Carp surveys of the Logan and Albert Rivers Catchment, 2006-2009

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Front cover photo: Tagged carp in the Logan River (Andrew Norris).

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1. Introduction

In 2006, a benchmarking fisheries assessment survey found that the Logan and Albert rivers catchment was heavily infested with carp. Benchmarking entailed electrofishing surveys at 28 sites across the catchment. The purpose was to document the status of carp and native fish species in the rivers before implementing carp management actions.

In 2007, research began into the cost effectiveness of a range of carp management strategies in parts of the catchment. As part of this research, we repeated electrofishing surveys at 18 of the 28 benchmarking sites in 2007. Heavy rains and a series of high-flow events prevented repeat sampling at the remaining ten sites. The repeated surveys were designed to detect changes in fish assemblages and habitat conditions due to both environmental variables and carp management actions. Treatment and control sites were sampled to assess the role of these factors.

In 2009, the research program on carp management strategies was completed and we assessed changes in the fish assemblages based on a final fisheries assessment survey. We electrofished at 17 sites encompassing areas where there had been intense carp removal, control areas where there had been no carp removal, and areas where carp had been removed in previous years. The survey results, presented in this report, detail the distribution, biomass and density of carp in the catchment and enable the impact of carp management activities to be assessed.

2. Methods

Electrofishing was used in the comparative fisheries assessments of the Logan and Albert rivers catchment. Electrofishing works by generating an electric field between anodes and cathodes placed in the water. The current causes muscle contraction and temporary paralysis, and most fish will float to the surface where they can be netted. Stunned fish usually recover quickly when the power is switched off. Unfortunately, fish in deep water are not often captured. During the project three different electrofishing methods (backpack, small boat and large boat) were used depending on local site conditions.

Backpack unit

The Smith–Root LR4 and LR24 backpack electrofishing units were used to sample bodies of water where the depth was typically less than 1.2 m. We electrofished with five standardised passes along each stretch of river, with each pass consisting of standard power on times as the operator manoeuvred in and out of bankside vegetation along 50 m of the river. The ends of passes were bounded by stop nets to prevent startled fish escaping. Total power on time for each pass was approximately 600 seconds at voltages between 300–600 V. Stunned fish were dip-netted from the water, and then transferred to a 72 L live-well on the bank. At the end of each pass fish were anaesthetised, identified and counted. For each pass, introduced species and those of commercial and/or recreational fishery interest were weighed and measured. Lengths were measured to the tip of the tail for species with rounded tails (eg Mary River cod, Figure 1) or to the fork of the tail for species with forked tails (eg Australian bass, Figure 2). All fish were released after recovering from anaesthesia.

Figure 1. Juvenile Mary River cod: note the rounded tail. Image: Keith Chilcott

Figure 2. Australian bass: note the forked tail. Image: Michael Hutchison

Small boat

In many river reaches and shallower lagoons a small punt with a 2.5 kV Smith–Root electrofishing unit was used. The set-up consisted of a 3.6 m punt with two anode poles attached to the front. The hull acted as the cathode and a single person used a net up front. The effective stunning range was approximately 2–3 m but varied according to water temperatures and conductivities. We electrofished with six standardised passes at various points around the margins of larger water bodies and river reaches. Each pass consisted of standard power on times and boat manoeuvres in and out along 50 m of the shore or its vegetated margins, and a 50 m mid-water run 10–15 m out and parallel to the shoreline (Figure 3). Total power on time for each pass was approximately 300 seconds and the voltage used was 500 V. During electrofishing stunned fish were dip-netted from the water, and then transferred into an onboard 72 L live-well. At the end of each pass fish were anaesthetised, identified, counted, weighed, measured and released.

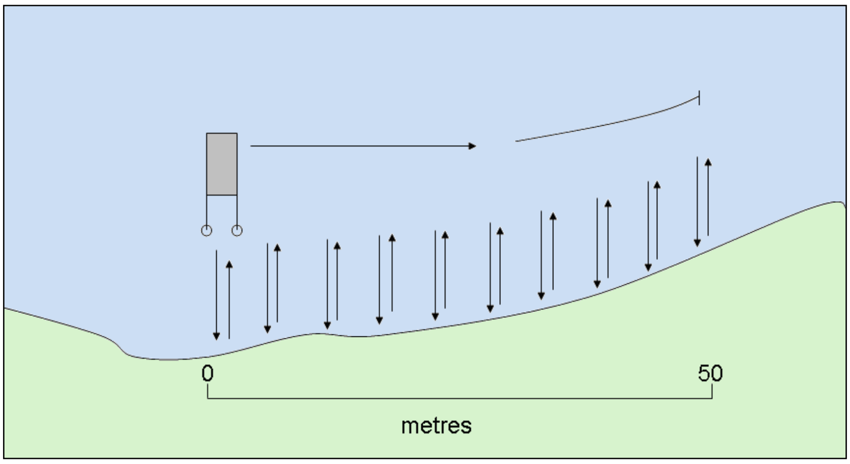


Figure 3. Standard electrofishing pass used in the boats in dams, lagoons and river reaches. Total power on time was approximately 300 seconds.

Large boat

In large lagoons, irrigation dams and open river reaches, a large electrofishing vessel was used. This unit consisted of a 6 m plate alloy hull with a 7.5 kV Smith–Root electrofishing unit attached. Two netters operated up the front around the two anode booms, which had an effective range of 3–4 m (Figure 4). We electrofished with six standardised passes at various points around the margins of larger water bodies and rivers.

Figure 4. Large electrofishing boat in operation. Image: Michael Hutchison

Each pass consisted of standard power on times and boat manoeuvres in and out along 50 m of the shore or its vegetated margins, and a 50 m mid-water run 10–15 m out and parallel to the shoreline (Figure 3). Total power on time for each pass was approximately 300 seconds and the voltage either 500 V or 1000 V, depending on water conductivities. During electrofishing, stunned fish were dip-netted from the water and transferred into onboard live-wells. At the end of each pass fish were anaesthetised, identified, counted, weighed, measured and released.

Data analysis

Changes in carp catch density and biomass between years at paired control and intervention sites were analysed using GenStat (2008), via repeated-measures analyses of variance (Rowell and Walters 1976), with the observations at each site being repeated across years. The site was taken as the independent experimental unit, and passes within sites considered as subsamples. Pairs of sites were used as the blocking term, where appropriate. The validity of the analytical assumptions was checked via residual plots. Carp density proved to be positively skewed with heterogeneous variance, so the log10-transformation was used to stabilise this variable for analysis. Direct (rather than bias-corrected) back-transformations were used, so these estimates equate to geometric means. The standard Normal model was appropriate for the analyses of biomass and weight. We separately analysed the 2006–2007 and the 2007–2009 time periods, as some different sites were used for comparisons over the years.

3. Results

In 2006, 28 sites throughout the catchment were surveyed, with the number evenly spread between the Logan and Albert river basins. In 2007, only 18 sites were able to be surveyed. Two new sites were included in the 2007 survey to help track changes in the project's research plan. In 2009, 17 sites were surveyed. These sites had all been previously monitored, with the majority having been surveyed in both 2006 and 2007.

In 2009, a total of 19 fish species were recorded, consisting of 16 native and three introduced species (Table 1). This was less than the 27 species recorded in 2006 and the 23 species recorded in 2007. The reduction in the number of sites surveyed is the most likely explanation for this. A total of 44 fish species have been previously reported in the freshwater reaches of the catchment (Hutchison et al 2002, Jebreen et al 2002, Pusey et al 2004, Hutchison personal communication), but many of these are rare or predominantly found in the estuarine reaches.

