

Murray–Darling Basin Environmental Water Knowledge and Research Project

Multi–Year Research Plan — Addendum 2017/18

Prepared by: The Murray–Darling Freshwater Research Centre



June 2017

Final Report

MDFRC Publication 152



Murray–Darling Basin Environmental Water Knowledge and Research Project Multi-Year Research Plan 2016–2019 – Addendum 2017/18

Final Report prepared for the Department of the Environment and Energy by The Murray–Darling Freshwater Research Centre.

Department of the Environment and Energy
GPO Box 787
Canberra ACT 2601
Ph: (02) 6274 2710

This report was prepared by The Murray–Darling Freshwater Research Centre (MDFRC). The aim of the MDFRC is to provide the scientific knowledge necessary for the management and sustained utilisation of the Murray–Darling Basin water resources. The MDFRC is a joint venture between La Trobe University and CSIRO. Additional investment is provided through the University of Canberra.



For further information contact:

Jessica Davison

The Murray–Darling Freshwater Research Centre
PO Box 821
Wodonga VIC 3689
Ph: (02) 6024 9645; Fax: (02) 6059 7531

Email: j.davison@latrobe.edu.au
Web: www.mdfrc.org.au
Enquiries: mdfrc@latrobe.edu.au

Report Citation MDFRC (2017) Murray–Darling Basin Environmental Water Knowledge and Research Project: Multi-Year Research Plan 2016–2019 – **Addendum 2017/18**. Final Report prepared for the Department of the Environment and Energy by The Murray–Darling Freshwater Research Centre, MDFRC Publication 152/2017, June, 20 pp.

Cover Image: *Cherie Campbell, Rebecca Durant and Fiona Freestone Mesocosm site, Wonga Wetlands*

Photographer: Ben Gawne

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Document history and status

Version	Date	Reviewed By	Approved by	Reviewer/s
Draft V1	20 May 2017	Ben Gawne, Jessica Davison	MDFRC	Internal
Draft V2	22 May 2017	Ben Gawne, Jessica Davison	MDFRC	Internal

Distribution of copies

Version	Quantity	Date Issued	Issued to
Draft	1 x PDF	23 May 2017	Anthony Moore and Nadia Kingham, Department of the Environment
Final	1 x PDF	11 July 2017	Anthony Moore and Nadia Kingham, Department of the Environment

Filename and path: G:\SHE - Life Sciences\MDFRC\Projects\DSEWPC\465 MDB EWKR\PROJECT MANAGEMENT\PHASE 2 DELIVERABLES\2017-18 Milestones and Final Documents\MYRP Addendum\FINAL

Author(s): The Murray–Darling Freshwater Research Centre

Author affiliation(s): The Murray–Darling Freshwater Research Centre, La Trobe University, and CSIRO

Project Manager: Jessica Davison

Client: Department of the Environment and Energy

Project Title: Murray–Darling Basin Environmental Water Knowledge and Research Project: Multi-Year Research Plan 2016–2019 – **Addendum 2017/18**

Document Version: Final

Project Number: M/BUS/465, 17/00895

Contract Number: N/A

MDB EWKR: Multi-Year Research Plan 2016–2019 – **Addendum 2017/18**

Finalised July 2017

Acknowledgements:

The Murray–Darling Freshwater Research Centre offices are located on the land of the Latje Latje and Wiradjuri peoples. We undertake work throughout the Murray–Darling Basin and acknowledge the traditional owners of this land and water. We pay respect to Elders past, present and future.

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1 Introduction

The Murray–Darling Basin Environmental Water Knowledge and Research (MDB EWKR) project is a 5 year (to 2018–19), \$10 million project to improve the science available to support environmental water management, and thereby contribute to achieving Basin Plan objectives.

This document is the 2017/18 addendum to the Murray–Darling Basin Environmental Water Knowledge and Research Project Multi-Year Research Plan (MYRP) 2016–2019 (MDFRC Publication 129 - 2016) and provides updates to sections of the MYRP where details of the plan have been reviewed and updated in light of further research and analysis in 2016-17.

Updates are provided for all four themes:

- Vegetation
- Fish
- Waterbirds
- Food Web

This approach has been adopted to allow the MYRP to be updated from year to year to reflect minor refinements without the need for major rewriting, as it is anticipated that the majority of the plan will remain current from year to year for the life of the project.

This Addendum 2017/18 should be read in conjunction with and as part of The Murray–Darling Basin Environmental Water Knowledge and Research Project MYRP 2016–19 (MDFRC Publication 129 - 2016).

2 Vegetation

Authors: Cherie Campbell (MDFRC), Sam Capon (Griffith University), Cassandra James (James Cook University), Kay Morris (Arthur Rylah Institute), Jason Nicol (SARDI), Daryl Nielsen (MDFRC), Rachael Thomas (NSW OEH)

2.1 Abstract of Progress Report

In 2016/17, the Vegetation Theme completed (with final outputs on the way) the conceptualisation phase and used this information to refine research components. The Annual Research Plan (ARP) and MYRP were updated accordingly (December 2016 ARP and MYRP update). One of the key outcomes from the conceptualisation work was the development of a Vegetation Response Framework. This framework helps to define and consider vegetation responses across multiple scales of organisation (e.g. species, communities, vegscapes), multiple types of vegetation traits (e.g. compositional, structural and process) and link responses to the functional role of vegetation and the nested, temporal role of flow regimes. The conceptual framework was presented to the MDB EWKR SAG, the Australian Society for Limnology Conference and water managers (at EWAG and Long-term Watering Plan meetings).

