Engaging with the National Carp Control Plan: summary of a stakeholder workshop

October 2019

Jacki Schirmer[1,2], Helena Clayton[1,2] and Lain Dare[3]

[1] Centre for Research and Action in Public Health, Health Research Institute, University of Canberra

[2] Institute for Applied Ecology, University of Canberra

[3]Institute for Governance and Policy Analysis University of Canberra

This report has been reviewed by the scientific teams whose research was presented at the workshop. Stakeholder participants were also given the opportunity to provide feedback. Feedback was provided by one participant and has been integrated into the report.

ACKNOWLEDGEMENTS

We thank the many people who participated in the June 2019 workshop to hear and discuss research conducted as part of the National Carp Control Plan. This report is part of a project funded by the Fisheries Research and Development Corporation as part of the National Carp Control Plan.

SUMMARY

Background

A stakeholder workshop was held in June 2019 to discuss emerging research findings from several projects conducted as part of the National Carp Control Plan (NCCP). Participants were asked to discuss emerging research findings, with a focus on identifying their views about what they mean for developing recommendations about the future control of carp, with a focus on feasibility of the carp herpes virus (carp virus) as a method for carp control.

The Plan is focused principally on assessing the feasibility of carp virus release as a carp biocontrol strategy. Its terms of reference do not include investigating other carp control measures or investigating complementary measures that could increase the potential for improvement of environmental health in association with any reduction in carp populations. The Plan is therefore investigating a specific approach to carp control (carp virus release) rather than developing a final plan for carp control. The Plan is being prepared to show how the virus could be used as a biological control agent for carp, and whether it is a feasible option to consider. It is possible governments may consider other approaches to carp control and ecological restoration or using the virus as part of a suite of actions to achieve ecological restoration outcomes, but this is yet to be determined.

Key messages from the stakeholder workshop

Workshop attendees discussed different aspects of the Plan and carp control more broadly. Not all key messages listed below were agreed to by all attendees; unless otherwise stated they were agreed to by multiple workshop participants. Several other topics of discussion were also raised at the workshop with less evidence of agreement amongst attendees; these are being documented in the report from the workshop but are not being presented as key messages.

Key messages related to three themes:

- Communication and engagement
- Developing recommendations from Plan research
- Future development of a comprehensive carp control strategy

Theme 1: Communication and engagement

Key messages related to communication and engagement focused on enabling people with an interest in carp control to have a clear understanding of how future decisions will be made about actions for carp control and to identify opportunities for ongoing engagement and participation in the process. There are four elements highlighted across this theme.

1. Meaningful Traditional Owner engagement is needed

Lack of engagement with Traditional Owners was identified as a critical gap that requires addressing as an urgent priority.

2. Stakeholder communication and engagement

Participants wanted further opportunities to engage with scientists and discuss potential carp control strategies, particularly around many of the specific topics raised at the workshop. Potential to have input on forthcoming discussion papers being produced by the Plan was viewed positively.

3. Need for improved partnerships for future work on carp control

The Plan is focused on feasibility of virus release and has included stakeholder consultation as part of assessing this. Future development of a 'shovel ready' carp control strategy should focus on establishing more formal partnerships with the wide range of organisations with interest in carp control. This should include both people and organisations directly acting on and those affected by carp control actions.

4. Clear communication is needed about decision-making processes that will occur after the Plan is submitted to government

It was clarified at the workshop that the Plan is a 'road map' that will be at a broadscale level, and that full development of a carp control strategy would require substantial additional investment beyond the Plan. Workshop participants have asked for clearer guidance on the processes of decision-making that will occur after the Plan is submitted to government. In particular, clarity was sought about the agencies and committees that would be involved, the timeframe for the decision about whether governments would release the virus, and the length of time expected for planning for any release, or for implementing other carp control measures, after such a decision was made.

Theme 2: Developing recommendations from Plan research

The second theme focused on expectations for the interpretation of Plan research findings. This was focused on communication of the uncertainties across data, risks, and potential outcomes that could occur under different scenarios. This was highlighted as essential to allow interpretation of the science to support the development of robust and realistic recommendations about future carp control.

5. The benefits being sought need to be clearly articulated in the Plan

The reduction in carp populations needed to achieve environmental health outcomes (benefits) should be a key part of the virus feasibility assessment and the recommendations made in the Plan. In other words, the ultimate objective of reducing carp populations – improving environmental health – should be the focus, rather than assuming all levels of reductions in carp will result in improved environmental health. There is a need to document specific, measurable environmental health goals or benefits being sought from reducing carp populations, and of the carp population thresholds required to have a reasonable probability of achieving these environmental health outcomes. This is preferable to assessing feasibility based solely on whether the virus will achieve reduction in carp populations, as reduced carp populations are beneficial only if they can lead to improvements in environmental health outcomes (for example, water quality or native fish populations).

6. Acceptable levels of risk need to be clearly identified

When assessing feasibility of the carp virus, thresholds considered to represent 'acceptable' and 'unacceptable' risk in relation to potential environmental, economic and social impacts need to be clearly identified and defined.

7. 'Best case' and 'worst case' scenarios that reflect uncertainties in estimates should be explicitly used to inform the recommendations made about any future use of the virus

The Plan stated that recommendations in the Plan would be based on best to worst case scenarios of impact from virus release. Attendees supported this and wanted to ensure that worst case scenarios reflected the level of uncertainty inherent in estimates of things such as carp biomass, water temperature, water flow, likelihood of virus recrudescence, and existing nutrient levels in different parts of river and lake systems. Several stakeholders requested that estimates be communicated in ways that clearly identify levels of uncertainty in the estimations and results, for example as ranges (which was done in several presentations, but not all).

8. Feasibility criteria should include consideration of impacts and feasibility of mitigating the impact, effectiveness of the virus and over both short-term and long-term, and opportunity costs over time

Workshop participants made several suggestions for increasing the clarity and specificity of criteria to be used to assess the feasibility of the carp virus. These included more explicit assessment of cost-effectiveness, focus on both short-term and long-term outcomes, and definitions of both what is an effective level of carp reduction and what is considered an acceptable level of risk for different types of risk. A range of specific suggestions are provided in the workshop report.

9. Some stakeholders seek use of a wider range of estimates of carp biomass when examining potential impact of virus release

Some attendees queried estimates of carp biomass, feeling they were lower than they would expect and therefore they felt the current 'worst case' scenario estimates were not enough to cover all potential scenarios. Further discussion about biomass modelling and recognition of potential for a wider range of biomass estimates were requested by some attendees.

Theme 3: Future development of a comprehensive carp control strategy

In the workshop participants focused much of their discussion on identifying the elements they felt were needed to develop a comprehensive carp control strategy that went beyond the Plan's focus on the feasibility of the carp virus.

10. There is strong support for investing in carp control

All workshop participants strongly supported investing in carp control, irrespective of their views about the feasibility of the carp virus. Where there are differences of view it is not about whether carp control is desirable, but about how best to investigate and make decisions about future carp control strategies. This means workshop participants supported continued investment in developing carp control strategies. There was significant concern raised about the risks of a 'do nothing' approach if future investment in carp control does not occur. There were several stakeholders who strongly support future carp control that involves the release of the carp virus. Most stakeholders wanted future carp control strategy investment to include examination of a wider range of aspects of carp control than the Plan was asked to examine in its terms of reference.

11. Carp control should be accompanied by complementary strategies to improve environmental health

Before carp control strategies of any kind are implemented, they should be accompanied by forward planning for complementary strategies to improve environmental health and minimise potential negative impacts. The purpose of carp control is to improve health of freshwater and estuarine systems carp have invaded; maximizing potential improvements in ecological health resulting from carp control requires careful planning and investment before carp control actions occur. This requires substantial lead time to ensure adequate preparation for actions that may increase potential for improvement in environmental health if carp populations are reduced (for example, plans for native fish stocking, water flows, or other complementary actions). While recognizing that these complementary strategies are not part of the terms of reference of the Plan, workshop participants sought reassurance they would form part of future strategies to control carp that draw on the Plan's recommendations.

12. Carp control strategies should be integrated with other actions to improve health of freshwater and estuarine systems

Carp are one of multiple pressures affecting the health of the waterways they have populated in Australia. Workshop participants outlined multiple programs and strategies currently being used across different jurisdictions to invest in improving the health of areas affected by carp, for example native fish recovery strategies riparian health action programs, and others. There was agreement that future carp control action plans should be explicitly linked to these other actions so they can complement each other, increasing likelihood of improvements in environmental health resulting from both carp control and other actions. Concern was expressed about taking action to control carp without aligning this with other investments occurring at the same time. Several participants felt substantially more positive impact could be achieved by explicitly integrating carp control with other environmental recovery investments such as the Native Fish Management and Recovery Strategy being developed by the Murray-Darling Basin Authority.

Some felt the focus of the Plan on feasibility of the virus was problematic without also examining complementary actions needed to achieve benefits from reducing carp populations, for the following reasons:

i. The virus will not be effective on its own to address threatening processes associated with waterway health and native biodiversity
ii. Carp suppression on its own is less likely to deliver environmental, economic or social outcomes – and more likely if accompanied by other measures
iii. Presenting the virus as the “main game” may have unintended implications for resource allocation away from essential strategies required to achieve critical outcomes for waterways and biodiversity.

13. Multiple carp control measures should be considered

Many workshop attendees wanted a broader range of carp control measures to be actively investigated in addition to assessment of the feasibility of the carp virus. Some felt that options such as live harvest (supported by investment in tracking of carp aggregations using methods such as Judas carp and citizen science reporting tools, including the Carpmap tool used as part of the Plan), role of native fish restocking and genetic control should be more thoroughly investigated. For some, this was because they felt these could provide viable alternative options to virus release. For others, this was because they felt these could complement virus release, particularly in areas where feasibility of the virus is limited, or in the longer term over which they felt initial efficacy of virus would decline. Much of the workshop discussion focused on clarifying the role of the Plan, versus the future development of ‘shovel ready’ carp control strategies. The Plan’s focus is on assessing feasibility of the carp virus. Workshop participants called for additional investment beyond the investment made in the Plan, to better understand how other carp control methods could work to either complement or, for some, be used instead of, release of the virus.

14. The feasibility of the carp virus should not be considered in isolation of other carp control and environmental recovery measures

Some workshop participants felt the feasibility of the carp virus cannot be assessed in isolation from other carp control measures and environmental recovery measures. This is because the effectiveness of the virus in part depends on whether virus release occurs in combination with other actions that may have potential to increase or reduce overall effectiveness of the virus in reducing carp populations. Ideally, the Plan should identify areas to be investigated in which complementary actions have potential to increase effectiveness of any use of the virus, as well as identifying any actions that may reduce effectiveness of the virus in reducing carp populations.

15. Several stakeholders feel the terms of reference for the Plan are interpreted too narrowly and/or should be broader

Consideration of the feasibility of the virus out of the context of an integrated approach to pest management, waterway and biodiversity restoration objectives has limited legitimacy for many stakeholders. Several workshop participants questioned the current interpretation of the Plan's terms of reference, and/or felt the terms of reference should be broader than they currently are, to enable development of a full carp control plan that includes multiple aspects of carp control rather than focusing solely on the feasibility of the virus. Others agreed that it was important to focus limited resources on answering questions about feasibility of the virus but felt that future carp control strategies should have a broader focus, as noted in previous key messages.

Several stakeholders asked that their concerns about the focus of the Plan on 'virus feasibility' alone be communicated to government, together with their preference for terms of reference for a carp control strategy to focus on a holistic approach to carp control based on environmental health objectives rather than objectives focused on reducing carp populations. Related to this, some argued that because the Plan is not currently placed in the context of more fundamental questions about what the virus should achieve, the Plan may provide recommendations about the wrong question. A key message related to the this is that assessment of feasibility of the carp virus is different to the question of "should the virus be implemented?"

GLOSSARY

Term	Explanation	Term used in report
Cyprinid herpesvirus-3 CyHV-3	The virus being considered for release in Australia to reduce carp numbers. Sometimes referred to as KHV.	Carp virus
Cyprinus carpio	Pest fish species in Australian waterways	Carp
Recrudescence	The recurrence of a disease following initial outbreak	Recrudescence
Hypoxia	Low dissolved oxygen in water	Hypoxia and low dissolved oxygen
Anoxia	No dissolved oxygen in water. Anoxia results in a lack of oxygen supply to vital organs.	Anoxia
Cyanobacteria	Also known as blue-green algae, it is a bacteria that can produce toxins harmful to fish, animals and humans. Cyanobacteria are found almost everywhere, but particularly in lakes and in the ocean where, under high concentration of phosphorus conditions, they reproduce exponentially to form blooms.	Cyanobacteria and blue-green algae
Lotic	Refers to freshwater habitats with flowing water such as rivers and creeks	Lotic
Lentic	Refers to freshwater habitats with relatively still water such as ponds and waterholes disconnected from rivers	Lentic
Littoral	Littoral refers to the nearshore zone of a water body. It is relevant as fish species will have different preferences for near or off-shore habitat zones and this has been accounted for in the biomass modelling	Littoral
'Shovel ready'	Describes a project or program that is at the stage where physical work can begin	'shovel ready' carp control

CONTENTS

1. INTRODUCTION

1.1 The National Carp Control Plan

In 2016 the Australian Government announced a $15 million investment to develop the National Carp Control Plan (Plan). The Plan is being developed through research and consultation with stakeholders and community members. It focuses on evaluating the feasibility of releasing the carp virus Cyprinid herpesvirus-3 (referred to as the 'carp virus' from here) for reducing carp numbers. The Plan will be submitted to the Australian Government in December 2019, and the Government will draw on the Plan recommendations to make decisions about and inform development of future carp control strategies.

1.2 Stakeholder and community support

If the carp virus is evaluated to be a feasible strategy for reducing carp numbers, its potential release would be delivered over a large geographic area, in waterways and waterbodies that are essential to Australia's traditional owners, primary industries, household water consumption, and millions of recreational users each year.

Critical to the success of the Plan and any subsequent use of its recommendations in carp control actions is widespread support from the diverse range of stakeholders who depend on or have an interest in carp, freshwater health and fisheries, as well as from people living and spending time in the regions where carp control measures will be implemented.

Support for the recommendations made in the Plan, and for action to control carp more broadly, will depend on a range of factors, including:

- The extent to which people believe investing in carp control is an appropriate and effective way of improving environmental health
- Expected benefits versus costs of proposed carp control methods for different groups and communities
- Trust in the processes and evidence used to develop the Plan and subsequent carp control actions, and in the agencies tasked with implementing carp control, and
- The perceived environmental, economic and social risks of actions proposed for carp control.

Researchers at the University of Canberra have been commissioned to develop understanding of community and stakeholder attitudes across these areas and to evaluate anticipatory and potential socio-economic impacts of the Plan, focusing on potential use of the carp virus, while also examining views and preferences about carp control more broadly. This work aims to inform development of recommendations that will have support from communities and stakeholder groups, through guidance on how these actions could be designed in ways that appropriately address the needs, concerns and priorities of community and stakeholders.

1.3 Understanding community and stakeholder attitudes and social impacts – project overview

The University of Canberra project is focused on:

- Identifying and understanding stakeholder and community needs, concerns and expectations regarding carp control, so these are considered throughout the development of the Plan and integrated in the recommendations under the Plan
- Identifying how best to ensure processes used to develop the Plan meet stakeholder needs and expectations
- Identifying potential socio-economic impacts of carp control for different stakeholder groups and communities, and measures to reduce negative and support positive socio-economic impacts, and
- Understanding the types of information, consultation and engagement needed by different stakeholders in the process of developing the Plan.

This work is being used to inform both the process used to develop the Plan (including communication, consultation and engagement with stakeholders and communities) and the content of the Plan. The work will inform evaluation of the feasibility of carp virus and strategies to reduce minimising negative and maximising positive impacts of any carp control actions recommended in the Plan.

This project will also identify a framework for ongoing monitoring and evaluation of socio-economic impacts and community attitudes into the future beyond the life of this project. This is will facilitate capacity for rapid identification of actions needed to address community and stakeholder concerns during any future implementation of the Plan recommendations.

The project has included a focus on identifying stakeholder concerns, views and needs, and on identifying the potential impacts of releasing the virus on different groups. An initial round of phone interviews was conducted in 2017 with 23 representatives of stakeholder groups with differing interests in carp control. This included representatives of environmental groups, commercial carp fishers, Traditional Owners, farming groups, koi organisations, water providers, native fish breeders, recreational fishing organisations, tourism businesses, animal welfare organisations, and freshwater scientists. A second round of interviews was conducted in 2018 and a workshop in 2019. The findings of the June 2019 workshop are documented in this report.

