MONITORING AND EVALUATION PLAN FOR MDBA DEMONSTRATION REACHES

Demonstration Reach name

Bourke to Brewarrina.

Proponent and capacity to implement the M&E plan

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Experience:

The Aquatic Ecosystems Unit of NSW DPI provides the information necessary to manage the State's aquatic resources and environment by monitoring aquatic ecosystems and executing a large number and variety of research projects in fisheries conservation, aquaculture, commercial and recreational fisheries.

Dr Craig Boys has extensive experience researching the habitat associations of fish in dryland rivers of the Murray-Darling Basin and is leading a number of research projects tasked with monitoring the ecological response to fish passage remediation, floodgate management, irrigation offtake management and instream rehabilitation works. He recently co-authored a report outlining a framework with which to monitor ecological outcomes in Demonstration reaches. Craig has been coordinating the M&E plan for the Bourke to Brewarrina Demonstration Reach since its inception in 2006. Craig is currently coordinating the Monitoring, Evaluation, Reporting, Improvement and Innovation theme of the large scale Caring for Our Country (CFoC) bid and for the northern Basin, as well as the MDBA's business plan for the northern Basin.

Background to the demonstration reach

NSW DPI and the CRC for Freshwater Ecology, after a three-year study, published a report in 2005 entitled 'Fish Habitat Assessment and Protection in the Barwon-Darling and Paroo Rivers' (Boys *et al.* 2005). The study established a set of principles for the assessment of fish habitat and the distribution of fish assemblages within

large dryland rivers. The report highlighted the following areas of concern in the Barwon-Darling River:

- The low abundance of suitable in-channel habitat in some reaches;
- The presence of numerous weirs that impede fish passage;
- The prevalence of bank slumping;
- The lower densities of riparian vegetation in some areas;
- The dominance of alien species (including Carp).

The report outlined an action plan to protect the fish assemblage of the Barwon-Darling River and to facilitate its recovery. It was recommended that the stretch of river between the townships of Bourke and Brewarrina be used as a 'demonstration reach' to showcase to the community the cumulative benefits of undertaking a number of interventions for rehabilitation of native fish habitat and populations. Along with other demonstration reaches being implemented throughout the Murray-Darling Basin, this semi-arid region demonstration reach would give a truly basin-wide approach to restoring fish populations.

The B2B demo reach has been officially recognised by the Federal Government as a High Conservation Aquatic Ecosystem (HCVAE). This is a significant recognition as it identifies the demo reach as a key target with which to focus CFoC funding and on-ground works in upcoming years. To put this in perspective, the B2B demonstration reach is the ONLY non-Ramsar listed site currently prioritised for CFoC activities within NSW. As a result, the B2B demo reach is a key component of a large scale $20M bid currently being submitted under CFoC and is the focus of a medium scale bid. Under the large scale bid, $100K per year has been set aside for monitoring, the majority of which is likely to be used for fish monitoring.

The Bourke to Brewarrina Demonstration Reach project is a collaborative effort between NSW DPI (the practitioner) and the Western CMA and Murray-Darling Basin Authority. NSW DPI is also coordinating the ecological monitoring program. A Steering Committee consisting of representatives from the fore mentioned agencies also includes representatives from the local indigenous community, local council, local landholders and recreational fishing club.

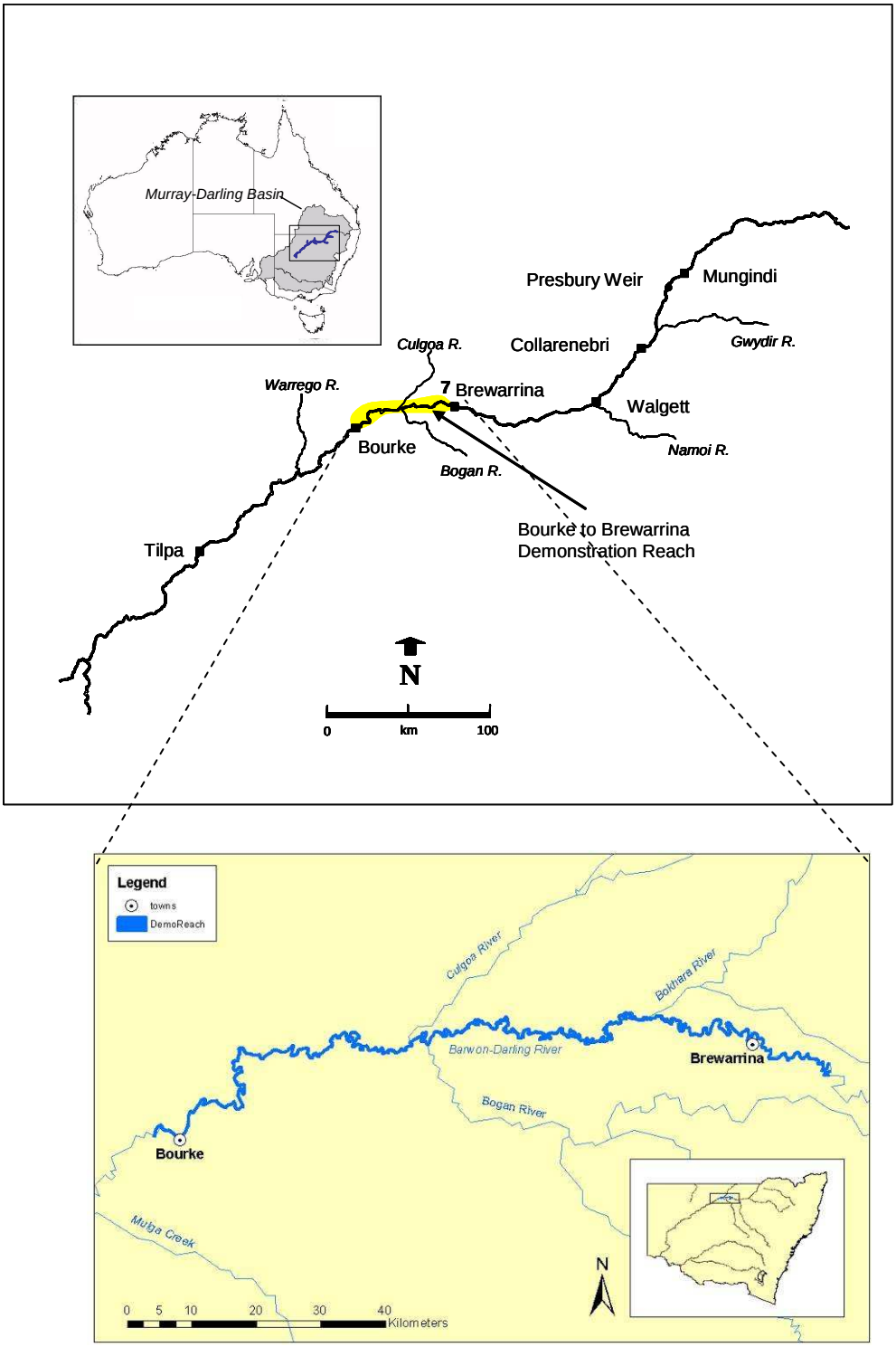
Key Issues to be addressed within the B2B Demonstration Reach

