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Natural Heritage Trust

Water notes

Water notes for rivers management

ADVISORY NOTES FOR LAND MANAGERS ON RIVER AND WETLAND RESTORATION

Simple fishways

Fishways or 'fish ladders', as they are often called, are structures designed to allow the movement of fish upstream around barriers that do not usually allow the ready passage of fish (e.g. small dams). Simple fishways are basically low-gradient channels that are designed to allow the movement of fish around or through the impassable barrier. This Water Note describes the migratory habits of some native Australian fish species, the benefits of fishways and the different types of fishways that can be easily constructed.

Fish migration within Australian streams

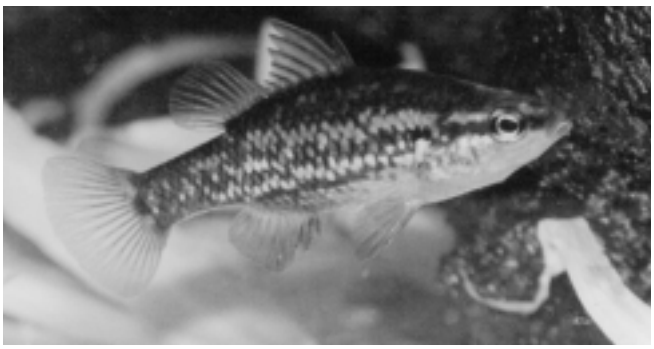
Many river systems in Australia are characterised by relatively large seasonal variation in flow. Many Australian fish species migrate within inland river systems in the course of their lifecycle. Often the migration is upstream in order to negate the displacement of eggs or larvae downstream due to water flow. The migration of fish often occurs in response to various stimuli, which may include:

- fluctuations in water levels, in particular flooding;
- water noise and turbulence;
- water temperatures; or
- oxygen levels of the water.

An example of a migratory native fish species in Western Australia is the western minnow (*Galaxias occidentalis*, pictured) which is found in the majority of river systems throughout the south-west of Western Australia (Arrowsmith River south of Geraldton to Waychinnicup River east of Albany). This species migrates to headwaters following early winter rains to spawn. It is able to leap from the water to negotiate very small obstacles, however, it is often observed gathering downstream of larger impassable barriers. Here, they often fall victim to predation by birds or the introduced trout species.

Another common native species that undergoes spawning movement is the western pygmy perch (*Edelia vittata*, pictured). This species is common in the aquatic systems throughout the south-west of Western Australia (Arrowsmith River to Two People's Bay east of Albany) and moves into the floodwaters of rivers or creeks to spawn in spring.

Western minnow. *D. Morgan*



Western pygmy perch. *D. Morgan*

An example of a rare native fish species that relies on migration is the trout minnow (*Galaxias truttaceus*, pictured). This species is restricted to the small Goodga and Angove river systems east of Albany and migrates upstream during autumn to spawn.

A more unusual migrating fish species is the primitive pouched lamprey (*Geotria australis*, pictured) found in south-western and south-eastern Australia, New Zealand, Chile and Argentina. This species spends much of its adult life in the ocean using its highly adapted mouth to latch on

to the surface of fish and feed on their flesh. They undertake an extensive upstream spawning migration during winter, before spawning in the spring of the following year. Their larvae reside in the substrate of streams over the next four and a half years. Their migration upstream is facilitated by the sucker-like mouth that enables them to climb vertically up obstacles such as dam walls and rocks.

Spotted minnow (top) and trout minnow. *D. Morgan*

Lampreys. *D. Morgan*

Potential problems of barriers in streams and rivers

Control structures, such as dams and gauging stations, are necessary for regulating and monitoring the flow of water in many rivers and streams throughout Western Australia, as well as providing the population with water resources for consumptive use. The potential impacts that these obstructions may have on the aquatic ecosystems in which they are placed are increasingly being understood by waterway managers.

