to estimate abundance of giant kōkopu, because the dark, tannin-stained and overgrown waters common in the region made backpack electrofishing and spotlighting methods inefficient. At each site seven fyke nets and 20 Gee's minnow traps were deployed haphazardly over a 150 metre reach. In reaches that were too narrow, shallow or overgrown for fyke nets, only Gee's minnow traps were deployed which meant that fyke nets were only used to sample 22 sites. Nets and traps were deployed between 6pm and 10pm each night, and retrieved between 10am and 4pm the following day. To reduce the catch rate of eels and intra-net predation, glowsticks were suspended in the first two funnels of each fyke net. A pilot study showed this reduced the catch rate of eels by 95%.

Data collection

The number of individuals from each fish species was recorded separately for each of the fyke nets. Gee's minnow trap catches were pooled into groups of two to four traps. Individual fish lengths were also recorded.

Results

On average, fyke net catches accounted for 58% (SE = 6%) of the total taxa richness observed at sites using combined gears (fyke nets and Gee's minnow traps). Species that were consistently missed from fyke net samples tended to be small-bodied species such as common bullies (*Gobiomorphus cotidianus*) and īnanga (*Galaxias maculatus*). Fyke nets did detect kōaro (*Galaxias* *brevipinnis*) and yellow-eyed mullet (*Aldrichetta forsteri*) which were not found in Gee's minnow traps.

Fyke nets detected giant kōkopu at 9 of the 13 sites where they were detected using combined gears. Fyke nets also detected giant kōkopu at two sites where they were not caught in Gee's minnow traps. Fyke nets accounted for 48 of the 100 giant kōkopu captured during the survey.

The highest catch rates for giant kōkopu obtained using fyke nets were recorded from Carran Creek 1 and Carran Creek 2 (Figure 1). The CPUE for giant kōkopu caught at sites where they were detected was highly variable and tended to be skewed towards 0, particularly at sites where few giant kōkopu were caught.

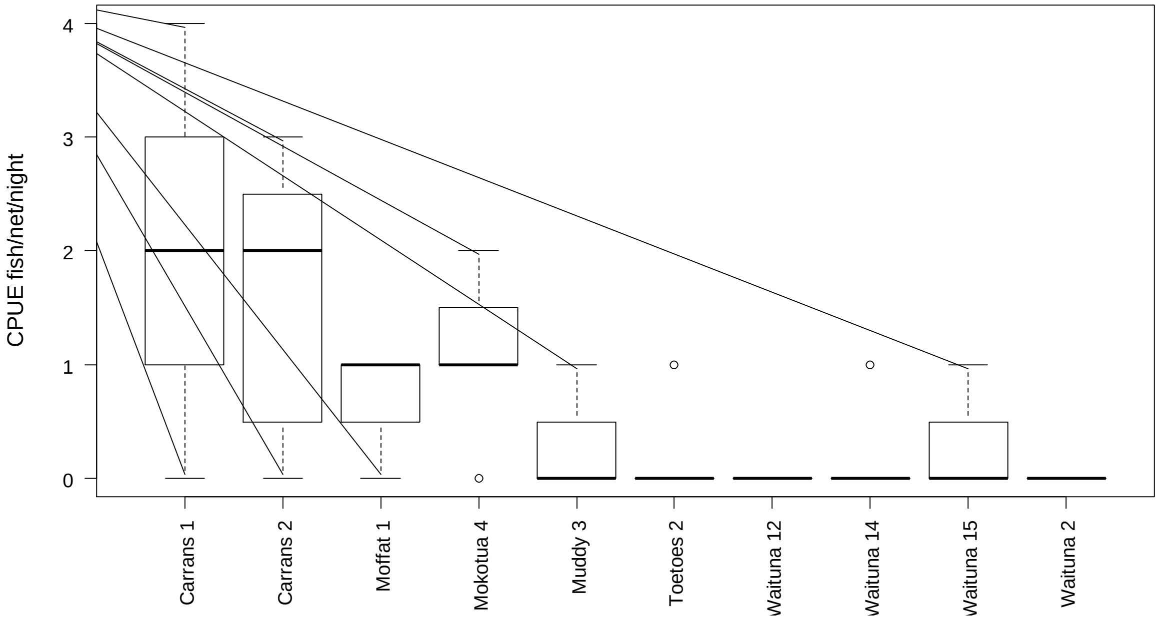

Figure 1. Boxplots of giant kōkopu catch per unit effort (CPUE) recorded using fyke nets in the Waituna Lagoon and five nearby reference catchments. Only sites where the species was detected using combined methods are included.

