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Annual progress report towards achievement of the Lower Murray Darling Catchment Action Plan 2004 – 2015: Fish Community Monitoring 2005/06

by
Dean Gilligan

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Lower Murray Darling CMA CATCHMENT MANAGEMENT AUTHORITY

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NON-TECHNICAL SUMMARY

Annual progress report towards achievement of the Lower Murray Darling Catchment Action Plan 2004 –2015: Fish Community Monitoring 2005/06

PRINCIPAL INVESTIGATOR: Dr Dean Gilligan

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OBJECTIVES:

The activities of the fish monitoring program, as specified in the project contract 122.05 are:

1. Determine the number and location of sites identified in Gilligan (2005) that will be monitored (number of sites monitored will vary according to seasonal conditions).
2. Conduct an annual fish monitoring program at sites across the Lower Murray Darling (LMD) catchment as per methodology outlined in Gilligan (2005) and monitor the fish assemblage parameters: species richness, total abundance, total biomass, proportion native species, proportion native abundance, proportion native biomass, proportion recruits and proportion with health condition.
3. Monitor water quality and habitat parameters as described in Gilligan (2005) at each of the monitoring sites.
4. Establish linkages between aspects of monitoring in this project and monitoring components of other LMD CMA projects, such as the algae, salinity and hydrology components and the wetland rehabilitation project, to enhance the data set that the annual fish monitoring report will be based on.
5. Produce a report on annual fish monitoring, habitat conditions and trend analysis.

The outcomes of the fish monitoring program are:

1. Determination of the progress toward the LMD Riverine Health Catchment Target in relation to improvements in the native to introduced fish ratio (55% improvement in species ratio, 25% improvement in abundance ratio, 25% improvement in biomass ratio).
2. Determination and analysis of trends in fish species & communities throughout the LMD catchment in terms of the parameters listed above.

SUMMARY:

The Lower-Murray Darling Catchment Action Plan (CAP) identifies Riverine Health as a Catchment Target: "An identifiable nett improvement in riverine health across the Lower Murray Darling Catchment by 2015". This annual report presents the freshwater fish data collected in 2006 and compares them with benchmark data collected in 2004, assesses progress towards the CAP fish community targets and discusses any patterns observed in the context of other riverine health targets regarding algal blooms, hydrological condition and salinity.

There was no measurable progress towards the CAP targets between 2004 and 2006. The Native : Alien species and biomass ratios declined slightly at the whole catchment level, although the changes were not statistically significant. The abundance ratio had increased at a whole of catchment level, but again the change was not statistically significant.

There was limited opportunity to asses the CAP algal target alongside the fish community data as the algal bloom frequency was generally poor in all catchment zones. There are few data to suggest negative impacts of algal blooms on fish communities. The observed increase in abundance of fly-specked hardyhead and eastern gambusia could actually lead to higher frequencies of algal blooms as these fish prey on zooplankton that would otherwise feed on planktonic algae.

The relative condition of the fish community across the catchment was highest in zones that had the poorest hydrological condition. However, fish community condition was higher in zones where the seasonality of flows was less impacted by river regulation, suggesting that the seasonality of flows is the most important hydrological parameter impacting on fish communities in the Lower Murray-Darling catchment.

Despite the current consensus that native fishes are generally tolerant of high salinity levels, there was some indication that fish community condition was related to salt levels in rivers as fish assemblage condition is generally best in those catchment zones with the lowest salinity levels and vice versa.

Further fish surveys were done in 2007 and the data will be combined with those in this report to produce a more comprehensive assessment of the fish assemblages in the Lower Murray-Darling catchment.

PROJECT BACKGROUND AND OBJECTIVES

The Lower-Murray Darling Catchment Action Plan (CAP) identifies Riverine Health as a Catchment Target: "An identifiable nett improvement in riverine health across the Lower Murray Darling Catchment by 2016. The CAP states that this will be determined by:

- an improvement in the native to introduced fish ratio (55% improvement in species ratio, 25% improvement in abundance ratio, 25% improvement in biomass ratio);
- a 20% reduction in the number of days subject to blue green algal alerts; and
- the reinstatement of more natural flow patterns as modelled in each of five river management zones.

This annual summary reports on progress towards these fish community catchment targets within the catchment area, with sites stratified within five pre-determined catchment zones (Figure 1):

1. Lakes & Reservoirs (Menindee Lakes, Lake Victoria, Euston Lakes and Broken Hill Reservoirs).
2. Darling River.
3. Great Darling Anabranch.
4. Murray River upstream of the Darling junction (Murray I).
5. Murray River downstream of the Darling junction (Murray II).

And a sixth additional category:

6. Floodplain wetlands (combined across zones 2 – 5 above).

The activities of the fish monitoring program, as specified in the project contract 122.05 are:

1. Determine the number and location of sites identified in Gilligan (2005) that will be monitored (number of sites monitored will vary according to seasonal conditions).
2. Conduct annual fish monitoring program at sites across the LMD catchment as per methodology outlined in Gilligan (2005).
3. Parameters monitored include species richness, total abundance, total biomass, proportion native species, proportion native abundance, proportion native biomass, proportion recruits and proportion with health condition.
4. Monitor water quality and habitat parameters as described in Gilligan (2005) at each of the monitoring sites.
5. Establish linkages between aspects of monitoring in this project and monitoring components of other LMD CMA projects, such as the algae, salinity and hydrology monitoring project and the wetland rehabilitation project, in order to enhance the data set that the annual fish monitoring report will be based on.
6. Produce a report on annual fish monitoring, habitat conditions and trend analysis.

The outcomes of the fish monitoring program are:

1. Determination of the progress toward the LMD Riverine Health Catchment Target in relation to improvements in the native to introduced fish ratio (55% improvement in species ratio, 25% improvement in abundance ratio, 25% improvement in biomass ratio).
2. Determination and analysis of trends in fish species & communities throughout the LMD catchment in terms of the parameters listed above.

Progress with each of these objectives and outcomes is outlined below.

ACTIVITY 1

Determine the number and location of sites (identified in Gilligan (2005)) that will be monitored.

The continued drought prevented sampling of the full complement of sites identified in the benchmarking phase in 2004 (Gilligan 2005). All seven core sites in each of the Darling, Murray I and Murray II zones, and all five of the core sites in the Lakes & Reservoirs zone were re-sampled as per the benchmarking surveys in 2004. One new site in the Lakes & Reservoirs zone, Lake Benanee, was sampled in 2006. Other new sites in the Lakes & Reservoirs zone (Lakes Menindee and Cawndilla in the Menindee Lakes system and Dry Lake in the Euston Lakes system) remained dry and/or unsampleable. As in 2004, all seven of the secondary Great Darling Anabranch sites were dry and could not be sampled. Therefore, as in 2004, only a single sample was collected from the Great Darling Anabranch mouth in 2006 as this was the only location in that zone which contained water.

Two of the tertiary wetland sites sampled in 2004 were re-sampled in 2006, Thegoa Lagoon (Murray II zone) and Peacock Creek (Murray I zone). Further, two wetlands that were dry in 2004 contained water in 2006 and were sampled, Wompinni wetland (Murray II zone) and Pomona wetland (Darling zone). All other wetlands within a 5 km radius of riverine sampling sites were dry.

In total, 32 fish community samples were collected in 2006. Twenty-nine of these were at locations sampled in 2004 and three were new sampling locations. Only a single site sampled in 2004, Tangles wetland (Murray I zone) was not sampled in 2006 as it was dry.

Table 1. Sites sampled within each of five catchment zones in the Lower Murray-Darling CMA catchment area. The four shaded sites in the Lakes & Reservoirs zone were not sampled during the benchmarking surveys in 2004 (Gilligan 2005), but are part of the ongoing annual monitoring program.

		UTM zone 54		Sampled in 2006	
Site name	**Waterway**	**Easting**	**Northing**	**Primary site**	**Associated Wetland**
Darling River					
Bono	Darling River	630500	6396700	Yes	Dry
Downham Farm	Darling River	593000	6254000	Yes	Dry
Moorara	Darling River	628000	6361200	Yes	Dry
Pooncarie	Darling River	645100	6305100	Yes	Dry
Lethero	Darling River	634100	6282500	Yes	Dry
Pomona	Darling River	583559	6239880	Yes	Yes
Lelma	Darling River	629300	6272800	Yes	Dry
Great Darling Anabranch					
Allanvale	Great Darling Anabranch	565800	6250000	Dry	Dry
Watara	Great Darling Anabranch	569600	6263400	Dry	Dry
Hunter waterhole	Great Darling Anabranch	586350	6322000	Dry	Dry
Milkengay Creek junction	Great Darling Anabranch	574000	6296250	Dry	Dry
Four-wings Shack	Great Darling Anabranch	592500	6327350	Dry	Dry
Bob's Lake	Tandou Creek	616350	6391600	Dry	Dry
Packer's Crossing	Redbank Creek	600250	6375000	Dry	Dry
Darling Anabranch mouth *	Great Darling Anabranch	570000	6227300	Yes	Dry
Lakes and Reservoirs					
Imperial Lake	Broken Hill reservoir	546811	6465397	Yes	
Copi Hollow	Menindee Lakes	630090	6428815	Yes	
Lake Pamamaroo	Menindee Lakes	641500	6424700	Yes	
Lake Wetherell	Menindee Lakes	643300	6423500	Yes	
Lake Victoria	Lake Victoria	526500	6233500	Yes	
Lake Menindee	Menindee Lakes			Dry	
Lake Cawndilla	Menindee Lakes			Dry	
Lake Benanee	Euston Lakes	671600	6177800	Yes	
Dry Lake	Euston Lakes			Dry	
Murray I					
Tangles Corner	Murray River	687500	6158500	Yes	Dry
Yangera Island	Murray River	680000	6160300	Yes	Yes
Carina Bend	Murray River	653700	6161500	Yes	Dry
Wemen	Murray River	647500	6149500	Yes	Dry
Lake Cantala	Murray River	636200	6162150	Yes	Dry
Nangiloc	Murray River	625500	6183200	Yes	Dry
Cowana Bend	Murray River	625500	6223200	Yes	Dry
Murray II					
Upper Kulnine	Murray River	577400	6222800	Yes	Yes
Frenchman's Creek	Frenchman's Creek	536800	6226500	Yes	Dry
Ned's Corner	Murray River	531200	6223200	Yes	Dry
Tareena	Salt Creek	500300	6241700	Yes	Dry
10 km below Lock 7	Murray River	517800	6229500	Yes	Dry
Hancock Hill – Wompinni	Murray River	504100	6232100	Yes	Yes
Salt Creek	Salt Creek	503700	6237500	Yes	Dry

** This site was sampled as it was the only part of the Great Darling Anabranch containing water in 2006. It is <u>not</u> one of the seven randomly selected fish monitoring sites designed to represent this zone.*

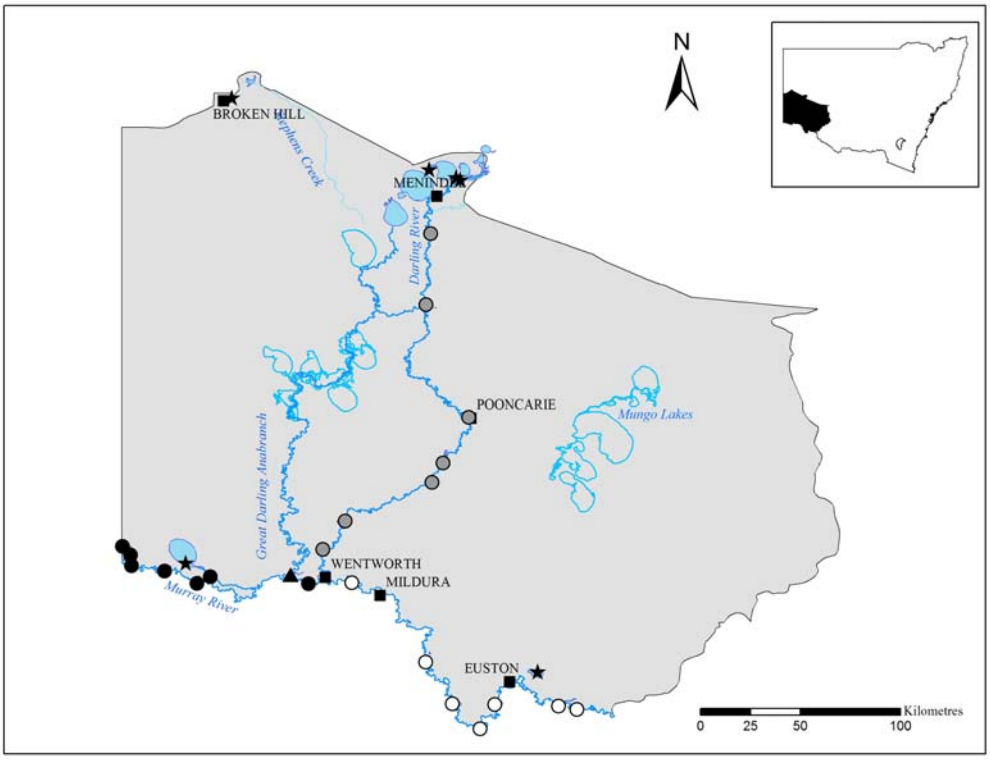

Figure 1. The locations of fish sampling sites sampled in the 2006 season. Stars – Lakes & Reservoirs zone, Grey circles – Darling zone, Triangle – Great Darling Anabranch zone, White circles – Upper Murray zone (Murray I) and Black circles – Lower Murray zone (Murray II).

ACTIVITY 2

Conduct annual fish monitoring program at sites across the LMD catchment as per methodology outlined in Gilligan (2005).

The sampling procedure used for the primary lake and riverine sites was identical to that used for the benchmarking surveys undertaken in 2004 (Gilligan 2005). In the 2006 season, the first sample was collected on 9 May and sampling had been completed by 2 June.

The sampling procedure used for floodplain wetland sites was much more intensive than had been used in 2004. Formerly, the wetlands were only sampled using a combination of 10 unbaited shrimp traps set for a minimum of two hours and 5 replicate hauls of a 5 m seine net (Gilligan 2005). Preliminary analysis of the wetland fish community data suggests that the sampling strategy used for the benchmarking surveys (shrimp traps and seine nets only) inadequately characterised the fish community present in a wetland. To make the wetland fish community data more comparable with the data collected from the adjacent riverine sites, the standard electrofishing procedure was also undertaken at wetland sites during the 2006 sampling round. Further, 4 fyke nets were set overnight and a single multi-panel gill net was set for a minimum of two hours (in wetlands greater than 2 metres deep) as per the wetland surveys of Ho *et al.* (2004) and the recommendations of Baldwin *et al.* (2005).

Preliminary analysis of the data from wetlands suggests that the addition of seine nets, fyke nets and a multi-panel gill net did not add any new taxa or size classes of fish that were not adequately represented by the standard combination of electrofishing and shrimp traps used at riverine and lake sites. These gear-type and cost-efficiency assessments will be undertaken in full at the conclusion of the current project when data from both 2006 and 2007 seasons are available.

ACTIVITY 3

Parameters monitored including species richness, total abundance, total biomass, proportion native species, proportion native abundance, proportion native biomass, proportion recruits and proportion with health condition.

The mean (± standard error (SE)) of each of the eight designated population parameters (species richness, total abundance, total biomass, proportion native species, proportion native abundance, proportion native biomass, proportion recruits and proportion with health condition) were calculated. These are plotted in the figures below.

Data from 2004 were collected during the benchmarking surveys (Gilligan 2005). Data from 2005 were collected for the Murray-Darling Basin Commission’s Sustainable Rivers Audit (SRA) IP1 sampling round. The data from Murray I zone were collected from six of the seven LMD CMA sampling locations (excluding Nangiloc) and a single new SRA site (Gol Gol). The data from the Darling zone was collected from three of the seven LMD CMA sampling locations (Downham Farm, Pooncarrie and Lethero) and four new SRA sites (Mararo, Chalky Well, Bellevue and Tolarno). Only three SRA sites were sampled in the Murray II zone, one of the seven LMD CMA sites (Upper Kulnine) and two new SRA sites (Kulcurna Station and Morna Station). No SRA sites exist within the Lakes & Reservoirs zone or the Great Darling Anabranch zone, and therefore no data are available from these zones in 2005. Although the sampling locations for the SRA in 2005 were not entirely consistent with those established for the LMD CMA monitoring program, both projects used a similar random site selection process and aim for the same site density per zone. Note however that only three sites were present in the Murray II zone as the zone boundary for the SRA straddles the NSW-SA border, and four of the seven SRA sites lay within South Australia. Comparing the 2005 SRA data with the 2004 and 2006 LMD CMA data is entirely appropriate for the Darling and Murray I zones, which both had seven sites sampled. However, using SRA data is less appropriate for the Murray II zone as only three sites were sampled in 2005, reducing the power of any statistical comparisons. No comparisons can be made for the Great Darling Anabranch and Lakes & Reservoirs zones as no SRA sampling was undertaken in these zones in 2005.

