AQUATIC SCIENCES

# Final report on the 'Fish' and 'Water Quality' components of the 2006 River Murray Wetlands Baseline Survey

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# 1. BACKGROUND

Wetlands are off-main channel or floodplain habitats (ephemeral or permanent) such as billabongs, swamps, backwaters, flood-runners or small/shallow natural lakes (MDBC, 2005). Ecologically, they are sites of high primary and secondary production, and contain diverse flora and fauna. Indeed, many riverine species are wholly or partially dependent on wetlands for food, shelter or habitat during some part of their life cycle, and they may act as a key source of dispersive offspring to the broader catchment (Nichols & Gilligan, 2004; Wilson, 2005). Economically, wetlands fulfil various ecosystem services such as the mitigation of floods (i.e., floodwater storage, reduction, and attenuation), water supply, salinity interception, and pollutant reduction and water purification by filtering-out dissolved nutrients, fertilisers and pesticides. Socially, wetlands are aesthetically pleasing, considered important for regional tourism and the conservation of biodiversity, and valued for fishing, boating and other recreational pursuits.

In regards to fish, thirty-two species occur, or are known to have occurred, within wetlands of the Murray-Darling Basin (Closs *et al.*, 2005; Smith & Hammer, 2006). Five of these species are introduced invaders and twenty-seven are native, including eleven species of regional conservation significance. The highest diversity of wetland fishes (88 % of all species) occurs in the South Australian Murray-Darling Basin where diadromous species (congolli, common galaxias and small-mouthed hardyhead) contribute to species richness (Closs *et al.*, 2005; Smith, 2006; Smith & Hammer, 2006). Of the introduced invaders, common carp, gambusia, redfin perch, goldfish and weatherloach all may be abundant in wetland habitats, but carp overwhelmingly dominate the biomass and are implicated in causing the greatest environmental impacts (Smith, 2006).

The fact that many wetlands contain rare and threatened fish species, sometimes in high numbers, reinforces the importance of healthy wetlands for the maintenance of diversity and likely, for the rehabilitation of fish communities back to 60 % of pre-European levels – the key goal of the Native Fish Strategy, after 50 years of implementation (MDBC, 2003). Rehabilitating wetland fish communities will require the amendment or reversal of existing human-induced threats to wetlands, which include altered hydrological regimes, introduced invasive species, salinisation, eutrophication, habitat destruction and grazing. Some threats are more of an issue at the wetland or reach scale (grazing, eutrophication and to some extent, salinisation), but altered hydrological regimes and invasive species are intimately related, and both are problematic at the catchment scale (Gehrke *et al.*, 1995).

**Table 1-1. List of native and invasive freshwater fish species known to occur (or have occurred) within wetlands of the Murray-Darling Basin (after Hammer & Walker 2004; Closs *et al.*, 2005; Smith, 2006). The conservation status of each species is indicated [State, SA = (DEH, 2003) (provisional listing) & SA *Fisheries Act 1982;* National = *EPBC Act 1999*]. CrEn, Critically Endangered; En, Endangered; Vu, Vulnerable; R, Rare; (P), Protected under the *Fisheries Act 1982*. Species with no proposed conservation status are often abundant and/or widespread, however those marked with an (*) have a limited range within the Murray-Darling Basin. $^{\Psi}$ Captured during current surveys in SA on the lateral migration patterns of freshwater fish. ♣ Presently < 400 km from the SA border, weatherloach are predicted to establish new populations in SA over the next few years.**

| | | *Conservation Status* | |
|---|---|---|---|
| ***Common Name*** | ***Scientific Name*** | *State (SA)* | *National* |
| ***Native fishes*** | | | |
| western blue-spot goby* | *Pseudogobius olorum* | * | |
| small-mouthed hardyhead* | *Atherinosoma microstoma* | * | |
| lagoon goby* | *Tasmanogobius lastii* | * | |
| golden perch | *Macquaria ambigua ambigua* | | |
| flathead gudgeon | *Philypnodon grandiceps* | | |
| common galaxias* | *Galaxias maculatus* | * | |
| carp gudgeon complex | *Hypseleotris* spp. | | |
| bony herring | *Nematalosa erebi* | | |
| Australian smelt | *Retropinna semoni* | | |
| unspecked hardyhead | *Craterocephalus stercusmuscarum fulvus* | | |
| Murray rainbowfish | *Melanotaenia fluviatilis* | | |
| dwarf-flathead gudgeon | *Philypnodon* sp. | | |
| ***Threatened native fishes*** | | | |
| congolli | *Pseudaphritis urvillii* | R | |
| silver perch | *Bidyanus bidyanus* | Vu | Vu |
| Murray hardyhead | *Craterocephalus fluviatilis* | En | Vu |
| Murray cod$^{\Psi}$ | *Maccullochella peelii peelii* | R | Vu |
| freshwater catfish$^{\Psi}$ | *Tandanus tandanus* | Vu (P) | |
| Yarra pygmy perch | *Nannoperca obscura* | En (P) | Vu |
| southern pygmy perch | *Nannoperca australis* | En (P) | |
| shortfinned eel$^{\Psi}$ | *Anguilla australis* | R | |
| chanda perch | *Ambassis agassizii* | CrEn (P) | |
| southern purple-spotted gudgeon | *Morgurnda adspersa* | CrEn (P) | |
| river blackfish | *Gadopsis marmoratus* | En (P) | |
| ***Invasive / Invasive fishes*** | | | |
| redfin perch | *Perca fluviatilis* | | |
| common carp | *Cyprinus carpio* | | |
| goldfish | *Carassius auratus* | | |
| eastern gambusia | *Gambusia holbrooki* | | |
| oriental weatherloach♣ | *Misgurnus anguillicaudatus* | | |
| ***Fishes found in wetlands outside of SA*** | | | |
| spangled perch | *Leiopotherapon unicolour* | | |
| Hyrtl's tandan | *Neosiluris hyrtlii* | | |
| spangled grunter | *Leiopotherapon unicolor* | | |
| Murray galaxias | *Galaxias rostratus* | | |
| **TOTAL wetland fishes in MDB** | | ***32*** | |
| **TOTAL wetland fishes in SA-MDB** | | ***27*** | |
| **Threatened native fishes** | | ***11*** | |
| **Invasive / Invasive fishes** | | ***5*** | |

The South Australian River Murray Wetlands Baseline Surveys (RMWBS) are the most comprehensive wetlands surveys ever undertaken in the Murray-Darling Basin (Closs *et al.*, 2005). They have occurred each year since 2004, and have covered 68 wetlands, with a further 20 wetlands expected to have been surveyed by February 2007. At each wetland, bi-annual (spring and autumn) baseline data on the site characteristics, fish, water quality, groundwater, vegetation, birds, frogs and macroinvertebrates has been collected. This information has already been used to derive wetland management plans for a number of wetlands, which include concise statements about local conservation values and planned management objectives. Importantly, the data provides a basis for evaluating the success of future management, to inform adaptive management ('learning by doing') strategies (see further, http://www.rivermurray.sa.gov.au/major/wetlands.html).

# 2. AIMS

The 'Fish' and 'Water Quality' components of the 2006 River Murray Wetlands Baseline Survey had three aims:

1. To describe the fish assemblage and water quality of 8 wetlands along the River Murray in South Australia; Pyap lagoon, Lake Bonney, Banrock Station, Big Toolunka, Markaranka, Noonawirra, Devon Downs North and Saltbush Flat.
2. To indicate the variability in fish species assemblages and water quality over space and time.
3. To identify management recommendations for each wetland, with regard for the above.

# 3. METHODS

## 3.1 FIELD SAMPLING

### 3.1.1 <u>Site selection within wetlands</u>

An initial inspection of each wetland was used to identify major habitat types for fish (e.g. emergent littoral-, submerged- and overhanging vegetation, rocks, woody debris including fallen red gums and complex fallen branches, open water, inlet/outlet channels, bare bank), and any obvious site variations related to disparities in hydro-geography. A minimum of five sampling sites were then chosen in each wetland to encompass the range of available habitat, and one fishing method (with replication) was used at each site. Thus, sites were selected to optimise the diversity of fish sampled; our aim was not to catch as many fish as possible, but to sample as many habitats as possible to ensure we sampled the entire fish community (all species including small and large bodied fish, and most life stages) and to limit the possibility that rare species might be missed.

### 3.1.2 Sampling gear and protocol

This survey incorporated a range of complementary fish sampling methods including fyke, gill and seine nets, and bait traps. Table 3-1 provides a description of each of the gear types, together with details of the habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight. For example, seine nets were used during the day and mostly amongst submerged and fringing littoral vegetation, although some open water/bare bank hauls were conducted. Seining is an active fishing method and accordingly, seine nets were not set overnight; three independent 10 m hauls were conducted at each site over relatively firm substrates.

Typically, a minimum of one standard set of gear including 3 fyke nets, 3 gill nets and 5 bait traps was employed at each wetland. In many cases, two sets of standard gear were set in geographically or hydrographically discrete sections of the wetlands. Fishing methods were standardised across specific habitat types to maintain consistency in the approach, and also to allow local and regional comparisons of the wetland fish communities.

Fish were processed immediately after capture. That is, the first 20 fish of each species were measured (total length, TL, mm) and returned to the water. The remaining fish were counted and visually inspected for rare/threatened species. All fish were released, including all invasive species.

NOTE: Gill netting requires a license that is only available to commercial fishers and professional research organisations such as SARDI Aquatic Sciences. Whilst we acknowledge this as a possible restriction on future community monitoring, this complementary method is important because none of the aforementioned methods specifically target large-bodied species; although fyke nets will catch some larger fish and their young.

**Table 3-1. Summary table describing each fishing method used in this Baseline Survey, together with the habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight.**

| Gear type | Mesh size and description | Min no. of replicates per site (habitat type) | Set/conducted overnight? |
|---|---|---|---|
| Fyke nets | single wing 5 m x 80 cm deep leader, 80 cm diameter entrance, 3 m funnel with 7 rings, 3 chambers and 8 mm fine mesh | 3 fyke nets | yes |
| Gill nets | 15 m long x 2 m deep, 3 panels of varied mesh size (45, 75 and 115 mm strecthed mesh) randomly positioned within net. Individual panels are 5 m long. | 3 gill nets | yes |
| Bait Fish Traps | 40 cm x 24 cm wide x 24 cm deep. Large diamter (7cm) plastic entrance holes baited with ocean flavoured cat food. | 5 bait traps | yes |
| Seine net | 8 m x 2 m deep x 8mm stretched mesh (hung to 'lose a third') with a 1.5 m cod-end sewed into the middle. The net is black in colour, and weighted to optimise catch rates whilst minimising pick up of mud and debris. | 3 x 10 m seine hauls | no |

### 3.1.3 Sub-sampling of fish within small-mesh fyke nets

Fyke nets are very efficient at sampling small-bodied wetland fish. In some instances, they catch several hundred fish per net, per night. Thus, sub-sampling and extrapolation was required at some sites to minimise the stress on captured fish and to ensure the timely completion of sample processing. When sub-sampling was required, we divided the catch into halves (or thirds). One half (or third) of the total catch was processed as normal, whilst the other was inspected for rare species and returned to the water.

### 3.1.4 Water Quality:

Five water quality parameters were recorded at each fish-sampling site: dissolved oxygen (DO), salinity ($\mu$s.cm-$^{1}$), pH and temperature ($^{\circ}$C) were recorded on a pre-calibrated water quality metre. Turbidity (NTU) was measured using a turbidity tube. Readings were always taken during the mid-late afternoon, when the nets were set or when the seine hauls were conducted. Spot sampling like this is useful for detecting 'extremes' such as high salinity or turbidity, or low dissolved oxygen, but repeat readings must occur at a similar time of day to allow temporal comparisons.

### 3.1.5 Additional data recorded

Data recorded for each site within each wetland included:

1. Date, location, site number & site code
2. GPS coordinates (UTM - 54H GDA94, Eastings and Northings)
3. Water Quality Measures: dissolved oxygen, salinity, pH, temperature, turbidity
4. Local weather conditions at the onset of sampling
5. Habitat description and photograph
6. Fishing time (start, finish, total) & field personnel

### 3.1.6 Voucher Specimens

Voucher specimens from each wetland were preserved in 10% formalin and then 75% ethanol, and retained for later laboratory analysis. These specimens are lasting records, which will be lodged with the South Australian Museum at the completion of this project.