Limitations and points to consider

- Fyke net samples tended to underestimate taxa richness at sites but increased the overall taxa richness observed during the survey by detecting two fish species not caught in Gee's minnow traps.
- Fyke net catches were biased towards large bodied species and this was most likely due to a combination of the ability of small fish to escape through the net mesh and eel predation within the nets.
- Fyke nets were found to be marginally less successful at detecting the presence of giant kōkopu than Gee's minnow traps but the two methods caught approximately the same number of giant kōkopu. The combined use of fyke nets and Gee's minnow traps was more successful than either method on its own and the data were successfully used to identify higher detection rates for this species in the Waituna catchment compared with the other five catchments.

- High intra-site variability in giant kōkopu CPUE meant that fyke net data was not considered particularly sensitive to differences in the abundance of giant kōkopu between sites. This would limit the usefulness of fyke nets in monitoring giant kōkopu abundance based on single sampling events. The project team is currently exploring the potential of multi-night depletion sampling using fyke nets as a tool for monitoring giant kōkopu abundance.

References for case study A

Allibone, R.M.; David, B.; Hitchmough, R.; Jellyman, D.; Ling, N.; Ravenscroft, P.; Waters, J. 2010: Conservation status of New Zealand freshwater fish, 2009. *New Zealand Journal of Marine and Freshwater Research 44*: 271–287.

Acknowledgements

The data used in the case study were obtained from a work undertaken by DOC Southland Conservancy through their Arawai Kākāriki programme.

Full details of technique and best practice

The standard fyke net design consists of a cylinder of netting wrapped around a series of hoops to create a trap (Figure 2). Fish enter through the mouth of the trap and are retained by a series of funnel-shaped throats. One or more leaders (or wings) are attached to the mouth and are used to direct fish into the fyke net. Leaders typically consist of a mesh at least as fine as the trap and have a float-line at the top and lead-line at the bottom.

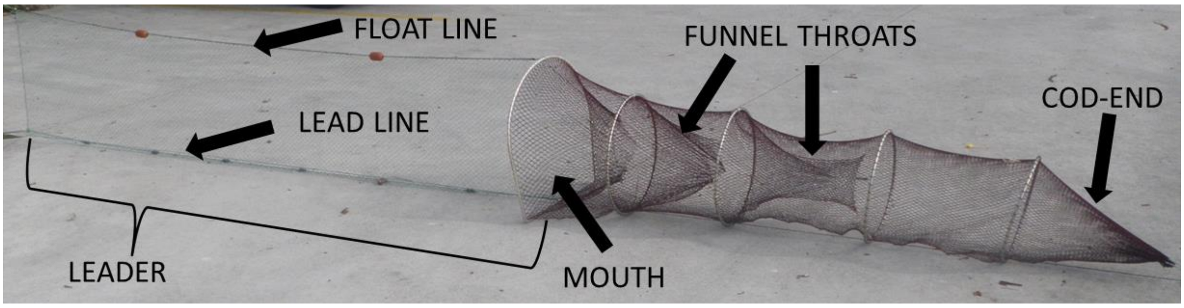

Figure 2. Standard fyke net design and elements.

There is currently no standard fyke net type for use in ecological surveys in New Zealand. However, one is currently being developed and tested for surveys in wadeable habitats (Joy et al. 2013). The standardised ecological survey net will include a separation grid for reducing predation effects on small fish. It is recommended that any new survey or monitoring programmes adopt the proposed standard fyke net design so long as it will still allow the key monitoring objectives to be achieved.

