Using risk analysis, power analysis and adaptive management to minimise ecological impacts of the Cotter Dam enlargement

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The enlargement of the Cotter Dam is being undertaken by ACTEW to provide a greater security of water supply to Canberra. The project involves constructing a larger, higher new dam wall immediately downstream of the existing Cotter Dam, to allow the present dam to continue functioning and supplying water while construction is underway. The project raised a number of environmental issues partly because the Cotter Dam currently supports a self-sustaining population of (endangered) Macquarie Perch, and because the Bendora Dam, upstream of Cotter Dam, contains a breeding population of (endangered) Trout Cod. Bendora Dam will not be physically affected by the works on Cotter Dam, but its operations may be altered. An ecological risk analysis was conducted to identify critical environmental risks that would need to be investigated and managed or ameliorated and management strategies were put in place to reduce risks. ACTEW have adopted an adaptive management approach to the project, but in order to implement that approach it is necessary to conduct effective monitoring of the fish populations of concern. These potentially include the two endangered species, as well as potential predators (such as cormorants) and competitors (such as trout). Power analysis has been used as a tool to evaluate whether it is feasible to monitor key populations sufficiently rigorously to be able to confidently detect a change (either an increase or decrease in a population). For Macquarie Perch and trout it should be possible to detect population changes statistically with a logistically feasible monitoring program.

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Introduction

The enlargement of the Cotter Dam is being undertaken to provide an increased security of water supply to Canberra, Australia. The Cotter River is a tributary of the Murrumbidgee River, and has been a major source of water supply to Canberra since 1915. The river has three existing water supply reservoirs: Cotter Dam, constructed initially in 1915 but enlarged several times since, Bendora Dam, constructed in 1961, and Corin Dam constructed in 1968.

The three dams are operated by ACTEW Corporation as a single system and an adaptive management system has been put in place to manage impacts on the environmental flows downstream. The dams have had a substantial environmental impact on the Cotter River (Nichols et al 2006) however, there is now a program to monitor the condition of the aquatic invertebrate communities in the Cotter downstream of the dam, and flow regimes for each year are decided based on previous monitoring results and anticipated water requirements and rainfall in the year ahead.

The dams have been stocked with native fish. In particular in 1989 and 1990 Bendora Dam was stocked with Trout Cod (*Maccullochella macquariensis*), which is a species listed as endangered under the Commonwealth EPBC Act. Subsequent sampling has not often collected specimens, but the collection of a small number of young of the year fish in several years indicated that the population was still present in the dam and was breeding there Lintermans 2007). Whether it is sustainable in the long term is unknown.

The Cotter Dam contains a population of native Macquarie Perch and exotic Brown Trout. Both species maintain breeding populations, and the population of Macquarie Perch is thought to be one of the healthier populations known of this species, which is classified as endangered under the EPBC Act. Both trout and Macquarie Perch run up the Cotter River, between the Cotter Dam and Bendora Dam to breed in the flowing water.

Macquarie Perch populations have undergone a substantial decline throughout south eastern Australia over the past 20 years (Lintermans 2007). There are a number of possible reasons that have been proposed to account for the decline, including river degradation and drought (McDowall 1996) however, one significant factor appears to be the viral disease epizootic haematopoietic necrosis virus (EHN)(Langdon 1989). This disease is widespread in English Perch or Redfin (*Perca fluviatilis*) populations in Australia, and does not appear to be fatal in that species, however it is fatal to Macquarie Perch.

Infection with EHN virus has been suggested as the causal factor behind the rapid decline in the Macquarie Perch population in Victoria's Eildon Reservoir in the early 1970s for example (Cadwallader 1981). The existing Cotter Dam has no facility to permit fish passage, thus the populations of Redfin which exist in the Murrumbidgee and lower Cotter River have not been able to migrate into Cotter Dam and spread the disease.

The Cotter Dam enlargement is being implemented by the construction of a new dam wall some 130m metres downstream of the existing dam wall. The new wall will raise the level of the impoundment by about 50 m, inundating an area of about 240 ha of river and river valley upstream.

Some of the initial environmental concerns revolved around the extent that the enlarged dam might negatively impact the populations of Macquarie Perch and Trout Cod

in the two reservoirs. For Macquarie Perch the major issues were:

- whether the new dam would provide sufficient habitat for the fish,
- whether the flooding of the upstream breeding area would negatively impact recruitment to the population,
- whether the construction and operation of the new dam would increase the risk of EHN infected Redfin invading the habitat, and
- whether the new dam would favour trout over Macquarie Perch leading to a decline in the Perch population.

For the Trout Cod there was concern that altered operation of the Bendora Reservoir could impact the population breeding there. In order to address these concerns a formal ecological risk analysis was undertaken.

Risk Analysis

Potential impacts of the action were assessed through a formal qualitative risk analysis process. The risk assessment process used the same methodology as the framework provided by Australian Standard AS/NZS 4360:2004 Risk Management. Risk was considered to be comprised of a likelihood function and a consequence function. It was assessed based on five level ratings of likelihood (from almost certain to remote) and consequences (from minimal to catastrophic). Potential impacts of the proposal were identified and a risk rating assigned to each of the impacts before and after the implementation of mitigation measures. The potential impacts relevant to Macquarie Perch, Murray Cod and Trout Cod were assessed separately (ACTEW 2009).

The risk analysis approach is now widely used in aquatic impact assessment in Australia. It is useful as a means for making the assessment process transparent, so that the issues and the factors considered to influence them are all explicit allowing them to be challenged and any gaps identified by those conducting or those assessing the impact assessment process.

