Carp in NSW: Assessment of Distribution, Fishery and Fishing Methods

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NON-TECHNICAL SUMMARY

Carp in NSW: Assessment of Distribution, Fishery and Fishing Methods

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OBJECTIVES:

1. Map the current carp distribution in New South Wales (2002-03).
2. Assess current and potential fishing methods with respect to impact on native fish and air-breathing vertebrates.
3. Update current fishery production and markets.
4. Test the effectiveness of an experimental carp trap ("Enviro-Trap") fitted with a bycatch reduction device (BRD) designed to release air-breathing vertebrates.
5. Conduct trials with small-scale and commercial fishing gear.

NON TECHNICAL SUMMARY:

The common carp (*Cyprinus carpio*) is an introduced species now widespread through much of southeastern Australia, including most of inland New South Wales (NSW). Carp are considered a major pest and contributor to the environmental degradation of many inland waterways. In particular, carp are blamed for increased water turbidity, bank erosion, and loss of native aquatic vegetation, all combining to reduce native fish populations. Consequently, there has been considerable ongoing research, both nationally and within New South Wales, into ways of controlling carp numbers. Following the 1997 NSW Rivers Survey which reported a serious decline in native fish numbers, the inland commercial fishery was reviewed resulting in a phasing out by September 2001 of the commercial harvesting of native fish. Although incentives were given to encourage commercial fishing for carp, few fishers showed interest in the fishery and commercial production has fallen to historically low levels.

Key components of the research described in this report were to map the present distribution of carp in NSW, review the carp fishery including catch data, and assess harvesting methods which were effective in catching carp but did not impact on native fish species or air-breathing vertebrates such as turtles and platypus. A fish trap designed for carp and incorporating a bycatch reduction device was tested and assessed.

Mapping of carp distribution in NSW

District Fisheries Officers provided up-to-date information on the distribution of carp in each of the inspectorial regions of NSW. This information, along with data derived from earlier scientific river survey studies, the Fish Kill database, recreational fisher reports, and commercial catch records were collated and compiled in a GIS database. This database is designed to be a living document which can be continually updated.

Overall, the data indicated that carp now inhabit about 77% of NSW waterways, and a further 2% are also likely to be infested. The data show that carp have continued to disperse throughout the inland waterways so that in the Murray-Darling Basin, only some upper catchment areas along the Great Dividing Range (mainly around New England and in the Snowy Mountains) are free of carp. Along the central coast of NSW, carp are now widespread in the Hunter River and the Hawkesbury-Nepean River systems. Carp have also spread through the southern tablelands, including the Shoalhaven River, the upper Murrumbidgee River, and in much of the ACT. From northern NSW, small numbers of carp were reported at several locations in the Richmond and Bellinger Rivers and tributaries.

Commercial fishing methods

Commercial fishing methods that have proven effective for carp include electro-fishing, hauling (seining), mesh-netting and trapping. The efficiency and viability of each of these methods varies and are dependent on the environmental conditions at the fishing locations, and ultimately the economic return to the fisher.

Hauling is the most effective method for catching large quantities of carp but can only be used in locations such as shallow lakes or dams where the lake-bed is clear of obstructions. However, there are few waterways in NSW that are suitable for hauling. As a harvesting method, hauling has relatively low impact on bycatch species (native fish and air-breathing animals) as they can be sorted from the carp catch and released unharmed.

Electro-fishing has been effective for carp harvest or removal in areas of high density but its high capital cost and labour intensity make it an unviable commercial method in most areas. Species other than carp stunned during electro-fishing will recover unharmed if left in the water. At present, no carp are commercially harvested in NSW using electro-fishing equipment.

Historically, most commercial fishing in inland NSW for native freshwater fish was with mesh-nets and traps (drum nets, hoop nets), with the gear often being set for relatively long periods (several hours or more). In their traditional (unmodified) form, these methods are unsuitable for carp as they have the potential to adversely impact on native bycatch species. Mesh-nets damage captured fish (through scale loss etc.) and drown air breathing animals that become entangled in the net. Similarly, while native fish can be released from traps unharmed, air-breathing vertebrates will drown in traps that have no inbuilt escape device.

By modifying their design and methods of deployment, mesh-nets and traps can be used for carp fishing with minimal or no bycatch mortality. One commercial fishing crew is successfully harvesting carp by ‘splash-meshing’, a technique that involves setting a mesh-net in shallow water, actively frightening carp into the net, and then immediately retrieving the net. The short soak-time allows for the immediate release of vulnerable bycatch species such as turtles and native fish. Traps that project above the water or are fitted with effective bycatch reduction devices (BRDs) may also be used to safely harvest carp.

NSW fishery, production and markets

From a peak of about 550 tonnes in 1977/78, NSW carp production quickly declined and from the mid 1980s has been less than 200 tonnes per annum. Since 2001, there have been about 30 fishers licensed to fish inland waters with most targeting yabbies. In 2002/03, the first full year after the native finfish fishery was closed, only seven fishers landed carp for a total reported production of about 70 t. In contrast to the small commercial fishery, the National Recreational and Indigenous Fishing Survey found that carp was the most common species caught by anglers fishing NSW inland waters and estimated annual catch by recreational fishers in NSW to be approximately 1.2 million carp weighing 877 tonnes. Although some recreational fishers target carp, most anglers catch carp while targeting native fish.

Most of the commercial catch in NSW is sold through the Sydney Fish Market (SFM) but demand is small. Annual volumes of carp through the SFM ranged between 30 and 70 tonnes during the ten years from 1980/81. In 1991/92 sales more than doubled to 124 t but have gradually declined to about 70 t in the last two years (2001/03). Average price has gradually risen, but appears to be sensitive to supply with supplies in excess of two tonnes within any week receiving very low prices; average price in 2003 was \$1.63/kg, a return that is only marginally profitable to the main suppliers. Small quantities of carp are periodically utilised for other products such as fertiliser and pet-food but, again, the limited demand and low price offered (< \$0.80) make carp production for these purposes unprofitable. It is this lack of market demand for carp, the low price, and general remoteness of the fish stocks that combine to make commercial fishing for carp unprofitable for most fishers.

Assessment of 'Enviro-Trap'

Accidental mortality of air-breathing vertebrates is potentially a major problem for inland fisheries that utilise fully submerged traps. A trap intended for commercial carp fishing ('Enviro-Trap') was made available to NSW Fisheries for testing. The design incorporated an escape aperture or bycatch reduction device (BRD) in the top of the trap to facilitate the escape of air-breathing vertebrates. Two more traps to the same design ('envirotraps') were made, and the effectiveness of these traps to release turtles and platypus was tested experimentally. These traps were later field tested in a number of localities containing carp and turtles.

Under experimental conditions, about 80% of freshwater turtles escaped through the BRD. Platypuses placed in the envirotrap were observed by video camera to actively avoid the in-built BRD. Small escape holes were then made around the front perimeter of the trap and proved successful, with all platypuses exiting the trap in less than two minutes of entry. Along with a box-trap, three envirotraps were trialed in an irrigation creek off the Murray River near Barham, southwestern NSW. When the creek was flowing, the traps caught substantial numbers of carp (up to 18 carp/28 kg per trap per night); almost no bycatch was taken. Envirotraps were also trialed in the Lane Cove River, Sydney; no carp but moderate numbers of freshwater turtles were trapped. Of 15 active turtles replaced in the traps, only two escaped before the traps were next inspected suggesting that further improvements were required to fully reduce bycatch mortality.

Conclusions

Carp continue to spread throughout inland NSW and are now present in several coastal catchments. Despite the widespread distribution and abundance of carp, a number of factors combine to inhibit any expansion of the commercial carp fishery in the near future. The general remoteness of the main carp resource, combined with the lack of market demand and hence low price for any product, make commercial fishing for carp largely unprofitable.

Electro-fishing, hauling, meshing and trapping, with appropriate modifications and deployment procedures, can safely be used for commercial carp fishing with minimal effects on bycatch species. Should the economic viability for carp improve, fishers will be in the best position to adapt and develop the most effective gear for harvesting carp. For government and non-government organisations which frequently contact NSW Fisheries about carp control in public and private waterways, any of the above methods can be adapted to help control carp numbers in relatively small waterways and streams. However, any gear or methods used to catch carp must be environmentally safe and conform to any legislative conservation requirements.

KEYWORDS:

carp, trapping, mesh-netting, bycatch reduction device, turtles, platypus

1. INTRODUCTION

Common carp (*Cyprinus carpio*) are widespread in lowland rivers and wetlands of inland southeastern Australia and have also invaded some major coastal river systems. The NSW Fisheries Rivers Survey (Harris & Gehrke 1997) and the Native Fish Recruitment Project have shown that carp are the dominant fish in many waterways, often contributing 80% or more of the total fish biomass. There is a widespread public concern that these high levels of carp infestation pose a major threat to these aquatic ecosystems. Carp are associated with the loss of native fish species and aquatic vegetation, poor water quality (eg. high turbidity), algal blooms, and bank erosion.

While carp spread quickly through much of the Murray-Darling River Basin in the 1970s, there has been no recent assessment detailing its present distribution. Carp have continued to spread into the upper reaches of many inland rivers, and the species has also become established in several coastal rivers and waterways after deliberate introductions. One of the primary objectives of the program was to collect and document current knowledge of carp distribution into a single working database. Mapping the current range of carp provides a means of identifying environmentally valuable areas as a basis for the implementation of strategies for high risk / high value areas most likely to respond to investment in carp control.

Although a national biological control program (e.g. Thresher & Bax 2003) offers the most promising long-term solution to the carp problem, encouraging the active harvesting of carp is a practical short to medium-term option for reducing carp numbers. Large-scale carp harvesting has the potential to remove thousands of tonnes of carp and, as a consequence, increase the health of aquatic systems degraded through the actions of carp. However, with minimal market demand, commercial fishing for carp is currently not financially viable through most of its range. Should these circumstances change and the commercial fishery expands, harvesting methods employed must have minimal impact on native species of fishes and other protected bycatch, and the aquatic ecosystem in general.

In the past, commercial fishing in inland waters mainly targeted native species with carp usually an unwanted bycatch. The total annual catch of carp rose to over 500 tonnes in the late 1970s but has since declined to less than 100 tonnes. To stimulate the harvesting of carp, the NSW Government implemented a Carp Production Incentive Scheme in 1999-2001. Now, with the banning of commercial fishing for native fish in 2001, a need arose to identify methods of catching carp that either exclude native species or enable their release unharmed. This project has mapped the current distribution of carp in NSW, assessed and investigated fishing methods for carp that have minimal impact on other species and habitats, and updated the catch history of the NSW carp fishery.

2. OBJECTIVES

1. Map the current carp distribution in New South Wales (2002-03).

2. Assess current and potential fishing methods with respect to impact on native fish and air-breathing vertebrates.

3. Update current fishery production and markets.

4. Test the effectiveness of an experimental carp trap (“Enviro-trap”) fitted with a bycatch reduction device (BRD) designed to release air-breathing vertebrates.

5. Conduct trials with small-scale and commercial fishing gear.

3. MAPPING OF CARP DISTRIBUTION IN NSW

3.1. Introduction

Details of the introduction and spread of carp in Australia are given in Koehn *et al*. (2000). In summary, carp were first imported around 1860 but deliberate attempts to establish them outside Melbourne and Sydney were initially unsuccessful. In 1907 there was a documented release of carp into an inlet pond above Prospect Reservoir, Sydney, and in the 1940s carp were introduced into irrigation canals of the Murrumbidgee Irrigation Area. However, the main spread of carp began in the 1960s, originating from an aquaculture venture at Boolarra in Gippsland, Victoria. Carp were sold to farmers for their dams, and some local waterways and reservoirs were also stocked. The Victorian fisheries authorities tried to stop this practice, but by the time legislation was invoked carp had spread throughout much of Victoria. In 1964 and 1965 carp were reported in Lake Hawthorn near Mildura, from where they gained access to the Murray River and quickly radiated throughout most of the Murray-Darling System. Carp are now established through most of inland NSW, much of Victoria, and the lower reaches of the Murray River in South Australia. There are localised infestations along coastal NSW and in the other states of Australia (Koehn 2004).

The distribution maps in Koehn *et al*. (2000) and Koehn (2004) provide overviews of the spread of carp across southeastern Australia. However, detailed information on the distribution and abundance of carp within NSW is limited to various scientific surveys and catch databases (both commercial and recreational). It was anticipated that expert local knowledge, principally sourced from departmental personnel (Regional Fisheries Officers), would provide a more comprehensive and accurate picture of carp distribution. The overall aim of the mapping project was to collect and integrate all available carp distribution information into a single GIS database that could be periodically updated, and also be made available to other agencies in NSW.

3.2. Methods

Digital geo-referenced 1:250,000 topographic maps purchased from Geoscience Australia were used to provide background display maps overlaid with the 28 Fisheries Districts. An enlarged map of each district was printed onto A3 size paper and sent to the respective Fisheries Offices. Fisheries Officers were briefed on the objectives of the project, and requested to give details of carp distribution along the waterways in their region, and/or to record waterways known to be free of carp. This information from Fisheries Officers was a combination of their personal knowledge of the region and reliable anecdotal reports by local residents, visitors and fishers. All information was marked on the supplied maps and returned to the Cronulla Fisheries Centre.

The underlying structural layer for the database was a 1:250,000-scale map of NSW water bodies, rivers and streams (Figure 3.1) provided by AUSLIG , and displayed in GIS format with Arcview software; this map included many small watercourses that are ephemeral but no map with only permanent watercourses was available in digital format.

A protocol for interpreting and entering the data was developed to standardise the mapping procedure. The carp distribution information for each waterway was coded as follows:

0 = carp absent
1 = carp present
2 = no information
3 = likely presence of carp

After allocating each code a colour, the information for each waterway was then entered in digital form onto the base or 'carp-layer'. In many areas, there were no data available for tributaries connected to main waterways known to contain carp. Code 3 ('likely presence of carp') was allocated to those tributaries where there was no obvious barrier (weir, dam etc.) to prevent the movement of carp from the main waterway. A data layer showing weir sites was constructed from departmental records; unless there was information to the contrary, areas upstream of the barriers were deemed to be free of carp. During the early stages of the process, Code 2 was used for many areas where the presence of carp was unknown; this was gradually replaced with the other codes as more information became available.

Scientific data came from departmental river surveys and other inland research projects between 1992 and 2004 (Freshwater Fish Research Database), the Fish Kills Database (1977-2001), and Section 37 permit data (Fishfiles Database) (Figure 3.2). Commercial catch information between 1984 and 2001 (NSW Fisheries ComCatch Database), and anecdotal reports from recreational fishers (e.g. Carp Location Database) were also collated (see Appendix 1).

In order to provide additional interpretive information for the final distribution map, point data were arbitrarily ranked according to the level of confidence in species identification and location data. Criteria were:

- Level 1 - scientific data (accurate identifications and location coordinates).
- Level 2 - Fisheries Officers' reports.
- Level 3 - recreational fisher (mostly from the Carp Location Database) and anecdotal reports: may contain misidentifications with goldfish; positional coordinates were not always available although accurate descriptions of the locations were frequently given.
- Level 4 - commercial data: commercial catch locations were generally vague; recorded positions were the regions or general descriptions given in fisher Catch Return forms.

The locations of carp captures from all these sources were entered onto a separate layer over the 'carp-layer'. A polygon layer was produced from these data broadly delineating the carp distribution; this was then overlayed with another layer showing the river catchments (see Figure 3.4 for NSW catchment boundaries). By projecting this composite map onto a grid map (Geographic Datum Australia 1994 Map Grids Australia Zone 55), estimates of carp infestation in each catchment were made by calculating the percentage of land area encompassing waterways containing carp (Table 3.3).

The GIS database and associated files are now administered by the Introduced Pests Section of DPI at the Port Stephens Fisheries Centre (see Appendix 1).

3.3. Results and Discussion

Carp distribution maps and associated information were returned from Fisheries Officers in all regions; Figure 3.3 shows the broad distribution of carp in NSW based on this information. Figure 3.4 is a composite map showing the broad distribution of carp in NSW and includes all point-data sites where carp were captured or reported. An enlarged map of the Richmond Fisheries District (Figure 3.5) gives an example of the fine detail available in the database.

The scientific, recreational fisher and anecdotal data mostly coincided with the distributional pattern derived from the Fisheries Officers' information, as well as highlighting some isolated areas inhabited by carp. The distributional information derived from commercial fishery data was mostly limited to areas of known high carp abundance.

