Murray–Darling Basin Environmental Water Knowledge and Research Project

Annual Research Plan 2018-19

Prepared by: Nikki Thurgate, Amina Price, Paul McInerney, Susan Gehrig, Heather McGinness (CSIRO), Lyn Smith

June 2018

MDFRC Publication 181/2018

Murray–Darling Basin Environmental Water Knowledge and Research Project Annual Research Plan 2018-19

Report prepared for the Department of the Environment and Energy, Commonwealth Environmental Water Office by La Trobe University (Murray–Darling Freshwater Research Centre).

Department of the Environment and Energy, Commonwealth Environmental Water Office
Allara St
Canberra ACT 2601

Ph.: (02) 6274 2710

For further information contact:

Nikki Thurgate

The Murray–Darling Freshwater Research Centre
PO Box 821
Wodonga VIC 3689
Ph.: (02) 6024 9647

Email: n.thurgate@latrobe.edu.au
Web: http://www.mdfrc.org.au/projects/ewkr/about/
Enquiries: mdfrc@latrobe.edu.au

Report Citation: Thurgate N, Price A, McInerney P, Gehrig S, McGinness H (CSIRO), Smith L (2018) Murray–Darling Basin Environmental Water Knowledge and Research Project – Annual Research Plan 2018–19. Report prepared for the Department of the Environment and Energy, Commonwealth Environmental Water Office by La Trobe University (Murray–Darling Freshwater Research Centre), MDFRC Publication 181/2018 June 2018, 25p.

Cover Image: Royal spoon display and gift

Photographer: Heather McGinness

Acknowledgements:

La Trobe University Albury–Wodonga and Mildura campuses are located on the land of the Latje Latje and Wiradjuri peoples. The Research Centre undertakes 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.

Disclaimer:

The material contained in this publication represents the opinion of the author only. Whilst every effort has been made to ensure that the information in this publication is accurate, the author and MDFRC do not accept any liability for any loss or damage howsoever arising whether in contract, tort or otherwise which may be incurred by any person as a result of any reliance or use of any statement in this publication. The author and MDFRC do not give any warranties in relation to the accuracy, completeness and up to date status of the information in this publication.

Where legislation implies any condition or warranty which cannot be excluded restricted or modified such condition or warranty shall be deemed to be included provided that the author's and MDFRC's liability for a breach of such term condition or warranty is, at the option of MDFRC, limited to the supply of the services again or the cost of supplying the services again.

Copyright in this publication remains with La Trobe University. No part may be reproduced or copied in any form or by any means without the prior permission of the University.

Document history and status

Version	Date Issued	Reviewed by	Approved by	Revision type
Draft	8 June 2018	Lyn Smith	Nikki Thurgate	draft
Final	15 June 2018	Nadia Kingham	Nikki Thurgate	client comment

Distribution of copies

Version	Quantity	Issued to
PDF	1	CEWO, Nadia Kingham

Filename and path: G:\SHE - Life Sciences\MDFRC\Projects\DSEWPC\465 MDB EWKR\PROJECT MANAGEMENT\PHASE 2 DELIVERABLES\2017-18 Milestones and Final Documents\2018-19 ARP\MDB EWKR Annual Research Plan 2018-19 FINAL Jun2018.docx

Author(s): Nikki Thurgate, Amina Price, Paul McInerney, Susan Gehrig, Heather McGinness (CSIRO), Lyn Smith

Author affiliation(s): La Trobe University, (Murray-Darling Freshwater Research Centre)

Project Leader: Nick Bond, Nikki Thurgate

Client: Department of Environment and Energy, Commonwealth Environmental Water Office

Project Title: Murray–Darling Basin Environmental Water Knowledge and Research Project

Document Version: Final

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

Contract Number: NA

Finalised June 2018

Contents

1 The Project **1**
2 Annual Research Plan 2018–19 ..... **1**
3 Vegetation Theme **2**
3.1 Introduction **2**
3.2 Description of Research Activities **5**
Component V1. Conceptualisation 5
Component V2. Data integration and synthesis 5
Component V3. Field assessments 6
Component V4. Mesocosm 6
4 Fish Theme **7**
4.1 Introduction **7**
4.2 Description of Research Activities **10**
Component F1 – Foundational activities 10
Component F2 – Research activities 10
Component F3 – Student projects 15
Component F4 - Synthesis and model development and management; 2018-19. 15
5 Food Webs Theme **16**
5.1 Introduction **16**
5.2 Description of Research Activities **17**
Component W1— Review and conceptualisation 17
Component W2 — Identifying critical basal resources 17
Component W3 — Identifying important sites of production. 21
Component W4 — Modelling bioenergetics within identified production sites 21
6 Waterbirds Theme **22**
6.1 Introduction **22**
6.2 Description of Research Activities **24**
Component B2 Field research 24
7 Theme Planning, Coordination and Reporting **25**
8 References **25**

List of tables

Table 1. Research priorities for Vegetation theme 3

List of figures

Figure 1. Structure of MDB EWKR showing Themes and other major components. 1
Figure 2. Structure of the research program for the Fish Theme showing linkages between activities and theme level questions and outputs 9

1 The Project

The Murray–Darling Environmental Water Knowledge and Research Project (MDB EWKR) will improve the science available to support evolving needs of environmental water managers in the Murray–Darling Basin. This research will support the Basin Plan environmental and adaptive management objectives and reporting needs. Research focuses on:

- improved identification, assessment and understanding of the links between ecological responses to watering regimes (e.g. natural and/or managed events) and incremental changes in ecological condition
- medium- and long-term changes in ecological condition, including the effects of threats (hydrological, aquatic and terrestrial) which may reduce or prevent the ecological improvement expected
- Queensland floodplain vegetation watering requirements.

Research will support the collaborative role of the Commonwealth in environmental watering within the Basin, in particular:

- Murray–Darling Basin Authority's (MDBA) role in implementing the Basin Plan
- Commonwealth Environmental Water Office's (CEWO) role in managing environmental water
- Basin States' role in managing environmental water and aquatic assets.

Research will also promote collaboration amongst research organisations which will be important in generating new knowledge about complex responses of aquatic ecosystems to changes in flows across a range of spatial and temporal scales.

Further information on project objectives, outcomes and operational details are included in Annual Work Plan 2018-19.

2 Annual Research Plan 2018–19

The Annual Research Plan 2018–19 outlines the research activities proposed to be undertaken under the four research themes – Vegetation, Fish, Waterbirds and Food Webs (Figure 1). The research themes address priority research questions determined through a process of consultation with environmental water managers, environmental asset managers and researchers working in the Murray–Darling Basin. As this is the fifth and final year of the project, emphasis is shifting away from research activities to analysis, synthesis and communication of project outcomes. So, the Multi-Year Research Plan (MYRP) document did not require significant updating. Minor changes to details of research activities are noted in Section 4.2.