Data collected in 2004 and 2006 were compared at an overall catchment level using paired *t*-tests. Prior to analysis, total abundance and total biomass were $\log_{10}$ transformed, the proportion of total abundance that was native was arcsine transformed and the proportion of individuals suffering a health condition was square-root transformed in order to normalise the data and/or equalise the variances. All other parameters were suitable for parametric analysis without transformation.

Species richness

Species richness is the total number of different species occurring at a site, including native and alien species. There were no significant changes in species richness within any individual zone, or across the catchment area as a whole between 2004 and 2006 (Figure 2). The species richness in the Lakes & Reservoirs and Wetlands zones was lower than that in riverine sites in general and the lower Murray zone (Murray II) had slightly higher species richness than the remaining riverine zones.

Total abundance

Total abundance is the total number of individuals sampled from a site, including native and alien fish. There were no significant changes in total abundance within any individual zone, or across the catchment area as a whole between 2004 and 2006 (Figure 3). There were significant differences in total abundance between zones, with the two Murray Zones having the highest abundance, the Darling River and Great Darling Anabranch zones having an intermediate abundance and the Lakes & Reservoirs and Wetlands zones having the lowest abundance (Figure 3).

Total biomass

Total biomass is the total weight of all fish sampled at a site, including native and alien fish. There was a significant decrease in total biomass in the upper Murray zone (Murray I) between 2004 and 2006 (*p*[1] = 0.018807). The decline in total biomass was most significant for carp (an average 7.15 kg decline across the zone), Murray cod (an average 5.71 kg decline across the zone) and bony herring (an average 1.71 kg decline across the zone). No significant changes in total biomass were observed within any other individual zone, or across the catchment area as a whole between 2004 and 2006 (Figure 4).

[1] *p* represents the *probability value*, a standard statistical term used to define the significance of statistical tests. Two samples are considered to be different at a statistically significant level if $p < 0.05$.

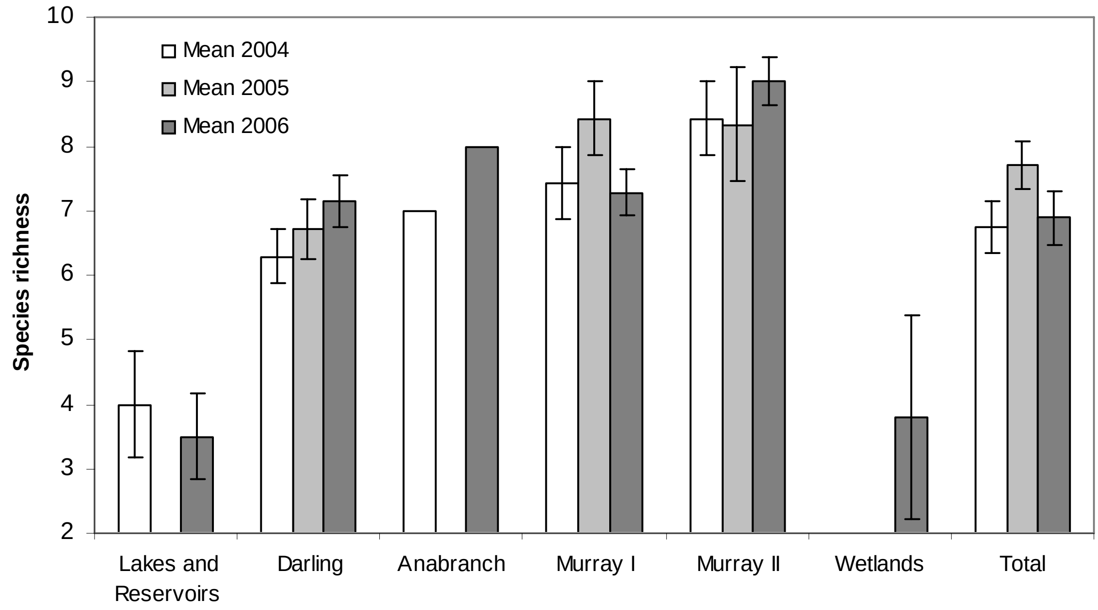

Figure 2. Total species richness. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (*n* = 7), Murray I (*n* = 7) and Murray II (*n* = 3) zones.

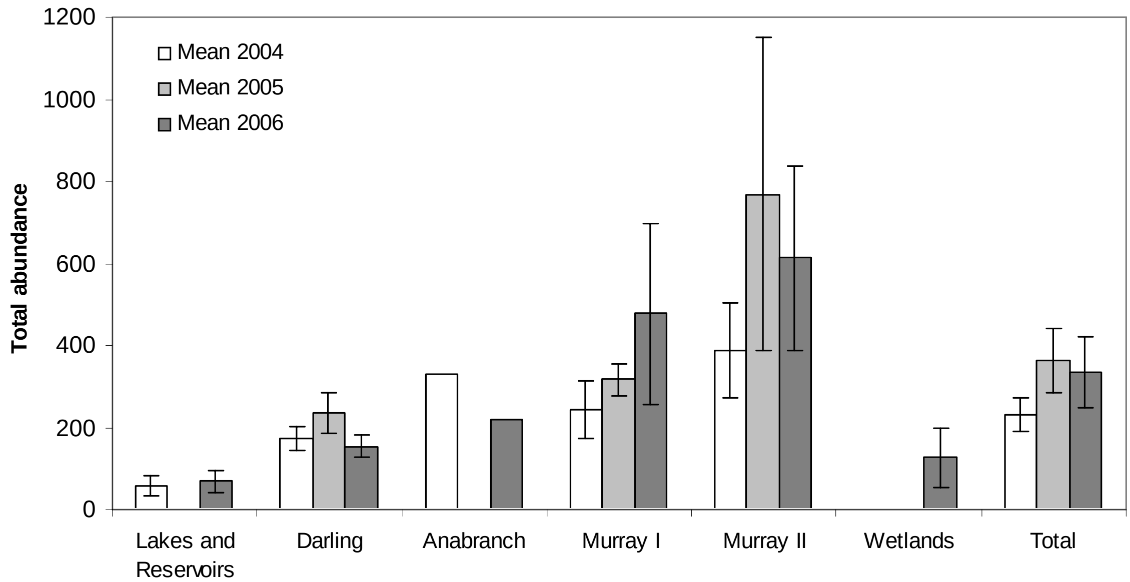

Figure 3. Total abundance. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (*n* = 7), Murray I (*n* = 7) and Murray II (*n* = 3) zones.

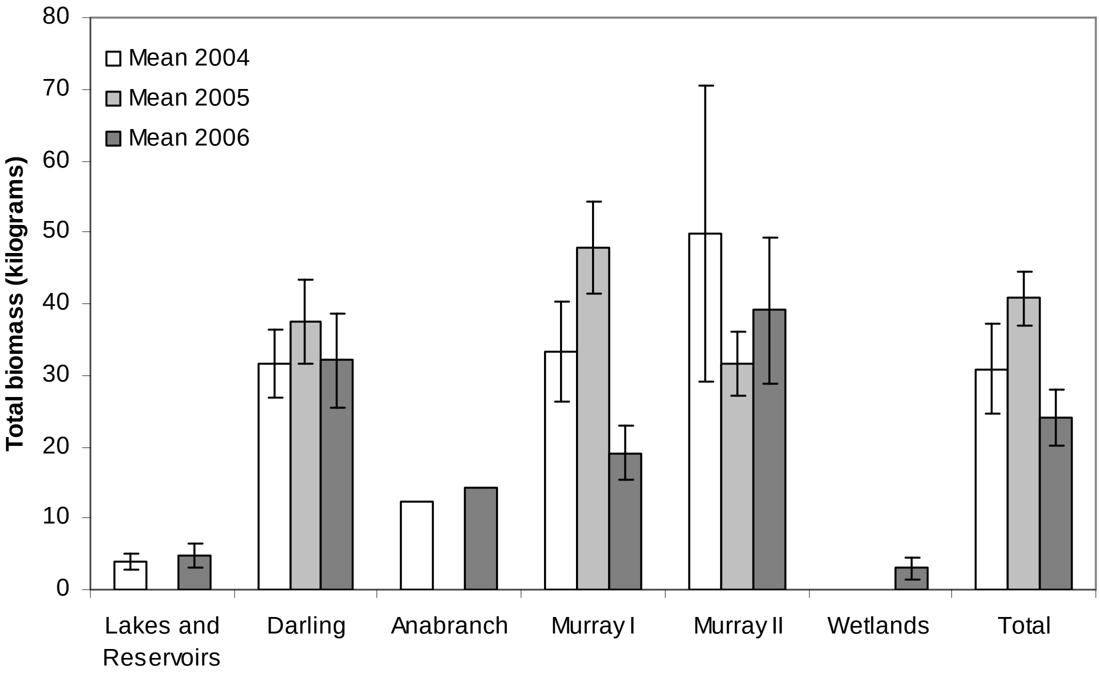

Figure 4. Total biomass. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (n = 7), Murray I (n = 7) and Murray II (n = 3) zones.

Proportion of total species richness that are native species

The proportion of total species richness that is native is the number of different native species collected at a site divided by the total species richness (native plus alien species). There were no significant changes in the proportion of total species richness that was native within any individual zone, or across the catchment area as a whole between 2004 and 2006 (Figure 5). The proportion of total species richness that were native was substantially lower in Wetlands than in the other zones and slightly lower in the Darling than in the two Murray zones.

Proportion of total abundance that is native species

The proportion of total abundance that is native is the total number of individuals collected at a site that are native species, divided by the total number of individuals (native plus alien species) collected at the site. There were no significant changes in proportion of total abundance that were native species within any individual zone, or across the catchment area as a whole between 2004 and 2006 (Figure 6). The proportion of total abundance that was native species was lower in Wetlands than in the other zones, and slightly lower in the Darling than in the two Murray zones.

Proportion of total biomass that is native species

The proportion of total biomass that is native is the total weight of fish collected at a site that is native, divided by the total weight of fish (native plus alien species) collected at the site. There were no significant changes in proportion of total biomass that were native species within any other individual zone, or across the catchment area as a whole between 2004 and 2006 (Figure 7). The proportion of total biomass that was native was much lower in Wetlands than in the other zones, with the biomass of wetlands being dominated by carp which made up an average 80% of the total fish biomass.

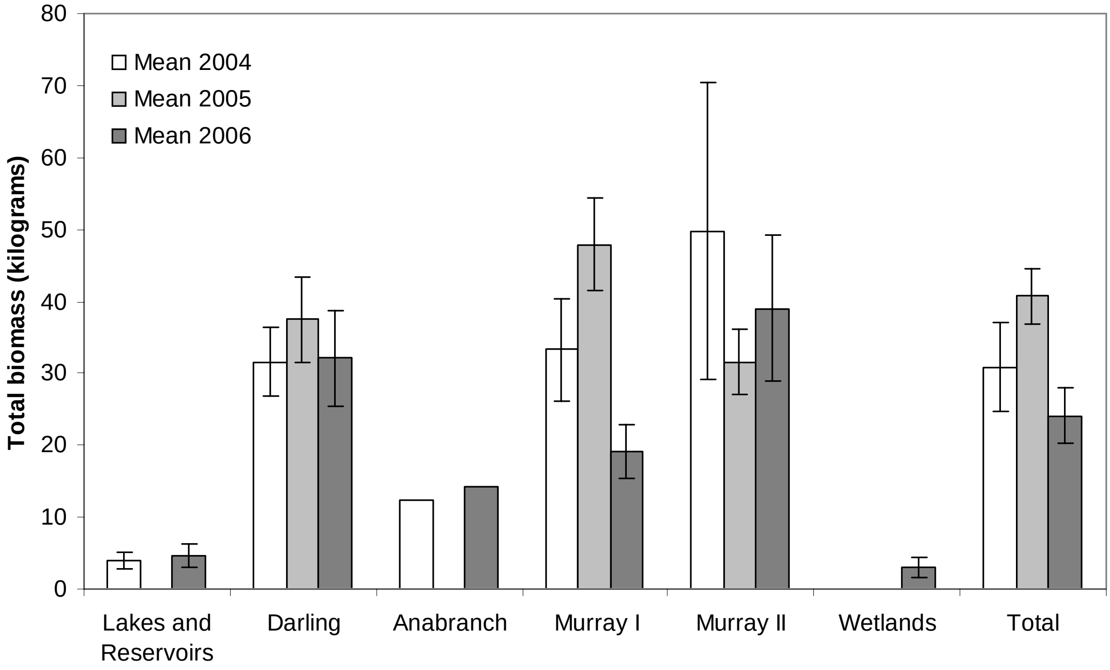

Figure 5. Proportion of total species richness that are native species. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (*n* = 7), Murray I (*n* = 7) and Murray II (*n* = 3) zones.

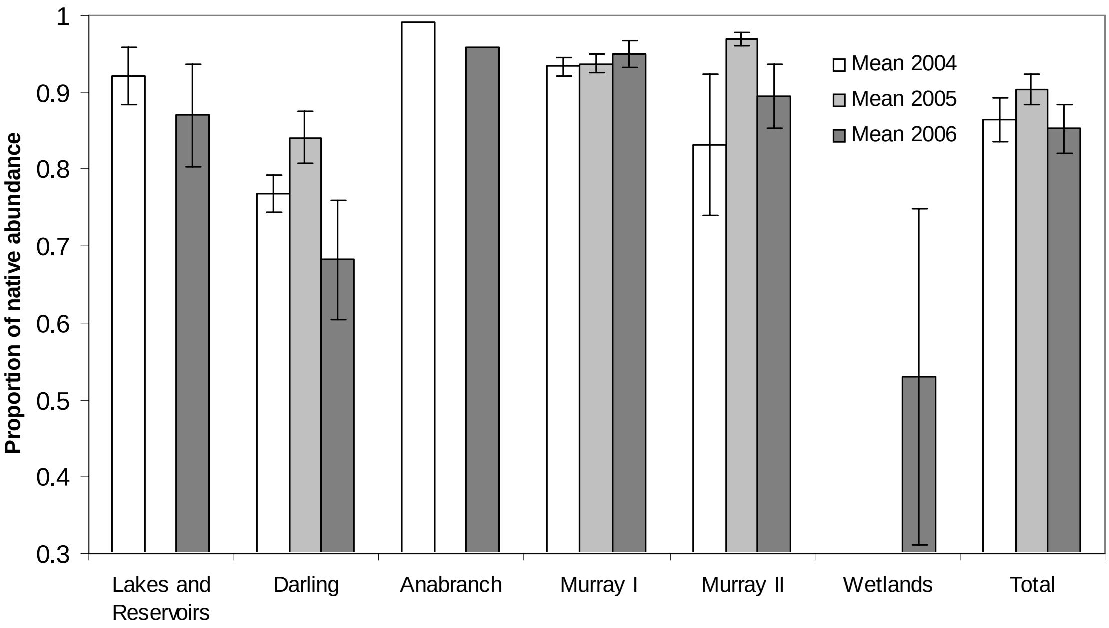

Figure 6. Proportion of total abundance that are native species. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (*n* = 7), Murray I (*n* = 7) and Murray II (*n* = 3) zones.

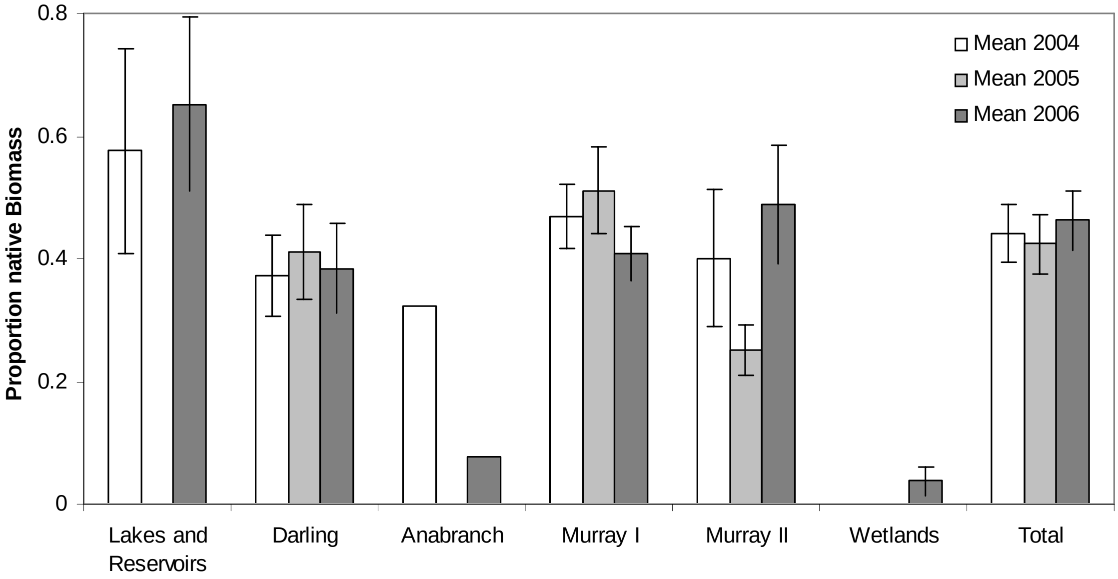

Figure 7. Proportion of total biomass that are native species. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (n = 7), Murray I (n = 7) and Murray II (n = 3) zones.