Key issue
Lack of in-channel habitat
Carp dominate the fish assemblage
Barriers to fish passage at Bourke and Brewarrina Weirs
Low densities of riparian vegetation in some areas
Entrainment of native fish in irrigation pumps
Lack of deep holes in some stretches

The overarching goal or vision of the demonstration reach is to address the key conservation issues within the site in a coordinated way in order to promote a measurable improvement in native fish. This M&E plans elaborates on what a "measurable improvement" is and how it will be quantified. More specifically, the goals of the reach are:

Goal	Intervention *
Increase the availability of in-channel habitat for fish	Re-snagging at multiple degraded sites [IH].
Reduce the proportion of carp within the reach	Locally-run Carp musters [IH]; Carp separation cage on Bourke and Brewarrina weir [FR].
Restore fish passage at the bottom (Bourke) and top (Brewarrina) of the reach	Concept designs being developed for a vertical-slot fishway at Bourke Weir and a rock-ramp fishway being built at Brewarrina Weir [Bourke FR, Bre IH].
Improve the density of riparian vegetation in some areas	Fencing of riparian zone in some sections to exclude stock [IH]; Off-channel water points to discourage stock from entering riparian zone [IH].
Reduce the entrainment of native fish in irrigation pumps	Scoping and pilot study of screens on pumps [IH].
Increase the availability of deep hole habitat in some stretches	Re-snagging to reinstate natural scouring processes [IH]; Potential channel deepening of some stretches [FR].

* Funding security:
IH: In hand
C: Committed
FR: Currently unfunded and dependent future fund raising
AS: Funding application submitted



Location of Reach

Links between interventions, goals, hypotheses, monitoring scales and chosen indicators

Interventions	Goals	Hypothesised response *	Scale of response / measurement Temporal (E.g. 0-4 years or ≥ 5 years)	Scale of response / measurement Spatial (E.g. demo reach or sub-reach)	Indicators to be measured
All interventions	Trajectory of improvement in native fish numbers in the whole demonstration reach.	H_1: Increase in the abundance of native fish at the demonstration reach scale when compared to control reaches on other rivers [IH]	>5	Demo reach	Assemblage attributes associated with native fish response such as proportion of natives to aliens, abundance of golden perch, silver perch and Murray cod.
Re-snagging	Increase hydraulic diversity in re-snagged reaches;	H_2: Hydraulic diversity increases at re-snagged sites compared to untreated control sites [IH]	0-4	Sub reach	Change in velocity parameters: direction, speed, turbulence
	Creation of deep hole habitat in re-snagged reaches;	H_3: Scour hole formation is greater associated with installed snags when compared to untreated sites [IH]	0-4	Sub reach	Depth profile: diversity, spatial arrangement of holes
	Increase in abundance of native fish species utilising treated sites;	H_4: The abundance of Murray cod, Golden perch and Silver perch increases at re-snagged sites when compared to control sites and approaches that of reference sites [IH]	0-4	Sub reach	Mean abundance and size class analysis of native and alien species likely to respond to instream habitat works e.g. golden perch, silver perch, Murray cod and carp.

Fishways (assuming Bourke fishway construction within next 3 years of project)	Demonstrate the passage of fish through the fishways and improved connectivity of habitats and dispersal of migratory fish species;	H_5: The Bourke fishway operates to specifications regarding the species and size classes of fish that can successfully negotiate the fishway [FR]	5 (depending on construction of Bourke fishway: within 2 years of construction)	Sub reach	Mean abundance and size class analysis of migratory species e.g. golden perch, silver perch, Murray cod and carp.
	Trajectories of improvement in the numbers of migratory native fish in the whole demonstration reach.	H_6: Reduction in accumulations of migratory species downstream of fishway [FR]	5 (within 2 years of fishway construction)	Sub reach	Mean abundance and size class analysis of migratory species e.g. golden perch, silver perch, Murray cod and carp.
		H_7: The abundance of migratory species increases upstream of the fishway and decreases in sites immediately downstream [FR]	>5 (within 2-3 years of construction)	Demo reach	Mean abundance and size class analysis of migratory species e.g. golden perch, silver perch, Murray cod and carp.
Riparian fencing, off-channel watering points	Regeneration of native trees, grasses and shrubs in treated areas;	Not to be monitored			
	Establishment of native trees, grasses and shrubs in treated areas.	Not to be monitored			