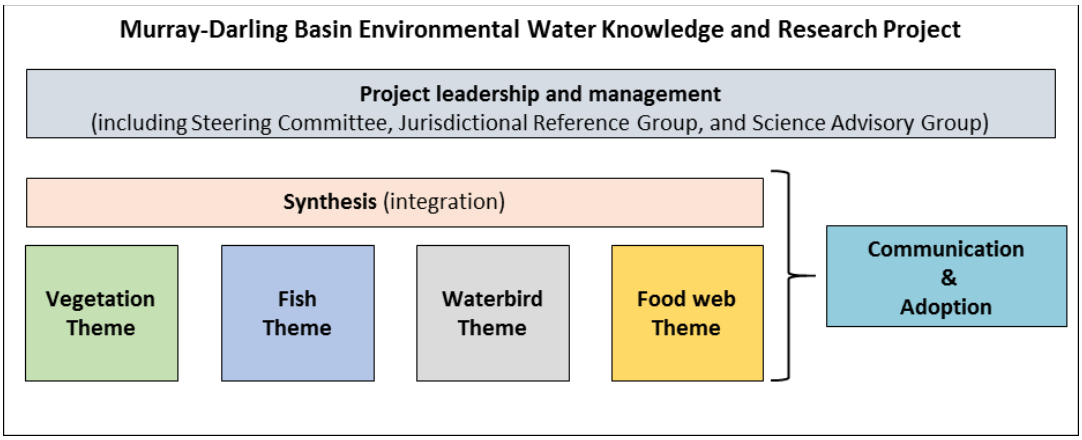

Figure 1. Structure of MDB EWKR showing Themes and other major components.

3 Vegetation Theme

Authors: Susan Gehrig (MDFRC), Cassandra James (James Cook University), Daryl Nielsen (CSIRO), Kay Morris (Arthur Rylah Institute), Jason Nicol (SARDI), Rachael Thomas Office of Environment and Heritage), Samantha Capon Griffith University)

3.1 Introduction

Wetland and floodplain plants and vegetation communities function as refuge, breeding habitat and dispersal corridors, provide important food sources and raw materials for a wide range of organisms, while also performing critical ecosystem services (e.g. nutrient and carbon cycling, water and sediment oxygenation) and providing intrinsic biodiversity, cultural and recreational values. For managers to achieve vegetation outcomes from environmental water use, a clear understanding of the effect of flow on vegetation response and how certain modifiers influence predicted vegetation responses is required to shape vegetation response objectives and targets. The MDB EWKR Vegetation Theme will advance our understanding of the effect of flow on wetland and floodplain plants, assist in identifying what flows best support vegetation responses, as well as increase our understanding of how non-flow modifiers (e.g. land use, grazing, and climatic conditions) influence predicted outcomes from the use of environmental water.

The Vegetation Theme links to the Fish, Waterbird and Food Web Themes through the provision of energy to support food webs, the provision of habitat and dispersal corridors for fauna, reducing erosion and nutrient run-off and enhancing water quality.

The overarching research aim for the Vegetation Theme is to determine what drives sustainable populations and diverse communities of water-dependent vegetation in the Murray-Darling Basin (MYRP 2016) and how we may define vegetation response objectives to consider a range of vegetation trait responses, ecological levels of organisations within the context of spatio-temporal scales.

Our research focuses on two main research areas (Table 1) relating to the diversity of non-woody floodplain understorey and wetland plant communities and recruitment of long-lived floodplain vegetation. Specific questions include:

- What flow regimes best support the diversity of floodplain understorey and wetland plant communities?
- How do threats impact on the drivers and diversity outcomes?
- What flow regimes best support recruitment within populations of long-lived vegetation species?
- How do threats impact on the drivers and recruitment outcomes of long-lived vegetation species?

Using the conceptual framework as a foundation, the vegetation theme explores compositional vegetation responses at different levels of ecological organisation, structural vegetation responses at different scales, and process vegetation responses (i.e. recruitment) of long-lived vegetation to show how nested flow regimes shape floodplain and wetland vegetation communities. Synthesis of the project outputs will help inform how adaptive management of environmental water delivery can best support vegetation outcomes.

Table 1. Research priorities for Vegetation theme

Component	Summary	Application
V.1 Conceptualisation	Supporting our research is the development of a framework, which focuses on the definition and conceptual understanding of the types of vegetation responses that occur among vegetation traits (compositional, structural and process), at different levels of ecological organisation (species, population, community and vegscape), and across different spatial and temporal scales. Key component question: *What are we managing for and why?*	Results will provide theoretical basis to underpin research and objectives planning.
		Results will provide structured approach to defining targeted vegetation responses
		Results will help guide planning, management and communication of watering decisions and actions
		Results will provide managers context to evaluate outcomes.
V.2 Data Integration and Synthesis (DIS)	Across the Basin there are numerous datasets that span multiple years and sites. The DIS component involves exploration of long-term (10+ year) wetland floristic data set and best available hydrodynamic data for relationships between wetland vegetation responses, flow and other non-flow (e.g. rainfall, temperature) drivers. Key component question: *What compositional variables best predict vegetation responses?*	Determine which compositional variables best predict of vegetation responses to flow/non-flow drivers over broad temporal scales.
		Results will provide information to help refine existing conceptual models
		Results will inform how flows should be managed to enhance drivers and diversity outcomes
V.3 Field Assessments	Field surveys: Vegetation responses are likely to vary between different regions of the Basin, such as between the north and south, potentially driven by differences in climate. The field assessment component involved field surveys undertaken at four priority locations across the Basin in autumn 2017 and 2018. Site selection within locations was stratified based on four flood return frequencies (near annual, 1.5 – 3 years, 3 – 5 years and 5 – 10 years) and three broad vegetation structure categories (inland woodland, inland shrubland and non-woody wetland) to allow for broad comparisons of the variability in the responses of vegetation. A range of response traits were measured, relating to composition, structure and recruitment processes of vegetation communities.	Results will inform what flow regimes best support the diversity of floodplain understorey and wetland plant communities
		Document the composition and structure of extant vegetation communities across the MDB and how this varies with flow regime and vegetation structural types.
		Results will identify key drivers on diversity of vegetation communities across this MDB
		Results will highlight what key drivers interact to influence diversity outcomes of vegetation communities across this MDB
		Results will inform how flows should be managed to enhance drivers and diversity outcomes
		Results will inform which threats impact on the drivers and diversity outcomes

Component	Summary	Application
	Key sub-component question: *How does the extant understorey response differ between structural class, flow regime and location?* Germination Trials: In the 2017 field surveys, soil samples were collected from all sites and simultaneous germination trials were established for each location to investigate how seedbank composition might vary in relation to flow frequencies, vegetation structural categories and treatments (damp and submerged). Key sub-component question: *How do seedbanks (the potential for vegetation response) vary in relation to structural class, flow regime and location?*	Document the diversity of species within soil seedbanks across the MDB and how they vary with flow regime and structural vegetation types Results will inform how seedbank composition differs between vegetation structural class, flow regime and location
V.4 Mesocosm	Mesocosm study investigated the recruitment of seedlings of dominant woody species (River Red Gum, Black Box, Coolibah and Lignum) to sequential flooding and drying events. Within an experimental block design, germinated seedlings were transplanted to pots and subjected to a range of treatments (constant dry, constant flooding, early flooding, late flooding and sequential flooding) for 6 months. Survivorship and a range of response traits relating to growth strategies were measured to assess the relationship between flow regime parameters and seedling establishment. Key component questions: *How do sequential flooding and drying events affect seedling growth?* *What growth strategies are important for the establishment of woody species in early life stages?*	Results will highlight differences and similarities in growth strategies of establishing woody species Results will help inform the sequencing of water events that best support early life stages of key woody species

3.2 Description of Research Activities

Vegetation theme outputs from completed research activities are noted in MDB EWKR Outputs Register. Following sections note research activities that will continue in 2018-19 and any changes from the Multi-Year Research Plan. Schedule of research activities is noted in Annual Work Plan and Budget 2018-19.