Proportion of total catch that is native fish recruits

Recruits are young juvenile fish that represent the recent breeding activity of the population. For this study, we assumed recruits to be fish less than one year old for larger long-lived species and immature individuals for smaller species that mature at less than one year of age. Individuals were identified as recruits if they were smaller than the length cut-offs provided in Gilligan (2005). For all species combined, there was a significant increase in the proportion of native recruits in the upper Murray (Murray I) zone (p = 0.03) (Figure 8). This was the result of a 162% increase in the proportion of fly-specked hardyhead recruits, 138% increase in the proportion of bony herring recruits, 26% increase in the proportion of Murray-Darling rainbowfish recruits, 12% increase in the proportion of Australian smelt recruits and the presence of Murray cod recruits that were absent in 2004.

There was a substantial decline in the proportion of native recruits in the Lakes & Reservoirs zone (Figure 8), but this was not statistically significant. There were no significant changes in the proportion of the total catch that was native recruits in any of the other zones, or in the catchment area as a whole.

The two Murray zones had a higher proportion of native recruits than the Darling, the Lakes & Reservoirs zone or the floodplain wetlands.

Proportion of total catch suffering from a health condition

The proportion of the total catch suffering from a health condition was the only one of the eight population parameters analysed that had changed significantly at a whole of catchment level between 2004 and 2006 (p = 0.002) (Figure 9). The proportion of individuals affected increased from 2.0 % to 4.3 % within two years. The trend was apparent in all five catchment zones and was statistically significant within the Upper Murray (Murray I) (p = 0.05) and Lower Murray (Murray II) (p = 0.004) zones.

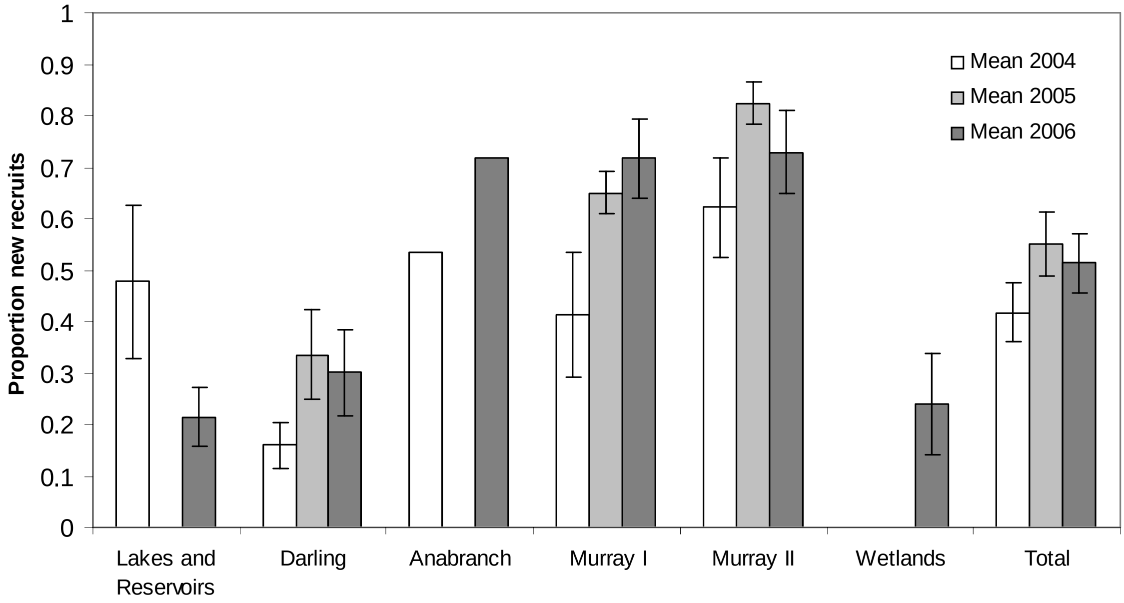

Figure 8. Proportion of total catch that are native fish recruits. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (*n* = 7), Murray I (*n* = 7) and Murray II (*n* = 3) zones.

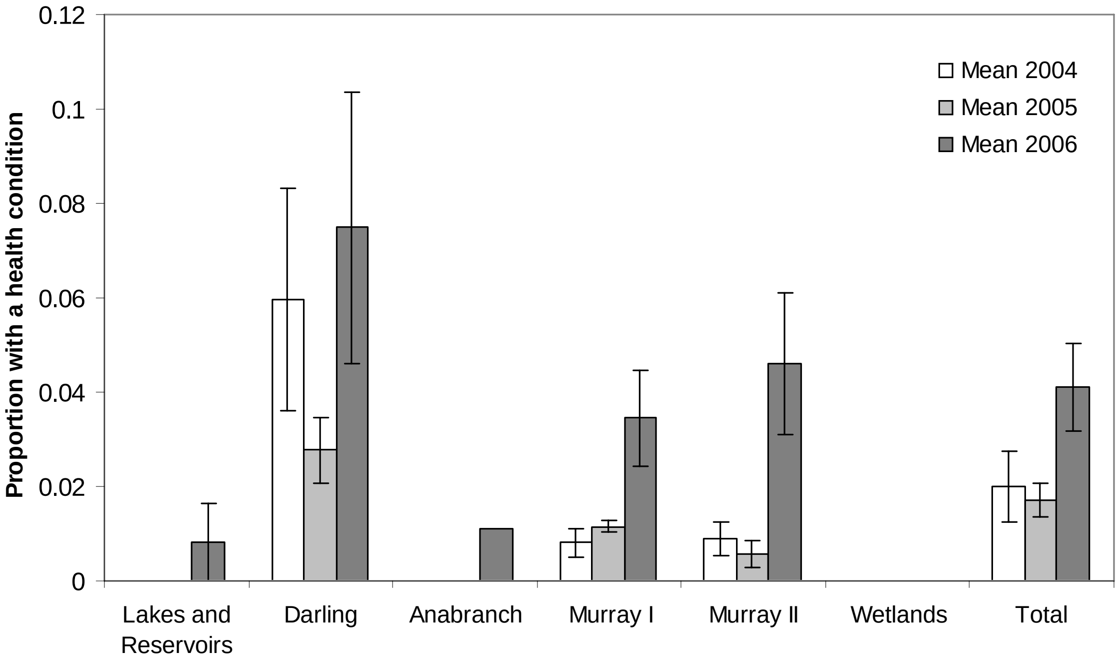

Figure 9. Proportion of total catch that are suffering from a health condition. Total = combined values across the catchment as a whole. The 2005 data presented as 'Total' only includes data from the Darling (*n* = 7), Murray I (*n* = 7) and Murray II (*n* = 3) zones.

The proportion of affected individuals was not consistent across species. Only six of the fourteen species collected had any individuals suffering a health condition. The most affected species was golden perch, with a maximum of 50% suffering some form of health condition (Figure 10).

The change from 2004 to 2006 was driven by increases in the proportion of individuals affected by parasitic anchor worm (*Lerneae* spp) and the proportion of individuals suffering fin damage (underlying cause unknown) (Figure 11). The trend for anchor worm parasitism varied with species, as the proportion of affected individuals increased for carp, golden perch and silver perch, but decreased for goldfish and Murray cod (Figure 12). The proportions also varied among zones, but there were no consistent similarities between any pair of species. Golden perch was the main species affected by increases in the frequency of fin damage (Figure 13). Affected individuals were restricted to the Murray River, being present at one of the Murray I zone sites (Cowana) and four of the Murray II zone sites, with 35% of individuals affected in each zone.

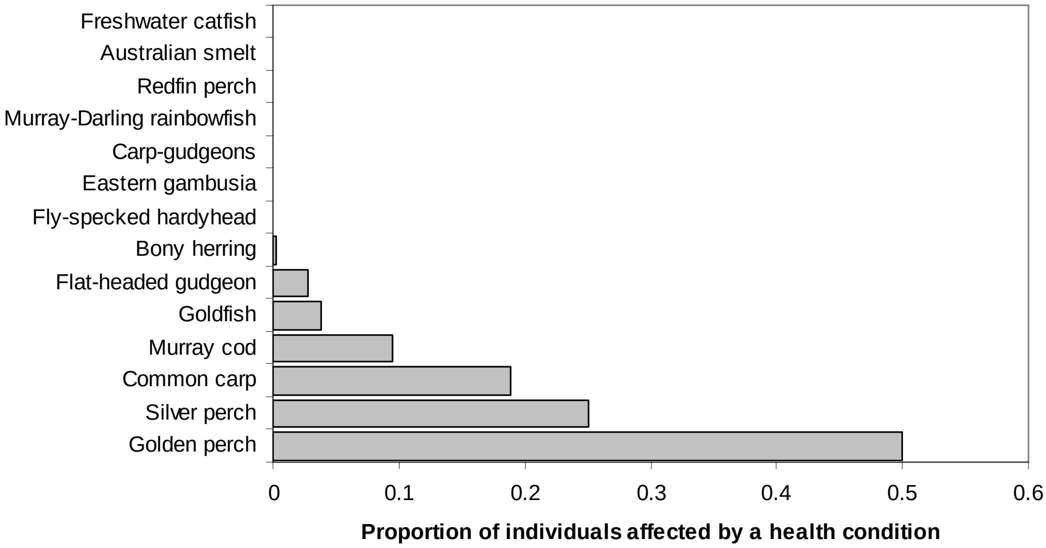

Figure 10. The proportion of each species affected by a health condition.

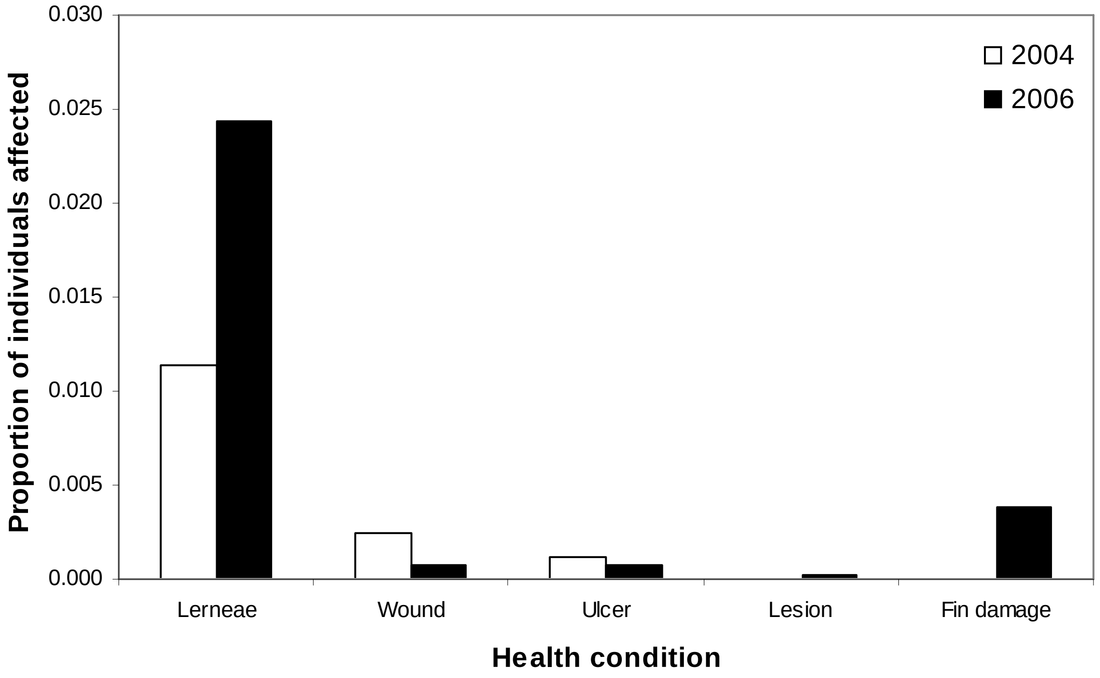

Figure 11. The proportion of individuals affected by each of the five health conditions observed.

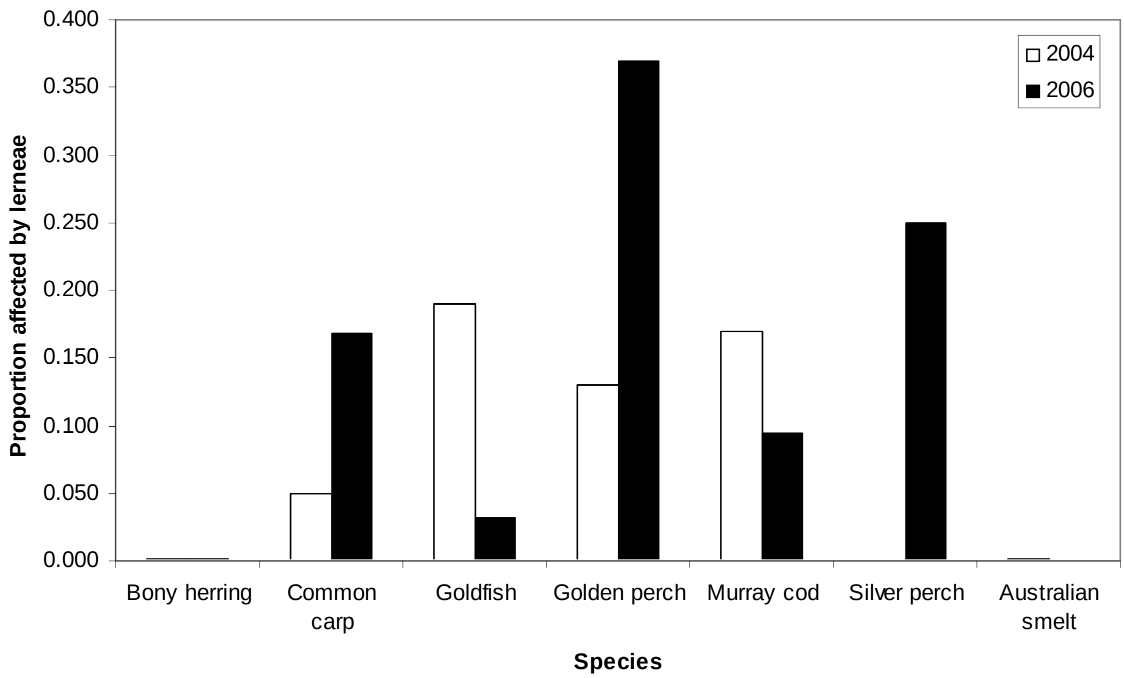

Figure 12. The proportion of individuals affected by anchor worm in 2004 and 2006.

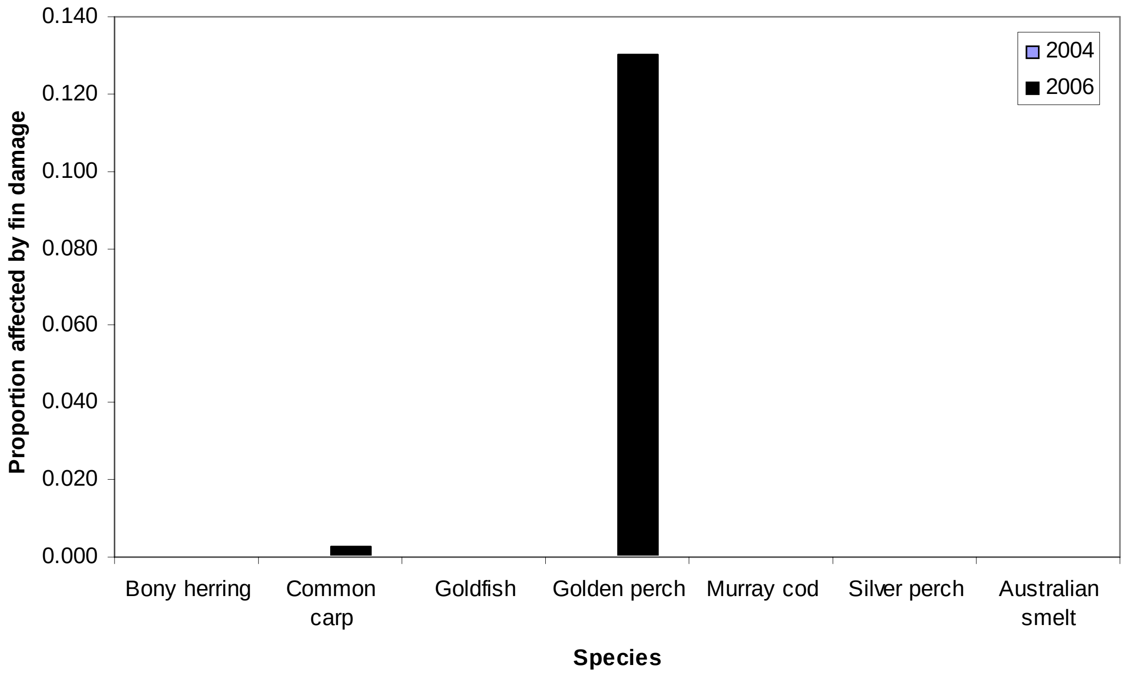

Figure 13. The proportion of individuals affected by fin damage in 2004 and 2006.