Research continued for Component V2 'Data integration and synthesis' with the collation of data, meetings with data custodians, other stakeholders and hydrologists, and pilot analysis of a sub-set of data. The first year's field work was successfully completed for Component V3 'Field site assessments'. This involved extensive collaboration with water managers, land managers and private land owners during the site selection phase and extensive collaboration between the vegetation theme leadership group to finalise the field methodology. Field work has been completed at all four MDB EWKR field locations and involved the collection of data from more than 150 sites. Seedlings mesocosm experiments have also been completed for Component V4 'Mesocosm studies'. These experiments assessed the response of four woody species to five different water regimes for a period of approximately six months.

Sub-contracts for the collaborators involved in the Research Activities and the Leadership Group have been finalised. An extensive number of meetings and communication activities were undertaken.

2.2 Identify new opportunities relevant to research

There is interest from the Murray-Darling Basin Authority about links between Basin Plan reporting requirements for vegetation and research within the Vegetation Theme – particularly in regards to Lignum and non-woody vegetation. To date this has involved meetings, emails and phone conversations however there may be further opportunities in 2017/18. A number of potential student projects have been identified by members of the leadership group. To date these projects have not been realised however opportunities will continue to be sort in 2017/18.

2.3 Changes

Any changes required to activities scheduled to occur in 2017/18 or 2018/19 are documented below. Activities completed in 2016/17 are not included here. Where those activities were notably different from what was described in the MYRP the changes have been or will be captured in progress and component reports.

2.3.1 Component V1 – Conceptualisation

Activity V1.3 – Reporting

Unchanged

2.3.2 Component V2 – Data integration and synthesis

Activity V2.3 – Data analysis

The completion date for the data analysis has been extended from the end of October 2017 (as reported in the MYRP – December 2016 update) to the end of December 2017. This component is being led by Cassie James who is currently on maternity leave.

Activity V2.4 – Reporting

The completion date for the reporting has been extended from the end of May 2018 (as reported in the MYRP – December 2016 update) to the end of June 2018. This component is being led by Cassie James who is currently on maternity leave.

2.3.3 Component V3 – Field site assessments

Activity V3.2 – Field surveys

Unchanged except for the clarification that the second round of field surveys will occur in autumn 2018.

Activity V3.3 – Reporting

Unchanged

2.3.4 Component V4 – Mesocosm studies

Activity V4.3 – Reporting

Unchanged

3 Native fish

Authors: Amina Price (MDFRC), Stephen Balcombe (Griffith University), Lee Baumgartner (CSU), Paul Humphries (Charles Sturt University), Alison King (Charles Darwin University), Brenton Zampatti (SARDI)

3.1 Abstract of Progress Report

In 2016/17, the Fish Theme had all literature and synthesis work completed (with final outputs on the way) and held a 3-day workshop to present and discuss the major outcomes from the Foundational Stage. Information from the workshop and synthesis work has been used to identify and prioritise knowledge gaps. Based on this, research plans were developed and the MYRP was updated accordingly (December 2016 update). One of the key outcomes from the conceptualisation work was the development of a River Ecosystem Recruitment Conceptual Model. This model predicts recruitment based on food, temperature and predation for species with different fish life-history strategies as a function of flow and geomorphic complexity.

Research commenced for Activity 2.3 'Multi-scale assessment of the spatial heterogeneity in the thermal and nutritional landscape'. The first year's field work was successfully completed for Activity F2.3.1 'Comparison of the thermal and nutritional regimes among main channel and floodplain habitat patches'. In addition, analysis was completed for Activity F2.3.3 'Preliminary assessment of the influence of structural habitat on prey composition and density'.

Sub-contracts for the collaborators involved in the Research Activities and the Leadership Group have been sent off and work has commenced on Activities F2.1 'Understanding the feeding requirements of larval fish in the northern Murray-Darling Basin', and F2.5 'Basin-scale population dynamics of golden perch and Murray cod: relating flow to provenance, movement and recruitment in the Murray-Darling Basin'.

3.2 Identify new opportunities relevant to research

There is significant interest from the North East CMA to work with the Fish Theme as part of their 'Our Catchment Our Communities - Lower Ovens' Project. To-date this has involved membership of the project steering committee but there may be further opportunities in 2017/18.

3.3 Changes

3.3.1 Component F1 – Foundational activities

Activity F1.1 – Fish Recruitment Conceptualisation

At the Fish Theme Workshop in March 2017 the dates for the final outputs from the three synthesis activities were discussed and revised. The revised dates for completion are:

- Theoretical synthesis: The paper will be submitted in August 2017.
- Knowledge and management of fish and flows in the MDB: Report will be submitted by May 2017 and the associated publication will be submitted by mid-year.
- Non-flow related threats/foundational synthesis paper: The focus of this paper was discussed by the Leadership Group and it was agreed that the paper would concentrate on the non-flow related threats. This was because the Leadership Group believed that the

Theoretical synthesis would describe the influence of flow and that it was important to put the influence of flow within the context of the influence of other stressors on the system. This approach aligns with MDB EWKR objectives to improve understanding of other stressors and will also help managers adapt their expected outcomes from environmental flows. The paper will provide a summary of current thinking regarding our capacity to influence fish recruitment using e-flows and recommendations regarding complementary actions. There would be a brief introduction referring to the current management context and drivers of fish recruitment. Consequently, this paper will not be submitted until after the previous two have been accepted.