Component V1. Conceptualisation

Description

This activity organised existing knowledge and new ideas into a conceptual framework to provide a strong theoretical basis to support research planning and to provide a clear understanding of the vegetation responses objectives, the effect of flow on vegetation response and how modifiers influence predicted responses.

Objectives

- finalise scientific paper
- provide appropriate adoption outputs including summary paper/fact sheets for managers

Activity V1.3 Reporting – complete

Roles: Sam Capon (Griffiths University) will lead the reporting of this component, with support from the Vegetation Leadership Group

Changes from MYRP

As the foundation component for our project research, the Leadership Group feels that further discussion is required at the upcoming workshop in mid-August to discuss and refine this component to ensure it best captures the needs of CEWO and water managers. The submission date of the final draft of the manuscript was changed to 30 September 2018 to allow for this.

Component V2. Data integration and synthesis

Description

The Data Integration and Synthesis component explores existing wetland vegetation datasets and best available hydrodynamic data for relationships between vegetation responses, flow and non-flow drivers.

Objectives

- *Data analysis*
  - *Finalise approach for larger collated dataset*
- *Reporting*
  - Finalise scientific paper
  - provide appropriate adoption outputs including summary paper/fact sheets for managers

Activities

- V2.3 Data analysis
- V2.4 Reporting

Roles

Cassie James (James Cook University) will undertake analysis of datasets with input from relevant quantitative ecologists identified by the project team to have the appropriate skills (funded by MDB EWKR as required), with support from MDFRC. Cassie James will lead the reporting

Changes from MYRP

Phase 1 of the DIS component is complete (pilot study), but Cassie James has also expressed interest in using the mid-August workshop for consultation with the Leadership Group to help discuss results and help identify the strongest predictors of vegetation response. Therefore, the submission date of the final manuscript has been changed to 30th November 2018 to allow for this.

Component V3. Field assessments

Description

The field assessment component involved field surveys undertaken at four priority locations across the Basin in autumn 2017 and 2018, to allow for broad comparisons of the variability in the responses of vegetation. A range of response traits were measured, relating to composition, structure and recruitment processes of vegetation communities. Germination trials from soil collected at all field survey sites were conducted to investigate how seedbank composition might vary in relation to flow frequencies, vegetation structural categories and treatments.

Objectives

- *Data analysis*
- *Reporting*
    - Analysis of field survey and germination trial data
    - Finalise scientific paper
    - provide appropriate adoption outputs including summary paper/fact sheets for managers

Activities

- V3.3 Reporting

Roles

MDFRC will undertake analysis of data with input from relevant quantitative ecologists identified by the project team to have the appropriate skills (funded by MDB EWKR as required), with support from MDFRC. Cherie Campbell will lead the reporting.

Changes from MYRP

None

Component V4. Mesocosm

Description

The mesocosm component investigated the recruitment of seedlings of dominant woody species to sequential flooding and drying events. Survivorship and a range of response traits relating to growth strategies were measured to assess the relationship between flow regime parameters and seedling establishment.

Objectives

- *Data analysis*
- *Reporting*
    - Finalise scientific paper

- provide appropriate adoption outputs including summary paper/fact sheets for managers and community audiences

Activities

- Activity V4.3 Data analysis and reporting

Roles

MDFRC will undertake analysis of data with input from relevant quantitative ecologists identified by the project team to have the appropriate skills (funded by MDB EWKR as required), with support from MDFRC. Cherie Campbell, with assistance from Rebecca Durant will lead the reporting.

Over the next 12 months ongoing communication from Leadership Group team with their respective local, regional and state water managers will occur to help relate key scientific outcomes from project components to help refine applications for environmental water management

Changes from MYRP

Rick Stoffels did a first analysis of the mesocosm data, but after discussions at the EWKR annual forum we required a re-analysis. Therefore, the submission date of the final manuscript has been changed to 30th September 2018 to allow for this.

4 Fish Theme

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

4.1 Introduction

The distribution and abundance of native species within the MDB have declined significantly in the last 50-100 years (MDBC 2004) and as such, are a key target for improvement under several basin-wide programs including The Basin Plan and The Living Murray. The Basin-wide environmental watering strategy lists improvements in distribution, abundances, population structure and movement as expected outcomes for fish (MDBA 2014). To appropriately design environmental watering programs to benefit native fish, it is vital that the links between key watering parameters and potential fish responses are clearly understood. This requires an understanding of the biotic processes that maintain fish populations, the key drivers of these processes and the interaction with flows. This will be the focus of the Fish theme, with research addressing the relative importance of key recruitment drivers and their interaction with flow and other variables at multiple spatial scales. Research outcomes will assist managers in gaining significantly improved predictive and explanatory capacity across a range of species.

The overarching question in relation to the MDB EWKR Fish Theme is: *What are the drivers of sustainable populations and diverse communities of native fish?* This is the key question that underpins the fish theme and it seeks to explore the key functional processes that drive outcomes for native fish populations and communities, as well as the situations under which each of these processes become limiting. This high-level question is broken down into three priority areas: recruitment (high priority), survival and condition (medium priority) and reproduction (lowest priority). The three identified priority areas encompass the entire life-cycle of fish and therefore all potential processes and drivers (Figure 2.)

The leadership group agreed that attempting to undertake targeted work for all priority areas will result in resources being spread too thinly to address any priority area in a meaningful way. Consequently, the leadership group agreed that the focus of the theme is recruitment (highest priority area) and that the remaining two priority areas will only be addressed where reproduction

and/or survival condition questions can easily be incorporated into recruitment-focussed activities. The priority recruitment questions for the fish theme are:

- What flow regimes best support the reproduction of native fish populations?
    - How significant are the individual drivers?
    - How do key drivers interact to influence outcomes?
    - How should flows be managed to enhance drivers and thereby the fish response?
- How do threats impact on the drivers and recruitment outcomes?

The first year of research was largely focussed on undertaking desktop-based foundational activities that provided the basis for identifying key knowledge gaps and generating specific testable hypotheses. In the second year, field-based research was undertaken to better understand two of the key recruitment drivers, food and temperature. In 2018-19, research will be more strongly focussed on fish movement and dispersal. Specifically, the relationship between flow, structural habitat, hydrodynamics and patterns larval settlement and retention will be investigated. In addition, the role of movement and connectivity at larger spatial scales will also be investigated. Finally, work in 2018-19 will focus on theme-level synthesis, which will be completed in May 2019 (see F4 below).

