Freshwater fish: spotlighting—multi-pass

Version 1.0

This specification was prepared by Richard Allibone in 2013.

Contents

Inventory and monitoring toolbox: freshwater fish

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Department of Conservation
Te Papa Atawhai

Synopsis

The multi-pass spotlighting fish survey is used to survey and collect nocturnally active freshwater fish. It is most effective for the kōkopu species—banded kōkopu, shortjaw kōkopu and giant kōkopu—but can be used with more limited success for kōaro and īnanga. While not extensively trialled, spotlighting is a useful survey method for some of the non-migratory galaxiids (e.g. Eldon's galaxias, dusky galaxias), and bully species too. No nationally recognised standard method has been developed for spotlighting. Rather, the development of the method has been via the experience of individual operators and as an extension of electrofishing practice, which requires repeated electrofishing runs to maximise the number of fish caught. Multi-pass fishing methods, in general, have been developed because it has been recognised that single-pass fish surveys only catch a proportion of the fish actually present. To obtain more accurate information on the fish populations present, multiple passes through a site are used.

The multi-pass method requires a reach of stream to be surveyed for fish three times (passes) in one night. The spotlighting method locates nocturnally active fish, including a range of native fish, such as adult kōkopu, which are difficult to capture by other methods. In the multi-pass method, fish captured during each of the three passes are retained in live buckets until the survey is complete. Capturing and retaining the fish avoids individual fish being counted multiple times during the multi-pass survey. As the target fish species are captured, fish metrics such as length, and possible weight, sex and spawning condition are usually measured or determined for the captured fish.

The capture and measurement of fish species, coupled with the collection of habitat data, can provide good information on the fish population present including size classes and recruitment. As opposed to electrofishing, which is highly efficient at capturing fish from riffle habitats, the spotlighting method samples nocturnally active fish and is most effective in pool and run habitats where the calm water surface allows good visibility into the water. The spotlighting method is more difficult to apply in riffle habitats and even very experienced operators will find it difficult to effectively spot fish in riffles where water is faster and turbulent.

Assumptions

- All fish within a species are equally likely to be seen and captured.
- Capture effort is the same for each pass.
- All survey staff are equally capable.

Advantages

- A highly effective method for detecting nocturnally active fish that can otherwise be difficult to detect using daytime fishing methods.
- The size of fish observed and/or collected is not limited, unlike trapping methods that are limited to fish small enough to enter traps (and avoids predation in the traps).

- Equipment costs are low and the equipment may be used on other projects.
- Training requirements are limited before the gear can be successfully used.
- The survey method, with best practice for handling fish, has little impact upon the fish aside from a short period of disturbance when the spotlight surveyors pass by.
- Health and safety aspects are more limited than for electrofishing.
- Streams can be surveyed rapidly.
- Large areas of wadeable streams can be surveyed relatively rapidly when compared to electrofishing methods.

Disadvantages

- The site will require a daytime visit to first check suitability and locate a good access route.
- Best practice requires the surveys are undertaken at normal or low flows when the water is clear and on calm nights with no rain.
- Not suitable for all fish species.
- Time consuming if target fish species are abundant due to the slow capture rate of each individual.
- Survey work requires work at night.
- Quality of the fish survey data depends on surveyors' skills at spotting and catching fish and water conditions.
- May be difficult to standardise results across multiple surveyors.
- Fish captures are limited to wadeable depths and large rivers cannot be surveyed.
- Riffle and cascade habitats are difficult to survey.
- May be difficult or not possible to use in dark, tannin-stained waters.

Suitability for inventory

The use of the multi-pass spotlighting method is good for inventory purposes and it provides the highest quality abundance data that can be gathered via spotlighting for target species such as kōkopu species. However, the method is not suitable for inventory of all freshwater fish species as it is selective for nocturnally active pool dwellers.

Suitability for monitoring

The use of the multi-pass spotlighting method is also good for monitoring purposes and it provides the highest quality abundance data that can be gathered via spotlighting for target species such as kōkopu species. However, the method is not suitable for monitoring of all freshwater fish species as it is selective for nocturnally active pool dwellers.

Skills

- Good field skills and fitness suitable for working in forest areas at night
- Good navigation skills if field sites are away from access tracks
- Wading and walking in stream skills
- Fish capture, handling and competent fish identification
- Sound judgement with regard to stream, river and weather conditions to ensure safe operations are carried out

Fish identification skills must be appropriate to identify the adults of common fish species seen (the adult galaxiids—īnanga, banded kōkopu, shortjaw kōkopu, giant kōkopu and kōaro; redfin bully; salmonids), and preferably without the fish being caught. Juvenile fish of many species are harder to identify and will either need to be captured in order to be identified in the field, euthanised and preserved for lab identification, or counted as juvenile fish of a genera (e.g. *Galaxias, Anguilla, Gobiomorphus*).