3.3.1. Western drainages

The only relatively large carp-free areas west of the Great Dividing Range are the northwest region of the state, and areas of high altitude in New England and Snowy Mountains (Figures 3.3 & 3.4). The catchments in the Far West Region (Cooper, Bulloo, Lake Bancannia, Lake Frome, and a small section of the Darling) contain mostly ephemeral waterways making them unlikely to sustain permanent populations of carp. However, carp were found in the area during a river survey in February 1999, and there were reports of two commercial catches from one river in 1992 and 1996. The Bureau of Meteorology Annual Rainfall Records show above average rainfall at the times of these reports, suggesting that carp moved with floodwaters into this flat country.

Several relatively small carp-free areas on the western slopes of the Great Dividing Range are detailed in Table 3.1. Around New England, high altitude sections of rivers free of carp include the upper MacIntyre and Severn Rivers, the Gwydir River above the Copeton Dam, the MacDonald River above Woolbrook, and the upper reaches of the Namoi River. In the central tablelands, the Cudgegong River above Rylstone, Winburndale Rivulet and Reservoir on the upper Macquarie River, Fish River above and including Lake Oberon, the Crookwell River and Blakney Creek (tributaries of the upper Lachlan River) were all reported to be free of carp.

Further south, carp were reported to be absent from the upper Queanbeyan River (including Googong Reservoir), the Tumut River above the Blowering Dam, Swampy Plain River above Khancoban, and storage lakes and headwaters of other rivers in the higher altitudes of the Snowy Mountains. In addition, there appears to be no carp in the Lake George catchment probably because of the ephemeral nature of the lake.

No new information was collected for the Australian Capital Territory. However, carp are widespread in parts of the ACT and there is recreational “coarse fishing” for carp in Lake Burley-Griffin. Streams in the ACT that are free of carp include the Tidbinbilla, Naas, Orroral, and Cotter (*ACT Vertebrate Pest Management Strategy,* ACT Government 2002).

3.3.2. Coastal NSW

In the northern rivers area of NSW, there were several reports of carp, mostly koi, in a number of small areas of the Richmond catchment. These locations were in Iron Pot Creek in the upper catchment, the Horseshoe Lagoon near Casino, the Richmond River downstream from Tatham, Bungawalbyn Creek (a large area of swampland), and Emigrant Creek (Table 3.2, Figure 3.5). Recreational fishers also reported carp in the Mann and Timbarra Rivers, tributaries to the upper Clarence River (Carp Location Database); however, scientific sampling has only ever caught goldfish (*Carrasius auratus*) in these rivers suggesting that the reports were based on misidentifications (D. Gilligan, personal communication). Independent scientific collectors reported koi carp in the Bellinger River, and the Coffs Harbour Fisheries Officer also reported koi in Warrell Creek, a tributary of the Nambucca River. A report by recreational fishers of koi carp in the upper Macleay (Carp Location Database) has not been confirmed by scientific sampling at a number of sites on the river.

Carp are widespread in the Hunter, Hawkesbury-Nepean, Port Jackson and Shoalhaven catchments. The Fish Kills database and recreational fisher reports confirm the presence of carp in several of the Hunter Valley tributaries and lakes, confirming that carp have spread from the main river e.g. Williams and Paterson Rivers in the lower valley, and Lakes Liddell and Glenbawn, the Isis River and Pages Creek in the upper Hunter Valley. Most freshwater bodies in and around the Sydney metropolitan area contain carp (e.g. Botany Ponds, Lane Cove River, upper Georges River) as does much of the Hawkesbury-Nepean system, including the Colo River, Wollemi River, and Cattai and

Mangrove Creeks. Above Warragamba Dam, carp are found in Lake Burragorang, the Wingecarribee River, and the lower reaches of the Wollondilly River. However, in the southern highlands, some parts of the upper system were reported to be free of carp e.g. Guineacor and Murruin Creeks above Barralier, the upper Wollondilly River above the Pejar Resevoir dam, and the Tarlo River. Carp have also spread through most of the Shoalhaven River catchment, above and below Tallowa Dam.

South coast catchments are mainly carp free. There is an isolated population in Long Swamp, a small coastal lagoon near Bermagui on the south coast. The local Fisheries Officer reported koi carp in the Towamba River, inland from Eden, but the extent of any spread in that catchment is unknown. The capture of a single small carp in the Snowy River below the Dalgety Weir was reported by P. Gibbs (NSW Fisheries, personal communication) but it may have been an escaped fish used for live-bait as all other reports from that river system (including the McLaughlan River) have proved to be goldfish (*Carassius auratus*). Recent research sampling of the Snowy River and tributaries below Jindabyne Dam, including the Dalgety Weir, did not find any carp (D. Gilligan, personal communication).

3.3.3. Summary

Based on land areas, the data indicate that carp now inhabit over 85% of NSW and ACT waterways west of the Great Divide, and about 30% in the eastern drainages (Table 3.3).

With no permanent waterways, the northwest corner of the state is free of carp, and the small pockets of carp-free waterways in the higher altitude regions of the Great Dividing Range are mostly above dams or waterfalls that form impediments to the unassisted spread of carp. More than half of coastal NSW remains free of carp although they now appear to be more widespread than indicated by Koehn *et al*. (2000). Carp now inhabit most freshwater rivers and lakes along the central coast between and including the Hunter and Shoalhaven catchments, and through much of the Southern Highlands and Tablelands (upper Shoalhaven catchment).

Almost all reports from northern NSW (north of the Hunter catchment) were of small numbers of ornamental koi carp (Table 3.2), a potentially less invasive strain than the Boolara phenotype which infests the Murray-Darling system. Regular scientific river surveys in these catchments during recent years have found no evidence to suggest that these introductions have spread widely through any of the northern NSW river systems (D. Gilligan, personal communication). It is also likely that some reports, particularly from recreational fishers, include misidentifications of goldfish.

Carp probably now inhabit all waters in NSW into which they can naturally spread. Any further spread of carp will most likely be achieved through deliberate introductions or the use of small carp as live-bait by anglers.

Table 3.1. Upper catchments of west draining rivers reported to be free of carp; the barriers are the upper limits of the reported carp distribution in each river.

Catchment	River	Barrier	Barrier Position
McIntyre	Tenterfield Ck	Tenterfield Falls	29°00’, 151°42’
McIntyre	McIntyre R.	McIntyre Falls	29°09’, 150°58’
McIntyre	Severn R	‘Dungeon’ gorge area	29°06’, 150°57’
Gwyder	Gwyder R.	Copeton Dam	29°59’, 150°59’
Namoi	upper MacDonald R.	no apparent barrier	
Macquarie	Cudgegong R.	Windamere Dam	32°44’, 149°46’
Macquarie	Winburndale R.	Winburndale Reservoir dam	33°23’, 149°46’
Macquarie	Fish R.	L. Oberon dam	33°43’, 149°52’
Lachlan	Crookwell R.	no apparent barrier	
Lachlan	Blakney Creek	no apparent barrier	
Lake George		ephemeral	
Murrumbidgee	Tumut R.	Blowering Dam	35°24’, 148°15’
Murrumbidgee	Queanbeyan R.	Googong Reservoir dam	35°25’, 149°16’
Murrumbidgee	Cotter R.	Cotter Dam	35°24’, 148°15’
Murrumbidgee	Tidbinbilla R.	no apparent barrier	
Murrumbidgee	Naas-Gudgenby R.	no apparent barrier	
Lake Hume	Swampy Plain R.	Khancoban Pondage (dam)	36°13’, 148°06’

Table 3.2. Localised occurrences of carp in NSW coastal catchments recorded during scientific surveys or from fishkill data (research), or reported by fisheries officers (FO) and/or recreational fishers (rec.). This data excludes widespread populations in the Hunter, Hawkesbury-Nepean, Port Jackson and Shoalhaven catchments.

Catchment	Waterway and area	Location	Report	Comment
Richmond	Iron Pot Creek near Toonumbar Dam	28°36’, 152°45’	FO/rec.	
Richmond	Horseshoe Lagoon near Casino	28°53’, 153°04’	FO/rec.	
Richmond	Richmond R. near Tatham	28°56’, 153°10’	FO	koi carp
Richmond	Bungawalbyn Creek	28°46’, 153°31’	FO	koi carp
Richmond	Lismore Lake	28°49’, 153°17’	research	
Richmond	Emigrant Creek	28°47’, 153°31’	research	koi carp
Clarence	Harwood	29°25’, 153°15’	research	
Bellinger	Bellinger R.	30°25’, 152°52’	research	koi carp
Bellinger	Warrell Ck, Nambucca R.	30°47’, 152°53’	FO	koi carp
Hastings	Hastings R. at Beechwood	31°27’, 152°40’	research	koi carp
Hastings	Hastings R. at Emerald Downs	31°27’, 152°54’	FO	koi carp
Hastings	Wrights & Mimosa Park Creeks	31°27’, 152°55’	FO	koi carp
P Stephens	Wallamba R. - dams on upper river	32°06’, 152°08’	FO	koi carp
P Stephens	Wallamba R. - dams near Darawank	32°07’, 152°29’	FO	koi carp
P Stephens	Pipers Bay – small creek	32°13’, 152°33’	FO	koi carp
P Stephens	Karuah R. near Booral	32°28’, 151°57’	FO	
L Macquarie	Wyong R.	33o16’, 151o25’	rec.	
Bega	Long Swamp near Bermagui	36°24’, 150°04’	research	
Snowy	Snowy R. at Dalgety Weir	36°34’, 148°50’	rec.	single fish
Towamba	Towamba R. near Towamba	37°06’, 149°43’	FO	koi carp

Table 3.3. Degree of carp infestation in each catchment (% land area with waterways inhabited by carp) (* unconfirmed in headwaters)

		Carp absent		Carp present		Carp likely	
Catchment	**Total area**	**Area**	**%**	**Area**	**%**	**Area**	**%**
Coastal							
Bega	2837	2837	100				
Bellinger	3484	3257	93	20	1	207	6
Brunswick	516	516	100				
Clarence	22420	22420	100				
Clyde	3438	3438	100				
Genoa	1140	1140	100				
Hastings	4550	4550	100				
Hawkesbury	22085	3094	14	12280	56	6711	30
Hunter	19244			19244	100		
L Illawarra				798	100		
L Macquarie				1583	100		
Macleay	11456	11456	100				
Manning	8218	8218	100				
Moruya	1486	1486	100				
Port Jackson				1828	100		
Port Stephens	4513	4513	100				
Richmond	7090	876	12	99	1	6114	86
Shoalhaven	7216	793	11	6424	89		
Snowy	8933	8933	100				
Towamba	2164	2164	100				
Tuross	2164	2164	100				
Tweed	1089	1089	100				
Total coastal:	*138232*	*82944*	*60*	*42256*	*31*	*13032*	*9*
Inland							
ACT	2360	800 ?	34	1560	66		
Bulloo	20393	20393	100				
Castlereagh	17422			17422	100		
Condamine	25767			25767	100		
Cooper	627	627	100				
Darling	113050	923	1	112127	99		
Gwydir	26627	5328	20	21300	80		
Lachlan	90858	1499	2	89359	98		
Lake Bancannia	23376	23376	100				
Lake Frome	19552	18284	94	1268	6		
Lake George	943	943	100				
Lake Hume	5205	1652	32	3553	68		
Lake Victoria	9084			9084	100		
Macintyre	24243	3753	15	20490	85		
Macquarie	74768	854	1	73914	99		
Moonie	745			745	100		
Murray	15041			15041	100		
Murrumbidgee	79259	7926	10	71333	90		
Namoi	42053	944	2	41109	98		
Paroo	40451			40451	100		
Peacock Creek	21406			21406	100		
Warrego	11375			11375	100		
Total Inland:	*664605*	*87302*	*13*	*577304*	*87*		
TOTAL:	**802837**	**170246**	**21**	**619560**	**77**	**13032**	**2**

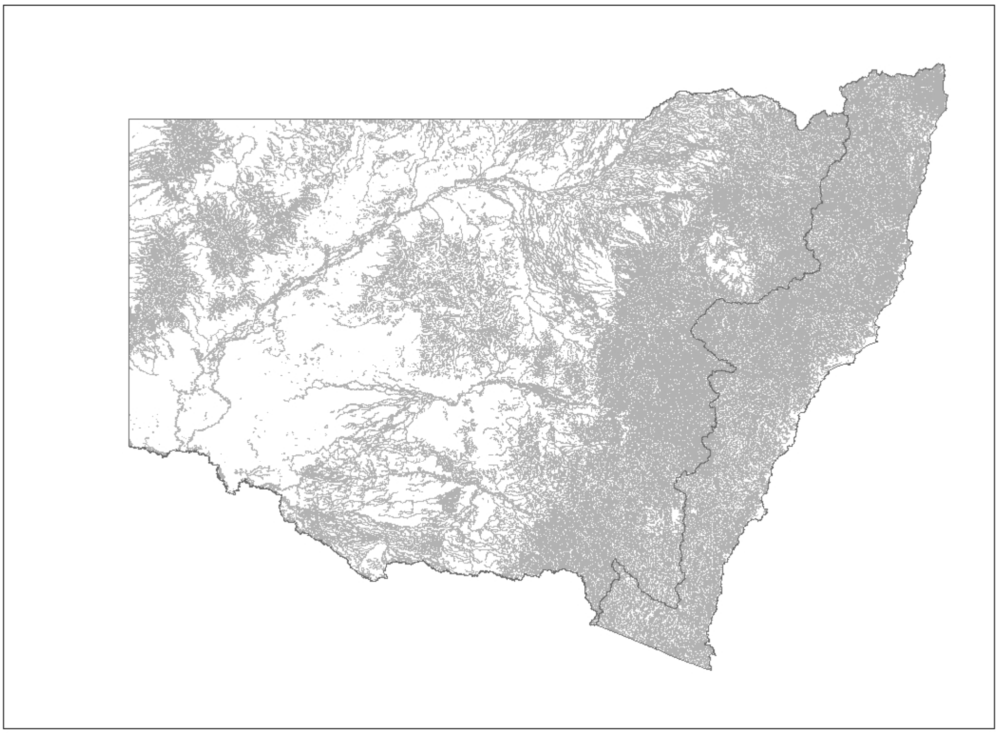

Figure 3.1. Map of NSW showing all watercourses, used as the underlying structural layer for the carp distribution database.

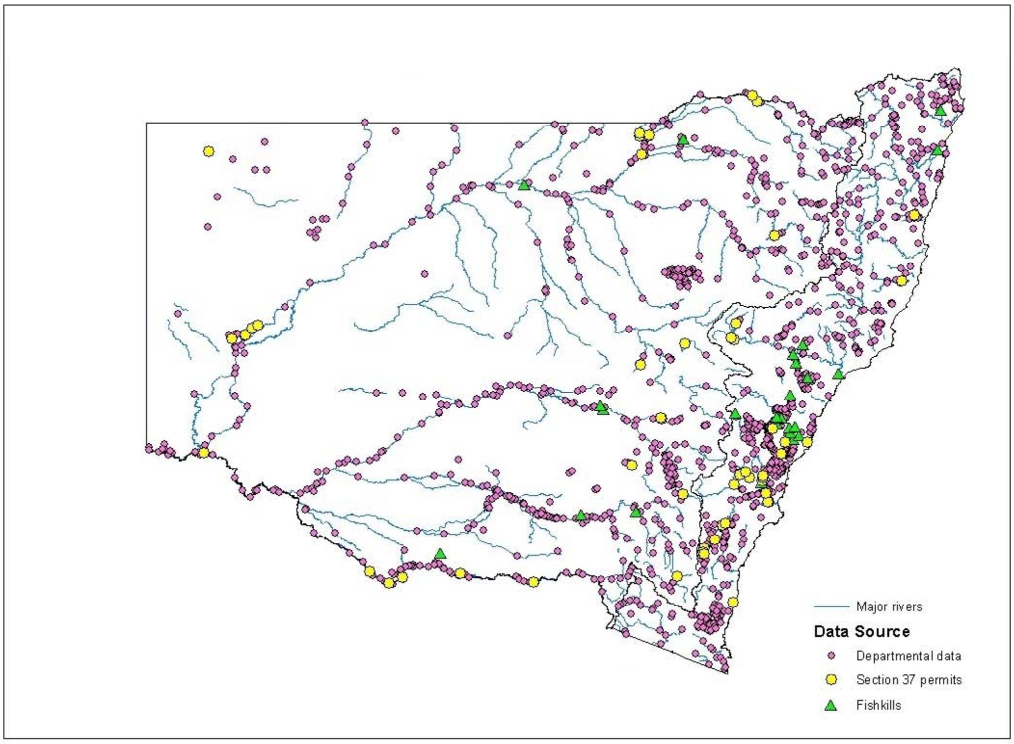

Figure 3.2. Locations of all sampling sites from various scientific research databases.