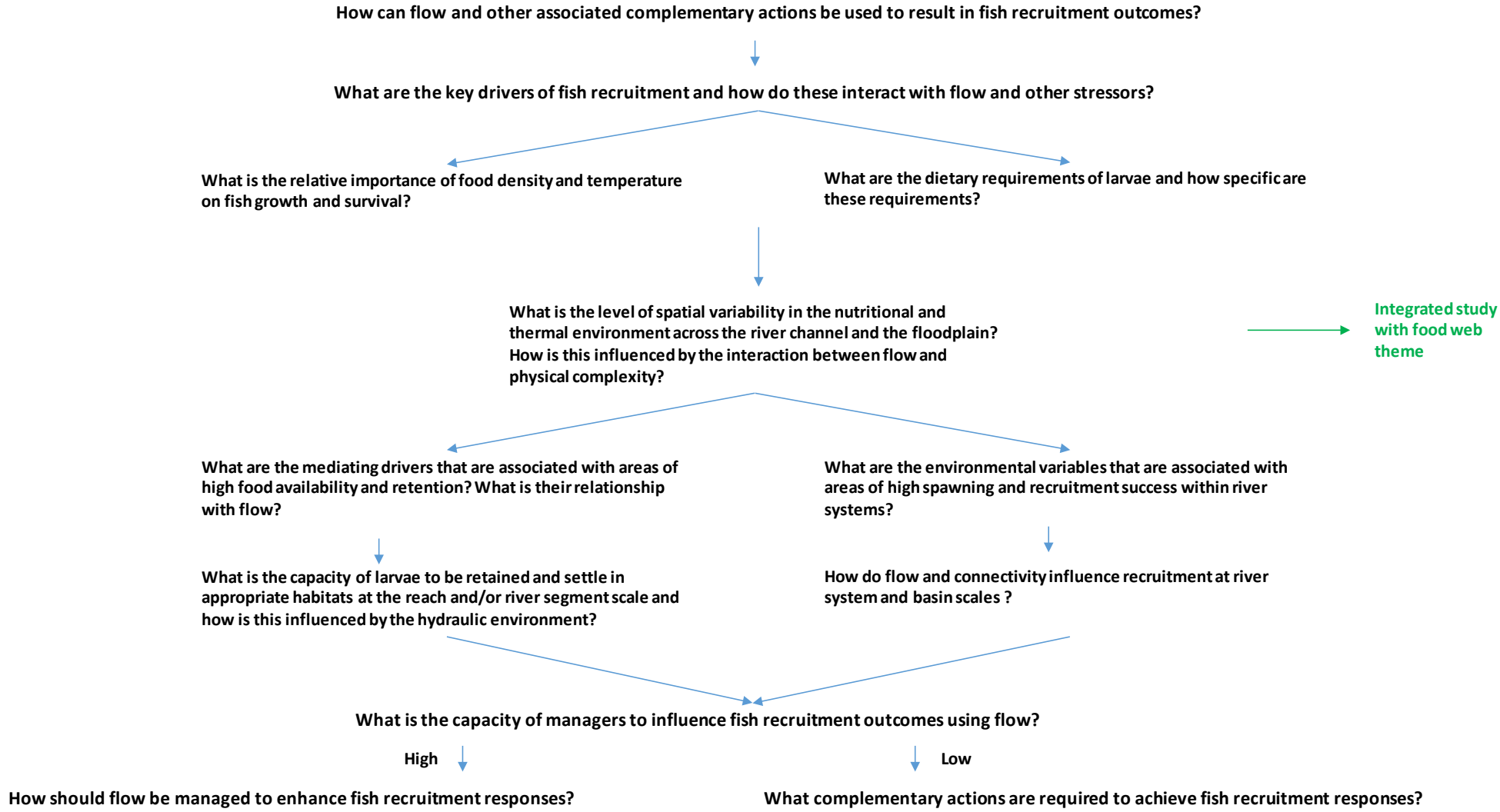

Figure 2. Structure of the research program for the Fish Theme showing linkages between activities and theme level questions and outputs

4.2 Description of Research Activities

Fish theme outputs from completed research activities are noted in MDB EWKR Outputs Register. Following sections note research activities that will continue in 2018-19 and any changes from the Multi-Year Research Plan. Schedule of research activities is noted in Annual Work Plan and Budget 2018-19.

Component F1 (foundational activities) are almost complete and are summarised below. Components 2 and 3 (2018-19 research activities) and Component 4 (Synthesis and model development and management) are then described in detail. Justification and context for the research activities is provided in the multi-year research plan.

Component F1 – Foundational activities

The refinement of our conceptual understanding was a critical component of the research plan and was comprised of several activities that informed the refinement of both the MYRP and the Annual Research Plan (2016-17). The review and synthesis activities were completed in 2016-17 and following some delays, the final outputs will be produced in 2018-19 as follows:

- The review and synthesis of the factors limiting spawning and recruitment publication will be submitted by the end of October 2018.

Component F2 – Research activities

Activity F2.1 Understanding the feeding requirements of larval fish in the northern Murray-Darling Basin (Griffith University); 2016-2019.

Description and Objectives

This activity aims to examine the relationships between prey abundance and diversity and size structure with the diet of larval fish species in the Narran and Culgoa Rivers (Lower Balonne system). Work will also focus on larval condition (using both body condition indices and RNA:DNA ratios) and how this relates to the nutritional quality of prey. Owing to the clear knowledge gaps in relation to larval ecology in the NMDB, this study provides an opportunity to provide some new learnings that will enhance our current understanding of the feeding requirements and feeding ecology of early life stage fish.

Activities and Roles

Work for this activity in 2018-19 will involve:

- Completion of laboratory processing of field samples (Griffith University and Department of Science, Information Technology and Innovation).
- Data analysis (Griffith University)
- Write-up (Griffith University)

In addition, one additional field trip may be undertaken in spring 2018 if the catchments remain wet (see End of year progress report 2017-18).

Outputs

Improved understanding of the dietary and nutritional requirements of the fish larvae of a few contrasting MDB species. The outputs from this work will be written up in scientific manuscript and associated adoption outputs.

Uses

The outputs will be integrated with, and provide supporting data for, other components and sub-components that are proposed to be undertaken by the Fish Theme. The outputs from this sub-component will also provide insight into the composition and nutritional value of different size-classes of prey. This information will add important value to the size-class biomass data that will be collected as part of Activity F2.3 (described below). The outputs will also link very strongly with the work proposed by the Food Web theme and will be used to inform the synthesis that will be developed at the end of the project.

Changes to MYRP

Possibility of additional field trip in spring.

Activity F2.2: Examination of the relationship between food density, temperature and early-life stage growth and survival (MDFRC); 2017-2019.

Description and Objectives

This activity aims to use laboratory experiments to investigate the relationship between food density and temperature on the growth and survival of the early life-stages of Murray cod and Golden perch. This activity had been scheduled to be completed in May 2018, however it has been rolled over to 2018-19 (see Mid-year Progress Report 2017-18).

Activities and Roles

1. Murray cod laboratory trials (MDFRC)
2. Golden perch laboratory trials (MDFRC)
3. Data analysis and model development (MDFRC)
4. Write-up (MDFRC)

Outputs

Quantitative models describing growth and survival as a function of food density and temperature and how these factors interact. The models will be written up in scientific manuscript and associated adoption outputs.

Uses

This information will provide significant insights into whether food density is likely to be a limiting factor for fish larvae. Outputs will be linked to the thermal and nutritional mapping of the riverscape (see sub-component F2.3) to identify those habitats in which optimal growth and survival of the larvae of different species can be expected to occur.