This initial round of interviews provided a baseline understanding of the views of stakeholders at the early stage of the Plan development (reported in the first report produced from the University of Canberra research). In the interviews most stakeholders expressed *conditional support* for the Plan, meaning they would support the eventual Plan if the process of developing it and its content adequately addresses their key questions and concerns. A smaller number of stakeholders actively opposed the Plan, and a similarly small number unconditionally supported the Plan.

In these initial interviews, it was identified that stakeholder support for any future carp control strategy was contingent upon the strategy including the following elements:

- Multiple measures to control carp
- Identification of how to best integrate carp control with other actions to improve environmental health in freshwater and estuary areas
- Development of detailed guidance on the planned timing and management of carp control actions, particularly virus release
- Clear identification of risks and how they will be managed and mitigated, including planning for worst-case scenarios
- Identification and appropriate mitigation of potential social and economic impacts of carp control on specific groups
- Appropriate involvement of different groups in decision making processes
- Sound governance, including clear commitment of funding and other resources to carp control and identification of responsibilities of different agencies
- Development of appropriate monitoring and evaluation strategies to ensure outcomes can be identified.

When discussing the recommendations being developed for the Plan, stakeholders also identified engagement with scientists undertaking research for the Plan as a priority, along with being able to discuss and provide their views on the emerging research findings. In response to this feedback, in June 2019 a workshop was organised in which emerging findings were presented and stakeholders were given the opportunity to discuss the findings as the implications of the emerging findings for assessing future carp control actions. This report documents the workshop discussion and key messages emerging from it.

2: OVERVIEW OF THE WORKSHOP

The purpose of the workshop, held in Canberra on June 20 and 21 2019, was to share key findings from the Plan research to date, and provide stakeholders the opportunity to contribute collaborative feedback and ideas about emerging Plan recommendations and future directions for carp control. The Plan is focused on evaluating the feasibility of releasing the carp virus in future and therefore much of the workshop discussion focused on presentation of research examining different aspects of feasibility and discussing these findings. Participants also discussed their views about carp control more generally and the approach and focus of the Plan.

The objectives of this report are to document the responses and feedback from stakeholders to the emerging findings presented from Plan commissioned research, and the broader discussion triggered by reflecting on this research. As a record of the workshop the report attempts to accurately reflect the wide range of perspectives expressed about the research into virus release, feasibility of the virus and related topics that emerged within discussion.

The workshop participants were selected to ensure as much diversity of perspectives, experiences and views as possible was represented at the workshop. This was for several reasons. First, previous work (documented in other reports produced from this project) has examined the views of individual stakeholders and specific groups but has not involved bringing a wide range of stakeholders together to share perspectives and experience and discuss differing views. Doing this can provide new perspectives, as sharing different views enables identification of shared understandings through challenging and contesting different points of view. Second, it is important to identify the range of responses to emerging results of the Plan: this helps identify the types of questions different stakeholders have about the research and want to see clarified in final reporting and recommendations of the Plan. This in turn can assist in the interpretation of research findings as recommendations are being developed: past studies have identified that support for stakeholders to engage with emerging data provides different insights into that data, raises questions that can then inform further analysis, and ultimately can better support the development of shared understanding about complex scientific topics (Schirmer 2013).

Throughout the report, we do not seek to quantify how many participants held different views, but rather to document the range of views expressed. This approach is taken as participants in the workshop were selected to ensure a diversity of views across stakeholder groups.

Stakeholders were invited to participate in the workshop through invitations sent to a stakeholder list identified by both the University of Canberra research team, and the Plan, through the life of the Plan. Invitations were sent to around 150 people, all of whom were invited to nominate other people to attend if they themselves could not attend. When developing the list of attendees, a list of the different types of stakeholders whose participation was sought was first developed, to ensure a diversity of experiences and perspectives about carp control was represented in those invited. Overall, the objective was to ensure attendance by representatives with the following experience and expertise:

- Traditional Owners
- Commercial carp fishers
- Scientists and consultants with expertise relevant to Plan research who had expressed interest in the Plan
- Native fish freshwater fish aquaculture industry
- Tourism industry (focused on tourism occurring in inland regions in and around freshwater and estuaries where carp invasion has occurred)
- Local government representatives
- Environmental and natural resource management groups
- Water managers (domestic and agricultural water supply, environmental water management)
- Recreational fishing
- Koi hobbyists and businesses
- Farmers and irrigators
- State and Federal government agencies with an interest in carp control
- Members of the Plan science advisory group: this group was invited to ensure the group reviewing research findings of the Plan was able to hear perspectives of stakeholders who were engaging with the research.

Those invited included both representatives of peak organisations representing these different stakeholder interests, and in many cases also individuals who represented businesses or smaller organisations with these interests. As shown in Table 1, at least one person from each type of stakeholder group attended, with a total of 55 attendees, of whom 48 were stakeholders across a wide range of interests.

Table 1 Workshop participants

Interest group	Number of participants
Commercial carp	3
Native fish aquaculture	2
Environmental NGO	3
Farming/irrigation	3
Traditional Owners	2
Natural resource management	2
Recreational fishing	3
Tourism	3
Domestic water management	2
Koi keepers	1
Government	
Local	5
State	6
Federal	1
Private consultants	3
Scientists – Independent	1
Scientists - Plan Science Advisors	5
Scientists – Presenters	4
Plan representatives and organisers	6
Total	55

The workshop was structured in three parts.

1. Before the workshop: Pre-workshop survey was circulated to ask participants what they wanted to discuss at the workshop, and questions they would like addressed. This was used to design the presentations at the workshop.
2. Day 1 and part of Day 2: Presentation of findings from research projects commissioned as part of the Plan development, and responses to stakeholder questions sent in before the workshop and during workshop discussions. These are described in Section 4, and included sessions with presentations on, and discussion of:
    a. National Carp Control Plan progress (Jamie Allnutt)
    b. Epidemiology and transmission of the carp virus (Peter Durr)
    c. Carp biomass and water quality (Jen Marshall)
    d. Non-target species – virus transmission and transport (Toby Piddocke)
    e. 'Clean up' options if virus is released (Jamie Allnutt)
    f. Environmental risks of virus release (Sam Beckett)
    g. Potential for ecological recovery/change (Sue Nichols)
    h. Socio-economic considerations (Jacki Schirmer).
3. Day 2: The agenda for Day 2 was developed in consultation with participants at the start of the day. The focus was on extending discussion from Day 1 to identify key

messages and recommendations from stakeholders on what needs to be considered in evaluating the 'feasibility' of carp virus release, and more broadly in developing future carp control strategies. Opportunity was also given for Traditional Owners attending the workshop to speak. This involved open discussion amongst all participants, as well as a session in which the participants split into several groups to discuss and provide input on criteria for assessing the feasibility of the carp virus. Participants also discussed the key messages beyond the topics of the individual talks that had emerged from the workshops.

Participants provided permission for the workshop to be recorded. The recordings were then transcribed. The workshop discussion was also captured with notes recorded electronically and on butcher's paper. The transcripts and workshop notes were reviewed thematically to support writing of this report. Rather than a formal coding process, when writing each section of this report, all workshop notes were reviewed to identify relevant input from stakeholders at the workshop. The workshop transcripts and notes were then reviewed to identify whether any topics raised at the workshop were missing from the report. This allowed more rapid writing of the report to provide input to the Plan than would occur with a formal process of thematically coding data. To ensure the voices of participants are 'heard', questions submitted by participants during the workshop are recorded in Appendix 1.

ETHICS

The workshop (together with other research conducted as part of the broader project this report forms part of) was approved by the University of Canberra Human Research Ethics Committee, protocol number HREC 17-152.

3: PRESENTATIONS ON PLAN PROGRESS AND RESEARCH FINDINGS – SUMMARY OF DISCUSSION

The workshop involved presentations providing updates on progress of the Plan and findings of key research projects. The findings from these projects and others are informing the Plan's evaluation of the feasibility of a carp virus release. The presentations provided stakeholders with the opportunity be informed about the scientific findings, ask questions, and discuss the implications.

The presentations covered the following areas of research commissioned by the Plan: modelling the efficacy of alternative virus release scenarios; assessment of species specificity of the carp virus; estimation of carp biomass in Australia; water quality modelling under carp virus release; cleanup needs and options; environmental risk assessment under carp virus release; opportunities for ecological recovery in response to reduced carp population; and consideration of social and economic impacts under carp virus release.

In this section a brief overview is presented of each of presentations, followed by a summary of the questions and discussion. The findings presented at the workshop are currently are undergoing peer-review prior to publication in the scientific literature. Therefore, in this report not all findings presented are reproduced.

3.1 National Carp Control Plan update

Presenter - Jamie Allnutt

Overview

At the start of Day 1, Jamie Allnutt provided a brief update on progress of Plan work and next steps. The focus of the Plan on evaluating the feasibility of using the carp virus as a biocontrol agent was explained.

Presentation summary

Jamie provided background on the history of the virus and consideration of its used for biocontrol, including that:

- It is a naturally occurring carp virus first described in 1998 and now found in more than 32 countries
- There has been a history of research on the carp virus in Australia prior to the Plan being established, extending back around eight years
- To be an effective biocontrol agent, a virus (or other biocontrol mechanism) needs to cause high mortality and be species specific, and these are two initial key conditions in assessing feasibility. While these then need to be accompanied by other conditions, investigation of the virus first focused on these two aspects. When initial research

indicated likelihood of high species specificity, and high mortality, there was a case for investing in further evaluation of the feasibility of the virus for use in Australia.

- The Plan is an investment of $10.2 million over three years, and its focus is on evaluating the broader range of issues that need to be examined to support recommendations about the feasibility of releasing the virus as part of future carp control actions. This includes assessment of environmental, social and economic aspects of feasibility; a description of the projects funded as part of the Plan can be found at https://www.carp.gov.au/.
- Research being undertaken as part of the Plan is focussed on addressing two questions: 1. Is it feasible to release the virus; and 2. If so, how could the virus be released and managed. In addition, there has been stakeholder engagement to provide input to answering these questions.
- This improved understanding will be used to develop recommendations to be submitted to the Federal government in late 2019. These recommendations will focus on identifying, feasibility of the virus release, how it could be released and managed, and any recommendations regarding next steps or further areas of investigation required in future.
- The complexity of assessing a possible virus release at a large scale was described. It is a more complex issue when considering release of a virus across a large and diverse landscape of many different types of waterways and waterbodies, than it is when considering a single waterbody such as a specific wetland. Carp invasion has occurred across a large geographic area, and as such the Plan needs to analyse virus release across large-scale diverse landscapes. This then has potential for increased uncertainty, increased impact and risk, increased social contention – but also for a longer-lasting impact on reducing carp populations than previous efforts which have typically focused on single waterbodies and not provided solutions to the larger problems of growth and spread in carp populations.

Questions and discussion

Questions and discussion focused on

(i) Understanding the likely timelines and processes for making decisions about whether to release the virus once recommendations of the Plan are submitted
(ii) Discussing the scope of the Plan and the focus on assessing feasibility of the virus versus on other aspects of carp control, and on the extent to which the Plan would examine aspects of carp control other than potential for use of the carp virus
(iii) How risk and uncertainties would be taken into account when making recommendations.

The specific questions asked included the following (see Appendix 1 for the full list of questions submitted both before and during the workshop)[1]:

- Pre workshop questions:
  - *Is there confidence that this process will remain open to a conclusion that, on balance of expected risks and benefits, a virus release won't work or is not a good idea. This is still a good outcome – we have learned and we have made an informed decision – and we have avoided negative outcomes.*
- Questions submitted at the workshop. At the workshop, participants could submit questions using the sli.do app, which also allowed all participants to 'upvote' questions they felt were important. The number of people who upvoted each question submitted is identified together with each question:
  - *Has enough work been done on the deployment (upvoted by 11)*
  - *Are you going to release the virus despite the science just to justify the huge amount of money spent (upvoted by 7)*
  - *Has there been costings done on the deployment – both virus inputs and field costs (upvoted by 7)*
  - *Menindee lakes were a small taste of the release of the carp herpes virus fish kills. Why pursue such an extreme option when scientists are saying too risky (upvoted by 5)*
  - *We need to talk more about commercial concepts and policy of alternatives to carp control (upvoted by 4)*
  - *Of the 32 nations with carp virus, how many can be said to have major reductions in carp population? (upvoted by 4)*
  - *Scale is irrelevant. You eat an elephant one bite at a time. The carp will populate and harvest strategy will have no markets (upvoted by 2)*
  - *Has any other nation purposefully released the virus? If not, why not? (upvoted by 2)*
  - *In the Decision Gateway, how will remaining uncertainty be considered? Uncertainty in efficacy, uncertainty in benefits, uncertainty in side effect risks (upvoted by 1)*

In subsequent parts of this report, individual questions are not documented in as much detail, and are instead summarised to enable a summary of responses to each key type of question. Refer to Appendix 1 for details of questions submitted before and during the workshop.

---

[1] Note that some questions were asked in this session that related to subsequent presentations. As these were discussed during the presentations they related to, they are documented in the reporting of those presentations rather than here.

In discussion of these questions, key responses from both Jamie and other attendees included:

- After the Plan submits its recommendations, there will be a process of decision-making about any future implementation of the virus and any other carp control measures. This includes several committees considering the recommendations, initial decisions about whether to proceed with specific carp control actions, applying for formal approvals required if a decision is made to release the virus, and developing an implementation plan.

  This process was expected by one attendee with experience in this area to take at least two to three years after submission of the Plan's recommendations:

  > "*this report goes to government and it will work its way through a series of committee recommendation decision making processes, culminating in ministers across the country deciding whether to proceed to assess this as biological control agent through at least three significant bits of legislation. … you wouldn't see release* [if a decision to release was made] *before I would say 2023 at the very earliest."*

  Given the number of processes involved, it is not possible to define an exact timeline, beyond that it will take at least 1-2 years and likely longer for any decisions about implementation to be made after recommendations are submitted, and for seeking and obtaining the necessary approvals if a decision to release the virus is made.
- It was emphasised that this decision-making process will involve both the Australian Government and State and Territory Governments, as well as public consultation for formal approval processes. Given this, it is important not to raise expectations regarding dates of final decisions or implementation of activity.

Subsequent parts of this report document discussion about the scope of the Plan and examination of carp control actions other than the virus; these began to be discussed in this session, and this discussion is integrated into subsequent sections discussing these topics.

3.2 Modelling effective release strategies of the carp virus to control carp

Presenter, Peter Durr, CSIRO.

Research team: Peter Durr, Kerryne Graham, Ken McColl, Agus Sunarto, Nick Moody (CSIRO AAHL); Klaus Joehnk, Ashmita Sengupta, Yun Chen and Danial Stratford (CSIRO Land & Water); Stephen Davis, Arathi Arakala and Jess Hopf (RMIT University); Stephen Taylor (CSIRO Data61).

Overview

Peter Durr presented findings from Plan research focused on informing virus release strategies. This research brought together multiple teams and agencies with expertise in rivers and waterways, fish biology, virology, disease spread ("epidemiology") and programming. This research is critical to assessing feasibility of the virus for carp control, as it is key to answering the question of whether a virus release could, if done the right way, achieve a meaningful reduction in carp populations.

Presentation overview

The simulation model developed and applied to predict the effect of different carp virus release scenarios on reduction of carp populations over time was presented. The modelling is based on a set of hierarchical integrated models developed that link (i) carp virus infectious disease models (how the virus transmits to/between carp), (ii) carp population demographic models (how carp populations move and change), (iii) carp habitat suitability models (which habitats work for carp and when), and (iv) hydrological models (modelling of waterways including factors such as water temperature, flow and inundation).

The integration across these areas provides scope to understand virus transmission under the wide range of conditions that can occur across areas of Australia with carp infestation. The modelling is being used to inform where, when and how the carp virus could be released to maximise reduction in carp populations and minimise adverse effects on water quality.

The modelling has involved extensive collation of field-data from catchments and consultation to scrutinise and ground-truth the model results. This was done for five study catchments that reflect a diversity of conditions across the types of habitats carp are present in: the Lachlan River, Moonie River, Lower Murray River, Mid Murray River, and Glenelg River. These were chosen based both on availability of data (those with best available data were selected), as well as to ensure a diversity of situations was assessed (ranging from high to lower temperature rivers, for example).

