Fish Surveys in Gunbower Forest and Gunbower Creek 2015

FINAL REPORT

Prepared for North Central Catchment Management Authority

10 June 2015

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Summary

Biosis Pty Ltd was commissioned by North Central Catchment Management Authority (NCCMA) to survey fish populations within the Gunbower Forest and Gunbower Creek lagoon systems. This report presents the findings of the 2015 fish monitoring conducted annually in the Gunbower Forest and associated lagoons since 2005 to date. Historically, inundation of the floodplain has been via a combination of overflows, overbank flooding from the Murray River and Gunbower Creek or managed inundation (environmental flows). Sixty gigalitres (60GL) of environmental water was delivered to Gunbower Forest, inundating approximately 3,800 hectares of floodplain and wetlands in 2014. Receding water post inundation has resulted in floodplain wetlands becoming disconnected from the Gunbower Creek and Murray River.

Ten waterbodies (comprising six wetlands and four lagoons) were surveyed as part of the monitoring of native fish communities of Gunbower Island. Survey methods are consistent with Living Murray Gunbower Island Fish Surveys conducted since 2005, using a combination of boat and backpack electrofishing, bait trapping and large and larval fyke nets at each site. In addition, freshwater turtles were assessed to determine the community composition, abundance and age structure of populations based on individuals caught within each wetland and lagoon. Turtles were only detectable through the use of large fyke nets for this project. Water quality was also measured at each site.

73,967 fish were recorded during monitoring in March 2015, the majority of these (>99%) were small bodied species. Twelve fish species were recorded; eight native and four exotic.

The greatest species diversity was recorded at Little Reedy wetland (nine species). The most abundant species recorded was native Carp Gudgeon with 46,504 individuals recorded. The greatest abundance of this species was recorded at Reedy Lagoon. Introduced Eastern Gambusia were the second most abundant species overall, again with the highest abundance recorded at Little Reedy wetland. Other native species including Un-specked Hardyhead, Australian Smelt, and Dwarf Flat-headed Gudgeon were recorded in low abundance in lagoon habitats, while Flat-headed Gudgeon were recorded in high abundances in this habitat type.

This same suite of native species was recorded from wetland habitats in comparable abundance with the exception of the Flat-headed Gudgeon, where only one was recorded. Dwarf-Flat-headed Gudgeon was not recorded in this habitat type. Freshwater Catfish were recorded from two lagoon sites (Phyland and Turners) consistent with previous years monitoring as was one Golden Perch from Upper Gunbower Lagoon. Exotic species, Carp and Gambusia were recorded at all sites. The greatest abundance of Carp was recorded at Green Swamp. Exotic Goldfish *Carassius auratus* were recorded from all sites except Black Swamp and Cockatoo Lagoon.

Sixty-six freshwater turtles were recorded from nine sites. Two Broad-shelled Turtles were recorded from Phyland Lagoon. One individual Murray River Turtle was recorded from Black Swamp. Sixty-three Eastern Long-necked Turtle were recorded overall.

Improvements to fish passage and environmental flow deliveries in recent years are expected to improve access to breeding habitat and ultimately breeding potential for a number of large and small bodied native species in keeping with The Living Murray (TLM) objectives for fish. The structure and distribution of the fish community within the Gunbower Forest is variable and demonstrates the value of ongoing monitoring, particularly to ascertain the effectiveness of recent improvements to environmental flow delivery and fish passage. This will ultimately inform future environmental water management strategies and priorities for the Gunbower Forest.

1. Introduction

1.1 Project background

Biosis Pty Ltd was commissioned by North Central Catchment Management Authority (NCCMA) to survey fish populations at ten sites within the Gunbower Forest and Gunbower Creek lagoon systems. This is the continuation of fish monitoring conducted annually in the Gunbower Forest and associated lagoons since 2005.

Historically, inundation of floodplain wetlands and lagoons has been via a combination of overflows (> 13,700ML/day) entering lateral distributor channel, overbank flooding from the Murray River and Gunbower Creek or managed inundation (i.e. environmental flows - Sharpe et al, 2013).

Sixty gigalitres of environmental water was delivered to Gunbower Forest, inundating approximately 3,800 hectares of floodplain and wetlands between May and December in 2014. Receding water post inundation has resulted in floodplain wetlands becoming disconnected from the Gunbower Creek and Murray River.

A fish exit strategy was implemented at the end of the environmental flows to encourage fish which had entered the forest floodplain and wetlands, including potential progeny, to exit prior to the wetlands becoming disconnected. However, many fish remain on the floodplain, retreating to the permanent wetlands for refuge.

Of particular interest are European Carp, which are known to have an impact on the establishment of wetland vegetation. In two key wetlands, Reedy and Little Reedy Complex, a carp exclusion trial is underway to understand the impact that carp may be having on these systems. This is the subject of a separate report based on the current field investigation.

1.2 Scope of assessment

Ten waterbodies were surveyed as part of the fish community monitoring assessment (Figure 1 to 5). Survey methods are consistent with Living Murray Gunbower Island Fish Surveys conducted since 2008. In addition, turtles were assessed to determine the community composition, abundance and age structure of populations based on individuals caught within each wetland / lagoon.

Figure 1: Location of the study area, Victoria.

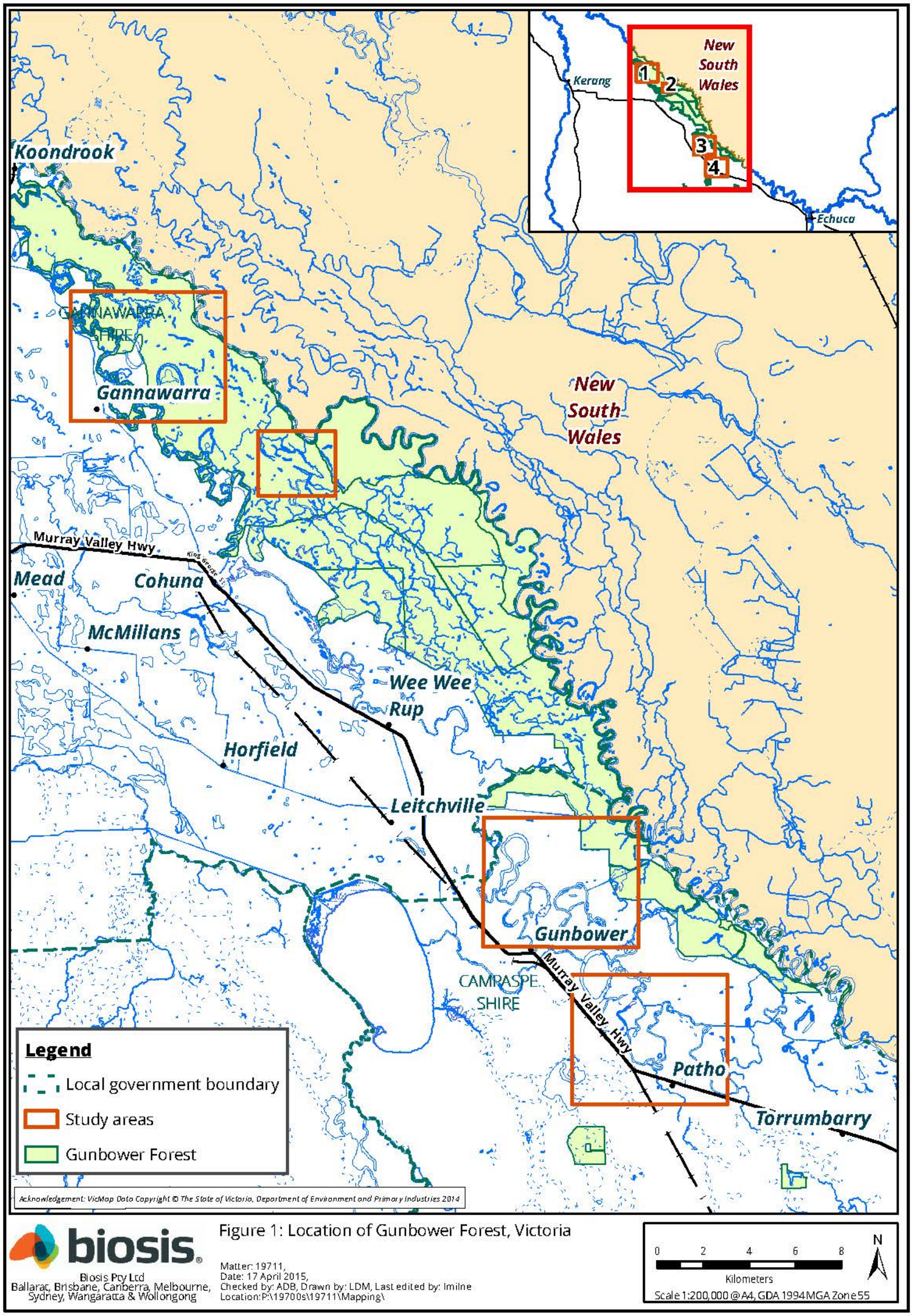

Figure 2: Fyke net monitoring locations for Crayfish/ Little Gunbower Wetland Complex, Black Swamp and Reedy Lagoon; Gunbower Forest, Victoria.

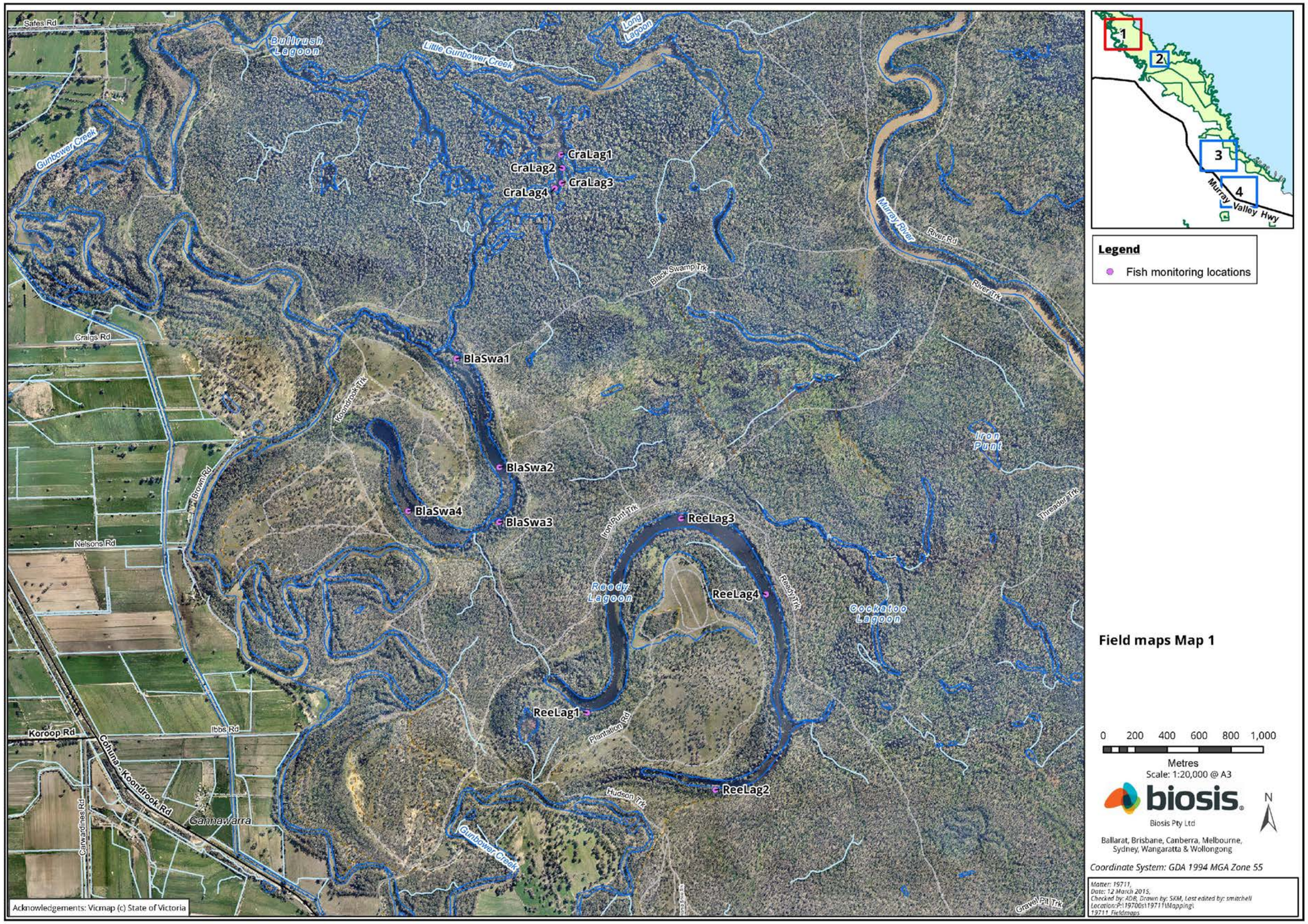

Figure 3: Fyke net monitoring locations for Green Swamp, Corduroy Swamp, Charcoal Swamp and Little Reedy Wetland Complex; Gunbower Forest, Victoria.

