RESEARCH **15**

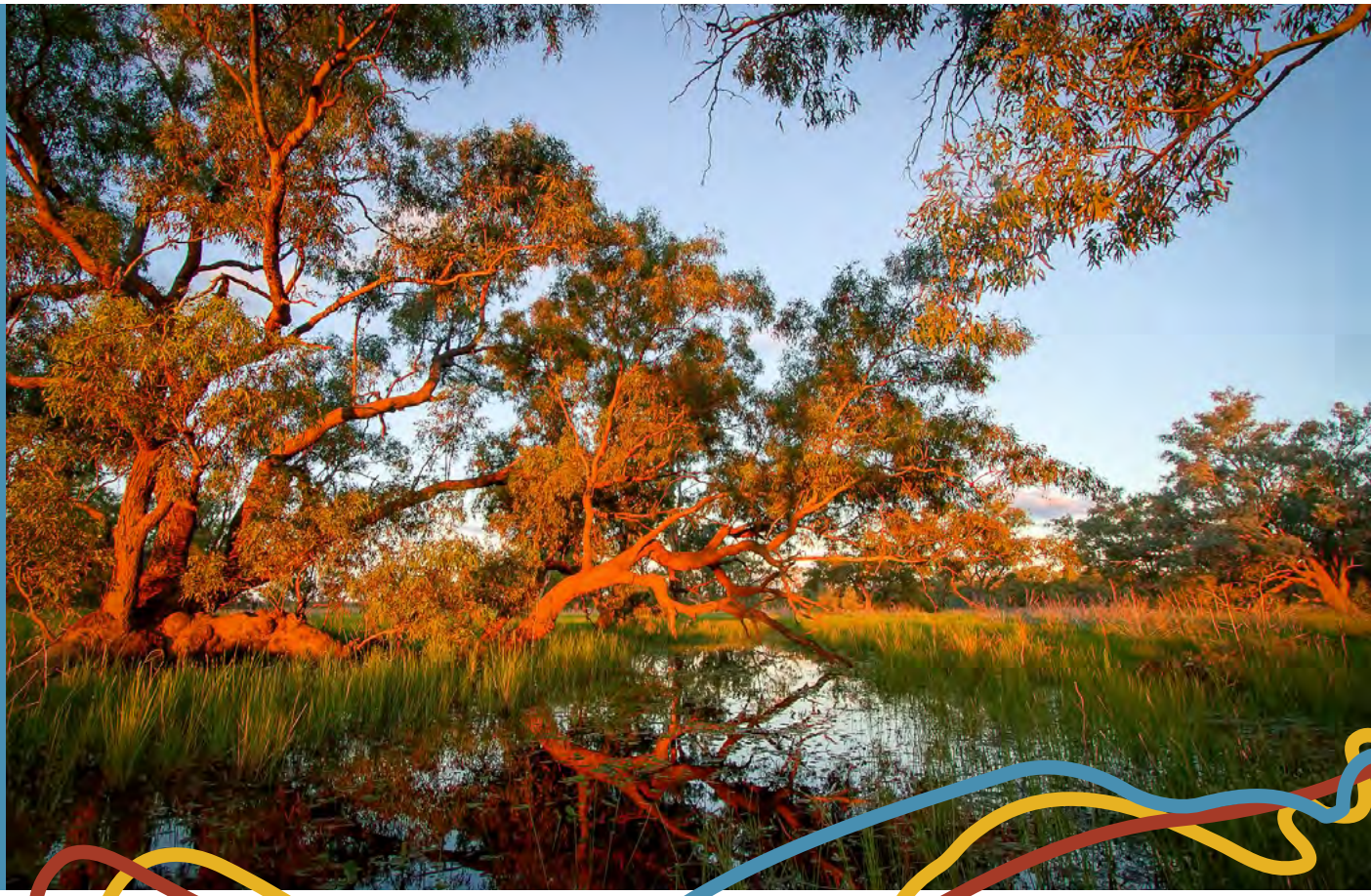
2017-054

WHAT ARE THE CARP VIRUS BIOCONTROL RISKS AND HOW CAN THEY BE MANAGED?

NATIONAL CARP CONTROL PLAN

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

VOLUME 3: Assessment of social risks



This suite of documents contains those listed below.

NCCP TECHNICAL PAPERS

1. Carp biocontrol background
2. Epidemiology and release strategies
3. Carp biocontrol and water quality
4. Carp virus species specificity
5. Potential socio-economic impacts of carp biocontrol
6. NCCP implementation
7. NCCP engagement report
8. NCCP Murray and Murrumbidgee case study
9. NCCP Lachlan case study

NCCP RESEARCH (peer reviewed)

Will carp virus biocontrol be effective?

1. 2016-153: Preparing for Cyprinid herpesvirus 3: A carp biomass estimate for eastern Australia
2. 2018-120: Population dynamics and carp biomass estimates for Australia
3. 2017-148: Exploring genetic biocontrol options that could work synergistically with the carp virus
4. 2016-170: Development of hydrological, ecological and epidemiological modelling
5. 2017-135: Essential studies on Cyprinid herpesvirus 3 (CyHV-3) prior to release of the virus in Australian waters
6. 2020-104: Evaluating the role of direct fish-to-fish contact on horizontal transmission of koi herpesvirus
7. 2019-163 Understanding the genetics and genomics of carp strains and susceptibility to CyHV-3
8. 2017-094: Review of carp control via commercial exploitation

What are the carp virus biocontrol risks and how can they be managed?

9. 2017-055 and 2017-056: Water-quality risk assessment of carp biocontrol for Australian waterways
10. 2016-183: Cyprinid herpesvirus 3 and its relevance to humans
11. 2017-127: Defining best practice for viral susceptibility testing of non-target species to Cyprinid herpesvirus 3
12. 2019-176: Determination of the susceptibility of Silver Perch, Murray Cod and Rainbow Trout to infection with CyHV-3
13. 2016-152 and 2018-189: The socio-economic impact assessment and stakeholder engagement
    Appendix 1: Getting the National Carp Control Plan right: Ensuring the plan addresses community and stakeholder needs, interests and concerns
    Appendix 2: Findings of community attitude surveys
    Appendix 3: Socio-economic impact assessment — commercial carp fishers
    Appendix 4: Socio-economic impact assessment — tourism sector
    Appendix 5: Stakeholder interviews
    Appendix 6: Socio-economic impact assessment — native fish breeders and growers
    Appendix 7: Socio-economic impact assessment — recreational fishing sector
    Appendix 8: Socio-economic impact assessment — koi hobbyists and businesses
    Appendix 9: Engaging with the NCCP: Summary of a stakeholder workshop
14. 2017-237: Risks, costs and water industry response
15. 2017-054: Social, economic and ecological risk assessment for use of Cyprinid herpesvirus 3 (CyHV-3) for carp biocontrol in Australia
    Volume 1: Review of the literature, outbreak scenarios, exposure pathways and case studies
    Volume 2: Assessment of risks to Matters of National Environmental Significance
    Volume 3: Assessment of social risks
16. 2016-158: Development of strategies to optimise release and clean-up strategies
17. 2016-180: Assessment of options for utilisation of virus-infected carp
18. 2017-104: The likely medium- to long-term ecological outcomes of major carp population reductions
19. 2016-132: Expected benefits and costs associated with carp control in the Murray-Darling Basin

NCCP PLANNING INVESTIGATIONS

1. 2018-112: Carp questionnaire survey and community mapping tool
2. 2018-190: Biosecurity strategy for the koi (*Cyprinus carpio*) industry
3. 2017-222: Engineering options for the NCCP
4. NCCP Lachlan case study (in house) (refer to Technical Paper 9)
5. 2018-209: Various NCCP operations case studies for the Murray and Murrumbidgee river systems (refer to Technical Paper 8)

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Biocontrol of European Carp

Ecological and social risk assessment for the release of Cyprinid herpesvirus 3 (CyHV-3) for carp biocontrol in Australia

Volume 3: assessment of social risks

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Volume 3: assessment of social risks

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INTRODUCTION

The Australian Government has invested in the development of a National Carp Control Plan (NCCP) to explore the potential use of *Cyprinid herpesvirus 3* (CyHV-3) for the biological control of carp in Australia. Carp occur in every state and territory except the Northern Territory and are now the dominant fish species within the Murray-Darling Basin. The ecological impacts of carp include increased turbidity, intensified algal blooms and reduced abundance of macrophytes, invertebrates and some native fish.

One of the core objectives of the NCCP is to undertake research and development to address knowledge gaps, and to better understand and manage risks to support the potential release of CyHV-3, subsequent clean-up, and the recovery of native fish and ecosystems. The ecological and social risk assessment detailed in the three volumes of this report was one of the projects funded through the NCCP.

The **ecological** component of the assessment was undertaken in two parts:

(a) A compilation of the science and epidemiology of CyHV-3 and an assessment of outbreak scenarios, exposure pathways and case studies (Volume I of this report)

(b) An assessment of the risks that the proposed release of CyHV-3 may pose to the assets that have been described under the EPBC ACT[1] as Matters of National Environmental Significance (MNES) (Volume 2 of this report).

Part (a) above provided the underpinning for part (b), but also gave a more comprehensive assessment of the environmental risks that may be associated with the release of CyHV-3. Part (b) was directed specifically at the needs of the Strategic Assessment that will be required by the Department of Environment and Energy, under the EPBC Act, if the release of CyHV-3 is judged to be feasible.

The standalone **social** component of the assessment is documented in Volume 3 of this report. This assessment included two forms of stakeholder interaction and was undertaken to evaluate perceptions about the risks attached to the proposed release of CyHV-3.

KEY FINDINGS

The **ecological risk assessment** made use of outbreak scenarios, exposure pathways and case studies to evaluate risks to species and ecological communities at a national scale. The development of outbreak scenarios enabled key aspects of the epidemiology of CyHV-3 to be considered in an Australian context. This included a range of outbreak settings, such as ephemeral

[1] Environment Protection and Biodiversity Conservation Act 1999

wetlands, perennial and disconnected river systems and lakes and other impoundments, as well as consideration of the implications of high-flow and lower-flow seasons. The outbreak scenarios were informed by the spawning behaviour of carp, and by the importance of aggregations and water temperature to the perpetuation of CyHV-3.

- Although aggressive outbreaks of CyHV-3 were considered possible in most settings, impacts on water quality are likely to require a relatively high carp biomass density and relatively poor connectivity of the waterway in which the outbreak occurs. In this context, impacts on water quality may include a reduction in dissolved oxygen as a result of increased biological oxygen demand (possibly to the point of anoxia), an increase in the likelihood of widespread cyanobacterial blooms as a result of an increase in phosphorous and dissolved organic carbon, and an increase in the risks associated with proliferating waterborne spoilage and other microorganisms. Native fish (small-bodied and large-bodied) and crustaceans are most at risk from low dissolved oxygen – in particular, species with a limited geographic range or a reliance on a small number of local populations. These and other aquatic and terrestrial water users, including waterbirds, will also be at risk from cyanobacterial blooms. Colonial-nesting waterbirds are more at risk than those that nest individually, as are the waterbird functional groups (such as the piscivorous seabirds and large waders) that are most closely associated with water.
- High-risk settings for the impacts of an outbreak of CyHV-3 on food webs include ephemeral wetlands during high-flow seasons, when the floodplains are inundated and a maximal number of breeding piscivorous waterbirds are present; and some permanent lakes and irrigation reservoirs that may act as a refugia for breeding waterbirds during lower-flow seasons. The emphasis on breeding (as opposed to nesting) waterbirds is relevant, as chicks are more likely to be stressed by the removal or suppression of juvenile carp than are adult birds. The removal of juvenile carp may result in piscivorous waterbirds switching to other prey species – including the juvenile large-bodied native fish, adult or juvenile small-bodied native fish, frogs and frog spawn, crustaceans and turtle eggs or hatchlings – and this may place stress on some important local populations.
- Botulism outbreaks in wildlife follow a highly-probabilistic process and are potentially a concern in any wetland, lake or waterhole where carcass accumulation occurs in the presence of large numbers of waterbirds. Although most terrestrial and aquatic species will be at risk in the event of an outbreak of type C (or C/D mosaic) botulism, fatalities are generally most striking amongst waterbirds – in particular, those that include insects in their diet.

These assessments speak to the risks faced by individuals, and by local populations. The risks faced by a species as a whole will reflect the exposure of individuals (as above) as well as a raft of population-level factors, such as the strength and geographic distribution of its population across Australia and the effectiveness of its recruitment or rejuvenation strategies.

A range of mitigations was considered for each of the identified exposure pathways. Following the dictates of the Department of Environment and Energy, these addressed, in decreasing order of preference, the avoidance, mitigation and offsetting of risk and ongoing adaptive management of residual threats. Risks to native species or communities can be avoided chiefly through the

strategy for release of CyHV-3, which should consider the implications of high-flow and lower-flow seasons for impacts in different settings and geographical locations. The partial removal of carp from waterways, ahead of the release of the virus, may provide another means by which water quality risks can be avoided. This strategy is likely to be particularly attractive in waterways that are prone to low flows or to the formation of disconnected waterholes. Risks that cannot be avoided may be mitigated, and this will be chiefly through the removal of carp carcasses or the use of water regulation to flush carcasses or the products of carcass decomposition (including cyanobacterial blooms) from sensitive areas. Offsetting the harm from any remaining risks will focus largely on the release of farmed species at strategic locations. The effectiveness of this will in most cases be bolstered through wild-caught broodstock. Ongoing adaptive management will include programmed monitoring of water quality data from the Murray-Darling Basin and beyond, as well as the programmed monitoring of key or indicator species.

The **assessment of EPBC Act MNES** covered the breadth of natural and built assets that might be exposed through the proposed release of CyHV-3. This included threatened and migratory species, as well as threatened ecological communities, Ramsar wetlands, World Heritage Properties, National Heritage Places, Commonwealth Marine areas, the Great Barrier Reef Marine Park and Commonwealth Lands. The assessment for threatened and migratory species focussed on the likelihood of a Major impact at a national level, while the balance of assessments was undertaken using the Department of Environment and Energy's significant impact criteria. With risk mitigations in place, Medium risks remained for some large-bodied and small-bodied native fish, shorebirds, large waders and native frogs. Species that are micro-endemic within areas that also include a high biomass density of carp were maximally exposed from a geographic standpoint, although the risk estimates also reflected exposure to (as relevant) poor water quality, food web disturbances and an outbreak of botulism. The only non-negligible residual risks for MNES assets other than threatened and migratory species were attributed to a range of Ramsar wetlands and two of the National Heritage properties (the Cowra Japanese Gardens and Cultural Centre and Centennial Park).

The **social risk assessment** was undertaken to evaluate perceptions about ecological and other risks attached to the proposed release of CyHV-3. The assessment showed that while communities are accepting of the use of CyHV-3 to control invasive carp in Australian waterways, their acceptance is dependent on familiarity with the NCCP, personal interactions with waterways, knowledge of carp impacts and values, and their sense of community responsibility towards environmental stewardship. Uncertainty underpinned baseline concerns about the possible impact of CyHV-3 on humans, and on animals other than carp. The results underscored the need for proactive and effective communication across a range of social strata, with clear messaging about both strategy for the release of the virus and site-specific plans for the clean-up and disposal of carcasses.

ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment was informed by an assimilation of the grey and published literature, and by the outputs of companion projects undertaken through the NCCP.

The review (Volume I of this report) encompassed the characteristics of Australia's freshwater waterways, the species and ecological communities that may be at risk in the event of an outbreak of CyHV-3, the ecology of carp in Australia and the underpinning for its success as an invasive species, the epidemiology of CyHV-3 in farmed and wild carp, and the impacts of fish kills on water quality, risk of botulism and food webs. The review provided an assimilation of key works from the published and grey literature. As they became available, the reports of other NCCP projects were also included. These included, in particular, the carp biomass modelling study (Stuart *et al*., 2019), and the water quality research (Walsh *et al.*, 2018) and modelling (Hipsey *et al*., 2019) studies. The report of the epidemiological modelling study (Durr *et al*., 2019a, 2019b and 2019c) was released in draft format immediately prior to the release of this risk assessment. An abstract from the epidemiological modelling study was included and key assumptions and conclusions were cross-checked for consistency with the outcomes of this risk assessment.

An expert elicitation study was embedded within the review and sought to clarify some of the critical questions concerning the role that juvenile carp may play as a food source for nesting piscivorous waterbirds. A quantitative joint-distribution modelling study was also carried out, with the aim of exploring the likelihood that other invasive species would rebound given the removal or suppression of carp. This study identified goldfish, tench, redfin perch, roach, Oriental weatherloach and eastern mosquitofish as invasive species whose habitat is currently correlated with that of carp. Dietary overlap, affinity for the highly-turbid waters that are likely to remain for the short-medium term, and shifts in pressures on zooplankton and phytoplankton, are all factors that may influence the likelihood that one or more of these species would benefit substantially from the removal or suppression of carp. Goldfish and eastern mosquitofish already coexist with carp in robust populations that include, in the case of goldfish, some hybridisation. Tench compete directly with carp and occupy a similar ecological niche and, although currently inhibited by carp, and likely to benefit from their removal or suppression, are considered far less destructive from an ecological standpoint. Redfin perch are a predatory species, and their success in the event of carp removal or suppression will relate to their ability to feed in turbid waters. As redfin perch also predate on other juvenile non-native fish, this may lead to secondary impacts that are more difficult to predict. Less is known about the ecology of roach or Oriental weatherloach in Australia, although both are substantially smaller fish than carp and neither is likely to recruit as effectively in high-flow seasons.

The assessment of ecological risk (Volume I of this report) built on the reviews and evaluations described above. One of the most striking characteristics of the assessment was the breadth of ecological assets (including species, communities and places) and settings that it was required to encompass in order to evaluate the possible impacts of CyHV-3 at a national scale. A national scale was chosen as the virus is likely to spread naturally from the place(s) of introduction, or through the translocation of affected live fish or carcasses, during one or several seasons. In order to address the breadth of concerns associated with release at a national scale, the assessment included outbreak scenarios for a range of freshwater environments, nine key exposure pathways describing the ways in which the release of CyHV-3 could result in harm to the environment, and a series of detailed case studies.

The outbreak scenarios focussed individually on ephemeral wetland settings, lakes and reservoirs, and riverine settings. Across these, the importance of aggregation events, carp biomass density and water temperature were underscored. The scenarios focussed on the events that are likely to unfold under a maximally aggressive outbreak. In most settings, this will correspond to the period immediately after release of the virus. In disconnected riverine environments, however, outbreaks are more likely to be aggressive during the dry season following from reconnection of the river system – that is, after affected fish have had an opportunity to be redistributed through the population.

Although aggressive outbreaks of CyHV-3 were considered possible in most settings, impacts on water quality are likely to require a relatively high carp biomass density and relatively poor connectivity of the waterway in which the outbreak occurs. In this context, impacts on water quality may include a reduction in dissolved oxygen as a result of increased biological oxygen demand (possibly to the point of anoxia), an increase in the likelihood of widespread cyanobacterial blooms as a result of an increase in phosphorous and dissolved organic carbon, and an increase in the risks associated with proliferating waterborne spoilage and other microorganisms. High-risk settings for impacts on water quality include spring or autumn outbreaks within the seasonally-disconnected waterholes that characterise many dryland river systems (for example, the Moonie River in Queensland), and spring and summer outbreaks within ephemeral wetlands during lower-flow seasons when aquatic biota are concentrated in available wetland or off-channel habitat (for example, the Barmah-Millewa Forest in New South Wales and Victoria). Conversely, it is relatively less likely that water quality will be diminished in the event of an outbreak of CyHV-3 within deep and flowing waterways such as the Murray River channel. Although there is a range in the susceptibility of individual species to low dissolved oxygen, most will be affected if levels lower than 3 mg/L persist. The Basin Plan target of ≥50 percent saturation (or a dissolved oxygen of approximately 4.5 mg/L at 20C) is widely regarded as the appropriate critical value for Australian freshwater river channels and anabranch creeks.

The accumulation of decomposing carcasses may also initiate a widespread cyanobacterial bloom. Some species of cyanobacteria are toxic, and this will have a direct impact on aquatic and terrestrial animals – including livestock and humans. As cyanotoxins may also bioaccumulate in animal tissue, a toxic threshold can be breached through repeated low-dose exposure. When the conditions change, or the substrate is depleted, the bloom will collapse and die. This results in a substantial increase in biological oxygen demand and a precipitous drop in dissolved oxygen. The impact of a collapsed bloom on dissolved oxygen is likely to exceed the impact of carcass decomposition (above) and will have a marked effect on water-breathing aquatic life.

Relatively less is known about the impact of decomposing fish carcasses on the proliferation of waterborne microorganisms. Carp gut flora and spoilage organisms may be present in high numbers, as might *E. coli*, some *Pseudomonas spp* and other opportunistic microorganisms. Shiga toxin-producing *E. coli* (STEC) has been isolated from ponds, streams, wells and water troughs, and have been found to survive for months in manure and water-trough sediments. *Aeromonas spp* have also been found in irrigation water, rivers, springs, groundwater, estuaries and oceans and are of public health concern. The decomposition of carp carcasses in mesocosms has resulted in a decrease in signature lake bacteria, and an increase in environmental copiotrophs and fish gut

bacteria. Potentially, some changes to the bacterial flora may persist once waterways have returned to an otherwise healthy state. Aquatic and terrestrial animals that have faced other challenges arising from an outbreak of CyHV-3 (for example, a cyanobacterial bloom) are likely to be stressed and immunocompromised and may have a diminished resistance to waterborne microorganisms that are pathogenic for their species or functional group. These possibilities notwithstanding, very little evidence was found within the published or grey literature to substantiate a link between substantive fish kills in Australian freshwater environments and the proliferation of, or disease resulting from, waterborne microorganisms.

The mitigation of risks associated with diminished water quality will rest largely on the timely removal of carp and other carcasses, noting that carcasses will in general only float for 1 to 3 days following death. Although the timely removal of carp carcasses is likely to be a practical proposition in some settings (for example, urban lakes and some irrigation reservoirs), the magnitude of the task or the accessibility of waterways may in other settings be problematic. This is likely to be the case in some seasonally-disconnected dryland rivers, for example, where the population is sparse and the monitoring of, and access to, individual disconnected waterholes, may not be practical. The collection of carcasses may also be difficult in some wetland settings – in particular, during a high-flow season when the floodplains are inundated, and access is limited to shallow-draft water craft. As an alternative, or adjunct, to the removal of carcasses and carcass materials, it may be practical in some situations to make use of regulatory structures to flush carcass materials or cyanobacterial blooms from affected areas and to refresh the quality of the water. Within the Chowilla Floodplain in South Australia, for example, the sophisticated Chowilla regulator and ancillary structures enable water to be directed to particular parts of the wetland complex, even when flows through the Murray River channel are relatively low.

High-risk settings for the impacts of an outbreak of CyHV-3 on food webs include ephemeral wetlands during high-flow seasons when the floodplains are inundated, and a maximal number of breeding waterbirds are present (for example the Macquarie Marshes in New South Wales); and some permanent lakes and irrigation reservoirs that may act as a refugia for breeding waterbirds during lower-flow seasons (for example, Kow Swamp in Victoria). In this context, the effects on food webs may include stress to the chicks of (in particular) colonial-nesting piscivorous waterbirds following the removal or suppression of juvenile carp, as well as an impact on native species as a result of prey-switching.

Mitigation of the food web effects of an outbreak of CyHV-3 on breeding waterbirds will largely be limited to consideration of the timing of virus introduction into a naïve population of carp. In some catchments, for example, it may be beneficial to ensure that the virus is introduced during a relatively lower-flow season. The situation is complex, however, as two caveats to this approach are that: (a) breeding waterbirds taking dry-season refuge in permanent lakes and impoundments within the same catchment may then be exposed; and (b) the impacts of the virus on water quality may then be more significant. Mitigation of the effects of prey-switching will again rest on timing, with the aim being to avoid high-flow seasons when a wide range of native species will be taking advantage of inundated floodplains. It may also be beneficial to plan for the restocking of key ecological communities with (in particular) juvenile native fish. This strategy may in turn be aided

by sourcing broodstock from key catchments and wetlands, to ensure that restocked juveniles have an optimum local fitness when released.

Botulism outbreaks in wildlife follow a highly-probabilistic process and are potentially a concern in many wetland, lake and waterhole settings. Most terrestrial animals (including livestock) are susceptible to type C (or C/D mosaic) botulinum toxin, the most likely form of botulism in Australian wildlife. Humans, however, are not susceptible, and fish are only partly susceptible. Waterbirds are commonly the most affected, and while all waterbird species are susceptible those that consume insects and those that are more closely affiliated with water are likely to be most at risk. Botulism outbreaks in wildlife may arise in two key ways: (a) through the death of animals carrying spores within their gastrointestinal tracts, and the initiation of what is termed the 'carcass-maggot cycle'; or (b) through the germination of spores within the environment. In both cases, the germination of spores is triggered by anaerobic conditions and the presence of a suitable organic substrate. Under the first pathway (a) large numbers of carp carcasses might result in the initiation of an outbreak of botulism. Under the second pathway (b) the accumulation of carp carcasses might result in a drop in dissolved oxygen within an aquatic environment; or might result in the initiation of a widespread cyanobacterial bloom, which then dies and results in a drop in dissolved oxygen. The mitigation of risks associated with botulism in wildlife will again focus on the timely removal of carcasses and the possible use of regulatory structures to divert water to affected areas. These considerations notwithstanding, Agriculture Victoria (for example) have investigated numerous major blackwater events and fish kills in Victorian waterways and wetlands and have not to-date identified any cases of botulism in associated waterbirds. The peer-reviewed literature is also absent of robust evidence for the role of large fish kills as initiators of botulism outbreaks in natural settings.

ASSESSMENT OF EPBC ACT MNES

The assessment of risks to assets defined under the EPBC Act as Matters of National Environmental Significance (MNES) was undertaken to provide the core material for a Strategic Assessment (Volume 2 of this report). The Strategic Assessment will be required under the EPBC Act if the Australian Government considers the proposed release of CyHV-3 to be feasible and chooses to take it forward.

The assessment of EPBC Act MNES included the following:

Threatened species
- Critically endangered species
- Endangered species
- Vulnerable species

Migratory species

Threatened ecological communities
- Critically endangered communities
- Endangered communities
- Vulnerable communities

Ramsar wetlands of international importance

World Heritage Properties

National Heritage Places

Commonwealth Marine areas

Great Barrier Reef Marine Park

Commonwealth Lands.

The assessment for threatened and migratory species was undertaken using a five-point likelihood scale and a risk scenario that represented Major impact at a national level. The assessments for the balance of MNES assets were undertaken using a simpler dichotomous scale based on the existence of a real chance or possibility of observing a significant impact. Criteria for significant impacts on each category of MNES are provided by the Department of Environment and Energy.[2]

For assessments other than for Commonwealth Lands, evaluation was undertaken: (a) without risk management measures; and (b) with risk management measures (that is, residual risk). Risk management included measures to avoid, mitigate and offset risks and to provide for ongoing adaptive management. Throughout the evaluation of risk management measures, it was assumed that resources would be sufficient to encompass the activities in the location(s) described. Although the evaluation focused on outcomes following directly from the release of the virus, it was also assumed that resources would encompass surveillance and (if required) ongoing mitigation during years subsequent to the release of the virus.

A summary of the outcomes of the assessments for threatened and migratory species is given in Figure 1 (unmanaged risks) and Figure 2 (managed or residual risks). No unmanaged risks were considered Extreme. High unmanaged risks were recorded for large- and small-bodied native fish, shorebirds, large waders and native frogs. With management measures in place, no High risks remained, although a range of Medium risks remained for large-bodied and small-bodied native fish, shorebirds, large waders and native frogs. These included risks associated with poor water quality (whether from low dissolved oxygen [DO], widespread cyanobacterial blooms or proliferating microorganisms), food web disturbances (including the removal of juvenile carp as a dominant and stable food source, and the impacts of prey-switching as a result of this) or an outbreak of type C (or C/D mosaic) botulism. Under the assessment framework used for threatened and migratory species a Medium risk equated to the view that a Major impact at a national level is unlikely – that is, uncommon, although the outcome has been known to occur in a range of circumstances.