ACTIVITY 4

Monitor water quality and habitat parameters as described in Gilligan (2005) at each of the monitoring sites.

Water quality

The following water quality parameters were recorded at each site at the time of fish community sampling:

- Temperature (^{o}C)
- pH
- Dissolved oxygen (mg/L)
- Conductivity (µS/cm)
- Turbidity (NTU)

Two measurements were taken at 20 cm below the surface in order to gauge whether the water quality meter was functioning properly. Then single measurements were taken at each 1 metre depth interval. These depth profile measurements were recorded in the deepest part of the sampling site.

The temperature (Figure 14) and dissolved oxygen (Figure 15) data are un-informative in the context of monitoring long term changes, as both parameters fluctuate on a daily as well as longer-term basis. For these parameters, long-term data continuously collected from instream data loggers is the most reliable means to detect long-term change. However, the temperature and dissolved oxygen concentrations at the time of data collection could help explain some aberrant fish community observations. For example, the absence of fish in the sample from Wompinni Wetland could be explained by the low dissolved oxygen concentration (2.15 mg/L) recorded at the time of sampling (Figure 15). The low value is likely to have resulted from the fact that Wompinni Wetland had only filled a short time before sampling was undertaken and the resulting bacterial breakdown of organic matter in the newly flooded waterbody resulted in de-oxygenation of the water column. Most fish species are stressed at dissolved oxygen concentrations of 2 – 4 mg/l (Francis-Floyd 2003). Therefore, the absence of fish in the wetland could have resulted from either; 1) Fish not colonising the wetland at the time of filling, or 2) Fish that colonised the wetland subsequently succumbed to low dissolved oxygen levels.

The lower temperature data recorded at the Darling zone is partially a reflection that they were sampled towards the end of the month-long sampling season, but this does not explain all of the variation as Thegoa Lagoon, the last site to be sampled over all, had the highest surface temperature recorded at any site. Therefore, it appears that the Darling River is cooler at the upper reaches and increases in temperature at sites further downstream. Perhaps this could be a reflection of thermal pollution caused by Menindee Main Weir.

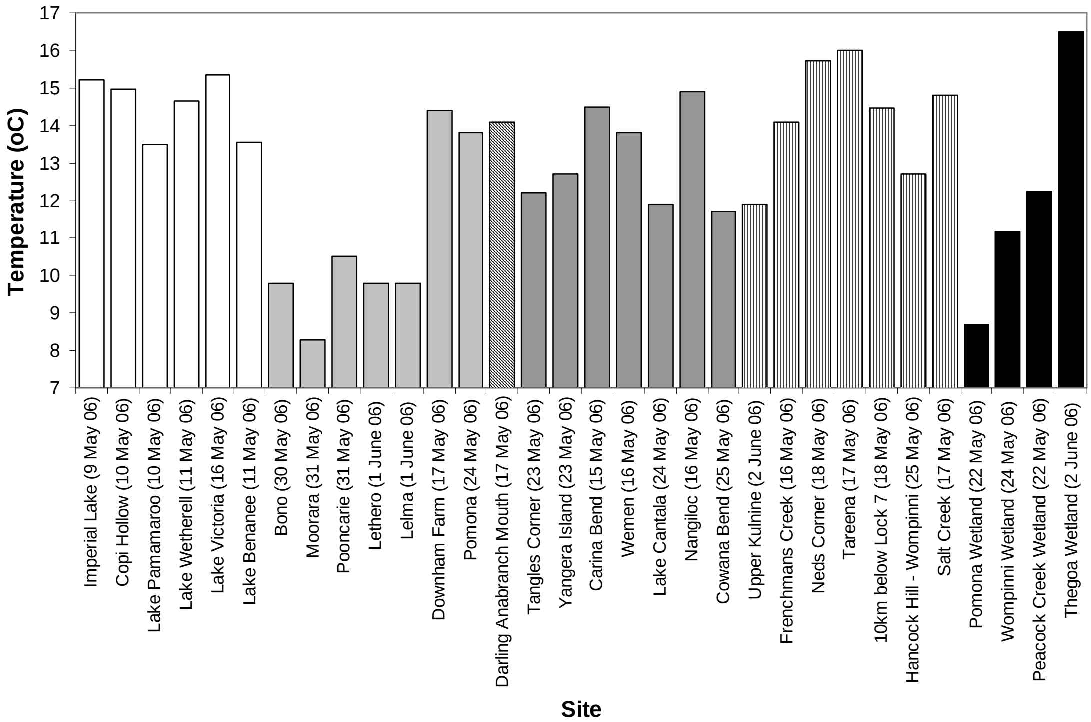

Figure 14. Average surface (20 cm) temperature recorded at each fish community sampling site at the time of sampling in 2006. The patterns correspond to catchment zones: white – Lakes & Reservoirs, pale grey – Darling, diagonal – Anabranch, dark grey – Upper Murray (Murray I), squares – Lower Murray (Murray II) and black – floodplain wetlands.

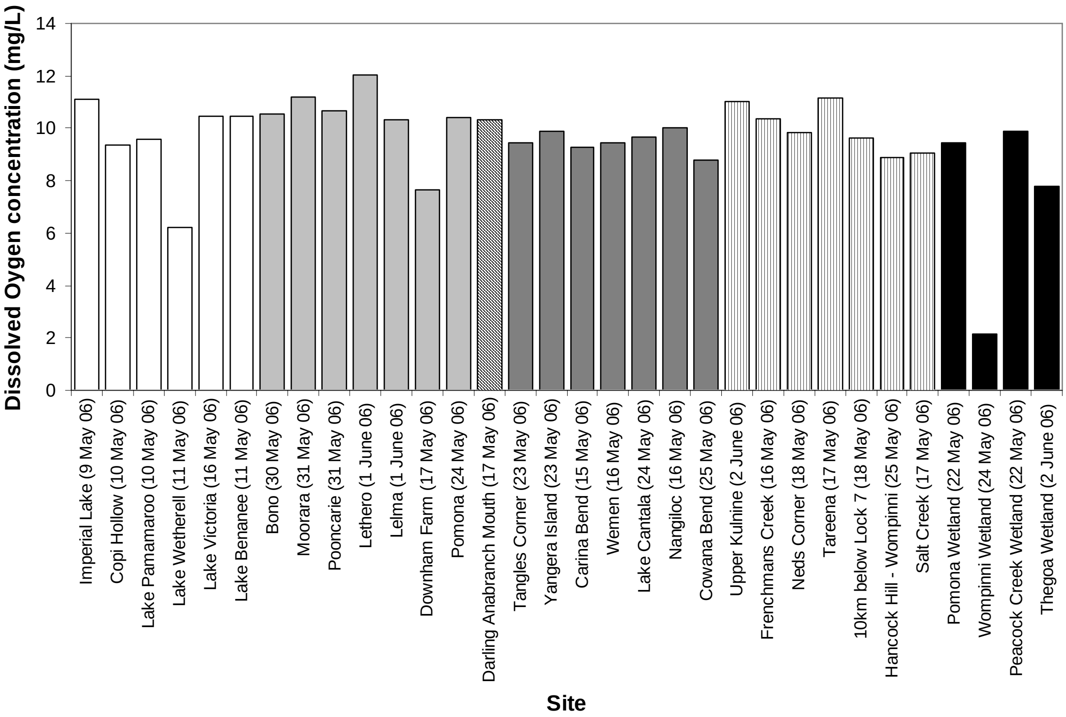

Figure 15. Average surface (20 cm) dissolved oxygen concentration (mg/L) recorded at each fish community sampling site at the time of sampling in 2006. The patterns correspond to catchment zones: white – Lakes & Reservoirs, pale grey – Darling, diagonal – Anabranch, dark grey – Upper Murray (Murray I), squares – Lower Murray (Murray II) and black – floodplain wetlands.

Although pH, conductivity and turbidity can also vary widely as a result of the immediate climatic and hydrological conditions, they are a little more indicative of the conditions in the weeks or months preceding fish community sampling and have the ability to drive changes in the composition of fish communities.

pH was generally lower (more acidic) within the Darling River than within any of the other zones and generally declined in a downstream direction (Figure 16). Similarly low pH values at Upper Kulnine and Thegoa Lagoon may reflect the fact that these two sites are immediately downstream of the Darling-Murray junction, or they may share similar soil or ground-water chemistry with sites in the Lower Darling region (Figure 16). In contrast, Imperial Lake, Lake Benanee and a single Darling River site (Moorara) had higher pH values (Figure 16). Most other sites had pH values in the 'normal' range of 6 – 8 (Figure 16).

No site had conductivity readings above 1,500 μS/cm at the time of sampling (Figure 17). Only three sites, Imperial Lake, Lake Benanee and Thegoa Lagoon had conductivity readings above 800 μS/cm (Figure 17). Six of the seven Darling River sites (excluding Downham Farm) and two of the Menindee Lakes (Copi Hollow and Lake Pamamaroo) had conductivity readings above 400 μS/cm (Figure 17). The conductivity readings at all the Murray River sites were below the CAP whole of catchment target of 463 μS/cm, and well below it for all but one site (Cowana Bend) (Figure 17).

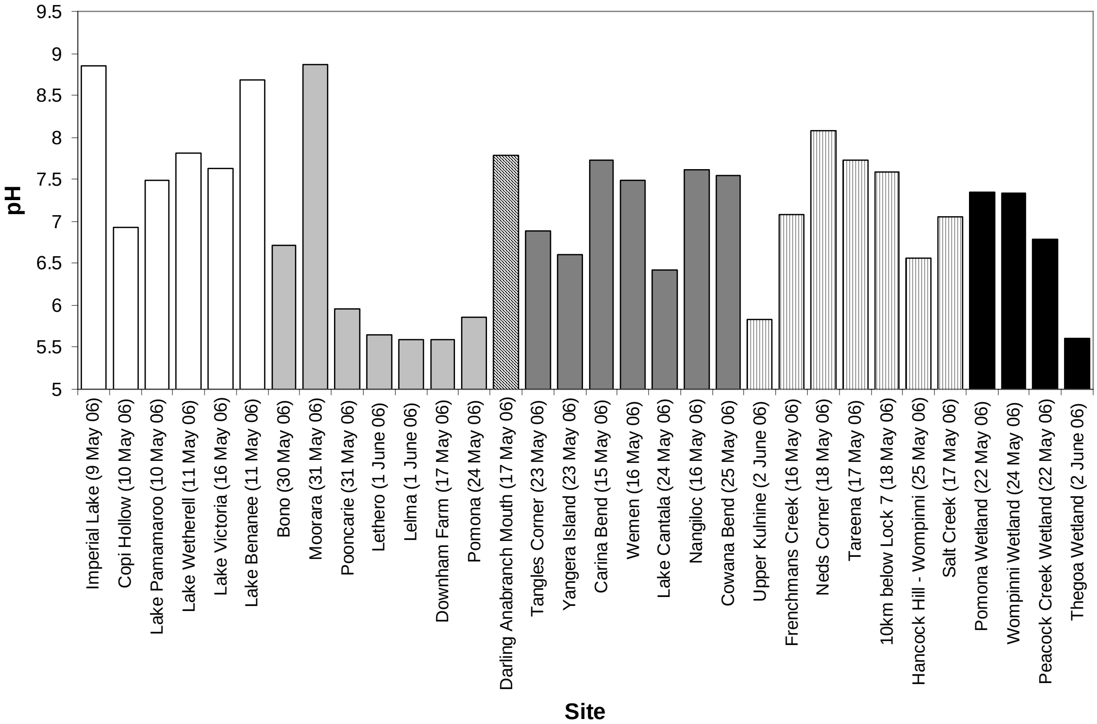

Figure 16. Average surface (20 cm) pH recorded at each fish community sampling site at the time of sampling in 2006. The patterns correspond to catchment zones: white – Lakes & Reservoirs, pale grey – Darling, diagonal – Anabranch, dark grey – Upper Murray (Murray I), squares – Lower Murray (Murray II) and black – floodplain wetlands.

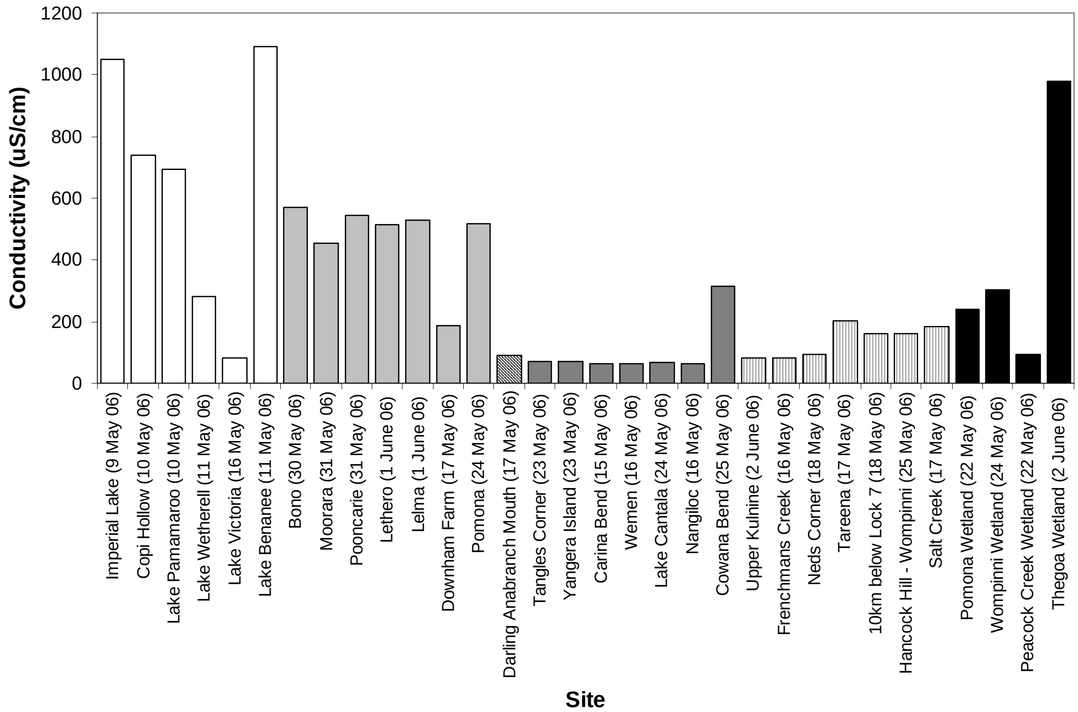

Figure 17. Average surface (20 cm) conductivity (μS/ cm) recorded at each fish community sampling site at the time of sampling in 2006. The patterns correspond to catchment zones: white – Lakes & Reservoirs, pale grey – Darling, diagonal – Anabranch, dark grey – Upper Murray (Murray I), squares – Lower Murray (Murray II) and black – floodplain wetlands.

Turbidity was recorded using both a Horiba Model U10 water quality meter and a secchi disk. The Horiba water quality meter is valuable in that it enables the recording of turbidity at various depths throughout the water column and can record the turbidity of clearer waters at shallow depths, but its turbidity probe is notoriously prone to malfunction. In contrast, secchi depth (the depth at which a secchi disk can be seen in the water from the surface) is robust in that it is simple and straightforward to use. However, it can be limited in that it cannot be used when the water is clear enough that the disk can be seen when it has reached the bottom of the water column (usually only a problem at very shallow sites). Rather than present both data sets, only turbidity readings from the Horiba are presented (Figure 18).

Pomona wetland and Thegoa Lagoon had much higher turbidity than any of the other sites (Figure 18) corresponding to secchi depths of only 12.5 cm and 5 cm respectively. Within the lower Murray zone (Murray II), the two sites in Salt Creek (Salt Creek and Tareena) had turbidity higher than the Murray River sites in that zone (secchi depths of 41 cm and 35 cm compared to an average of 50 cm) (Figure 18). Within the Lakes & Reservoirs zone, Lakes Benanee and Wetherell had higher turbidity than the remaining Lakes (secchi depths of 12 cm and 17 cm compared to an average of 35 cm). Averaged across sites, the most turbid to least turbid zones were floodplain wetlands (secchi depth = 25 cm), Lakes & Reservoirs (31 cm), lower Murray (46 cm), upper Murray (48 cm), Great Darling Anabranch (57 cm at a single site) and the Darling River (78 cm). This was a surprising result as the Darling River is typically considered an example of a turbid river, yet during the sampling period in 2006 it was the least turbid across the catchment as a whole.

