Fish population and fish passage monitoring for Orokonui Creek, Otago

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1. Introduction

A gabion basket weir is to be constructed just upstream of the tidal reach of Orokonui Creek, a small first-order stream flowing into Blueskin Bay, just north of Dunedin. The purpose of the weir is to prevent brown trout moving into Orokonui Creek from other streams entering Blueskin Bay. Exiting brown trout in Orokonui Creek will be removed by electric fishing following the construction of the weir. Brown trout are to be excluded as their presence is thought to have detrimental effects on the abundance of some native freshwater fish (McDowall 1990). The gabion basket weir is intended to allow water and small juvenile native fish to pass through the rocks within the basket or over the weir, but not trout.

The purpose of the brown trout exclusion is to maintain and/or improve the native fish community in Orokonui Creek. The stream has good populations of banded kokopu, redfin bully, common bully, and smaller numbers of inanga, koaro, shortfin eels, longfin eels, giant bully, giant kokopu, common smelt and lamprey (New Zealand Freshwater Fish Database, NZFFD). All the native fish present at Orokonui Creek are diadromous species that require access to and from the sea to complete their life cycle. Therefore, any barrier structure that prevents brown trout access to the stream may also hinder or prevent the diadromous native species gaining entry to the stream. Loss of passage for the native fishes would defeat the purpose of the operation. However, all the native species, apart from lamprey, that occur in Orokonui Creek migrate from the sea into freshwater as small juvenile fishes (e.g. whitebait and glass eels or elvers). The gabion basket weir is intended to allow these small fish to pass upstream by allowing them to penetrate through the rocks that make the gabion, but block the passage of larger fish (e.g. age 1+ or older brown trout).

To determine if the gabion weir functions as designed, monitoring of fish passage and the upstream fish community is required. The monitoring should seek to answer three questions. Firstly, is the upstream passage of diadromous native fishes being maintained when the gabion weir is in place? Secondly, has brown trout passage has been halted? Thirdly, if the brown trout exclusion is successful, is there any change to the native fish community structure or fish abundance in Orokonui Creek? The first two monitoring objectives seek to show the barrier performs the desired functions while the third objective seeks to quantify the response of the native fish community to the removal of trout.

2. Monitoring methods

2.1 INITIAL SURVEY

Prior to the construction of the gabion weir it is important to determine the fish distributions within Orokonui Stream and estimates of density be obtained.

Distributional knowledge is required to determine if some of the native fishes in Orokonui Stream only occur downstream of the proposed site of the gabion weir. Species such as giant bully, common smelt and inanga, may have limited upstream distributions (Jellyman et al. 1997). If species do not occur upstream of the proposed weir site then monitoring passage success for these species is not required. Conversely fish species that have high densities upstream of the weir site should be a high priority for determining if fish passage has been maintained.

Long-term monitoring sites should be established at which fish density and community structure are assessed. These provide the baseline data to determine if the weir or/and brown trout removal has led to changes in the native fish community. However, given that brown trout have already been removed, on occasions, from Orokonui Stream, the assessment of the effect of brown trout removal may be compromised, but this assessment should still continue, as the native fish community response to removal may be slow.

2.2 JUVENILE NATIVE FISH PASSAGE

The majority of New Zealand's migratory native freshwater fish return to freshwater in spring and summer (Appendix 1). Monitoring of the ability of these fish to pass through the gabion basket weir can then be carried out during spring and summer. For the rapid assessment of juvenile fish passage, simply electric fishing or fish trapping immediately below the weir will detect any large accumulations of juvenile fish. This would indicate a passage problem, but will not distinguish between complete blockage of passage and a restriction or slowing of passage. Rapid assessment of this type should be carried out towards the start and end of the migration period of any fish species of interest. A large increase in the abundance of fish below the weir would indicate fish passage has been reduced or prevented. This method is, however, not very useful for comparisons of the density of juvenile fish in the upstream and downstream areas. Juvenile fish passing the barrier will have over 2 km of stream to inhabit, whereas those below the barrier will be restricted to just a few 10s of metres and therefore may occur in much higher densities if passage is reduced or slowed. An assessment of fish passage can also be achieved by tracking the movement of dye-marked juveniles. Dye marking with bismarck brown and neutral red (chemical dyes) in overseas studies has marked elvers for up to seven days (C. Briand, Institut d'Amenagement de la Vilaive pers. comm.). In New Zealand these dyes have been used to dye and track whitebait for up to three days (Stancliff et al. 1989, Allibone et al. 1999).

