Regional Water Strategies Public Exhibition Submission Questionnaire

The NSW Government is taking action to improve the security, reliability, quality and resilience of the state's water resources. The Lachlan Regional Water Strategy will deliver healthy and resilient water resources for a liveable and prosperous regional NSW.

This draft strategy is being developed by the Department of Planning, Industry and Environment and provides an opportunity to re-shape what we are doing in regional water management and chart a path forward.

We have been working with local water utilities, councils, communities, Aboriginal people and other stakeholders to ensure local and traditional knowledge informs the draft Lachlan Regional Water Strategy and that it serves the regional community, including Aboriginal people, the environment and industry.

Your Voice is important

We have prepared this draft strategy to continue our discussions with you. We would like to hear your views on the draft strategy as a whole including the process we used to develop the strategy and the evidence that supports it. We are also seeking your feedback on the options presented in the draft strategy and whether you have any further information that could help us to assess the benefits and disadvantages of any of the options.

Please provide your feedback in the submission form below and email your completed submission to regionalwater.strategies@dpie.nsw.gov.au or post to Regional Water Strategies, Department of Planning, Industry and Environment, Locked Bag 5022, Parramatta NSW 2124 by **13 November, 2020.**

The questionnaire includes general questions about the regional water strategy including objectives, vision, modelling, opportunities and challenges. It also includes questions regarding the draft options along with personal information questions.

The questionnaire will take approximately 15 minutes to complete and your response can remain anonymous if you wish (see question 1).

Questions marked with an asterisk (*) require an answer.

If you have any questions about the questionnaire, please email:
regionalwater.strategies@dpie.nsw.gov.au

Making your submission public

We collect information about you, which may include personal information, to assess submissions in response to the department's dealings and activities, and perform other functions required to complete the project. This information must be supplied. If you choose not to provide the requested information we may not be able to assess your submission.

To promote transparency and open government, we intend to make all submissions publicly available on our website, or in reports. Your name or your organisation's name may appear in these reports with your feedback attributed.

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If you request your submission be kept confidential, it will not be published on our website or included in any relevant reports, however it will still be subject to the *Government Information Public Access Act 2009.*

Your submission will be stored securely consistent with the department's Records Management Policy and you have the right to request access to, and correction of, your personal information held by the department.

Further details can be found in our privacy statement available on our website.
https://www.industry.nsw.gov.au/privacy

Information from this form is collected for the purpose of receiving your feedback on the draft regional water strategy. The supply of this information is voluntary. Your details will be stored in NSW Department of Planning, Industry and Environment records. Information will be stored and managed in accordance with provisions under the Privacy and Personal Information Protection Act 1998. It will not be used for any other purpose and will not be given to any other third party except where required by law. To access or correct your personal information, contact us using the information at dpie.nsw.gov.au/contact

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1. Information on confidentiality and privacy *

I give my permission for my submission to be publicly available on the NSW Department of Planning, Industry and Environment website.

◉ Yes ○ No

I would like my personal details to be kept confidential.

◉ Yes ○ No

2. Your details

Email address *

[redacted]

Name *

[redacted]

Address *

[redacted]

Contact phone number *

[redacted]

Do you identify as an Aboriginal person?

- ○ Yes
- ● No

Are you an individual or representing an organisation?

- ● Individual
- ○ Organisation

3. Organisation or business details

Who do you represent?

- ○ **Government:**
  - ○ Commonwealth
  - ○ New South Wales
  - ○ State other
  - ○ Local
- ○ **Local Water Utility**
- ○ **Peak representative organisation:**
  - ○ Environment
  - ○ Industry
  - ○ Business group or business chamber
  - ○ Community organisation
- ○ **Other**

4. Draft regional water strategy objectives and vision

The draft Lachlan Regional Water Strategy is one of 13 strategies (12 regional water strategies and a Greater Sydney Water Strategy) being developed by the department. All regional water strategies are being developed in line with the following objectives.

- **Deliver and manage water for local communities**
  -Improve water security, water quality and flood management for regional towns and communities.
- **Enable economic prosperity**
  - Improve water access reliability for regional industries.
- **Recognise and protect Aboriginal water rights, interests and access to water**
  - Including Aboriginal heritage assets.
- **Protect and enhance the environment**
  - Improve the health and integrity of environmental systems and assets, including by improving water quality.
- **Affordability**
  - Identify least cost policy and infrastructure options.

All draft regional water strategy options need to address at least one of the above objectives. Our vision for this strategy is to have healthy and resilient water resources (that withstand extreme events and adapt to these changes) for a liveable and prosperous Lachlan region.

To achieve this, we need to position the region so there is the right amount of water of the right quality, delivered in the right way to meet the future needs of Aboriginal people, towns, communities, industries and the environment.

Do you support this vision for the Lachlan Regional Water Strategy?

○ Yes ◉ No

If no, please outline your vision for the long term management of water resources in this region?

The vision should follow section 60 of the Water Management Act 200 with it's priorities for water giving people first, then environment, then stock purposes, then high security licences. The Strategy seems to put the environment towards the end. The strategy should clarify what the word "Right" means in their vision. All living creatures not just people should be provided with a liveable environment. Lake Cargelligo Wetlands listed under Options 27 and 31 should be in the category "Protecting and enhancing natural ecosystem" and not

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- **Review of existing studies**
  - to identify drivers and risks for water resource management.
- **Community engagement:**
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A) Do you have any comments about the information used to develop this strategy?

It does not appear that the Cargelligo Wetlands & Lakes Council were consulted concerning Lake Cargelligo Wetlands and this water strategy. I think the wetlands at Lake Cargelligo should be recognised as a wetland in the strategy. Dr Adam Kerezsy (2020) has provided scientific evidence to indicate it is critical a environment for fish and aquatic life. Birdlife Australia recognises it as a place where threatened birds survive and the wetlands are included as international bird watching sites.

B) Please provide details if there is additional information you think we should consider?

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A) Do you have any comments about the modelling method used to develop this strategy?

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B) Is there any additional information that you believe could help us assess the benefits and disadvantages of draft options?

7. Opportunities and challenges for water management in the Lachlan region

During the Lachlan Regional Water Strategy drafting stage, the following opportunities, risks and challenges were identified.

- **Climate conditions place considerable stress on towns, communities, industries and ecosystems:**
  - Region has a naturally variable climate and modelling suggests periods between droughts could shorten.
  - Low inflows to Wyangala Dam.
  - Cowra and Forbes at a low risk of experiencing supply shortfalls.
  - Water security for towns and villages with single supply sources will be more challenging.
  - General security users could experience a decrease in average water availability.
  - Delivering water along the entire length of the Lachlan River will remain a challenge.
- **Review how we manage, use and deliver water to meet future challenges:**
  - Use new climate modelling to review water allocations and river operations.
  - Expansion in horticulture and mining developments is changing water use and demand patterns.
  - Growth is expected in the region's major centres.
  - Water reliability is critical to attract business and jobs.
- **Water is essential for Aboriginal people's health, wellbeing and connection to Country:**
  - Health of waterways impacts the wellbeing of the Traditional Owners and Custodians.
  - Provisions for accessing water for cultural purposes.
  - Improve Aboriginal people's involvement in water management.

- **Protecting critical environmental assets:**
  - Healthy water sources support the region's environment.
  - The Lachlan catchment has significant wetlands and environmental assets.
  - The fish community is in poor health and some species are under threat.
  - Coordinated action and planning across the region should support environmental outcomes.
- **Better management of groundwater:**
  - Groundwater sources are critical for towns industries and ecosystems.
  - Groundwater levels in areas of concentrated use are in decline.
  - Sustainable access to groundwater resources by all water users.
  - More knowledge is needed about groundwater recharge rates.

A) Do you have any comments on the opportunities, risks and challenges identified?

Inter-regional transfer of water will make less water available to the Lachlan catchment. Over time if water is transferred outside our catchment it may become the norm outside critical periods disadvantaging the Lachlan. this strategy talks about the future 20-40 years time. Don't sacrifice the Lachlan River and it's catchment for the sake of a government plan to substantially increase the population of Orange which lies in another catchment.

B) Are there any additional opportunities, risks and challenges that we should consider and what options could address these?

The risk to the Lake Cargelligo wetlands and Robinson Crusoe Island is extreme if dams/cells and pipelines are constructed degrading the environment reducing biodiversity, social cultural, economic and agricultural values. Agriculture, horticultural and mining industries could be regulated to rely on water re-use (waste sewerage, drainage water and storm water) recycling and waste management. People (domestic and town water supply) first, environment, stock purposes and then high security licences, should continue. Lake Cargelligo wetlands

8. Draft Lachlan Regional Water Strategy options

We have developed a long list of options that could be included in the final Lachlan Regional Water Strategy. The options consider the opportunities and challenges facing the region and meet at least one regional water strategy objective.

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- Protecting and enhancing natural ecosystems.
- Supporting water use efficiency and conservation.
- Strengthening community preparedness for climate extremes.
- Improving recognition of Aboriginal people's water rights, interests and access to water.

Only feasible options will be progressed to the final strategy stage – following a rigorous assessment process. We are seeking your feedback to inform the options assessment process.

Draft options for the Lachlan Regional Water Strategy are outlined below.

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40. Land use change impact on water resources

Improving recognition of Aboriginal people's water rights, interests and access to water

41. Culturally appropriate water knowledge program	45. Water portfolio project for Aboriginal communities
42. Water-dependent cultural practices and site identification project	46. Co-management investigation of Travelling Stock Reserves
43. Shared benefit project (environment and cultural outcomes)	47. Regional Aboriginal Water Advisory Committee
44. Aboriginal cultural water access licence review	48. Regional Cultural Water Officer employment program

A) Which five (5) options do you think are *most* important?

Please list the option numbers in order of importance with the first option being most important

Option Number 40
Option Number 9
Option Number 36
Option Number 43
Option Number 7

B) Please comment on why you think these options are most important?

Water to some extent dictated the types of land use when water licences were attached to the land. Since water was taken away from the land large scale pursuits (such as force feeding of almonds, etc) have occurred.
Reuse recycle and stormwater projects could help towns and industry with water requirements
Improved data and collection and storage can only assist as long as it is monitored and scientifically done.
shared benefit project (environmental and cultural outcomes) can only be good

C) Which five (5) options do you think are *least* important (if any)?

Please list the option numbers in order of least importance with the first option being least important

Option Number 27
Option Number 31
Option Number 6
Option Number 25
Option Number 39

D) Please comment on why you think these options are least important?

dividing a natural lake into 3 dams is contrary to the aims of the water Management Act 2000 in that it causes degradation of a natural resource and environment

Pipelines instead of natural waterways reduce riparian values and the environment and all living creatures.
Transfer of water to another catchment increases the risk of water supply failing in the Lachlan catchment and i

E) Do you have any comments on the draft options?

Consultation has been extremely poor to the Lake Cargelligo community. The strategy when I read it contained no details of the specific options so it is difficult to make informed decisions. For instance if it contained 3 cells could people walk along them, get to robinson Cruseo Island (which contains significant evidence of Aboriginal people in the past, shell middens, tools and also contains cultural history from early European settlement, the remains of a divis hall (where hostloads of people were ferried across the lake from

9. Option combinations

The option list provided in the draft strategy also identifies potential combinations of options. These combinations recognise that most options require associated works, further assessments and/or legislative, policy and planning changes to ensure they address the risks and challenges identified in the Lachlan region and do not have unintended impacts.

A) Do you have any thoughts on how the options could be combined with other options?

B) Are there additional options that we should consider?

Lake Cargelligo Wetlands should be included in option 12, 14 and 18 and Options 27, 31 and 6 should be deleted from the strategy.

10. Other comments

Do you have any other comments about the Lachlan Regional Water Strategy?

no

11. How did you hear about the public exhibition of this strategy?

We are interested to know how you heard about the opportunity to make a submission. Please indicate the communication methods below:

- ◯ Newspaper
- ◯ Radio
- ◯ Department of Planning, Industry and Environment website
- ◯ Direct email
- ◯ Social media
- ◯ Have your say NSW Government website
- ◯ Communication from peak body
- ✓ Other

a friend told me

12. Additional Information and submission process

If you would like to provide any supporting documents to help us understand your view, please either, email these from the same email you provided in this form, or attach supporting documents to this form if you are returning your submission by mail.

All submissions on the draft Lachlan Regional Water Strategy will be reviewed following the public exhibition period. Further targeted engagement will be undertaken along with the final phase of stakeholder engagement later in the year to review the final documents.

Please email your completed submission and supporting documents to regionalwater.strategies@dpie.nsw.gov.au

or post to Regional Water Strategies, Department of Planning, Industry and Environment, Locked Bag 5022, Parramatta NSW 2124 by 13 November, 2020.

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Thank you for your submission.

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Name *

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Address *

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Contact phone number *

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Option Number 7

B) Please comment on why you think these options are most important?

Water to some extent dictated the types of land use when water licences were attached to the land. Since water was taken away from the land large scale pursuits (such as force feeding of almonds, etc) have occurred.
Reuse recycle and stormwater projects could help towns and industry with water requirements
Improved data and collection and storage can only assist as long as it is monitored and scientifically done.
shared benefit project (environmental and cultural outcomes) can only be good

C) Which five (5) options do you think are *least* important (if any)?

Please list the option numbers in order of least importance with the first option being least important

Option Number 27
Option Number 31
Option Number 6
Option Number 25
Option Number 39

D) Please comment on why you think these options are least important?

dividing a natural lake into 3 dams is contrary to the aims of the water Management Act 2000 in that it causes degradation of a natural resource and environment

Pipelines instead of natural waterways reduce riparian values and the environment and all living creatures.
Transfer of water to another catchment increases the risk of water supply failing in the Lachlan catchment and

E) Do you have any comments on the draft options?

Consultation has been extremely poor to the Lake Cargelligo community. The strategy when I read it contained no details of the specific options so it is difficult to make informed decisions. For instance if it contained 3 cells could people walk along them, get to robinson Cruseo Island (which contains significant evidence of Aboriginal people in the past, shell middens, tools and also contains cultural history from early European settlement, the remains of a divis hall (where hostloads of people were ferried across the lake from

9. Option combinations

The option list provided in the draft strategy also identifies potential combinations of options. These combinations recognise that most options require associated works, further assessments and/or legislative, policy and planning changes to ensure they address the risks and challenges identified in the Lachlan region and do not have unintended impacts.

A) Do you have any thoughts on how the options could be combined with other options?

B) Are there additional options that we should consider?

Lake Cargelligo Wetlands should be included in option 12, 14 and 18 and Options 27, 31 and 6 should be deleted from the strategy.

10. Other comments

Do you have any other comments about the Lachlan Regional Water Strategy?

no

11. How did you hear about the public exhibition of this strategy?

We are interested to know how you heard about the opportunity to make a submission. Please indicate the communication methods below:

- [ ] Newspaper
- [ ] Radio
- [ ] Department of Planning, Industry and Environment website
- [ ] Direct email
- [ ] Social media
- [ ] Have your say NSW Government website
- [ ] Communication from peak body
- [ ] Other

a friend told me

12. Additional Information and submission process

If you would like to provide any supporting documents to help us understand your view, please either, email these from the same email you provided in this form, or attach supporting documents to this form if you are returning your submission by mail.

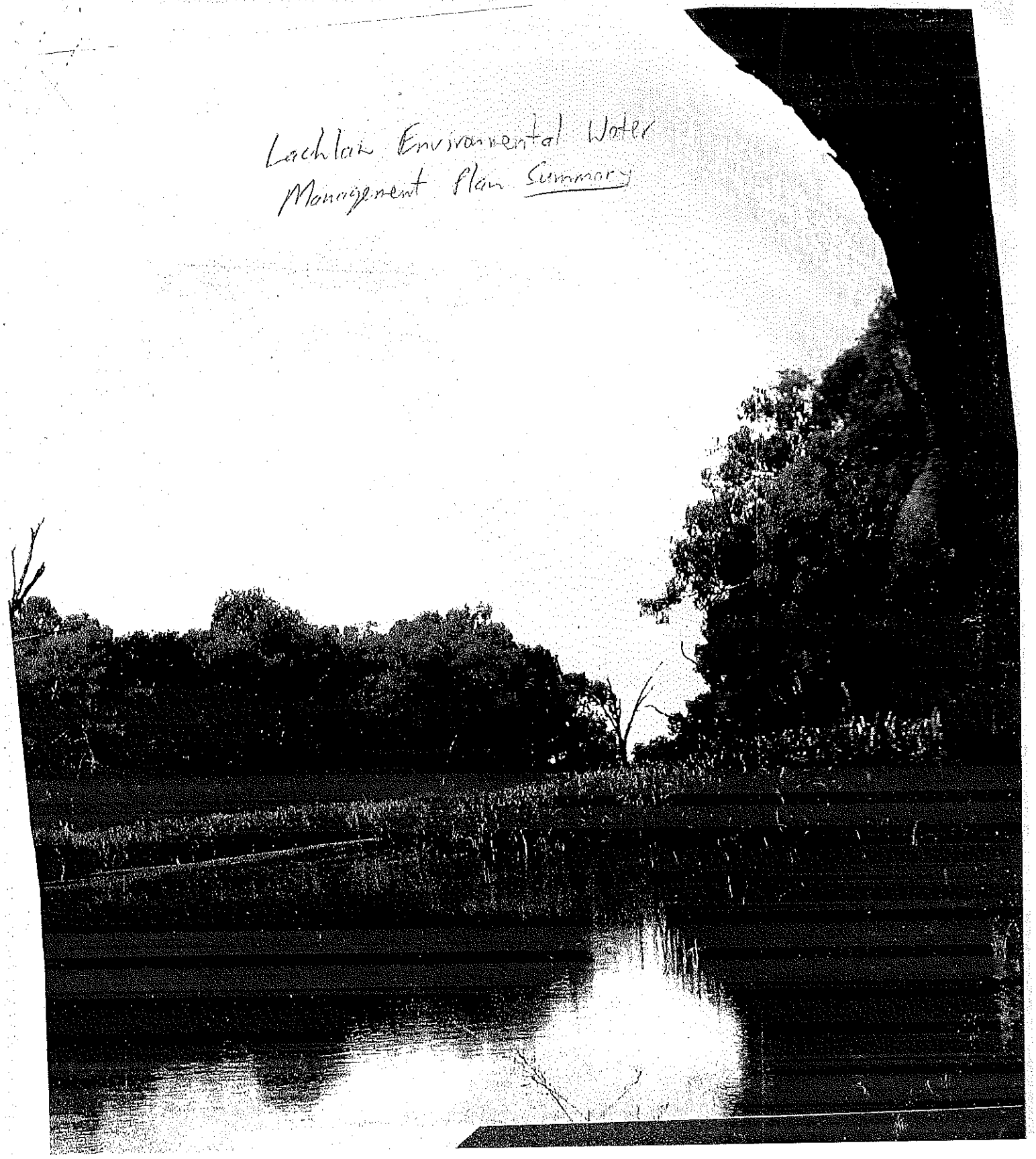
All submissions on the draft Lachlan Regional Water Strategy will be reviewed following the public exhibition period. Further targeted engagement will be undertaken along with the final phase of stakeholder engagement later in the year to review the final documents.