3.3.2 Component F2 – Research activities

Activity F2.1 – Understanding the feeding requirements of larval fish in the northern Murray-Darling Basin (Griffith University)

This Activity is unchanged apart from clarification of the relationship between the EWKR work and the work that DSITI is doing. This project is no longer described as a joint project but rather, the EWKR work will complement work that will be undertaken by DSITI.

Activity F2.2 – Examination of the relationship between food density, temperature and early-life stage growth and survival (MDFRC)

Unchanged

Activity F2.3 – Multi-scale assessment of the spatial heterogeneity in the thermal and nutritional landscape (MDFRC and CSU).

Unchanged

Activity F2.3.1 – Comparison of the thermal and nutritional regimes among main channel and floodplain habitat patches

Unchanged

Activity F2.3.2— Examination of variability in food density and larval abundance at the river segment, reach and riverscape scales

The approach that is being undertaken for this activity has changed significantly and consequently, the Activity is now entitled 'Identification of optimal thermal and nutritional zones, and the scales at which they function within a lowland river system'. Rather than the sampling design being based on arbitrary spatial scales (reach, segment and riverscape scales), the design will now be based on testing hypotheses regarding the location and scale of fish recruitment functional zones.

There are a number of existing river ecosystem models which attempt to explain sources of energy (C), sources of nutrients (N & P) and the nature of storage, transport & transformation of material and energy in riverine ecosystems. These include the River Continuum Concept, the Serial Discontinuity Concept, the Flood Pulse Concept, the Riverine Productivity Model, the Riverine Ecosystem Synthesis and the River Wave Concept. These models were reviewed and synthesised as part of the Foundational Work. We will use these existing models to generate hypotheses regarding areas of nutrient and carbon concentration and retention within riverine systems. Given that the processes underpinning concentration and enrichment are believed to operate at different spatial scales, these functional zones are likely to vary in scale. Consequently identification of the appropriate scales for management will still be outcomes from this Activity.

This approach represents a significant improvement because:

- it focuses on the scales at which processes underpinning recruitment occur, rather than arbitrary scales
- it is firmly based in existing theory and science regarding river ecosystem functioning and will build on the work undertaken in the Foundational Stage
- it will provide us with greater ability to test key aspects of the conceptual model that was developed in the Foundational Stage.

Activity F2.3.3 — Preliminary assessment of the influence of structural habitat on prey composition and density

Unchanged

Activity F2.4 — Investigating the relationship between flow, structural habitat, hydrodynamics and patterns larval settlement and retention (CSU and MDFRC).

Unchanged

Activity F2.5 — Basin-scale population dynamics of golden perch and Murray cod: relating flow to provenance, movement and recruitment in the Murray-Darling Basin (SARDI).

Preliminary planning following the \$100,000 budget reduction for this Activity has suggested that it may not be possible to undertake all of the work that was proposed in the original project description. However, until a detailed project plan and associated budget is developed it will not be clear to what extent the original plan will have to be modified. A detailed project plan and budget cannot be produced until:

- the full project team has met to discuss what samples are available from what sites
- the degree to which water chemistry varies across the Murray-Darling Basin.

Consequently, this Activity will occur in two stages. Stage 1, the initial planning and preliminary analyses of water samples will be completed by November 2017 and Stage 2, Basin-wide collection and analysis of otoliths. Stage 2 will most likely be undertaken in collaboration with CEWO LTIM fish sampling in Autumn 2018. Stage 1 will comprise:

- Sr analysis of existing northern Basin water samples: Conduct $^{87}\text{Sr}:$ ^{86}Sr analysis of ~40 water samples collected in 2015/16 and 2016/17 from rivers in the northern MDB to determine spatio-temporal variability in water $^{87}\text{Sr}:$ ^{86}Sr as a precursor to fish otolith Sr investigations
- Project Planning Workshop: Workshop of the key project participants to determine final project design and contemporary field projects that can contribute data to Stage 2 of the project
- revision of Research Plan: Revise research plan (including budget) in light of above activities and available budget (\$400K).

3.3.3 Component F3 – Swimming capacity, settlement cues and environmental tolerances of the early life stages of Murray-Darling Basin fishes (student projects)

Activity F3.1: Investigating swimming capacity and environmental tolerances of the early life stages of Murray-Darling Basin fishes (2016-2018)

This project is no longer going ahead as the student decided on a change of focus for his PhD. The Leadership Group decided that the money that had been allocated to this project should be kept either for strategic funding (e.g. providing extra support to a project if needed) or could possibly be used to support honours students. If the money was used to support honours students then the student projects will be linked to existing EWKR project activities.

Sub-component F3.2: Water infra-structures and challenges for fish conservation: Larval trait-based analysis to foresee fish recruitment in regulated rivers (2016-2018)

Unchanged

3.3.4 Component F4 – Synthesis and model development and management

Unchanged

4 Waterbirds

Authors: Heather McGinness (CSIRO), Kate Brandis (UNSW), Veronica Doerr (CSIRO), Richard Kingsford (UNSW), and Ralph Mac Nally (University of Canberra)

4.1 Abstract of Progress Report

The nests of three species are being monitored by cameras: Australian White Ibis, Straw-necked Ibis, and Royal Spoonbill. Every camera location is GPS marked and mapped. Three camera types are being used, each collecting slightly different data. There are two main categories of data collected by cameras:

1. Egg and chick counts over time, yielding hatching rates and fledging rates (nest success).
2. Bird behaviour and predation.

Monitoring camera images are primarily processed manually, with data extracted visually and entered into standard spreadsheets. Data extraction has been completed and analysis has begun.