For dye-marked fish assessment of upstream fish passage at the gabion weir whitebait, bullies and elvers should be captured in the estuarine reaches of the stream by trapping, netting and/or electric fishing. The fish should then be dyed by immersing it for 10 minutes in an aerated solution of bismarck brown (0.15 g/l of bismarck brown) or neutral red (0.05 g/l neutral red). Using these concentrations of dye whitebait can retain enough dye to still be recognisable up to 60 hours after dye marking occurred. Bismarck brown marking does appear to last longer than neutral red and is less toxic to the fish and is therefore recommended as the dye to use. Neutral red can be used to distinguish between two releases of dye-marked fish if the releases are made within three days of each other. It is recommended that the solution used to dye the fish is buffered with the addition of sodium bicarbonate (approx. 1 g/1), and if this is done, dye immersion time for the fish could be extended and hopefully dye retention time increased. Once the fish have been dyed they can be released back into the stream downstream of the weir. Fish trapping, netting and observations can then attempt to locate dyed fish upstream of the weir and also immediately below the weir. The greater the numbers found upstream of the weir the smaller any restriction on fish passage. The time taken for fish to achieve passage through the gabion weir can also be determined. This form of study can produce good quantitative results if standardised trapping methods are used. The best standardised method would be to place a whitebait trap that fish cannot pass immediately downstream of the gabion. All the fish collected are dye marked and released. Another trap, again trapping the whole width of the stream, is placed immediately upstream of the weir. The percentage of dye-marked fish appearing in the upstream trap and the time taken to arrive at the trap will indicate if passage problems exist. Paired traps, with standardised fishing effort, can be operated at any time of the year to assess numbers of fish moving upstream (or downstream). Traps should be checked at least daily and it should be remembered that while trapping collects fish moving in one direction it also blocks movement of fish in the other direction, so long-term placement is not recommended.

Unmarked juvenile fish numbers can also be monitored during the monitoring of the dye-marked fish. If the total number of juvenile fish of any or all the native species caught below the weir is far greater than juvenile fish numbers above the weir passage problems are indicated. Such results should be matched by the limited passage of dye marked fish through the weir. However, if dye-marked fish have not accumulated immediately below the gabion weir other behavioural factors may be limiting upstream fish movement. This is unlikely for whitebait, as once they enter freshwater they will migrate rapidly upstream (e.g.,Allibone et al. 1999).

A trapping programme could be run over three- or four-day periods once a month during the whitebait season. The first day is for collecting fish below the weir (or a trap is left in place for several days to accumulate fish).The captured fish are then dye marked and released. The following two or three days' trapping is carried out above and below the weir to collected dye-marked and unmarked fish in both areas.

During the period that dye-marked fish are present in Orokonui Creek, observations can be made at the gabion basket weir. Whitebait migrate near the water surface during the day. The dye-marked fish are therefore often highly visible and can be seen moving upstream. An observer (or video camera) positioned at the gabion weir could assess the behaviour of dye-marked fish when they reach the weir. Observations could include noting which areas of the gabion basket the fish attempt to penetrate (e.g., at the centre of the stream or at the stream margins) and how long it takes fish to pass through the rock barrier. The points of entry that fish use to penetrate the weir and upstream exit points are very important to note. Measurements of the water velocity at the downstream entry points and opening size could provide information to improve the weir design. The identification of entry and exit points would also be useful so that maintenance work (e.g., sediment and weed removal) on the weir keeps these areas open to passage.