Please email your completed submission and supporting documents to regionalwater.strategies@dpie.nsw.gov.au

or post to Regional Water Strategies, Department of Planning, Industry and Environment, Locked Bag 5022, Parramatta NSW 2124 by 13 November, 2020.

Further details on all regional water strategies can be found on our website https://www.dpie.nsw.gov.au/regional-water-strategies

Thank you for your submission.



LC – noted as regionally significant.

Overview

This document outlines the Lachlan Environmental Water Management Plan by providing:

- The purpose of environmental water ;
- Nationally and regionally important wetlands of the Lachlan River and their watering needs;
- How wetlands are selected for environmental watering;
- The role of the Lachlan Riverine Working Group in delivering this plan;
- What types of environmental water currently exist in the Lachlan; and,
- How the success of the Plan will be measured.

The purpose of environmental water

Environmental water is used to achieve a number of purposes including:

- Protecting creeks, rivers and wetlands during dry periods;
- Restoring more natural flow patterns and distribution for rivers and wetlands;
- Reducing the impact of in-stream barriers, particularly for fish;
- Improving the health of ecosystems associated with rivers, floodplains and wetlands;
- Improving water quality; and,
- Providing better habitats for native flora and fauna that rely on rivers and wetlands.

Environmental watering also increases the capacity of river systems to withstand or recover from impacts such as drought by:

- Improving the connection between wetlands, floodplains and rivers;
- Restoring plant and animal communities and the way different species interact;
- Enabling plants and animals to breed an replenish local populations;
- Improving carbon and nutrient cycling in riverine systems;
- Recharging groundwater systems;
- Supporting habitat diversity; and,
- Protecting drought refuges.

Important Wetlands of the Lachlan

One of the objectives of the Lachlan Environmental Water Management Plan (LEWMP) is to set priorities for environmental watering. To do this a number of wetlands have been selected as priority areas for environmental water. These wetlands include those recognised at national and regional levels as containing important ecological, cultural or social values. The wetlands selected as priorities for the delivery of environmental water include eight wetlands that have been recognised in the Directory of Important Wetlands in Australia as crucial waterbird habitats or good examples of wetland types associated with lowland rivers.

These wetlands are:

The Great Cumbung Swamp, Lake Cowal and Wilbertroy Wetlands, Lake Brewster (Ballyrogan), Booligal Wetlands, Lake Merrimajeel/Murrumbidgil Swamp, Cuba Dam, Merrowie Creek - Cuba Dam to Chillichil Swamp, Lachlan Swamp

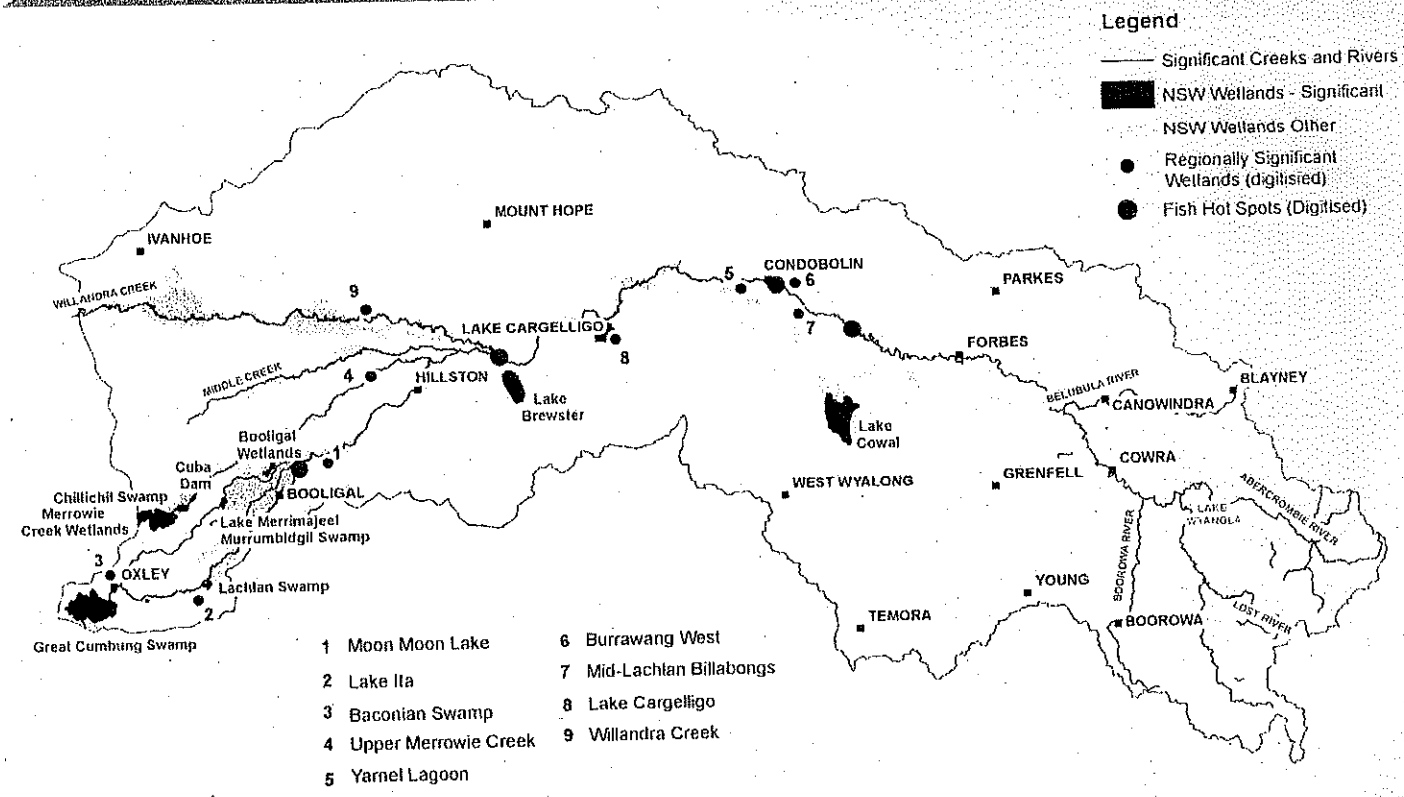
Nine regionally significant wetlands in the Lachlan have also been included as representative areas contributing to the Lachlan landscape.

These regionally significant wetlands are:

Lake Cargelligo, Lake Ita, Burrawang West Lagoon, Willandra Creek, Moon Moon Swamp, Yarnel Lagoon, Baconian Swamp, Upper Merrowie Creek, Mid Lachlan Floodplains and Billabongs

In-stream habitat is also considered important as drought refuge and fish habitat. These fish "hotspots" indicated below.

Wetlands and Fish Hot Spots



Why are these wetlands significant?

The riverine assets and values of the Lachlan Catchment are defined for the purposes of this Plan as the ecological components, processes and sites of significance known to contribute to the essential character of the Lachlan Catchment. They have been identified from a number of sources and studies focused on the ecological, cultural and social systems of the Lachlan.

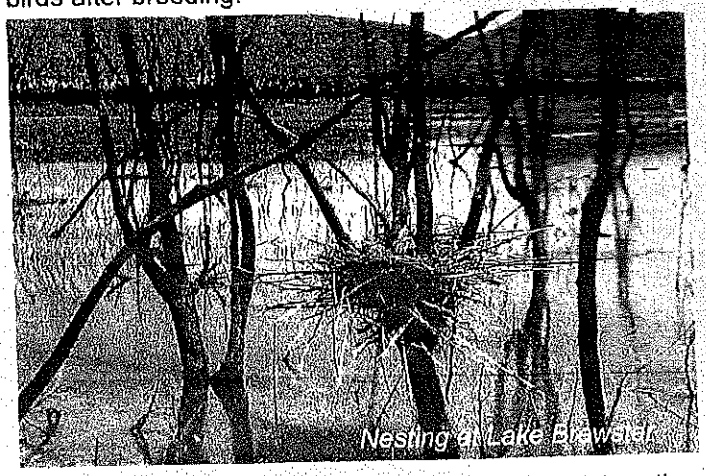
The riverine ecological assets identified for the Lachlan Catchment include:

- Riparian zones
- Waterbirds and waterbird habitat
- Native fish and native fish habitat
- Frogs and frog habitat
- Woodland birds
- Semi-permanent wetland vegetation
  - River red gum forest and woodland
  - Common reed grassland
  - Water couch grassland
  - Lignum shrubland
  - Black box woodlands
  - River cooba, coolibah woodlands, myall woodlands
  - Gilgai depressions
  - Mudflats
  - Chain of ponds – swampy meadows
- The endangered aquatic ecological community

The values and benefits of the features which have the greatest influence on determining water requirements are described below.

Riparian areas include the bed and banks of rivers and tributaries, as well as wetlands. Riparian areas play an important role in ecological functions such as filtering sediments and pollutants, slowing run-off and providing wildlife habitat. They are the last line of defence for aquatic ecosystems from terrestrial inputs. Some of the functions that healthy riparian zones provide include supporting a diversity of aquatic habitats through root structures or snags; stabilising banks; filtering sediment and nutrients; providing food for terrestrial and aquatic animals; and historical, cultural and spiritual significance. In the mid-Lachlan, riparian vegetation is dominated by yellow box, river red gums and river oak, while the lower Lachlan is dominated by river red gums. Riparian vegetation relies on frequent, watering to remain healthy.

Waterbirds are a valued component of the Lachlan Catchment, making up a large proportion of the native faunal biomass in lower Catchment. Large-scale waterbird breeding events (>40 000 nests) in the lower Lachlan indicate that the whole ecological system is functioning. Waterbirds tend to have preferred locations and vegetation for shelter and nest sites. Most waterbird breeding sites are located in semi-permanent wetland vegetation, requiring regular and prolonged flooding. There is a broad knowledge with regard to the flow size, timing and duration required for different sized breeding events, food requirements and what happens to both adult and young birds after breeding.


Nesting at Lake Brewster

Of the waterbirds that breed in the Lachlan, colonial nesting species are prominent, and have been the most studied. Some species that have been recorded breeding in the Lachlan are included under International Agreements, including the great egret, intermediate egret, little egret, Nankeen night heron, Pacific heron, glossy ibis, black swan, Australian pelican, Australian white ibis, straw-necked ibis, little pied cormorant and little black cormorant.

Native fish habitats have been impacted by river regulation by reducing the flow conditions upon which many native fish depend. The changed flow patterns and degraded riparian zones have increased bank erosion and sedimentation within channels, filling pools and smothering habitats, including macrophytes, woody debris and gravel substrates. Constant mid to low flows reduce ecosystem productivity by removing the boom (wet) and bust (dry) cues that trigger and sustain aquatic cycles. Other threats include increased pollutants, competition with introduced species and structures in the river restricting movement. Some structures threaten fish directly, as research suggests that larval and juvenile fish are extracted from the river by pumping. Weirs with an undershot design are also known to cause high mortality in larval and juvenile fish.

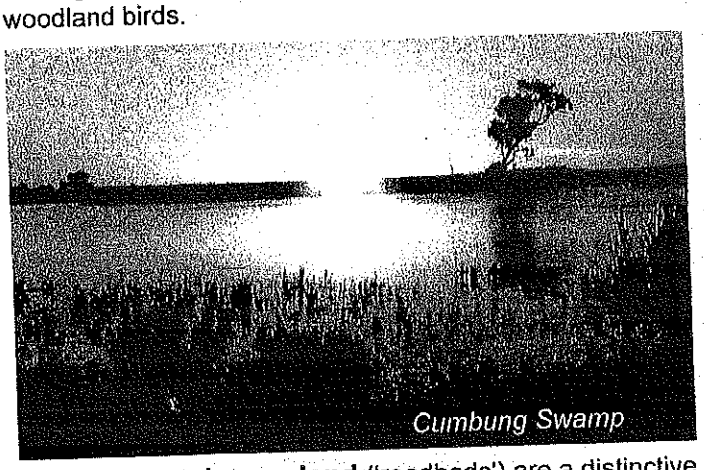
As fish cannot disperse to other catchments, like waterbirds, or become dormant, like plants or frogs, as habitats dry out, they are dependant on permanent water remaining in river and creek channels to a much greater extent than other species. A number of important fish habitats have been identified in the Lachlan including the Lachlan River around Warroo Bridge, the Lachlan River and Goobang Creek near Condobolin, the Lachlan River and Mountain Creek near Brewster Weir and the Lachlan River between Gonowlia and Booligal Weirs.

Semi-permanent wetland vegetation provide essential habitats for invertebrates, plants, fish and birds. Wetlands also increase the productivity of associated aquatic and terrestrial ecosystems, provided connectivity with these systems is maintained. The benefits of healthy wetlands include:

- Flood mitigation by spreading flood peaks, storing floodwaters and releasing them gradually;
- Drought refuge for wildlife and grazing for stock;
- Groundwater replenishment;
- Improving water quality by absorbing, recycling and releasing nutrients and trapping sediment;
- Providing breeding sites for native fish, birds, plants and invertebrates;
- Recreation and tourism; and,
- Enhanced scenic and aesthetic values.

Semi-permanent wetland vegetation types in the mid to lower Lachlan require regular, frequent and prolonged flooding. Some have specific legislative protection, and some plants, such as river red gum, river cooba, cumbungi and nardoo have iconic Aboriginal cultural values. Wetland types which exist throughout the Lachlan are listed below.

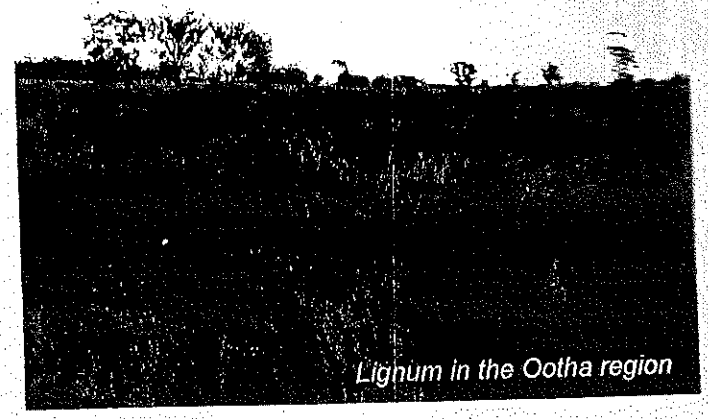
River red gum forest and woodland is widespread in Australia and occurs most commonly in narrow bands fringing watercourses. In the Lachlan it forms extensive floodplain forests and woodlands and is a distinctive and important part of their character. The community is listed as vulnerable with approximately 50% of its pre-European extent remaining in western NSW. It provides waterbird nesting sites and habitat for many animals including woodland birds.



Cumbung Swamp

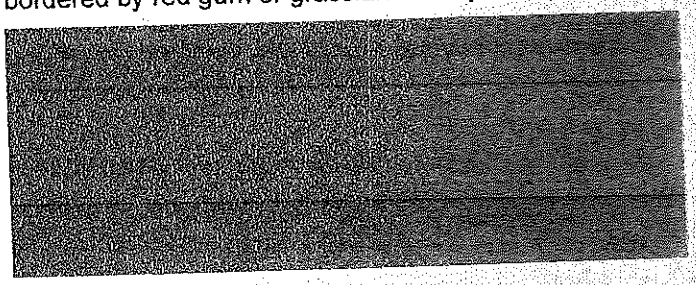
Common reed grassland ('reedbeds') are a distinctive part of the character of the Great Cumbung Swamp, as it provides habitats for fish, birds and invertebrates and is also a major drought refuge. Common reed tolerates a range of flood frequencies from permanent inundation to infrequent flooding. If large stands are lost they can be difficult to restore and this may be a critical factor for the Cumbung . Common reed is habitat for many waterbirds, providing nest platforms for large breeding colonies of Ibis.

Lignum shrubland occurs throughout the mid to lower Lachlan as either an understorey plant or the dominant plant species. Lignum provides valuable waterbird breeding habitat especially for ibis and is listed as a vulnerable community in NSW. Surface soil drying between flood cycles is important to maintain healthy lignum.

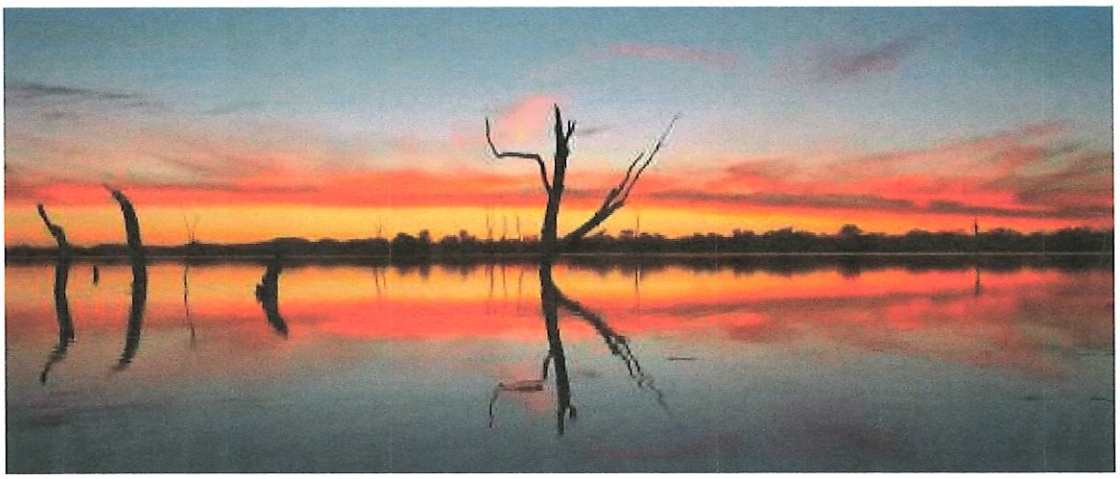


Lignum in the Ootha region

Black box woodlands are considered to be a vulnerable plant community in NSW. There has been decline in its distribution due mostly to clearing for agriculture. Black box woodland is found on flat to slightly undulating landscapes on alluvial soils in within rainfall ranges of between 250 to 450mm a year. In most areas black box woodland is bordered by red gum or grassland ecosystems.