Peter explained the conceptual elements of the models used for the hierarchical integrated model, including:

- Damage functions – what is the carp density (kg/ha) above which carp are likely to cause ecological damage, and below which less damage is likely to occur? An "average" damage threshold of around 100kg/ha was identified, above which rate and extent of environmental damage is believed to have a 'step change' increase, suggesting that reducing carp populations below this threshold could improve environmental health. Not all catchments have carp densities above this threshold.
- Infection models: The ways in which the infection process operates in carp populations was discussed, including the difference between infection, transmission and

recrudescence. Modelling was based on the understanding that there would be around an 80-90% mortality rate of initially infected carp, and that the remainder of carp would have a latent infection that was not active, and in which the virus could later recrudesce (become active), resulting in further death and further transmission of the virus to other carp once recrudescence occurred. Infection can only occur when the water temperature is in a specific range (16°C to 25°C) and evidence suggests it requires close proximity between carp.

Key findings presented from the modelling included that:

- In many areas, water temperature will limit transmission to spring and autumn, with the virus becoming inactive when the water is outside the 'permissible temperature range' of around 16°C to 25°C
- Aggregation of carp is needed to achieve large outbreaks, with virus transmission likely to be less successful outside large aggregations of carp
- Noticeable mass mortality events of carp are likely to occur with initial release, but not with subsequent release or ongoing transmission of infection through recrudescence. An 80-90% initial probability of mortality for carp that become infected is expected, and then subsequent much smaller death from the virus in remaining carp populations due to lower populations and lower rates of transmission after the initial mortality
- The modelling indicates carp population suppression to about 40% of pre-release carp population densities is likely to occur for more than five years, suggesting potential for meaningful reductions in carp population
- Uncertainty remains in the modelling, as expected, and this uncertainty will be documented to ensure areas of uncertainty are understood.

Overall, these findings suggest greatest effectiveness of virus transmission would occur if the virus was release in spring, when water temperature has been above 16°C for 10 to 14 days, when carp are aggregating, and in locations where carp density is above the damage threshold.

The technical options for releasing the virus were also briefly discussed, including key advantages and disadvantages of releasing via:

- Catching carp in spring, injecting them with the virus and releasing them
- Rearing carp in ponds, infecting via water, and releasing them
- Catching carp in winter, injecting them with the virus, and releasing them.

A key consideration when evaluating these technical options is identifying any risk to humans from handling the virus. While the virus is not transmissible to humans (see subsequent sections), handling the materials associated with injecting virus (such as other chemical components that accompany the virus), as well as handling fish, can pose health risks such as being stuck with fish spines and other injuries. Part of evaluating the optimal methods should include evaluation of these issues.

Results were presented for alternative release strategies for an initial carp virus release across ‘broadscale’ versus ‘targeted’ virus release options. The results indicate there is a tradeoff that needs to be considered between maximizing the impact of the release on initial knock down of carp (broadscale release strategy) and minimizing the risk of unexpected consequences for water quality (targeted release strategy).

Questions and discussion

The questions and discussion arising from the presentation is summarized below across five themes: virus transmission, carp virus release strategies; efficacy of the carp virus, long-term response, and uncertainty and lessons from overseas.

1. Virus transmission

Several technical questions were asked in relation to understanding how the carp virus spreads across carp populations, including what the optimal conditions are for virus spread and how these conditions vary by season, carp population densities and water flow conditions.

Peter Durr acknowledged that these are fundamental questions and developing understanding of the conditions required for virus transmission was pivotal to the simulation modelling presented. The fundamental conditions for virus transmission incorporated into the modelling were: water temperatures must be between 16 ^{o}C and 28 ^{o}C for 10-14 days and carp must be in close contact (i.e. aggregating during spawning events). These two conditions narrow down the window for virus release to spring.

This led to discussion amongst participants about whether the virus is more active in shallower waters such as wetlands where conditions may be more conducive to transmission due to the length of time for favorable temperatures and fish proximity.

2. Ecological damage threshold

The ecological damage threshold was also discussed, with a focus on how ‘damage’ is defined. There were differing views about what an appropriate damage threshold is: given that ecological damage does not clearly start or stop at particular thresholds, it is difficult to identify the ideal threshold below which carp populations should be reduced to enable potential for ecological recovery. This threshold will vary across different types of ecological damage. The work in this project relied on existing literature and, in particular, the major review undertaken by Lorenzo Vilizzi and colleagues who identified ten different ways of defining damage from carp, including impact to water turbidity and water birds (Vilizzi et al. 2014).

Other questions raised that were outside the scope of the research presented were the following:

- *How long does the carp virus persist in the wild without its target host?*
- *If the virus finds its way into urban water supply catchments, what is the likelihood that it will remain active after chlorination & fluoridation when being used in koi hobbyist pond top-ups?*

3. Virus release strategies

A contained, targeted initial release (rather than widespread release) was suggested as a potential preferred option for virus release if priority is given to reducing the risk of adverse effects on water quality. The representative from the Commonwealth Department of Agriculture confirmed that all options for virus release would be considered, based on recommendations of the Plan, and that the specific preference for any given approach to virus release if it did occur, would be made based on assessing evidence such as that presented which identifies advantages and disadvantages of different approaches to releasing the virus.

Several stakeholders were interested in whether any areas had been suggested for a possible trial of the virus release. It was confirmed that the virus release is being evaluated at a more conceptual level where the Australian Government is asking the National Carp Control Plan to provide a clear determination about whether the use of virus as a biocontrol agent is feasible prior to any decision about any release of the virus, whether in a trial or more broadly. It was also emphasised that because the carp virus would be released into the natural environment, any approval of release, including for a small trial, would first need to go through a legislative approval process.

In the discussion several stakeholders asked questions about the feasibility of a phased approach to virus release, with a focus on whether it was possible to assess the risk of unintended virus transmission occurring beyond the 'targeted' release area, from either human or animal vectors (humans or animals transporting infected materials to new locations, e.g. a bird feeding on an infected fish transporting infected material to a new location when it flies)

In the discussion Peter Durr agreed these are very important questions as the transmissibility of the virus and the mechanism of transmission are fundamental to the modelling of virus efficacy and water quality outcomes. However, it was also emphasised that the current understanding about the carp virus is that it is not a highly infectious virus. This is because its transmission is limited to a narrow water temperature range and close contact is required for transmission. Peter Durr agreed that unintended transmission via humans and birds cannot be ruled out but that existing evidence suggested that the risk is low of outbreaks occurring due to the movement of inflected fish via people, birds or other animals.

The evidence of this was drawn from the experience in the US where the virus has been very slow spreading over the last 15 years since it was first detected. The concept of "Carpaggedon" – the uncontained, rapid spread of the virus with mass carp mortalities - has not been the experience of countries that do currently have the virus.

The spread of the virus in Japan was described as different in nature, with initial rapid spread of the carp virus experienced. This rapid spread predominately initially occurred in carp aquaculture ponds and lake-based rearing , rather than in wild populations. Large outbreaks in wild carp population in Japan only appeared om the following spring and were generally associated with outbreaks in domesticated carp.

Other questions raised by participants that were either outside the scope of the research being discussed, or were not able to be discussed in detail, mostly focused around different potential scenarios for virus release and their pros and cons, and around use of complementary measures (discussed later in this report):

- *Is it best to introduce the virus upstream or downstream?* This was discussed briefly, highlighting that there are arguments for and against each of these options, and it requires specific discussion of individual locations to answer.
- *Will the virus need to be introduced more than once in the same place?* This was briefly answered: reintroduction of the virus over time is a possibility, which may be useful in some situations – particularly where carp aggregate, which would enable targeting smaller remaining populations of carp
- *Are solutions [to the tradeoff between effectiveness and ecological risk across release strategies] being considered, such as initial targeted virus release in a small disconnected, isolated site, with intensive Before-After-Control-Impact monitoring, analysis and adaptive management, then if all is well do a wider simultaneous release?* This was discussed to some extent as part of the broader discussion about potential release options, with a 'trial' release one of the multiple options to be considered when the Plan forms recommendations.
- *What other complementary measures should be taken to prepare for & manage the release?* The discussion around this topic is documented further subsequently in this report.

4. Effectiveness of the carp virus

There was significant interest in the effectiveness of the virus in reducing carp numbers. Several questions were asked about the level of uncertainty in the carp mortality assumptions. Peter Durr clarified that the modelling was not designed to find the most optimistic outcome, but to model the efficiency of the virus under a range of assumed mortality rates: 80%, 60% and 40%. Participants expressed a desire to see results for the lower mortality rates as well as higher in final reports, and for the impact of different mortality assumptions to be clearly identified.

A question was asked about whether the modelling results indicate that a live harvest control strategy could achieve the same effectiveness through fishing carp down below damage thresholds. A range of perspectives were shared around questions of live harvest and alternative methods for controlling carp. The discussion suggested stakeholders felt there is a need to assess the feasibility of live carp harvesting as a carp control strategy using the same criteria applied to assessing feasibility of the carp virus, i.e. feasibility of reducing carp populations meaningfully (e.g. below a given 'damage threshold') rather than feasibility of achieving eradication or greater levels of reduction in carp. Further detail of the feasibility of live harvest is discussed later in the report.

In the discussion, the following questions were also raised, which were not discussed in detail, and suggest areas for further investigation as part of developing future carp control strategies:

- *Can you predict the percentage of biomass killed per month for the first 12 months: what is the short-term pain for the long-term gain?*
- *Would initial removal of carp from known breeding hotspots assist with the effective strategy to achieve major reduction in the total carp population prior to virus release?*

5. Long-term efficacy

Participants asked about the likely effectiveness of the virus for achieving long-term suppression of carp populations, and how quickly populations are expected to rebuild after the initial release.

In the discussions Peter Durr indicated the answer to how long populations will be suppressed depends upon recrudescence rates - the recurrence of carp virus infections following initial release – but also that it is difficult to accurately predict because there is high uncertainty about recrudescence rates. It was explained that recrudescence will be influenced by several elements including the development of immunity across the surviving carp populations and mechanisms for virus transmission.

The modelling indicates that if recrudescence does not occur then the population will rebound within five years. However, there is strong acceptance across the biology literature that recrudescence does and will occur, although the likely rate for the carp virus remains unconfirmed at this stage.

In this session, as in others during Day 1 of the workshop, several participants expressed concerns that additional or complementary carp control actions are not being evaluated as part of the Plan. In this session, this was identified as a concern in relation to the likelihood of carp population rebound after a virus release: if carp populations are likely to increase again after an initial release, several participants felt it was important to have a range of additional carp control measures implemented to ensure carp population reduction could be maintained over time. While these participants viewed other carp control methods as important to complement virus release, others felt these alternative measures may be a substitute for virus release (see further discussion subsequently in this report).

One question asked that could not be answered in the discussion, as it was not a focus of the research project and no attendees had knowledge that could be drawn on, was *'Is the level of carp immunity to CyHV-3 in countries like Japan and S. Africa significantly higher than NCCP are predicting for Australia?'.*

6. Uncertainty and lessons from overseas

Stakeholders were keen to understand how the modelling had been informed by experience from other countries that have the virus (in addition to being informed by data from the five case study regions on things such as water flows, temperatures and carp populations), and whether predictions from the modelling are consistent with that experience. In response to this, Peter Durr highlighted that there is an important distinction between the impact of the virus on carp being raised in aquaculture pond settings versus on populations in the wild. In aquaculture in Japan and elsewhere, the virus is a serious problem. While there is substantial experience of the virus in aquaculture situations where conditions for transmission are in many cases ideal in terms of having close contact between carp and optimal water temperature, there has been relatively little study of virus transmission in wild carp populations. In North America some research has occurred on virus transmission in the wild because carp are an invasive carp species in North America rather than endemic. Japan there is also interest in what is occurring for wild populations because wild carp have a cultural significance. However, the predominate concern in Japan (and elsewhere) is in aquaculture.

A small number of other questions were raised:

- *Has the predictive and hindcast modelling of carp populations post-release been based on real hydrology? And has it accounted for the effect of both large and small overbank flood events and on carp recruitment? Has the modelling been extended beyond the specific circumstances of the Millennium Drought to account for the widespread flooding and other conditions experienced between 2010 - 2019?*

  The answers to these questions are yes, with modelling including modelling of overbank flood events and drawing on real-world data on hydrology of the five case study systems. It also included some data for wet as well as dry years, to ensure a range of conditions were modelled.

- *Has the predictive and hindcast carp population modelling been done for more than two case study locations presented.* The modelling was done for five case study locations in total.

3.3 Assessment of species specificity of the carp virus

Presenter: Toby Piddocke, FRDC

Research team: Katrina Roper (PI), Laura Ford (ANU), Stephen Pyecroft (PI), Ben Jones (Uni Adelaide); and prior CSIRO viral challenge trials lead by Ken McColl, funded under the Invasive Animals Cooperative Research Centre

Overview

Toby Piddocke presented findings of research that has examined species specificity of the carp virus.

Presentation summary

Toby Piddocke presented research findings on behalf of three research teams that have investigated species specificity of the carp virus. It was explained that high confidence in the specificity to the target species (in this case, carp) is a fundamental consideration in evaluating the feasibility of releasing a biocontrol agent such as the carp virus into the environment.

The presentation covered background to the science of viruses, what has been done on carp virus species specificity to inform the Plan, and what work is underway or remains to be done to address areas of uncertainty.

In the presentation an important distinction was made between viral infection and viral presence (the presence of a virus on or in a host). It was explained viral infection involves the virus entering the cells of a host and replicating by hijacking the cellular machinery. This is distinct to detection of the presence of the virus on a host, where the virus is not entering host cells and replicating.

The three areas of research presented covered:

1) Evaluation of the risk of carp virus infection in humans by Katrina Roper (ANU) and Laura Ford (ANU) (published in Roper and Ford 2018)
    - In a review of evidence on risk of human infection by the carp virus, no evidence was found that the virus poses any direct infection risk to humans. This is consistent with evidence: across large numbers of virus outbreaks in multiple countries, there has not been any human infection recorded in the two decades since the virus was first identified.
2) Virus challenge trials which involved deliberate exposure of 22 non-target species to the carp virus to determine susceptibility to infection. This involved 13 native fish species, rainbow trout, lampreys, two frog species, two reptile species, yabbies, chickens and mice. This research was led by Ken McColl at CSIRO (see McColl 2016 for published final report on these trials)
    - No evidence was found of virus infection across the 22 non-target species

  - The presence of carp virus (as distinct to virus infection) was detected in some of the tested species
  - Uncertainties remained: for some tested species, mortality was higher in treatment groups (received virus) than in control groups (no virus).

3) At the time of the workshop, a review of virus challenge trial methodology was in the process of being conducted by Stephen Pyecroft and Ben Jones at the University of Adelaide. The aim of the review was to establish best-practice guidelines for testing susceptibility to infection by the carp virus and help determine whether the Plan's recommendations to government should include further virus challenge testing. The review was nearing completion at the time of the workshop, peer-review and results would be shared when available. The review was examining:
    i) techniques for diagnosing carp virus infection (are we using the right 'measuring stick'?)
    ii) investigating undiagnosed deaths in viral challenge trials
    iii) addressing false positives in species exposed to the carp virus
    iv) use of deliberate stressors to assess susceptibility to carp virus infection
    v) assessing the life history stages (i.e. larval, juvenile, adult) that should be tested for susceptibility to infection
    vi) determining how many species should be tested for susceptibility to infection, and what criteria should be used for their selection.

Questions and discussion

Three key themes were raised in questions and discussion on this presentation: (i) risks to non-target species, (ii) virus challenge trial methods and findings, and (iii) risk of virus mutation.

1. Risks to non-target species

Stakeholders raised several questions following the presentation on the risk of the carp virus to non-target fish species and humans. It was asked if it is possible to rule out with 100% certainty that the virus will be confined to the target species, and if not, if the risk to non-target species can be quantified.

In response to these and other questions about uncertainty, Plan staff emphasised that it is not possible to provide 100% certainty across the scientific findings, and this is not something that is possible when evaluating an action that has not been undertaken previously. However, in relation to the susceptibility of non-target species, instances of host switching have not been detected and results indicate the risk to non-target species is very low. This is discussed further below under 'virus mutation'.