The analysis did not identify any risks higher than negligible for Trout Cod in Bendora Reservoir. However for Macquarie Perch in Cotter reservoir there were 8 risks identified as medium. In all but one case the risk, if realised, would result in a relatively slow decline in the Perch population in the reservoir. Factors that could contribute to the decline were identified as shelter habitat loss, spawning habitat loss, increased predation by cormorants, competition with alien fish, and loss of food sources. The one risk factor that could lead to a rapid loss of fish would be infection with EHN virus.

Adaptive Management

The outcome of the risk analysis still allowed for substantial uncertainty in ecological consequences of the dam enlargement.

For a number of the factors which could cause a slow decline in the fish population it would be possible to develop management responses which could reduce the threat. For example removal of an upstream barrier, a culvert, could increase the available spawning habitat. Fish shelter habitat is being provided in the enlarged dam in the form of a network of rock reefs. Numbers of predatory cormorants could be controlled, as could numbers of trout.

There was also the possibility that the alterations to breeding habitat in the Cotter River upstream would prove better suited to trout than to Macquarie Perch. Although the two species have been co-existing in the existing dam, adult trout are known to predate on young Macquarie Perch (Linternans 2007), so if a change in breeding habitat led to a substantial change in trout recruitment, the existing balance between the two species may be altered. Under that scenario it is possible that the Macquarie Perch population could decline.

One widely accepted solution to managing natural resources, such as fish populations, in the face of uncertainty is adaptive management. The adaptive management process involves a cycle of making management decisions, implementing the decisions, monitoring the implementation and the outcome and then revising management in the light of the monitoring results.

In the case of impacts which could occur through a reduction in breeding success or increased competition between long-lived fish, the response in populations would be relatively slow. That is, they would become apparent over periods of 5 years to decades. That is important because it will allow time for change to be detected, and management to be altered to reduce or counteract the negative impacts.

However for adaptive approaches to succeed it is important that there is an adequate monitoring program, and a high level of confidence that the programs will be able to detect negative impacts in time to allow adjustment of management actions.

A key question for management of the enlarged dam is whether it is practical to mount a monitoring program that is sufficiently sensitive to detect changes in the population in time to vary management decisions where necessary. Or would the change in population be so difficult to detect with confidence that by the time the change is detected it will be too late to save the population.

Power Analysis

Power analysis can be used to examine the strength of sampling programs. The most common statistical tests

have been developed based originally on agricultural and pharmaceutical studies, and are designed to give a high level of confidence that a false positive has not been detected. That is, we do not believe that a treatment has had an effect when in reality it has not had an effect. In environmental work we are more often confronted by situations where we want a high level of confidence that when we are unable to demonstrate an effect, there has not been an effect.

Power analysis is based on the relationships between the variability of a parameter, the size of the effect we wish to detect, the number of samples and the level of confidence we require in our conclusion.

In the case of the Cotter Reservoir, there was a substantial existing sampling program that had produced data on the numbers of trout and Macquarie Perch which had been collected both in the Cotter River upstream of the dam, and in the Cotter Reservoir. That data was used in a power analysis to determine whether a sampling program that was developed concurrently with the environmental effects assessment would be sufficiently sensitive to detect population changes in the fish.

A detailed fish management plan has been developed for fish in the Cotter Reservoir and in the Cotter River between the Cotter and Bendora dams. It includes specifications of the monitoring equipment, the numbers of traps and trap exposure times and frequency of sampling.

Three key fish species have been identified for monitoring: Macquarie Perch, Two-Spined Blackfish and Brown Trout. Macquarie Perch are the key species of interest because of their conservation status and the possible risks. Two-Spined Blackfish are the major other significant native fish in the system, and large Blackfish have been known to predate small Macquarie Perch. There are two species of trout recorded from the Cotter, but Brown Trout are the most abundant and thought to be the alien species most likely to compete with Macquarie Perch, should the habitat conditions in the enlarged dam or the breeding sites in the river upstream favour them ahead of the Perch.

Power analysis has indicated that population changes of all three species will be able to be detected sufficiently early to allow management actions to respond to changes in fish populations.

Although there is a regular fish sampling program conducted in the reservoir, Trout Cod are rarely caught. When they are collected it appears to be only very young fish which seem to occur around the edges of the reservoir. It is assumed that there must be a population of adult fish which occurs in the deep waters of the reservoir, beyond the area that can be sampled, and is apparently reproducing, although not every year (Mark Lintermans, personal communication). Since only small numbers of Trout Cod are collected in occasional samples, it is not possible to accurately estimate population size or changes in population.

While this is not of concern because the risk to Trout Cod is negligible in this project, it does raise an important issue for the management of rare species in situations where there is potential for them to be impacted by human activities. It is often not possible to monitor populations, or even distributions of such species in any meaningful manner, which makes either the impact or lack of impact on such a species impossible to detect.

Conclusion

Risk analysis and adaptive management approaches are now quite widely used in environmental management in Australia. However the application of power analysis as an additional tool in assessing the Cotter Dam enlargement, and developing the Fish Management Plan, is a powerful addition to the management process.

Adaptive management relies on effective monitoring of environmental change, and an effective feedback loop so that management does adapt, incorporating the additional understanding produced by monitoring. However, too often monitoring programs are conducted with too little statistical power to detect the changes that are of concern.

Where there is sufficient existing data, power analysis can be a useful additional tool to assist with the design of monitoring programs. In some cases it may indicate that parts of monitoring programs are pointless and should be abandoned. In other cases it may indicate that extra monitoring effort is required on key parameters.

Once monitoring has commenced, power analysis is an essential tool in situations where we are trying to assure the community that there has not been an impact arising from a development. A test that fails to demonstrate an impact is not sufficient to demonstrate that there has not been an impact. The environmental studies conducted for the Cotter Dam enlargement project provide a valuable illustration of the way in which power analysis can be utilised.

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