HABITAT CHANGES AND DECLINES OF FRESHWATER FISH IN AUSTRALIA: WHAT IS THE EVIDENCE AND DO WE NEED MORE?

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Introduction

Many freshwater fish species in Australian river systems have declined in their range and abundance during the last 100 years and habitat changes are frequently considered to be the major cause. In this paper I am going to briefly examine the published evidence for these declines, the habitat changes which are implicated, and the quality of the evidence linking the two.

While there is general consensus among fish biologists that many native freshwater fishes now have a reduced distribution and abundance compared with pre-European settlement, the published evidence is sparse. Records of commercial catch have been used to document the decline of Murray cod (*Maculloch ella peeli*) in New South Wales (Rowland 1989), barramundi (*Lates calcarifer*) in Queensland (Pollard *et al.* 1980), and silver perch (*Bidyanus bidyanus*) in the Murray-Darling river system (T.J. Johnson pers. comm.). In Victoria, museum records, published reports and interviews with anglers and biologists have been used to document the decline of Murray cod, trout cod (*M. macquariensis*), Macquarie perch (*M. australasica*) and golden perch (*M. ambigua*) (Cadwallader 1981; Cadwallader and Gooley 1984; Brumley 1987).

Habitat loss and degradation by human activites have been hypothesized by many authors as the main cause of declines in the abundance and distribution of freshwater fish in Australian rivers (e.g. Lake 1971; Cadwallader 1978; Pollard *et al.* 1980; Merrick and Schmida 1984; Koehn and O'Connor 1990; Lloyd *et al.* 1991). However, what is the real evidence linking the two?

In Table 1 have been listed the major elements of habitat that have been affected by human activities with an estimate of the quality of the evidence linking these with declines of native fish in Australia.

Dams and weirs as barriers to fish movement

The first element of habitat I have listed is 'access' (to suitable habitat), which is a basic need of freshwater fish. In modified river systems, movement of fish along streams and onto floodplains is restricted to varying degrees by dams, weirs, levee banks, road crossings and culverts. In the streams of coastal south-eastern Australia half of the aquatic habitat has been obstructed by man-made barriers (Harris 1984). The disappearance of many migratory species above large dams is readily acknowledged, but there are few published studies documenting these declines in Australian rivers, probably because the evidence linking the adverse impacts of the impoundment on fish migration is clear-cut. A notable example is the disappearance of natural populations of golden perch from

the upper River Murray following the construction of Hume Dam and Yarrawonga Weir (Lake 1971). Low weirs can be submerged by floodwaters which provide some passage for fish. However, these barriers still very seriously restrict fish movement. One of the few published studies demonstrating this is by Harris (1988) who sampled with gill nets above and below a tidal weir (Liverpool) near Sydney and found no migratory species above the weir and abundant fish below the weir. A less quantitative but notable example of this type of impact is the decline of the commercial catch of barramundi in Queensland attributed to tidal barrages preventing migration (Pollard *et al.* 1980). Despite the lack of published information, the restriction of fish movements particularly at large dams and weirs is obvious and the links between the human activity, habitat change and declines of fish are good.

River regulation

River regulation has had direct and measurable effects on the flow and temperature regimes of streams in Australia (Walker 1985; Cadwallader 1986). However the causal links between these changes and declines in freshwater fish populations are difficult to demonstrate. The evidence is usually anecdotal and difficult to separate from other changes in habitat. Some evidence is provided by Rowland (1989) who linked the decline of Murray cod in NSW in the 1950's and 60's to the reduction in flooding caused by major dams in the tablelands. Similarly, Harris (1988) demonstrated that flooding was important in the reproduction of Australian bass (*Macquaria novemaculeata*) and linked the decline in recruitment of this species with flood suppression caused by dams.

Other experimental research on the biology of native fish has produced stronger, but still indirect, evidence linking river regulation and declines of fish. Specifically, flooding and temperature have been identified in fish hatcheries as an important cue for spawning of native species (Lake 1967; Rowland 1983). The effects of river regulation can be direct and obvious, such as a fish kill below a dam when the flow is stopped completely and fish are stranded (Bishop and Bell 1978). Fish kills have also been reported when floodgates are opened on coastal streams releasing poor quality water (Richardson 1981). However, the direct evidence for river regulation causing a decline in freshwater fish in Australia is generally absent.

Records of fish movement through fishways provide some evidence of declines in fish movement and abundance due to changes in flows caused by river regulation. The numbers of golden perch using the Euston (Lock 15) fishway in the River Murray have declined by 43% over the last 50 years, while the movement of silver perch has declined by 93 % (Figure 1). Over the same period the small floods (5,000-10,000 ML/day) that stimulate migration in these fish have declined by approximately half (Close 1990). In this case, river regulation appears to have reduced the stimulus to migrate, although other factors such as water quality may also have contributed. For silver perch, and perhaps for golden perch also, the reduced numbers provide some quantitative evidence of the decline in their abundance. These declines cannot be attributed solely to river regulation, as this is very difficult to separate from other habitat changes such as siltation and barriers to migration.

Changes in water quality

In some cases changes in water quality through human activities have produced visible and direct evidence such as fish kills from chemical pollutants. Toxicological studies in Australia have also produced indirect evidence from laboratory studies of the effects of pollutants on fish (e.g. Baker and Walden 1984; Gehrke 1988). Sewage and fertilisers have decreased water quality through nutrient enrichment and in-

creased algal growth, leading to reduced oxygen in the water (Williams 1980). In Australia, this has probably changed the composition of fish communities and reduced the distribution of some native species, but there appears to be no published evidence.