Table 1. Number of sites at which fish species were found in the 17 sites surveyed in 2009.

Introduced species	Albert River sites	Logan River sites	Total
Carp, *Cyprinus carpio*	7	6	13
Mosquitofish, *Gambusia holbrooki*	6	7	13
Tilapia, *Oreochromis mossambicus*	0	1	1
Native species			
Firetail gudgeon, *Hypseleotris galii*	8	5	13
Long-finned eel, *Anguilla reinhardtii*	8	3	11
Duboulays rainbowfish, *Melanotaenia duboulayi*	7	4	11
Australian smelt, *Retropinna semoni*	6	3	9
Carp gudgeon, *Hypseleotris sp.*	3	5	8
Eel-tail catfish, *Tandanus tandanus*	5	3	8
Australian bass, *Macquaria novemaculeata*	4	3	7
Spangled perch, *Leiopotherapon unicolor*	3	4	7
Sea mullet, *Mugil cephalus*	0	4	4
Striped gudgeon, *Gobiomorphus australis*	2	2	4
Olive perchlet, *Ambassis agassizii*	1	3	4
Freshwater mullet, *Myxus petardi*	0	3	3
Flathead gudgeon, *Philypnodon grandiceps*	1	1	2
Dwarf flathead gudgeon, *Philypnodon macrostomus*	2	0	2
Empire gudgeon, *Hypseleotris compressa*	0	1	1
Fly-specked hardyhead, *Craterocephalus stercusmuscarum*	0	1	1

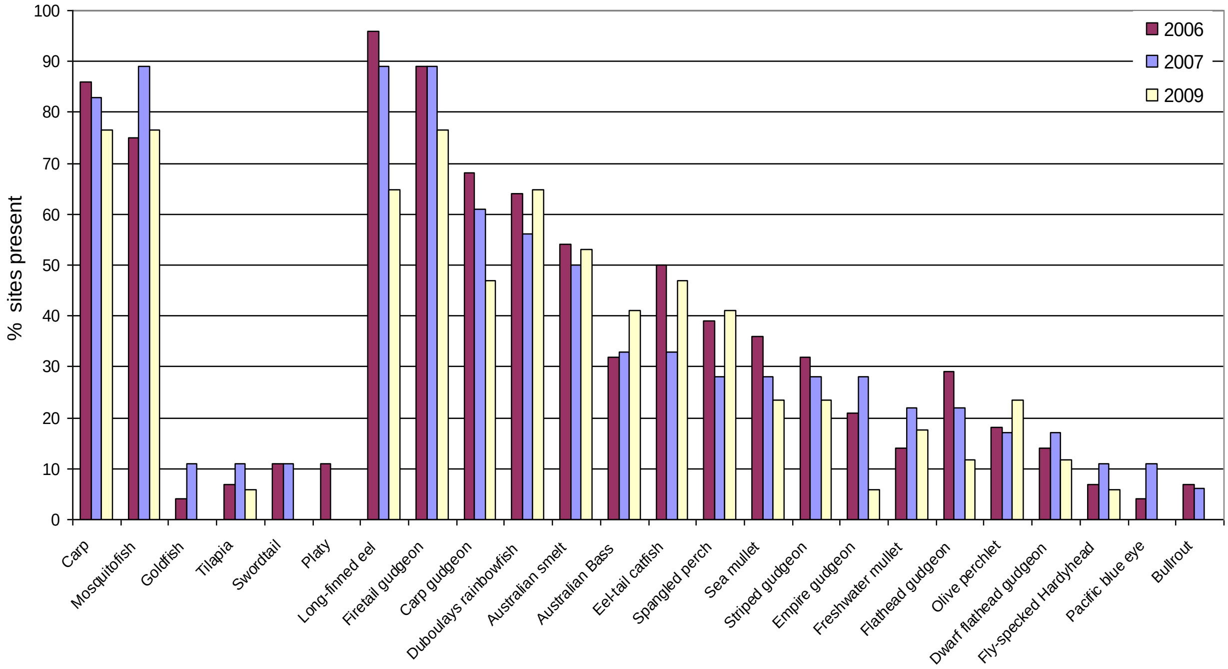


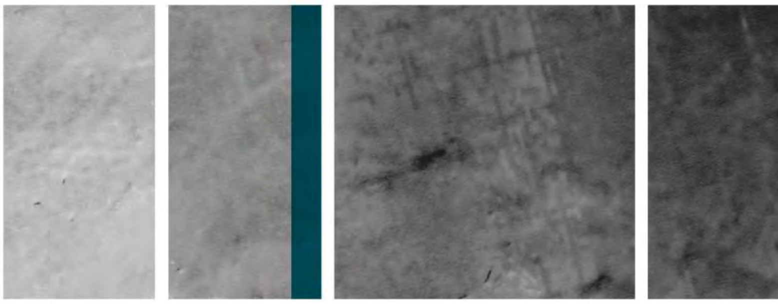
Figure 5. Prevalence of native and introduced fish species at survey sites in the Albert and Logan river systems during 2006, 2007 and 2009.

In the Albert River system (from here on referred to as ‘the Albert’), 14 species were observed and 18 species in the Logan River system (from here on referred to as 'the Logan'). The Logan had one more introduced species than the Albert. This species, Tilapia, was found at low density in the lower reaches where the environment was highly urbanised.

Carp

In total, 250 carp (38–650 mm fork length) were captured in riverline, lagoon and dam habitats during the 2006-2009 surveys. They were widespread throughout the catchment and were present at 13 of the 17 sites surveyed. Many carp were caught around fallen woody debris within the survey sections.

Almost nine times the number of carp were caught in the Albert (n=225) than the Logan (n=25), although more sites were surveyed in the Albert. The mean number of carp caught in the Albert was 22.5 fish per site and was strongly influenced by the high number of small carp found in several irrigation dams. In the Logan, the mean number of carp caught was 3.6 fish per site, approximately six times less than in the Albert. Many of the carp in the Albert were juveniles or small fish, while the Logan fish were typically larger. This is evident in the peak around 50–100 mm in the Albert carp length-frequency histogram (Figure 6). Small length-frequency peaks also occurred around 350–400 mm in the Albert, representing fish 3–4 years of age (Smith 2005). Very few carp greater than 450 mm were caught, suggesting low survival or recruitment from cohorts prior to 2004–2005.