The Lower Lachlan Endangered Aquatic Ecological Community - The entire aquatic ecological community of the lower Lachlan is listed as an endangered ecological community in NSW under the provisions of the NSW Fisheries Management Act 1994. Historically, this area has supported a diverse aquatic community comprising at least 19 native fish species, 10 crustacean species, 8 mollusc species, 2 sponge species and many insects. River regulation, land management practices (e.g. riparian clearing) and species introductions, however, have resulted in substantial modifications to aquatic habitats in the lower Lachlan and the abundance and distribution of many aquatic species have exhibited considerable reductions. In particular, 4 native fish species and 1 snail are listed in the schedules of the NSW Threatened Species Conservation Act 1995 as either endangered, vulnerable or with endangered populations in the western region.



Fish community sampling in the Robinson Crusoe Island area of Lake Cargelligo, April and September 2019

A report for Cargelligo Wetlands and Lakes Council

Adam Kerezsy, Dr Fish Contracting, October 2019

Contents

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Preamble

The following report relates to sampling of aquatic biota in the central section of Lake Cargelligo in the Lachlan catchment, Murray-Darling Basin, Australia, during 2019. As such, this work follows on from previous work in Lake Cargelligo which is well-documented in Kerezsy and Lenehan 2018 (included as an appendix) and an Honours thesis relating to similar subject matter (Kerezsy 2005). The results from these studies have not been replicated in this report.

The catalyst for this research was the granting of a conservation lease on Robinson Crusoe Island to the local group Cargelligo Wetlands and Lakes Council in 2017. The Council aims to manage the Robinson Crusoe Island area for the conservation of local and regional native fauna and flora, however several knowledge gaps exist with regard to baseline data from which to develop management plans.

The research detailed here aims to improve this basic data, particularly for fish and other aquatic biota that may rely on Lake Cargelligo for their survival.

Executive Summary

- Fish were sampled in the central section of Lake Cargelligo, close to Robinson Crusoe Island, in April and September 2019.
- 903 individual fish were sampled.
- Eight fish species were detected: native fish included bony bream, Australian smelt, Murray cod, flathead gudgeons and carp gudgeons, and alien fish included carp, gambusia (or mosquitofish) and redfin.
- Native species were most common in the samples, and alien species were sampled in comparatively small numbers.
- Monitoring the fish population in the area around Robinson Crusoe Island through time is likely to yield a strong dataset from which to develop management plans relating to optimising habitat for native species.

Introduction

For a general introduction to the Lake Cargelligo system please consult Kerezsy and Lenehan 2018 (Appendix) or Kerezsy 2005.

The water that surrounds Robinson Crusoe Island is supplied as part of the general operations of WaterNSW. In general, water is held in Lake Cargelligo in order to supply the lower Lachlan River. This means that no water is specifically supplied to Lake Cargelligo in order to maintain ecological communities, but rather that this is a by-product of large-scale commercial storage of water should it occur.

Due to its size and location Lake Cargelligo is a popular area for water sports and bird-watching, and it also sustains a community of approximately 1300 people. A small number of these people formed the Cargelligo Wetlands and Lakes Council in order to preserve and enhance the amenity of Lake Cargelligo for these purposes, but with a primary aim of conserving the naturally-occurring landscape and biota. The acquisition of Robinson Crusoe Island is therefore a significant achievement and step towards these goals.

The 'island' itself is comprised of two separate areas of land that are sometimes isolated from land to the north (see map in Kerezsy and Lenehan 2018). The southern island is separated whenever the level of Lake Cargelligo exceeds 50%, while the northern island is separated when the level of the Lake exceeds 85%. This creates a mosaic of habitats that often become wet and dry down several times within a calendar year.

Similarly, for aquatic biota, the area that borders Robinson Crusoe Island is nutrient and food rich due to the shallow water, diversity of habitat and wetting and drying cycles.

The purpose of the sampling described in this report was to sample the fish communities around Robinson Crusoe Island in order to establish baseline data relating to species that are present.

Methods

Study area and sampling sites

Sampling was conducted in April and September 2019, at three sites within 100 metres of the eastern shoreline of Robinson Crusoe Island.

Fish sampling

Fish populations were sampled using a combination of large and small fyke nets. These methods successfully capture fish of all body sizes and life stages in Australian inland waterways (Arthington et al. 2005; Balcombe et al. 2007). Large double-winged fyke nets with a 13 millimetre stretched mesh and eight metre wings (one metre deep) were set with their openings facing in opposite directions from a central post. Cod-ends were secured above the water surface in order to allow air-breathing vertebrates to survive if they became entrapped. Small double-winged fyke nets with a stretched mesh of two millimetres and a wing width of three metres (one metre deep) were set in an identical manner. All fyke nets were set overnight. Following the clearing of fyke nets, all fish were held in shaded water-filled buckets prior to processing.

Fish species were identified using a combination of published literature relating to fishes of the Murray-Darling Basin (Allen *et al.* 2002; Lintermans 2007). All sampled fish were measured from the tip of the snout to the caudal peduncle to obtain a standard length (SL) measurement in millimetres. Following identification and measurement for standard length (millimetres), all native fish were returned to the water alive and alien species were euthanased using standard methods (ie: Aqui-S at standard dilution).

Water quality

Water quality parameters such as temperature, dissolved oxygen, pH, conductivity and turbidity were taken at all sites using a Eutech PCD 650 multi-meter, and flow and depth were also measured or estimated using manual methods.

Results

A total of 903 individual fish were sampled, with the vast majority sampled in April.

The most commonly sampled native species was bony bream, *Nematolosa erebi* (524 individuals), followed by carp gudgeons, *Hypseleotris* spp. (202), and Australian smelt, *Retropinna semoni* (110).

Native species sampled in smaller numbers included two flathead gudgeon, *Philypnodon grandiceps*, and two Murray cod, *Macchullochella peelii peelii* (Figure 1).

Three alien species were sampled. These comprised 60 gambusia (or mosquitofish), *Gambusia holbrooki*, two carp, *Cyprinus carpio*, and one redfin, *Perca fluviatilis*.

Sampled bony bream ranged in size from 30mm to 370mm, with the vast majority between 50 and 70mm (Figure 2).

Carp gudgeons were similarly sampled in sizes ranging from juvenile to adult (9 – 40mm).

All of the Australian smelt sampled were adult fish between 60 and 70mm.

Both of the flathead gudgeon were 40mm long.

The Murray cod were 700 and 800mm.

Gambusia were sampled between 20 and 35mm.

The carp were 650 and 520mm, and the redfin was 105mm.

Bycatch in the waters surrounding Robinson Crusoe Island included the short-necked turtle, *Emydura macquarii*, the long-necked turtle, *Chelodina longicollis*, freshwater prawns, *Macrobrachium australiense* and shrimp (Atyidae).

Figure 1. A mature 700mm Murray cod sampled in Lake Cargelligo in September 2019. Photo Robin Carter.

Figure 2. A large sample of bony bream sampled in Lake Cargelligo in April 2019. Photo Adam Kerezsy

Discussion and recommendations

The surveys described provide further evidence of the positive attributes of Lake Cargelligo as a habitat for native freshwater fish (Kerezsy and Lenehan 2018) and are particularly encouraging regarding the role the waters surrounding Robinson Crusoe Island may play in sustaining the ecosystem.

Both bony bream and Australian smelt are schooling species that utilise all areas of the water column. It is likely that the presence of large numbers of fish-eating birds such as cormorants and pelicans at Lake Cargelligo is directly linked to such a reliable food source. The presence of large numbers of juvenile bony bream suggests that the area around Robinson Crusoe Island may provide a suitable nursery area for this species, particularly as bony bream feed on algae and detritus, and the shallow and fluctuating Lake level likely produces algae – especially – in abundance.

The presence of a robust population of both juvenile and adult carp gudgeon is also a positive result, as this species may play an important role as food for larger carnivores such as flathead gudgeon and Murray cod.

The fact that two large adult Murray cod were sampled is interesting because this species is more-generally associated with deep river sections in areas where there is cover (as opposed to large, shallow, open lakes). Both specimens appeared to be female and looked to be holding eggs – an expected result given the time of year, but encouraging nonetheless.

The low numbers of alien species sampled during the surveys is notable, particularly the fact that only two adult carp were sampled. A commercial carp fishing operation has been operating in Lake Cargelligo for close to 12 months, and it is possible that constant fishing pressure and removal of carp may be having some effect on their numbers and the overall health of the ecosystem (Keith Bell, K&C Fisheries, pers. com.). Research directed towards determining the effect of sustained carp removal within Lake Cargelligo would/could be beneficial in order to inform management of the system.

Ultimately, these surveys and those undertaken previously (Kerezsy and Lenehan 2018; Kerezsy 2005) all demonstrate that the Lake Cargelligo system continues to provide habitat for most – if not all – fish species that occur in the mid-Lachlan, and also that it provides nursery habitat for at least some. The flow-on effects are reasonably obvious, particularly the proliferation of fish-eating bird species that occur within the general area.

Continuing to monitor the fish populations within Lake Cargelligo – and especially around Robinson Crusoe Island - is therefore recommended in order to determine patterns of seasonal presence/absence and possibly abundance. As mentioned, incorporating carp removal data may be a useful addition to such work, especially if it is to continue within the system.

Last, given that Lake Cargelligo is dependent on storage water, the results of these surveys indicate that there is a strong argument to possibly augment these filling events with environmental water should any be available.

Acknowledgements

Thanks to Cargelligo Wetlands and Lakes Council for initiating and funded this research, and thanks to Joanne Lenehan from DPIE who has been the primary driver of the Lachlan work, and an enthusiastic advocate of all initiatives with the aim of securing the ecological integrity of the catchment for future generations. All described sampling work was carried out under DPI Scientific Collection Permit P17/0063-1.0 and OEH Animal Research Authority AEC Approval Number 171017/01.

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Appendix

Fish presence/movement during three flow periods in 2017/2018 within Lake Cargelligo, an off-river storage in the Lachlan catchment, Murray-Darling Basin, Australia

Adam Kerezsy, Dr Fish Contracting, and Jo Lenehan,

Office of Environment and Heritage

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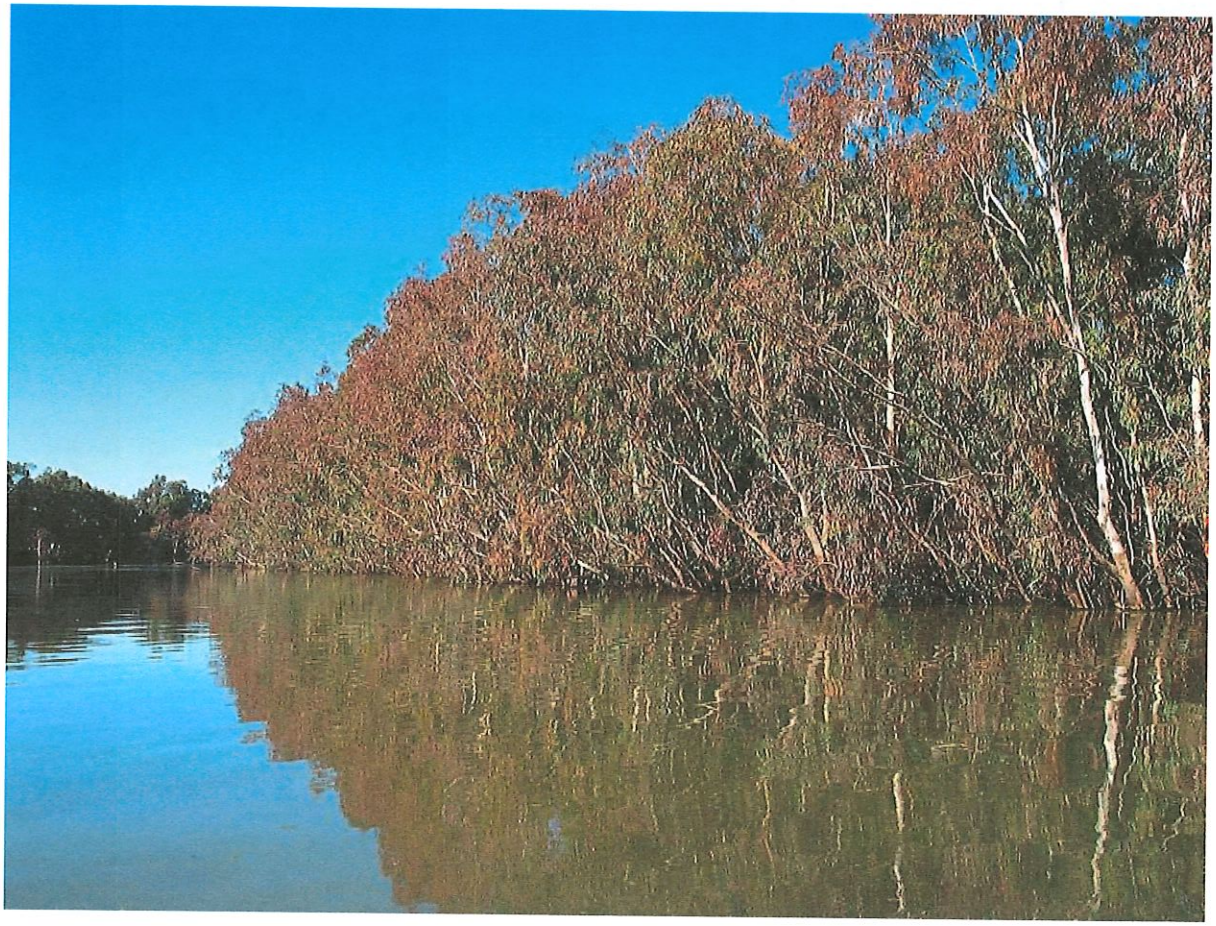
All photographs in this report by Adam Kerezsy

Contents



Executive summary

- Fish were sampled in Lake Cargelligo, a regulated off-river storage in the Lachlan catchment, during flows in December 2017, March/April 2018 and May 2018.
- 10 274 individual fish were sampled during the three sampling periods.
- Ten fish species were detected: native fish included bony bream, carp gudgeons, flathead gudgeon, yellowbelly, un-specked hardyhead and Australian smelt, and alien fish included goldfish, carp, gambusia and redfin.
- Native fish greatly outnumbered alien fish and comprised 94.3% of the total.
- The most commonly sampled fish species were bony bream and carp gudgeon, and the vast majority of all sampled fish (86.2%) were moving downstream (ie: with the flow).
- Sampling of others flows in different seasons may yield different results and is recommended.
- Given the majority of sampled fish were juveniles, sampling a range of habitats within the Lake Cargelligo system may yield more detailed information regarding its value as a fish nursery.

Introduction

There is a growing recognition of the importance of ephemeral river reaches, tributaries and floodplains with regard to supporting food webs in riverine environments (Datry *et al.* 2017). Globally, such areas are recognised as fish nurseries due to their habitat complexity and concomitant food resources, particularly as these characteristics do not generally occur in adjacent main stem rivers (Kerezsy *et al.* 2017).

In south-eastern Australia, the regulated Murray-Darling Basin is an area where native fish decline has been highlighted for over two decades (Harris and Gehrke 1997), with the primary drivers considered to be regulation infrastructure (such as dams and weirs), alteration of natural flow regimes and the impact of invasive species (Kerezsy 2011).

The Lake Cargelligo system is a 5000 hectare off-river storage located in the mid-Lachlan catchment in New South Wales (Figure 2). The Lake Cargelligo system comprises three lakes, interconnecting channels and riverine areas (Figures 1 and 2). The system was regulated from 1902 when channels were excavated to link the lacustrine areas, and inlet and outlet regulator gates were installed in order to allow water to be harvested from and delivered to the main stem of the Lachlan River (Figure 2).

Water enters the Lake Cargelligo system when the inlet regulator on the Lachlan River is lifted (Figure 2). The water passes through the inlet canal (0.8km) before entering the first small lake (Sheet of Water), and then flows through the first canal (Canal 1; 3.9km) before entering Lake Curlew (Figure 2). Water enters the main lake, which is approximately 7km long and 5km wide, after moving through the second canal (Canal 2; 1.2km; Figure 2).

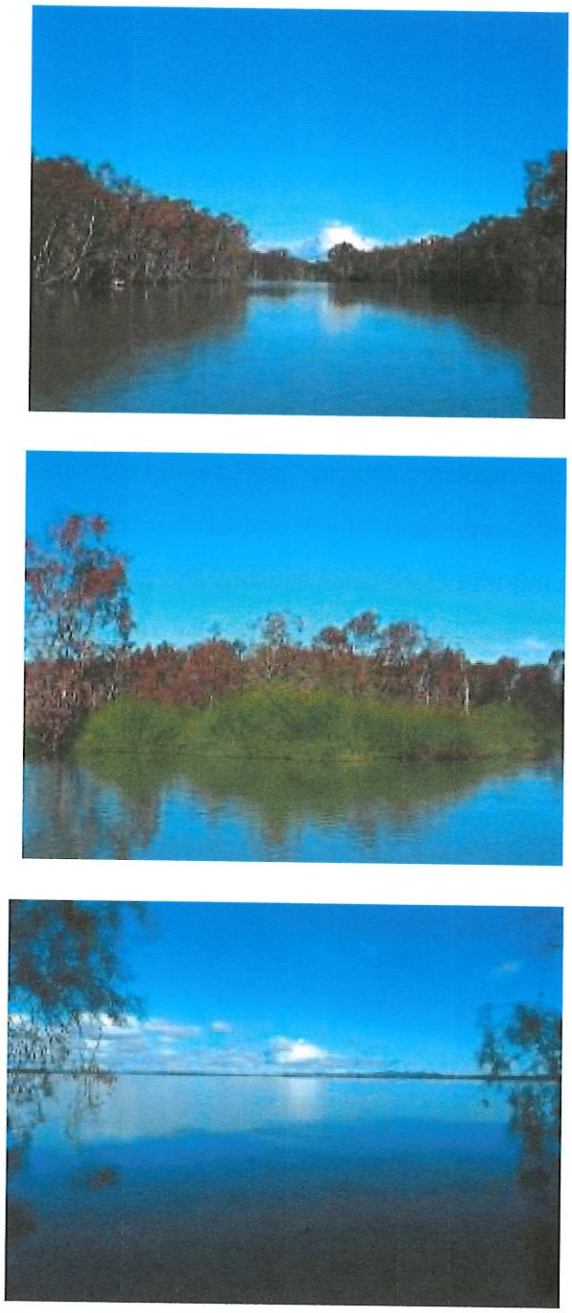


Figure 1: Habitat within the Lake Cargelligo system is varied and includes riverine channels (top), shallow areas dominated by lignum (middle) and large expanses of open water (bottom).