Fish screens on pumps	Demonstrate the effectiveness of screens in reducing the entrainment of native fish and scope feasibility of larger-scale roll-out. Guide the roll-out of this technology to other reaches	H_8: Fish screens reduce the number of fish entrained in treated pumps relative to unscreened pumps [IH]	1-4	Sub reach	Adundance of fish entrained. Size class of fish entrained, mortality of fish entrained. The relative frequency of entrainment, escapement and impingement will also be quantified using DIDSON
Carp control	Trial and demonstrate the effectiveness of carp separation cage on a vertical slot fishway at Bourke	H_9: The relative abundance of carp decreases in the demonstration reach [FR]	>5	Demo reach	Mean abundance and size class analysis of carp
		H_{10}: Carp separation cage significantly reduces the abundance of carp that can successfully pass through a vertical slot fishway [FR]	Within 2 years after carp cage installation	Sub reach	Mean abundance and size class analysis of carp
		H_{11}: Carp separation cages do not significantly reduce the passage of native fish [FR]	Within 2 years after carp cage installation	Sub reach	Mean abundance and size class analysis of golden perch, bony herring, silver perch and Murray cod
	Optimise trap “tipping” times to develop operational protocols that maximise carp catch and minimise interference with native fish	H_{12}: Carp separation cage has optimal ‘tipping’ or cycle time to maximise carp capture whilst not negatively impacting on native fish passage [FR]	Within 2 years after carp cage installation	Sub reach	Relative proportion of native to alien passage and capture between different cycle times

	Use carp musters to inform community on impact of carp and demo reach as a whole	No hypothesis set as this is purely an engagement tool and unlikely to have measurable effect (see conceptual model)	NA	NA	NA

