Government of South Australia
South Australian Murray-Darling Basin
Natural Resources Management Board

The Living Murray – Lower Lakes, Coorong and Murray Mouth Icon Site

# CONDITION MONITORING PLAN

# Lower Lakes, Coorong and Murray Mouth Icon Site Condition Monitoring Plan

Prepared for

**South Australian Murray-Darling Basin Natural Resources Management Board**

Prepared by

**Maunsell Australia Pty Ltd**
Level 28, 91 King William Street, Adelaide SA 5000, Australia
T +61 8 7100 6400 F +61 8 7100 6499 www.maunsell.com
ABN 20 093 846 925

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Revised by SA MDB NRM Board
GPO Box 2834 Adelaide SA 5001
www.samdbnrm.sa.gov.au
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- Adrienne Frears, SA MDB NRM Board
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# Table of Contents

# Part 1: Background: Management Requirements and Administrative Setting

# 1.0 The Living Murray Program

The Living Murray is Australia's most significant river restoration program. It aims to achieve a healthy working River Murray system for the benefit of all Australians. The Living Murray was established in 2002 in response to the declining environmental health of the River Murray systems.

The Program's "First Step", to be implemented by 2009, focuses on recovering 500GL of water for the River Murray. This recovered water will be used to specifically benefit the environmental health of the River Murray. The Living Murray (TLM) Program aims to improve the environment at six designated Icon Sites (Figure 1). The six Icon Sites of The Living Murray program include:

- Barmah–Millewa Forest (Victoria, NSW)
- Gunbower–Koondrook–Perricoota Forest (Victoria, NSW)
- Hattah Lakes (Victoria)
- Chowilla Floodplain and Lindsay–Wallpolla Islands (SA, Victoria, NSW)
- River Murray Channel (SA, Victoria, NSW)
- Lower Lakes, Coorong and Murray Mouth (SA).

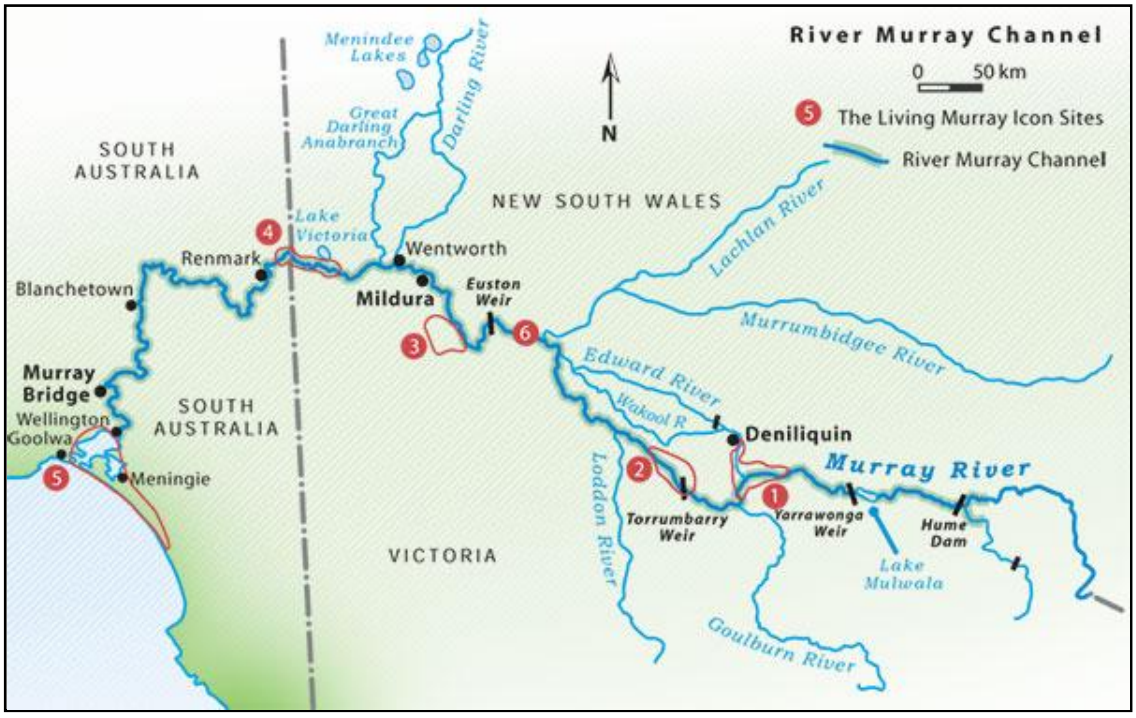



**Figure 1: Location of The Living Murray Icon Sites. 1: Barmah–Millewa Forest; 2: Gunbower–Koondrook–Perricoota Forest; 3: Hattah Lakes; 4: Chowilla Floodplain & Lindsay–Wallpolla Islands; 5. Lower Lakes, Coorong and Murray Mouth; 6: River Murray Channel** (Source: http://www.thelivingmurray.mdbc.gov.au ).

The Living Murray Icon Sites were chosen for their high ecological value – most are listed as internationally significant wetlands under the Ramsar convention – and also their cultural significance to Indigenous people and the broader community. Ecological objectives have been developed for each Icon Site and are aimed at retaining, restoring or improving the sites' ecosystems, habitats, and species of flora and fauna.

The Lower Lakes, Coorong and Murray Mouth (LLCMM) cover approximately 140,000 hectares, covering 23 different wetlands types ranging from fresh to hypersaline. The Lower Lakes, Coorong and Murray Mouth is one of the 10 major havens for large concentrations of wading birds in Australia, and is recognised internationally as a breeding ground for many species of waterbirds and native fish.

This LLCMM Icon Site Condition Monitoring Plan outlines specific methodologies that will address Icon Site Targets which can be used to assess changes in ecological condition of the Icon Site against higher level ecological objectives.

# 2.0 Icon Site Management

Prior to establishing an Icon Site Condition Monitoring Plan, it is important to understand the context and framework for The Living Murray initiative and specifically those policies that establish the requirements for condition monitoring.

The following sections summarise the purposes of The Living Murray's Business Plan, Outcomes Evaluation Framework and condition monitoring requirements. It also presents recent Murray-Darling Basin Authority (MDBA) developments relating to requirements for preparing Icon Site condition monitoring plans. Further detail is available in those supporting references cited below.

## 2.1 The Living Murray Business Plan

The Living Murray Business Plan (MDBC 2007a) requires the development of a comprehensive monitoring and evaluation plan that will report on the environmental objectives identified in each Icon Site Environmental Management Plan. The monitoring and evaluation plan will also provide a consistent approach to monitoring and reporting across the all six The Living Murray Icon Sites.

The outcomes of monitoring and evaluation inform the annual review of investment and water recovery targets and review of the Intergovernmental Agreement by Murray-Darling Basing Ministerial Council. The Council will consider performance against:

- Objectives of the Intergovernmental Agreement (2004)
- Appropriateness of interim ecological objectives
- Scope of remaining water recovery opportunities
- Further funding and water recovery commitments for The Living Murray.

A complete description of monitoring and reporting obligations can be found in The Living Murray Business Plan (MDBC 2007a, Section H).

## 2.2 The Living Murray Outcomes Evaluation Framework

The Living Murray Outcomes Evaluation Framework (MDBC 2007b) guides the development of monitoring, evaluation and reporting arrangements across all Icon Sites. Specifically, the Outcomes Evaluation Framework provides the guidelines for developing and implementing monitoring programs (e.g. Icon Site Condition Monitoring Plans) and reporting arrangements.

The overriding principle of the Outcomes Evaluation Framework is to provide a structure and process that will secure the minimum information needed to report on the success of The Living Murray First Step Decision. It will also guide development of monitoring arrangements under each of the Icon Site Environmental Management Plans.

A definition and description of all The Living Murray monitoring types and requirements can be found in the Outcomes Evaluation Framework (MDBC 2007b).

## 2.3 The Living Murray Condition Monitoring Purpose

Icon Site condition monitoring aims to determine change in the environmental condition of an individual Icon Site resulting from those water applications and works programs implemented through The Living Murray.

The overarching objective for Icon Site condition monitoring is to assess whether native fish, bird and vegetation communities are being maintained at sustainable levels across the Icon Sites. This may also include non-native species subject to international agreements (e.g. Ramsar Convention).

Icon Site condition monitoring follows a similar approach to that of Programmed Monitoring Activities. Programmed Monitoring Activities are to be performed at a network of pre-designated, permanent sites, according to a predetermined schedule, and provide information to monitor and assess progress towards the ecological targets that have been defined (see DWLBC 2006, MDBC 2006a).

Site condition monitoring will be specifically tailored to determine if the outcome and objectives for each Icon Site are being met.

The desired outcome (or vision) for the Lower Lakes, Coorong and Murray Mouth Icon Site (LLCMM Icon Site) is "*a healthier Lower Lakes and Coorong estuarine environment*". The ecological objectives used to define this are:

- An open Murray Mouth
- More frequent estuarine fish spawning
- Enhanced migratory wader bird habitat in the Lower Lakes.

A number of targets have been developed to assess the success of the objectives (see MDBC 2006b). These targets form the basis of the Icon Site Condition Monitoring Plan. Icon Site condition monitoring does not attempt to assign ecological responses to management actions; this is the purpose of intervention-based monitoring (see McCarthy et al. 2006 and MDBC 2007b, for more information on intervention monitoring).

A complete description of condition monitoring requirements can be found in Section 3 of the Outcomes Evaluation Framework (MDBC 2007b).

## 2.4 Icon Site Condition Monitoring Plan: Outline of Requirements

An Icon Site Condition Monitoring Plan should guide the development of monitoring arrangements to provide the bare minimum information needed to report to Murray-Darling Basin Ministerial Council (see Sections 2.2 and 2.3).

The Murray-Darling Basin Authority recognises that there are non-The Living Murray monitoring activities underway at each Icon Site, and that it is desirable for Icon Site teams to have all monitoring activities identified in the same document. However, it is important to be able to clearly identify The Living Murray monitoring activities within the monitoring document.

A summary of LLCMM Icon site sampling programs is discussed in Marsland and Nicols (2006). This list may not be fully inclusive of all monitoring or research programs conducted within the Icon Site.

A review of developed condition monitoring plans by The Living Murray Monitoring Taskforce will identify opportunities for consistencies and efficiencies for delivery of monitoring components across all Icon Sites and other management and monitoring programs.

### The Living Murray Baseline

Experimental design and statistical analyses for Icon Site condition monitoring must be able to detect a deviation from the defined The Living Murray baseline condition trajectory. Baseline information for The Living Murray is currently being collated and its description will encapsulate the trajectory concept (using historical and current data).

### Icon Site Targets

Icon Site targets are used to either directly or indirectly assess the success of The Living Murray water applications against higher ecological objectives.

Icon Site Managers are responsible for setting Icon Site targets. Each target should include clearly identified variables to be measured in Icon Site Condition Monitoring Programs.

Targets should be spatially and temporally quantitative (e.g. abundance, diversity). Qualitative or 'directional' targets can be used if quantitative targets cannot be established (e.g. increased number of migratory wading birds). Targets must be time-bound, and where feasible, be presented as short term (5 years) and long term (20 years) targets.

### Monitoring Activities

Murray-Darling Basin Authority recommends consideration is given to the guidelines stated in Baldwin et al. (2004) and Cottingham et al. (2005) when developing monitoring programs.

While 'standard monitoring techniques' have been developed by the MDBA for use across all Icon Sites, many of these techniques are not applicable in the Lower Lakes, Coorong and Murray Mouth Icon Site. For example, electro-fishing is not effective in high salinities as experienced in the Lakes and Coorong, and the standard condition assessments and remote sensing techniques for river red gums and black box cannot be applied here, as these species are not present. As such, site specific techniques are more than often employed within this framework.

### Implementing Study Design

Each site condition monitoring program will identify the arrangements in place for undertaking data collection, including whether the agency itself will undertake data collection or a consultant.

Quality assurance should be considered as part of developing a monitoring program. Cottingham et al. (2005) outlines quality assurance considerations (e.g. ANZECC and ARMCANZ 2000) that are relevant to The Living Murray monitoring.

### Data Management

A clear data management protocol will be established that includes how data will be archived, and how and when data will be provided to the Murray-Darling Basin Authority.

### Data Storage

The SA MDB NRM Board is currently developing a Management Action Database, which will be maintained by the Board. The database will assist in tracking environmental watering activities, entering and interrogating spatial information, generating spatial products, recording historical

site information (including past reports relevant to a particular wetland or floodplain), developing reports for various partners, and standardized recording of ecological and site data. The database is due for completion in late 2009, after which Icon Site condition monitoring data will be stored within it. In the interim, data collected through condition monitoring programs is to be stored in Excel format; using standard metadata fields for existing South Australian agency databases (see review by Hydro Tasmania, 2003).

### Data Analysis and Review

Data analysis for condition monitoring will be undertaken by the individual monitoring contractors, and then interpreted by Icon Site Manager (or delegate). A review will be undertaken by the Coorong, Lower Lakes and Murray Mouth Scientific Advisory Group (CLLMM SAG). The CLLMM SAG will undertake periodic reviews of the site condition monitoring program as directed by the TLM Monitoring Taskforce. This is likely to occur every 3-5 years, in response to changes in monitoring needs within the Coorong, Lower Lakes and Murray Mouth Icon Site.

Opportunities for implementation of intra-, and inter Icon Site analyses utilising innovative statistical techniques will be considered as will opportunities for further analyses which promote system understanding.

### Reporting

Icon Site condition monitoring will be reported annually through the annual report for implementation of the Icon Site Environmental Management Plan. Along with reports from the other Icon Sites, this will be consolidated into a single report for the Murray-Darling Basin Ministerial Council to consider in September each year (see MDBC 2007c for a recent example).

## 2.5 Management Summary

The policy requirements from the above documents drive the structure of the condition monitoring plan. The following section can be used as a stand alone condition monitoring plan.

