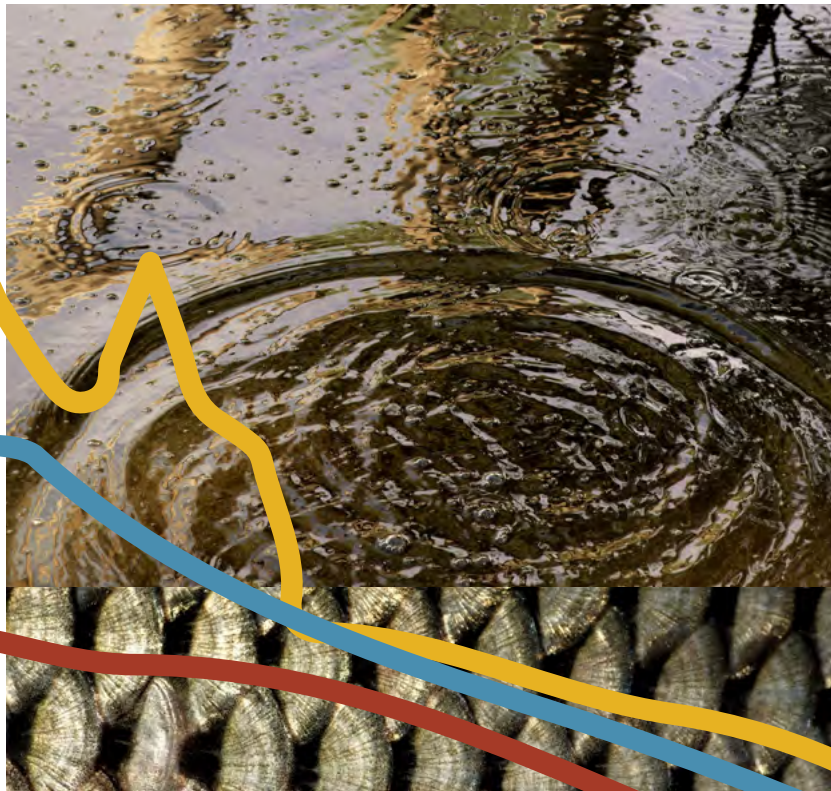
Australian Government

NATIONAL CARP CONTROL PLAN
RESTORING NATIVE BIODIVERSITY

The National Carp Control Plan Strategic Research and Technology Plan provides a framework to address priority knowledge gaps and risks associated with possible implementation of an integrated program for the control of common carp (*Cyprinus carpio*) in Australia from 2019.

NCCP Strategic Research and Technology Plan 2017–2019



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The National Carp Control Plan [NCCP] Strategic Research and Technology Plan 2017–2019

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1 CONTEXT

1.1 National Carp Control Plan

The Australian Government has invested in the development of a National Carp Control Plan to explore potential use of the virus known as Cyprinid herpesvirus 3 (CyHV-3, hereafter 'the carp virus') for the biological control of Common carp, *Cyprinus carpio*, in Australia. The carp virus is a double-stranded DNA virus of the family Alloherpesviridae (Gotesman et al., 2013). Carp occur in every state and territory except the Northern Territory, and are now the dominant fish species within the Murray–Darling Basin (Koehn et al., 2000; Koehn, 2004; Smith et al., 2009; Vilizzi et al., 2014, 2015; Forsyth et al., 2015). The ecological impacts of carp include increased turbidity, intensified algal blooms, and reduced abundance of macrophytes, invertebrates, and some native fish species (King et al., 1997; Weber & Brown, 2009; Vilizzi et al., 2014, 2015). For example, Weber and Brown (2009) found that carp increased turbidity in 91 per cent of surveyed studies, reduced invertebrates in 94 per cent, and reduced macrophytes in 96 per cent of surveyed studies.

The objectives of the National Carp Control Plan (NCCP) are to:

- undertake research and development to address knowledge gaps, and better understand and manage risks to support the potential release of the carp virus, subsequent clean-up and recovery of native fish and ecosystems
- plan for an integrated approach to control carp in Australia's waterways
- build community awareness and support for the proposal to release the carp virus, and identify and address stakeholders' and communities' concerns about the proposal
- develop detailed strategies for release of the carp virus and subsequent clean-up
- support national coordination on all elements of the NCCP's development.