# 4. RESULTS

## 4.1 FISH SURVEY

In total 18,564 fish from 13 species, including 9 native species and 4 invasive species, were sampled from 8 wetlands along the River Murray in South Australia. Sampling occurred during 3-13 April 2006 and 30 October – 10 November 2006. The wetlands sampled included Pyap Lagoon, Lake Bonney, Banrock Station, Big Toolunka, Noonawirra, Devon Downs North and Purnong, which all have had a permanent connection with the main river channel. Conversely, Markaranka wetland is sited above pool level (standard river water level dictated by weir operations) and in the absence of floods must be filled via pumping; which began in May 2006.

Table 4-1 lists the total species captured (common and species names) and provides details of their conservation status (State and Federal), relative abundances and distribution, the total number and average length of each species captured, and the water quality conditions that they were found in. Native species represented 91.5 % of the total number of fish captured during this survey; 91.4 % were generalist fishes (widespread and abundant) and only 0.1 % were threatened fishes (silver perch, $n$ = 17). Indeed, only 1 of the 9 native freshwater fish species captured during this survey (silver perch) is currently protected under state (*South Australian Fisheries Act* 1982) or federal (*EPBC Act* 1999) legislation (Table 4-1) [1]. The most abundant and widely distributed native fish taxa were unspecked hardyheads and the carp gudgeons (a species complex of uncertain taxonomy, see Bertozzi *et al.*, 2000). Common carp and eastern gambusia were the most abundant and widespread invasive species. Whilst the remaining species were not abundant, they were generally widespread, occurring at >60 % of the wetlands surveyed (but see data for silver perch).

No estuarine or euryhaline (tolerant of a wide-range of salinities) species, such as small-mouthed hardyhead, common galaxias, western blue-spot gobies, lagoon gobies, southern pygmy perch, congolli, Murray hardyhead, Yarra pygmy perch, Australian salmon, sandy sprat, Tamar River goby, bridled goby, or yellow-eyed mullet were sampled due to the distance between the wetlands sampled and the Coorong and Lower Lakes region (> 100 river km; see further, Holt *et al.*, 2004; Smith, 2006; Smith & Hammer, 2006). However, these species were all captured during the 2005 wetlands Baseline Survey, which included wetlands in the Lower Lakes and Lower swamps regions (Smith 2006). Table 4-2 lists the species which are know to occur, or have occurred, within the South Australia Murray-Darling Basin but were not captured during this survey.

[1] Three species: Murray rainbowfish (*Melanotaenia fluviatilis*), dwarf-flathead gudgeon (*Philypnodon sp*.) and unspecked hardyhead (*Craterocephalus stercusmuscarum fulvus*) have been removed from the Draft Threatened Species Schedule for South Australia (DEH 2003) since the last Baseline Survey (Smith 2005). Whilst they are not abundant, they are widespread, as evidenced by the catches during this year's and last year's Wetlands Baseline Surveys.

**Table 4-1. Summary table of the fishes captured during the 2006 River Murray Wetlands Baseline Survey, including their total abundance (% of catch) and distribution (% of wetlands), a comparison of catches between regions, and the conductivity of the waters that they were found in.**

| Family | Common Name | Species Name | Total | Abundance (% of catch) | Distribution (% of sites) | Number of Fish | | Length (mm) | | | Conductivity (us) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Murray Gorge | Riverland | Ave | Min | Max | Ave | Min | Max |
| ***Native Fish*** | | | | | | | | | | | | | |
| Retropinnidae | Australian smelt | *Retropinna semoni* | *875* | *4.7* | *75* | *771* | *104* | *57* | *35* | *74* | *5095* | *264* | *8630* |
| Clupeidae | bony herring | *Nematalosa erebi* | *2077* | *11.2* | *88* | *1549* | *528* | *225* | *29* | *475* | *1766* | *282* | *8680* |
| Eleotridae | carp gudgeon complex | *Hypseleotris spp.* | *6823* | *36.7* | *88* | *4312* | *2511* | *35* | *16* | *106* | *4025* | *264* | *8760* |
| Atherinidae | unspecked hardyhead | *Craterocephalus stercusmuscarum fulvus* | *5879* | *31.6* | *88* | *2338* | *3541* | *42* | *19* | *66* | *6409* | *264* | *8760* |
| Eleotridae | dwarf-flathead gudgeon | *Philypnodon sp.* | *267* | *1.4* | *88* | *259* | *8* | *40* | *32* | *47* | *1510* | *323* | *8610* |
| Eleotridae | flathead gudgeon | *Philypnodon grandiceps* | *864* | *4.6* | *75* | *424* | *440* | *53* | *20* | *84* | *5763* | *264* | *8630* |
| Percichthyidae | golden perch | *Macquaria ambigua ambigua* | *33* | *0.2* | *63* | *30* | *3* | *318* | *110* | *465* | *492* | *318* | *896* |
| Melanotaeniidae | Murray rainbowfish | *Melanotaenia fluviatilis* | *170* | *0.9* | *75* | *106* | *64* | *48* | *27* | *67* | *358* | *264* | *864* |
| ***Threatened Native Fish*** | | | | | | | | | | | | | |
| Terapontidae | silver perch | *Bidyanus bidyanus* | *17* | *0.1* | *13* | *17* | | *363* | *270* | *420* | *809* | *677* | *896* |
| ***Exotic / Invasive Fish*** | | | | | | | | | | | | | |
| Cyprinidae | common carp | *Cyprinus carpio* | *803* | *4.3* | *88* | *125* | *678* | *164* | *22* | *715* | *631* | *288* | *8430* |
| Poeciliidae | eastern gambusia | *Gambusia holbrooki* | *613* | *3.3* | *88* | *444* | *169* | *32* | *19* | *48* | *3003* | *318* | *8630* |
| Percidae | redfin perch | *Perca fluviatilis* | *119* | *0.6* | *63* | *108* | *11* | *63* | *30* | *397* | *1515* | *264* | *8610* |
| Cyprinidae | goldfish | *Carassius auratus* | *24* | *0.1* | *63* | *19* | *5* | *181* | *50* | *389* | *853* | *349* | *1347* |
| **Total Fish** | | | **18564** | | | **10502** | **8062** | | | | | | |
| **Total Species** | | | **13** | | | **13** | **12** | | | | | | |

**Table 4-2. Summary table of additional Murray-Darling Basin fishes *not* captured during this year's River Murray Wetlands Baseline Survey.**

| | | | Conservation Status | |
|---|---|---|---|---|
| **Family** | **Common Name** | **Species Name** | *State* | *National* |
| ***Native Fish*** | | | | |
| Atherinidae | small-mouthed hardyhead | *Atherinosoma microstoma* | * | |
| Galaxiidae | common galaxias | *Galaxias maculatus* | * | |
| Gobiidae | western blue-spot goby | *Pseudogobius olorum* | * | |
| Gobiidae | lagoon goby | *Tasmanogobius lastii* | * | |
| ***Threatened Native Fishes*** | | | | |
| Anguillidae | shortfinned eel | *Anguilla australis* | R | |
| Percichythyidae | Murray cod | *Maccullochella peelii peelii* | R | Vu |
| Anguillidae | pouched lamprey | *Geotria australis* | En | |
| Atherinidae | Murray hardyhead | *Craterocephalus fluviatilis* | En | Vu |
| Mordaciidae | shortheaded lamprey | *Mordacia mordax* | En | |
| Eleotridae | southern purple-spotted gudgeon | *Morgurnda adspersa* | CrEn (P) | |
| Ambassidae | chanda perch | *Ambassis agassizii* | CrEn (P) | |
| Percichythyidae | southern pygmy perch | *Nannoperca australis* | En (P) | |
| Percichythyidae | Yarra pygmy perch | *Nannoperca obscura* | En (P) | Vu |
| Plotosidae | freshwater catfish | *Tandanus tandanus* | Vu (P) | |
| Pseudaphritidae | congolli | *Pseudaphritis urvillii* | R | |
| ***Estuarine Fish*** | | | | |
| Arripidae | Australian salmon | *Arripis trutta* | | |
| Clupeidae | sandy sprat | *Hyperlophus vittatus* | | |
| Gobiidae | Tamar River goby | *Favonigobius tamarensis* | | |
| Gobiidae | bridled goby | *Amoya bifrenatus* | | |
| Mugilidae | yelloweyed mullet | *Aldrichetta forsteri* | | |
| ***Exotic Fishes*** | | | | |
| Cyprinidae | carp x goldfish hybrid | *Cyprinid x Carassius* hybrid | | |
| Cobitidae | oriental weatherloach | *Misgurnus anguillicaudatus* | | |

## 4.2 REGIONAL COMPARISON

Following the 2005 RMWBS, key differences in the fish communities of the disparate regions of the South Australian River Murray (Riverland, Murray Gorge, Lower Swamps and Lower Lakes) were analysed and discussed (Smith, 2006). In this year's survey, we sampled only 8 wetlands from the Riverland ($n = 3$) and Murray Gorge ($n = 5$) (none from the Lower Swamps or Lower Lakes regions), effectively precluding detailed regional comparisons. Nevertheless, some broad comparisons for each region are outlined below[2]. These are in agreement with the conclusions of previous surveys (Holt *et al*. 2004; Smith 2006):

**Riverland Region: wetlands from the SA border to Overland Corner**

The three wetlands surveyed in the Riverland region included Pyap Lagoon, Lake Bonney and Banrock Station wetland. A total of 8,062 individuals from 12 species, including 8 native species and 4 invasive species, was captured (Table 4-1; Table 4-3). All of the species collected are widespread throughout the South Australian Murray. Whilst dwarf-flathead gudgeons and Murray rainbowfish are not abundant, there is no evidence to suggest that their abundance has changed over time (due to a lack of previous baseline data). However, there is evidence to suggest that overfishing, river regulation and other anthropogenic effects have led to a significant reduction in the abundance of golden perch, which comprised <0.01% of the total catch for the region in this study (MDBC 2003). Similar abundances were documented in the 2004 and 2005 RMWBS, which examined the fish communities of 27 and 22 River Murray wetlands, respectively (Holt *et al*. 2004; Smith 2006).

Overall, unspecked hardyheads and carp gudgeons were the most abundant native species captured, followed by bony herring, flathead gudgeon and Australian smelt. Of the invasive species, common carp dominated the catch, followed by eastern gambusia, redfin perch and goldfish. Across wetlands, species richness varied from 12 at Pyap to 9 at Lake Bonney, and total abundances varied from 5753 at Lake Bonney to 817 at Banrock Station wetland. Native to invasive species ratios varied from 2:1 at Pyap and Lake Bonney to 1.5:1 at Banrock Station wetland (Table 4-3).

[2] Note that fishing effort may have varied across wetlands and that total abundances are discussed (rather than relative abundances). See site summaries for exact methods used and the number of sites (habitats) fished.

**Table 4-3. Summary table of the fishes captured at Pyap, Lake Bonney and Banrock Station within the Riverland region.**

| | 'Riverland' | | |
|---|---|---|---|
| **Common Name** | **Pyap** | **Bonney** | **Banrock** |
| ***Native Fish*** | | | |
| Australian smelt | 27 | 67 | 10 |
| bony herring | 228 | 295 | 5 |
| carp gudgeon complex | 743 | 1617 | 151 |
| unspecked hardyhead | 330 | 3191 | 20 |
| dwarf-flathead gudgeon | 5 | 2 | 1 |
| flathead gudgeon | 33 | 407 | |
| golden perch | 3 | | |
| Murray rainbowfish | 50 | | 14 |
| ***Threatened Native Fish*** | | | |
| silver perch | | | |
| ***Exotic/Invasive Fish*** | | | |
| common carp | 54 | 19 | 605 |
| eastern gambusia | 12 | 151 | 6 |
| redfin perch | 4 | 4 | 3 |
| goldfish | 3 | | 2 |
| **TOTAL FISH** | 1492 | 5753 | 817 |
| **COUNT OF SPECIES** | 12 | 9 | 10 |
| **NATIVE : EXOTIC** | 2.0 | 2.0 | 1.5 |

## Murray Gorge Region: wetlands from Overland Corner to Mannum

The wetlands surveyed in the Murray Gorge region included Big Toolunka, Markaranka, Noonawirra, Devon Downs North, and Saltbush Flat. A total of 10,502 individuals from 13 species, including 9 native species and 4 invasive species were captured (Table 4-1, Table 4-4). With the exception of Markaranka (where no fish were captured) and Big Toolunka (where 17 silver perch were captured), these wetlands contain a similar fish community (species composition) to those of the Riverland region. There was some variation in abundances among species from the different regions but this relates to the number of wetlands sampled per region.