[2] Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (see: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance)

Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies, Significant impact guidelines 1.2 (See: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-12-actions-or-impacting-upon-commonwealth-land-and-actions)

Figure 1 Summary of unmanaged risks for threatened and migratory species

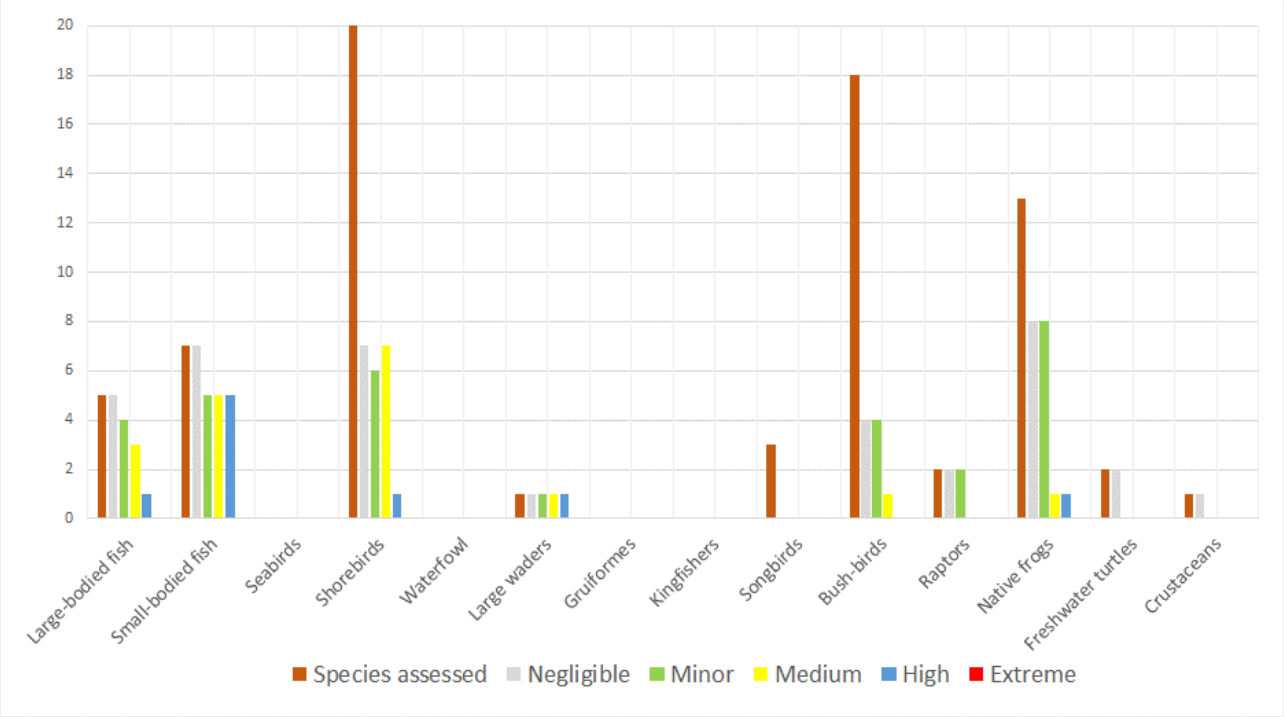
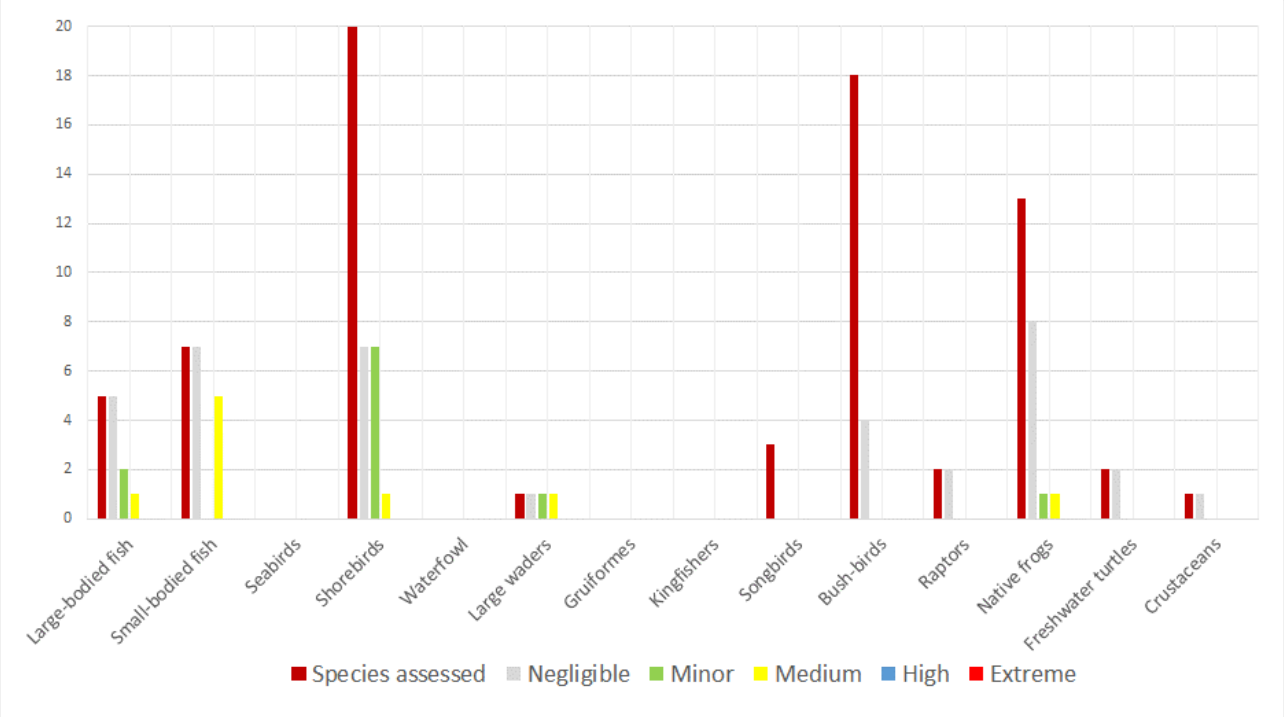


Figure 2 Summary of residual risks for threatened and migratory species



When management measures were considered, the only non-negligible risks for the balance of the MNES assets were attributed to Ramsar wetlands (including Ramsar wetlands of the northern Murray-Darling Basin, Ramsar wetlands of the southern Murray-Darling Basin and Wetlands within the Coorong and Lakes Alexandrina and Albert Wetland) and to two of the National Heritage properties (the Cowra Japanese Gardens and Cultural Centre and Centennial Park).

Additional planning could be undertaken to protect both the Cowra Japanese Gardens and Cultural Centre and Centennial Park, or to enable any harm that resulted from an outbreak of CyHV-3 to be rectified. In the case of the Cowra Japanese Gardens and Cultural Centre this might include vaccination of valuable ornamental Koi carp, a provision for restocking, or the use of effective biosecurity measures. Carp are a pest species within the Centennial Park ponds, and mitigation in this context would include additional resources for the immediate removal of carcasses and minimisation of harm to the amenity values of the park. The management of Ramsar wetlands will be more complex and is likely to require the development of a plan for each individual site. This plan would reiterate the values of each site, and the measures that can be taken to ensure that those values are protected or restored. These measures would address threats arising from the water quality effects of an outbreak of CyHV-3, as well as impacts on food webs or the risk of an outbreak of botulism. Additional analysis may be warranted to clarify the assets at stake within some categories of Commonwealth Land held by the Department of Defence and the Department of Finance.

RESIDUAL UNCERTAINTY

The breadth of this ecological risk assessment was considerable and, without any direct experience of the epidemiology of CyHV-3 in an Australian context, a degree of residual uncertainty is inevitable. In particular, this concerned the likely behaviour of the virus in a range of Australian freshwater settings and key components of the identified exposure pathways. Although largely beyond the scope of this assessment, there was also some residual uncertainty about the likely efficacy and practicality of some mitigations when applied in certain settings.

The likely behaviour of CyHV-3 was encapsulated in the detailed outbreak scenarios discussed above. Although the assumptions underpinning these scenarios concurred, in broad terms, with the NCCP's epidemiological modelling, it was recognised that the behaviour of an exotic disease in such diverse and complex settings cannot be predicted with certainty. It is possible, for example, that CyHV-3 will not penetrate local carp populations to the extent envisaged. It is equally possible, however, that the virus will be more successful than expected, or that particular characteristics of its epidemiology (such as the higher sensitivity of juvenile carp) will lead to an impact on carp populations that is more marked than modelling and qualitative assessment have suggested.

As noted, residual uncertainty also exists in respect of the identified exposure pathways.

The tolerance of each lifecycle stage of every native water-breathing aquatic species that may be exposed to low DO is not known, although this may be inferred with varying degrees of confidence from the literature about blackwater events. Similarly, whilst the NCCP water quality modelling studies showed that a dangerously low DO was only likely to occur within partially-connected or disconnected waterways, with a very high carp biomass density, there remained a degree of uncertainty about the importance of local conditions. A similar situation existed for widespread cyanobacterial blooms, with inference in that case based on the development and impacts of blooms that have occurred naturally throughout Australian freshwater waterways. Substantial uncertainty also surrounded the assessment of waterborne microorganisms that may be released into waterways with the decomposition of carp carcasses. In this case, uncertainty included the

species of microorganisms that are likely to be involved, and their pathogenicity for particular functional groups and native species, as well as the persistence of epidemics within waterways after the dissolution of carcass materials.

In addition to the water quality pathways, substantial uncertainty remained in respect of the impact of CyHV-3 on food webs – in particular, in settings that include large numbers of nesting piscivorous waterbirds. The two aspects of this scenario included the putative effects of removing a stable and plentiful food source (juvenile carp), and the likelihood that piscivorous waterbirds would then switch to native fish, crustaceans, frogs and turtle eggs and young as an alternative source of food. Very little is currently known about the likelihood, and likely severity, of either pathway, and this was reflected in the conservative estimates.

Botulism in wildlife is considered to be an inherently probabilistic process, with relatively few outbreaks observed in Australia given the ubiquity of spores and the frequent alignment of suitable conditions. Compounding this is a paucity of reports specifically linking fish kills to outbreaks of type C (or C/D mosaic) botulism in waterbirds, despite the fact that substantial fish kills (as a result of blackwater events and other processes) are not uncommon within Australian waterways. This notwithstanding, it was recognised that concurrent outbreaks of CyHV-3 across a catchment or river system have the potential to create a uniquely high-risk scenario – in particular, given the co-occurrence of: (a) carp at a relatively high biomass density; and (b) large numbers of nesting waterbirds. In view of this, conservative estimates were assigned to this pathway. Type E botulism was ruled out of the case studies and assessment of MNES on the grounds that there is no evidence that it exists within Australia. This was considered a practical and realistic standpoint, although it was also noted that there has not been a systematic search for type E *C. botulinum* across Australian waterways, and that none of the experts consulted was willing to state categorically that type E is an exotic strain. The importance of type E is twofold: (a) it is primarily a disease of fish (although waterbirds are severely impacted), and therefore more likely to arise in the context of a widespread and multifocal fish kill; and (b) it is highly-toxic (frequently fatal) to humans.

SOCIAL RISK ASSESSMENT

The social risk assessment was undertaken to evaluate perceptions about ecological and other risks attached to the proposed release of CyHV-3. This standalone work was based on qualitative and quantitative analysis of stakeholder surveys.

The qualitative survey focussed on interviews with a range of stakeholders, including recreational fishers and water sports enthusiasts, farmers and irrigators, retirees, Indigenous Australians and the general public more broadly. Respondents were members of local communities who in many cases possessed both local knowledge and practical experience dealing with the effects of significant environmental issues such as blackwater events. The quantitative component of the social risk assessment focussed on the deployment and analysis of a national survey. The survey was informed by an analysis of social groups and demographic profiling, with a focus on those who lived on or close to major waterways and those from urban settings. In total, 2,026 people participated in an online survey that was developed and administered by Taverner Research (an online market-research provider).

The social risk assessment showed that while communities are accepting of the use of CyHV-3 to control invasive carp in Australian waterways, their acceptance is dependent on familiarity with the NCCP, personal interactions with waterways, knowledge of carp impacts and values, and their sense of community responsibility towards environmental stewardship. The assessment showed that those who agree in general that carp control is necessary – and can recognise potential ecological benefits of carp control – are also more likely to accept the release of CyHV-3 as a possible means to this end. This trend meant that people who live within the Murray-Darlin Basin and are closely involved with the river system, better appreciate the need for carp control. This group, however, was also attuned to the ecological and other risks associated with the proposed release of CyHV3 – in particular, the risks associated with the accumulation of decomposing carp carcasses. Uncertainty underpinned baseline concerns about the possible impact of CyHV-3 on humans, and on animals other than carp. These concerns extended to agricultural products irrigated with water from waterways in which the virus was active. Whether linked to these concerns, or to the effects of carcass accumulation and decomposition, anxiety about the control of carp using CyHV-3 was negatively correlated with acceptance of the virus. This result underscored the need for proactive and effective communication across a range of social strata, with clear messaging about both strategy for the release of the virus and site-specific plans for the clean-up and disposal of carcasses.

Part V Assessment of social risks

An assessment of the social for the release of *Cyprinid herpesvirus 3* (CyHV-3) for carp biocontrol in Australia

1 Qualitative survey: identification of social risk endpoints

1.1 Introduction

Historically, efforts to understand stakeholder perspectives of community risks has relied on the opinions of experts or peak body representatives. However, understanding the risk perceptions of community members whose livelihoods are likely to be affected by the release of biological control initiatives is paramount to their effectiveness of such initiatives (Warner, 2011). Interviews and group discussions are considered to be the best methods to generate rich information on a complex topic (Crandall *et al.*, 2018).

The qualitative component of the social risk assessment sought to gather insights from individuals living in situ to a potential release or clean-up site. Our respondents were members of local communities who in many cases possessed local knowledge and previous experience relating to significant environmental 'disasters' such as black water events caused by flooding. Rural and regional communities in particular rely on extensive social networks for their livelihoods and wellbeing. They also have direct experience of local institutions (such as local councils) which at times struggled to adequately address infrastructure failings.

While this qualitative research is a stand-alone activity, it also revealed more precise social constructs for use in the development of the large-scale national survey (quantitative component) including assessment of public values, levels of trust and drivers of acceptance. This qualitative component of work also provided an opportunity to corroborate the current literature on public responses to the use of biological release agents for the control of invasive pest species.

Discussions with members of the general public across four select sites were aimed at identifying major social risks related to carp control using the carp virus. This was achieved through interviewing key stakeholders, including recreational fishers and water sports enthusiasts, farmers and irrigators, retirees, Indigenous Australians and the general public more broadly.

1.2 Method

The sites selected for focus group discussions (FGDs) were of social and environmental significance and included Charleville, Penrith, Griffith and Goolwa. To ensure future anonymity, FGD locations referenced in this report will be labelled randomly from A-D from this point. Previously published NCCP stakeholder mapping documents and more recent direct consultation with the NCCP informed our selection of sites and stakeholder groups. It is important to note that our use of the term 'stakeholder' applies to any individual with a vested interest in the process or outcome.

A mixed approach to sampling was used including purposive sampling and relationship-building – a method essential for engaging with Indigenous Australians. In total, eight FGDs were held across the four sites (Table 1). In addition, seven in-depth semi-structured interviews (telephone and

face-to-face) were conducted. Of these, three telephone interviews and one FGD specifically sought Indigenous perspectives.

Table 1 Focus group discussion (FGD) locations, dates and composition

Location	Group(s)
Location A 22-23 November 2017	1 FGD – multicultural perspectives 3 individual interviews (general public including recreational fishers) Secondary data (NCCP stakeholder workshop)
Location B 1-2 February 2018	2 FGDs – mix of general community perspectives including local community organisation representatives (e.g. Rotary, Scouts), local fishing club representatives, local NRM representatives. 1 FGD –Indigenous perspectives plus general public
Location C 16-17 January 2018	3 FGDs – mix of general community perspectives including property owners living near waterways, retirees, recreational fishers, young adults, sporting and fishing groups
Location D 20-21 November 2017	1 FGD with mostly farmers/irrigators plus general public Community shopping centre walk-through (3 informal conversations) Secondary data (NCCP stakeholder workshop)

For FGD participants who were unable to attend the sessions already committed to, invitations to participate in individual interviews were extended.

Indigenous perspectives were analysed as part of the general sample, given the original methodology was to include general community perspectives and not specifically Indigenous groups. However, due to anticipated difficulties in representatively recruiting Indigenous participants for a national survey, we specifically designed and conducted a focus group and a series of phone interviews with Indigenous people currently living in and around waterways to address this challenge. Due to an unexpected funeral held for an Indigenous leader on the day of our Location B visit, three individual interviews were held via telephone at a later date. Through this targeted qualitative approach, we have developed some understanding of Indigenous values and risk perceptions related to carp and carp control using the virus, noting that due to our limited scope for such engagement, they should not be considered representative of Indigenous perspectives more broadly.

It is also important to note that while FGDs participants may identify themselves as being members of the general community, they may also self-report as being a recreational fisher, a retiree, and a mother, for example. In interpreting the qualitative findings, we would advise not focussing too deeply on specific categories of 'stakeholder groups' beyond acknowledging that our FGDs were designed to capture the risk perceptions of individuals living in close proximity to socially and ecologically important waterways.

1.2.1 Strategy 1: Focus Group Discussions

The FGDs sought group perspectives on four key themes considered significant to understanding risk perspectives. These themes are described below:

- **Theme 1**: What do you see as the positives (of carp control- using CyHV-3)? What benefits do you perceive (in relation to carp control) that relate to you, your family, your community.
- **Theme 2**: What do you see as the risks (of carp control)? Are there any negatives to carp control?

- **Theme 3**: Are there any sticking points for you? What are your deal breakers? (i.e. circumstances in which the release of the virus would be absolutely unacceptable?)
- **Theme 4**: What questions do you have about this technology? What information do you need to make an informed decision about release of the virus? From whom would you expect to receive this information? What level of detail do you prefer?

Groups were asked to initially discuss one theme at a time before collating their responses on flip chart paper. Participants were allocated 10 minutes to discuss each question/theme before a plenary discussion was facilitated. Any general questions raised which related to either the science or the implementation of the virus were responded to at the very end of each session, and only if facilitators were confident of providing accurate responses. The majority of questions raised during this session related to enquiries about the suite of research projects underway in the NCCP, the timing of potential release, experiences with other FGDs and sites visited. Each focus group session lasted approximately 1.5 hours.

1.2.2 Strategy 2: telephone interviews

Seven in-depth semi-structured interviews (telephone and face-to-face) were also conducted. Of these, three telephone interviews and one FGD (Location B) specifically sought Indigenous perspectives. The remaining interviews were conducted with individuals who were unable to attend the pre-organised FGDs sessions or who attended out-of-session on the day.

The interview schedule followed the same themes as the FGDs with the exception of Indigenous interviews, where two additional information points were sought – namely, perceived risks to Country, Kinship and an articulation of relationship to one's Aboriginal community.

All participants in both FGDs and interviews were asked for their permission to audio record their contributions. Interviews were between 45-60 minutes in duration.

Qualitative thematic analysis was used to code, categorize and synthesise key risk-related themes. Section 1.3 below summarises and describes the themes which emerged from this process.

1.3 Results and discussion

1.3.1 General results

While an initial list of social risk endpoints was generated at the commencement of this project by the social and ecological risk assessment team, the FGDs and interviews revealed a more nuanced picture of social risks as they relate to local community members' perspectives of how the carp virus might potentially affect their lives, their towns, and more broadly, the Australian landscape (Table 2).

Table 2 Key themes to emerge from FGDs and interviews

Theme	Description
Perceived problem	• The 'carp problem' is a complicated problem with interrelated causes and effects. • It is widely believed that broader environmental change (e.g. effects of drought); intensive agricultural activity; basin regulation (e.g. environmental flow and allocations) and; climate variability have all impacted on current state Australian waterways. • These conditions favour carp proliferation.
Existing social and economic benefits (of carp)	• Carp assist in mosquito control (SA) • Food source for humans, especialy multicultural groups (city and country) • Food source for native birds (e.g. pelicans) • Source of livelihood (formal and informal markets) • Contributes to local economy (e.g. tourism) • Provides cultural and recreational amenity
Values (linked to decision-making about acceptability)	• Biodiversity (fragility of ecosystems) • Indigenous cultural connection to Country • Environmental stewardship • Responsibility to future generations • Important role of integration (of management strategies post release) and careful long-term planning. A measured response to a complex problem.
Impact of previous experiences and events	Past events (and their outcomes) impact on decision-making about acceptability esp levels of trust in virus effectiveness and safety. This is irrespective of relevance to the current problem. For example: • Previous biocontrol failures (e.g. cane toads) – bad outcome - ineffective; • History of virus mutation (human influenza) – bad outcome – mutations continue; • Local blackwater events – bad outcome - scale of clean-up and effort required; absence of government assistance. • Myxomatisis – good outcome - resulted in increased porcupine populations – bush tucker. • Previous local council failures – bad outcome – e.g. threat to potable water quality due to negligence. • Federal government scandals – bad outcome – poor handling of MPs Citizenship saga. • Existing tensions between government and Indigenous groups – ongoing
Trust and confidence (in institutions*) *Institutions are the cultures, ideas, norms, practices, processes, interactions, etc., between individuals and organisations.	• Least trusted organisations are local councils. Low levels of trust relate to capacity (to manage/implement/act), integrity, and transparency. Flow and accuracy of information from councils is poor. • Low levels of trust in government (at all levels) to implement in general. • Most trusted organisations include CSIRO and other science organisations (but they are not infallible). Track record contributes to trust. • Some media organisations for information (e.g. ABC and SBS). • Trust can relate to confidence in information provision, implementation of program, procedural fairness, trust in science (efficacy and safety, levels of certainty). • Trust in peers and professional networks typically high.
Perceived Benefits (of virus release)	• Cleaner water • Clearer water • Increased native fish populations – reduced predation on native fish – recreational amenity improved (benefit for fishers especially) • Preservation of Indigenous cultural practice • Spiritual connectivity between People and Country restored. • Livelihood security (formal and informal trade) • Local tourism security – esp rural (travel for good fishing minimised)
Perceived Risks (of virus release) - General	• Virus mutation/evolution and potential impact on humans, animals and environment • Cross-species transmission (fish and birds) • Risks for human consumption of carp • Water quality and security – for human and livestock consumption, recreation, irrigation, trade and health (e.g. skin disease)
Other - Biosecurity and trade risks	• Perceived risk of damage to international trade (virus is notifiable disease) • Current movement of carp for human use may pose biosecurity risk (existing cultural and livelihood practices) • Movement of virus through food web (eg birds) • Unknown food web changes • Unknown ecosystem effects • Selling of potentially infected carp (formal and informal markets)

Theme	Description
Information (needs and preferences)	• From trusted sources (eg CSIRO) • Widely available • Easily accessible • Containing helpful messages (where, when and who) • Consistently delivered • Localised to context
Program implementation issues (General)	• Careful planning essential. Tailored to local and seasonal conditions. • A comprehensive plan, with detailed infrastructure and dedicated resourcing must exist prior to program commencement. • Discrete dams and private waterholes will provide challenges for release. • Integrated management plan post-release is important. • Environmental regeneration will not be immediate.
Deal Breakers* *Described as "circumstances in which release would be totally unacceptable"	• Transmission risk to flora, fauna and livestock • Risk to humans (water security, safety) • Negative ecological effects (e.g. pelicans, hawks, eagles) • Protracted clean-up • Release occurs despite known risks
Engagement	• Deliberative and deep (inclusive; face-to-face) engagement identified as essential for Indigenous groups and rural and regional communities. • Current NCCP 'consultations' not generally visible more broadly. • Existing cynicism in relation to NCCP motivations. • For Indigenous and rural communities, local knowledge and youth unemployment provide opportunities for involvement. • Voice – for Indigenous groups especially, speaking with the right people and hearing the right people is critical. Relevant traditional custodians, tribal owners and elders must be approached – the government does not always engage with rightful custodians of land and knowledge.
Biomass kill and clean-up* *Issue largely for fishers and other water users. Not an issue readily identified by others. **Clean-up issue almost always connected to other indicators of acceptability (trust; engagement)	• Largely accepted as inevitable BUT regional and rural areas seek involvement in management of clean-up. • Local knowledge identified as critical for effectiveness. • Large kill could attract predators (e.g. feral pigs) – potential impact on riverbanks. • Contractors and others with an economic incentive to complete task effectively and efficiently are best placed to undertake clean-up.

Focus group discussions and interviews consistently revealed participants did not view the 'carp problem' as separate from broader environmental, political and economic drivers of change. On the contrary, the data revealed sophisticated perspectives of waterway systems, local biodiversity knowledge and familiarity with the multiple and interconnected drivers that influence the health of local catchments, including climate change, and federal water governance arrangements. The proliferation of carp was not attributed to a single cause and this more dynamic view often led to discussions about greater goals beyond carp eradication and more towards restoration of catchment health. It also revealed participants' preference for an integrated approach to carp control rather than a 'silver bullet' approach to environmental management.

In addition, there were multiple existing benefits of carp identified by some participants including carp providing a source of food for both humans and animals, and a source of livelihood for both formal and informal (local, unregulated) trade. Carp also provides cultural and recreational amenity for recreational fishers, both large organised groups and independent families (e.g. tourists).

Acceptability of the carp virus is dependent upon a range of factors including individual values, previous experiences and social norms. The values most strongly expressed during discussions about acceptability of virus release can be grouped into two categories: (1) those that relate to the complex relationships humans have with their environment and; (2) people's understanding of the

problem at hand. We commonly encountered views conveying the importance of an integrated approach to pest management including long-term planning, measured responses to a problem considered complex, and a closer focus on biodiversity restoration as opposed to carp eradication. A deeply held concern for the fragility of ecosystems was expressed in several groups.

For Indigenous participants especially, their deep cultural connection to Country was highlighted as a core value. For all Indigenous respondents and others living in rural settings, a responsibility to protect the local environment for future generations was a strong value reflecting deeply held connections to Country, Kinship and ecosystems services more broadly.

Past events (and their negative outcomes) and previous experiences with local organisations' management of local-scale environmental problems influenced perceptions about virus acceptability especially confidence in virus effectiveness and safety. This was irrespective of any previous event's relevance to the current problem, its history, or its likelihood of occurring. Previous biocontrol failures and successes, previous blackwater events and failures in local and federal governance including poor or non-existent community consultation in relation to previous programs strongly influenced both risk perceptions and related levels of trust. In addition, for some, general awareness of virus evolution (e.g. human influenza) contributed to scepticism about virus safety.

Themes relating to trust and confidence were prominent. Trust was a not a static concept and was identified as relating to more than individual organisations. It included the practices, cultures and processes within organisations and their interactions with others. We repeatedly encountered poor confidence in local councils to manage, implement and act on important initiatives in a timely and transparent manner. This conceivably has implications for NCCP local implementation.

Trust can refer to the science itself, scientific and research organisations, professionals working in those organisations, implementing organisations and communication partners. It was noted that CSIRO continues to be perceived as a trustworthy source of scientific information for these communities and the wider Australian public.

Identified benefits of virus release were clear and shared across all groups. These included: cleaner, clearer water; increased native fish populations; preservation of Indigenous cultural practices and; livelihood security for organised business (e.g. local tourism); as well as informal trade.

Identified risks of release included: cross-species transmission (e.g. to native fish and birds, through consumption of infected carp); risks to human health from consumption of infected carp; water quality and security (for human and livestock use) and; the risk of virus mutation and impact for humans, animals and the broader environment. A number of additional risks were identified by participants including perceived risks to biosecurity and trade (local and international). This related to the knowledge that the virus is an internationally notifiable disease. Possible ecosystem effects were also raised especially those that are yet unknown to science.

We asked participants to identify social risk endpoints (described as "deal-breakers") which were explained as "circumstances under which the virus release would be totally unacceptable". Clear views were expressed in relation to this question. Deal-breakers included virus transmission pathways to flora, fauna and livestock; and risks to human health, water safety and water security. Negative ecological effects on the food web (potential impacts on pelicans, eagles and hawks were

a concern in some regions) were also mentioned. A protracted clean-up process was consistently identified as a deal-breaker. Finally, virus release despite known (and serious risks) was considered as totally unacceptable.

Views important to implementation were shared and again reflected careful, integrated and systematic perspectives of the problem and the proposed solution. The challenges of accessing private waterholes and dams were identified potentially difficult as was the need to tailor virus release to local and seasonal conditions. Individuals spoke of needing clear and accessible information about proposed release, from a trusted source, well in advance of virus release. The information provided needed to be localised and contain helpful messages about release (e.g. where, who and when).

A recurring theme in discussions was the desire and expectation that communities be included in decision-making about virus release and its impacts (e.g. clean-up). Regional and rural participants particularly sought to be engaged (not simply informed) at all stages of decision-making. Local knowledge was considered critical for program success.

For Indigenous groups, deliberative engagement, led by respected facilitators and involving relevant custodians and appropriate spokespersons was seen as critical to a fair process. We encountered cynicism of the recent NCCP-led stakeholder consultation process among several groups we engaged with, indicating some communities required more meaningful engagement with decision-makers than they believed the stakeholder consultation process afforded. The risk of community distrust and outrage in small, tight-knit rural communities is very real.

1.3.2 Limitations

Despite employing a range of methods to invite participants to the FGDs (including social media, direct telephone contact, and face-to-face interaction), overall, general public attendance was relatively poor. This may reflect a lack of community interest in the issue for those not directly affected by the ‘carp problem’. However, for one group in Location B, the unexpected death of a local aboriginal Elder reduced a planned group of eight Indigenous participants to a group of two. We thus adapted our methodology to include individual interviews so that a wide range of perspectives were still canvassed.

2 Quantitative nationwide survey: evaluation of social risk endpoints

2.1 Introduction

Large-scale interventions to control invasive species in sensitive environments are often regarded as controversial and involve a range of social as well as ecological risks. Understanding the range of public perceptions, attitudes and social risks is therefore increasingly important for effective planning and management of such interventions. The national survey aimed to assess social risks associated with carp control using Cyprinid herpesvirus 3 (aka, CyHV-3 or carp virus) and identify potential mitigating strategies.

To develop a framework for the social risk assessment of carp control using CyHV-3, we conducted a series of qualitative focus groups and interviews with key stakeholders, as well as an extensive literature review of research on public attitudes and social risks associated with invasive species management. Through integrating the findings from literature and the research findings from qualitative research with key stakeholders (see Section 1), a number of potential drivers of risk perceptions and attitudes towards carp control using CyHV-3 were identified. These included personal knowledge and views of carp awareness of its impacts and how management of carp virus might be implemented. The relationships between these factors were complex and interacted with each other in influencing individuals' perception of and attitudes towards management approaches and trust.

The objective of the national survey was to quantitatively assess the effects of identified factors on attitudes towards carp control using CyHV-3, and consequently help inform decision-making on the implementation of carp control using the carp virus. Our aim was to develop a systematic and quantitative framework to:

- Evaluate and quantify public risk perceptions associated with the use of the carp virus
- Identify contributing factors that can shape risk perceptions
- Investigate potential moderating factors which might mitigate the impact of risk perceptions.

In addition, key social groups as well as demographic profiling were incorporated in the survey design and analysis. The survey findings will provide a detailed understanding of social risks associated with controlling carp using the carp virus in Australian waterways and help design an effective engagement process if the carp population is going to be controlled by releasing CyHV-3.

2.2 Method

2.2.1 Measures

To assess the key factors identified in Section 1.1, a survey (questionnaire) was designed through adapting existing social risk and attitudinal measurements in the relevant literature to the carp control context, while also drawing on previously conducted qualitative research, and through

consultation with CSIRO's ecological risk assessment team and the NCCP for specific carp control knowledge. The detailed assessment scales are presented in the following Results section. The full survey is also attached in Appendix A.

To achieve the goals of the research project, the survey was designed to collect data toward the following objectives:

- To assess current general knowledge and perceptions of carp and its impact, as well as awareness of the proposed carp control using CyHV-3, as possible antecedents to social risk interpretation
- To understand perceived needs and benefits, as well as concerns and potential psychological harm, associated with carp control after receiving specific information on carp, its impacts and proposed control approach
- To evaluate risk-related attitudes towards hypothetical scenarios of potential ecological impacts caused by carp control using CyHV-3
- To assess attitudes towards carp control using CyHV-3 and identify influential underlying drivers
- To identify key management strategies if proposed carp control goes ahead.

2.2.2 Procedures and participants

Online research company Taverner Research was engaged to conduct recruitment and data collection, as is standard practice in quantitative social science survey research. The study was approved by CSIRO's Social Science Human Research Ethics Committee, in accordance with the Australian National Statement on Ethical Conduct in Human Research. A pilot survey of 45 participants was conducted and minor adjustments were made to the survey. The final survey was conducted during the period of 24 September and 28 October 2018. Participants were offered a token incentive by the research recruitment company for their participation.