## 2.6 Conceptual Models

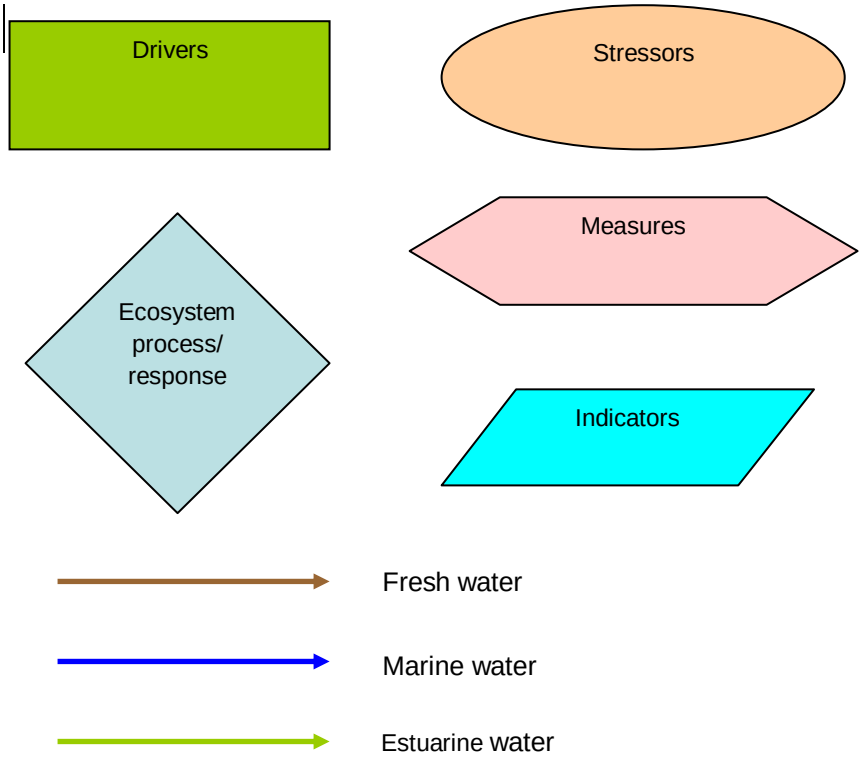
A series of conceptual models have previously been developed for the Icon Site (e.g. MDBC 2006b, Wilkinson et al. 2007a; 2007b; Appendix A). The models were initially commissioned by managers to assist in the design of monitoring programs for the various targets for the region under the Living Murray initiative and had a specific focus on the management of freshwater inputs. The models were a useful starting point for the future modeling of the Icon Site but are now in a state of revision.

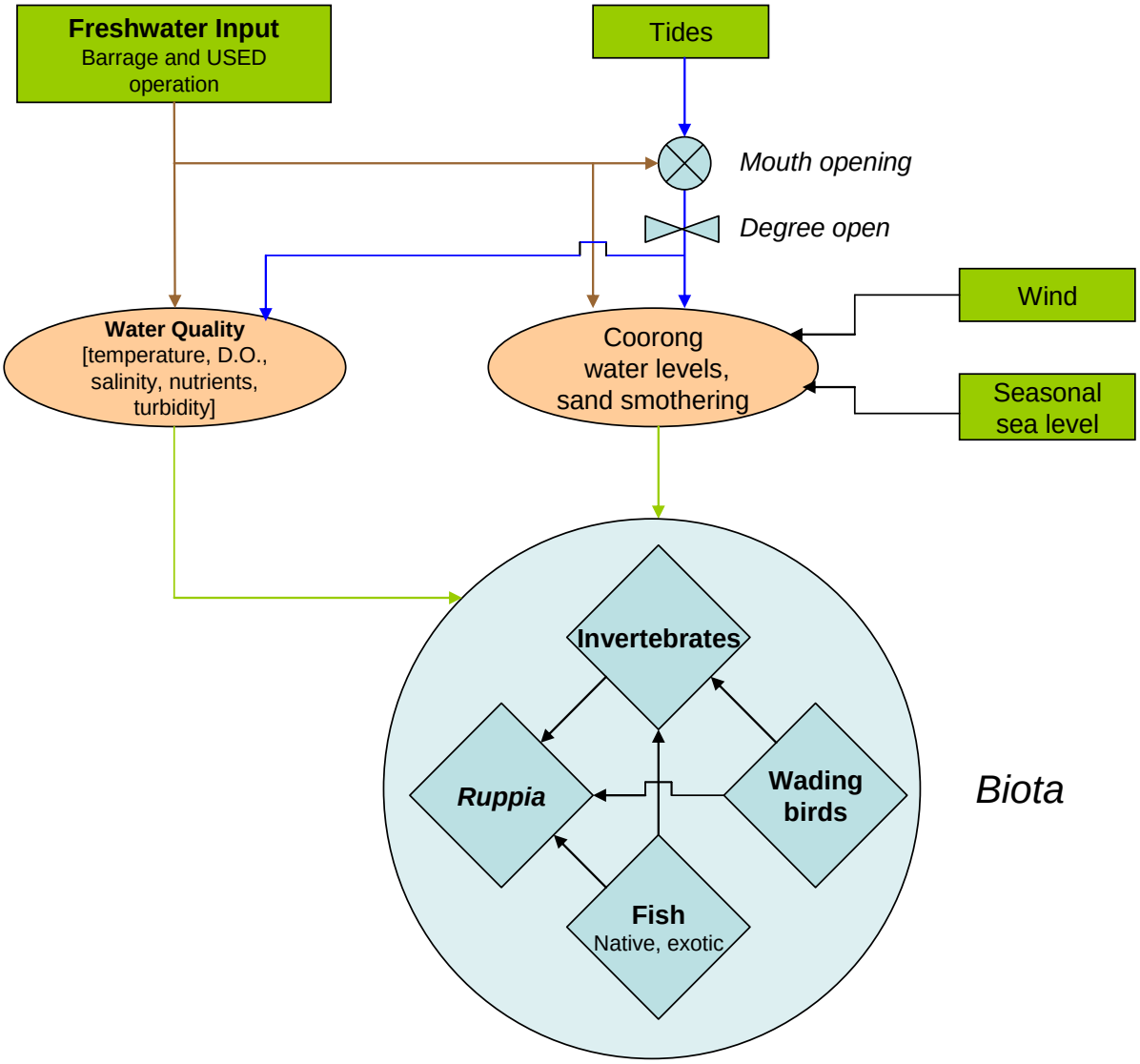
It is likely that a number of sub-models will be developed for various sub-components within the system (e.g. fish, birds, vegetation sub-models). Any future conceptual models are likely to result from outcomes of the DEH Murray Futures/CLLAMM ecology projects in consultation with the Board's Coorong, Lower Lakes and Murray Mouth Scientific Advisory Group as knowledge about the system advances.

The following conceptual models are modifications of those initially presented in MDBC (2006b). They have since been developed to aid the selection of monitoring measures and indicators according to Wilkinson et al. (2007a,b).

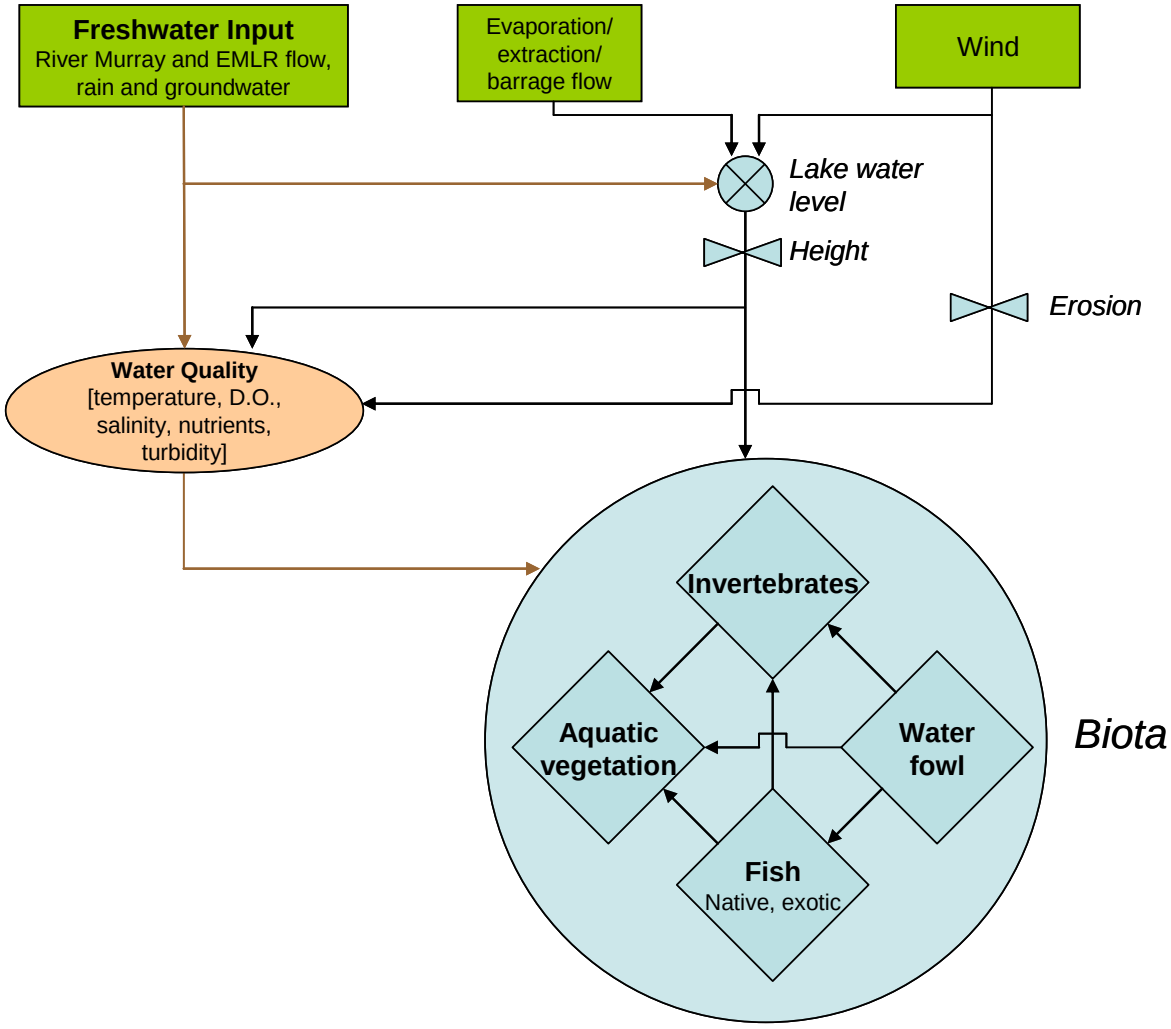
A legend of the symbology used in the models is presented below. See Wilkinson et al. (2007a,b) for a more detailed description of these models.

**Model Symbology**






**Coorong Model initially presented in MDBC (2006b), with modifications as outlined in Wilkinson *et al*. (2007 a, b).**




**Lower Lakes Model initially presented in MDBC (2006b), with modifications as outlined in Wilkinson *et al.* (2007 a, b).**

# Part 2: LLCMM Icon Site Condition Monitoring Plan

# 3.0 LLCMM Icon Site EMP Targets

This section aims to highlight the measurables (outputs) and methodologies to be addressed through condition monitoring in relation to:

- Biotic groups: birds, fish, vegetation, invertebrates
- Abiotic groups: mudflats, water.

The condition monitoring outputs required for fish, vegetation, birds and invertebrates are presented in Table 1; mudflats and water outputs are presented in Table 2.

Linkages between objectives and targets within the Lower Lakes Coorong and Murray Mouth Icon Site are presented in Table 3.

It should be noted that different zones within the LLCMM Icon Site have different species of interest, for example small bodied threatened fish are targeted in the Lower Lakes, diadromous species near the barrages and commercial/hypermarine specialists in the Coorong.

**Table 1: Objectives for biotic (bird, fish, invertebrate, vegetation) groups that will be monitored to assess the ecological condition of the LLCMM Icon Site (modified after Table 1a, MDBC 2007b).**

| GROUP | OBJECTIVE | VARIABLES |
|---|---|---|
| **Birds** | | |
| Assemblage | Sustainable communities of waterfowl and waders. | • Species diversity<br>• Distribution |
| Species | Healthy Lower Lakes and Coorong that supports improved populations of:<br>• Australasian bittern (*Botaurus poiciloptilus*)<br>• Australian pelican (*Pelecanus conspicillatus*)<br>• Australian spotted crake (*Porzana tabuensis*)<br>• Banded stilt (*Cladorhynchus leucoceohalus*)<br>• Black swan (*Cygnus atratus*)<br>• Chestnut teal (*Anas castanea*)<br>• Common greenshank (*Tringa nebularia*)<br>• Curlew sandpiper (*Calidris ferruginea*)<br>• Fairy tern (*Sterna nereis*)<br>• Latham's snipe (*Gallinago hardwickii*)<br>• Pied oyster catcher (*Haematopus longirostris*)<br>• Red-capped plover (*Charadrius ruficapillus*)<br>• Red-necked avocet (*Recurvirosta novaehollandiae*)<br>• Red-necked stint (*Calidris ruficollis*)<br>• Sanderling (*Calidris alba*)<br>• Sharp-tailed sandpiper (*Calidris acuminata*). | • Abundance |
| **Fish** | | |
| Assemblage | Sustainable native fish communities of River Murray, Lower Lakes, Murray Mouth estuary and Coorong<br>• Diadromous species. | • Species diversity<br>• Distribution |

| GROUP | OBJECTIVE | VARIABLES |
|---|---|---|
| Species | Viable populations of:<br>• Black bream (*Acanthopagrus butcheri*)<br>• Common galaxias (*Galaxias maculatus*)<br>• Congolli (*Pseudaphritis urvillii*)<br>• Greenback flounder (*Rhombosolea tapirina*)<br>• Mulloway (*Argyrosomus japonicus*)<br>• Murray hardyhead (*Craterocephalus fluviatilis*)<br>• Pouched lamprey (*Geotria australis*)<br>• Southern pygmy perch (*Nannoperca australis*)<br>• Short-headed lamprey (*Mordacia mordax*)<br>• Small-mouthed hardyhead (*Atherinosoma microstoma*)<br>• Yarra pygmy perch (*Nannoperca obscura*). | • Abundance<br>• Size/age structure<br>• Recruitment<br>• Distribution |
| **Invertebrates** | | |
| Assemblage | Sustainable communities of benthic invertebrates | • Community composition<br>• Abundance<br>• Species diversity<br>• Biomass<br>• Distribution |
| Species | • Amphipods<br>• Chironomid larvae<br>• *Arthritica helmsi*<br>• *Capitella* spp.<br>• *Ficopomatus enigmaticus*<br>• *Nephtys australiensis*<br>• *Paragrapsus gaimardii*<br>• *Simplisetia aequisetis*<br>• Diatoms*<br>• Dinoflagellates*<br>• *E. coli*^.<br>Note: *phytoplankton; ^bacteria. | • Abundance<br>• Distribution |
| **Vegetation** | | |
| Assemblage | Healthy, diverse communities of aquatic, emergent and littoral vegetation. | • Community composition<br>• Abundance<br>• Species diversity<br>• Distribution |
| Species | Viable populations of:<br>• *Gahnia filum*<br>• *Melaleuca halmaturorum*<br>• *Myriophyllum* spp.<br>• *Phragmites australis*<br>• *Ruppia megacarpa*<br>• *Ruppia tuberosa*<br>• Samphire | • Relative abundance<br>• Distribution<br>• Age structure<br>• Condition<br>• Recruitment |

| GROUP | OBJECTIVE | VARIABLES |
|---|---|---|
| | • *Schoenoplectus* spp.<br>• *Typha domingensis.* | |

**Table 2: Objectives for abiotic (mudflats and water) groups that will be monitored to assess the ecological condition of the LLCMM Icon Site (modified after Table 1a, MDBC 2007b).**

| GROUP | OBJECTIVE | VARIABLES |
|---|---|---|
| **Mudflats** | | |
| Habitat | Frequently exposed sediments along the shores to provide foraging ground for shorebirds. | • Emergence and submergence frequency<br>• Spatial extent<br>• Sediment size<br>• Organic content |
| **Water** | | |
| Habitat | Increased River Murray inflow to the Lower Lakes and Coorong that will ensure:<br>• Sufficient water to maintain water quality and provide a healthy ecosystem<br>• Re-establishment of ideal estuarine conditions with preferred salinity gradient and area extent<br>• Sufficient barrage outflow to maintain an open Murray Mouth without dredging<br>• Continuous operation of fishways<br>• Tidal inundation of estuarine mudflats. | • Water level<br>• Water quality<br>• Water quantity<br>• Salinity |

Direct questions pertaining to target outcomes as stated in the Lower Lakes Coorong and Murray Mouth Icon Site Environmental Management Plan (MDBC 2006b) have been developed. Results from condition monitoring assessments can be quantified and/or inferred against higher level objectives (Table 3). The ecological objectives have been discussed in Section 2.3.