Fish kills from acidic water have been described overseas (e.g. Leivestad and Muniz 1976). In Australia acidic soils and runoff from inappropriate land use have been implicated in fish kills but it has only been reported in the media and not in the scientific literature. Acidic water has also been implicated in red-spot disease in fish but again there is no published evidence in the scientific literature. Although there is some indirect evidence from laboratory work for the need for high water quality (e.g. Gehrke and Fielder 1988) the evidence linking changes in water quality with declines of freshwater fish in Australia is generally poor.

Substrate

Soil erosion resulting from land clearance, agriculture, timber harvesting and other activities has led to increased turbidity and suspended solids. When these suspended solids settle, the substrate of the stream is modified by siltation and sedimentation. There is strong direct and indirect evidence from overseas research that such habitat changes severely affect fish, particularly the early life stages (Alabaster and Lloyd 1980; Campbell and Doeg 1989).

However, in Australia there are only two reported studies of the effect of turbidity and sediment on fish; Richardson (1985) found a decrease in *Galaxias maculatus* populations following forestry operations in southern New South Wales, and Koehn *et al.* (1991) reported that in artificial conditions, eggs of freshwater blackfish *Gadopsis marmoratus*, spotted galaxias *Galaxias truttaceus*, climbing galaxias *G. brevipinnis* and Macquarie perch *Macquaria australasica* showed high mortalities when smothered with a fine layer of silt. River channelization directly affects the substrate. Although there is much evidence from research overseas that channelization is detrimental to fish (e.g. review by Swales 1982) the evidence for adverse effects on native fish in Australian rivers is limited to one study by Hortle and Lake (1982). These researchers compared fish of channelized and unchannelized sections of the Bunyip River in Victoria and found that fish numbers, biomass and species richness were all reduced in the channelized sections. Channelization, however, is not widespread in Australia compared with catchment erosion and siltation.

Instream cover and riparian vegetation

Instream cover and riparian vegetation have frequently been removed to improve navigation or channel capacity, or for sand and gravel extraction. This important element of habitat can be replaced by introduced aquatic plants. There are only two studies examining the relationship between freshwater fish and instream cover in Australia; Hortle and Lake (1983), discussed above, and Arthington *et al.* (1983). The latter study related the loss of native aquatic plants and the increase in introduced plants in streams near Brisbane to a decline in the distribution of five native fish species.

Apart from these two studies the direct evidence linking declines in instream cover and riparian vegetation with declines in fish abundance in Australian streams is poorly documented, although again there is reasonable evidence from studies overseas (e.g. Angermeir and Karr 1984; Fausch and Northcote 1992). There is, however, indirect evidence through life history studies of Australian fishes which describe the use of habitat by fish and hence the inherent value of the habitat before it is removed or degraded (e.g. Pollard 1971; Cadwallader and Rogan 1977; Harris 1988).

Conclusions

In other countries there has been considerable research carried out and published which links human activities, changes in habitat and declines of freshwater fish. In Australia there has been little such research published. It may be possible to apply the broad principles from the overseas studies to the management of Australian freshwater ecosystems, but we still need to carry out and publish research which quantifies the responses of fish species and populations to the environmental conditions typical of coastal and inland rivers in Australia. To answer the fundamental questions asked by managers, such as how much of a particular impact is acceptable in a particular habitat, there is an urgent need for research in the following areas:

- determination of habitat utilisation by fish and derivation of key habitat requirements, such as instream cover, substrates, role of aquatic and riparian vegetation, and use of floodplains;
- flow needs of fish - for breeding, movement, dispersal and recruitment;
- experimental evidence is needed on the levels of silt and sediment tolerated by fish at all life stages, and their responses to key water quality variables; and
- fish passage requirements - fishways have been developed which are suitable for some species (Mallen-Cooper 1992), but the requirements of many species are unconfirmed or unknown. In addition, a broader knowledge of the swimming ability of native fishes is needed to design access onto floodplains and through culverts and pipes in road crossings.

To maintain fish populations which are viable in the long-term, and to prevent the further decline of populations of threatened species, we need to devise new approaches to the management of aquatic and riverine ecosystems in Australia. As part of this process, we need to understand the full environmental consequences of activities which are contributing (or have contributed in the past) to the current decline in fish diversity and abundance. The research priorities listed above are essential to this understanding.

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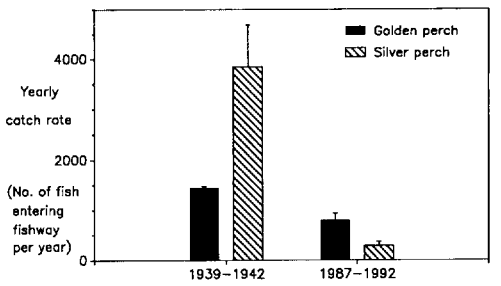

Figure 1. Yearly catch rate (mean ± s.e.) of golden perch and silver perch from the Euston fishway on the River Murray over periods 1939–1942 and 1987–1992.

Table 1. Impacts of human activities on fish habitat and the quality of the evidence linking these impacts with declines in fish abundance and distribution in Australia

Habitat	*Human activity*	*Quality of evidence for causing decline in native fish distribution or abundance*
access (to habitat)	dams, weirs, levee banks	good
flow and temperature regimes	river regulation	indirect
water quality	domestic, industry, agriculture	some good, some poor
substrate	siltation, sedimentation, channelization	poor
instream cover and riparian vegetation	de-snagging, increasing channel capacity	poor