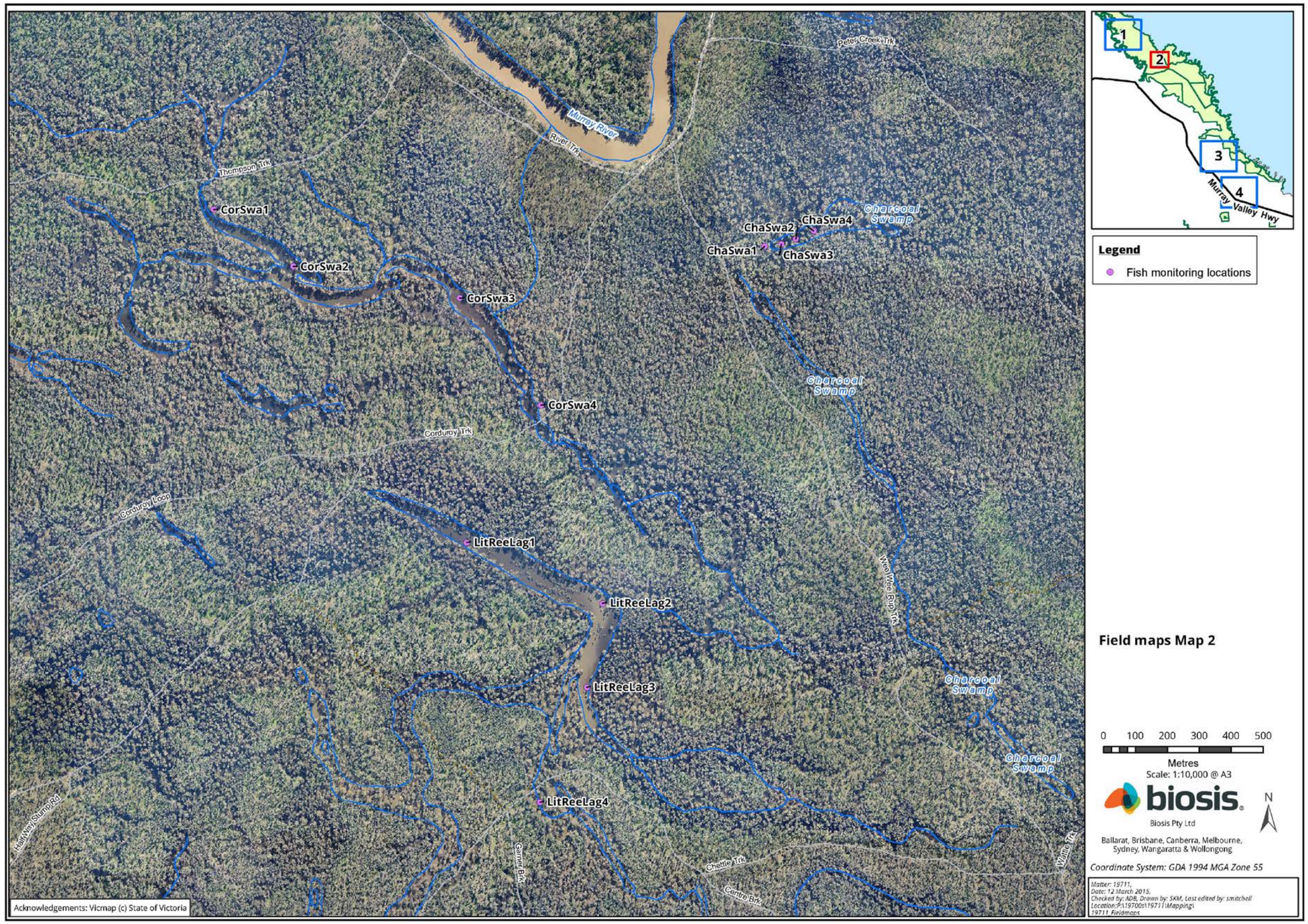

Figure 4: Fyke net monitoring locations for Cockatoo Lagoon and Upper Gunbower Lagoon; Gunbower Forest, Victoria.

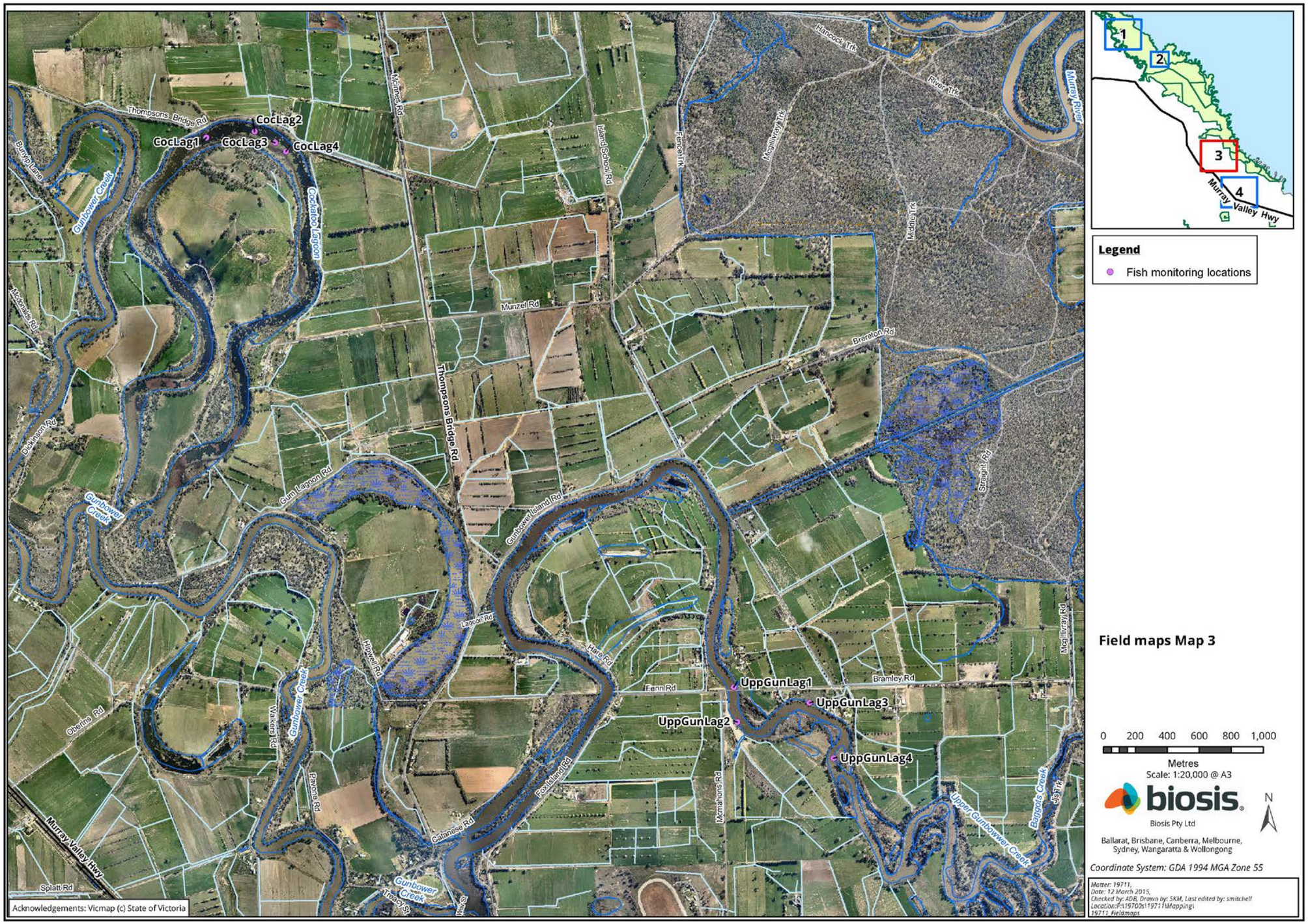

Figure 5: Fyke net monitoring locations for Phyland Lagoon and Turner Lagoon; Gunbower Forest, Victoria.

2. Methods

2.1 Fish Monitoring

Monitoring methods consistent with the Living Murray Gunbower Island Fish Surveys were used to assess fish populations at ten sites. These methods are derived from the *TLM Consistent Monitoring Framework for Fish (MDBC, 2009)* and are further detailed here. Survey locations, dates and methods used at each site are detailed in Table 1. Boat electrofishing was conducted using a Smith-Root 7.5 GPP electrofishing boat. Boat electrofishing followed Sustainable Rivers Audit (SRA) protocols of 12 x 90 second shots (power on time) at four sites; Phyland, Turner, Upper Gunbower and Cockatoo Lagoons. Backpack electrofishing was conducted using a Smith-Root LR24 unit. Consistent with SRA protocols, 8 x 150 second shots were used to sample five sites; Green Swamp, Corduroy Swamp, Little Gunbower Wetland, Reedy Lagoon and Little Reedy Wetland Complex. Reduced electrofishing effort (4 x 150 second shots) was used to sample Black Swamp due to low water levels resulting in a greatly reduced area of inundated habitat. Both electrofishing methods were complimented by the deployment of ten concertina bait traps at each waterbody for a minimum two hours soak time. Both electrofishing and bait trapping methods targeted suitable and representative habitats for a range of fish species (both large and small bodied) at each site.

In addition to electrofishing and bait trapping, eight fyke nets were set at each waterbody. Four sampling points at each waterbody have been defined for the Gunbower fish monitoring program. Large mesh (single 10 metre wing, 1 cm mesh), and larval fyke nets (dual 2.5 metre wing, 2mm mesh with 2cm^2 exclusion grill) were paired at each monitoring point. Due to receding water, certain sites were unable to be sampled using fyke nets. Sampling was conducted as near as possible to monitoring points and set amongst suitable and representative habitat for each waterbody. Fyke nets were set in the evening and collected the following morning with sampling duration recorded to calculate catch per unit effort (CPUE) defined as number of individuals detected for a single species per sampling hour.

The first 50 individuals of each species collected at each waterbody (regardless of sampling method) were measured (total length = TL) to the nearest one millimeter. The first 50 large bodied native fish species were measured to the nearest millimeter (mm) and weighed to the nearest gram (gm) at each waterbody and indications of individual condition (i.e. injury, parasitism, deformity or evidence of disease) recorded. A separate data submission accompanies this report. Abundance of all species at each waterbody was recorded. Fish species identifications followed McDowall (1996) and Lintermans (2007). Carp Gudgeon were identified to genus level only due to taxonomic uncertainty within the group, (e.g. *Hypseleotris* spp.).

Table 1: Site survey details for Gunbower fish monitoring, March 2015.

Site Name	Site Code	Survey Dates	Habitat	Easting	Northing	Survey Method
Black Swamp	BlaSwa1	16-17/3/2015	Wetland	245466	6044251	Backpack electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Charcoal Swamp	ChaSwa1	19/03/2015	Lagoon	253561	6039605	DRY - Not Surveyed, WQ Only.

Site Name	Site Code	Survey Dates	Habitat	Easting	Northing	Survey Method
Cockatoo Lagoon	CocLag1	17-18/3/2015	Lagoon	261817	6022844	Boat electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Corduroy Swamp	CorSwa1	19-20/3/2015	Wetland	251837	6039720	Backpack electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Crayfish Island / Little Gunbower Wetland	CraLag1	16-17/3/2015	Wetland	246119	6045526	LOW WATER - Reduced Survey. Backpack electrofisher, 10 x Bait Traps
Little Reedy Lagoon	LitReeLag1	18-19/3/2015	Wetland	252629	6038679	Backpack electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Phyland Lagoon	PhyLag1	15-16/3/2015	Lagoon	266733	6015401	Boat electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Reedy Lagoon	ReeLag1	18-19/3/2015	Wetland	246283	6042039	Backpack electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Turner Lagoon	TurLag1	15-16/3/2015	Lagoon	268100	6012696	Boat electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Upper Gunbower Lagoon	UppGunLag1	17-18/3/2015	Lagoon	265114	6019410	Boat electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets
Green Swamp	GreSwa1	19-20/3/2015	Wetland	251044	603937	Backpack electrofisher, 10 X Bait Traps, 4 X Fyke Nets, 4 X Larval Fyke Nets

2.2 Turtle Monitoring

Turtles were not targeted as part of this investigation but were expected to form a significant proportion of by-catch through the use of large fyke nets. All turtles captured were identified to species, sexed (where possible) and measurements of straight carapace length (SCL) and plastron length (PL) taken to determine the age class of individuals in accordance with Spencer (2002) and Howard et al (2011). Adult female Broad-shelled Turtle *Chelodina expansa* turtles were palped for oviducal eggs as the surveys coincided with this species nesting season.

2.3 Water Quality

Water quality measurements were collected *in situ* using a calibrated Horiba U-52 Water Quality Meter. Measures of dissolved oxygen (mg/L), oxygen saturation (% sat.), pH, turbidity (NTU), electrical conductivity

(mS/cm) and temperature (◦C) were recorded for each waterbody prior to commencement of electrofishing. These measurements provide an indication of water quality at the time of sampling, and are not intended to be used for determinations of long term trends, outside of notable gross changes.

2.4 Permits

Biosis undertakes flora and fauna assessments under the following permits and approvals:

- Research Permit/Management Authorisation and Permit to Take Protected Flora & Protected Fish issued by the Department of Environment and Primary Industries under the *Wildlife Act 1975, Flora and Fauna Guarantee Act 1988* and *National Parks Act 1975* (Permit number 10006240, expiry date 9 May 2015)
- Approvals 04.12 and 14.12 from the Wildlife and Small Institutions Animal Ethics Committee
- Permit RP1220 issued by the Department of Environment and Primary Industries (Fisheries Victoria) under the *Fisheries Act 1995.*

2.5 Qualifications

Ecological surveys provide a sampling of aquatic fauna at a given time and season. There are a number of reasons why not all species will be detected at a site during survey, such as low abundance, patchy distribution and species dormancy, seasonal conditions that may result in variable flows at monitoring sites and migration / breeding movements. The current survey is considered sufficient to document the fish community at each sampling location (waterbody) at the time of survey and thus comparable with previous years monitoring with the exception of Black Swamp. Water levels at Black Swamp precluded the use of both large and larval fyke nets and the area of inundated habitat was greatly reduced. Sampling was consequently restricted to a reduced number of backpack electrofishing shots (4 x 150 seconds) and standard bait trap sampling (ten traps x two hours). Results are sufficient for comparison for these two methods based on CPUE to previous year monitoring data.

Charcoal Swamp was identified as a sampling site during the procurement phase of the project. Water levels were insufficient to conduct survey (netting or electrofishing) and in consultation with NCCMA, Green Swamp was chosen as a substitute for monitoring.

3. Results

3.1 Summary

73,967 fish were recorded during monitoring in March 2015, the majority of these (>99%) were small bodied species (Table 2). Twelve fish species were recorded; eight native and four exotic. The greatest diversity was recorded at Little Reedy Wetland (9 species). The most abundant species recorded was the Carp Gudgeon *Hyspeleotris* spp. with 46,504 individuals recorded. The greatest relative abundance of these species was recorded at both the Reedy Lagoon (12,874) and Little Reedy Wetland (10,792) sites, though comparable levels of abundance were recorded at the Black Swamp (8,482) and Cockatoo Lagoon sites (6,231). Introduced Eastern Gambusia *Gambusia holbrooki* were the second most abundant species overall, again with the highest abundance recorded at the Reedy Lagoon (8,523) and Little Reedy Wetland (10,152) wetland sites, however comparatively lower abundances were recorded from the Black Swamp and Cockatoo Lagoon sites (Table 2). Unspecked Hardyhead (*n*=39) were recorded from six sites, including all four lagoon sites with low abundance recorded at wetland sites. Murray-Darling Rainbowfish were only recorded from wetland sites (Green Swamp and Little Reedy). Australian Smelt were recorded in low abundance from both lagoon and wetland sites indicating no particular fidelity to either habitat type. Two large bodied native species were recorded at three sites. Five juvenile Freshwater Catfish *Tandanus tandanus* (<96mm) were recorded at Phyland Lagoon (Plate 1) and one sub-adult female was recorded at Turners Lagoon. An individual Golden Perch (TL=502mm) was recorded from the Upper Gunbower Lagoon site.

