NATIONAL CARP CONTROL PLAN
RESTORING NATIVE BIODIVERSITY

THE NATIONAL CARP CONTROL PLAN

PROGRESS REPORT - MARCH 2018

Above University of Adelaide researcher Richie Walsh heads out to sample water quality at the site of a carp decomposition experiment near Berri, South Australia.

Anyone visiting freshwater habitats in coastal or inland south-eastern Australia is likely to encounter invasive common carp (*Cyprinus carpio*). Feeding carp siphon sediment from the riverbed, muddying waters, damaging aquatic plants and triggering cascading impacts through aquatic ecosystems.

A species-specific virus, Cyprinid herpesvirus 3 (CyHV-3), may offer an opportunity to substantially reduce carp numbers and restore the balance for native species. Decision-making on whether virus release should proceed is awaiting evidence from research, planning and consultation underway as part of the National Carp Control Plan (NCCP).

If the carp virus is released, major carp mortality events are likely. Determining best strategies for cleaning up these dead carp to protect water quality for human consumption, stock watering, and native aquatic species is central to the NCCP.

Maintaining water quality following carp kills emerged as an urgent priority at more than 70 NCCP community consultation events held throughout Victoria, South Australia and New South Wales between October and December 2017.

Social scientists helping the NCCP understand community attitudes towards carp biocontrol have also identified the importance of delivering an effective clean-up strategy as a recurring theme in survey responses. In this NCCP progress report we discuss some of the research that is playing a critical role in developing clean-up solutions. This will be an important part of the Australian Government's considerations on whether or not the virus should be released.

Maximum impact
A capacity to predict the size, seasonality and location of carp kills following a future virus release is fundamental to planning the clean-up. The NCCP's epidemiological modelling project, led by CSIRO veterinary epidemiologist Peter Durr, will provide this ability.

Epidemiologists investigate the distribution and movement of disease, often with a particular focus on the mechanisms underlying disease transmission and spread. Famous historical epidemiological studies include John Snow's work tracing cholera outbreaks in Victorian London to contaminated water pumps, and Louis Pasteur's discovery that earthworms perpetuated anthrax outbreaks by bringing bacterial spores from buried sheep carcasses to the surface.

These historical examples relate to halting disease spread; epidemiologists working on biocontrol identify ways to enhance spread of the biocontrol agent through the target population.

Key ingredients for success
Kill rates from the carp virus are likely to be most strongly influenced by water temperature, concentration of virus particles and the prevalence of dense schooling (aggregating) behaviour. The carp virus can cause disease in carp at water temperatures between 16°C and 26°C, with 20°C to 24°C optimal for infection and disease.

Viral transmission is also maximised at high carp densities, especially when fish are in direct physical contact. Infection is also most likely when carp are stressed.

Infection windows
By assessing the factors that influence carp virus transmission and spread, Peter Durr's team has identified seasonal 'windows' within which virus-induced carp kills are most likely.

Water temperatures in south-eastern Australia are suitable during spring to autumn, but temperature is only part of the picture. Carp in Australia form spawning aggregations in spring and early summer, and spawning is physically stressful for carp.

Spring spawning events therefore provide the 'full house' of optimal temperatures, dense aggregations and compromised immunity necessary to achieve optimal levels of mortality.

Peter Durr's early results have important practical implications for both potential virus release and clean-up. A spring window of viral effectiveness means virus release will need to be carefully targeted, yet also simplifies clean-up planning to some extent.

Advance notice
Clean-up equipment can be prepared and crews recruited well in advance of conditions likely to trigger kills. A narrow seasonal window also facilitates an 'adaptive management' approach, providing the opportunity to refine clean-up approaches between seasons. Nonetheless, natural systems are inherently variable and clean-up strategies will need the capacity to deploy resources at short notice.

The understanding of viral behaviour that Peter Durr and his colleagues are building requires computer modelling to assess outcomes of different combinations of environmental and carp behaviour variables. While powerful, predictive computer models are only as good as the data driving them.

This work consequently requires data on water temperature and carp abundance and behaviour across the varied habitat types inhabited by the species in Australia. Some of these data will be supplied by the NCCP's biomass project.

How many jelly beans? A carp biomass estimate for eastern Australia
Jarod Lyon, principal investigator for the NCCP's carp biomass estimation project, likens his project to guessing the number of jelly beans in a jar. Except in this case, the 'jar' is the entire carp habitat in Australia.

Carp population density varies substantially across the species' distribution in Australia. Carp density is believed to play a critical role in sustaining viral spread. This means that good estimates of the total weight (biomass) of carp present in Australia and its distribution within our waterways are essential if epidemiological modelling is to accurately predict the seasonality, location and magnitude of carp kills.

The project uses multiple biomass estimation methods to 'triangulate' the most accurate result across techniques. Collation of historical datasets was the first step.

Historic records

Numerous fish surveys and environmental monitoring programs have recorded carp captures, but the sampling techniques these used inevitably varied considerably. To enable a direct comparison across this disparate data, the biomass group is developing statistical conversion factors based on field experiments.

Mining existing datasets is an efficient way to estimate biomass, allowing field sampling to target areas where there are real data gaps.

DNA estimates

In addition to techniques commonly used by fisheries scientists, the biomass project is also testing the use of environmental DNA (eDNA) to estimate carp abundance. eDNA refers to detection of the target species' DNA in water or sediment samples. The technique was originally developed to detect the presence or absence of rare species, but recent advances suggest that eDNA can also be used to measure biomass as well.