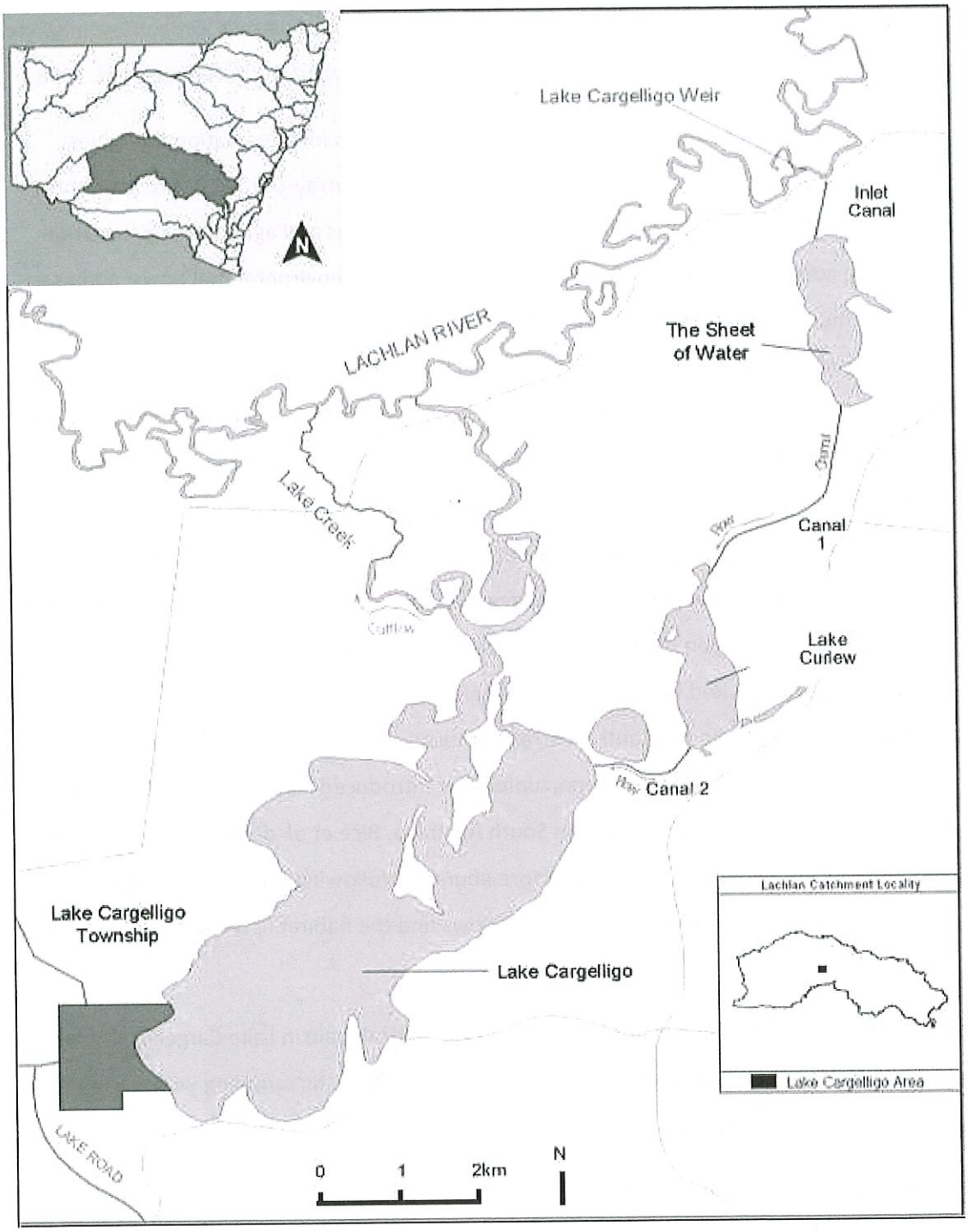


Figure 2. The Lake Cargelligo system.

Worldwide interest in and research into the ecological role of flows and flooding has increased since the original Flood Pulse Concept was published by Junk *et al*. in 1989, with much of this work directly related to managing ecosystems sustainably in the face of increasing anthropogenic water demands. Australian research has pioneered new interpretations of the role of flow (Humphries *et a*l. 1999;

Kerezsy *et al.* 2011; Cockayne *et al.* 2015), predominantly because Australia – the driest inhabited continent – possesses the most erratic and unpredictable river systems (Puckridge *et al.* 1998).

The so-called 'Millenium Drought' exacerbated and brought into high resolution the issues confronting Australian river management, particularly in the Murray-Darling Basin. Attempts to maintain riverine integrity while simultaneously sustaining towns and agricultural production resulted in the concepts of environmental water allocation and environmental flows, and as a consequence much research has been directed towards gauging the effectiveness of these flows. In the Macquarie Marshes, Rayner *et al.* found that following small environmental flows recruitment of native species occurred but was overshadowed somewhat by an increase in the predominance of alien species (2009). In a manipulated trial involving pumping out wetlands in the Murray, Jones and Stuart found that regulated flows into wetlands could result in mass strandings following subsequent isolation and drying (2008). In general, studies of the movement of fish between riverine and off-channel areas has delivered varying results, suggesting that individual catchments and wetlands may behave in different ways. Lyon *et al.*, working in the upper Murray, found that water level rises associated with flows resulted in fish exiting the main channel and moving to flooded areas (2010), but Conallin *et al.*, working in the South Australian Murray, found that delivering environmental water resulted in increased spawning opportunities for introduced carp (*Cyprinus carpio*) in inundated floodplain habitat (2012). Also in South Australia, Bice *et al.* demonstrated that although large-bodied species were likely to become more abundant following flooding, the same was not true for smaller species that benefitted from low flows and the habitat associations they afforded (2014).

The current study aims to investigate the role of flow at a local scale in Lake Cargelligo by sampling fish opportunistically when flows occur. Data from this opportunistic sampling will be used to answer the following questions:

1. Which fish species and size classes move upstream (ie: away from a large lake) when flows occur, and how does this vary with season?
2. Which fish species and size classes move downstream into lake habitat when flows occur, and how does this vary with season?
3. Does the Lake Cargelligo system function as a nursery and/or breeding area for certain species of fish (including alien species)?

The results may be useful to management agencies, particularly if certain time periods facilitate mass migration of either native species or carp and/or other alien species.

Methods

Sampling site and times

Sampling was conducted during three separate flow periods that occurred during the last few days of 2017 and/or the first six months of 2018 (as advised by Daniel Scherrer. Water NSW, pers. comm.). All sampling was conducted at the point where Canal 2 meets Lake Cargelligo (Figure 2); as such, each sample was an aggregate of three replicates taken over consecutive (or close to consecutive) days.

The first flow was sampled on December 28, 29 and 20, 2017. The second flow was sampled on March 29, April 5 and April 6 2018. The third flow was sampled on May 7, 8 and 9, 2018.

Fish sampling

Fish populations were sampled using a combination of large and small fyke nets. These methods successfully capture fish of all body sizes and life stages in Australian inland waterways (Arthington *et al.* 2005; Balcombe *et al.* 2007). Large double-winged fyke nets with a 13-millimetre stretched mesh and eight metre wings (one metre deep) were set parallel to the bank with their openings facing in opposite directions upstream and downstream from a central post. Cod-ends were secured above the water surface in order to allow air-breathing vertebrates to survive if they became trapped. Small double-winged fyke nets with a stretched mesh of two millimetres and a wing width of three metres (one metre deep) were set in an identical manner. All fyke nets were set in the afternoon (as close as possible to four pm) and retrieved the following morning (as close as possible to nine am). Fyke nets were set in order to take advantage of the narrow (approximately 10m wide) waterway at the point where Canal 2 meets Lake Cargelligo (Figures 2 and 3).

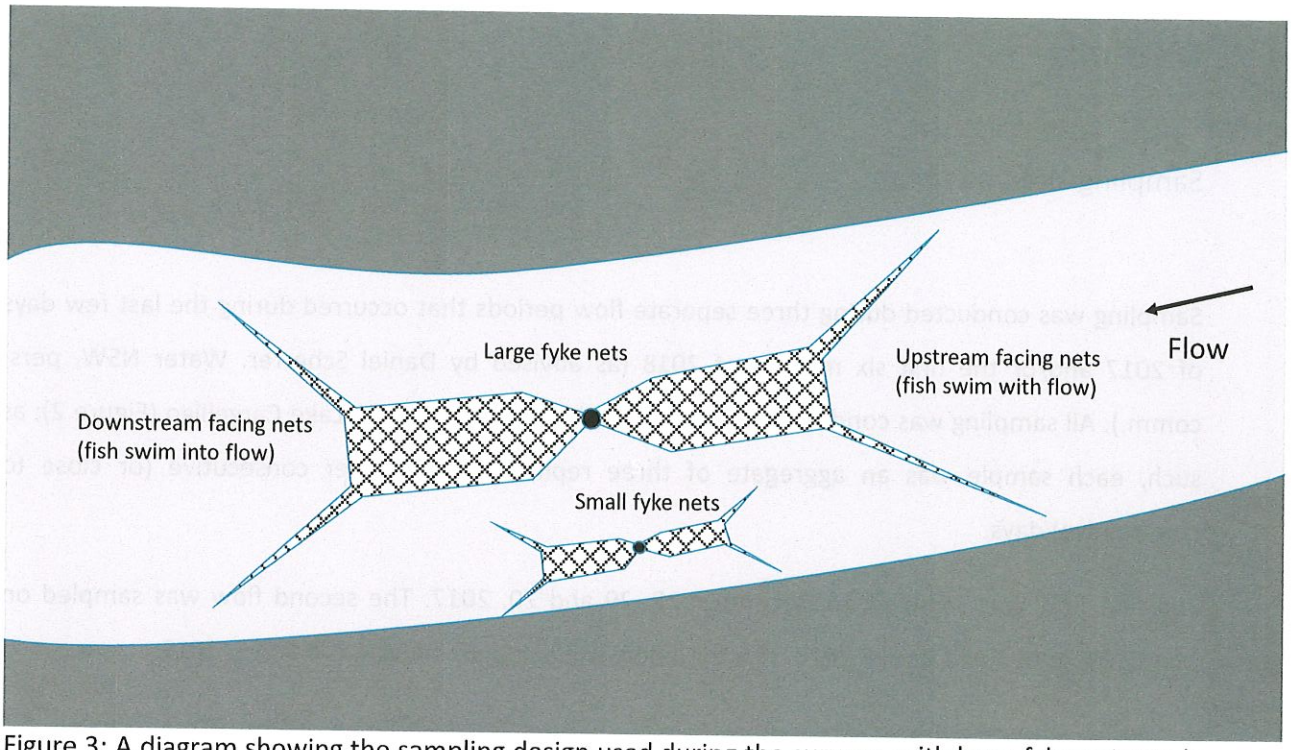


Figure 3: A diagram showing the sampling design used during the surveys, with large fyke nets set in order to capitalise on the narrowness of the site.

Following the clearing of fyke nets, all fish were held in shaded water-filled buckets prior to processing. Fish species were identified using a combination of published literature relating to fishes of the Murray-Darling Basin (Allen *et al.* 2002; Lintermans 2007). Sampled fish were measured from the tip of the snout to the caudal peduncle to obtain a standard length (SL) measurement in millimetres. In cases where over 100 individuals of a species were sampled, the first 100 were measured and the remainder counted (but not measured). Following identification and measurement for standard length (millimetres), all native fish were returned to the water alive and alien species were euthanised using standard methods (ie: Aqui-S at standard dilution).

Water quality

Water quality parameters such as temperature, dissolved oxygen, pH, conductivity and turbidity were taken at all sites using a Eutech PCD 650 multi-meter, and flow and depth were also measured or estimated using manual methods.

Results

A total of 10 274 individual fish were sampled at Lake Cargelligo during the three flow periods (December 2017, March/April 2018 and May 2018; Table 1). Flow was highest in May 2018 (0.5m/sec^{-1}) and lowest in December/January (0.12m/sec^{-1}). Water temperature was highest in December/January (29.7°C) and lowest in May 2018 (15.8°C), and all other water quality parameters similarly fell within expected ranges (ie: conductivity 328.6 – 368.6µS, pH 7 – 8.5, dissolved oxygen 4.3 – 8.5 mg/L, turbidity 12 – 15cm).

The majority of sampled fish were native species (94.3%), and the majority were fish sampled in upstream-facing nets (ie: fish moving downstream in the same direction as the flow; 86.2%, Table 1).

Bony bream was the most common species (4928 individuals) and carp gudgeon were sampled in similar numbers (4489 individuals; Table 1).

Other native species included flathead gudgeon (228), Australian smelt (20), yellowbelly (17) and un-specked hardyhead (five; Table 1).

The most common alien fish species was gambusia (560 individuals) and all other alien fish were sampled in low numbers (ie: 15 redfin, 11 carp and one goldfish; Table 1).

All samples were characterised by the presence of juvenile fish of all species (Table 1), and this was most evident in the large samples of bony bream and carp gudgeon.

Table 1 (overleaf): Total numbers of all fish sampled in upstream and downstream facing fyke nets during three flow periods (December 2017, March/April 2018 and May 2018) in Lake Cargelligo. Numbers in brackets denote the size range (standard length SL) of sampled fish.

SPECIES (* denotes alien fish)	DECEMBER 2017 (0.12m/sec^{-1})		MARCH/APRIL 2018 (0.2m/sec^{-1})		MAY 2018 (0.5m/sec^{-1})	
	Fish moving with flow	Fish moving against flow	Fish moving with flow	Fish moving against flow	Fish moving with flow	Fish moving against flow
Nematolosa erebi Bony bream	273 (20 – 140mm)	55 (20 – 60mm)	4041 (30 – 250mm)	93 (30 – 110mm)	407 (30 – 200mm)	59 (40 – 100mm)
Retropinna semoni Australian smelt	17 (28 – 50mm)	0	0	0	3 (42 – 60mm)	0
Craterocephalus stercusmuscarum fulvus Un-specked hardyhead	4 (25 – 43mm)	0	0	0	1 (45mm)	0
Macquaria ambigua Yellowbelly	12 (32 – 175mm)	0	2 (55, 60mm)	0	3 (50 – 65mm)	0
Hypseleotris spp. Carp gudgeons	840 (13 – 32mm)	113 (15 – 35mm)	2325 (13 – 31mm)	636 (15 – 25mm)	475 (10 – 35mm)	100 (13 – 30mm)
Philypnodon grandiceps Flathead gudgeon	218 (28 – 50mm)	4 (25 – 40mm)	0	2 (40, 65mm)	4 (35 – 60mm)	0
*Carassius auratus** Goldfish	1 (50mm)	0	0	0	0	0
*Cyprinus carpio** Carp	3 (35 – 530mm)	6 (50 – 170mm)	0	0	0	2 (225, 720mm)
*Gambusia holbrooki** Gambusia	3 (15 – 35mm)	2 (23, 35mm)	163 (18 – 29mm)	43 (20 – 30mm)	47 (18 – 38mm)	302 (12 – 35mm)
*Perca fluviatilis** Redfin	11 (50 – 90mm)	2 (55, 60mm)	0	2 (60, 70mm)	0	0

Discussion

Although native fish populations in the Murray-Darling Basin are generally considered to be declining and in poor health (Harris and Gehrke 1997), it is salient to consider that despite this, no known extinctions have occurred at species level (Lintermans 2007), and several studies have demonstrated that under prolonged no or low flow conditions, many species (a prescient example being carp gudgeons; Figure 4) may continue to breed (Humphries *et al.* 1999; King *et al.* 2002). Work carried out in the adjacent Lake Eyre Basin (which hosts similar or the same species but is generally unregulated) has demonstrated that the majority of present species evince continual recruitment, with success (more than breeding itself) possibly influenced by episodic flooding and flows (Kerezsy 2011).

The results from the current study concur with much of this previous work. All common native fish species that are known to occur in the lowland Lachlan catchment were detected, with exceptions limited to listed vulnerable species and/or endangered populations such as silver perch, *Bidyanus bidyanus*, Murray cod, *Maccullochella peelii peelii*, olive perchlet, *Ambassis agassizii*, and freshwater catfish, *Tandanus tandanus*.

Figure 4: Carp gudgeon (above) and bony bream were the most commonly-sampled species during the first half Of 2018 in Lake Cargelligo. It appears highly likely that both species play important roles in sustaining other aspects of the local ecosystem.

It is notable that the vast majority of sampled fish were moving downstream – from a 10 metre wide channel into a five kilometre wide lake. This indicates that small flows, whether 'natural' or induced by the opening of a regulator gate, are likely to generate mass movement of (predominantly) juvenile native fish to downstream habitats. It is unknown whether this dispersal is random (ie: fish are carried by random flows) or whether it is a migratory response, but the commonality of results from all three sampling periods (December 2017, March/April 2018 and May 2018) suggests that the latter explanation may be slightly more likely than the former. It is also noteworthy that the patterns evinced by native fish – particularly bony bream and carp gudgeon but also (to a lesser extent) juvenile flathead gudgeon, un-specked hardyhead, yellowbelly and Australian smelt – were not mirrored by the four alien species that are also present. Indeed, gambusia (and carp) were two species that appeared just as likely to move upstream (into flowing water) as they were to disperse downstream.

The presence of large numbers of fish-eating birds – particularly pelicans (Figure 5), and most noticeably during the March/April sampling (when the largest samples of bony bream and carp gudgeons were recorded; Table 1) – gives an indication of the value of native fish recruitment and dispersal to inland ecosystems such as Lake Cargelligo. This phenomenon also indicates that, despite the perturbations that have occurred due to river regulation and the imposition of alien species, Australian floodplains, off-river areas and tributaries almost certainly provide considerable resources enabling such ecosystems to continue functioning.

Figure 5: Large numbers of pelicans were present in areas close to the sampling site in March/April 2018, suggesting that the large numbers of juvenile bony bream (in particular) may sustain these flocks when they (both fish and birds) are in abundance.

The presence of juvenile native fish species from a range of families suggests that the Lake Cargelligo system is likely to provide nursery habitat that is suitable for the majority of extant species, and this is probably due to the diversity of habitats that are available. Of particular note is the presence of yellowbelly in very small size classes (ie: <50mm), indicating that these individuals are most likely to be local recruits (ie: bred within the Lake Cargelligo system or the adjacent Lachlan River) rather than stocked fingerlings.