Plate 1: Young of year Freshwater Catfish *Tandanus tandanus* from Phyland Lagoon, 16 March, 2015.

Dwarf Flat-headed Gudgeon *Philypnodon macrostomus* was recorded from Cockatoo Lagoon only, (3 individuals) consistent with previously low abundances recorded during monitoring. Flat-headed Gudgeon (*n*=698) were conspicuously absent from the majority of wetland sites with the exception of an individual within the Little Reedy complex. Low abundances were recorded within wetland habitat types in 2008-2010 and were absent in wetland habitats from 2011-2013 (Sharpe et al, 2013). This species was recorded in low to moderate abundance at all lagoon sites. Exotic species, Carp and Gambusia were recorded at all sites. The greatest abundance of European Carp was recorded at Green Swamp (*n*=196) composed of mostly young of year fish (<100mm). A complimentary project to investigate the impacts of European Carp upon wetland vegetation is being conducted at the Reedy Lagoon and Little Reedy wetland sites. Carp exclusion fencing has been added to the flood runners connecting Reedy Lagoon but not the Little Reedy complex. Two juvenile

Carp (TL=123 and 95) were recorded at Reedy Lagoon. Six individuals were recorded from the Little Reedy complex without exclusion fencing including the largest individual European Carp at TL=670mm recorded for all sites during monitoring. Exotic Goldfish *Carassius auratus* were recorded from all sites except Black Swamp and Cockatoo Lagoon.

Sixty-six freshwater turtles were recorded from nine sites. Two large female Broad-shelled Turtles *Chelodina expansa* were recorded from Phyland Lagoon. Both individuals were gravid. One individual juvenile (3 year old) Murray River Turtle *Emydura macquarii* was recorded from Black Swamp. Sixty-three Eastern Long-necked Turtle *Chelodina longicollis* were recorded from seven of nine sites where appropriate methods to capture these species were utilised (i.e. large fyke nets). The greatest abundance for this species was recorded at Reedy Lagoon (*n*=23) and Little Reedy wetland sites (*n*=17).

3.2 Fish Community - Macrohabitat Observations

Large bodied native species were recorded in lagoon sites only. Small bodied native species were found to have variable distribution with respect to habitat type (lagoon versus wetland). Dwarf Flat-headed Gudgeon were recorded from lagoon sites only, though in very low abundance (*n*=3). The closely related Flat-headed Gudgeon was recorded in greater abundance (*n*=698) from all lagoon sites (Table 2). One individual was recorded within the wetland site Little Reedy. Un-specked Hardyhead were recorded in relatively low abundance at two of the six wetland sites. It was recorded in moderate abundance at all lagoon sites. Australian Smelt were recorded in low abundance (⩽46) across all wetland sites excluding Crayfish Swamp. Reduced survey effort was used for sampling at this site however, due to low water levels and consequently may not have been present and not detected using electrofishing and bait trapping. This species was recorded at only two of the four lagoon sites. Murray-Darling Rainbowfish were recorded only within wetland sites (Reedy and Little Reedy). The most abundant species for all sites was the native Carp Gudgeon and was recorded in high abundance in wetland and lagoon macrohabitats. Of the large bodied exotic species, European Carp were recorded from all sites of both habitat types in low to moderate abundance (≤196), though younger cohorts were typically observed in wetland sites. The exception being an individual European Carp (TL=670 mm) recorded from the Little Reedy wetland site; the largest individual recorded during survey. The same was observed for Goldfish where distribution was ubiquitous with respect to habitat type, with younger cohorts observed in wetland sites. This species was not recorded from two sites; Black Swamp (wetland) or Turners Lagoon (lagoon). Oriental Weatherloach were more abundant in wetland sites compared with lagoon sites where between one and two individuals were recorded at three of the four lagoon sites. This species was not recorded from Turners Lagoon. Eastern Gambusia were recorded at all sites and were the second most abundant species overall. Relative abundance of Gambusia was typically higher within wetland sites than lagoon sites (Table 2).

Table 2: Results of Gunbower Forest fish sampling, March 2015.

Location	Habitat Type	Unspecked Hardyhead	Carp Gudgeon	Golden Perch	Murray Rainbowfish	Flathead Gudgeon	Dwarf Flathead Gudgeon	Australian Smelt	Freshwater Catfish	Oriental Weatherloach	Goldfish	Carp	Gambusia
Black Swamp	Wetland		8482					4		1		2	1845
Reedy Lagoon	Wetland	1	12874					13		6	40	2	8523
Corduroy Swamp	Wetland		2815					8		38	12	20	3811
Crayfish Swamp	Wetland		35							1	4	3	71
Green Swamp	Wetland		1648		1			4		9	17	196	578
Little Reedy Complex	Wetland	7	10792		14	1		46		5	7	6	10152
Phyland Lagoon	Lagoon	12	1997			488		9	5	2	2	35	42
Cockatoo Lagoon	Lagoon	1	6231			3	3			2		7	243
Turners Lagoon	Lagoon	12	516			204		10	1		6	10	588
Upper Gunbower Lagoon	Lagoon	6	1114	1		2				1	6	26	120
Totals		**39**	**46504**	**1**	**15**	**698**	**3**	**94**	**6**	**65**	**94**	**307**	**25973**

Indicates Wetland Macrohabitat | **Indicates Lagoon Macrohabitat**

3.3 Population Monitoring Results

3.3.1 Small-bodied Fish

Carp Gudgeon *Hypseleotris spp.*

46, 504 Carp Gudgeon were recorded during sampling. This was the most abundant fish species recorded during monitoring overall. The greatest abundances were recorded at Reedy Lagoon (12,874) and Little Reedy Wetland (10,792) presented in Table 2. The lowest comparative abundance recorded was at Turners Lagoon with 516 fish. While low abundance was recorded at Corduroy, Green, Phyland and Upper Gunbower sites, Carp Gudgeon were still recorded in numbers ranging from 1, 648 (Green Swamp) to 2,815 individuals (Corduroy Swamp) and was the most abundant fish species at all sites with comparable abundance of Eastern Gambusia at one site only (Little Reedy). Lowest abundance for this species is recorded for Crayfish Lagoon (*n*=35) where reduced sampling was required, the catch per unit effort (CPUE) however has Crayfish Lagoon ranked fifth overall for abundance of Carp Gudgeon (Figure 6).

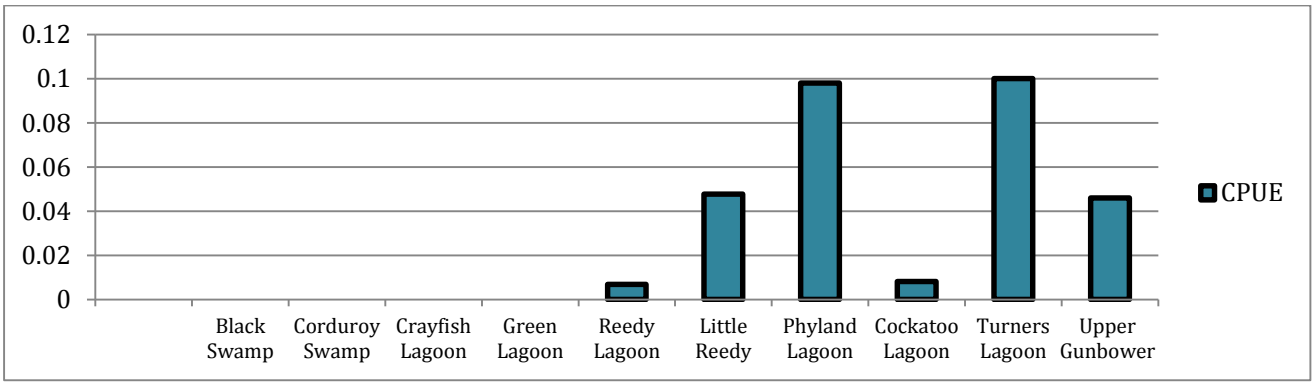

Figure 6: Carp Gudgeon CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Length-frequency distribution of Carp Gudgeon (Figure 7) indicates a well structured population with evidence of recent recruitment, the young of year (size at maturity ≤25mm) the most abundant size class detected. Older individuals (2-3 years / 30-45mm) were also recorded in relatively high abundance (approximately 20% of individuals measured).

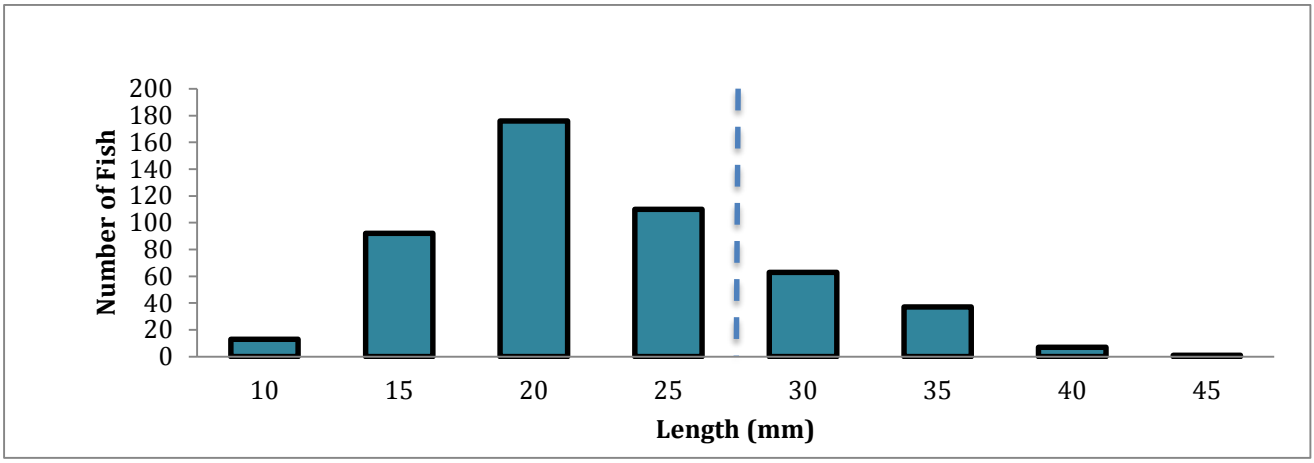

Figure 7: Length-frequency distribution for Carp Gudgeon, Gunbower Forest, March 2015. Broken line indicates size at maturity.

Un-specked Hardyhead *Craterocephalus stercusmuscarum*

39 Un-specked Hardyhead were recorded during surveys. The greatest abundance was recorded at Phyland and Turners Lagoons (12 from each site). This species was similarly abundant between Little Reedy and Upper Gunbower Lagoon (7 and 6 individuals respectively). This species was recorded at all lagoon sites and two of the six wetland sites (Table 2, Figure 8).

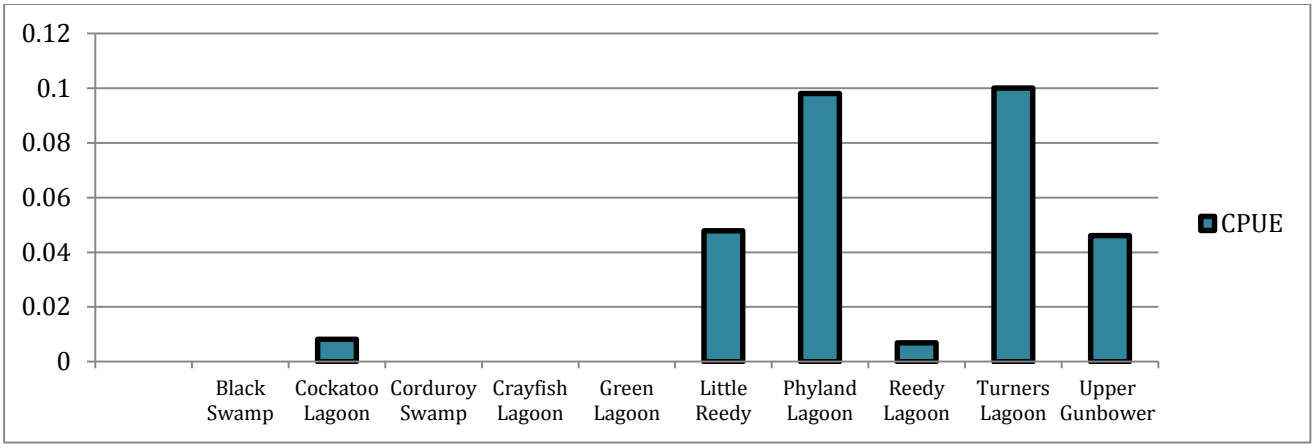

Figure 8: Un-specked Hardyhead CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

The population of Un-specked Hardyhead was dominated by young of year fish (≤25mm), evidence of recruitment with lower levels of abundance for plus two year old fish (up to 52mm) (Figure 9). Significantly the larger size classes (40-50mm) were only detected at lagoon sites. The length-frequency results from lagoon sites (notably Phyland and Turners) detail a well structured population, with evidence of recent recruitment and broad size range of adult fish evidence of multiple cohorts.