The most readily available fyke nets for DOC staff are likely to be the fyke nets used by commercial and recreational eel fishers. These typically have the following dimensions:

- Mesh size of 15 mm (knot-to-knot or square mesh)
- Leader length of 2.5–3 m
- Total length of 5 m
- Height of 50 cm (measured at first hoop/D-ring)
- 1–2 funnel throats (not including trap mouth)

Some surveys or monitoring programmes may require the use of specialised fyke nets, such as double-wing designs for sampling fish movements. For existing monitoring programmes it is important to continue to use the same fyke net types used in previous sampling episodes to ensure catch data are comparable.

The mesh size of leaders and trap bags will have a strong influence on the size range of fish caught and there are trade-offs between using finer or coarser mesh nets. The minimum size of fish caught is largely determined by the mesh size because fish that can pass through the mesh will not be retained in the trap. Mesh size can also have an effect on injury and mortality rates for captured fish. Smaller fish can become wedged in the mesh in a similar fashion to gill nets. Larger mesh can also cause injury when appendages (e.g. fins and tails) become wedged in the mesh. These effects can be minimised by using finer mesh sizes; however, fine mesh tends to reduce water flow through the net and may increase fish stress, particularly in low dissolved oxygen environments or where very large catches are made. There is also a view that catch efficiency for larger fish is lower in fine mesh fyke nets.

Waterproof labels identifying that the nets are being used by DOC and providing a contact phone number should be attached to all nets. These will help prevent well-meaning people from removing nets during sampling.

Fyke net catches can be increased by baiting. However, baiting should be avoided where possible because it can attract large numbers of predatory fish, and influence the species composition of catches. Catch variability may also be increased because the response of fish may vary with bait quality, currents and appetite at the time of sampling. Baiting of nets may also attract fish from outside of the location of interest (Balcombe & Closs 2000). If baiting is used, care should be taken to ensure that bait type and quality is standardised as much as possible.

Fyke nets will work best in water depths roughly equal to the height of the leader but can be set in deeper water provided a good 'set' can be achieved. As a minimum, the mouth of the net must be submerged to allow fish to enter the net and minimise the potential entry of water birds. Ensure that water levels will remain above the fyke net for the entire time that it is set to avoid fish stranding and maintain constant catch efficiencies.

Setting the cod-end higher than the leader may reduce catch efficiencies (for guidance, see 'Protocols for pest fish inventory and monitoring best practice guidance'—docdm-756153). However, if a site has the potential to experience deoxygenation overnight or if there is a high risk of birds entering the net, then ensure that there is an air gap along the top of each net chamber. This air gap will allow birds to breath and will provide fish with access to more oxygen-rich surface water. A large float placed in the chambers could also be used to help maintain an air gap.

There are many ways of setting a fyke net and the approach adopted at any site will depend to some degree on the habitat that is encountered. The general sequence of steps for setting fyke nets is as follows:

1. Ensure that the cod-end is tied securely before setting the net. Poorly secured cod-ends can result in partial or total catch loss.

2. Anchor one end of the fyke net using either an anchor-weight or long pole. Poles usually achieve a better leader 'set' than an anchor-weight but can only be used in relatively shallow water. Stretch the net out until it is taut and anchor the other end of the net. This step will need to be done using a boat if the site is non-wadeable. An alternative technique in non-wadeable still water habitats is to carefully lob the cod-end weight and fyke net body from the bank or boat before anchoring the leader in place.

3. Ensure that the leader is hanging vertically, is not twisted or sagging, and has the float line at the top and lead-line on the bottom.

4. Repeat steps 1–3 until all nets have been set at the site. Consider spacing between nets, especially if sampling in flowing water, as effective fishing areas may vary.

5. Mark the location of nets and/or extent of sampled area using a GPS. Unless they are clearly visible, nets should also be marked using flagging tape. It is also recommended that net locations at the site be recorded using a quickly drawn map.