Conclusion

Flow-based fish sampling within Lake Cargelligo in the first half of 2018 detected an overwhelming majority of a) native species and b) fish dispersing downstream in/with the flowing water. The presence of juvenile bony bream, carp gudgeons, flathead gudgeon, yellowbelly, un-specked hardyhead and Australian smelt is encouraging and indicates that the area probably functions as a nursery for these (and possibly other) native species. On-going sampling of flows in different seasons and years is likely to produce a more complete set of data that may be useful for river, conservation and water managers. Wider, habitat-specific fish surveys of different areas within the Lake Cargelligo system would be useful in elucidating the attributes of the system as a fish nursery.

Acknowledgements

Thanks to Daniel Scherrer at WaterNSW for his information regarding the timing of flows, and thanks to Alison Wheeler and Gary Breheny for their assistance with fish sampling.

All described sampling work was carried out under DPI Scientific Collection Permit P17/0063-1.0 and OEH Animal Research Authority AEC Approval Number 171017/01.

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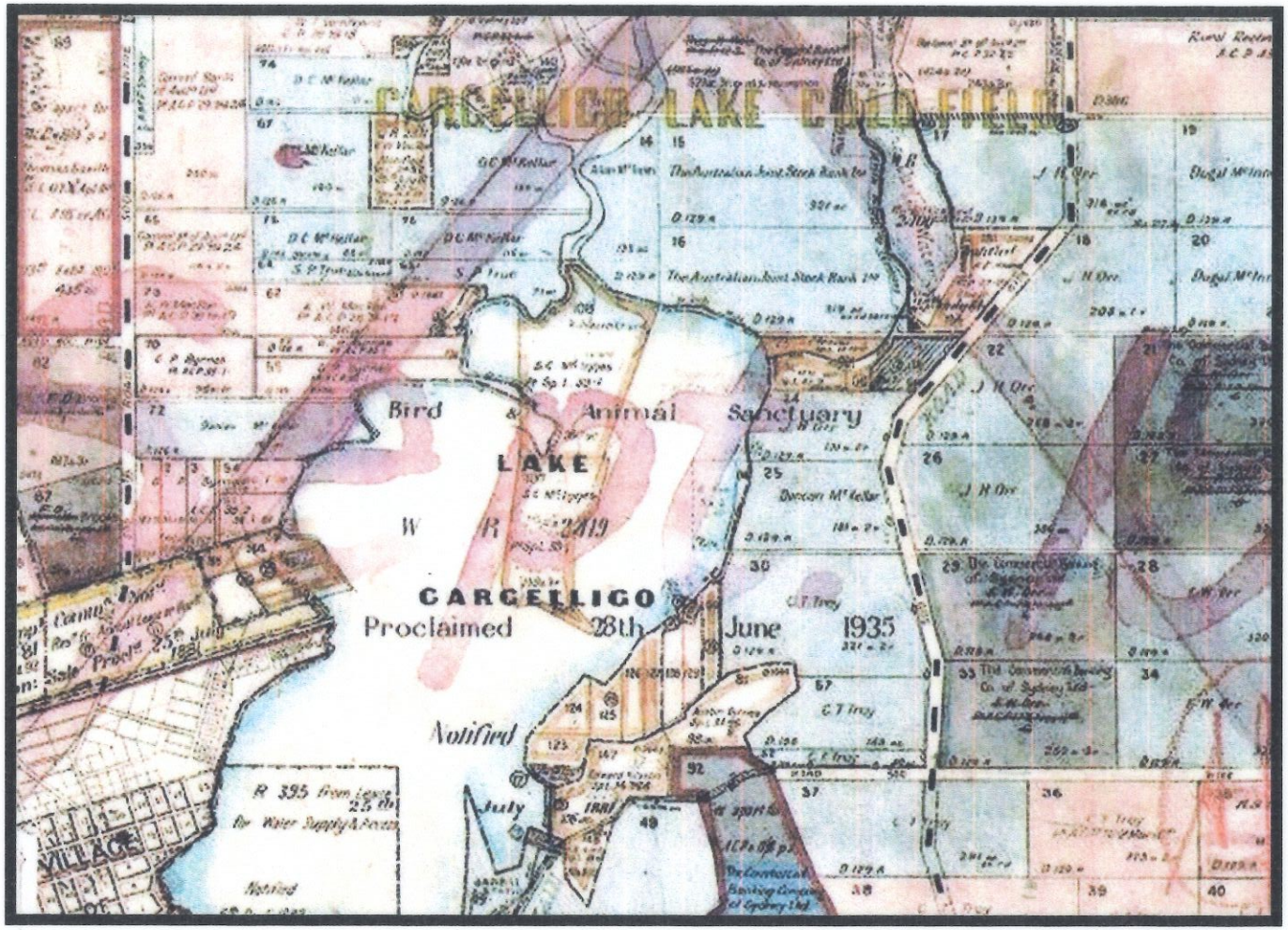
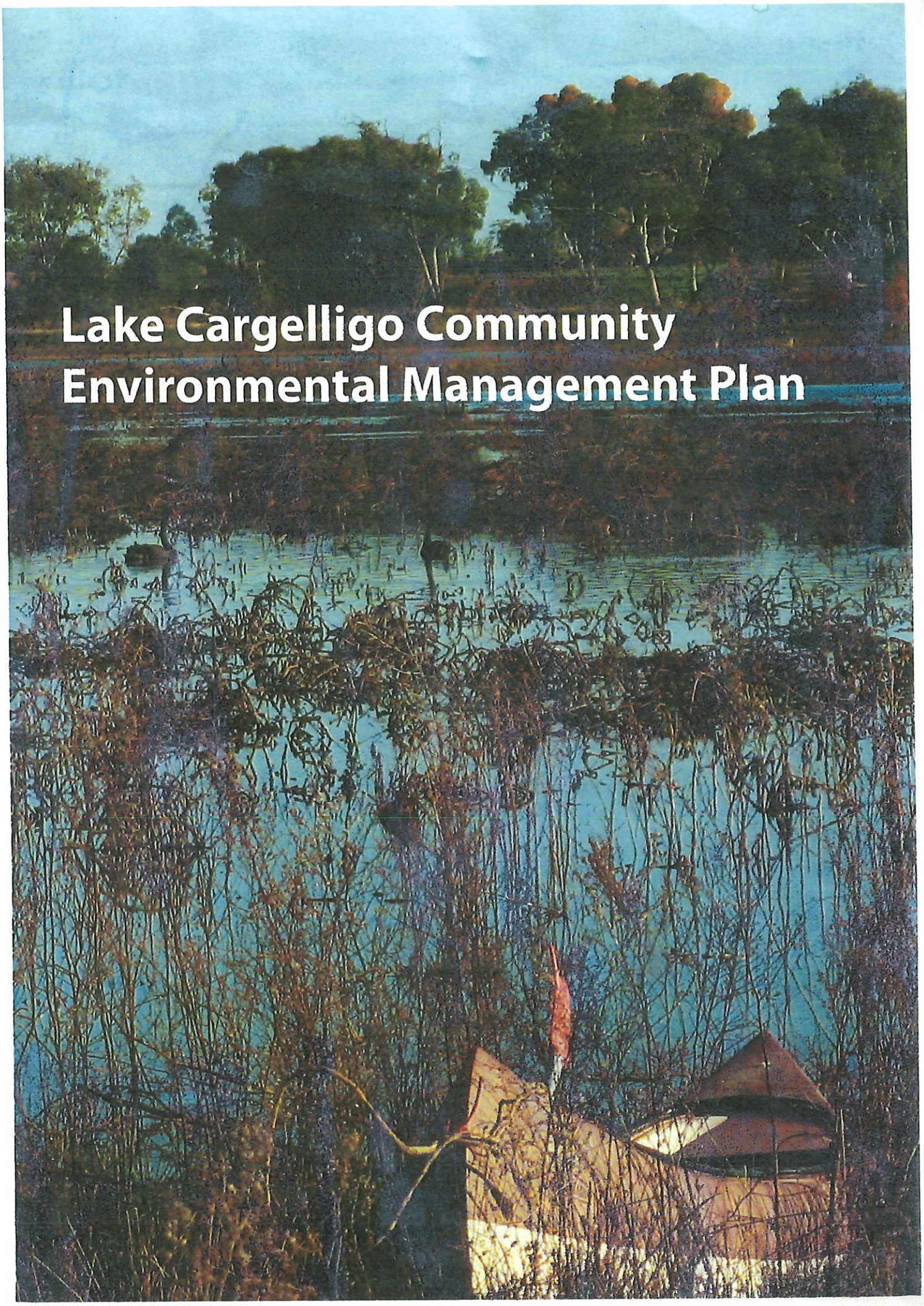

CARGELLIGO LAKE GOLD FIELD
Bird & Animal Sanctuary
LAKE
CARGELLIGO
Proclaimed 28th June 1935
Notified
VILLAGE

Carmel Gleeson

Lake Cargelligo Community Environmental Management Plan



Forward

This Environmental Management Plan has been developed in consultation with the Cargelligo Wetlands and Lakes Council and the Lake Cargelligo community, with financial assistance from the Lachlan Catchment Management Authority (CMA).

Acknowledgments are given to the following contributors:

Barbara Nilsson

Bob Sanson

Doug Hart

Ian Kemp

James Blacker

James Brown

John Twommey

Mark Hall

Peter Nilsson

Peter Skipworth

Robert King

Terry Mann

Photographic images contained within this document have been provided by James Blacker.

Chairman of the Lachlan CMA, Rob Gledhill congratulates all contributors to this collaboration as working together is the key to the success of any project.

Together We're Making a Difference
LACHLAN CATCHMENT
MANAGEMENT AUTHORITY

Contents

Overview

Lake Cargelligo is located on the Lachlan River floodplain in the central west of NSW, with a population of 1300 supporting a number of industries and mixed farming enterprises.

Prior to regulation, Lake Cargelligo was originally a natural wetland system, filled by flooding flows which travelled across the floodplain from the Lachlan River. When inundated, the lake supported a large Aboriginal Community through the presence of waterbird and native fish populations.

As it is downstream of all major tributaries in the Lachlan, the operation of filling and releasing water from this storage has a significant impact on flow in the lower Lachlan and benefits downstream water users.

The Lake Cargelligo community values the Lake system as:

- A valuable wetland habitat and drought refuge for many native species;
- A town, stock and domestic water supply; and,
- A recreation and tourism facility.

As the system comprises of a variety of habitat types in a highly variable environment and is one of the few wetland systems in the lower Lachlan Catchment to receive inflows over drought years, it is proving to be an important refuge for native fish and waterbirds. It is also known to support a number of endangered or vulnerable species including the painted snipe, blue-billed duck , Australasian bittern, and freckled duck. The Lake is also known for its significant cultural and heritage values. For these reasons it has been included as a regionally significant wetland in the Lachlan Environmental Water Management Plan.

Purpose

The purpose of the Lake Cargelligo Community Environmental Management Plan (LCCEMP) is to enhance the environmental, cultural and social values attached to this riverine system. This will be achieved through utilising community knowledge and resources.

Objectives

Broad objectives which are relevant to all management units within the LCCEMP include:

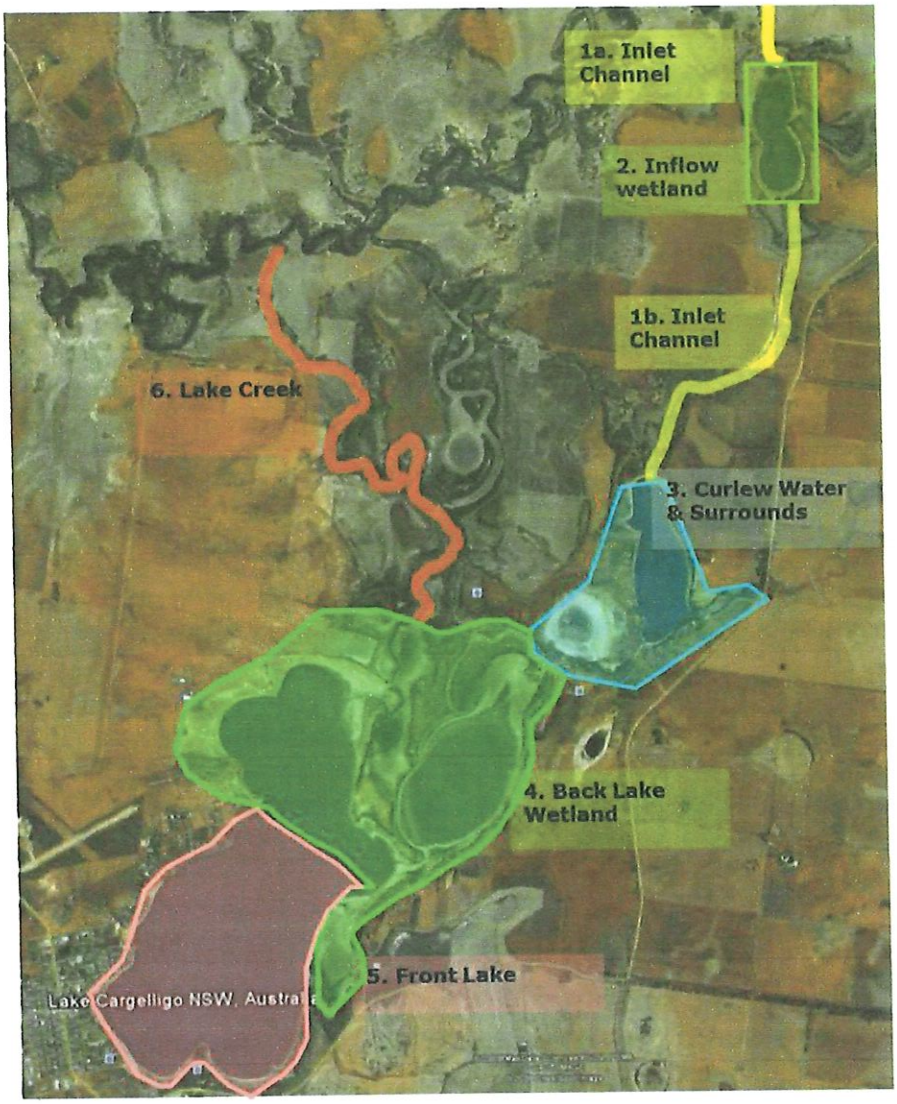
- By 2015, increased water security through improved water management and long-term vision;
- By 2015, the Lake Cargelligo community, to gain recognition for Lake Cargelligo as significant and valuable riverine system and drought refuge;
- By 2020, Improve the management and control of carp through carp separation cages and harvesting, reducing carp biomass;
- By 2020, protect 100% of existing waterbird and native fish habitat and increase available habitat by 150ha, through improved land and water management;
- By 2015, appropriate flow regimes that improve wetland and riparian condition in the Lake Cargelligo system and downstream environment in line with the Lachlan Environmental Water Management Plan will be in place;
- By 2020, stabilisation of banks and substrates, through improved grazing and water management, reducing sediment inputs, resulting in a 25% reduction in turbidity and suspended solids within the Lake by 25%;
- By 2020, increased hydrological and habitat connectivity of 25% of the adjacent floodplain by reducing barriers, changing flow regimes and protecting/enhancing native vegetation;
- By 2015, water regulator operation by State Water which places minimum impact upon native fish entering and/or leaving the lake system, reducing native fish mortality;
- By 2020, improved water quality through better land and water management, reducing blue-green algal bloom frequency and severity;
- By 2020, increased knowledge of indigenous history, connection and values relating to Lake Cargelligo through improved community education and increased indigenous involvement in natural resource management and tourism; and,
- By 2015, increased opportunities for environmental education and tourism associated with Lake Cargelligo through greater access and improved facilities to four recreational areas.

Through meeting these objectives it is hoped that water quality and wetland functions will be improved, connectivity between the river and floodplain and lake system will increase and native plant, fish and bird populations will benefit. However, this Plan must also ensure that the Lachlan River between the Lake Cargelligo inlet and Lake Creek is not adversely affected as a result of LCCEMP management actions.

The LCCEMP relies heavily on community knowledge and involvement. The objectives of this Plan cannot be met without the assistance and acceptance of the local community.

Lake Cargelligo Units

As this diverse system is in a highly variable environment, particular care has to be taken to ensure the environmental, economic and social values relating to each habitat type is taken into account in the management plan. This can be achieved through dividing the lake system into specific units.



Lake Cargelligo Units

Each unit has different values and therefore objectives and management of each unit varies.

Unit 1 – The inflow channel has limited habitat value, however management changes can improve water quality and native fish survival, reduce carp biomass and protect banks. This can be achieved by:

- Controlling large-bodied carp through the installation and management of carp separation cages on the inlet channel;
- Changing regulator operation to protect native fish attempting to pass through;
- Protecting channel banks by reducing flow fluctuations within channel, controlling carp numbers and stock access; and,
- Protecting inundated areas associated with the inlet.

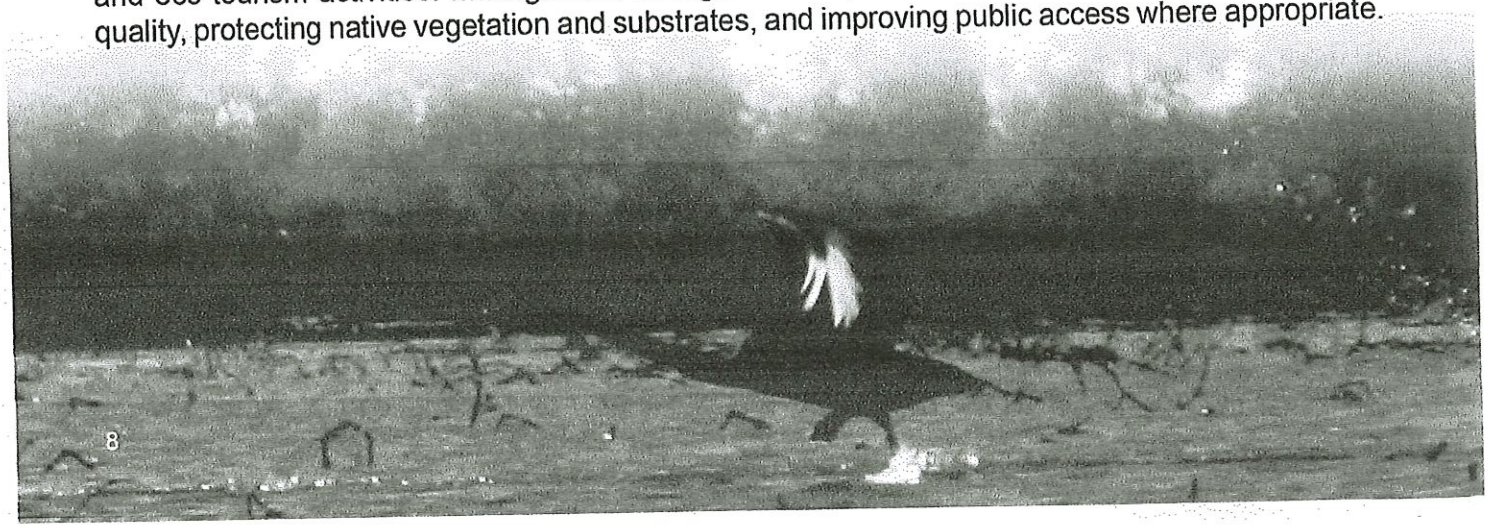
Unit 2 – The inflow wetland (also known as Sheet of Water) contains wetland values particularly for migratory waders. Management changes can improve habitat values and water quality by increasing ground cover and protecting substrates, particularly when inundated. This can be achieved by:

- Ensuring groundcover is in place to protect substrates and weeds are controlled. These changes could be implemented by provided incentives;
- An appropriate wetting and drying regime;
- Providing cues to ensure native fish leave the wetland when drying;
- During times of inundation the wetland is protected from grazing impacts, also achieved through providing advice and incentives; and,
- Promoting the area as a bird-watching facility.