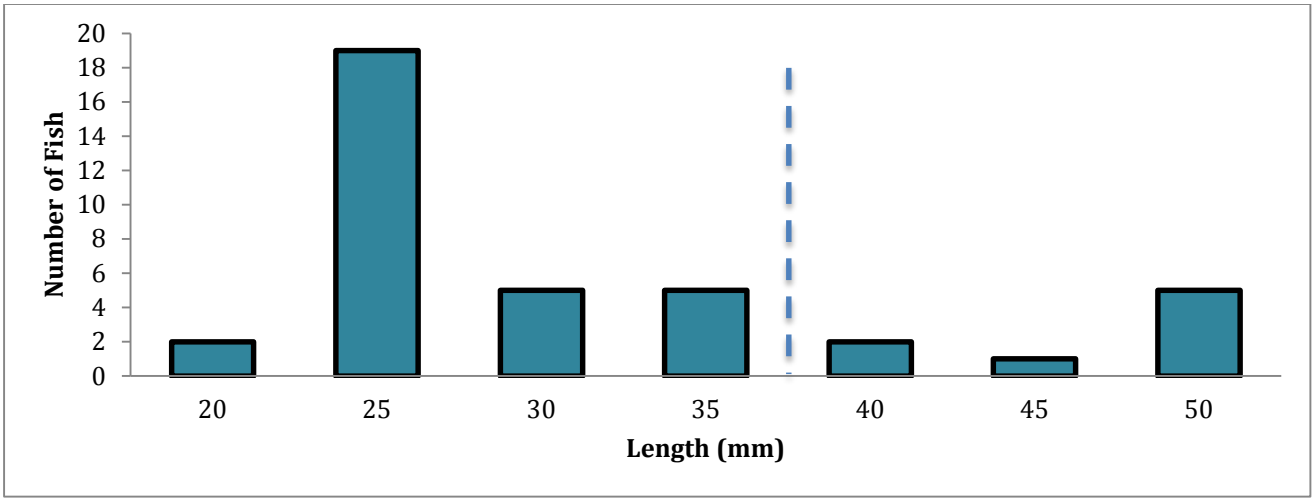

Figure 9: Length-frequency distribution for Un-specked Hardyhead, Gunbower Forest, March 2015. Broken line indicates size at maturity.

Australian Smelt *Retropinna semoni*

Ninety-four Australian Smelt were recorded during survey. This species was most abundant at the Little Reedy wetland site (*n*=46) (Figure 10; Table 2). This species was recorded from both lagoon and wetland sites excluding the Upper Gunbower, Crayfish and Cockatoo sites. This species was however detected in relatively low abundance at all other sites, and is likely present in low abundance at sites where it was not recorded.

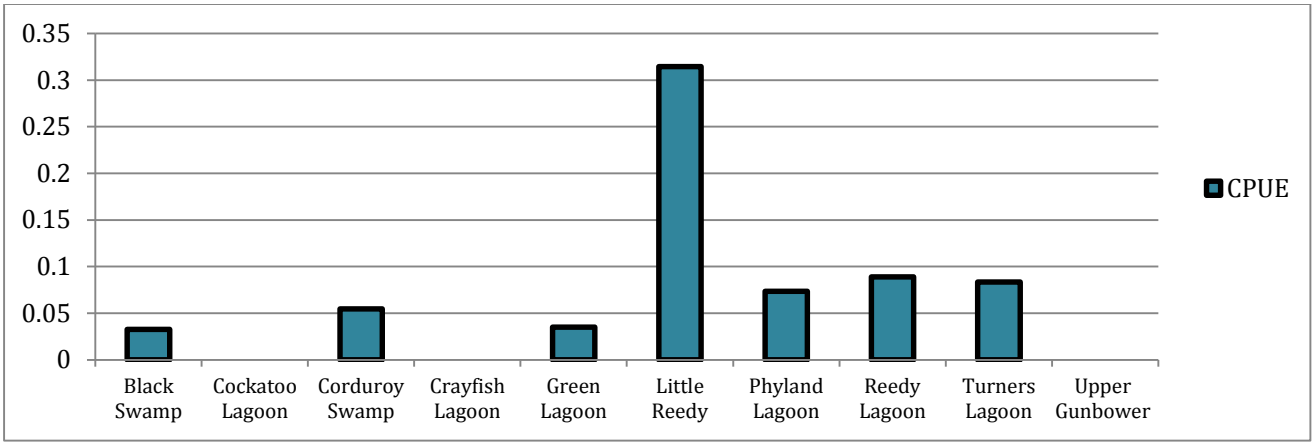

Figure 10: Australian Smelt CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Length-frequency distribution indicates that the population of Australian Smelt is dominated by sub-adult fish (~67%) with relatively low abundances of adult fish (>35mm). These results suggest consistent recruitment over consecutive years (Figure 11).

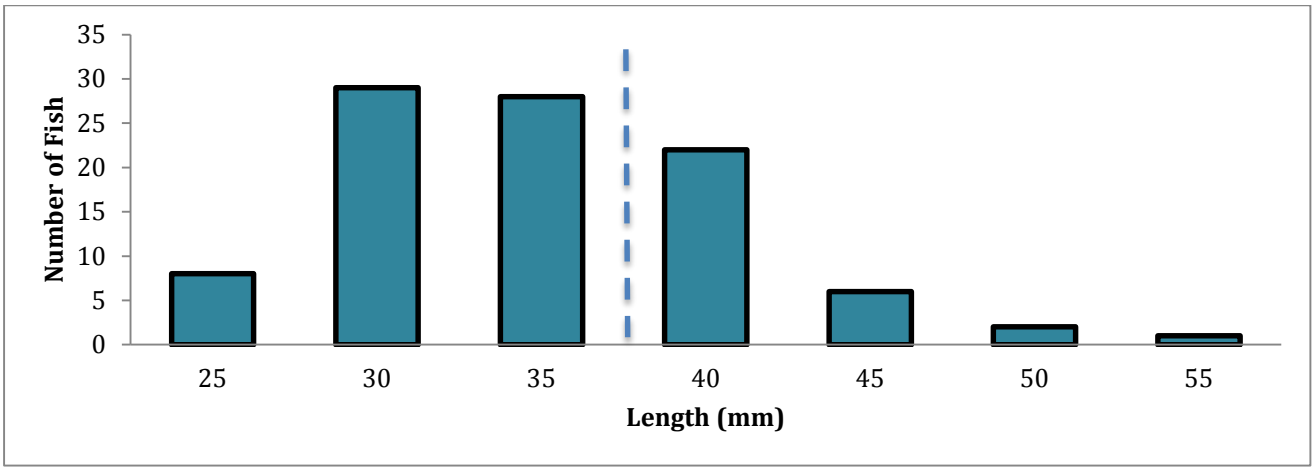

Figure 11: Length-frequency distribution for Australian Smelt, Gunbower Forest, March 2015. Broken line indicates size at maturity.

Murray-Darling Rainbowfish *Melanotaenia fluviatilis*

Murray-Darling Rainbowfish were recorded from two wetland sites only, Green Swamp and Little Reedy. Fifteen individuals were recorded in total from all sites (Figure 12, Table 2). Again this species may be present in low abundance at other sites.

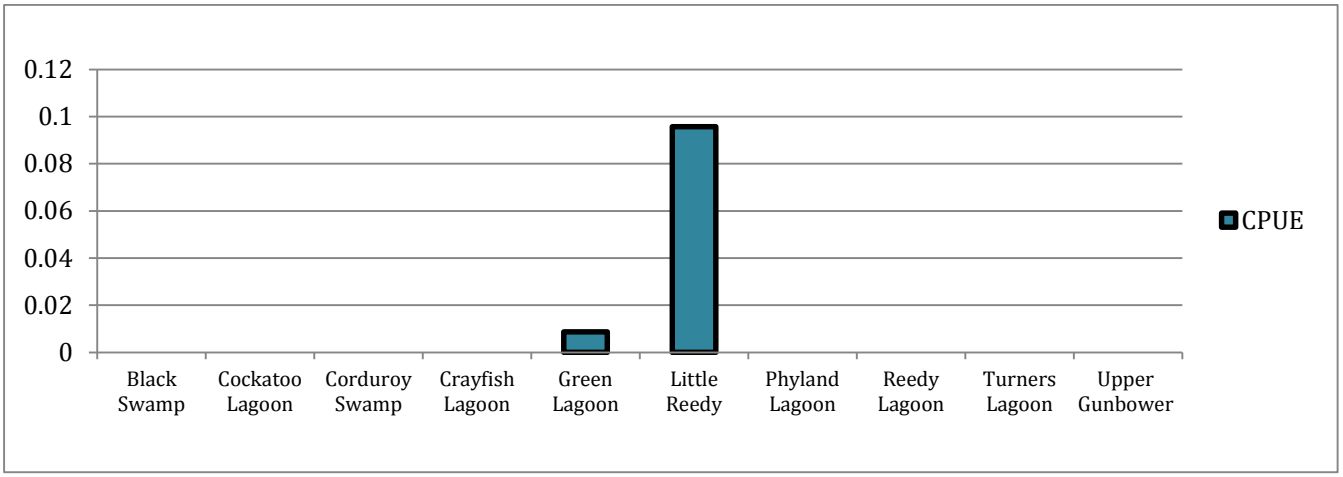

Figure 12: Murray-Darling Rainbowfish CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Despite being based on a small number of individuals caught, length-frequency does not indicate recent recruitment (i.e. young of year), with only mature adult fish detected (Figure 13). Eighty percent of these individuals were between 45 and 50mm in length and of last year's cohort.

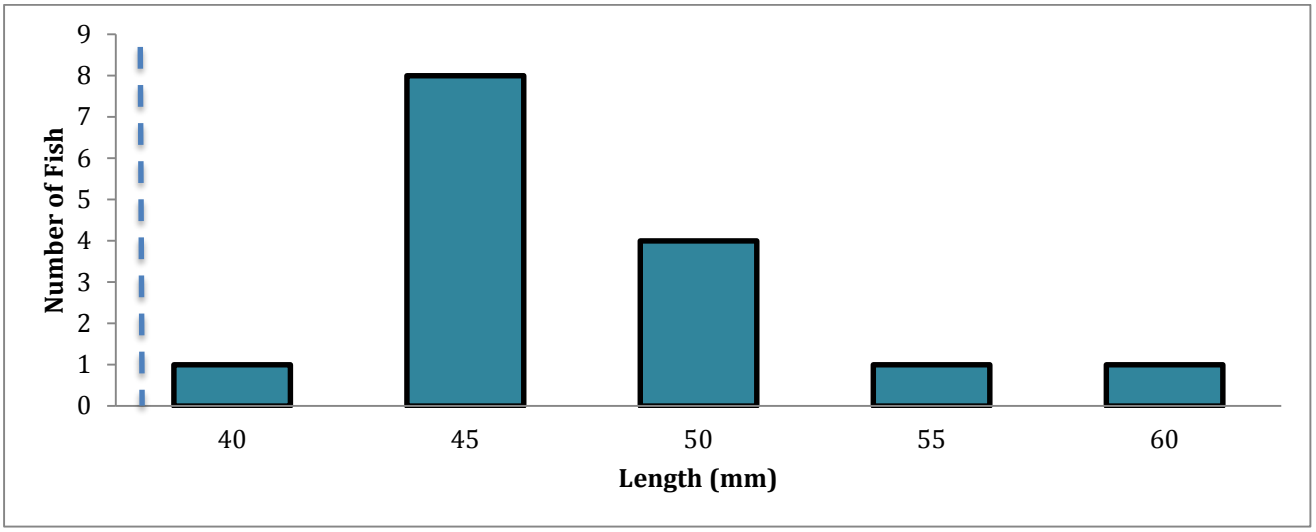

Figure 13: Length-frequency distribution for Murray-Darling Rainbowfish, Gunbower Forest, March 2015. Broken line indicates size at maturity.

Flat-headed Gudgeon *Philypnodon grandiceps*

698 Flat-headed Gudgeon were recorded from all sites during monitoring. This species was predominately detected from lagoon sites, with one individual recorded from a wetland site (Little Reedy) Comparatively low abundances of this species were detected at Upper Gunbower and Cockatoo Lagoons (2 and 3 individuals respectively) (Figure 14, Table 2). This species was recorded in high numbers at the Phyland and Turners sites (488 and 204 respectively) and was the third most abundant fish species recorded from all sites.

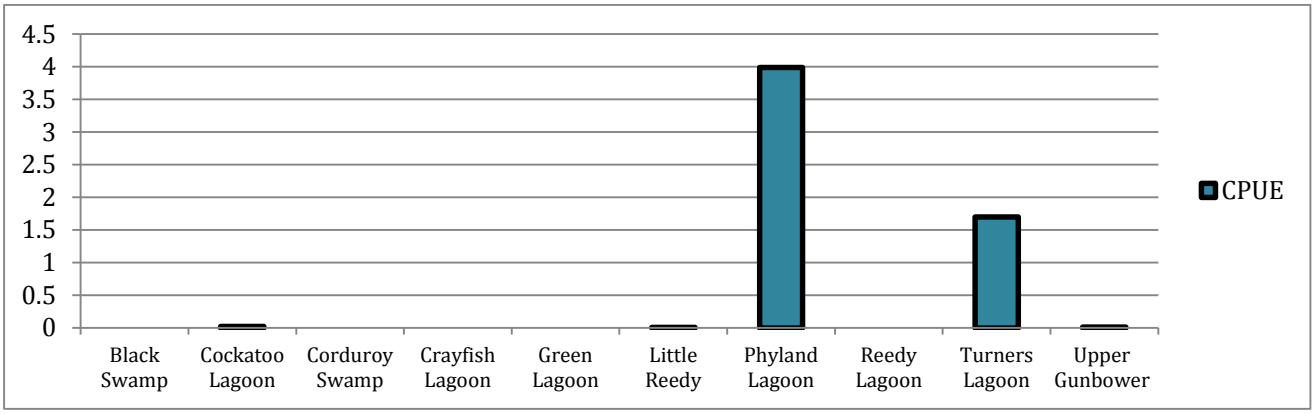

Figure 14: Flat-headed Gudgeon CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Length-frequency indicates two distinct cohorts with young of year forming the majority (~85%) of the individuals measured (*n*=106) (Figure 15). This indicates a well structured population within the Phyland and Turners sites. Abundance was too low at other sites to provide an insight into their respective populations of Flat-headed Gudgeon. While no Flat-headed Gudgeon were recorded at any other wetland sites, patchy distribution amongst lagoon sites might suggest low abundance at all sites.