The survey sampling strategy was designed to catch a wide and representative range of people who lived along waterways, especially the Murray Darling regions (as requested by the NCCP) and in urban areas across Australia. In total, 2026 people participated in the online survey (Table 3). Table 1 presents the demographics of the participants and represents alignment with Australian Bureau of Statistics demographic profiles, where possible.

Table 3 Demographic detail about participants

Categorisation	Number	%
Gender		
Male	890	44.2%
Female	1125	55.8%
Age		
18-24 years	130	6.4%
25-34 years	332	16.4%
35-44 years	357	17.6%
45-54 years	326	16.1%
55-64 years	396	19.6%
65-74 years	397	19.6%
65 years or over	87	4.3%
Education		

Categorisation	Number	%
Completed Year 10	305	15.1%
Completed Year 12	331	16.3%
Certificate or Diploma	708	34.9%
Tertiary undergraduate	426	21.0%
Tertiary postgraduate	256	12.6%
Residential location		
Metropolitan areas	1024	50.5%
Murray Darling Basin	1002	49.5%
Hobby fishing		
Yes	666	32.9%
No	1360	67.1%

2.2.3 Statistical analysis

Independent sample t-test, bivariate correlation, and structural equation modelling were employed to analyse the survey data.

2.3 Results and discussion

Social risk results pertaining to the ecological risk assessment (Section 2.3.1) are presented first, followed by the more general social risk findings (Section 2.3.2 onwards).

2.3.1 Social-ecological parameters of carp control and management

2.3.1.1 Direct social risk impacts of carp mortality

Visual disturbance and stench from significant carp mortality arising from CyHV-3 virus infection at points of aggregation.

The potential impacts of visual disturbance and stench from significant carp mortality were assessed through measuring concerns over the impacts on local tourism, business, and people. Participants were asked to indicate how concerned they were in relation to the following statements (1 = not concerned at all, 3 = somewhat concerned, 5 = concerned a lot):

- "*Large quantities of dead carp may negatively affect local tourism*"
- "*Large quantities of dead carp may negatively affect local business*"
- "*Large quantities of dead carp may negatively affect local people*"
- "*The smell of dead carp may negatively affect local people.*"

Generally speaking, general public concerns over the negative impacts of visual disturbance and stench from significant carp mortality on local tourism, business, and people were moderate, being at around the levels of "somewhat concerned". There were significant differences between male and female participants ($p<0.0001$, Figure 3), such that female participants expressed comparatively stronger concerns over the potential impacts than male participants.

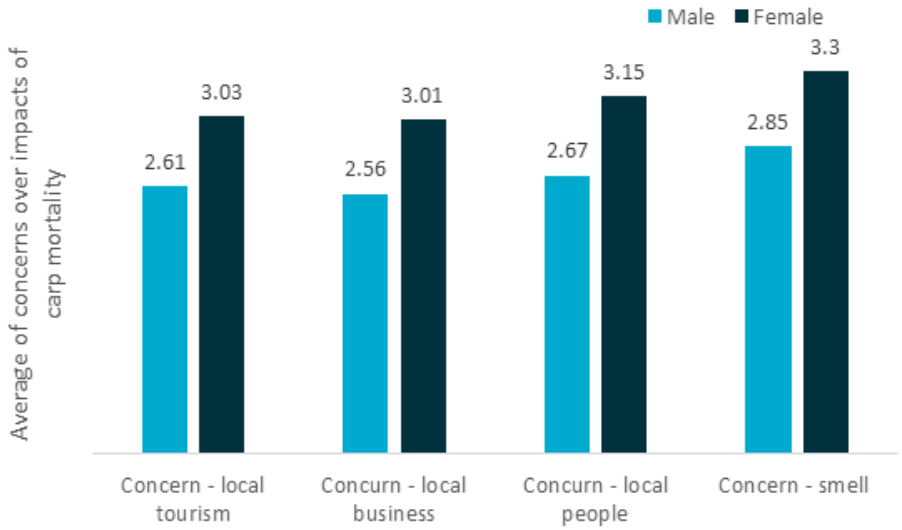


Figure 3 Concerns over visual disturbance and smell from carp mortality by gender

Note: 1=not concerned at all, 5=concerned a lot

The differences between metro and MDB participants were statistically significant but less pronounced ($p<0.013$, Figure 4). MDB participants were comparatively less concerned than metro participants.

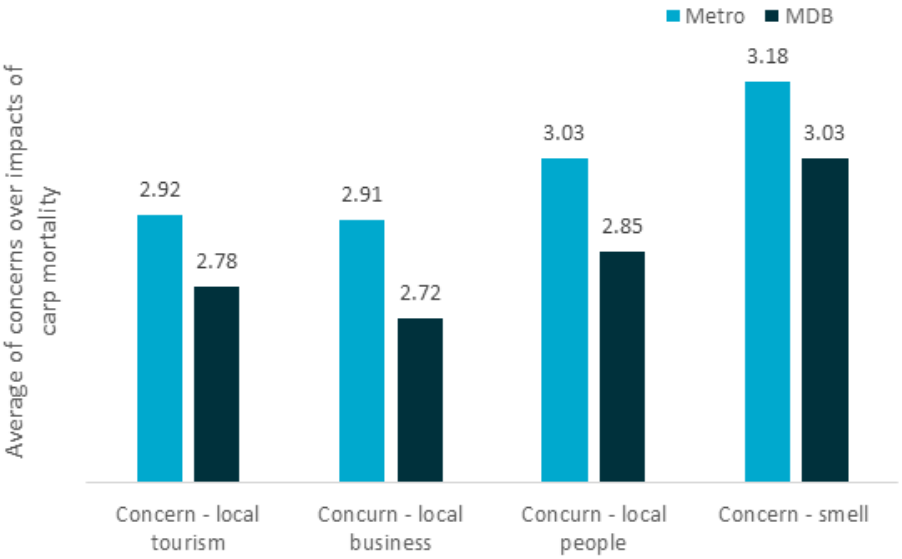


Figure 4 Concerns over visual disturbance and smell from carp mortality by location of residence

Note: 1=not concerned at all, 5=concerned a lot

In addition, age was negatively and significantly associated with the various concerns, such that older participants tended to be less concerned over the impacts on local tourism ($p<0.001$), local business ($p<0.001$), local people ($p<0.001$) and smell ($p<0.001$), while controlling for the effects of gender and location of residence.

Non-target species susceptibility to infection with CyHV-3 virus or affected by consuming dead carp.

Perceived risks that non-target species may be infected by the CyHV-3 virus, or be harmed through consumption of carp killed by the virus, were assessed by asking participants their level of concern regarding the following two possibilities (1 = not concerned at all, 3 = somewhat concerned, 5 = concerned a lot):

- "The carp virus may affect native species in the virus-treated waterways"
- "Domestic pets may get sick if they eat dead carp that are killed by the virus"

Overall, concerns about the risks of non-target species being infected in virus-treated waterways and domestic pets getting sick through consumption of dead carp were moderate, typically around the level of "somewhat concerned". There were significant differences between male and female participants (Figure 5), such that female participants were comparatively more concerned about the non-targeted species being affected than male participants. Although the differences between metro and MDB participants were significantly different, the differences were of a smaller magnitude.

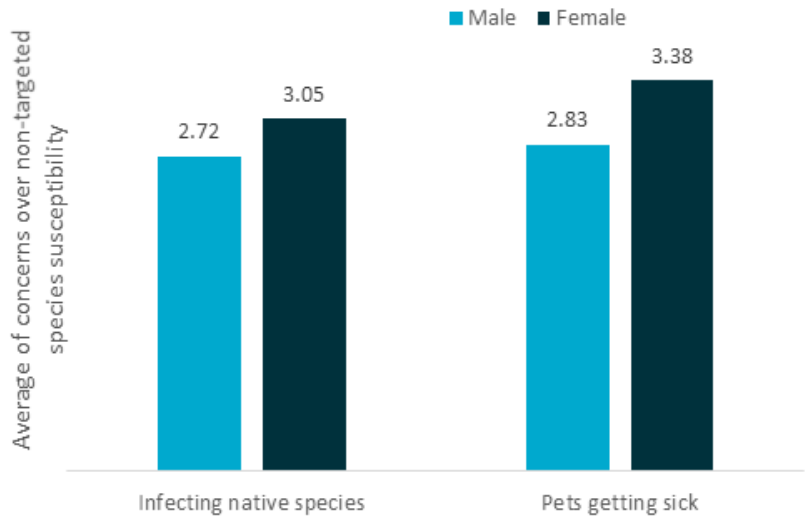


Figure 5 Concerns over non-targeted species being affected by gender

Note: 1=not concerned at all, 5=concerned a lot

While controlling for the effects of gender and location of residence, age was negatively and significantly associated with concern ($p<0.0001$). In particular, older participants were less concerned about native species being infected by the virus and domestic pets getting sick from consuming dead carp. However, these concerns were not related to participants' levels of education.

It is interesting to note, here, that participants typically reported lower perceived risks with respect to the virus affecting humans. However, participants typically reported higher perceived risks of the virus when considering non-target environmental factors and the health of domestic animals.

Reduced carp abundance arising from CyHV-3 virus release affecting top order species and cascading to other species.

Concerns over the risks that reduced carp population may affect top order species and cascading to other species were assessed by asking participants how concerned they were with the following three possibilities (1 = not concerned at all, 3 = somewhat concerned, 5 = concerned a lot):

- "*Reducing carp populations may remove an important food source for some animals*"
- "*Removing carp from the waterways will negatively affect the livelihoods of people who live near waterways*"
- "*Reducing carp populations may encourage other pests to fill the gap*."

Overall, participants expressed limited concern over the risks that reduced carp populations may affect top order species and cascading to other species. Among the three possible risks assessed, concern over the possibility that reduced carp population may encourage other pests to fill the gap was comparatively stronger. There were significant differences between male and female participants ($p<0.0001$, Figure 6), such that female participants expressed comparatively stronger concerns than male participants. There were also significant differences between metro and MDB participants ($p<0.0001$, Figure 7), such that metro participants expressed relatively stronger concerns than MDB participants. In addition, after the effects of gender and location of residence were controlled for, age was negatively related to the concerns, and education was positively related to the concerns to a lesser degree (Table 4). That is, older participants were less concerned about those risks compared to young people; and participants with higher levels of education expressed stronger concerns compared to those with lower levels of education.

Table 4 Partial correlations between concerns over affecting top order species and age and education while controlling for gender and location of residence

Category	Removing food source for some animals	Affecting livelihoods of local people	Encouraging other pests filling the gap
Age	-0.32***	-0.23***	-0.18***
Education	0.07**	0.07**	0.09***

Note: *** $p<0.001$, ** $p < 0.01$.

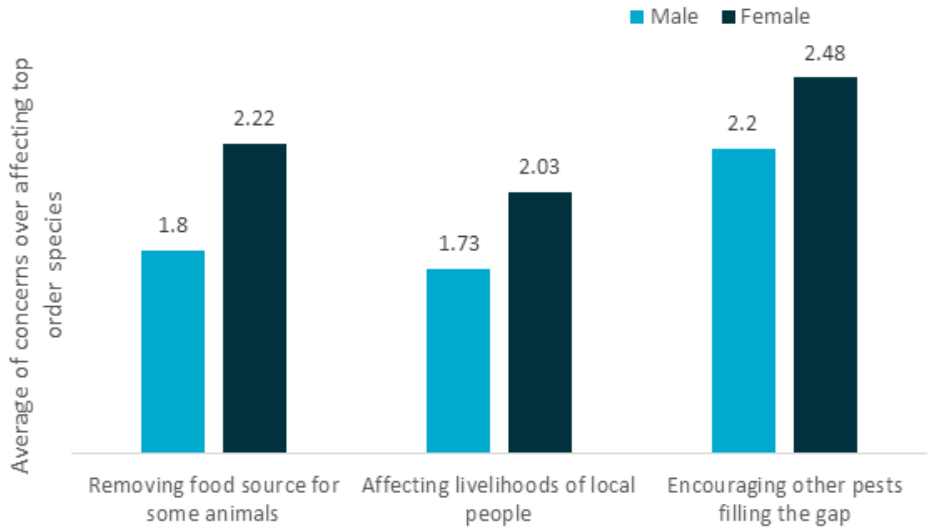


Figure 6 Concerns over affecting top order species through reduced carp population by gender

Note: 1=not concerned at all, 5=concerned a lot

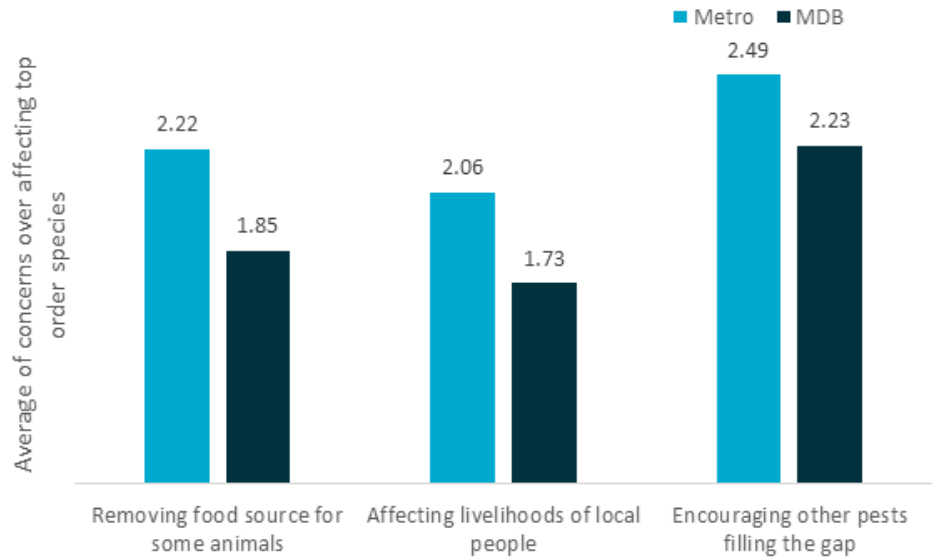


Figure 7 Concerns over affecting top order species through reduced carp population by location of residence

Note: 1=not concerned at all, 5=concerned a lot

2.3.1.2 Attitude towards hypothetical scenarios of ecological impacts

Ecological risk assessment was conducted by CSIRO's ecological impact assessment team to evaluate the potential ecological impacts from using Cy-HV3 to control carp population. A number of hypothetical scenarios associated with potential ecological impacts were developed in collaboration with the ecological risk team. Participants were presented with the scenarios and then asked to indicate how much they would be willing to accept the outcomes of each scenario respectively. The survey assessed participants' reactions to the hypothetical scenarios.

Native aquatic species mortality from poor water quality caused by dead carp

One potential ecological impact is that the carp virus may kill large quantities of carp, leading to reduced oxygen levels in the water and increased potentially harmful bacteria. Participants were

asked to indicate the level of acceptability with the potential impacts on native aquatic species (1 = not at all acceptable, 4 = not sure, 7 = very acceptable) as the following:

"*Large quantities of dead carp may impact water quality in the short term, through reducing available oxygen in the water and increasing potentially harmful bacteria. This could mean that…"*

- *"The poor water quality causes a few deaths of native species, but their population will quickly recover"*
- *"The poor water quality causes some deaths of native species, and their population will take a while to recover"*
- *"The poor water quality causes many deaths of native species, and some of them may become locally extinct."*

Overall, the levels of acceptability decreased as the magnitudes of impacts increased (Figure 8). In addition, female participants displayed significantly lower levels of acceptability compared to male participants across all possible impact outcomes ($p<0.0001$). When the impact was described as a few deaths with quick recovery, the levels of acceptability were around the midpoint for both male and female participants. It appears that this level of impacts may be tolerable but would likely be conditional acceptance given this level of uncertainty in responses. However, when the impact was portrayed as "many deaths and some may become locally extinct", both male and female participants stated that this outcome was not acceptable.

The differences between metro and MDB participants were not significant or were not pronounced in these scenarios ($p<0.0001$, Figure 9). Similarly, a few deaths with quick recovery was the only option that could be accepted by both metro and MDB participants.

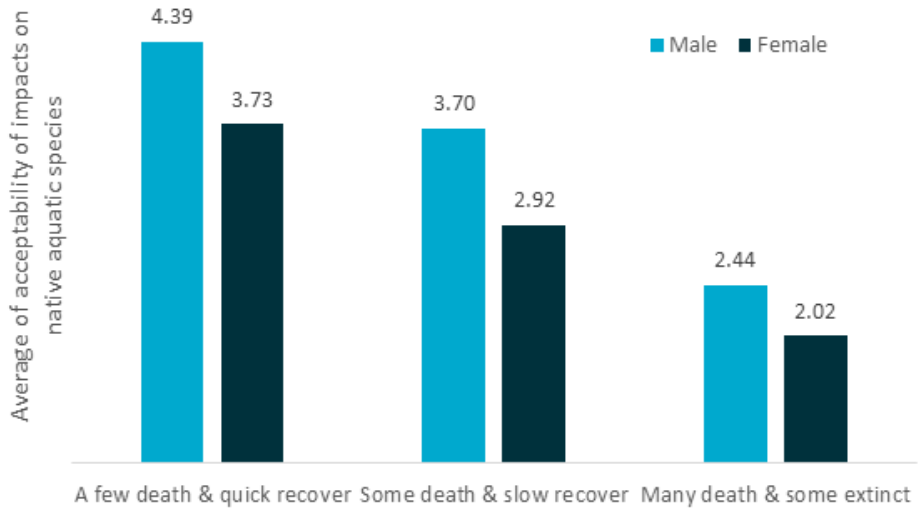


Figure 8 Acceptability of impacts on native aquatic species from poor water quality by gender

Note: 1=not at all acceptable, 7=very acceptable

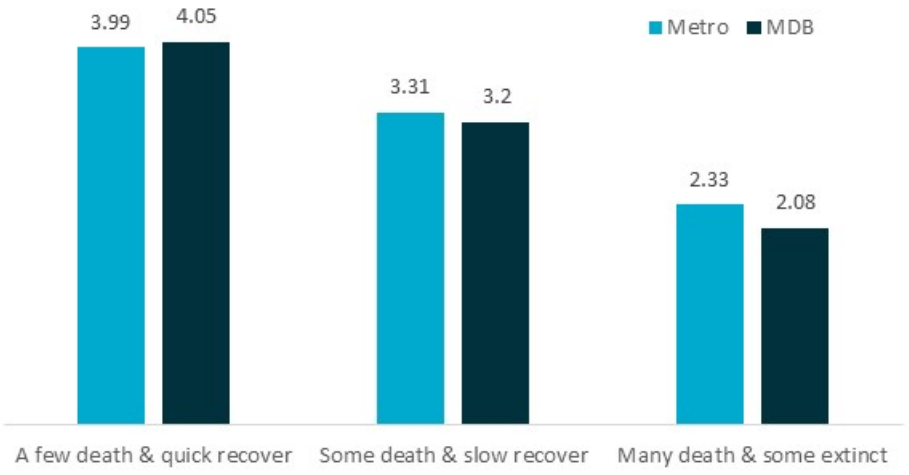


Figure 9 Acceptability of impacts on native aquatic species from poor water quality by location of residence

Note: 1=not at all acceptable, 7=very acceptable

Clean-up scenarios for significant carp mortality arising from CyHV-3 virus infection at points of aggregation.

Three hypothetical scenarios were constructed regarding the geographic scales of dead carp, with time frames for clean-up and options of clean-up being described for each scenario. Participants were informed that the scenarios were hypothetical only with an intention to gauge how people felt about different possibilities surrounding fish clean-up. They were then presented with the scenarios as well as possible time frames and approaches for fish kill clean up; participants were asked to indicate the level of acceptability with each possible condition under each scenario (1 = not at all acceptable, 4 = not sure, 7 = very acceptable).

Scenario 1: Carp killed in closed/isolated locations

To assess the levels of acceptability with three clean-up options when carp are killed in closed/isolated locations, the following instruction and clean-up approaches were presented to participants – "*If the virus is released, many carp are killed by the virus in closed/isolated location, and:*

- *They are subsequently cleaned up in a short period of time (e.g. within 1 week)*
- *They are subsequently cleaned up over an extended period of time (e.g. within 2-3 weeks), may lead to substantial foul smell.*
- *They are subsequently cleaned up only near waterway access points and human populations*."

In general, the results suggested that clean-up in a short period of time is the only option that was acceptable to all participants. There were significant differences in the levels of acceptability across the three clean-up approaches between genders, such that male participants expressed relatively higher acceptable levels compared to female participants ($p<0.0001$, Figure 10). As shown in Figure 10, the option of clean-up occurring within a week of a fish kill event was favourably accepted by both genders. However, when the time frame for clean-up was increased to 2-3 weeks, male participants were unsure whether it was acceptable, while female participants

clearly regarded it as somewhat unacceptable. The option of clean-up only near waterway access points and human populations was the least acceptable, especially for female participants.

The comparison in acceptability levels between metro and MDB participants revealed that, while both metro and MDB participants were in favour of clean-up within a week, MDB participants expressed significantly stronger acceptability levels ($p<0.0001$, Figure 11). When the time frame for clean-up was increased to 2-3 weeks, both metro and MDB participants regarded it as somewhat unacceptable. The final option of clean-up only near waterway access points and human populations was even less acceptable.

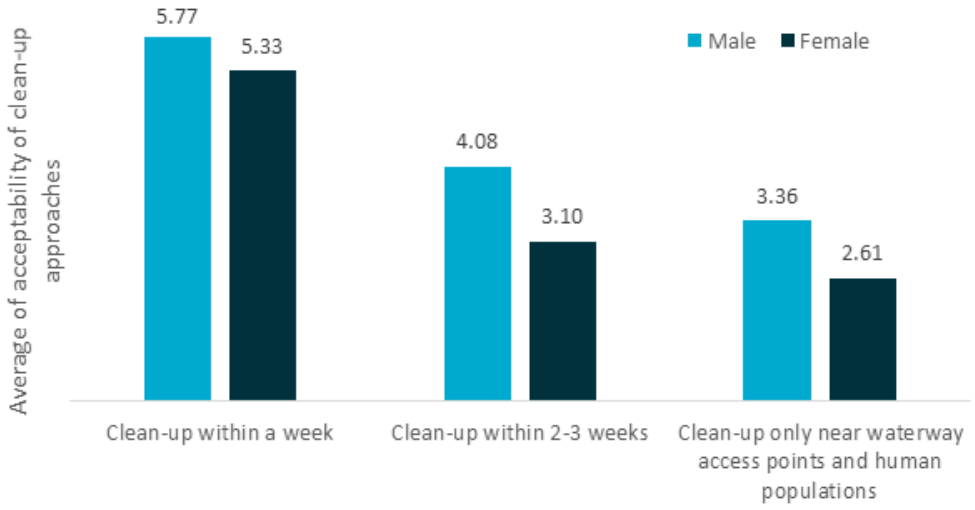


Figure 10 Acceptability of various clean-up approaches when carp killed in closed location by gender

Note: 1 = not at all acceptable, 7 = very acceptable

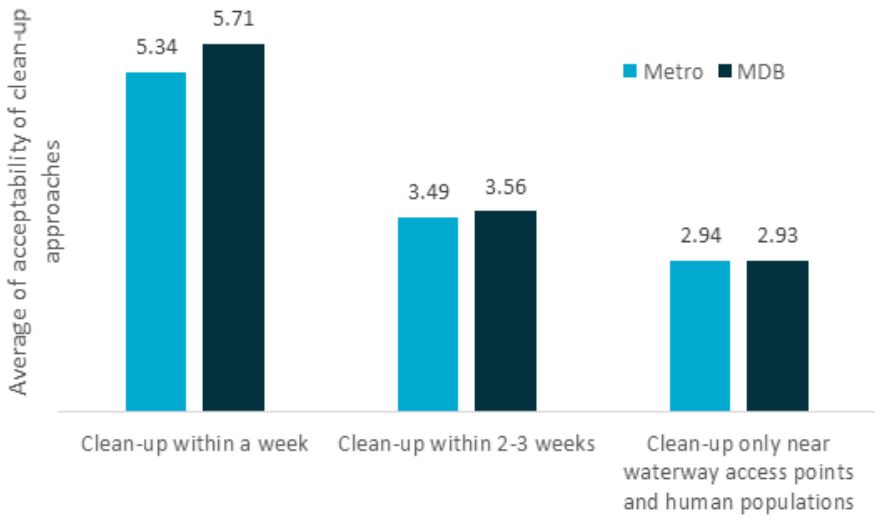


Figure 11 Acceptability of various clean-up approaches when carp killed in closed location by location of residence

Note: 1 = not at all acceptable, 4 = not sure, 7 = very acceptable

Scenario 2: Carp killed in moderate stretches of water (e.g. 10s of km)

To assess the levels of acceptability with three clean-up options when carp are killed in moderate stretches of water, the following instruction and clean-up approaches were presented to participants – "*If the virus is released, many carp are killed by the virus along moderate stretches of water (e.g. 10s of km), and:*

- *They are subsequently cleaned up in a short period of time (e.g. within 1 week)*
- *They are subsequently cleaned up over an extended period of time (e.g. within 2-3 weeks), may lead to substantial foul smell*
- *They are subsequently cleaned up only near waterway access points and human populations.*"

As shown in Figure 12 and Figure 13, the acceptability levels for the three clean-up options by gender and location of residence displayed the same pattern as reported in Scenario 1, but with lower mean acceptability scores.

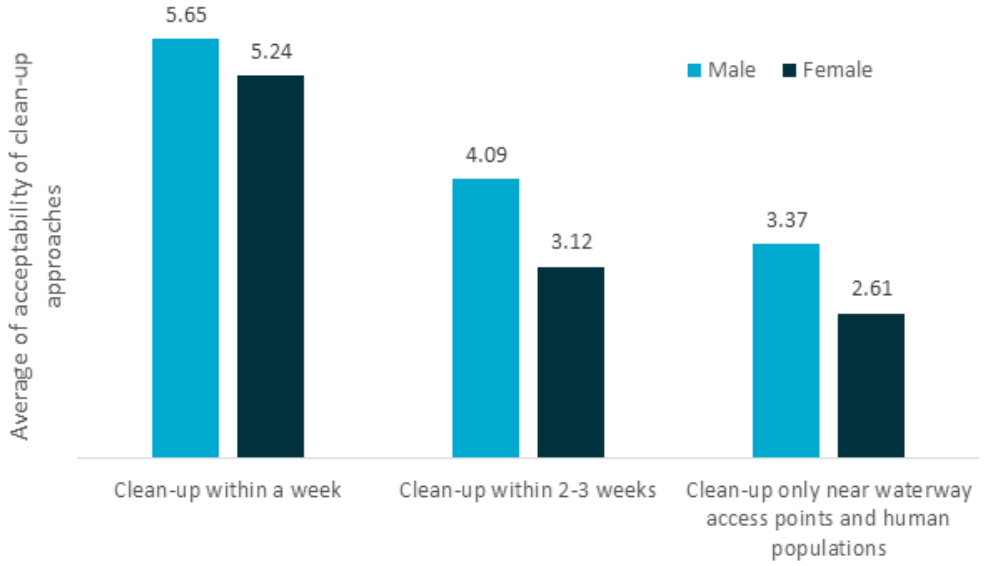


Figure 12 Acceptability of various clean-up approaches when carp killed in moderate stretches of water by gender

Note: 1 = not at all acceptable, 7 = very acceptable

Figure 10 Acceptability of various clean-up approaches when carp killed in moderate stretches of water by gender (1 = not at all acceptable, 7 = very acceptable)

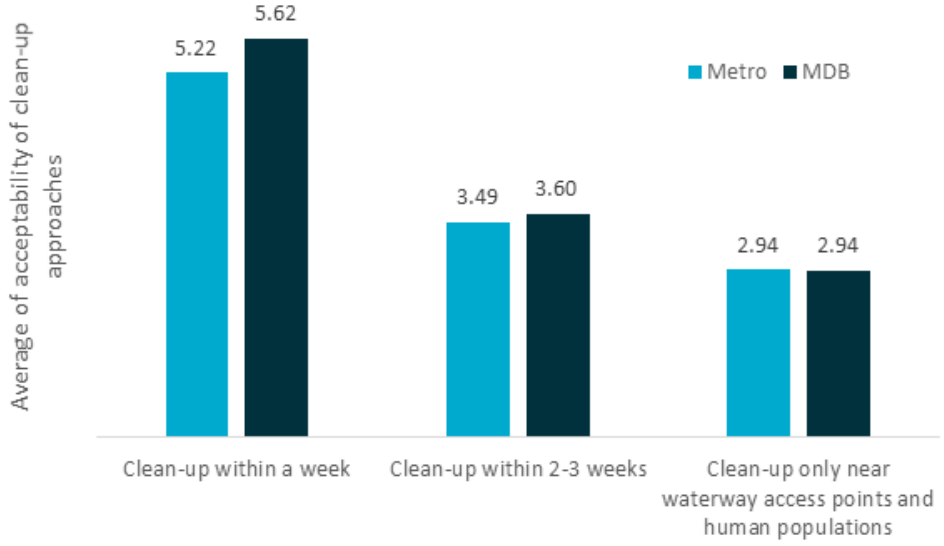


Figure 13 Acceptability of various clean-up approaches when carp killed in moderate stretches of water by location of residence

Note: 1 = not at all acceptable, 4 = not sure, 7 = very acceptable

Scenario 3: Carp killed in large stretches of water (e.g. 100s of km)

To assess the levels of acceptability with three clean-up options when carp are killed in large stretches of water, the following instruction and clean-up approaches were presented to participants – "*If the virus is released, many carp are killed by the virus along large stretches of water (e.g. 100s of km), and:*

- *They are subsequently cleaned up in a short period of time (e.g. within 1 week)*
- *They are subsequently cleaned up over an extended period of time (e.g. within 2-3 weeks), may lead to substantial foul smell*
- *They are subsequently cleaned up only near waterway access points and human populations*"

As shown in Figure 14 and Figure 15, the acceptability levels of the three clean-up options by gender and location of residence displayed the same pattern as reported in Scenarios 1 and 2, with even lower mean acceptability scores.

