Freshwater fish: spotlighting—fixed reach

Version 1.0

This specification was prepared by Richard Allibone in 2013.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

A fixed-reach spotlighting survey is a survey of streams using a standard length of stream as the basis unit of effort for the survey. The reach length should be in the order of 100–400 m to ensure a sequence of pool, run and riffle habitat is surveyed. The method does not standardise for area so the same reach length is surveyed regardless of stream width. No nationally recognised standard method has been developed for fixed-reach spotlighting. Rather, the development of the method has been via the experience of individual operators and as an extension of single-pass electrofishing methods.

For each reach a spotlighting team will survey the reach in a single pass looking for nocturnally active fish species. This method targets migratory galaxiids—banded, shortjaw and giant kōkopu in particular. Additional species that will be observed include other whitebait (īnanga and kōaro), non-migratory galaxiids (e.g. Eldon’s galaxias, dusky galaxias), various bully species, eels and trout.

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

Assumptions

- All fish of a species are equally likely to be seen and captured.
- All fish survey staff are equally capable.
- Reaches are representative of larger areas of the rivers and streams.

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 electric fishing.
- Substantial lengths of stream can be surveyed in a single night.

- Large areas of wadeable streams can be surveyed relatively rapidly when compared to electrofishing methods.

Disadvantages

- Will underestimate total fish density as an unknown proportion of fish present will not be observed.
- Site will require a daytime visit to first check suitability and locate good access route.
- Not suitable for all fish species.
- Can be time consuming if all individuals of an abundant fish species need to be captured (capture may be required to identify or measure fish).
- Survey work requires work at night.
- Quality of the fish survey data depends on surveyors' catching skill and water conditions.
- May be difficult to standardise results across multiple surveyors.
- Riffle and cascade habitats are difficult to survey.
- Fish captures are limited to wadeable depths and large rivers cannot be surveyed.
- May be difficult or not possible to use in dark, tannin-stained waters.

Suitability for inventory

Fixed-reach spotlighting is highly suitable for inventory assessment of nocturnally active fish species as it has a high probability of capturing or observing these fish. A well conducted single-pass survey will have a high probability of detecting pool dwelling fish and a minimum density estimate can be obtained. Furthermore, if fish are captured, data on length frequency, fish spawning condition and fish weight can be collected.

Suitability for monitoring

The fixed-reach spotlighting method can be used for monitoring a population at a single site and can be used for monitoring among sites. Comparisons among multiple sites have to consider confounding effects of different total area searched, varying capture probability at different sites and different habitat availability among reaches.

To conduct monitoring at fixed-reach sites, the reach must be of sufficient length to ensure relatively large sample sizes of the target fish species are captured and/or observed. For shortjaw and giant kōkopu, large populations can be considered to be in the order of 20–30 individuals in a survey reach. A maximum length for a fixed-reach study is in the order of 400 m. This provides a large length of stream to survey and also avoids surveyor fatigue that would become a factor on longer reaches. No research has been conducted into the frequency of fixed-reach surveys or the duration of a monitoring programme to detect trends and this will depend on the monitoring programme.

However, it can be expected that to detect long-term population trends at a site, fixed-reach surveys need to be conducted for at least 5 years.

Skills

- Good field skills and fitness for working in forest and stream areas at night
- Good navigation skills if field sites are away from access tracks
- Wading and walking in streams skills
- Fish capture, handling and identification
- Sound judgement and risk assessment with regard to stream or 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

Initial set-up for spotlighting:

- Spotlight—hunter's spotlight with standard 50-watt bulb or equivalent with LEDs
- Handheld torch and/or head lamps
- Gelcel batteries, either 6–7 amphour or 18 amphour
- Battery charger (trickle chargers appropriate for gelcel batteries)
- Map and/or GPS to record fishing site location
- 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
- Marker pegs
- Fish measuring board
- Buckets
- Camera

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

- Backpack for carrying batteries while spotlighting
- Fish ID guide book
- Pencil and waterproof paper or notebook
- Other equipment appropriate for the field conditions

Additional equipment that can be included to increase data collected includes a balance to weigh fish.

No permits are required for survey work for DOC staff. Access permission may be required depending on the location of the survey reach.

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).

For each survey location the following must be recorded:

- Stream name and site location
- Surveyors’ names
- Survey data and time
- Length of stream surveyed
- Time taken to survey reach
- Upstream and downstream ends of the survey reach
- Average width
- Estimate of the area of water actually spotlighted in reach survey
- Water and weather conditions during the survey
- All fish species observed
- Abundance categories (rare, occasional, common, abundant) or counts of fish observed (by species or genus)
- Notes on whether fish identifications were confirmed by capture and identification of any fish

Additional attributes (not critical for the implementation of the method):

- Water colour and clarity
- Individual fish lengths
- Individual fish weights
- Sex of fish
- Fish spawning condition

- A suite of water depth and widths to characterise habitat
- Substrate particle frequencies (e.g. percentage of boulder, cobble, gravel, sand, bedrock) along the reach
- Area of each habitat type (e.g. percentage of 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 omission can be identified and corrected (when 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 the site location details, fishing date and 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 reformatting data. For each reach fished, the following data collected about the fish populations may be stored on the spreadsheet:

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

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].