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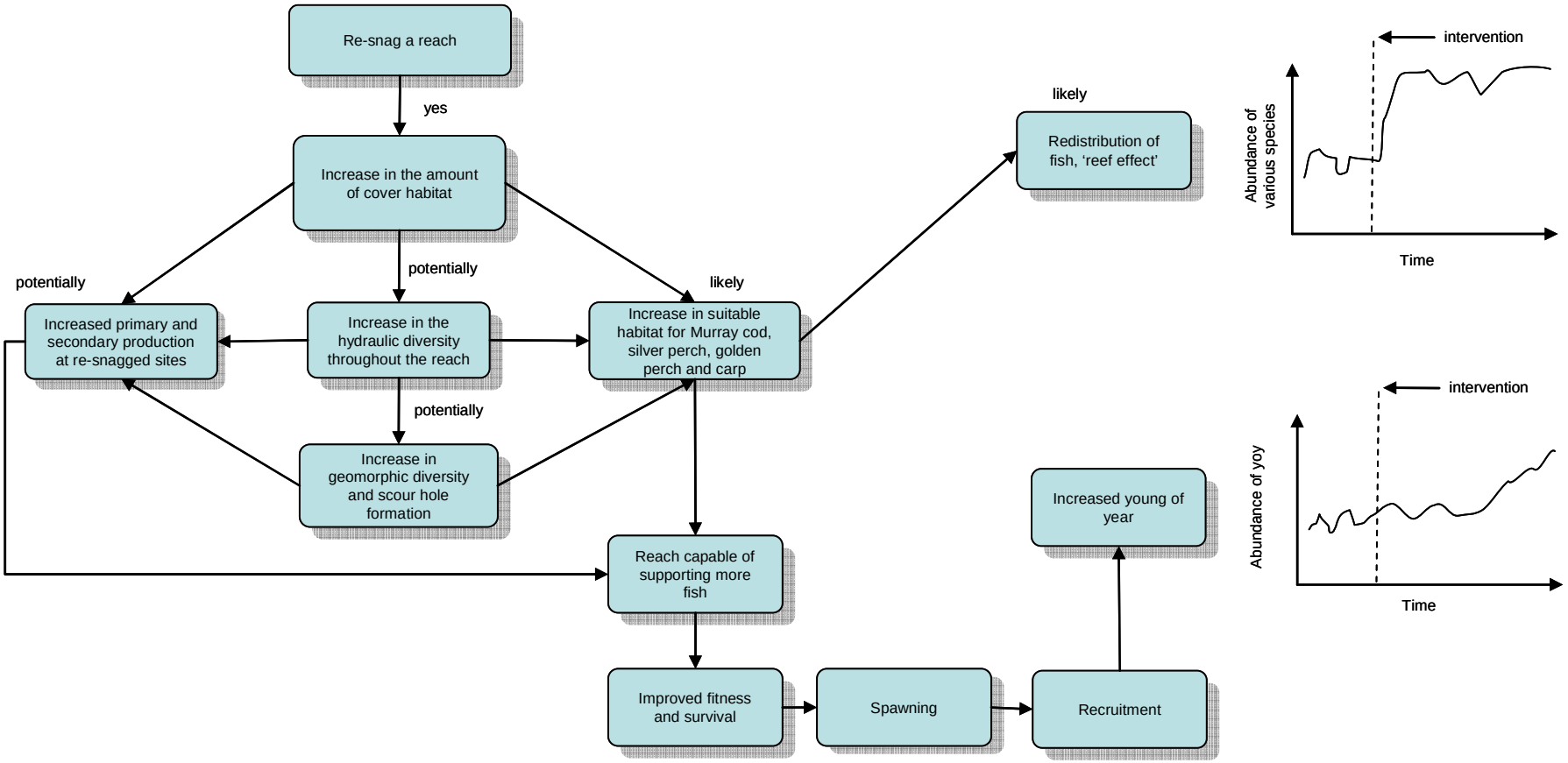
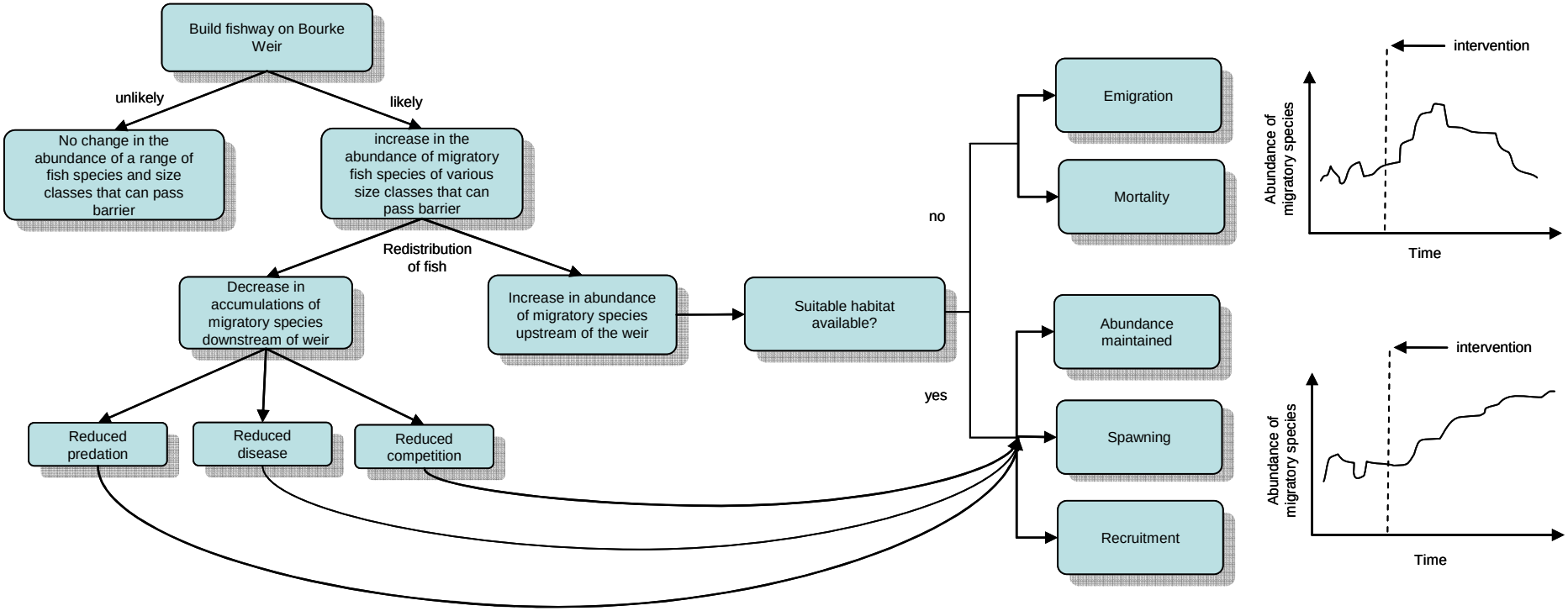
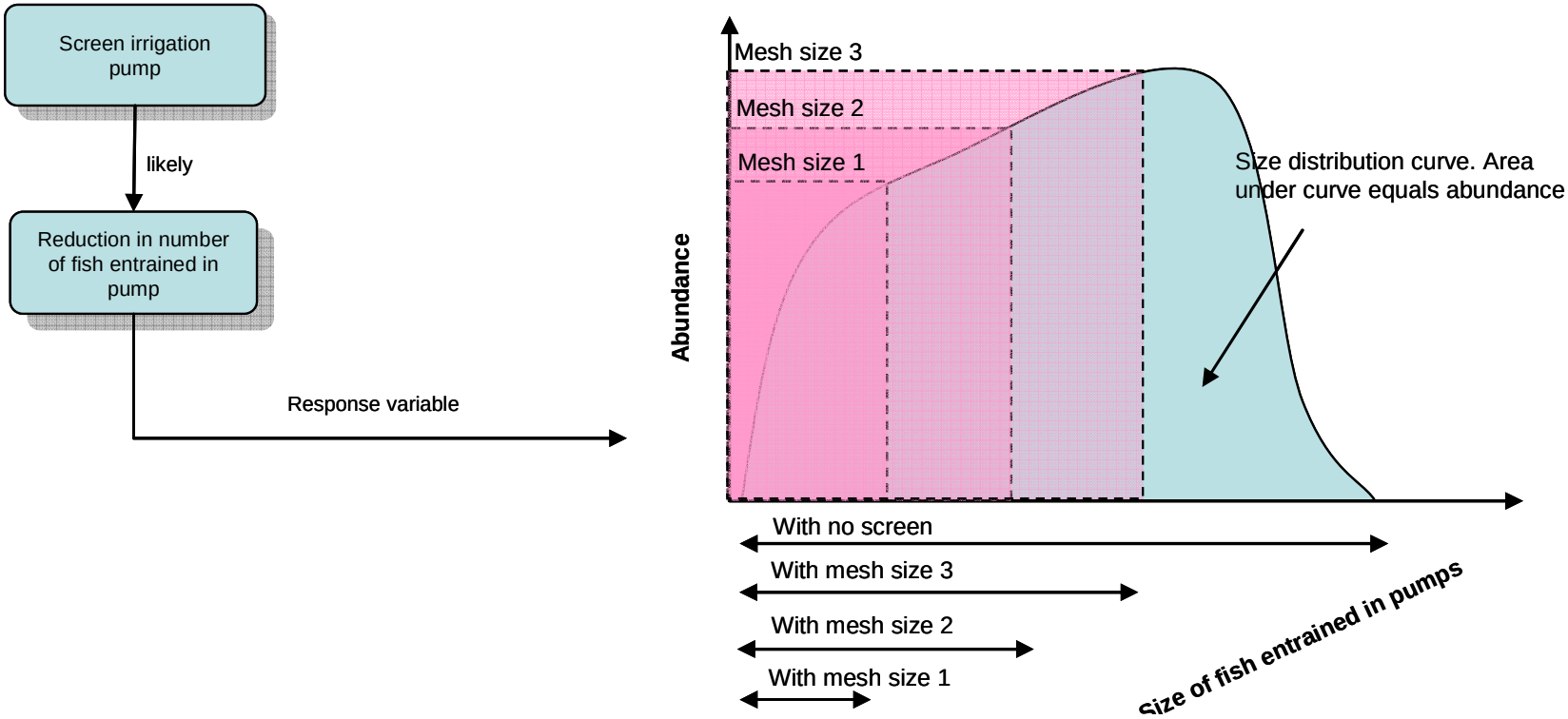
Conceptual models