Condition monitoring reports should not limit discussion to answering the requirements of targets as they are stated here. Condition monitoring reports should, as a minimum, specifically state a conclusion against the condition monitoring purpose of the specific target. Reports should also provide discussion of a target's results in a management context. Where possible, results should be mapped and/or graphically presented to assist in visually communicating The Living Murray outcomes.

**Table 3: A comparison of targets against objectives to determine which targets will contribute to achieving each objective. Open Mouth = an open Murray Mouth. Fish Recruitment = more frequent estuarine fish spawning. Bird Habitat = enhanced migratory wader bird habitat in the Lower Lakes. Categories are classed as follows for monitoring types; A = recommended TLM standard, B = icon site specific method linked to FSD objectives, O= other specific method not easily linked to FSD objectives.**

| ID | Target | Open Mouth | Fish Recruitment | Bird Habitat | Category |
|---|---|---|---|---|---|
| | **Birds (B)** | | | | |
| B-1 | Maintain or improve bird populations in the Lower Lakes, Coorong and Murray Mouth. | | | ✓ | **A, B** |
| | **Fish (F)** | | | | |
| F-1 | Maintain or improve recruitment success of diadromous fish in the Lower Lakes and Coorong. | ✓ | ✓ | | **B** |
| F-2 | Maintain or improve recruitment success of endangered fish species in the Lower Lakes. | | ✓ | | **B** |
| F-3 | Provide optimum conditions to improve recruitment success of small-mouthed hardy head in the South Lagoon. | | ✓ | | **B** |
| F-4 | Maintain or improve populations of black bream, greenback flounder and mulloway in the Coorong. | ✓ | ✓ | | **B** |
| | **Invertebrates (I)** | | | | |
| I-1 | Maintain or improve invertebrate populations in mudflats. | ✓ | ✓ | ✓ | **B** |
| I-2 | Provide freshwater flows that provide food sources for Goolwa cockles. | ✓ | | | **B** |
| | **Mudflats (M)** | | | | |
| M-1 | Facilitate frequent changes in exposure and submergence of mudflats. | ✓ | | ✓ | **B** |
| M-2 | Maintain sediment size range in mudflats. | | | ✓ | **B** |
| M-3 | Maintain organic content for mudflats. | | | ✓ | **B** |
| | **Vegetation (V)** | | | | |
| V-1 | Maintain or improve *Ruppia megacarpa* colonisation and reproduction. | | ✓ | ✓ | **B** |
| V-2 | Maintain or improve *Ruppia tuberosa* colonisation and reproduction. | | ✓ | ✓ | **B** |
| V-3 | Maintain or improve aquatic and littoral vegetation in the Lower Lakes. | | ✓ | ✓ | **B** |
| | **Water (W)** | | | | |
| W-1 | Establish and maintain variable salinity regime with >30% of area below sea water salinity concentrations in estuary and North Lagoon. | | ✓ | ✓ | **O** |
| W-2 | Maintain a permanent Murray Mouth opening through freshwater outflows with adequate tidal variations to improve water quality and maximise connectivity. | ✓ | ✓ | ✓ | **O** |
| W-3 | Maximise fish passage connectivity between the Lower Lakes and Coorong. | | ✓ | | **O** |
| W-4 | Maximise fish passage connectivity between the Coorong and the sea. | ✓ | ✓ | | **O** |

# Icon Site Condition Monitoring: Minimum Requirements and Methodologies

In order to appropriately address the administrative requirements of condition monitoring, the "Condition Monitoring Purpose" section is the focus of the condition monitoring plan. The results from any condition monitoring program can then be used to inform the ecological target. The Condition Monitoring Purpose removes any ambiguity, should it exist, within the Target title. It establishes a clear answerable objective for each monitoring program.

Raw data should be a deliverable in any future monitoring contract. This will permit supplemental data analyses to be performed as necessary by the Icon Site Manager (or delegate) or MDBA as required.

A description and explanation of the items and the requirements used in the following section are provided in Table 4.

**Table 4: Terminology used to define the condition monitoring program for each target.**

| Item | Requirement |
|---|---|
| **Target ID** | Provides a clear identifiable reference for each target. |
| **Target Title** | Title of Target as approved by the Icon Site Manager. |
| **Target Definitions** | Clarification of terminology used in the target title. 'Increase in abundance' is often used as a target during drought as ecological populations have crashed to low levels. |
| **Condition Monitoring Purpose** | Rewording of the target title to clearly state what is essential under the MDBA requirements for condition monitoring. The results (outputs) from condition monitoring are then used to inform the target title. That is, the condition monitoring purpose is the objective of the monitoring program. |
| **Selected Species** | Species that are the specific focus of the monitoring program associated with the target. |
| **Outputs** | The specific measurable that are required to be answered (i.e. monitoring deliverables). The objects are based on the requirements stated in MDBC (2006b):<br>• Quantify: Empirical measurements required. Any results should be described in detail.<br>• Map: A visual representation of the specific output is required<br>• Report: Succinct discussion required. May involve comparison of data between this and other studies and/or between years. There should be a clear explanation of results and statements made.<br>• Comment: General discussion on a particular output where supporting data may be lacking. This should also include discussion of environmental and management implications for any observed changes. |
| **Timing** | Months or seasons that monitoring should be conducted. |

| Item | Requirement |
|---|---|
| **Sub regions** | States which sub regions of the Lower Lakes, Coorong and Murray Mouth apply to this target. The sub-regions are:<br>• Lake Alexandrina - including lower reaches of the Eastern Mount Lofty tributaries (i.e. Currency and Tookayerta Creeks; Finniss, Bremer and Angas Rivers) and Hindmarsh Island creeks and channels<br>• Lake Albert – main lake body to Narrung Narrows<br>• Murray Mouth estuary (including Boundary Creek and Mundoo Channel downstream of the barrages) extending from Goolwa barrage to Pelican Point<br>• North Lagoon – Pelican Point to Parnka Point<br>• South Lagoon – Parnka Point to southern most extremity of South Lagoon. |
| **Sites** | Specific sites that must be sampled. These will become standard reference sites. |
| **Methodology** | The specific methodology required to monitor this target. |
| **Implementation** | Outlines who is currently performing work to address the target. |
| **Comments** | Any additional relevant information including knowledge gaps which may need to be addressed separately to the condition monitoring plan (i.e. gaps may be beyond the definition or responsibility of Icon Site condition monitoring). |

## 3.1 Modification of Prescribed Requirements

The Icon Site Manger may be required to modify information (e.g. methodologies, sites, outputs) prescribed within this section due to limiting environmental conditions (e.g. low water levels caused by drought).

**Destructive Sampling**

Modification to sampling methodologies may include limiting future impacts resulting from destructive sampling. For example, if reliable age and length relationships have been established for certain fish species, it may be possible to use size structure as a surrogate for age. This will limit the need for the ongoing collection and sacrifice of individuals for subsequent age determination using otoliths.

The number of individuals sacrificed should be reported as part of any condition monitoring contract.

## 3.2 Review

The Lower Lakes Coorong and Murray Mouth Icon Site Condition Monitoring Plan should be revised in conjunction with the Lower Lakes Coorong and Murray Mouth Icon Site Environmental Management Plan.

The requirements detailed within the Condition Monitoring Plan may need to be amended at shorter time periods (e.g. annually) to reflect changes in sampling sites, methodologies, targeted species, outputs, analysis and/or data as knowledge advances.

# 4.0 Condition Monitoring Targets - Minimum Requirements

## 4.1 Birds

**Monitor populations of selected bird species in the Lower Lakes and Coorong (B-1).**

| Item | Requirement |
|---|---|
| **Target ID** | **B-1** |
| **Target Title** | Maintain or improve bird populations in the Lower Lakes Coorong and Murray Mouth. |
| **Target Definitions** | Improved is defined as an increase in population abundances over time (i.e. populations display a positive trajectory). |
| **Condition Monitoring Purpose** | **Monitor populations of selected bird species in the Lower Lakes and Coorong.** |
| **Selected Species** | Species have been selected based on their presence contributing to the Ramsar status of the site and their importance to indigenous culture, and from a suite of different functional groups (e.g. waders, cryptic, piscivorous, herbivorous).<br><br>Migratory<br>• Sharp-tailed sandpiper (*Calidris acuminata*)<br>• Curlew sandpiper (*Calidris ferruginea*)<br>• Red-necked stint (*Calidris ruficollis*)<br>• Sanderling (*Calidris alba*)<br>• Banded stilt (*Cladorhynchus leucoceohalus*)<br>• Latham's snipe (*Gallinago hardwickii*)<br>• Common greenshank (*Tringa nebularia*).<br>Resident<br>• Chestnut teal (*Anas castanea*)<br>• Australasian bittern (*Botaurus poiciloptilus*)<br>• Red-capped plover (*Charadrius ruficapillus*)<br>• Black swan (*Cygnus atratus*)<br>• Pied oyster catcher (*Haematopus longirostris*)<br>• Australian pelican (*Pelecanus conspicillatus*)<br>• Australian spotted crake (*Porzana tabuensis*)<br>• Red-necked avocet (*Recurvirosta novaehollandiae*)<br>• Fairy tern (*Sterna nereis*). |
| **Outputs** | 1) Quantify the Icon Site population abundances of each selected species.<br>2) Report on the population distribution of the selected species within each sub-region of the Icon Site.<br>3) Report on the population change of the selected species against the previous year, and base line year (if known).<br>4) Comment on any trend in population change and comment on national and/or international populations changes where relevant.<br>5) Comment on the 1% flyway population for listed migratory species. State any issues with total flyway populations (e.g. date of last census) and comment on any recent flyway populations reviews, if applicable. |
| **Timing** | • Independent ground surveys (total site census) are conducted over summer (December - February)<br>• Annual Icon Site Aerial Waterbird Survey is conducted in November. |

| Item | Requirement |
|---|---|
| | • Monthly spot-surveys to coincide with November aerial survey and late-summer census<br>Reporting against this target should be conducted once all data is available (April). |
| **Sub regions** | • Lake Alexandrina (including lower reaches of the Eastern Mount Lofty tributaries and Hindmarsh Island creeks and channels)<br>• Lake Albert<br>• Murray Mouth estuary (Barrages)<br>• North Lagoon<br>• South Lagoon. |
| **Sites** | • n/a |
| **Methodology** | Desktop consolidation of field data (for TLM reporting purposes):<br>• Consolidate data from Australian Wader Studies Group (AWSG), SA Department for Environment and Heritage (DEH), The University of Adelaide, MDBA (Kingsford) aerial surveys.<br>A summary of the field based studies are presented below:<br><br><u>The University of Adelaide (B-methodology)</u><br>(a) <u>Coorong Census</u><br>• See Paton (2003) for more detail<br>• Conducted annually in January<br>• The Coorong and Murray Mouth is divided into 1 km sections (110 sections)<br>- Murray Mouth estuary (18 sections)<br>- Coorong North Lagoon (44 sections)<br>- Coorong South Lagoon (48 sections).<br>• Between 10-20 sections censused per day<br>• Between 7 and 16 days may be required to complete census<br>• Waterbird counts conducted on foot, and by boat<br>• Eastern and western shorelines counted (two observers each)<br>• Deeper waterbodies, inaccessible areas and islands counted from a boat (two observers).<br>• All waterbirds observed within each 1-km section are recorded<br>- Reported by sub-section (e.g. eastern shoreline, western shoreline, centre, island).<br>• Behavioural observations recorded (e.g. groupings, distributions)<br>• Habitat information relating to chironomid larvae, *Ruppia* spp. and distribution of small mouth hardyhead also collected.<br>(b) <u>Lower Lakes Census</u><br>• See Rogers, Paton and Bailey (2009) for more detail<br>• Conducted annually in January<br>• Shoreline of each lake divided into 1km x 1km cells<br>• Each grid cell visited and all waterbirds observed<br>• Total of 13 days survey time on foot<br>• Identification using binoculars (10x magnification) or spotting scope (20-60x magnification)<br>• Birds identified to species, counted and activity classified as either foraging, resting, fly-over or heard.<br><br><u>Australian Wader Studies Group</u><br>• See Wainwright and Christie (2008), and references therein, for more detail |

| Item | Requirement |
|---|---|
| | • Shorebirds only<br>• Conducted annually in February<br>• North Lagoon, South Lagoon, Murray Mouth Estuary<br>• 25 sections surveyed (in 2008)<br>• Conducted over two days<br>• Land and boat based teams.<br><br><u>Coorong Nature Tours (David Dadd) (A-methodology)</u><br>• Regular Surveys currently undertaken monthly<br>• Fixed sites<br>- Lake Albert & Alexandrina – 23 sites (covering a range of habitats)<br>- Coorong North –10 Sites<br>- Coorong South –10 Sites<br>- Barrage Survey – 14 sites.<br>• Each site scanned in an arc radius of approximately 1.5km<br>• All bird species and numbers viewed are recorded<br>• Special attention is paid to unusual birds for accurate identification (up to 30 mins)<br>• All flagged birds observed are recorded and submitted to Birds Australia<br>• Equipment: Spotting scope, Binoculars, Field Guides<br>• Field notes recorded in note book and later transferred to electronic survey forms.<br>Data maintained by DEH in digital database (SVY 177).<br><br><u>The University of New South Wales (A-methodology)</u><br>• Annual aerial survey of all Icon Sites<br>• See Kingsford and Porter (2009) for more detail<br>• Takes place in November each year |
| **Implementation** | • A report, based on the results obtained through the current programs, to be prepared by Icon Site Coordinator (or delegate) or relevant consultant (e.g. Birds Australia or DEH). |
| **Comments** | • The AWSG project has been funded and conducted independently of the present condition monitoring program<br>• The University of Adelaide is now (since 2008) funded through The Living Murray program<br>• The University of Adelaide survey is a census of the entire Coorong and now also the Lower Lakes<br>• The information collected through all these programs has been used historically to report against this target<br>• Monthly fixed surveys (Dadd) should coincide with the annual MDBA aerial survey conducted by Richard Kingsford. This would permit cross-validation of data sets, and will also provide the TLM-standard methodologies which can be compared across icon sites.<br>• A comparative review of the University of Adelaide, AWSG and SA DEH surveys is discussed in Rogers (2007). |