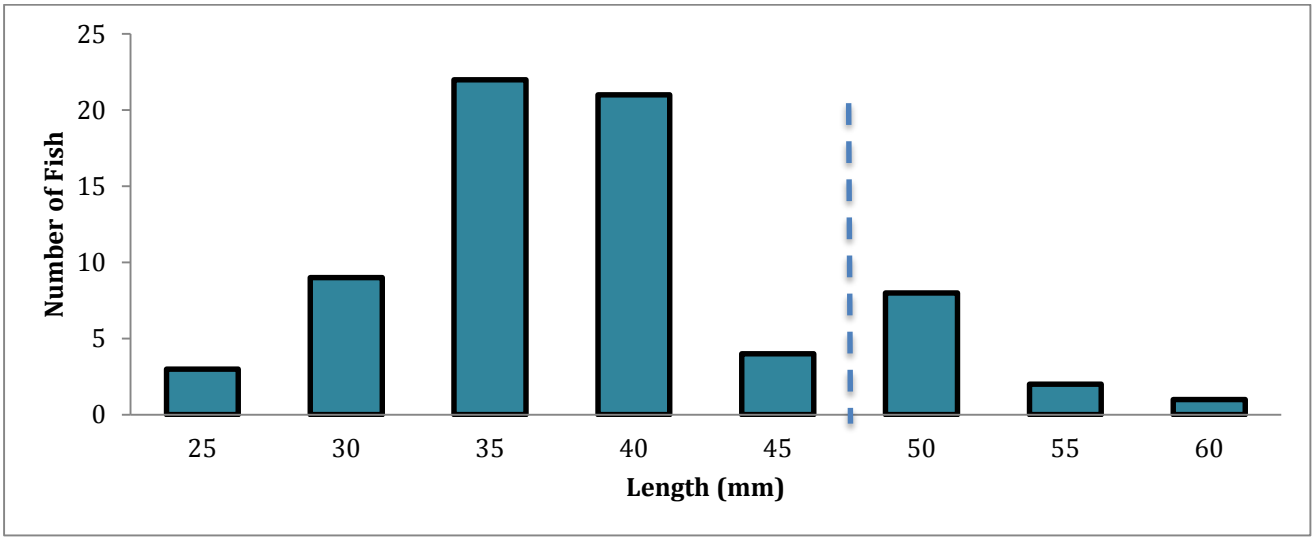

Figure 15: Length-frequency distribution for Flat-headed Gudgeon, Gunbower Forest, March 2015. Broken line indicates size at maturity.

Dwarf Flat-headed Gudgeon *Philypnodon macrostomus*

Three Dwarf Flat-headed Gudgeon were detected at Cockatoo Lagoon. All three individuals were sexually mature individuals (>25mm) at 32, 33 and 36mm in length. No evidence of recruitment though uncertain based on these results (very low abundance recorded). Presentation of CPUE and length-frequency for this species is not therefore considered necessary for interpretation of results.

Eastern Gambusia *Gambusia holbrooki*

25,973 Eastern Gambusia were recorded during survey. This was the second most abundant species recorded at all sites. The highest abundance was recorded from Little Reedy and was only marginally less abundant than Carp Gudgeon at this site (10,792 versus 10,152). Gambusia were more abundant than Carp Gudgeon at one site, Corduroy Swamp (Figure 16, Table 2) with 3,811 Gambusia and 2,815 Carp Gudgeon. Numbers of Gambusia were conspicuously low at Phyland Lagoon with only 42 individuals recorded, the lowest CPUE for this species overall. CPUE was comparatively low for all lagoon sites compared with wetland sites.

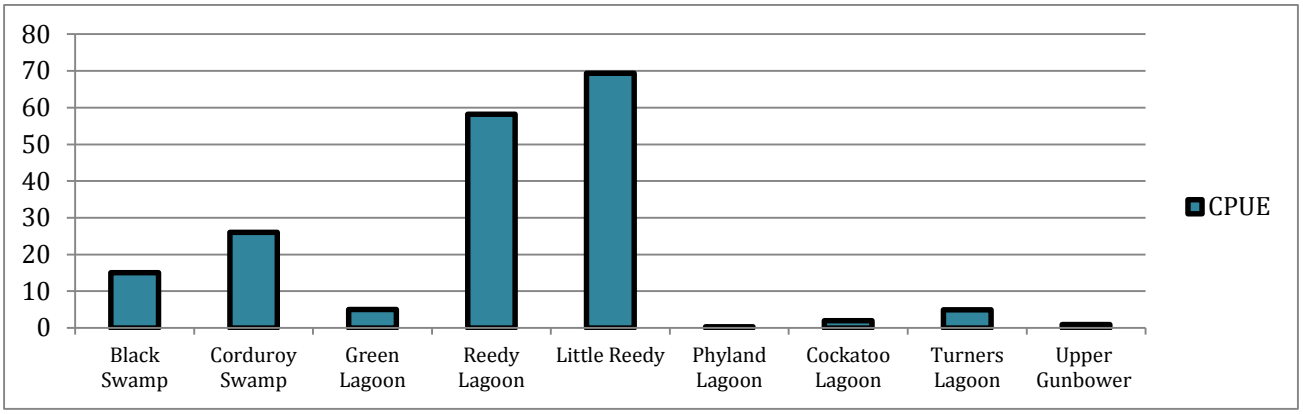

Figure 16: Eastern Gambusia CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Length-frequency indicates strong recruitment into the population of young of year fish (Figure 17). This is consistent with known life history traits (1-2 year life span) of this species.

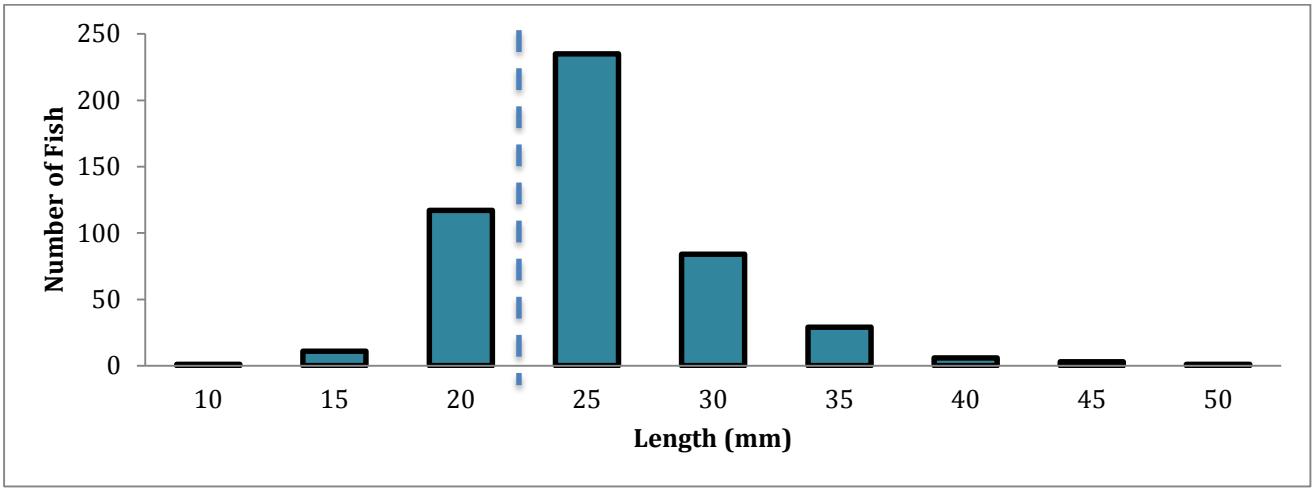

Figure 17: Length-frequency distribution for Eastern Gambusia, Gunbower Forest, March 2015. Broken line indicates size at maturity.

Oriental Weatherloach *Misgurnus anguillacaudatus*

65 Oriental Weatherloach were recorded during survey. The highest abundance was recorded at Corduroy Swamp (*n*=38) (Table 2, Figure 18). Low numbers of this species (between 1 and 9 individuals) were recorded at all other sites with the exception of Turners Lagoon where it was not recorded.

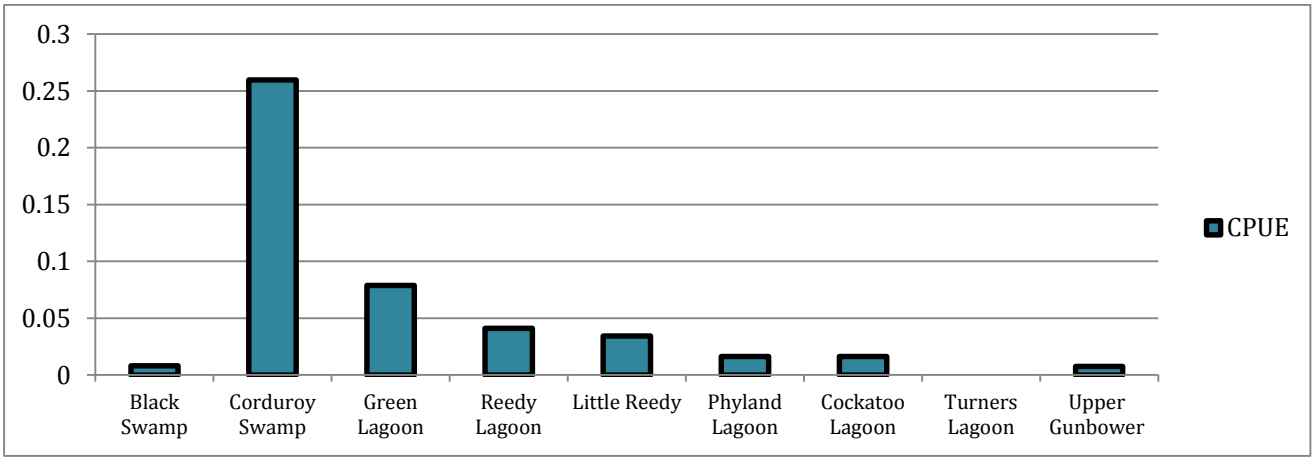

Figure 18: Oriental Weatherloach CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Length-frequency indicates a fragmented population structure with the majority of individuals (90%) within the 85 to 125mm size range being 1-2 year old fish. Low numbers of young of year fish were recorded (*n*=4). This species is recorded living in excess of 10 years in captivity (Gomon and Bray, 2011). The absence of older cohorts (130 to 160mm – 3 years plus) and low numbers of older cohorts suggests intermittent recruitment into the population and/or dispersal periods in intervening years (Figure 19).

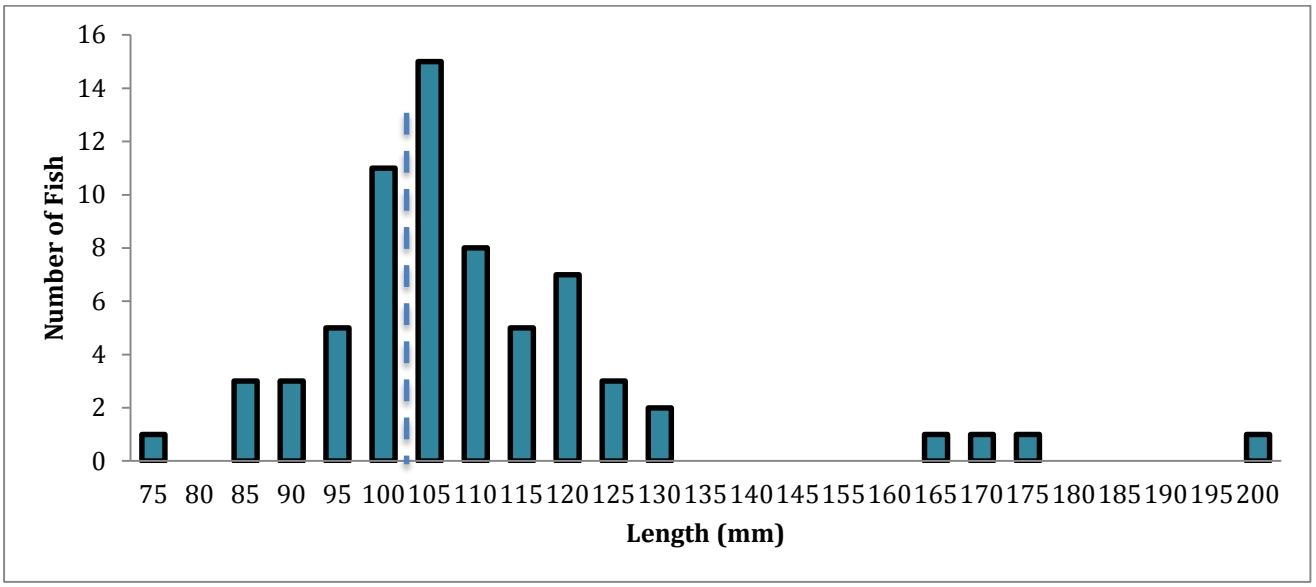

Figure 19: Length-frequency distribution for Oriental Weatherloach, Gunbower Forest, March 2015. Broken line indicates size at maturity.

3.3.2 Large-bodied Fish

Freshwater Catfish *Tandanus tandanus*

Six Freshwater Catfish were recorded during monitoring at two sites, Phyland and Turners Lagoons. The highest abundance was recorded from Phyland Lagoon where five young of year (<100mm) individuals were recorded. One sub-adult female (TL=228mm) was recorded from Turners Lagoon (Table 2, Figure 20).

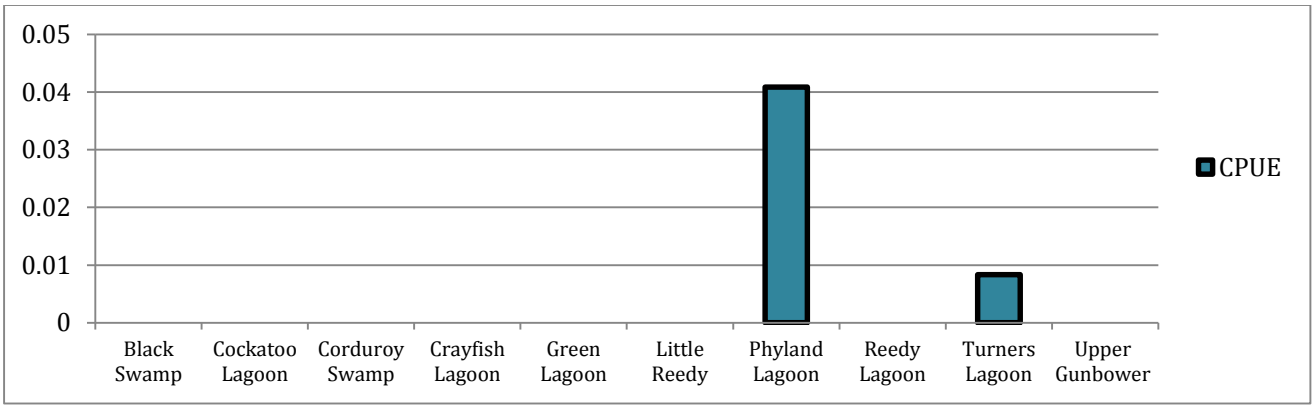

Figure 20: Freshwater Catfish CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Length at sexual maturity not indicated previously as no individual exceeded this size range. Young of year and sub-adult fish only were detected. Size at sexual maturity after Davis (1977) defined as 395-460mm (~ 4-5 years) for males and females respectively. Consistent recruitment, at least in the last two to three years is evident with 2012 and 2013 cohorts detected (Figure 21). The presence of an older cohort in Turners and juvenile fish in Phyland Lagoon is of note and consistent with previous observations (Sharpe et al, 2012 and Sharpe et al; 2013).