Unit 3 – Curlew Water contains values as a drought refuge and as a recreational facility. Management changes can improve habitat values by protecting banks and riparian zones, improving water quality, ensuring permanent inundation and controlling carp. This can be achieved by:

- Carp control through professional harvesting and community carp fishing events as part of the Lachlan River Revival;
- Riparian protection and enhancement through land holder partnerships;
- Ensure this area remains a drought storage for TWS; and,
- Some speed restrictions on powered watercraft in certain areas to protect banks and riparian vegetation.

Unit 4 – Back Wetland Area contains many wetland values and has potential for some educational and eco-tourism activities. Management changes can improve habitat values by improving water quality, protecting native vegetation and substrates, and improving public access where appropriate.



This can be achieved by:

- Forming voluntary partnerships with landholders to improve grazing, weed and pest animal management to ensure wetland habitats are protected and enhanced;
- Carp control;
- Improved water management so that water delivery takes into account the requirements of the wetland community;
- Increase opportunities for cultural activities and the creation of an interpretative walk and cultural heritage tours; education and eco-tourism opportunities where appropriate;
- Enforcement of the power boat speed restriction zone;
- Formal recognition of this area as important wetland habitat within the lower Lachlan;

Unit 5 – Front Lake Area provides aesthetic and recreational values for the township and has potential for many educational activities. Management changes can improve these values by improving water quality and access and providing information. This can be achieved by:

- Changes in the flow regime, improved land management and increased carp control;
- The extension of interpretative walks and other facilities such as bird hides;
- The enhancement of a small wetland on the western side of the Lake; and,
- Power craft speed limit zones in sensitive areas of the Lake.

There may be a future requirement to manage aquatic plant growth in the front sections of the lake as historically this proved to be an issue for power-boat users. Prolific aquatic plant growth and associated decay was found to cause odour, access and aesthetic problems.

Unit 6 – Lake Creek is recognised by the community as a valuable wetland habitat, also providing riparian values and maintaining connectivity between the wetland and river. Management changes can improve water quality and wetland habitat, improve native fish survival, reduce carp biomass and protect banks. This can be achieved by:

- Forming voluntary partnerships with landholders to improve grazing, weed and pest animal management to ensure wetland habitats are protected and enhanced;
- Carp control through carp separation cages; and,
- Employing a range of management actions to stabilise banks and reduce sediment and nutrient input into the river.

Implementation

The LCCEMP has been developed by and for the Lake Cargelligo community. The Plan objectives, priorities and management options have been guided by interested Cargelligo community groups. To continue to support the Community and the implementation of the Plan, the Lachlan Catchment Management Authority (Lachlan CMA) have assigned a part-time position to Lake Cargelligo. This position will support the community in funding applications, facilitation and project management. Apart from the Lachlan CMA, other agencies such as Department of Environment, Climate Change and Water, NSW Office of Water, NSW Industry and Investment (Fisheries) and State Water can also provide information and support.

The LCCEMP needs to address the full range of natural resource management issues, including land use, wetland and water management. Wetland protection and management is also a goal and national priority for various Commonwealth and State programs through which natural resource management funding is directed. The Plan should also meet the natural resource planning requirements of the both the State and Commonwealth Governments by providing aspirational targets; resource condition assessment and guidance to conserve and manage wetlands. The most relevant Plans to the LCCEMP are the Lachlan Environmental Water Management Plan (LEWMP), the Lachlan Catchment Action Plan (LCAP) and the Murray-Darling Basin Plan.

The Lachlan CMA leads a number of projects which can complement the LCCEMP, these projects including:

1. Management planning for high conservation wetlands.
2. River Revival – carp management. This project links closely with the Lake Cargelligo Fish Management and Operations Plan which is part of the LCCEMP.
3. River Revival – habitat restoration to promote native fish recruitment to build their resilience from impacts of carp populations.
4. Native fish refuge (Lower Lachlan) - it is a generally considered that during no-flow periods, isolated pools function as key refugia for aquatic communities and more information and better management in relation to these pools is required.
5. On-farm irrigation efficiency – a federally funded project designed to generate water savings by improving the efficiency and productivity of on-farm water use and management.

Links to information regarding these Projects can be found on the Lachlan CMA website.

Current Lake Cargelligo Projects

Lake Cargelligo Urban Wetland

The construction of a small wetland (<2ha), located on the western side of Lake Cargelligo had been identified in the LCCEMP as an important educational tool. The construction of a small wetland on the edge of the main Lake where stormwater runoff enters the system, also supports a number of other LCCEMP objectives, including the reduction of sediments and nutrient inputs, improved riparian condition, improved water quality and opportunities for environmental education.

The site already has a walkway and small foot-bridge which provides access and an opportunity to inform the community, through signage, of the importance of wetlands. The site also provides an opportunity to intercept stormwater before it enters the Lake and, after the establishment of appropriate wetland plants, may reduce sediment and nutrients contained within the runoff.

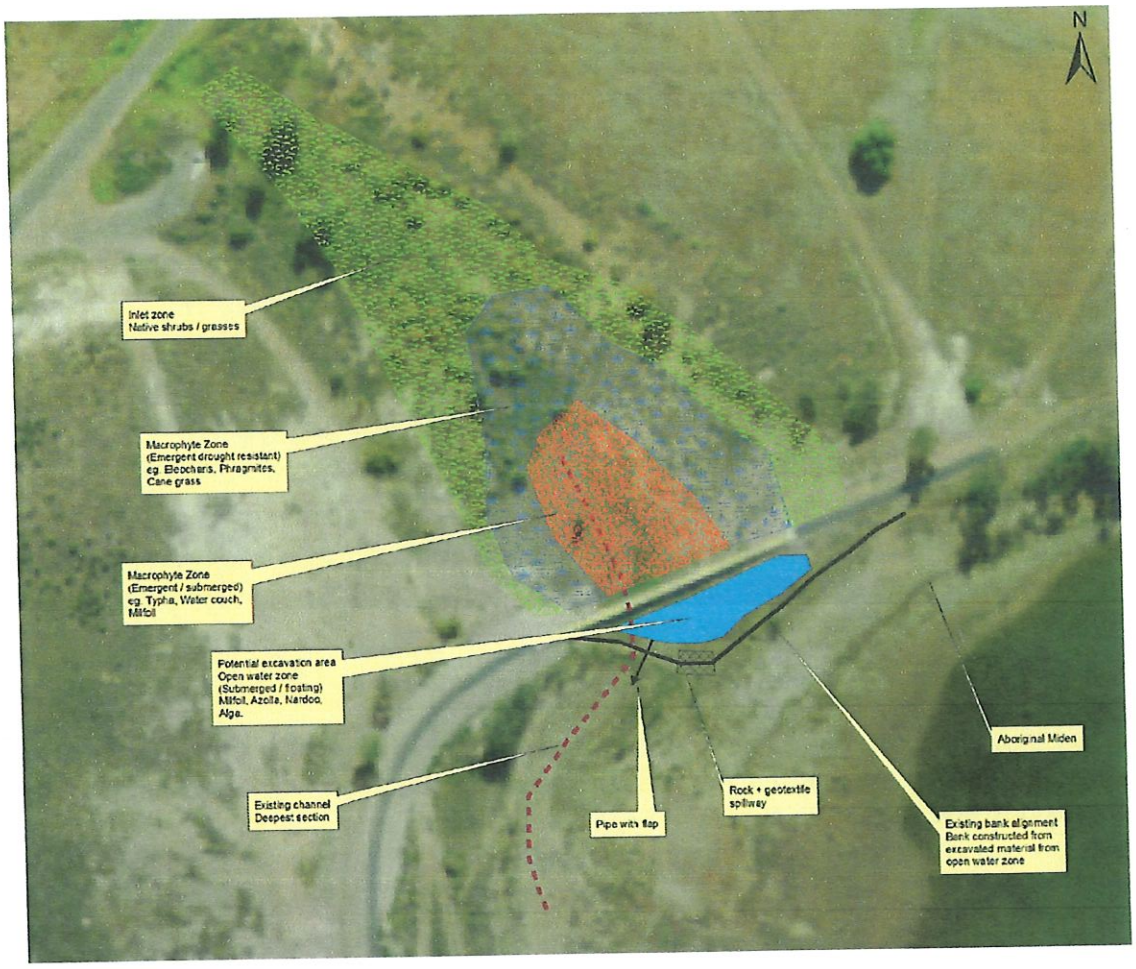
In time it is hoped the site will support a wide range of native aquatic plants, frogs and invertebrates and, on a small scale, some wetland bird species. It is also envisaged that the presence of aquatic plants will stabilise substrates, reduce runoff velocity and increasing retention time, thereby reducing suspended sediment and nutrients transported into the Lake through stormwater.

Aboriginal middens are also located nearby and can add to the educational and cultural benefits of rehabilitating this site.

This wetland will be designed to visually blend with the surrounding public open space and will be an environmental feature along the Lake walking track. Interpretative signage will explain its role in treating stormwater and other benefits relating to wetlands.

The simple wetland design below, demonstrates the use of emergent macrophytes on the shallow fringes of the wetland to trap sediment and nutrients. The deeper sections of the wetland would support a variety of submerged and floating macrophytes, which would utilise available nutrients. The structural variety provided by the different types of macrophytes would also add to habitat diversity and provide a useful education tool showing the different zones within wetlands and the functions these provide.

Preliminary constructed wetland design



Adaptive Management

To measure the outcomes achieved through implementing this Plan, it is necessary to monitor and evaluate responses to management. This information is then able to inform of the success of the Plan and provides an adaptive management tool.

An important part of adaptively managing the Lake and its assets will depend upon the effective use of different sources and types of information. This includes researchers, managers/operator and the community. While we need to recognize the many gaps in our existing knowledge of the Lake and best management approaches, it is important that apply the information we currently have and continue the information gaps as we manage and monitor.

This can be achieved through strong links and effective communication between researchers, managers and policy makers. A research/monitoring/evaluation/reporting plan will be developed as part of the Plan's implementation program. This will need to address the priorities for research and ensure that all monitoring and reporting requirements are met.

The monitoring program also needs to measure the effectiveness of management against the Plan objectives in terms of restoring critical ecological functions and habitats. This could include:

- Changes in the extent of semi-permanent wetland vegetation;
- The proportions of healthy and stressed semi-permanent wetland vegetation;
- The diversity and density of aquatic invertebrates; and
- The diversity and density of waterbird species.

Research and monitoring activities also need to be evaluated, including uptake of information into management actions.

Community monitoring can also greatly assist in filling information gaps and also educate and motivate those involved. Annual events such as the Lake Cargelligo fishing competition could be used to supply information to improve management. This could be added to with other events such as bird counts, carp catching events and school involvement in the newly created urban wetland on the shores of Lake Cargelligo.

Annual reporting of Plan activities and achievements should be undertaken. Reporting relating to

Adaptive Management continued

the progress towards longer-term targets should occur every 5 years. There will also be reporting requirements associated with funding.

Evaluation outcomes are used to support decision-making and adaptive management. Outcomes can be used to improve any methods relevant to the LCCEMP.

- Monitoring and evaluation provides information regarding opportunities to improve the Plan and delivery of management actions. Some examples where the outcomes from monitoring and evaluation are considered include:
- The appropriateness of targets, are they achievable
- Accounting for and improving the management of land and water;
- Determining the need for further investment and on-ground actions in order to achieve objectives. This includes the identification of priority areas and appropriate actions; and,
- Assessment of interactions with and between the all aspects of the LCCEMP.

Lake Cargelligo at sunset

The Benefits of Community and Stakeholder Driven Fish Monitoring Projects in a Murray-Darling Basin River

Adam Kerezsy[1]

Abstract

River and catchment management in Australia's Murray-Darling Basin underwent a transformation in the latter part of the twentieth century, from being focused on delivering water predominantly for human and agricultural needs to also considering environmental considerations. The main driver of this change was the realisation that a comparatively long period of river regulation and associated alterations to natural systems had resulted in negative consequences. Native fish communities, in particular, have been considered to be in a poor or degraded condition. The centrally located Lachlan River, in New South Wales (NSW), is a poignant example, as the fish community has been rated as 'extremely poor' in both of the basin-scale Sustainable Rivers Audit reports in 2008 and 2012. River management can generally be regarded as a top-down process, with the Murray-Darling Basin Authority and state-based agencies simultaneously relied on and looked to for advice, but also blamed for any perceived problems and inequities. However, neither the federal nor state governments and their agencies have the capacity to undertake accurate monitoring of individual catchments at localised scales. In order to achieve this, local communities and stakeholders can make a difference to the management of their catchments by actively sponsoring and participating in sampling and monitoring projects that can then inform broader catchment management. This process has begun with positive results within the Lachlan catchment, and offers a representative case study that can be applied to other areas within the Murray-Darling Basin.

Keywords: Lachlan River, off-river areas, Lake Cargelligo, Booberoi Creek, community involvement, fish surveys, endangered species

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Introduction

In Australia's heavily modified Murray-Darling Basin (M-DB) in the nation's south-east, rivers were historically managed (from the mid-1800s) in order to ameliorate the effects of Australia's unpredictable weather systems and ensure that water could be supplied for towns and agriculture and – somewhat later – for the establishment and sustenance of irrigation districts and the generation of hydroelectricity.

Due to Australia's dry climate, the principal tools for controlling flows in the M-DB were (and remain) large headwater dams that enabled flows from the highest-rainfall areas to be harvested and stored, and a series of smaller weirs or other structures situated at various points downstream that similarly enabled water to be prevented from following riverine channels until it was required (Water Conservation and Irrigation Commission, 1971). Today, there are very few rivers in the M-DB that are unaffected by such regulation (a notable exception is the Paroo River in far western Queensland and New South Wales; Kingsford & Thompson, 2006).

By the latter part of the twentieth century, and facilitated by evolving areas of study within applied science and ecology, it became obvious that the regulated rivers of the M-DB were affected by

a range of negative issues, including damming of rivers preventing natural flows, the introduction and spread of alien species, over-allocation of water, riparian denudation, pollution, and the decline of native fish species and stocks (Arthington, 1991; Walker et al., 1995; Humphries et al., 1999; King et al., 2003; Koehn, 2004). However, these issues were also complicated by geographic location, for the basin occupies four Australian states and one territory: Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory. Within each jurisdiction, agencies with associated responsibilities (water, planning, natural resources and fisheries) worked autonomously to develop 'their' rivers and associated infrastructure. However, within 100 years it became necessary to create an over-arching organisation, first called the Murray-Darling Basin Commission (MDBC) and then the Murray-Darling Basin Authority (MDBA), as it became obvious that addressing basin issues at basin scale was essential.

The observed problems were also confounded by a general absence of historical records that documented these perturbations in a quantitative manner (the survey work of J. O. Langtry, in Cadwallader, 1977, being a notable exception). Given that fish are the ecological focus of this paper, a dataset that illustrates native fish decline in the M-DB is the commercial catch data from New South Wales (Reid et al., 1997). From 1947 (when records commenced) the catch records for three of the four native species targeted by commercial fishers (Murray cod, *Maccullochella peelii*; silver perch, *Bidyanus bidyanus*; and freshwater catfish, *Tandanus tandanus*) plummeted by the 1970s (Reid et al., 1997). Following a peak in 1960 (80 tonnes), Murray cod capture fell rapidly and stabilised to less than 10 tonnes per year within seven years. Silver perch peaked in 1958–1959 with a catch of 44 tonnes, but the fishery was exhausted by 1984–1985. Catfish were similar: 43 tonnes in 1974–1975 and complete decline by 1990. This compelling evidence led to the closure of the inland riverine commercial fishery for native species in September 2001 and is indicative of the wider problems within the basin by that time (Lintermans, 2007).

The imposition of a top-down framework to manage the M-DB (including the MDBA and state government agencies, supported by research by universities and other groups) has often led to friction between jurisdictions and – most noticeably – anger within local riverine communities who sometimes feel affronted by this approach. Graphic examples include irrigators in Griffith, New South Wales publicly burning copies of the draft Murray-Darling Basin Plan in 2010 (Australian Broadcasting Commission, 2010), and the worldwide media reaction to fish kills in the Darling River near Menindee in the summer of 2018–2019 (*The Guardian*, 2019). A more consultative approach to managing these rivers is therefore clearly desirable.

The Lachlan catchment is the geographic focus of this paper and is centrally located in the basin within NSW (Figure 1). It is the northernmost catchment in the southern M-DB, the fourth-longest river in Australia, and somewhat unique within the M-DB as it most usually reaches a terminus in the Great Cumbung Swamp (near Oxley), so is essentially an isolated catchment. The Lachlan rises in the Great Dividing Range west of Sydney, and the headwater reservoir – Wyangala Dam – harvests water from both the upper Lachlan and Abercrombie Rivers.

With the exception of the native species caught by commercial fishers and targeted by recreational and illegal fishing (those mentioned above and golden perch or yellowbelly, *Macquaria ambigua*), there is limited historical knowledge of the fish communities within the Lachlan catchment (Roberts & Sainty, 1996; Trueman, 2011). Indeed, the first published record of species within the Lachlan did not occur until Llewellyn's survey (1983), where nine native and four alien species were detected.

In response to the realisation that fish communities within the M-DB (in particular) were declining, NSW Fisheries and the Cooperative Centre for Freshwater Ecology conducted the NSW Rivers Survey (Harris & Gehrke, 1997) in an effort to generate baseline river health data across the state. The Lachlan delivered poor results, with only six native fish species present.