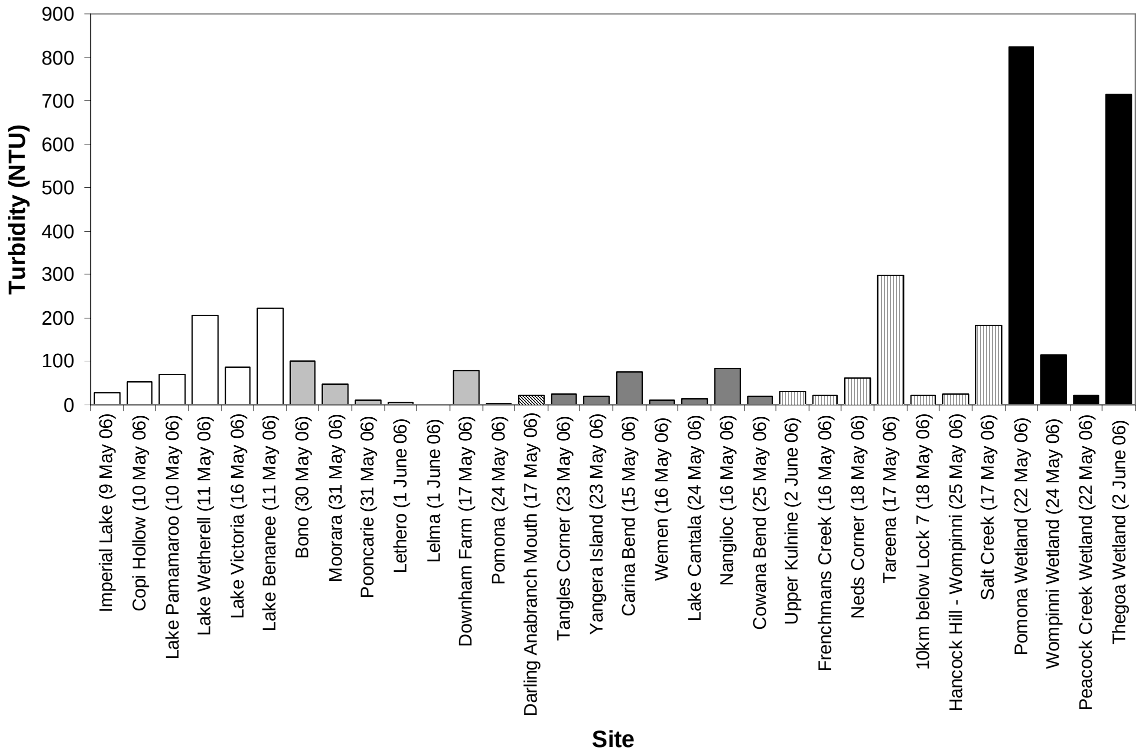

Figure 18. Average surface (20 cm) turbidity (NTU) recorded at each fish community sampling site at the time of sampling in 2006. The patterns correspond to catchment zones: white – Lakes & Reservoirs, pale grey – Darling, diagonal – Anabranch, dark grey – Upper Murray (Murray I), squares – Lower Murray (Murray II) and black – floodplain wetlands.

Habitat

Aquatic habitat features were recorded as present or absent within each of the replicate electrofishing operations, each corresponding to a transect of 79 ± 4 m (mean ± SE). The presence/absence data are presented as the proportion of operations at each site where each habitat feature was present (i.e., if native trees were present in 9 of the 12 replicate operations, then they would be scored as 9 / 12 = 0.75). Additionally, the depth and width were recorded for each electrofishing operation and averaged across operations. Flow velocity was assessed as either, no flow, slow, medium or fast for each operation and the modal velocity (the value that occurs most frequently) is presented.

Data were recorded for each site. Only the means for each zone are presented in this annual report.

Table 2. Aquatic habitat parameters recorded in each catchment zone.

	Wetlands	**Murray II**	**Murray I**	**Lakes & Reservoirs**	**Darling**	**Anabranch**
Substrate						
Bedrock	0.00	0.00	0.07	0.00	0.04	0.00
Boulder	0.00	0.00	0.00	0.08	0.01	0.00
Cobble	0.00	0.00	0.06	0.06	0.00	0.00
Gravel	0.00	0.00	0.00	0.00	0.00	0.00
Sand	0.03	0.12	0.00	0.50	0.08	1.00
Mud	1.00	0.93	0.90	0.67	1.00	1.00
Clay	0.00	0.29	0.24	0.64	0.19	1.00
Riparian and instream vegetation						
Native trees	0.80	0.92	0.90	0.21	1.00	1.00
Exotic trees	0.00	0.01	0.00	0.00	0.00	0.00
Native shrubs	0.46	0.65	0.52	0.11	0.36	1.00
Exotic shrubs	0.05	0.12	0.00	0.03	0.06	0.00
Terrestrial grass	0.36	0.61	0.33	0.22	0.75	0.00
Floating macrophytes	0.00	0.45	0.13	0.03	0.02	1.00
Emergent macrophytes	0.25	0.48	0.26	0.39	0.24	1.00
Submerged macrophytes	0.00	0.25	0.44	0.03	0.90	1.00
Filamentous algae	0.00	0.02	0.04	0.00	0.01	0.00
Suspended algae	0.00	0.00	0.00	0.00	0.02	0.00
Biofilms	0.65	0.00	0.00	0.63	0.00	0.00
Structural fish habitat						
Rock	0.00	0.07	0.15	0.06	0.04	0.00
Timber	0.67	0.88	0.89	0.48	0.98	0.75
Undercut banks	0.15	0.24	0.13	0.00	0.05	0.00
Plant litter	0.09	0.01	0.06	0.00	0.00	0.00
Macrophytes	0.31	0.76	0.40	0.32	0.92	1.00
Stream characteristics						
Riffle	0.00	0.00	0.00	0.00	0.00	0.00
Run	0.00	1.00	1.00	0.01	0.71	0.83
Pool	1.00	0.00	0.00	0.94	0.00	0.17
Rapid	0.00	0.00	0.00	0.00	0.14	0.00
Modal velocity score	No flow	Slow	Slow	No flow	Slow	Slow
Average width (m)	72.47	85.90	112.32	2405.32	35.73	96.33
Average depth (m)	0.64	1.92	2.49	1.52	1.43	1.81

ACTIVITY 5

Establish linkages between aspects of monitoring in this project and monitoring components of other LMD CMA projects, such as the Algae, Salinity and Hydrology Monitoring project and the Wetland Rehabilitation project, in order to enhance the data set that the annual fish monitoring report will be based on.

In general, this objective was difficult to achieve as only the hydrology indicator produced a concise index of the relative quality of each of the five pre-determined catchment zones. Other themes should be encouraged to adopt this single index approach in order to enable across theme comparisons.

There is also inconsistency amongst themes of how data from the Euston Lakes and Lake Victoria are used. For the fish theme, all data from these and the Menindee Lakes system are aggregated as a Lakes & Reservoirs zone. Whilst the hydrology theme was not implemented in any lakes at all and the river salinity theme did not incorporate data from the Euston Lakes or Lake Victoria, the algal theme allocated these waterbodies to the Upper and Lower Murray zones respectively. The CMA needs to provide direction to each theme regarding the stratification of these waterbodies in terms of the overall catchment plan.

Algae Indicator

Data presented in Buchan and Merrick (2006) summarise the algal bloom occurrences in the 2003/04 and 2004/05 financial years. The benchmark fish community sampling reported in Gilligan (2005) was collected in the Autumn of the 03/04 period. Only SRA fish sampling was undertaken in the 04/05 financial year, so no CMA-funded fish data correspond to the algal data from that year. The riverine health catchment target for algae is:

A 20% reduction in the number of days subject to blue-green algal alerts by 2015.

Buchan and Merrick (2006) indicate that the occurrence of algal blooms in each of the catchment zones, and in the catchment as a whole were substantially more frequent than the benchmark 'normal' conditions for algal blooms. In 2003/04 algal blooms were around three times the target and at least twice the target in 04/05.

Interactions between fish and algal blooms are discussed in Gehrke and Harris (1994), who conclude that the relationships are little studied in Australian systems. Of the 1,195 fish kills identified on the NSW DPI Fish kills database (since the late 1970s), only 10 were attributable to cyanobacterial blooms. So there appears to be little evidence to suggest negative impacts of algal blooms on fish communities (Allan Lugg, NSW DPI, unpublished data). In contrast, the data summarised by Gehrke and Harris (1994) suggest that changes in fish community structure may drive algal bloom dynamics. Increased abundance of planktivorous fish species limit the grazing of zooplankton on phytoplankton, and as a result, can increase the frequency of algal blooms. Further, the abundance of carp is assumed to affect the availability of nutrients upon which algal blooms predominate. Carp are also assumed to affect algal blooms by damaging aquatic macrophyte beds, which would otherwise compete with cyanobacteria for available nutrients.

At present, none of the available data are sufficiently robust to assess these relationships under Australian conditions, but Gerhke and Harris (1994) suggest that a reduction in the abundance and biomass of carp, in addition to the promotion of populations of large predatory fish (such as Murray cod and golden perch), which could subsequently limit populations of smaller planktivorous fish, may aid in the control of algal blooms.

The fish data collected within the Lower Murray-Darling CMA area to date suggest that the abundance of only two species has changed since 2004; fly-specked hardyhead and eastern gambusia. Both are small planktivorous species which, if the hypotheses of Gehrke and Harris (1994) are correct, may actually exacerbate algal bloom problems.

Hydrology

Summerell (2006*a*) presents river hydrology assessments using the Murray-Darling Basin Commission's *Sustainable Rivers Audit* (SRA) hydrology approach, which reports on flow volumes, rates, variability and seasonality using five sub-indices, which are combined using an expert rule ranking system (MDBC 2004). Each sub-index and the combined hydrological index are rated between 0 and 1, with '1' representing no change from natural hydrological conditions.

The riverine health catchment target for hydrology is:

The reinstatement of more natural flow patterns as modelled in each of five river management zones by 2015.

For the overall hydrological index, the Great Darling Anabranch ranked most highly, followed by the Darling River, Upper Murray and Lower Murray. This order is also reflected by the high flow event sub-index, low flow event sub-index and variability sub-index. However, for the seasonality sub-index, the ranks were generally in the opposite direction, with the lower Murray River ranked most highly, followed by the upper Murray, Great Darling Anabranch and Darling River. For the flow volume sub-index, the Great Darling Anabranch was quite variable, but generally higher than the other three rivers, which were quite consistent.

An equivalent 'overall' fish index calculated by ranking the species richness, total abundance, total biomass, proportion natives, proportion recruits and proportion with health condition within each site and then averaging the ranks for each parameter, indicates that the fish community in the lower Murray River is in the best condition, followed by the upper Murray River, Great Darling Anabranch, Darling River, Lakes & Reservoirs and the floodplain wetlands are the most degraded.

These fish community rankings are generally the opposite of those observed on the overall hydrological condition, but consistent with the ranks observed for the seasonality sub-index. If anything, this suggests that perhaps the seasonality of flows is the most important hydrological parameter for fish communities.

River salinity

Summerell (2006*b*) presents river salinity assessments relevant to the Salinity Catchment Target:

To maintain the year 2000, 95th percentile salt concentration of 463 EC at lock 6 over the duration of the plan (with variations due to climatic conditions and external salt contributions excepted), with within valley salinity targets specified within individual zones.

No clear statements of the relative condition of each zone were provided. The Menindee Lakes targets were exceeded in Lake Pamamaroo but not Lake Menindee or Lake Cawndilla, the Great Darling Anabranch target was exceeded, The Darling River targets were exceeded in summer but not in winter, the upper Murray River salinity exceeded one of the two targets at one of the sites and the salinity in the lower Murray River was below both targets. General perusal of the data presented by Summerell (2006*b*) suggests that the general ranking of the salinity conditions in each of the catchments zones is that lower Murray zone is in the best condition, followed by the upper Murray River, Menindee Lakes and lastly the Darling River.

Although native fishes are generally very tolerant of high salinity levels (Cadwallader and Backhouse 1983; Close 1990), these rankings are generally similar to the rankings for fish community condition, with the exception that the rankings of the Menindee Lakes and Darling River have been reversed.

Wetland Rehabilitation

NSW DPI will be in a position to advise the wetland rehabilitation monitoring project of potential rehabilitation activities and locations, and can also provide a rigorous before-after-control-impact (BACI) design assessment of rehabilitation activities in some cases. But collaboration between NSW DPI and the LMD CMA is required to design such projects.

OUTCOME 1

Determination of the progress toward the LMD Riverine Health Catchment Target in relation to improvements in the native to introduced fish ratio (55% improvement in species ratio, 25% improvement in abundance ratio, 25% improvement in biomass ratio).

The CAP riverine health catchment targets related to fish community include:

- A 55% improvement in the native to introduced fish species ratio
- A 25% improvement in the native to introduced fish abundance ratio
- A 25% improvement in the native to introduced fish biomass ratio

To test progress towards these targets, data collected in 2004 (Gilligan 2005) was used as the benchmark for each of the target ratios.

As stated in Gilligan (2005), ratios are problematic indices given that a zero value in the denominator (as occurs when no alien fishes are collected at a site) results in an invalid value and the ratio can be very large if the number of natives exceeds the number of aliens. Use of an alternative value, the proportion of the total sample that is native (species, abundance or biomass) results in a similar index that is not prone to these difficulties. However, the targets set under the CAP are specified as ratio values. If proportions were to be used instead of ratios, a 55% improvement in the proportion of total species richness that is native and 25% improvement in the proportion of total abundance that is native would mean that the catchment target for both indices is the elimination of all alien species from the catchment. But a 25% improvement in the proportion of total biomass that is native would constitute a reasonable alternative CAP target. Relevant data on the proportion of total biomass that is native is presented in Figure 7. The 25% improvement target for this proportion would be an end result of 55% of the total biomass being native. The benchmark 2004 value was 44% and this had increased to 46% by 2006.

However, as the CAP targets were specified as ratios, assessments of progress towards the ratio targets are necessary. There were three instances of fish community samples that did not collect any alien species, meaning that ratio assessments are not possible. These are Imperial Lake in 2004 and Copi Hollow and Lake Pamamaroo in 2006. The only option to enable assessment of the three ratios was to omit these samples from the data set.

Native : Alien species ratio

There were no statistically significant changes in the native : alien species ratio between 2004 and 2006. Although the changes were non-significant, the ratio had declined in the Lakes & Reservoirs, Darling and lower Murray zones and across the catchment overall. The upper Murray was the only zone where the ratio had improved between 2004 and 2006.

At a catchment level there has been no progress towards the CAP target.

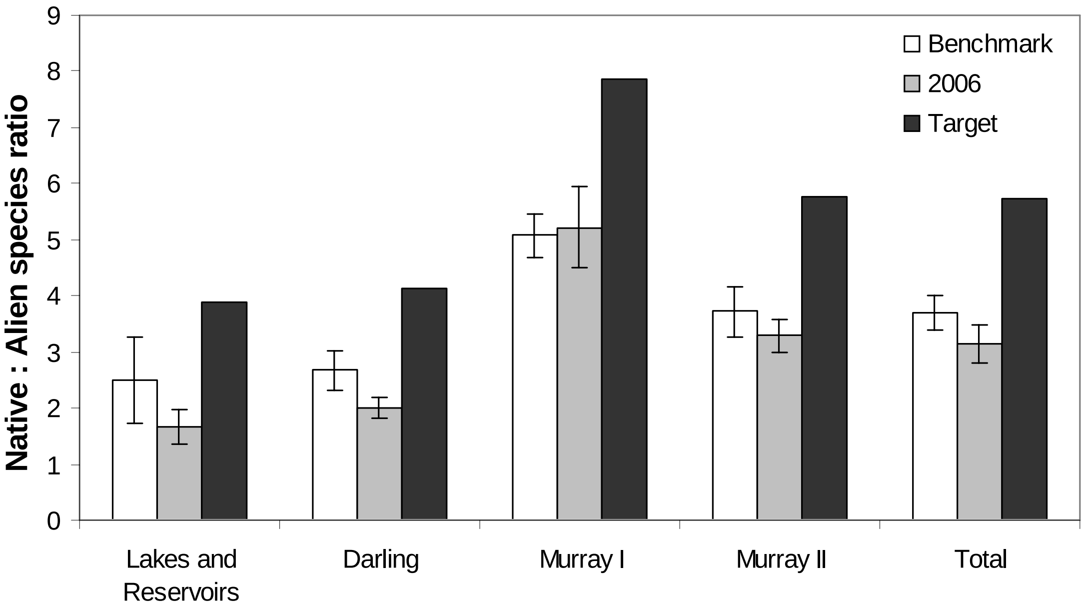

Figure 19. Comparison of the mean (±SE) native : alien species ratio observed in 2006 with the benchmark (2004) and target (55% improvement) ratios.