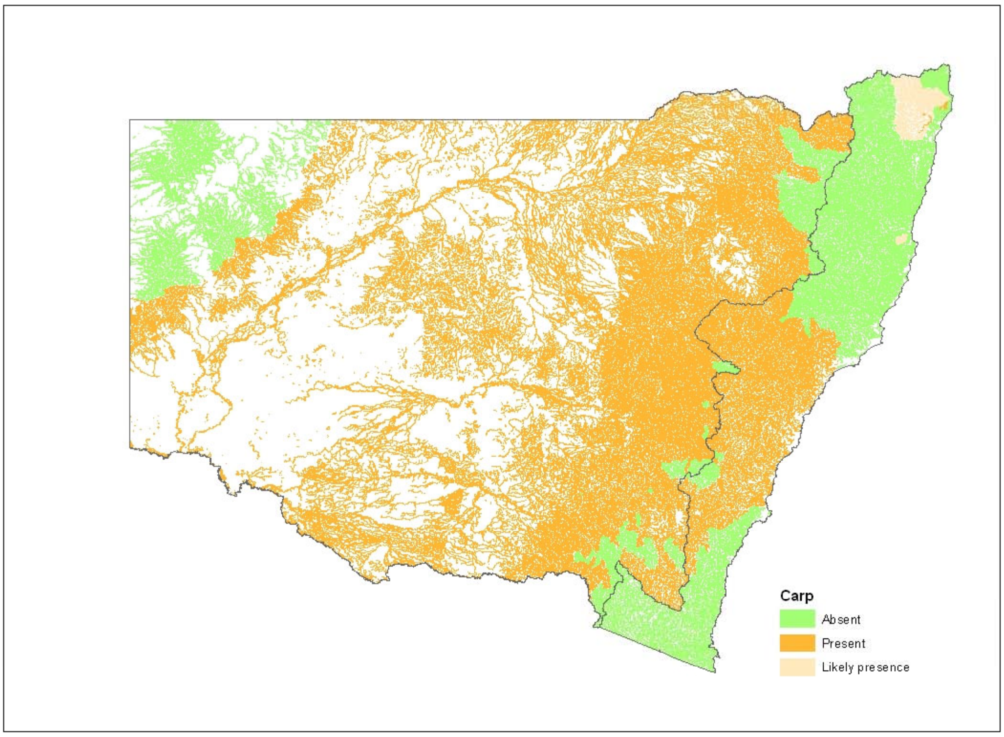

Figure 3.3. Map of NSW showing carp distribution compiled from the information supplied by Fisheries Officers; the black line on the eastern side delineates the Great Dividing Range.

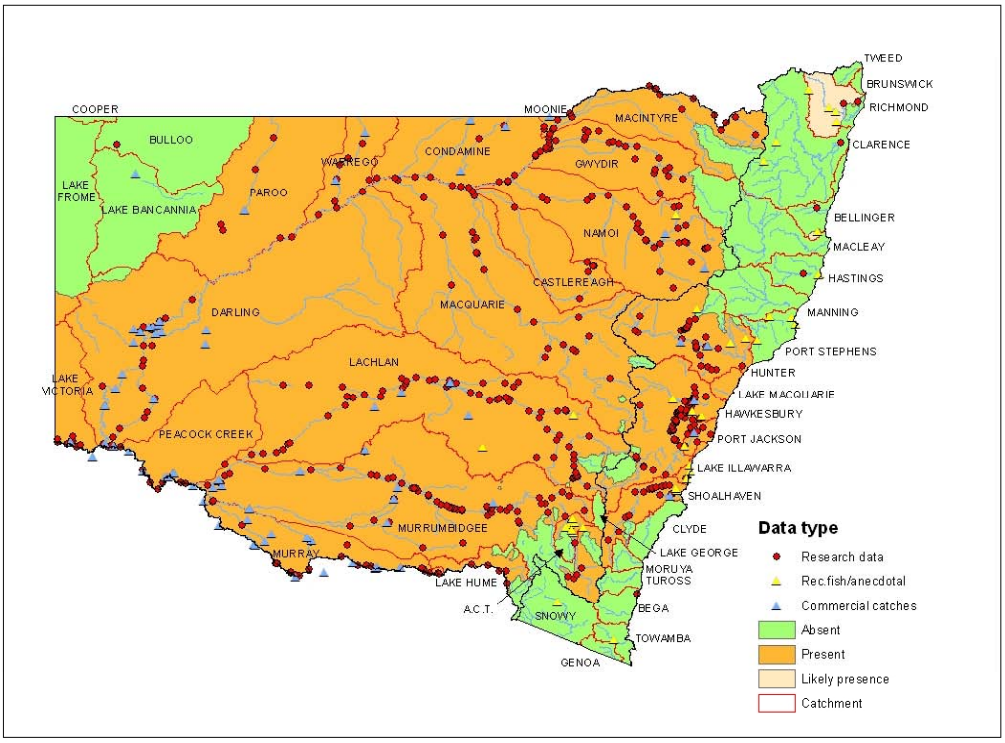

Figure 3.4. Map of carp distribution in NSW including locations of all carp capture sites from the research databases (scientific surveys, fishfiles, fishkills), commercial catch database, and carp observations from recreational fisher and anecdotal sources.

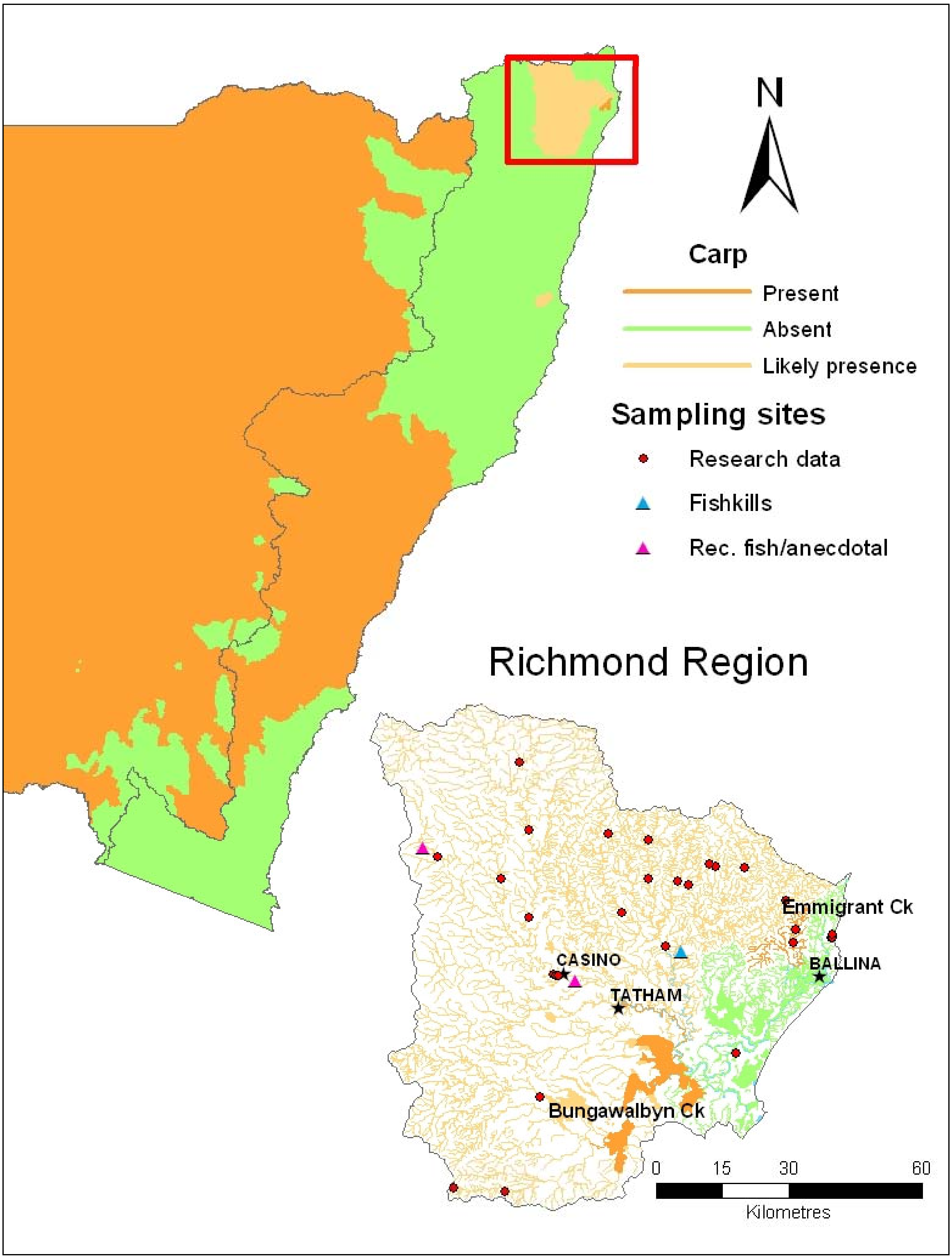

Figure 3.5. Details of carp distribution in the Richmond Fisheries District in northern NSW. Shown are locations of known carp presence (Emmigrant Creek, Lismore Lake, upper Richmond River near Toonumbar, Casino and Tatham, and the Bungawalbyn Creek swamps); the adjoining watercourses have no impediments to prevent the spread of carp from the known infested waterways.

4. COMMERCIAL FISHING METHODS

4.1. Introduction

Commercial fishing methods for carp appropriate for NSW were described and discussed by Wilson & Hyde (1999). Methods that have proven effective include electro-fishing, hauling, mesh-netting and trapping. The efficiency and viability of each of these methods vary and are dependent on the environmental conditions at the fishing locations, and ultimately the economic return to the fisher. Carp harvesting methods are reviewed, and a locally successful commercial carp harvesting venture is discussed.

4.2. Carp harvesting methods

4.2.1. Electro-fishing

Electro-fishing has been effective for carp harvest or removal in areas of high density, but its high capital cost and labour intensity make it unlikely to be a cost-effective commercial method in most locations (Wilson & Hyde 1999). They also observed that electro-fishing equipment requires substantial maintenance and operation by well-trained people. With proper use, species other than carp that are stunned during electro-fishing will recover unharmed if left in the water. However, the use of higher than optimal voltage can result in mortality of non-target species.

At present, no carp are commercially harvested in NSW using electro-fishing equipment. In Victoria, supplies of carp to the processing factory at Sale (*see* Bell 2003) are regularly supplemented with electro-fished carp from tributaries into Gippsland Lakes, particularly during drought conditions when carp retreat into the rivers as the lakes become more saline (K. Bell, personal communication).

4.2.2. Hauling

Hauling (seining or ‘drag-netting’) is potentially the most effective method for catching large quantities of carp. Protected bycatch species (native fish and air-breathing animals) taken during hauling operations can be sorted from the carp catch and released unharmed. The method is best suited to locations such as shallow lakes or dams where the bottom is relatively smooth, firm, and clear of snags. However, most natural waterways are probably unsuited to hauling as lake and river beds are normally littered with woody debris and other snags. As these provide important refuges and breeding sites for native fish (Koehn *et al*. 2000), clearing (de-snagging) areas for carp hauling is not an option.

However, artificial lakes and irrigation impoundments or canals may provide suitable opportunities for hauling. During times of low water levels (e.g. during droughts), potential hauling sites around the shores of lakes can be identified and mapped. In practice, carp catch rates by hauling may be increased by first attracting carp with berley into the hauling area before shooting the seine.

Catch records show that hauling has only occasionally been employed for carp in the NSW inland (see Section 5.2.1). In 2001/02 about 15 t were caught by drag net from Lake Brewster, after carp were attracted to the hauling area with berley (P. Angel, NSW DPI, personal communication). In Victoria, up to 1000 t of carp are harvested annually, mostly by seine, from Lake Wellington, Gippsland (Bell 2003), and during recent years around 5 tonnes per week are hauled from Lake Boga to supply a small factory in Deniliquin producing fertilizer and berley products.

4.2.3. Trapping

Unbaited drum-nets (drum shaped traps; see Reid *et al*. 1997) were used commercially across inland NSW until 2001 for trapping native fish in streams and rivers; a relatively small bycatch of carp was also reported for this method (Figure 5.2). Larger baited rectangular traps can also be effective for carp but, because of their shape and size are restricted to locations with easy access to the water (Wilson & Hyde 1999). Baited traps are most effective in flowing waterways (see Section 7.3) and catches are enhanced if the traps are fitted with netting wings to one or both banks to guide carp into the trap. The traps are set facing down-current to optimise the effect of the bait; carp also tend to move upstream when feeding. Bait found to be effective includes bread, chicken pellets (Wilson & Hyde 1999), and dog-food pellets.

However, trapping has the potential to adversely impact on native bycatch species if unmodified traps are set fully submerged. While native fish can be released unharmed when traps are cleared, air-breathing vertebrates may drown in traps that have no inbuilt escape device or accessible air space. Rectangular traps can be set with sufficient of the trap projecting above water to allow animals such as turtles to breathe. In deeper water, traps can be floated to maintain a space above the water or, if fully submerged, be fitted with an escape ‘sock’ to the surface. Care must be taken to prevent twisting or blockages in a netting sock or codend by securing it to a stake or other fixed point above the surface (see Grant *et al*. 2004). Regular clearing of traps is also essential as crowding can result in turtle or platypus mortality if too many animals are forced into the codend at the surface (D. Gilligan, NSW DPI, personal communication).

4.2.4. Mesh-netting

Historically, mesh-netting was the principal method of harvesting native fish in inland NSW, and carp was the main bycatch (see Figure 5.2). The minimum mesh size specified by the Fisheries Management Act 1984 was 130 mm. Through their design, mesh-nets can damage captured fish (by scale loss etc.) and drown air breathing animals that become entangled in the net. However, with modified procedures, mesh-nets can be used to catch carp while having minimal impact on bycatch species.

Commercial carp fishers in northern NSW have used their experience of ‘splash-meshing’ for mullet in estuaries to successfully catch carp (see Section 4.6). Splash-meshing involves setting mesh-nets in shallow water where carp are feeding and then frightening the fish towards the net with noise and/or splashing the surface. Carp hit the net hard and entangle their serrated dorsal and/or ventral spines. The nets are immediately retrieved and the carp are landed alive; any native fish or air-breathers such as turtles are quickly released. To allow easy release and to minimise injury to bycatch animals, relatively heavy netting (18 ply) is used; the heavy ply also reduces damage to the net should it become snagged on underwater obstructions such as tree branches.

4.2.5. Angling (line fishing)

Large numbers of carp are caught on line by recreational fishers (see Section 5.2.2). While line fishing is unlikely to have commercial potential, it may be possible to reduce carp density in small waterways by angling, particularly by encouraging competitions or other similar angler activity.

4.3. Discussion and summary

The characteristics of commercial methods applicable for harvesting carp in NSW are summarised in Table 4.1. The viability of any of these methods is dependent on local logistic and environmental conditions, and ultimately on the likely economic return. The low acceptability of carp in Australia as a food fish, with the consequent limited market and low price, make commercial fishing for carp economically marginal at best. For any substantial carp fishery to be profitable, bulk supplies must be readily available for little effort (Roberts & Ebner 1997). Wilson (1998) suggested that fishers, at the time of writing, needed to catch 5-6 tonnes of carp per week (at 80 cents/kg) to make an economic return. Hauling is the only method likely to produce catch rates of that magnitude but, as discussed above, suitable hauling sites are limited in the NSW inland. While one fisher-crew is successfully employing the splash-meshing method for carp, their viability relies on marketing relatively small quantities (< 2 tonnes per week) of fresh carp through the Sydney Fish Market and surviving the fragility of that market.

Electro-fishing, hauling, meshing and trapping, with appropriate modifications and deployment procedures, can safely be used for commercial carp fishing with minimal effects on bycatch species. Industry is aware and, for the most part, experienced in the use of most methods effective for carp. If the economic viability for carp improves, fishers will be in the best position to develop the most effective fishing gear. However, any gear or methods used to harvest carp must be environmentally safe and conform to any legislative conservation requirements. Government and non-government organisations frequently contact NSW Fisheries about carp control in public and private waterways. Any of the above methods can be adapted to help control carp numbers in relatively small waterways and streams.