On-ground monitoring of tagged nests is occurring during breeding events at fortnightly intervals. The nests of three species are monitored in Barmah-Millewa Forest: Australian White Ibis, Straw-necked Ibis, and Royal Spoonbill. Nest clumps are marked with yellow cattle eartags, and individual nests are marked with sheep eartags. During each visit, the number of eggs and chicks at each age stage is recorded, together with water depths. Data analysis is underway.

Colony maps will be produced based on nest clump GPS locations and GPS tracks after the data processing for on-ground tagged-nest and water depth monitoring is complete. Drone colony mapping was completed in mid-late December and processing has begun.

The MDB EWKR project funded purchase and maintenance of 20 GeoTrak ARGOS GPS tracking transmitters in the 2016-17 breeding season – 10 for adult straw-necked ibis, and 10 for juveniles, with hourly location fixes and at least two years longevity. A further 20 or more transmitters will be deployed in the 2017-18 season, subject to Animal Ethics Committee approval.

The transmitters record hourly GPS location fixes between 7am and 7pm, plus a midnight fix to record roosting/nesting locations. They have an accuracy of approximately 10 metres. They are solar-charged, and are expected to transmit for at least two years. Location fixes are recorded and stored for 36 hours, and then transmitted during an 8-hour window via the ARGOS satellite system.

While the plan was to deploy all MDB EWKR transmitters in Barmah-Millewa forest this year, the Waterbird Theme leadership group decided that with the large breeding event occurring in the Macquarie Marshes, it would be worthwhile to deploy 5 GeoTrak ARGOS transmitters on adult ibis in the Macquarie Marshes (and the remainder in Barmah-Millewa). These will provide managers with information on individual bird movements in and around the Marshes, dispersal routes and stopovers after breeding, and potential natal philopatry. The breeding provided an opportunity to gain information about where ibis from the Marshes go vs where ibis from the Barmah-Millewa go in the same year. The CEWO funded the additional fieldwork necessary for deployment of transmitters in the Macquarie Marshes.

Five satellite GPS transmitters were deployed on adult straw-necked ibis in the Macquarie Marshes, while five were deployed on adults and ten were deployed on juveniles in Barmah-Millewa Forest. Each bird was fitted with ABBBS leg bands, weighed and measured for bill and head+bill length.

Tracking of straw-necked ibis from the northern and southern basin has already advanced our knowledge of previously unknown or poorly understood ibis movement and population patterns and trends.

Foraging habitat and behaviour surveys were conducted at sites at which tracked birds spent significant periods foraging, and at other opportunistic sites at which straw-necked and Australian white ibis were observed foraging.

Birds were monitored with telescopes and/or binoculars for five minutes continuously. The number of food capture attempts and successes in that period were recorded, together with the date, time, location GPS, total time monitored, total time the bird spent foraging in that location vs resting, roosting, preening and other behaviours.

4.2 Identify new opportunities relevant to research

1. Macquarie Marshes satellite transmitter deployment as above:

While the plan was to deploy all MDB EWKR transmitters in Barmah-Millewa forest this year, the Waterbird Theme leadership group decided that with the large breeding event occurring in the Macquarie Marshes, it would be worthwhile to deploy 5 GeoTrak ARGOS transmitters on adult ibis in the Macquarie Marshes (and the remainder in Barmah-Millewa). These provide managers with information on individual bird movements in and around the Marshes, dispersal routes and stopovers after breeding, and potential natal philopatry. The breeding event provided an opportunity to gain some information about where ibis from the Marshes go vs where ibis from the Barmah-Millewa go in the same year. The CEWO funded the additional fieldwork necessary for deployment of transmitters in the Macquarie Marshes.

2. Citizen science funding application submitted:

In response to a need for more real-time and on-ground information on the characteristics of the foraging habitats used by the MDB EWKR tracked waterbirds across the entire Murray-Darling Basin and beyond, the Waterbird Theme submitted an application for funding for a Citizen Science project to the Inspiring Australia - Science Engagement Programme, Commonwealth Department of Industry, Innovation and Science.

The idea of the project is that to inform optimisation of waterbird habitat management, scientists from CSIRO and collaborators will engage with local communities in scientific surveys of waterbirds and their habitats, data management, and interpreting and communicating results. At least 50 sites from across regional eastern Australia will be surveyed monthly, with site selection based on satellite tracking of waterbird movements and historical volunteer surveys. Data will be used to analyse changes in waterbird habitats and communities and to inform prioritisation of sites for water and land management.

3. Tracking waterbirds from the Narran Lakes:

Discussions with CEWO have indicated some interest in tracking movements of iconic waterbird species in the Narran Lakes, should a breeding event occur there and funding be available at the time. Several potential species were flagged for both scientific and cultural interest, including brolgas, magpie geese, egrets, royal spoonbills and yellow-billed spoonbills. There may be

potential for purchase of tracking devices prior to confirmation of a flooding event, in order to be ready for deployment. Tracking devices need to be ordered at least three months in advance of deployment dates, preferably more.

4. Developing a proposal for funds to track additional species:

This is a new proposal to track a species that is representative of a dominantly water-foraging bird guild E.g. Royal spoonbills. Data from these species would complement the Ibis tracking data as Royal spoonbills nest with ibis and (probably) respond to the same flow triggers, but have different foraging habitat requirements. It would be cost-efficient to do this during next season's straw-necked ibis tracker deployment(s).