The potential release of the carp virus will not occur before the end of 2018, following national and state-territory legislative approval processes. Should a decision be made to implement the NCCP and proceed with a release of the carp virus, this will be managed by the relevant state and territory governments through existing interjurisdictional governance structures (e.g. Invasive Plants and Animals Committee, or IPAC and the Agriculture Senior Officials Committee, or AgSOC).

This Strategic Research and Technology Plan articulates research needs to underpin development of the NCCP across three themes:

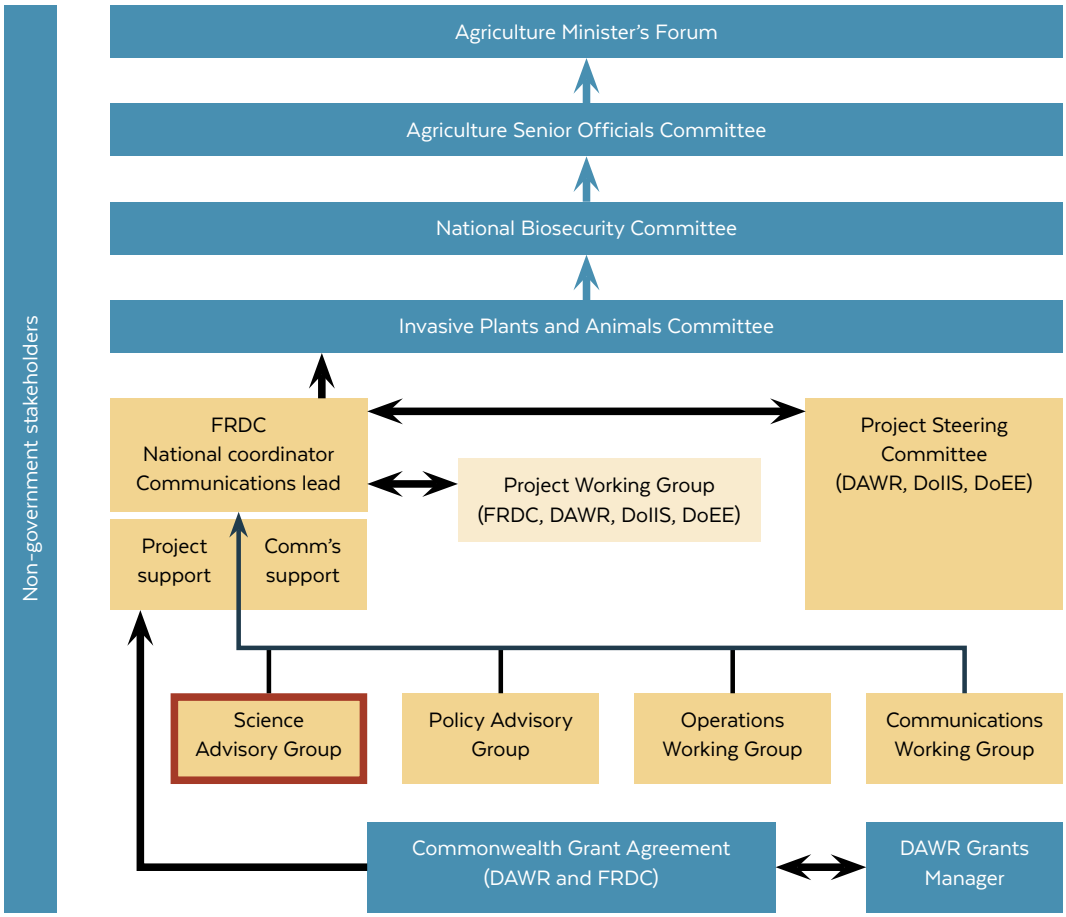
1. Environment
2. Communities
3. Informing possible implementation

Investment across these themes will occur during 2017–19 to ensure that key knowledge gaps are addressed, and primary risks are well understood. Outputs of this investment will then inform decision making on how to proceed with carp control in Australia.

1.2 Governance and priority setting

A framework for governance of the NCCP has been established (see Figure 1). This framework provides for the establishment of a Science Advisory Group to provide scientific advice to IPAC and the Fisheries Research and Development Corporation (FRDC) on knowledge gaps and key risks that need to be better understood to enable informed decision making on whether to proceed with the release of the carp virus. This newly-established advisory group comprises nominated representatives from all affected states and territories with collective expertise in aquatic ecology, fish virology/epidemiology, water management, social science and human health. Consultation through this group has enabled development of a Strategic Research and Technology Plan that addresses remaining knowledge gaps and key risks.