6. Leave the net in place over the duration of the required sampling period. Capture rates will be maximised by setting nets overnight to include both the dusk and dawn periods when fish movement is greatest. On completion of sampling, retrieve the fyke nets by pulling in the leader end of the net first. Setting traps for longer will not necessarily increase catch rates due to gear saturation, predation and escapement effects but may increase injury and mortality rates.

7. Untie the cod-end and empty the contents of the net into a fish bin by lifting the front end of the net first. If the fyke incorporates a separation grid then fish from the front chamber will need to be emptied through the side opening. Process the catch by recording the number of species and any other variables of interest (e.g. length) separately for each individual net. If the net incorporates a separation grid then record the catches from the small and large fish chambers separately. Recording this data separately allows more flexibility at the data analysis stage.

8. Measure and record all of the habitat parameters that are relevant to the survey. The minimum parameters that should be recorded are outlined in 'Minimum attributes'. Recommended parameters are outlined in more detail in the sections below.

9. Decontaminate all sampling gear to prevent the spread of pest species. Guidelines for net decontamination are provided in 'Freshwater fishing net decontamination protocol' (docdm-428359). Additional useful guidance can be found in 'Review of weed transfer risk associated

with mudfish sampling and mitigation strategies' (docdm-645392), and on the Ministry for Primary Industries website[3].

Considerations for setting fyke nets in streams and rivers:

- Standardised protocols for sampling using a combination of fyke nets and Gee's minnow traps are currently being developed for New Zealand wadeable streams (Joy & David in press). It is recommended that these protocols be adopted for any future stream surveys carried out by DOC staff. The advantage of using standardised protocols is that they will provide data that can be more directly compared regionally and nationally. This in turn allows the development of large, long-term datasets with a much greater ability to detect patterns against the high background variability normally associated with fisheries data (Bonar et al. 2009). Finally, standardisation encourages data sharing between organisations and creates synergies between different monitoring programmes (Bonar et al. 2009).
- It can be difficult to set fyke nets in flowing water because of the potential accumulation of debris in the leader or net. Fyke nets should be set with the mouth facing downstream to minimise the accumulation of debris. Set the cod-end hard against one bank and set the leader across on an angle to the opposite bank if possible. Avoid setting fyke nets perpendicular to the bank because the potential to accumulate debris and/or roll over will be highest in that orientation.
- If setting fyke nets in high flows it may be necessary to secure them to the bank using an anchor rope to ensure that they are not washed downstream.
- National protocols for assessing habitat in wadeable streams have been developed by Harding et al. (2009) and most regional councils will have appropriate standardised methods that could be adopted. Note that many of these methods won't be applicable to large non-wadeable streams and rivers. Habitat variables that should be recorded as part of fyke net surveys in rivers and streams are:
  - Temperature, dissolved oxygen and pH (including time of day measurement was made)
  - Average stream width and depth
  - Substrate composition
  - Meso-habitat composition
  - Riparian cover and condition
  - Aquatic macrophyte cover (a useful method has been developed by Collier et al. 2006)
  - Qualitative habitat assessments (e.g. P1 and P2d field sheets from Harding et al. 2009)

Considerations for setting fyke nets in lakes:

- Fyke nets should be orientated so that they are perpendicular with the shoreline and with the mouth facing towards shore.
- To prevent fish movement around the end of the leader, choose net positions that enable a good seal between the end of the leader and the shore or instream objects.
- Use points at end of bays and passages between instream objects (e.g. macrophyte beds) to maximise catch rates.

[3] http://www.biosecurity.govt.nz/pests/didymo/cleaning

- Avoid setting fyke nets where there is a high risk of hypolimnetic deoxygenation[4], as it may result in high mortality rates amongst fish.
- Habitat variables that should be recorded in conjunction with fyke net catches include:
  - Water depth
  - Water temperature
  - Dissolved oxygen concentrations (preferably at surface and 1 m off the bottom)
  - Habitat description including presence of any macrophytes or other structure and type of substrate nets were set on.