The urgency of the M-DB problems prompted the MDBC/MDBA to initiate a large-scale and ambitious project – the Sustainable Rivers Audit (SRA) – in an effort to measure several indicators (fish, macroinvertebrates, vegetation and hydrology) in all major M-DB catchments. However, against

the SRA criteria, the fish theme presents sobering reading, as the Lachlan fish community consistently rates as 'extremely poor' (Davies et al., 2008; Davies et al., 2012).

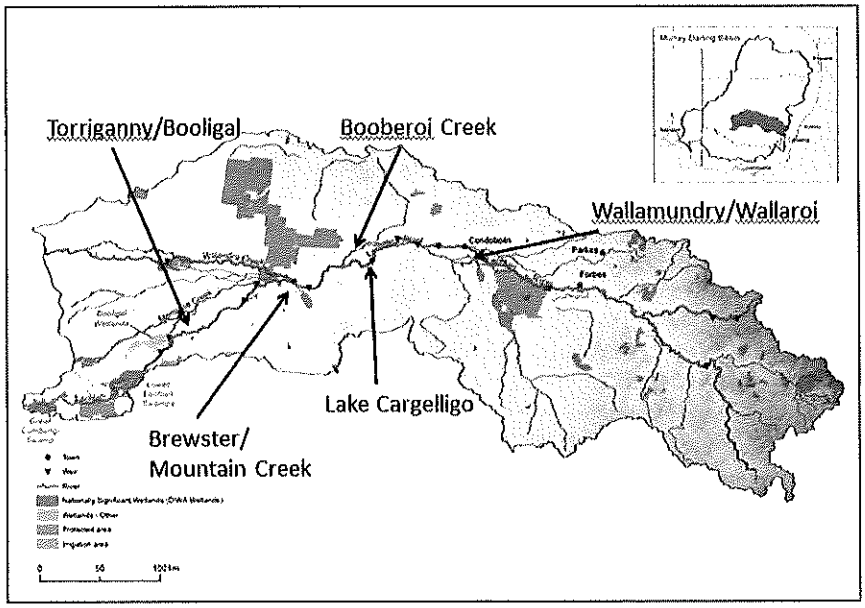
The data presented in this paper relate to fish from multiple surveys at multiple locations in the mid-Lachlan (i.e. roughly between Condobolin and Booligal; Figure 1), conducted at various times and for many different reasons between 2017 and 2020. These data have not been collected as part of a large-scale study, but instead have been sponsored and supported by local and/or regional groups – both government and not-for-profit – with an interest in auditing and then contributing to improvement of the riverine environment at local scales. The data are presented and then discussed under five headings that highlight the benefits of this 'bottom-up' approach to river management: the involvement, interest and education of local participants; the delivery of records for unknown or poorly known areas that can inform riverine management; the ecological relevance of sampling off-river areas away from the main stem of M-DB rivers; the longevity and flexibility afforded by localised monitoring; and the creation of new projects that can ensue following initial engagement. The results and discussion may, therefore, be relevant to other systems throughout the M-DB and are intended to inform future monitoring programs and management strategies.

Materials and Methods

Study Area

All fish sampling described in this paper was undertaken in what could be termed the 'mid-Lachlan' between 2017 and 2020. The sampling area stretches from Condobolin (elevation 220 m) in the east to Booligal (elevation 83 m) in the south-west, across a distance of approximately 253 km (Figure 1). As such, the mid-Lachlan represents a typical meandering, low-gradient river valley that is similar to many of the longer M-DB rivers such as the Murrumbidgee, Darling and Macquarie. The principal land use within this stretch of the Lachlan is dryland agriculture (cereal cropping combined with livestock production); however, irrigated systems are also common, with concentrations around Hillston and Condobolin producing cotton and tree crops (nuts and citrus). The climate of the mid-Lachlan is mediterranean, with long, hot summers (temperatures frequently exceed 40°C between November and March) and short, cold winters with multiple frosts.

Figure 1. Map of the Lachlan catchment. Arrows indicate areas where the fish sampling described herein has occurred between 2017 and 2020.



The mid-Lachlan is characterised by a deep (frequently deeper than 10 m) and incised main channel, and several creeks and off-river areas that are generally regulated by weirs and lock gates managed by WaterNSW. The majority of sampling was undertaken in these off-channel areas, such as the Wallamundry Creek complex close to Condobolin, Booberoi Creek between Condobolin and Lake Cargelligo, Torriganny Creek between Hillston and Booligal, and within the Lake Cargelligo system (Figures 1 & 2). Constructed from 1902–1904 by excavating channels to link low-lying areas, the Lake Cargelligo storage comprises three connected lakes that hold 36,000 ML when full. The Lake Cargelligo storage is used in conjunction with Wyangala Dam and the Lake Brewster storage to supply water to the lower sections of the Lachlan. Sampling was also undertaken at main channel sites close to the Booberoi Creek offtake and re-entry points; in the Brewster weir pool; and in Mountain Creek, which drains Lake Brewster back to the main channel of the Lachlan (Figure 1).

Sampling Rationale and Timing

The data presented do not derive from a discrete project but are the cumulative data collected from several projects that have occurred within the mid-Lachlan since 2017. As such, some sites have been sampled on multiple occasions, whereas others have been sampled only once or twice. Nevertheless, the same sampling methodology (described below) has been used during all sampling events, thus allowing the data to be used to infer general trends regarding the fish communities in this section of the Lachlan catchment.

Booberoi Creek was sampled on eight occasions between November 2017 and January 2020. The purpose of this sampling was to monitor the short- and long-term changes in the fish community following environmental flow releases by state and/or national water holders, who also enabled/sponsored the monitoring (NSW Department of Primary Industries and Environment (DPIE) and Commonwealth Environmental Water Office (CEWO)). Main channel sites in the vicinity of Booberoi Creek were sampled as an addition to Booberoi Creek sites in September–October 2019.

The Lake Cargelligo system was sampled on seven occasions between December 2017 and January 2020. The purpose of this sampling was to provide basic inventory information to a local not-for-profit group, the Cargelligo Wetlands and Lakes Council, in order to inform their management of an island (Robinson Crusoe Island) which they lease and manage for conservation.

The weir pool above Brewster Weir was sampled in both February and March 2019 and also in February 2020 in order to monitor the population of the endangered olive perchlet (*Ambassis agassizii*) that is known to inhabit this area. This work was undertaken in conjunction with volunteers from NSW ANGFA (Australia and New Guinea Fishes Association). Mountain Creek, which drains Lake Brewster back to the main channel of the Lachlan River, was also sampled in February 2019 in order to monitor the population of olive perchlet.

Yarrabandai Creek and Wallamundry Creek (both close to Condobolin) were sampled in October 2019 in order to provide basic inventory information and monitor an environmental flow (NSW DPIE/CEWO), and Torriganny Creek (close to Booligal) was also monitored in October 2019 for the same reasons.

In all areas, a minimum of three sites were sampled on each sampling occasion.

Fish Sampling Methods

Fish populations were sampled at all sites and on all sampling occasions using a combination of large and small fyke nets. These methods successfully capture fish of all body sizes and life stages in Australian inland waterways (Arthington et al., 2005; Balcombe et al., 2007). Large double-winged fyke nets with a 13 mm stretched mesh and 8 m wings (1 m deep) were set parallel to the bank with their openings facing in opposite directions upstream and downstream from a central post. Cod-ends were secured above the water surface in order to allow air-breathing vertebrates to survive if they became entrapped. Small double-winged fyke nets with a stretched mesh of 2 mm and a wing width of 3 m (1 m deep) were set in an identical manner. All fyke nets were set in the afternoon (as close as possible to 4.00 pm) and retrieved the following morning (as close as possible to 9.00 am). Following the clearing of fyke nets, all fish were held in shaded water-filled buckets prior to processing.

Figure 2. Habitats sampled between 2017 and 2020 ranged from areas of open water in the Lake Cargelligo system (top) to channelised riverine environments such as Booberoi Creek (bottom) (Photos: Adam Kerezsy).

Fish species were identified using a combination of published literature relating to fishes of the Murray-Darling Basin (Allen et al., 2002; Lintermans, 2007). All sampled fish were measured from the tip of the snout to the caudal peduncle to obtain a standard length (SL) measurement in millimetres. Following identification and measurement for standard length, all native fish were returned to the water alive and alien species were euthanised using a dilute solution of Aqui-S (as per OEH Animal Research Authority AEC Approval No. 171017/01).

Data Presentation and Comparison with Previous Studies

Owing to the large number of sites and the fact that some sites were sampled on multiple occasions whereas others were only sampled once over the extended seasonal sampling timeframe, analysis of the entire dataset was neither envisaged nor attempted.

Overall total catches were calculated and tabulated for each site and species. Totals were calculated by adding all results from all sampling events in a particular area, with the number of sampling occasions also noted.

Totals were used in areas sampled multiple times (Lake Cargelligo and Booberoi Creek) in order to graph and compare fish community composition and provide a visual representation of the contribution of common and alien species in such areas.

Fish species' presence/absence was compared to previous sampling data within the Lachlan catchment (Llewellyn, 1983; Harris & Gehrke, 1997; Growns, 2001; Kerezsy, 2005; MDBC, 2004a; Davies et al., 2008; Price, 2009; Davies et al., 2012) in order to permit discussion of the current state of fish communities within the mid-Lachlan catchment.

Results

Total Fish Results, 2017–2020

Close to 30,000 individual fish were sampled at all sites in the mid-Lachlan between 2017 and 2020, with the vast majority (84%) being native species (Table 1). Small gudgeons of the genus *Hypseleotris* were the most commonly sampled species and were found at all sites except in the main channel of the Lachlan (Table 1). Bony herring (*Nematolosa erebi*) were also sampled in large numbers (>10,000; Table 1); however, their range was generally concentrated in the open water habitats (such as Lake Cargelligo and the Brewster Weir pool; Table 1).

Small-bodied native species such as un-specked hardyhead (*Craterocephalus stercusmuscarum fulvus*), Australian smelt (*Retropinna semoni*) and flathead gudgeon (*Philypnodon grandiceps*) were sampled in reasonable numbers; however, they were generally detected more often in Lake Cargelligo and Booberoi Creek, the two areas that were sampled on multiple occasions.

Large-bodied native species such as yellowbelly and Murray cod were sampled in small numbers, and only from Lake Cargelligo, and the endangered population of olive perchlet was detected within its known range in the Brewster Weir pool (Figure 1; Table 1).

Freshwater catfish – classified as a listed endangered population within the M-DB – was found at four locations, including Booberoi Creek, Mountain Creek, Wallamundry Creek and Lake Cargelligo. At each location, one adult catfish was sampled (Figure 1; Table 1).

The most commonly sampled alien species was gambusia (*Gambusia holbrooki*), which was present at all sites except the main channel of the Lachlan River and Yarrabandai Creek (Figure 1; Table 1). Carp were similarly distributed, occurring at all sites except Wallamundry Creek. Goldfish and redfin were sampled in far lower numbers and at a more limited number of sites (Table 1).

Fish Communities in Different Areas

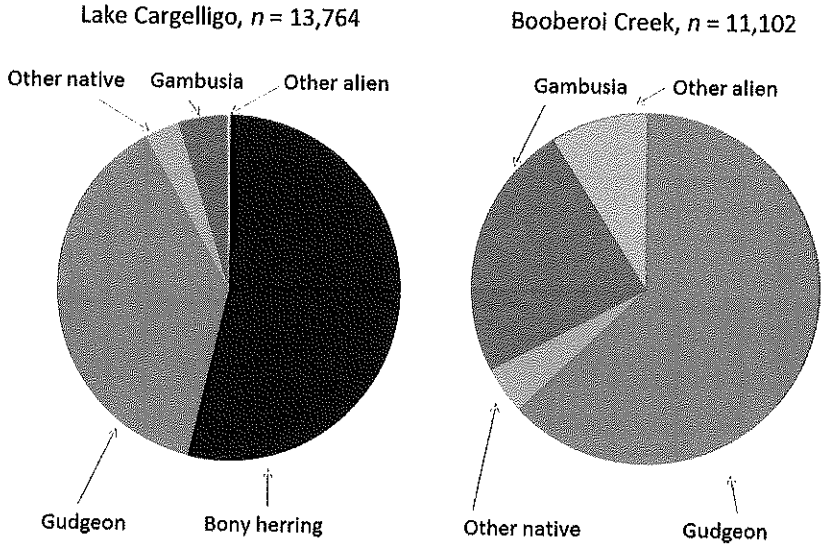
The fish community in the meandering and riverine Booberoi Creek (summed from eight sampling occasions) was dominated by small species such as gudgeons and gambusia, whereas the open-water habitat of Lake Cargelligo was dominated by bony herring (Figure 3).

In Booberoi Creek, gudgeons and gambusia were sampled during all surveys (eight) and carp were sampled during seven. Goldfish were sampled during five surveys, and un-specked hardyhead and flathead gudgeon during four. All other species in Booberoi Creek (bony herring, freshwater catfish, Australian smelt and redfin) were sampled during one survey.

Table 1. Total numbers of fish sampled at sites throughout the mid-Lachlan catchment from 2017–2020, including number of times each site was sampled.

Scientific name	Common name	Booberoi Creek (sampled eight times)	Lake Cargelligo (sampled seven times)	Brewster Weir Pool (sampled three times)	Mountain Creek (sampled once)	Wallamundry Creek (sampled once)	Yarrabandai Creek (sampled once)	Torriganny Creek (sampled once)	Lachlan main channel (sampled once)	Totals
Native species										
Nematolosa erebi	Bony herring	7	7400	1690	1569	—	—	—	—	**10666**
Retropinna semoni	Australian smelt	79	131	—	—	3	—	—	—	**213**
Tandanus tandanus	Freshwater catfish	1	1	—	1	1	—	—	—	**4**
Craterocephalus stercusmuscarum fulvus	Un-specked hardyhead	140	52	1	—	—	—	—	—	**193**
Ambassis agassizii	Olive perchlet	—	—	11	—	—	—	—	—	**11**
Macquaria ambigua	Yellowbelly	—	18	—	—	—	—	—	1	**19**
Maccullochella peelii peelii	Murray cod	—	3	—	—	—	—	—	—	**3**
Philypnodon grandiceps	Flathead gudgeon	269	245	12	—	—	—	—	—	**526**
Hypseleotris spp.	Carp gudgeons	6981	5242	712	97	25	149	25	—	**13231**
Alien species										
Cyprinus carpio	Carp	976	22	6	73	—	17	13	3	**1110**
Carassius auratus	Goldfish	28	1	—	—	—	1	2	5	**37**
Gambusia holbrooki	Gambusia	2620	631	259	89	6	—	125	—	**3730**
Perca fluviatilis	Redfin	1	18	—	—	—	—	—	—	**19**

Figure 3. Proportional representation of summed totals of all fish sampled in Lake Cargelligo (left) and Booberoi Creek (right) between 2017 and 2020.



In Lake Cargelligo, gudgeons and bony herring were sampled during all surveys (seven), carp and gambusia during six, flathead gudgeon during five, and yellowbelly, redfin and Australian smelt during four. Un-specked hardyhead were sampled during three surveys, Murray cod during two, and both freshwater catfish and goldfish were sampled during one survey.

The population of native fish sampled in Booberoi Creek represented 67% of the total, whereas in Lake Cargelligo native fish comprised 95% of the total.

Comparison with Existing Surveys in the Lachlan Catchment

Two native species (yellowbelly and *Hypseleotris* gudgeons) and three alien species (carp, goldfish and gambusia) have been detected during nine surveys in the mid-Lachlan since 1983 (Tables 1 & 2).

Two native species (bony herring and flathead gudgeon) have been detected during eight of the nine surveys, and two native species (Murray cod and Australian smelt) and one alien species (redfin) have been detected during seven (Tables 1 & 2). Native species detected in fewer surveys include un-specked hardyhead (five surveys), freshwater catfish (four surveys), silver perch (three surveys) and olive perchlet (two surveys; Tables 1 & 2). Southern pygmy perch, flathead galaxias, Murray-Darling rainbowfish, southern purple-spotted gudgeon and trout cod have not been detected by any of the surveys of freshwater fish in the mid-Lachlan (Tables 1 & 2).

Discussion

Fish Records for Unknown or Poorly Known Areas Can Inform Management

River and catchment management relies on accurate records such that decisions can be made in relation to restoration works or the provision of flows that may have ecological benefit. During the monitoring studies presented here, both NSW DPIE and CEWO have used the fish survey results from specific areas to inform the timing and volume of environmental flows (J. Lenehan, DPIE, pers. comm.).

Following the detection of endangered freshwater catfish in Booberoi Creek, environmental flows were directed down this off-river system, and during subsequent sampling events populations of small native species such as un-specked hardyhead and flathead gudgeon were also recorded (Table 1). Subsequent sampling of other off-river creeks such as Wallamundry and Mountain Creeks also found catfish present and may become target areas for future environmental flows (J. Lenehan, NSW DPIE, pers. comm.).

TTable 2. Records of fish species in the mid-Lachlan catchment during surveys undertaken since 1983. Empty squares indicate absence.

Family	Scientific name	Common name	Llewellyn	Harris & Gehrke	Growns	MDBC SRA Pilot Study	Kerezsy	SRA 1 Davies et al.	MDFRC Price	SRA 2 Davies et al.	Recent surveys
			1983	1997	2001	2004	2005	2008	2009	2012	2017–1920
Native species											
Clupeidae	*Nematolosa erebi*	Bony herring		*	*	*	*	*	*	*	*
Retropinnidae	*Retropinna semoni*	Australian smelt	*	*	*	*	*	*			*
Plotosidae	*Tandanus tandanus*	Freshwater catfish	*		*		*				*
Atherinidae	*Craterocephalus stercusmuscarum fulvus*	Un-specked hardyhead	*				*	*	*		*
Ambassidae	*Ambassis agassizii*	Olive perchlet	*								*
Percichthyidae	*Macquaria ambigua*	Yellowbelly	*	*	*	*	*	*	*	*	*
Percichthyidae	*Maccullochella peelii peelii*	Murray cod	*		*	*		*	*	*	*
Terapontidae	*Bidyanus bidyanus*	Silver perch	*	*			*				
Eleotridae	*Philypnodon grandiceps*	Flathead gudgeon	*	*	*	*	*		*	*	*
Eleotridae	*Hypseleotris* spp.	Carp gudgeons	*	*	*	*	*	*	*	*	*
Alien species											
Cyprinidae	*Cyprinus carpio*	Carp	*	*	*	*	*	*	*	*	*
Cyprinidae	*Carassius auratus*	Goldfish	*	*	*	*	*	*	*	*	*
Poeciliidae	*Gambusia holbrooki*	Gambusia	*	*	*	*	*	*	*	*	*
Percidae	*Perca fluviatilis*	Redfin	*	*	*	*	*			*	*

In Lake Cargelligo, the presence of most expected species in the Robinson Crusoe Island area similarly prompted the managers of this reserve (Cargelligo Wetlands and Lakes Council) to ask the water provider (WaterNSW) to consider altering their traditional management of the lake as a storage to also factor in the ecological and social benefits of more regular water delivery (P. Skipworth, CWLC, pers. comm.). The result has been that some water that normally would have flowed down the Lachlan has been diverted through the Lake Cargelligo system, and this appears to have had a positive effect on aquatic fauna (Tables 1 & 2).

