

# **Fish passage improvements in NSW**

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## **ABSTRACT**

Restrictions to fish passage by structures such as dams, weirs, floodgates, causeways and culverts will prevent the natural behaviour of many fish species.

NSW Fisheries is working to restore fish passage with activities such as the Floodgate Program, State Weir Review Program, Weir Removal Program, the assessment and construction of fishways and development of guidelines for causeway and culvert construction.

The floodgate program is attempting to deal with 1030 floodgates across waterways throughout coastal rivers. By devolving responsibility to landholders and councils, over 50 gates are now actively managed. The State Weir Review Program has, for the first time, provided an initial assessment of the impact of the 3327 licensed weirs in NSW. With the scale of the problem partially understood Catchment Management Boards are being asked to place fishway construction, weir removal and weir management as priority actions on catchment blueprints. The scale of the problem with road crossings is yet to be assessed but is known to be a serious problem for fish passage.

Recognising these problems, NSW Fisheries has commenced a Weir Removal Program with funding from the recreational fishing licence. A number of weirs have now been removed, improving fish passage to hundreds of kilometres of water. NSW Fisheries has also published the 'Policy and Guidelines for bridges, roads, causeways, culverts and similar structures 1999'. All Councils in NSW now use this document.

Recognising that structures that are not needed will be removed and new structures will be built according to the guidelines, the enormity of retrofitting improvements to existing causeways and culverts has also been addressed. A grant from the MD2001 Fish Rehab Program has allowed NSW Fisheries to analyse how improvements to road crossings could be achieved and provided funds to three councils for retrofitting improvements. Assessments have indicated positive effects on fish passage and, as a consequence, National Guidelines for 'fish friendly' road crossings have been drafted in consultation with all jurisdictions.

NSW Fisheries is also trialing innovative fishways, installing and assessing different designs, pursuing improvements to old fishways and continuing to pursue knowledge on the fish passage requirements of native fish. The key element for the success of all of these activities is the partnerships between other state agencies, local government, recreational fishers and landholders. This paper discusses this issue and makes recommendations for future actions throughout Australia.

floodgates, road crossings and weirs.

## THE PROBLEMS

There are 3,327 weirs and barriers on rivers and streams listed on the NSW Weir Inventory database. The number of barriers to fish passage is significantly greater however as the database only contains structures (generally weirs holding greater than 7ML) licenced by the Department of Land and Water Conservation. Weirs smaller than 7ML capacity and structures built illegally were not included. In addition most minor road crossings of waterways involve causeways and culverts, and thousands of these exist, yet the extent of their impact is unknown.

NSW Fisheries also recorded all coastal barriers restricting fish passage and tidal inundation in NSW. The project found 4,229 barriers to fish passage and tidal inundation on the NSW Coast. Of these, 1,035 were floodgates, the bulk occurring on the floodplain river valleys of the North Coast (Tweed, Richmond, Clarence and Macleay Rivers) (Williams et al, 1996).

Restrictions to fish passage by structures such as dams, weirs, floodgates, causeways and culverts will prevent the natural behaviour of many fish species. Restricted fish passage can prevent spawning migration, limit the dispersal of juvenile fish from spawning and nursery grounds, restrict localised movement of fish between habitats or feeding grounds, reduce the gene flow between fish populations and create aggregations of fish below barriers which are more susceptible to predation and disease.

As a result of these impacts on fish the *installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams* is listed as a Key Threatening Process in Schedule 6 of the Fisheries Management Act. Not only have the impacts of these structures been on fish passage but they have also had additional impacts on aquatic biodiversity as described by the Fisheries Scientific Committee (2002):