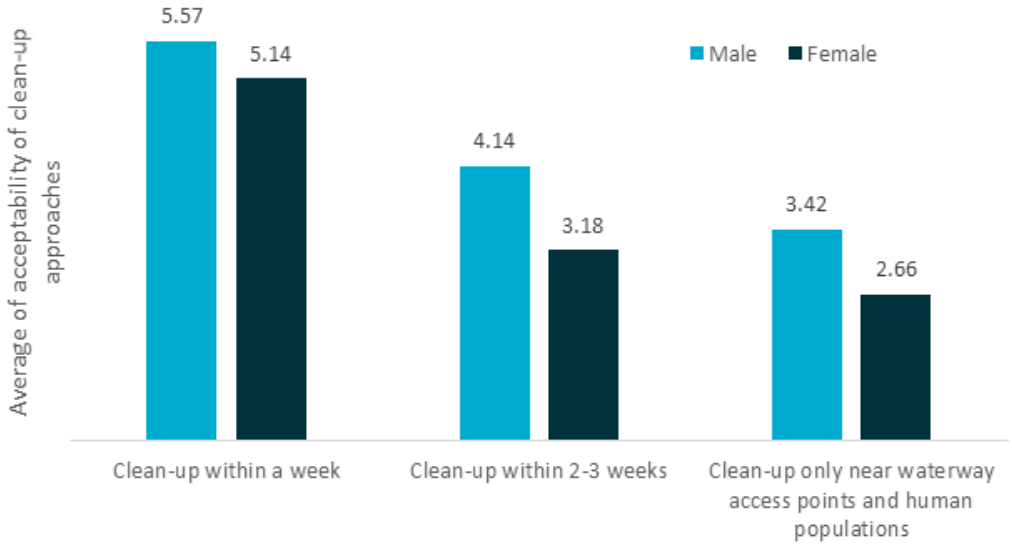


Figure 14 Acceptability of various clean-up approaches when carp killed in large stretches of water by gender

Note: 1 = not at all acceptable, 7 = very acceptable

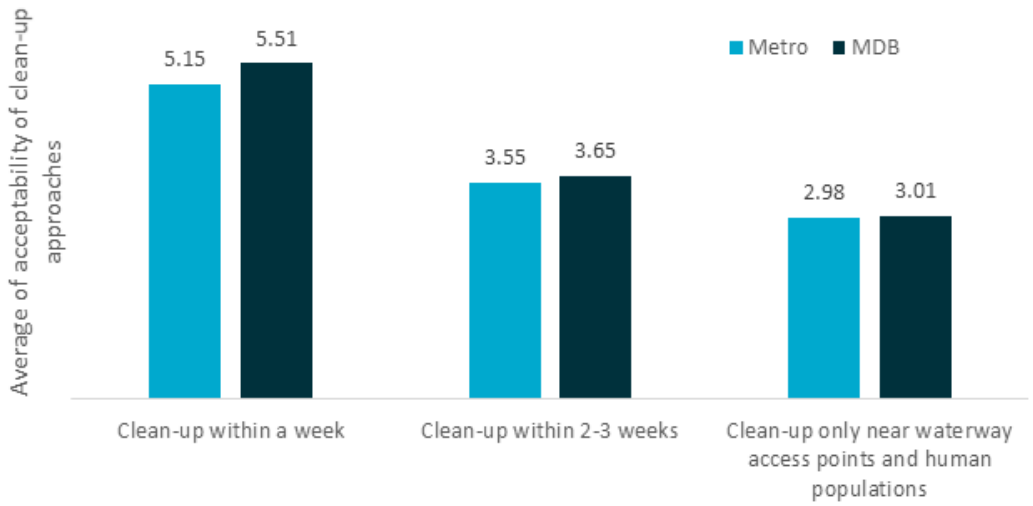


Figure 15 Acceptability of various clean-up approaches when carp killed in large stretches of water by location of residence

Note: 1 = not at all acceptable, 7 = very acceptable

Comparison between the three hypothetical scenarios

Figure 16 presents the average acceptable levels of three clean-up approaches across the three scenarios (i.e. carp killed in closed/isolated locations, or moderate stretches of water, or large stretches of water). The findings suggest that, across the three scenarios, clean-up within a week is the only readily acceptable option; clean-up within 2-3 weeks can be manageable but would require effective strategies in place to engage greater support; clean-up near waterway access points and human populations only will not receive support from the public and impose the social risk of public resistance.

Interestingly, there were no significant differences in the levels of acceptance for each clean-up options between the three scenarios ($p<0.0001$), suggesting that the magnitude of impacted areas may not affect public acceptance levels as long as the clean-up is conducted and completed in a short period of time (i.e. within a week).

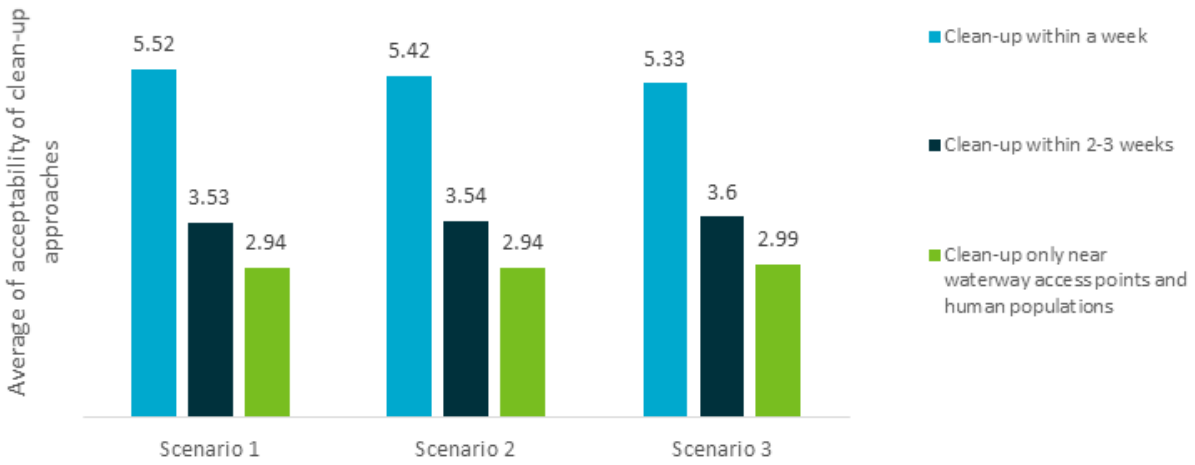


Figure 16 Acceptability of three clean-up approaches under three impact areas

Note: 1 = not at all acceptable, 7 = very acceptable

Carp deaths arising from CyHV-3 infection recurring at reduced levels, over multiple years.

CSIRO's epidemiological modelling indicates that, once the CyHV3 virus is released and the initial wave of deaths has slowed, there will likely be spontaneous virus outbreaks over time when conditions are favourable. Social acceptability of this likelihood was assessed using the following statement:

"*Once released, virus outbreaks will naturally reoccur in future years if conditions are favourable. This will once again result in dead carp, but at lower numbers than in the initial release. Please indicate how acceptable this would be to you. (1 = not at all acceptable, 4 = not sure, 7 = very acceptable*".

There were significant difference in levels of acceptability between genders ($p<0.0001$), such that male participants were far more comfortable than female participants in accepting recurring carp deaths caused by virus outbreak when conditions are favourable, even though female participants also expressed moderate acceptability levels (Figure 17). The difference between metro and MDB participants was statistically different, but very weak.

Figure 17 Acceptability of future dead carp caused virus outbreak

Note: 1 = not at all acceptable, 7 = very acceptable

Participants were further asked to indicate that "for the ongoing carp deaths, how often the clean-up should be conducted?" As shown in Figure 18, nearly half of the participants (46%) preferred an immediate clean-up (i.e. as soon as the dying carp surface), with a further 26% preferred the clean-up happening on a weekly basis.

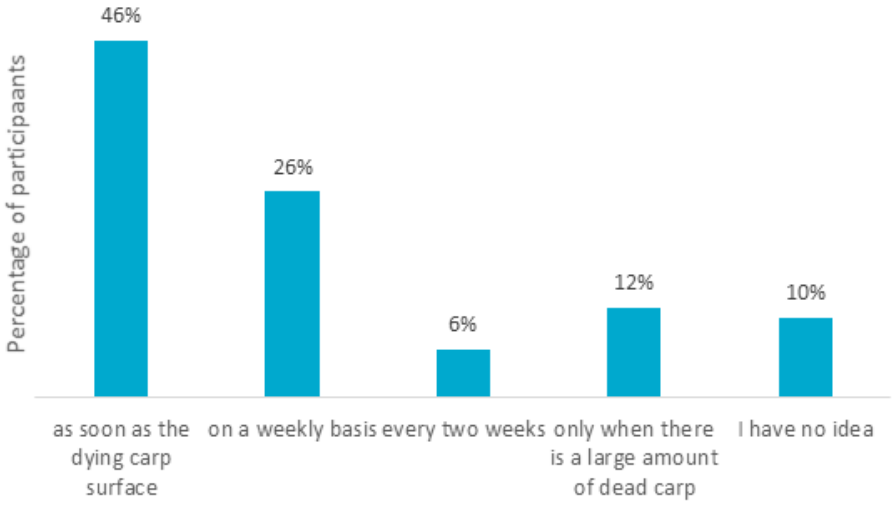


Figure 18 Preferred frequency of clean-up for the recurring carp death

Responsibility for clean-up of dead carp.

Participants were asked to indicate which organisations should be responsible for the clean-up of dead carp; they were able to select up to three organisations from a list of six. Figure 19 presents the percentage of participants who nominated each organisation for the clean-up of dead carp. The results suggest that local council/government was the most nominated organisation for the clean-up (62%), followed by state government agencies (55%), natural resource management agencies (53%), federal government agencies (34%), community clubs (7%), and local citizens (4%).

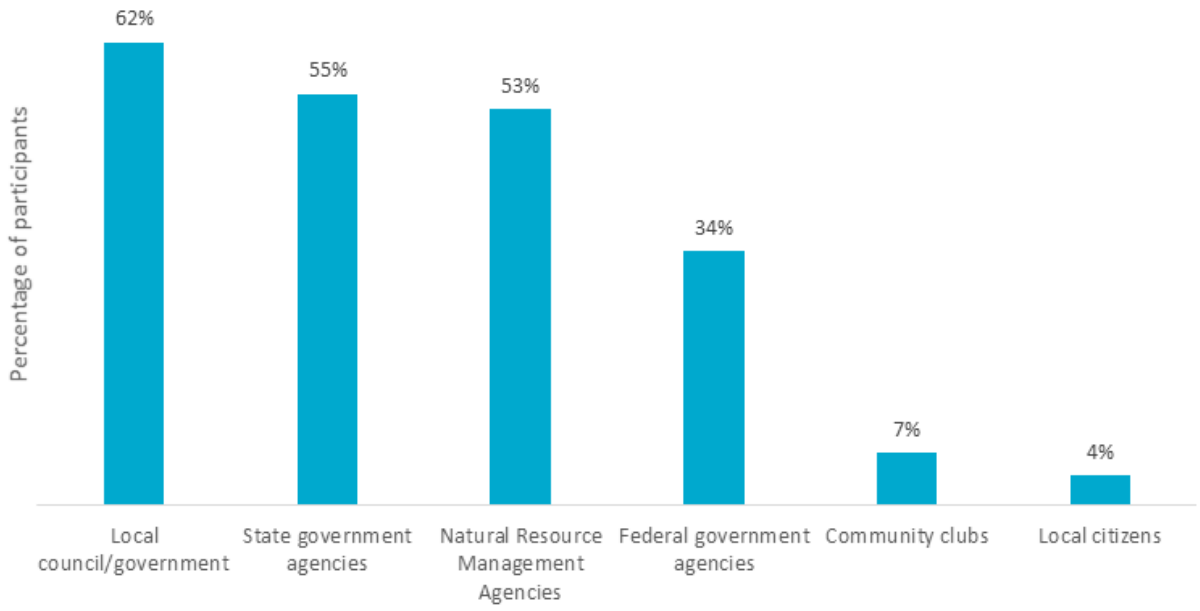


Figure 19 Nominated organisations for clean-up of dead carp by percentage of participants

Procedural fairness.

It has been well established that procedural fairness is key for obtaining public support, particularly for contested issues. The proposal of using CyHV-3 to control carp populations has already been met with challenges from various stakeholders and interest groups. Hence, a fair procedure to engage the public will be critical if the proposal is to go ahead. This survey aims to develop insights into what a fair procedure looks like from the public's perspective. Such understanding will help design an effective and responsible engagement process to gain public support, should CyHV-3 be used to control carp.

To assess what is important in a fair process from the public's perspective, participants were informed that while scientists, governments, and resource management agencies worked on strategies to manage carp in Australian waterways, it was also important to know/understand how members of the public wished to be kept informed and involved. Participants were asked to indicate the extent to which they agreed with the following statements (1 = strongly disagree, 4 = not sure, 7 = strongly agree).

- "*It is important for me to be informed about the decision-making process*"
- "*It is important for me to have opportunities to provide my views and feedback*"
- "*It is important to have all relevant information published on the NCCP's website and social media (e.g. Facebook)*"
- "*It's important for majority views to be acted on in implementing the carp control plan.*"

The results show that participants regarded all key components of procedural fairness (i.e. being informed, opportunities to provide feedback, information transparency, and majority views to be adopted) as moderately-highly important (Figure 20). There were no significant differences between gender or between locations of residence ($p>0.05$).

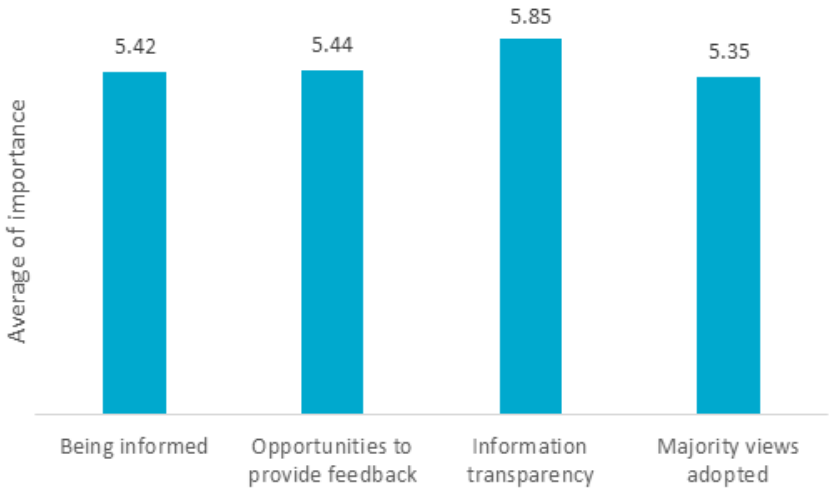


Figure 20 Importance of being involved and engaged

Note: 1 = strongly disagree, 7 = strongly agree

Trust.

Trust specific to which organisations should manage the carp control program was assessed by asking participants to rate the level of trust they had in each of the following four types of organisations to manage the carp control program on a 5-point scale (1 = very low trust, 3 = moderate trust, 5 = very high trust):

- Federal government agencies
- Natural Resource Management Agencies
- State government agencies
- Local council / government.

As shown in Figure 21, among the four types of organisations, natural resource management agencies were regarded the most trusted organisations to manage the carp control program including virus release, clean-up, and disposal. Less trust was displayed towards the other three types of organisations, with local council/government, state government agencies and federal government agencies. There were no remarkable differences between levels of trust across the four types of organisations, or between male and female participants and metro and MDB participants.

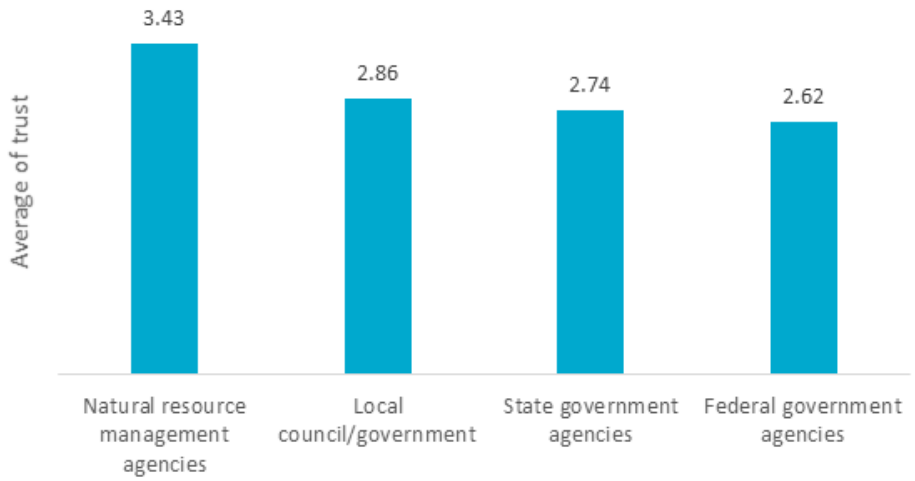


Figure 21 Trust in various organisations to manage carp control program using CyHV-3

Note: 1 = very low trust, 4 = moderate trust, 5 = very high trust

Safety and management of carp control program.

We evaluated the importance of particular activities and practices that could be carried out if the carp virus were to be released. Participants were asked to indicate how important each of the following activities were to them on a 5-point scale (1 = not important at all, 3 = moderately important, 5 = extremely important).

- Regular independent auditing and regulation of water systems
- Public reporting of water quality tests and virus effectiveness following virus release
- Open days to visit virus release sites and talk with authorities
- Community updates/briefings for those who are interested
- Information on the carp virus release in newspapers, radio or television
- A visitor's centre at virus release sites or local Natural Resource Management offices
- Public talks by carp virus experts and scientists, with 'Question and Answer' sessions
- Education programs in schools.

Figure 22 presents the average importance for each of the safety and management activities, as reported by all participants. The results indicate that independent auditing and regulation, as well as public reporting of water quality tests and virus effectiveness, are the most important activities from participants' perspective. Having visitor centres or open days were regarded as the least important activities – but these were still seen as moderately important overall. Generally speaking, and as shown in Figure 23 and Figure 24, recreational fishers and carp consumers put higher levels of importance on most of the management activities than their counterparts.

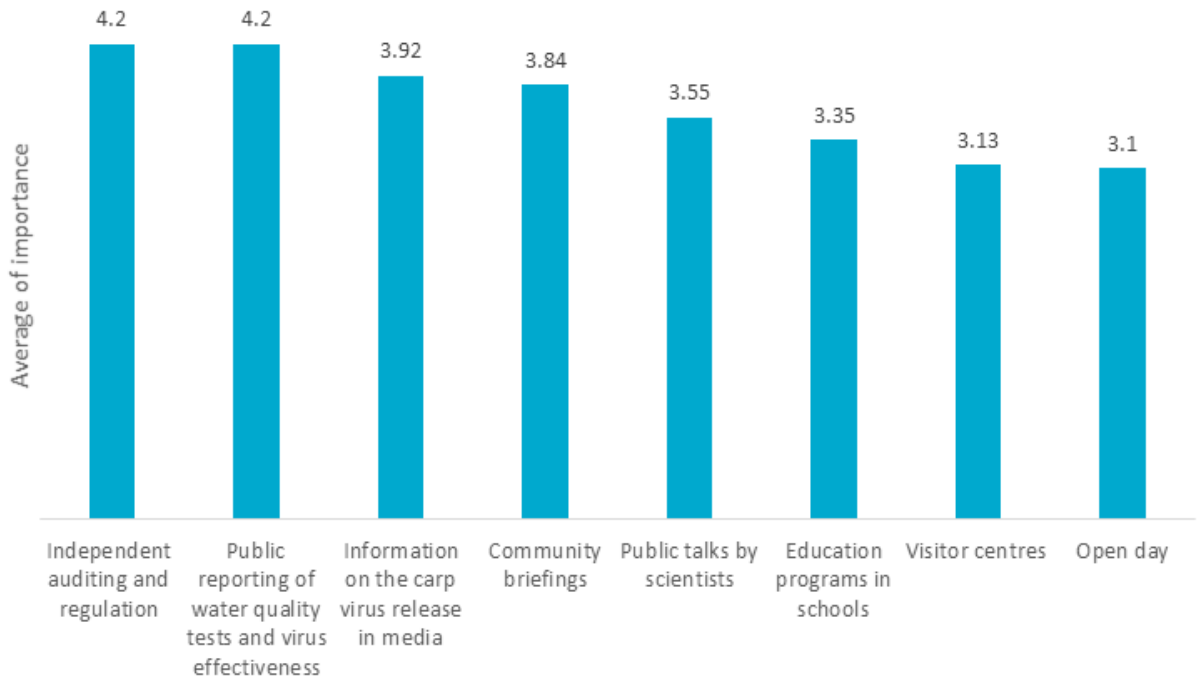


Figure 22 Reported importance of management activities by all participants

Note: 1 = not at all important, 3 = moderately important, 5 = extremely important

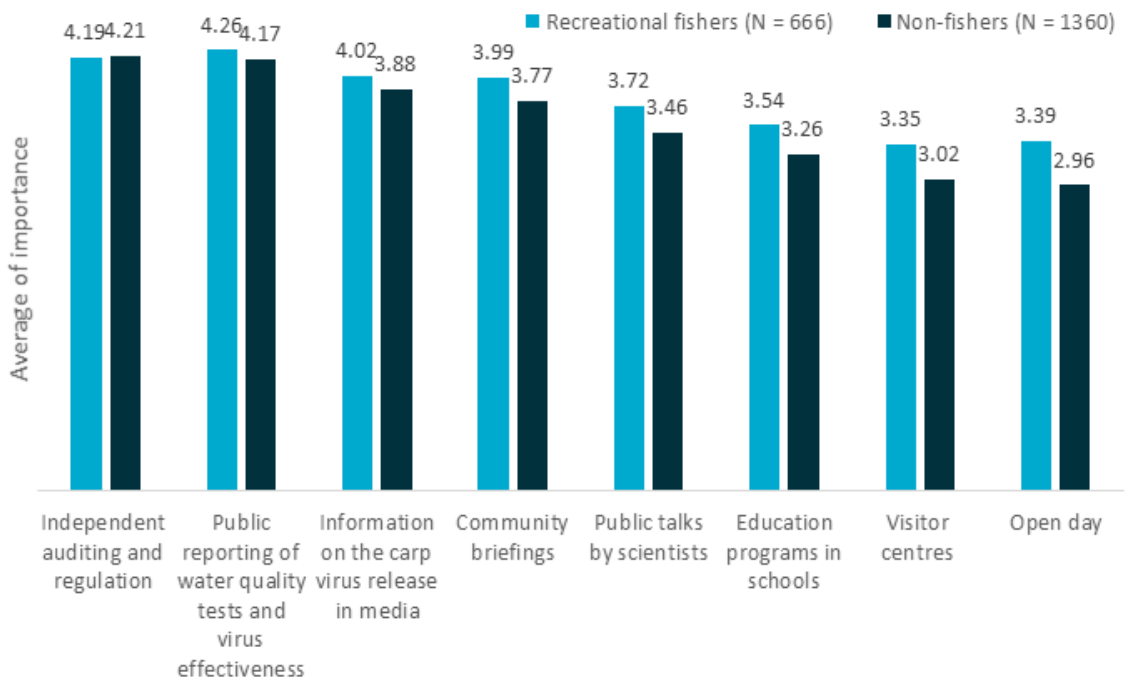


Figure 23 Reported importance of management activities by recreational fishers and non-fishers

Note: 1 = not at all important, 3 = moderately important, 5 = extremely important

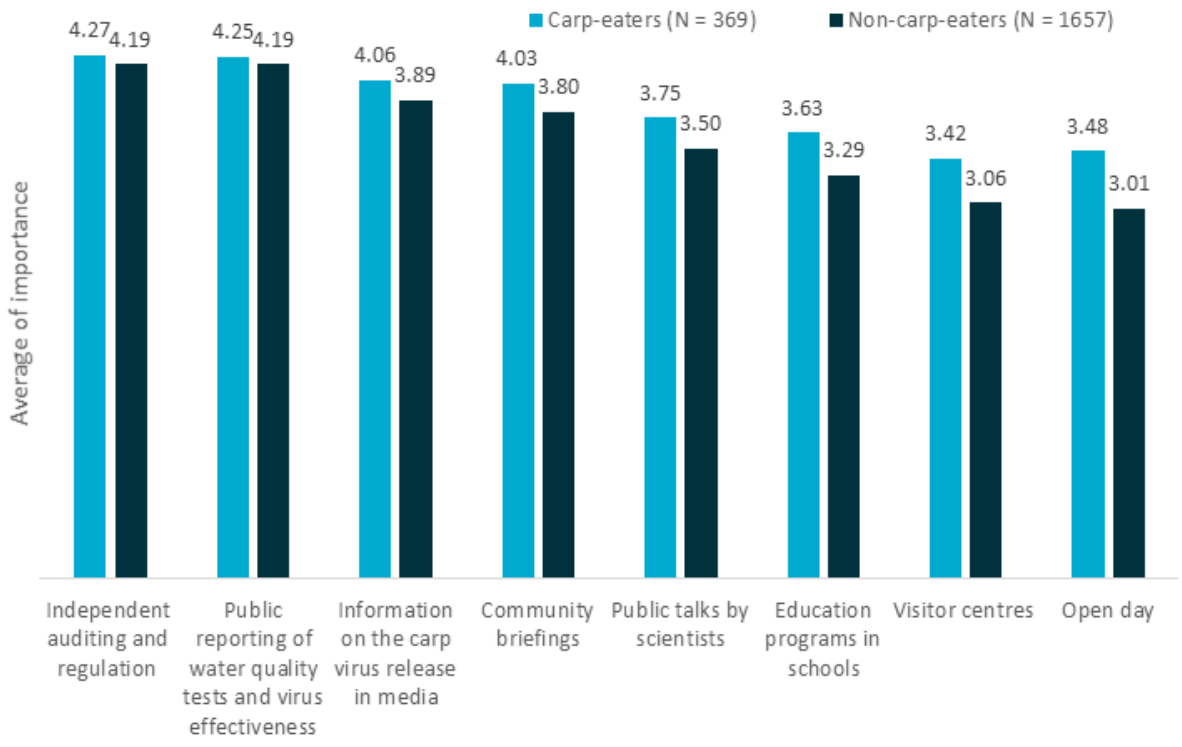


Figure 24 Reported importance of management activities by carp eaters and non-eaters

Note: 1 = not at all important, 3 = moderately important, 5 = extremely important

Generally, this reflected a favouring of more passive information exchange amongst participants; however, it is clear that options should be available for both passive and active forms of information exchange and participation in the decision-making process.

Behavioural intention to engage with carp control activities.

Behavioural intention towards engaging with carp control was assessed by asking participants to indicate the likelihood they would perform the following four activities on a 7-point scale (1 = very unlikely, 4 = not sure, 7 = very likely):

- To be actively involved in community discussions regarding this topic?
- To regularly check NCCP's online information (e.g. website, Facebook or Twitter accounts)?
- To provide feedback regarding how to control carp to NCCP?
- To support the use of the carp virus to control carp in Australia?

Participants were unsure at this stage how likely they would be to engage with carp control activities. However, they were more certain that they would support the use of the carp virus to control carp in Australia, especially older participants and those who lived around the MDB. In addition, as shown in Figure 25, male participants reported comparatively higher levels of likelihood to engage, and in supporting the use of a carp virus.

The differences in behavioural intentions were further explored between recreational fishers and the rest of the participants (Figure 26), as well as between carp consumers and non-consumers (Figure 27). Understandably, both recreational fishers and carp consumers reported stronger interests in engaging with carp control activities. It is noteworthy that recreational fishers

displayed significantly higher levels of support for using the carp virus to control carp than their non-fishing counterparts ($p<0.0001$).

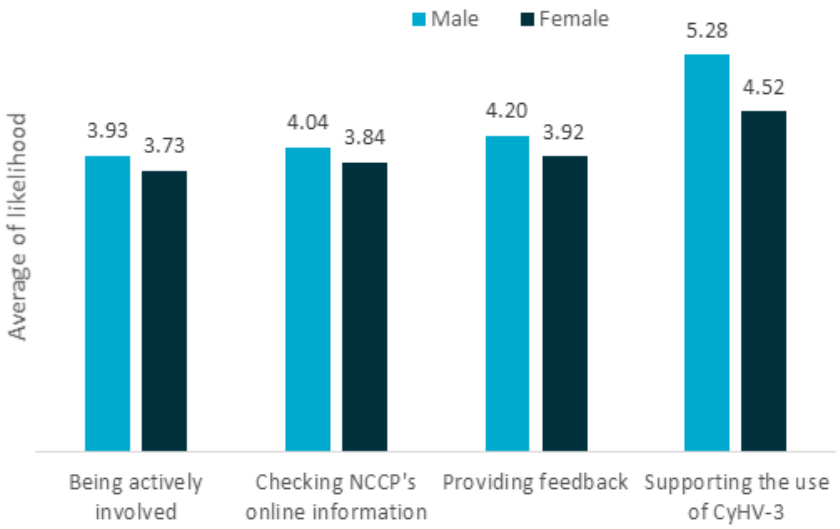


Figure 25 Behavioural intentions by gender

Note: 1 = very unlikely, 7 = very likely

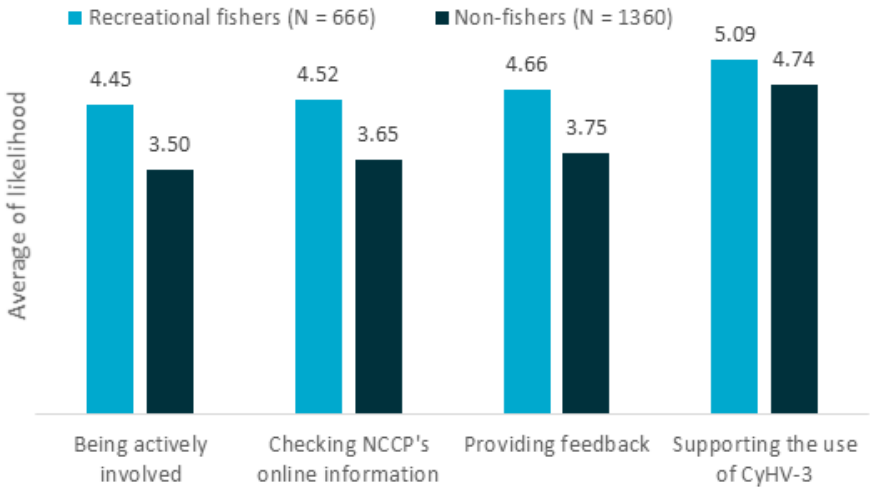


Figure 26 Behavioural intentions by recreational fishers and non-fishers

Note: 1 = very unlikely, 7 = very likely

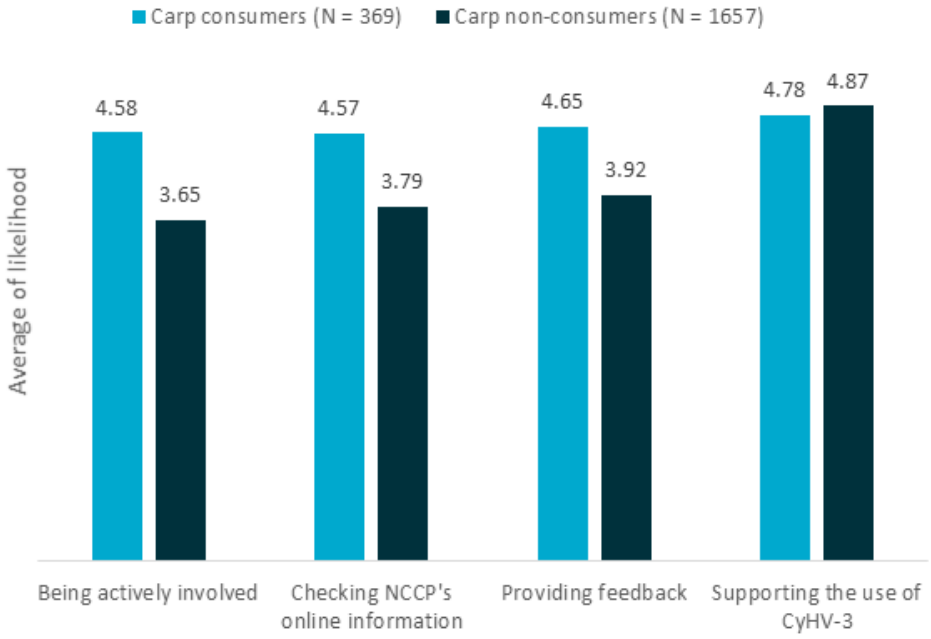


Figure 27 Behavioural intentions by carp consumers and non-consumers

Note: 1 = very unlikely, 7 = very likely

2.3.2 Use of waterways and general knowledge of carp and its impact

Use of waterways

Fresh water fishing.