Across wetlands, species richness varied from 12 at Devon Downs North to 0 at Markaranka, and total abundances varied from 3705 at Devon Downs North to 1488 at Noonawirra (0 at Markaranka). Native to Invasive species ratios varied from 2.7: 1 at Big Tolunka, Noonawirra and Saltbush Flat to 2:1 at Devon Downs North (0 at Markaranka).

**Table 4-4. Summary table of the fishes captured at Big Toolunka, Markaranka, Noonawirra, Devon Downs North, and Saltbush Flat in the Murray Gorge region.**

| | 'Murray Gorge' | | | | |
|---|---|---|---|---|---|
| **Common Name** | **Toolunka** | **Markaranka** | **Noonawirra** | **DD North** | **Saltbush** |
| ***Native Fish*** | | | | | |
| Australian smelt | | | 223 | 547 | 1 |
| bony herring | 224 | | 123 | 1079 | 123 |
| carp gudgeon complex | 901 | | 635 | 546 | 2230 |
| unspecked hardyhead | 722 | | 373 | 920 | 323 |
| dwarf-flathead gudgeon | 1 | | 6 | 15 | 237 |
| flathead gudgeon | 11 | | 10 | 146 | 257 |
| golden perch | 10 | | 4 | 14 | 2 |
| Murray rainbowfish | 12 | | 9 | 83 | 2 |
| ***Threatened Native Fish*** | | | | | |
| silver perch | 17 | | | | |
| ***Exotic/Invasive Fish*** | | | | | |
| common carp | 21 | | 11 | 64 | 29 |
| eastern gambusia | 2 | | 90 | 243 | 109 |
| redfin perch | 68 | | | 40 | |
| goldfish | | | 4 | 8 | 7 |
| **TOTAL FISH** | 1989 | 0 | 1488 | 3705 | 3320 |
| **COUNT OF SPECIES** | 11 | 0 | 11 | 12 | 11 |
| **NATIVE : EXOTIC** | 2.7 | 0:0 | 2.7 | 2 | 2.7 |

## 4.3 METHODS COMPARISON

There is considerable variation in the efficiency and usefulness of methods for sampling large and small-bodied fish in wetland environments. This topic is complex however, as catch rates are governed by numerous factors including the prevailing abiotic (i.e. water depth, river flow, habitat type and availability, substrate type), biotic (i.e. food, predators, competitors) and chemical (i.e. water temperature, oxygen, salinity, pH) environment, wetland geomorphology and type (i.e. lowland, upland, anabranch, permanent, ephemeral), and even factors such as site access issues (i.e. the difficulties of launching an electrofishing boat with no ramp, launching a small boat from a steep bank or trying to carrying heavy gear across a floodplain; you can't catch fish without the appropriate sampling gear). Consequently, only a brief overview of the efficiency of key methods used in this year's survey is provided below.

Sampling using complementary methods ensures that the full variety of species, sizes (small and large fish) and life-histories (juveniles and adults) of fish are sampled. In this survey, a combination of small-mesh fyke nets ($n$ = 3 per site or habitat type), multi-panel gill nets (3, 4, 5" mesh; $n$ = 3) and bait traps ($n$ = 5) were used as the 'standard set' of fishing gear in most wetlands, although in many cases, two sets of standard gear were set in geographically or hydrographically discrete sections of the wetlands. Replicate seine net hauls

($n = 3$) were also used at some wetlands, whilst electrofishing (boat-and backpack) was removed from this year's survey because it has been found to be an inefficient fish sampling method in shallow wetlands due to high turbidity, difficult access and occasional high salinities (Smith 2006). See Table 4-5 for the total number and length of fish sampled using the various methods.

Fyke nets are a simple and efficient method of capturing diverse small-bodied fish assemblages, including some large-bodied fishes and their early life stages. They are also appropriate for use in most habitats and in water depths from c. 30 cm – 1.5 m. In this survey, fyke nets captured 92 % of the species (only silver perch were not collected) and c. 83 % of all fish sampled.

Gill nets catch large-bodied species (i.e. average size > 10 cm total length, Table 4-5) and in this survey, they caught all 6 large-bodied species, which comprised 4.2% of the total catch. Bony herring constituted an overwhelming proportion (85 %) of the total catch of large fish from gill nets, followed by common carp (10 %) and golden and silver perch (~2 % each). Bony herring are fragile and most die after handling and removal from gill nets, particularly on hot days (low dissolved oxygen combined with higher respiration) or if they have been in the nets for more than a few hours. The remaining species can also suffer from general body damage after being trapped in gill nets, but post-release survival rates are not documented. Thus, the use of gill nets should be carefully considered and alternate means such as boat-electrofishing or fyke nets should be used in preference to gill nets when possible. However, with the appropriate licenses/permits, gill nets provide a useful measure of the relative abundance of larger specimens not caught using the other gear types (i.e silver perch in this survey)[3].

Bait traps are widely used in community and other fish monitoring programs because of their low cost and ease of use. In this survey, bait traps caught 61.5 % of all species and 8.7 % of the total catch. The species that they 'missed' include three generalist native fishes (one is large-bodied), one threatened native fish (large-bodied), and one invasive species (large-bodied) (Table 4-5). Whilst bait traps are very effective at capturing abundant small-bodied species, fyke nets should always complement their use when possible.

In contrast to the aforementioned 'passive' methods of sampling fish, seine netting is an 'active' method that is useful for targeting specific sites and habitats. In this survey, seine netting captured 61.5 % of all species but only 3.9 % of the total catch. Whilst physically demanding, seining is useful for rapid assessments of small-bodied fish communities in small waterbodies, but is not as effective as fyke nets.

[3] To minimise stress/damage to captured fish during future monitoring (without time constraints), large-mesh fyke nets (3 x 3″ square mesh) or shorter gill nets of only one mesh size (i.e. 5 m long, 4″ mesh), which are inspected frequently (every 1 hr), could be considered.

**Table 4-5. Summary table of the number of each species captured using the disparate sampling methods, including length data.**

| | | | | | | Length by Method (TL, mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Total** | **Total by Method** | | | | **Bait Trap** | | | **Fyke Net** | | | **Gill Net** | | | **Seine Net** | | |
| **Common Name** | **Captured** | **Bait Trap** | **Fyke Net** | **Gill Net** | **Seine Net** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** |
| ***Native Fish*** | | | | | | | | | | | | | | | | | |
| Australian smelt | 875 | | 835 | | 40 | | | | 58 | 36 | 74 | | | | 51 | 35 | 70 |
| bony herring | 2077 | | 1393 | 666 | 18 | | | | 95 | 29 | 370 | 325 | 167 | 475 | 66 | 36 | 79 |
| Murray rainbowfish | 170 | 12 | 158 | | | 58 | 50 | 67 | 47 | 27 | 66 | | | | | | |
| carp gudgeon complex | 6823 | 1478 | 5038 | 1 | 306 | 32 | 18 | 48 | 36 | 16 | 106 | | | | 34 | 24 | 47 |
| unspecked hardyhead | 5879 | 72 | 5602 | | 205 | 40 | 29 | 53 | 43 | 25 | 66 | | | | 36 | 19 | 50 |
| dwarf-flathead gudgeon | 267 | 2 | 264 | | 1 | 44 | 44 | 44 | 40 | 33 | 47 | | | | 32 | 32 | 32 |
| flathead gudgeon | 864 | 11 | 702 | | 151 | 55 | 39 | 63 | 56 | 30 | 84 | | | | 36 | 20 | 65 |
| golden perch | 33 | | 19 | 14 | | | | | 245 | 110 | 380 | 417 | 305 | 465 | | | |
| ***Threatened Native Fish*** | | | | | | | | | | | | | | | | | |
| silver perch | 17 | | | 17 | | | | | | | | 363 | 270 | 420 | | | |
| ***Exotic/Invasive Fish*** | | | | | | | | | | | | | | | | | |
| common carp | 803 | 2 | 722 | 78 | 1 | 213 | 196 | 230 | 98 | 22 | 715 | 415 | 224 | 690 | 26 | 26 | 26 |
| eastern gambusia | 613 | 33 | 572 | | 8 | 29 | 19 | 48 | 32 | 20 | 47 | | | | 32 | 23 | 36 |
| redfin perch | 119 | 1 | 113 | 5 | | 62 | 62 | 62 | 46 | 30 | 60 | 360 | 326 | 397 | | | |
| goldfish | 24 | | 17 | 7 | | | | | 152 | 50 | 268 | 251 | 200 | 389 | | | |
| **Total** | **18564** | **1611** | **15435** | **788** | **730** | | | | | | | | | | | | |

## 4.4 WATER QUALITY

**Conductivity (µs.cm$^{-1}$)**: River water at Overland Corner varied from ~280-430 µs.cm$^{-1}$ during the survey period (see further, http://e-nrims.dwlbc.sa.gov.au/sitedata/A4260652/A4260652.htm). Conductivity increased at all wetlands, except Saltbush Flat, from autumn to spring. The decrease in conductivity at Saltbush Flat (from a mean of 2600 to 1757 µs.cm$^{-1}$) is due to dredging activities at the northern inlet, which have re-established a continuous connection with the main river channel. Lake Bonney recorded the highest mean salinity (~7,000 µs.cm$^{-1}$), likely due to evapo-concentration; Lake Bonney receives river water through Chamber's Creek but there is no flow-through. The terminus of Pyap lagoon is also slightly saline (~1000 µs.cm$^{-1}$) due to the incursion of ground water (seepage of saline ground water is evident on the shore of the lagoon). The conductivity of the remaining wetlands (average 350-800 µs.cm$^{-1}$) is typical of River Murray wetlands, which have permanent connections with the main channel and are unaffected by groundwater intrusion (Holt *et al*. 2004).

**Turbidity (NTU, Nephelometric Turbidity Unit):** Turbidity decreased significantly at all wetlands, except Noonawirra, from autumn to spring. The reason for this is unknown but may relate to declining river flow in relation to the continuing drought (fallout & settlement of particulate matter) and water shortages throughout the Murray-Darling Basin. Nevertheless, mean turbidity values were > 50 NTU at 50% of the wetlands surveyed, likely a result of wind-induced turbulence and disturbance of soft muddy substrates. The highest turbidity reading (300 NTU) was recorded at the mouth of Pyap Lagoon in autumn, where river water containing dense filamentous algae was flowing into the wetland. The lowest turbidity readings were recorded at Pyap, Lake Bonney, Markaranka and Big Toolunka during spring (<15 NTU).

**Water Temperature**: Water temperatures approximately reflected the air temperatures at the time of sampling. Minimum temperatures of 17.6$^{o}$C were recorded in autumn, and a maximum temperature of 25.8$^{o}$C was recorded in spring.

**Dissolved Oxygen:** Average dissolved oxygen values > 8 mg.L$^{-1}$ are likely to reflect the shallow nature of the wetlands surveyed (wind-assisted oxygenation of the water column occurs readily) and the time of day that the samples were taken. In regards to the latter, sampling typically occurred during the mid-late afternoon after aquatic plants had been actively photosynthesizing (consuming CO2 and producing oxygen) during the day. Regardless, dissolved oxygen is unlikely to pose a problem for aquatic fauna in the wetlands surveyed.