5. Goulburn-Broken Catchment Management Authority (GBCMA) nesting habitat modification experiment: nesting habitat characteristics and preferences and how they affect breeding initiation and success:

GBCMA are planning an experiment in Boals Deadwoods (Barmah) that involves clearing holes in areas of giant rush that have been invading and filling in the wetland, to see if birds will select those places to nest. The hypothesis is essentially that ibis and spoonbills prefer 'water views' in Barmah-Millewa and that therefore the giant rush invasion explains declining nesting numbers and frequency in Boals. This experiment is relevant to the EWKR Waterbird Theme component focusing on nesting habitat characteristics and preferences and how they affect breeding initiation and success. The Waterbird Theme will be collaborating with GBCMA by assisting with monitoring camera deployment at the experimental sites and at control sites. The monitoring cameras will document bird arrivals, nesting activity and nesting success at both 'treatment' and 'control' sites, allowing an initial evaluation of the effectiveness of habitat modifications to encourage breeding.

4.3 Changes

The Waterbirds Theme addresses critical knowledge gaps that were identified through consultation with environmental water managers and scientists, and review of existing literature.

These include:

Where and what are the critical foraging habitats during and after breeding events that support recruitment? How might these be affected by water management and threats such as habitat change?

Flow regimes, water management and threats such as habitat change and habitat loss affect the availability (quantity and distribution) and quality of foraging sites at multiple scales. These, in turn, will affect the survival of young birds and consequently recruitment. However, data describing waterbird foraging preferences, locations and movements (and how these affect survival) are scarce, limiting our ability to predict the effects of changes in water management and threats to habitat. The high-level questions of relevance for management that this research will address are:

1. Where do juveniles and adults forage *after* a breeding event?
2. Where do adults forage *during* nesting (where are they getting the food for the chicks?)
3. How can environmental flows be managed to better support foraging habitats?

Comment: In the first year, we have limited data to answer Question 2 above, because only two birds definitely continued to nest or re-nest post-capture (others may have but we can't be sure). If birds with trackers survive until subsequent breeding events this will allow more data collection. However most adults leave the nesting area after capture and tagging.

What are critical nesting habitat characteristics we need to maintain and how do these affect recruitment? How do water and vegetation management and threats, such as predation, interact with nesting habitat characteristics to affect recruitment?

This research aims to produce information that will allow managers to better target water, vegetation and feral animal management actions to ensure 'event readiness' at nesting sites between flooding events and to maximise recruitment during flooding events. Maximising recruitment of young colonial waterbirds into the adult population necessarily depends on maximising the number of birds that fledge from each nesting colony. Management for protection and maintenance of nesting habitat both between and during flood events is critical. However, recent declines and losses of colonies have raised questions concerning the influence of nesting habitat management, type, condition, and configuration on species site choice, predation impacts, nest success and eventual recruitment.

The questions of relevance for management that this research will address are:

1. Do nesting habitat characteristics affect accessibility to predators (e.g. vegetation type, nest position, water level) and therefore the number of fledglings produced?
2. Do nesting habitat characteristics influence exposure of chicks to extremes in temperature or weather, and therefore the number of fledglings produced?
3. How can environmental flows be managed to better support nesting habitats?

The research outcomes for the Waterbirds Theme will inform recommendations for environmental water planning, prioritisation and management and other natural resource management actions at local to basin scales. Specifically, this research will provide improved understanding for land and water managers of:

- locations and characteristics of critical foraging habitats for adult and juvenile colonial-nesting waterbirds both during and between breeding events.

In the first year, we have limited data to answer questions of foraging locations DURING nesting, because only two birds definitely continued to nest or re-nest post-capture (others may have but we can't be sure). If birds with trackers survive until subsequent breeding events this will allow more data collection. However most adults leave the nesting area after capture and tagging.

- the required extent and duration of inundation of foraging habitats around nesting sites to support recruitment.

See above comment re. during nesting.

- where juveniles and adults go after fledging/breeding, and if juveniles return to their natal site.

In the first year, the juvenile mortality rate was 100%. While tracking data can be used to document where they go after fledging, it will not be possible to establish whether these birds would have returned to their natal site.

- waterbird diet composition, quality, and changes over time (with the Food Webs Theme).

Logistical issues have prevented collection of regurgitate samples for analysis of diet quality. UNSW Honours student Emily Webster has analysed the content of scat samples from chicks, however the usefulness of these data was limited and this will not be repeated. A new plan for a collaborative bioenergetics project has been designed for the 2017-18 breeding season. More detail is described in the section for Sub-Activity B2.3.2 in the 2017-18 Annual Research Plan

- how nesting habitat characteristics influence the numbers of fledglings produced, including whether physical accessibility to predators (nest position, water level) affects fledging rates, and how much nesting habitat influences exposure of chicks to extremes in temperature or weather
- how water and vegetation management and threats such as habitat loss and predation interact to affect recruitment.

4.3.1 Component B2 – Field Research

Activity B2.3 – 2017–18 field research

Activity B2.3 will involve essentially the same activities as those conducted during the previous year, with modifications based on results to-date. These are described below.

Sub-Activity B2.3.1 – Preparation and equipment purchase

Objective

To prepare for field data collection activities.

Description

- engagement with stakeholders (e.g. travel, phone meetings)
- animal ethics applications, amendments, meetings and reporting (CSIRO, University of NSW)
- scientific licence applications, meetings and reporting (CSIRO, University of NSW)
- volunteer/student/staff engagement and management (CSIRO, University of NSW)
- equipment purchase and setup (CSIRO, University of NSW)
- revision of bird capture and satellite device attachment methods including bird harnesses (CSIRO, University of NSW).

Outputs

- equipment ready for use in field data collection
- fieldwork planned and ready to implement.