A specific question was asked about the potential for the virus to be carried by species other than carp, and for these species to then infect carp. Toby Piddocke acknowledged that this is an important question, with several studies showing that detection of the carp virus on a non-target species and suggesting its transmission to carp, usually, but not always, without clinical signs of disease. In one study, rainbow trout were exposed to the virus, then housed with naïve (i.e. not previously exposed to the virus) carp that subsequently developed disease. In other trials using similar protocols, viral DNA was detected in the carp, but without clinical signs of disease. Explaining this variability is one of the areas being explored in the review being conducted by Stephen Pyecroft and Ben Jones.

2. Virus challenge trials

There has been a significant amount of interest and scrutiny around the virus challenge trials undertaken prior to the Plan in Australia, particularly in relation to the unexplained mortality rates of some native fish in the trials. In the workshop discussions stakeholders were interested in whether the Plan felt confident the findings of these trials were sufficient to demonstrate species specificity of the carp virus. As discussed earlier, in response to questions raised about aspects of the trials, the Plan commissioned a review of best practice in virus challenge trials.

3. Risk of virus mutation

Several participants asked questions about the potential for the carp virus to mutate in the future, and the risk any mutation could pose to non-target species. Participants asked how much is known about how the virus first emerged in Israel, whether this was a mutation of a known virus, and if this history provides any insight into the risk of further mutations which may transmit to other species.

In response Toby acknowledged the importance of questions about mutation in relation to the Plan's evaluation of feasibility. He identified that while viruses typically mutate, the nature and rate of occurrence of mutation depends on the type of virus. The carp virus is a *double stranded DNA* virus which mutates much less frequently compared to *single stranded RNA* viruses which are known to mutate rapidly and host-switch easily (single stranded RNA viruses include HIV and Ebola). While double stranded DNA viruses are known to still mutate, they do so much less often than single stranded RNA viruses. Additionally, Toby identified that mutation is not the only mechanism of viral evolution – viruses can also evolve by recombination, which involves two different viruses infecting the same cell and exchanging genetic information.

In the discussion, it was acknowledged that predicting and quantifying uncertainty around virus evolution and host switching is very difficult. Toby also stated that it is important to understand that it is not possible to give a 100% guarantee of host specificity for the carp virus, but everything that is known about the virus suggests that it is relatively stable.

3.4 Estimating carp biomass in Australia

Presenter: Jennifer Marshall, FRDC

Research team: Andrew Bennett (Principal Investigator; La Trobe University), Ivor Stuart, Jarod Lyon, Ben Fanson, John Koehn, Charles Todd (Arthur Rylah Institute), Jerom Stocks (NSW DPI), Leigh Thwaites, Qifeng Ye (SARDI Aquatic Sciences), Andrew Norris, Michael Hutchison (QDAF), Shane Brooks, (LitePC), Matt Beitzel (ACT Government), Michael Hutchinson (QDAF), Tim Brown (University of Melbourne)

Overview

Jennifer Marshall presented research findings on behalf of a large team of researchers involved in establishing a carp biomass estimate for Australia. The research collaboration has aimed to develop an international best-practice methodology to estimate carp biomass in Australia. Estimates of carp biomass then formed modelling of likely virus transmission under different conditions (see section 3.2).

Presentation summary

In this project carp biomass was estimated by integrating habitat models, contemporary and historical catch-per-unit-effort (CPUE) data, and detection rates for carp in spatial field sampling.

The project had access to large volumes of data on carp CPUE with good spatial coverage. However, CPUE does not provide total abundance data from which biomass estimates can be derived – the amount of catch achieved for given effort cannot be easily translated into an estimate of the total biomass of carp present in a given area. Yet biomass estimates are needed to examine potential impacts of virus release, as the rate of virus transmission, and impacts of virus and subsequent volumes of dead carp on things like water quality, depend on how many carp are present.

This meant that the researchers had to identify how electrofishing detection rates achieved in different aquatic habitats (i.e. rivers and wetlands) correlate to actual carp biomass – which in turn would enable modelling of the total biomass of carp using the existing large body of carp CPUE data.

To achieve meaningful modelling, CPUE data from different states and territories were amalgamated into a single database. Different aquatic areas across Australia were then classified using the Australian National Aquatic Ecosystem (ANAE) framework, enabling classification of the many thousands of aquatic sites based on their characteristics (e.g. rivers, floodplains, estuaries, wetlands, lakes, storages, irrigation channels with multiple specific habitat classifications used). This was a large task, with 31,935 kilometres of permanently flowing rivers, 683,368 kilometres of intermittent rivers and streams, 9,838 temporary lakes, 5,319 permanent lakes, 152 estuaries and 1,641 reservoirs in the regions being modelled, to name just some examples. Farm dams were not included in the model, due to lack of capacity and available data to do so (with 780,000 farm dams and ring tanks mapped in the Murray-Darling Basin alone). Fieldwork was conducted to identify detectability of carp across different habitat types, and a detection model built. The biomass estimate model could then be built, combining habitat modelling, contemporary and historical CPUE data, and using the detection model to translate data from CPUE to biomass estimates.

This modelling was then used to estimate carp biomass in different habitats at different points in time, and the level of certainty of estimates. For example, in May 2018 which was an 'average' year scenario, the estimate was that across South-East Australia, there was just under 206,000 tonnes of carp, with a 95% confidence interval of 117,532 to 356,482 tonnes. This was a reduction from the 368,360 tonnes estimates for May 2011 (with a 95% confidence interval range of 184,234 to 705,630 tonnes) which was for a 'wet' year scenario. Specific aquatic habitats in different parts of Australia were estimated as well, and the presentation included maps showing estimated density of carp in different types of habitat at specific points in time.

The work on carp biomass estimation has been applied to a range of habitat types including rivers, lakes, billabongs, and estuaries, and allowance has been made for fluctuating carp numbers through time. The model estimates were validated against absolute carp biomass estimates from a series of wetland drying events and from other independent biomass estimates. It was not possible to validate estimates in rivers (removing and weighing the total biomass of carp in a defined stretch of river and comparing it to predictions from modelling).

Understanding the abundance of carp across different areas and habitats will be critical for guiding risk management strategies if virus release is implemented. The biomass estimations have also help to inform other areas of Plan research, including virus release strategies; clean-up planning; evaluating potential impacts from dead carp on water quality; and designing pre and post-post release ecological monitoring.

The biomass modelling highlights that, as expected, carp populations change substantially depending on the conditions: for example, in particularly wet years carp populations can be double what they are in an 'average' water flow year. More recently, there has been dynamic biomass modelling for a series of three flood (1-in-20 year events) years. This scenario leads to even greater biomass estimates (mean 444,063 tonnes CI: 307,425-596,307 tonnes). However, for a series of three drought years the biomass was much reduced (mean 167,880 tonnes CI: 116,410-220,678. These scenarios are dependent on antecedent carp biomass and where the 2018 upper CI is used to populate the model for three consecutive flood scenarios, then the biomass reaches the maximum estimate (mean 804,826 tonnes CI: 525,722-1,049,644 tonnes)

Overall, waterbodies such as lakes hold greater total carp biomass than rivers.

Questions and discussion

The discussion of this presentation predominantly focused on whether the biomass estimates were consistent with observations of carp abundance by workshop participants in the regions they were familiar with, particularly the Lakes and Coorong region, and how uncertainties were incorporated in the biomass estimations.

The interest in uncertainty related to the biomass estimates presented being lower than what some participants would have expected. Some participants queried the biomass estimates, and felt they were an underestimate of the population of carp they believed were present in their local region, particularly for the Lakes and Coorong region.

In response, the science team has acknowledged there are regionally specific circumstances that do not apply Australia-wide, and this variation is reflected in the biomass modelling. For example, the modelling has accounted for conditions in many parts of New South Wales and Victoria where carp numbers have significantly reduced due to drought conditions and drying out of some significant habitats. However, the modelling has also accounted for the relatively higher carp biomass in the lower Lakes and Coorong region.

A question was also asked about whether the biomass modelling had accounted for not only how but why carp enter a system – the specific behavioural patterns of carp and the choices they make regarding movement. In response, the science team has indicated that the carp biomass model is an application of a static model to estimated carp biomass at a point in time. However, consideration of dynamics of carp populations has been incorporated into the epidemiology modelling.

Some participants asked whether the biomass modelling had accounted for the influence of different water columns on carp movement, as this may give different results of carp loading and water quality outcomes. In response, the science team has indicated that this has been accounted for in the modelling via parameters that capture habitat preferences of carp including their depth and littoral versus offshore preferences in impoundments and large lakes.

Questions about the validation of the biomass estimates came up in other sessions throughout the day, particularly in relation to water quality and cleanup planning. There was interest among many stakeholders in whether the Plan feels further work is needed to validate the current biomass estimates, and whether recommendations of the Plan would include investing in further work to increase specificity of models and test them further. In response the science team acknowledged that model validation is important and always welcome.

3.5 Water quality risks from carp mortality under carp virus release

Presenter: Jennifer Marshall, FRDC

Research team: Matt Hipsey, Brendan Busch (UWA), Justin Brookes (PI) Richie Walsh, Sanjina Upadhyay, Mark Laws (University of Adelaide); Rolando Fabris (PI), Leon van der Linden, Tim Kildea, Edith Kozlik, Con Kapralos, Miriam Nedic, Elloise Trotta, Martin Harris, Stella Fanock, Melody Lau, Brendan King, Joe Pera (Water Research Australia).

Overview

This presentation identified emerging findings on how virus release could impact water quality in different situations. Jennifer Marshall presented results on the behalf of the research teams that have evaluated water quality risks from carp mortality occurring in response to a carp virus release.

Presentation summary

The research has involved modelling of water quality under different carp biomass assumptions for a variety of water body conditions and drew on the research presented in Sections 3.2 and 3.4 to assess this, as well as conducting specific field work on water quality.

The findings are critical to quantifying ecological, economic, and social risks in the context of potential release of the carp virus, with impacts on water quality a critical contributor to the level of these risks.

In the presentation, the mechanisms by which dead carp could contribute to water quality problems were first identified. This focused on explaining the composition of carp, and how carbon, nitrogen and phosphorous are released into water when fish die and their flesh, bones, scales and fins decay. Carbon can then be used by bacteria, which consume oxygen through respiration; at large scales this can result in reduced oxygen levels in water and what is termed a 'blackwater' event in which loss of oxygen causes widespread death of plants and animals reliant on that water. Nitrogen and phosphorous, in turn, can fuel algal growth (cyanobacteria). This meant that as part of the Plan it was important to assess what levels and rates of release of carbon, phosphorous and nitrogen could potentially occur, and what this would mean for levels of dissolved oxygen and risk of cyanobacteria blooms in different aquatic habitats under differing circumstances (e.g. different water flow, water temperature and geomorphology etc).

The research approach involved modelling based on four areas:

1. Identifying the loadings of dead carp that could negatively impact water quality, considering:
    1. Habitat setting/geomorphology
    2. Water temperature

    3. Water flow regime
2. Identifying conditions where hotspots of accumulation of dead carp may occur, e.g. where water flow may carry carp carcasses
3. Assessing risk of hypoxia, anoxia and cyanobacteria, with incorporation of factors such as how win, currents, light and benthic conditions affect oxygen metabolism in systems (for example, high wind can increase dissolved oxygen levels, reducing risk of blackwater events)
4. Provide recommendations on priority areas to monitor, and to prepare for management interventions.

Both controlled tests in which dead carp were placed in containers, and field tests in which decay of dead carp in a small lagoon was measured, were undertaken to inform the modelling. These experiments were performed using very high biomass densities of carp.

A combination of experiments and hydrodynamic-biogeochemical modelling was undertaken to determine how carp density and water flow will alter the risk of hypoxia (low oxygen) or anoxia (no oxygen). The hydrodynamic-biogeochemical model was applied to a range of river types, floodplain wetlands and reservoirs to determine the relative risk of low oxygen and/or high cyanobacteria, and whether flow management can mitigate the risk.

The analysis provided predictions of cyanobacterial growth and dissolved oxygen (DO) concentration across different habitat settings (wetlands, rivers and floodplains). Research also predicted on how water quality conditions across different habitats will respond to changes in hydrologic flushing, temperature, and dead carp accumulation.

The presentation showed findings of modelling that indicate how this dynamic model identified changes in oxygen and nutrient levels at different sites over time after a modelled release of the virus. Eight sites were modelled, representing a diversity of habitats and climates. The model could support multiple simulations for each aspect modelled, enabling the range of potential outcomes to be modelled incorporating the level of uncertainty of estimates in each parameter being modelled. This resulted in capacity to model the potential range of outcomes that could occur under 'worst case' to 'best case' scenarios. Overall, the findings enable identification of where and when there would be higher risk versus lower risk of adverse impacts on water quality resulting from a virus release and can support modelling of worst case to best case scenarios under differing conditions.

Questions and discussion

Workshop participants asked multiple questions about the assumptions used in the water quality modelling, and how the modelling accounted for a range of conditions and circumstances and the degree of certainty in model predictions. Some questions focused on concerns about potential risk of the carp virus release to domestic drinking water for towns, communities and businesses that draw domestic water directly from the river.

Some of the discussion focused on the fish kill that occurred in Menindee during the 2018-19 summer, and whether lessons could be drawn from the Menindee fish kill event in terms of water quality outcomes and validation of the water model predictions undertaken under carp virus release modelling. A representative for the NSW Fisheries team who was involved in the response to the Menindee fish kill event provided input into the discussion. It was explained that there has been communication with the Plan about what can be learned both ways about responses to fish death events. However, there are limitations to making direct comparisons because of the sometimes large differences in the systems and circumstances. There is fieldwork currently being undertaken within NSW Fishers to examine the impact of the fish kill within the region, compared to control sites, with the aim of quantify the effects that occurred in the lower Darling. The findings will be shared with the Plan.

There was also interest from several stakeholders in how the water quality monitoring has incorporated the complexity of the unique environment in the Lakes and Coorong. The nutrient conditions in the Coorong as a natural delta system was described and questions were asked about how water quality modelling had accounted for the potential interaction between the existing high nutrient loads in the system and the additional nutrient load from the predicted carp mortalities.

In response, the approach to addressing complexity in the modelling was described as a stepped process starting from bucket experiments and then increasing complexity with river-based experiments which included interaction with sediments, and then a to a whole wetland ecosystem. Additionally, the literature was reviewed to gain insights into the different interactions of sediments across different water characteristics. It was confirmed that the interactions with sediment were considered for each of the case study areas, which represent the different habitat types, flow scenarios and geomorphology of the regions.

Participants sought further discussion in future around the following topics:

- Does the modelling incorporate consideration of water quality impacts of non-carp fish, plant or other animal death that could accompany a low oxygen event?
- What are the thresholds under which water quality impacts won't arise, and how does this vary across different conditions and environments?
- What is the extent of risk of botulism arising from decaying carp?
- Can specific water flows be released to increase flow and reduce risk of low oxygen and/or high nutrients in water after carp deaths? How would this occur and how would water be sourced for these flows? If this is done, would it push dead fish and poor-quality water downstream and cause water quality problems downstream?
- Specific questions were raised about impacts in areas with acid sulphate soils, and whether future trials could include permanently wet areas to add to the existing work examining decay of carp in a lagoon that regularly dries out.

3.6 What are the cleanup needs and options under carp virus release

Presenter: Jamie Allnutt, FRDC

Research team: Plan Operations Working Group, Karl Mathers (Wedge Consulting Group), Kevin Cooper (Independent consultant), and Luiz Silva (Charles Sturt University),

Overview

Jamie Allnutt presented findings from work undertaken to evaluated cleanup needs, strategies and priorities on behalf of the Plan Operations Working Group. The presentation also drew upon findings from research lead by Luiz Silva which has provided a systematic review of published material on fish-kill clean-up world-wide, and consultation with people experienced in in fish-kill clean-up response, including fish farmers, commercial fishers, and water infrastructure operators.

Presentation summary

A framework has been developed to identify cleanup response required to manage water quality during major carp kills. The framework has been informed by several research areas including the biomass estimations, epidemiological modelling, water quality modelling, assessment of operational cleanup technologies and strategies, modelling of water flow strategies and cleanup cost considerations.

The framework is drawing on the large body of work and expertise that already exists in Australia to manage incidents, particularly the Australian Incident Management System and the Biosecurity Incident Management System. However, in the case of any future release of the carp virus, the advantage would be the ability to plan for clean-up, enabling a 'planned management' approach as distinct from 'unpredicted incident management'. The aim is to identify practical, carefully planned clean-up strategies tailored to habitat types that could be used for clean-up activities.