**pH**: Mean pH values ranged from 8.2 to 9.5. Whilst these figures are relatively high (basic), they probably reflect the underlying geology of the wetlands (Holt et al. 2004), and do not appear to be affecting the wetland flora and fauna.

**Table 4-6. Summary of mean water quality data for each wetland sampled during this Wetlands Baseline Survey. Water quality samples were taken at each fish-sampling site. Empty cells indicate seasons within wetlands where no water quality samples were taken.**

| | Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| **Location** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** |
| Pyap | 487 | 282 | 859 | 598 | 352 | 910 | 706 | 264 | 1347 | 100 | 29 | 300 | 33 | 20 | 80 | 21 | 13 | 35 | 8.9 | 7.5 | 9.8 | 10.7 | 8.9 | 13.1 |
| Lake Bonney | 6830 | 651 | 8630 | 7451 | 4720 | 8210 | 7342 | 2146 | 8760 | 22 | 13 | 60 | 14 | 0 | 30 | 13 | 9 | 25 | 9.4 | 8.6 | 10.4 | 9.7 | 8.7 | 10.4 |
| Banrock Station | | | | | | | 296 | 288 | 317 | | | | | | | 65 | 37 | 90 | | | | 8.2 | 7.3 | 9.7 |
| Big Toolunka | 628 | 580 | 677 | 755 | 681 | 829 | 842 | 627 | 1225 | 30 | 25 | 36 | 17 | 15 | 20 | 10 | 9 | 11 | 8.8 | 7.7 | 10.2 | 10.5 | 8.6 | 12.6 |
| Markaranka | | | | | | | 648 | 643 | 656 | | | | | | | 9 | 9 | 11 | | | | 8.2 | 7.7 | 9.0 |
| Noonawirra | 346 | 330 | 357 | 411 | 377 | 452 | 477 | 472 | 490 | 56 | 38 | 90 | 62 | 46 | 92 | 100 | 100 | 100 | 9.7 | 9.0 | 10.4 | 8.6 | 8.6 | 8.6 |
| Devon Downs North | 323 | 318 | 324 | 399 | 393 | 403 | 594 | 562 | 685 | 108 | 90 | 120 | 47 | 31 | 75 | 51 | 40 | 80 | 9.1 | 8.9 | 9.4 | 11.9 | 11.2 | 12.7 |
| Purnong | 2600 | 2460 | 2710 | 2363 | 2340 | 2380 | 1757 | 1716 | 1788 | 118 | 90 | 170 | 219 | 78 | 483 | 90 | 80 | 100 | 9.5 | 9.1 | 9.9 | 9.4 | 9.2 | 9.6 |

| | Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** | **Ave** | **Min** | **Max** |
| Pyap | 19.2 | 17.8 | 19.8 | 10.5 | 9.0 | 11.3 | 24.6 | 23.8 | 25.8 | 8.9 | 8.3 | 9.3 | 7.2 | 7.0 | 7.5 | 9.5 | 9.0 | 10.0 |
| Lake Bonney | 20.7 | 19.6 | 22.1 | 10.9 | 10.5 | 11.4 | 22.8 | 21.8 | 23.8 | 8.7 | 8.6 | 8.8 | 7.8 | 7.0 | 8.0 | 8.8 | 8.7 | 8.8 |
| Banrock Station | | | | | | | 21.5 | 17.8 | 25.5 | | | | | | | 8.7 | 8.5 | 9.3 |
| Big Toolunka | 19.8 | 19.2 | 20.4 | 10.0 | 8.8 | 10.4 | 22.8 | 21.4 | 24.0 | 8.2 | 7.9 | 8.6 | 6.8 | 6.5 | 7.0 | 9.1 | 9.0 | 9.4 |
| Markaranka | | | | | | | 22.0 | 21.1 | 23.1 | | | | | | | 8.2 | 7.8 | 8.6 |
| Noonawirra | 17.7 | 17.6 | 17.8 | 11.4 | 10.8 | 11.7 | 23.0 | 22.8 | 23.6 | 8.2 | 8.0 | 8.5 | 6.6 | 6.0 | 6.9 | 8.2 | 8.1 | 8.3 |
| Devon Downs North | 21.4 | 21.1 | 21.9 | 13.4 | 13.2 | 13.5 | 22.7 | 21.5 | 23.4 | 8.4 | 8.3 | 8.5 | 6.8 | 6.5 | 7.1 | 9.5 | 9.2 | 9.7 |
| Purnong | 21.1 | 20.7 | 21.9 | 9.5 | 9.2 | 10.0 | 24.9 | 23.6 | 25.6 | 8.8 | 8.7 | 8.9 | 6.8 | 6.2 | 7.1 | 8.6 | 8.6 | 8.6 |

## 4.5 SITE SUMMARIES

### 4.5.1 Riverland Region: wetlands from the SA border to Overland Corner

#### *4.5.1.1 Pyap Lagoon*

**General information**

At Pyap, fish and water quality surveys were conducted during 03-04 April and 19-20 November 2006. The number of sites, and the habitat type and fishing method used at each site is indicated in Table 4-7. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Pyap lagoon receives current flows from the main channel, and is relatively deep (>1.5 m) for most of its length. At the terminus of the wetland, saline groundwater seeps through the sediment, and this is evident around the shoreline (Figure 4-1). In that area, water conductivity is around 1000 µs.cm$^{-1}$, whilst the remainder of the wetland is typically <500-700 µs.cm$^{-1}$. Turbid incoming water from the main channel contributed to the high maximum turbidity measure recorded for the lagoon in autumn 2006 (Table 4-9). Otherwise, water quality within the wetland is comparable to that of the main channel.

**Figure 4-1. Photographs showing the constant incursion of saline groundwater into the south-eastern end of Pyap lagoon; midday and early-evening.**

A total of 1492 fish from 12 species, including 8 native species and 4 invasive species, was captured (Table 4-8). Bony herring, carp gudgeons and unspecked hardyhead were the most abundant native fishes, whilst common carp and eastern gambusia were the most abundant invasive species captured. Two of the lesser-abundant species, dwarf-flathead gudgeon and Murray rainbowfish, were recently removed form the revised *National Parks and Wildlife Act* 1972 (DEH 2003) due to a lack of *a-priori* information regarding their historic abundance. None of the other species listed have conservation status.

Carp gudgeons and common carp were more abundant in spring than in autumn. Eastern gambusia was only sampled in autumn, whilst goldfish were only sampled in spring. Freshwater shrimps (*Macrobrachium australiense* and *Paratya australiensis*) were abundant, and we captured predatory redfin perch and golden perch, which would take advantage of such abundant food resources (Figure 4-2).

Other fluctuations in fish abundances between seasons may be related to the general mobility and patchy distribution of riverine/wetland fish, or to seasonal changes in temperature and other environmental factors (water level, conductivity etc). The presence of small (young) individuals of bony herring, unspecked hardyhead, common carp (spring only) and redfin perch (spring only) is evidence of relatively recent reproduction. This reproduction may have occurred within or adjacent to the wetland. The native to invasive species ratio was 2.6:1 and overall, the invasive species contributed little to the total abundance of captured fish.

**Implications for management**

- Overall, the wetland has good water quality due to its wide and permanent connection with the main channel. There is a diversity of shallow (<1 m) and deep-water (1.5 m) habitats, and a range of other habitat types including submerged and emergent vegetation, large woody debris, overhanging vegetation, grassy banks, and open water that should remain unaltered.
- Groundwater incursion at the south-eastern end of the wetland has resulted in the absence of littoral vegetation but a dense bed of submerged eel grass (*Valisneria* sp.) is still present in that area. Dense beds of *Potamogeton* sp. were also abundant throughout the wetland in spring, likely due to reduced turbidities, and would have provided good habitat for small-bodied fish.
- Some water level manipulation might encourage the development of a richer and more complex riparian/littoral vegetation community around the remainder of the wetland. As well as providing good fish habitat, this would improve water quality, and act as a source of organic matter, shade and food items.
- Whilst cattle were seen on the property, there was little evidence of 'pugging' or destruction of wetland vegetation through direct grazing.

**Figure 4-2. Photographs showing abundant shrimp (left), a golden perch (top right) and a redfin perch (bottom right).**

**Table 4-7. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|
| 1 | Fyke Net | Inlet, adjacent island, some submerged vegetation & snags, emergent reeds, 1-1.5 m deep | 447872 | 6193542 | √ | √ |
| 2 | Bait Trap | Wetland edge, large willow, 2 m deep | 448136 | 6192995 | √ | √ |
| 3 | Gill Net | Wetland edge, clumped emergent reeds with interspersed snags, 0.4-1.5 m deep | 448392 | 6192854 | √ | √ |
| 4 | Seine Net | Wetland edge, grassy bank, submerged *Vallisneria* , firm substrate, 0.5-1 m deep | 448895 | 6192416 | √ | √ |
| 5 | Bait Trap | Wetland edge, overhanging *Acacia,* some submerged vegetation, 1m deep | 448794 | 6192314 | √ | √ |
| 6 | Gill Net | Open water, bare bank, soft substrate, 1-2 m deep | 449650 | 6192018 | √ | √ |
| 7 | Fyke Net | Open Water, dense *Vallisneria,* 0.7 m deep | 449921 | 6192021 | √ | √ |

**Table 4-8. Summary table indicating the number of species captured per season at Pyap, together with length data.**

| | | Pyap Lagoon | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Autumn | | | | Spring | | | |
| | | | Length (mm) | | | | Length (mm) | | |
| Common Name | Species Name | Total | Ave | Min | Max | Total | Ave | Min | Max |
| ***Native Fish*** | | | | | | | | | |
| Australian smelt | *Retropinna semoni* | 5 | 44 | 35 | 51 | 22 | 54 | 49 | 64 |
| bony herring | *Nematalosa erebi* | 181 | 189 | 29 | 430 | 47 | 289 | 85 | 396 |
| carp gudgeon complex | *Hypseleotris spp.* | 122 | 35 | 22 | 45 | 621 | 35 | 24 | 52 |
| unspecked hardyhead | *C. s. fulvus* | 147 | 38 | 27 | 50 | 183 | 41 | 28 | 64 |
| dwarf-flathead gudgeon | *Philypnodon sp.* | 3 | 34 | 32 | 36 | 2 | 44 | 44 | 44 |
| flathead gudgeon | *Philypnodon grandiceps* | 25 | 49 | 37 | 63 | 8 | 64 | 57 | 75 |
| golden perch | *Macquaria ambigua ambigua* | 2 | 407 | 403 | 410 | 1 | 450 | 450 | 450 |
| Murray rainbowfish | *Melanotaenia fluviatilis* | 20 | 37 | 27 | 60 | 30 | 49 | 40 | 66 |
| ***Threatened Native Fish*** | | | | | | | | | |
| silver perch | *Bidyanus bidyanus* | | | | | | | | |
| ***Exotic/Invasive Fish*** | | | | | | | | | |
| common carp | *Cyprinus carpio* | 3 | 273 | 157 | 415 | 51 | 149 | 22 | 690 |
| eastern gambusia | *Gambusia holbrooki* | 12 | 36 | 23 | 47 | | | | |
| redfin perch | *Perca fluviatilis* | 1 | 362 | 362 | 362 | 3 | 45 | 43 | 49 |
| goldfish | *Carassius auratus* | | | | | 3 | 243 | 104 | 389 |
| **Number of Fish** | | 521 | | | | 971 | | | |
| **Count of Species** | | 11 | | | | 11 | | | |
| **Native : Exotic Ratio** | | 8:3 | | | | 8:3 | | | |
| **Overall Fish** | | 1492 | | | | | | | |
| **Overall Species** | | 12 | | | | | | | |

**Table 4-9. Summary of mean water quality data recorded at Pyap Lagoon.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 487 | 282 | 859 | 598 | 352 | 910 | 706 | 264 | 1347 | 100 | 29 | 300 | 33 | 20 | 80 | 21 | 13 | 35 | 8.9 | 7.5 | 9.8 | 10.7 | 8.9 | 13.1 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 19.2 | 17.8 | 19.8 | 10.5 | 9.0 | 11.3 | 24.6 | 23.8 | 25.8 | 8.9 | 8.3 | 9.3 | 7.2 | 7.0 | 7.5 | 9.5 | 9.0 | 10.0 |

### *4.5.1.2 Lake Bonney*

**General information**

At Lake Bonney, fish and water quality surveys were conducted on 04-05 April and 30-31 November 2006. The number of sites, and the habitat type and fishing methods used at each site are indicated in Table 4-10. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Lake Bonney is around 7 km long and 3.5 km wide, and the average depth is c. 1-2 m. There is little riparian or submerged vegetation and the lake is exposed to strong wind and wave action. Lake Bonney receives some River Murray water via Chambers Creek at its north-eastern inlet. However, water exchange is minimal and whilst the salinity of the incoming water is around 600 $\mu s.cm^{-1}$, salinities within the lake are typically 7-9,000 $\mu s.cm^{-1}$ due to evapo-concentration (Table 4-12). Indeed, an obvious boundary between the turbid incoming river water and the darker, more-saline Lake water could be seen from the Chambers-Creek Bridge (Figure 4-3).