How will the output(s) be used?

Outputs will prepare the theme staff for conducting field data collection (*B2.3.2*) and other research activities.

Sub-Activity B2.3.2 — Field data collection

Objective

- to collect field data describing waterbird recruitment and movement and their drivers.

Description

A minimum of three main field data collection trips are planned for the summer of 2017–2018, most likely in either Barmah–Millewa Forest or the Macquarie Marshes (CSIRO and University of NSW). If bird breeding occurs at both sites, satellite tagging and banding of waterbirds may be conducted at both sites. Site selection for other activities, such as camera deployment, will be based on the nature of the flooding and breeding events in each location (e.g. species, event size, accessibility and other logistical issues), and the comparative quality of the data obtainable.

1. At breeding initiation (nest building or egg-laying):
 - fieldwork preparation and packing
 - capture, satellite tagging and banding of adult waterbirds
 - colony mapping
 - nest tagging and egg counts
 - surveys of nesting habitat characteristics
 - motion-sensing/time-lapse camera installation
 - data collation/entry.
2. During breeding (chicks):
 - fieldwork planning, preparation and packing
 - colony mapping
 - nest tagging and egg and chick counts
 - surveys of nesting habitat characteristics
 - motion-sensing/time-lapse camera maintenance and downloads
 - chick allometry measurements
 - data collation/entry.
3. At the end of the breeding event:
 - fieldwork planning, preparation and packing
 - capture, satellite tagging and banding of juvenile waterbirds
 - chick/juvenile allometry measurements
 - colony mapping
 - nest tagging and egg and chick counts
 - surveys of nesting habitat characteristics
 - motion-sensing/time-lapse camera collection and downloads
 - data collation/entry
 - communications.

Other minor fieldtrips may also be required, depending on: (i) which species breed, where, and when; (ii) if circumstances change in terms of breeding event timing, size, location, and success; and (iii) if time-lapse and motion-sensing cameras require maintenance more frequently than anticipated (e.g. changing batteries and memory cards).

Following consideration of the outcomes of the 2016-17 fieldwork, the following changes are planned for the 2017-18 field season:

- Discontinuation of on-ground foraging habitat surveys. Instead, foraging habitats will be described using a combination of existing mapping and remote sensing data. Foraging efficiency and habitat surveys were conducted last season, but with limited opportunities. In particular, it was difficult to locate foraging birds during the nest season as intended, when time was available for surveys. The tracked birds did not remain in the area for long enough for the team to use their locations. In addition, to be useful, foraging habitat data ideally need to compare foraging sites with non-foraging sites. A Citizen Science grant proposal has been submitted in collaboration with the MDFRC, also incorporating some broilga work in NW VIC, in order to support local surveys of foraging habitats where tracked birds are located across the Murray-Darling Basin.
- Discontinuation of regurgitate and scat sample collection for diet/bioenergetics research. Instead, bioenergetics will be modelled based on chick allometry (weights and measurements at two different ages), a literature review and data for similar species from overseas. Logistical issues have prevented collection of regurgitate samples for analysis of diet quality. Sampling for regurgitates was unsuccessful, with the UNSW Honours student unable to obtain samples from chicks. UNSW Honours student Emily Webster has analysed the content of scat samples from chicks, however the usefulness of these data was limited and this will not be repeated. An MDFRC summer student tested a method of extraction of feeding frequency data from the previous year's cameras. Methods and issues were identified that will inform analyses from this year's images from the new cameras. A new plan for a collaborative bioenergetics project has been designed for the 2017-18 breeding season – see the Food Web theme research plan for more detail.
- Earlier camera deployment at known nesting clumps used by birds in the past two seasons, potentially before birds arrive and lay eggs, in order to reduce the number of disturbances during nesting.
- Ceasing camera deployment and image analysis when chicks are at 'flapper' stage. At this age onward, it is too difficult to tell which nest chicks come from – particularly for ibis.
- Changes in the total numbers of waterbirds to be tracked and addition of a second species to be tracked. Combining recovered transmitters from last season, discounts, efficiencies and purchase of some cheaper transmitters, it will be possible to expand the number of transmitters to be deployed in the 2017-18 season. Following extensive exploration of various options, the Waterbird Theme leadership has decided the following (subject to approval of the relevant Animal Ethics Committee):
 - Juveniles will be tracked again in order to facilitate data analyses describing recruitment outcomes and drivers of mortality i.e. if we really want to boost recruitment, at the moment the greatest scope seems to be through boosting juvenile survival.
 - Where possible, smaller/lighter transmitters will be used and older juveniles will be caught
 - Argos Geotrak type satellite transmitters will be deployed on juveniles, in order to enable establishment of individual fates (these transmitters have full Australian and worldwide coverage)
 - GSM phone network transmitters will be deployed on adults for long-term data collection – if the appropriate technology is ready for the networks available by mid-2017. Otherwise Geotrak Argos type transmitters will be used (but fewer).
 - More juveniles will be tracked than adults (if approved by animal ethics committee)
 - If circumstances allow (flooding, breeding and accessibility), two species will be tracked: straw-necked ibis and royal spoonbills. Royal spoonbills are more dependent on surface water for foraging than straw-necked ibis, and have other advantages described elsewhere.