Resources

- Spotlight—hunter's spotlight with standard 50-watt bulb or equivalent with LEDs
- Handheld torch and/or headlamp
- Gelcel batteries, either 6–7 amphour or 18 amphour, 12 volt
- Battery charger (trickle chargers appropriate for gelcel batteries)
- Map and/or GPS to record fishing site locations
- 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]
- Hand nets
- Tape measure
- 1 m rule
- Camera
- Live buckets (buckets with good lids and small holes or wire mesh in the side that allow water but not fish to pass through)
- Fish measuring board
- Buckets
- Backpack for carrying batteries and buckets while spotting
- Fish identification guide book
- Pencil and waterproof paper or notebook

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

- Other equipment appropriate for the field conditions

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).

Minimum attributes to record:

- Site location
- Site length
- Time taken to survey reach
- Average wetted width
- Habitat map to determine proportion of fishable area
- Fishing date and time of day
- Number of people conducting the survey
- Fish caught during each fishing pass
- Fish observed but not caught in final pass
- Weather and water conditions during survey

The following attributes are optional and depend on the survey objective and additional equipment available to the survey team:

- Water colour and clarity
- Individual fish lengths
- Individual fish weights
- Fish spawning condition
- A suite of water depth and widths to characterise habitat
- Substrate particle frequencies along the reach (e.g. percentage of boulder, cobble, gravel, sand and bedrock)
- Area of each habitat type (e.g. percent pool, riffle, run, cascade)
- Flow history in previous month
- Riparian vegetation
- Flow source

Data storage

Data collected during the field phase of the spotlighting work should be transcribed to spreadsheets as soon as possible after collection to ensure data are not lost and errors and omissions are identified and corrected where possible. Data should be retained on hardcopy field sheets and in electronic format. This allows field data to be checked if electronic data are lost or questioned. The spreadsheet should record all site location details, fishing date, time, number of surveyors, area surveyed and habitat data.

A consistent data table in a spreadsheet programme is recommended so that data from multiple sites can be compared without the need for reformatting. For each reach fished, it is recommended that the following data be stored in spreadsheets:

- Species of fish observed
- Number of each fish species observed or an abundance scoring (rare, occasional, common abundant)
- Number of individuals of each fish species collected (as opposed to observed)
- Individual fish lengths and weights (if data collected)

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]

Analysis, interpretation and reporting

It is recommended that statistical advice from a biometrician or suitably experienced person is obtained prior to finalising study design and to undertaking any analysis.

Analysis of the raw data can include the following:

- Species diversity
- Estimated fish density within survey reach
- Estimated individual fish species densities within the survey reach
- Length frequencies for each fish species where individuals were collected and measured
- Biomass per m^2 for each fish species where fish weights were collected
- Condition factor for each individual fish where length and weight data were obtained

More complex analysis could include:

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

- Estimates of capture probability for each fish species
- Estimates of the total number of individuals of the target species present
- Mean condition factor for size classes of each fish species

Data collected from any one site may be compared with data collected from other sites to compare fish species diversity, fish density, fish condition and fish length frequency. Results can be presented in a number of ways depending on whether data is to be analysed for a single site or multiple sites and can include the following:

- Table and/or graphs with total species diversity at sites
- Length frequency graphs for each species collected and measured
- Length v. condition factor graphs for each fish species caught and where individual fish lengths and weights were measured

Case study A

Case study A: population structure, individual movement and growth rate of shortjaw kōkopu (*Galaxias postvectis*) in two North Island, New Zealand streams (Allibone et al. 2003)

This study used multi-pass spotlighting (usually three-pass) in conjunction with fish tagging to assess a series of population demographics and life history characteristics of shortjaw kōkopu in two streams on Mt Taranaki.

Synopsis

A 3-year, twice-yearly three-pass spotlighting survey was used to collect shortjaw kōkopu in two streams on Mt Taranaki. The multi-pass fish collection captured a far greater percentage of the target kōkopu species than a single-pass operation. The survey, in conjunction with fish tagging, was used to monitor fish abundance, fish site residence and fish growth. A key factor in the success of the study was the ability to capture a significant percentage of the population of shortjaw kōkopu on any one survey. Data analysis after completion of the field programme included the comparison of fish density, fish condition, growth rates, site fidelity, fish density and recruitment rates at the two streams surveyed.