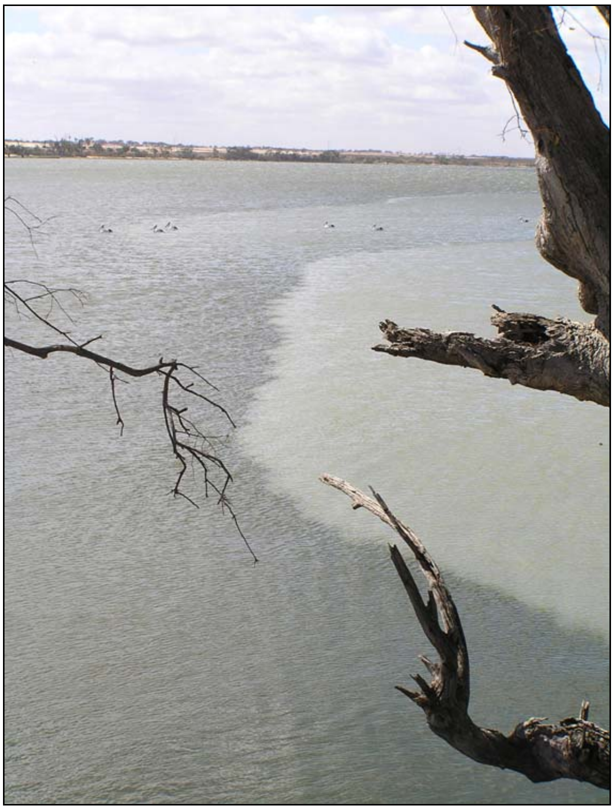

**Figure 4-3. Photograph showing the boundary between turbid incoming river water and the darker, more-saline water of Lake Bonney.**

A total of 5753 fish from 9 species, including 6 native species and 3 invasive species, was captured (Table 4-11). All of the species captured are generalist riverine species, able to tolerate the higher salinities. Flathead gudgeon and bony herring were particularly abundant in autumn, as was eastern gambusia for the invasive species. Whilst electrofishing was attempted within the lake as part of another project, no small fish were captured due to the high salinities (electricity takes the path of least resistance - and bypasses the fish). Only a few bony herring and carp were captured using this method. All captured species appeared to have reproduced within the lake (or recruited from nearby locations), as was evidenced by the capture of juveniles of each species, and bony herring were observed actively spawning around the lake margins. However, invasive species contributed little to the overall abundance of fish captured, and the recruitment of common carp and redfin perch may be hampered by high salinities and a virtual absence of submerged vegetation (as a substrate for spawning).

An order of magnitude more fish was sampled in spring than in autumn. Primarily, this difference is due to the capture of high abundances of unspecked hardyheads and carp gudgeons during spring. Whilst eastern gambusia were only sampled in autumn, dwarf flathead gudgeons and juvenile redfin perch were only sampled in spring (Table 4-11).

**Implications for management**

- Salinity may be the single greatest factor influencing the fish and vegetation communities of Lake Bonney. At around 9,000 $\mu s.cm^{-1,}$ the high salinities appear to be preventing the establishment of littoral/riparian vegetation, and there is virtually no submerged vegetation. Large woody debris from fallen redgums will provide habitat for some large-bodied fishes, but common carp and bony herring are the only large-bodied fishes utilising the wetland; no golden perch or other large native fish were captured.
- If actions to reduce conductivities to <2000 $\mu s.cm^{-1}$ cannot be undertaken, the 'health' of the aquatic flora and fauna within the Lake is unlikely to improve. However, salinities would need to exceed ~20,000 EC before the existing fish community was adversely affected (Clunie *et al.*, 2002).
- Whilst broad-shelled turtles (*Chelodina expansa*) were not captured, Lake Bonney is speculated to be an important breeding ground for the species (T. Steggles, SA MDB NRM Board, Pers. Comm); only 5 long-necked turtles (*Chelodina longicollis*) were captured at this site.
- Due to the Lake's close proximity to Barmera, it is perhaps most favoured for a range of recreational pursuits including camping, water skiing, swimming and sail-boarding. Thus, attempts to re-vegetate the surrounding floodplain may increase the aesthetic value of the Lake, and thereby increase visitation by tourists, which would benefit the local economy/community.

**Table 4-10. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|
| 1 | Fyke Net | Wetland edge, dense grassy bank, fallen woody debris, firm substrate, 0.5-1 m deep | 447254 | 6214700 | √ | √ |
| 2 | Gill Net | Open water, large woody debris, firm substrate, 0.5-1.5 m deep | 448578 | 6212730 | √ | √ |
| 3 | Fyke Net | Wetland edge, emergent reeds and submerged grass, sparse snags, 0.5-1 m deep | 448872 | 6211400 | √ | √ |
| 4 | Bait Trap | Wetland edge, exposed to wind and wave action, emergent reeds, sandy substrate, 30 cm deep | 449920 | 6215701 | √ | √ |
| 5 | Gill Net | Inlet near bridge, freshwater side, emergent reeds, large snag, 1 m deep | 446891 | 6215695 | √ | √ |
| 6 | Seine Net | Wetland edge, emergent reeds, sandy bottom, 0.4-1 m deep | 447149 | 6215915 | √ | √ |
| 7 | Seine Net | Wetland edge, bare sandy bank, bare sandy substrate, to 1 m depth | 451182 | 6211806 | √ | √ |

**Table 4-11. Summary table indicating the number of species captured per season at Lake Bonney, together with length data.**

| | | Lake Bonney | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Autumn | | | | Spring | | | |
| | | | Length (mm) | | | | Length (mm) | | |
| **Common Name** | **Species Name** | **Total** | **Ave** | **Min** | **Max** | **Total** | **Ave** | **Min** | **Max** |
| ***Native Fish*** | | | | | | | | | |
| Australian smelt | *Retropinna semoni* | 26 | 50 | 38 | 70 | 41 | 65 | 55 | 74 |
| bony herring | *Nematalosa erebi* | 106 | 217 | 36 | 437 | 189 | 369 | 236 | 475 |
| carp gudgeon complex | *Hypseleotris spp.* | 24 | 38 | 24 | 46 | 1593 | 36 | 24 | 50 |
| unspecked hardyhead | *C. s. fulvus* | 46 | 38 | 19 | 54 | 3145 | 45 | 23 | 61 |
| dwarf-flathead gudgeon | *Philypnodon sp.* | | | | | 2 | 41 | 39 | 42 |
| flathead gudgeon | *Philypnodon grandiceps* | 204 | 54 | 21 | 75 | 203 | 47 | 20 | 78 |
| golden perch | *Macquaria ambigua ambigua* | | | | | | | | |
| Murray rainbowfish | *Melanotaenia fluviatilis* | | | | | | | | |
| ***Threatened Native Fish*** | | | | | | | | | |
| silver perch | *Bidyanus bidyanus* | | | | | | | | |
| ***Exotic/Invasive Fish*** | | | | | | | | | |
| common carp | *Cyprinus carpio* | 14 | 225 | 88 | 625 | 5 | 123 | 26 | 500 |
| eastern gambusia | *Gambusia holbrooki* | 151 | 35 | 25 | 45 | | | | |
| redfin perch | *Perca fluviatilis* | | | | | 4 | 44 | 40 | 47 |
| goldfish | *Carassius auratus* | | | | | | | | |
| **Number of Fish** | | 571 | | | | 5182 | | | |
| **Count of Species** | | 7 | | | | 8 | | | |
| **Native : Exotic Ratio** | | 5:2 | | | | 6:2 | | | |
| **Overall Fish** | | 5753 | | | | | | | |
| **Overall Species** | | 9 | | | | | | | |

**Table 4-12. Summary of mean water quality data recorded at Lake Bonney.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 6830 | 651 | 8630 | 7451 | 4720 | 8210 | 7342 | 2146 | 8760 | 22 | 13 | 60 | 14 | 0 | 30 | 13 | 9 | 25 | 9.4 | 8.6 | 10.4 | 9.7 | 8.7 | 10.4 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 20.7 | 19.6 | 22.1 | 10.9 | 10.5 | 11.4 | 22.8 | 21.8 | 23.8 | 8.7 | 8.6 | 8.8 | 7.8 | 7.0 | 8.0 | 8.8 | 8.7 | 8.8 |

#### *4.5.1.3 Banrock Station Wetland*

**General information**

At Banrock Station, an impromptu fish survey was conducted on 11 Nov 2006. Approximately 60 t of carp were removed in 1994 when the wetland was first dried. Since then, carp have returned to the wetland (probably as larvae/juveniles via the mesh of the carp screens), where they spawn and recruit every year. Their recruitment has probably been assisted by past water management practises, which have been tied to irrigation and water pumping requirements. In that regard, wetland water levels are lowered during winter (a time of low water need) and raised during spring. This regime effectively allows floodplain grasses and other vegetation to establish during winter, which then acts as a spawning substrate (and nursery habitat) for carp in spring. The irrigation pumps, however, have now been relocated to the main river channel, so the prospects for water management are much more flexible.

The number of sites, and the habitat type and fishing method used at each site is indicated in Table 4-13. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Banrock Station wetland lies on the River Murray floodplain, opposite the township of Overland Corner and 14 km northwest of Barmera in South Australia. It bypasses Weir and Lock 3, the construction of which converted what was previously a seasonally flooded system of creeks and a lagoon into a permanently inundated one. At pool level, the wetland has one inlet and one outlet, and has a surface area of approximately 120 ha. It is best described as a seasonal, shallow (average depth < 1 m), freshwater wetland, fed by regulated streams from a regulated river system. It is surrounded by dense uninterrupted stands of emergent littoral vegetation and is turbid with sparse submerged vegetation.

Flow regulating structures were installed at both the inlet and outlet in 1992 to manipulate water levels – the wetland may be partially dried (in 3-4 days), completely dried (via evaporation and partial drying) or flooded (equivalent to 60,000 ML/d in the River Murray main channel). Five stop logs control flow through the inlet and outlet structures, although generally, the inlet (with permanent carp screens) is operated without boards in place, maintaining a flow of water through the main lagoon. Consequently, water quality in the wetland is generally similar to that of the River Murray (Table 4-15).

**Figure 4-4. Photograph illustrating the typical difference in abundance between common carp (top and in right-hand tray) and small native fish (left-hand tray) within our fyke nets at Banrock Station wetland.**

A total of 817 fish from 10 species, including 6 native species and 4 invasive species, was captured (Table 4-14). Common carp (juveniles and adults) were by far the most abundant fish in the wetland. Indeed, they comprised 75% of the total number of fish captured, and a much larger (but un-calculated) percentage of the biomass. Invasive redfin perch and goldfish recruits were also captured. Carp gudgeons were the most abundant native fishes (18.5 % of the total), whilst the remaining species (Australian smelt, bony herring, unspecked hardyhead, Murray rainbowfish and dwarf-flathead gudgeons) were not abundant (6 % of the total).