In both of these cases, locally sponsored monitoring provided survey results that have then been used by managers to make informed decisions regarding catchment management.

The Biological Relevance of Repeated Sampling in Off-river Habitats

Broad-scale river surveys provide a snapshot of fish community composition in a catchment but are generally restricted to main channel sites, as opposed to lotic or lentic sites that are situated in creeks, lakes and floodplains (Davies et al., 2008; Davies et al., 2012; Price, 2009). Localised sampling has the potential to fill knowledge gaps with regard to catchment fish communities by augmenting broad-scale surveys with monitoring in a wider range of off-river habitat types. Furthermore, the repeated nature of some of this sampling (for example in Booberoi Creek and Lake Cargelligo) may deliver more informative and useful fish community data from which to inform river and water management.

Results from the mid-Lachlan between 2017 and 2020 compare favourably with all previous surveys with regard to species present (Table 2) and suggest that these off-river areas may provide valuable habitat and ecosystem services, particularly as potential refuge or nursery areas (Datry et al., 2017).

The Lake Cargelligo system (Figures 1 & 2) was essentially altered from an ephemeral wetland to a permanent storage from the early 1900s (Kerezsy, 2005). This has created large areas of shallow, open water and provided ideal habitat for pelagic schooling species such as bony herring, Australian smelt and un-specked hardyhead. The numerical dominance of bony herring in this habitat is exemplified by the survey results from 2017 onwards (Table 1), and unsurprisingly, the species also favours the similar lacustrine environment created by the Brewster Weir (Table 1).

In contrast, in the channelised and riverine habitat that occurs in Booberoi Creek (Figure 2), bony herring are uncommon and the community is dominated by small generalists such as gudgeons (*Hypseleotris* spp.) and alien gambusia (Table 1).

Carp are generally present in off-river habitats of the mid-Lachlan. However, it is notable that commercial carp fishers have been operating in Lake Cargelligo since 1 May 2018 and estimate they have removed approximately 180 tonnes of carp from the system in the intervening period (Steve Hounsell, pers. comm). It is therefore possible that sustained carp removal may be contributing to the positive results for all native species recorded from Lake Cargelligo since mid-2018 (Table 1).

Monitoring undertaken in the mid-Lachlan between 2017 and 2020 has confirmed the presence of endangered species such as freshwater catfish in four areas (Table 1) and has similarly confirmed the presence of olive perchlet within the Lake Brewster weir pool (Table 1) following the discovery of this isolated population approximately 10 years earlier (McNeill et al., 2008).

However, five species remain elusive in the mid-Lachlan, despite predictions that they were historically present and may still occur (Davies et al., 2008; Davies et al., 2012). Flathead galaxias (*Galaxias rostratus*), Murray-Darling rainbowfish (*Melanotaenia fluviatilis*), trout cod (*Maccullochella macquariensis*), southern pygmy perch (*Nannoperca australis*) and southern purple-spotted gudgeon (*Mogurnda adspersa*) have not been recorded in mid-Lachlan surveys since 1983 (Table 2), and museum records do not exist for any of these species except for a single record of a rainbowfish from Hillston in 1950 (Amanda Hay, Australian Museum, pers. comm.).

The Longevity and Flexibility Associated with Localised Monitoring Projects

Localised and locally supported fish sampling can be timed to coincide with and/or inform environmental watering events, and can be tailored and expanded to meet desired project management goals where necessary. For example, all of the

sampling that has occurred in Booberoi Creek has been targeted with a view to obtaining before, during and after samples of fish populations relative to the timing and volume of environmental water deliveries (J. Lenehan, DPIE, pers. comm.), and the sampling in Wallamundry Creek was initiated for the same reason. It is envisaged that long-term monitoring of Booberoi Creek is likely to continue (J. Lenehan, NSW DPIE, pers. comm.), and commencing in late 2020, another project aimed at mid-Lachlan creeks in the Forbes/Condobolin area is also planned (Mary Ewing, Lachlan Valley Water, pers. comm.).

In Lake Cargelligo, the local not-for-profit Cargelligo Wetlands and Lakes Council made a decision to continue fish monitoring in the Robinson Crusoe Island reserve area on a regular basis from 2019–2020 onwards. This decision was based on the early fish survey results and the need to create a longer-term dataset upon which to base environmental watering management plans (P. Skipworth, CWLC, pers. comm.).

This flexible approach to sampling and monitoring can have unintended benefits, with a good example being the detection of freshwater catfish in Mountain Creek (Table 1), which was initially sampled (along with the Brewster weir pool) for the purposes of auditing the Lachlan population of the endangered olive perchlet.

Locally sponsored sampling can complement established long-term monitoring projects (Dyer et al., 2019) by expanding the overall sampling area within a catchment and focusing on specific habitats or areas that are beyond the scope of larger projects.

Involvement, Interest and Education of Local Participants

Monitoring that is sponsored and supported by community and/or stakeholder groups – by its very nature – encourages the participation of local communities, and in the mid-Lachlan numerous examples relating to the work that has been carried out between 2017 and 2020 suggest that the flow-on effects regarding community engagement are beneficial.

During two of the Booberoi Creek monitoring events (spring 2018 and spring 2019), fish sampling took place as part of stakeholder engagement weekends/overnight trips that included local landholders, representatives from the local Aboriginal community and government agents (from NSW DPIE and CEWO). The majority of participants – but most notably the landowners – expressed interest (and surprise) at both the variety and abundance of small-bodied native fish, and most commented that although they had lived adjacent to the creek for extended periods, they were somewhat ignorant of (but keen to learn about) the local biodiversity (landowners D. Stewart, J. Ireland, pers. comms).

In April 2019, as part of routine sampling of the Robinson Crusoe Island area sponsored by Cargelligo Wetlands and Lakes Council, two coordinators and six Aboriginal teenagers from the Down The Track youth-at-risk program attended and assisted with both fish sampling and bird counts, as well as staying overnight and helping with general chores associated with bush camping (Figure 4). Coordinator Lana Masterson commented that the participants were all completely engaged with the activities, and – as soon as they were heading back to the 'mainland' by boat – enquired as to when they would be repeating the exercise (L. Masterson, Down The Track, pers. comm.).

Similarly, interest in ecological projects and associated work has become an accepted and possible career/occupation pathway for school-aged students, with one Year 10 student working on fish sampling within Lake Cargelligo as part of the local 'School to Work' work experience program (T. Kendall, careers advisor, Lake Cargelligo Central School, pers. comm.).

The Creation of New Projects Following Initial Engagement

Fish monitoring work undertaken in the mid-Lachlan from 2017 onwards has yielded some encouraging results regarding native fish, particularly for the areas that have been sampled on multiple occasions (Table 1; Figure 3). The communication of results from this work – mainly through informal networks and word of mouth – appears to have had a positive influence within the catchment, and as a consequence, monitoring of other areas, sponsored by different stakeholders, has commenced or will be commencing from 2020.

Figure 4. Members of the Down The Track program for at-risk youth participating in fish sampling at Robinson Crusoe Island, Lake Cargelligo, in March 2020 (Photo: Mal Carnegie).

From mid-2020, the ongoing monitoring of the Robinson Crusoe Island area within Lake Cargelligo will be funded and supported by a partnership between Cargelligo Lakes and Wetlands Council (a local not-for-profit group) and Lachlan Shire Council (P. Skipworth, CWLC, pers. comm.). This is an important development as it indicates that local governments have the ability to contribute positively to community-based projects that have a broad utilitarian goal (i.e. better management of the catchment for the benefit of all parties).

Commencing in spring 2020, a three-year project will commence in the Belubula catchment, and this work will be supported by Newcrest Mining (T. Thornberry, Newcrest, pers. comm.). The Belubula, which rises in high country between Bathurst and Orange and joins the Lachlan close to Gooloogong, can be considered an upstream tributary of the Lachlan, as opposed to the majority of sites discussed and sampled to date (Table 2). However, the Belubula is also poorly known regarding fish communities; thus, there is demonstrated interest from local landholders and government agencies (G. Fitzhardinge, M. Martin, C. Dunhill, J. Sanders, M. Payten, C. Proctor, pers. comms), and the results from these surveys are also likely to contribute to management of both the Belubula and Lachlan Rivers.

In a similar fashion, Lachlan Valley Water – a water users group with a focus on irrigation – will sponsor the aforementioned fish monitoring in another poorly known area of the Lachlan (from Jemalong, downstream of Forbes, to Wallamundry, in the vicinity of Condobolin) commencing in spring 2020.

Lastly, based on the success of the community-based monitoring workshops held at Booberoi Creek (spring 2018 and spring 2019), NSW DPIE is planning to repeat this model (incorporating fish sampling, bird sampling and other ecological information) in the lowland section of the Lachlan in the area close to Booligal, again commencing in spring 2020 (J. Lenehan, NSW DPIE, pers. comm.).

Conclusions

Monitoring specific or targeted areas within a catchment is beset by the same problems that apply to broad-scale monitoring, because not all areas are likely to be sampled, and some important areas will inevitably be missed. However, if this monitoring is supported by a broad range of local and regional groups – as the surveys presented and discussed here have been – the chances of obtaining accurate information that can guide catchment management can certainly be improved.

Contrary to the results from broad-scale riverine surveys (Davies et al., 2008; Price, 2009; Davies et al., 2012), the results from specific areas within the mid-Lachlan (for example Booberoi Creek and Lake Cargelligo) indicate that off-river areas are likely to provide habitat for the majority of extant native species. The importance of these habitats can be confirmed by targeted fish surveys, especially if sampling is carried out on multiple occasions. Replicating surveys such as those documented herein, both within individual catchments and across the M-DB, would undoubtedly provide enhanced records and reliable information upon which fishery and catchment managers can base decisions.

Though desirable, monitoring at these scales is beyond the capacity of state agencies and the MDBA. However, the work cited demonstrates that there is both capacity and intent within local riverine communities to learn about and improve river management with a view to enhancing biodiversity and overall catchment health. The diversity of interested community and stakeholder groups – encompassing a local not-for-profit, a local council, a mining company, an irrigation group, Indigenous owners, and state and federal agencies charged with delivering environmental flows – is indicative, perhaps, of a changing mood within riverine communities in the M-DB, and bodes well for the future.

A bottom-up approach to catchment management, where local and regional people can invest in monitoring programs that seek to document the biota and health of their rivers and waterways, could be an extremely effective way of sharing the considerable load associated with making informed management decisions. The template that has evolved – and is evolving – in the Lachlan catchment in New South Wales could easily be adapted and replicated in other catchments across the M-DB and elsewhere.

Acknowledgements

Special thanks to Jo Lenehan from NSW DPIE for her continued and dedicated work in the Lachlan, and for facilitating much of the sampling and associated work that has occurred between 2017 and 2020. Thanks also to Fiona Dyer and the LTIM/MER crew from University of Canberra, Mal Carnegie from Lake Cowal Conservation Centre, Francis, Damo and Hilton from CEWO, Lachy Nevinson and Dave Matheson from ANGFA, Nathan McGrath (DPIE), Jase, Marty, Luke, Rod and Sam from NSW Fisheries, Keith Bell, Peter and Barb Nilsson, Peter Harris, Dennis and Sue Stewart, Mark Kearines, Jimmy and Jen Ireland (and Steve), Keith and Beth Fisher (especially for the dry night in the shearing shed), Jim and Alison Crossley, Gary Breheny, Craig Cromelin, Robin Carter, Lana, Emma, Katie and the Down The Track crew, Mary Ewing (LVW), Casey Proctor (LLS), Guy Fitzhardinge, Mandy Martin, Charlie Dunhill, Jon Sanders, Michael Payten, Teiya Thornberry and Matt Armstrong (Newcrest), Steve Hounsell, Skippy, Smithy and Leanne, and Alison Wheeler. The author thanks the PRSQ editor and reviewers for their detailed contributions, particularly two reviewers of an earlier version of this paper. All described sampling work was carried out under DPI Scientific Collection Permit P17/0063-1.0 and OEH Animal Research Authority AEC Approval No. 171017/01.

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Author Profile

Adam Kerezsy completed his PhD at Griffith University (Brisbane) on the distribution and recruitment of fish in far western Queensland, and then worked for the not-for-profit Bush Heritage Australia, principally on the conservation of endangered fish at Edgbaston Reserve in central western Queensland. He is the author of many scientific papers and the natural history book *Desert Fishing Lessons: Adventures in Australia's Rivers*. In 2016 he returned to his home in western New South Wales, and now works as a consultant on the ecology of inland rivers and springs in New South Wales and Queensland.

Extracted answers from fillable form above:

Question 4.
The vision should follow section 60 of the Water Management Act 200 with it's priorities for water giving people first, then environment, then stock purposes, then high security licences. The Strategy seems to put the environment towards the end. The strategy should clarify what the word "Right" means in their vision. All living creatures not just people should be provided with a liveable environment. Lake Cargelligo Wetlands listed under Options 27 and 31 should be in the category "Protecting and enhancing natural ecosystem" and not sacrified to water efficiency. Option 6 is not looking at the liveability of the whole of the Lachlan, as transferring water out of the catchment to another region means there is less water for the length of the Lachlan catchment .Critical water planning in the past had seen restriction of flows, seeing no water available for anything below Condobolin, causing severe hardship. It is contrary to the Lachlan Draft Regional Water Strategy's objectives and vision. Water quality is improved by riparian zones and pipelines degrade biodiversity in the catchment. Options 31 and 27 would reduce riparian zones, reduce biodiversity particularly the movement of native fish (Kerezsy 2020). water quality has increased since State Water has run water into, through and out of Lake Cargelligo wetlands as have cumbungi and other water plants. Economic prosperity is to a large extent (apart from agriculture) cause by tourism at Lake Cargelligo as people enjoy boating, fishing, birdwatching, swimming and enjoy the wetlands. The Lachlan Environmental Management Plan listed it as a significant wetland in the Lachlan landscape. the DRWS sees our Lake Cargelligo wetland as a storage and refers to "separation of the main lake at Cargelligo into three". It does not even recognise its true name as Lake Cargelligo. The spiritual significan of living beside 3 dams is significantly different to living beside a large wetland. The ecology, environment, tourism and economic prosperity would decrease. Options 27 and 31 do not assist to sustain resources in the future and will destroy the regionally significant environment asset of Lake Cargelligo Wetlands, which was proclaimed a Bird and Wildlife Sanctuary in 1935. No details of the cells/pipelines or financial cost has been supplied, however the environmental, social and cultural cost is too high for Lake Cargelligo.

Question 5A.

It does not appear that the Cargelligo Wetlands & Lakes Council were consulted concerning Lake Cargelligo Wetlands and this water strategy. I think the wetlands at Lake Cargelligo should be recognised as a wetland in the strategy. Dr Adam Kerezsy (2020) has provided scientific evidence to indicate it is critical a environment for fish and aquatic life. Birdlife Australia recognises it as a place where threatened birds survive and the wetlands are included on international birdwatching sites.

Question 5B.

Kerezsy, A. (2005). The distribution and abundance of fish in theLake Cargelligo system, New south Wales. Honours Thesis, charles Sturt University, Wagga

Kerezsy, A. (2020). the benefits of community stakeholder driven fish monitoring projects in a Murray-Darling Basin river, Proceedings of the Royal Society of Queensland, 128, 57-71

community engagement in Lake Cargelligo has been extremely poor, apparently the Department PI&E held a public meeting about this strategy to which only 1 person attended. They obviously did not engage. Why was not the Cargelligo Wetlands & Lakes Council Inc targeted as an organisation who could provide information on the Lake Cargelligo Wetlands? It should be viewed as a peak body by the department for this strategy.

Question 7B.
The risk to the Lake Cargelligo wetlands and Robinson Crusoe Island is extreme if dams/cells and pipelines are constructed degrading the environment reducing biodiversity, social cultural, economic and agricultural values. Agriculture, horticultural and mining industries could be regulated to rely on water re-use (waste sewerage, drainage water and storm water) recycling and waste management. People (domestic and town water supply)first, environment, stock purposes and then high security licences should continue. Lake Cargelligo wetlands should be protected and enhanced not dammed and piped. The strategy is an opportunity to ensue any Water Sharing Plan recognizes Lake Cargelligo wetlands for a wetland and pursue a water allocation for it and ensure water continues to flow into, through and out of it. If Option 27 and 31 and 6 go ahead the wetlands will be degraded. The strategy is an opportunity to give it environmental water.

Question 8B.
Water to some extent dictated the types of land use when water licences were attached to the land. Since water was taken away from the land large scale pursuits (such as force feeding of almonds, etc) have occurred.
Reuse recycle and stormwater projects could help towns and industry with water requirements
Improved data and collection and storage can only assist as long as it is monitored and scientifically done.
shared benefit project (environmental and cultural outcomes) can only be good
Water quality treatment works upgrades are a health issue and should be carried out.

Question 8D.
dividing a natural lake into 3 dams is contrary to the aims of the water Management Act 2000 in that it causes degradation of a natural resource and environment

Pipelines instead of natural waterways reduce riparian values and the environment and all living creatures.
Transfer of water to another catchment increases the risk of water supply failing in the Lachlan catchment and I am opposed to this. Sacrificing the mid and lower Lachlan by piped schemes along natural creeks and perhaps linking to other southern rivers can only deplete the environment and reduce liveability for people and all living things.
In-stream storage for the Lower Lachlan may mean less water in the Lake Cargelligo Wetlands. It is difficult because no specific plans have been shown so it is hard to decide.

Question 8E.
Consultation has been extremely poor to the Lake Cargelligo community. The strategy when I read it contained no details of the specific options so it is difficult to make informed decisions. For instance if it contained 3 cells could people walk along them, get to robinson Cruseo Island (which contains significant evidence of Aboriginal people in the past, shell middens, tools and also contains cultural history from early European settlement, the remains of a dixie hall (where boatloads of people were ferried across the lake from various points to dance).