Considerations for setting fyke nets in wetlands:

- An advantage with using fyke nets in wetlands is that they can be relatively easily set amongst dense aquatic vegetation. It may sometimes be necessary to clear holes in the vegetation and/or pin the leader and mouth of the net to the substrate to ensure that they fish effectively.
- It is possible to use 'mini' fyke nets, which are less than half the size of standard fyke nets and which fish well in shallow waters such as those typically found in wetlands.
- Habitat variables that should be recorded in conjunction with fyke net catches include
  - Water depth
  - Water temperature
  - Dissolved oxygen concentrations (preferably at surface and 1 m off the bottom)
  - Habitat description including presence of any macrophytes or other structure and type of substrate nets were set on

References and further reading

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[4] Where the bottom layers of the lake (hypolimnion) become deoxygenated. This frequently occurs during still, warm conditions.

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Appendix A

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

docdm-346005	Boat competency SOP
docdm-428359	Freshwater fishing net decontamination protocol
docdm-870579	A guideline to monitoring populations
docdm-1008026	Introduction to monitoring freshwater fish
docdm-756153	Protocols for pest fish inventory and monitoring best practice guidance
docdm-645392	Review of weed transfer risk associated with mudfish sampling and mitigation strategies
docdm-1470778	Set nets and diving birds: best practice guidance
docdm-146272	Standard inventory and monitoring project plan
olddm-566603	Wading safely

Appendix B

Data entry template for passive netting methods

This is an example of how to enter fish data collected using passive netting methods. This data entry template uses a 'long format' where individual records are entered in rows and variables are entered in columns. While this format can be more time consuming than other formats when entering data, it will save a lot of time and effort when it comes to data analysis. Multiple analyses can be quickly carried out using this one dataset thereby avoiding the need to re-enter the same data. This dataset format can be readily manipulated and summarised using filter, sort and pivot table tools found in Microsoft Excel. Most statistical software packages require that data be entered in 'long format'.

Net type	Net number	Species	Length (mm)	Number of fish	Comment
Type of net or trap used	Number assigned to each net/trap of a given type	Fish species caught. Important to record 'No fish' where none were caught in a net/trap.	Length measured for individual fish	Number of fish in this record. Note that this will always be 1 when the fish is measured.	Any comments regarding record (e.g. any injury or disease observed in fish)
Fyke net	1	*Anguilla australis*	600	1	
Fyke net	1	*Anguilla australis*	600	1	
Fyke net	1	*Anguilla australis*	570	1	
Fyke net	1	*Anguilla australis*	404	1	
Fyke net	1	*Anguilla australis*	506	1	
Fyke net	1	*Anguilla australis*	506	1	
Fyke net	1	*Anguilla australis*	606	1	
Fyke net	1	*Anguilla dieffenbachii*	407	1	
Fyke net	2	*Anguilla australis*	502	1	
Fyke net	2	*Anguilla australis*	505	1	
Fyke net	2	*Anguilla australis*	500	1	
Gee's minnow trap	1	*Galaxias maculatus*	76	1	partially eaten
Gee's minnow trap	2	*Galaxias maculatus*	68	1	partially eaten
Gee's minnow trap	2	*Galaxias maculatus*	67	1	partially eaten
Gee's minnow trap	2	*Galaxias maculatus*	88	1	
Gee's minnow trap	2	*Galaxias maculatus*	79	1	
Gee's minnow trap	2	*Galaxias maculatus*	92	1	
Gee's minnow trap	2	*Galaxias maculatus*	76	1	
Gee's minnow trap	2	*Galaxias maculatus*	74	1	
Gee's minnow trap	2	*Galaxias maculatus*	79	1	
Gee's minnow trap	2	*Galaxias maculatus*	88	1	
Gee's minnow trap	2	*Galaxias maculatus*	63	1	
Gee's minnow trap	2	*Galaxias maculatus*	69	1	
Gee's minnow trap	2	*Gobiomorphus basalis*	60	1	gravid female
Gee's minnow trap	3	*Galaxias maculatus*		14	
Gee's minnow trap	4	No fish			
Gee's minnow trap	5	No fish			