Monitoring of whitebait passage through the gabion weir can take place at any time during the whitebait season. However, two factors should be considered when deciding on when to carry out monitoring if time and resources are limited. The galaxiid fauna of Orokonui Creek is dominated by banded kokopu (NZFFD). Therefore the timing of any monitoring of whitebait migration should attempt to monitor the run of banded kokopu. McDowall & Eldon (1980) report that kokopu whitebait species run towards the end of October and in November. More recent monitoring of whitebait runs (in the North Island) have also indicated that runs synchronise with the tide. Peak runs (of inanga) are associated with incoming tides one or two days prior to the highest spring tides in the tidal cycle (Charles Mitchell unpubl. data). Therefore peak runs of banded kokopu could be expected to occur just around high spring tides in late October or in November. At this time the largest sample of whitebait should be available and monitoring should be targeting the largest run of most common whitebait species.

Glass eel migration into freshwater on the east coast of the South Island begins in September or October (Jellyman 1999) with longfinned eels arriving before the more common shortfinned eels. Movement of glass eels up into freshwater is usually limited to areas just above the tidal zone. Once in freshwater glass eels develop their brown elver coloration. Upstream migration monitoring should target the coloured elvers that will probably be attempting to pass the gabion weir in late spring and early summer.

Monitoring of the passage of bully species will require assessment in summer. McDowall (1965, 1990) indicates that redfin bully and common bully undertake migrations from the sea to freshwater starting in late spring and continuing through the summer.

2.3 BROWN TROUT MONITORING

Monitoring sites for brown trout should be established at sites above and below the gabion weir (if possible). Upstream sites should be established in areas where brown trout have been caught prior to the barrier being established. This site selection will monitor habitat the brown trout has previously utilised in Orokonui Creek and therefore may occupy again and also provide evidence of native fish responses to the removal of brown trout. Brown trout captured downstream of the gabion weir should be marked or tagged (fin clips, paint mark or tag) to allow future identification. This will allow the monitoring to detect brown trout passage over the weir if trout from the lower estuarine reaches are moving upstream. Monitoring of these fish will also establish which, if any, size classes are entering Orokonui Creek and which size classes, if any, are managing to gain access to the areas upstream of the weir. The need for a downstream site is not essential and should not be considered an important factor when determining where to place the gabion weir. Sites can be monitored on an annual basis or more frequently.

It is assumed that during these surveys any brown trout found above the weir will be removed from Orokonui Creek. Therefore, any captures upstream of the weir will either be trout that have previously avoided capture or fish that have passed the gabion barrier. Distinguishing the resident brown trout from any brown trout that have managed to pass the gabion weir will be difficult. If brown trout removal is not complete immediately after the placement of the gabion basket weir, monitoring should look for a decline over time in brown trout numbers upstream of the weir. Furthermore, if the gabion weir forms a complete barrier to upstream movement of brown trout and no spawning occurs in Orokonui Creek, the resident brown trout population will increase in age as well as decline in number.

Scale and/or otolith samples from all trout captured above the weir should be collected and used to age the brown trout. A series of scales from along the lateral line of the fish should be collected. These scales and otoliths can be dried and stored, along with information on the fish's length, date and capture location. Analysis of the scale and otolith samples need not be carried out unless brown trout are regularly found upstream of the gabion weir for a number of years after construction of the weir. If ageing indicates that the trout are younger than the weir, either a resident population is spawning in the stream or fish are managing to pass the gabion weir.

A length frequency analysis is not recommended for determining if the brown trout population is ageing. Given the small size of Orokonui Creek, resident brown trout are likely to be stunted (under 30 cm) and size will be a poor indicator of age. Length frequency analysis also requires large sample sizes, and if the removal operations are successful and passage prevented, brown trout sample sizes should be small.

Monitoring of sites for brown trout should take place in summer. The fish most likely to penetrate the barrier are the small 0+ fry. It is possible that fry move down to the lower reaches of the Waitati River and have access to Orokonui Creek via Blueskin Bay. Summer monitoring may also detect any fry production in Orokonui Creek if any remaining resident brown trout successfully spawn in the stream. At present, fisheries data (NZFFD) do not indicate that brown trout spawning in the stream, but this must be confirmed.