FIGURE 1. National Carp Control Plan governance framework. The Science Advisory Group (highlighted in red) provides advice to the FRDC and IPAC on knowledge gaps and key risks that require further investigation to enable informed decision making on whether to proceed with the release of the carp virus.



FRDC Fisheries Research and Development Corporation
DAWR Department of Agriculture and Water Resources
DoIIS Department of Industry, Innovation and Science
DoEE Department of the Environment and Energy

2 OPERATING ENVIRONMENT

2.1 Overview

Carp have been identified as a priority pest species by the Freshwater Fish Working Group of IPAC (Koehn et al., 2000; Chadderton et al., 2003). The species has been established in Australia for over 100 years and now occurs in all states and territories except the Northern Territory. Carp occupy most of the south-east Australian mainland, with isolated populations in Tasmania and Western Australia. Carp are now the MDB's dominant fish species (Smith et al., 2009; Forsyth et al., 2015), with biomasses exceeding 350 kilograms per hectare in parts of the Basin (Vilizzi et al., 2014).

A recent national attitudinal survey reports that the public perceive carp as the fourth most significant vertebrate pest in Australia (after cane toads, feral cats and rabbits) (Fisher et al., 2012). Internationally, the International Union for Conservation of Nature identified carp as one of the eight most invasive fish species globally (Lowe et al., 2000). Carp impact numerous aspects of aquatic ecosystems, including water quality and biodiversity values (Matsuzaki et al., 2009; Weber & Brown, 2009, 2015; Gilligan et al., 2010; Bajer & Sorensen, 2015). For at least the last two decades there has been a shared desire among natural resource management agencies and communities for control programs to reduce these impacts (Roberts & Ebner, 1997; Roberts & Tilzey, 1997; Koehn et al., 2000).

Photo South Australian Research and Development Institute (SARDI).

Potential use of a biological control agent for the control of carp in Australia

Over the past few decades, research on carp biology, impacts, and control tools and strategies has primarily been undertaken and coordinated by the Invasive Animals Cooperative Research Centre (IA CRC), and the preceding Pest Animal Control CRC. One of the potential carp control tools investigated by the IA CRC is the carp virus. In 2006, CSIRO's Australian Animal Health Laboratories began assessing the carp virus's potential as a carp biocontrol agent. This work involved testing a series of native Australian fishes, Rainbow Trout and model species of reptiles, crustaceans, amphibians, birds and mammals for susceptibility to disease caused by the carp virus (McColl et al., 2016). Results suggest that the carp virus represents a potentially viable and effective biological control agent for carp in Australia, although, as with previous viral biocontrol agents, optimal carp population reductions would be obtained by using the carp virus in conjunction with other geographically widespread complementary control measures (together with standard regional controls) (McColl et al., 2016a).

Complementary control measures and the NCCP

If employed as a single control measure, the carp virus is unlikely to produce desired long-term reductions in carp abundance. Rather, modelling indicates that use of the virus as a stand-alone control would reduce carp populations by 70–80 per cent in the years immediately following its release, with subsequent population rebuilding to 30–40 per cent of pre-release levels as carp developed resistance to the virus (Thresher et al., 2014). In contrast, modelling the combined use of the carp virus and a sex-biasing construct predicts eradication of carp in fewer than 10 generations (Thresher et al., 2014). While it is important to note that eradication is unlikely to be achievable, an integrated approach is clearly essential to long-term reduction in carp impacts. Identifying and refining optimal methods for use in concert with biocontrol is therefore a priority under the NCCP.

Photo SARDI.

3 STRATEGIC RESEARCH AND TECHNOLOGY PLAN 2017–2019

3.1 Purpose

The NCCP Science Advisory Group's Strategic Research and Technology Plan provides a framework to identify the key strategic research needs to underpin development of the NCCP for the two-year period from 2017–19.