Changes to MYRP

Work should have been completed in May 2018 but won't be because of need to repeat experiments.

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

Description and Objectives

This activity aims to describe the spatial heterogeneity in the thermal and nutritional landscape at multiple spatial scales to determine at what scale and to what extent thermal and nutritional habitat quality for early life-stages varies.

The work is broken into three activities:

1. Detailed assessment of thermal and nutritional patch-level variability among main channel and floodplain habitat patches at one river-floodplain area (see Activity 2.3.1).
2. The relationship between discharge, reach hydraulic complexity, zooplankton production and retention in a lowland river system. Fieldwork was undertaken during spring, summer in 2017-18 (see Activity 2.3.2).
3. Preliminary investigation into variability in larval food availability in relation to different structural habitat types using existing data. This was undertaken in 2016-17 (see Activity 2.3.3).

This activity is focused on temperature and food density and does not include associated fish sampling. The rationale for this is that the distribution and abundance patterns of larvae is relatively well-understood and that it is the mechanisms underpinning these distribution patterns which we lack a clear understanding of.

Activity F2.3.1: Comparison of the thermal and nutritional regimes among main channel and floodplain habitat patches; 2016-2018.

Description and Objectives

This activity aims to compare temperature and prey density across a range of sites in the main channel and up to four different floodplain habitats: permanent wetlands, ephemeral wetlands, permanent creeks/anabranches, and ephemeral creeks/anabranches.

Activities and Roles

1. Completion of data analysis (MDFRC).
2. Write-up (MDFRC and CSU).

Activity F2.3.2 The relationship between discharge, reach hydraulic complexity, zooplankton production and retention in a lowland river system; 2017-2018.

Description and Objectives

Flow regimes and flow events may be conceived as waves (Humphries, Keckeis, & Finlayson, 2014), which interact with the geomorphology, and other types of structure of rivers to create a diversity of hydrogeomorphic patches, which in turn influence the transport and retention of energy and nutrients in rivers (Humphries et al., 2014; Thorp, Thoms, & Delong, 2006). For example, at the extreme trough of a wave, when a river ceases to flow: there is very limited transport of energy and nutrients along a river; most of the inputs and production occur locally; and hydrogeomorphic patches are limited to disconnected, lentic pools. At the extreme crest of a wave, on the other hand, during overbank flooding: there tends to be large-scale transport of energy and nutrients longitudinally and laterally; the floodplain may have a major input to river ecosystem metabolism; and there is typically a high diversity of in-channel and floodplain hydrogeomorphic patches. At intermediate positions on the river wave, longitudinal transport will tend to dominate over lateral transport of energy and nutrients, and there will be an intermediate diversity of hydrogeomorphic patches. It is the hydrogeomorphic patches with velocities < 10 cms^{-1} – retention zones known to be conducive to the maintenance, growth and reproduction of plankton in rivers (Reynolds, 2000b; Schiemer, Keckeis, Reckendorfer, & Winkler, 2001; Vranovsky, 1995) - that we propose are the habitats within which recruitment processes of riverine fishes takes place.

This activity aims to test key elements of our conceptual synthesis, which proposes that: *interactions between flow and structural complexity will create locations in rivers, at meso-scales, where energy and nutrients are enriched, the resultant production of small prey concentrated, and prey and fish larvae located (either through dispersal or retention) so that the larvae can feed, grow and recruit.* Specifically, it will document the mean density and composition of epibenthic and pelagic

zooplankton in reaches representing a gradient from high-low complexity (and so, high-low retentiveness), and follow these over time as discharge declines from summer-autumn in an unregulated river. The project will also document the nutrient and thermal landscapes in these reaches, to determine if reaches with greater retentiveness are both conducive nutritionally and thermally for the growth and survival of fish larvae.

The following hypotheses will be tested:

1. That under moderate discharges, a gradient of reach retentiveness is positively related to the mean density of benthic and pelagic zooplankton;
2. That a gradient of reach retentiveness is negatively correlated with the loss of zooplankton from a reach, relative to inputs upstream;
3. That as discharge declines over summer-autumn, the relationship between the gradient of reach retentiveness and mean density of benthic and pelagic zooplankton breaks down;
4. That as discharge declines over summer-autumn, the relationship between the gradient of reach retentiveness and loss of zooplankton from a reach, relative to inputs upstream, breaks down.

Activities and Roles

1. Murray cod laboratory trials (MDFRC)
2. Golden perch laboratory trials (MDFRC)
3. Data analysis and model development (MDFRC)
4. Write-up (MDFRC)

Outputs

The results from this sub-component will enable evaluation of the fundamental triad model and inform its application to the management of environmental flows. The results from Activity F2.3.2 combined with the outcomes of Activities F2.3.1 and F2.2 will inform development of a model of the influence of food and temperature on larval recruitment. The results from the field sampling will be published in a scientific manuscript and associated adoption outputs.

Uses

This information will provide guidance as to the scale at which sub-component F2.4, examining larval retention and settlement with respect to flow, should focus. The outputs will be important in guiding managers as to the scale at which management actions should occur.

Changes from MYRP

When the last ARP was written we didn't yet know what hypotheses this activity would be testing. Consequently, the title of this activity has changed and this is the first time that the specifics have been described.

Activity F2.4: Investigating the relationship between flow, structural habitat, hydrodynamics and patterns larval settlement and retention (CSU); 2018-2019.

Description and Objectives

This work aims to generate information regarding the capacity of larvae to be retained and settled within appropriate habitats (as determined by the previous sub-components). The project will quantify relationships among flow (discharge) and the retention and settlement of larvae in rivers by using field-based experimental releases of Murray cod and golden perch larvae and passive particles. The influence of flow will be assessed by measuring how discharge drives changes in the dispersal and settlement patterns of larval fish in reaches of river in which flow can be manipulated. The scale at which this work will be undertaken is dependent on the outcome from Activity F2.3.2. The specific

approach that will be undertaken will depend on the scale that the work is being done at. This flow manipulation experiment will also provide the opportunity to test flow-related hypotheses that have arisen from the previous work.

Activities and Roles

1. Development of detailed project plan to be reviewed and approved by the Leadership Group (CSU)
2. Project planning (CSU)
3. Field work: River Surveys and field experiments – larval dispersal & neutrally buoyant passive particles (CSU)
4. Field work: larval settlement (CSU)
5. Laboratory processing of field samples (CSU)
6. Data analysis (CSU)
7. Write-up (CSU)

Outputs

Models will be developed to explain how different flow management scenarios influence the dispersal and retention of native species with different life history strategies.

Uses

The outputs from this work will be able to be fed into hydrodynamic models to predict settlement and retention patterns on larvae in different river sections or reaches. The outputs developed by this work will be also used to inform the predictive model that will be developed at the end of the project.

Changes from MYRP

This has been changed to be a CSU project only rather than a joint MDFRC/CSU project.

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); 2016-2018.

Description and Objectives

This project aims to elucidate spatio-temporal relationships between flow and key population processes for one to two long-lived, large-bodied species in order to improve large-scale flow management to improve population outcomes for species whose populations operate at larger spatial scales.