The majority of participants (67%) did not fish in fresh water over the past 12 months (Figure 28). Among the 666 participants who fished, 66% reported that they never, rarely, or occasionally caught carp, while 15% reported that they caught carp all the time (Figure 29); 44% reported that the presence of carp negatively affected their fishing experience (Figure 30).

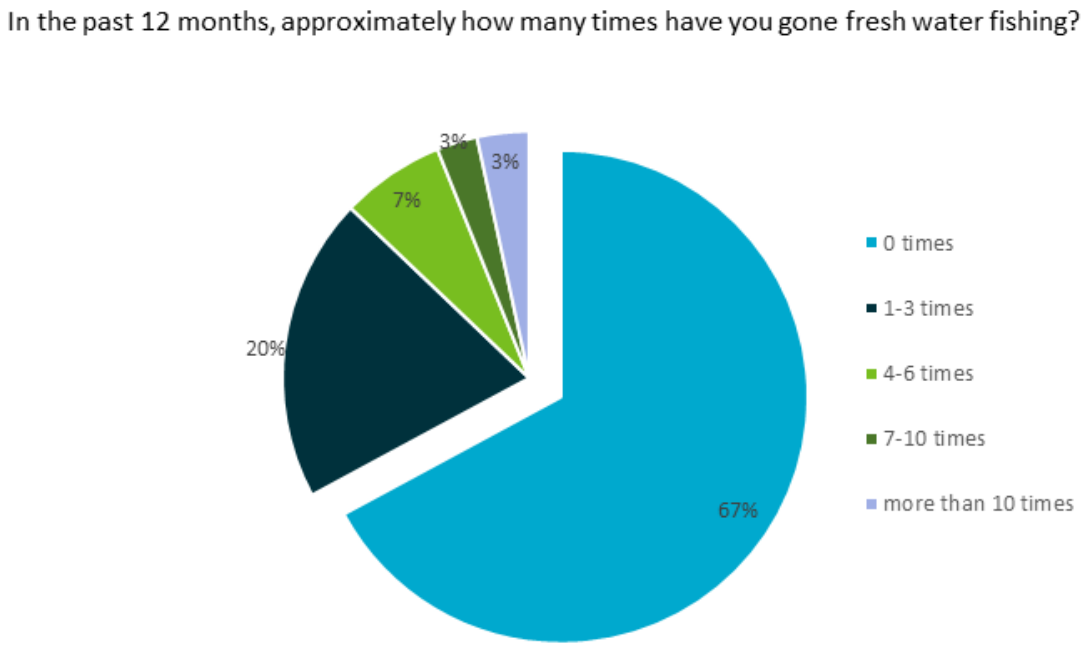


Figure 28 Number of times fishing in fresh water over the past 12 months

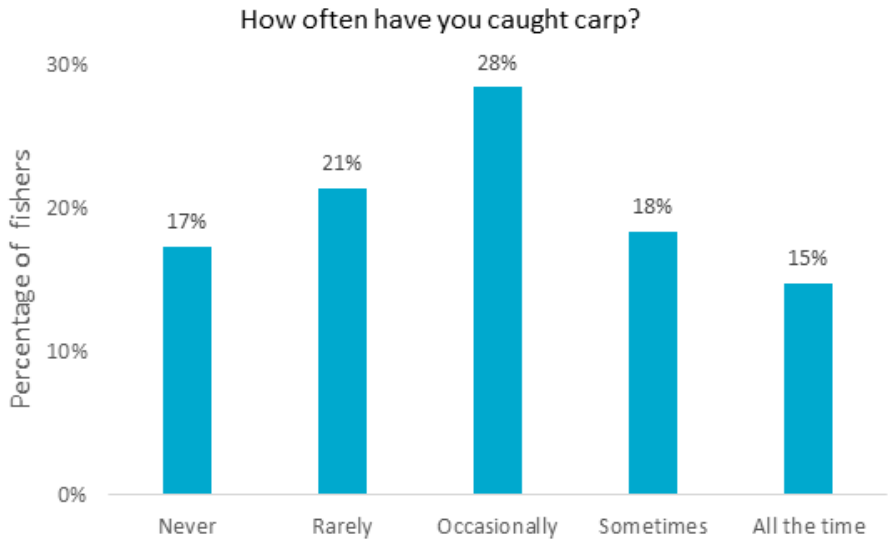


Figure 29 Frequency in catching carp by percentage of fishers (N = 666)

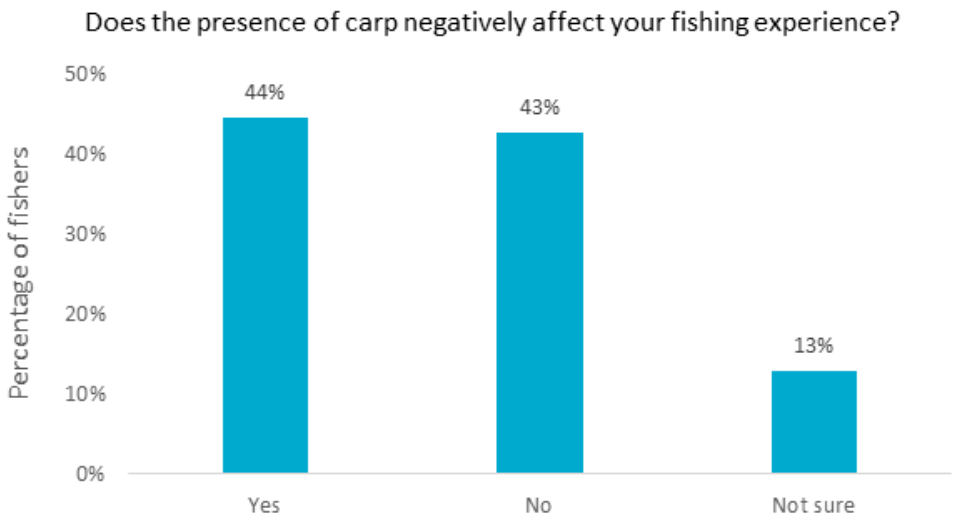


Figure 30 Impact of carp's presence on fishing experience (N = 666)

Recreational use of waterways.

A majority of participants undertook recreational activities such as swimming, camping, or just having fun at waterways (Figure 31). In comparison to metropolitan participants, more participants from the MDB regions used waterways frequently for recreational purposes. Generally speaking, participants who lived closer to water were more likely to undertake more recreational activities at waterways, especially for those living in the MDB regions ($p<0.0001$) than those from metropolitan areas ($p<0.0001$).

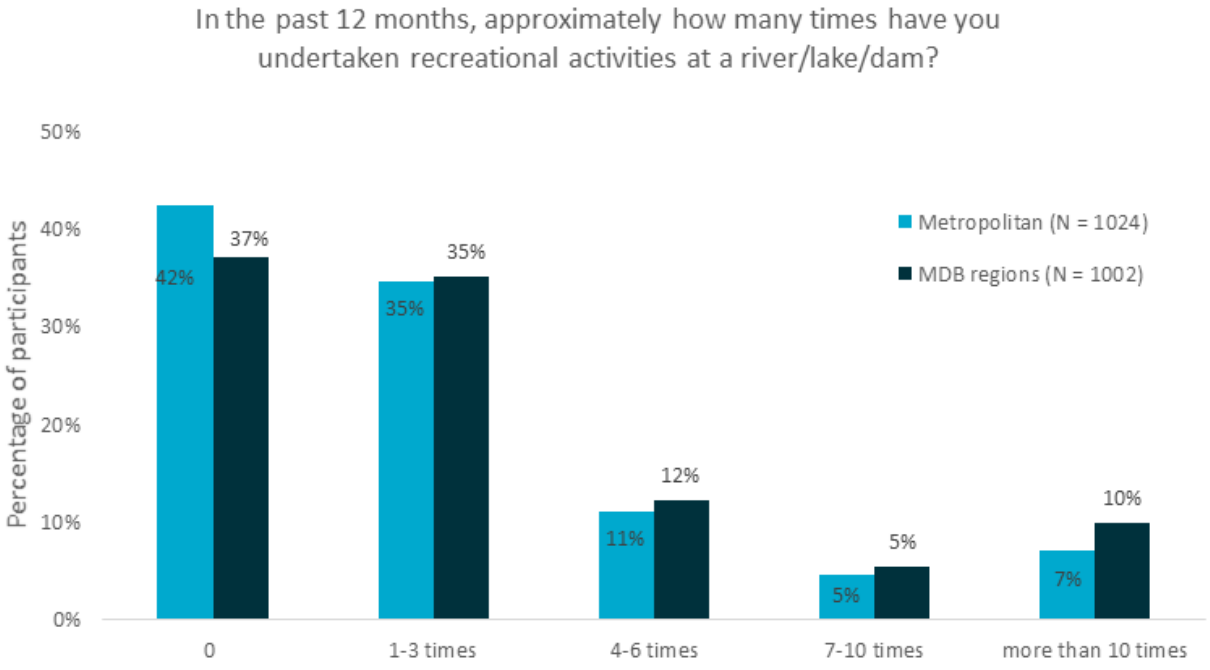


Figure 31 Frequency of undertaking recreational activities at waterways by location of residence

General knowledge of carp

Carp population.

Carp population estimates in Australian waterways, made by survey participants, were reasonably low; metropolitan participants in particular (Figure 32). For example, 47% of participants from MDB regions stated that there were many or a lot of carp in the waterways they visited, while only 24% of metropolitan counterparts held the same view. Noticeably, nearly half of metropolitan participants (48%) and 30% of MDB participants reported no knowledge about the carp population at all.

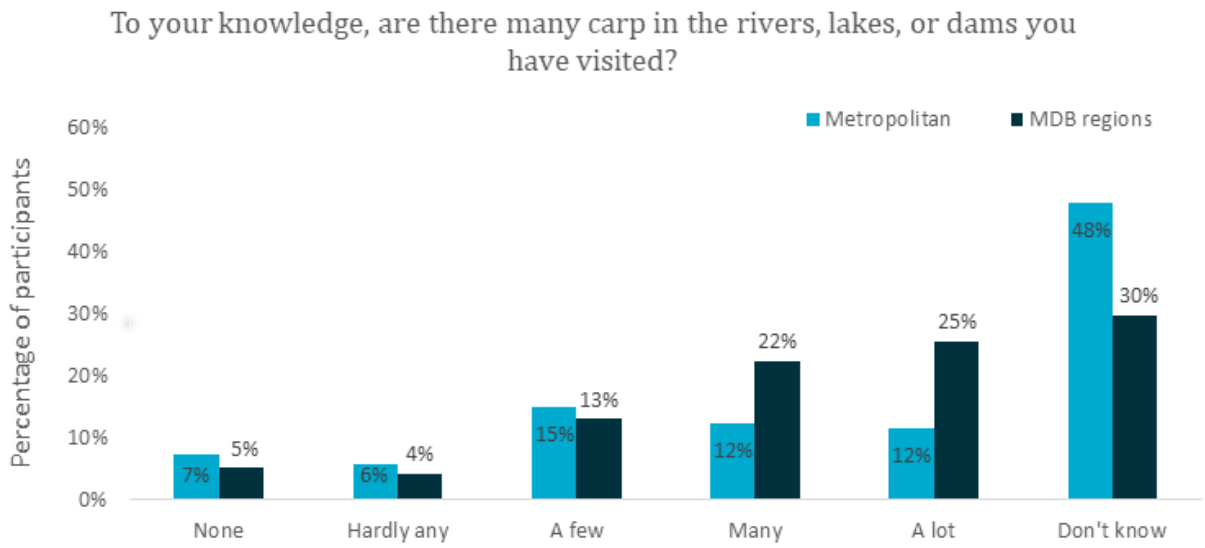


Figure 32 Frequency of undertaking recreational activities at waterways by location of residence

Knowledge of carp.

Overall, participants reported very low level of knowledge about carp (Figure 33). For example, 74% of metropolitan and 68% of MDB participants reported that they had no knowledge or a little knowledge about carp. Only 7% of metropolitan and 7% MDB participants, respectively, stated that they had a lot or extensive knowledge about carp.

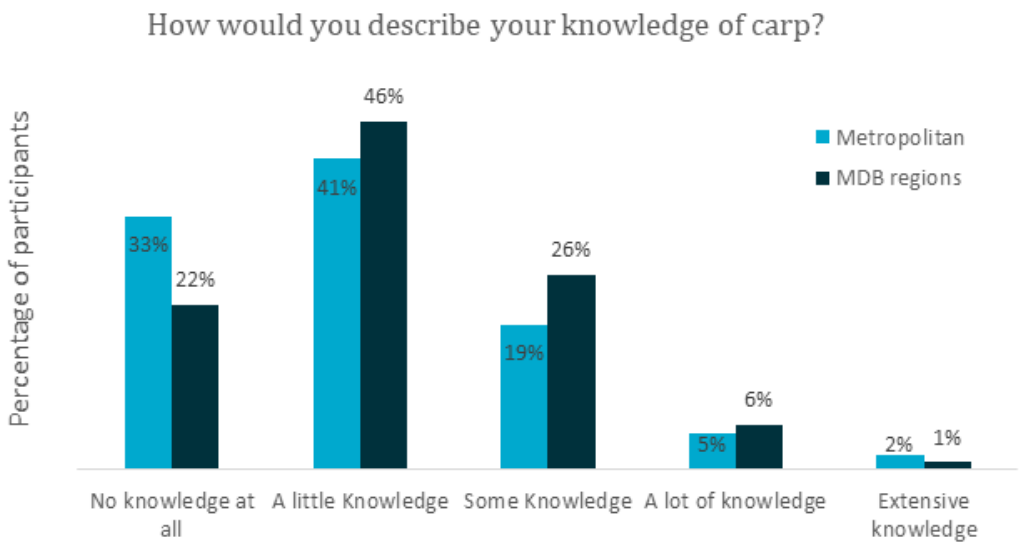


Figure 33 Self-reported knowledge of carp by location of residence

Carp as pest fish.

Most participants recognised that carp are a pest fish (Figure 34). In particular, the majority of MDB participants (73%) regarded carp as a pest fish (e.g., 66% regarded carp as non-native pest fish, and 7% regarded carp as native Australian pest fish), in comparison to 53% metropolitan participants (e.g., 47% and 6% respectively) holding the same view. Noticeably, 23% of metropolitan participants and 14% of MDB participants had no knowledge at all.

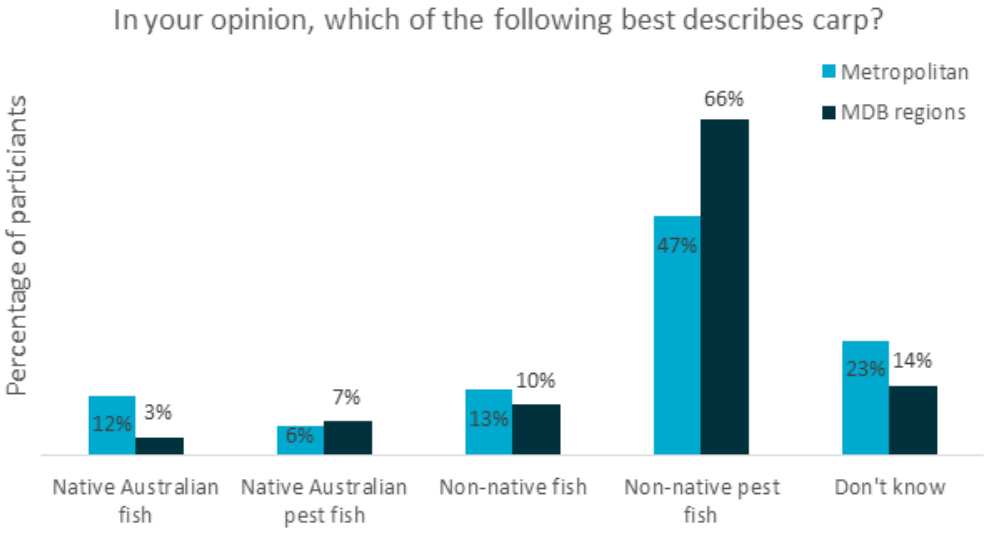


Figure 34 Understanding of the nature of carp by location of residence

Carp's environmental and economic impacts.

Given the overall limited knowledge about carp, the following information regarding carp and their impacts were provided to the participants:

> *Carp in Australian waterways and their impact*
>
> *European carp is one of Australia's most significant introduced pest species. Carp have significant social, environmental and economic impacts. For example, they can impact on*

native fish populations by consuming eggs and larvae, competing for food sources, and altering habitat. They dominate the Murray Darling Basin, making up 80-90 per cent of the fish in many of the waterways in the basin. The economic impact of carp to agricultural and ecotourism industries has been estimated at up to $500 million per year.

After reading the above information, participants were first asked to indicate how much they knew about carp's environmental and economic impacts prior to reading the information excerpt (1 = no knowledge at all, 5 = extensive knowledge). In line with the findings that participants reported limited knowledge about carp in general, a substantial number of participants self-reported no knowledge or limited knowledge about carp's negative impacts prior to receiving the carp-specific information (Figure 35 to Figure 37). Consistently, participants from MDB reported significantly ($p<0.0001$) higher levels of knowledge to their metropolitan counterparts.

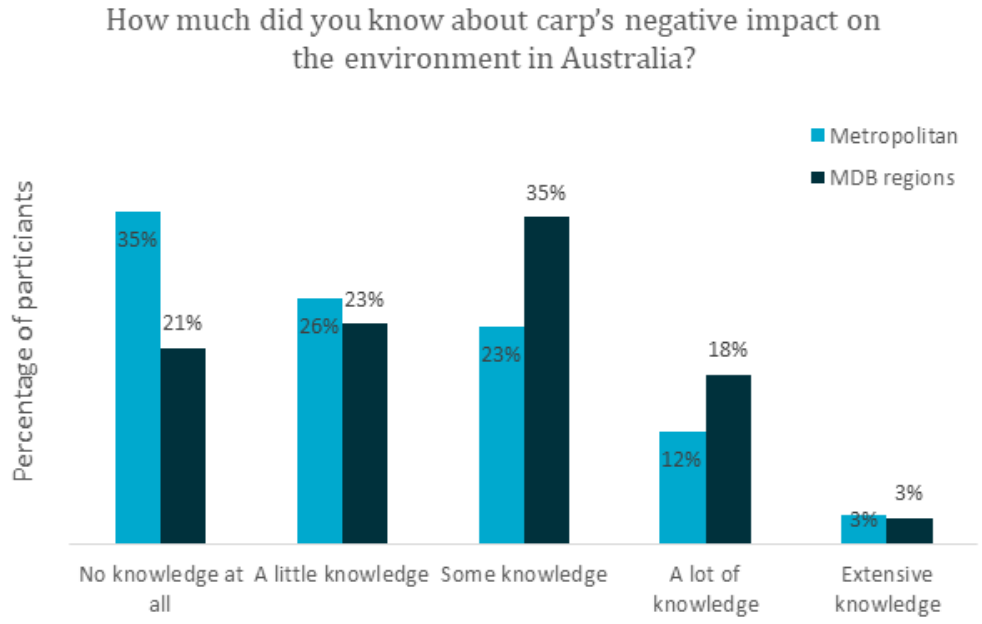


Figure 35 Knowledge about carp's negative impact on environment by location of residence

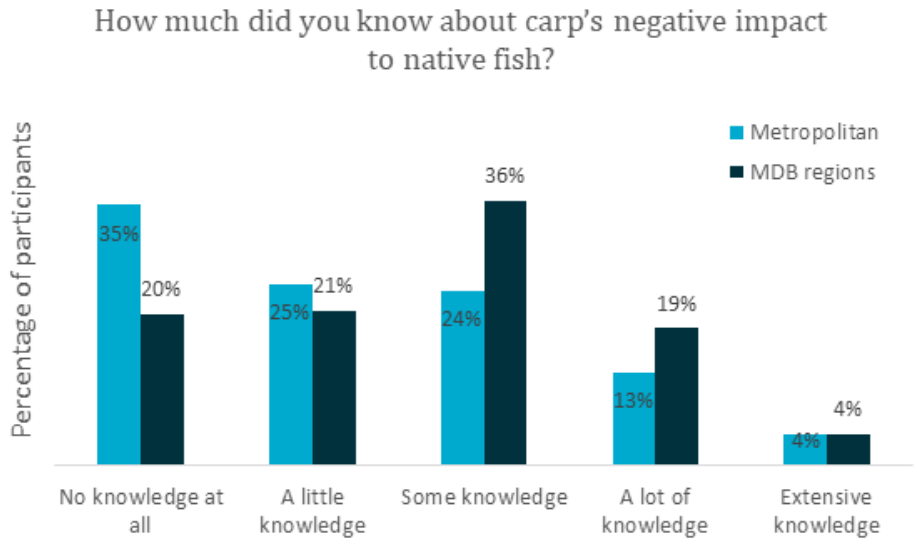


Figure 36 Knowledge of carp's negative impact on native fish by location of residence

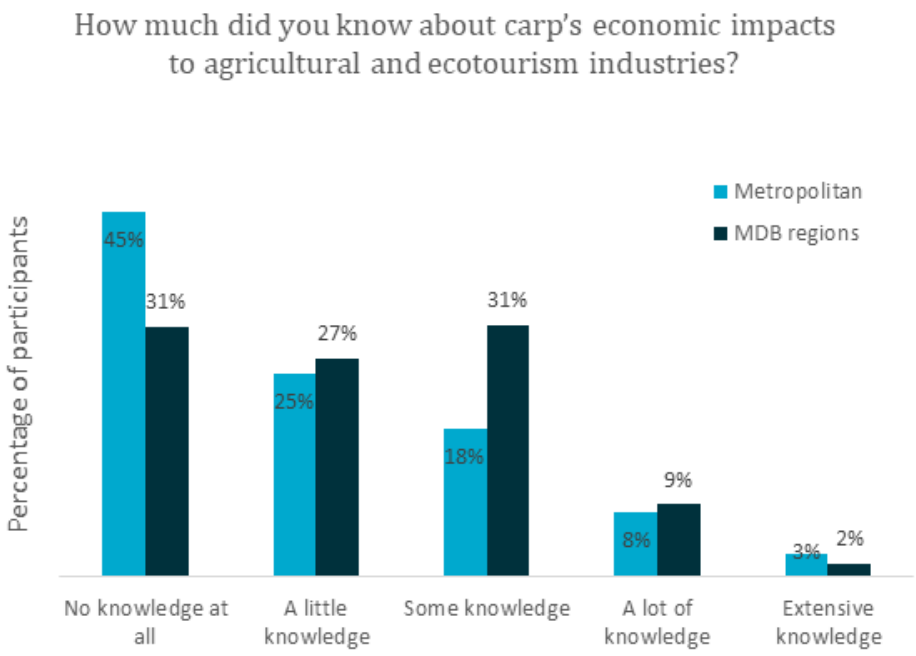


Figure 37 Knowledge of carp's economic impacts by location of residence

Value existence and use of carp.

While carp is considered an invasive pest, carp can be still be valued in terms of its commercial, food and cultural utility, which may affect participants' attitudes toward carp control. We measured this aspect by asking participants to indicate the extent to which they agreed with the following statement on a 7-point scale (1 = strongly disagree, 4 = not sure, 7 = strongly agree):

- "*Carp are a natural part of the Australian ecosystem*"
- "*Carp are useful fish to have in our waterways*"
- "*I value carp because they are an important part of my culture*".

Generally speaking, participants did not see much value for carp in either the ecosystem or culturally. In comparison, female participants reported comparatively more value for carp (Figure 38), and MDB participants saw less value in carp than Metro participants (Figure 39). It appears that carp eaters (N = 369) regarded carp as more valuable than non-carp eaters (Figure 40). In addition, older participants reported less value of carp.

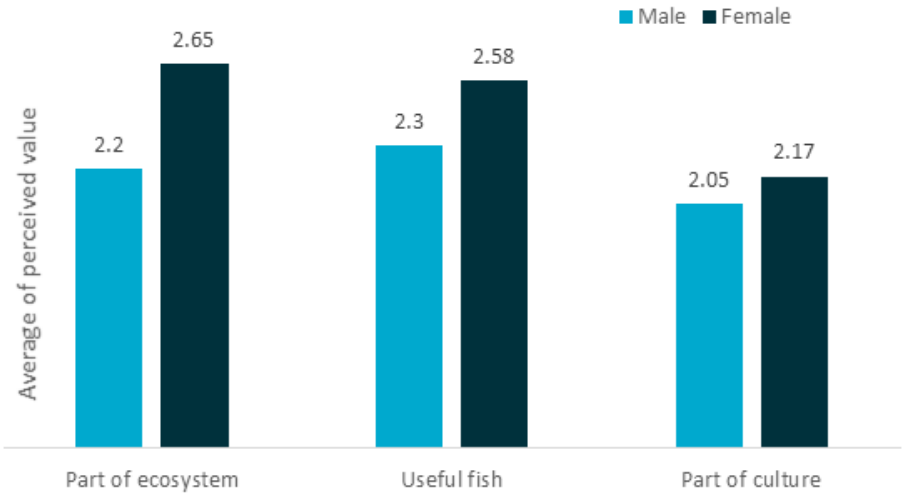


Figure 38 Perceived value of carp by gender

Note: 1=strongly disagree, 7=strongly agree

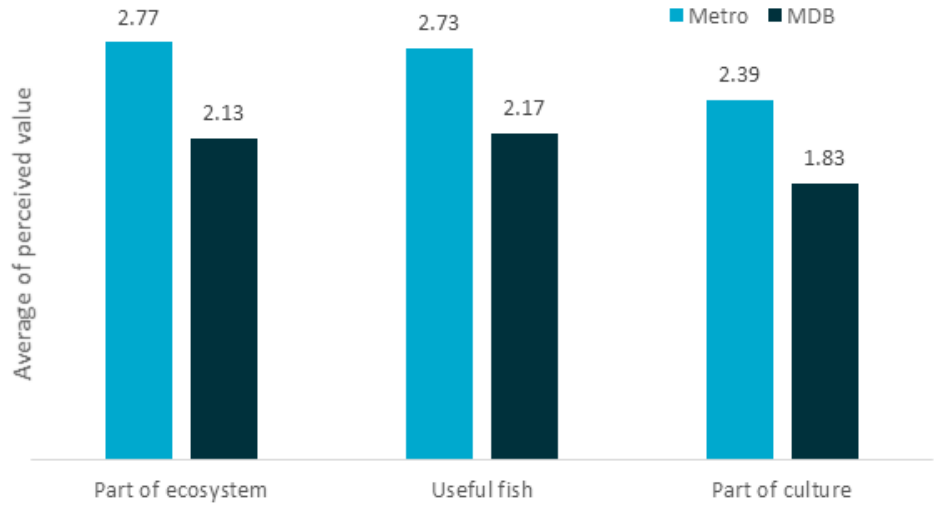


Figure 39 Perceived value of carp by location of residence

Note: 1=strongly disagree, 7=strongly agree

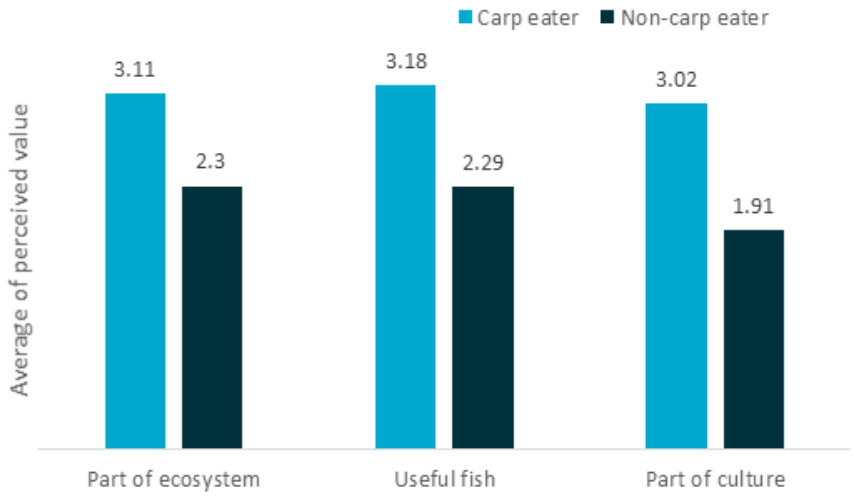


Figure 40 Perceived value of carp by carp eater and non-carp eater

Note: 1=strongly disagree, 7=strongly agree

Awareness of the National Carp Control Plan.

Awareness of the proposed carp control plan among participants was very low, especially participants living in metropolitan areas (Figure 41). In particular, 74% of metropolitan and 58% of MDB participants had not heard about the government's proposal of controlling carp populations using CyHV-3.