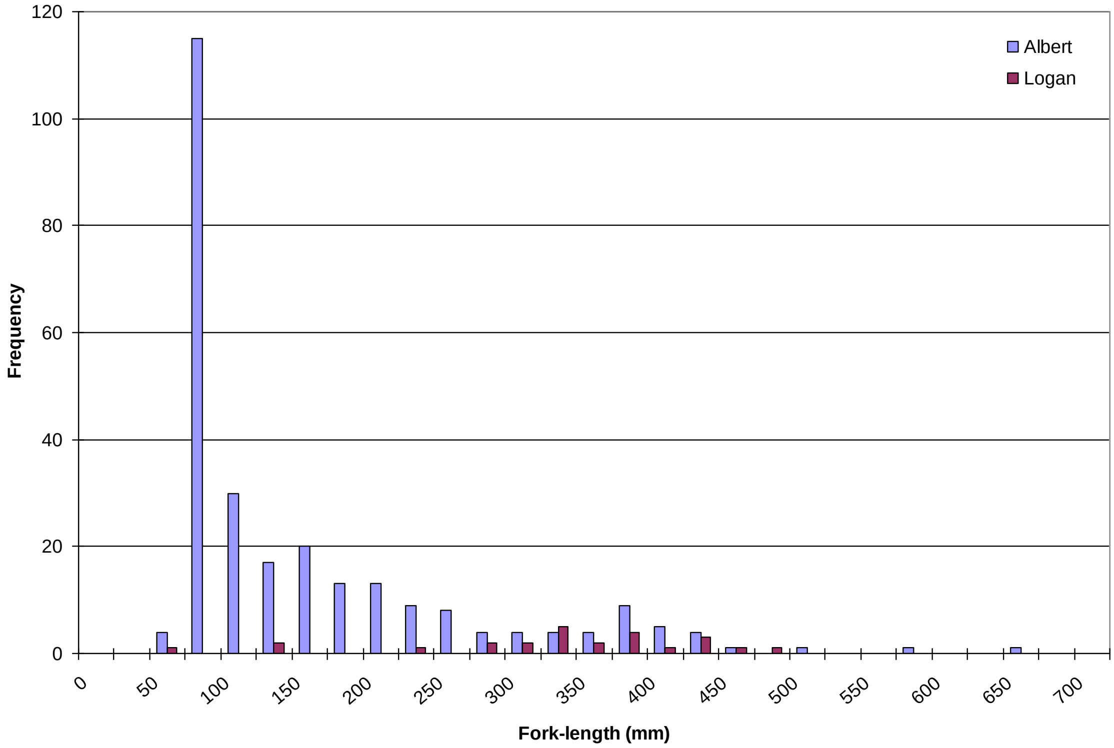


Figure 6. Carp length frequencies in the Albert and Logan river systems from the 2009 monitoring survey at 18 sites.

Carp catch densities ranged between 0-244 fish/ha and carp biomass from 0-38 kg/ha. Carp catch densities in lagoons and dams were more than eight times those of rivers and tributaries in the Albert (Figure 7). Conversely, in the Logan carp catch densities were twice as high in flowing waterways than still waters. Mean carp biomass was greater for lagoons in the Albert, but substantially higher (70 times) in the flowing waters of the Logan (Figure 7).

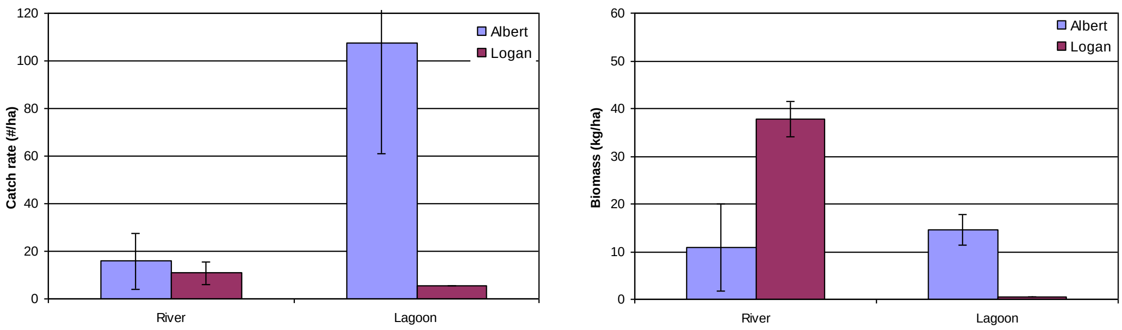


Figure 7. Mean carp catch densities (fish/ha ± SE) and catch biomass (kg/ha ± SE) for onstream and offstream sites in the Albert and Logan river systems.

Carp catch densities were greatest in the mid reaches of the Albert and the upper reaches of the Logan (Figure 8). Carp densities were more than three times greater in mid reaches than the lower reaches in the Albert. For each reach, the mean carp catch biomass was greater in the Logan than in the corresponding reach in the Albert (Figure 8). The greatest carp catch biomass was recorded in the mid reaches of the Logan. In the Albert, the highest carp catch biomass was recorded in the smaller upper reaches.

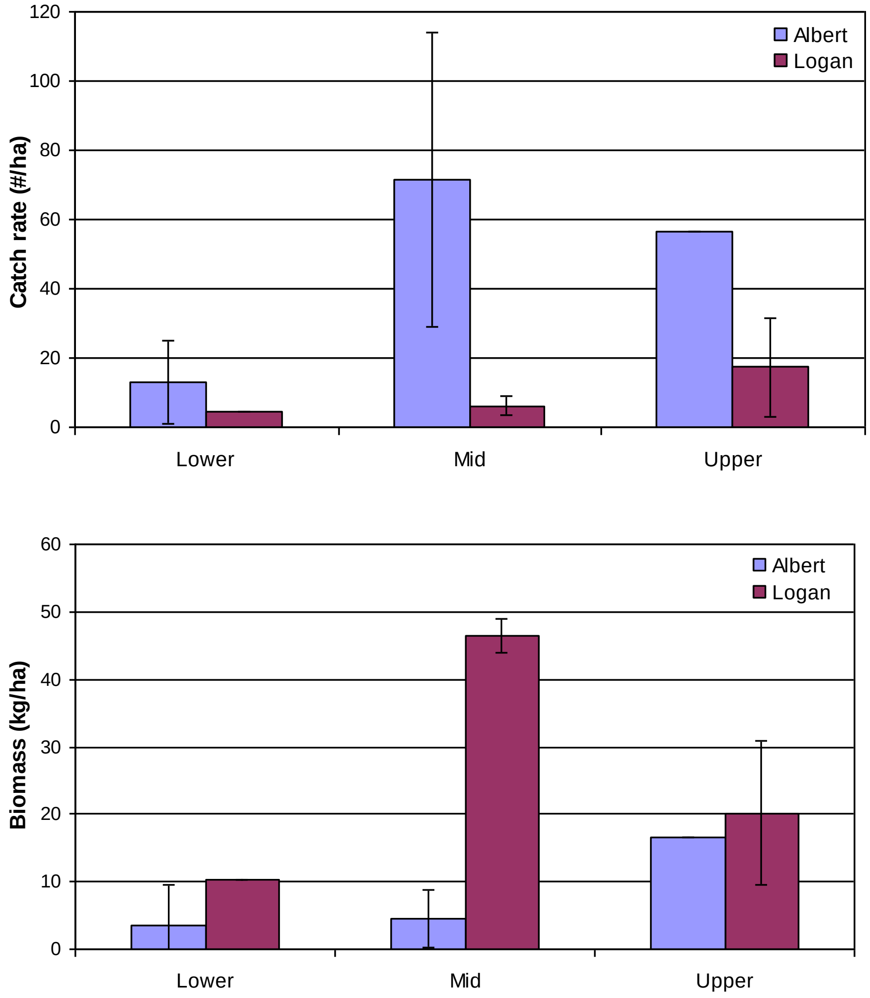


Figure 8. Mean carp catch densities (fish/ha ± SE) and catch biomass (kg/ha ± SE) for reaches of the Albert and Logan river systems.

Native species

Six native fish species considered to be of recreational or commercial interest were found in the catchment. Of these, five were sufficiently abundant to consider length-frequency and distribution characteristics.

Australian bass

Australian bass were heavily stocked in the catchment by recreational sports-fishing groups. The majority of the 37 bass captured during the surveys came from sites adjacent to stocking areas. They were present in seven of the 17 sites surveyed. The bass ranged in size from 100–355 mm fork length.