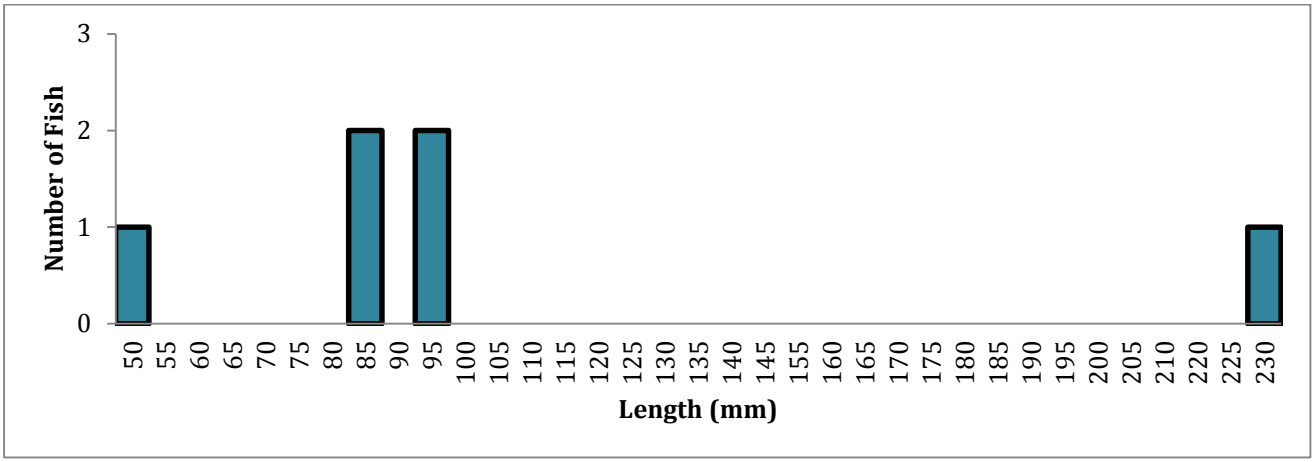

Figure 21: Length-frequency distribution for Freshwater Catfish, Gunbower Forest, March 2015.

Golden Perch *Macquaria ambigua*

An individual Golden Perch (TL=502mm) was collected from the Upper Gunbower Lagoon site. This individual was the only large bodied native species collected from all sites.

European Carp *Cyprinus carpio*

307 European Carp were recorded during survey and was the most abundant large bodied fish overall. The highest abundance was recorded from Green Lagoon wetland site with 196 individuals (Table 2, Figure 22). This species was recorded in low to moderate abundance (between 2 and 36 individuals) at all sites with higher abundance typically recorded at lagoon sites (i.e. 26 for Upper Gunbower and 35 for Phyland Lagoons.

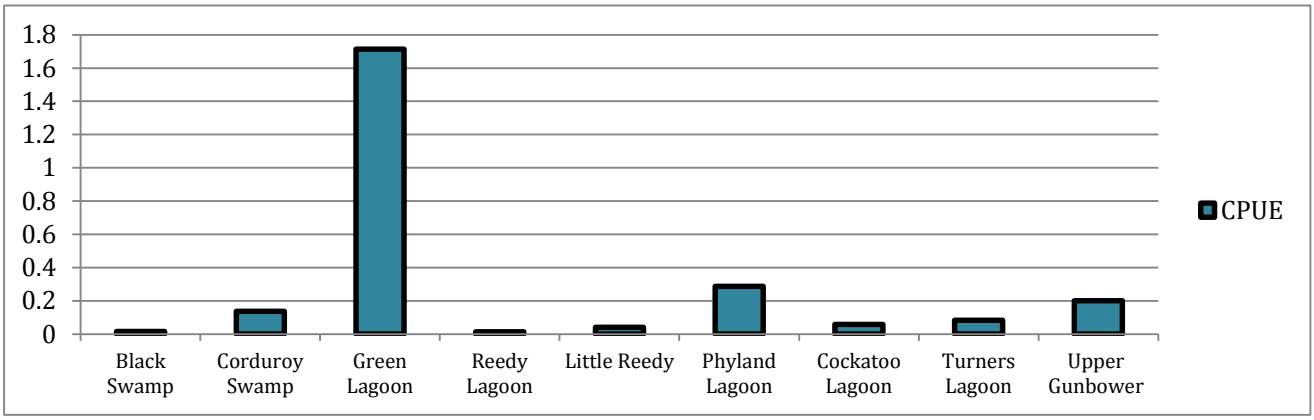

Figure 22: European Carp CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

Length-frequency of individuals measured (*n*=161) indicates multiple cohorts between one and ten years plus within the population. There is however a notable absence of two to three year old fish recorded. All other cohorts for the past ten years are otherwise represented in the population (Figure 23). The largest European Carp (TL=670mm) was recorded from the Little Reedy wetland site. Approximately 50% of the individuals measured were of the one to two year old cohorts. Periodic increases in length-frequency of larger size classes reflect known length-age relationships for the species again suggesting regular recruitment into the European Carp population in Gunbower Forest.

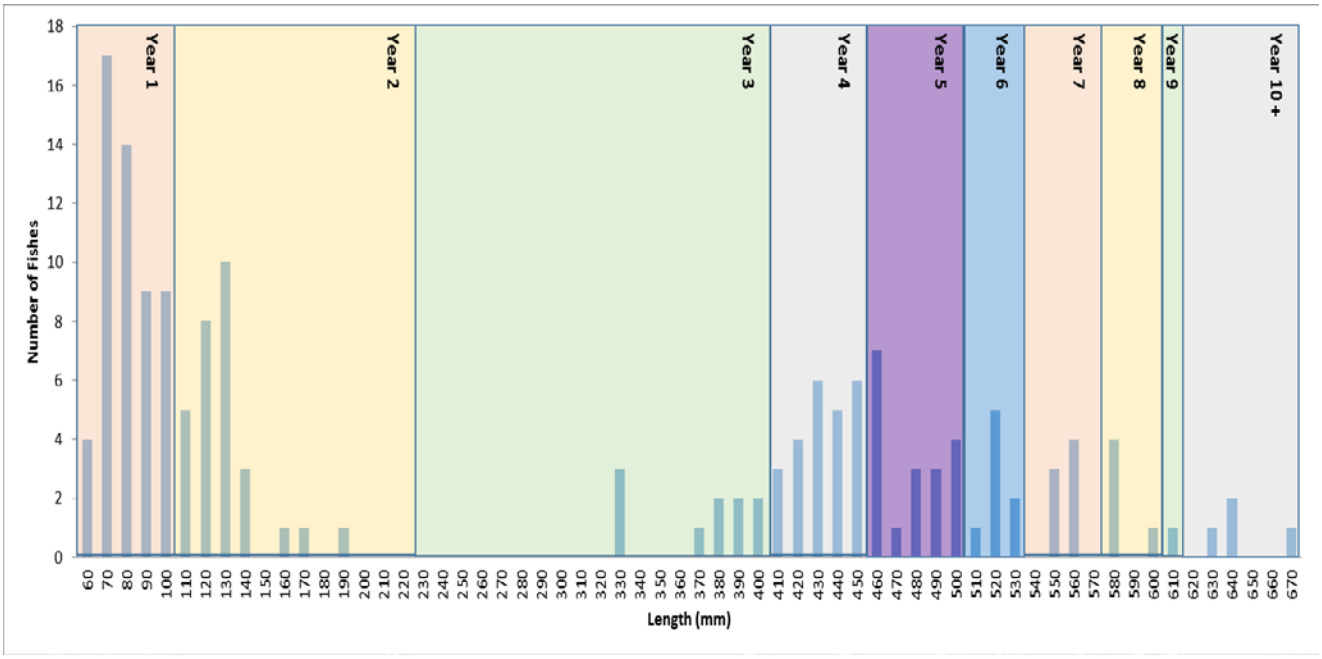

Figure 23: Length-frequency distribution for European Carp, Gunbower Forest, March 2015. Border between 1 and 2 year size classes indicates size at maturity. Shaded cells indicate age classes after Vilizzi and Walker, 1999.

Goldfish *Carassius auratus*

Ninety-four Goldfish were recorded during survey and were the second most abundant large bodied fish species overall. The highest abundance was recorded in Reedy Lagoon (*n*=40). Abundance at other survey sites ranged from 2 to 17 individuals but was absent from Black Swamp and Cockatoo Lagoon (Figure 24, Table 2). The population detected within Reedy Lagoon was comprised of young of year fish (40 to 85mm).

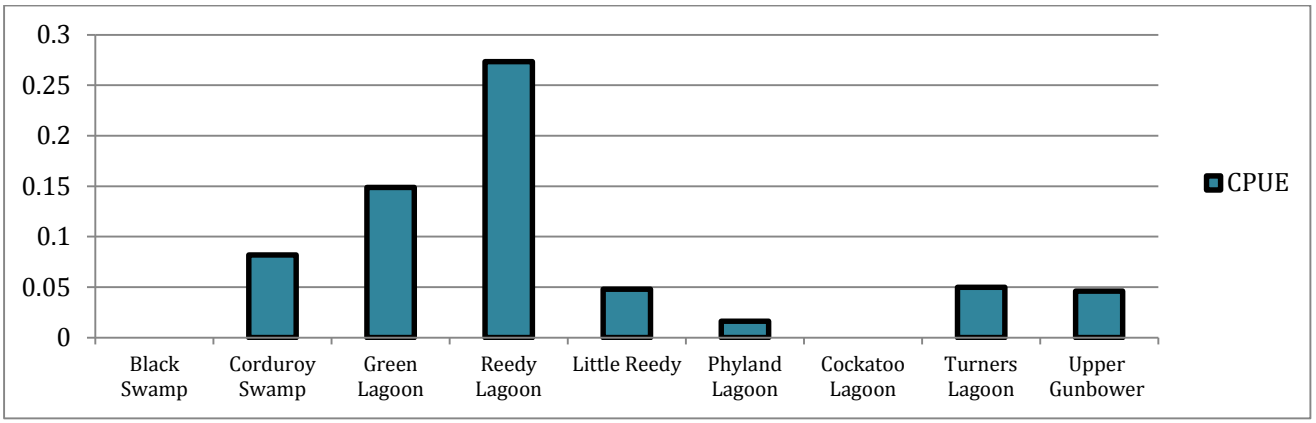

Figure 24: Goldfish CPUE (number of fish/hr) for Gunbower Forest fish monitoring, March, 2015.

The Goldfish population is dominated by one and two year old cohorts (~87%). There are however individuals representing a continuous range of older cohorts suggesting consistent recruitment within the population over time (Figure 25). Larger individuals were typically recorded from lagoon sites. The largest individual was recorded from Upper Gunbower Lagoon (TL=325mm). The population is also typified by low numbers of mature fish (> 2 years or 100mm).

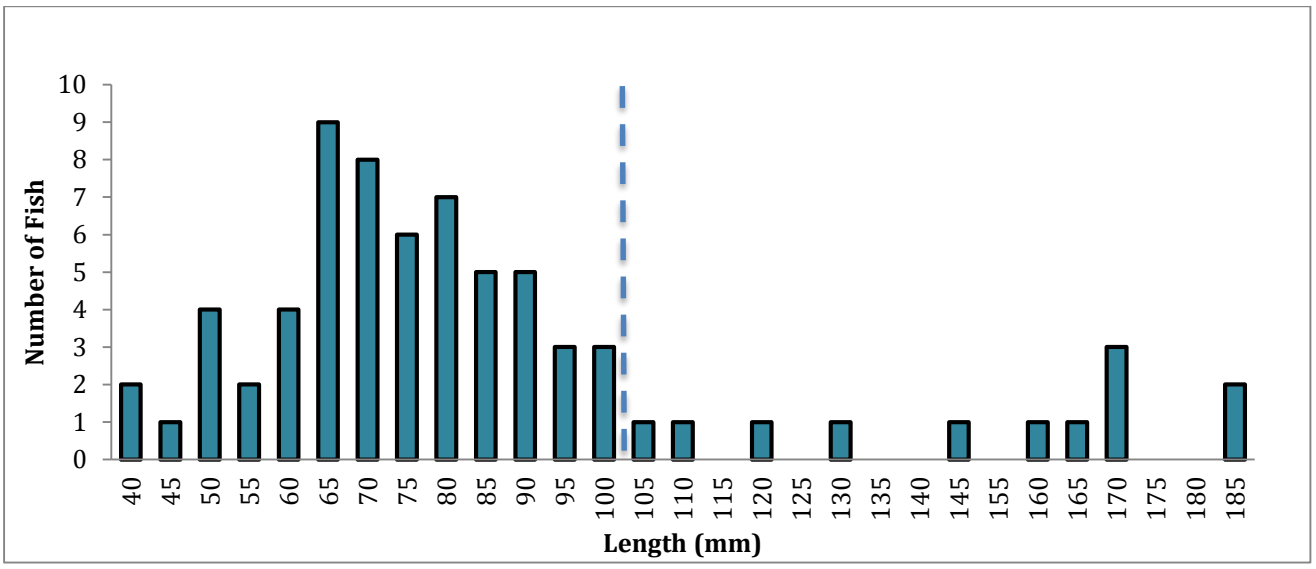

Figure 25: Length-frequency distribution for Goldfish, Gunbower Forest, March 2015. Broken line indicates size at maturity.

3.4 Population Monitoring Comparison (2012-2015)

A comparison of fish monitoring results over the past three years (2012 to 2015) for wetland and lagoon sites sampled in 2015 is presented in Appendix 1. Only two large bodied large bodied native fish, Freshwater Catfish and Golden Perch, have been recorded at these sites in the last three years. An individual Golden Perch has been consistently recorded in the Upper Gunbower Lagoon and low numbers of Freshwater Catfish again consistently at two sites; Phyland and Turners Lagoons. Of the large bodied exotic species, comparatively low to moderate abundance has been recorded at all sites in all years with the exception of Turners Lagoon and Little Reedy where the species was not recorded in 2012-2013. The highest abundance in each year has been recorded in Green Swamp though comparative abundance was recorded in both Corduroy and Charcoal Swamps in 2012-2013. Both of these sites were dry at the time of survey in 2013-14 as was Charcoal Swamp in 2015 (current survey).