The Plan aims to ensure that the research program addresses key knowledge gaps and risks, for use in procuring research activities under the NCCP. A timeline for delivery of the NCCP research program is provided in Figure 2:

Where possible, this plan will link with other related strategies to enable efficiency and leverage opportunities, e.g. other Research Advisory Committees, FRDC subprograms, FRDC coordination programs, FRDC sector-based programs, recreational fishing trust and grant priorities, and other strategies.

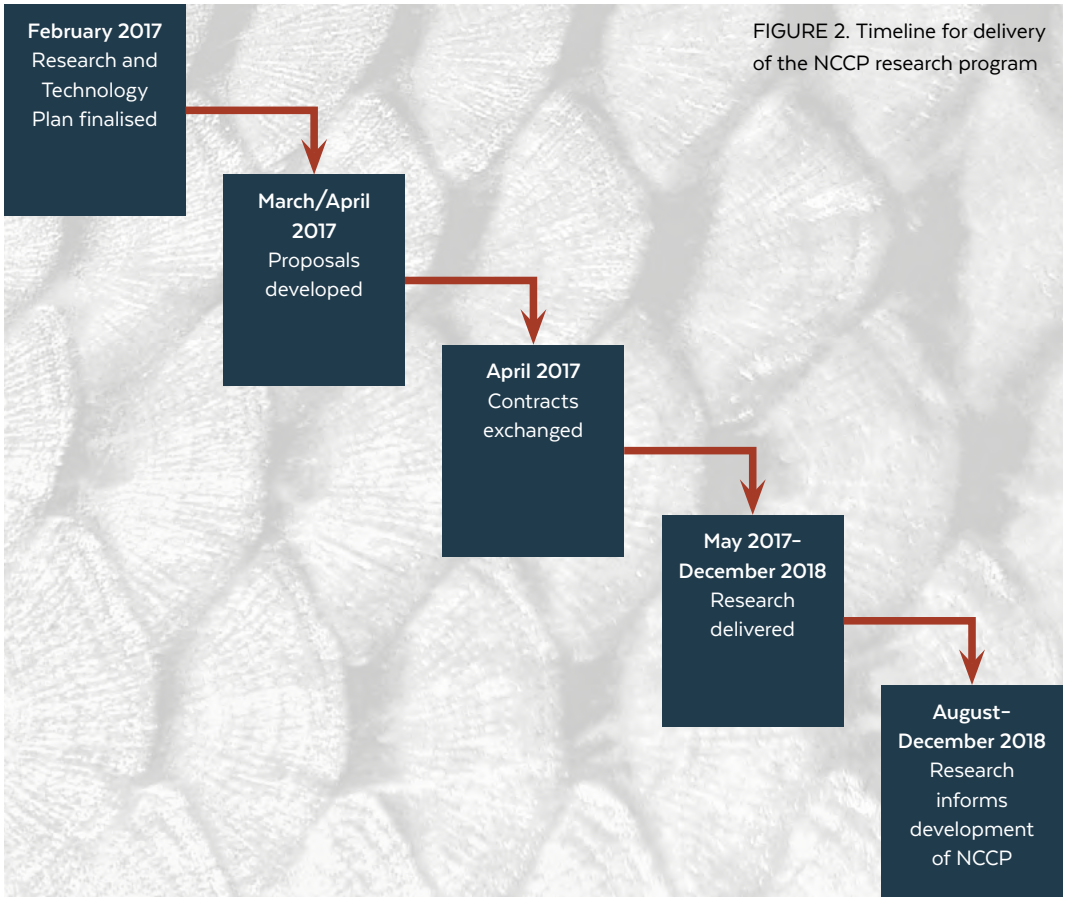


FIGURE 2. Timeline for delivery of the NCCP research program

3.2 Research framework overview

Purpose: Guide investment in research and technology to underpin development of the National Carp Control Plan (NCCP)

Goals

1. Investment in research and technology activities under the NCCP is targeted to address priority knowledge gaps and risks.
2. Projects funded under the NCCP are outcome focused, and deliver timely outputs cost effectively.
3. Investment in research and technology projects under NCCP play a vital role in informing decision making.