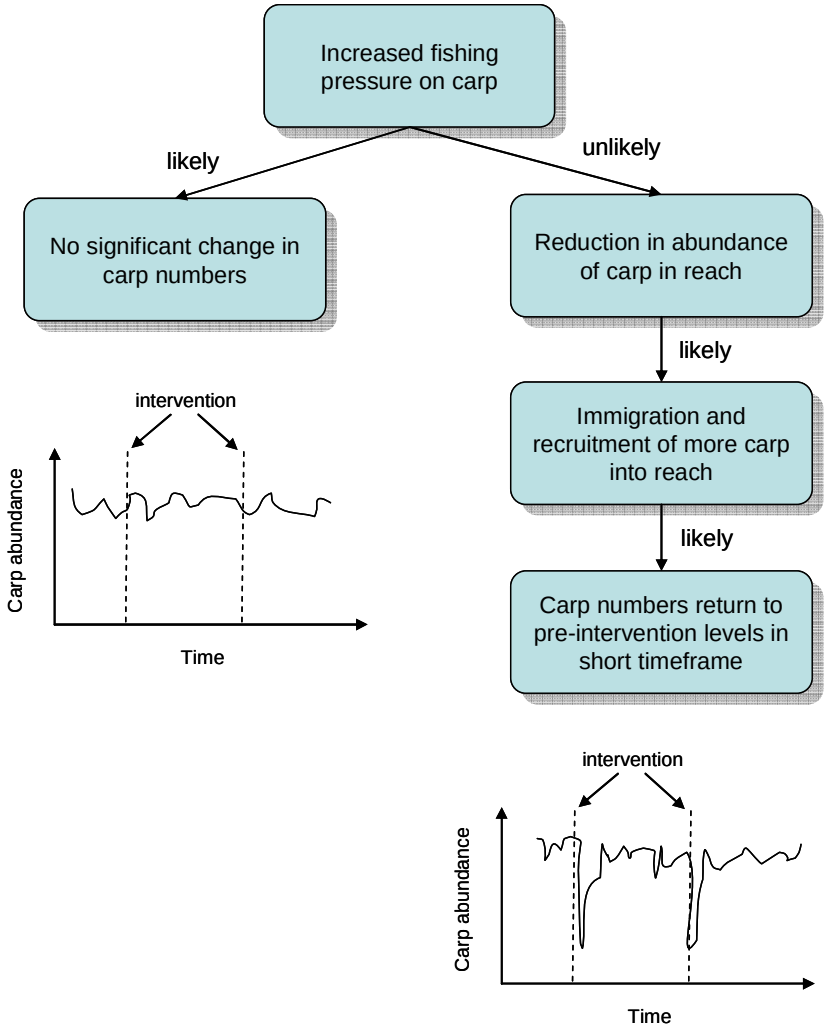
Conceptual model for response to re-snagging (Hypotheses 2-4).



Conceptual model of response to Bourke Weir Fishway (Hypotheses 5-7)



Conceptual model of response to offtake modifications (Hypothesis 8)



Conceptual model of response to carp muster. **Conceptual model of carp separation trap (Hypotheses 9 & 10) to be developed in late 2009**

Experimental and statistical design

An informal power analysis was performed with the assistance of NSW DPI biometricians to address the question of how to best allocate sampling effort within this trial. That is, what level of effort (number of replicate sites) is required to give the greatest level of precision (smallest standard error) and therefore greatest level of power to detect change. Abundance data for Murray cod, golden perch, carp and bony herring were obtained for 14 sites on the Barwon-Darling River (NSW DPI 2007). Standard error was used as a measure of precision and the model used was for an impact-control experiment. It was evident that, regardless of species, most of the improvement in the ability to detect change due to extra replication is obtained by 7 replicates.

Task 1. Demo reach scale trend in fish assemblage (Hypothesis 1, Status: underway): Annual fish surveys (November to January) both within the DR and at external control reaches. Since 2006, 31 sites have been monitored within the DR, however this is likely to be reduced to seven sites once the re-snagging trial is completed (see timeline). Initially six sites in each of two external control rivers were used Namoi and Gwydir Rivers, see map below) as data was available back to 2006 as part of the Sustainable Rivers Audit (SRA) and Integrated Monitoring of Environmental Flows (IMEF) projects. The use of the Namoi reach, however, is now somewhat confounded since rehabilitation activities are now underway as part of NSW's second demonstration reach. These Namoi sites will therefore be incorporated into the Namoi Demo Reach M&E plan.