## 4.2 Fish

**Monitor diadromous fish populations attempting to migrate between estuarine and freshwater habitats (F-1).**

| Item | Requirement |
|---|---|
| **Target ID** | **F-1** |
| **Target Title** | Maintain or improve recruitment success of diadromous fish in the Lower Lakes and Coorong. |
| **Target Definitions** | Improved recruitment success is defined as an increase in the number of young fish, which would lead to an increase in population abundances over time (i.e. a population displays a positive trajectory from baseline year). |
| **Condition Monitoring Purpose** | **Monitor diadromous fish populations attempting to migrate between estuarine and freshwater habitats.** |
| **Selected Species** | • Congolli (*Pseudaphritis urvillii*)<br>• Common galaxias (*Galaxias maculatus*)<br>• Short-headed lamprey (*Mordacia mordax*)<br>• Pouched lamprey (*Geotria australis*)<br>• Other diadromous species collected (list). |
| **Outputs** | 1) Quantify the age/size class structure of congolli and common galaxias.<br>2) Quantify the proportional abundance of congolli and common galaxias young-of-year.<br>3) Quantify adult lampreys present in fishway monitoring.<br>4) Quantify other diadromous fish collected during monitoring.<br>5) Report on any changes in population trajectories for each selected species.<br>6) Comment on any impacts relating to changes in connectivity (e.g. operationally efficient fishways).<br>Proportional abundance is within [intra] species (i.e. proportional abundance of young-of-year against all other age/size classes of that particular species). |
| **Timing** | Fortnightly fishway sampling between July and March. |
| **Sub regions** | • Lake Alexandrina<br>• Murray Mouth estuary. |
| **Sites** | Barrage Fishways<br>• Goolwa vertical slot<br>• Tauwitchere vertical slot (× 2)<br>• Tauwitchere rock ramp<br>• Other fishways as commissioned. |
| **Methodology** | Field methods *sensu* Bice et al. (2007).<br>General<br>• Goolwa vertical slot, Tauwitchere vertical slot (× 2), Tauwitchere rock ramp fishways<br>• Aluminium framed cage traps for vertical-slot fishways<br>• Large double-winged fyke net for rock-ramp fishway<br>• Traps and net to be set for approximately 24 hours<br>• Each fishway sampled 2-3 nights during each sampling event |

| Item | Requirement |
|---|---|
| | • All fish captured to be removed from traps and net and placed in large aerated holding tanks<br>• All fish to be identified, counted, measured and released upstream of the fishway<br>• Water quality parameters (temperature, salinity, pH and dissolved oxygen) were measured directly below the fishways after each trap pull.<br>Age/size class – young-of-year<br>• A sub-sample of 100 individuals (for abundant species >100 individuals) measured to represent size structure of individuals utilising the fishway<br>• An additional subsample of 30 individuals per species per site per sampling event will be kept for laboratory analysis to study age-growth of the young-of-year recruits.<br>Analyses<br>• Data analyses should involve descriptive and statistical presentations of population, community and water quality data. This should include species composition, richness and evenness, the distribution, abundance, and size/age structure of targeted species<br>• Statistical analyses (e.g. ANOVA) should be used to compare spatial and/or temporal variations of key biological performance indicators (e.g. abundance, level of recruitment). Consideration could be given to using co-variates (e.g. flow, salinity) to help explain variations.<br>Multivariate analyses (e.g. using applications in PRIMER or PC ORD Software) could be applied to examine spatial and/or temporal variations in fish assemblage structure and potential linkages to environmental variables. |
| **Implementation** | Presently conducted by SARDI Aquatic Sciences and MDBA Tri-state fishway team. |
| **Comments** | Barrage fishway expertise and sampling infrastructure (previously funded) remains with this group.<br>Present study (Bice et al. 2007) is investigating fish attempting to migrate between estuarine and freshwater environments.<br>The study is also assessing the effectiveness of the present fishways to pass fish.<br>The interpretation of this target can be used in conjunction to comment against W-3. |

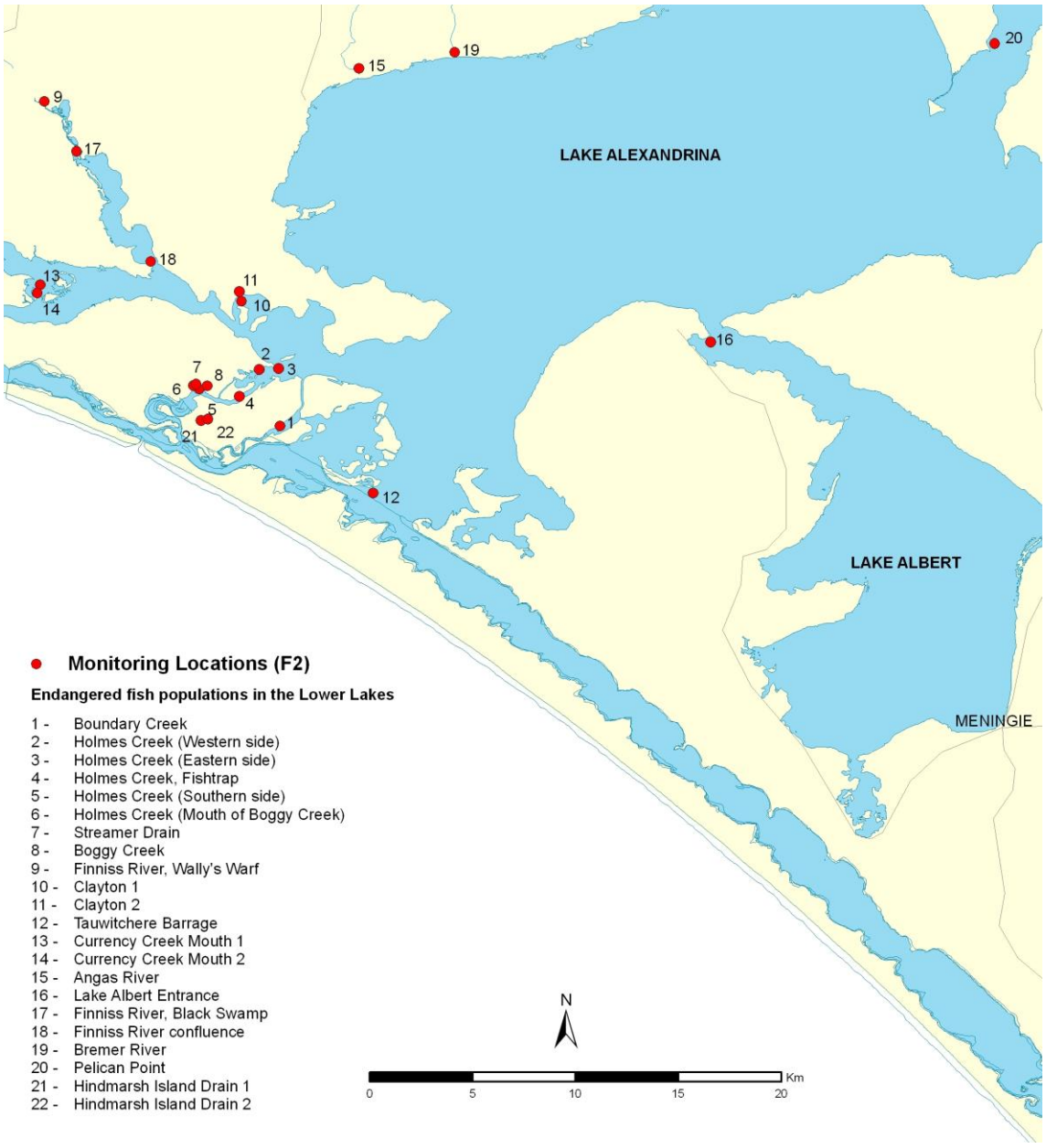
**Monitor endangered fish populations in the Lower Lakes (F-2).**

| Item | Requirement |
|---|---|
| **Target ID** | **F-2** |
| **Target Title** | Maintain or improve recruitment success of endangered fish species in the Lower Lakes. |
| **Target Definitions** | Improved recruitment success is defined as an increase in the number of young fish, which would lead to an increase in population abundances over time (i.e. a population displays a positive trajectory from baseline year). |
| **Condition Monitoring purpose** | **Monitor endangered fish populations in the Lower Lakes.** |
| **Selected Species** | • Murray hardyhead (*Craterocephalus fluviatilis*)<br>• Yarra pygmy perch (*Nannoperca obscura*)<br>• Southern pygmy perch (*Nannoperca australis*)<br>• Other native species collected (list). |
| **Outputs** | 1) Quantify the age/size class structure of each selected species.<br>2) Quantify the proportional abundance of each selected species young-of-year.<br>3) Report on all fish species captured during monitoring.<br>4) Report on any changes in population trajectories for the selected species.<br>5) Comment on any impacts relating to changes in habitat.<br>Proportional abundance is within [intra] species (i.e. proportional abundance of young-of-year against all other age/size classes of that particular species). |
| **Timing** | October/November and February/March. |
| **Sub region** | • Lake Alexandrina (including lower reaches of the Eastern Mount Lofty tributaries and Hindmarsh Island Creeks)<br>• Lake Albert. |
| **Sites** | Twenty-two (22) sites, which may vary in number and location depending on conditions (e.g. water levels) where necessary.<br>Location of sampling sites (map datum WGS84) and seasons sampled (spring 2007 and/or summer 2008) (Bice et al. 2008).<br><br>**No. / Location / Latitude / Longitude**<br>1 Boundary Creek 35.55214S 138.95394E<br>2 Holmes Creek (western side) 35.52702S 138.94335E<br>3 Holmes Cr. (eastern side) 35.52676S 138.95387E<br>4 Holmes Cr. Fishtrap 35.53858S 138.93251E<br>5 Holmes Cr. (Southern side) 35.53506S 138.91112E<br>6 Holmes Cr. (Mouth of Boggy) 35.53353S 138.90814E<br>7 Steamer Drain 35.53285S 138.90969E<br>8 Boggy Creek 35.53373S 138.91543E<br>9 Finniss River, Wallys Wharf 35.40750S 138.83153E<br>10 Clayton 1 35.49708S 138.93481E |

| Item | Requirement | | | |
|---|---|---|---|---|
| | 11 | Clayton 2 | 35.49267S | 138.93364E |
| | 12 | Tauwitchere Barrage | 35.58236S | 139.00314E |
| | 13 | Currency Creek Mouth 1 | 35.48791S | 138.82713E |
| | 14 | Currency Creek Mouth 2 | 35.49133S | 138.82556E |
| | 15 | Angas River | 35.39588S | 139.00019E |
| | 16 | Lake Albert Entrance | 35.51894S | 139.18578E |
| | 17 | Finniss River, Black Swamp | 35.42959S | 138.84816E |
| | 18 | Finniss River Confluence | 35.47877S | 138.88672E |
| | 19 | Bremer River | 35.38972S | 139.05170E |
| | 20 | Pelican Lagoon | 35.39007S | 139.34061E |
| | 21 | Hindmarsh Island Drain 1 | 35.54892S | 138.91158E |
| | 22 | Hindmarsh Island Drain 2 | 35.54827S | 138.91556E |
| | Recent drought conditions has resulted in the majority of the above sites drying, and additional sites included as follows (Wedderburn and Barnes 2009): | | | |
| | **No.** | **Location** | **Eastings** | **Northings** |
| | 23 | Dog Lake entrance | 0311065 | 6064130 |
| | 24 | Irrigation channel | 0337121 | 6091435 |
| | 25 | Dog Lake channel | 0329963 | 6084901 |
| | 26 | Old Clayton | 0310519 | 6070104 |
| | 27 | Milang | 0316188 | 6079597 |
| | 28 | Point Sturt | 0322934 | 6069625 |
| | 29 | Poltalloch | 0342532 | 6071580 |
| | 30 | Mundoo (channel near Boundary) | 0313752 | 6063750 |
| | 31 | Boggy Creek | 0312194 | 6067197 |
| | 32 | Mundoo (channel 1) | 0312275 | 6064403 |
| | 33 | Boggy Creek (pool near culvert) | 0310998 | 6065773 |
| | 34 | Wyndgate north | 0311165 | 6067555 |
| | 35 | Mundoo (channel 2b) | 0311285 | 6064063 |
| | 36 | Campbell House | 0339327 | 6049381 |
| **Methodology** | Field methods Bice & Ye (2007) and Bice et al. (2008).<br><br>General<br>• All sites to be sampled using fyke, seine net and/or box traps<br>• Three fyke nets set overnight<br>• Baited box traps<br>• Dip nets<br>• All fish sampled will be identified and counted<br>• Temperature, pH, conductivity, dissolved oxygen, turbidity will be recorded at each site to link fish assemblages with environmental parameters<br>• Pool size, bank slope, mean depth, wetted width, percent cover of submerged and emergent vegetation will also be recorded at each site to describe habitat characteristics.<br>Age/size class – young-of-year<br>• Length-frequency distribution analysis will be used to determine population | | | |

| Item | Requirement |
|---|---|
| | age/size-structure and assess spawning and recruitment<br>• Total length (TL, for Yarra pygmy perch and Southern pygmy perch) and caudal fork length (FL, for Murray hardyhead) ~100 fish per species per site for each gear type.<br>Analyses<br>• Data analyses should involve descriptive and statistical presentations of population, community and water quality data. This should include species composition, richness and evenness, the distribution, abundance, and size/age structure of targeted species<br>• Statistical analyses (e.g. ANOVA) should be used to compare spatial and/or temporal variations of key biological performance indicators (e.g. abundance, level of recruitment). Consideration could be given to using co-variates (e.g. flow, salinity) to help explain variations<br>• Multivariate analyses (e.g. using applications in PRIMER or PC ORD Software) could be applied to examine spatial and/or temporal variations in fish assemblage structure and potential linkages to environmental variables. |
| **Implementation** | Presently conducted by Adelaide Research and Innovation, The University of Adelaide, School of Earth and Environmental Sciences. |
| **Comments** | • The significance of the Lower Lake's fish community, including its relatively high diversity and threatened species, was first recorded by the DEH Biological Survey (Hammer et al. 2002) and the Lower Lakes Fish Inventory (Wedderburn and Hammer 2003)<br>• During drought conditions, new sites to be monitored as existing sites dry-out<br>• Timing of sampling should coincide with V-3. |