RESEARCH AND TECHNOLOGY THEMES

1. Environment	2. Communities	3. Informing possible implementation
Priority areas 1. Completing non-target species susceptibility trials 2. Understanding efficacy under real-world conditions 3. Predicting ecological responses 4. Establishing benefits and costs of the NCCP	Priority areas 6. Understand attitudes towards the NCCP	Priority areas 7. Developing integrated carp control measures 8. Defining information needs for release and clean-up strategies

5. Understand and manage ecological, social and economic risks to successful implementation (applied to all three themes)

Research and Technology Theme 1. Environment

PRIORITY AREA 1. Completion of non-target susceptibility trials

Projects

- Completion of non-target species testing for teleost orders Osteoglossiformes, Beloniformes, and Synbranchiformes, and Western Australian endemic species Salamanderfish, *Lepidogalaxias salamandroides* and Nightfish *Bostockia porosa*
- Discussion paper: Investigating need for immunocompromising individuals prior to challenge during further testing of non-target species

Outcomes

- Insusceptibility of remaining un-tested taxononomic orders (Beloniformes, Osteoglossiformes and Synbranchioformes), and two Western Australian endemic species (Salamanderfish, *Lepidogalaxias salamandroides* and Nightfish *Bostockia porosa*) is demonstrated
- Independent guidance provided on merits of immunocompromising (stressing) individuals prior to experimental viral challenge

Theme 1. Environment (continued)

PRIORITY AREA 2. Understanding efficacy under real-world conditions

Projects

- Independent review of pilot epidemiological modelling for Lachlan catchment
- Expanded epidemiological modelling, including ecological consequence modelling
- Review of available information on Cyprinid herpesvirus 3 (CyHV-3) outbreaks and their long-term impacts on wild carp populations internationally
- Examine risk and response to potential genetic resistance to Cyprinid herpesvirus 3 (CyHV-3)

Outcomes

- Future epidemiological modelling is well designed, draws on appropriate data and delivers desired outputs to inform decision making
- Predictions of viral efficacy are improved by better understanding the impact of spatial and temporal variability in water temperature throughout the range of common carp
- Predictions of ecological outcomes are improved by better understanding the impact of variability in carp biomass on transmission via cohabitation
- Predictions of the carp virus's effectiveness on wild populations outside of intensive aquaculture is better understood by examining international case studies
- Risk of immunity to the carp virus is well understood, and strategies are developed to address this risk
- Spatial variability in susceptibility of wild carp populations to carp virus is understood
- Cost efficient and effective methods developed for monitoring spread of the carp virus and disease in remote areas

Theme 1. Environment (continued)

PRIORITY AREA 3. Predicting ecological responses

Projects

- Population modelling to understand ecological responses of key invasive species to carp removal
- Investigating likely responses of key parasites and pathogens to carp mortality events
- Investigation of nutrient interception pathways to circumvent possible cyanobacterial blooms following carp mortality events
- Modelling to understand risk of anoxia within main river channel habitats is expanded to consider shallow wetlands
- Expansion of monitoring to determine ecological outcomes, including changes in carp populations

Outcomes

- Likely responses of key pest species to carp mortality events/abundance reduction are understood
- Likely responses of key parasites and pathogens to carp mortality events are understood
- Nutrient interception pathways are understood to enable short-term risk of cyanobacterial blooms to be effectively managed
- Modelling provides understanding of anoxia risk in shallow, low-flow areas away from main river channels
- Water quality impacts at different carp biomass levels are understood and planned for. Ecological monitoring informs assessment of effectiveness of NCCP

PRIORITY AREA 4. Determining benefits and costs of the NCCP

Projects

- Completion of detailed benefit/cost analysis

Outcomes

- Likely social, economic and ecological benefits and costs of NCCP are quantified
- Detailed costings for possible implementation of NCCP are calculated and communicated

Research and Technology Theme 2. Communities

PRIORITY AREA 5. Identify and manage risks

Projects

- Conducting social, economic, and ecological risk assessment for use of Cyprinid herpesvirus 3 (CyHV-3) for carp biocontrol in Australia

Outcomes

- Strategies developed to mitigate risks to communities that rely upon waterways subject to carp biocontrol as primary water sources
- Risk of unfounded negative attitudes towards the NCCP by community members are managed through addressing concerns and designing effective engagement strategies
- Potential impacts on water treatment plant efficiency are understood
- Strategies to manage risk of unplanned human spread of the virus post release are identified
- Risk to business ventures that are dependent on carp are understood, and effective strategies to manage these risks are developed
- Risks to ornamental Koi enthusiasts are understood, and effective strategies to manage these risks are developed
- Effective stakeholder and community engagement strategies build community understanding and optimise acceptance by addressing concerns
- Options are identified to minimise risk to water quality or critical life phases of key native species
- Risks to international trade of native fish and other relevant commodities are well understood