Native : Alien abundance ratio

There were no statistically significant changes in the native : alien abundance ratio between 2004 and 2006. Although the ratio had declined in the Lakes & Reservoirs zone, it had improved in the Darling, upper Murray, lower Murray and the catchment overall. The change was substantial in the upper Murray zone, although it was non-significant given the extensive variability between sites in this zone in 2006. In all three of these zones and the catchment overall, the target of a 25% improvement in the native : alien abundance ratio has been exceeded. However, until the change in ratio is statistically significant, success cannot be claimed. Statistical significance may be achieved by either striving for an even greater response in the abundance ratio, or by increasing the power of the comparison by sampling additional replicate sites.

Native : Alien biomass ratio

There were no statistically significant changes in the native : alien biomass ratio between 2004 and 2006. Although not statistically significant, the ratio had declined in the Lakes & Reservoirs and upper Murray (Murray I) zones (Figure 21). In contrast, there was a substantial (but non-significant) increase in the lower Murray (Murray II) zone (Figure 21). No progress towards the catchment-wide target of a 25% improvement in the native : alien biomass ratio has been made between 2004 and 2006.

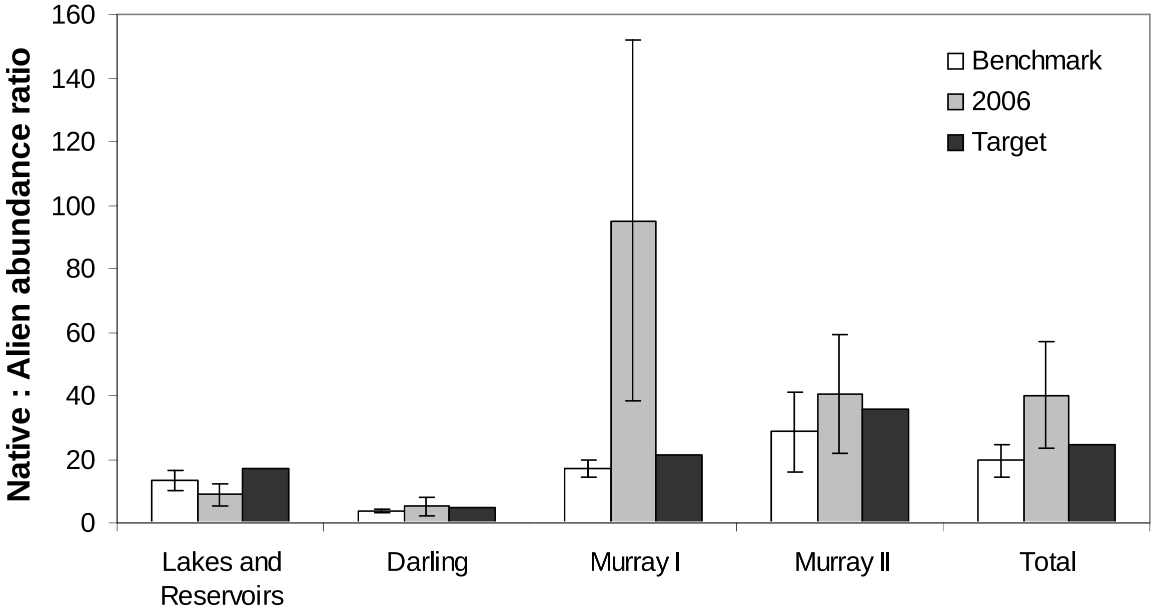

Figure 20. Comparison of the mean (±SE) native : alien abundance ratio observed in 2006 with the benchmark (2004) and target (25% improvement) ratios.

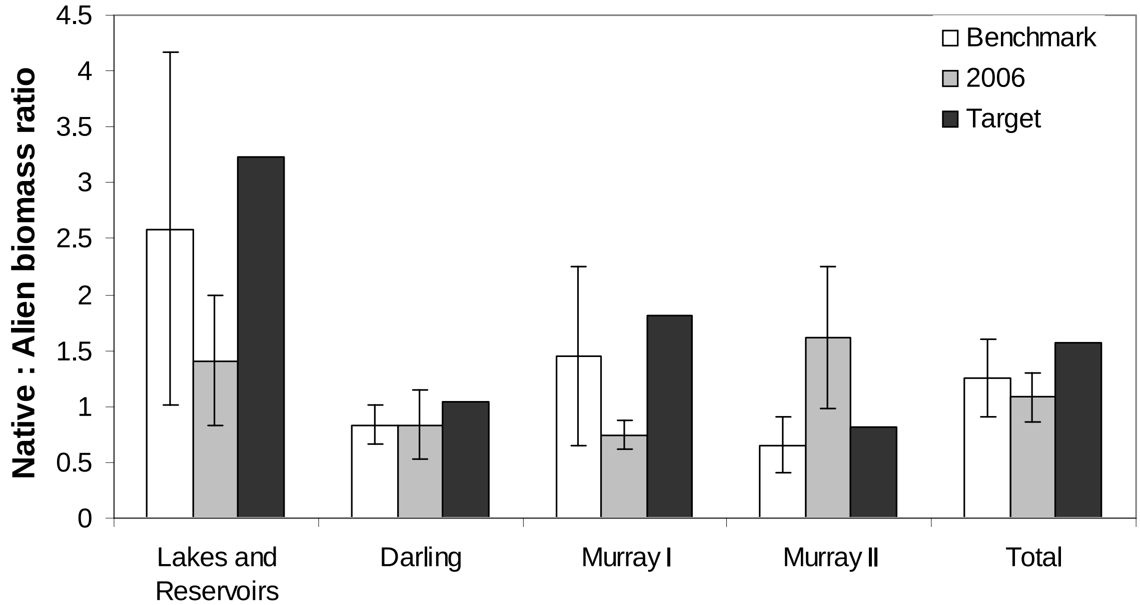

Figure 21. Comparison of the mean (±SE) native : alien biomass ratio observed in 2006 with the benchmark (2004) and target (25% improvement) ratios.

OUTCOME 2

Determination and analysis of trends in fish species & communities throughout the LMD catchment in terms of the parameters listed above.

Data on changes in fish community parameters are presented under activity 3 and are not repeated here.

At a catchment level, all the fish species collected in 2004 (Gilligan 2005) were also collected in 2006 and no new fish species were collected.

SRA sampling in the LMD CMA area in 2005 reported a single Murray hardyhead at Upper Kulnine in the lower Murray zone (unfortunately, the specimen was not retained for verification, and there is a chance that it was not a Murray hardyhead, but the very similar fly-specked hardyhead). However, no Murray hardyhead were collected in 2006.

The proportional changes in the abundance of each species across the catchment between 2004 and 2006 are presented in Table 3. These changes are statistically significant at the catchment level for two species, fly-specked hardyhead (p = 0.02) and eastern gambusia (p = 0.04).

Table 3. The proportional change in the abundance of each species (across the whole catchment) between the benchmark surveys in 2004 (Gilligan 2005) and 2006.

Species	Percentage change
Fly-specked hardyhead	750% increase
Eastern gambusia	733% increase
Silver perch	233% increase
Bony herring	106% increase
Goldfish	90% increase
Freshwater catfish	68% increase
Murray cod	64% increase
Common carp	10% decrease
Golden perch	16% decrease
Redfin perch	25% decrease
Carp-gudgeon species complex	41% decrease
Flat-headed gudgeon	53% decrease
Murray-Darling rainbowfish	69% decrease
Australian smelt	72% decrease

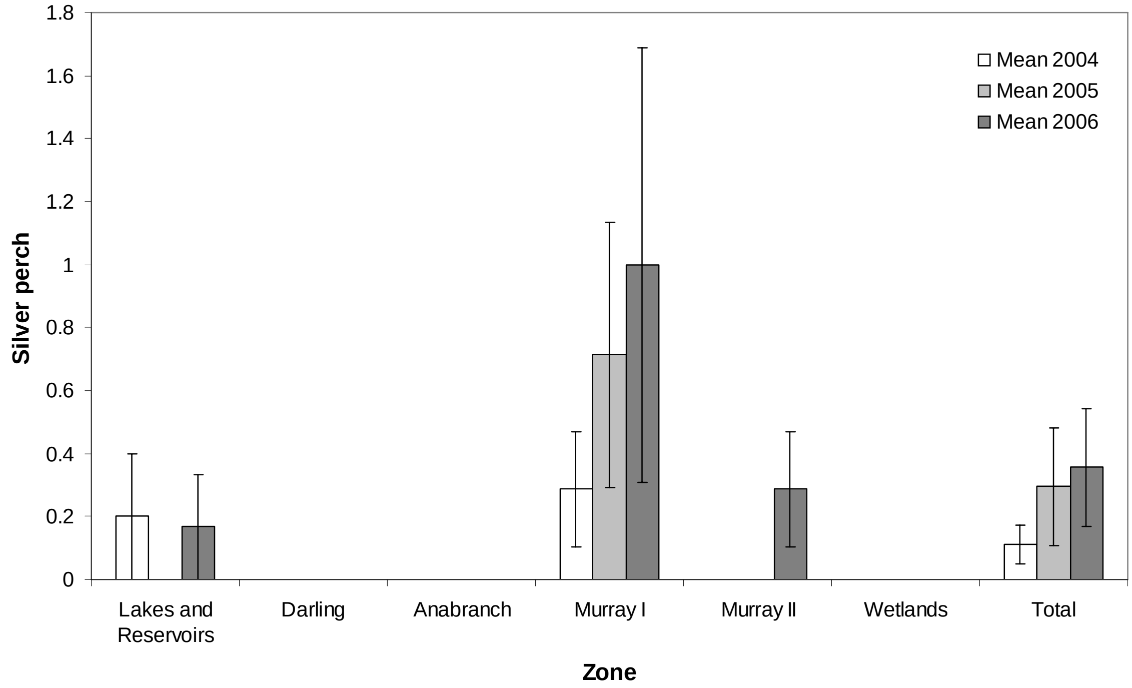

Figure 22. Comparison of the mean (±SE) abundance of silver perch in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

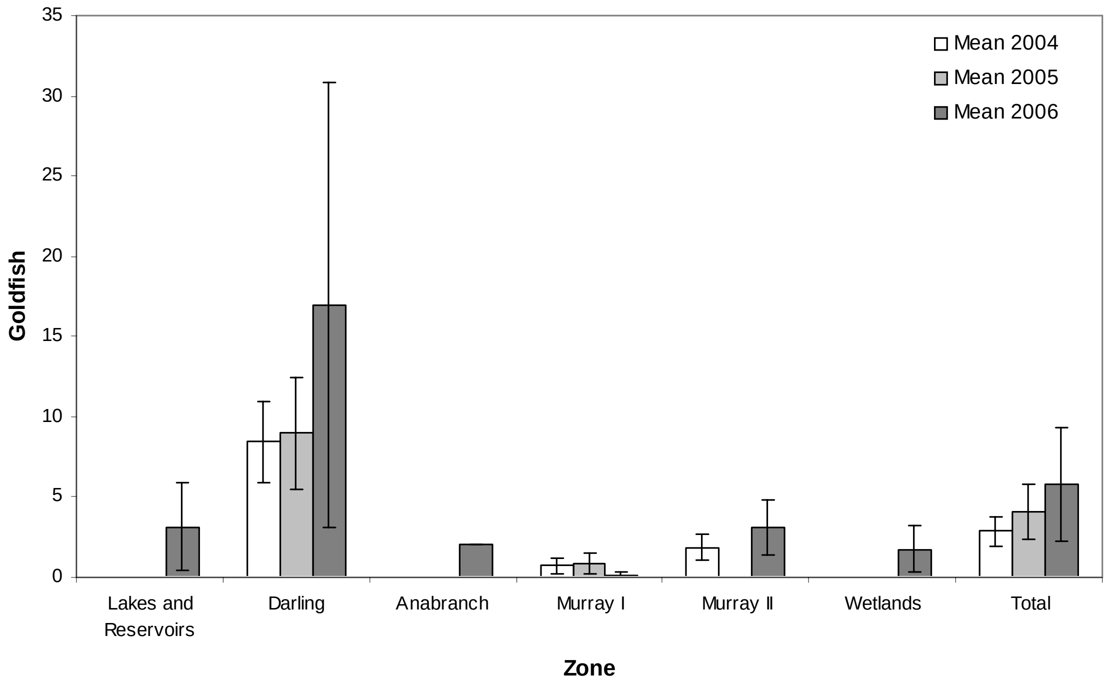

Figure 23. Comparison of the mean (±SE) abundance of goldfish in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

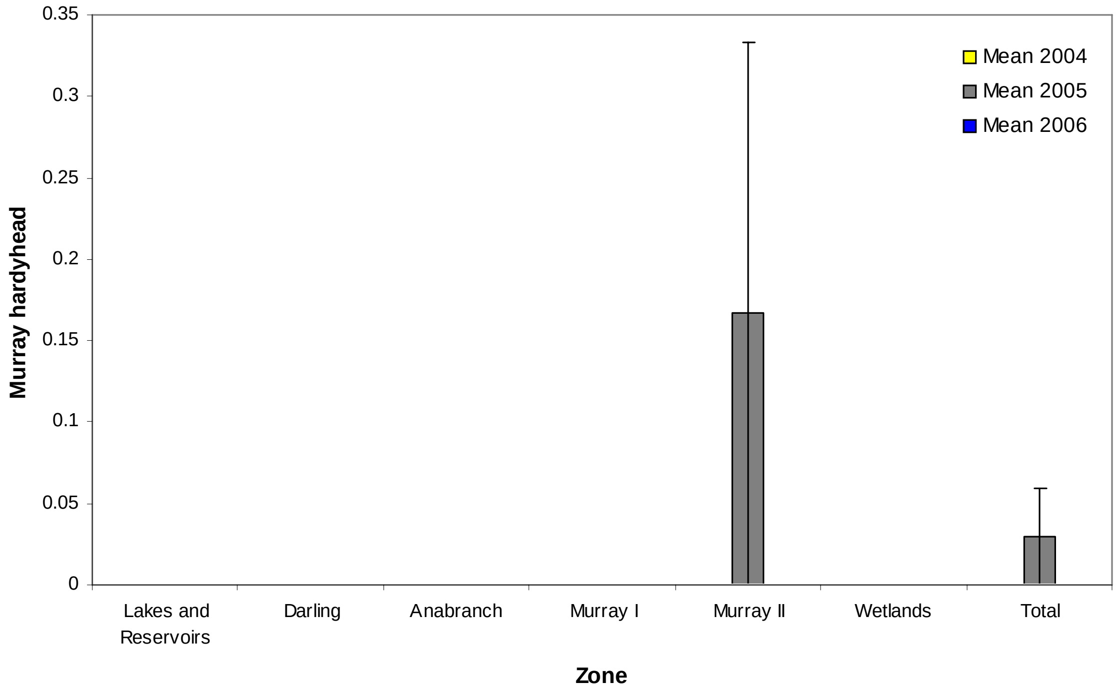

Figure 24. Comparison of the mean (±SE) abundance of Murray hardyhead in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

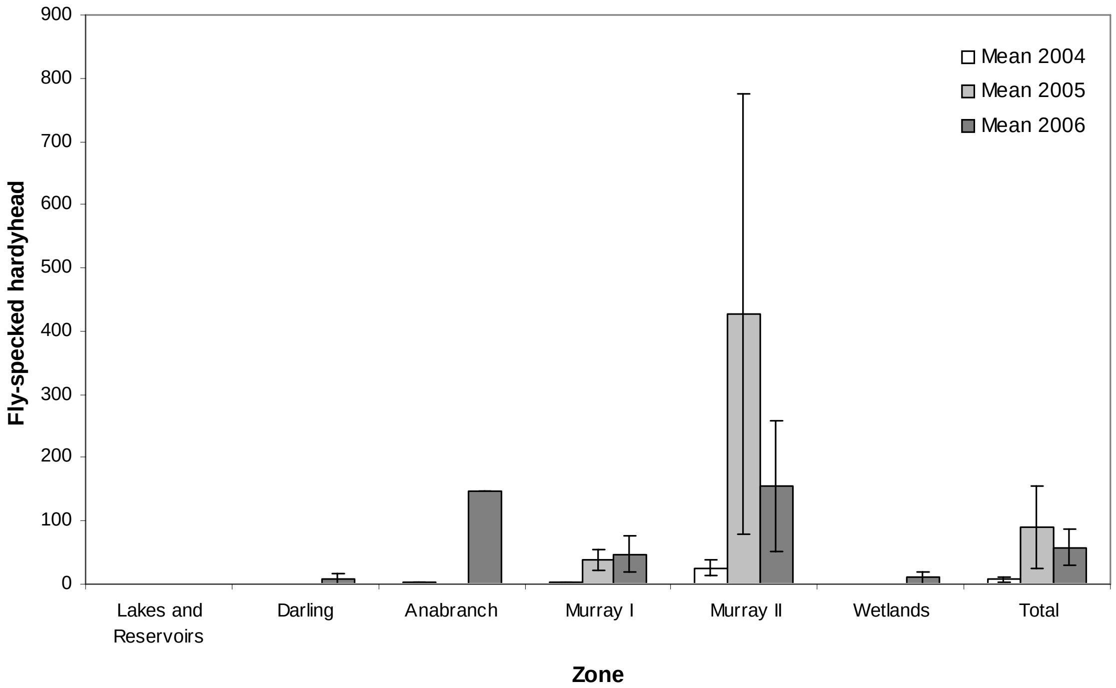

Figure 25. Comparison of the mean (±SE) abundance of fly-specked hardyhead in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