- Cold water releases from low level outlets in large dams impair spawning, growth, recruitment, feeding and other life cycle processes in native fish species.
- Weir pool environments provide ideal conditions for harmful algal blooms and the proliferation of non-native species such as carp and water hyacinth.
- Changes to natural seasonality and variability of flow regimes (duration, extent and rate), as a result of water regulation for flood mitigation and irrigation, impact on native species by disrupting natural environmental cues necessary for reproductive cycles (including migration, spawning, growth and recruitment).
- Reduction of habitat due to changes in the area, frequency and duration of inundation of floodplains and terminal wetlands limits distributions and reduces spawning successes. Some fish and invertebrates use these areas during flood periods for the purposes of breeding and dispersal.
- Extraction of water at all scales, ranging from diversion into irrigation canals to pumping, reduces the total availability of water for riverine ecosystems.
- The natural processes of sediment deposition, erosion and transport are affected by instream structures in various ways. Weir pool environments enhance the deposition of sediments. Elevated water velocity in tailwater environments increases erosion. In addition, rates of rise and fall of river levels downstream of large dams are often unnaturally rapid, leading to bank slumping and other erosional impacts, and degradation of the riparian zone. These altered sedimentary processes have been shown to result in the loss of fish habitat including important breeding and feeding sites, causing declines in native fish numbers.
- Alteration to the natural flow regimes by instream structures and other mechanisms can cause changes in physical, chemical and biological conditions that in turn alter the biota. Species composition can change. For example, due to changes in natural flow regimes, algal biofilms

have replaced bacterial biofilms in some rivers and, as a result, some invertebrates may no longer occur.

Causeways and culverts may affect fish passage in a number of ways. These normally relate to:

1. high flow rates, or velocities within the pipe or box cells of the crossing;
2. shallow water levels within the pipe or box cells of the crossing restricting large fish from moving through;
3. debris or material blocking the entrance or exit of the crossing; or
4. a “waterfall” on the downstream side of the crossing stopping fish movement upstream (Fairfull and Witheridge, in preparation).

Research conducted by NSW Fisheries on waterway crossings on four streams in northern NSW has found that the numbers and diversity of native fish species is generally greater below the first culvert or causeway crossing of a stream, at the lower end of a catchment. The numbers and diversity of native fish were progressively reduced at each consecutive culvert or causeway crossing (Fairfull and Witheridge, in preparation).

Research by NSW Fisheries has shown that tidal barriers and floodgates, like weirs and waterway crossings, block juvenile fish migration and restrict their distribution (Pollard and Hannan, 1994). Their additional impacts are different in some respects but just as wide ranging (eg Walsh et al, 2002). Such impacts include drying out of wetlands, proliferation of weed species, reduction in drought proof pasture refuges, exposure to air of acid sulfate soils and reduced water quality.

One significant example of the impact of these floodgates and associated drains was the massive North Coast fish kills which severely reduced the estuarine fish stocks of the Richmond and Macleay Rivers. Millions of estuarine fish and crustaceans of varying species were killed, and water quality monitoring indicated that low dissolved oxygen (commonly measured at <0.1 mg/L) was the cause of these kills (Westlake and Copeland, in prep). This low dissolved oxygen resulted from the floodwaters causing breakdown of floodplain vegetation and the resultant water with a high biochemical oxygen demand being rapidly transported into the river (in 5 days as opposed to up to 100 days without drains and floodgates). As a result of these kills, both rivers were closed to fishing, in some form, for six months.

## THE SOLUTIONS

### **Information Gathering – Weir assessment**

In 1997 the government released the *State Weirs Policy* which aims to mitigate or prevent the environmental impacts of weirs and floodgates in NSW. The Policy also called for the establishment of a State Weir Review Committee to oversee its implementation and to further develop a weir review program.

NSW Fisheries on behalf of the State Weir Review Committee has managed the Initial Weir Review component. It aims to examine the impacts of some of the existing works, and to develop a strategy leading to enhanced environmental outcomes (NSW Fisheries, 2002). Through the ongoing implementation of the Weir Review Program it is intended to continue conducting environmental assessments of weirs throughout NSW.

This initial NSW Weir Review was a preliminary assessment intended to stimulate further reviews and consultation regarding the management of specific weirs within the state. Recommendations for future works and weir management based on this initial assessment will be subject to further, more detailed investigations.

This assessment (from NSW Fisheries, 2002) consisted of a preliminary desktop investigation of weirs on the database and a subsequent more detailed field assessment using a proforma. Preliminary assessment involved ranking weirs using criteria based on methods outlined in Pethebridge *et al.* (1998).