### Implications for management

- Continuous water flow through the wetland provides excellent water quality. However, the sheer number and biomass of resident carp appears to be affecting the abundance and distribution of native fish and submerged vegetation. Drying the wetland will enable the existing carp population to be harvested and the system to be 're-set'; free of large-bodied carp.
- Due to the shallow nature of the wetland, and the configuration of the inlet (with carp screens) and outlet (approximately 1 m head, at pool level), the wetland will only support small-bodied fishes, or the larvae/juveniles of larger-bodied species, which was confirmed in this study. Larger-bodied native species (Murray catfish, golden perch, silver perch, and possibly Murray cod) require deep-water habitats, which are absent from Banrock Station – the deepest pool is around 1.5 m and only 300 m long x 100 m wide.
- If carp management is a primary management objective, then the wetland must be dried every 2-3 years to prevent carp larvae/juveniles from growing to a size where they cause ecological harm (> ~300 mm).

**Table 4-13. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|
| 1 | Fyke Net | Northern end of the lagoon, near reeds and sticks, 60cm deep | 438828 | 6217808 | | √ |
| 2 | Gill Net | Northern end of the lagoon, near wetland outlet, >1.5 m deep. Note - only 1 gill net set | 438828 | 6217808 | | √ |
| 3 | Fyke Net | Vallisneria beds, emergent littoral reeds, 50 cm deep | 438898 | 6217078 | | √ |
| 4 | Fyke Net | Adjacent southern boardwalk, patchy submerged vegetation, 50 cm deep | 439239 | 6214936 | | √ |
| 5 | Gill Net | Adjacent southern boardwalk, dense emergent reeds, 1m deep | 439239 | 6214936 | | √ |

**Table 4-14. Summary table indicating the number of species captured per season at Banrock Station, together with length data.**

| | | Banrock Station | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Autumn | | | | Spring | | | |
| | | | Length (mm) | | | | Length (mm) | | |
| **Common Name** | **Species Name** | **Total** | **Ave** | **Min** | **Max** | **Total** | **Ave** | **Min** | **Max** |
| ***Native Fish*** | | | | | | | | | |
| Australian smelt | *Retropinna semoni* | | | | | 10 | 57 | 55 | 62 |
| bony herring | *Nematalosa erebi* | | | | | 5 | 67 | 54 | 80 |
| carp gudgeon complex | *Hypseleotris spp.* | | | | | 151 | 41 | 31 | 52 |
| unspecked hardyhead | *C. s. fulvus* | | | | | 20 | 41 | 34 | 48 |
| dwarf-flathead gudgeon | *Philypnodon sp.* | | | | | 1 | 42 | 42 | 42 |
| flathead gudgeon | *Philypnodon grandiceps* | | | | | | | | |
| golden perch | *Macquaria ambigua ambigua* | | | | | | | | |
| Murray rainbowfish | *Melanotaenia fluviatilis* | Not Sampled | | | | 14 | 56 | 37 | 65 |
| ***Threatened Native Fish*** | | | | | | | | | |
| silver perch | *Bidyanus bidyanus* | | | | | | | | |
| ***Exotic/Invasive Fish*** | | | | | | | | | |
| common carp | *Cyprinus carpio* | | | | | 605 | 52 | 22 | 650 |
| eastern gambusia | *Gambusia holbrooki* | | | | | 6 | 39 | 28 | 46 |
| redfin perch | *Perca fluviatilis* | | | | | 3 | 48 | 45 | 50 |
| goldfish | *Carassius auratus* | | | | | 2 | 53 | 50 | 55 |
| **Number of Fish** | | 0 | | | | 817 | | | |
| **Count of Species** | | 0 | | | | 10 | | | |
| **Native : Exotic Ratio** | | 0:0 | | | | 6:4 | | | |
| **Overall Fish** | | 817 | | | | | | | |
| **Overall Species** | | 10 | | | | | | | |

**Table 4-15. Summary of mean water quality data recorded at Banrock Station wetland.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| | | | | | | 296 | 288 | 317 | | | | | | | 65 | 37 | 90 | | | | 8.2 | 7.3 | 9.7 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| | | | | | | 21.5 | 17.8 | 25.5 | | | | | | | 8.7 | 8.5 | 9.3 |

### 4.5.2 Murray Gorge Region: wetlands from Overland Corner to Mannum

#### *4.5.2.1 Big Toolunka*

**General information**

At Big Toolunka, fish and water quality surveys were conducted on 05-06 April 01-02 November 2006. The number of sites, and the habitat type and fishing method used at each site is indicated in Table 4-16. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Big Toolunka is around 3 km long and 200 m wide, and the average water depth is c. 1-2 m. There is abundant submerged, littoral and riparian vegetation, and the water is relatively clear and fresh due to a good connection with the main channel at the north-eastern inlet. The majority of the riparian zone tapers quickly to 1-2 m depth, except at the terminal southern end where there is a dense and widespread bed of *Vallisneria sp*.

A total of 1989 fish from 11 species, including 8 native species and 3 invasive species, was captured (Table 4-17). A significant find for this wetland was the capture of 17 silver perch > 270 mm TL (Figure 4-5). Silver perch are protected under state and federal legislation; they are listed as Vulnerable under the *South Australian Fisheries Act* 1982 and the *EPBC Act* 1999. Only two other silver perch have been captured as part of previous Baseline Surveys of 61 wetlands; these fish were captured in Mundic Creek (in the Riverland Region) (Holt *et al.*, 2004; Smith, 2006).

Carp gudgeons and unspecked hardyhead comprised the majority of the catch (>80 %), but there were still good numbers of large-bodied species; probably due to the above average depth of the wetland and relative scarcity of shallow littoral habitat (except at the terminal end). These large-bodied species included >220 bony herring, 10 golden perch, 21 common carp and 68 redfin perch (invasive predator). A virus known as EHN (Epizootic Haematopoietic Necrosis), which causes infection and lesions, and which has controlled redfin perch populations since the early 1990's in the South Australian Murray, affected all the redfin perch sampled (Figure 4-5). Mature common carp were abundant within the shallow *Vallisneria* beds, but no carp recruits were captured during spring (Figure 4-5).

Murray rainbowfish ($n$ = 12) and dwarf-flathead gudgeon ($n$ = 1) were sampled only in spring. Carp gudgeons, unspecked hardyhead and redfin perch (young recruits) were much more abundant in spring than in autumn. The presence of small (young) individuals of all species, except golden perch and silver perch, is evidence of relatively recent reproduction. This reproduction may have occurred within or adjacent to the wetland. The native to invasive species ratio was 2.6:1 and overall, the invasive species (carp and redfin perch) were relatively abundant. Indeed, in all of the wetlands sampled, adult carp appear more abundant than our catch data suggests. This is because adult carp are 'net-aware' i.e. they are very good at avoiding fyke nets and gill nets.

**Figure 4-5. Photographs showing a silver perch (top left), EHN-infected redfin perch (bottom left) and a dense bed of *Vallisneria* sp (left).**

### Implications for management

- Maintain the status quo. This is a diverse wetland with good water quality and a diversity of deep-water and shallow habitats, submerged and emergent vegetation, rocks, woody debris and overhanging vegetation. It containing abundant native fish species including one protected species; silver perch. Indeed, this wetland contains the largest population of silver perch discovered during the 3-year life of the RMWBS.
- A second significant find for the wetland was the capture of 4 large redfin perch in autumn and 64 juvenile redfin perch in spring. This also is the highest number recorded from any wetland in the RMWBS, and the highest level of observed recruitment. Redfin perch are voracious predators and their impact on native fishes such as dwarf-flathead gudgeons, Murray rainbowfish, juvenile catfish and other native fishes needs to be quantified so that management can adequately reflect this impact.

**Table 4-16. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Location | Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|---|
| Big Toolunka | 1 | Fyke Net | Wetland end, dense *Vallisneria* beds, soft substrate, 1 m deep | 402047 | 6219750 | √ | √ |
| Big Toolunka | 2 | Gill Net | Wetland edge, dense *Typha,* soft muddy bottom, 1-2 m deep | 401404 | 6219770 | √ | √ |
| Big Toolunka | 3 | Bait Trap | Wetland edge, dense tree roots, undercut bank, 50 cm deep | 401173 | 6220051 | √ | √ |
| Big Toolunka | 4 | Gill Net | Channel between island and shore, large woody debris, firm substrate, 1-2 m deep | 400634 | 6220484 | √ | √ |
| Big Toolunka | 5 | Fyke Net | Wetland edge, dense emergent reeds, 1-2 m deep | 400395 | 6220698 | √ | √ |
| Big Toolunka | 6 | Bait Trap | Wetland edge, bare grassy bank, 40 cm deep | 400329 | 6220883 | √ | √ |

**Table 4-17. Summary table indicating the number of species captured per season at Big Toolunka, together with length data.**

| | | Big Toolunka | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Autumn | | | | Spring | | | |
| | | | Length (mm) | | | | Length (mm) | | |
| **Common Name** | **Species Name** | **Total** | **Ave** | **Min** | **Max** | **Total** | **Ave** | **Min** | **Max** |
| ***Native Fish*** | | | | | | | | | |
| Australian smelt | *Retropinna semoni* | | | | | | | | |
| bony herring | *Nematalosa erebi* | 153 | 249 | 60 | 432 | 71 | 313 | 123 | 424 |
| carp gudgeon complex | *Hypseleotris spp.* | 154 | 27 | 16 | 38 | 747 | 32 | 23 | 48 |
| unspecked hardyhead | *C. s. fulvus* | 15 | 43 | 35 | 58 | 707 | 39 | 28 | 58 |
| dwarf-flathead gudgeon | *Philypnodon sp.* | | | | | 1 | 38 | 38 | 38 |
| flathead gudgeon | *Philypnodon grandiceps* | 7 | 53 | 36 | 67 | 4 | 58 | 56 | 59 |
| golden perch | *Macquaria ambigua ambigua* | 4 | 407 | 390 | 420 | 6 | 441 | 405 | 465 |
| Murray rainbowfish | *Melanotaenia fluviatilis* | | | | | 12 | 58 | 50 | 67 |
| ***Threatened Native Fish*** | | | | | | | | | |
| silver perch | *Bidyanus bidyanus* | 3 | 357 | 355 | 360 | 14 | 364 | 270 | 420 |
| ***Exotic/Invasive Fish*** | | | | | | | | | |
| common carp | *Cyprinus carpio* | 10 | 352 | 95 | 525 | 11 | 397 | 298 | 458 |
| eastern gambusia | *Gambusia holbrooki* | 1 | 31 | 31 | 31 | 1 | 37 | 37 | 37 |
| redfin perch | *Perca fluviatilis* | 4 | 359 | 326 | 397 | 64 | 49 | 40 | 62 |
| goldfish | *Carassius auratus* | | | | | | | | |
| **Number of Fish** | | 351 | | | | 1638 | | | |
| **Count of Species** | | 9 | | | | 11 | | | |
| **Native : Exotic Ratio** | | 6:3 | | | | 8:3 | | | |
| **Overall Fish** | | 1989 | | | | | | | |
| **Overall Species** | | 11 | | | | | | | |

**Table 4-18. Summary of mean water quality data recorded at Big Toolunka during April 2006.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 628 | 580 | 677 | 755 | 681 | 829 | 842 | 627 | 1225 | 30 | 25 | 36 | 17 | 15 | 20 | 10 | 9 | 11 | 8.8 | 7.7 | 10.2 | 10.5 | 8.6 | 12.6 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 19.8 | 19.2 | 20.4 | 10.0 | 8.8 | 10.4 | 22.8 | 21.4 | 24.0 | 8.2 | 7.9 | 8.6 | 6.8 | 6.5 | 7.0 | 9.1 | 9.0 | 9.4 |

### *4.5.2.2 Markaranka*

**General information**

At Markaranka, fish surveys were conducted on 02-03 November 2006. The number of sites, and the habitat type and fishing method used at each site is indicated in Table 4-19. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Markaranka wetland was gradually filled via pumping in May 2006 and will dry via evaporation in 2007. The surface area of the wetland is approximately 120 Ha, and the average depth is around 1.5 m. The water is fresh, clear and well oxygenated, but partly tannin-stained, and contains abundant macro-invertebrates, long-neck turtles (*Chelodina longicollis*) and tadpoles. Regenerating stands of Redgum (established in 2001) are scattered throughout the wetland, and littoral grasses and new seedlings have established around the shoreline (Figure 4-6).