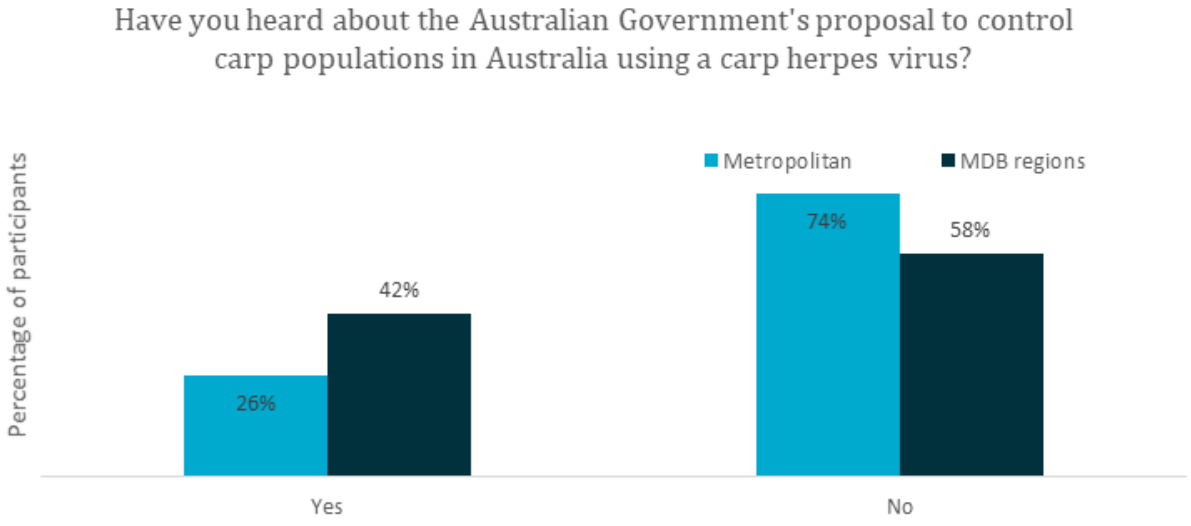


Figure 41 Awareness of proposed carp control plan using CyHV-3 by location of residence

2.3.3 Acceptance of carp control using CyHV-3 without relevant information provided

To try and tease out the influence of information on acceptance of carp control using the virus, we included a measure of carp virus acceptance prior to and after the introduction of a carp-specific information vignette. Before general information on carp was presented to participants (i.e. carp populations in Australian waterways, general carp impacts, a description of carp herpes virus, and the proposed carp control plan), participants were asked to indicate how acceptable they would

find the release of the carp herpes virus in reducing numbers of carp (1 = not at all acceptable, 4 = not sure, 7 = very acceptable, and "don't know").

After excluding those who stated, "don't know" (n=161), the overall acceptance level was positive and significantly above the mid-point (p<0.0001). However, a closer examination of responses (Figure 42) revealed that participants who were aware of the proposed carp control plan (n=673) were significantly (p<0.0001) more in favour of releasing the carp herpes virus to reduce carp population. For those who had no knowledge of the carp control proposal (n=1192), responses reflected uncertainty regarding whether to accept the carp control approach or not, likely due to their inability in making a decision about something they had no knowledge of.

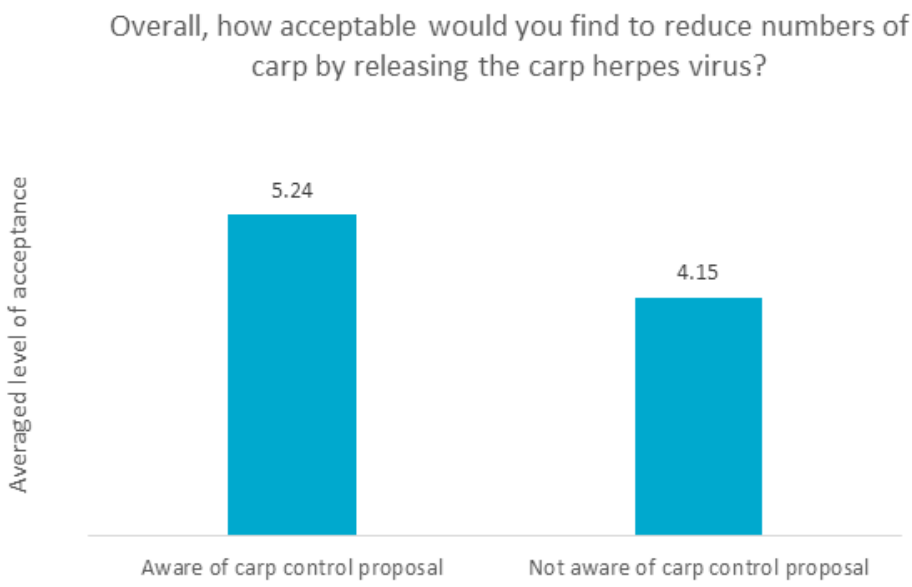


Figure 42 Acceptance level by awareness of carp control proposal

Note: 1=not at all acceptable, 7=very acceptable

Further analyses indicated that acceptance of carp control without relevant information provided was largely informed by participants' existing knowledge of carp's negative environmental and economic impacts. Level of acceptance was positively associated with knowledge of carp's negative impacts, while age, gender, education, and location of residence were controlled for (Table 5). In addition, reported knowledge of carp's various negative impacts were highly correlated. That is, if participants had certain knowledge of carp's negative impacts, they tended to have a reasonable understanding of carp's impacts on other aspects, and vice versa.

Table 5 Partial correlations between knowledge of impacts and acceptance of CyHV-3

Knowledge	M (SD)	1	2
1. Impact on environment	2.47 (1.13)	-	
2. Impact on native fish	2.53 (1.17)	.86***	
3. Impact on economy	2.17 (1.09)	.78***	.76***
Acceptance	4.55 (2.09)	.32***	.32***

Note: *** p<0.001. Age, gender, education, and location of residence (i.e. metropolitan or MDB) were controlled for in the correlations reported here. Items on knowledge of impact were measured on a 5-point scale (1 = no knowledge

at all, 5 = extensive knowledge), and acceptance was measured on a 7-point scale (1 = not at all acceptable, 4 = not sure, 7 = very acceptable).

The above findings highlight the importance of carp-specific knowledge in determining acceptance of carp control. These results indicate that the extent to which the public accepts the proposal of control carp using the virus will depend on their understanding of carp's negative impacts and awareness of the proposed control plan. Therefore, an accurate measure of public acceptance of the carp virus cannot occur in the absence of contextual information.

Furthermore, the limited knowledge reported by participants on carp and the proposed control plan highlights the limitations of previous public acceptance research which has measured carp virus acceptance without essential contextual information on carp.

To make implementation decisions based on uninformed public acceptance would be to increase the risk of public rejection for controlling carp populations using a virus. Our findings show that it is essential to develop effective strategies to communicate and engage with the public to raise their collective awareness, particularly in high-exposure areas, if the proposed control approach is to go ahead.

2.3.4 Perceptions of and attitudes toward using CyHV-3 to control carp population

Given the predicted influence of knowledge about carp and carp control on acceptance levels, as demonstrated in Section 3.2, our survey chose to provide an information vignette. The vignette provided information to participants to enable them to make informed assessments and decisions about acceptance of the carp virus and to articulate social risk. Hence, to assess perceptions and attitudes towards carp control and social risk using CyHV-3, we first presented participants with the following information on carp control history, CyHV-3, and the science of using CyHV-3 to control carp population. Participants' perceptions of and attitudes towards carp control using CyHV-3 were then assessed.

Some history of carp control

Various methods, including netting and electrofishing, have been used to control carp in Australian waterways. However, none have been effective in significantly reducing carp populations.

As a result, the Australian Government is proposing to use a carp virus to more effectively control carp populations.

The carp virus

The National Carp Control Plan (NCCP) is investigating the feasibility of using Cyprinid herpesvirus 3, also known as carp virus, as a biological control agent to manage carp in Australia's freshwater environments. The carp virus is a naturally occurring virus in over 33 countries worldwide. However, it is not currently present in Australian waterways.

The science of using carp virus to control carp populations

CSIRO has conducted extensive scientific research and shown that under optimal conditions, the carp virus could kill over 70 per cent of carp in a given population, in 5-7 days following release. The carp virus can only survive in the water for 3-4 days. The carp virus is specific to common carp and does not affect humans, other species of fish, other animals or plants.

The virus acts quickly and will lead to significant dead and dying carp in targeted waterways following release. Research is currently underway to investigate optimal release conditions (e.g. timing, location) for the virus and possible clean-up strategies.

Perceived needs for controlling carp population

Perceived needs for controlling carp population were measured by asking participants to indicate the extent to which they agreed with the following statement on a 7-point scale (1 = strongly disagree, 4 = not sure, 7 = strongly agree):

- "*Carp are pests in Australian waterways*"
- "*Carp populations should be controlled in Australian waterways*"
- "*I believe it's necessary to control carp populations immediately*".

In general, participants agreed that carp are pests in Australian waterways and should be controlled. The results also indicate that there were significant ($p<0.001$) differences in perceived need to control carp between gender and location of residence (Figure 43 and Figure 44). In particular, male participants and MDB participants held stronger views on the need for carp control than females.

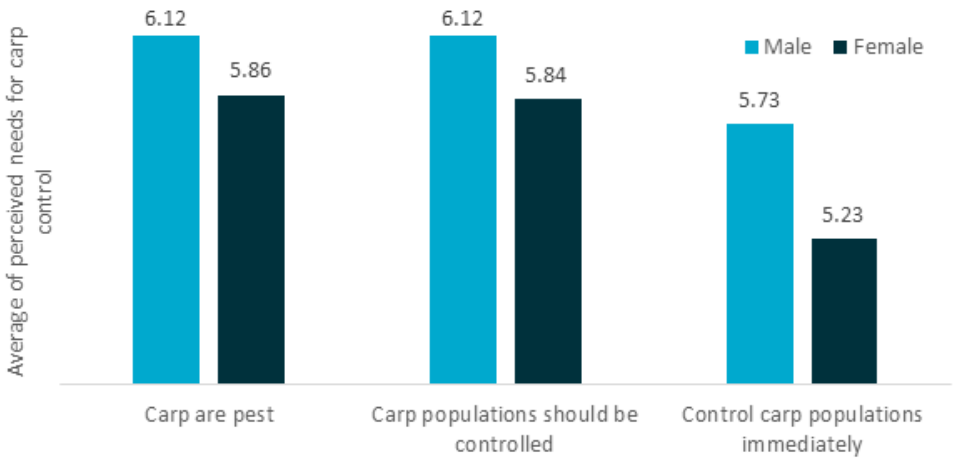


Figure 43 Perceived needs for controlling carp population by gender

Note: 1=strongly disagree, 4=not sure 7=strongly agree

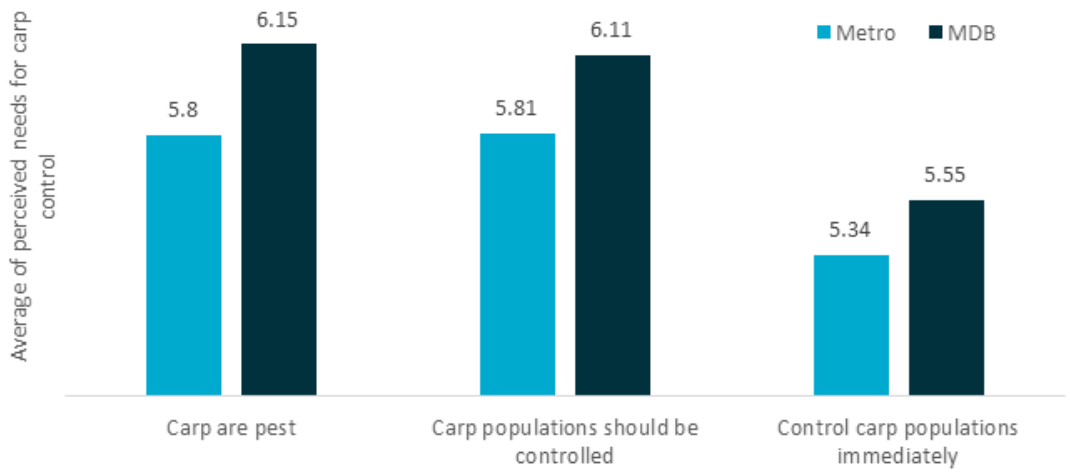


Figure 44 Perceived needs for controlling carp population by location of residence

Note: 1=strongly disagree, 4=not sure 7=strongly agree

In addition, after controlling for differences in gender and location of residence, perceived needs were positively and significantly associated with age ($p<0.0001$), such that older participants perceived stronger needs for carp control. Interestingly, perceived needs for carp control were not related to participants' levels of education, fishing activities, or frequency of recreational use of waterways.

Perceived benefits of controlling carp population

Perceived benefits of controlling carp populations were assessed by asking participants to indicate the extent to which they agreed with the following statement on a 7-point scale (1 = strongly disagree, 4 = not sure, 7 = strongly agree):

- "*Reducing the number of carp will help restore native fish numbers*"
- "*Reducing the number of carp will make the waterways cleaner and clearer*"
- "*Reducing the number of carp will encourage greater biodiversity*".

Overall, participants recognised the benefits of controlling carp populations for biodiversity and cleaner waterways. In addition, male participants and MDB participants held stronger views than their counterparts respectively (Figure 45 and Figure 46). Furthermore, after controlling for gender and location of residence, perceived benefits were significantly associated with age ($p<0.0001$), such that older participants recognised the benefits of carp control more than younger participants; levels of education were only significantly related to benefits in encouraging greater biodiversity ($p=0.002$).

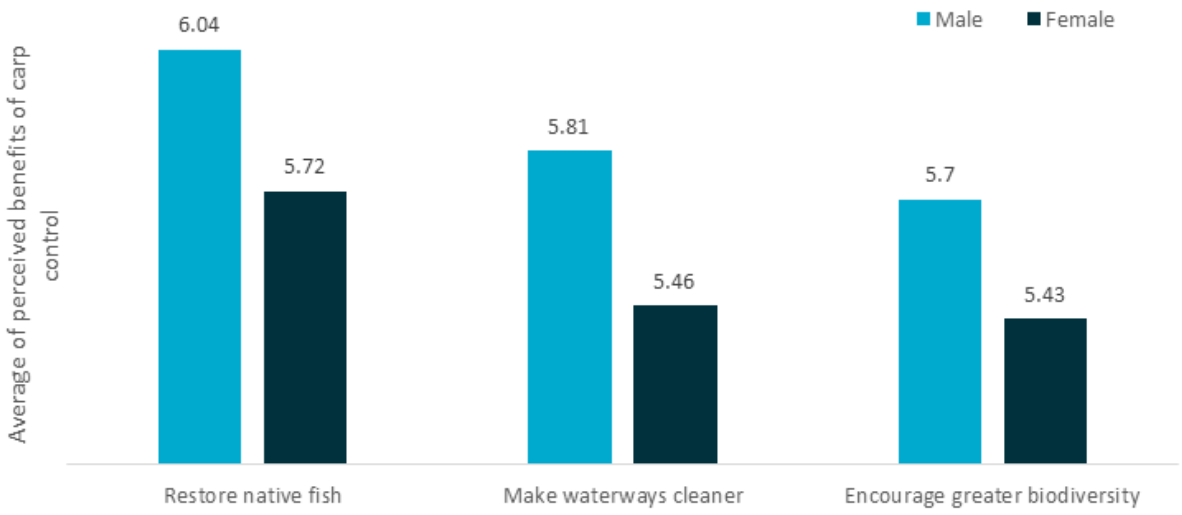


Figure 45 Perceived benefits of carp control by gender

Note: 1=strongly disagree, 4=not sure 7=strongly agree

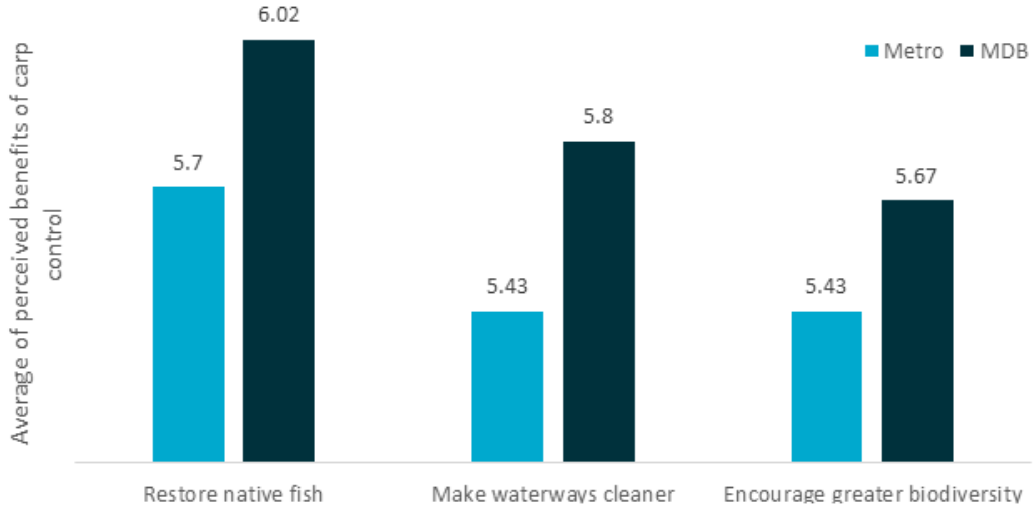


Figure 46 Perceived benefits of carp control by location of residence

Note: 1=strongly disagree, 4=not sure 7=strongly agree

Concerns associated with using CyHV-3 virus to control carp population

Presence of CyHV-3 virus in drinking water supplies and food.

Concerns over the presence of the carp virus in drinking water and food were assessed by asking participants to indicate the extent to which they agreed with the statement: "*I would be afraid to drink local water if the virus was released*" (1 = strongly disagree, 4 = not sure, 7 = strongly agree), and how concerned they were that "*humans or animals consuming produce irrigated by virus-treated waterways*" (1 = not concerned at all, 3 = somewhat concerned, 5 = concerned a lot).

Overall, participants were not sure whether they would be fine with drinking local water if the carp virus was released, but they expressed moderate concerns that humans and animals may consume produce irrigated by virus-treated waterways. There were significant differences between genders, such that female participants were comparatively more concerned ($p<0.0001$,

Figure 47). In particular, concern over the safety of drinking local water expressed by female participants was above the neutral point (i.e. 'not sure'), while male participants' concerns were below the neutral point.

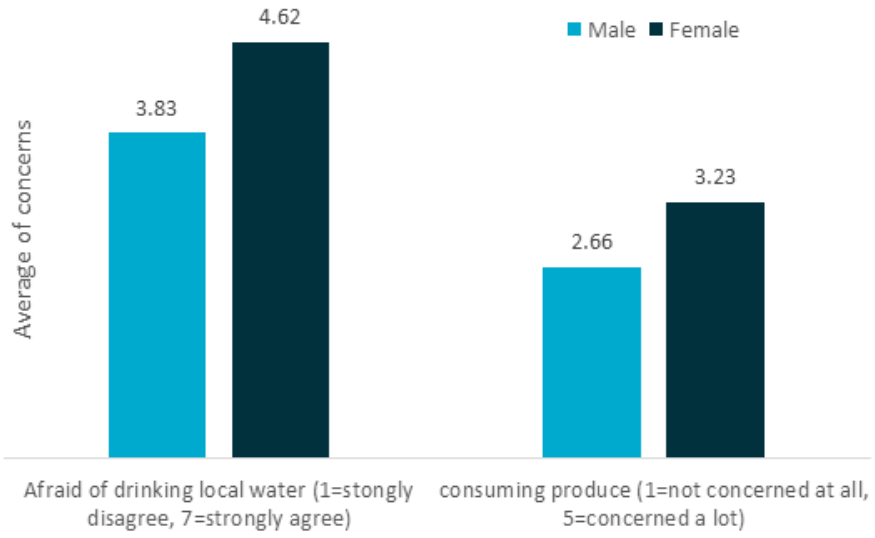


Figure 47 Concerns over CyHV-3 in drinking water and food items by gender

There were significant differences between metro and MDB participants, such that metro participants were comparatively more concerned ($p<0.0001$, Figure 48). Metro participants also expressed comparatively stronger concern over the safety of drinking local water, which was above the neutral point (i.e. 'not sure'), while MDB participants were not sure regarding whether it was safe to drink local water.

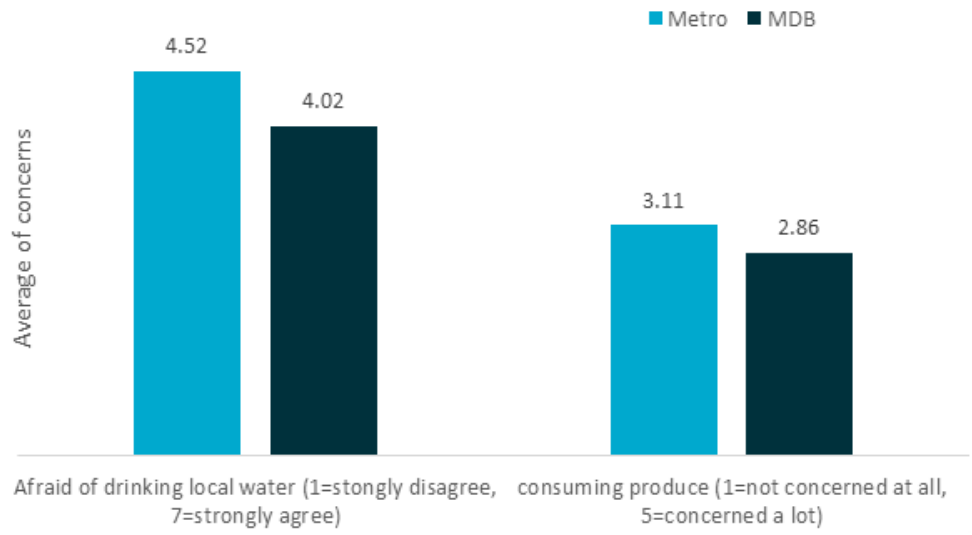


Figure 48 Concerns over CyHV-3 in drinking water and food items by location of residence

After controlling for the effects of gender and location of residence, age was negatively associated with concern of drinking local water ($r = -0.24$, $p<0.001$), and humans or animals consuming produce irrigated by treated waterways ($r = -0.22$, $p<0.001$). However, education was not related to those concerns.

Unsanctioned introduction of CyHV-3 virus into Australia.

Concerns over the risk that the carp virus may be introduced into Australia or put into rivers without official permission were measured by asking participants the extent to which they agreed with the following two statements (1 = strongly disagree, 4 = not sure, 7 = strongly agree):

- "*I am concerned that the virus may be introduced to Australia without permission from the authorities, either accidently or intentionally*"
- "*I am concerned that others may try and put the virus into rivers without permission from authorities*".

Overall, participants were unsure of this possibility, with their responses being around the neutral point (i.e. 4). There were significant differences between male and female participants with respect to concerns over unsanctioned introduction of CyHV-3, such that female participants expressed comparatively higher levels of concerns than male participants ($p<0.0001$, Figure 49). There were also significant differences between metro and MDB participants, such that metro participants were relatively more concerned than MDB participants ($p<0.001$, Figure 50). After controlling for the effects of gender and location of residence, age was weakly correlated with concern, and education was not related to concern at all.

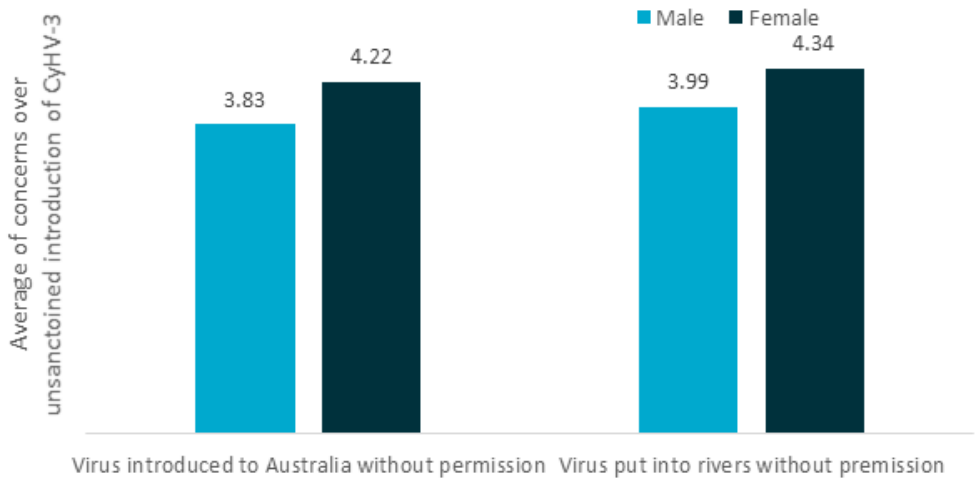


Figure 49 Concerns over CyHV-3 introduced without official permission by gender

Note: 1=strongly disagree, 7=strongly agree

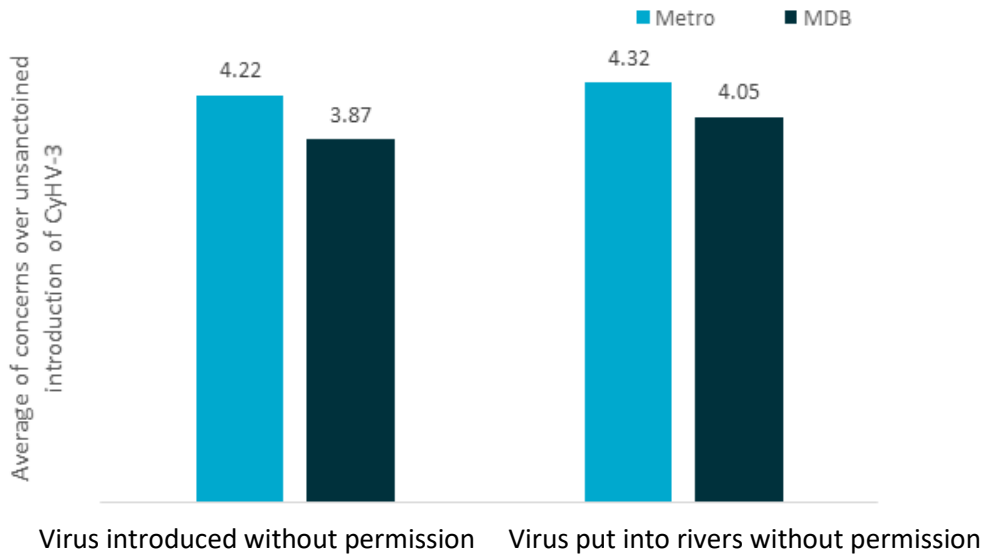


Figure 50 Concerns over CyHV-3 introduced without official permission by location of residence

Note: 1=strongly disagree, 7=strongly agree

Unintended impacts of using CyHV-3 virus not yet predicted by current scientific knowledge.

The information excerpt presented in the survey gave participants insight into the findings from CSIRO's research on how CyHV-3 virus works to specifically kill carp and its safety with humans, other animals, water, and plants. Epidemiological research so far has shown that, under optimal conditions, the carp virus can be effective in killing large numbers of carp without affecting humans, other animals, water or plants.

With the carp and virus information provided, participants were asked whether they were concerned that the carp virus may have unintended impacts not already predicted by scientists. The results suggest that 73.4% of the surveyed participants were concerned with unintended impacts. As shown in Table 6, more female participants (79.6%) were concerned about the unintended impacts in comparison to male participants (65.4%). Similar percentages of metro (74.9%) and MDB (72.0%) participants were concerned

Table 6 Concerns about impacts of CyHV-3 virus by gender and location of residence

	Gender		Location of residence	
	Male	Female	Metro	MDB
Concerned	65.4%	79.6%	74.9%	72.0%
Not concerned	34.6%	20.4%	25.1%	28.0%

Note: * Concerns over unintended impacts of CyHV-3 virus by percentages of gender and location of residence

Participants were also asked to give details on particular issues they were concerned about. Table 7 presents the details of major concerns participants reported.

Table 7 Concerns about impacts of CyHV-3 (open ended)

Concern: response theme	Number	% of respondents
Risks to other species associated with waterways (native and domestic)	435	32.5%
Unpredicted / unpredictable flow-on consequences	306	22.9%
Risks to humans (health or other)	220	16.4%
Historical precedent(s) of failed biocontrol interventions (e.g. cane toads)	217	16.2%
Potential for virus to mutate and transmit to other species	211	15.8%
General concern for effects on health of waterways and environment	159	11.9%
General concern about the introduction/use of a virus	153	11.4%
Distrustful of science / scientists and/or insufficient testing	124	9.3%
Environmental consequences of fish carcasses	78	5.8%
Risks to water supplies (e.g. for drinking, irrigation)	58	4.3%
Unknown longer-term effects (non-specific)	51	3.8%
Potential for virus to be ineffective	41	3.1%
Potential for virus transmission to humans	33	1.6%
Problems with clean-up / removal of dead carp	25	1.9%
Uncertainty of flow-on effects to ecological roles of other species	24	1.8%
General concern about human intervention / interference in nature	22	1.6%
Humaneness of control method	12	0.9%
Other / non-specific / unrelated comments	68	5.1%
Don't know / unsure	37	2.8%
No concerns / unconcerned	15	1.1%
TOTAL RESPONSES	2289	
No response (left blank)	*688*	

Note: * Respondent concerns about potential impacts of carp virus (open-ended responses, coded thematically; n=2027)

Exposure of ornamental koi population to CyHV-3 virus.

Concern over the risk of koi fish being exposed to CyHV-3 virus was assessed amongst a sub-sample of participants who had indicated that they had cared for ornamental koi fish as a hobby or pet. Among the 2026 participants who completed the survey, 300 people reported to having owned koi fish at some time (of which 40% were male and 47% were from MDB regions).

This sub-sample of participants were asked to rate their concern that the use of the carp virus would harm their koi fish (1 = not concerned at all, 3 = somewhat concerned, 5 = concerned a lot). The finding suggests that koi hobbyists were "a little bit concerned" that the carp virus may harm their koi if it was used to control carp population (Figure 51).