Long-finned eel

The most abundant large native fish species was the long-finned eel, which was recorded at 11 of the 17 sites surveyed. In total, 131 specimens of 80–925 mm length were caught (Figure 10). Long-finned eels were more abundant in the Albert in all size classes. Several very large eels were captured in dams in the Albert system.

Sea mullet

Sea mullet were abundant only in four of the 17 survey sites, all in the Logan, with a total of 108 captured during the surveys. No sea mullet were recorded in the Albert system. The mullet ranged in length from 85–445 mm fork length. Several small sea mullet (100–125 mm) were caught in the Logan system, suggesting that juveniles of this species had successfully navigated multiple vertical slot fishways that were present in the lower reaches.

Eel-tail catfish

In total, 57 eel-tail catfish were caught, ranging from 47–450 mm total length. Catfish were recoded at eight of the 17 survey sites. The high number of small fish (Figure 12) reflects a period of strong recruitment in the catchment, most likely associated with the heavy rainfall experienced during early and late 2008.

Spangled perch

A total of 107 spangled perch were captured at seven of the 17 sites surveyed, 34–192 mm in fork length (Figure 13). This species was far more common in the Logan, with a length-frequency peak at 90 mm. In the Albert, the low numbers recorded showed an evenly-spread length distribution. Few spangled perch were captured in offstream waterbodies in the mid reaches of the Albert.

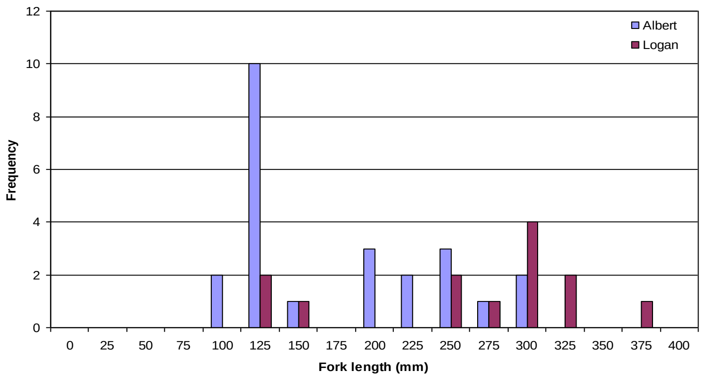


Figure 9. Length versus frequency of Australian bass, *Macquaria novemaculeata*, in the Albert and Logan river systems (n=37).

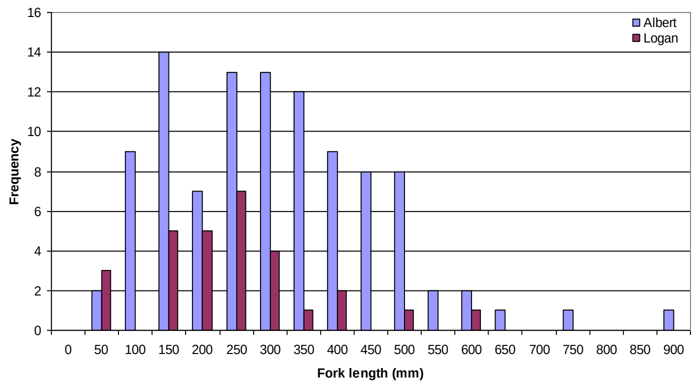


Figure 10. Length versus frequency of long-finned eels, *Anguilla reinhardtii*, in the Albert and Logan river systems (n=131).

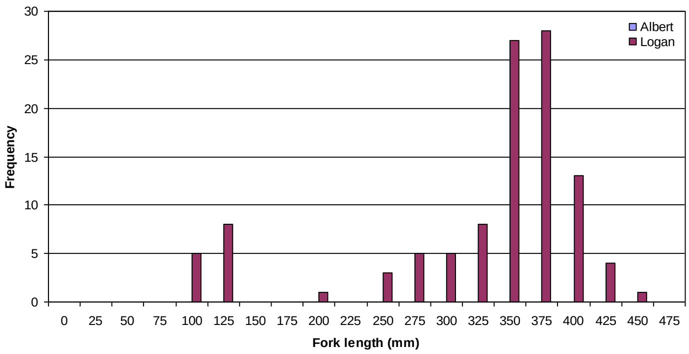


Figure 11. Length versus frequency of sea mullet, *Mugil cephalus*, in the Logan River system (n=108).

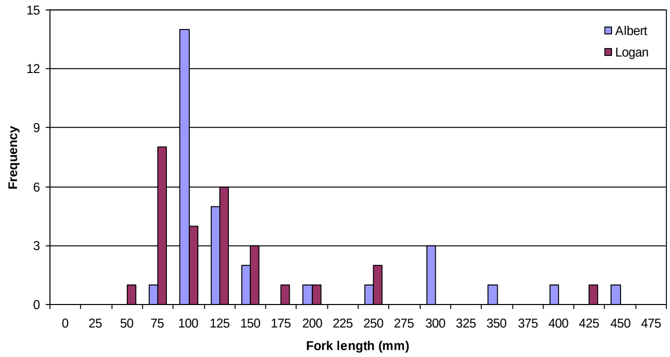


Figure 12. Length versus frequency of eel-tail catfish, *Tandanus tandanus*, in the Albert and Logan river systems (n=57).

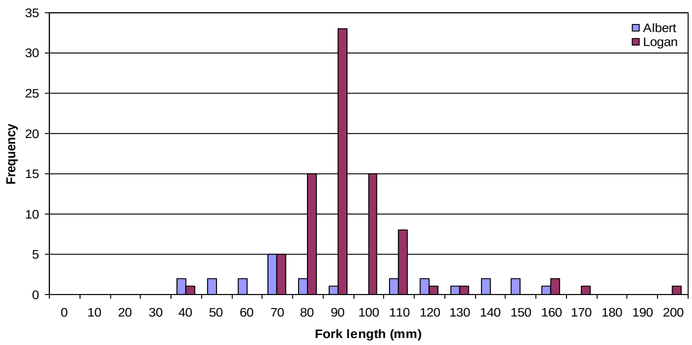


Figure 13. Length versus frequency of spangled perch, *Leiopotherapon unicolor*, in the Albert and Logan river systems (n=107).

Comparison between 2006, 2007 and 2009 surveys

The frequency of occurrence at survey sites demonstrated a generally declining trend for most species (Table 2). No species were substantially more prevalent in 2009 than they were in 2006.

Table 2. Frequency of occurrence at sampling sites for fish species recorded in the 2006, 2007 and 2009 catchment surveys.

Introduced species	Frequency (% of sites)		
	2006	2007	2009
Carp	86	83	76
Mosquitofish	75	89	76
Goldfish	4	11	0
Tilapia	7	11	6
Swordtail	11	11	0
Platy	11	0	0
Native species			
Long-finned eel	96	89	76
Firetail gudgeon	89	89	65
Carp gudgeon	68	61	47
Duboulays rainbowfish	64	56	65
Australian smelt	54	50	53
Australian bass	32	33	41
Eel-tail catfish	50	33	47
Spangled perch	39	28	41
Sea mullet	36	28	24
Striped gudgeon	32	28	24
Empire gudgeon	21	28	6
Freshwater mullet	14	22	18
Flathead gudgeon	29	22	12
Olive perchlet	18	17	24
Dwarf flathead gudgeon	14	17	12
Fly-specked hardyhead	7	11	6
Pacific blue eye	4	11	0
Bullrout	7	2	0

Across the catchment, carp populations experienced a steady decline between 2006 and 2009 (Figure 14). The mean number of carp caught in surveys only varied slightly between years, but the mean weight of individual carp decreased dramatically from 0.670 ±0.032 kg in 2006 to only 0.275 ±0.032 kg in 2009. Mean carp density in 2006 and 2007 was almost identical (approximately 50 carp/ha), but decreased by 30% in 2009. The maximum carp density detected each year was consistent and varied by less than 1.5%. The mean carp biomass displayed a linear trend, declining by approximately 11 kg/ha each year. The maximum recorded biomass declined dramatically between 2006 and 2007, before remaining constant.