The first part of the field assessment process involved accessing the Licensing Administration database System (LAS) created by Department of Land and Water Conservation to identify the location for licensed weirs and contact details for owners. Landholders were contacted by phone and, where necessary, by mail and informed of the Weir Review Program. Permission to inspect sites was gained and meetings arranged with landholders to discuss the social, ecological and hydrological issues associated with the weir/dam.

Following the initial desktop study to prioritise the weirs, field assessments were undertaken using additional criteria to consider environmental and socio-economic factors. These included: weir purpose and consideration of the number of users and benefactors; heritage and cultural values; whether or not the weir owner had noted evidence of specific water quality problems such as salinisation of surrounding land, deoxygenation, and blue green algal blooms; and evidence of riparian degradation such as localised erosion, sedimentation, reduced health of riparian vegetation.

The weir assessment was carried out using a field survey proforma developed by the State Weir Review Committee. Photographs were also taken of the weir from the upstream and downstream sides. Additional photos were taken to show any other important details, such as fishways, spillways, sites of erosion or where repairs may be required. All information was then entered into a database and a summary report outlining sociological, ecological and hydrological issues associated with each structure was produced. Recommendations were based on these initial reviews. A copy of the information gathered and the summary report was distributed to each individual weir owner. An 1800 Freecall number was established to allow weir owners to respond with any corrections they believed were necessary.

### **Information Gathering – Fishway assessment**

The project to construct fishways on all structures along the Murray River between Lake Hume near Albury and the Murray River mouth – the Lake Hume to the Sea Project is now underway. The project will run for five years and see the construction of 11 fishways in conjunction with the upgrade of the navigable pass sections of the Murray River weirs. Assessment of the fishways constructed will be a collaborative effort for NSW Fisheries, the Victorian Department of Natural Resources and the South Australian Research and Development Institute. The first year's pilot sampling has been completed and will be used to formulate the sampling program for the rest of the project. Preliminary results from the pilot show significant accumulation of native fish downstream of the weirs. The development of a tri-state monitoring team as part of the Murray River Fishway Assessment Program has brought added benefits to aquatic researchers in the basin. The collaborative project has allowed significant levels of information sharing and capacity building between and within agencies. Specific outcomes have included the development of a standardised electrofishing protocol and agreement on common technology for radio tracking and remote fishway assessment. The tri-state program has helped foster a “basin-wide” approach to the problems of fish passage, and a collective response to common challenges.

### **Information Gathering – Floodgate assessment**

To address the environmental impacts of floodgates, NSW Fisheries recently completed a three-year project to audit and actively manage floodgates on the north coast. This three-year project

stemmed from both the original inventory of tidal barriers carried out by NSW Fisheries (Williams et al, 1996) and subsequent floodgate management workshop organised by NSW Fisheries. It commenced in early 1999, initially funded by the Natural Heritage Trust, NSW Fisheries and Tweed Shire Council. The project involves a more detailed prioritisation of floodgates and greater consultation with stakeholders within each north coast catchment.

Specifically, the project aimed to achieve sustainable land management on the coastal floodplains of northern NSW through the development of a model and approach to improved floodgate management improve coastal floodplain management practices, based on *in situ* trials of floodgate modifications or removal.

For the floodgate assessment, key criteria and a scoring system were used to audit each floodgate. The criteria included a mix of fish habitat attributes, physical habitat characteristics and landholder willingness to implement a changed management regime to their floodgates and drains. The criteria (from Walsh et al, 2002) included:

1. *naturalness of the waterway* – this involved an assessment of how natural the fish habitat is behind the floodgate. Natural creeks and wetlands were given a higher score than straightened agricultural drains.
2. *waterway length* - longer waterways scored higher than shorter waterways as they were considered to have a higher habitat value for fish.
3. *habitat value* – each drain was assessed for physical changes and diversity of fish habitats within the system. Drains or creeks with good riparian and overhanging vegetation, meandering channels, differing depths and widths, snags and other fish habitats scored more highly than those that were relatively limited in habitat diversity.
4. *landholder willingness* – this criterion was the most important in determining which floodgates that could be opened. Each landholder on a floodgated drainage network was sent a brief survey requesting their feedback on issues with their drainage and floodgate system, and ascertaining whether they were interested in active management of the floodgate. This was followed up with a phone call and face-to-face meeting to discuss active floodgate management in more detail. Those floodgates with a 100% landholder support for active management received a higher score than those with limited or no support.