The project team have also been working with water authorities as they conduct planned lake and wetland drainings. These events provide valuable opportunities to crosscheck eDNA biomass estimates with absolute measures of carp biomass.

Water quality and decaying carp

Carp biocontrol cannot proceed unless the effects of decaying carp on water quality are understood and effective mitigation strategies are developed.

Justin Brookes, from the University of Adelaide, is leading the NCCP's water-quality research, complemented by parallel work led by scientists from WaterNSW, the University of Technology Sydney and SA Water.

At the simplest level, dead carp – if present in sufficient amounts – can promote hypoxic (low-oxygen) or anoxic (no-oxygen) conditions as the microbes feeding on the dead fish use oxygen from the water column. The research aims to identify the level of decaying carp biomass – or how many dead carp are needed to cause oxygen depletion. This will allow clean-up activities to be planned and prioritised.

Role of river flows

Justin Brookes's research also focuses on the role of decaying carp and the nutrients they release as part of complex interactions involving river flows, oxygen levels and both harmful and beneficial algae. Harmful algae of the kind that cause blue-green algal (cyanobacterial*)* blooms are able to exploit degraded, nutrient-rich environments, such as warm, slow-moving water filled with decaying carp.

Cyanobacterial blooms are more likely in deep, still water where the water column can split (stratify) into layers of different temperature. Stratified conditions favour cyanobacteria, which possess tiny gas bladders that help them regulate buoyancy. Algal species lacking these gas bladders may sink to the riverbed in still water, losing access to the sunlight they need to grow.

The competitive advantage cyanobacteria hold under stratified conditions forms the basis of a chain reaction. Still water near the riverbed becomes deoxygenated as organic processes in the sediment use up dissolved oxygen.

As oxygen declines, chemical reactions cause nutrients to move from the sediment into the water column. Cyanobacteria can use their capacity to regulate buoyancy to travel down through the water column to access these newly liberated nutrients, before rising back to the surface layers.

Nutrients liberated from decaying carp could exacerbate this situation, providing extra fuel for cyanobacteria growth. Increasing cyanobacterial populations in turn demand increasing amounts of oxygen as they metabolise nutrients, driving an ever-tightening feedback loop.

Adding oxygen

Manipulating river flows could break this cycle by mixing and oxygenating the water column, diverting nutrients away from cyanobacteria and into environmentally benign pathways.

Critically, nutrients that could benefit native species are currently 'locked up' in carp bodies. Allowing some of the nutrients and carbon locked up in carp to productively re-enter aquatic systems is desirable.

Water-quality research is identifying the flow regimes needed to achieve these goals, combining computer modelling and experimental approaches.

The modelling combines river flow conditions with chemical transfers between living organisms and the environment (a 'hydrodynamic–biogeochemical' model). The data comes from field and laboratory experiments assessing the impact of dead carp on dissolved oxygen and algal abundance.

Field experiments are currently underway at a closed wetland adjacent to the Murray River near Berri, SA. The wetland trials involve stocking approximately 6 tonnes of dead carp (harvested elsewhere) into the 2.5 hectare waterbody and measuring water-quality responses. The wetland trials are intended to mimic high carp biomass levels, providing an insight into a worst-case scenario. Early results indicate rapid decomposition and associated declines in dissolved oxygen. These findings reinforce the importance of identifying critical biomass thresholds and implementing effective rapid clean-up responses.

RAPID RESPONSE STRATEGIES

Above and right Researchers from the Arthur Rylah Institute (ARI) for Environmental Research remove carp downstream from Yarrawonga Weir, on the Murray River. ARI is leading a project that aims to answer the question: how many carp are in Australian waterways?

The results of the NCCP's other research will define the clean-up challenge and calculate how many carp there are to be removed. Understanding the practicalities of collecting and removing these fish is essential.

To ensure the NCCP benefits from Australian and international experience with fish kill clean-up, Luiz Silva, from Charles Sturt University, has teamed up with commercial carp fisher Keith Bell.

Luiz Silva has helped to clean up numerous fish kills downstream of hydropower plants in Brazil. Keith Bell has also cleaned up several major fish kills in Australia, including carp, and has extensive commercial fishing experience.

Access issues

Their review reveals that fish kill clean-ups are most effective and prevent water-quality issues when the response is rapid. Physical access and ease of movement on a given water body determine the best clean-up approach.

In small waterways constricted with snags, physical collection using basic equipment such as scoop nets may be required. In open water, boat-based clean-up is feasible. Mechanised approaches such as modified trawls and vacuum pumps can reduce labour requirements.

It may be possible to modify vessels used for aquatic harvesting of waste or weed removal to collect carp.

Productive uses

Once collected, dead carp need to be disposed of. Janet Howieson, from Curtin University in Western Australia, is leading research to identify economically viable and productive uses for carp. She is conducting commercial-scale trials of carp-based fertilisers, compost, fishmeal and aquaculture feeds.

One project component will consider the feasibility of using carp waste as insect feed – specifically for the Black Soldier Fly, which produces larvae that can be used as a high-quality aquaculture feed. Products from the trials will be then be market tested to evaluate acceptance.

The research that will shape the NCCP clean-up strategy is now well underway. Future progress reports will provide updates on results and emerging challenges.

HOW CAN YOU GET INVOLVED?

The NCCP has been consulting extensively with communities across areas affected by carp. This work will continue in 2018.

The project team wants to understand your local waterways, what's important about them and how you use them, and your concerns and questions so that they can be addressed in the plan.

For more information contact the National Carp Control Plan team at:
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To stay up to date with progress and submit comments online:

www.carp.gov.au

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