Objectives

- To assess the number of shortjaw kōkopu present in each study reach.
- To assess fish density, individual growth rates, residency patterns and recruitment of shortjaw kōkopu in each stream.

Sampling design and methods

A 150–200 m study reach was selected on each of two streams known to have sizeable populations of shortjaw kōkopu (i.e. 20–40 fish along the survey reach). Habitat was mapped within each reach and all pools were numbered to track the location of where individual fish were captured. For 3½ years, each reach was visited during low flow periods in May and October to undertake spotlight fishing. Each reach was fished beginning from the downstream end, and two spotlighters walked upstream through the reach searching for fish. Three passes (or occasionally four) were made along each reach during each night-time survey. Attempts were made to catch all shortjaw kōkopu seen in the reach and any fish captured were placed in live buckets at the site of capture. On the third pass, fish that escaped capture were also noted. All fish captured were measured and weighed. All fish captured had visual implant tags inserted in the caudal (tail) region of the fish to allow the identification of individual fish during subsequent fish surveys. This allowed the study to track an individual fish's movement and the growth.

Results

The study marked 89 fish in total and included 44 fish in one stream and 45 fish in the other. The size range of shortjaw kōkopu collected was between 79 and 242 mm. The number of fish captured on any one sampling event from one stream ranged between 15 and 27 fish and in the second stream between 8 and 16 fish. On no survey occasion were all the previously tagged fish captured, indicating that despite three passes (or more) through the study reaches, fish were evading capture. After 3 years, the number of fish captured without tags declined. After six surveys using the multi-pass method, only juvenile fish (recruits) at the more easily fished site had no tags, which indicated the entire adult population of shortjaw kōkopu within the reach had been captured and tagged. Capture and recapture rates were lower in the stream with less pool habitat and greater proportion of faster flowing run habitat due to difficulty locating and capturing the fish.

The tagging study found that 53% of recaptures were in the same pool and a further 25% of recaptures occurred in adjacent pools to the previous capture event, which indicates limited movement by the majority of tagged shortjaw kōkopu.

Limitations and points to consider

Observation and capture rates were strongly correlated to the type of habitat being fished. The capture and observation rates both decreased with decreasing water visibility and increasing water velocity due to difficulty seeing fish and increasing difficulty using the hand nets to capture fish seen.

On no single survey occasion were all the shortjaw kōkopu at a site observed or caught, and at best, possibly two-thirds of the resident fish were observed on any one night.

Capture of the fish at times required both spotlighters to work together to hold the spotlights and hand nets and to move cobbles and boulders on the streambed to get access to the fish.

Although both study streams rose on Mt Taranaki and had very little problem with suspended sediment and could be surveyed soon after periods of rain, fishing was limited to periods of low flow and good visibility that maximised the effectiveness of the method in observing and capturing fish.

References for case study A

Allibone, R.M.; Caskey, D.; Miller, R. 2003: Population structure, individual movement and growth rate of shortjaw kokopu (*Galaxias postvectis*) in two North Island, New Zealand streams. *New Zealand Journal of Marine and Freshwater Research 37*: 473–483.

Case study B

Case study B: shortjaw kōkopu (*Galaxias postvectis*) in the northern Tararua Ranges (Bowie & Henderson 2002)

Synopsis

Fifty 100-m reaches were fished by spotlighting in the Mangatainoka, Makakahi and Ruamāhanga rivers in the northern Tararua Ranges. At each site macrohabitat data was collected to determine the habitat preferences of shortjaw kōkopu. Shortjaw kōkopu were collected at 9 of 37 study sites in the Mangatainoka and Makakahi rivers, but at none in the Ruamāhanga River. A total of 41 shortjaw kōkopu were collected from the 50 sites fished.

Objectives

- To determine the habitat preferences of shortjaw kōkopu.

Results

The shortjaw kōkopu were only found in sites in the Mangatainoka and Makakahi rivers; none were found in the 13 reaches in the Ruamāhanga River catchment. A total of 41 shortjaw kōkopu were found and these ranged in size from 70 to 220 mm. Other fish species observed were kōaro, banded kōkopu, longfin eel, and Cran's bully.

The habitat analysis for the sites in the Mangatainoka and Makakahi rivers found the Pfankuch index (a measure of habitat quality and stability) was the best predictor of the occurrence of shortjaw kōkopu.

References for case study B

Bowie, S.; Henderson, I. 2002: Shortjaw kokopu (*Galaxias postvectis*) in the northern Tararua Ranges. *Department of Conservation Science Internal Series 30*.