It is likely that this design will create a temporally asymmetrical design with relatively few 'before' rehabilitation years (two) and many more than 'after' years. Additionally it is hard to make a clear distinction between 'before' and 'after' phases as more and more interventions become applied throughout the life of the reach. It is therefore likely that DR scale trends in the fish assemblage will be measured using a site trajectory approach which enables treatment sites to be compared to untreated controls with limited need for 'before' data (Boys *et al.* 2009).

Task 2. Hydraulic and bathymetric surveys of re-snagging sites (Hypotheses 2 & 3, Status: complete):

A total of 31 sites were surveyed for the purpose of this study. These corresponded to the same re-snagging, control and reference sites used in re-snagging trial (Task 3). am. Reaches were between 100 – 400 metres in length and were grouped into either 'Control', 'Reference' and 'Re-snagging" reach types.

The following is an excerpt from the University of Canberra final report that outlines the statistical design:

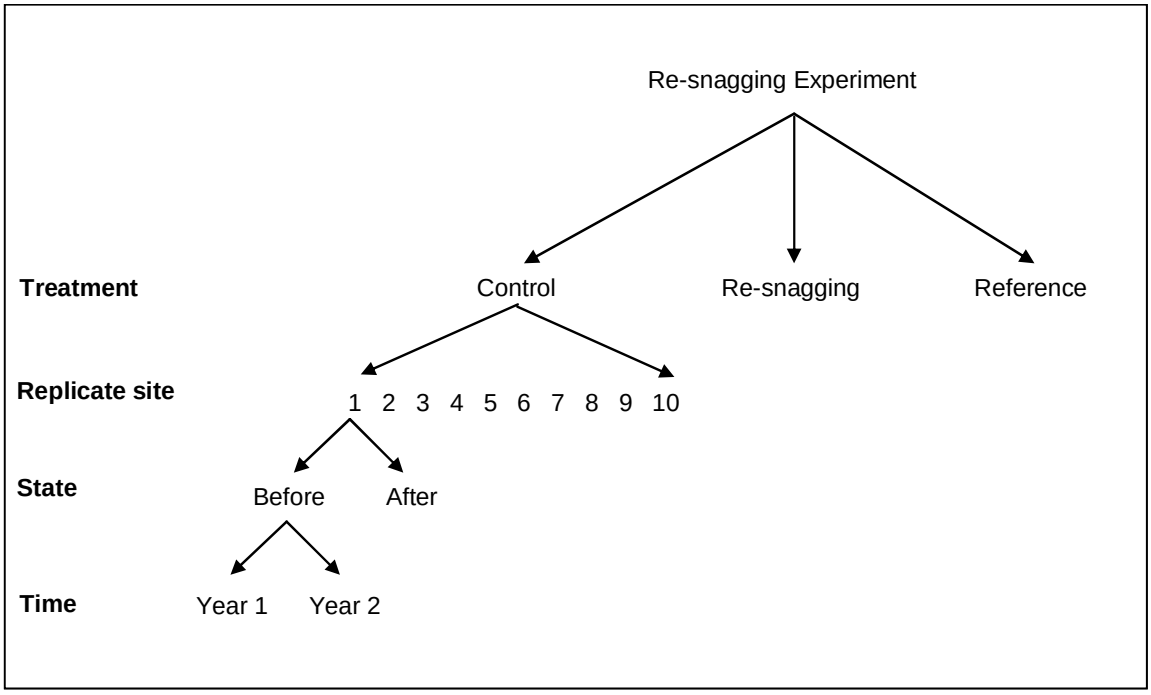
> *"Individual velocity profiles were summarised as depth-averaged velocities in cm s^{-1} using the Sontek River Surveyor program. For each reach and survey time, the depth-averaged velocities were interpolated to raster grids in ARCGIS 9.1 using an Inverse Distance Weighted transformation. Grids were then reclassified into classes or hydraulic patches based on boundaries determined*

from the break points in the cumulative frequency curve of all depth-average velocity points. These grids which represent a "landscape" or "reach-scape" of velocity patches were used to derive a number of metrics using the spatial analysis package FRAGSTATS Version 3.3 McGarigal and Marks 1995. The nine metrics selected describe the abundance, shape, size, spatial arrangement and diversity of hydraulic patches belonging to each of the a priori determined classes for each reach-scape.

The character of the reach-scapes was investigated using a range of multivariate statistical analyses. Firstly, association matrices were calculated using the Gower environmental difference measure, as suggested for non-biological data by Belbin, 1993. These were calculated for two datasets; a dataset containing all patch variables and all reach-scapes (all reach dataset), and a second containing only "re-snagged" reach-scapes (re-snagged only dataset). Analysis of Similarity (ANOSIM) was then run on these association matrices to test for differences between time, reach type and time x reach type for the all reach dataset and time for the re-snagged only dataset. Semi-Strong-Hybrid Multidimensional Scaling (MDS; Belbin 1993 was then used to represent these similarity matrices graphically. Stress levels of less than 0.2 indicated that the ordination solutions were not random. Principle Axis Correlation (PCC; Belbin 1993) was then used to identify relationships between the patch variables and the location of each reach-scape in multidimensional space. Only those patch variables with an R^2 of greater than 0.8 were considered. In addition, univariate t-tests were used to compare individual patch variables between the two survey times, when the data was separated by reach type."