PRIORITY AREA 6. Understand stakeholder attitudes to the NCCP

Projects

- Undertake surveys to understand factors influencing communities' attitudes towards the NCCP
- Development of strategies to optimise social acceptability, address any concerns, and effectively engage stakeholders and the general public

Outcomes

- Willingness of stakeholder groups to be involved in implementation is understood, and motivators and barriers to participation are identified
- Stakeholder views of the NCCP are well understood, as are the factors influencing these views. Strategies are developed to optimise social acceptability of the NCCP through addressing concerns, building knowledge and awareness of benefits, and building community capacity to observe and interpret local outcomes

Research and Technology Theme 3. Informing possible implementation

PRIORITY AREA 7. Integrated program development

Projects

- Development of flow management strategies to optimise outcomes delivered through carp biocontrol
- Desktop study to identify optimal secondary control measure(s) to complement carp biocontrol
- Integrated sex-biasing research project

Outcomes

- Strategies are developed to manage flow, supported by ecohydrological modelling, within regulated catchments to optimise release and clean-up effectiveness
- Optimal secondary carp control measures are identified, and preparation for deployment commenced

PRIORITY AREA 8. Informing release and clean-up strategy

Projects

- Estimation of carp biomass at regional scales
- Exploring technical feasibility of release and clean-up methodology through phase I trial
- Investigating options for use of harvested carp biomass post virus release
- Development of serological monitoring approaches for CyHV-3
- Citizen Science CyHV-3 surveillance app and web platform development and extension

Outcomes

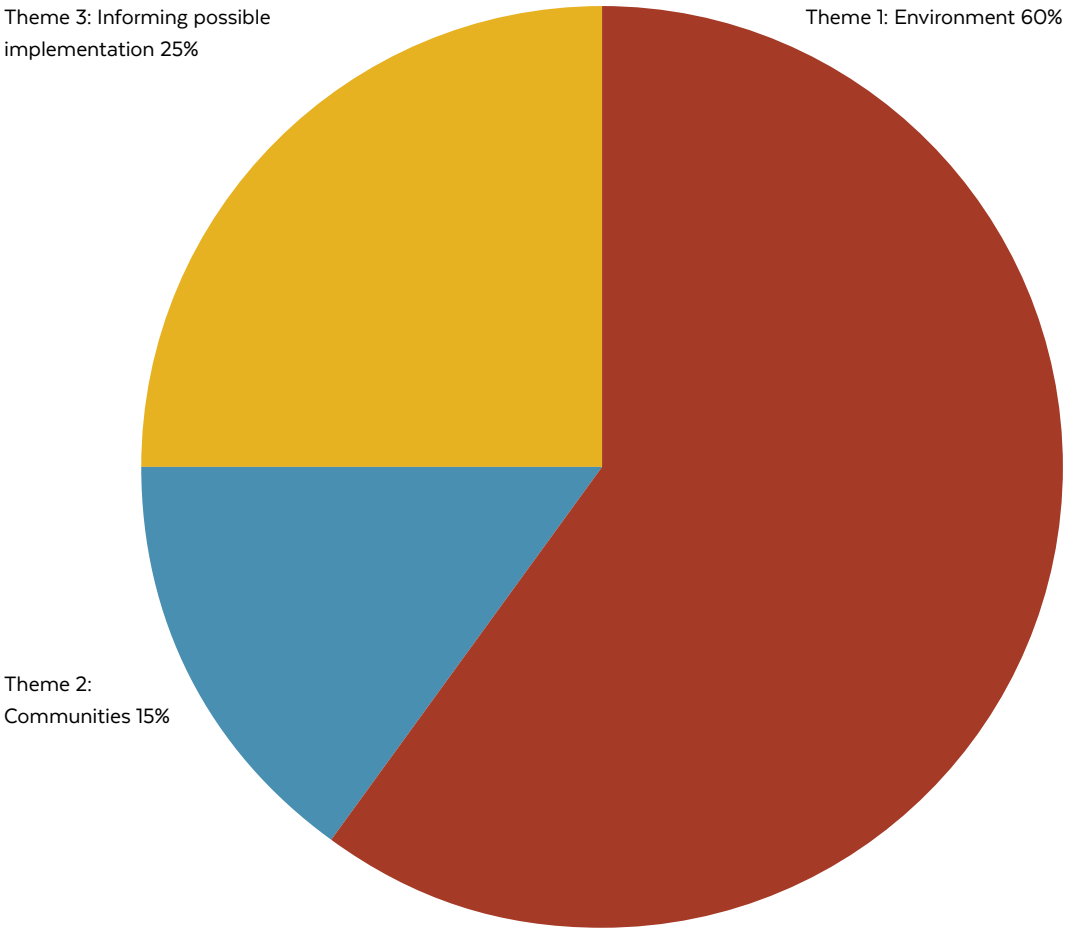
- There is an improved understanding of carp biomass in Australia, its spatial distribution, and how this changes following release of the carp virus
- Opportunities to phase possible release and clean-up activities are understood
- Effective strategies are developed to deliver release and clean-up activities within unregulated systems
- Proposed methods for release and clean-up are shown to be effective
- Viable solutions are identified for carp biomass utilisation, and relevant logistical and legislative considerations are addressed
- Effective tools are available to monitor the carp virus's spread
- Effective strategies are identified to manage water quality post-release, including within ephemeral systems known to contain critical populations of native fish species
- Effective methods are identified for engaging communities in observing, understanding and, where appropriate, participating in NCCP implementation