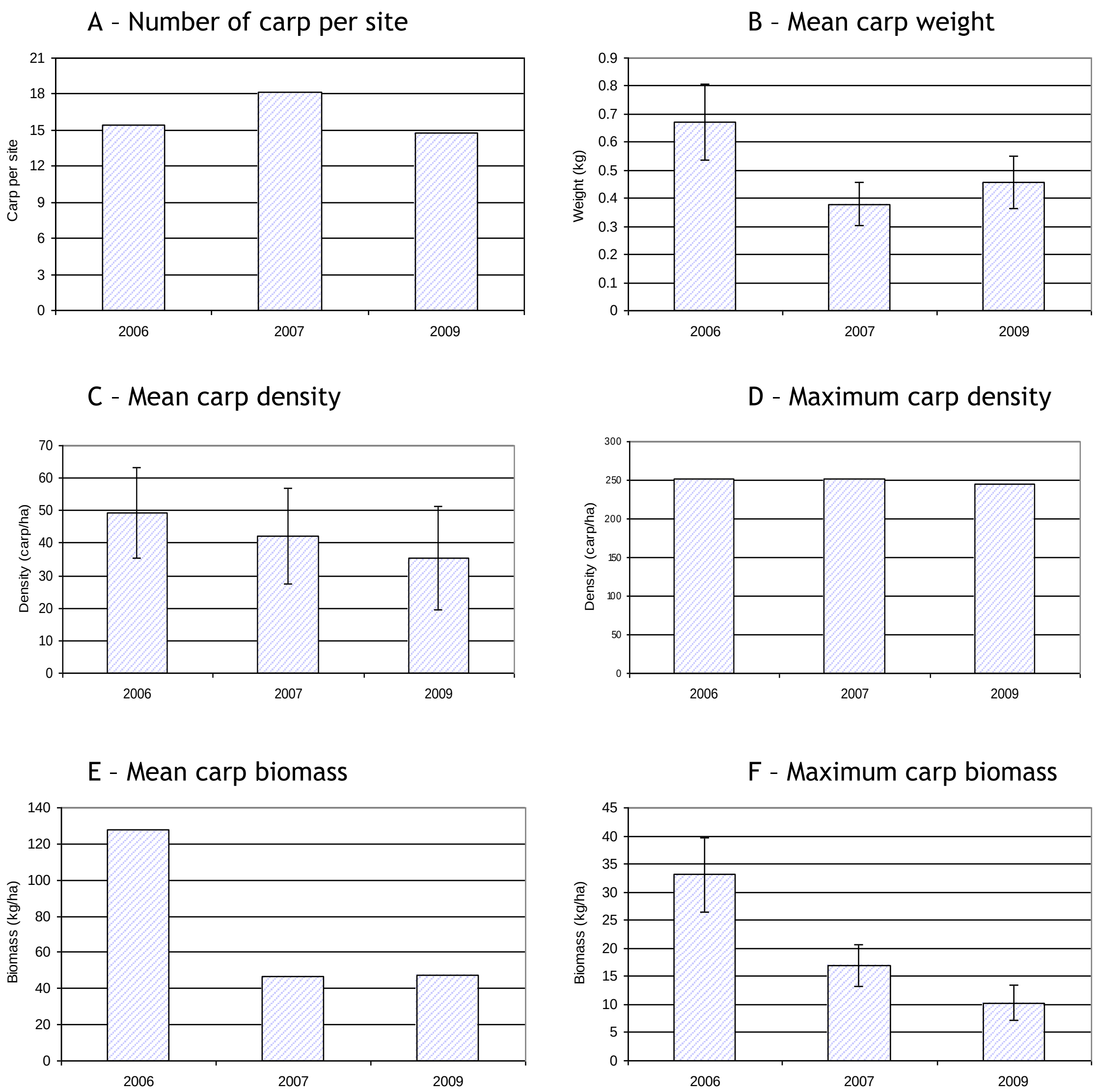


Figure 14. Carp population dynamics for the Logan and Albert catchment in 2006, 2007 and 2009.

Carp intervention sites

We removed carp at six survey sites between the 2006 and 2007 surveys. Repeated-measures analyses of variance revealed that these activities significantly reduced catch density (P=0.016) and biomass (P=0.021) in comparison to control sites. At the control sites, mean catch density rose from 1.22 carp/ha to 1.80 carp/ha (47.5% increase) and mean catch biomass from 22.8 kg/ha to 32.4 kg/ha (42.1% increase). In comparison, at the treatment sites, mean catch density fell from 2.01 carp/ha to 1.71 carp/ha (14.9% decrease) and mean catch biomass from 86.4 kg/ha to 28.8 kg/ha (66.6% decrease).

At four of these treatment sites, there was no further interventions prior to the 2009 survey. A further four control sites had no intervention activities at any stage. Repeated-measures analyses of variance showed no significant difference between treatment and control sites for carp catch density (P=0.242) and biomass (P=0.361) in 2009. This indicates that the effects of the carp removals did not persist.

Table 3. Changes in carp catch density and biomass between 2006 and 2009 at removal and untreated control sites. We removed carp only once in late 2006 and then not again until after the 2009 survey.

Site	Intervention	Change in density (%)	Change in biomass (%)
Albert at Darlington	Carp removal	62	-28
Rathdowney	None (Control)	-63	-18
Chardon's Bridge	Carp removal	45	-76
Jimboomba	None (Control)	-64	117
ALC	Carp removal	-38	-62
Bromelton	None (Control)	-92	-94
JTF	Carp removal	-83	-96
Riemore lagoon	None (Control)	-33	50

We removed carp at eight locations between the 2007 and 2009 surveys. Six of these locations were survey sites and were matched to untreated control sites to examine the effectiveness of the carp removal (Table 3). Comparison with repeated-measures analysis of variance found no significant difference in the change of carp catch density (P=0.234) and biomass (P=1.88) between the two site types. However, the magnitude of change was similar to that observed between 2006 and 2007 at the treatment sites. For control sites, mean catch density changed little, from 1.191 carp/ha to 1.187 carp/ha (0.3% decrease) and mean catch biomass decreased from 20.9 kg/ha to 18.3 kg/ha (12.4% decrease). In comparison, at the treatment sites mean catch density declined from 2.01 carp/ha to 1.71 carp/ha (14.9% decrease) and mean catch biomass from 24.0 kg/ha to 7.0 kg/ha (70.8% decrease). The values for the control sites were highly variable, and this most likely masked any statistically significant effects of the treatments in 2009.

Table 4. Changes in carp catch density and biomass at carp removal and untreated control sites between 2007 and 2009.