Once high priority floodgates were determined from the audit, efforts were focused on tackling those floodgates where landholders had indicated their full support. On-site meetings and discussions were held with landholders, council and state agencies to determine the criteria required for the active management of a floodgate. Once a plan of action has been determined, the owners of the structure were asked to sign a management plan detailing an operational plan for the structure to mitigate potential environmental impacts.

The reviews of weirs and floodgates have resulted in a clearer picture of both the extent of impact of these structures and the opportunities available to rectify the problem (see Table 1). Catchment based reports have been published documenting these results.

Finally, NSW Fisheries has been active in gathering information to support the managed opening of floodgates. In a 3 year project, jointly funded by NSW Fisheries and the Fisheries Research and Development Corporation, the effect of managed floodgate openings on aquatic communities and other environmental factors is being examined in cooperation with Clarence Floodplain Project.

Preliminary results support our prediction that active management of floodgates improves fish passage and water quality. Juveniles of various commercially and recreationally important fish and prawn species moved into drainage systems with actively managed floodgates. This indicates that regular and frequent opening of floodgates will increase the proportion of potential nursery habitat used, with potential effects on stock size (Andrew Bruce, NSW Fisheries pers. comm. ).

## **Actions on the Ground**

### *Fishways*

By far the most serious problem for fish passage are the larger (greater than 2m) weirs and associated regulators managed by State Water as part of the irrigation water infrastructure in NSW. There are 33 fishways in NSW that have been constructed using designs appropriate for Australian fish species. In a joint exercise State Water will over the next two years construct or prepare to construct a further 13 fishways. NSW Fisheries, with funding from State Water, will provide design advice as well as monitoring the success of these fishways. Although there are many structures left which are barriers, this is a significant step both in terms of cost and benefits to aquatic biodiversity generally and fish passage in particular.

### *Weir Removal*

As a direct result of the Weir Review Program, NSW Fisheries sought the support of freshwater anglers and gained funding from the NSW Recreational Fishing (Freshwater) Trust. This enabled the appointment of a Project Officer with the role to facilitate the removal of redundant weirs in NSW. To date 5 weirs have been removed restoring more than 350km of waterway to unimpeded fish passage. Also, at Wellington Dam, State Water and the Department of Land and Water Conservation recently completed the removal of this decommissioned 32m structure. Freshwater fishers, via their fishing licence, have recently extended the Weir Removal Program for three years and many more structures are now being investigated for removal.

### *Waterway Crossings*

How fish cross roads is the focus of a two-year project being managed by NSW Fisheries. The project, funded by the Murray Darling Basin FishRehab 2000 Program aims to develop National Guidelines for “fish friendly” road crossings. Three new crossing designs have been built at 3 sites and fish passage monitoring has been completed to test the effectiveness of the new designs with promising results. The results at three sites indicate significant improvement in fish passage (Fairfull and Witheridge, in preparation)

As a result of these positive actions and the support of local Councils (in particular Copmanhurst Shire Council) NSW Fisheries has been actively pursuing funding from a range of sources to support Councils in their progressive retrofitting of fish friendly causeways and culverts.