Goldfish abundance appears to be patchy with regard to particular sites, absent some years (2012-13 at Crayfish and Green) and in relatively high abundance at the same sites in other years (2013-14). Consistent levels of abundance have been recorded at lagoon sites and fluctuations in abundance have been recorded for wetland sites, presumably in response to variable flows in these more dynamic habitat types.

Carp Gudgeon are consistently the most abundant species recorded with the greatest abundance recorded during the current years survey except for Phyland Lagoon where 2,996 were recorded in 2012-13 and 1,997 in 2015. Results for Eastern Gambusia are highly variable over the past three years with no discernible pattern apparent. This species is typically the second most abundant small bodied species over time and was recorded in high abundance in 2015 at all sites (between 42 and 10,152). Gambusia are however recorded in comparatively low abundances in 2012-13 (between 1 and 33). An increase in abundance is evident in 2013-14, particularly within the Reedy and Cockatoo Lagoon sites in 2013-14. Abundance recorded for wetland sites appears to have spiked dramatically in 2015 and displayed a moderate increase at lagoon sites. Of the other small bodied natives, levels of abundance appear to be consistently low with the exception of Un-specked Hardyhead. Eight-hundred individuals were recorded at Reedy Lagoon in 2013-14 and only one at the same site in 2015. Similarly high levels of abundance were recorded within the Upper Gunbower Lagoon in 2012-13 and 2013-14 (410 and 374 respectively) and only six individuals in 2015.

The Murray-Darling Rainbowfish has been recorded in low abundance in all years in wetland and lagoon sites. Australian Smelt have been recorded in lagoon sites only in the previous two years, but were recorded in similar abundance within lagoon and wetland sites in 2015. Flat-headed Gudgeon have been recorded in consistent numbers in lagoon sites only, with comparatively greater abundance at Turners and Phyland lagoons. This species was not recorded from these wetland sites in the previous two years; one individual was recorded in Little Reedy in 2015. Dwarf Flat-headed Gudgeon have only been recorded from lagoon sites in low abundance (between 1 and 3 individuals) between 2012 and 2015.

3.5 Freshwater Turtles

All three species of turtles native to the Gunbower area were captured during the 2015 surveys (Table 3) using large fyke nets. *Chelodina logicollis*, the Eastern Long-necked Turtle was most frequently captured with 63 individuals recorded. The greatest abundance for this species was recorded from Reedy Lagoon (*n*=23) and Little Reedy complex (*n*=17). Two adult female Broad-shelled Turtles (*Chelodina expansa*) were collected from in Phyland Lagoon and both were found to be gravid. In addition to this, a single juvenile Murray River turtle *Emydura macquarii* entering its third year was also recorded in Black Swamp. Of the 63 eastern long-necked turtles captured during surveys only two individuals were not of a pubescent or adult size class (Figure 26). While for lentic habitats it is expected that in unbaited fyke nets will principally capture turtles of a larger

size, the lack of relatively smaller individuals captured during surveys is of concern. Age class of individuals is presented in Appendix 3.

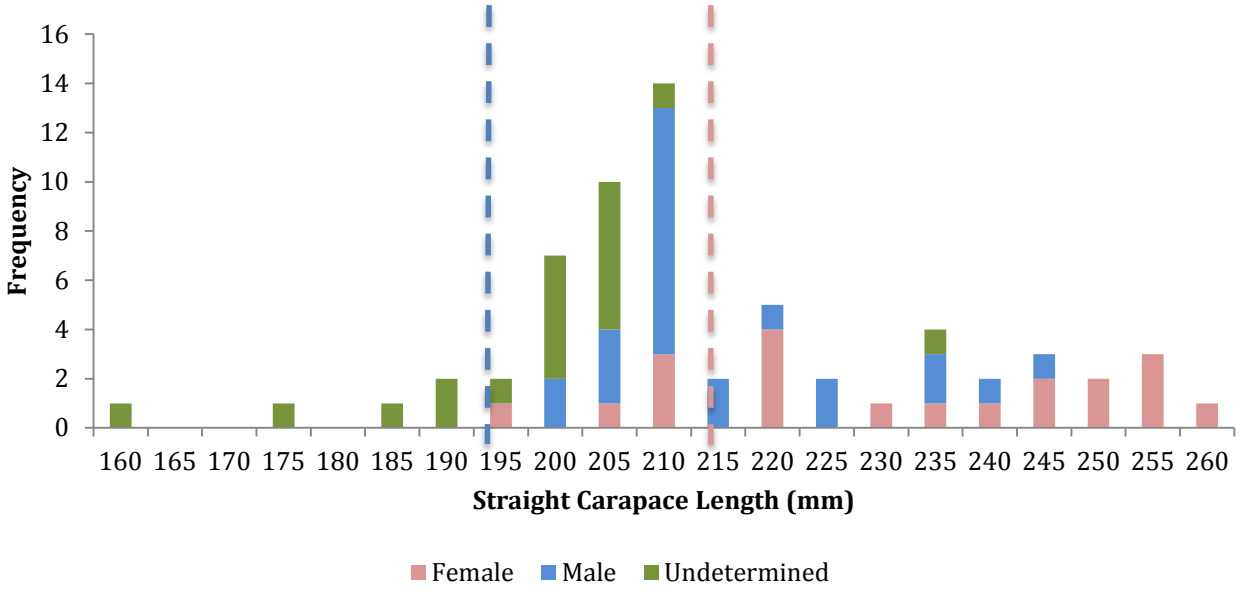

Figure 26: Size frequencies of Chelodina longicollis captured during the 2015 surveys. Blue broken line indicates maximum size at maturity for males (180 – 190 mm) and pink broken line indicates size at maturity for females (210 mm). After Kennett and Georges (1990).

Table 3: Results of Freshwater Turtles captured during monitoring, March 2015.

Site	Eastern Long-necked Turtle	Murray River Turtle	Broad-shelled Turtle
Black Swamp	4	1	
Cockatoo Lagoon	4		
Corduroy Swamp	8		
Crayfish Lagoon			
Green Lagoon	6		
Little Reedy	17		
Phyland Lagoon			2
Reedy Lagoon	23		
Turners Lagoon	1		
Upper Gunbower			
TOTALS	**63**	**1**	**2**

3.6 Water Quality

Water temperature was relatively stable between sites, typically 18-20◦C degrees, the exception being Little Reedy wetland (26.87°C) which was sampled when atmospheric temperatures were in excess of 37◦C. This was presumably exacerbated by extensive areas of shallow water. Measures of pH were typically between 6 and 7, though 8.1 was recorded for Little Reedy wetland. Electrical conductivity was typically low (<0.2 mS/cm). The highest value was recorded at Reedy Lagoon (0.292 mS/cm). Dissolved oxygen was inconsistent between sites and in excess of expected diel variability. Water availability and quality was variable between both habitat types (lagoon and wetland) and within habitat types (wetlands). Dissolved oxygen was typically higher in lagoon sites with the exception of Upper Gunbower lagoon (5.4 mg/L). The lowest and highest levels of dissolved oxygen were recorded in wetland sites (Black Swamp – 3.75 mg/L; Reedy Lagoon 9.34mg/L) (Table 4).

Table 4: Water quality results for Gunbower Forest Fish Monitoring, March, 2015.

Site	Time : Date	Temperature (◦C)	pH	Electrical Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%sat.)	Turbidity (NTU)
Black Swamp	**8.15am : 16.3.2015**	19.18	6.36	0.18	3.75	41.8	40.2
Reedy Lagoon	**11.45am : 18.3.2015**	19.51	6.72	0.292	9.34	104.6	25
Corduroy Swamp	**12.45pm : 19.3.2015**	19.36	7.16	0.181	8.02	89.7	8.9
Crayfish Lagoon	**8.45am : 17.3.2015**	17.92	6.11	0.166	4.5	48.9	20
Green Lagoon	**6pm : 19.3.2015**	18.27	6.79	0.137	4.72	51.7	297
Little Reedy	**2.30pm : 19.3.2015**	26.87	8.1	0.182	9.87	102.7	99.7
Phyland Lagoon	**4.30pm : 15.3.2015**	21.1	7.6	0.218	7.5	86.6	66.8
Cockatoo Lagoon	**3pm : 19.3.2015**	20.16	5.97	0.073	8.04	87.8	18.6
Turners Lagoon	**4.35pm : 20.3.2015**	20.97	7.73	0.74	9.11	103.9	16
Upper Gunbower	**12pm : 16.3.2015**	20.4	6.25	0.056	5.4	62	17.9

3.7 Incidental Observations

Anumber of amphibian observations were made in the field. An individual adult Peron's Tree Frog *Litoria peronii* was recorded at Cockatoo Lagoon and Green Swamp. Numerous adult Plains Froglet *Crinia parinsignifera* were also recorded from Green Swamp.

4. Discussion

The fish community of the Gunbower Forest is defined by both habitat type and flow regimes within each habitat type. Both permanent lagoon and semi-permanent / ephemeral wetland habitats were surveyed during monitoring. The large bodied fish community within these habitats is dominated by exotic species, mainly European Carp, with typically younger cohorts (including young of year) found associated with wetland habitats. Small bodied native fish were relatively diverse within lagoon and wetland habitats though diversity was variable between sites within each habitat type, particularly in wetland habitats.

Two large bodied native species, Freshwater Catfish and Golden Perch were only recorded in lagoon habitats, consistent with previous years monitoring where large bodied natives, even juvenile phases were absent from wetland habitats (Rehwinkle and Sharpe, 2009; Rehwinkle et al, 2010; Sharpe et al, 2011; Sharpe et al, 2012; Sharpe et al 2013). Freshwater Catfish were again only recorded from two lagoon sites, consistent with previous years and indicate a highly restricted distribution for this species within the Gunbower Forest. Consistent evidence of breeding and recruitment throughout the monitoring period (2008-2015) further indicates the value of these sites for this threatened species. One Golden Perch was recorded from Upper Gunbower Lagoon, consistent with previous years monitoring where between one and four individuals have been recorded in lagoon habitats in each year. No juvenile Golden Perch have been recorded in recent years (2012-13) in lagoon habitats. Golden Perch have been more consistently recorded in channel habitats (Gunbower Creek) and this is considered preferential habitat for the species, though again low numbers of juvenile fish were recorded in 2010-11, possibly due to flood connection to the Murray and are absent from all habitats in 2012-13. Improvements to fish passage (Torrumbarry, Yarran Creek, Gunbower Creek) and enhancements in flow delivery (Hipwell Rd, Headworks and Torrumbarry) in recent years are expected to improve access to breeding habitat and ultimately breeding potential for a number of large and small bodied native species in keeping with TLM objectives for fish.

Five small bodied native species were present within the Little Reedy wetland site, the greatest diversity of small bodied native fish for either habitat type. Two small bodied native species were recorded for Corduroy Swamp wetland. One individual Flat-headed Gudgeon was recorded at a wetland site (Little Reedy) and in moderate to high abundance at lagoon sites in 2015 (n=488 at Phyland Lagoon). This species does not appear to be accessing wetland habitats in recent years, though it was recorded in moderate abundance (n=4-43) between 2008 and 2010 in these habitats. The presence of a range of age / size classes for particular native species within wetlands subject to varying flow regimes is of interest and may benefit from more detailed investigation.

Flows within wetlands are more variable than for lagoon sites with some having persistent water over consecutive years (inter-annual - Green Swamp, Reedy Lagoon) and other wetland sites experiencing annual drying (ephemeral sites – Charcoal Swamp, Crayfish Swamp/Little Gunbower Wetland). These variable inundation periods also influence the fish community at each wetland site where a successional community is evident at certain sites (i.e. older cohorts of Australian Smelt and Un-specked Hardyhead at Reedy Lagoon). Certain species, such as Australian Smelt, Murray-Darling Rainbowfish and Un-specked Hardyhead are more mobile in response to flow variation (Lintermans, 2007; Humphries et al, 1999). While other species are expected to persist in floodplain wetland habitats with receding water levels (Carp Gudgeon and Eastern Gambusia). The low abundance or absence of more migratory species (i.e. Australian Smelt) from wetland habitats in 2012 and 2013 may be an artefact of migration of these species out of wetland habitats, retreating to channel and riverine refugia with receding waters.

In 2014, 60GL of environmental water was delivered to wetland habitats over a period of eight months from May to December 2014. This inundated an area of approximately 3,800 hectares with an estimated 60% of this area being wetland habitats. The commissioning of the Hipwell Road regulator was part of this delivery strategy. A fish exit strategy was incorporated within environmental flow delivery plan where variations in flows (reverse pulses) were initiated towards the end of the delivery period to stimulate movement of fish from the floodplain wetlands via flood channels. Future monitoring in wetland, lagoon, channel and riverine habitats will ultimately determine to what degree the recent environmental flow delivery mechanisms and improvements to fish passage has improved the viability of the native fish community within the Gunbower Forest. A review of the monitoring data with respect to these wetland types and flow regime may provide a greater insight to the fish population dynamics of these systems.

Large numbers of exotic species were recorded in lagoon and wetland habitats, both large (European Carp) and small bodied (Eastern Gambusia and Oriental Weatherloach). Eastern Gambusia were the second most abundant fish species detected during monitoring and were particularly abundant in wetland sites, being preferential habitat within the Gunbower Forest. The abundance of Eastern Gambusia has increased in recent years where higher numbers were detected in lagoon sites rather than wetland sites in 2012-2013 with the exception of Reedy Lagoon where 990 were recorded in 2013. 8,523 Eastern Gambusia were recorded from the same site in 2015. The impacts of Gambusia upon native fish are well known (Pyke, 2005; Rowe et al, 2008). Management options to reduce the abundance of this species could have positive implications for the diversity and abundance of native fish in keeping with TLM objectives and may be facilitated by the timing and frequency of environmental flows. Investigations into flow regime, timing and comparative abundance of Eastern Gambusia and other native species (Ho et al, 2012) found that Eastern Gambusia may be disadvantaged by regular flooding and that spring flooding resulted initially in increased abundance of native Carp Gudgeon.