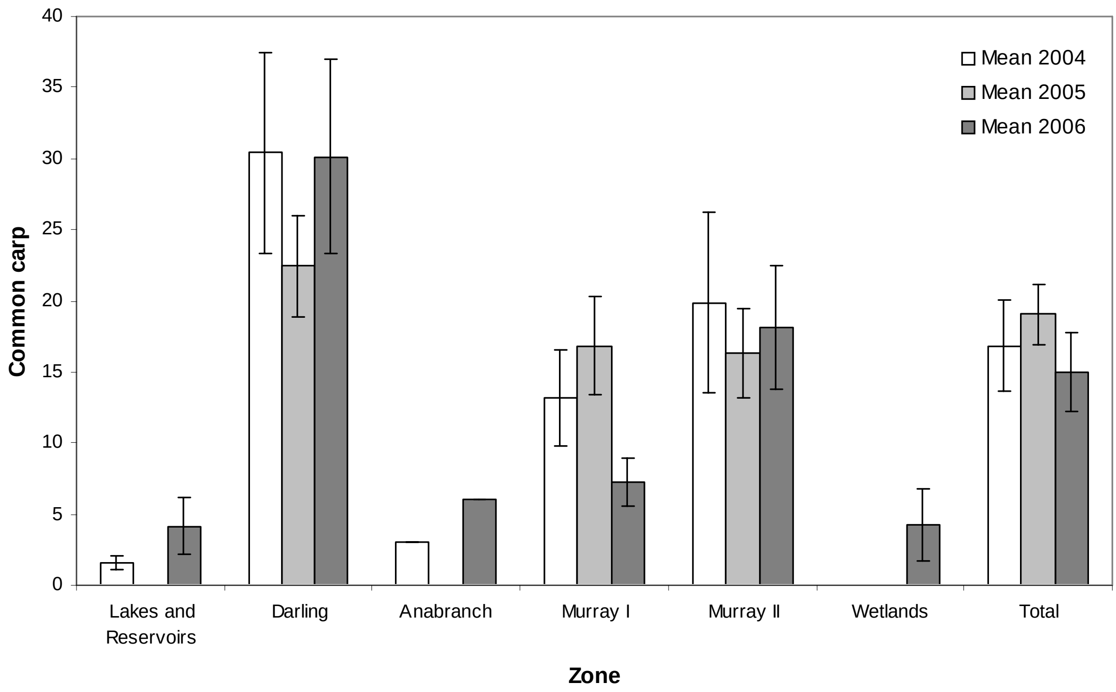

Figure 26. Comparison of the mean (±SE) abundance of common carp in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

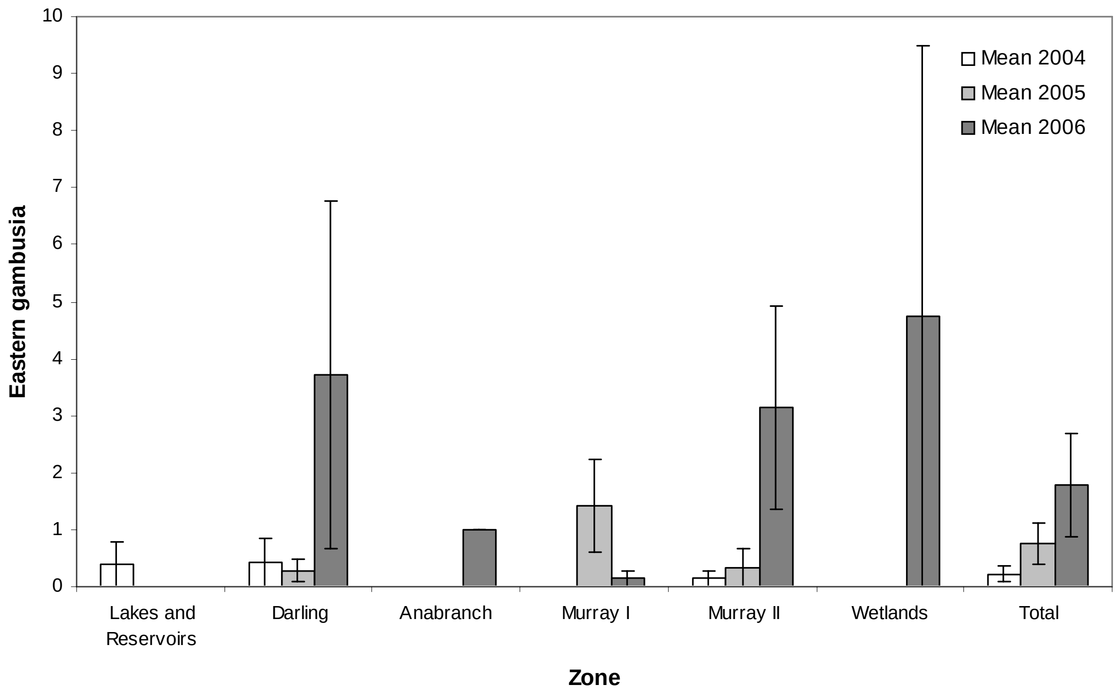

Figure 27. Comparison of the mean (±SE) abundance of Eastern gambusia in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

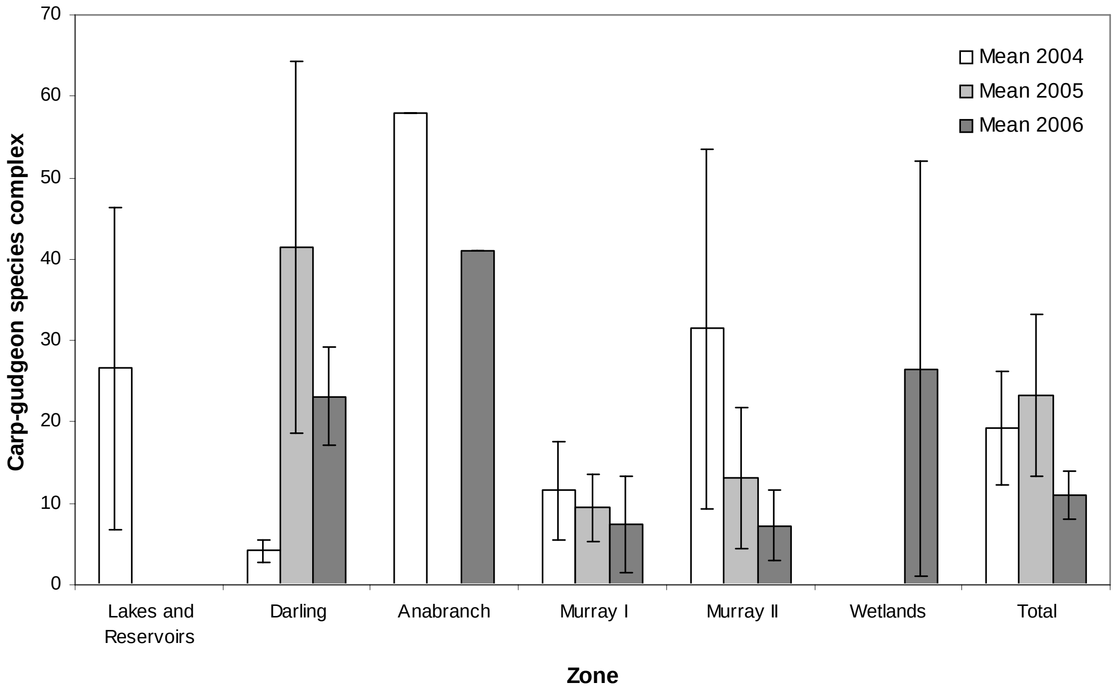

Figure 28. Comparison of the mean (±SE) abundance of carp-gudgeon species complex in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

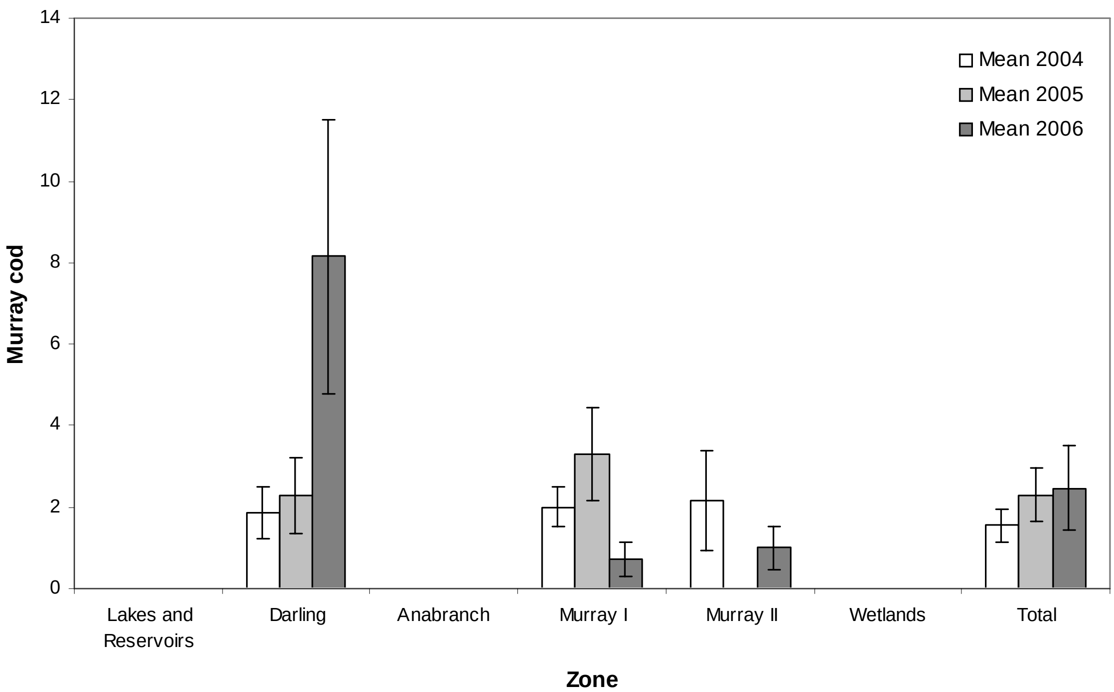

Figure 29. Comparison of the mean (±SE) abundance of Murray cod in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

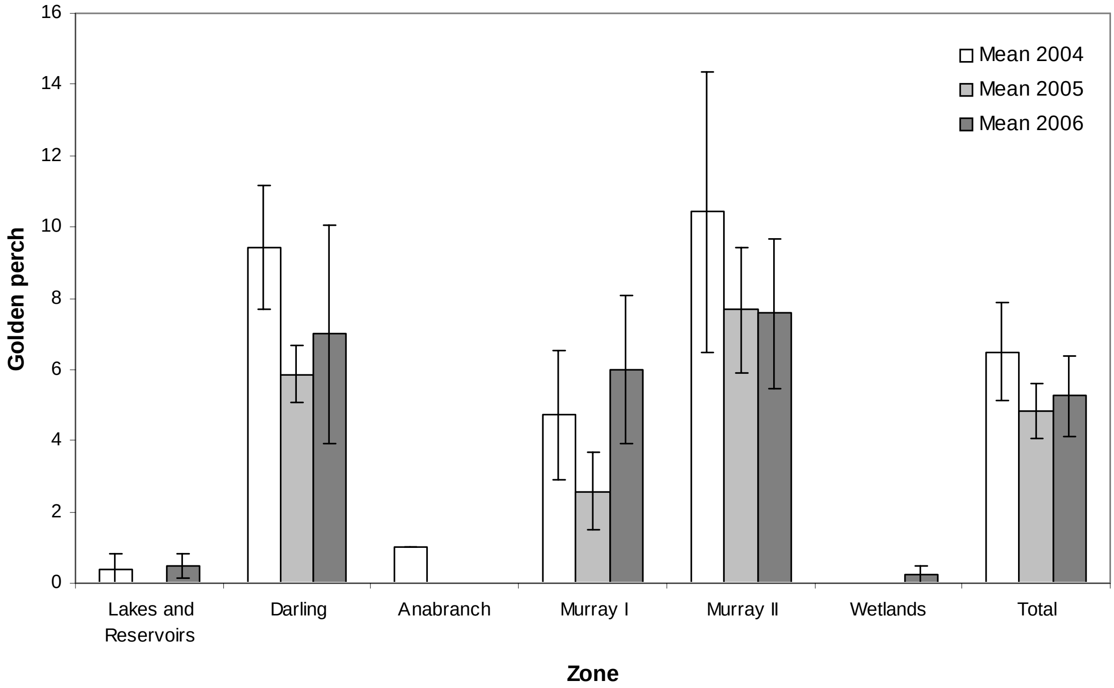

Figure 30. Comparison of the mean (±SE) abundance of golden perch in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

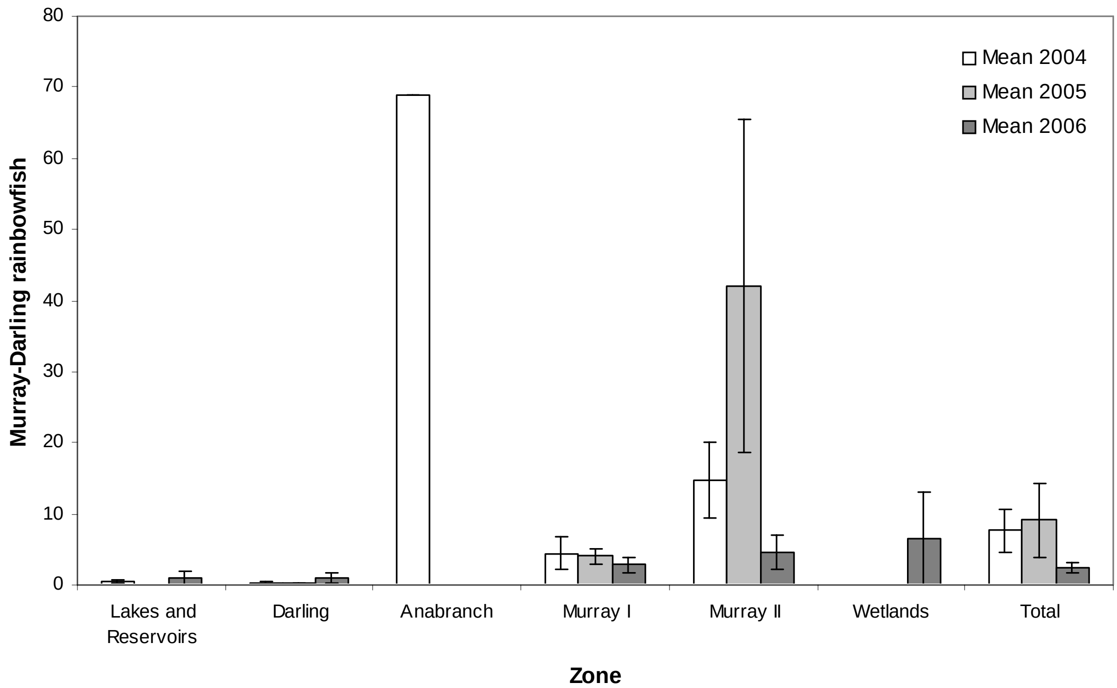

Figure 31. Comparison of the mean (±SE) abundance of Murray-Darling rainbowfish in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