### *Floodgates*

The intent of the North Coast Floodgate Project was to audit floodgated coastal waterways and to set up a few demonstrations of managed floodgate openings. NSW Fisheries also facilitated the development of the Clarence Floodplain Project with Clarence River County Council that has similar aims. The success of these projects and work done by Hastings Municipal Council and

**Table 1. Final results of the Initial Weir Review.**

Catchments	Fishway	Detailed review Fishway*	Removal	Management	No Action	Not Reviewed –		Licence Review	Total
						named	unnamed		
Northern Rivers	2		17	93	577	3	184	6	<b>882</b>
Upper North Coast	3		3	78	233	26	71	4	<b>418</b>
Mid North Coast	2		0	44	60	48	1	0	<b>155</b>
Lower North Coast	2		0	0	2	12	1	0	<b>17</b>
Hunter	4		2	4	40	29	0	5	<b>84</b>
Central Coast	3		1	1	7	14	0	0	<b>26</b>
Hawkesbury-Nepean	12	7	15	4	118	72	264	5	<b>497</b>
Sydney	3		4	6	14	8	53	8	<b>96</b>
Shoalhaven Illawarra	5		5	2	19	4	32	6	<b>73</b>
South Coast	0		5	0	15	1	66	1	<b>88</b>
Border Rivers	7	2	3	8	22	28	12	0	<b>82</b>
Gwydir	10		7	4	23	10	16	14	<b>84</b>
Namoi	7	3	9	3	44	28	15	7	<b>116</b>
Central West	33	13	9	6	169	98	21	80	<b>429</b>
Lachlan	17		4	7	106	98	89	30	<b>351</b>
Murrumbidgee	14	4	4	6	109	70	137	0	<b>344</b>
Murray	13		14	6	65	40	41	41	<b>220</b>
Snowy	4		1	1	7	1	8	2	<b>24</b>
Upper Darling	6		0	5	28	62	0	10	<b>111</b>
Lower Darling	4		1	0	11	27	6	0	<b>49</b>
<b>All</b>	<b>151</b>	<b>29</b>	<b>104</b>	<b>278</b>	<b>1669</b>	<b>679</b>	<b>1017</b>	<b>219</b>	<b>4146</b>

\* these are major dams where fish passage may not be possible or will be very costly

Shoalhaven City Council has resulted in 50 floodgates now being actively managed, opening 152km of estuarine waterways to fish passage. NSW Fisheries, with the funding from the NSW Environmental Trust, will achieve a further 50 managed openings over the next two years. NSW Fisheries is actively pursuing environmental and fish passage improvements through the Catchment Blueprints of coastal catchment boards.

### **Innovations**

When the North Coast Floodgate Project commenced, one design was available to actively manage floodgates. Due to the increasing requests from Councils and a growing interest from engineering companies, at least 7 designs are now in use in NSW and more are being developed. This level of design development prompted NSW Fisheries to run a workshop to explain to Councils with floodgate management responsibilities the costs and benefits of the various designs. One of the key outcomes was recognition that the variety of designs now allowed operators more flexibility to provide the design that best suits the variability common among floodgated creeks and their associated floodplain and land use.

NSW Fisheries has continued to explore innovative options for the restoration of fish passage. Collaboration with Sydney Catchment Authority in developing the Tallowa Dam High Fishway Project continues towards the installation of Australia's first high fishway development.

While the investment in proven technology for priority sites throughout the state is necessary, the wider application of fishway technology in NSW is dependent on the development of lower-cost alternatives. The NHT-funded Innovative Fishway Development project has focussed on low-cost options for the remediation of existing fishways and the development of transferable technology to reduce the capital cost of fishway construction. The project has facilitated the development of a Deelder Fish Lock concept for Balranald Weir (currently at tender) as a means of remediating over 40 existing "pool and weir", and "submerged orifice" fishways throughout the state. Further experimental designs in the form of denil and partial-width rock ramp fishways are also the focus of current research projects. At Euston Weir, with the support of the Murray-Darling Basin Commission, a denil insert with an adjustable slope is being retrofitted to a "submerged orifice" fishway. NSW Fisheries will monitor the success of this trial.

### **Legislation, Policy and Guidelines**

Two significant improvements have occurred with legislation and policies in regard to fish passage in NSW. In 1997 NSW Fisheries developed what was then thought to be the definitive document that promoted the Government's policies on Aquatic Habitat Management and Fish Conservation, and provided guidance for developers and Councils on how best to develop in, or adjacent to, water. However, putting those policies and guidelines into practice caused staff to recognise the need for a specific document to deal with road infrastructure alone. This document; *Policy and Guidelines for Bridges, Roads, Causeways, Culverts and Similar Structures* (NSW Fisheries, 1999) is now widely utilised by the Roads and Traffic Authority and local Councils and private road contractors.