The carp fishery in the USA preceded that in Australia but has many similarities, both in its history and in the methods of harvest. Broodstock was imported in the 1870s and during the following 40 years waterways throughout the USA were deliberately stocked with carp to create a fishery (Cooper 1987). A carp fishery quickly developed, peaking at almost 20 000 t in the early 1900s; the current harvest in the USA is about 10 000 t per year. As in Australia, most carp in the USA are harvested by large seines; in southern states carp are also caught in trammel nets, mesh-nets (including splash-meshing) and hoop nets (fykes). In some areas during the summer, the carp harvest is increased by chumming. Grains such as corn or barley, used fresh or soaked for several days to sour, are used to concentrate the carp before seining. Bags of ground grain, soybean cakes or alfalfa pellets are also put inside hoop-nets to increase the catch (Cooper 1987).

Table 4.1. Summary of carp harvesting methods applicable to NSW inland waters.

Gear type	**Fishing locations**	**Potential bycatch**	**Remedy**	**Advantages**	**Disadvantages**
electro-fisher	shallow rivers, channels	none if operated correctly		potential high volume catch	high capital cost; labour intensive
hauling net	open water with no snags	native fish, turtles	release bycatch alive	potential high volume catch	needs clear, firm lake-bed
mesh-net	open shallow water with few snags	native fish, platypus, turtles, birds	short soak-time; release bycatch alive	quality product, low capital cost	moderate to low catch rate; labour intensive
traps and drum-nets	rivers, channels with flow	native fish, platypus, turtles, birds	release alive; escape aperture or space for air-breathers	quality product, low capital cost; suitable for small streams, channels	moderate to low catch rate

4.4. Case Study: Mesh-netting in northern NSW storage dams by C & P Hyde

4.4.1. Introduction

Messrs Cec. and Paul Hyde work together as a two-man fishing operation in the carp fishery. Before entering the fishery in 1999, they investigated the commercial feasibility of carp fishing in northern NSW, tested a variety of gear, and participated in a project to collect and test carp for pesticide residues (Wilson 1998, Wilson & Hyde 1999).

They are based in Port Macquarie and market their catch through the Port Macquarie Fishermens Co-operative. Formerly estuary fishers, they have applied their knowledge of estuary fishing for mullet and other species to the harvesting of carp. A principal source of fishery income for the Hyde businesses is now carp, and in recent years they have been the main supplier of carp to the Sydney Fish Market. Their businesses are licensed for the Inland Restricted Fishery with one non-transferable and one transferable Class D Carp endorsements. These licences allow them to harvest carp from inland waters (western drainages).

4.4.2. Fishing area

Most fishing is done in the artificial water storages of Lake Keepit and Chaffey Dam in the Tamworth area (Figure 4.1).

4.4.3. Fishing gear and methods

The fishing set-up is self-contained and mobile. Two 5-6 m net-boats are towed on trailers by pickup trucks (Figure 4.2). Fishing gear is contained in the boats, and large ice-containers are carried on the trucks. The principal fishing method is “splash meshing”, a technique practised in estuaries for species such as mullet. A large rectangular trap was also developed to catch carp, and catches are occasionally supplemented by line fishing.

4.4.3.1. Splash-meshing

Two 350 m x 5 m monofilament mesh-nets are used; the netting is 18 ply and mesh size 150 mm (6 inch). Nets are set in shallow water (< 4 m depth) either in areas where carp have previously been caught, or where carp are seen feeding along the shoreline (Figures 4.3, 4.4). The nets are streamed from the boats while being rowed quietly, to avoid frightening the fish from the area. Along a shoreline, the ends of the net are run into the water edge. At the completion of setting, fish are scared into the net by motoring the boat along the shallow side, and/or “splashing” with an oar. The nets are then retrieved after a soak time of about 15 minutes. Total time per set is about one hour, but will vary depending on the number of fish caught. There are up to four sets per day, but varies according to catch rates and/or weather. Fish are retained under cover in the boat until landed; in hot weather, fish maybe kept alive in a pen before being iced-down.

The net-boats are of traditional low freeboard design that offers minimal windage (Figure 4.5). Construction is of wood and fibre-glass, making them quiet to operate. The 18-ply monofilament netting may not be optimal for meshing but the relatively heavy netting was selected as a compromise to withstand damage on snags, and to facilitate the untangling of carp and any protected bycatch. In their flight-response to splashing, carp hit the net hard and are usually tangled by their serrated dorsal and/or ventral spines (Figure 4.6).

This style of fishing produces a high quality product but is only economically viable when the catch is destined for human consumption i.e. attracts prices greater than about $1.50 per kg. The short soak for each set (usually less than one hour) ensures that the catch is landed alive and any bycatch of native fish or turtles can be released alive. Bycatch in Keepit and Chaffey Dams has comprised mainly freshwater turtles (fam. Chelidae), with very small numbers of catfish (*Tandanus tandanus*), silver perch (*Bidyanus bidyanus*), golden perch (*Maquaria ambigua*) and bony bream (*Nematalosa erebi*). Catches of any of these species have averaged less than four (in number) per set.

4.4.3.2. Trapping

A large rectangular box-trap was also developed by the Hydes to catch carp (Figure 4.7). The dimensions of the trap is approximately 3 m x 2 m x 1 m, and it is covered with 100 mm (4 inch) 36 ply trawl netting. The netting at one end is shaped into a funnel entrance. The frame is of light-weight square steel tubing (20 mm sides) with right-angle collars at the corners which are pinned. The trap can then be dismantled and rolled up for easy handling and transport (Figure 4.8).

The trap can be set in shallow water with the top clear of the surface to allow air-breathing animals room to breathe. Carp have been trapped in water as shallow as 50 cm with much of trap above the surface. In deeper water, two sealed plastic pipes attached along the sides of the trap about 25 cm from the top float the trap. In operation, the trap was baited with bread and chicken pellets contained in a berley-bag made from shade-cloth; small holes were punched in the bag to allow some dispersal of the bait, and also to allow some feeding by carp in the trap which encourages more to enter.

Experience has shown that the trapping is most effective in streams or channels with some water flow; in these situations, the trap is set facing down-stream. However, catches up to 700 kg were taken with the trap set near the edge of a lake. When using the box trap in still water, carp were first attracted to the area with berley; after about a day the berley and a bait-bag was placed inside the trap and carp then entered the trap to feed.

4.4.4. Carp production

Usually, 10 to 15 days per month are fished for monthly landings of 4-8 tonnes. Daily catch rates are usually between 200 and 500 kg, but can exceed 1000 kg. Since the year 2000, relatively high catch rates were reported for most months with no obvious seasonality to the catches. Factors that have impacted on their operations have included weather, lake-levels, water quality, interaction with other water users, and market acceptance (see below).

In general, carp catches are greatest during the afternoons in the warmer part of the day (particularly during winter), and during calm conditions; windy weather makes fishing difficult and carp less available in the shallows. Carp were most abundant in shallow water when the lake-levels were rising or were close to full (C. Hyde, personal communication). As carp cannot be taken for human consumption from waters with high blue-green algae concentrations, water quality impacts on the fishery. Blue-green algal concentrations are usually greatest during periods of low water levels in the dams, and advice on algal concentrations in Keepit and Chaffey Dams is obtained from the local Catchment Authority and/or NSW Fisheries. Fishing is usually suspended during holiday periods when large numbers of recreational craft and water skiers utilise the lakes.

4.4.5. Markets

The catch is sold through the Sydney Fish Market and, since 2000, the Hydes have supplied about 50% of all carp through the SFM. Carp are consigned from the Port Macquarie Fishermen's Co-op, and trucked to Sydney in ice slurry. Relatively strong demand on the market floor is limited to about two tonnes per week, usually realising prices between $1.50 and $2.00 per kg. When weekly supply exceeds about 2.5 t, the selling price can fall to about $1.00 per kg or less, making the operation unprofitable. Consequently, the Hydes regulate their consignments to Sydney but additional supplies from other sources readily depress the floor price.

Figure 4.1.

Lake Keepit with net boat in foreground.

Figure 4.2.

Fishing unit of truck and trailer with net boat. A large insulated container containing ice is on the back of the truck.

Figure 4.3.

The nets are set along shallow shorelines in 2-3 m depth. Carp feeding in the shallows are then frightened into the net by “splashing” and making noise between the shore and the net.

Figure 4.4.

Net set through flooded woodland.

Figure 4.5.

Scouting for feeding carp in shallows.

Figure 4.6.

Untangling carp caught by its dorsal spine.

Figure 4.7.

Collapsible box-trap. The frame is bolted together and a netting trap is secured to it. The trap can be fished on the bottom, or floated at the surface.

Figure 4.8.

Rectangular trap dismantled and ready for transport.

Figure 4.9.

Fresh carp catch.

5. NSW CARP PRODUCTION & MARKETS

5.1. Introduction

Inland NSW fishery production for the years 1947-1996 was summarised in Reid *et al*. (1997). Reported carp catches to 1970/71 were less than 10 kg per year but following the introduction of carp into the Murray/Darling River system (in 1968), carp production rose quickly to peak at almost 550 t in 1977/78. Reported landings then declined to less than 200 t in 1984/85, and until 1995/96 fluctuated between 100 and 200 t per annum. In the early years, most of the catch was dumped, and the decline in catches was attributed mainly to the limited market opportunities combined with its low value, and changes in fishing practices in an effort to avoid carp while targeting native species (Reid *et al*. 1997).

In 1997, the NSW Rivers Survey reported that native fish were under threat from habitat degradation, fishing pressure, disease, and introduced species (Harris & Gehrke 1997). Following a review of the inland commercial fishery in early 1998, a decision was made to phase out commercial fishing for native finfish by 1 September 2001, and to redirect fishing effort towards under utilised yabby and carp resources. A structural adjustment package was developed to enable transition from native finfish to the yabby and carp only fishery. The inland commercial fishery is now managed as a 'restricted fishery' and includes endorsements that authorise fishing for carp and yabbies only. Since 2001, there have been about 30 fishers licensed to fish inland waters, and most have targeted yabbies. In that time, only six fishers reported carp catches in excess of five tonnes.

Relatively small but regular sales of fresh carp are made through the Sydney Fish Market (SFM), and occasionally some NSW production is processed in Sale, Victoria (Bell 2003). There is also some industrial processing of carp for pet-food and fertiliser.

In this section, the commercial and recreational catch data is updated and recent market data are presented. The impact of closing the inland fishery to native finfish is discussed.

5.2. Annual production

5.2.1. Commercial catch

Annual production of carp from NSW inland waters reported by commercial fishers between 1970/71 and 2002/03 (from Comcatch, August 2003) is shown in Figure 5.1. Over recent years, annual landings gradually declined from 110 t 1997/98 to about 70 t in 2002/03. The number of participants in the fishery has also declined in recent years (Table 5.1). More than 30 fishers reported carp catches prior to 1999 and this number decreased to about 20 fishers in 2000/02. In these years, the majority of fishers landed less than 5 tonnes per annum, mostly as bycatch when targeting native fish. In 2002/03, the first full year after the native finfish fishery was closed, only 7 fishers landed carp; four fishers each reported between 7 and 13 tonnes and a two-fisher operation caught 33 t in northern NSW.

Fishing method was not recorded for a large proportion of the carp catch but, where specified, most carp were caught by mesh-nets, with small but consistent catches in drum-nets (Figure 5.3). One large catch of 36 t was taken by a 'drag net' or seine in 2001/02 when the net was set across the outlet of a small lake (Moira Lake; see Stuart & Jones 2002) after it was opened to the Murray River; in the same year about 15 t were caught by drag net from Lake Brewster.

NSW was arbitrarily divided into three broad regions (Appendix 4) showing the main areas of carp production since 1984 (Figure 5.2). Prior to the year 2000, most carp were caught in the southwest (Murray, Murrumbidgee and Lachlan River drainages) and the far western (Lower Murray) and northwestern (Darling River and Menindee Lakes) areas of NSW, mostly as bycatch from the native fish fishery. However, by 2000, catches from the southwest had declined to very low levels. Apart from the 50 t caught by drag-net in 2001/02, almost no carp have been recorded from the southwest since the fishery was restricted. Similarly, carp catches were very small in the western part of NSW after the native finfish fishery closed; the 35 t of carp reported in 2002/3 were harvested from drying lakes. There have been significant catches from northern NSW since 1999/2000 (30-70 t per year), principally from a single fishing enterprise that targets carp in storage lakes around Tamworth (see Section 4.6).

5.2.2. Recreational catch

The National Recreational and Indigenous Fishing Survey (Henry & Lyle 2003) found that carp was the most common species caught by anglers fishing NSW inland waters. The estimated annual catch by recreational fishers in NSW was approximately 1.2 million carp weighing 877 t; the survey found that about 11% of carp were released after capture. Although some recreational fishers target carp (‘Coarse Fishing’), it is probable that most are captured while targeting native fish.

5.3. Sydney Fish Market Sales

Sydney Fish Market (SFM) sales data were available from Annual Reports (1980/81 to 1991/92), and subsequently from their website (www.sydneyfishmarket.com.au). A breakdown of sales according to size grades and presentation were detailed on the website from 1992.

5.3.1. Annual sales and price

In the years between 1980/81 and 1991/92, total annual sales through the SFM ranged between 33 and 65 tonnes (Figure 3.4). Sales more than doubled in 1991/92 to 124 t, the maximum volume for any single year to date. Annual sales have remained in excess of 70 t since, but show an overall slow decline.

The average market price for carp slowly increased from about 80 c/kg in 1980/81 to about $2.00/kg in 2000/01 (Fig. 3.4). A sharp rise in average price to about $1.85/kg occurred in 1989-91 when supplies were relatively small. Possibly in response to this price increase, the quantity of carp offered for sale in 1991/92 more than doubled, but the price sharply declined and fell back to below the 1987 level. Another marked increase in price occurred in 2001/02, this time to over $2.00/kg, again possibly as a response to lower supplies. However, despite similarly low levels of supply to the market in 2002/3 (and the calendar year 2003), the average price reverted to the near the trend average of $1.63/kg.

There was little size-grading of carp until 1999; since then, between 50 and 80% have been graded for sale. Most carp have been graded as ‘large’ or ‘extra-large’), with only small quantities as ‘small’ or ‘medium’ (Fig. 3.5). Generally, small and medium carp attracted higher prices than were paid for larger carp. In 2001, the mean price for small carp was 16c/kg higher than for medium carp and, in turn, mediums were 16c/kg higher than for large/extra-large carp. In 2003, medium, large and ungraded carp attracted similar average prices of $1.57-$1.69 (Figure 3.5).

About 95% of carp are presented for sale as whole fish on ice or in ice slurry; a very small quantity is presented for sale headed and gutted or ‘cleaned’. There appeared to be no price advantage for any of the different methods of presentation.

In summary, annual volumes of carp through the SFM have ranged between 33 t (1980/81 and 1989/90) and 124 t (1991/92); sales have declined from 98 t to 70 t over the last three years. Average price has gradually risen, but appears to be sensitive to supply with supplies in excess of two tonnes within any week receiving very low prices. The market seems to favour small to medium sized carp (although only small quantities were graded as small or medium), and carp in ice or ice-slurry are equally accepted.

5.4. Other markets

Apart from the SFM, the only other southeastern Australian outlets for carp for human consumption are the Melbourne Fish Markets and K & C Fisheries in Sale, Victoria. The Melbourne Fish Markets handle similarly small quantities of carp to the SFM, and most is supplied by K & C Fisheries.

K & C Fisheries catches and processes about 80% of Australia’s carp production (Bell 2003). The business handles in excess of 1000 tonnes of carp per annum with most coming from Lake Wellington (Gippsland) where the factory is located. K & C Fisheries have developed markets for carp and carp products in Europe and the Middle East, as well as supplying the limited domestic market in Victoria. Other outlets for their carp include rock lobster bait, pet food and fertiliser products. This business is also licensed to fish in NSW and occasionally accesses significant quantities of carp from inland NSW when suitable opportunities arise (e.g. Moira Lake catch: see *Section 4.2.1* above).

Some carp is processed for industrial use in NSW. The “Charlie Carp” factory in Deniliquin processes 5-10 tonnes per week into liquid fish emulsion for plant fertiliser and ‘berley marinade’; at present almost all the carp supplied to this factory comes from nearby Victorian waters (Lake Boga).

5.5. Discussion

There have been no formal stock assessments for carp because its widespread distribution and range of habitats would require enormous effort and expense that would be difficult to justify (Koehn *et al*. 2000). However, it is clear from the early commercial catch history and the present recreational catch that the carp stock in the NSW inland could support a fishery well in excess of 1000 tonnes per annum. Wilson (1998) made a simplistic estimate of the NSW carp stock to be about 76 000 t, and suggested an annual harvest of 15 000 t. Even if these estimates cannot be validated, the standing stock of carp is very large and grossly underutilised. Nevertheless, with catching techniques applicable to most NSW waterways, there is a limited amount of carp that can be economically harvested. Wilson (1998) investigated the commercial opportunities for carp in NSW but concluded that the very low demand and consequent low value of carp in NSW provided no financial incentive for any expansion of the commercial fishery.