A key point is that clean-up would not aim to remove all carp carcasses. The total volume that requires clean-up is the proportion of the total carp biomass that would (i) contract the disease, (ii) die and (iii) accumulate in sensitive areas where water flow could not be used to manage the carcasses. In many areas clean up would not be required due to either low volumes of dead carp, or the area having low sensitivity.

proportion

The assessment of carcass removal needs is focused on areas of the catchment where carp density is greater than 150kg per hectare, at known aggregation and predicted accumulation points. The assessment has also identified the time of the year the cleanup would be required, and for how long.

The methods for carcass removal were being assessed across different waterway types from small waterways that are unnavigable to large areas that can be navigated by large vessels. Consideration was also given to water depth and the amount of vegetation. The methods of removal considered range from manual land-based methods to boat-based manual removal and large mechanical vacuum-based removal.

The cleanup assessment also includes evaluation of who would do the clean-up across different scenarios, from contractors, federal and state government agencies, local councils, and community groups and volunteers. Jamie presented findings from collaborative workshops in the Lachlan catchment that integrated expertise of multiple representatives of different groups and agencies to identify key clean-up issues and potential methods.

Questions and discussion

Questions and discussion focused on (i) understanding where clean-up might be prioritized and what this might mean for impacts of carp control, (ii) comparison of clean-up needs is other carp control methods were used, and (iii) addressing uncertainty when identifying the likely investment required in clean-up.

1. Prioritising clean-up with a focus on reducing risk of socio-economic impacts

Discussion around prioritization of clean-up focused on participants asking what criteria were likely to be recommended for prioritization of clean-up. This was strongly linked to concerns about social and economic impacts of large volumes of dead carp for rural communities and businesses who depend on aquatic areas, such as many inland tourism businesses. Participants identified criteria they felt should be included in selecting which areas were prioritized for clean-up, and one also asked whether there was a likelihood of businesses who were financially impacted by the presence of large volumes of dead carp being supported to cope with those impacts.

Areas in which prioritization of clean-up was identified as a need included:

- Areas of high tourist visitation, where reduction in visitation would result in economic loss for local businesses
- Areas where water is used for domestic consumption
- Areas that may be affected if an accumulation of poor-quality water flows downstream
- Irrigation channels, where in some cases carp carcasses could potentially compromise irrigation activities
- High profile areas where reporting of fish deaths may result in negative impacts on recreational use, even if the water quality is not affected in those areas.

Members of the tourism industry attending emphasized that when considering clean-up, the issues to be considered include not only investing in the clean-up but investing in clear communication. They identified that perceptions of poor water quality of visitation experience often resulted in long-term decreases in visitation to large areas around where a water quality or water flow problem occurred, including decreases in visitation to nearby areas unaffected by the problem that had occurred. The clean-up strategy therefore needed to include adequate investment in development of communication to reduce the high risk of visitation reducing due to negative perceptions (even if those perceptions were not accurate).

Participants asked that in addition to identifying what areas would be prioritized, care be given to identifying who might ‘miss out’ on clean-up and experience impacts from the presence of carp carcasses. In what circumstances would it be considered appropriate and acceptable not to invest in clean-up, and how would this be communicated to those potentially affected by this decision?

Jamie Allnutt acknowledged that there are important social and economic considerations associated with any potential virus release and cleanup response, and that it will be important for governments to consider whether there will be clear long-term benefits from a carp virus release, otherwise it would not worth doing. It was also reiterated the findings from the water quality research suggest the risk of large-scale impacts on water quality was not as high as many had expected, reducing the risk of subsequent impacts on social and economic conditions, and making clean-up more feasible in those situations where it was needed.

2. Comparing the virus to other carp control methods

Some participants asked about the relative cost of releasing the virus and incurring costs of clean-up compared to the cost and benefits of live harvest of carp for commercial sale. They wanted to see more evaluation of these relative costs and benefits in consideration of future carp control action. This would require having a clear understanding of realistic end-uses for dead carp removed in clean-up activities versus commercial sale of live-harvested carp. While the Plan is examining potential end-uses for carp carcasses removed in clean-up, the workshop time available did not enable presentation and discussion of this research.

3. Uncertainty

There was interest across all stakeholders in how uncertainty is being considered and integrated into the cleanup planning. This includes uncertainty about the location and scale of fish kills after virus release, and about the rapidity of virus spread and hence the number of simultaneous or closely timed fish kills in different locations. There was concern that a planned management approach could fail if fish kills occurred in patterns not predicted in initial planning. Other areas of uncertainty raised related to the resourcing of clean-up activities, something that would be determined by the government after consideration of Plan recommendations. In response, Jamie Allnutt acknowledged that the task is complex, and the cleanup needs and priorities will vary across regions. It was also acknowledged that it is not possible to predict outcomes without uncertainty, and for this reason the cleanup planning is being based on an adaptive management approach so there is flexibility to respond quickly and to change the response.

4. Use of water flows

Some questions were raised about the potential to specifically use water flows to help reduce potential clean-up needs. Questions were asked about whether the downstream impacts of the accumulation of carp carcasses and particles had been considered when considering the use water flows in the cleanup planning. This emerged from concerns that areas already experiencing stress and at risk of easily 'tipping' into poor water quality could be further impacted by any impact of poor water quality flows. It was confirmed that modelling was factoring in the flow with emphasis on evaluating the implications for particle accumulation in the Lakes and Coorong as a case study.

In addition, participants wanted further understanding and clarification of:

- What volumes of water might be required in different situations to achieve an outcome
- Where water would be sourced from, and in particular whether environmental water would be used.

3.7 Environmental risk assessment for the release of CyHV-3 for carp biocontrol in Australia

Presenter: Sam Beckett, CSIRO

Research team: Sam Beckett, Peter Caley, Matt Hill, Sam Nelson and Brent Henderson (CSIRO)

Overview

In this session Sam Beckett presented an overview of the CSIRO research undertaken to evaluate the ecological risks under carp virus release. CSIRO was also undertaking research examining social risks, which was not presented on in this session.

Presentation summary

In the presentation, an overview was provided of how the researchers were conducting the ecological risk assessment, which integrated three areas of research: i) a review of the literature on water quality, ecological assets at risk, carp in Australia, the carp virus, botulism in wildlife, and food-web effects of carp die-offs, ii) findings from Plan projects on biomass estimates, epidemiological and water quality modelling and iii) expert elicitation of food-web effects of the removal of juvenile carp.

A precis of the ecological case studies was presented, focusing on emerging findings related to expected ecological risks for large and small-bodied native fish, waterbirds and other native species (frogs, turtles and crustaceans). Case study sites included Barmah-Millewa forest, Chowilla floodplain, Mid-Murray River (Yarrawonga to Tocumwal), Moonie River Catchment, the Coorong (including Lakes Alexandrina and Albert), Upper Lachlan catchment (Abercrombie River), Macquarie marshes, Kow swamp and the lower Glenelg.

Findings from the assessment of key exposure pathways were also presented. Key pathways included, low dissolved oxygen, widespread cyanobacterial blooms, proliferating waterborne microorganisms, removal of juvenile carp as a stable source of food and prey switching with the removal of juvenile carp. The ecological risk assessment was based on a series of putative outbreak scenarios, covering high-flow and low-flow seasons in setting such as permanent lakes and reservoirs, perennial wetlands and floodplains, and permanent and seasonally-disconnected riverine environments.

The other MNES considered in the risk assessment are outlined below. For each of these, a two-step assessment process was applied. First their relevance to an outbreak of the carp virus was assessed, and secondly for those where risks were relevant, risk assessment of individual or grouped MNES assets was undertaken.

1. Ecological communities
2. Ramsar wetlands
3. World Heritage properties
4. National Heritage places
5. Commonwealth Marine Areas
6. Great Barrier Reef Marine Park

Questions and discussion

Questions and discussion of this presentation focused around understanding (i) the scope of the risk analysis being undertaken, and (ii) whether the risks of a 'do nothing' scenario were also being evaluated.

1. Scope of the risk analysis

Several questions focused on understanding the scope of the risk analysis – what had been included in it, and any areas not examined. This included:

- Had international literature been used to inform the research scope and questions about ecological risks? It was confirmed that a review of the international literature had been undertaken as part of scoping the research.

- Had variations across different ecosystems been examined? There was interest in whether the research accounted for unique ecosystems such as those in South Australia, where there is lower flow, and a system of permanently inundated wetlands in the lower part of the system. It was confirmed that these variations were accommodated in the risk assessment. However, inherent uncertainty associated with data limitations and variability were also acknowledged and were being identified as part of the risk assessment.
- Was risk to the cultural heritage of First Nations people considered as part of the risk assessment? Sam Beckett indicated these were not specifically targeted as part of the risk assessment, although some risks to listed national heritage sites of importance to Aboriginal nations were examined, such as specific examination of whether there was any risk to the Brewarrina Aboriginal Fish Traps. Additionally, the Plan had invested in a specific project, separate to CSIROs, seeking to consult First Nations about their views on virus release and potential impacts and opportunities (see further discussion of this in Section 6).
- Would risks to specific fish species be identified in the risk assessment? It was clarified that the risk assessment would include assessment of risk to several specific species.
- Did the risk assessment examine whether outbreaks of *hemorrhagic e-coli* following carp mortality pose risk to people? This was raised with reference to the human health risks in cleanup of the dead carp. The response to this question identified that there are preliminary results from water quality monitoring showing the relative abundance of bacteria in dead carp, but at this stage work is ongoing, with further research invested in by the Plan to better quantify the likelihood of blooms for particular bacterial species of concern.
- To what extent were food-web effects being assessed? This was raised in the context of questions about whether risks to a range of species through the food web could be assessed, and whether analysis of risks to water-birds associated with water quality changes relating to a fish kill incorporated impacts on other important food sources for these birds such as crustaceans, frogs and invertebrates. Sam Beckett confirmed that the risk assessment included separate pathways looking at: (a) the that removing juvenile carp might have on piscivorous species (principally waterbirds); and (b) the significance of prey switching following the removal of juvenile carp for native species such as frogs and native fish.

2. Risks under ‘do nothing’ scenario

There were questions raised by participants about whether the risks of a ‘do nothing’ scenario in which carp control was not invested in were being assessed as well as the risks of a virus release. This was associated with questions about the extent of current ecological impacts of carp, and whether reduction in carp biomass in recent years identified in earlier presentations (see Section 3.4) had reduced these impacts.

In the discussion that followed, there was general agreement that current carp populations pose significant and ongoing ecological risks, and that the risks associated with current carp populations were unlikely to stabilize because of the unique capacity of carp to achieve enormous recruitment. Attending scientists identified that the carp virus has potential to address this ongoing recruitment issue because of the possibility of a second outbreak at the end of summer within newly recruited juvenile population that start moving from the flood plains towards the main channels, reducing the numbers that reach main channels.

There was overall agreement that 'do nothing' scenario was not desirable and investment in carp control was needed. However, several stakeholders also argued that it is important to acknowledge that a 'virus release versus do nothing' scenario does not accurately represent the range of carp control options, as complements or alternatives, to virus release, that can be and are currently being implemented.

3.8 Opportunities for ecological recovery: The medium to long-term ecological effects of major carp reductions

Presenter: Sue Nichols, University of Canberra

Research team: Sue Nichols, Mark Lintermans, Ben Gawne, and Ross Thompson (University of Canberra), Rob Richards (Evidentiary)

Overview

Sue Nichols presented findings from research that investigated the potential for ecological recovery in the medium to long-term (i.e. over a 10 to >20 year timescale) from major carp reductions.

Presentation summary

The research explored the ecological effects of reducing carp populations, irrespective of how carp reduction occurred. It therefore did not focus on the use of the carp virus. It focused on identifying the likely medium (5 to 10 years) to long-term (longer than 10 years) outcomes of a reduction in carp population caused by any mechanism. It did not examine the short-term ecological effects of specific methods used to reduce carp, as this was being examined by other Plan projects in relation to use of the carp virus. The aim of this study was to better understand likely medium to long-term positive and negative ecological outcomes under different carp reduction scenarios, and to identify and quantify the level of uncertainty about these outcomes. The work has informed other Plan projects that are evaluating costs and benefits of carp control.

The project included (i) a review of the existing literature on the long-term ecological effects of carp removal and carp population reduction and (ii) an expert elicitation process in which an online survey and two face-to-face workshops were used to elicit views of individuals with scientific expertise in different aspects of aquatic ecology. A total of 103 experts who were published researchers examining this area were invited to participate and 49 contributed.

The researchers identified conceptual models to help clarify the questions being asked of experts, and asked experts to identify the specific pathways they were aware of, their confidence in the presence of those pathways and their effects.

Experts were specifically asked to identify likely effects for the components of aquatic ecosystems they had expertise in, ranging from large bodied native fish to amphibians, water quality, small-bodied native fish, water plants, water birds and macroinvertebrates. They were asked to identify whether their knowledge related to specific types of aquatic ecosystem, including estuaries, floodplains, wetlands, small reservoirs, lakes and large reservoirs, temporary/intermittent rivers and permanent rivers.

Experts were then asked the extent to which their knowledge suggested there would be ecological response to reducing carp under four different carp reduction scenarios:

- Scenario 1: No carp reduction from current biomass
- Scenario 2: 25% reduction in carp
- Scenario 3: 70% reduction in carp
- Scenario 4: Complete (100%) elimination of carp

The experts were asked to:

- explain the relationship between carp and the specific ecosystem attributes they had expertise in
- To evaluate likely ecosystem responses to the four carp reduction scenarios
- To provide a confidence rating and explain the evidence-base on which their input was based, e.g. published academic papers, other reports, direct observation or others.

In the presentation, results for the predicted magnitude of effect of carp reductions on large-bodied native fish were presented. The findings indicated that outcomes are likely to be highly variable and uncertain, but that recovery of large-bodied native fish populations is considered likely after a reduction in carp populations under specific circumstances. These circumstances were where carp are the major driver of degraded conditions, a sustained reduction in carp of over 70% reduction is achieved, and complementary measures are implemented to address other stressors affecting ecosystem health. These other stressors included things such as coldwater pollution, habitat loss, siltation, nutrient loadings, connectivity and barriers to fish passage, increased water extraction and flow regulation/regimes/diversions, other alien fish species and climate change.

The overall conclusions from the project were that:

- There is uncertainty in how ecosystems will respond to carp removal
- Responses will vary spatially (ecosystem type) & temporally (e.g. depending on flows and climatic conditions)
- Other stressors are a significant issue which require specific consideration to achieve best possible outcomes from investment in carp control:
    - For native fish, key factors included water quality, flow & presence of native fish to re-colonize
    - For water plants, key factors included site and seed bank condition, both of which will influence response to carp removal
- For large-bodied native fish, a 'Moderate-large' and 'Large' positive ecological responses to carp reduction were considered more likely to occur in wetlands, large reservoirs and permanent rivers than in other ecosystem types
- There was low confidence that positive ecological response would result from lower levels of carp reduction, for example a 25% carp reduction
- There was a medium likelihood of hysteresis or novel system emergence as a response to carp population reductions – this means that there is a likelihood of aquatic systems shifting to a new state that has not occurred before with a different set of food web relationships and species, for example because of invasion or increase in population of alien species not previously dominant in that system
- Achievement of reduction of 70% or more of carp population was predicted to lead to a 30-70% long-term improvement over the current situation in terms of ecological health, with low to medium confidence
- Water plants and macroinvertebrates were identified as likely to respond positively and significantly to carp population reductions of 70%, with medium to high confidence
- Local conditions (including the presence of other stressors) are key determinants of both the ecological effects of carp and the potential long-term ecological benefits of a reduction in carp population.

Overall, the findings suggest that in situations where carp are a major driver of ecological degradation, and carp populations are significantly reduced (by 70% or more) over a sustained period of at least 5 years and ideally 10 years or more, and other stressors are also managed, positive ecological responses are most likely to occur. The likelihood of positive ecological response can be increased through specific investment in complementary measures such as restocking of native fish and habitat restoration investment.

Questions and discussion

Discussion of this presentation focused on uncertainty and the importance of investment in complementary action.

1. Responding in situations of uncertainty

The documentation of uncertainty in this study led to discussion about how to best balance risks of virus release with the level of uncertainty about whether ecological recovery would result from carp population reduction. The discussion focused on the challenges of identifying how to weigh up these different things.