Full details of technique and best practice

The multi-pass spotlighting survey method has two key elements: it is a night-time method of fishing using spotlights, and each reach is fished on three (or more) occasions on a single night.

The reason for multiple passes along a fishing reach is that individual fish will evade capture during single-pass fishing and multi-pass fishing improves the probability of capturing the majority of the target fish species within a reach.

For each study reach, a daytime site visit is required prior to the fishing operation to assess the area to be fished, assess potential hazards and to map habitat at the site (measurements of stream widths and lengths and order of pool, riffle and run habitats). This visit should also determine whether access permission is required from landowners adjacent to the stream of interest. The pre-spotlighting site visit should involve checking water conditions to see whether conditions are suitable for spotlighting—most importantly that the streambed in pools, backwaters and runs is visible. If the streambed cannot be seen, it will not be possible to see all (or any) fish during the spotlighting survey. The daytime visit should include selecting the fishing reach and marking the upstream and downstream limits in a manner that can be recognised at night. For a typical site, a 100–300 m stream reach within the area of interest is selected and should include pool and run habitat where the water surface is smooth and unbroken. Site length may be determined by instream obstacles such as waterfalls, long reaches of unfishable habitat, or other instream features that limit fishing. Alternatively, earlier surveys may have provided information on the fish densities, and the area surveyed is determined by the length required to catch a target number of particular fish species. The survey reach does not have to be dominated by these types of habitat and may rather be representative of the stream in general. The stream reach should also be wadeable for the majority of the area, although deep pools can be included and fished using long-handled dip nets. For sites that will be revisited as part of a long-term monitoring programme, the daytime visit may be discounted if the site is well known by the survey team.

If the survey needs individual capture details, a habitat map should be drawn up with each pool and run numbered. Habitat maps can be drawn up by measuring the length of each habitat unit (pool, riffle, run), and measuring widths and depths in each unit. These measurements are then used to draw up a map of the study reach. The area of each habitat unit and the total length of stream to be surveyed should be estimated. The daytime site visit prior to the spotlight survey should consider safety issues for night-time work. Particular attention should be paid to riparian vegetation that may represent a hazard at night, the nature of the streambed and how slippery it may be, and the ease with which the stream can be accessed, walked and exited in the dark.

There is some debate as to whether spotlight fishing should be avoided on nights with a full moon and clear skies, as brighter nights may make fish more cautious and light sensitive, and therefore more difficult to capture. Fishing should avoid nights when there is rain or strong winds, as either of these can cause rippling of the water surface and reduces water visibility and survey effectiveness. Therefore, the ideal spotlighting night is a calm, overcast night on a new moon when stream flows are low and water is clear.

Night-time spotlighting should not commence until an hour after dark. This allows the nocturnally active fish time to leave their daytime cover and take up feeding positions in pools and runs. The survey team should set up their survey equipment (spotlights, head lamps, catching equipment, etc.) away from the study reach to prevent disturbance of the site prior to fishing. Live buckets for placing captured fish in should be carried along during the first pass through the site and set out in each pool as the surveyors work up through the study reach. This avoids walking the stream while placing these buckets out prior to undertaking the survey work and potentially disturbing fish.

Fish surveys usually start from the downstream end of the reach, but either upstream or downstream is possible and may depend on access to the site, and nature of the streambed (silty streams need to be fished in an upstream direction). Fishing a site entails two or three people, depending on the width of the stream, walking carefully along the reach spotlighting the water 0–1.5 m in front and to the side, and looking for fish illuminated by the spotlight. Streams wider than 7 m are best fished with three surveyors as this reduces the amount of cross-channel movements undertaken by individual survey team members. This in turn reduces the amount of disturbance in the water from footsteps and can reduce the disturbance of fish. Spotlights should not be shone further ahead than 1.5 m when surveying as this may disturb fish outside the immediate area where the operator can effectively see and catch them. Care must be taken to survey all areas of the stream including hard-to-fish riffle areas, along the stream edges and amongst overhanging vegetation and banks. The surveyor must also make sure they look for small and large fish and avoid biasing surveys toward easy-to-spot larger fish. Progress may be slow as each area is searched, although as a general rule experienced surveyors can still move rapidly through a study reach. Team members should progress upstream through the site at the same pace. This may require team members to wait while difficult habitats are searched by other team members.