- Including the 10 recovered transmitters and satellite/network costs, we should be able to track approx. 40-50 birds, including the following numbers of each species and age group:

	Juveniles	Adults
Straw-necked ibis	10-15	5-10
Royal spoonbill	10-15	5-10

- We will make a final decision on numbers of GSM phone network vs Argos Geotrak transmitters in late June, when we know a) if e-obs transmitters will be ready; b) if tracking juveniles is still approved by AEC
- Tracking will be conducted from Barmah-Millewa or Macquarie Marshes as priority sites. Other sites will be considered depending on conditions if the latter two sites are not hosting breeding colonies.
- Catching this many birds will be dependent on purchase and Animal Ethics Committee approval of a net gun for capture.

Outputs

- datasets describing colony size, location, nest, egg and chick counts, and fledging rates
- datasets describing nesting habitat characteristics
- chick allometry data for bioenergetics modelling
- motion-sensing/time-lapse photographs documenting egg, chick, and fledgling survival and mortality, predation, nest defence and feeding rates by parents over time for selected species
- data describing foraging movements of immature and adult waterbirds.

Sub-Activity B2.3.3 — Data processing and analysis

Objective

The objective of this activity is to analyse data collected in *Activity B2.3.2*.

Description

Data to be processed and analysed includes:

- motion-sensing and time-lapse camera image data extraction (CSIRO with assistance from UNSW)
- data analysis: predation, nest defence, nest attendance, nest success (CSIRO)
- data analysis: tagged nest success, nesting habitat characteristics, colony mapping (UNSW)
- data analysis: movement and/or foraging (CSIRO and University of NSW)
- data analysis: bird allometry/bioenergetics (University of NSW, CSIRO, EWKR Food Webs Theme)
- collation of inundation, wetland area, cropping area/type, vegetation type, vegetation condition, and weather datasets (spatial and temporal — ARCGIS and G-EARTH) (EWKR Vegetation Theme, CSIRO, University of NSW and University of Canberra)
- integrative data analyses and interpretation (CSIRO, University of NSW and University of Canberra).

The data analysis will identify breeding colony size, including numbers of breeding pairs, eggs, chicks, and fledglings and address the following questions:

- What are the locations and characteristics of foraging habitats — e.g. vegetation type, distance from colony?

The focus for this question will now be on foraging between breeding events. In the first year, we have limited data for this question for adults during nesting, because only two birds definitely continued to nest or re-nest (others may have but we can't be sure). If birds with trackers survive until subsequent breeding events this will allow more data collection. However most adults left the nesting area after capture and tagging in the first year.

- How do nesting habitat characteristics influence the numbers of fledglings produced?
- How much does physical accessibility to predators (nest position, water level) affect fledging rates?
- How much does nesting habitat influence exposure of chicks to extremes in temperature or weather?
- How much predation takes place on eggs and chicks and which species are responsible?
- What are the relationships between nesting habitat characteristics, predation, temperature and weather variables and fledging rates?

Further analysis of data will be undertaken in subsequent years as further breeding events are studied.

5 Food Web

Authors: Paul McInerney (2017-) (MDFRC), Nick Bond (MDFRC), Rebecca Lester (Deakin University), Barbara Robson (CSIRO), Darren Ryder (University of New England), Ross Thompson (University of Canberra) and Ben Gawne (University of Canberra)

5.1 Abstract of Progress Report

In 2016/17 Component W1 – review and conceptualisation was completed, with the three manuscripts outlined within the Multi-Year Research Plan finalised and submitted to target journals. Fieldwork commenced for Activity 2.1 – Fish field program and sampling on the Ovens floodplain was conducted in collaboration with the Fish and Food Web Themes. These samples are currently being processed by MDFRC and will be sent for analysis before the end of the 2016 financial year.

Due to problems surrounding regurgitate and scat sample collection for diet/bioenergetics research within Activity 2.2, this work was discontinued and has been modified as outlined below. Sub-contracts for Activity 2.3 have been finalised and mesocosm experiments being conducted at UNE are underway.

Keller Kopf was awarded a CSU funded post-doctoral fellowship project on the influence of flow mediated food web changes on carp invasion. Keller's project is comparing diets of native fish and carp under different flow regimes. The results of Keller's work will be of direct relevance to the Food Web Theme and provide insight into the influence of one of the major stressors on M-DB rivers (invasive carp). Work on Component W4- Modelling bioenergetics within identified production sites continues with a submission of the ACEAS manuscript expected in July.

5.2 Identify new opportunities relevant to research

Keller Kopf was awarded a post-doctoral fellowship with CSU that aligns well with Component W3- identifying important sites of production. It has provided us with an excellent opportunity to maximise the outputs for this component of work. Details are included below under the changes section.

5.3 Changes

5.3.1 Component W1- review and conceptualisation

Activity 1.1 – The influence of flow on lowland river food webs

Unchanged

Activity 1.2 – Incorporating food web indicators into monitoring and evaluation of environmental flows

Unchanged

Activity 1.3 – A review of approaches to modelling predictive capacity

Unchanged

5.3.2 Component W2- identifying critical basal resources

Activity 2.1 — Fish field program

Unchanged

Activity 2.2 — Water bird field program

The waterbird theme have discontinued regurgitate and scat sample collection for diet/bioenergetics research. Instead, bioenergetics will be modelled based on chick allometry (weights and measurements at two different ages), a literature review and data for similar species from overseas. Logistical issues have prevented collection of regurgitate samples for analysis of diet quality. Sampling for regurgitates was unsuccessful, with the UNSW Honours student unable to obtain samples from chicks.

UNSW Honours student Emily Webster has analysed the content of scat samples from chicks from the 2016-17 breeding season, however the usefulness of these data was limited and this will not be repeated. An MDFRC summer student tested a method of extraction of feeding frequency data from the previous year's cameras. Methods and issues were identified that will inform assessments of feasibility and analyses for subsequent years. A new plan for a collaborative bioenergetics project using a different approach has been designed for the 2017-18 breeding season.