Physical barriers that prevent the migration of fish may have one or more potentially negative impacts on fish populations, depending on the fish species and the aquatic system. These include the following:

Pemberton Weir. *D. Morgan*

Gauging station – Pemberton. *D. Morgan*

- The completion of life cycles of fish may be prevented by not allowing upstream migration necessary for successful spawning. Some gauging stations ‘drown out’ during winter rains, thus allowing migration. However, until this occurs, many fish will be unable to move upstream which may delay or prevent their spawning to the extent that population numbers decline.
- The spread of juvenile fish from spawning and nursery grounds to habitats in other geographical areas may be limited.
- Fish may be restricted from the headwaters of creeks, particularly seasonally-flowing systems, by structures that cannot be passed, altering the structure of food webs of the headwaters.
- Predation rates by exotic fish and birds on native fish species may increase, as they gather in large numbers below an obstruction.
- Physical damage may occur to adult fish as they attempt to pass control structures.

- Obstructions may result in the geographical fragmentation of fish populations. This in turn may have genetic implications by restricting the gene flow within these populations.
- The creation of relatively deep bodies of water upstream of obstructions can result in the alteration of the water temperature and oxygen regimes that occurred prior to the barrier being constructed. These altered regimes may have unforeseen impacts on fish species, e.g. low temperatures or low oxygen levels may affect the swimming performance of fish thus altering their migration.

Benefits of simple fishways

By allowing the movement of fish past barriers, fishways may increase the overall size of native fish populations through increasing the extent or amount of accessible habitats and by decreasing predation. Fishways can therefore play a role in conserving threatened or endangered native fish species. Increasing the geographical range of native fish can also result in reducing the impact of larger exotic fish species, such as carp (*Cyprinus carpio*) and redfin perch (*Perca fluviatilis*) on remnant native fish populations. Fishways are also being developed to trap the larger introduced species, whilst allowing the smaller native fish to pass.

Simple fishways need not be overly expensive or complex in design and their benefits have seen them become increasingly important to native fish conservation.

Types of fishways

There are a number of different types of fishways, the selection of which depends largely on the obstruction to be overcome, the species of fish that will be using the fishway and the amount of money available for construction. Passive fishways rely on the flow of water to allow the fish to move past the barrier. These fishways are usually constructed on low barriers, up to six metres high. Active fishways are employed on larger barriers, such as dams, and must actively pump or lift the fish over the wall in order for them to travel upstream.

- Vertical slot fishways

The most common fishway on larger rivers in eastern Australia is the passive, vertical slot fishway. It consists of a series of weirs and pools connected by a vertical slot in each weir allowing water flow down to the next level. This allows the fish to move past the barrier by moving between the series of pools. These fishways are created at a gradient level of between 1:18 for adult fish, to 1:30 for juvenile animals. Denil fishways are also passive devices that consist of a sloping channel within which there are closely spaced U-shaped baffles. These baffles angle upstream which creates a slower moving region of water at the base of the channel that allows the movement of fish upstream. These fishways are usually built with a gradient of 1:12.

- Rock-ramp fishways

Rock-ramp fishways (Figures 1A and 1B) are simpler structures commonly used on low obstructions less than four metres high. They consist of rocky ramps with a series of pools separated by ridges over which the water flows. These ridges are low enough to enable fish to move between the pools and therefore pass upstream. The gradient on which they are built is usually 1:20.