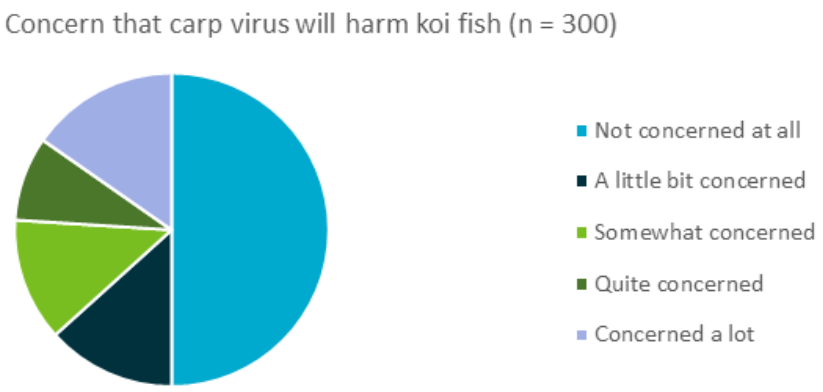


Figure 51 Self-reported concern amongst koi owners that the CyHV-3 virus would harm ornamental koi

Interestingly, when comparing (post-information) acceptance of virus use between the 'koi' sub-sample and the rest of the survey population, there were no significant differences in virus acceptance between koi owners and the general population ($p<0.0001$).

Potential psychological harm

The social risk of psychological harm was investigated through the assessment of attitudes towards using the carp virus to control carp population, and emotional reactions to the thought of dead or dying carp as a result of the virus.

General attitudes and feelings associated with using a virus to control carp

Social values associated with using a virus to control carp populations were measured by asking participant to indicate their attitudes and feelings towards the following statements:

- "*Using a virus to control carp sounds: 1 = very bad, 3 = neutral, 5 = very good*"
- "*Using a virus to control carp sounds: 1 = very unpleasant, 3 = neutral, 5 = very pleasant*"
- "*Using a virus to control carp sounds: 1 = very harmful, 3 = neutral, 5 = very beneficial*"
- "*Using a virus to control carp sounds: 1 = very foolish, 3 = neutral, 5 = very wise*"
- "*Using a virus to control carp sounds: 1 = very unsafe, 3 = neutral, 5 = very safe*"

Generally speaking, participants' attitudes towards using a virus to control carp scored around or just above neutral points, indicating uncertainty or neutrality with respect to whether using a virus was a positive or negative action. There were significant differences between male and female participants ($p<0.0001$, Figure 52). While male participants tended to have comparatively more positive attitudes, female participants tended to remain at the neutral point. However, in relation to the feeling of "unpleasant – pleasant", female participants reported a slightly negative (unpleasant) feeling while male participants remained neutral.

The differences between MDB and metro participants were marginal in magnitude, even though they tended to be statistically significant ($p<0.065$). In addition, attitudes were significantly and positively related to age while controlling for the effects of gender and location of residence, such that older participants reported more positive attitudes (Table 8). General attitudes were not linked to participants' education levels.

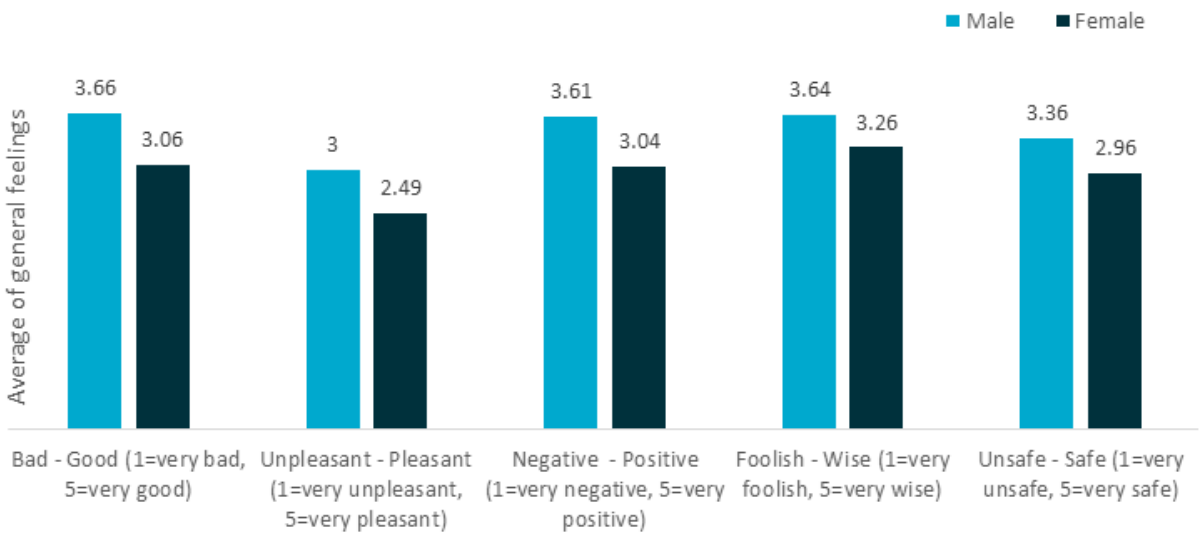


Figure 52 General attitudes towards the use of a virus to control carp by gender

Table 8 Partial correlation between age and attitudes towards the use of a virus to control carp while controlling for gender and location of residence

	Bad – Good	Unpleasant – Pleasant	Negative – Positive	Foolish – Wise	Unsafe – Safe
Age	.25***	.14***	.28***	.19***	.22***

Note: *** P<.001

Carp welfare.

Concerns over carp welfare were assessed by asking participants to indicate the extent to which they agreed with the statement: "I think controlling carp using a virus is humane" (1 = strongly disagree, 4 = not sure, 7 = strongly agree); and how concerned they were that "Carp may physically suffer from the effects of the virus (e.g., difficulty breathing due to damaged gills)" (1 = not concerned at all, 5 = concerned a lot).

While both male and female participants somewhat agreed that controlling carp using a virus was humane, male participants expressed a significantly stronger view than females ($p<0.0001$, Figure 53). In addition, both male and female participants showed moderate concerns over the possibility that carp may physically suffer from the effects of the virus, but male participants reported less concerns comparatively.

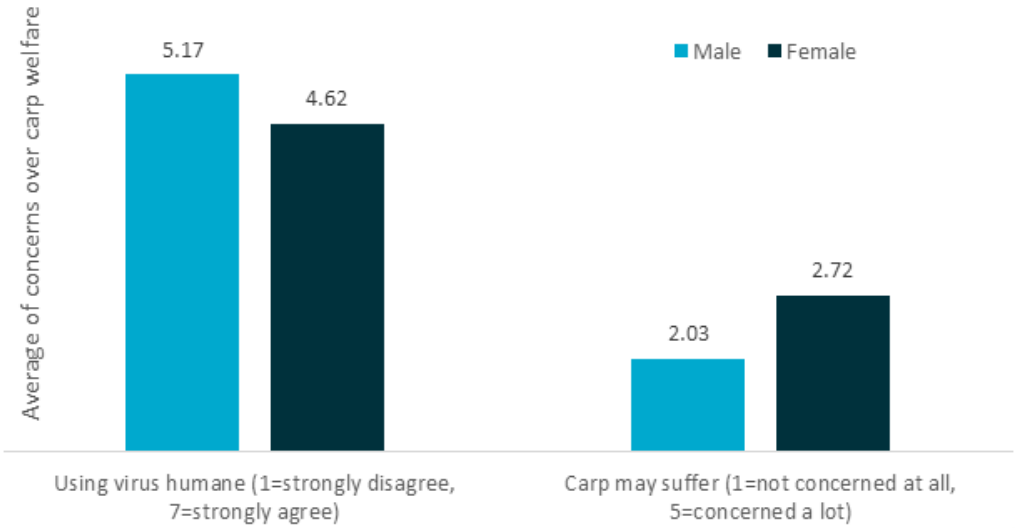


Figure 53 Concerns over carp welfare by gender

Although the differences in concerns over carp welfare between metro and MDB participants were significant ($p<0.008$) the differences were less pronounced in magnitudes (Figure 54).

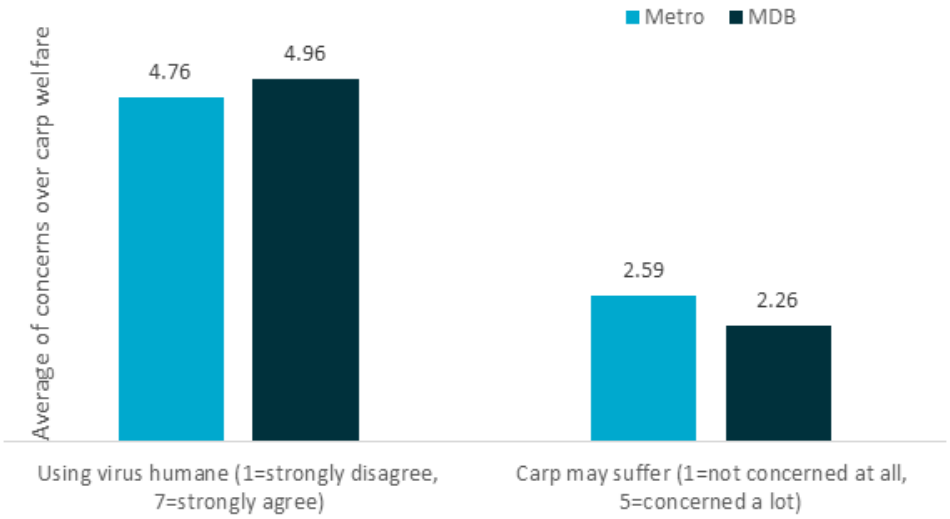


Figure 54 Concerns over carp welfare by location of residence

Concerns over carp welfare were significantly related to age while controlling for the effects of gender and location of residence ($p<0.0001$). Older participants tended to hold stronger views that using a virus to control carp was humane and were less concerned about the possibility that carp may physically suffer from the virus. Such concerns were not related to participants' levels of education.

Emotional distress associated with using a virus to control carp.

This was assessed by asking participants to indicate the extent to which they agreed with the following statements (1 = strongly disagree, 4 = not sure, 7 = strongly agree):

- "*I would feel worried about my safety if carp were controlled using the carp virus*"
- "*The idea of controlling carp using a virus upsets me*"

- "*I feel scared when I think about the carp virus*".

Generally speaking, the concept of using a virus to control carp did not evoke much emotional stress among participants. In addition, male participants were, comparatively, even less distressed (Figure 55). The evoked emotional distress reported by male participants was significantly below the neutral point (i.e. 4) with all three statements ($p<0.0001$). Female participants reported neutral reaction to whether they would feel worried about their safety if carp were controlled using the carp virus, but their reactions to statements regarding whether they would feel "upset" and "scared" in relation to the virus were below the neutral point.

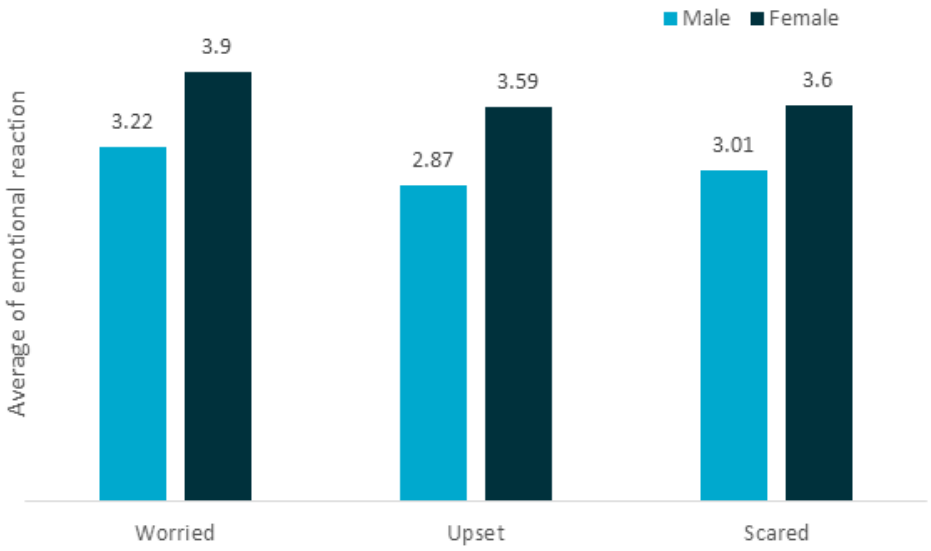


Figure 55 Emotional distress associated with using a virus to control carp by gender

Note: 1=strongly disagree, 7=strongly agree

While the idea of using a virus to control carp did not evoke substantial emotional distress from either metro or MDB participants (i.e. their responses were significantly below the neutral point of 4), there were significant differences between metro and MDB participants ($p<0.0001$, Figure 56). MDB participants reported lower levels of emotional distress compared to their metropolitan counterparts.

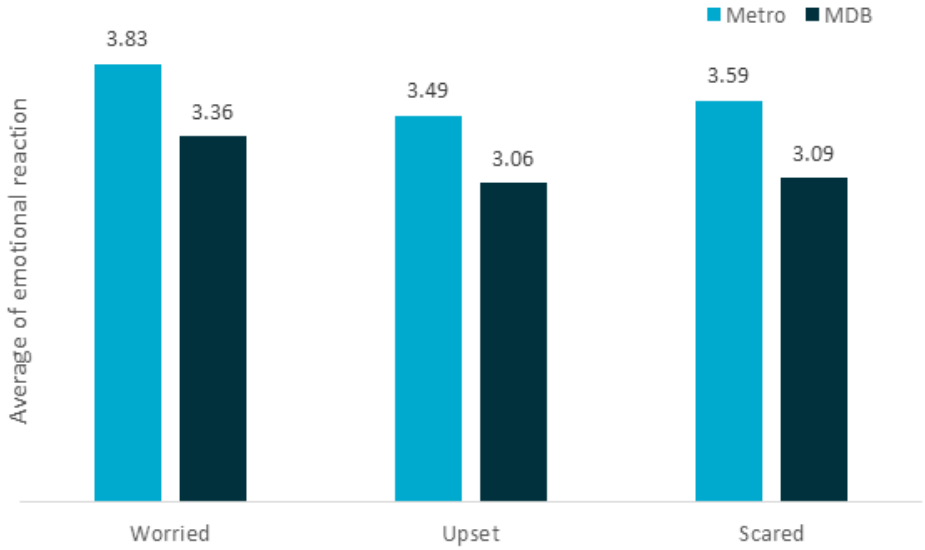


Figure 56 Emotional distress associated with using a virus to control carp by location of residence

Note: 1=strongly disagree, 7=strongly agree

In addition, emotional reactions to the idea of using a virus to control carp population were significantly related to age while controlling for the effects of gender and location of residence ($p<0.0001$, Table 9). Older participants experienced less emotional distress regarding the use of CyHV-3 virus.

Table 9 Partial correlation between age and emotional reactions to using a virus to control carp while controlling for gender and location of residence

	Worried	Upset	Scared
Age	-0.22***	-0.22***	-0.12***

Note: *** P<0.0001

Emotional distress associated with dead and dying carp.

Emotional distress associated with dead carp was assessed by asking participants to indicate the extent to which they agreed with the following two statements (1 = strongly disagree, 4 = not sure, 7 = strongly agree):

- "*It would stress me out if I saw a large number of dead carp near the water*"
- "*Thinking about carp dying from a virus bothers me*".

Overall, participants were not overly stressed by the thought of seeing a large number of dead carp (M = 3.72, SD = 2.08), nor were they bothered too much over the thought of dying carp (M = 3.25, SD = 1.92). The large standard deviations (SD) indicate that there were diverse differences amongst participants. Closer examination reveals that there were significant differences between male and female participants ($p<0.0001$, Figure 57). Male participants reported significantly lower levels of emotional distress over dead or dying carp in comparison to female participants. In particular, the evoked emotional distress over dead or dying carp reported by male participants was significantly below the neutral point (i.e. 4). However, female participants reported slight distress over dead carp. This was different from the neutral point, although marginal in

magnitude, and their reactions to the thought of carp dying from a virus was weaker and below the neutral point.

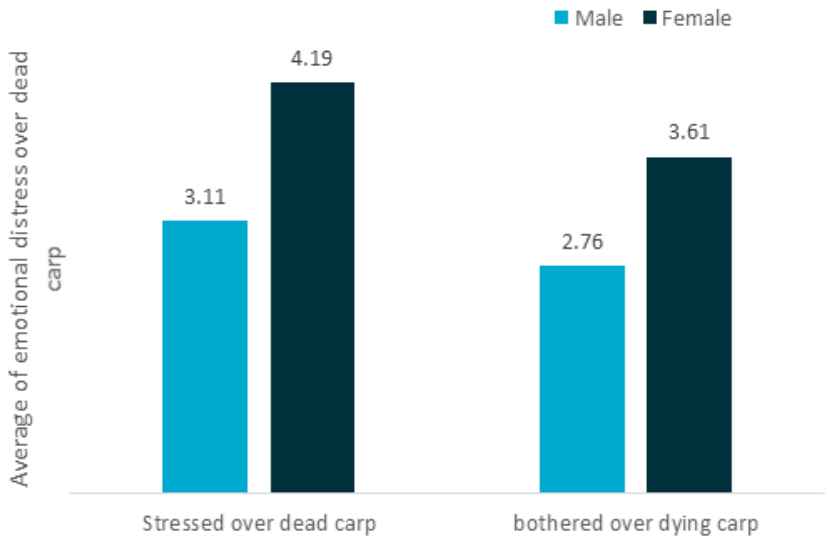


Figure 57 Emotional distress associated with dead carp by gender

Note: 1=strongly disagree, 7=strongly agree

There were significant differences in emotional reactions over dead or dying carp between metro and MDB participants ($p<0.0001$, Figure 58). MDB participants' reactions were below the neutral point. Metro participants were not sure how they would react towards dead carp (i.e. at the neutral point) and their reaction to dying carp was below the neutral point.

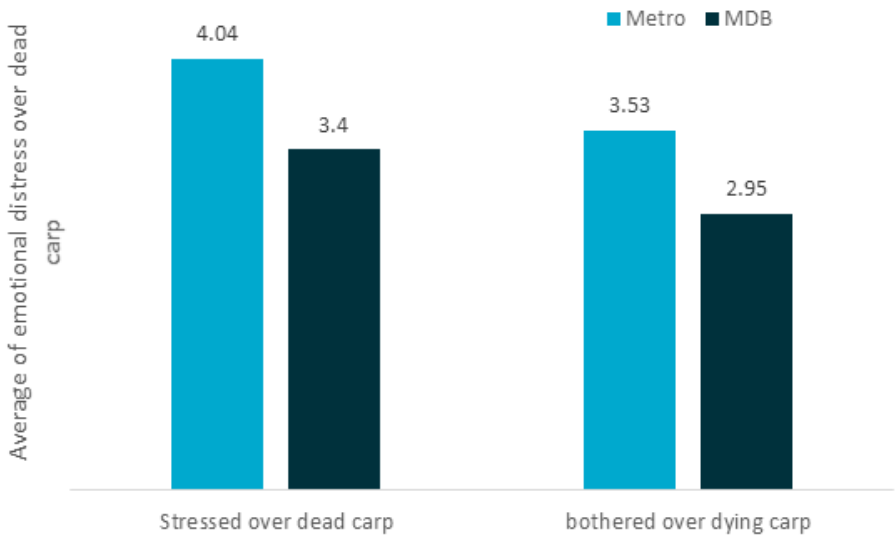


Figure 58 Emotional distress associated with dead carp by location of residence

Note: 1=strongly disagree, 7=strongly agree

Age was negatively related to emotional reactions over dead carp ($p<0.0001$) or dying carp ($p<0.0001$) while controlling for the effects of gender and location of residence, such that older participants tended to react less stressfully compared to younger participants. In addition, participants' levels of education were positively but weakly associated with a stronger reaction over dead carp ($p=0.001$), but not with the thought of dying carp.

Attitude towards using CyHV-3 virus to control carp population.

To assess attitudes towards using CyHV-3 virus to control carp populations, we asked participants to indicate the extent to which they agreed with the following statements on a 7-point scale (1 = strongly disagree, 4 = not sure, 7 = strongly agree):

- "*It is necessary to control carp using the carp virus*"
- "*I believe the proposed way of controlling carp using the carp virus would be fair to everyone in Australia*"
- "*As long as scientists are confident that the virus will not affect humans or other animals, I am happy with using the virus to control carp*"
- "*I would feel happy if carp were controlled using the carp virus*"
- "*Using the carp virus to control carp is a good option*".

Overall, participants were moderately positive about using CyHV-3 virus to control carp populations. As shown in Figure 59, there were significant differences between male and female participants ($p<0.0001$) such that male participants were more supportive of using CyHV-3 virus to control carp. Noticeably, in relation to being happy if carp were controlled using the carp virus, the levels of agreement were increased after adding "as long as scientists are confident that the virus will not affect humans or other animals", especially for female participants.

In addition, attitude towards using CyHV-3 virus was significantly and positively associated with age ($p<0.0001$) such that older participants were more supportive of using CyHV-3 virus to control carp population (Table 10). However, differences in attitudes between metro and MDB participants were marginal, and attitudes were not related to participants' levels of education.

Table 10 Partial correlation between age and attitude towards using CyHV-3 virus while controlling for gender and location of residence

	Necessary to use carp virus	Fair to use carp virus	Happy for using carp virus if scientists are confident	Happy to use carp virus	Good option to use carp virus
Age	0.21***	0.22***	0.15***	0.24***	0.21***

Note: *** $p<0.0001$

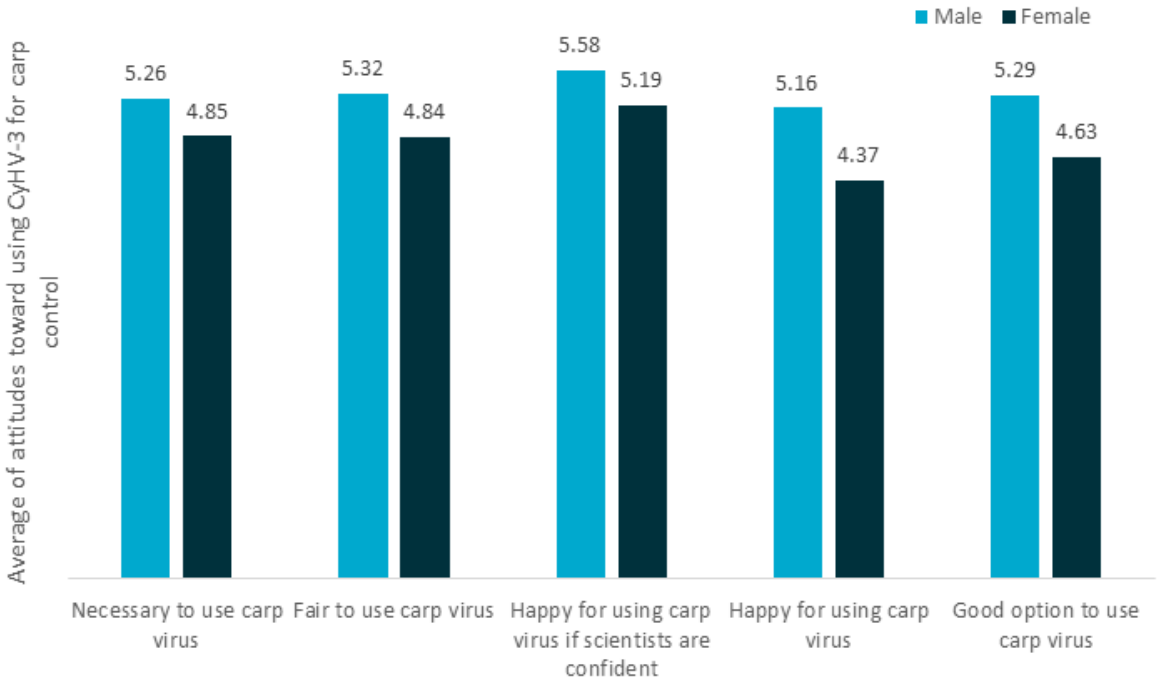


Figure 59 Attitude towards using CyHV-3 virus to control carp population by gender

Note: 1=strongly disagree, 7=strongly agree

2.4 Integrative model for public acceptance of CyHV-3

Potential paths were developed based on literature review and the results of the previous analyses (see Figure 60 for the path model). In this model, we aimed to identify the key variables that contribute to participants' attitudes towards carp control using the virus, and the underlying mechanism of how those variables interact to affect the attitude.

2.4.1 Measures

For measures with multiple items, scores on individual items were averaged to represent a single score depicting the level of the measured construct.

Recreational use of waterways was measured by participants indicating approximately how many times they had undertaken recreational activities at a river/lake/dam (e.g. swimming, camping, or just having fun) in the past 12 months.

Knowledge of carp impact was measured with 3 items ($\alpha = 0.93$)[3]. After reading the information on carp control history, CyHV-3, and the science of using CyHV-3 to control carp population (see Section 3.3 for details), participants were asked to indicate how much they knew about carp's negative impact on 1) the environment in Australia and 2) native fish, and 3) carp's economic

[3] For measurement with multiple items, internal consistency (α) was computed to examine how well the items worked together in measuring the construct. An α value greater than 0.7 is regarded as acceptable (George and Mallery, 2003).

impacts on agricultural and ecotourism industries (1 = no knowledge at all, 5 = extensive knowledge).

Care for future generations was measured by asking participants to indicate the extent they agree with two statements: “We have a responsibility to manage waterways for future generations,” and “We need to leave the country in a good state for our young people.” (α = 0.78; 1 = strongly disagree, 7 = strongly agree).

Awareness of control proposal was measured by asking participants to indicate whether they had heard about the Australian Government's proposal to control carp populations in Australia using a carp herpes virus (1 = yes, 2 = no).

Value existence and use of carp was measured by asking participants to indicate the extent to which they agreed with three items (α = 0.88). They are: “Carp are a natural part of the Australian ecosystem,” “Carp are useful fish to have in our waterways,” and “I value carp because they are an important part of my culture” (1 = strongly disagree, 7 = strongly agree).

Carp control necessary was measured by asking participants to indicate the extent to which they agreed with two items (α = 0.77). They are: “Carp populations should be controlled in Australian waterways,” “I believe it's necessary to control carp populations immediately” (1 = strongly disagree, 7 = strongly agree).

Impact of the virus was measured using three items (α = 0.92). Participants were asked to indicate how concerned they were that: “The carp virus may affect native species in the virus-treated waterways,” “The carp virus may affect agricultural irrigation in the vicinity of virus-treated waterways,” “The carp virus may affect the safety of people living in the vicinity of virus-treated waterways” (1 = not concerned at all, 5 = concerned a lot).

Benefit of carp control was measured by asking participants to indicate the extent to which they agreed with three items (α = 0.82). They are: “Reducing the number of carp will encourage greater biodiversity,” “Reducing the number of carp will help restore native fish numbers,” and “Reducing the number of carp will make the waterways cleaner and clearer” (1 = strongly disagree, 7 = strongly agree).

Emotional stress was measured by asking participants to indicate the extent to which they agreed with five items (α = 0.90). They are: “The idea of controlling carp using a virus upsets me,” “I feel scared when I think about the carp virus,” “Thinking about carp dying from a virus bothers me,” “It would stress me out if I saw a large number of dead carp near the water,” and “I would be afraid to drink local water if the virus was released” (1 = strongly disagree, 7 = strongly agree).

Acceptance of carp control using CyHV-3 was measured by asking participants to indicate the extent to which they agreed with three items (α = 0.92). They are: “It is necessary to control carp using the carp virus,” “I would feel happy if carp were controlled using the carp virus,” and “Using the carp virus to control carp is a good option” (1 = strongly disagree, 7 = strongly agree).

2.4.2 Analysis

A path analysis was conducted to examine the interactive relationship between the key attitudinal variables in predicting support for carp control using CyHV-3. The goodness of fit of the model was assessed using the chi-square test, the comparative fit index (CFI), normed fit index (NFI), and

standardised root mean square residual (SRMR). A satisfactory fit is indicated by a non-significant chi-square test, CFI≥0.95, NFI≥0.95 and SRMR≤0.06 (Hu and Bentler 1999; Kenny and McCoach 2003). It has been noted, however, that chi-square tests are almost always significant with large samples. Due to the large size of the samples in the present study (n=2026), the satisfactory fits of other indices are particularly useful (Kenny and McCoach, 2003).

2.4.3 Results and Discussion

This specified integrative model provided good fit for the data (Figure 60). Although the value for Chi-square test was significant (χ^2_{18df} = 438.06, p<0.001) due to the large sample, the values for other fit indices suggested the model was a good fit: CFI=0.96, NFI=0.96, SRMR=0.05. The model explained 63% of the variance in acceptance of carp control using CyHV-3 virus, which represents a very strong model. Figure 60 presents the standardised parameter estimates for the integrative model predicting acceptance of carp control using CyHV-3.

As shown in Figure 60, acceptance of carp control using CyHV-3 was positively associated with perceived benefits of carp control (β=0.25, p<0.001), and negatively related to perceived impact of the virus (β=-0.17, p<0.001), and emotional stress aroused from the potential consequences of carp control using the virus (β=-0.41, p<0.001). That is, perceiving the benefits of carp control led to higher acceptance level of carp control using the virus. On the other hand, concerns over the impacts of the virus and the emotional stress associated with carp control using CyHV-3 reduced acceptance levels.