Activities and Roles

1. Otolith collection (SARDI, NSW Fisheries, ARI)
2. Otolith analysis and data collation (Melbourne University, SARDI)
3. Data analysis (SARDI)
4. Write-up (SARDI, NSW Fisheries, ARI, Griffith University, MDFRC, CDU)

Outputs

Information regarding:

- The environmental factors (particularly hydrology) that are associated with the spawning, recruitment and dispersal of golden perch (and Murray cod) in the MDB.
- The patterns of spatio-temporal variation in these parameters and whether dispersal between regions influences population dynamics.
- A scientific manuscript and associated adoption outputs.

Uses

The outputs from this activity will inform the restoration of flow regimes (volumes, spatial scales, etc.) for golden perch (and Murray cod) objectives, and provide a basis for the design of monitoring programs that are undertaken at appropriate spatio-temporal scales, and using suitable indicators, to rigorously measure fish population responses to flow restoration, including environmental water allocations.

Changes from MYRP

None

Component F3 – Student projects

Activity F3.1 Water infra-structures and challenges for fish conservation: Larval trait-based analysis to foresee fish recruitment in regulated rivers (2016-2019).

Objective and Description

This student project is investigating and modelling the influence of several key mediating recruitment drivers, such as water velocity and flow on the swimming ability of fish larvae with differing reproductive strategies. The ability of larvae to actively select nursery habitats under different hydraulic scenarios is being experimentally tested in a flow laboratory in which water velocity can be precisely controlled. This data will be used to develop a model that can predict the likelihood of larval settlement under different hydraulic habitat scenarios.

This project is being undertaken by an existing PhD student, Lorena Noguiera, who is being supervised by Amina Price (MDFRC), Lee Baumgartner (CSU) and Paul Humphries (CSU).

Outputs

The key output from this work will be the predictive model for larval swimming and settlement based on flow and hydraulics for a number of species with differing traits.

Uses

The outputs from this work will provide managers with critical information regarding flow delivery to enable larval settlement. The work will also inform a critical knowledge gap regarding the fate of larvae that encounter lentic habitats associated with impoundments and weirs.

In addition, this work links strongly with other work being undertaken by the Fish Theme, most notably sub-component F2.4, which is examining using field experiments to examine larval transport and retention at different discharges with a focus on hydraulic and structural habitat.

Changes from MYRP

It had originally been anticipated that the results from laboratory swimming experiments would be validated in the field as part of activity F2.4.2. However, due to delays in the project, this component has been dropped.

Component F4 - Synthesis and model development and management; 2018-19.

Objective and description

This component will draw together all outputs from the conceptualisation and research activities to produce a conceptual model for MDB fish that will describe:

1. which recruitment drivers are most important for water managers to consider when managing for recruitment of different:

- species
- seasons
- systems and
- flow scenarios

2. How can water managers best manage delivery of environmental water to target the most appropriate recruitment drivers for the species and system of interest?

3. What non-flow related factors are likely to impact on the key recruitment drivers and how? What complementary actions can be used to improve recruitment outcomes.

Activities and Roles

1. Delivery of all key findings from each Activity Leader to the Leadership Group (MDFRC, CSU, Griffith Uni, SARDI).
2. Synthesis workshop (February 2019)
3. Write-up of model and synthesis report.

5 Food Webs Theme

Authors: Paul McInerney (MDFRC), Nick Bond (MDFRC), Rebecca Lester (Deakin University), Darren Ryder (University of New England), Ross Thompson (University of Canberra), Keller Kopf (Charles Sturt University).

5.1 Introduction

Food webs are one of several critical ecosystem functions believed to be important in sustaining patterns of diversity in the MDB. It is anticipated that improved understanding of the influence of environmental flow on food webs will complement our understanding of the influence of flow on habitat and connectivity and that in combination, this knowledge will enable better management of environmental flows within the Basin. A food web describes the pathways that energy and essential nutrients are routed through an ecosystem, from basal resources such as organic matter, through consumers, to apex predators such as fish and waterbirds. While most major conceptual models of river ecosystems propose food webs as a critical ecosystem function, our knowledge of the influence of flow on food webs is not robust enough to make specific predictions about how flow's effects on food webs influence outcomes. Addressing these knowledge gaps is the focus for research in the Food Webs Theme.

The two broad research questions addressed by the Food Webs Theme are:

(1) What flow regimes best support food webs that transfer energy to support recruitment of native fish and waterbirds?
(2) How do other stressors (e.g. land use change, invasive species) impact on food web processes and the achievement of native fish and waterbirds outcomes?

Within each of the two main questions, a set of subsidiary questions have been generated based on existing knowledge of likely sources of variation in energy flow.

Subsidiary questions generated under question **(1)** include:

(1A) What are the main energy sources contributing to larval fish biomass and waterbird recruitment in the field?
(1B) Are there clear spatial patterns in the importance of different energy sources?
(1C) Are there clear temporal patterns in the importance of different energy sources?

(1D) Is there evidence of 'energy bottlenecks' preventing passage of energy to higher trophic levels?
(1E) How does provision of flow affect any patterns detected in 1.1A–D?

Subsidiary questions generated under question **(2)** include:

(2A) Is there evidence for energy being diverted away from native fish and waterbirds (e.g. by carp)?
(2B) Is there evidence that productivity in the channel is limited by other factors (e.g. water turbidity, availability of productive substrates)?

5.2 Description of Research Activities

Food webs theme outputs from completed research activities are noted in MDB EWKR Outputs Register. Following sections note research activities that will continue in 2018-19 and any changes from the Multi-Year Research Plan. Schedule of research activities is noted in Annual Work Plan and Budget 2018-19.

Component W1— Review and conceptualisation

Description

Component W1 identified our current knowledge status and critical knowledge gaps. A detailed literature review of the existing knowledge on large river food webs, approaches to modelling them, and potential interactions between environmental flows and energy flows has been completed. Three manuscripts have been prepared, two of which have been published. In 2018-19 the third manuscript will be modified to address peer reviewer comments and resubmitted to a scientific journal.

Objectives

Manuscript submission

Activities

- Food web leadership group participation in editing draft manuscript

Roles

- address of reviewer comments (Food Web Leadership Group)
- resubmission of manuscript (Rob Rolls, lead author)

Uses

- conceptual models that express potential energy pathways to taxa of interest
- identification of key knowledge gaps
- identification of potential modelling approaches

Changes from MYRP

None

Component W2 — Identifying critical basal resources

Activity 2.1 — Fish field program

Description

The Fish Theme is seeking to test the fundamental triad concept of fish recruitment, which proposes that fish recruitment is associated with habitat patches in which food resources are enriched and

concentrated and where both food and larvae are retained. This activity aims to describe the spatial heterogeneity in the thermal and nutritional landscape at multiple spatial scales to determine at what scale and to what extent thermal and nutritional habitat quality for early life-stages varies. In January 2017 the Food Web and Fish Themes collaborated to collect field samples from the Ovens River floodplain.

In 2018-19 the field data collected from the Ovens floodplain with the Fish Theme will be analysed and a scientific manuscript prepared.