Despite setting 2 sets of standard fishing gear and an additional set of fyke nets, no fish were captured. This may be an artefact of 1) filling the wetland via pumps, which can be destructive to fish, 2) the location of the pump intakes in the main river channel (few metres from shore in deep, open water), which would affect the likelihood of fish being entrained into the pumps, 3) a scarcity of fish within the wetland, meaning the chance of capture was low, or 4) a possible black water event after the wetland was filled, caused by the decay of floodplain vegetation and other organic matter, leading to low oxygen and fish death.

**Implications for management**

- Currently, the wetland has abundant frogs/tadpoles, macroinvertebrates, birds and regenerating vegetation. The floodplain appears in good condition. However, the water quality in the wetland will progressively decline as the wetland dries during 2007. This is unavoidable, but if it is continually monitored, it will help to understand changes to the resident flora and fauna communities. Fish and water quality will be re-surveyed in autumn 2007.
- Fish should not be a key management concern for this wetland, as their long-term prospects are poor.

**Figure 4-6. Photographs showing regenerating red gums, and establishing seedlings and littoral grasses.**

**Table 4-19. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|
| 1 | Bait Trap | Edge habitat, snaggy tree shoreline, 50cm deep | 394772 | 6228103 | | √ |
| 2 | Fyke Net | Dense lignum/redgum stand, firm substrate, 70cm deep | 395050 | 6227346 | | √ |
| 3 | Gill Net | Group of trees in open water, 1.5m deep | 395268 | 6227430 | | √ |
| 4 | Bait Trap | Deep water edge adjacent to sparse redgums, 1m deep | 395404 | 6226986 | | √ |
| 5 | Fyke Net | *Cyperus* reeds from edge into deeper water, 70cm deep | 395518 | 6227350 | | √ |
| 6 | Gill Net | Inlet channel, sparse redgum saplings, 1.5m deep | 394791 | 6228975 | | √ |
| 7 | Fyke Net | Inlet channel, sparse redgum saplings, 1.5m deep | 394803 | 6229282 | | √ |

**Table 4-20. Summary of mean water quality data recorded at Markaranka during November 2006.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| | | | | | | 648 | 643 | 656 | | | | | | | 9 | 9 | 11 | | | | 8.2 | 7.7 | 9.0 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| | | | | | | 22.0 | 21.1 | 23.1 | | | | | | | 8.2 | 7.8 | 8.6 |

### *4.5.2.3 Noonawirra*

**General information**

At Noonawirra, fish and water quality surveys were conducted on 10-11 April and 07-08 November 2006. The number of sites, and the habitat type and fishing method used at each site is indicated in Table 4-21. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Noonawirra proper is around 1.3 km long and 50 m wide, and the average water depth is < 1 m. The adjoining wetland (southern end of Portee Creek) was also included in the autumn round of sampling but discontinued in spring due to catching the same fish assemblage. Water levels were not constant in either wetland during the times of sampling due to changes in the direction of flow between the river and wetland (filling/emptying velocities through pipe culverts was up to c. 10 $cm.s^{-1}$ at the time of sampling). Submerged, littoral and riparian vegetation is patchily distributed with stretches of bare/grassy banks. The water was relatively clear in autumn but became more turbid in spring, and it was one of the freshest wetlands sampled due to its strong connection with the main channel at the southern inlet (5 pipe culverts) (Table 4-23).

A total of 1488 fish from 11 species, including 8 native species and 3 invasive species, was captured (Table 4-22). Aside from the carp gudgeons, bony herring, Australian smelt and unspecked hardyhead dominated the catch for the native species. Gambusia was the most abundant invasive fish and only a few carp were observed/captured within the wetland. Since May 2006, the wetland has had temporary carp screens installed at the pipe culverts as part of another project investigating the lateral migration patterns of freshwater fishes (to and from wetlands). These screens appear not to have affected the number of large-bodied species captured between sampling events, although fewer bony herring were captured in spring.

Whilst dwarf-flathead gudgeons were only sampled in spring, other fluctuations in fish abundances between seasons may be related to the general mobility and patchy distribution of riverine/wetland fish, or to seasonal changes in temperature and other environmental factors (water level, conductivity etc). The presence of small (young) individuals of all species, except golden perch, is evidence of relatively recent reproduction. This reproduction may have occurred within or adjacent to the wetland. The native to invasive species ratio was 2.6:1 and overall, the invasive species contributed little to the total abundance of captured fish.

Four golden perch (152-290 mm TL) were captured near the wetland inlet. They may reside in that area to optimise their foraging success - by ambushing prey as they move through the pipe-culverts whilst still maintaining access to deeper refuge habitats in the main river channel. These fish all displayed lesions and inflammation around the dorsal fins, which is common during the warmer months (particularly late summer). The State Veterinary Pathology Laboratory has examined a single fish exhibiting these symptoms. This examination did not identify or isolate any bacteria, fungi or other disease-causing agents, but did indicate a possible cause; it is likely that the lesions were the result of an infection, linked to a combination of physical damage, and poor water quality (including low DO, high salinity and pH away from optimal) and high organic load in the water (PIRSA Fisheries Press Release, 21 July 2006). Thus, it is currently unknown if there are any additional risks posed by handling/consuming fish with fin rot but to avoid injury and the risk of infection, fish should always be handled with care.

**Figure 4-7. Photographs showing golden perch displaying lesions and inflammation around the dorsal fins.**

### Implications for management

- Maintain the status quo. The water quality within the wetland is good, and the surrounding floodplain also appears healthy.
- Due to the shallow nature of the wetland, it will only support small-bodied fishes (and carp), or the larvae/juveniles of larger-bodied species, which was confirmed in this study. Larger-bodied native species (Murray catfish, golden perch, silver perch, and possibly Murray cod) require deep-water habitats, which are absent from Noonawirra – the maximum depth of the entire wetland is only around 80 cm.
- Fish passage through the pipe culverts is probably affected at low river levels (caused by wind effects on surface waters) due to a lack of water within the pipes, and at high water levels due to high water velocities. An increased number of larger-diameter pipes may be beneficial in this regard.

**Table 4-21. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|
| 1 | Fyke Net | Wetland inlet end, dense reeds, firm substrate, 0.5 m deep | 369087 | 6181883 | √ | √ |
| 2 | Gill Net | Open Water, firm substrate, sparse *Vallisneria* beds | 369297 | 6182342 | √ | √ |
| 3 | Bait Trap | Open Water, firm substrate, sparse *Vallisneria* beds | 369297 | 6182342 | √ | √ |
| 4 | Fyke Net | Wetland edge, emergent reeds (*Cyperus* spp.), firm substrate, 0.5 m deep | 369315 | 6182410 | √ | √ |
| 5 | Gill Net | Eastern channel, near 2nd causeway, soft substrate, emergent & overhanging vegetation, 0.5 m deep | 369876 | 6182445 | √ | |
| 6 | Bait Trap | Eastern channel, near 2nd causeway, soft substrate, emergent & overhanging vegetation, 0.5 m deep | 369876 | 6182445 | √ | |
| 7 | Fyke Net | Eastern channel, near 1st causeway, large woody debris, soft substrate, 0.4-0.8 m deep | 369246 | 6181698 | √ | |

**Table 4-22. Summary table indicating the number of species captured per season at Noonawirra, together with length data.**

| | | Noonawirra | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Autumn | | | | Spring | | | |
| | | | Length (mm) | | | | Length (mm) | | |
| **Common Name** | **Species Name** | **Total** | **Ave** | **Min** | **Max** | **Total** | **Ave** | **Min** | **Max** |
| ***Native Fish*** | | | | | | | | | |
| Australian smelt | *Retropinna semoni* | 14 | 45 | 37 | 52 | 209 | 56 | 47 | 70 |
| bony herring | *Nematalosa erebi* | 91 | 109 | 47 | 320 | 32 | 169 | 65 | 323 |
| carp gudgeon complex | *Hypseleotris spp.* | 188 | 35 | 21 | 50 | 447 | 36 | 26 | 48 |
| unspecked hardyhead | *C. s. fulvus* | 124 | 38 | 25 | 54 | 249 | 41 | 27 | 61 |
| dwarf-flathead gudgeon | *Philypnodon sp.* | | | | | 6 | 42 | 37 | 47 |
| flathead gudgeon | *Philypnodon grandiceps* | 8 | 51 | 39 | 70 | 2 | 51 | 40 | 62 |
| golden perch | *Macquaria ambigua ambigua* | 2 | 205 | 152 | 257 | 2 | 264 | 237 | 290 |
| Murray rainbowfish | *Melanotaenia fluviatilis* | 8 | 41 | 37 | 45 | 1 | 55 | 55 | 55 |
| ***Threatened Native Fish*** | | | | | | | | | |
| silver perch | *Bidyanus bidyanus* | | | | | | | | |
| ***Exotic/Invasive Fish*** | | | | | | | | | |
| common carp | *Cyprinus carpio* | 5 | 213 | 84 | 608 | 6 | 331 | 168 | 640 |
| eastern gambusia | *Gambusia holbrooki* | 65 | 29 | 21 | 48 | 25 | 35 | 25 | 43 |
| redfin perch | *Perca fluviatilis* | | | | | | | | |
| goldfish | *Carassius auratus* | 1 | 70 | 70 | 70 | 3 | 118 | 104 | 130 |
| **Number of Fish** | | 506 | | | | 982 | | | |
| **Count of Species** | | 10 | | | | 11 | | | |
| **Native : Exotic Ratio** | | 7:3 | | | | 8:3 | | | |
| **Overall Fish** | | 1488 | | | | | | | |
| **Overall Species** | | 11 | | | | | | | |

**Table 4-23. Summary of mean water quality data recorded at Noonawirra during April 2006.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 346 | 330 | 357 | 411 | 377 | 452 | 477 | 472 | 490 | 56 | 38 | 90 | 62 | 46 | 92 | 100 | 100 | 100 | 9.7 | 9.0 | 10.4 | 8.6 | 8.6 | 8.6 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 17.7 | 17.6 | 17.8 | 11.4 | 10.8 | 11.7 | 23.0 | 22.8 | 23.6 | 8.2 | 8.0 | 8.5 | 6.6 | 6.0 | 6.9 | 8.2 | 8.1 | 8.3 |

### 4.5.2.4 Devon Downs North

**General information**

At Devon Downs, fish and water quality surveys were conducted on 11-12 April and 08-09 November 2006. The number of sites, and the habitat type and fishing method used at each site is indicated in Table 4-24. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Devon Downs North is around 7 km long and 700 m wide, and the average water depth is around 50 cm. The substrate is soft and muddy, and there are plentiful freshwater River mussels (*Alathyria jacksoni*). Mature common carp were present in extremely high numbers (unquantified, but constantly seen moving away from the boat). The south-western inlet is blocked by willows and other vegetation, and local landholders indicate that several boats were historically sunk there to hinder the access of incoming recreational boats from the main channel (Figure 4-8). Hence, the only navigable inlet is at the north-eastern end of the wetland. This inlet has been dredged, and is 1-2 m deep throughout its length. It must facilitate reasonable water exchange, as the water quality within the wetland is good, although it was quite turbid in autumn (Table 4-26). The margins of the wetland are surrounded by dense stands of emergent vegetation (Figure 4-8), although submerged vegetation was sparse; perhaps due to the high abundance of common carp.

**Figure 4-8. Photographs showing the blocked south-western inlet (left) and the dense emergent riparian vegetation (right).**

A total of 3705 fish from 12 species, including 8 native species and 4 invasive species were captured (Table 4-25). Australian smelt, bony herring, carp gudgeons and unspecked hardyheads dominated the catch (>85 %), and these species were significantly more abundant in spring than in autumn. Golden perch ($n$ = 14) were only sampled in autumn, whilst redfin perch (juveniles) and goldfish were only sampled in spring.