3.3 Forecast investment across strategic research and technology priority areas

Approximately $5.5 million will be invested to address knowledge gaps and key risks under the NCCP's Strategic Research and Technology Plan during 2017–19. It is proposed that this investment be divided across the three themes as shown in Figure 3.

Successful integrated pest control programs require management and investment strategies that are capable of dealing with uncertainty (e.g. Shea et al., 2002). Most research projects proposed under the NCCP are heuristic in nature, and in recognition of this, 10 per cent of the total research budget (i.e. approximately $500,000) will be held back to enable funding of research priorities that emerge as projects progress.

FIGURE 3. Estimated allocation of funding across program areas 2017–19



4 STRATEGIC RESEARCH AND TECHNOLOGY PLAN GUIDELINES

4.1 Investment collaboration

The Science Advisory Group will be mindful of collaborative opportunities with external funding sources to maximise benefit derived from investment against this plan. Collaboration provides the opportunity to share investment across common areas of interest and promote research and technology execution efficiency.

4.2 Extension

Effective extension of project findings to end users will be critical to realise benefit from investment. Consideration will be given to appropriate extension methods during proposal development, and will continue during execution through to the final published report. It is a requirement that an extension and adoption plan be developed and submitted for each project to assist in this process. Extension and adoption plans will be reviewed by the Science Advisory Group, with input from the Communications Working Group.

On 23 April 2010, the Primary Industries Ministerial Council approved a National Strategy for Fishing and Aquaculture Research, Development and Extension which establishes future directions to improve the focus, efficiency and effectiveness of research, development and extension to support Australia's fishing and aquaculture industry.

The FRDC have adopted these as key principles with regard to encouraging and promoting extension and adoption. They are:

Principle 1: All stakeholders to value extension and adoption activities in the same way as research activities.

Principle 2: Extension will be a key focus in research project development.

Principle 3: Project knowledge and outputs are actively managed.

Principle 4: Effectiveness and impact of project extension activities are evaluated.

Principle 5: Extension and adoption capacity is maximised and built upon.

4.3 Evaluation

During the life of the Strategic Research and Technology Plan, the Science Advisory Group will evaluate the Plan's performance against its identified priority areas as well as monitoring investment to ensure balance.

4.4 Review of the Strategic Research and Technology Plan

The Science Advisory Group will review the Strategic Research and Technology Plan on completion of year one (2017). This review is intended to enable:

- performance to be assessed against the identified priority areas of the plan and key performance indicators
- gaps to be identified against the priority areas of the plan
- priority areas for investment to be determined against these gaps and other priority-setting processes that may have been undertaken.

At each meeting the Science Advisory Group will also undertake a situational scan of the jurisdiction to identify any tactical or immediate areas of research that require short term or immediate remediation.

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Photo above Luis Garcia.