Objectives

- identify critical basal resources supporting fish recruitment
- trace the flow of energy through these ecosystems

Activities

- analysis of stable isotope and fatty acid data collected from the floodplain
- data analysis and preparation of manuscript

Roles

- collation and initial preparation of data (MDFRC)
- analyses and manuscript preparation (MDFRC with Food Web and Fish Leadership Groups)

Uses

These data will be used to inform both the refinement of the ACEAS model and development of new models.

Changes from MYRP

Originally the food web theme had planned to replicate the summer 2016-17 field sampling in 2017-18, but discussion at the July 2017 workshop among the leadership group team resulted in the second field trip being deemed unnecessary. It was decided that the funds would be better spent in strengthening our capacity to understand mechanisms (particularly those lacking in existing models and literature) and build these into models that allow predictions of food webs and trophic carrying capacity. It is expected that the fatty acid results from the Ovens River fieldwork will be received in June 2018, and discussion of these results at the monthly food web leadership group meeting will inform the direction of further analyses in 2018-19 to fill knowledge gaps.

Activity 2.2 — Waterbird food requirements research program

Description

Waterbird theme fieldwork has resulted in a large collection of straw-necked ibis, Australian white ibis and royal spoonbill feather, scat and regurgitate samples, plus blood samples from royal spoonbill juveniles. The Food Web Theme has funded Kate Brandis (waterbird leadership group, UNSW) to conduct manual identification and SIA analyses of regurgitate and scat samples to determine what chicks are eating, the energy value and trophic position of individual prey items and the food chain length from basal resources to waterbirds. Analyses are expected to be completed in July 2018 so that this information may be incorporated into models being developed by the Food Web Theme in Component W4.

In 2018-19 data generated from the above laboratory work will be analysed and written up.

Objectives

- determine what chicks are eating
- determine the energy value and trophic position of individual prey items

- determine food chain length from basal resources to waterbirds

Activities

- manual identification and SIA analyses of regurgitate and scat samples (underway)
- data analysis and preparation of manuscript

Roles

- sample analyses and data preparation (UNSW)
- data analyses (CSIRO, UNSW, MDFRC)
- manuscript preparation (CSIRO, UNSW, MDFRC, Food Web and Waterbird leadership groups)

Uses

This work will help inform managers of how much of each energy source is needed to meet waterbird requirements. The data will be integrated with outcomes from the waterbird theme to identify critical foraging habitats and the bioenergetics data will help improve water requirements to support waterbird recruitment. This knowledge will inform managers how to use environmental water at their sites to maximise energy production for bird breeding success. This information will be incorporated into models being developed by the Food Web Theme.

Changes from MYRP

Initially it was intended that an honours student would carry out this work. However, a suitable honours student was not available, so a CSIRO funded summer cadet (Lauren O'Brien) was appointed to undertake the background work for this activity - estimated energy requirements for ibis and spoonbill chicks based on biometric measurements and literature. Following preliminary work, discussion between Food web and Waterbird Theme groups determined that the best use of the funds set aside by the Food Web Theme would be to proceed with the activity detailed above. This activity will begin in July 2018 and be completed in time for analysis and reporting.

Activity 2.3 — Basal resource transfer efficiency between a range of basal resources and to first-order consumers (mesocosm experiments)

Description

Activity 2.3 seeks to determine basal resource utilisation and rates of transfer into the food web from controlled mesocosm experiments conducted at UNE and overseen by Darren Ryder. Understanding the way that basal resources are assimilated into the food web and the efficiency with which this material is transferred through the food web will improve our ability to predict the outcomes of environmental flows. The review of our understanding of the influence of flow on food webs identified that:

- variations in food quality may influence an animal's capacity to grow or reproduce
- changes in the number of trophic steps will affect the amount of food available to support animal populations

In 2018-19 data generated from the above mesocosm work will be analysed and written up.

Objectives

- determine basal resource utilisation
- determine rates of transfer into the food web

Activities

- interpretation of Fatty acid and SIA analyses from mesocosm experiment (underway)

- data analysis and preparation of manuscript

Roles

- collation and initial preparation of data (UNE)
- analyses and manuscript preparation (UNE with Food Web Leadership Group)

Uses

The output from this activity will inform future model development (Component W4).
The manuscript will provide the basis for presentations to managers and the development of summary material to be made available through the web, as per the process described in the adoption strategy.

Changes from MYRP

None

Activity 2.4 — Basin scale resource use by fish

Description

This activity seeks to determine the generality of food web patterns across the Basin. Keller Kopf (CSU) has been collaborating with members of the LTIM project to sample fish and basal resources using comparable methods to those used in Activity 2.1 — Fish field program. Keller will also be determining trophic niche width for a number native fish species. Trophic niche is a fundamental dimension of food webs and measures of trophic position are used increasingly in applied fisheries and environmental management. The fish field sampling is now complete and in 2018-19 sample preparation, data analysis and interpretation will occur. Keller's work will be incorporated with information from other EWKR activities (e.g. Fish Theme activity F2 - Understanding the feeding requirements of larval fish in the northern Murray-Darling Basin, Fish Theme 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) along with information generated from LTIM.

Objectives

- determine the extent to which the patterns observed in field sampling in the southern basin can be applied across the basin
- develop an annual indicator for monitoring long-term changes in the trophic niche (trophic position and diversity of basal carbon sources) of Murray-Darling Basin fishes

Activities

- sample preparation
- data analysis
- manuscript preparation

Roles

- collation and initial preparation of data (CSU)
- analyses and manuscript preparation (CSU with Food Web Leadership Group)

Uses

Annual indicator for monitoring long-term changes in the trophic niche (trophic position and diversity of basal carbon sources) of Murray-Darling Basin fishes, with potential application for management and restoration activities including monitoring ecological responses to environmental flows and release of koi-herpes virus.

Changes from MYRP

None

Component W3 — Identifying important sites of production.

Description and Objectives

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
- Waterbirds: 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.

Activities

- Analysis of theme synthesis reports
- Identification of critical sites
- Report of critical site location
- Manuscript preparation

Roles

- All work conducted by MDFRC with guidance from project leader

Uses

A map and supporting documentation will be provided to CEWO and stakeholders outlining where the critical sites are and recommending management activities that best support the ecological outcomes for the system. This will help identify exactly where actions can be taken to best support MDB biodiversity. This information can be used by managers to guide water allocations and provide public confidence that the MDB Plan is achieving environmental goals.

Changes from MYRP

None, more specific information has been provided in this plan.

Component W4 — Modelling bioenergetics within identified production sites

Description

Previous research by the Australian Centre for Ecological Analysis and Synthesis (ACEAS) developed a numerical model to simulate fish carrying capacity in the southern connected MDB. There are obvious synergies between the aim of that model and the proposed research to be undertaken as a part of EWKR and we propose adapting the existing model and modifying it to suit the specific needs of the current project.

Objectives

- Collate additional sources of data for integration.
- Identify aspects of the conceptual model that are disproportionately important in the ranking of scenarios, and those most sensitive to the parameter values and shape of the relationships included to identify those elements which are most critical to understand and

model precisely.