**Figure 2: Location of F-2 sampling sites.**

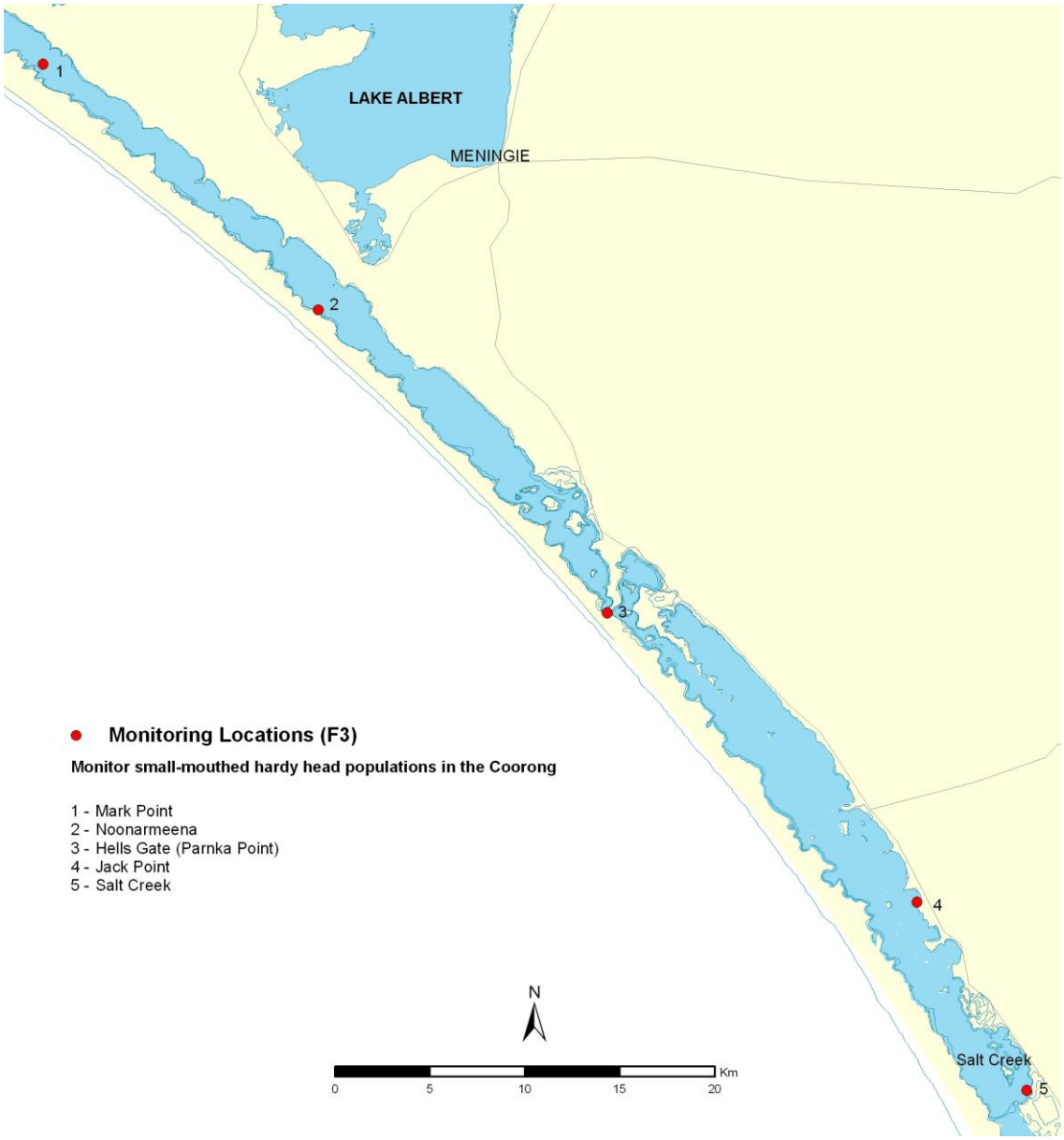


**Monitor small-mouthed hardyhead populations in the Coorong (F-3).**

| Item | Requirement |
|---|---|
| **Target ID** | **F-3** |
| **Target Title** | Provide optimum conditions to improve recruitment success of small-mouthed hardyhead in the South Lagoon. |
| **Target Definitions** | Improved recruitment success is defined as an increase in the number of young fish, which would lead to an increase in population abundances over time (i.e. a population displays a positive trajectory from baseline year). |
| **Condition Monitoring purpose** | **Monitor small-mouthed hardyhead populations in the Coorong.** |
| **Selected Species** | Small-mouthed hardyhead (*Atherinosoma microstoma*). |
| **Outputs** | 1) Quantify the abundance of small-mouthed hardyhead in the Coorong.<br>2) Quantify the size/age population structure of small-mouthed hardyhead.<br>3) Quantify the proportional abundance of small-mouthed hardyhead young-of-year.<br>4) Map the distribution and abundance of small-mouthed hardyhead in the Coorong.<br>5) Map the salinity profile of the Coorong.<br>6) Report on any seasonal and spatial changes in salinity.<br>7) Comment on any impacts a changing salinity profile may have on small-mouthed hardyhead.<br>8) Comment on any relationship between *Ruppia tuberosa* (see V-2) and small-mouthed hardyhead. |
| **Timing** | Spring and summer. |
| **Sub region** | • South Lagoon<br>• North Lagoon. |
| **Sites** | Five (5) Sites<br>**Region** / **Location** / **Easting** / **Northing**<br>North Lagoon / Mark Point / 325756 / 6054547<br>Noonameena / 340202 / 6041577<br>Hells Gate (Parnka Point) / 355408 / 6025656<br>South Lagoon / Jack Point / 371706 / 6010424<br>Salt Creek / 377464 / 6000510 |
| **Methodology** | Field methods *sensu* Ye et al. (2006)<br><br>General<br>• Targeted fish sampling in the North and South Lagoons during spring and summer<br>• Five sites along the North and South Lagoons<br>• Samples collected using seine nets<br>• Three standard sweeps at each site will be undertaken<br>• All fish collected will be identified to species and counted |

| Item | Requirement |
|---|---|
| | • On each sampling occasion, water quality (temperature, salinity, dissolved oxygen, pH and turbidity) will be measured at each site.<br>Age/size Class<br>• A sub-sample (100 max) individuals per site per sampling occasion will be measured for length.<br>Optional<br>• An additional subsample of 30 individuals per site per sampling occasion will be kept for laboratory analysis to study age-growth and population structure<br>• Age will be determined using otoliths to estimate growth rate and to confirm the presence of young-of-year to assess the level of recruitment.<br>Analyses<br>• Data analyses should involve descriptive and statistical presentations of population, community and water quality data. This should include species composition, richness and evenness, the distribution, abundance, and size/age structure of targeted species<br>• Statistical analyses (e.g. ANOVA) should be used to compare spatial and/or temporal variations of key biological performance indicators (e.g. abundance, level of recruitment). Consideration could be given to using co-variates (e.g. flow, salinity) to help explain variations<br>• Multivariate analyses (e.g. using applications in PRIMER or PC ORD Software) could be applied to examine spatial and/or temporal variations in fish assemblage structure and potential linkages to environmental variables. |
| **Implementation** | Presently conducted by SARDI Aquatic Sciences. |
| **Comments** | Can be done in conjunction with F-4.<br>Some information from the CLLAMM ecology fish project could be used as baseline data. |

**Figure 3: Locations of F-3 sampling sites.**



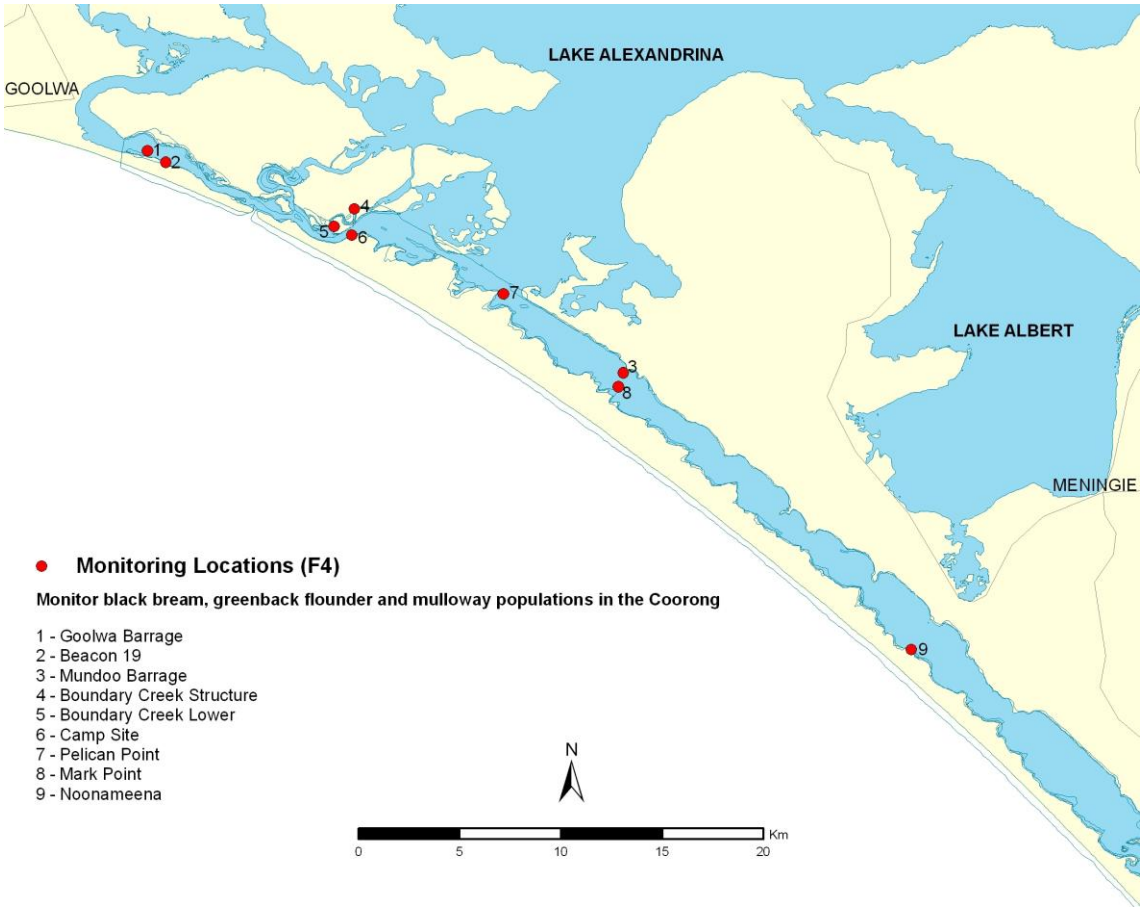
**Monitor black bream, greenback flounder and mulloway populations in the Coorong (F-4).**

| Item | Requirement |
|---|---|
| **Target ID** | **F-4** |
| **Target Title** | Maintain or improve populations of black bream, greenback flounder and mulloway in the Coorong. |
| **Target Definitions** | Improved recruitment success is defined as an increase in the number of young fish, which would lead to an increase in population abundances over time (i.e. a population displays a positive trajectory from baseline year). |
| **Condition Monitoring purpose** | **Monitor black bream, greenback flounder and mulloway populations in the Coorong.** |
| **Selected Species** | • Black bream (*Acanthopagrus butcheri*)<br>• Greenback flounder (*Rhombosolea tapirina*)<br>• Mulloway (*Argyrosomus japonicus*). |
| **Outputs** | 1) Quantify the population abundances of each selected species using commercial fishery data.<br>2) Quantify the age/size class structures of each selected species.<br>3) Quantify the proportional abundance of each selected species young-of-year.<br>4) Quantify adult lampreys (if any) collected during monitoring.<br>5) Report on any changes in population trajectories for each selected species.<br>6) Comment on any impacts relating to changes in connectivity and freshwater inflow to the Coorong (e.g. operationally efficient fishways, open Murray Mouth).<br>7) Comment on estimates of recruitment success based on relative abundance of young-of-year for each species.<br>Proportional abundance is within [intra] species (i.e. proportional abundance of young-of-year against all other age classes of that particular species). |
| **Timing** | Black bream: November/December (adults), February/March (young-of-year) .<br>Greenback flounder: July (adults), November/December (young-of-year). |
| **Sub regions** | • Murray Mouth estuary<br>• North Lagoon. |
| **Sites** | Nine (9) sites |

| Region | Location | Easting | Northing |
|---|---|---|---|
| Murray Mouth Estuary | Goolwa Barrage | 302550 | 6066196 |
| | Beacon 19 | 303465 | 6065616 |
| | Mundoo Barrage | 326001 | 6055252 |
| | Boundary Creek Structure | 312743 | 6063312 |
| | Boundary Creek Lower | 311735 | 6062448 |
| | Camp Site | 312626 | 6062013 |
| | Pelican Point | 320082 | 6059130 |
| Northern Lagoon | Mark Point | 325756 | 6054547 |
| | Noonameena | 340202 | 6041577 |

| Item | Requirement |
|---|---|
| **Methodology** | Field methods *sensu* Ye et al. (2006)<br>General<br>• Samples collected using seine nets<br>• Three standard sweeps at each site will be undertaken<br>• All fish collected will be identified to species and counted<br>• On each sampling occasion, water quality (temperature, salinity, dissolved oxygen, pH and turbidity will be measured at each site.<br>Age/size Class<br>• A sub-sample (100 max) individuals per species per site per sampling occasion will be measured for length<br>• An additional subsample of 30 individuals per species per site per sampling occasion will be kept for laboratory analysis to study age-growth and population structure.<br>Supplementary<br>• Population information available from PIRSA Fisheries, commercial fishery statistics<br>• Samples may also be obtained from commercial fisheries particularly for analysis of age class structure.<br>Analyses<br>• Data analyses should involve descriptive and statistical presentations of population, community and water quality data. This should include species composition, richness and evenness, the distribution, abundance, and size/age structure of targeted species<br>• Statistical analyses (e.g. ANOVA) should be used to compare spatial and/or temporal variations of key biological performance indicators (e.g. abundance, level of recruitment). Consideration could be given to using co-variates (e.g. flow, salinity) to help explain variations<br>• Multivariate analyses (e.g. using applications in PRIMER or PC ORD Software) could be applied to examine spatial and/or temporal variations in fish assemblage structure and potential linkages to environmental variables. |
| **Implementation** | Presently conducted by SARDI Aquatic Sciences. |
| **Comments** | Some information form the CLLAMM ecology fish project could be used as baseline data. |