Less than 100 t of carp are sold in NSW each year for human consumption and there appears to be little likelihood of any marked increase. The main outlet is through the SFM but analysis of the SFM sales shows that the demand for fresh carp is very limited. The sale-price is very susceptible to volume and during 2003, average price regularly fell below $1.50 per kg when weekly supply exceeded one tonne. Most of the carp sold through the SFM is supplied by one fishing operation, and it limits its production to market demand. The SFM data also show that any variation from the normal presentation of whole fish (e.g. headed and/or gutted) derives no price advantage.

The distance from market outlets appears to inhibit any development of the carp fishery in the west and southwest of NSW (Murray-Darling Basin). K & C Fisheries in Sale, Victoria, is a successful carp processing enterprise with well-developed infrastructure. However, because of distance from the company's processing base, they have found it difficult to maintain quality and remain cost effective when accessing carp from northern Victoria and NSW (Bell 2003). With fresh carp attracting less than $2.00 per kg, and carp for industrial use (bait, fertiliser, pet food) less than $1.00 per kg, the cost of catching, handling and transport means that fishers in remote areas will not cover costs on relatively small amounts of fish (Wilson 1998, Bell 2003).

Table 5.1. Number of licensed fishers landing carp between 1996/97 and 2002/03 (* single carp fishing operation).

	No. of fishers per catch weight category						
Annual catch (t)	**1996/97**	**1997/98**	**1998/99**	**1999/00**	**2000/01**	**2001/02**	**2002/03**
< 0.5	6	9	8	11	4	7	1
0.5-1.0	3	5	7	2	2	3	0
1.0-2.5	8	10	6	9	5	3	0
2.5-5.0	8	7	7	3	6	2	1*
5.0-10	3	2	5	1	0	1	3
10-20	2	0	0	0	3	1	1
>20	1	2	0	1	1	2	1*
Total	31	35	33	27	21	19	7

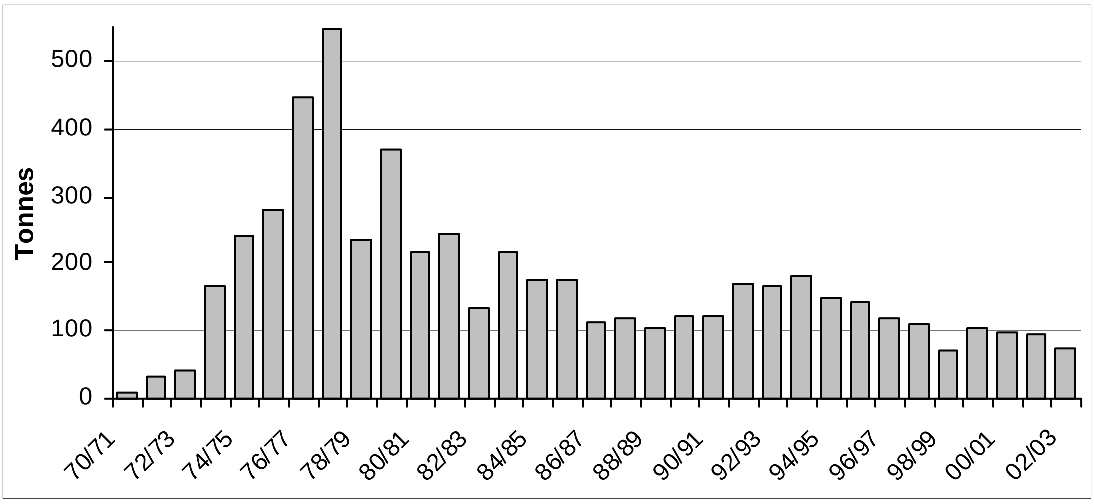

Figure 5.1. Annual catch of carp reported by NSW commercial fishers between 1970 and 2003 (source: NSW Fisheries CatchCom database).

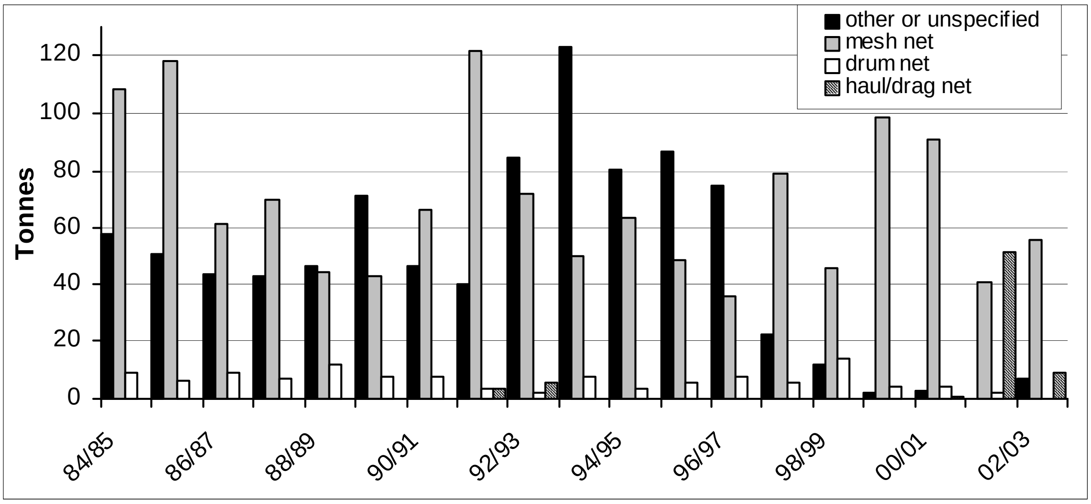

Figure 5.2. Annual catch of carp between 1984 and 2003 by fishing method (source: NSW Fisheries CatchCom database).

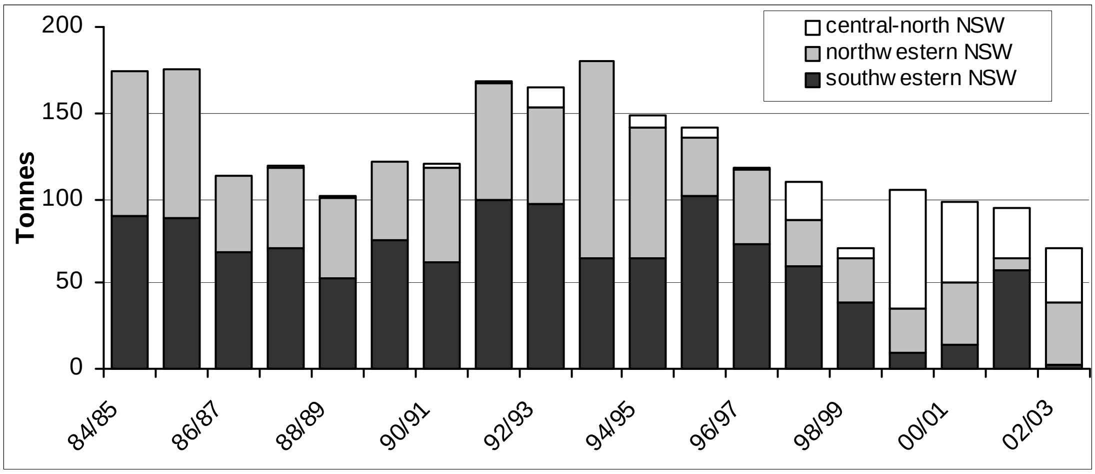

Figure 5.3. Annual catch of carp between 1984 and 2003 from main catchment areas of NSW (source: NSW Fisheries CatchCom database).

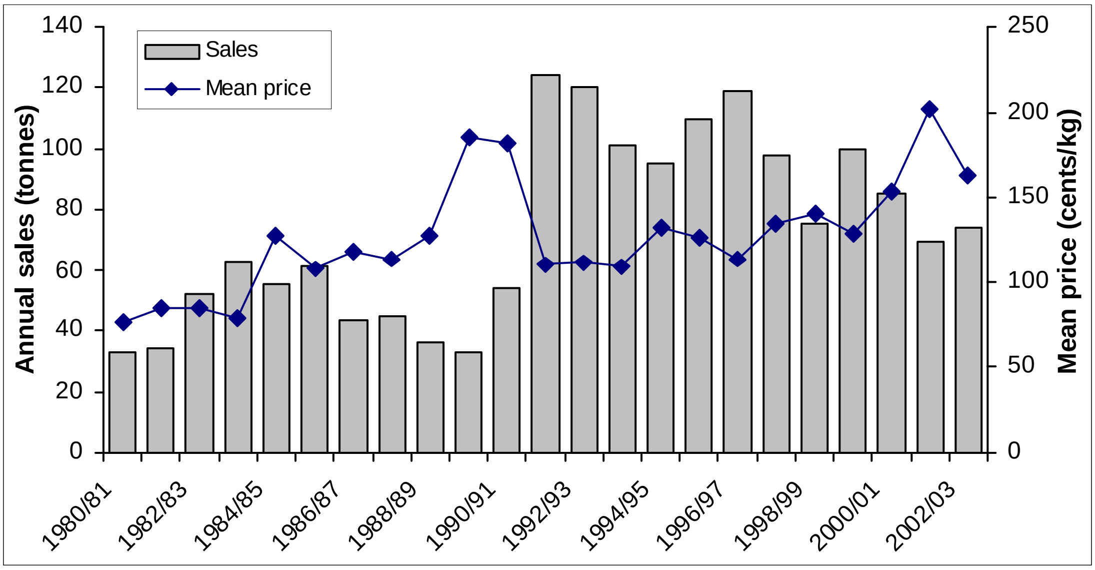

Figure 5.4. Annual sales and mean price of carp through the Sydney Fish Market 1980-2003 (source: FMA Annual Reports and SFM website).

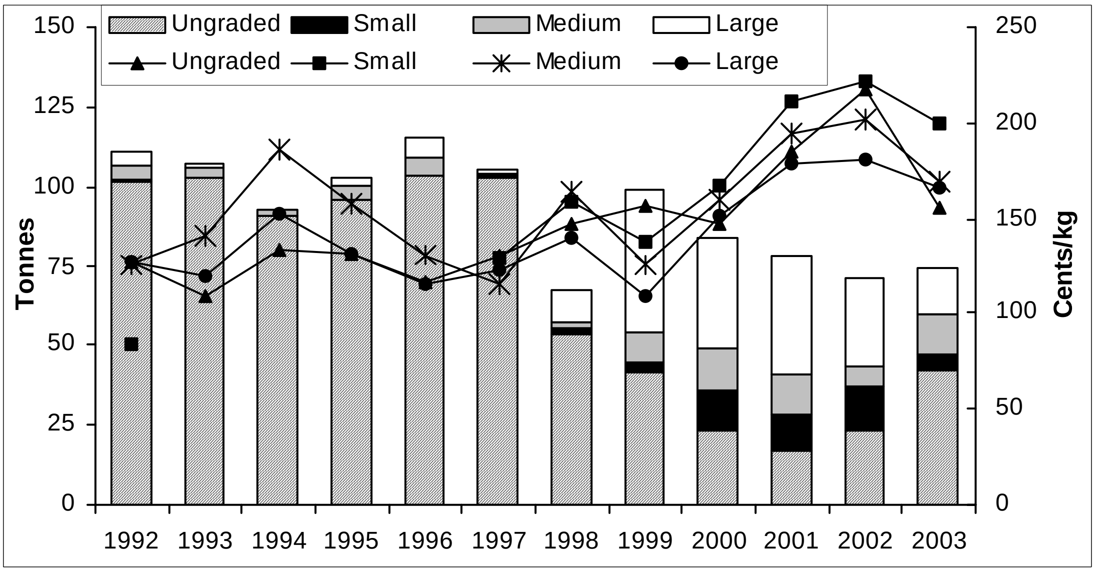

Figure 5.5. Annual sales (tonnes) and mean price (c/kg) for each size grade of carp sold through the Sydney Fish Market 1992-2003 (source: FMA Annual Reports and SFM website).

6. ENVIRO-TRAP TRIALS

6.1. Introduction

Bycatch mortalities of air-breathing vertebrates caught in traps used in coastal and inland commercial fisheries have been documented in the USA by Roosenburg *et al*. (1997) and Guillary & Prejean (1998), and in southeastern Australia by Beumer *et al*. (1981) and Spencer (2001). Commercially fished traps are normally left unattended for prolonged periods, usually 24 hours or more. Accordingly, fishers prefer to use fully submerged traps because traps that project above the surface frequently attract interference from unauthorised people. However, accidental mortality of air-breathing vertebrates is potentially a major problem for inland fisheries that employ fully submerged traps. Particularly vulnerable in NSW are several species of short and long-necked freshwater turtles (fam. Chelidae) and platypus (*Ornithorhynchus anatinus*) which all inhabit coastal and inland freshwater environments and are protected under the National Parks and Wildlife Act (NSW) 1974.

New South Wales Fisheries recognised that traps used to harvest freshwater eels *(Anguilla* spp.*)* and yabbies (*Cherax destructor*) posed risks to platypus and freshwater turtles. In an effort to reduce bycatch mortality, surface codends are usually attached to eel and yabby traps to provide an air space for air-breathing animals that enter the traps. To further decrease bycatch mortality, means to restrict platypus and turtles from actually entering the traps were investigated (Grant *et al*. 2004, Lowry *et al*. 2005). The findings resulted in the mandatory use of bycatch reduction devices (BRDs) in yabby traps, while the fitting of appropriate BRDs to eel traps is the subject of a current NSW DPI-Industry discussion paper. Any future harvesting of carp with traps would require gear that was robust, easy to handle and could be fished fully submerged without impacting on protected bycatch. The “Enviro-Trap” was developed to address these requirements, having an inbuilt BRD designed to release air-breathing vertebrates underwater.

The Enviro-Trap (Figure 6.1) is similar in style to the drum-net used historically to trap native fish in Australian inland waters (see Reid *et al*. 1997), and was developed in South Australia specifically for the commercial harvesting of carp. A BRD was positioned in the top of the trap in the form of a shallow platform leading to a circular escape gap. The design assumed that trapped air-breathing vertebrates would swim upwards towards the water surface; on impacting the roof of a trap, they would search along it for a means of escape (surface/search behaviour). Trapped native fish could be released when the trap was cleared. Carp, which normally swim upright, were assumed to be less likely to escape through a narrow laterally oriented gap at the top of the trap but to remain congregated near the bottom of the trap around the bait bag.

An application was made to NSW Fisheries to use the Enviro-Trap in NSW inland waters, and a trap was provided to NSW Fisheries for testing. Two similar traps (referred to below as ‘envirotraps’) with BRDs identical to the original Enviro-Trap were constructed so replicated experiments could be done. The effectiveness of the BRD to release freshwater turtles and platypus while retaining carp was tested. Envirotraps were also field-tested in a number of locations where turtles and carp were present (Section 7).

6.2. Description of Enviro-Trap

The Enviro-Trap is cylindrical in shape, 90 cm diameter x 1.7 m long, and covered by black plastic square mesh (45 mm x 40 mm). The cone-shaped entrance funnel was made from the same plastic material as the outer cover (Figure 6.1). The two new traps were fitted with entrance funnels made from 90 mm mesh trawl netting (braided 3 mm diameter polyethylene twine); the funnel in each trap was pulled tightly inwards by twine secured to the trap frame (Figure 6.2). In all three traps, a round-cornered rectangle of stainless steel rod 230 mm x 115 mm framed the apex of the funnel where it opened into the trap. A stainless steel ring of 230 mm diameter (the same as the longer dimension of the entrance funnel) formed a circular escape aperture in the top of each trap. This top opening was located at the end opposite the entrance funnel in the Enviro-Trap (Figure 6.3); for experimental purposes, the escape opening in one of the new traps was located centrally. A wire mesh ramp (50 x 40 cm) was positioned beneath the aperture (Figures 6.3, 6.5) for escaping animals to climb onto and then move to the escape aperture; at the centre, gap between the ramp and the roof of the trap was 85 mm. The ramp was also designed to inhibit carp from exiting through the aperture. To provide a smooth surface and to highlight the escape aperture, the upper surface inside the top of the trap was lined with black plastic ‘fluteboard’. A rope bridle was rigged from each end of the trap and met at a single point above the centre; a large polystyrene float was attached to the bridle to keep the trap upright and the BRD at the top while the trap was submerged.

6.3. Carp retention trials

Effective BRDs are designed to release unwanted bycatch while retaining the target species. An angling competition targeting carp in Lake Liddell (Hunter Valley) provided a source of live carp to test whether carp would escape from the envirotrap through the BRDs. The experiments were conducted on 18-21 August, 2001.