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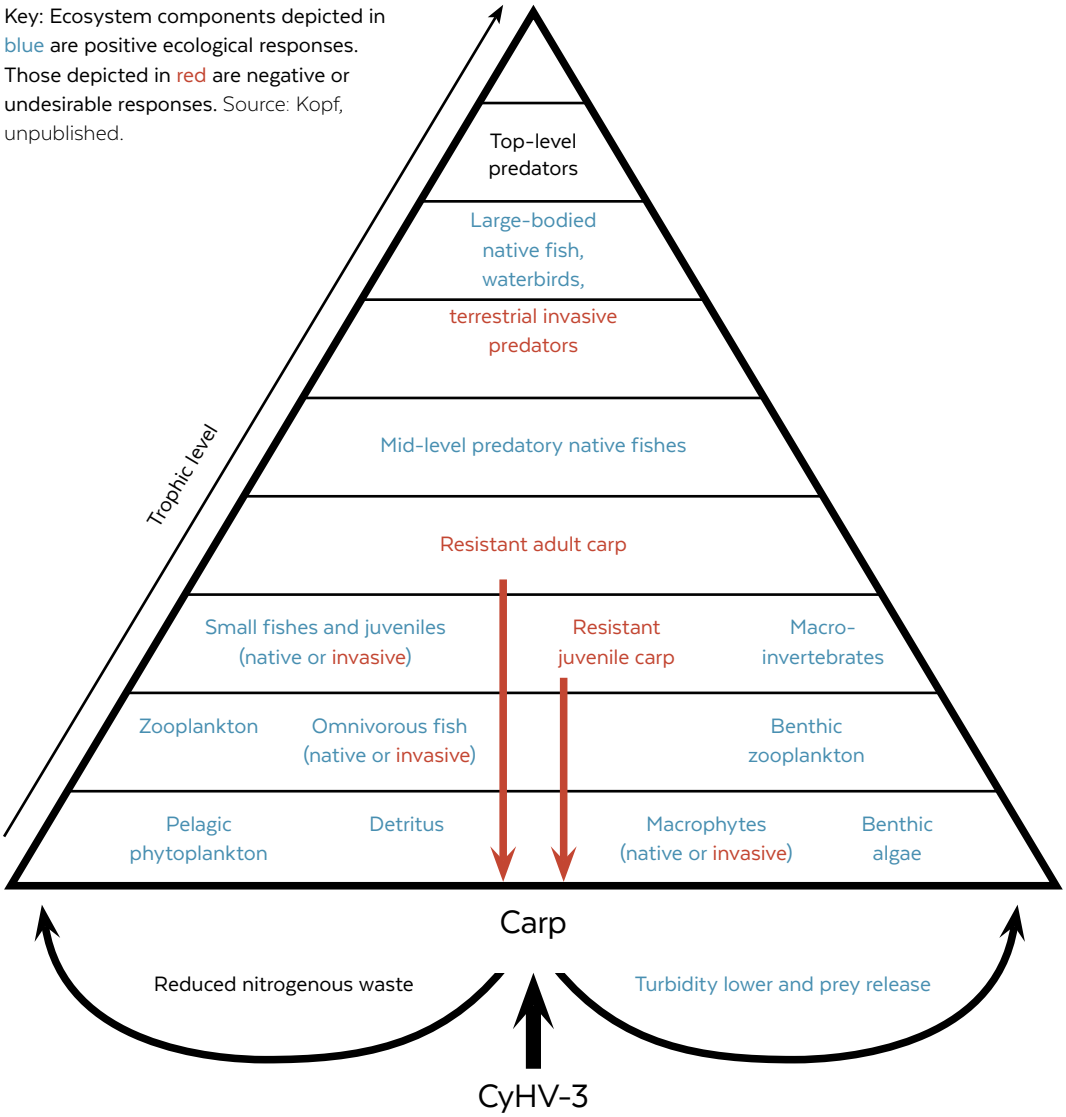
APPENDIX. CONCEPTUAL DIAGRAM OF PREDICTED ECOLOGICAL RESPONSES TO CARP BIOCONTROL USING CYPRINID HERPESVIRUS 3

Key: Ecosystem components depicted in blue are positive ecological responses. Those depicted in red are negative or undesirable responses. Source: Kopf, unpublished.



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