**Figure 4: Locations of F-4 sampling sites.**



## 4.3 Invertebrates

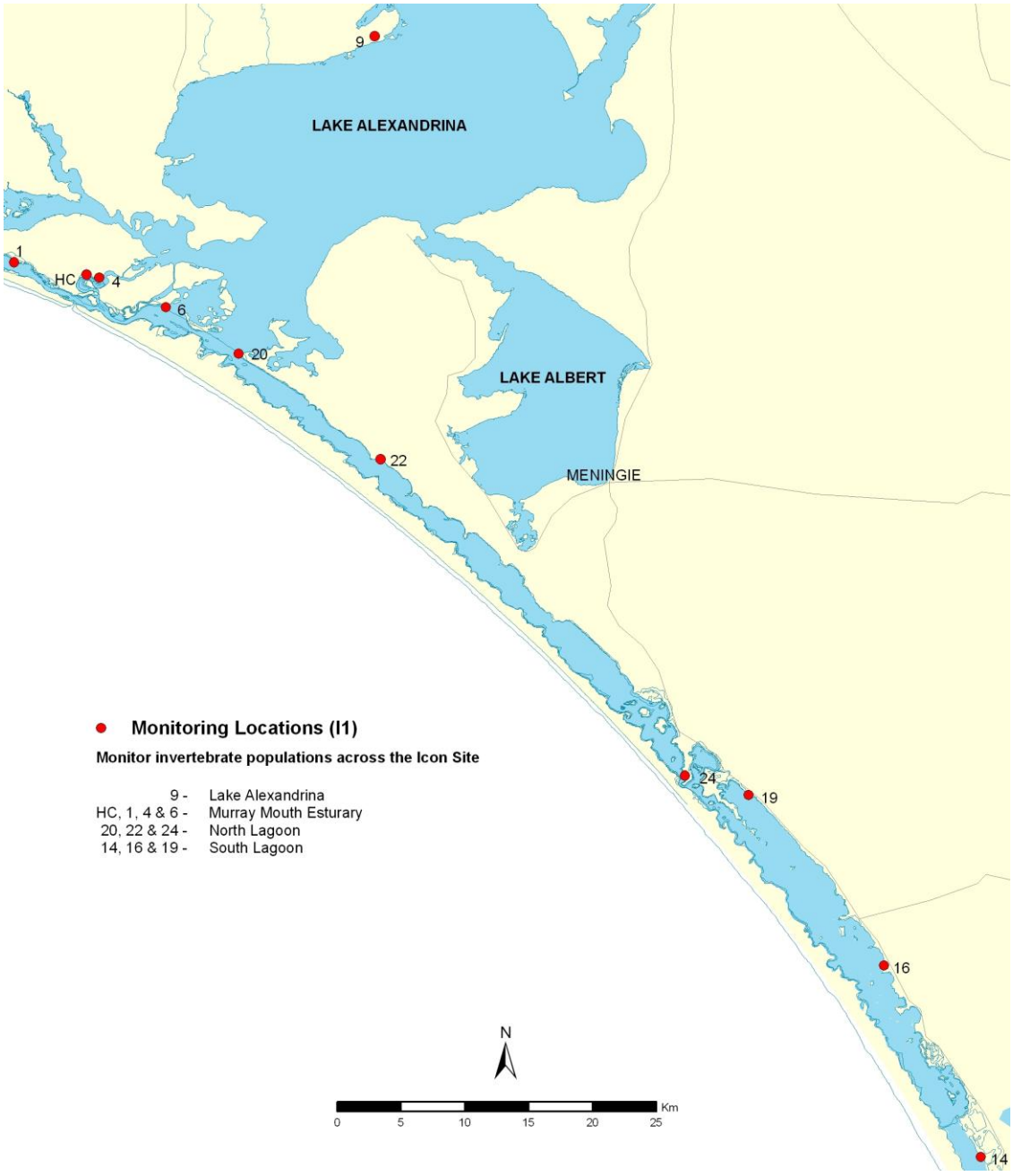
**Monitor invertebrate populations across the Icon Site (I-1).**

| Item | Requirement |
|---|---|
| **Target ID** | **I-1** |
| **Target Title** | Maintain or improve invertebrate populations in mudflats. |
| **Target Definitions** | Improved is defined as an increase in population abundances, biomass and species diversity over time (i.e. benthic populations display a positive trajectory). |
| **Condition Monitoring purpose** | **Monitor invertebrate populations across the Icon Site.** |
| **Selected Species** | Annelida: Polychaeta<br>• *Capitella capitata*<br>• *Ficopomatus enigmaticus*<br>• *Nepthys australiensis*<br>• *Simplisetia aequisetis.*<br>Mollusca; Bivalvia<br>• *Arthritica helmsi.*<br>Arthropoda Crustacea<br>• *Paragrapsus gaimardii*<br>• Order Amphipoda.<br>Insecta: Diptera<br>• Family Chironomidae (larvae). |
| **Outputs** | 1) Quantify the distribution and abundance of each selected species.<br>2) Report on diversity, abundance and distribution, and community structures in each icon site sub region.<br>3) Report on the biomass of benthic organisms in the Murray Mouth estuary and Coorong.<br>4) Comment on changes in diversity, abundances and biomass over time.<br>5) Comment on biomass changes over time. |
| **Timing** | December and May. |
| **Sub regions** | • Lake Alexandrina (including lower reaches of the Eastern Mt Lofty tributaries and Hindmarsh Island Creeks)<br>• Lake Albert<br>• Murray Mouth estuary<br>• North Lagoon<br>• South Lagoon. |
| **Sites** | Thirty (30) Sites.<br>Location of sites used to sample for macroinvertebrates (Dittmann et al. 2006). HC = Hunters Creek.<br>**Sub-Region** / **No.** / **Easting** / **Northing**<br>Murray Mouth estuary / HC / 308774 / 6065536<br>1 / 303120 / 6066509<br>4 / 309754 / 6065310<br>6 / 314973 / 6062980 |

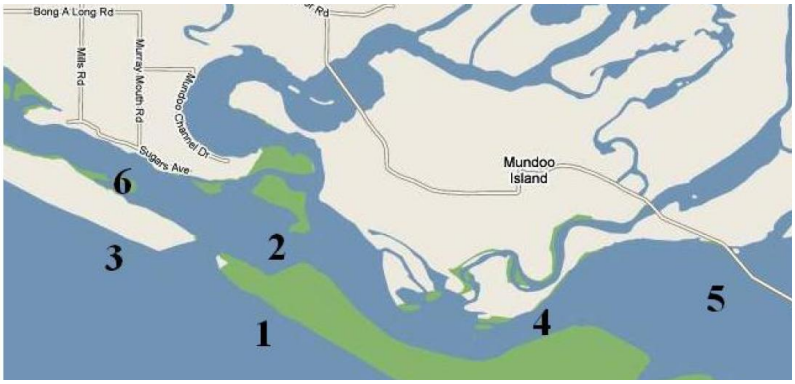
| Item | Requirement | | | |
|---|---|---|---|---|
| | North Lagoon | 20 | 320676 | 6059359 |
| | | 22 | 331780 | 6051162 |
| | | 24 | 355577 | 6026464 |
| | South Lagoon | 14 | 378737 | 5996705 |
| | | 16 | 371168 | 6011641 |
| | | 19 | 360577 | 6024954 |
| | Goolwa Channel | L1 | 300898 | 6066621 |
| | | L7 | 301588 | 6069219 |
| | | L2 | 311490 | 6070452 |
| | | CC1 | 301083 | 6071623 |
| | | TF | 306203 | 6075071 |
| | Lake Alexandrina | L16 | 309981 | 6065259 |
| | | L17 | 315204 | 6062842 |
| | | L6 | 320744 | 6059813 |
| | | L11 | 326978 | 6061606 |
| | | L10 | 328117 | 6067827 |
| | | L9 | 335085 | 6069125 |
| | | L4 | 316422 | 6079464 |
| | | L5 | 342509 | 6071437 |
| | | L3 | 331798 | 6083065 |
| | | L15 | 351069 | 6077013 |
| | | L18 | 335451 | 6090780 |
| | Lake Albert | L13 | 339051 | 6051394 |
| | | L14 | 349733 | 6061163 |
| | | L8 | 352433 | 6058911 |
| | | L12 | 343877 | 6045620 |
| **Methodology** | Field methods *sensu* Dittmann et al. (2006).<br>General<br>• Samples taken in a stratified random sampling approach at several locations between the shoreline (vegetation) and the water line (high, mid, low tide levels)<br>• Macrofauna sampled using hand-held corers<br>• Sediments sieved through 0.5mm mesh<br>• Individuals retained on mesh transferred to lab, sorted alive, identified and counted<br>• Biomass (ash-free dry weight) determined for higher taxa per site and location.<br>Data analyses<br>• ANOVA or non-parametric tests of abundances and biomass within and across sites as well as times<br>• Diversity indices calculated (using PRIMER software) include<br>- Shannon-Wiener diversity (H')<br>- Margalef's index (d) for species richness<br>- Pielou's index (J') for equitability<br>- Simpson index - an evenness index independent of sampling effort, adjusted to small sample sizes<br>• Multivariate community analyses (MDS, ANOSIM, SIMPER). | | | |

| Item | Requirement |
|---|---|
| **Implementation** | Presently conducted by Sabine Dittmann, Flinders University. |
| **Comments** | n/a |

**Figure 5: Locations of I-1 sampling sites (original Murray Mouth and Coorong sites only).**



**Monitor diatoms in the Murray Mouth estuary (I-2).**

| Item | Requirement |
|---|---|
| **Target ID** | **I-2** |
| **Target Title** | Provide freshwater flows that provide food sources for Goolwa cockles. |
| **Target Definitions** | Demonstrates an open Murray Mouth. |
| **Condition Monitoring purpose** | **Monitor diatoms in the Murray Mouth estuary.** |
| **Selected Species** | Diatoms generally, but make specific comment on<br>• *Asterionella* spp.<br>• *Pseudonitzschia pseudodelicatissima.*<br>Dinoflagellates generally, but make specific comment on<br>• *Dinophysis caudata*<br>• *Gonyaulax* sp.<br>Coliforms generally, but make specific comment on<br>• *Escherichia coli.*<br>**Asterionella* is the primary food source for Goolwa cockles (*Donax deltoides*). |
| **Outputs** | 1) Quantify the density of the selected species.<br>2) Report of the types of diatoms, dinoflagellates and coliforms collected (i.e. toxic vs. non-toxic spp).<br>3) Report on the estimated fraction of phytoplankton biomass exported out to sea by River Murray outflow and/or tidal pumping.<br>4) Report on seasonal changes in selected species and comment of possible source(s).<br>5) Comment on any interactions with the Goolwa cockle fishery.<br>6) See also W-2 and comment. |
| **Timing** | February, May, August, November. |
| **Sub region** | • Murray Mouth estuary. |
| **Sites** | Six (6) sites.<br>Location of the six sampling stations used to estimate diatoms, dinoflagellates and coliforms (Seuront and Leterne, 2008).<br>  |

| Item | Requirement |
|---|---|
| **Methodology** | Field methods *sensu* Seuront & Leterne (2008).<br>General<br>• Sample for phytoplankton (diatoms, dinoflagellates) and viruses and bacteria (including coliforms) populations<br>• Physical-chemical properties of the water column (i.e. salinity, temperature, inorganic nutrient concentration, dissolved oxygen, turbidity).<br>Nutrient analysis<br>• At each site, triplicate 12 mL filtered water samples<br>• Standard colorimetric methods for selected DIN nutrients $NH_4^+$, $NO_3^-$, $NO_2^-$, $H_3PO_4^-$, $Si(OH)_4$.<br>Phytoplankton analysis<br>• At each site, triplicate 100-ml water samples<br>• 10 to 20-ml sub-samples to be settled and counted<br>• Identification by inverted microscopy under contrast illumination<br>• Species richness (S), diversity (H) and evenness (J) to be calculated.<br>Viral and microbial communities<br>• At each site, triplicate (1 ml) samples collected<br>• Virus-like particles (VLP) and heterotrophic bacteria enumerated using flow cytometery analysis software. |
| **Implementation** | Presently conducted by Laurent Seuront & Sophie Leterne, Flinders University. |
| **Comments** | Standard reference sites to be established with GPS. |