European Carp are also present in high numbers at both lagoon and wetland sites. European Carp are a highly successful noxious species in regulated floodplain habitats (Stuart and Jones, 2006), with deleterious implications for the health of native fish populations (Koehn et al, 2000) and floodplain wetland environments (Vilizzi et al, 2013) and according to conservative estimates account for 80-90% of the fish bio-mass in the Murray-Darling basin (Lintermans, 2007). Management options for European Carp exclusion are being trialled as part of an independent investigation into the impacts of this species upon wetland vegetation. This has involved the placement of an exclusion fence across the flood-runner connecting Reedy Lagoon wetland. Two small individuals, able to pass through the exclusion fence were recorded at Reedy Lagoon, the lowest abundance recorded for this species at all sites. The investigation of the implications of employing similar structures to manage Carp incursions into wetland sites may have positive implications for the small bodied native fish community. The potential for these structures to impact upon large bodied native species in wetland habitats would need to be evaluated. No large bodied native fish (of any life stage) have been recorded in wetland habitats throughout the monitoring period, though one Golden Perch has been identified exiting the floodplain in 2015 (Kathryn Stanislawski, pers. comm.).

As the surveys coincided with the Broad-shelled Turtle nesting season, opportunistic nesting surveys were undertaken concurrently. While no egg shell fragments from predated nest or emerged nest were detected, two adult female Broad-shelled Turtles were observed undertaking nesting attempts. One of these females had already nested when she was discovered. As nesting was only commencing for Broad-shelled Turtles and it was some time since the Eastern Long-necked Turtle nesting season concluded it was not unusual that egg shell had not been detected. These capture records are reflective of the expected turtle populations of the Gunbower area. While Eastern Long-necked and Broad-shelled turtles are both wetland species, the Eastern Long-necked is relatively abundant in the area. Broad-shelled Turtle is both lower in abundance and less readily captured (Bower and Hodges, 2014). The Murray River Turtle is primarily a riverine species rather than a wetland species, while they would be present in some permanent wetlands this is not their preferential habitat (Chessman, 1988). As the areas surveyed were within lagoon and wetland habitats, it was

not expected that large numbers of Murray River Turtle would be captured. Murray River Turtle were typically collected in lagoon and creek macrohabitat sites in 2012 (Sharpe et al, 2012) and 2013 (Sharpe et al, 2013). In addition to this the chosen fyke net capture method biases data for both species and size class. The Murray River turtle is captured more effectively if baited cathedral traps are used (Chessman, 1988) which is not a method used for the fish monitoring project.

5. Conclusion

The structure and distribution of the fish community within the Gunbower Forest is variable and demonstrates the value of ongoing monitoring, particularly to ascertain the effectiveness of recent improvements to environmental flow delivery and fish passage. This will ultimately inform future environmental water management strategies and priorities for the Gunbower Forest.

While natural variability, even within managed systems is expected, the small bodied fish assemblage within wetland habitats has been extremely variable over the previous six years where species diversity has declined from six species in 2008-09 to one species in 2010-11. Five species were detected in wetlands in 2015. Wetlands, considered only as an overall macrohabitat type as has been done to date, may conceal the inherent variability between wetland sites. A review of the current data set, with respect to individual wetland sites will enhance our understanding of the dynamics of these systems and may refine the management units currently considered, as either discreet wetland types (semi-permanent or ephemeral) or as individual sites. This may have further implications for future management of the site. Improvements to the environmental flows delivery network for the Gunbower Forest may also enable more sensitive management of specific wetlands where priority ecological values are identified through this process.

6. Recommendations

- Continuation of the fish monitoring program is recommended to investigate the effectiveness of environmental flows delivery (Hipwell Rd regulator) and improvements to fish passage. This is of value given the recent inclusion of these elements in the environmental management infrastructure for the Gunbower Forest Icon Site.
- A review of the historical fish monitoring data set with a more detailed look at different wetland types, if not each wetland within the Gunbower Forest wetland complex. This information, correlated against flow data will provide a more comprehensive picture of the dynamics of fish populations within these more variable habitats. This may have implications for management in refining the criteria for these management units (either as semi-permanent or ephemeral wetlands or as individual wetlands) – beyond the scope of this report.
- Conduct an environmental risk assessment to determine the implications of exclusion fencing on flood runners connecting wetlands (i.e. barrier to large bodied fish passage – habitat utilisation). While exclusion is effective only during non-flood years. Exclusion of this species in intervening years will have presumably positive implications for wetland biota and reduce the reproductive output of European Carp by restricting access to large areas of breeding habitat.
- Investigate options to refine environmental water delivery to simulate a flooding schedule that enhances the breeding potential of native species over invasive species (i.e. spring flooding to increase numbers of Carp Gudgeon in wetlands).
- Consider refinement of the monitoring program to include criteria for reduction of larval fyke nets under certain circumstances due to animal welfare concerns. For example; initially conduct backpack electrofishing, bait trapping and water quality measurement at each site. The bait trap catch will indicate the abundance of small bodied native fish detectable using passive methods. If more than 500 individuals are recovered for a two hour soak time using bait traps, and dissolved oxygen is less than 50% saturation, reduce the number of larval fyke nets by half. This will still provide a comparative unit (CPUE) for comparison at both spatial and temporal scales within the existing monitoring program. The abundance and presence / absence of certain fish species, particularly large bodied native species may be more adequately evaluated at some wetland sites through the use of bank mounted electrofishing.

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Appendices

Appendix 1: Comparative Fish Monitoring Results (2012-2014)

Site Name	Year	Black Swamp (wetland)	Corduroy Swamp (wetland)	Crayfish Lagoon (wetland)	Green Lagoon (wetland)	Little Reedy Wetland (wetland)	Reedy Lagoon (wetland)	Charcoal Swamp (wetland)	Cockatoo Lagoon (Lagoon)	Phyland Lagoon (Lagoon)	Turners Lagoon (Lagoon)	Upper Gunbower Lagoon (Lagoon)
Golden Perch	2012	0	0	0	0	N	0	0	0	0	0	1
	2013	N	D	0	0	N	0	D	0	0	0	1
	2014	0	0	0	0	0	0	D	0	0	0	1
Freshwater Catfish	2012	0	0	0	0	0	0	0	0	3	1	0
	2013	N	D	0	0	N	0	D	0	3	1	0
	2014	0	0	0	0	0	0	D	0	5	1	0
Goldfish	2012	1	0	0	2	0	1	1	0	2	0	0
	2013	N	D	31	61	N	2	D	11	2	3	11
	2014	0	12	4	17	7	40	D	0	2	6	6
Carp	2012	4	95	3	99	0	23	92	9	24	0	6
	2013	N	D	23	53	N	49	D	4	10	25	11
	2014	2	20	3	196	6	2	D	7	35	10	26
Oriental Weatherloach	2012	0	2	0	1	0	1	1	0	1	0	0
	2013	N	D	0	1	N	0	D	1	1	0	2
	2014	1	38	1	9	5	6	D	2	2	0	1

Site Name	Year	Black Swamp (wetland)	Corduroy Swamp (wetland)	Crayfish Lagoon (wetland)	Green Lagoon (wetland)	Little Reedy Wetland (wetland)	Reedy Lagoon (wetland)	Charcoal Swamp (wetland)	Cockatoo Lagoon (Lagoon)	Phyland Lagoon (Lagoon)	Turners Lagoon (Lagoon)	Upper Gunbower Lagoon (Lagoon)
Unspecked Hardyhead	2012	0	0	0	0	0	0	0	41	3	80	410
	2013	N	D	0	0	N	800	D	0	8	20	374
	2014	0	0	0	0	7	1	D	1	12	12	6
Carp Gudgeon	2012	830	330	242	169	0	430	65	51	2996	82	80
	2013	N	D	302	33	N	2114	D	530	1035	739	435
	2014	8482	2815	35	1648	10792	12874	D	6231	1997	516	1114
Murray-Darling Rainbowfish	2012	0	0	0	1	0	0	0	0	0	1	0
	2013	N	D	0	0	N	0	D	0	0	6	0
	2014	0	0	0	1	14	0	D	0	0	0	0
Flathead Gudgeon	2012	0	0	0	0	0	0	0	0	257	22	0
	2013	N	D	0	0	N	0	D	2	249	265	7
	2014	0	0	0	0	1	0	D	3	488	204	2
Dwarf Flathead Gudgeon	2012	0	0	0	0	0	0	0	0	2	0	1
	2013	N	D	0	0	N	0	D	0	0	0	0
	2014	0	0	0	0	0	0	D	3	0	0	0
Australian Smelt	2012	0	0	0	0	0	0	0	2	0	13	0
	2013	N	D	0	0	N	9	D	0	1	69	9
	2014	4	8	0	4	46	13	D	0	9	10	0

Site Name	Year	Black Swamp (wetland)	Corduroy Swamp (wetland)	Crayfish Lagoon (wetland)	Green Lagoon (wetland)	Little Reedy Wetland (wetland)	Reedy Lagoon (wetland)	Charcoal Swamp (wetland)	Cockatoo Lagoon (Lagoon)	Phyland Lagoon (Lagoon)	Turners Lagoon (Lagoon)	Upper Gunbower Lagoon (Lagoon)
Gambusia	2012	18	0	16	1	0	1	2	33	2	6	9
	2013	N	D	80	9	N	990	D	371	3	135	39
	2014	1845	3811	71	578	10152	8523	D	243	42	588	120

Appendix 2: Fish Monitoring CPUE Results (2014)

SITE		Black Swamp	Cockatoo Lagoon	Corduroy Swamp	Crayfish Lagoon	Green Lagoon	Little Reedy Wetland	Phyland Lagoon	Reedy Lagoon	Turners Lagoon	Upper Gunbower
Unspecked Hardyhead	*n=*	-	1	-	-	-	7	12	1	12	6
	CPUE	-	0.008	-	-	-	0.048	0.098	0.007	0.100	0.046
Carp Gudgeon	*n=*	8482	6231	2815	35	1648	10792	1997	12874	516	1114
	CPUE	69.34	50.95	19.24	16.28	14.41	73.75	16.33	87.98	4.30	8.55
Golden Perch	*n=*	-	-	-	-	-	-	-	-	-	1
	CPUE	-	-	-	-	-	-	-	-	-	0.008
Murray-Darling Rainbowfish	*n=*	-	-	-	-	1	14	-	-	-	-
	CPUE	-	-	-	-	0.009	0.096	-	-	-	-
Flathead Gudgeon	*n=*	-	3	-	-	-	1	488	-	204	2
	CPUE	-	0.025	-	-	-	0.007	3.990	-	1.701	0.015
Dwarf Flathead Gudgeon	*n=*	-	3	-	-	-	-	-	-	-	-
	CPUE	-	0.025	-	-	-	-	-	-	-	-
Australian Smelt	*n=*	4	-	8	-	4	46	9	13	10	-
	CPUE	0.033	0.000	0.055	-	0.035	0.314	0.074	0.089	0.083	-
	n=	-	-	-	-	-	-	5	-	1	-

Freshwater Catfish	CPUE	-	-	-	-	-	-	0.041	-	0.008	-
Oriental Weatherloach	*n=*	1	2	38	1	9	5	2	6	-	1
	CPUE	0.008	0.016	0.260	0.465	0.079	0.034	0.016	0.041	-	0.008
Goldfish	*n=*	-	-	12	4	17	7	2	40	6	6
	CPUE	-	-	0.082	1.860	0.149	0.048	0.016	0.273	0.050	0.046
Carp	*n=*	2	7	20	3	196	6	35	2	10	26
	CPUE	0.016	0.057	0.137	1.395	1.714	0.041	0.286	0.014	0.083	0.200
Gambusia	*n=*	1845	243	3811	71	578	10152	42	8523	588	120
	CPUE	15.082	1.987	26.043	33.023	5.055	69.376	0.343	58.244	4.904	0.921

Appendix 3: Results of Turtle Population Monitoring

Appendix 3: Results of Turtle Population Monitoring

Common Name	Species name	SCL (mm)	PL (mm)	life stage	sex	Comments
Eastern Long-necked turtle	Chelodina longicollis	231	179	adult		
Eastern Long-necked turtle	Chelodina longicollis	192	151	pubescent	female	
Eastern Long-necked turtle	Chelodina longicollis	238	190	adult	female	
Murray River turtle	Emydura macquarii	44	34	post hatchling		Entering 3rd year by scutes
Eastern Long-necked turtle	Chelodina longicollis	252	198	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	190	150	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	210	168	adult		
Eastern Long-necked turtle	Chelodina longicollis	192	158	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	188	152	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	251	198	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	209	168	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	209	166	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	204	160	pubescent	female	
Eastern Long-necked turtle	Chelodina longicollis	208	166	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	209	162	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	223	170	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	208	168	pubescent	female	

Common Name	Species name	SCL (mm)	PL (mm)	life stage	sex	Comments
Eastern Long-necked turtle	Chelodina longicollis	219	175	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	199	161	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	196	148	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	198	158	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	198	172	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	204	158	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	241	192	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	235	180	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	210	168	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	200	160	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	220	170	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	201	160	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	204	158	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	210	168	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	210	158	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	182	148	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	206	174	adult	male	
Broad-shelled turtle	Chelodina expansa	315	224	adult	female	
Broad-shelled turtle	Chelodina expansa	325	234	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	246	196	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	212	162	adult	male	

Common Name	Species name	SCL (mm)	PL (mm)	life stage	sex	Comments
Eastern Long-necked turtle	Chelodina longicollis	248	192	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	202	160	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	256	208	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	202	160	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	204	162	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	234	192	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	158	124	juvenile		
Eastern Long-necked turtle	Chelodina longicollis	252	204	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	242	198	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	220	176	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	242	194	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	232	184	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	206	164	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	196	154	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	208	164	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	237	182	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	200	160	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	202	164	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	218	178	adult	female	
Eastern Long-necked turtle	Chelodina longicollis	218	166	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	228	180	adult	female	

Common Name	Species name	SCL (mm)	PL (mm)	life stage	sex	Comments
Eastern Long-necked turtle	Chelodina longicollis	175	143	juv		
Eastern Long-necked turtle	Chelodina longicollis	212	170	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	222	172	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	202	158	pubescent		
Eastern Long-necked turtle	Chelodina longicollis	202	162	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	210	160	adult	male	
Eastern Long-necked turtle	Chelodina longicollis	210	160	adult	female	