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

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:

- Species diversity detected
- Total observed fish density in the reach
- Individual species observed fish density
- 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

When data on the total area are available, estimates of fish density can be made for each fish species and also total fish density. However, these estimates will provide **minimum** density estimates as it is extremely unlikely that all fish present in a reach will be seen for any species, hence the densities are referred to as observed fish densities.

More complex analysis includes:

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

The data collected at any one site may be compared with the data from other sites to compare fish species diversity, fish density, fish condition, fish length frequency.

The results can be presented in a number of ways depending on whether the data are being analysed for a single site or multiple sites:

- 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 species collected measured and weighed

Case study A

Case study A: shortjawed kōkopu conservation status in Nelson/Marlborough (Studholme et al. 1999)

Synopsis

The survey was designed to investigate coastal rivers and streams in and adjacent to the Abel Tasman National Park for the presence, abundance and size structure of shortjaw kōkopu to provide good inventory data on populations in that region. At each of 37 streams a 400 m section of stream was fished by a two-person spotlighting team.

Objectives

- Determine whether Abel Tasman National Park streams had significant populations of shortjaw kōkopu when compared with areas adjacent to the national park
- Gain some understanding of the populations in individual rivers in the park and the length frequencies of the fish present

Sampling design and methods

The lower reaches of the 37 streams were selected for the study and a readily accessible reach of 400 m was used for the survey. The sites were visited during the daytime to mark out the 400 m reaches for fishing, with a lower reach section close to the coast being selected for each site that had reasonable access.

Fish surveys commenced at least 1 hour after dark with two surveyors conducting the work with 35-watt and 75-watt spotlights and hand nets for catching fish. Fish were captured during the first surveys to confirm the identity of fish, but as the survey team gained experience fish identifications were conducted by sight. Attempts were made to capture all shortjaw kōkopu seen and those captured were measured and returned to the stream. Records of other fish species present were kept and recorded using abundance categories—rare, occasional, common and abundant.

The area surveyed varied as the stream width varied at each site and the amount of fishable habitat varied according to the proportion of riffle, run, pool, and backwater present. To determine area fished, the average width was estimated to estimate total reach area (400 m × estimated average width). The total area was adjusted to area fished by reducing the total area by the estimated proportion that was unfishable, e.g. riffle habitat. Additional data on catchment and riparian landuse, maximum water depth, water conductivity, percentages of each habitat type, and streambed substrate were collected to characterise each reach fished.

Comparisons between sites were made for the estimated density of shortjaw kōkopu, length frequency distributions for shortjaw kōkopu, and the general fish communities present in each stream.

Results

Shortjaw kōkopu were found in 12 (32%) of the 37 stream reaches surveyed. A total of 96 shortjaw kōkopu were caught with 61 of these fish caught in the national park. The area fished was not correlated with the numbers of shortjaw kōkopu collected and the density of the shortjaw kōkopu was highly variable among the sites. The number of shortjaw kōkopu in a reach varied from 1 to 19. The size range of shortjaw kōkopu caught ranged from 90 to 260 mm.

Comparison of the occurrence of shortjaw kōkopu with habitat variables found the occurrence of the fish was most closely correlated with cobble and boulder substrates. The catchment landuse was less significant, with shortjaw kōkopu found in agricultural streams outside the national park as well as full forested streams in the national park.

A range of other fish species were observed during the survey: banded kōkopu (59% of the water courses surveyed), giant kōkopu (16% of the water courses surveyed), īnanga (32% of the water courses surveyed), kōaro (70% of the water courses surveyed) and brown trout (25% of the water courses surveyed).

Limitations and points to consider

The study followed a well set up method that standardised the reach length and then adjusted the number of fish seen/collected by the area fished to determine the estimated densities of the target species—shortjaw kōkopu. The collection of length data from the shortjaw kōkopu also allowed the survey to provide additional data on the occurrence of juvenile and adult fish. The survey plan was adhered to for the 37 sites; this is important for any fixed-reach survey as altering the reach length or other parts of the survey during the survey programme add un-necessary complications for the analysis.

Recording the presence of other fish species provided additional general inventory data on a range of threatened native fish.

As previously noted the survey required two site visits, the initial daytime site visit and the main night-time fishing operation. This is important to avoid arriving at a site at night and finding the reach is not fishable or the fixed-reach length is not available.