In response, it was suggested that it is important to identify what will happen in the absence of efforts to control carp. The study showed that there was high confidence that under a 'do nothing' scenario, there is high certainty that there will be a worsening of ecological health, whereas under significant carp population reduction there was potential – albeit uncertain – for positive ecological response, which could be increased through investment in appropriate complementary measures. It was also highlighted that high uncertainty surrounds ecological responses in many management contexts. Sue Nichols also clarified that a significant amount of the uncertainty can be attributed to uncertainty about whether there will be other complementary control measures alongside the carp virus: certainty of positive ecological response would increase in scenarios where there was investment in complementary measures.

2. Consideration of complementary actions

The role of investment in complementary actions to improve ecological health was discussed by workshop participants. The focus on what complementary actions could be implemented prior to virus release was an important area of questions and discussion, with interest in what complementary strategies could help to mitigate potential negative effects and support ecological recovery. Key points raised in this discussion included that:

- There was strong support for a carp control strategy to include investment in complementary measures to increase likelihood of ecological response
- This could occur through direct investment by a carp control strategy, or (the preference of several participants) through specifically linking to other existing programs that are investing in ecological restoration, to ensure carp control efforts can align with these other investments already being made and maximise their effect
- Any carp control strategy needs to actively consider complementary measures, whether or not it directly invests in them, as many measures require significant lead time – often years – to put in place. For example, to enable restocking of specific fish species after a reduction in carp population requires investment in scaling up

appropriate breeding facilities in the years prior to carp control and careful timing to ensure sufficient stock will be available for restocking after carp populations reduce.

- Some participants expressed frustration that investigation of feasibility of the virus was occurring without consideration of other potential carp control measures and the broader context of ecological condition of systems or other investments occurring in environmental restoration.

This led to a discussion about the ultimate purpose of the Plan. While the focus of the Plan is on identifying the feasibility of the virus for reducing carp populations, this focus does not then answer the question of whether a reduction in carp populations will be beneficial or – most importantly – what action should accompany efforts to reduce carp populations in order to achieve positive ecological outcomes over the medium to long-term.

3.9 Social and economic impact considerations

Presenter: Jacki Schirmer, University of Canberra

Research team: Jacki Schirmer, Helena Clayton, Lain Dare (University of Canberra)

Overview

In this session Jacki Schirmer presented findings from research into social and economic considerations in the development and implementation of the Plan.

Presentation summary

The presentation first explained that work examining social and economic considerations had included research examining?

- Perceptions: What are the views people hold about carp control and potential use of the virus, including both stakeholders with a strong interest in management of areas where carp invasion occurs, and the general public? In this work, the focus was on (i) those potentially impacted by carp control (stakeholders); (ii) those with a strong interest in carp control (stakeholders), and (iii) the broader community (who often have no/limited awareness/interest)
- Social license: Who feels it is acceptable to release the virus, and who doesn't? Why/why not? And what conditions are needed to achieve social license for virus release?
- Communication: What information do people need about carp control, and how can this need met?
- Socio-economic impacts: What is the potential for virus release to have positive or negative social or economic impacts, and under what circumstances would different impacts occur?
- Mitigation of impacts: What can be done to reduce potential negative impacts and increase potential for positive impact?
- Implementation & monitoring of impacts: Monitoring and evaluation of impacts over time, by group, and circumstances.

The research exploring these different areas has involved both large-scale online surveys of the general community and in-depth stakeholder interviews and workshops. This included interviews with stakeholders including natural resource managers, vets, environmental non-government organisations, animal welfare organisations, Traditional owners, water managers, farmers and irrigators, koi keepers and breeders, tourism businesses and organisations, local government representatives, commercial Fishers, native fish breeders and growers, and recreational fishers.

The workshop presentation was focused on the research on potential social and economic impacts of carp virus release and strategies for reducing risk of negative impacts. This research has involved in-depth interviews and collaborative workshops with representatives across key stakeholder groups who may be involved in and affected by carp control measures proposed in the Plan. Four of these groups were discussed in the presentation: commercial carp fishers, native fish aquaculture, tourism, and koi keepers and breeders. Recreational fishers are also included in the study but were not discussed in the presentation as work was ongoing into potential impacts for recreational fishers.

Key findings of the research include that:

- Stakeholders have a wide range of views about whether the virus should be released and under what circumstances. These views are all conditional on the recommendations eventually included in the Plan, meaning they may change depending on the content of the specific recommendations made. In particular:
    - Outright (unconditional) support for virus release is uncommon, although a small number of stakeholders have relatively unconditional support for use of the virus
    - Conditional support is common, with the conditions for support commonly including that virus release occur as part of an integrated set of multiple actions to control carp, and that complementary actions be invested in to support ecological recovery, potential for negative impacts on water quality can be suitably minimized, suitable resourcing is made available, and carp control is governed appropriately with clear accountability for actions. Amongst this group there is willingness to accept some short-term negative impacts of virus release, as long as the longer-term benefits clearly outweigh these impacts.
    - No position or mixed views are common, with many of the same queries raised as those listed above
    - Conditional opposition is somewhat common, in which the stakeholder is opposed to virus release but would reconsider if some conditions were met, such as putting in place actions to mitigate key negative impacts of concern
    - Outright opposition is somewhat common, with some stakeholders not supporting virus release under any circumstances.
- Amongst the general public, multiple surveys have shown similar findings:
    - Typically, more people think virus release is acceptable than find it unacceptable (usually twice as many find it acceptable as unacceptable) – in recent surveys, around 44-46% found it acceptable to some degree compared to 19% who found it unacceptable
    - Uncertainty is high, with a further 36% to 37% being unsure whether they would find virus release acceptable or not.

Similar proportions of people would prefer to release the virus (34%), not release the virus (29%) or are unsure what they would prefer (37%).

Those living in rural areas, farmers and recreational fishers are more likely to support use of the virus than those living in large urban areas. Younger people are less likely to support use of the virus than older people, due to higher levels of uncertainty amongst younger age groups.

Overall, there is strong public support for carp control in general, with 65% agreeing the government should invest money in controlling carp.

Key concerns held about virus release include concerns about transmissibility of the virus to fish or animals other than carp, the virus having unintended effects that weren't predicted, the potential for water quality problems, the challenges of cleaning up dead fish, and concerns about whether the virus could be 52transmissible to humans. Much of the Plan research has involved investigating these issues to enable provision of data to respond to these types of concerns. Despite these concerns, 50% of people felt any short-term problems caused by virus release would be worth it if there were long-term benefits, while 38% felt the virus should only be released if it wouldn't cause short-term problems.

The research has identified a number of potential impacts and potential actions to mitigate impacts for the four groups discussed in the presentation. Both the impacts of the development of the Plan, and potential future impacts, were identified in the research.

Tourism sector

While most tourism businesses had not experienced any change in business during the period since the Plan was established, some reported reduced certainty in the future, and that customers making bookings for future years were sometimes querying whether there was a risk of carp death in the time they were making bookings for. Key potential impacts of virus release were:

- Reduced visitor numbers, business revenue and flow on impacts of this for employment, during periods of virus release and large-scale carp death or periods where these events were perceived to be occurring: This would occur either if the virus release causes some waterways to become unusable or unpleasant for a lengthy period of time, or if customers perceived this to be the case (irrespective of the actual condition of the waterway)
- Loss of certainty about the future and reduced forward bookings, due to concern about potential future carp deaths
- Longer term increases in visitor numbers, business revenue and income associated with improvement in ecological conditions after a reduction in carp populations; if this occurred it could also increase certainty about future bookings

- In association with the impacts described above there may be increased or decreased long-term investment in the inland and estuary-based tourism industries operating in areas where carp are present.

Research asking consumers about their behaviour was consistent with these concerns and suggested that tourists are likely to reduce visitation if they have concerns about water quality, smell or presence of dead fish, even in areas some distance from those affected by those issues. However, it was also identified that many people currently do not visit areas due to concerns about water or other ecological health issues, suggesting potential for increase in longer term visitation if carp reduction was successfully achieved together with a positive ecological health response.

Negative impacts for the tourism industry could be mitigated through a range of actions including development of comprehensive and appropriate communication strategies to limit impacts on visitation, ensuring clean-up contractors utilized businesses affected by any downturn in visitation, targeting clean-up areas to those important to tourism, and carefully identifying how timing of virus release will interact with key tourism periods.

Commercial carp fishers

The commercial carp industry is currently a small industry, with limited numbers of permits issues and widely varying regulatory regimes across jurisdictions in which commercial carp fishing is permitted. For some commercial carp fishers, it is difficult to obtain permits to fish when aggregations are occurring. Many (but not all) report that regulatory constraints reduce their ability to provide regular supply to markets for some. There is not a coordinated management plan or strategy to assist effective removal of carp through live fishing across different jurisdictions.

This group has experienced significant impacts since established of the Plan. These ‘anticipatory impacts’ include high uncertainty about the future for fishers, reduced interest from markets due to uncertainty about whether commercial fishers will be able to supply carp in future, inability to obtain or maintain business financing due to reluctance of financial institutions to provide finance to businesses with an uncertain future. Associated with this, may businesses reported being unable to invest in their business or sell their business. The establishment of the Plan and uncertainty about the future has caused high psychological stress for many fishers. Some types of communication about carp control have exacerbated this stress, particularly communication in which commercial carp fishing has been described as unviable or unable to expand in scope.

Future impacts of the virus is released would include:

- Loss of markets due to both uncertainty of supply and negative market perceptions about the quality of fish, with many domestic and international markets expected to be reluctant to purchase product that may be affected by the virus, and several

international markets considered to have a high likelihood of refusing to allow export from Australia into their markets
- Potential for increase in business costs due to a reduction in carp numbers: This was not considered a high risk by many carp fishers due to the nature of carp fishing which often focuses on fishing aggregations of carp
- Increased business opportunities in the form of live fishing as a carp control measure, or for some participation in clean-up; not all commercial fishers wanted involvement in clean-up activities, with concern about how they would be perceived publicly if they were

Research into consumer perceptions supported that consumer demand would likely fall initially for carp products due to negative perceptions. However, the reduction was not always high and positive communication campaigns would have reasonable potential to overcome this, if suitable resourcing were available for them.

Key actions identified with potential to reduce extent of negative impact included:

- Recognising and respecting expertise of commercial carp fishers and taking care not to portray the industry negatively
- Supporting campaigns to increase carp consumption or use of carp products, to assist in mitigating negative perceptions, expanding markets
- Increasing opportunity for live harvest to form part of longer-term carp control
- Providing a more enabling regulatory environment for live harvest, and developing a coordinated live carp harvest strategy (e.g. in areas too warm or cold for virus to be effective)
- Addressing potential additional constraints to markets introduced by release of virus, including
  - Providing clarity on regulatory requirement for selling into different markets if virus is released
  - Actively working with regulatory authorities to reduce potential for perverse outcomes in the form of unnecessary market restrictions
- If feasible, provide meaningful business opportunities or support to help businesses transition into new activities.

Native fish aquaculture

The native fish aquaculture industry is a small but growing industry, which is expanding in both domestic and export markets. Many of these markets are highly sensitive to any change in product quality, and price premiums received by Australian producers that make businesses viable rely on their products having a strong 'clean and green' image. This sector supplies fingerlings for stocking, export fingerlings for growing on overseas, and some grow stock into table fish size for domestic consumptions. Markets include both conservation and recreational fishing markets, and fish consumption markets.

Many of the anticipatory impacts associated with establish of the Plan and potential future impacts of virus release reported by commercial carp fishers were also reported by the native fish aquaculture sector, however with lower overall levels of stress reported. Many reported having high levels of uncertainty about whether they could continue investing in their business, associated with uncertainty about whether their markets would still accept their product in future if the virus was released, and whether there would be expanded demand for restocking of native fish associated with virus release. In particular, the response of export markets was of high concern, with concern that virus release could be accompanied by refusal of some countries to continue importing fingerlings from Australia.

These businesses identified both positive and negative potential future impacts, with potential to increase supplies for restocking, but also for reduced market demand. For advantages to occur would require forward planning to enable sufficient investment.

Actions that could assist in mitigating negative impacts included:

- Providing support through addressing existing regulatory constraints, which could offset some impacts to some degree
- Clarifying and addressing any additional constraints likely to occur if virus is released, such as potential for export restrictions due to the presence of an internationally notifiable disease in waterways
- Investment in marketing and diplomatic strategies into export markets
- Investment in marketing and other actions into domestic markets
- Restocking assessment, planning and preparedness: development of a native fish restocking strategy that provides more certainty to enable business investment.

Koi hobbyists and businesses

Koi keeping is a relatively small hobby in Australia compared to other countries, however it still involves thousands of people in New South Wales and Western Australia where koi keeping is permitted and supports many businesses. Koi keeping has a long cultural history and is culturally important to many koi keepers, who have strong connections to their pet koi, and connections to koi communities in other countries. Key challenges for the koi sector in Australia include that there are a limited number of domestic breeders who rely completely on domestic stock due to a ban on import of koi. Breeding lines have been built over long periods, often decades, and cannot be readily replaced if koi die due to contracting the carp virus. The sector has also experienced rising costs in recent years that have acted as barriers to participation for some koi keepers.

When the Plan was announced, some koi keepers and businesses noticed an initial reduction in koi sales at auctions and reduced demand from breeders, although some felt this had since recovered to an extent. Key concerns were uncertainty about the future, stress for breeders who had built significant capital in their breeding stock, and reduced ability to invest in or sell businesses. Several also felt there was reduced likelihood of new people entering the hobby or of investment by existing hobbyists.

The potential impacts of virus release for the koi industry are associated with the risk of koi contracting the virus and dying or having to be euthanized due to their exposure. This risk is associated with many impacts:

- For koi keepers (both hobbyists and breeders), high levels of psychological distress would be caused by loss of koi to the virus
- Loss of business for koi breeders, with limited ability to rebuild breeding businesses if stock is lost
- Reduced socialization amongst the koi keeping community, and loss of the social connections that provide important benefits to koi keepers, with koi owners less likely to visit each other due to risk of spreading the virus
- Reduced number of hobbyists due to fear of losing stock, and/or inability to afford costs of biosecurity measures
- Increased costs for businesses due to need to implement biosecurity measures, which for some may make their business unsustainable depending on the level of cost involved.

Key actions to reduce negative impacts included:

- Identifying cost-effective biosecurity options: the Plan had invested in some work on this, to respond to concerns about the cost and feasibility of effective biosecurity
- Greater clarity around risk to pet koi and potential virus vectors
    - What is the likelihood of transmission via vectors such as birds/lizards/frogs drinking from koi pond?
    - How can social aspects of koi hobby such as visiting, and inspecting be maintained safely?
    - What water can be safely used in ponds?
- Ensuring clear communication to the koi keeping community, particularly via vets and suppliers
- Develop support for koi owners impacted by virus
- Consider changing import restrictions to enable importing of new breeding stock if a breeder’s existing stock are killed by the virus.

Questions and discussion

Social and economic considerations were raised in the discussions across all areas of research presented at the workshop. The research findings across biomass estimates, water quality modelling, cleanup planning, and ecological risks and recovery all have implications for the stakeholders represented at the workshop. In the discussions it was evident that the potential positive and negative impacts of releasing the virus have the potential to profoundly impact people's lives and livelihoods over both the short and long-term, and have already had significant impacts for some, particularly commercial carp fishers.

There were several questions and concerns raised about potential for the carp virus release to negatively impact on livelihoods of commercial freshwater fishers, native fish breeders, and tourism operators. Jacki Schirmer confirmed that the range of concerns raised in the workshop discussions have been documented in the social and economic impact assessments undertaken across the five stakeholder reports that will be submitted to the Plan.

The concerns about potential risks from the carp virus release were also discussed in the context of complementary and alternative pathways for carp control. This is discussed in more detail in Section 5.

A key response to the presentation was identification of the need to make clear recommendations about how people potentially negatively impacted by virus release should be supported. This includes identifying:

- Potential for flow-on economic and social impacts to communities
- Potential to provide financial and other support to those impacted, particularly those who lose current markets
- Commitment to resourcing mitigation actions such as development of communication and marketing strategies.

It was emphasized that these impacts involve people's livelihoods and businesses, and that current uncertainty is having important impacts already. This is best summarised in the following comment submitted by a workshop participant:

> *Who will wear the consequences if this all goes horribly wrong? Do you lose your jobs and homes? Not academic or theoretical exercise for us. Real life problem,*

4: FEASIBILITY CRITERIA

On Day 2 of the workshop, participants were given a list of broadly phrased criteria for assessing the feasibility of the carp virus. They were asked to work in small groups to identify whether they felt the criteria were appropriate, whether any were missing, whether they made sense, and to provide any other feedback they wished to on them.