## 4.4 Vegetation

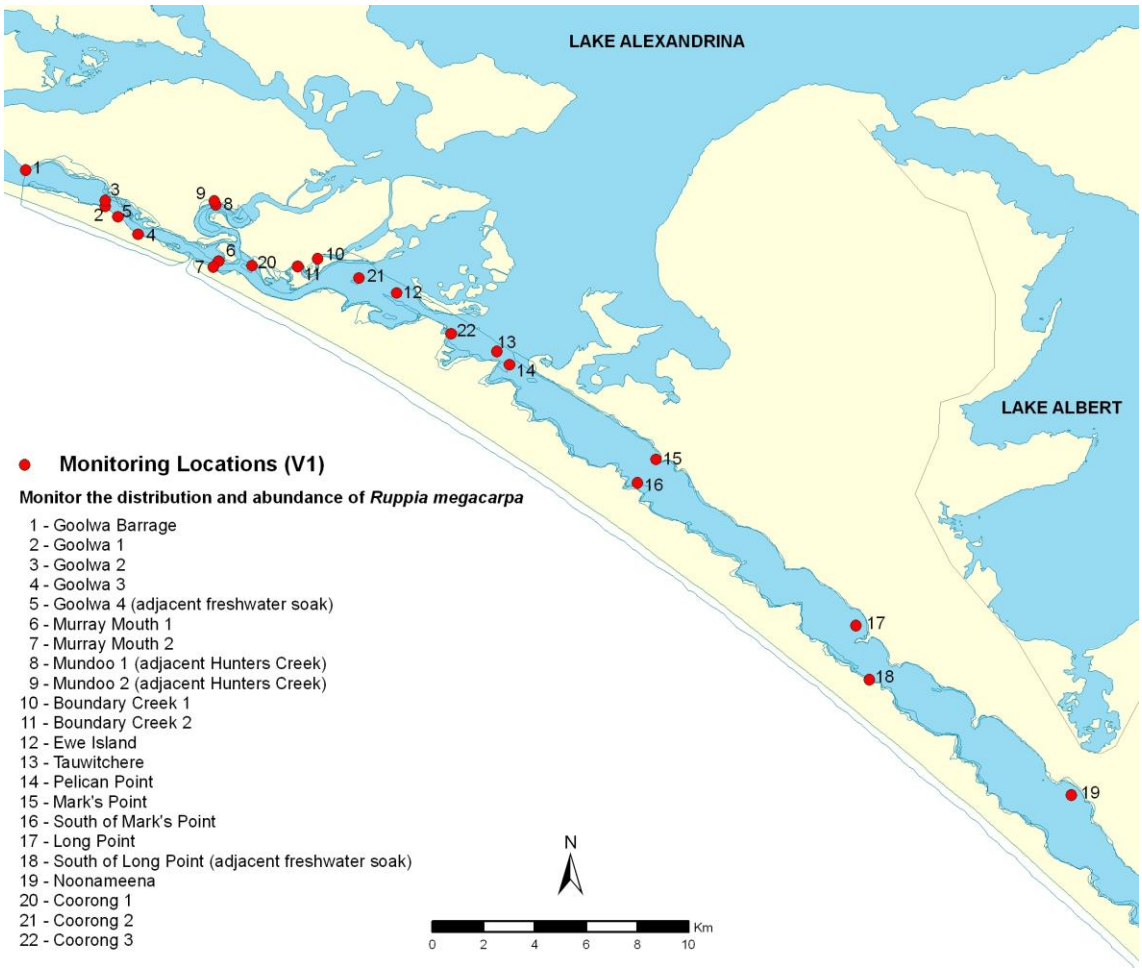
**Monitor the distribution and abundance of *Ruppia megacarpa* (V-1).**

| Item | Requirement |
|---|---|
| **Target ID** | **V-1** |
| **Target Title** | Maintain or improve *Ruppia megacarpa* colonisation and reproduction. |
| **Target Definitions** | Improved is defined as an increase in extent of occurrence (EOO), area of occupation (AOO) and abundance over time (i.e. density display a positive trajectory). |
| **Condition Monitoring purpose** | **Monitor the distribution and abundance of *Ruppia megacarpa.*** |
| **Selected Species** | *Ruppia megacarpa.* |
| **Outputs** | 1) Quantify the EOO of *Ruppia megacarpa* within each sub region.<br>2) Quantify the AOO of *Ruppia megacarpa* within each sub region.<br>3) Quantify the abundance of *Ruppia megacarpa* within the AOO.<br>4) Quantify seed and shoot density of *Ruppia megacarpa* within the AOO.<br>5) Report on any trajectory changes over time (between years and from baseline).<br>6) Comment on historical, existing and potential EOO within each sub-region.<br>7) Comment on scale, cover within the study region and cover within the areas where the plant currently exists.<br>8) Comment on any potential impacts to birds, fish, invertebrates. |
| **Timing** | September and March. |
| **Sub regions** | • Murray Mouth estuary<br>• North Lagoon. |
| **Sites** | Twenty-two (22) sites.<br>Location of sampling sites (map datum WGS 84) (Nicol 2007). |

| Site | Easting | Northing |
|---|---|---|
| Goolwa Barrage | 301398 | 6066731 |
| Goolwa 1 | 304514 | 6065304 |
| Goolwa 2 | 304505 | 6065556 |
| Goolwa 3 | 305781 | 6064227 |
| Goolwa 4 (adjacent freshwater soak) | 304990 | 6064911 |
| Murray Mouth 1 | 308918 | 6063179 |
| Murray Mouth 2 | 308712 | 6062942 |
| Mundoo 1 (adjacent Hunters Creek) | 308811 | 6065366 |
| Mundoo 2 (adjacent Hunters Creek) | 308750 | 6065524 |
| Boundary Creek 1 | 312778 | 6063273 |
| Boundary Creek 2 | 311989 | 6062969 |
| Ewe Island | 315864 | 6061934 |

| Item | Requirement | | |
|---|---|---|---|
| | Tauwitchere | 319761 | 6059645 |
| | Pelican Point | 320253 | 6059136 |
| | Mark's Point | 325962 | 6055426 |
| | South of Mark's Point | 325247 | 6054515 |
| | Long Point | 333752 | 6048938 |
| | South of Long Point (adjacent freshwater soak) | 334280 | 6046836 |
| | Noonameena | 342149 | 6042321 |
| | Coorong 1 | 310218 | 6062984 |
| | Coorong 2 | 314391 | 6062509 |
| | Coorong 3 | 317978 | 6060328 |
| **Methodology** | Field methods based on Nicol (2007).<br>At each site<br>• Four depths sampled below the low water mark<br>• Twenty-five cores collected per depth<br>• Sediments sieved through a 500 µm sieve and material retained sorted.<br>• Enumerate *Ruppia megacarpa* shoots and seeds in each sample. | | |
| **Implementation** | Previously conducted by SARDI Aquatic Sciences, not currently undertaken due to *R. megacarpa* extinct in North Lagoon of Coorong. | | |
| **Comments** | | | |

**Figure 6: Locations of V-1 sampling sites.**



**Monitor the distribution and abundance of *Ruppia tuberosa* (V-2).**

| Item | Requirement |
|---|---|
| **Target ID** | **V-2** |
| **Target Title** | Maintain or improve *Ruppia tuberosa* colonisation and reproduction. |
| **Target Definitions** | Improved is defined as an increase in extent of occurrence (EOO), area of occupation (AOO) and abundance over time (i.e. density display a positive trajectory). |
| **Condition Monitoring purpose** | **Monitor the distribution and abundance of *Ruppia tuberosa*** |
| **Selected Species** | *Ruppia tuberose.* |
| **Outputs** | 1) Quantify the EOO of *Ruppia tuberosa* within each sub region.<br>2) Quantify the AOO of *Ruppia tuberosa* within each sub region.<br>3) Quantify the abundance of *Ruppia tuberosa* within the AOO.<br>4) Quantify seed and shoot density of *Ruppia tuberosa* within the AOO.<br>5) Report on any trajectory changes over time (between years and from baseline).<br>6) Comment on historical, existing and potential EOO within each sub-region.<br>7) Comment on scale, cover within the study region and cover within the areas where the plant currently exists.<br>8) Comment on any potential impacts to birds, fish, invertebrates (e.g. chironomid relationships). |
| **Timing** | July and January. |
| **Sub Regions** | • North Lagoon<br>• South Lagoon. |
| **Locations** | • Sites paced at 5km intervals.<br>Location of sites (WGS 84):<br><br>**Site** / **Easting** / **Northing**<br>Tea Tree Crossing / 378832 / 5996641<br>Salt Creek / 377782 / 6000984<br>Parnka Point / 372607 / 6000905<br>Villa de Yumpa / 360339 / 6064227<br>Noonameena / 342635 / 6042214 |
| **Methodology** | Field methods *sensu* Paton (2000; 2005).<br><u>IN JULY</u><br>• Establish a sampling grid at each site<br>• This grid is subsequently divided into smaller quadrats<br>• A minimum of 200 core (7.5cm diameter x 4cm deep) samples may be collected from each sampling grid<br>• The number of cores (out of 200) with *Ruppia tuberosa* shoots present is used to estimate cover. The number of shoots in each core is also counted to provide a measure of abundance |

| Item | Requirement |
|---|---|
| | • The number of seeds and turions within a sampling grid is based on a series of 10 core samples taken along transect perpendicular to the shore at each of 5 depths (0.2, 0.4, 0.6, 0.8 and 0.9m) spread across the grid<br>• Ten samples to be collected at each depth contour<br>• Samples to be sieved and sorted through a 500µm sieve<br>• *Ruppia tuberosa* seeds, turions and shoots counted.<br><u>IN JANUARY</u><br>• Revisit sites and resample with 10-25 cores across mudflats to identify ongoing presence of *Ruppia tuberosa* plants (shoots, and propagules).<br>Water quality parameters<br>• pH, electrical conductivity, dissolved oxygen, total dissolved solids, temperature and turbidity will be measured and recorded at each site on each visit.<br>Analyses<br>• Data analyses should involve descriptive and statistical presentations of abundances, AOO and EOO<br>• Statistical analyses (e.g. ANOVA) should be used to compare spatial and/or temporal variations of key biological performance indicators. Consideration could be given to using co-variates (e.g. water levels, salinity) to help explain variations<br>• Multivariate analyses (e.g. using applications in PRIMER or PC ORD Software) could be applied to examine spatial and/or temporal variations and potential linkages to environmental variables. |
| **Implementation** | Presently conducted by David Paton, The University of Adelaide. |
| **Comments** | |

**Assessment of aquatic and littoral vegetation in the Lower Lakes (V-3).**

| Item | Requirement |
|---|---|
| **Target ID** | **V-3** |
| **Target Title** | Maintain or improve aquatic and littoral vegetation in the Lower Lakes. |
| **Target Definitions** | Improved is defined as an increase in extent of occurrence (EOO), area of occupation (AOO) and abundance over time (i.e. density display a positive trajectory). |
| **Condition Monitoring purpose** | **Assessment of aquatic and littoral vegetation in the Lower Lakes.** |
| **Selected Species** | • *Myriophyllum* spp.<br>• *Schoenoplectus* spp.<br>• *Typha domingensis*<br>• *Phragmites australis*<br>• *Melaleuca halmaturorum*<br>• *Gahnia filum*<br>• *Ruppia megacarpa*<br>• Samphire. |
| **Outputs** | 1) Quantify the EOO of each selected species.<br>2) Quantify the AOO of each selected species.<br>3) Quantify the abundance of each selected species within the AOO.<br>4) Report on the aquatic and littoral vegetation communities including, but not limited to, the selected species.<br>5) Report on the life stage and recruitment of *Melaleuca halmaturorum.*<br>6) Under current knowledge, comment on existing and potential EOO habitats for small-bodied native fish.<br>7) Comment on the EOO of core habitats for small-bodied native fish in the Lower Lakes.<br>8) Comment on any known or observed relationships between native fish populations (e.g. Yarra pygmy perch, Murray hardyhead and southern pygmy perch) and aquatic and/or littoral habitat.<br>9) Comment on any temporal changes to aquatic and littoral vegetation and their potential impacts to native fish populations. |
| **Timing** | October and March. |
| **Sub Regions** | • Lake Alexandrina (including lower reaches of Eastern Mount Lofty tributaries and Hindmarsh Island Creeks)<br>• Lake Albert. |
| **Methodology** | Baseline methods<br>• Community monitoring methods for understorey vegetation described in Section 4 of Tucker (2004)<br>• *Melaleuca halmaturorum* methods are described in Stewart (2000) and Telfer (2000). |
| **Implementation** | Presently conducted by SARDI Aquatic Sciences. |
| **Comments** | Timing of sampling coincides with F-2. |

**Figure 8: Locations of V-3 sampling sites**

## 4.5 Mudflats

**Report on exposure and available foraging habitat of mudflats across the Icon Site (M-1).**

| Item | Requirement |
|---|---|
| **Target ID** | **M-1** |
| **Target Title** | Facilitate frequent changes in exposure and submergence of mudflats. |
| **Target Definitions** | Mudflats have the greatest habitat value when they are frequently submerged and exposed, by tides or wind driven water movements. Permanent submergence eliminates foraging ground for waders, while permanent exposure will result in solid and dry sediments devoid of benthic fauna, which is unsuitable for foraging. Therefore, intermediate conditions are optimal. |
| **Condition Monitoring purpose** | **Report on exposure and available foraging habitat of mudflats across the Icon Site.** |
| **Selected Species** | n/a |
| **Outputs** | 1) Report on the average diurnal tidal ratio within the Murray Mouth estuary.<br>2) Report on the average exposure of mudflats.<br>3) Report on the duration(s) of maximum exposure of mudflats within each sub region.<br>4) Report on the temporal changes in mudflat exposure within each sub region.<br>5) Comment on the area of mudflat exposed in the Coorong during summer?<br>6) Comment on the percentage of exposed mudflat that was suitable for foraging.<br>7) Comment on any impacts to benthic invertebrates (see I-1) and birds (B-1). |
| **Timing** | Monthly between October and March. |
| **Sub regions** | • Lake Alexandrina (including lower reaches of the Eastern Mount Lofty tributaries and Hindmarsh Island creeks and channels)<br>• Lake Albert<br>• Murray Mouth estuary<br>• North Lagoon<br>• South Lagoon. |
| **Sites** | n/a |
| **Methodology** | Desktop approach.<br>Water level data available through River Murray Data (http://data.rivermurray.sa.gov.au)<br>Use bathymetry and water level data to estimate area of mudflats exposed. |
| **Implementation** | Report could be prepared by Icon Site Coordinator (or delegate), relevant consultant (e.g. DWLBC or professional company). |
| **Comments** | Highly dynamic system with very shallow gradients predictive model of limited use.<br>A model could be developed the computes mudflat area exposed with water level. Comprehensive bathymetry may be required to support such a model. The 2008 commissioning of the TLM-funded surface water monitoring stations along the Coorong will assist with documenting water levels. |