As surveyors encounter fish, any individuals of the fish species of interest should be captured and transferred to the live bucket. For multi-pass spotlighting, you can record fish observed but not caught in the first two passes. Observations do indicate that kōkopu, at least, will re-emerge from hiding rapidly if disturbed and will most likely be observed during the third pass and then counted. The counting of fish not captured during a multi-pass survey should only be conducted on the last survey pass. Captures are usually made by the surveyor continuing to shine the spotlight on the target fish and moving closer to it in a careful manner to avoid disturbance in the water. Once close enough to the fish to attempt netting it, the surveyor can use handheld dip nets to capture the fish. The capture requires the use of two hand nets. When the fish is within reach, the spotlight must still be shone on the fish either by a second person or by the netting person by holding the spotlight between their knees (in shallow water) or holding the spotlight handle in their mouth. Alternatively, some individuals have switched to a high-power headlamp to illuminate the fish at this stage. Hand nets can be placed at the head and tail of the fish. Kōkopu will often not move while the nets are being placed in front and behind them and can be quickly scooped out using the net placed at their tail end. On other occasions, the fish can be very gently nudged from the head or tail by one net to scare them into the other net. The key factors here are to ensure the nets are open and, as most kōkopu sit near the streambed, that the nets are touching the streambed to prevent the fish escaping under the nets. The capture technique is the most critical skill that requires some practice, especially in areas where the water current is strong as flowing water will close the upstream net quickly. In pool habitat, fish that have avoided capture may only move a short distance and can be seen by spotlight and another capture attempt made. If fish are not immediately obvious, they often quickly re-emerge from hiding if spotlights are left off.

All fish captured are placed in live buckets and left in the approximate location of the capture site. Additional fish captured may be placed in the same live buckets if it comes from the same area (pool, run or riffle). Different live buckets should be used for each pool or run to ensure fish are returned to the same location for which they were caught. Fish placed in live buckets are left in the buckets until all the three survey passes have been completed.

After each pass through the reach, the survey team should return to the start point. Once at the start point, the survey team should allow 10 minutes or longer for fish to return to feeding after any disturbance caused by the previous pass and the survey team walking back along the reach to the start point. Once a quiet period has lapsed, the survey team can repeat the survey using the same effort as the previous pass or passes. During the quiet period, the survey team can record notes on the numbers of fish caught in the just-completed pass and should include both the total number along the reach and number of fish caught within each habitat unit (if important). Surveyors should also note where individuals from the target fish species were observed but not captured so they can be targeted in subsequent passes. Prior to starting the next pass, discuss any improvements to the fishing operation or issues that may have arisen during the previous pass, especially with respect to the capture of target species.

On the final pass through a site, in addition to recording all the fish caught and placed in live buckets, the survey team should also note the number of fish from the target species that evade capture. If this information is recorded, then the total number of fish known to be present within the study reach is the total number in the live buckets plus any fish known to have escaped during the third and last fishing pass. Care needs to be taken with recording the identification of fish seen but not caught to ensure different species are not confused.

Following the completion of the third and final fish pass, all fish in live buckets can be weighed and measured, and sex and spawning condition assessed. Once the fish in each live bucket have been assessed, the fish are released. Always release fish back into the area of the stream where they were captured. This is especially important for sites that are long-term monitoring sites as it minimises disturbance and distortion of results in future surveys.

All fish handling should be done following best practice, which includes minimising the unnecessary handling of individual fish and wetting hands prior to handling fish to avoid damaging the skin or surface mucus layer. When returning fish to the water from live buckets, lids should be removed from the bucket and the bucket submerged in water allowing fish to swim free.

References and further reading

Allibone, R.M.; Caskey, D.; Miller, R. 2003: Population structure, individual movement and growth rate of shortjaw kokopu (*Galaxias postvectis*) in two North Island, New Zealand streams. *New Zealand Journal of Marine and Freshwater Research 37*: 473–483.

Bowie, S.; Henderson, I. 2002: Shortjaw kokopu (*Galaxias postvectis*) in the northern Tararua Ranges. *Department of Conservation Science Internal Series 30*.

David, B.; Closs, G.P.; Arbuckle, C. 2002: Distribution of fish in tributaries of the lower Taieri/Waipori Rivers, South Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 36*, 797–808.

McCullough, C.D.; Hicks, B.J. 2002: Estimating the abundance of banded kokopu (*Galaxias fasciatus* Gray) in small streams by nocturnal counts under spotlight illumination. *New Zealand Natural Sciences 27*: 1–14.

Studholme, B.; Barrier, R.; Jack, D. 1999: Shortjawed kokopu (*Galaxias postvectis*) conservation status in Nelson/Marlborough—year one. Interim report, Department of Conservation, Nelson.

Appendix A

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

docdm-146272	Standard inventory and monitoring project plan
olddm-566603	Wading safely