Task 3. Sub-reach scale responses to re-snagging (Hypothesis 4, Status: underway):

The re-snagging experiment is being run as a full rehabilitation model, utilising data from three different treatments: (a) areas requiring re-snagging and receiving re-snagging, *'impact sites'*; (b) areas requiring re-snagging but not re-snagged, *'control sites'*; and (c) areas not requiring re-snagging and not re-snagged, *'reference sites'*. With such a design the control condition will inform whether a change has resulted from the re-snagging impact and the reference condition will inform whether the change is in the desirable direction. To build in contingency and allow for the loss of sites throughout a study it was decided to sample a minimum of 11 re-snagging, 10 control and 10 reference sites. The final design for intervention monitoring of the re-snagging works is as follows:



Experimental design of re-snagging experiment.

Task 4. Assessment of Bourke Fishway performance (Hypothesis 5, Status: awaiting funding, not underway): This in contingent on the construction of Bourke Fishway, which in itself is contingent on obtaining CFoC funding. The exact design will be developed once funding is secured. It will involve a combination of PIT tagging looking at ascent success and ascent times for large native species and direct top/bottom trapping as per the experimental and statistical design outlined in Baumgartner *et al.* (2008). The key objectives will be to determine whether the fishway is allowing passage of a full range of size classes and species of fish. It will also be possible to determine whether modifications can be made to future fishway installations to make them more efficient. Finally, it will be possible to ascertain whether fish are successfully negotiating fishways and gaining access to some of the newly 'connected' key aquatic habitats. The construction and monitoring of Bourke Fishway is a key activity planned under current Caring for Our Country (CFoC) large scale and medium scale bids and also as part of MDBA's Northern Basin Business Plan. Should the fishway be built, sampling will commence on completion of fishway construction.

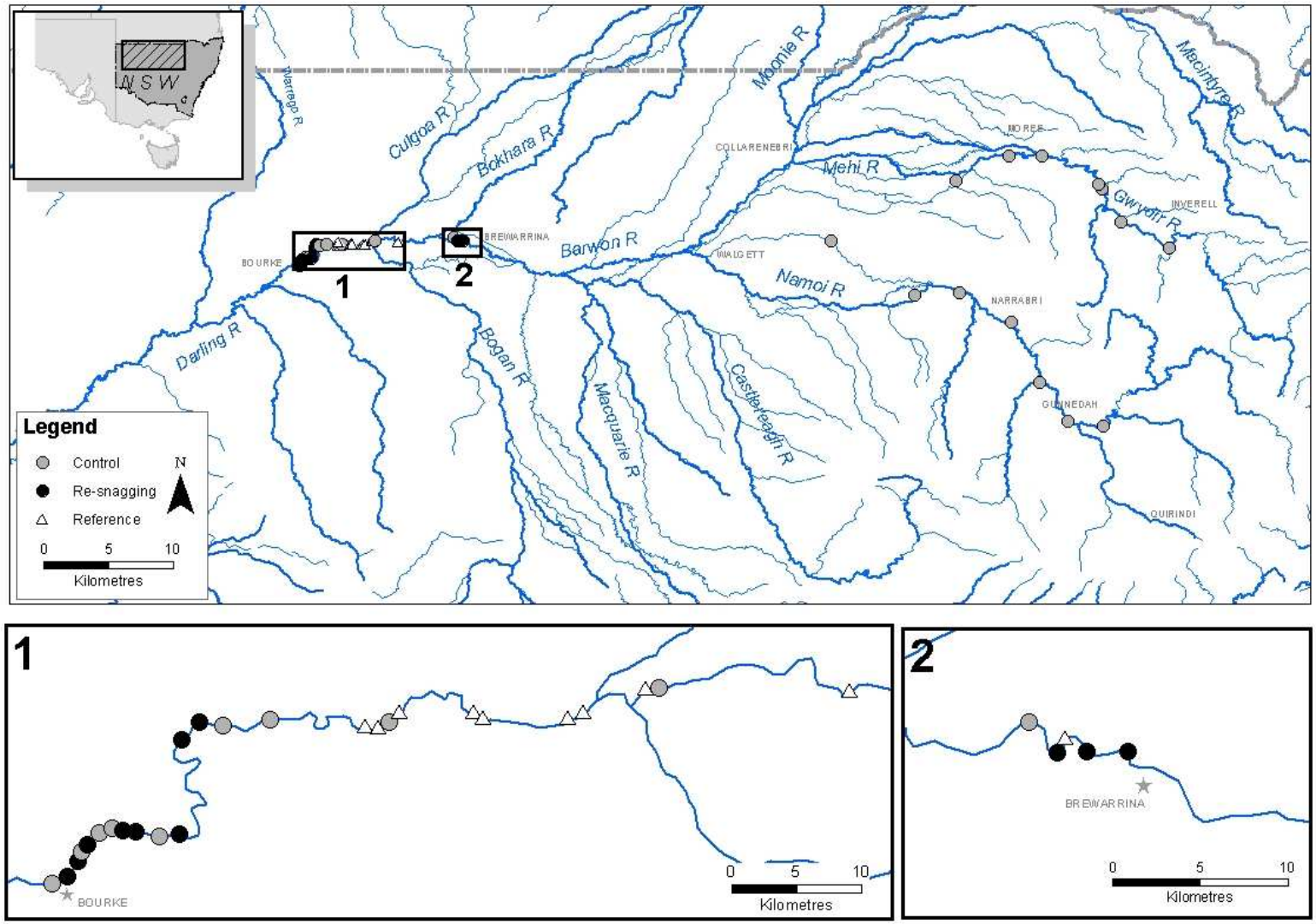
Task 5. Assessing impact of Bourke Fishway on passage of fish into demo reach (Hypotheses 6 & 7, Status: awaiting funding, not underway): The final experimental design will be dependent on how it can be integrated into the wider M&E plan of the DR and also meet the targets and budget within the large scale CFoC project for the northern Basin. This component will be further developed should the fishway become funded under the CFoC bid process. Targets relating to both habitat connectivity and fish response can be evaluated. Hydrological modelling at barriers, before and after fishway construction, will allow direct measurements to be made regarding changes in the seasonality, duration and frequency of fish passage events (and therefore habitat connectivity). This will then be related to the migratory