More Murray rainbowfish were found in Devon Downs North than at any other wetland, although they were only in relatively deep (> 0.8 m) water near the inlet, where there was good water exchange. This channel also appears to support abundant small and large golden perch, juvenile redfin perch (invasive predator), flathead gudgeons and to a lesser extent, Australian smelt. In contrast, more eastern gambusia and carp (invasives) were captured at the southern end of the wetland where there was little to no flow. The native:invasive species ratio was 2:1, and although relatively few carp were captured, their observed abundance was extreme. As mentioned previously, low carp catches may result from carp being 'net-aware' i.e. they are very good at avoiding fyke nets and gill nets

**Implications for management**

- This wetland is suited to small-bodied native fish and large-bodied carp as a feeding, spawning and nursery area. It would benefit from being dried, as this would consolidate the sediment, improve the clarity of the water and promote the establishment of submerged and emergent vegetation. The majority of native fish could continue to utilise the wetland inlet and adjacent main channel during the drying phase, whilst significant numbers of carp could be harvested.
- This wetland may be a suitable candidate for the installation of a carp separation cage, once research/trials to optimise the cages for use within wetland inlets are complete (around mid-2009). These cages will prevent large carp (> ~300 mm TL) from entering the wetland and causing ecological harm.
- Access to the wetland by car is mostly limited to the northern and southern ends, although there are a few landholders on the western side, which may allow access to the wetland via their property. Travel around the wetland by boat is made difficult by its shallow depth (<50 cm in most places, although this co-varies with changes in water levels within the main channel). Thus, any planned management actions should keep these access issues in mind.

**Table 4-24. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|
| 1 | Fyke Net | Wetland edge, emergent reeds, firm substrate, 0.5 m deep | 374815 | 6160761 | √ | √ |
| 2 | Gill Net | Open water, soft muddy substrate, 0.5 m deep | 374909 | 6160826 | √ | √ |
| 3 | Bait Trap | Open water, soft muddy substrate, 0.5 m deep | 375017 | 6160843 | √ | √ |
| 4 | Fyke Net | Adjacent deep channel inlet - north, dense emergent reeds, soft substrate, 0.8 m deep | 376213 | 6164127 | √ | √ |
| 5 | Fyke Net | Adjacent deep channel inlet - south, dense emergent reeds, soft substrate, 0.8 m deep | 376435 | 6164330 | √ | √ |

**Table 4-25. Summary table indicating the number of species captured per season at Devon Downs North, together with length data.**

| | | Devon Downs North | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Autumn | | | | Spring | | | |
| | | | Length (mm) | | | | Length (mm) | | |
| Common Name | Species Name | Total | Ave | Min | Max | Total | Ave | Min | Max |
| ***Native Fish*** | | | | | | | | | |
| Australian smelt | *Retropinna semoni* | 8 | 46 | 36 | 57 | 539 | 59 | 47 | 74 |
| bony herring | *Nematalosa erebi* | 194 | 79 | 36 | 320 | 885 | 158 | 38 | 370 |
| carp gudgeon complex | *Hypseleotris spp.* | 142 | 38 | 25 | 50 | 404 | 39 | 22 | 55 |
| unspecked hardyhead | *C. s. fulvus* | 61 | 45 | 28 | 63 | 859 | 43 | 30 | 66 |
| dwarf-flathead gudgeon | *Philypnodon sp.* | 8 | 39 | 33 | 45 | 7 | 40 | 35 | 44 |
| flathead gudgeon | *Philypnodon grandiceps* | 90 | 50 | 30 | 79 | 56 | 60 | 41 | 72 |
| golden perch | *Macquaria ambigua ambigua* | 14 | 248 | 110 | 380 | | | | |
| Murray rainbowfish | *Melanotaenia fluviatilis* | 43 | 42 | 28 | 60 | 40 | 55 | 40 | 65 |
| ***Threatened Native Fish*** | | | | | | | | | |
| silver perch | *Bidyanus bidyanus* | | | | | | | | |
| ***Exotic/Invasive Fish*** | | | | | | | | | |
| common carp | *Cyprinus carpio* | 13 | 341 | 116 | 645 | 51 | 214 | 25 | 700 |
| eastern gambusia | *Gambusia holbrooki* | 203 | 31 | 21 | 44 | 40 | 37 | 25 | 42 |
| redfin perch | *Perca fluviatilis* | | | | | 40 | 38 | 30 | 48 |
| goldfish | *Carassius auratus* | | | | | 8 | 195 | 120 | 240 |
| **Number of Fish** | | 776 | | | | 2929 | | | |
| **Count of Species** | | 10 | | | | 11 | | | |
| **Native : Exotic Ratio** | | 8:2 | | | | 7:4 | | | |
| **Overall Fish** | | 3705 | | | | | | | |
| **Overall Species** | | 12 | | | | | | | |

**Table 4-26. Summary of mean water quality data recorded at Devon Downs North during April 2006.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 323 | 318 | 324 | 399 | 393 | 403 | 594 | 562 | 685 | 108 | 90 | 120 | 47 | 31 | 75 | 51 | 40 | 80 | 9.1 | 8.9 | 9.4 | 11.9 | 11.2 | 12.7 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 21.4 | 21.1 | 21.9 | 13.4 | 13.2 | 13.5 | 22.7 | 21.5 | 23.4 | 8.4 | 8.3 | 8.5 | 6.8 | 6.5 | 7.1 | 9.5 | 9.2 | 9.7 |

### 4.5.2.5 Saltbush Flat

**General information**

At Saltbush Flat, fish and water quality surveys were conducted on 12-13 April and 09-10 November 2006. The number of sites, and the habitat type and fishing method used at each site is indicated in Table 4-27. For a detailed description of each gear type together with details of the general habitats in which they were used, the minimum number of replicates that were fished at each site, and whether the gear was set overnight, see Table 3-1.

Saltbush Flat is around 2.5 km long and up to 500 m wide, and the average water depth is around 1 m. The margins of the wetland are surrounded by dense stands of emergent vegetation, although submerged vegetation was sparse. There are two causeways across the ends of the lagoon, and emergent reeds choke the southern inlet where significant earthworks have occurred in the past. Excavation of the northern inlet, prior to and during the time of the second survey in spring, has re-established flow between the wetland and the main river channel. This re-connection has already led to a significant reduction in water conductivity (max 2710 $\mu s.cm^{-1}$ in autumn to 1788 $\mu s.cm^{-1}$ in spring), although turbidity remains high (Table 4-29).

A total of 3320 fish from 11 species, including 8 native species and 3 invasive species, was captured (Table 4-28). Significantly more individuals of all species, except Murray rainbowfish and eastern gambusia were captured in spring. On that note, Murray rainbowfish and eastern gambusia were only captured in autumn, whilst Australian smelt ($n$ = 1), dwarf-flathead gudgeons ($n$ = 237, significantly more than in any wetland sampled), and goldfish (invasive species) were only captured in spring.

An increased number and diversity of native fish captured in spring might reflect the reduction in wetland salinity and re-establishment of water exchange with the main channel, but this can not be resolved from our data. Further, length frequency data does not indicate that the freshening and re-connection of the wetland has led to strong recruitment by any species (Table 4-28).

### Implications for management

- The southern inlet has been blocked for several years and if it too was excavated, perhaps with some modification to that culvert, continuous and strong water exchange with the main channel may prevent the inlets from being overgrown with emergent reeds (*Typha* and *Phragmites spp.*) in the future – as is apparent at North Purnong wetland.
- This wetland is suited to small-bodied native fish and large-bodied bony herring and carp as a feeding, spawning and nursery area. Thus, prior to any further excavation work, the wetland may actually benefit from being dried, as this would consolidate the sediment, improve the clarity of the water and promote the establishment of submerged vegetation – effectively, it would 're-set' the ecology of the wetland, which appears to have been affected by long periods of high salinities, high turbidity, and carp-related impacts (lack of submerged vegetation, high turbidity).

**Table 4-27. Summary table indicating the number of sites and habitat type sampled per season, and the fishing method used at each site.**

| Site # | Method | Habitat description | Eastings | Northings | Autumn | Spring |
|---|---|---|---|---|---|---|
| 1 | Fyke Net | Open water, firm substrate, eastern end, 0.7 m deep | 375964 | 6140758 | √ | √ |
| 2 | Gill Net | Open water, soft substrate, 1 m deep | 375739 | 6141022 | √ | √ |
| 3 | Bait Trap | Wetland edge, emergent reeds *(Cyperus* spp.), firm substrate, 0.5 m deep | 375147 | 6141379 | √ | √ |
| 4 | Fyke Net | Wetland edge, emergent reeds *(Typha* & *Phragmites* spp.), firm substrate, 0.5-1 m deep | 375019 | 6141649 | √ | √ |
| 5 | Gill Net | Wetland edge, emergent reeds (*Typha* & *Phragmites* spp.), firm substrate, 0.8 m deep | 374878 | 6141613 | √ | √ |

**Table 4-28. Summary table indicating the number of species captured per season at Saltbush Flat, together with length data.**

| | | Saltbush Flat | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Autumn | | | | Spring | | | |
| | | | Length (mm) | | | | Length (mm) | | |
| **Common Name** | **Species Name** | **Total** | **Ave** | **Min** | **Max** | **Total** | **Ave** | **Min** | **Max** |
| ***Native Fish*** | | | | | | | | | |
| Australian smelt | *Retropinna semoni* | | | | | 1 | 62 | 62 | 62 |
| bony herring | *Nematalosa erebi* | 44 | 265 | 220 | 374 | 79 | 283 | 140 | 390 |
| carp gudgeon complex | *Hypseleotris spp.* | 284 | 32 | 21 | 106 | 1946 | 36 | 25 | 47 |
| unspecked hardyhead | *C. s. fulvus* | 4 | 47 | 37 | 52 | 319 | 46 | 32 | 57 |
| dwarf-flathead gudgeon | *Philypnodon sp.* | | | | | 237 | 40 | 36 | 47 |
| flathead gudgeon | *Philypnodon grandiceps* | 97 | 61 | 37 | 84 | 160 | 57 | 45 | 75 |
| golden perch | *Macquaria ambigua ambigua* | 1 | 255 | 255 | 255 | 1 | 305 | 305 | 305 |
| Murray rainbowfish | *Melanotaenia fluviatilis* | 2 | 48 | 40 | 55 | | | | |
| ***Threatened Native Fish*** | | | | | | | | | |
| silver perch | *Bidyanus bidyanus* | | | | | | | | |
| ***Exotic/Invasive Fish*** | | | | | | | | | |
| common carp | *Cyprinus carpio* | 11 | 462 | 390 | 578 | 18 | 478 | 310 | 715 |
| eastern gambusia | *Gambusia holbrooki* | 109 | 29 | 19 | 43 | | | | |
| redfin perch | *Perca fluviatilis* | | | | | | | | |
| goldfish | *Carassius auratus* | | | | | 7 | 216 | 165 | 278 |
| **Number of Fish** | | 552 | | | | 2768 | | | |
| **Count of Species** | | 8 | | | | 9 | | | |
| **Native : Exotic Ratio** | | 6:2 | | | | 7:2 | | | |
| **Overall Fish** | | 3320 | | | | | | | |
| **Overall Species** | | 11 | | | | | | | |

**Table 4-29. Summary of mean water quality data recorded at Saltbush Flat during April 2006.**

| Conductivity (us) | | | | | | | | | Turbidity | | | | | | | | | Dissolved Oxygen | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | | Autumn | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 2600 | 2460 | 2710 | 2363 | 2340 | 2380 | 1757 | 1716 | 1788 | 118 | 90 | 170 | 219 | 78 | 483 | 90 | 80 | 100 | 9.5 | 9.1 | 9.9 | 9.4 | 9.2 | 9.6 |

| Water Temp | | | | | | | | | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn | | | Winter | | | Spring | | | Autumn | | | Winter | | | Spring | | |
| Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max | Ave | Min | Max |
| 21.1 | 20.7 | 21.9 | 9.5 | 9.2 | 10.0 | 24.9 | 23.6 | 25.6 | 8.8 | 8.7 | 8.9 | 6.8 | 6.2 | 7.1 | 8.6 | 8.6 | 8.6 |

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