- Develop a model capable of representing likely outcomes of scenarios of individual flows on fish recruitment outcomes, based on the synthesised knowledge generated within EWKR and previous research. This model will be an adaptation of the ACEAS model where possible, but is likely to combine conceptual, empirical and numerical relationships, depending on the quantity and quality of data available and our knowledge of the relationships involved.
- Rank scenarios of individual flows based on their ability to achieve fish recruitment outcomes at agreed sites within the MDB. These rankings may be qualitative or quantitative, depending on the form of the relationships able to be developed.
- Identify the range of sites and flow bands over which the modelled relationships hold to ensure appropriate application of the model.
- Identify next steps in terms of research and modelling to further develop the science of environmental flow delivery beyond the life of EWKR.

Activities

- Completion of the ACEAS code and manuscript submission
- Identify available data
- Sensitivity and importance analyses
- Identify potential new inputs
- Adapt ACEAS model
- Develop new model inputs
- Develop empirical and/or conceptual relationships
- Identify suitable sites/flows for extrapolation
- Evaluate flow scenarios

Roles

- ACEAS code completion and manuscript submission (MDFRC and Jian Yen)
- Development and adaption of new model (Deakin and Food Web leadership group)

Uses

- Integration of knowledge across the EWKR project.
- Incorporation of existing knowledge with the knowledge generated by EWKR.
- Conceptualisation as to how EWKR data collection adds to the science of environmental flows.
- Guidance as to the optimal delivery of individual flow events to achieve fish recruitment outcomes at agreed sites.
- Clear identification of remaining knowledge gaps and the relative importance of each.

Changes from MYRP

None

6 Waterbirds Theme

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

6.1 Introduction

The use of valuable 'environmental water' within Australia's Murray-Darling Basin has often been focused on supporting completion of ibis and spoonbill breeding events at key colonial nesting sites. However, managers and policy-makers are becoming increasingly conscious of the need to also manage feeding sites at Basin scales. Appropriately managing environmental water placement is

critical to facilitating the recruitment of juvenile birds into waterbird populations. Yet we lack basic knowledge of how water flows interact with other factors such as predation, weather extremes and food abundance to influence recruitment in Australia. We also lack knowledge of the movements of adults and young during and between breeding events – where do they go, and why? Filling these knowledge gaps is key to improving the efficiency of environmental water management – applying water to the right places at the right times – and ensuring the success of future breeding events and waterbird recruitment.

The Waterbird Theme of the Murray-Darling Basin Environmental Water Knowledge and Research Project has begun filling these knowledge gaps. By quantifying survival rates, movements, and their drivers using innovative modern technology such as remote nest cameras and GPS satellite tracking, it is assisting managers to identify key waterbird habitats and gain a better understanding of the scales at which habitats and environmental flows are required to support waterbird recruitment.

The Waterbird Theme key research questions are:

Component 1: Foraging habitats and movements

1. Where and what are the critical foraging habitats that support recruitment?
2. How might these be affected by water and land management and threats such as habitat loss?

Component 2: Nesting habitat requirements

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

MDB EWKR focuses on waterbird recruitment and movement for the following reasons:

- Management relevance: The Basin-Wide Environmental Watering Strategy seeks to increase abundance and increase breeding success; both depend on recruitment and movement.
- Key knowledge gap: Consultation with managers and researchers together with review of the literature has identified that recruitment and movements are key knowledge gaps.
- Potential to improve predictive capacity: Recruitment is an area in which there are significant opportunities to improve predictive capacity within the time and budget constraints of MDB EWKR.

A synthesis of the results of Waterbird Theme research will be provided in the form of a report in May 2019. This will allow finalisation of EWKR wide synthesis to be completed in early June.

The research outcomes for the Waterbirds Theme will fill key knowledge gaps and inform recommendations for environmental water planning, prioritisation and management and other natural resource management actions at local to basin scales.

What do managers want to know?

- Critical foraging, roosting and stopover sites
- Critical habitat characteristics (nesting, foraging, roosting, stopover)
- Foraging trip distances
- Critical routes/movement corridors
- Land and water management actions/policies required to support the above

Other biological / ecological knowledge gaps

- Sub-population boundaries/connectivity/existence, ranges
- Philopatry and natal philopatry
- Movement cues and modifiers – e.g. flooding characteristics, thermals, weather
- Movement paths, directions and distances (foraging, dispersal etc.)
- Variation among individuals, sexes, and age categories
- Timing of departures and arrivals and relationships with other factors
- Physical and behavioural changes as birds age (how can we 'age' them more accurately?)

6.2 Description of Research Activities

Waterbirds theme outputs from completed research activities are noted in MDB EWKR Outputs Register. Following sections note research activities that will continue in 2018-19 and any changes from the Multi-Year Research Plan. Schedule of research activities is noted in Annual Work Plan and Budget 2018-19.

Work for 2018-2019 comprises the following components: Data processing and analysis; and Theme planning, coordination and reporting.

Component B2 Field research

Activity B2.4 — 2018–19 Field research analyses

Activity B2.4 will involve final data collation, processing, analysis and reporting for the field research component.

Activity B2.4.1 — Data processing and analysis

Objective

The objective of this activity is to analyse data collected as part of the field research, including:

- Detailed satellite-tracking movement studies
- Identification and characterisation of important foraging and roosting habitats and their locations
- Surveys of nesting habitat characteristics and species preferences
- Quantifying egg and chick survival rates
- Quantifying predation (species, impacts, timing, location)
- Estimating impacts of nest/egg/chick exposure

Activities and Roles

Data to be processed and analysed include:

- 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 UNSW)
- data analysis: diet/bioenergetics (UNSW, 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 and UNSW)
- integrative data analyses and interpretation (CSIRO and UNSW).

Outputs

Data analysis outputs to support reporting and other communications.

Uses

Analysis results will be used to inform reporting and other communications.

Changes from MYRP

None

7 Theme Planning, Coordination and Reporting

Each of the research themes have a theme planning, coordination and reporting activity which includes the following:

- theme research coordination, ensuring that the research activities are administered effectively and delivered in a coordinated manner to deliver MDB EWKR objectives, including participation in Annual Research Forum and integration between themes
- theme research planning, including contributions to budgets, workplans and subcontracts
- development and refinement of the ARP and MYRP. The ARP will be revised each year to reflect proposed activities for the forthcoming year. The MYRP will be undated each year if any significant changes are required.
- project reporting, including contributions to:
    - mid-year and annual progress reporting
    - Scientific Advisory Group (SAG) Workshops
    - Jurisdictional Reference Group (JRG) Workshops
    - Regional Adoption Workshops
- theme level reporting, including the theme Final Research Report, and contributions to the Final Research Report for each site and the overall MDB EWKR Synthesis Report (noting that these reports will build on the specific outputs associated with individual research components and activities)
- reporting, communication and engagement with stakeholders external to the project team as opportunities arise. This fosters collaboration and networks and builds the basis for successful adoption of MDB EWKR research outcomes.

8 References

Associated MDB EWKR project documents are available for download at https://www.mdfrc.org.au/projects/ewkr/resources/.

Murray–Darling Basin Authority (2014) *Basin-Wide Environmental Watering Strategy*. MDBA Publication No 20/14. Murray–Darling Basin Authority, Canberra, Australia.

Murray–Darling Basin Commission (2004) *Native Fish Strategy for the Murray–Darling Basin 2003-2013*. MDBC Publication No. 25/04. Murray–Darling Basin Commission, Canberra, Australia.