Pair	Site	Intervention	Change in density (%)	Change in biomass (%)
A	Sandy Creek	Carp removal	-83	-90
	Albert at Darlington	None (Control)	+86	-19
B	Canungra Creek 2	Carp removal	-100	-100
	Canungra Creek 1	None (Control)	-89	-96
C	Luscombe weirpool	Carp removal	-70	-80
	Albert at Chardon's Bridge	None (Control)	-30	-70
D	Sth McLean weirpool	Carp removal	-84	-72
	Logan at Jimboomba	None (Control)	-64	+117
E	Turf Force 2 lagoon	Carp removal	+511	-34
	ALC lagoon	None (Control)	+8	+1306
F	Tabragalba lagoon	Carp removal	-89	-41
	Riemore Estate lagoon	None (Control)	-68	-97

4. Discussion

General trends

The surveys in 2006, 2007 and 2009 produced quite similar results — a small reduction in the number of species observed and the frequency of occurrence of some species. This can be partially explained by the changes to the number of sites monitored and also environmental conditions. The most notable trend from 2006 to 2009 was the general decrease in the number of each species caught at most sites. This decrease is most likely resultant from the severe ongoing drought. Flow events in late 2008 and early 2009 may have removed a large amount of deposited sediment that had accumulated over the prior years of poor flow and re-established many deeper, more permanent water holes in the catchment. It is anticipated these changes will lead to increases in fish numbers over coming years, particularly if good rainfall occurs.

Gudgeons

The greatest decline in prevalence for any fish group between 2007 and 2009 was observed with gudgeons. The greatest reductions occurred in firetail gudgeons (-24%), empire gudgeons (-22%) and carp gudgeons (-21%). Recruitment for these species appears to have been poor, and the number of larger individuals declined. The decline cannot be explained by differences in survey sites because the majority of sites were sampled in both years. For catadromous species, such as empire gudgeons, it was anticipated that the increased number of flow events would assist their spawning migrations and lead to good recruitment.

Recreationally important species

The prevalence of fish species targeted by recreational anglers increased between 2007 and 2009, except for long-finned eels and spangled perch. It would appear that recreationally important species have taken advantage of the good flow regimes during their spawning periods, resulting in successful recruitment. This was evidenced by the number of small eel-tail catfish (75–125 mm total length, Figure 12), sea mullet (100 mm fork length, Figure 11) and Australian bass (125 mm fork length, Figure 9). Australian bass are stocked throughout the catchment, and the abundance of small fish may be a reflection of better survival of stocked fingerlings and not increased natural recruitment. The high prevalence of Australian bass fingerlings in the Albert supports this explanation because few fish would be able to navigate their way beyond the Luscombe Weir in the lower reaches.

Mullet abundances

The main difference observed in the abundance of native fish species between the Albert system and the Logan system occurred in mullet species. Sea mullet were highly common in the Logan, while no specimens were captured in the Albert during surveys. A similar pattern was observed for freshwater mullet. This trend mirrors those observed in 2006 and 2007. Both of these mullet species undergo annual migrations and predominantly spawn in estuarine or coastal waters. In the lower reaches of both the Albert and Logan rivers significant weirs exist, which have the potential to impede fish migration. In the Albert, Luscombe Weir is located at the upper tidal limit and is believed to be a major impediment to fish movement. The weir does have a fast-flowing fish ladder, but the design is generally thought to be unsuitable to native fish species (ie European design) due to its high-flow velocities and steep angle. The fishway is also commonly clogged with debris and only works at high water levels. In the Logan, all of the major weirs have vertical slot fishways installed. The presence of mullet throughout the Logan suggests that the vertical slot fishways are working as intended and allowing the mullet to migrate for spawning.

The lack of mullet in the Albert suggests that the Luscombe fishway is preventing such migrations. Several major flow events occurred between the 2007 and 2009 surveys. During these flows, Luscombe Weir was barely visible and access over the weir would have been possible, although against an extremely strong current. It is likely that some fish travel over the weir during these times but only in small numbers. This notion is supported by the 2007 survey where a low number of mullet was captured in the pool above the weir.

Pest fish

The presence of pest fish species other than carp and mosquitofish in the catchment appears to be linked with urbanisation, particularly in the lower Logan. Tilapia, swordtail and goldfish have only been found in the lower, more urbanised reaches of the catchment. These species are commonly kept as display fish by aquarists, and their presence may be due to releases of unwanted pets into local waters. Tilapia are valued as an angling and food fish by some people and may have been transferred illegally from adjacent catchments to create angling opportunities. They have been found at an increasing number of locations in the catchment and pose a significant risk to the region. It is believed that the species is illegally cultivated in several farm dams as a family food source.

Several of the sites in the more urbanised, lower reaches were not surveyed in 2009. These sites previously had the highest numbers of pest fish species. The exclusion of these sites from the 2009 survey resulted in the absence of any platys, swordtails and goldfish being recorded. These species do not appear to have established in any of the waterways further up the catchment.

It seems somewhat surprising that goldfish still appear rare in the Logan and Albert catchment. In comparison, in the Queensland sections of the Murray–Darling Basin, goldfish are far more prevalent and constitute a considerable proportion of large-sized pest fish numbers (Table 4).

Table 5. Examples of the goldfish-to-carp ratio from biodiversity surveys in the Queensland Murray–Darling Basin (Norris and Butcher, unpublished data).

Region	Carp	Goldfish
upper and mid Condamine River 2008	20	127
McIntyre River at Goondiwindi 2007	186	66
McIntyre River at Goondiwindi 2008	430	212
Moonie River at Thallon 2008	1036	73

Carp density and biomass

A general declining trend for carp numbers was observed between 2006 and 2009. The mean number of carp per site declined by 18.7% between 2007 and 2009. Reasonable rainfall in 2008 resulted in several flow events, which in turn resulted in carp spawning at a number of locations. The decline in carp numbers occurred despite the recruitment from the spawning events. The maximum site density barely altered across the observation period, but the site with the maximum density changed each year. This suggests that localised conditions may be driving recruitment.

Fish caught in the 2009 surveys were also generally of smaller size than in previous years. The mean carp weight decreased by 59.0% between 2006 and 2009. Comparison of biomass between the survey years probably more accurately represents the trend for carp population in the catchment. The maximum site biomass recorded fell dramatically between 2006 and 2007, before remaining relatively constant between 2007 and 2009. Like maximum density, the maximum biomass occurred at different sites each year. This could be due to the change in sites surveyed between years, but is more likely to represent reductions in the carp population due to environmental conditions.

The Albert and Logan catchment experienced prolonged drought conditions from mid 2001 up to the start of 2008. During this period there were few heavy falls of rain and associated flow events in the rivers. These conditions reduced the available habitat for carp and other fish species. They also denied carp access to spawning grounds and the environmental cues thought to be required for spawning. The declining trends in carp density and particularly biomass at the survey sites reflect the population declines expected under these conditions. Heavy rainfalls in 2008 and early 2009 provided carp with the necessary cues and habitat access to spawn. This was reflected in the surveys by the small decrease in density but the large and ongoing decrease in biomass and mean fish size.

The method of carp capture also has a significant bearing on estimated biomasses. Electrofishing tends not to catch every fish in the sampling area. Electrofishing efficiencies have been reported to vary between as little as 10% up to 40% for a single pass (Kolz et al 2000, Temple et al 2000, Rosenberger and Dunham 2005, Norris personal observation). Fish are often seen avoiding the boat/operator, and thus, values generated are an under-representation. Similarly, electrofishing becomes less efficient in deep waters, and therefore, we surveyed mostly in shallower margins. While the efficiency of the equipment increases in the shallower water, it requires that the fish be present in the same area and not residing in deeper locations. Thus, electrofishing-based population/biomass estimates for large, deep bodies of water will always be less than the actual value.