The initial feasibility criteria participants were asked to examine were that to be feasible, release of the carp virus would need to achieve the following:

- Reduction and suppression in carp populations in Australian aquatic ecosystems.
- Release of the carp virus is safe.
- Avoid significant environmental impacts.
- Enable appropriate quality of water to be available for the purposes of town water supply, stock and domestic water supply, irrigation, and cultural and recreation purposes.
- Effective measures and actions that mitigate risks and impacts associated with the release of the carp virus.
- Benefit for the environment and communities.

After discussing the feasibility criteria, participants provided feedback, which has been organized into several key themes below.

More specifically define outcomes being sought – feasibility 'for what'?

Ultimately, feasibility is about whether a particular outcome can be achieved. Participants wanted more specificity in the outcomes being assessed, for example setting of a threshold of potential carp population reduction considered to be the minimum required over a given period of time for virus release to be considered feasible.

Identify specific benchmarks for outcomes, safety, impacts risks etc

Specifying benchmarks required more specificity in language: participants felt broad terms such as 'safe' or 'significant' should not be used and instead specification of the levels of types of conditions considered feasible should be defined.

For example, instead of 'reduction and suppression in carp populations', identify the criterion as 'reduction of carp populations to below XX% of populations as at YEAR, and ongoing suppression of populations to below XX% of population over a period of at least X years'.

Benchmarks should clearly identify what is considered acceptable versus unacceptable risk, impact etc in relation to each feasibility criterion. Different impacts and risks assessed should each be clearly defined, as what is considered to constitute feasibility defined.

Clearly address spatial variability

The feasibility criteria should explicitly identify how variance in risks, impacts and benefits across different spatial areas will be evaluated. For example, if you have benefit upstream and negative impact downstream how will that be built into the criteria, and on what basis would a decision be made about feasibility or lack of it in that circumstance?

Clearly address temporal variability

Specification is needed of the time periods assessed for both carp reduction and impacts of this reduction in assessing feasibility. Over what time period would virus release need to achieve a particular level of carp reduction to be considered feasible? What length of time could negative impacts of virus release occur for before virus release was not considered feasible?

Assess technical feasibility

Feasibility criteria should include explicit assessment of whether it is technically feasible to release the virus in the quantities/locations/timing required for effectiveness, and whether clean-up required to reduce risk of impacts is technically feasible. This also suggests a need to assess whether partner organisations who would be involved are likely to be able to implement the actions being proposed and clearly identify required resourcing.

Assess and communicate necessary conditions for feasibility

The feasibility assessment should include criteria clearly identifying *under what circumstances* virus release would and would not be feasible, including any assumptions about climatic conditions, water flow and temperature, and investment in other carp control actions or complementary ecological recovery actions likely to be needed to achieve benefit from virus release. This also requires assessing in which conditions feasibility would not be achieved, for example when other environmental stressors would reduce likely effectiveness of virus in either reducing carp populations over the long term or achieved positive ecological response after reduction in carp populations.

Identifying conditions under which feasibility is possible also requires clearly identifying the mitigation actions that need to be invested in to achieve feasibility. These include things such as education campaigns, marketing campaigns, provision of support for impacted businesses and others.

Have clear measures of confidence and sensitivity

When assessing each aspect of feasibility, levels of confidence in the findings of the assessment, and sensitivity of the conclusions to changes in conditions or evidence are needed. Clear criteria should be established identifying what are considered appropriate levels of confidence and sensitivity.

Include assessment of social acceptability

Virus release needs to be socially acceptable to be feasible: one table suggested adding 'does it pass the public perception test' as additional feasibility criteria separate to assessment of social impact. This requires having clear understanding of what levels of risk are considered acceptable by stakeholders and the community and drawing on this understanding when assessing feasibility.

Include cost-effectiveness as a criterion

The cost-benefit analysis of use of the virus should be included as a specific criterion, with identification of the level of cost to potential benefit considered to indicate feasibility.

Assess sufficiency of evidence

Feasibility criteria should include assessment of whether available evidence is sufficient to support making recommendations about feasibility, and clearly identifying any aspects of feasibility unable to be assessed due to a lack of sufficient evidence, or lack of certainty in available evidence. This in turn requires having clear criteria for assessing acceptable levels of certainty and risk.

5: KEY THEMES EMERGING FROM THE WORKSHOP

This section synthesises the discussions occurring during the workshop to identify key themes and messages, which were presented as specific messages in the executive summary.

5.1 Support for carp control

One key theme emerging from the workshop was strong support from workshop participants for investment in carp control. All workshop participants strongly supported investing in carp control, irrespective of their views about the feasibility of the carp virus. Where there are differences of view, it is not about whether carp control is desirable, but about how best to investigate and make decisions about future carp control strategies. This means, the workshop participants supported continued investment in developing carp control strategies. Most wanted future carp control strategy investment to include examination of a wider range of aspects of carp control than the Plan was asked to examine in its terms of reference, reflected in the focus of much discussion on identifying the elements participants felt were needed in a comprehensive carp control strategy.

Feedback on the draft version of this report from one stakeholder, was that the ecological, economic and social risks of a 'do nothing' scenario needed to be emphasised in the reporting of key themes emerging from the workshop. There was significant discussion about such risks in the workshop and for most participants, a nationally coordinated carp control strategy was strongly desired whether it ultimately includes release of the carp virus. There were several stakeholders who strongly support future carp control that involves the release of the carp virus. And all stakeholders agreed that an absence of investment in carp control was not considered acceptable.

5.2 Plan 'Terms of Reference'

Much of the workshop discussion focused on clarifying the role of the Plan, versus the future development of 'shovel ready' carp control strategies. The Plan's focus is on assessing feasibility of the carp virus. Several workshop participants questioned the current interpretation of the Plan's terms of reference, or felt the terms of reference should be broader than they currently are, to enable development of a full carp control plan that includes multiple aspects of carp control rather than focusing solely on the feasibility of the virus. In discussion of this issue, others agreed that it was important to focus limited resources on answering questions about feasibility of the virus but felt that future carp control strategies should have a broader focus, as noted in previous key messages.

Several stakeholders asked that their concerns about the focus of the Plan on 'virus feasibility' alone be communicated to government, together with their preference for terms of reference for a carp control strategy to focus on a more holistic approach to carp control based on environmental health objectives rather than objectives focused on reducing carp populations. Some felt that this could be addressed through ensuring further work undertaken after consideration of the recommendations of the Plan regarding feasibility of the virus examined the broader actions needed for a carp control strategy.

However, others felt that because the Plan is not currently placed in the context of more fundamental questions about what the virus should achieve, it may provide recommendations about the wrong question. A key message related to the this is that assessment of feasibility of the carp virus is different to the question of “should the virus be implemented?”

Overall, the discussions highlighted that consideration of the feasibility of the virus out of the context of an integrated approach to pest management, waterway and biodiversity restoration objectives has limited legitimacy for many stakeholders. The recommendations of the Plan will be viewed as having legitimacy by many only if they are then used to inform a more integrated approach to carp control.

5.3 First Nations involvement

Lack of engagement with Traditional Owners was identified as a critical gap that need to be addressed as an urgent priority. This was discussed on Day 2 of the workshop, where Grant Rigney, a representative of Murray Lower Darling Rivers Indigenous Nations (MLDRIN), spoke and raised the following points:

- Indigenous Nations have been left out of discussions and consultations about carp control, despite initial promises of ongoing engagement when the Plan was initiated
- There is strong concern that no opportunity was given for Indigenous Nations or other groups to have input into the design and shaping of the original terms of reference for the Plan. This is reflected in concerns raised by workshop participants about the narrow focus of the terms of reference in the workshop
- There is concern about lack of communication to Indigenous National about the Plan and what is happening
- Indigenous representatives should be at the ‘table’ as part of decision-making and carp control implementation processes, not after decisions are made. In additional to consultation, there should be formal roles for Indigenous people as part of the governance framework of the Plan and any subsequent carp control actions. To ensure appropriate input, this requires meaningful, formalised roles, rather than simply networking of the type occurring at events such as this workshop: inclusiveness and building genuine relationships and partnerships requires formalisation of roles in decision-making processes.
- The criteria to evaluate the feasibility of the carp virus need to include those that are meaningful and acceptable to First Nations based on their knowledge and

understanding of complexity of natural and cultural systems. This should be made explicit in feasibility criteria.

- While issues such as using water flows were raised in the workshop, there is no clear identification of issues around indigenous water rights, water volume, native title, access to lands and other critical issues concerned with how any actions to control carp will be conducted in ways that follow both Indigenous and western law. The rights of Indigenous people are affected by carp control and should be a central consideration in the Plan recommendations.
- Carp control actions of any kind will impact on Country and on the rights of Traditional Owners, and, as a matter of urgency, additional engagement with Traditional Owners is needed. There is a need to progress the Plan project which has been established to enable input from Indigenous people into the Plan recommendations
- Ownership of the limited consultation and engagement is needed, and it should be prioritised to address rather than regularly identified as an issue and not then acted upon.
- Meaningful opportunities for Indigenous Nations to be able to participate in research and have dialogue about proposals for carp control are needed. This requires ensuring there are formal requirements for this to occur.

In response, Jamie Allnutt committed to following up this as an urgent priority.

5.4 Stakeholder engagement and partnerships

Participants wanted further opportunities to engage with scientists and discuss potential carp control strategies, particularly around many of the specific topics raised at the workshop. Potential to have input on forthcoming discussion papers being produced by the Plan was viewed positively.

The Plan is focused on feasibility of virus release and has included stakeholder consultation as part of assessing this but has not developed formal stakeholder partnerships. In terms of governance, some stakeholders have been included in some advisory groups, but not all, and the scope of the Plan did not include developing formal partnerships with stakeholder groups or agreements about working together on carp control going forwards – this type of formal partnership would occur once government decisions are made based on consideration of Plan recommendations.

In discussions, several participants felt there was a need to focus on developing improved partnerships for future work on carp control. These should go beyond consultation or engagement via workshops such as this one, with future development of a 'shovel ready' carp control strategy much more likely to succeed if more formal partnerships were developed with the wide range of organisations whose support, investment or action will be needed as part of carp control. This should include both organisations directly acting on and those affected by carp control actions. These participants wanted the recommendations of the Plan to include recommendations about establishing formal partnerships as part of future carp control strategies, with clear identification of roles and responsibilities, and of resourcing of partnerships and the actions different partners will participate in.

5.5 Clarity on future decision-making processes

It was clarified at the workshop that the Plan is a 'road map' that will be at a broadscale level, and that full development of a carp control strategy would require substantial additional investment beyond the Plan. Workshop participants wanted clearer guidance on the processes of decision making that will occur after the Plan is submitted to the government. In particular, clarity was sought about the agencies and committees that would be involved, when a decision might be made about whether governments would release the virus, and the length of time expected for planning for any release, or for implementing other carp control measures, after such a decision was made. This can enable stakeholders to plan for the future with better understanding of when they might expect decisions to be made and any investment in on-ground carp control action to occur.

5.6 Carp control actions other than the carp virus

Many workshop attendees wanted a broader range of carp control measures to be actively investigated in addition to the feasibility of the virus. Some felt that options such as live harvest (supported by investment in tracking of carp aggregations using methods such as Judas carp and citizen science reporting tools, including the carpmap tool used as part of the Plan), the role of native fish stocking, and genetic control should be more thoroughly investigated. For some, this was because they felt these could provide viable alternative options to use of the virus. For others, this was because they felt these could complement use of the virus, particularly in areas where feasibility of the virus is limited, or in the longer term over which they felt initial efficacy of virus would decline. Workshop participants called for additional investment beyond the investment made in the Plan, to better understand how other carp control methods could work to either complement or, for some, be used instead of, release of the virus.

5.7 Complementary measures for ecological recovery

Several important themes about the use of complementary measures for ecological recovery were raised at the workshop. First, many felt that it was not possible to adequately assess the feasibility of the virus without identifying the differences in outcome likely to occur depending on the level of investment in complementary measures. Second, many participants emphasized that to ensure benefits resulted from carp control, it should be accompanied by complementary strategies that increase the likelihood of a positive ecological response to reductions in carp population. This led to the third key point, which was that there is a need to integrate carp control actions with other actions to improve health of freshwater and estuarine systems.

Several participants felt strongly that the feasibility of the carp virus should not be considered in isolation of other carp control and environmental recovery measures. They felt that this was inappropriate as:

i. The virus will not be suitably effective on its own to address threatening processes associated with waterways and native biodiversity
ii. Carp suppression on its own may not deliver environmental, economic or social outcomes – but may if accompanied by other measures.
iii. Presenting the virus as the "main game" may have unintended implications for resource allocation away from essential strategies required to achieve critical outcomes for waterways and biodiversity.

These participants felt the feasibility of the carp virus cannot be assessed in isolation from other carp control measures and environmental recovery measures. This is because they felt the effectiveness of the virus will in large part depends on whether virus release occurs in combination with other actions that may have potential to increase or reduce overall effectiveness of the virus in reducing carp populations. Effectiveness here refers to the effectiveness of the virus in achieving positive ecological outcomes from a reduction in carp population, as well as the effectiveness of the virus in achieving reduction in carp populations. From this perspective, the Plan should identify areas to be investigated in which complementary actions have potential to increase effectiveness of any use of the virus, as well as identifying any actions that may reduce effectiveness of the virus in reducing carp populations.

Other participants agreed that complementary measures should be considered, but felt that it was appropriate to first assess the broader feasibility of the virus for reducing carp populations and then follow this with identification of appropriate complementary measures once a decision was made about whether or not the virus would be released.

There was stronger agreement that eventual carp control strategies developed based on recommendations of the Plan should include consideration of complementary strategies to improve environmental health. This included identifying what forward planning was needed and ensuring that sufficient forward investment was made in preparing complementary measures (whether as part of a carp control strategy, or as part of other programs being invested in at the same time as carp control) so they could be implemented with the right timing to achieve maximum effectiveness. The ultimate purpose of carp control is to improve health of freshwater and estuarine systems carp have invaded; maximizing potential improvements in ecological health resulting from carp control requires careful planning and investment before carp control actions occur. This requires substantial lead time to ensure adequate preparation for actions that may increase potential for improvement in environmental health if carp populations are reduced (for example, plans for native fish stocking, water flows, or other complementary actions). While recognizing that these complementary strategies are not part of the terms of reference of the Plan, workshop participants sought reassurance they would form part of future strategies to control carp that draw on the Plan's recommendations.

Following on from this point, for maximum effectiveness most participants felt carp control strategies should be integrated with other actions to improve health of freshwater and estuarine systems. This did not mean participants expected that a carp control strategy would invest in actions other than carp control, but that they wanted to see careful and clear coordination of carp control actions with other investments occurring in ecological restoration in the same areas. Carp are one of multiple pressures affecting the health of the waterways they have populated in Australia. Multiple programs and strategies are currently being used across different jurisdictions to invest in improving the health of areas affected by carp, for example native fish recovery strategies, riparian health action programs, and others. Future carp control action plans should be explicitly linked to these other actions so they can complement each other, increasing likelihood of improvements in environmental health resulting from both carp control and other actions. Concern was expressed about taking action to control carp without aligning this with other investments occurring at the same time. Several participants felt substantially more positive impact could be achieved by explicitly integrating carp control with other environmental recovery investments such as the Native Fish Management and Recovery Strategy being developed by the Murray-Darling Basin Authority.

5.8 Developing the Plan recommendations: addressing uncertainty and risk

The workshop discussions identified that to achieve support and trust in the recommendations of the Plan, there is a need to

- Clearly identify and define the benefits being sought through carp control and assess feasibility of the virus with reference to these
- Identify what are considered acceptable levels of risk, and clearly define this for different types of environmental, social and economic risk
- Clearly identify levels of uncertainty and ensure best-case and worst-case scenarios based on the levels of uncertainty in the research are articulated and assessed as part of making recommendations
- Ensure feasibility criteria include consideration of impacts, effectiveness and opportunity costs over both short-term and long-term, opportunity costs over time, and feasibility of mitigating impacts

The extent of reduction in carp populations required to achieve benefits for environmental health should be a key part of assessing feasibility of the virus and the recommendations made in the Plan. In other words, the ultimate objective of reducing carp populations – improving environmental health – should be focused on, rather than assuming all levels of reduction in carp population are necessarily beneficial in terms of achieving improved environmental health. Clearly identifying benefits being sought from reducing carp populations, and thresholds of population reduction required to have a reasonable probability of achieving improvement in these aspects of environmental health, is needed. This is preferable to assessing feasibility based solely on whether virus will achieve reduction in carp populations, as reduced carp populations are beneficial only if they can lead to improvements in defined aspects of environmental health (for example, water quality or native fish populations).