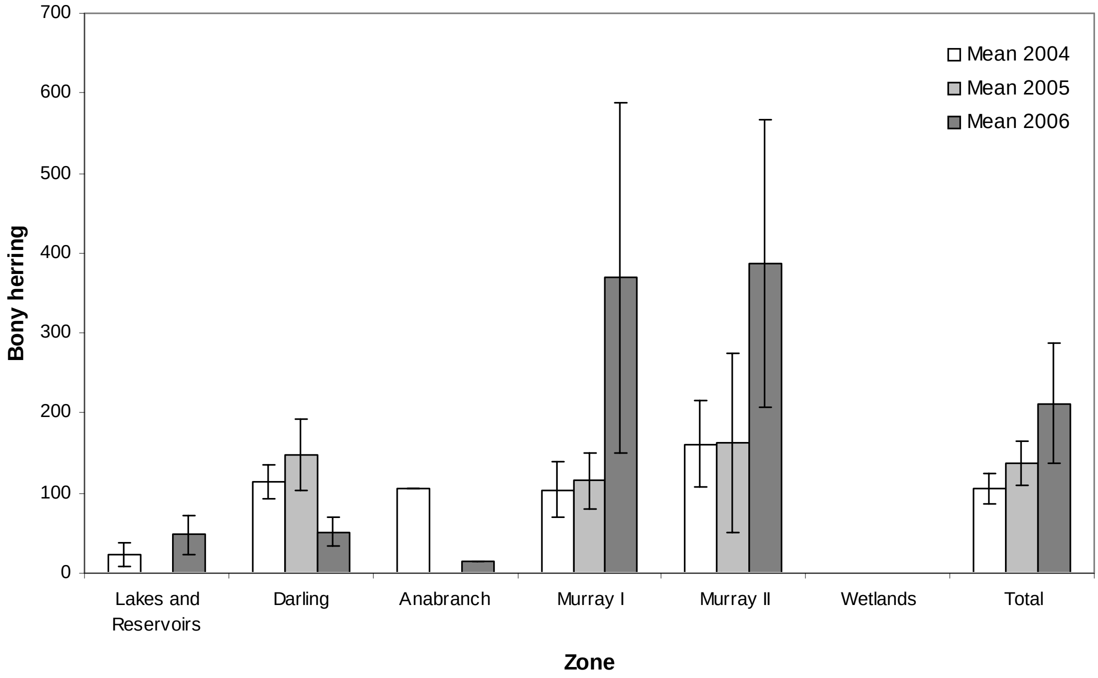

Figure 32. Comparison of the mean (±SE) abundance of bony herring in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

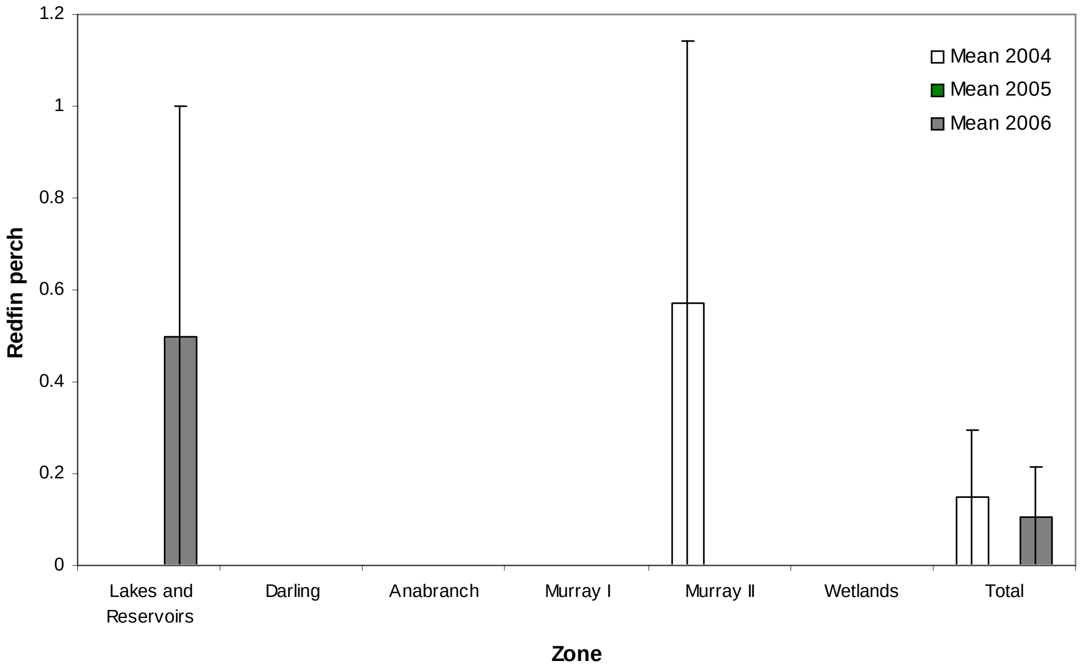

Figure 33. Comparison of the mean (±SE) abundance of redfin perch in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

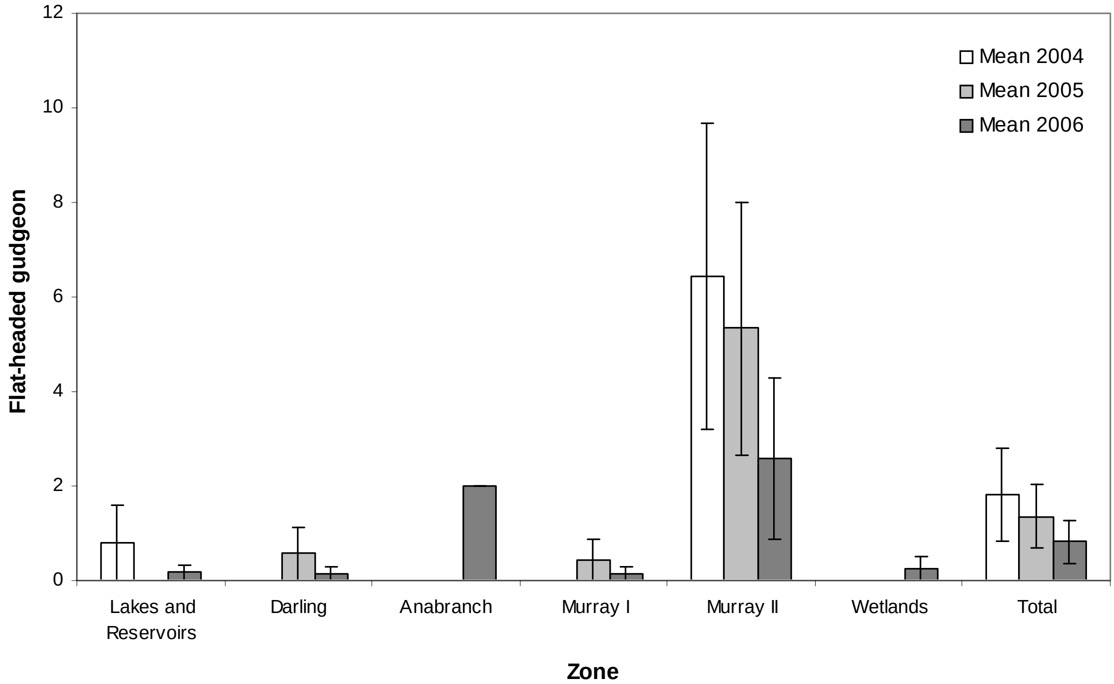

Figure 34. Comparison of the mean (±SE) abundance of flat-headed gudgeon in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

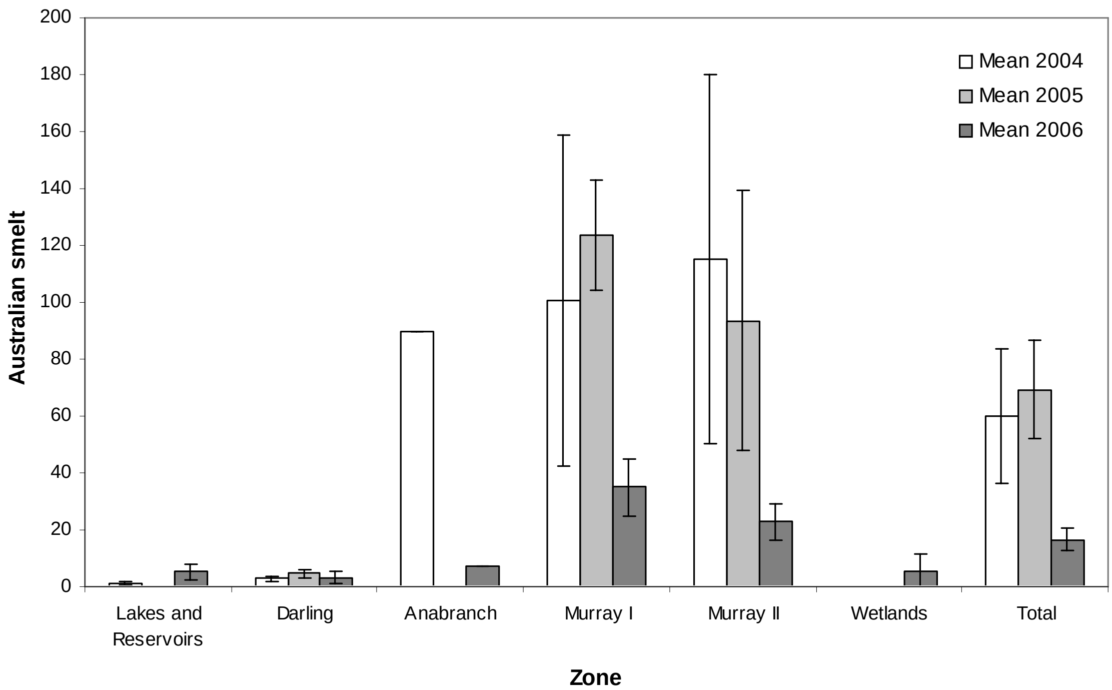

Figure 35. Comparison of the mean (±SE) abundance of Australian smelt in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

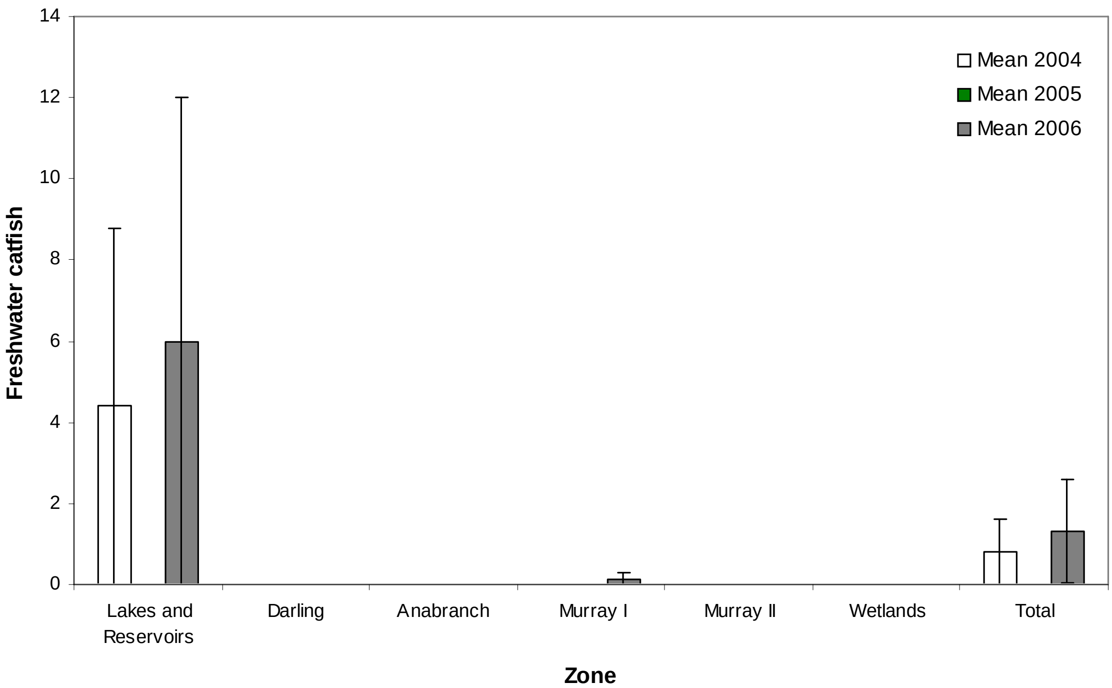

Figure 36. Comparison of the mean (±SE) abundance of freshwater catfish in each of the monitoring years. The 2005 data were provided by the MDBC's Sustainable Rivers Audit (SRA). This project provided data for seven sites in each of the Darling and Murray I zones, three sites in the Murray II zone, but no data from the Lakes & Reservoirs or Anabranch zones, or the floodplain wetlands.

Those species that increased in prevalence by more than 10% (in terms of the proportion of sites at which they were sampled) were eastern gambusia (23%) and fly-specked hardyhead (14%) (Figure 37). Those species that decreased in prevalence (by more than 10% of sites) were Murray cod (21%), Australian smelt (16%), carp-gudgeons (15%) and bony herring (11%) (Figure 37).

Although the complement of species across the whole catchment had not changed, the species complement within some of the catchment zones had. These changes were as follows:

- Silver perch were not collected in the lower Murray zone in 2004 but were in 2006.
- Goldfish were not collected in the Lakes & Reservoirs zone or the Great Darling Anabranch site in 2004 but were in 2006.
- Fly-specked hardyhead were not collected in the Darling in 2004 but were in 2006.
- Eastern gambusia were collected in the Lakes & Reservoirs zone in 2004 but not in 2006 and they were not collected in the upper Murray zone or the Great Darling Anabranch site in 2004 but were in 2006.
- Carp-gudgeons were collected in the Lakes & Reservoirs zone in 2004 but not in 2006.
- Golden perch were collected in the Great Darling Anabranch site in 2004 but not in 2006.
- Murray-Darling rainbowfish were collected in the Great Darling Anabranch site in 2004 but not in 2006.
- Redfin perch were collected in the lower Murray zone in 2004 but not in 2006.
- Flat-headed gudgeon were not collected in the Darling or upper Murray zones or the Great Darling Anabranch site in 2004 but were in 2006.
- Freshwater catfish were not collected in the upper Murray zone in 2004 but were in 2006.

Therefore, the distribution of silver perch, goldfish, fly-specked hardyhead, eastern gambusia, flat-headed gudgeon and freshwater catfish had increased and the distribution of carp-gudgeons, golden perch, Murray-Darling rainbowfish and redfin perch had decreased.

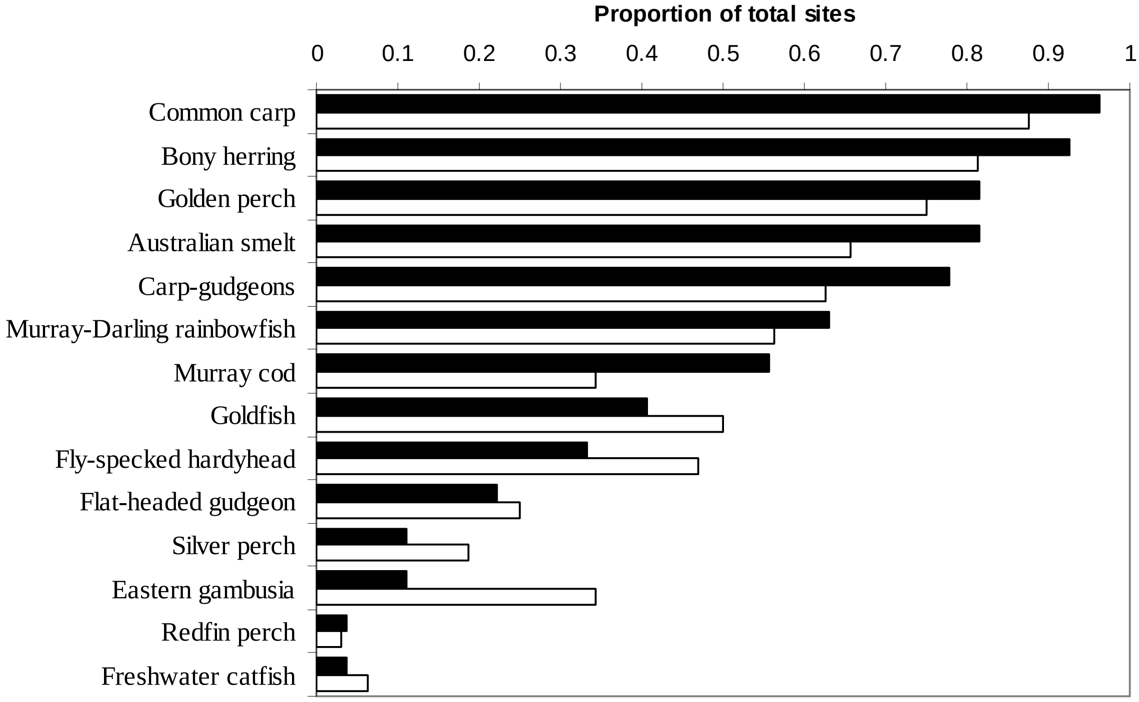

Figure 37. The proportion of sites across the Lower Murray-Darling catchment where each species was collected in 2004 (black bars) and 2006 (white bars).

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