Past studies have reported carp biomasses of around 150 kg/ha in Lake Cooper, Loch Garry and Poques Billabong (Hume et al 1983), 609 kg/ha in the Bogan River (Reid and Harris 1997), 144 kg/ha in the Campaspe Irrigation channels (Brown et al 2003), 190 kg/ha in the Barmah Forest, 190 kg/ha in Moira Lake and approximately 22 kg/ha in the Millewa Forest wetlands (Brown et al 2003). The survey biomasses recorded in the Logan and Albert catchment are low compared to these, even when the method of capture and estimation is taken into consideration. However, the maximum biomass observed in 2006 (128 kg/ha in an irrigation dam) is within the vicinity of these figures.

The small or shallow nature of many of the water bodies sampled in the Albert and Logan catchment may contribute to the relatively low carp biomass values recorded. Deeper waters allow the fish to occupy a greater volume of water per unit surface area and thus have the potential to sustain greater numbers of fish. The upper parts of the catchment also remain quite pristine with clear flowing water and gravel or pebble substrates. These conditions are not as suitable for the way carp feed and may partially inhibit the presence of the species in these areas.

Carp length-frequency and age structure

The carp length–frequencies observed in 2009 closely mirror the distribution patterns observed in 2007 (Figure 14). In 2009, the surveys were carried out later in the year. Strong recruitment occurred during the summer preceding the 2009 survey, which is evidenced in the length–frequency peak for 75 mm carp. This peak occurs at a slightly larger size than in the preceding surveys, most probably because we s later in year, which enabled the fingerlings to grow more.

Such a result could also be obtained through a very early season spawning event, but the environmental conditions in early spring were not conducive to stimulating large-scale spawning events. Despite good conditions for recruitment, the number of carp fingerlings detected in 2009 was 15% less than observed in 2007. The majority of fingerlings caught in both years came from offstream sites, such as irrigation dams and other semi-natural lagoons.

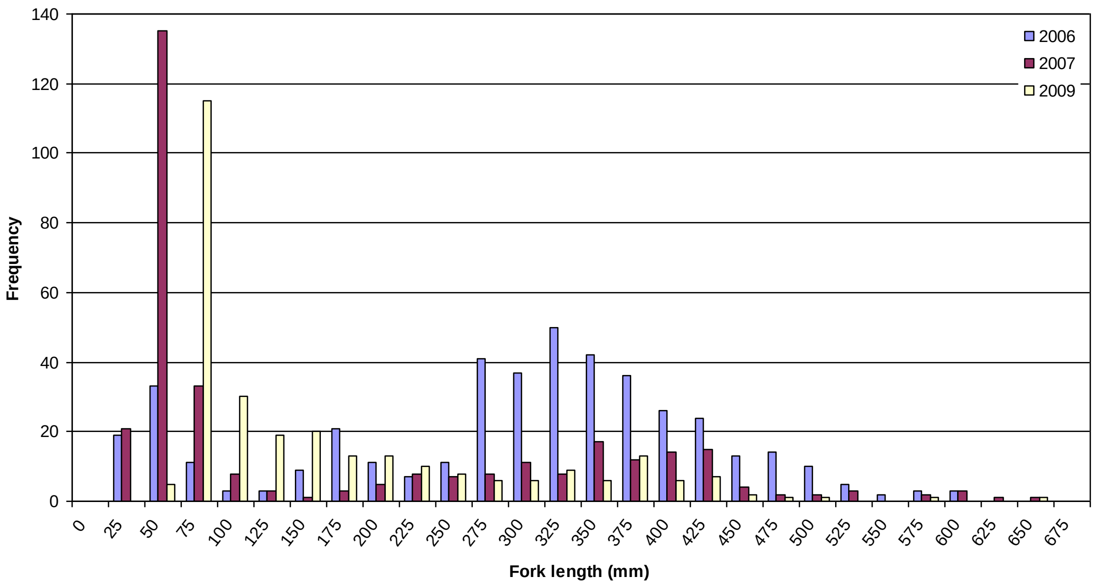


Figure 15. Length versus frequency of carp in the Albert and Logan river systems caught during monitoring surveys in 2006, 2007 and 2008.

The 2009 length–frequencies for larger carp closely resemble the 2007 results, where only a low proportion of large carp were caught. Significantly more large carp were captured in 2006, suggesting that a reduction occurred in this size range of the carp population sometime between the 2006 and 2007 surveys. Carp removal efforts as part of the project in late 2006 and early 2007 may partially account for this because many of the techniques trialled were targeted towards the capture of larger fish.

Carp control sites

Carp removal activities at six sites between 2006 and 2007 led to significantly lower carp density and biomass compared to matching control sites. The carp catches at the control sites rose, while at the intervention sites the catches fell. We removed carp at six survey sites between 2007 and 2009, but no significant differences in density or biomass between intervention and control sites were detected. During this period, the mean biomass and density at both the control and interventions sites decreased, but to different extents. At control sites carp density barely changed (-0.3%) while the biomass decreased a small amount (12.4%). In comparison, at the intervention sites the mean carp density decreased by 12.4% and the biomass by 70.8%. The differences in the mean values are quite substantial. A high degree of variability within the catch values from the control sites masked the statistical differences between the two treatments.

An interesting aspect of the rise in carp catches at the control sites, and the fall of catches at the intervention sites is that half of the treatment sites were in open river locations. It was expected that migration would partially or wholly obscure the removal impacts on the local carp population. Radio-tracking research on carp movements in the system has shown that fish are generally quite static, only moving at large scales during flow events. The lack of flow events between the 2006 and 2007 surveys meant that few carp were migrating, thus reducing the probability of removed carp being quickly replaced.

In general, the effects of removal activities between 2006 and 2007 did not persist through to 2009 when there was no further intervention. Typically, the amount of carp removed was not high enough to tip the local populations into natural decline, or immigration could have easily occurred in that timeframe, to replace the removed fish. In one large irrigation dam, the carp population was drastically reduced when the water was almost fully drained to allow excavation and bank stabilisation. Approximately 15 tonnes of carp, presumably a large proportion of the local population, were removed during this operation. The dam does not connect to the river except during major flow events and thus no immigration can occur. Upon refilling the dam, the remaining carp spawned and recruitment appeared to be high. This was reflected in the 2007 survey, which recorded a density decrease of only 43.7%, but a biomass decrease of 97%. The density in 2009 was similar to that detected in 2007, but the biomass had increased 12-fold to be 37% of the original population. This suggests that survival from the 2007 spawning event was high and the carp continued to grow well.

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Websites:

The Invasive Animals Cooperative Research Centre website contains a wide range of information on carp and other introduced pest species (see http://www.invasiveanimals.com).

Vertebrate pest information portal: www.feral.org.au

Queensland Primary Industries and Fisheries website (http://www.fishweb.qld.gov.au)

Appendix A.