When assessing feasibility of the carp virus, thresholds considered to represent 'acceptable' and 'unacceptable' risk in relation to potential environmental, economic and social impacts need to be clearly identified.

Some attendees queried estimates of carp biomass, feeling they were lower than they would expect. They felt the current 'worst case' scenario estimates were not sufficient to cover all potential scenarios as a result. Further discussions about biomass modelling and recognition of potential for a wider range of biomass estimates were requested by some attendees. This also led to discussion of the broader need to ensure uncertainties in knowledge were clearly identified and explicitly incorporated in recommendations of the Plan. The Plan stated that recommendations in the Plan would be based on best to worst case scenarios of impact from virus release. Attendees supported this and wanted to ensure that worst case scenarios reflected the level of uncertainty inherent in estimates of things such as carp biomass, water temperature, water flow, likelihood of virus recrudescence, and existing nutrient levels in different parts of river and lake systems. Several stakeholders requested that estimates be communicated in ways that clearly identify levels of uncertainty in estimation, for example as ranges (which was done in several presentations, but not all).

Workshop participants made several suggestions for increasing the clarify and specificity of criteria to be used to assess the feasibility of the carp virus. These included more explicit assessment of cost-effectiveness, focus on both short-term and long-term outcomes, and definitions of both what is an effective level of carp reduction and what is considered an acceptable level of risk for different types of risk. The specific areas considered important to evaluating feasibility were identified in Section 4.

6: CONCLUSIONS

The workshop enables stakeholders to better understand the emerging findings from Plan research and to discuss their views on how this research should inform recommendations of the Plan. From the workshop, the following key messages were identified:

1) Meaningful Traditional Owner engagement is needed
2) Ongoing stakeholder communication and engagement with research findings is strongly supported
3) There is a need to develop improved partnerships for future work on carp control
4) Clear communication is needed about decision making processes that will occur after the Plan is submitted to the government
5) The benefits being sought from carp control need to be clearly articulated
6) Acceptable levels of risk need to be clearly identified
7) 'Best case' and 'worst case' scenarios that reflect uncertainties in estimates should be explicitly used to inform the recommendations made about any future use of the virus
8) Feasibility criteria should include consideration of impacts, effectiveness and opportunity costs over both short-term and long-term, opportunity costs over time, and feasibility of mitigating impacts
9) Some stakeholders seek use of a wider range of estimates of carp biomass when examining potential impact of virus release
10) There is strong support for investing in carp control
11) Carp control should be accompanied by complementary strategies to improve environmental health
12) Carp control strategies should be integrated with other actions to improve health of freshwater and estuarine systems
13) Multiple carp control measures should be considered
14) The feasibility of the carp virus should not be considered in isolation of other carp control and environmental recovery measures
15) Several stakeholders feel the terms of reference for the Plan are interpreted too narrowly and/or should be broader.

Some of these key messages can be acted on during the remaining life of the Plan, particularly to inform the development of the recommendations ultimately submitted to government in late 2019. Others are messages that are relevant to development of carp control strategies and implementation of actions after the Plan has submitted its recommendations.

REFERENCES

McColl, K. 2016. Final report: Phase 3 of the carp herpesvirus project (CyHV-3). Invasive Animals Cooperative Research Centre. URL: https://www.pestsmart.org.au/wp-content/uploads/2016/11/Final-report-Phase-3-of-the-carp-herpesvirus-project-CyHV-3.pdf

Roper, K. and Ford, L. 2018. *Cyprinid herpesvirus 3* and its relevance to human health. FRDC project No 2016-183. Fisheries Research and Development Corporation, Canberra. URL: http://www.carp.gov.au/-/media/Fish-NCCP/NCCP-research-project-reports/2016-183-final-report-2018.ashx

Schirmer, J. 2013. Engaging with scientific data: making it meaningful. In *Engaged environmental citizenship* (pp. 87-105). Charles Darwin University Press.

Vilizzi, L., Thwaites, L. A., Smith, B. B., Nicol, J. M., & Madden, C. P. (2014). Ecological effects of common carp (Cyprinus carpio) in a semi-arid floodplain wetland. *Marine and Freshwater Research*, *65*(9), 802-817.

APPENDIX: WORKSHOP PARTICIPANT QUESTIONS

The following tables document questions raised by workshop participants prior to the workshop being conducted. All participants were contacted and asked to identify the key questions they had regarding the different topics the workshop would be discussing, with each of these topics identified in the online survey they were asked to complete.

The following documents questions raised by workshop participants that were documented on the app sli.do or documented in written notes handed in by workshop participants or that participants asked the workshop organisers to record. The only questions not documented below are a small number (three) that contained content considered to be potentially directly offensive or harmful to individual people; these were removed, and instead the broader question asked has been included in italics, phrased to remove the part of the original comment considered inappropriate to record in this report.

1. Virus release strategy and efficacy – Peter Durr

Themes	Slido question
Feasibility – economics	Has there been costings done on the deployment. Both virus inputs and field costs
Feasibility – efficacy	If the goal isn't to eradicate carp then what is the threshold or go/no-go scenario for not doing it at all?
Feasibility – efficacy	Not how do carp come into a system but why do they come into the system. This makes such a difference on the outcome
Feasibility – efficacy	What are the differences of survival rates of the virus in different water types / columns. Eg. Darling water, lackland water gippsland water
Feasibility – thermal pollution considerations	Has there been any investigation on thermal pollution of affected stretches of river forming safe havens for carp, due to constant unnatural low temperatures?
Release	How would an isolated trial be managed? This is a notifiable disease, internationally.
Release	Why is handling of virus a disadvantage? Isn't species specific and benign in humans?
Release	Outbreak Scenarios- Need to consider permanently connected wetlands, which is the majority in the regulated section of the Murray
Transmission	Is virus more active in shallower waters e.g. wetlands etc more so than in deeper waters
Transmission	The reality is this virus has spread widely and reasonably quickly in other countries despite efforts to prevent spread. I'd bet it would spread the same here
Transmission	How do we promote aggregation in large storages?
Immunology	A better understanding of fish immunology with respect to CyHV3 is needed to inform the risk assessment and epidemiolgy.

Immunology	Can you describe how the immune response in fish responds to infection with the virus?
Immunology	Is resistance to the virus a significant issue?
Science and uncertainty	What did we learn from [redfin] decline caused by EN38 virus?
Science and uncertainty	Has enough work been done on the deployment?
Science and uncertainty	Of the 32 nations with carp virus, how many can be said to have major reductions in carp population?
Science and uncertainty	Has any other nation purposefully released the virus? If not, why not?
Science and uncertainty	Data and skill sets does not trump on ground experience. How accurate is your modelling? Because rubbish in = rubbish out.
Science and uncertainty	How big was lake Biwa in Japan?
Science and uncertainty	Lake Biwa, Japan has 2 strains of carp. The endemic Japanese strain died en mass but the common wild strain didn't. Relevance to Australia is questionable.
Science and uncertainty	There is significant potential to manipulate & create aggregations in 'operated' parts of the system but these require trade off planning and can require long lead times
Science and uncertainty	80% mortality is much higher than seen in wild carp overseas. Recrudescence is unconfirmed in CyHV-3. Model prediction is extremely optimistic.
Science and uncertainty	How is 'damage' defined? Water quality? Bioengineering damage by carp? What criterion are being used?
Science and uncertainty	Compare apples with apples lake Biwa Area: 670.4 km² Catchment area: 3,174 km² Max. depth: 104 m (341 ft) totally different to MDB
Science and uncertainty	Has a lack of low flow / no flow data across the M-D basin limited modeling?
science and uncertainty	Are there other forms of the carp herpes virus?

2. Virus specificity – Toby Piddocke

Theme	Slido Question
Specificity	Recent research has shown that Rainbow Trout carrying CyHV can infect naive Carp (Bergmann et al 2019). How does this affect transmissivity and non-target risk?
Specificity	Has the study on transmission to humans been released yet?
Specificity	Is the virus as specific as claimed?
Virus mutation	What would be the chances of a different virus evolving anyway - such as may happen when populations of any animal get large?
Virus mutation	Over time, would there be a possible risk of mutation
Science and Uncertainty	The tank experiments are all in controlled environments, without stratification or significant genetic variability. How will these affect the individual kill?
Science and uncertainty	Why did so many native fish die (sometimes more than carp and in controls) in the CSIRO trials?

3. Current carp biomass estimates – Jennifer Marshall

Theme	Slido Question
Science and uncertainty	Have carp numbers/densities decreased “naturally” in some catchments?
Science and uncertainty	I would like to hear some response to Justin Brooke's recent statements that Carp populations have decreased by an order of magnitude over the last 50 years?
Science and uncertainty	What further work will be undertaken to increase validity of current biomass calculations? Currently not at a satisfactory level based on today’s presentation.
Clarification	In estimating fish numbers is there a standard average weight for a carp?
Clarification	What was the biomass taken out of the darling?
Clarification	Is carp:a) confined to the Murray-Darling basin; or b) only a problem in the M-D basin? Is the National Carp Control Plan a nationwide plan?

4. Water quality modelling – Jennifer Marshall

Themes	Slido Questions
Risk	Menindee lakes were a small taste of the release of the carp herpes virus fish kills. Why pursue such an extreme option when scientists are saying too risky
Risk	Are humans / stock at risk from environmental botulinum spores?
Risk	With an envisaged or ongoing die-off of carp would this also result in the necessity to upgrade country towns filtration plants for potable wateruse?
Water flow	Where is the flow coming from to mitigate deoxygenation? haven't got enough water for town water, mines and irrigation now
Water flow	Where do you think the " flow" is going? What affects will this "flow" of particles have on the waterways both on the way down stream and destination?
Water flow	Do you have a suggestion of the volume of water needed to create the "flow" required to remove the toxins and disease from fish kills
Potable water	With an envisaged or ongoing die off of carp would this also result in the necessity to upgrade country towns filtration plants for potable wateruse
Alternative pathways	That [biomass] estimate is very low. But if you are going to go by that, then harvest strategy is very manageable. One Chinese order is for 200,000 tonnes
Alternative pathways	Then doesn't the modeling also show that a harvest control strategy doesn't need to fish down as many carp to be just as effective as the virus?
Science and uncertainty	Little Duck lagoon is regularly dried out, so sediment issues are less – Was a permanently wet area trialled?

Science and uncertainty	Any consideration of the fact that the hotspots in the Lower Lakes are also Acid Sulphate Soil (ASS) triggered areas, so have a high Chemical Oxygen Demand (COD) – has that been considered?
Science and uncertainty	How is the current and post-kill upstream sourced contamination of the water considered in this model?
Science and uncertainty	Do models take into account nutrient loads from other species that die due to deoxygenation - rather than only the carp
Science and uncertainty	Has the water quality model been compared to the real life fish kill in the darling?

5. Cleanup assessment – Jamie Allnutt

Theme	Slido Question
Governance	Would the creation of a 'market' incentivise efficient cleanup?
Planning	How can contingency planning be used at local council level in future native fish kills?
Planning	Given the scale of the irrigation network which is currently excluded as reported today, what work is planned for these waterways to be considered?
Social impacts	How would you ensure people accessing water don't accidentally damage culturally important sites?
Prioritisation	Cleanup was discussed as "what we need to clean up" not a full clean up. Who misses out? Will there be compensation for tourism businesses, shack owners, and other businesses in towns affected by fish kills?
Resources	Some local councils along the river system are in huge debt and have no resources for a clean up. The lakes and coorong council cannot afford cleanup Who pays??
Alternative pathways	So why isn't this coordination of groups that is being put into cleanup being considered for live fish and getting millions of dollars income for these groups?
Alternative pathways	Is it more effort to clean up dead fish for landfill than harvest live carp for a commercial product?
Water flow	Will the "flow" volume come from environmental water?
Science and uncertainty	If you can't remove enough using electro-fishing over time, how can you ever hope to achieve clean-up post-virus, when you are on a timeline?
Science and uncertainty	What percentage of dead carp will sink - how will these be "cleaned up "?
Science and uncertainty	Planned management breaks down if the virus spreads in an unplanned pattern

6. Ecological risk assessment – Sam Beckett

Theme	Slido question
Base case comparison	It's critical to consider that the do nothing option is full of continuing and expanding environmental risk
Base case comparison	What's the environmental risk of virus release compared to ongoing carp infestation?
Boltulism	What aspect (environmental/genetic/host) determines which toxin is produced by the one species group of bacteria (Clostridium botulium)?
Boltulism	Does botulism of any of its types effect turtles that eat fish?
Cyanobacteria	Over summer, the South Lagoon of the Coorong had a cyanobacterial bloom of 1.25M cells/mL. We have dredges in the mouth. A pea soup waiting for more phosphorus.
Native fisheries	How many different native fish species are present in waterways effected by carp?
Native species	Can we have clarity on risks to native species
Science and uncertainty	How was the stratification of the Lakes and Coorong water bodies considered?
Science and uncertainty	The South Australian River Murray is a series of lentic habitats. How has the lower flow conditions of the South Australian River considered?
Science and uncertainty	Concerns have been raised by international scientists several with carp expertise, over past 12 months. What weight have you given to their concerns if any?

7. Ecological recovery – Sue Nichols

Theme	Slido question
Native fisheries	If a catchment gets to 40% density of carp post release, at what density would native fish displace/reduce carp populations even further?
Complementary actions	Important to include what we need to be doing to enable our native fish to take the opportunity presented by a reduction in carp numbers eg: habitat restoration
Science and uncertainty	Uncertainty high and not great confidence for recovery of native fish is not a ringing endorsement for such a high risk action. Is it worth the risk?
Complementary actions	Is there any evidence of the effects of increasing native fish numbers on carp numbers/densities
Population dynamics	With the void space of carp have we looked at the other invasive out there that will fill the void and possibly develop another issue. Many aquarium species
Population dynamics	What is the likely effects on other introduced fish populations particularly Redfin

8. Consideration of social and economic impacts

Themes	Slido question
Communications & tourism	We will need a major PR strategy to manage visitor expectations and tourism risk. All messages around carp control/management will need to be positive.
Risks	Are your reports going to clearly define the risks and not just "we can manage it"
Structural adjustment	Where is the scenario planning for structural adjustment for the greater good?
Governance	Who will wear the consequences if this all goes horribly wrong? Do you lose your jobs and homes? Not academic or theoretical exercise for us. Real life problem

9. Plan scope, governance, and carp control strategies –questions for Jamie

Theme	Slido Question
Feasibility evaluation	When designing feasibility metrics please ensure there is a section on what success looks like or a set of performance metrics
Governance	What is a realistic timeline of completion for the research, and how far off are we from a decision on the virus release?
Governance - costs	When will the costs of implementation be estimated
Governance - Plan scope	Why is it called National Carp Control Plan when it is obviously, it is Carp virus release plan?
Governance - science and uncertainty	In the Decision Gateway, how will remaining uncertainty be considered? Uncertainty in efficacy, uncertainty in benefits, uncertainty in side-effect risks.
Governance - science and uncertainty	How do we avoid 'paralysis by analysis'?
Governance - Science and uncertainty	I hear a lot of downplaying risks. In fisheries management "precautionary principle" is [a focus]. Where is precautionary principle here? Precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically
Carp control strategies - alternative biocontrol options	Has there been consideration of other biocontrols such as predator prey model where more cod and predatory natives reduce carp
Carp control strategies - Commercial harvest	The carp will re-populate and harvest strategy will have no markets
Carp control strategies - Commercial harvest	Viability of live harvest. Some felt possible but expensive. Fishers with experience said can reduce costs if do it well/ right
Carp control strategies - commercialisation	We need to talk more about commercial concepts and policy of alternatives to carp control

Carp control strategies - complementary/alternative	Not talking about doing nothing if carp control through a basin wide harvest strategy is adopted
Carp control strategies - governance	There was always talk about complementary control strategies, where are they?
Carp control strategies - water flow	Complimentary measures require more water. How will you achieve that?