References for case study A

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

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 were 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 that the Pfankuch index, a measure of habitat stability, was the best predictor of the occurrence of shortjaw kōkopu with more stable habitat preferred (a high Pfankuch index score). Reaches with a low gradient were also more likely to have shortjaw kōkopu as opposed to steeper gradient reaches where kōaro were dominant. The study also concluded that factors other than habitat were, most likely, excluding the shortjaw kōkopu from the Ruamāhanga River catchment and that these other unknown factors can confound the habitat preference analysis.

Limitations and points to consider

The study fished 100-m reaches and had a relatively low success rate for the detection of shortjaw kōkopu. Any study design needs to consider carefully the balance between the number of sites investigated and the amount of survey effort at any one site. Longer reaches will increase the probability of detecting a target species if it is present, but if the work programme has a fixed budget fewer sites can be surveyed as the size of sites increases. The study design also needs to consider site selection issues and whether a random site selection is appropriate, sites with the preferred habitat of the target species, or a combination of the two.

The study found shortjaw kōkopu were absent in the Ruamāhanga River sites and concluded that this was due to factors other than habitat and this is a key factor to consider with fish surveys. On a reach level, habitat may be suitable for fish, but downstream issues such as a lack of fish passage may restrict or prevent migratory fish accessing upstream areas of river systems. Survey designs need to consider the influence of downstream effects on upstream fish communities. Historical survey data should be reviewed prior to designing a study to determine if previous surveys provide useful background information on the fish communities likely to be present at the potential study reaches.

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

Fixed-reach spotlighting has two key elements: it is a night-time method of fishing using spotlights, and a fixed length of stream is fished at each survey site in a study. The fishing at a site is also conducted on a single night to avoid complicating factors associated with fish observations on multiple nights.

For each study reach, a site visit is required prior to the fishing operation to assess the area to be fished and to map the site if required. The assessment needs to check the water conditions at the site to see if the conditions are suitable for spotlighting—most importantly that the streambed in the 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. This daytime visit should select the fishing reach and mark the upstream and downstream limits in a manner that can be recognised at night. For a typical site a 100–400 m reach of stream in the area of interest is selected that has pool and run habitat where the water surface is smooth and unbroken. The site does not have to be dominated by these types of habitat and may just be representative of the stream reach in general. The stream reach should also be wadeable for the majority of the area, although deep pools can be included and can be fished using long-handled dip nets.

If the survey needs individual capture details, a habitat map should be drawn up with each pool and run numbered, and an estimate of area made for each habitat unit and the total length of stream to be surveyed. The site assessment should also consider safety issues for night-time work and pay particular attention to riparian vegetation that may represent a hazard at night, access permission details, and the ease with which the stream can be accessed and walked in the dark.

There is some debate as to whether fishing should avoid nights with a full moon and clear skies as these lighter nights may make the 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 causes rippling of the water surface and reduces the survey visibility. Therefore, the ideal spotlighting night is a calm, overcast night on a new moon when streams flows are low and clear.

Night-time spotlighting should not commence until an hour after it becomes dark. This allows the nocturnally active fish time to leave their daytime cover and take up feeding positions in the pools and runs. The survey team should set up their survey equipment (spotlights, head lamps, catching equipment, etc.) at a site away from the study reach to prevent disturbance of the site prior to fishing. Buckets for placing the captured fish in should be carried along during the survey through the site, rather than being set out along the reach prior to the survey commencing. This avoids walking the stream prior to the survey as this may disturb the fish.

The fish surveys usually work from the downstream end of the site, but either upstream or downstream is possible and may depend on access to the site. 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 of themselves 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 the fish. Spotlights should not be shone further ahead than 1.5 m when surveying as this may frighten fish outside the immediate area where the operator can see and catch them. Care must be taken to survey all areas of the stream, even hard-to-fish riffle areas along the stream edges and amongst overhanging vegetation and banks. Progress upstream in streams with complex habitat may be slow as each area is searched. The team members should progress upstream through the site at the same pace. This may require team members to wait while habitats are searched by other team members.

As surveyors encounter fish, any fish of the species of interest should be captured. Captures are usually done by the surveyor continuing to shine the spotlight on the target fish and moving closer in a careful manner. Once close enough to the fish to attempt netting, the surveyor can use handheld dip nets to capture the fish. The capture requires the use of two hand nets and at this time 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 used 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 of all species will often not move while the nets are being placed in front and behind them and they can be quickly scooped out using the net placed at their tail. On other occasions the fish can be very gently nudged from the head or tail to scare it 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 net(s). The capture technique is the most critical skill that does require some practice, especially in areas where there is a strong water current as this will close the upstream net very quickly.

All fish captured can be identified, measured and sexed if the survey requires this information and then released back into the stream into areas that the survey has already passed through.

All fish handling should be done following best practice, minimising the handling of the fish, and the handlers should have wet hands to avoid damaging the fish skin or surface mucus layer. When returning fish to the water from buckets, the bucket can be submerged in the water allowing the 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