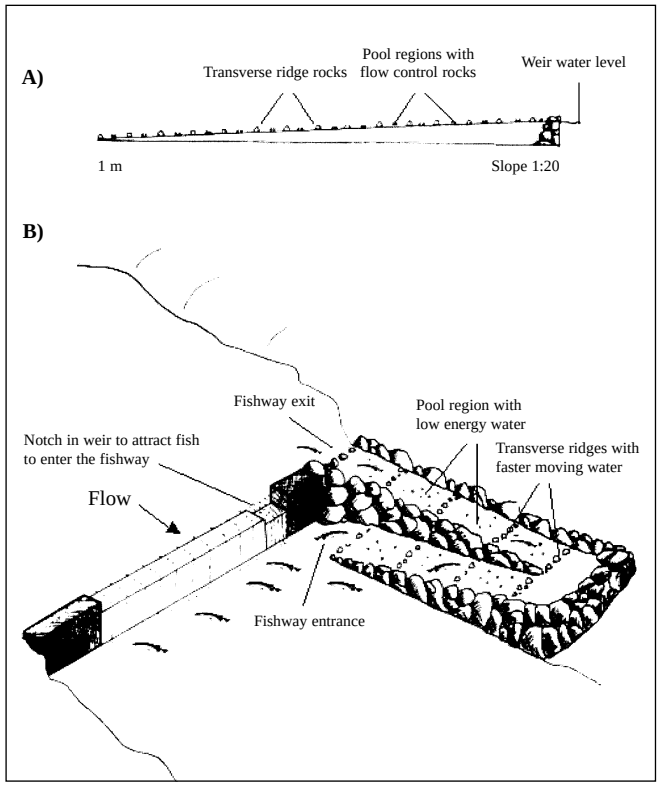


Figure 1. Conceptual rock-ramp fishway. Cross section (A) and plan view (B). [Modified from Sharp and Fairfull (2000)].

- Bypass channel fishways

Bypass channel fishways (Figure 2) are also simple structures used to allow fish movement past relatively low obstructions. They are earthen channels that consist of a series of pools connected by flow control structures, often rocks, that create riffles or faster moving water regions that are still negotiable by fish. The channels mimic natural streams and completely bypass the barrier.

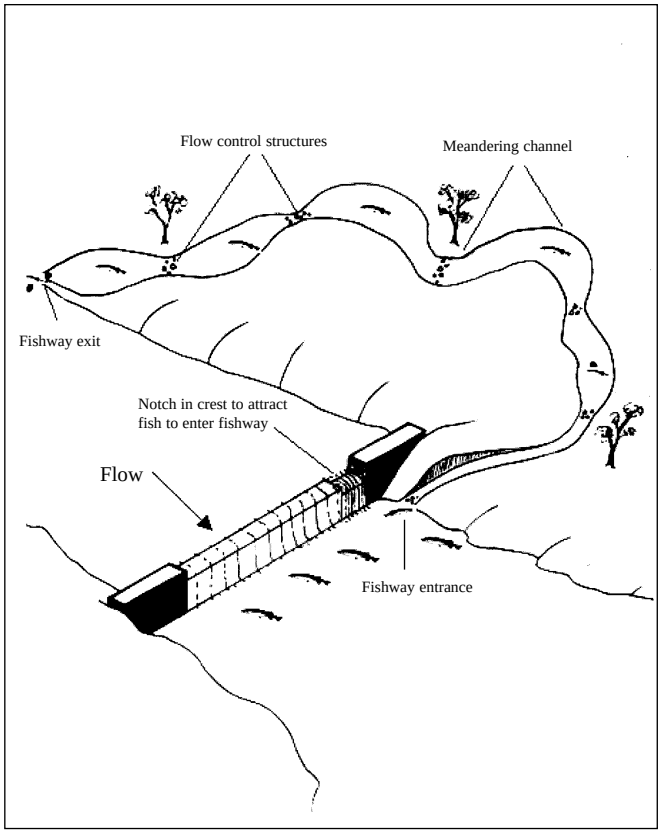


Figure 2. Conceptual bypass channel fishway. [Modified from Sharp and Fairfull (2000)].

Constructing simple fishways

- Planning approvals

Approval to construct a fishway will be required from the land owner if on private land, or from the vesting agency if on Crown land. The construction of such structures may be subject to the local Town Planning Scheme and therefore may require local government approval. Regardless of ownership or vesting, approval to interfere with the bed and banks of a stream will be required for those streams proclaimed under various water resource and drainage management acts. Advice on the approvals required can be obtained from the local regional office of the Water and Rivers Commission.