Activities for 2017–18

Two primary activities are planned for 2017-2018. These may be conducted separately or concurrently:

Colonial-nesting waterbird allometry (2017-2018 summer)

1. Field measurements of straw-necked ibis chick weight, bill length, head-bill length, tarsus length, wing length, tail length at two age stages: Hatchling/squitter and flapper/flyer. The Waterbird Theme can probably incorporate measurements into existing fieldwork if done only at hatchling/squitter and flapper/flyer stages, since hatchlings/squitters are regularly visited anyway and flappers/flyers will be caught for satellite tracking. A subset of hatchlings/squitters may be colour-marked as individuals and monitored with motion-sensing and time-lapse cameras to gather growth and survival data. A subset of flappers/flyers caught will also be tagged with satellite GPS trackers (as part of the main Waterbird Theme research program).
2. Statistical analysis of the resulting database.
3. Drafting a scientific journal paper.

Colonial-nesting waterbird allometry and energy requirements: literature review and model development

1. Review of both local and international literature and construction of a database describing the allometry, feeding frequency and energy requirements of colonial-nesting waterbirds, focusing on species similar to Australian ibises and spoonbills.
2. Development of a model based on the above database for Australian colonial-nesting waterbird species.
3. Drafting a scientific journal paper.

It is expected that this work could either be all completed by an honours student OR part completed by a summer cadet at MDFRC in summer 2017-18. A decision has yet to be made on which option is preferred, but it is expected that the Food Web Theme would contribute to funding, supervision and/or analysis.

Activity 2.3 — Basal resource transfer efficiency to first order consumers (mesocosm experiments)

Unchanged, except that some potential overlap was identified with the Vegetation Theme at the Annual Research Forum and the mesocosm experiment tank will be used by the Vegetation Theme if successful plant germination occurs as a by-product of the Food Web experiments.

Activity 2.4 — Basin-scale resource use by fish

This Activity will be integrated with a number of other MDB EWKR activities and external projects, including:

- Fish Theme Activity F2.1 - Understanding the feeding requirements of larval fish in the northern Murray-Darling Basin. This Activity seeks to improve our understanding of larval fish diets in the Northern Basin. The planned Activity provides the Food Web Theme with an opportunity to undertake complementary sampling that would help identify the basal resources supporting larval fish recruitment in these systems.
- Fish Theme activity F2.5 - Basin-scale population dynamics of golden perch and Murray cod: relating flow to provenance, movement and recruitment in the M-DB. This activity seeks to develop a river-scale understanding of golden perch and Murray cod life-history, movement and population dynamics, and response to flow. A key component of this work will be identifying the environmental conditions associated with successful recruitment. Food Web sampling in areas known to be important for recruitment would both help identify the basal resources supporting recruitment for comparison with the results from the Ovens River.
- Keller Kopf's CSU funded post-doctoral fellowship project on the influence of flow mediated food web changes on carp invasion. Keller's project is comparing diets of native fish and carp under different flow regimes. The results of Keller's work will be of direct relevance to the Food Web Theme and provide insight into the influence of one of the major stressors on MDB rivers (invasive carp). The details of the relationship between Activity 2.4 and the CSU project will be finalised at a Leadership Group meeting in July 2017. The meeting will identify opportunities for collaborative sampling, data sharing, analysis and interpretation. Once the details have been agreed, the Department will be consulted on the proposal and the integration of outputs into the adoption activities.
- CEWO Long-Term Intervention Monitoring (LTIM) project is undertaking monitoring work at seven Areas across the Basin. Monitoring undertaken by the LTIM program of both adult and larval fish provides an opportunity for complementary sampling to be undertaken in collaboration with the Area monitoring teams. The complementary monitoring would seek to identify the critical basal resources supporting fish recruitment.

The Food Web Theme will liaise with the collaborating projects to secure adult fish tissue, larval fish and basal resource samples from sites across the MDB that represent both a range of flow regimes but that are also believed to be important native fish recruitment areas.

Once samples have been collected, a similar process to that described in Activity W2.1 will be undertaken to identify the samples that will be analysed for stable isotopes and fatty acid composition to provide insight into variations in basal resource use by fish across the MDB.

Negotiation with the collaborating projects will be undertaken through May, June and July of 2017. It is expected that samples will be collected from August through to January with the Basin scale fish sampling due to be undertaken in March 2018. Once samples have been collected the Leadership team will review the available samples and decide on those to be analysed. This decision will be influenced by the prevailing flow conditions and the samples that have been collected by the various projects.

5.3.3 Component W3- identifying important sites of production

This work will seek to integrate information generated by all four research themes to identify critical sites of production. The information generated by each of the Themes will be identification of:

- Vegetation: habitats associated with high plant biomass
- Fish: habitats associated with high fish food resources
- Water birds: critical foraging habitats
- Food Webs: critical basal resources.

The Food Web Leadership team will seek to synthesise the outputs from the four research themes to identify areas that are important due to their productivity or their role in making food available to higher trophic levels.

No explicit activities will be undertaken in this area in 2017-18 as it is dependent on the outputs from the other research themes. There will, however, be ongoing communication with the other Themes to enable the work to be planned. Activities undertaken in the Food Web modelling activity will also inform the activities to be undertaken in 2018-19 in this area in terms of both potential approaches and their feasibility.

5.3.4 Component W4- Modelling bioenergetics within identified production sites

Unchanged