6.3.1. Methods

The original Enviro-Trap and the two new envirotraps were used in the trials, but only the two new traps were used in replicated experiments. The new traps were identical except for the positioning (centre and end) of the BRDs (Figure 6.5). At the time of these tests, the new traps were not fitted with entrance funnels, so the only avenue of escape for carp was through the BRD apertures.

About 120 carp were collected from the anglers and retained in three holding pens. For each treatment, 20 fish were randomly selected from the holding pens, measured (FL) (but not individually marked) and put into each trap. The traps were then fully submerged in the lake with their upper surfaces about 30 cm underwater. No traps were baited. On completion of each treatment, fish remaining in each trap were counted and again measured to determine the number and sizes of any escaped carp.

There were two experimental treatments. Carp were held in the traps over each of three nights (14 hour soak-time per night); all traps were tested on the first night, but only the two new traps on nights 2 & 3. The new traps were also tested during daytime with a series of 2-hour soak times (total = 6 replicates for each trap).

6.3.2. Results

Carp used in the tests ranged between 36 cm and 60 cm fork length (Figure 6.6).

All carp escaped from the original Enviro-Trap during the first overnight trial. During the three nights, 14 of the 120 carp held in the new traps escaped: 11 during the first night, three during the second, and none during the third night. Eleven of the 14 escaped carp were from the trap with the BRD located at the end (as in the original trap). No significant differences in retention were detected between the new traps over the three 14 hour periods ($U = 3$, $n=6$, $p>0.05$).

No carp escaped from either trap during any of the 2-hour treatments.

6.3.3. Comments

Carp escaped from traps only during the three overnight soaks. Most were lost during the first night when a strong wind blew and the traps were buffeted by considerable wave action. All carp escaped from the original Enviro-Trap through either the trap entrance or the BRD aperture. The combination of wave action and lack of bait probably agitated the carp to actively search for an exit, and the extra opening facilitated their escape. Fewer carp escaped from the new traps where the BRD was the only avenue of escape. Most (11 of 14) were lost during the first night when it was windy, but only three escaped during the second and third nights when conditions were calm. The results suggested that under more optimal fishing conditions in sheltered waterways few carp would escape through the BRD opening, particularly when the attraction of bait is likely to lessen the escape response of carp from the trap.

6.4. Turtle escape experiment

Experiments were conducted to evaluate the effectiveness of the envirotrap BRD to release freshwater turtles; the short-necked turtle *(Emydura macquarii)* was used in the experiments. The study assessed two configurations of the envirotrap: the escape chute (BRD) in the top of the trap was in the centre of Trap A and at the end opposite to the entrance in Trap B (Figure 6.5). The working hypothesis was that Trap A would achieve a higher rate of escape than Trap B, because the central BRD gave turtles two sides of the escape chute to access, whereas in Trap B there was only a single entry onto the escape chute.

6.4.1. Methods

A total of 52 short-necked turtles were captured with fyke nets and small fish traps from the Botany Wetlands pond in the Lakes Golf Course, Eastlakes (hereafter referred to as Botany Pond). Each turtle was individually marked and measured for straight carapace length (CL), straight carapace width (CW) and girth (Appendix 3). The experiments were conducted in a small swimming pool containing untreated water. For each experiment, 10 animals were randomly selected and placed in a trap which was then fully submerged for four hours. Both trap configurations were trialed concurrently. Six replicate treatments were done for each of the two trap types (12 trials) giving a total of 120 turtle-responses. Turtles leaving the trap were identified (by their markings) and their time of escape recorded. Turtles remaining in the trap after each four-hour period were also identified and recorded.

The two sample Kolmogorov-Smirnov test was used to: (i) compare the escape rates of turtles from carp Trap A to Trap B, and (ii) test for possible differences in the sizes between escaped and retained turtles from Traps A and B. The Mann-Whitney-U test was used to compare the physical measurements (carapace length, carapace width, girth) of escaped and retained turtles between

Traps A and B. Linear regression analysis was used to test for possible relationships between the escape times from carp Traps A and B and the turtle physical variables (length, girth and width). Statistical test values with a *p* value less than 0.05 were assumed to be significant.

6.4.2. Results

The ambient water temperature in the pool was 19.5-20° C. Fifty of the 52 available turtles were each selected (randomly) between one and four times across the six treatments (Table 6.1). The carapace lengths (CL) of the turtles ranged from 106 to 244 mm (Figure 6.7); there were close linear relationships between CL and carapace width (r^2=0.96), and CL and girth (r^2=0.95) (Figure 6.8).

Across all experiments, 118 turtle-responses were recorded (Table 6.1); observations on two turtles were missed. Overall, 92 (78%) turtles placed in the traps escaped during the 4-hour observation periods. Almost identical numbers escaped the two traps: 47 exited through the central BRD (Trap A) and 45 through the end BRD (Trap B). Across the 12 trials, only twice did all 10 turtles placed in a trap escape; of the other 10 trials, between one and six turtles remained in each trap after four hours. Seven individual turtles placed in traps (total of 13 placements) did not exit on any occasion, and 31 individuals (72 placements) exited on every occasion. Eleven turtles, each used between two and four times, exited during some trials, but remained trapped at other times.

Across all treatments, most turtles were inactive during the first 20 minutes of submergence with only six escaping in that time. However, after 90 minutes, 65 (71%) had left the traps; the remaining 27 escapees exited periodically through the last 150 minutes of observation (Figure 6.9). The mean time for escapes from Trap A was 62.6 ± 7.0 minutes, and from Trap B 91.5 ± 10.5 minutes; the difference was not significant (D=0.209, n=92, $p > 0.05$). A number of times, turtles were observed to move onto the ramp in small groups, suggesting a “follow the leader” response. Turtles resting on the chute sometimes appeared to block access to other turtles.

Carapace lengths of turtles that escaped ranged from 106 to 244 mm (mean 168.5 ± 33.6 mm CL); those that remained in the traps measured 120-244 mm (mean 183.5 ± 25.9 mm CL). Seven turtles (163-204 mm, mean 182 ± 19 mm CL), each used in 1-3 trials, failed to escape the trap at any time. The mean length of escaping turtles was significantly smaller than those that remained within the traps (D= 0.325, n=118 $p < 0.05$). No correlation was found between the length of time taken to escape and carapace length (r^2 = 0.093), carapace width (r^2 = 0.095) and girth (r^2 = 0.087).

6.4.3. Comments

The position of the BRD did not influence the overall numbers of turtles that escaped from each trap. Although not statistically significant, the mean escape-time of 62 minutes for turtles exiting from Trap A (centrally located escape chute) was considerably less than the 92 minutes for Trap B. The lower mean escape time may have resulted from the observed “follow the leader” behaviour, with the dual entrances onto the escape platform in Trap A allowing more turtles to exit during periods of peak activity. The opaque liner covering the upper inside surface of the trap assisted turtles to move freely along the top of the trap without being meshed, and encouraged movement towards the escape ring. However turtles often pushed their heads through the mesh along the intersection with the liner; they then frequently moved along this intersection past the opening to the escape chute. The current design may be improved by extending the liner further down the circumference of the trap thereby encouraging the turtles to move along the top of the trap. Turtle escape may also be improved by tapering the edge of the black liner in towards the escape chute (see Figure 7.8) in order to guide the trapped animals onto the escape platform.

Most turtles readily escaped through the envirotrap BRDs but a substantial proportion (22% overall) had not exited after four hours. Although these remaining turtles were significantly larger than the escaped animals, there was no suggestion that the BRD opening physically impeded the larger sized turtles. In fact, each of the five largest turtles used (208-244 mm CL) escaped one or more times through the BRD (in total, 10 from 13 attempts). It seems likely that the larger animals were more able to remain submerged for extended periods and, as some turtles exited after 220-240 minutes in the traps, it is probable that some of these would have eventually escaped if allowed more time. However, it was apparent that some of the turtles that failed to escape had become inactive and seemed to have insufficient energy to seek out the BRD at the top of the trap. It was possible that those turtles would ultimately have drowned if left in the traps.

6.5. Platypus escape experiment

There is considerable overlap in NSW between the distribution of carp and platypus, making the potential use of submerged traps for harvesting carp a concern. The objective of this study was to test the effectiveness of the envirotrap BRD for platypus. Although platypuses close their eyes, ears and nostrils when under water and use the sensory mechanisms in their bills to find their way around (Pettigrew *et al*. 1998), it was expected that the platypuses would exhibit the surface/search behaviour the BRD was designed to accommodate, and readily escape through the hole in the top of the trap. Observations to determine if this hypothesis held true were conducted in pools in the Wingecarribee River during 25-27 November 2002. As a response to these observations, the traps were modified and a second experiment testing the BRDs with platypus was done, initially in the Wingecarribee River (27 November) and later in the upper Shoalhaven River during 21-23 December 2002. During both experiments, the entrance funnel to each trap was blocked in order that the BRDs were the only available exit.

All experiments were done cooperatively with Dr T.R. Grant, platypus researcher with the School of Biological, Earth and Environmental Sciences, University of NSW.

6.5.1. Experiment 1

6.5.1.1. Methods

The trap was fully submerged in the pool from which the platypuses were captured. A remote lens for a video camera was mounted inside the trap to record the behaviour of the animals. Platypuses were captured using unweighted mesh-nets in three pools in the Wingecarribee River in New South Wales. Each animal was weighed and measured, then marked with a piece of brightly coloured tape wrapped around the tail making the platypus more visible to observers and to the video camera. Based on previous observations of platypuses inside eel traps (T. Grant, per. obs.), individuals were immersed for a maximum of 3 minutes before the trap was lifted to permit them to breathe. If they exited before 3 minutes, the elapsed time was recorded. The numbers of times each animal approached the platform below the escape hole was also recorded. All animals were used only once in the trials and were released immediately after they were removed from the traps if they had failed to find the escape hole.

6.5.1.2. Results

Table 6.2 shows the dimensions of the five platypuses used, the time in the trap, the number of approaches onto the platform below the escape hole, and whether or not individuals escaped. Only one male platypus managed to find the escape hole (after 30 seconds in the trap), but showed reluctance to swim over the steel ring around the hole. After taking a breath, it re-entered the body of the trap; it repeated this three more times before swimming away from the escape hole.

Interestingly this animal seemed to have no trouble in repeatedly finding the escape hole after re-entering the trap, taking 30, 50 and 50 seconds respectively to re-emerge under the hole before finally escaping. The other four trial animals failed to find the escape hole and were released after 2-3 minutes.

Unexpectedly, the hypothesis that the platypuses would search along the top of the trap was not supported by the observations, as all (including the one which escaped) spent most of the time inside the trap seeking to escape through the bottom or ends of the trap. In fact, the platypuses seemed to actively avoid the platform area below the escape hole. All animals searched with their bills around the corners of the trap at the intersections of the sides and ends. The video showed that they frequently investigated the acute angled corner between the base of the entrance funnel and the sides of the trap.

6.5.2. Experiment 2

In response to the observations in Experiment 1, it was decided to test whether platypus would exit through escape holes positioned around the base of the entrance funnel. This part of the trap was selected as the gap between the funnel and the trap sides becomes quite narrow at the base of the funnel and it was considered that most carp would be too large to access openings in this position in the trap. Experiment 2 describes the testing of these modifications.

6.5.2.1. Methods

Every fourth mesh of the netting funnel was released from the trap frame and tied back to make 90 mm sided triangular openings (Figure 6.4). In the initial experiment in the Wingecarribee River six openings were made in the upper half of the trap, but in the later trials in the Shoalhaven River, six openings were also made in the lower half of the trap. Fourteen platypuses were individually placed in the submerged trap as described in Experiment 1. Most trials were at night but, when possible, the platypus movements in the trap were recorded; observations were again aided by brightly coloured tape attached to the tails of the animals, and the use of a red-filtered spotlight (see Grant *et al*. 2004). Escape time and location of escape hole around the funnel (upper or lower half) were recorded for each platypus. Some underwater video observations were made but the turbidity of the pools made viewing difficult. Again, if the platypus was not seen to escape, the trap was lifted from the water after three minutes.

6.5.2.2. Results

All 14 platypuses escaped from the trap within three minutes (Table 6.2), with all but one exiting through the gaps around the base of the funnel; one individual escaped from a larger hole inadvertently left in the back end of the trap. As was observed in Experiment 1, all animals attempted to find an escape route around the bottom or ends of the trap. In the second trial (in the Shoalhaven River) six platypuses exited from the ‘upper’ and five from the 'lower’ openings, indicating no preference. One individual moved onto the BRD platform but returned back into the trap and eventually exited by another opening; only one other platypus was seen to approach the BRD platform. Two platypuses were not seen escaping but were absent when the traps were lifted after 3 minutes; it is likely that both exited quickly through one of the lower escape holes as any prolonged searching or escape through the upper holes would have been observed.

6.5.3. Comments

Platypuses are known to be vulnerable to traps used in freshwater fisheries targeting eels and yabbies (Grant *et al*. 2004). Experiment 1 indicated that fully submerged carp traps, without effective BRDs, would almost certainly kill platypuses if deployed in areas inhabited by both species. In the traps, the platypus exhibited little or no surface/search behaviour, with all animals constantly searching the bottom, sides or ends of the trap for an avenue of escape. Consequently, the inbuilt BRD in the envirotrap was rendered ineffective. However, Experiment 2 showed that a trap with appropriate escape holes could be effective in preventing platypus mortality. Platypuses over a wide size range (690-1880 g) were able to exit relatively quickly (15-157 seconds) through the 90 mm triangular openings inserted around the mouth of the envirotraps. That the platypuses showed no preference for the lower escape gaps suggests that if similar traps were used for carp in areas inhabited by platypus, appropriate escape gaps could be confined to the upper half of the trap, thus reducing the likelihood of carp finding these gaps.

It should be noted that the platypuses used in these experiments were not particularly large. There is considerable sexual dimorphism in the species, with the average male being around 75% heavier and 20% longer than females (Carrick 1995; Grant 1995). Individuals of up to twice the size of those used in these experiments are found in some mainland areas (especially in streams west of the Great Dividing Range. Further experiments to determine the size of escape gaps effective for such large animals should be carried out if similar traps are to be deployed in areas where larger platypuses are found. However, it is recommended that if fully submerged traps were to be used for the harvesting of carp in platypus habitats, those deployed in east-flowing streams in NSW should have triangular escape gaps with sides no less than 100 mm; traps used in streams west of the divide require openings of at least 120 x 120 mm.

6.6. General discussion

The effectiveness of BRDs is directly related to the ability of the design to exploit physical and behavioural differences between target and bycatch species. The envirotrap BRD is essentially a strategically positioned escape gap. Its positioning and structure, combined with the opaque lining along the top of the trap, were designed to exploit behavioural differences between the carp and accidentally caught air-breathing vertebrates. Turtles, platypus and carp were observed directly and by video, and each species exhibited behaviour relevant to the effectiveness of the BRD. Inside the trap, carp grouped close to the bottom and oriented into any water flow; few were lost through the BRD suggesting that under normal fishing conditions with bait present, most carp would stay in the envirotrap. Turtles, after initially moving around the trap bottom, swam upwards and actively sought to escape along the interface of the opaque liner and the trap mesh until most eventually found the mesh platform and exited through the escape ring. In contrast, platypus were seen to actively search the bottom, corners and ends of the trap looking for holes through which to escape; they seldom swam near the top of the trap and appeared to deliberately avoid the BRD chute. The experiments supported the expectations that few carp and most turtles would exit through the BRD. The observed behaviour of platypus led to a different means of facilitating their escape.

Envirotrap trials with platypus found that, with the creation of small holes around the front edge of the trap, all animals escaped in less than three minutes suggesting that platypus mortality in submerged traps could be avoided with appropriately located escape gaps. While not tested with carp, it was felt that by positioning the escape gaps around the upper front perimeter of the trap, such a BRD would be totally effective for platypus while carp, with their normal habit of remaining near the bottom of the trap and close to the bait bag, were unlikely to find the platypus escape holes.

However, the turtle BRD was less successful. Under experimental conditions, about 20% of turtles failed to escape from the envirotrap after four hours and the position of the BRD (in the centre or at one end of the trap) did not affect this outcome. Although it was likely that some remaining turtles would have eventually escaped if given more time, it appeared that others were exhausted after being submerged for four hours and had ceased actively searching for an escape avenue. It seemed likely that these turtles would eventually drown. The ability of NSW species of freshwater turtles to survive prolonged periods of submergence, as may happen in commercial trapping procedures, is unknown and, for ethical reasons, experiments could not be done to determine the maximum survival time for submerged turtles.