In addition, NSW Fisheries has sought to develop national guidelines for "fish friendly" road crossings. The drafting of the national guidelines is underway, in consultation with a national steering committee, and will be finalised this year. An extensive, easy-to-use guide for engineers involved in the design and construction of waterway crossings and an associated PowerPoint training presentation are being produced by an independent consultant.

The success of legislation and policy is often only as good as the enforcement of these rules. NSW Fisheries Office of Conservation compliance staff have spoken to most local Councils in NSW in regard to fish passage issues, in particular, outdoor staff responsible for the works that may impact fish passage. NSW Fisheries has also instituted catchment-wide compliance reviews and, on detecting breaches of the act in regard to blocking fish passage, has fined the offenders. More importantly, restitution orders have then been issued to remove the illegally constructed barriers.

### LESSONS LEARNED

Almost all of the aquatic ecosystems in NSW are under stress, evidenced by the growing list of species and communities listed as threatened under the *Fisheries Management Act, 1994*. As such the rehabilitation efforts will need to be substantial. Yet the rapid turnaround in activities aimed at improving fish passage indicates that the tasks required are not beyond our capacity and the goal of a sustainable fishery is not beyond our reach. The change has been as a result of the following actions.

A typical action that precedes most major natural resource management is the assessment of condition. Both the floodgate audits and the weir review incorporated, in addition to the assessment of ecological status, an assessment of landowner willingness to participate in these management changes. The highest ranking gates for active management in the floodgate audit and the priorities being pursued for weir removal are where the owners have indicated their approval for the action. In a number of instances, this has resulted in fish passage improvements at sites where the greatest benefit to fish has not occurred. However, we took the view that it was best to work with what could easily be achieved. Then, by demonstration, active communication means, and word of mouth, we convinced other landholders that NSW Fisheries was not trying to force actions upon them, that we were open to negotiation and, most importantly, that we were willing to act. One of the most soul destroying aspects of natural resource management as practiced by Government for landholders is the significant efforts spent by Government agencies which result in no action occurring. Even if they weren't fully on side, landholders like to see things done rather than talked about.

Secondly, it is also typical of Government to talk about shared visions and joint programs. This is not easy to achieve, however, nor is it commonplace. In addition, it is also rare that engineers and ecologists work together. However, when it does occur the results are worthwhile. Fishway construction is an exercise which is costly and every effort needs to be made to get it right. State agencies working together with engineers across the Murray-Darling Basin has resulted in an increasing recognition of the complexity of the fish passage problem. At the same time it has raised interest in providing cost effective engineering solutions. Probably the greatest outcome from a fish passage point of view has been the increasing understanding by organisations like State Water that their infrastructure is a significant part of the problem and, as such, they should be part of the solution. That they intend to construct fishways on their major weirs (as time and budgets permit) indicates that the future for fish passage is well down the path to resolution.

Thirdly, it has been a common objective of State natural resource managers to devolve responsibility on a number of issues to Local Councils. This has often worked but, too often, the responsibility has gone down without the resources. The improvements to fish passage in coastal areas from managed floodgate openings is in part due to ownership of the fish problem by Councils and the sugar cane industry. This outcome was a direct result of negotiations between Councils and NSW Fisheries. Moreover, the works on the ground have resulted from the willingness by NSW Fisheries and the Department of Land and Water Conservation to provide funds directly to landholders and Councils and to actively pursue funds on their behalf.

Finally, we often hear about the extent of the problem facing our rivers and, all too often, that we need more information before we can fix the problem. However, enough information is available to confidently predict the type of actions needed to restore our rivers (eg Copeland and Lewis, 1997). Our information gathering needs, therefore, to be targeted at how to implement actions rather than to describe once more the extent of the problem.

In NSW, as a result of learning these lessons and acting with vigour, the fish passage problem is being resolved.

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