**Report on sediment grain size in mudflats of the Icon Site (M-2).**

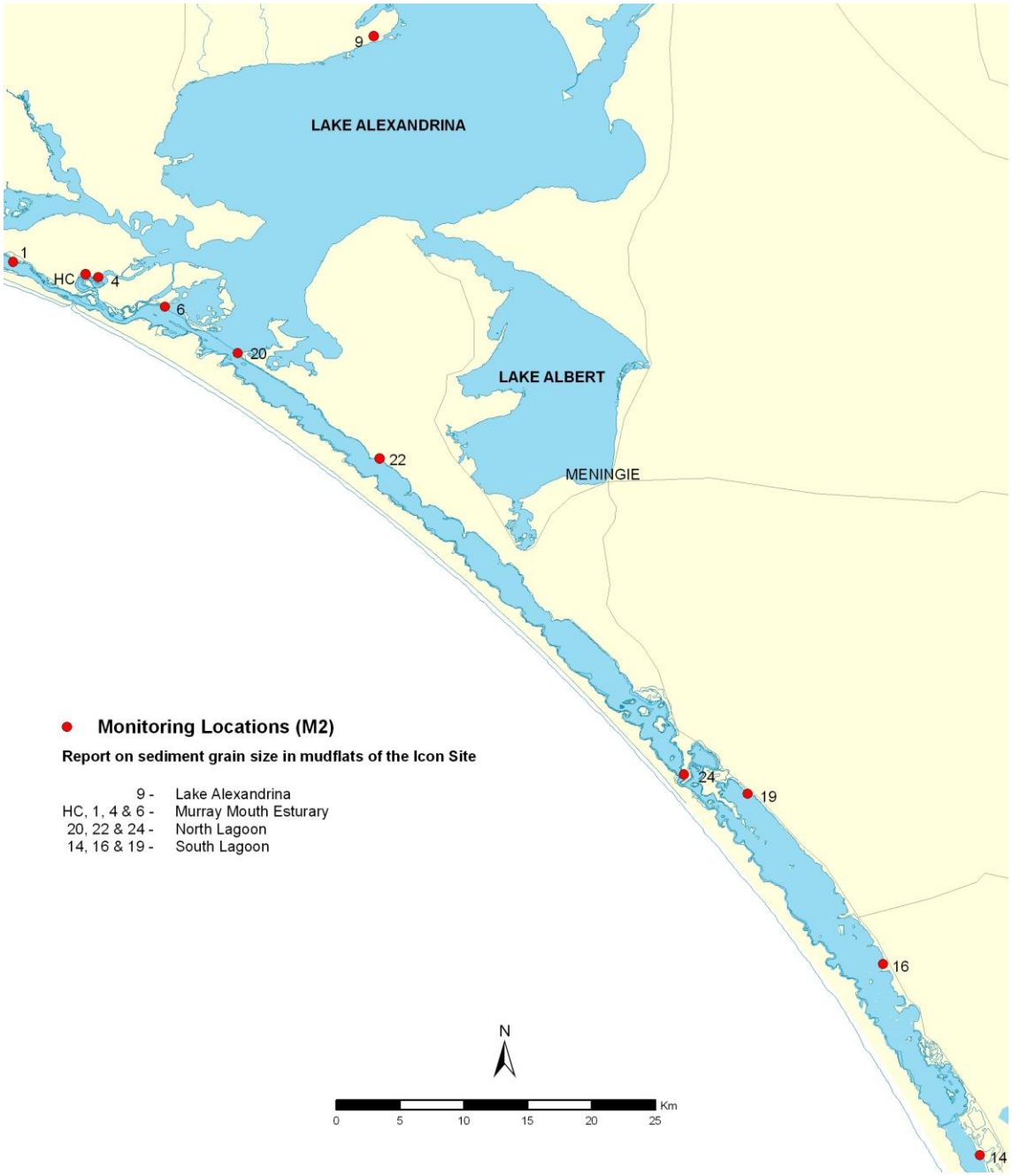
| Item | Requirement |
|---|---|
| **Target ID** | **M-2** |
| **Target Title** | Maintain sediment size range in mud flats. |
| **Target Definitions** | No change to baseline year values. |
| **Condition Monitoring purpose** | **Report on sediment grain size in mudflats of the Icon Site.** |
| **Selected Species** | n/a |
| **Outputs** | 1) Quantify the sediment grain size distribution of mudflats across the Icon Site (Lower Lakes, Murray Mouth estuary, North Lagoon, South Lagoon).<br>2) Report on any changes over time.<br>3) Comment on any potential impacts to benthic invertebrate and bird foraging. |
| **Timing** | December |
| **Sub regions** | • Lake Alexandrina (including lower reaches of the Eastern Mt Lofty tributaries and Hindmarsh Island creeks and channels)<br>• Lake Albert<br>• Murray Mouth estuary<br>• North Lagoon<br>• South Lagoon. |
| **Sites** | Thirty (30) Sites.<br>Location of sites used to sample for macroinvertebrates (Dittmann et al. 2006). HC = Hunters Creek. |

| Sub-Region | No. | Easting | Northing |
|---|---|---|---|
| Murray Mouth estuary | HC | 308774 | 6065536 |
| | 1 | 303120 | 6066509 |
| | 4 | 309754 | 6065310 |
| | 6 | 314973 | 6062980 |
| North Lagoon | 20 | 320676 | 6059359 |
| | 22 | 331780 | 6051162 |
| | 24 | 355577 | 6026464 |
| South Lagoon | 14 | 378737 | 5996705 |
| | 16 | 371168 | 6011641 |
| | 19 | 360577 | 6024954 |
| Goolwa Channel | L1 | 300898 | 6066621 |
| | L7 | 301588 | 6069219 |
| | L2 | 311490 | 6070452 |
| | CC1 | 301083 | 6071623 |
| | TF | 306203 | 6075071 |
| Lake Alexandrina | L16 | 309981 | 6065259 |
| | L17 | 315204 | 6062842 |

| Item | Requirement | | | |
|---|---|---|---|---|
| | Lake Albert | L6 | 320744 | 6059813 |
| | | L11 | 326978 | 6061606 |
| | | L10 | 328117 | 6067827 |
| | | L9 | 335085 | 6069125 |
| | | L4 | 316422 | 6079464 |
| | | L5 | 342509 | 6071437 |
| | | L3 | 331798 | 6083065 |
| | | L15 | 351069 | 6077013 |
| | | L18 | 335451 | 6090780 |
| | | L13 | 339051 | 6051394 |
| | | L14 | 349733 | 6061163 |
| | | L8 | 352433 | 6058911 |
| | | L12 | 343877 | 6045620 |

| Item | Requirement |
|---|---|
| **Methodology** | Field methods *sensu* Dittmann et al. (2006).<br>General<br>• Three locations per each site<br>• Three vertical shore levels per location<br>• Three replicate cores per level<br>• Cores to about 5 cm sediment depths<br>• Samples to taken at three levels (high, mid, low tide levels) per location<br>• Sediment characteristics should describe grain size composition for single size fractions, the median grain size and sorting coefficient. |
| **Implementation** | Presently conducted by Sabine Dittmann, Flinders University. |
| **Comments** | Any potential ASS should be recorded and reported to Icon Site Manager and DEH. |

**Figure 9: Locations of M-2 sampling sites (Murray Mouth and Coorong sites only).**



**Assessment of organic content in sediments from mudflats of the Icon Site (M-3).**

| Item | Requirement |
|---|---|
| **Target ID** | **M-3** |
| **Target Title** | Maintain organic content for mud flats. |
| **Target Definitions** | No change to baseline year values. |
| **Condition Monitoring purpose** | **Assessment of organic content in sediments from mudflats of the Icon Site.** |
| **Selected Species** | n/a |
| **Outputs** | 1) Quantify the organic content in mudflat sediments of the sub regions.<br>2) Report on any seasonal variation.<br>3) Comment on trajectory changes over time.<br>4) Comment on any potential impacts to benthic invertebrate, bird foraging and/or water quality. |
| **Timing** | December and June |
| **Sub regions** | • Lake Alexandrina (including lower reaches of the Eastern Mt Lofty tributaries and Hindmarsh Island Creeks)<br>• Lake Albert<br>• Murray Mouth estuary<br>• North Lagoon<br>• South Lagoon. |
| | Thirty (30) Sites.<br>Location of sites used to sample for macroinvertebrates (Dittmann et al. 2006). HC = Hunters Creek. |

| Sub-Region | No. | Easting | Northing |
|---|---|---|---|
| Murray Mouth estuary | HC | 308774 | 6065536 |
| | 1 | 303120 | 6066509 |
| | 4 | 309754 | 6065310 |
| | 6 | 314973 | 6062980 |
| North Lagoon | 20 | 320676 | 6059359 |
| | 22 | 331780 | 6051162 |
| | 24 | 355577 | 6026464 |
| South Lagoon | 14 | 378737 | 5996705 |
| | 16 | 371168 | 6011641 |
| | 19 | 360577 | 6024954 |
| Goolwa Channel | L1 | 300898 | 6066621 |
| | L7 | 301588 | 6069219 |
| | L2 | 311490 | 6070452 |
| | CC1 | 301083 | 6071623 |
| | TF | 306203 | 6075071 |
| Lake Alexandrina | L16 | 309981 | 6065259 |
| | L17 | 315204 | 6062842 |

| Item | Requirement | | | |
|---|---|---|---|---|
| | Lake Albert | L6 | 320744 | 6059813 |
| | | L11 | 326978 | 6061606 |
| | | L10 | 328117 | 6067827 |
| | | L9 | 335085 | 6069125 |
| | | L4 | 316422 | 6079464 |
| | | L5 | 342509 | 6071437 |
| | | L3 | 331798 | 6083065 |
| | | L15 | 351069 | 6077013 |
| | | L18 | 335451 | 6090780 |
| | | L13 | 339051 | 6051394 |
| | | L14 | 349733 | 6061163 |
| | | L8 | 352433 | 6058911 |
| | | L12 | 343877 | 6045620 |

| Item | Requirement |
|---|---|
| **Methodology** | Field methods *sensu* Dittmann et al. (2006).<br>General<br>• Three locations per each site<br>• Three levels per location<br>• Three replicate cores per level<br>• Cores to about 5 cm sediment depths<br>• Samples to taken at three levels (high, mid, low tide levels) per location<br>• Sediment characteristics should describe grain size composition for single size fractions, the median grain size and sorting coefficient.<br>• Determine sediment organic matter by combustion or CHN<br>• Record soil pH. |
| **Implementation** | Presently conducted by Sabine Dittmann, Flinders University. |
| **Comments** | Any potential ASS should be recorded and reported to Icon Site Manager and DEH. |

**Figure 10: Locations of M-3 sampling sites (Murray Mouth and Coorong only).**

## 4.5 Water

**Assessment of estuarine conditions between Goolwa Barrage and Pelican Point (W-1).**

| Item | Requirement |
|---|---|
| **Target ID** | **W-1** |
| **Target Title** | Establish and maintain variable salinity regime with >30% of area below sea water salinity concentrations in Murray Mouth Estuary and North lagoon. |
| **Target Definitions** | Estuarine conditions defined as shallow salinity gradient ranging between ~1ppt and <35ppt.<br>Murray Mouth estuary defined as an area on the ocean side of barrages extending from Goolwa barrage to Pelican Point. |
| **Condition Monitoring purpose** | **Assessment of estuarine conditions between Goolwa barrage and Pelican Point.** |
| **Selected Species** | n/a |
| **Outputs** | 1) Quantify the extent and duration of any estuarine conditions established between Goolwa barrage and Pelican Point.<br>2) Map temporal changes (e.g. monthly) in estuarine conditions between Goolwa barrage and Pelican Point.<br>3) Report on the estuarine conditions of the Murray Mouth between Goolwa barrage and Pelican Point.<br>4) Report on the extent and duration of any estuarine conditions established in the North Lagoon.<br>5) Report on the extent and duration of any estuarine conditions established?<br>6) Report on the salinity gradient of any estuarine conditions established.<br>7) Comment on implication for diadromous fish. |
| **Timing** | Summarise annually. |
| **Sub regions** | • Murray Mouth estuary<br>• North Lagoon. |
| **Sites** | n/a |
| **Methodology** | Desktop Method.<br>Data available from SA Water, DWLBC (surface water monitoring stations http://e-nrims.dwlbc.sa.gov.au/Telemetry/Default.aspx?App=RMW, ) MDBA, DEH. |
| **Implementation** | Report could be prepared by Icon Site Coordinator (or delegate), relevant consultant (e.g. DWLBC or professional company). |
| **Comments** | Highly dependent upon freshwater inputs. |

**Assessment of Murray Mouth opening (W-2).**

| Item | Requirement |
|---|---|
| **Target ID** | **W-2** |
| **Target Title** | Maintain a permanent Murray Mouth opening through freshwater outflows with adequate tidal variations to improve water quality and maximise connectivity. |
| **Target Definitions** | Mouth would remain open through adequate River Murray discharge and without mechanical intervention (e.g. dredging). |
| **Condition Monitoring purpose** | **Assessment of Murray Mouth opening.** |
| **Selected Species** | n/a |
| **Outputs** | 1) Quantify the total volume of water discharged through the Lower Lakes barrages and fishways?<br>2) Quantify the number of days has the Murray mouth remained open?<br>3) Quantify many days was dredging undertaken?<br>4) Report on the average annual diurnal tide ratio at Goolwa.<br>5) Report on the average annual diurnal tide ratio at Tauwitchere. |
| **Timing** | Summarise annually. |
| **Sub regions** | Murray Mouth estuary. |
| **Sites** | n/a |
| **Methodology** | Desktop approach.<br>Data available from SA Water, DWLBC, MDBA. |
| **Implementation** | Report could be prepared by Icon Site Coordinator (or delegate), relevant consultant (e.g. DWLBC or professional company). |
| **Comments** | Report on assessing the ecological benefits of an open mouth currently in preparation. |

**Assessment of fish passage between the Lower Lakes and Coorong (W-3).**

| Item | Requirement |
|---|---|
| **Target ID** | **W-3** |
| **Target Title** | Maximise fish passage connectivity between the Lower Lakes and Coorong. |
| **Target Definitions** | Assumes that barrage fishways are operationally efficient. |
| **Condition Monitoring purpose** | **Assessment of fish passage between the Lower Lakes and Coorong.** |
| **Selected Species** | n/a |
| **Outputs** | 1) Quantify the total number of days each barrage fishway has operated.<br>2) Report on the continuity of fishway operation.<br>3) Quantify the volume and timing of fishway releases. |
| **Timing** | Summarise annually. |
| **Sub regions** | Murray Mouth estuary. |
| **Sites** | n/a |
| **Methodology** | Desktop approach.<br>Data available from SA Water, DWLBC, MDBA. |
| **Implementation** | Report could be prepared by Icon Site Coordinator (or delegate), relevant consultant (e.g. DWLBC or professional company). |
| **Comments** | |

**Assessment of connectivity between the Coorong and the sea (W-4).**

| Item | Requirement |
|---|---|
| **Target ID** | **W-4** |
| **Target Title** | Maximise fish passage connectivity between the Coorong and the sea. |
| **Target Definitions** | Maximise defined as Murray Mouth open 100% of the time. |
| **Condition Monitoring purpose** | **Assessment of connectivity between the Coorong and the sea.** |
| **Selected Species** | n/a |
| **Outputs** | 1) Quantify the number of days has the Murray Mouth been open?<br>2) Has the opening been continuous?<br>3) Comment on any impacts of closure fish passage and life histories.<br>4) See also W-1. |
| **Timing** | Summarise annually. |
| **Sub regions** | n/a |
| **Sites** | n/a |
| **Methodology** | Desktop approach.<br>Data available from SA Water, DWLBC, MDBA. |
| **Implementation** | Report could be prepared by Icon Site Coordinator (or delegate), relevant consultant (e.g. DWLBC or professional company). |
| **Comments** | |

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# Appendix A Conceptual Models

# Appendix A Conceptual Model

**Simplified model for the Lakes and Coorong, taken from Lester & Fairweather (2007).**