ecology of individual species, allowing inferences to be made about the potential responses that will be observed in the migratory fish community. These responses are all quantifiable with a sampling program targeted around newly constructed fishways and their adjacent habitats upstream and downstream. Key objectives will be to determine whether fishways are reducing accumulations of fish downstream of the barrier and contributing to positive changes in the abundance and diversity of fish upstream with respect to both native and alien species.

Task 6. Offtake trial (Hypothesis 8, Status: underway): The offtakes monitoring (to be undertaken as part of another research project) will utilise a latin square design and movable pumping station. This design has been developed in close consultation with an independent biometrician (Wayne Robinson) and approved through the relevant projects steering committee.

Task 7. Reach scale carp surveys (Hypothesis 9, Status underway): Will utilise experimental design outline in Task 1. Sampling is being undertaken to as part of reach scale community surveys but are not aligned with any hypotheses yet, as an integrated carp program is awaiting CFoC funding.

Task 8. Assessment of carp separation cages (Hypothesis 10 Status: awaiting funding, not underway): These activities are contingent on CFoC activities associated with the construction and monitoring of Bourke Fishway and carp separation cages on Bourke and Brewarrina Fishways. The experimental and statistical design will be developed by Craig Boys and other scientists if and when funding is secured (most likely as part of the CFoC bid process). In essence the experiment will trial relative success of carp cages on a vertical slot fishway (Bourke), and on the first rock ramp application in the Basin (Brewarrina).



Location of electrofishing sampling reaches within the Demonstration reach and external controls in Namoi and Gwydir Rivers. The establishment of a Namoi demonstration reach is now likely to make the Namoi unsuitable as a control, however, these sites will be utilised as part of the Namoi Demo reaches M&E plan.

Methods

By key Tasks

Task 1. Demo reach scale trend in fish assemblage (Hypothesis 1): Annual fish surveys (September to January) using boat mounted electrofishing and bait trapping as per SRA protocols.

Task 2. Hydraulic and bathymetric surveys of re-snagging sites (Hypotheses 1 & 2): Canberra University Hydrologists contracted to survey hydraulic conditions and bathymetry of re-snagging, control and reference reaches within B2B reach (see location map below). Surveys were carried out on two occasions; once in May (1/05 – 8/05), several weeks before re-snagging commenced, and November (10/11 – 14/11) 2008 after re-snaggging was completed. Low flow conditions were present during both survey occasions. Flows of 40-63 MLD at the Bourke Town Gauge station occurred during the May survey trip, while flows of 26-46 MLD were present at the Bourke Town Gauge during the November survey trip. Depth and flow velocities and direction were recorded along each reach using a boat mounted Acoustic Dopler Profiler (ADP). Depth-velocity profiles were recorded at 5 second intervals as the boat was slowly driven in a zigzag pattern from bank to bank up each study reach. This equated to an average of 261 depth-velocity profiles per reach. X, Y co-ordinates were recorded using the ADP for each profile allowing for the derivation of reach scale depth-averaged velocity grids.

Task 3. Sub-reach scale responses to re-snagging (Hypothesis 3): Fish surveys carried out using boat mounted electrofishing as per SRA protocol, targeting larger species likely to respond to re-snagging (i.e. cod, golden perch, silver perch and carp). This is a four year trial utilising annual sampling at re-snagging, control and reference sites within demo reach (two years before re-snagging and two years after). The trial will be complete after the year 4 fish survey is complete (see timeline). Tag and recapture studies will help determine whether changes are due to redistribution of individuals.

Task 4. Assessment of Bourke Fishway performance (Hypothesis 5): Key objectives will be to determine whether the fishway is allowing passage of a full range of size classes and species of fish. Methods will employ both PIT tag monitoring and direct trapping using a purpose built assessment cage that can be placed at the bottom (entrance) and top of the fishway (as per methods of Baumgartner *et al.* 2008).

Task 5. Assessing impact of Bourke Fishway on passage of fish into demo reach (Hypotheses 6 & 7): It is likely that a combination of fish sampling methods will be used including fish community surveys (using boat electrofishing) above and below barriers and a combination of both Passive Integrated Transponder (PIT) and external dart tagging. This data will enable both the state and trend of the fish community to be tracked in response to the works. An experimental design and methods will be developed over the next 12 months and sampling will start at the conclusion of the re-snagging trial and involve sampling multiple times before and

after the fishway becomes operational. Annual PIT tag-outs will begin on word of successful CFoC funding and continue annually to maintain a tagged population of fish.

Task 6. Offtake trial (Hypothesis 8): To be undertaken as separate NSW DPI/MDBA study utilising direct trapping of fish entrained by pumps and a combination of Acoustic Doppler and DIDSON to look at impingement and velocity thresholds surrounding pumps. Methods developed and endorsed by separate steering committee. The results will be used to roll out this technology in this and other demonstration reaches throughout the Basin.

Task 7. Reach scale carp surveys (Hypothesis 9): Will utilise sampling carried out under Task 1.

Task 8. Assessment of carp separation cages (Hypothesis 10): Design and methodology to be developed in late 2009 (see explanation in previous section)

References

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