2.4 NATIVE FISH POPULATION MONITORING

The native fish monitoring should target all native fish species present in Orokonui Creek. Monitoring sites should be not concentrate on the area immediately upstream of the weir, but rather cover the lower, middle and upper reaches of the stream. This is to ensure that recruitment is continuing to occur in all sections of Orokonui Creek. If the passage of juvenile native fish is reduced, native fish populations may decline only in the headwaters, and monitoring of the lower reaches will not detect this. As indicated above, it is important to determine the present distribution of native fish and their densities in various areas of the stream prior to the gabion weir being constructed to provide important baseline data (some of which may already available from previous surveys, NZFFD). Monitoring sites can be standardised to 30-50 m sections with three or four established on the stream (see Allibone 1999 for details of method).

It is likely that multiple monitoring methods are required to properly assess the status of all native species. Spotlighting surveys should monitor banded and giant kokopu numbers. Set sections of streams should be fished. Banded kokopu (and giant kokopu) should be captured (by hand netting) while spotlighting to obtain accurate counts of the fish present. Three sweeps of a spotlighting section should be carried out, as it unlikely all fish will be seen and captured in a single pass through a section. On the third pass through a section the number of fish that escape capture should also be recorded. All fish captured should be measured and weighed, as these data can be used to monitor growth and fish condition. Handling should be kept to a minimum and all fish returned to the stream as close as possible to the site of capture. Live buckets can be placed along the stream section so fish can be kept at capture sites prior to processing and release. Electric fishing may better target bully species, and the numbers of these fish can be monitored during fishing to detect any trout upstream of the barrier. Kokopu and koaro captured during electric fishing should be recorded, and similarly bullies and eels seen spotlighting should be noted. The surveying for bullies should take particular care to attempt to capture small bullies. Fish passage of bullies at the weir is likely to be hard to monitor. Their return to freshwater can be prolonged, and marking and tracking of juvenile bullies around the gabion weir may be difficult. Therefore fishing surveys should make every effort to determine the number of juvenile bullies present.

2.5 MONITORING THE GABION WEIR

The gabion weir also requires monitoring. Flood flows at the weir need to be assessed to determine if brown trout can by-pass the weir during high-flow events. If this is so then the gabion weir will not be an effective barrier. Sediment and vegetation accumulation rates within the gabion and on the upstream side of the weir also need to be monitored. If sediment accumulates within the weir this will reduce fish passage and increase the water level upstream of the weir. An increased water level upstream may lead to the stream flowing around the weir. Monitoring sediment and vegetation buildup will also indicate when and how frequently the weir will need cleaning. The monitoring should include the upstream water level, the water level at high flows, and bank stability at the edges of the weir, and determine if the outflow points on the downstream side of the weir are stable and accessible to fish.

3. Discussion

Monitoring of the effectiveness of the gabion weir will be required for a number of years. It is likely that at least five years' worth of data will be required to assess the effectiveness of the weir and then the monitoring programme could be reassessed. A long time period for the monitoring is required because yearly variation in native fish recruitment is high, and misleading results are possible if monitoring is carried only for a year or two. Furthermore, high flow events that may allow fish passage around the weir may be rare and therefore may not occur if monitoring is restricted to a short time period.

The brown trout and native fish community monitoring objectives can be achieved in conjunction with one another. Sites selected to monitor for brown trout occurrences upstream of the weir can also be used to monitor bully and eel numbers. Similarly, spotlighting for kokopu (and koaro) may also detect brown trout. It is, however, recommended that spotlighting and electric fishing sites are kept separate to reduce the disturbance of native fish in any particular section and to increase the chance of detection of any brown trout present.

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Appendix 1. Timing of the upstream migratory movements of native fish species in Orokonui Creek (peak movement periods indicated by double ticks). Lamprey is not included as migration timing is unknown.

Fish species	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
Inanga		✓	✓	✓✓	✓✓	✓	✓					
Banded kokopu				✓	✓✓	✓✓						
Giant kokopu					✓	✓						
Koaro			✓	✓	✓							
Longfin eel (glass eels)			✓	✓	✓	✓						
Longfin eel (elver)					✓	✓	✓	✓	✓			
Shortfin eel (glass eel)			✓	✓	✓	✓						
Shortfin eel (elver)					✓	✓	✓	✓	✓			
Redfin bully						✓	✓	✓✓	✓✓	✓		
Giant bully*						?	?	?	?			
Common bully						✓	✓	✓	✓	✓		
Common smelt						✓	✓	✓				

* No data available but assumed to be the same as other bully species