- Design and construction

Rock-ramp and bypass channel structures are the simplest effective fishways used to allow fish to overcome relatively low obstructions. The basic design principles are similar for both these simple fishways. The aim is to create a channel structure with a series of pools or low energy water regions. The channel or ramp should be constructed with relatively impermeable substrata, such as concrete. In order to create the gradient, the regions of low energy water should be connected by small falls (for rock-ramp fishways, see Figure 1) or riffle regions (for bypass channel fishways, see Figure 2) produced by larger rocks. The rapid regions should still allow fish to negotiate them to reach the next pool. An important feature of both bypass channel and rock-ramp fishways is that water is diverted over the adjacent obstruction, via a notch in the wall, to pour at the base of the fishway. This attracts the fish to the entrance of the fishway (Figures 1 and 2).

It is necessary to survey the site properly to ensure that the design, especially the height levels, is adequate to permit water flow down the fishway and that it is of low enough energy to allow fish to pass around the barrier. Individual designs vary depending on the site (taking into account factors such as the stream size, flow rates, stream gradients, stream bank slope and stream bed substrata type), the availability of materials (especially suitable rocks/concrete) and the nature of the obstruction to be overcome (such as the height and morphology of a weir wall). The construction of fishways should occur in periods of low flow during mid to late summer (in the south-west). Usually the goal is to create a 1:20 gradient ramp for the rock-ramp fishway or 1:30 gradient for the bypass channel fishway.

- Costs

The cost of construction of simple fishways, such as the rock-ramp and bypass channel structures, depends entirely upon each individual project. Generally, the major costs involved are the design process, surveying, earthworks (depends on the size of the project but may include use of an excavator or other earthmoving equipment) and materials such as suitable rocks. Another important consideration is the transport of equipment and materials to the site. Details of the cost of the construction of a fishway are provided in the example below.

A well vegetated native riparian zone is important for fish species as it provides shade and anti-predator cover, as well as contributing to the overall health and functionality of their habitat and the ecosystem. Therefore, the costs for undertaking rehabilitation of the riparian zone adjacent to the fishway may also need to be considered.

Example of a fishway

An excellent example of a simple fishway can be found at Mussel Pool in Whiteman Park which flows into Bennett Brook, a tributary of the Swan River. The wall of the pool has sluice gates which result in a one metre waterfall and which is too high for native fish such as the western minnow, western pygmy perch and the nightfish (*Bostockia porosa*) to negotiate.

The 40 metre fishway is constructed of concrete with rocks and pools to allow movement of fish up to Mussel Pool. Water from Mussel Pool is directed to pour into a whirlpool at the base of the fishway to encourage fish to enter the

ladder. The actual flow length of the fishway is approximately 60 metres, due to its internal meanders. The meanders are gentle, having a grade of about 2 degrees, as smaller fish would not have been able to negotiate anything steeper. Large rocks and riparian vegetation were placed at regular intervals along the fishway to create protective ledges and shelter for the fish during their journey (P. Murray, *pers. comm*. 2001).

The cost to construct this fishway commercially is estimated at $22,000, and would take roughly four weeks. This does not include the costs of planning, design and the time of a skilled supervisor for the works (P. Murray, *pers. comm*. 2001).

However, the Whiteman Park fishway was constructed for considerably less. Approximately $5,000 was spent on construction materials such as concrete, steel, adhesive, plastic sheets, cement and gravel as well as earthworks. Labour was provided through the Work for the Dole scheme (approximately six people working full time for about 12 weeks). The project supervisor had engineering experience and river restoration skills, gained primarily through the completion of a River Restoration Workshop run by the Water and Rivers Commission. This was an added advantage that ensured the success of the project and further reduced costs. Other cost saving benefits were that the location was central and accessible (costs are generally lower in the metropolitan area) and the team improvised, supplementing bought materials with locally sourced material where possible (P. Murray, *pers. comm*. 2001).

All environmental parameters specific to the site were considered in the design and construction of the fishway, and the fundamental principles of river restoration were applied. As a result, the fishway is extremely successful. On revisiting the site a year later, the project team found significant numbers of native fish using it to migrate upstream (P. Murray, *pers. comm*. 2001).

Fishway at Whiteman Park looking upstream towards Mussel Pool. *D. Morgan*

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