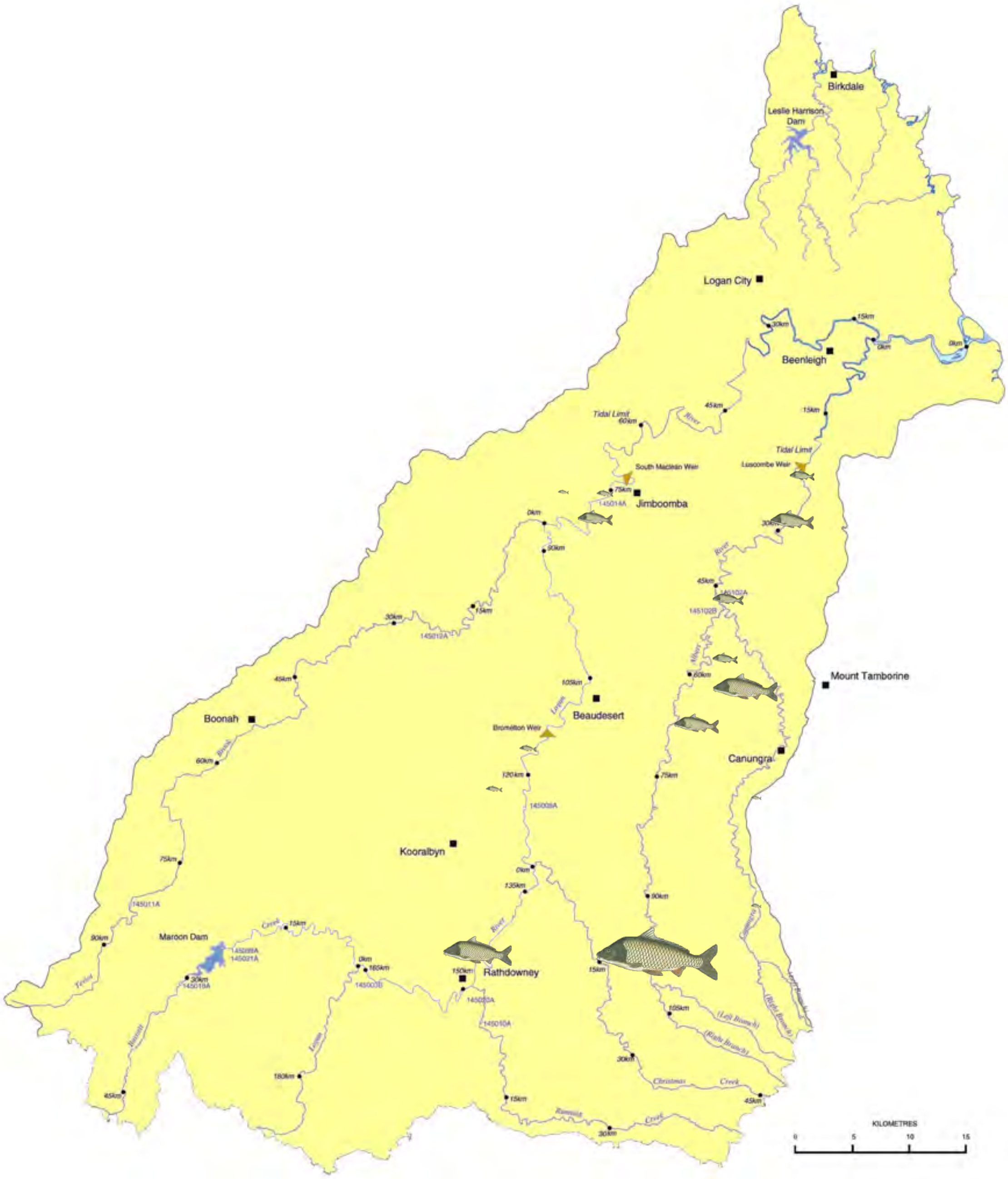

Figure 16. Relative biomass of carp (kg/ha) in the Logan and Albert catchment. The size of the carp image ( ) depicts the relative biomass at that site. The largest carp represents a biomass of 48 kg/ha.

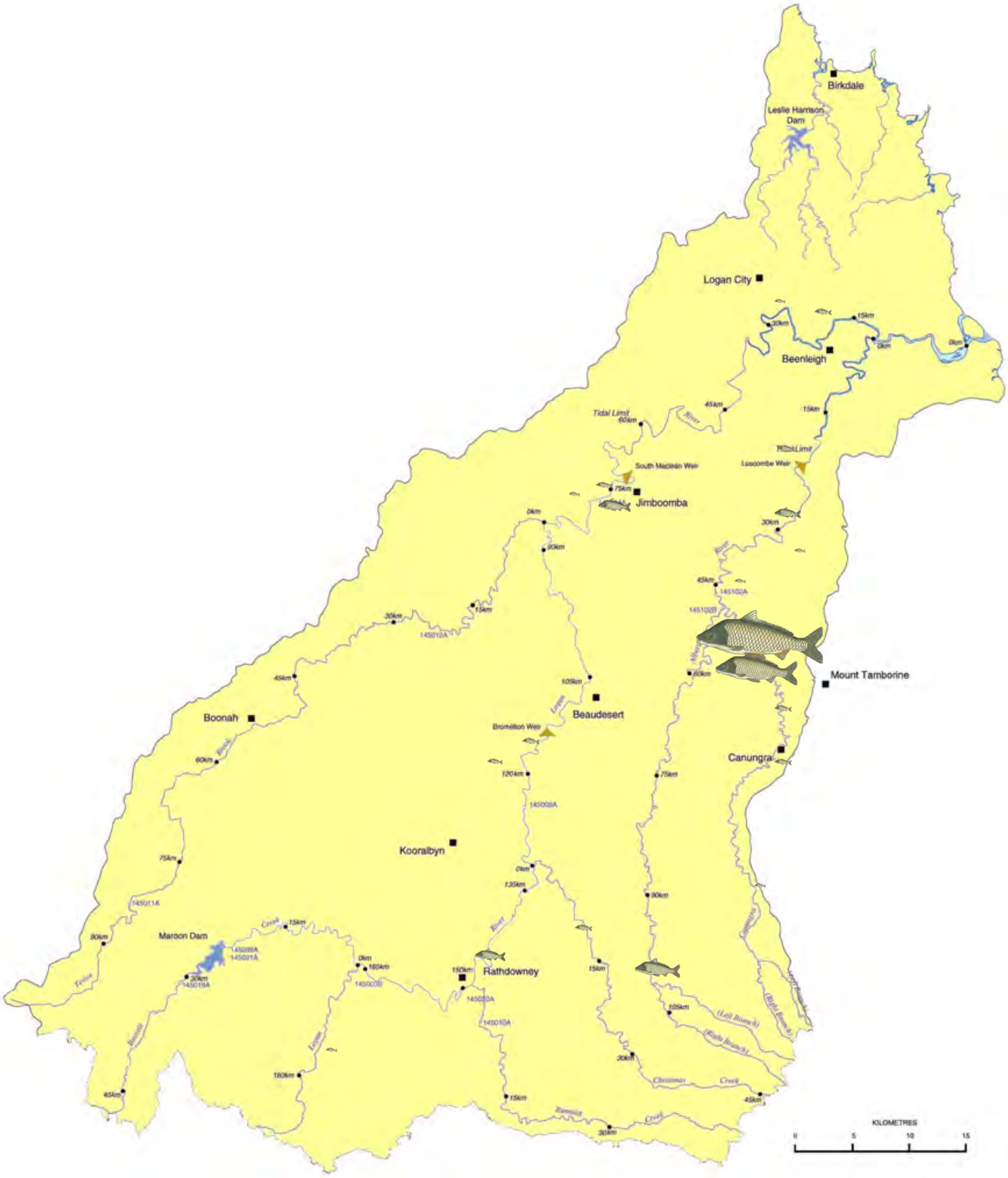

Figure 17. Relative carp density (carp/ha) in the Logan and Albert catchment. The size of the carp image ( ) depicts the relative density at that site. The largest carp represents a density of 244 carp/ha.

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