There is little information available for freshwater turtles which details average submergence times and how the ability to remain submerged is affected by factors such as water temperature, size and stress levels, but studies have shown that water temperature will affect feeding and capture rates of turtles. The minimum water temperature at which short-necked turtles (*E. macquarii*) will feed is about 16^{o}C (Chessman 1978) and at higher water temperatures both turtles and carp actively feed and are both likely to be caught in traps. It is known that ffreshwater turtles can remain submerged for extended periods and several studies have described the recovery of a number of species after extensive periods of submergence (e.g. Caligiuri *et al*., 1981, Lutz and Kabler 1997, Jackson 2000). Some species are known to hibernate underwater during winter but the survival time of actively feeding animals is almost certainly less than 24 hours. For example, the North American painted turtle (*Chysemys picta bellii*) has survived for three months submerged in 3^{o}C water, but only six hours in 20^{o}C water (Herbert & Jackson 1985). An eastern USA study of turtle mortality in crab traps found that the diamondback terrapin (*Malachlemys terrapin*) could not remain submerged for longer than 12 hours during summer water temperatures (Roosenburg et. al 1997). In southeastern Australia, Beumer *et al*., (1981) captured a total of 272 long-necked turtles (*Chelodonia longicollis*) in fyke nets during a two year sampling period, with the majority being caught in summer when water temperatures were as high as 34^{o}C. As the fykes were soaked overnight, some of the captured turtles could have been submerged for up to 18 hours but, of the 272 captures, there were only two mortalities. During the present study, however, field trials with envirotraps in the Lane Cove River (see Section 7.3.4) in water temperatures of about 20^{o}C found that some short-necked and long-necked turtles left in traps overnight were moribund by morning and were unlikely to survive further submergence.

The evidence suggests that in water temperatures optimal for both carp and turtle feeding (i.e. > 18^{o}C), trapped turtles are unlikely to survive being submerged longer than 12-18 hours. Such a relatively short survival time has implications for any commercial trap fishery for carp where the gear is unlikely to be inspected more often than daily. Fully submerged traps in such a fishery would need to be fitted with BRDs that were totally effective for air-breathing vertebrates. If the envirotrap BRD could not be modified so that all turtles escaped, another means for turtle survival would be required. An appropriate BRD may be a properly rigged netting escape tunnel to the surface (as required in the NSW eel and yabby fisheries). Alternatives would be to inspect traps twice daily, or employ traps which protrude above the surface and provide an air space for turtles.

The development and assessment of the envirotrap BRD has resulted in a valuable conservation outcome. The trials demonstrated that the trap would retain most carp while releasing most turtles; however, further modifications are required to fully eliminate turtle mortality. Although these experiments focused on one species of turtle, the results are probably applicable to other similarly sized species in the NSW inland. For platypus, the inbuilt BRD was found to be ineffective. However, the value of video camera technology was demonstrated by recording and analysing platypus behaviour inside the traps. These observations resulted in the placement of different apertures which successfully released all platypus from the traps.

Two papers describing the above experiments and observations have been published (Grant *et al*. 2004; Lowry *et al*. 2005). Abstracts are in Appendix 4.

Table 6.1. Carapace length (CL, mm) and escape times (mins) for short-necked turtles from envirotraps with central BRD (C) and end BRD (E). X = remained in trap after 240 minutes; ER = escape ratio (no. of escapes / no. of times used).

Trial:	**1**		**2**		**3**		**4**		**5**		**6**		
BRD:	**C**	**E**	**C**	**E**	**C**	**E**	**C**	**E**	**C**	**E**	**C**	**E**	**ER**
106	-	-	-	-	-	-	-	26	-	-	-	13	2/2
112	-	17	-	-	-	-	-	-	-	-	-	-	1/1
112	-	-	-	192	-	226	-	-	43	-	-	-	3/3
113	-	-	-	-	-	-	-	35	-	38	-	-	2/2
118	-	-	-	-	-	175	-	-	49	-	-	-	2/2
121	-	-	-	-	-	-	-	59	-	-	55	-	2/2
121	-	151	-	-	-	99	-	-	-	X	-	-	2/3
128	-	-	-	-	-	-	59	-	41	-	-	-	2/2
131	-	-	-	-	-	-	58	-	-	-	-	60	2/2
133	-	-	20	-	30	-	-	-	-	-	-	-	2/2
138	-	-	28	-	-	-	-	32	-	-	-	24	3/3
139	-	-	-	-	-	-	28	-	-	-	26	-	2/2
143	-	-	-	-	30	-	-	-	-	-	-	-	1/1
153	-	-	-	-	-	-	-	-	-	123	230	-	2/2
154	-	-	-	-	-	-	33	-	-	38	-	-	2/2
155	17	-	28	-	-	-	-	-	-	X	-	-	2/3
158	-	69	-	-	-	104	-	-	-	-	-	-	2/2
160	-	-	24	-	-	-	-	32	-	-	-	36	3/3
163	-	-	-	-	-	-	-	-	-	X	-	-	0/1
167	-	-	-	-	-	X	-	-	-	X	-	-	0/2
167	X	-	-	-	-	-	-	X	-	-	X	-	0/3
170	-	-	24	-	-	-	-	44	58	-	-	-	3/3
170	-	X	-	-	-	-	-	-	-	-	-	-	0/1
172	-	-	-	-	-	-	-	-	-	-	-	37	1/1
172	-	-	-	-	-	-	12	-	-	-	-	-	1/1
172	X	-	-	205	-	-	64	-	-	-	-	-	2/3
172	-	-	-	52	X	-	-	-	-	-	-	X	1/3
175	-	-	-	X	-	-	-	X	55	-	-	-	1/3
176	-	-	-	45	30	-	-	-	-	-	47	-	4/4
179	-	-	65	194	-	-	39	-	-	X	-	-	3/4
183	49	-	108	-	61	-	-	-	223	-	-	-	4/4
183	-	205	-	-	-	228	-	-	-	-	-	240	3/3
183	52	-	51	-	-	-	23	-	-	-	-	-	3/3
185	-	-	-	-	-	-	-	-	-	-	-	46	1/1
185	-	-	-	X	-	-	-	-	-	-	100	-	1/2
190	-	-	-	89	-	100	-	-	-	-	-	56	3/3
191	-	-	-	45	-	-	X	-	72	-	-	-	2/3
195	-	-	-	-	X	-	-	-	-	X	-	-	0/2
196	-	57	-	-	-	-	-	-	-	-	44	-	2/2
198	-	137	-	-	-	-	-	-	-	89	-	-	2/2
200	-	-	61	-	-	-	-	42	-	-	-	-	2/2
204	-	-	-	-	X	-	-	-	-	-	-	-	0/1
206	-	114	-	-	130	-	-	-	100	-	-	-	3/3
207	-	5	-	-	-	45	-	-	-	-	30	-	3/3
207	X	-	-	X	-	-	X	-	-	-	-	-	0/3
208	-	-	-	-	-	-	-	-	-	-	-	48	1/1
210	95	-	-	-	X	-	-	-	-	-	126	-	2/3
211	157	-	-	-	-	207	-	-	113	-	-	-	3/3
236	-	-	50	-	30	-	-	-	-	-	X	-	2/3
244	X		-	-	-	202	-	-	72	-	-	-	2/3

Table 6.2. Details and escape responses of platypus in the envirotrap BRD Experiment 1.

Date	Sex	Age	Length (cm)	Weight (g)	Time in trap (secs)	Approaches to platform	Escape
25.11.02	female	adult	48.5	1080	150	0	No
25.11.02	male	adult	55.2	1880	165	0	No
27.11.02	male	juvenile	56.5	1790	180	0	No
27.11.02	male	juvenile	53.0	1400	30-50	4	Yes
27.11.02	male	adult	57.5	1880	180	0	No

Table 6.3. Details and escape responses of platypuses in envirotrap BRD Experiment 2 (+ lower openings not available; * escape not observed; # escaped through unsecured opening in trap).

Date	Sex	Length (cm)	Weight (g)	Time in trap (seconds)	Approaches to platform	Escape upper/lowe r
27.11.02	F	43.0	850	85	1	upper +
27.11.02	M	50.5	1740	147 #	0	-
27.11.02	M	55.2	1850	35	1	upper +
21.12.02	F	41.0	690	15	0	lower
21.12.02	F	46.0	900	22	0	lower
21.12.02	F	43.5	940	15	0	lower
22.12.02	F	44.0	900	40	0	upper
22.12.02	F	41.0	790	41	0	upper
22.12.02	F	43.5	870	140	0	upper
22.12.02	F	44.0	930	33	0	upper
22.12.02	F	44.0	860	<180*	0	lower
22.12.02	F	43.5	840	45	0	upper
22.12.02	F	43.0	790	156	0	upper
22.12.02	M	52.0	1740	<180*	0	lower

Figure 6.1. The original Enviro-Trap showing the conical entrance and the black fluteboard lining the upper surface.

Figure 6.2.

Envirotrap with netting funnel-entrance.

Figure 6.3.

Enviro-Trap showing the escape aperture; the rust coloured platform is visible beneath the ring.

Figure 6.4.

Close-up of funnel perimeter showing platypus escape holes (two mesh openings tied back with white twine.

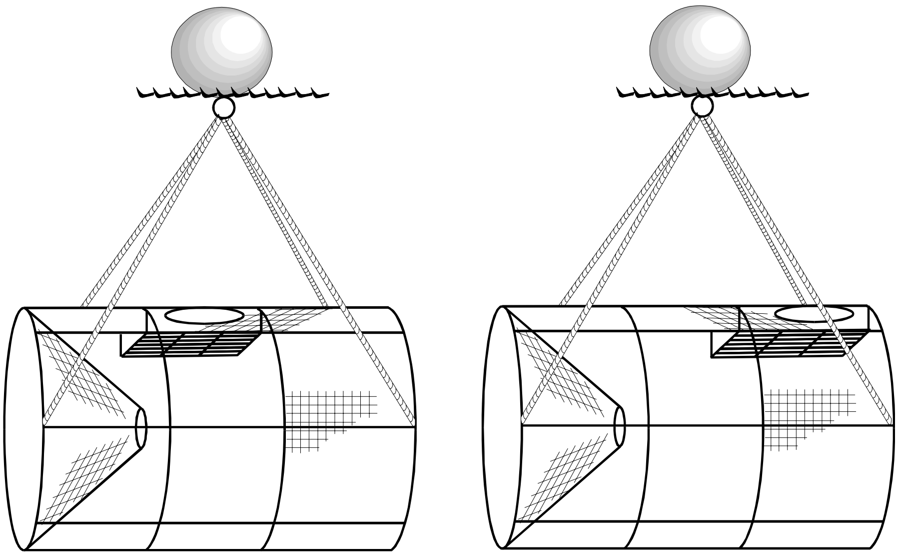

Figure 6.5. Diagram of envirotraps showing central (left) and end (right) positions of the BRD.

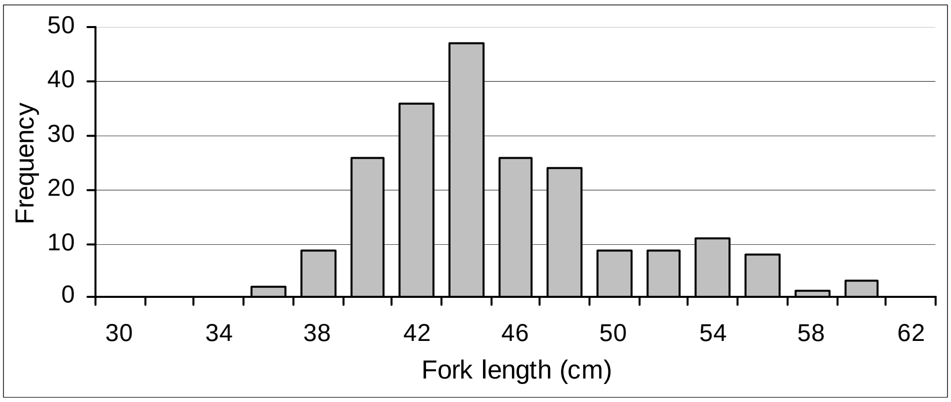

Figure 6.6. Length distribution of carp from Lake Liddell used for carp retention experiments (n=212).

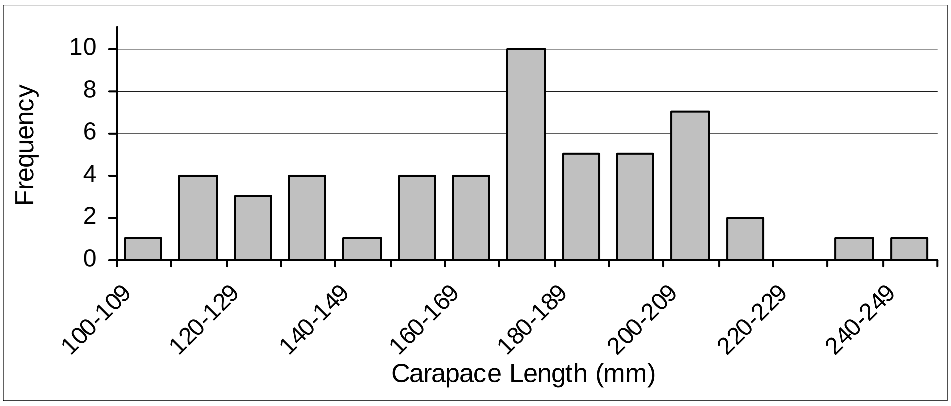

Figure 6.7. Length distribution of short-necked turtles from Botany Pond used for envirotrap BRD experiments (n=52).

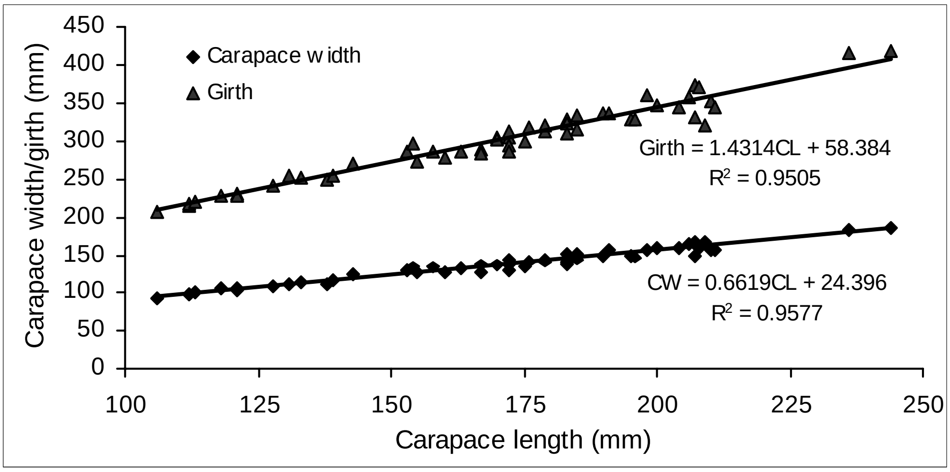

Figure 6.8. Relationships between carapace length (CL) & carapace width (CW), and CL & girth for short-necked turtles.

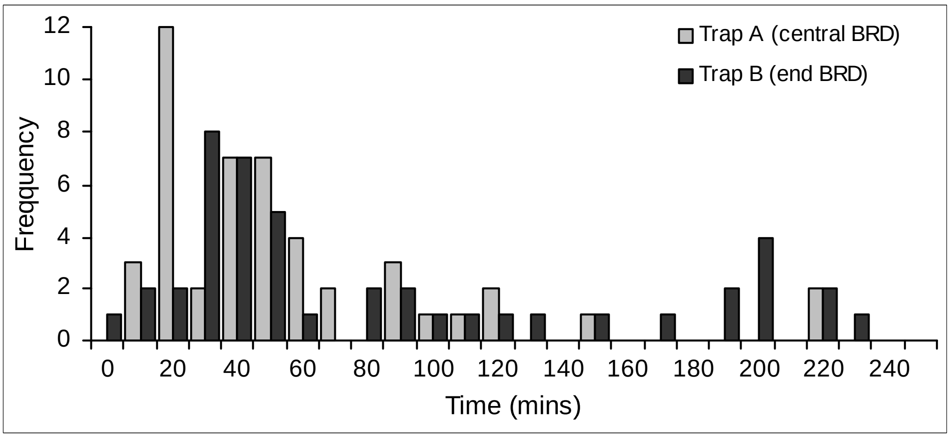

Figure 6.9. Number of escapes over time by short-necked turtles through the BRD of each envirotrap.