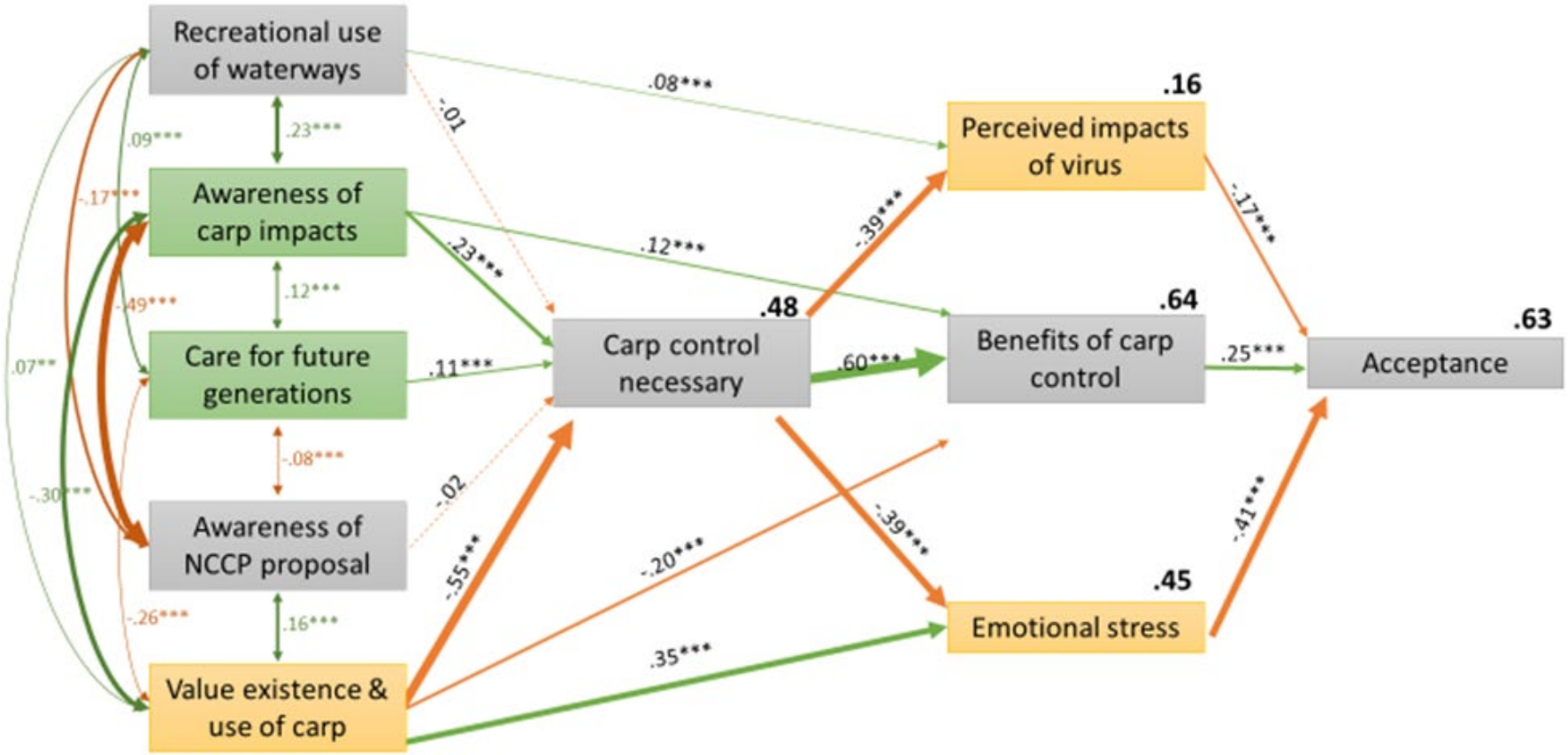


Figure 60 An integrative model of predicting acceptance of carp control using CyHV-3

Note: **p<0.01, ***p<0.001. Solid lines represent statistically significant relationships; dashed lines indicate statistically non-significant relationships. The value next to each line is the standardised regression coefficient and represents the strength of relationship between variables, with positive values denoting positive relationships and negative values denoting a negative relationship. The values above variables “Carp control necessary”, “Perceived impact of virus”, “Benefits of carp control”, “Emotional stress”, and “Acceptance” represent the variance explained for each variable.

Belief that carp control was necessary (i.e. Carp control necessary) was strongly linked with high perceived benefits of carp control ($\beta=0.60$, $p<0.001$), and fewer perceived impacts of the virus ($\beta=-0.39$, $p<0.001$) and less emotional stress ($\beta=-0.39$, $p<0.001$). That is, the more participants saw the need for controlling carp in Australia, the more they would perceive the benefits of carp control, and the less they would report concerns over the impacts of using the virus and experience emotional stress.

In addition, regarding carp as valuable for the ecosystem and culturally important (i.e. value existence and use of carp) led to stronger emotional stress ($\beta=0.35$, $p<0.001$) and fewer perceived benefits of carp control ($\beta=-0.20$, $p<0.001$). Knowing carp's negative impacts on the environment and the economy (i.e. knowledge of carp impacts) led to higher perceived benefits of carp control ($\beta=0.12$, $p<0.001$), while recreational use of waterways was associated with concerns of the impacts of the virus ($\beta=0.08$, $p<0.001$).

Finally, a belief that carp control was necessary was positively related to one's knowledge of carp impacts ($\beta=0.23$, $p<0.001$) and a desire to protect the environment for future generations ($\beta=0.11$, $p<0.001$). The more participants knew about carp's impacts on the environment and economy, and the more they believed that waterways should be managed responsibly for the future generations, the more they saw the need to control carp's populations. A belief that carp control was necessary was also negatively associated with valuing the existence of carp and use of carp ($\beta=-0.55$, $p<0.001$); the more participants regarded carp as part of ecosystem and of cultural value, the less need they saw in controlling carp populations.

In summary, the integrative model (Figure 60) highlights that a belief that carp control is necessary is the key factor in predicting public acceptance of carp control using the virus. It influences acceptance through three different pathways: increased perceived benefits of carp control, reduced concerns over the impacts of using the virus, and reduced emotional stress associated with the potential consequences of carp control using the virus. Hence, to predict public acceptance of carp control using the virus, it is imperative to understand public attitude towards the necessity of controlling carp population in Australian waterways.

The model further highlights that a belief that carp control is necessary is determined by three key factors: knowledge of carp impacts, care for future generations, and value existence and use of carp. More knowledge about carp's impact on the environment and the economy as well as a desire to manage our waterways responsibly for future generations leads to higher levels of belief in the necessity of carp control, while seeing carp as a valuable part of the ecosystem and culturally important leads to a decreased belief that carp control is necessary.

The findings have important implications for strategically managing a carp control program if release is supported as scientifically sound. First, increasing public knowledge on carp's negative impacts will lead to increased understanding of carp control as necessary and benefits of carp control. The present survey indicated that the public had very limited knowledge of carp's negative impacts on the ecosystem and economy. Given that those who were aware of the National Carp Control Plan reported more knowledge about carp impacts, and only 34% of participants had heard about the carp control proposal, there is huge potential for improvement on public knowledge of carp's negative impacts through effective public education. Second, reducing the perceived value of carp in our waterways will lead to an increased understanding of carp control as necessary and an understanding of the benefits of carp control, as well as lead to

reduced emotional stress associated with carp control using the virus. The more knowledge participants had about the impacts of carp, the less value they attributed to the role of carp within natural ecosystems. Equally, those who were aware of, and understood, the proposal for the biocontrol of carp attributed less value to the protection of carp. These results showed that public education is likely to be an effective means by which to minimise unnecessary resistance to biocontrol. Theoretically, these results support a knowledge deficit model because base levels of carp knowledge are very low. Future research could examine where the threshold lies for the positive effect of knowledge on acceptance of CYHV-3.

Underlying causes for differences in attitudes between gender and region.

Integrating the findings from analyses of difference in gender and locations of residence with the integrative model, Figure 61 and Figure 62 highlight the key underlying causes for the difference in attitude towards carp control using CyHV-3 virus between gender and between participants from metropolitan and MDB areas.

As suggested by Figure 61, the comparatively lower level of acceptance by female participants were due to their lower knowledge of carp's negative impacts, being less likely aware of carp control proposal, and perceiving more value existence and use of carp.

For MBD participants (Figure 62), their comparatively more positive attitude towards carp control using the virus was linked to their higher level of knowledge about carp's negative impacts, being more likely aware of carp control proposal, perceiving less value existence and use of carp, and caring more about waterways for future generations.

Linking the underlying causes for the differences in gender and location of residence with the above discussion about implications for strategically managing carp control program (see Section 4.3), it is clear that the same pathways would apply.

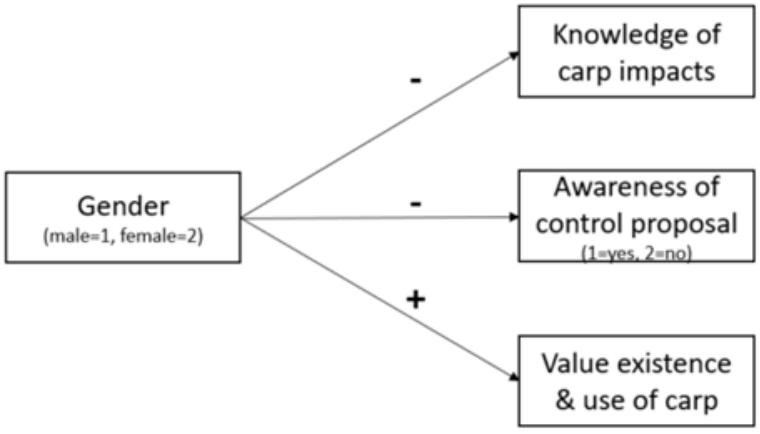


Figure 61 Underlying causes for gender difference in attitude towards carp control

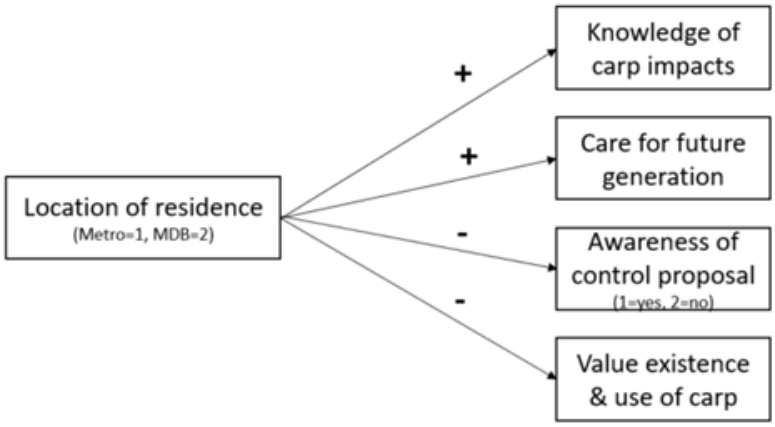


Figure 62 Underlying causes for location difference in attitude towards carp control

3 Mitigations, communications and engagement

1. Despite ongoing efforts by the NCCP to engage and consult with communities along the MDB and surrounds, the survey found awareness of the NCCP was generally low. Teasing out those results and what it means for ongoing consultation and communication strategies is recommended.
2. Survey respondents' perceived need for carp control was not related to participants' levels of education, fishing activities, or frequency of recreational use of waterways. This finding may have implications for how the NCCP communicates its key messages.
3. Women expressed higher levels of concern across a number of measures. Tailoring communication methods and tools to account for gender roles and relations may communicate the NCCP's vision more effectively. For example, applying gender-specific language to messages, identifying how women use specific communication and social media platforms, including women and families in communication and promotional materials, etc.
4. A majority of survey respondents named local governments/councils as their preferred organisations for responsibility of carp clean-up. Focus group discussions revealed that confidence in local councils to implement and effectively monitor local initiatives was very poor mainly due to historical breaches of trust. Consideration should be given to assessing the potential effectiveness of local institutions to implement components of the NCCP especially for communities who will be severely affected by significant biomass inundation.
5. There are clear expectations from survey respondents about the timeliness and efficiency of carp clean-up post virus release. If the NCCP considers the feasibility of any proposed clean-up program to fall outside of those expectations, communication with affected communities is paramount.

List of references

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Appendix: survey questionnaire

Survey: Carp Survey

Welcome

You have been invited to participate in an important CSIRO research project on public views of European/common carp fish and their control in Australian waterways. The findings of this study will be used to inform government policy and strategies on how to manage carp populations in Australian waterways. This study is being funded by Fisheries Research and Development Corporation and CSIRO.

If you choose to participate, you will be asked to fill out this online questionnaire that will take approximately 20 minutes to complete.

Participation and withdrawal

To participate in this research you have to be 18 years old or over. Participation in this study is completely voluntary and you are free to withdraw from this study at any time. If you wish to withdraw, simply cease completing the questionnaire and close the browser window, and your data will be deleted. We do not anticipate that any of the questions are sensitive. However, please feel free to omit answering any questions that make you feel uncomfortable. In the reporting of this study, your information will not be identifiable. Your responses will be aggregated with thousands of other responses from other participants.

Risk and confidentiality

Aside from giving up your time, there are no foreseeable risks associated with participating in this study. All information collected in this survey will be confidential. Your responses will only be seen by members of our research team and will be stored securely by CSIRO.

The aggregated survey data will be used to prepare reports, journal publications, and conference presentations. Once again, you will not be identifiable at any stage or reporting.

Further information, ethical clearance and contacts

If you would like further information on this project, please feel free to contact the research team via email at carpsocialresearch@csiro.au. This study has been cleared in accordance with the ethical review processes of CSIRO, within the guidelines of the National Statement on Ethical Conduct in Human Research. If you have any questions concerning your participation in the study, feel free to contact the researcher. Also, any concerns or complaints about the study can be raised with CSIRO's Social Science Human Research Ethics Committee by email at csshrec@csiro.au or by phoning the Manager of Social Responsibility and Ethics on 07 3833 5693.

If you consent to take part in the survey, please click the 'Next' button below to begin.

---

*

Thank you for participating in this survey!

Please don't use the browser to go back to previous pages.

Where do you live?

- ○ Sydney
- ○ Other regions of NSW
- ○ Brisbane
- ○ Other regions of QLD

- Melbourne
- Other regions of VIC
- Adelaide
- Other regions of SA
- Perth
- Other regions of WA
- ACT
- Tasmania
- Northern Territory
- Not in Australia

---

* **Which council area do you live in?**

-- Select --

---

* **Which council area do you live in?**

-- Select --

---

* **Which council area do you live in?**

- Brisbane City Council
- Logan City Council

Which council area do you live in?

-- Select --

---

* **Which council area do you live in?**

-- Select --

---

* Which council area do you live in?

-- Select --

---

* Which council area do you live in?

-- Select --

---

* Which council area do you live in?

-- Select --

---

* Gender

○ Male ○ Female ○ prefer not to disclose

* Your postcode

* Your age

-- Select --

---

*

What is your highest level of education?

-- Select --

* Approximately how far is your home from the nearest fresh water body such as a river, or lake, or dam?

-- Select --

* In the past 12 months, approximately how many times have you gone fresh water fishing?

O 0 O 1-3 times O 4-6 times O 7-10 times O more than 10 times

* How often have you caught carp ()?

O Never O Rarely O Occasionally O Sometimes O All the time

* Does the presence of carp negatively affect your fishing experience?

O Yes O No O Not sure

---

* To your knowledge, are there many carp () in the rivers, lakes, or dams you have visited?

O None O Hardly any O A few O Many O A lot O Don't know

* To your knowledge, how healthy are most of the rivers, lakes, or dams you have visited in general?

O Very poor O Poor O Ok O Good O Very good O Don't know

* In the past 12 months, approximately how many times have you undertaken recreational activities at a river/lake/dam (e.g., swimming, camping, or just having fun)?

O 0 O 1-3 times O 4-6 times O 7-10 times O more than 10 times

* Have you ever looked after ornamental koi fish (part of the carp family) as a hobby or as pets?

O Yes O No

* Are carp a good food source for people?

O Yes O No O Don't know

* Have you ever eaten carp?

O Yes O No

* How often do you eat carp?

O hardly ever O 1-2 times a year O 3-4 times a year O 5-6 time a year O more than 6 times a year

---

* In your opinion, which of the following best describes carp?

-- Select --

* How would you describe your knowledge of carp?

-- Select --

Carp Survey

QuestionPro

* **Have you heard about the Australian Government's proposal to control carp populations in Australia using a carp herpes virus?**

O Yes O No

Overall, how acceptable would you find the following?

	Not at all acceptable			Not sure			Very acceptable	Don't know
* Reducing numbers of carp by releasing the carp herpes virus	O	O	O	O	O	O	O	O

Listed below are statements about the relationship between humans and the environment in general. Please indicate the extent to which you agree with each statement.

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* Humans have the right to modify the natural environment to suit their needs.	O	O	O	O	O	O	O
* The balance of nature is strong enough to cope with the impacts of modern industrial nations.	O	O	O	O	O	O	O
* Humans are severely abusing the environment.	O	O	O	O	O	O	O
* The so-called "ecological crisis" facing humankind has been greatly exaggerated.	O	O	O	O	O	O	O
* When humans interfere with nature it often produces disastrous consequences.	O	O	O	O	O	O	O
* All animals have as much right as humans to exist.	O	O	O	O	O	O	O

Listed below are statements about the relationship between humans and the environment in general. Please indicate the extent to which you agree with each statement.

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* Waterways provide valuable natural resources for my community.	O	O	O	O	O	O	O
* We need to leave the country in a good state for our young people.	O	O	O	O	O	O	O
* The balance of nature is very delicate and easily upset.	O	O	O	O	O	O	O

* Waterways provide business

opportunities for people in my community.	O	O	O	O	O	O	O
* We have a responsibility to manage waterways for future generations.	O	O	O	O	O	O	O
* Waterways provide amenity and recreation facilities for people in my community to enjoy.	O	O	O	O	O	O	O
* Humans were meant to rule over the rest of nature.	O	O	O	O	O	O	O

In the following section, you will read some brief information about carp in Australian waterways and the potential to use a carp virus to control their populations. Please read carefully, as you will be asked to answer some questions based on the information provided.

Carp in Australian waterways and their impact

European carp is one of Australia's most significant introduced pest species. Carp have significant social, environmental and economic impacts. For example, they can impact on native fish populations by consuming eggs and larvae, competing for food sources, and altering habitat. They dominate the Murray Darling Basin, making up 80-90 per cent of the fish in many of the waterways in the basin. The economic impact of carp to agricultural and ecotourism industries has been estimated at up to $500 million per year.

Some history of carp control

Various methods, including netting and electrofishing, have been used to control carp in Australian waterways. However, none have been effective in significantly reducing carp populations.

As a result, the Australian Government is proposing to use a carp virus to more effectively control carp populations.

The carp virus

The National Carp Control Plan (NCCP) is investigating the feasibility of using *Cyprinid herpesvirus 3*, also known as carp virus, as a biological control agent to manage carp in Australia's freshwater environments. The carp virus is a naturally occurring virus in over 33 countries worldwide. However, it is not currently present in Australian waterways.

The science of using carp virus to control carp populations

CSIRO has conducted extensive scientific research and shown that under optimal conditions, the carp virus could kill over 70 per cent of carp in a given population, in 5-7 days following release. The carp virus can only survive in the water for 3-4 days.

The carp virus is specific to common carp and does not affect humans, other species of fish, other animals or plants.

The virus acts quickly and will lead to significant dead and dying carp in targeted waterways following release. Research is currently underway to investigate optimal release conditions (e.g. timing, locations) for the virus and possible clean-up strategies.

Please indicate how much you knew before reading the above information.

	No knowledge at all	A little knowledge	Some knowledge	A lot of knowledge	Extensive knowledge
* How much did you know about carp's negative impact on the environment in Australia?	O	O	O	O	O
* How much did you know about the carp virus?	O	O	O	O	O
* How much did you know about carp's negative impact to native fish?	O	O	O	O	O
* How much did you know about carp's economic impacts to agricultural and	O	O	O	O	O

ecotourism industries?

Please indicate the extent to which you agree with the following statements.

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* As long as scientists are confident that the virus will not affect humans or other animals, I am happy with using the virus to control carp.	O	O	O	O	O	O	O
* I believe the proposed way of controlling carp using the carp virus would be fair to everyone in Australia.	O	O	O	O	O	O	O
* Carp are pests in Australian waterways.	O	O	O	O	O	O	O
* The idea of controlling carp using a virus upsets me.	O	O	O	O	O	O	O
* It is necessary to control carp using the carp virus.	O	O	O	O	O	O	O
* Carp populations should be controlled in Australian waterways.	O	O	O	O	O	O	O
* I think controlling carp using a virus is humane.	O	O	O	O	O	O	O

Please indicate the extent to which you agree with the following statements.

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* I am concerned that others may try and put the virus into rivers without permission from authorities.	O	O	O	O	O	O	O
* It would stress me out if I saw a large number of dead carp near the water.	O	O	O	O	O	O	O
* I feel scared when I think about the carp virus.	O	O	O	O	O	O	O
* Thinking about carp dying from a virus bothers me.	O	O	O	O	O	O	O
* Carp are a natural part of the Australian ecosystem.	O	O	O	O	O	O	O
* I am concerned that the virus may be introduced to Australia without permission from the authorities, either accidentally or intentionally.	O	O	O	O	O	O	O

Please indicate your feelings towards the following statements.

* **Using a virus to control carp sounds ...**

O Very bad O Bad O Neutral O Good O Very good

* **Using a virus to control carp sounds ...**

O Very unpleasant O Unpleasant O Neutral O Pleasant O Very pleasant

* **Using a virus to control carp sounds ...**

O Very negative O Negative O Neutral O Positive O Very positive

* **Using a virus to control carp sounds ...**

O Very foolish O Foolish O Neutral O Wise O Very wise

* **Using a virus to control carp sounds ...**

O Very unsafe O Unsafe O Neutral O Safe O Very safe

Based on your current level of knowledge, how much would you support or oppose controlling carp using the following action?

	Strongly oppose			Not sure			Strongly support	Don't know
* Release of the carp virus in rivers, lakes or wetlands you spend time at	O	O	O	O	O	O	O	O

Please indicate the extent to which you agree with the following statements.

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* Reducing the number of carp will encourage greater biodiversity.	O	O	O	O	O	O	O
* I believe it's necessary to control carp populations immediately.	O	O	O	O	O	O	O
* Carp are useful fish to have in our waterways.	O	O	O	O	O	O	O
* I would feel happy if carp were controlled using the carp virus.	O	O	O	O	O	O	O
* I value carp because they are an important part of my culture.	O	O	O	O	O	O	O
* I would be afraid to drink local water if the virus was released.	O	O	O	O	O	O	O

---

* I would feel worried about my safety if carp were controlled using the carp virus.	O	O	O	O	O	O	O
* I think we need to wait until another option for carp control becomes available.	O	O	O	O	O	O	O

Please indicate the extent to which you agree with the following statements.

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* Reducing the number of carp will help restore native fish numbers.	O	O	O	O	O	O	O
* Considering the damage carp have done to Australian waterways, it is worthwhile to control carp populations.	O	O	O	O	O	O	O
* This is a test question for verification, to answer this question, please choose option 'agree'.	O	O	O	O	O	O	O
* I would be willing to accept the use of a carp-specific virus to reduce carp numbers in Australian waterways	O	O	O	O	O	O	O
* Using the carp virus to control carp is a good option.	O	O	O	O	O	O	O
* Reducing the number of carp will make the waterways cleaner and clearer.	O	O	O	O	O	O	O
* Using the carp virus to control carp would be effective in reducing carp numbers.	O	O	O	O	O	O	O

The following questions are about your views on controlling carp populations using the carp virus.
How concerned are you that ...

	Not concerned at all	A little bit concerned	Somewhat concerned	Quite concerned	Concerned a lot
* humans or animals consuming produce irrigated by virus-treated waterways'?	O	O	O	O	O
* domestic pets may get sick if they eat dead carp that are killed by the virus?	O	O	O	O	O
* large quantities of dead carp may negatively affect local people?	O	O	O	O	O
* large quantities of dead carp may negatively affect local tourism?	O	O	O	O	O
* carp may physically suffer from the effects of the virus (e.g. difficulty breathing due to damaged gills)?	O	O	O	O	O

* large quantities of dead carp may negatively affect local business?	O	O	O	O	O
* the smell of dead carp may negatively affect local people?	O	O	O	O	O

The following questions are about your views on controlling carp populations using the carp virus.
How concerned are you that ...

	Not concerned at all	A little bit concerned	Somewhat concerned	Quite concerned	Concerned a lot
* removing carp from the waterways will negatively affect the livelihoods of people who live near waterways?	O	O	O	O	O
* reducing carp populations may remove an important food source for some animals?	O	O	O	O	O
* the carp virus may affect agricultural irrigation in the vicinity of virus-treated waterways?	O	O	O	O	O
* the carp virus may affect native species in the virus-treated waterways?	O	O	O	O	O
* the carp virus may affect the safety of people living in the vicinity of virus-treated waterways?	O	O	O	O	O
* reducing carp populations may encourage other pests to fill the gap?	O	O	O	O	O

*** Are you concerned that using the carp virus to control carp will harm your koi fish?**

O Not concerned at all O A little bit concerned O Somewhat concerned O Quite concerned O Concerned a lot

*** Are you concerned that the carp virus may have unintended impacts not already predicted by scientists?**

O Yes O No

Please give details on what you are concerned about:

Carp Survey

QuestionPro

The following series of questions provide you with a set of options for each scenario. Please rate how acceptable you find each option to be.

Large quantities of dead carp may impact water quality in the short term, through reducing available oxygen in the water and increasing potentially harmful bacteria. This could mean that....

	Not at all acceptable			Not sure			Very acceptable
* The poor water quality causes a few deaths of native species, but their population will quickly recover.	O	O	O	O	O	O	O
* The poor water quality causes some deaths of native species, and their population will take a while to recover.	O	O	O	O	O	O	O
* The poor water quality causes many deaths of native species, and some of them may become locally extinct.	O	O	O	O	O	O	O

The following scenarios are hypothetical only. They are intended to get a sense of how people feel about different possibilities surrounding fish clean-up. Please indicate your level of acceptability for each of the following hypothetical scenarios.

Scenario 1. If the virus is released, many carp are killed by the virus in closed/isolated locations, and

	Not at all acceptable			Not sure			Very acceptable
* they are subsequently cleaned up in a short period of time (e.g. within 1 week).	O	O	O	O	O	O	O
* they are subsequently cleaned up over an extended period of time (e.g. within 2-3 weeks), may lead to substantial foul smell.	O	O	O	O	O	O	O
* they are subsequently cleaned up only near waterway access points and human populations.	O	O	O	O	O	O	O

Scenario 2. If the virus is released, many carp are killed by the virus along moderate stretches of water (e.g. 10s of kms), and

	Not at all acceptable			Not sure			Very acceptable
* they are subsequently cleaned up in a short period of time (e.g. within 1 week).	O	O	O	O	O	O	O
* they are subsequently cleaned up over an extended period of time (e.g. within 2-3 weeks), may lead to substantial foul smell.	O	O	O	O	O	O	O
* they are subsequently cleaned up only near waterway access points and human populations.	O	O	O	O	O	O	O

Scenario 3. If the virus is released, many carp are killed by the virus along large stretches of water (e.g. 100s of kms), and

	Not at all acceptable			Not sure			Very acceptable
* they are subsequently cleaned up in a short period of time (e.g. within 1 week).	O	O	O	O	O	O	O
* they are subsequently cleaned up over an extended period of time (e.g. within 2-3 weeks), may lead to substantial foul smell.	O	O	O	O	O	O	O
* they are subsequently cleaned up only near waterway access points and human populations.	O	O	O	O	O	O	O

* **Once released, virus outbreaks will naturally reoccur in future years if conditions are favourable. This will once again result in dead carp, but at lower numbers than in the initial release. Please indicate how acceptable this would be to you.**

O Not at all acceptable O O O Not sure O O O Very acceptable

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*

For the ongoing carp deaths, how often should the clean-up be conducted?

-- Select --

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* **Who do you think should organise the clean-up of dead carp? You can choose up to 3 organisations.**

- O Local council/government
- O State government agencies
- O Federal government agencies
- O Natural Resource Management Agencies
- O Local citizens
- O Community clubs

While scientists, governments and resource management agencies work on strategies to manage carp in Australian waterways, how important it is for members of the public (e.g. you) to be informed and involved?

Please indicate your agreement with the following statements. Please note NCCP = National Carp Control Plan

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* It is important for majority views to be							

acted on in implementing the carp control plan.	O	O	O	O	O	O	O
* It is important to have all relevant information published on the NCCP's website and social media (e.g. Facebook).	O	O	O	O	O	O	O
* It is important for me to have opportunities to provide my views and feedback.	O	O	O	O	O	O	O
* It is important for me to be informed about the decision-making process.	O	O	O	O	O	O	O

Please rate the level of trust you have in each of the following organisations to manage the carp control program using the carp virus (virus release, clean-up & disposal).

	Very low trust	Low trust	Moderate trust	High trust	Very high trust
* Federal government agencies	O	O	O	O	O
* Natural Resource Management Agencies	O	O	O	O	O
* State government agencies	O	O	O	O	O
* Local council/government	O	O	O	O	O

If there are other organisations you trust, please name here:

Please indicate your agreement with the following statements.

	Strongly Disagree	Disagree	Slightly disagree	Not sure	Slightly agree	Agree	Strongly Agree
* I believe my family would support the use of a carp virus to control the number of carp in Australian waterways.	O	O	O	O	O	O	O
* I believe my friends would support the use of a carp virus to control the number of carp in Australian waterways.	O	O	O	O	O	O	O
* I would feel morally obliged to support the use of a carp virus to help control carp in Australian waterways.	O	O	O	O	O	O	O
* I would feel guilty if I didn't support the use of a carp virus to help control carp in Australian waterways.	O	O	O	O	O	O	O
* Regardless of what others would do, I feel it is important to support the use of a carp virus to help control carp in Australian waterways.	O	O	O	O	O	O	O

* I believe my neighbours would support the use of a carp virus to control the number of carp in Australian waterways.	O	O	O	O	O	O	O
* I believe the people of Australia would support the use of a carp virus to control the number of carp in Australian waterways	O	O	O	O	O	O	O

Please indicate how likely you are to do the following.

	Very unlikely	Unlikely	Somewhat unlikely	Not sure	Somewhat likely	Likely	Very likely
* How likely are you to support the use of the carp virus to control carp in Australia?	O	O	O	O	O	O	O
* How likely are you to provide feedback regarding how to control carp to NCCP?	O	O	O	O	O	O	O
* How likely are you to regularly check NCCP's online information (e.g. website, Facebook or Twitter accounts)?	O	O	O	O	O	O	O
* How likely are you to be actively involved in community discussions regarding this topic?	O	O	O	O	O	O	O

If the carp virus were to be released in Australian waterways to control carp, how important are each of the following activities to you?

	Not important at all	A little important	Moderately important	Important	Extremely important
* A visitor's centre at virus release sites or local Natural Resource Management offices	O	O	O	O	O
* Education programs in schools	O	O	O	O	O
* Open days to visit virus release sites and talk with authorities	O	O	O	O	O
* Public reporting of water quality tests and virus effectiveness following virus release	O	O	O	O	O
* Public talks by carp virus experts and scientists, with "Question & Answer" sessions	O	O	O	O	O
* Community updates/briefings for those who are interested	O	O	O	O	O
* Regular independent auditing and regulation of water systems	O	O	O	O	O

* Information on the carp virus release in newspapers/radio/TV	○	○	○	○	○

Other

---

*

Do you identify as:

-- Select --

*** Do you feel as though the proposed release of a carp virus to control carp conflicts with your cultural heritage and/or values?**

○ Yes ○ No

Please briefly explain why:

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NATIONAL CARP CONTROL PLAN

The National Carp Control Plan is managed by the
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