7. FISHING GEAR TRIALS

7.1. Introduction

As discussed in Section 4, there are a number of environmentally friendly methods available for the commercial harvesting of carp but their use is dependent on the economic viability of the fishery. However, government and non-government organisations frequently contact NSW Fisheries about relatively small-scale carp control in public and private waterways. While there is potential for commercial methods such as seining or splash-meshing to help control carp numbers in open and clear waterways, smaller gear such as longlines or suitably modified traps may be better suited to more restricted waters which are often littered with fallen branches and trees and have difficult access.

Preliminary fishing trials were conducted with several types of small gear in Botany Pond and the Lane Cove River, two locations known to contain carp. The larger, commercial-sized envirotraps (see Section 6) were fished in Eagle Creek in the southern Riverina near Barham, the Lane Cove River, and South Creek near Penrith.

7.2. Small-scale gear

7.2.1. Gear and methods

Fishing trials were conducted with small baited traps, eel fyke-nets, and a small long-line. The trials were done in Botany Pond and the Lane Cove River. Initial trials were in April and May, 2002, and further fishing was done in September 2002.

Two types of traps were tested: i) round 1.5 m diameter collapsible traps covered with small-mesh polyethylene netting (designed for small fish), and ii) small rectangular (80 x 50 x 50 cm) wire lobster traps. All traps were fitted with netting escape-tubes to the surface to allow air-breathing vertebrates to survive. The traps were baited with a mixture of bread, dry dog-food and corn contained in a porous bait-bag, and set near the edges of the pond under overhanging trees or adjacent to aquatic vegetation such as reeds.

Fyke-nets (1 m diameter) with 5 m wings were fished in shallow water (< 2 m depth) near the bank or reed beds in Botany Pond; the wings were staked about 10 m apart, and the back-end (cod-end) of the net was floated or staked above the water surface to provide airspace for turtles.

The small longline consisted of a 48 ply nylon twine main-line, with 20 hooks about 4.0 m apart on monofilament snoods; hook sizes were 3/0, 4/0 and 5/0. The long-line was anchored at each end, and to keep the line near the surface, small floats were located at 20 m intervals. Hooks were baited with corn, meat and fish, and the area around the line berleyed with corn; soak time for each set was about two hours.

7.2.2. Results and comments

Initial daytime trials (April-May 2002) with small traps caught no fish but five short-necked turtles. During subsequent fishing in September 2002 when the gear was used to collect turtles for BRD experiments (see Section 6.), the traps and fykes were set overnight and checked each morning. Three fyke nets and four traps were used over a period of three weeks; total soak-time for each gear type was: 54 trap-nights, and 31 fyke-nights. The long-line was set four times during the day, and once overnight.

Although carp were seen in the areas where the different gears were set, none was caught by any method. The only fish captured were two estuary catfish (*Cnidoglanus macrocephalus*) and one longfinned eel (*Anguilla reinhardtii*), all taken in the fyke-nets. About 60 turtles (short and long-necked) were also caught in the traps and fyke-nets.

Large carp were seen at both fishing locations during the periods the gear was deployed. While the size of the available carp may have inhibited their entry into the relatively small traps, the most likely reason for the zero carp capture was the lack of appreciable water movement or current in either Botany Pond or the Lane Cove River. Historically, traps (drum-nets) used in the NSW inland fishery were invariably set in flowing water, and large traps subsequently deployed in Eagle Creek (see below) caught few carp when the creek stopped flowing. It seems likely that current is required to spread the bait-odour, or to activate feeding movement by the carp. The fine-mesh covered collapsible traps were expected to catch small carp as these traps had been successfully used for the capture of juvenile estuarine fish. That no small carp were caught suggests that juveniles were either in low numbers or absent from the fishing sites. However, the easy capture of turtles in traps and fyke-nets emphasised the necessity to incorporate escape apertures for air-breathing vertebrates in fully submerged gear.

7.3. Trials with large fish traps

7.3.1. Gear

Envirotraps were fished in Eagle Creek, the Lane Cove River, and South Creek; a large collapsible box-trap, based on the design of the Hyde box-trap (Figure 4.7), was also fished in Eagle Creek. The 1.7 m x 90 cm diameter drum-shaped envirotrap (Figure 6.1) is fully described in Section 6.2. The box-trap (Figure 7.1) was 2.3 m x 1.5 m x 0.8 m, constructed of 20 mm square steel tubing bolted at each corner, and covered with black 36 ply polyethylene trawl netting. The single funnel-shaped side entrance was shaped from netting to give an opening similar in size to the envirotraps. All traps were baited with a mixture of bread and dry dog-food pellets contained in porous (onion) bags hung inside the traps.

7.3.2. Trapping in Eagle Creek

Eagle Creek is a permanent watercourse that provides irrigation water to the dairy and citrus farms, and market gardens along its length. To maintain supply, water from the Murray River is pumped into its headwater near Barham, usually each weekend, giving rise to flow for a few days each week along much of its length. Following a request by the Eagle Creek Pumping Syndicate (ECPS) to NSW Fisheries for advice on carp control, trapping trials were conducted in Eagle Creek during 4-12 December 2002. The request by the ECPS provided an opportunity to test the envirotrap and box-trap in the field. The main objectives of the trials were to determine whether carp could be trapped in small waterways such as Eagle Creek, demonstrate the utility of the two trap designs, and test the effectiveness of the turtle BRD under field conditions (no platypus inhabited the area.)

For a detailed description of Eagle Creek, fishing sites, methods and results, see Appendix 5. Methods and results are summarised below.

7.3.2.1. Methods

Envirotraps were set fully submerged in relatively narrow parts of the creek; two traps were rigged with netting wings to each bank and were set from a small punt. The third envirotrap was fished without wings beneath a small bridge. The box-trap was set in relatively shallow water with 10-20 cm of the trap above the surface. All traps were cleared between 6 a.m. and 8 a.m. each day; the envirotraps were also inspected in late afternoon (6-8 p.m.) to compare day and night catch rates. Bait bags were renewed every 2-3 days. Length, weight and reproductive data were recorded from all captured carp.

7.3.2.2. Results

Trapping was for eight days across a full cycle of the creek's normal flow regime, from Wednesday evening (4 Dec.) to Thursday morning (12 Dec.). The total catch was 194 fish weighing 210 kg, comprising 181 carp (203 kg), 4 goldfish (*Carassius auratus*), 5 carp/goldfish hybrids, 2 redfin perch (*Perca fluviatilis*), and 2 bony bream (*Nematalosa erebi*). No air-breathing vertebrates were caught in the traps, although a long-necked turtle was found unharmed clinging to one of the trap wings when the gear was retrieved from Site 2 at the end of the trials.

The average catch from all traps for the 8 fishing days was six carp (7 kg) per day, but the mean catch ranged from about 3 carp/trap on the two Thursdays, to 10 carp/trap on Sunday. Catches in all traps increased markedly during the weekend, coinciding with the beginning of pumping on Friday evening and the onset of flow in the creek (Figure 7.2). Catches were greatest in the envirotrap (with wings) at Site 2 (see Appendix 4) where the flow was strongest and most consistent. The maximum catch at Site 2 was 18 carp weighing 28 kg (Tuesday) and, across the 8 days, averaged 11 carp (15 kg) per day. Other sites were less productive: the average catches of the envirotrap fished without wings (Site 3) and the box-trap (Site 4) were less than half that of Site 2 (about 5 carp, 5 kg per day). The other envirotrap was fished at two sites (Site 1: 5 days; Site 5: 2 days) but caught relatively few carp at either location. About 75% of the total carp catch was caught during the night; of the catch taken during daylight hours, almost all was taken during Saturday, immediately after the onset of pumping.

The catch comprised almost equal numbers of male (97) and female (84) carp. Sizes ranged between 22 cm and 58 cm FL (Figure 7.3) with an even spread of males and females between 20 and 50 cm; most carp larger than 50 cm were females. Individual weights of carp ranged from about 200 g to 4.6 kg (Figure 7.4). Most males and females of all sizes had developing or mature gonads. About 60% of males had well developed testes and another 20% were 'running-ripe'. The ovaries in more than half of the females (55%) were close to or were mature, but only two were running-ripe.

7.3.2.3. Comments

With good access to the creek bank, there were no problems with the transport and deployment of the traps. Two people easily handled the envirotraps and, at suitable sites, it is likely that one person could manage these traps. The box trap was light to handle, but its shape required a smooth bank and creek bed so that it could easily slide in and out of the water. In contrast, the more robust construction and shape of the envirotrap make it the preferable option in areas where access is difficult, and fishing sites confined.

Both the envirotrap and box-trap effectively caught carp but the scope of the trials did not allow direct comparisons between traps or the effectiveness of wings. With no knowledge of carp abundance along the creek, the differences in catch rates may have reflected local density rather than a better trap or trap set-up at any particular site. However, it was clear that catches were related to water flow. Carp catch rates at all sites increased immediately after the onset of pumping, and the highest catch rates were at Site 2 where the water flow was greatest and continued for the longest.

The size range of the carp catch seemed to be typical for the region. Although carp up to 10 kg are relatively common in southeastern Australia, fish between 50 g and 5 kg are more common (Koehn *et al*. 2000). As there was no physical barrier to larger carp entering the traps, it was probable that very large specimens were absent from the trapping areas. The age-length key in Koehn *et al*. (2000) shows that the peak in abundance between 25 and 30 cm FL comprise carp about 2 years old, and most of the catch were probably less than 6 years old. Several of the large females were close to spawning or had recently spawned which is consistent with the main spawning period of October-December (Stuart & Jones 2002).

Only one turtle was seen, and none was caught, so the effectiveness of the BRD in the envirotraps could not be determined. It was possible that some turtles did enter the envirotraps and subsequently escaped. However, it seems more likely that no turtles actually entered any trap as none was caught in the box trap. (This suggestion is supported by subsequent field trials in the Lane Cove River where significant numbers of turtles failed to escape from envirotraps during extended soak times; see below). As only two native fish (bony bream) and no air-breathing animals were caught, potential bycatch of protected species in fully submerged traps would appear to be minimal in Eagle Creek. However, if freshwater turtles were subsequently found to be a problem during more extensive carp trapping in Eagle Creek or other similar waterways, box traps or modified envirotraps could be utilised. Box-traps can be set at a depth where sufficient air-space is maintained above the water surface for turtles to breathe. Alternatively, fully submerged traps can be fitted with a netting codend or escape tube staked or buoyed above the water surface, in the manner required for eel fykes or yabby traps.

7.3.3. Trapping in Lane Cove River

Large carp are commonly seen above the Lane Cove River weir in the Lane Cove National Park, Chatswood West. Local residents have expressed concern about their presence to NSW Fisheries, and the Park Rangers (National Parks & Wildlife Service) were also keen to cooperate in any action that may lead to a reduction in carp numbers. The initial exploratory fishing in the Lane Cove River with small baited traps and a longline were unsuccessful (see above) but it was felt that larger traps may be more effective.

The Eagle Creek trials demonstrated that envirotraps were effective for carp capture but the turtle BRD was still untested under normal fishing conditions with extended soak times. While the experiments testing the BRD had shown that most turtles readily exited the trap through the escape aperture, a small number remained after each four-hour treatment (see Section 6.4). The Lane Cove River, inhabited by both carp and turtles, provided an accessible and suitable site to field test the envirotrap and its BRD.

7.3.3.1. Methods

Three sites were selected where traps could be deployed directly from the riverbank; one site was adjacent to the weir, and the other two were about 200 m and 300 m upstream on the southern bank. Much of the Lane Cove River is relatively deep and, at each location, the traps were able to be fully submerged about one metre below the surface close to the bank. The traps were tethered with ropes to railings or trees on the bank; by using the ropes and a long pole, the traps were oriented with the entrance facing down-stream and the large float kept the BRD uppermost. No netting wings were attached to the traps.

The baited traps were fished for seven days and nights (weekdays only) between 10 March and 20 March 2003, and inspected twice daily (8-9 am, and 5-6 pm). Captured fish were weighed and measured, and turtles measured; the fish and some turtles were then released back into the river. On an opportunistic basis, some very active turtles were put back into the traps to test the BRD; they were also released (if still present) when the trap was next inspected.

7.3.3.2. Results

River conditions varied during the trapping period. Heavy rain during the first fishing night put the river into minor flood with increased flow, turbidity and debris load for two days. The river was relatively normal for the remaining time with little flow, and calm, clearer water conditions.

No carp were caught; non-target catch comprised 4 Australian bass (*Macquaria novemaculeata*), 7 long-necked turtles and 18 short-necked turtles (see Appendix 6 for capture details and measurements). Ten turtles (7 short-necked and 3 long-necked) were caught overnight, the remaining 15 during the daytime. All turtles caught during the day were active when the traps were inspected but four turtles (2 short-necked, 2 long-necked) caught overnight were moribund when the traps were lifted; they recovered when removed from the traps.

Fifteen 15 turtles (10 short-necked, 156-244 mm CL; 5 long-necked, 150-213 mm CL) were placed back in the traps after initial capture but only two long-necked turtles (171 & 214 mm CL) escaped; the others were inactive or moribund when the traps were retrieved, but all eventually recovered and were released.

7.3.3.3. Comments

No carp were caught at any of the three trapping locations in the Lane Cove River, although carp were observed in the vicinity of the weir where visitors to the park frequently feed ducks and other water fowl. The envirotraps were set without wings which may have reduced their effectiveness, but failure to catch carp was probably more likely because of the lack of flow and nature of the river. Carp normally feed along the shallow edges of water bodies and the relatively deep water adjacent to the banks of the Lane Cove River may change the feeding habits of the local carp. They appear to be attracted to the duck feeding area by the weir. So it is possible that carp numbers could be reduced in the Lane Cove River with more targeted trapping by first attracting fish into a relatively small area with berley, and then into a large baited trap (see Section 4.2.3).

Mesh-netting and electro-fishing are other possible methods that could be utilised but the depth of the river above the weir, bottom snags and the likely impact on turtles and other inhabitants, make those methods less appropriate. The Lane Cove River runs through the Lane Cove National Park and any large-scale fishing for carp in this popular recreation area would attract the attention of the public. Fully submerged traps like envirotraps are the most convenient and least obtrusive means of reducing carp numbers. It is possible that there are other locations in the river or different water conditions when traps would successfully catch carp. However, if traps were left unattended for longer than 12 hours, they would need to be fitted with totally effective BRDs, such as surface codends, to prevent turtle mortality.

The observations on the efficacy of the BRD were not from a fully quantitative and designed experiment, and there was no measure of the number of turtles that may have entered and exited the traps during the soaktimes. However, that only two of the 15 turtles placed back into the traps escaped suggests that, in practice, the BRD was not totally effective. The observations indicated that turtle mortality may occur if envirotraps were fished fully submerged for prolonged periods.

While the turtles trapped overnight slowly recovered, it was apparent that they were unlikely to survive soaktimes longer than about 12 hours.

7.3.4. Trapping in South Creek

7.3.4.1. Background

Greening Western Sydney (GWS) is a project partnership between PlanningNSW and Greening Australia (NSW). Since 1992, GWS has been rehabilitating open-space corridors and Regional Parklands in western Sydney, a project that has grown into the largest urban vegetation management and restoration project in Australia (D. Williams, GWS, personal communication). Included in this project is restoration work along the riparian zone of South Creek. In connection to this, GWS is also looking at the feasibility of long-term native fish restoration program for South Creek and adjoining waterways as part of the overall habitat enhancement. It was thought that the proliferation of carp in these waterways would inhibit any restoration of native fish populations. Following a request from GWS to NSW Fisheries for advice on carp control in South Creek, it was agreed that South Creek was an appropriate location for further evaluation trials of the envirotrap. A section of South Creek was inspected in late March 2003, and carp were seen at several places in the creek. Three sites were selected and traps were set during the nine day period April 7-16.

The principal objectives were to investigate whether carp could be effectively caught in traps in waterways such as South Creek, and to further test the effectiveness of the turtle escape chutes built into the carp traps.

7.3.4.2. Location and description of trapping sites

Traps were set in a section of South Creek west of Mamre Road, St Clair. The locations were several hundred metres apart with differing characteristics.
Site 1: a relatively large, wide pool with clay substrate; depth in middle 1-2 m; water turbid; creek partly shaded (Figure 7.6).
Site 2: a narrow shallow (max. about 1 m) section of creek with sandy/muddy substrate; water relatively clear; creek almost fully shaded (Figure 7.7).
Site 3: a relatively wide and deep section of the creek; estimated depth 1-3 m; dense *Casuarina* trees along the banks; creek bed matted with *Casuarina* needles; surface ‘scum’ evident (Figure 7.8).

During the period of the trials, the creek level was very low with very little or no water flow. Traps were set near the centre of the creek.

7.3.4.3. Gear and methods

The original Enviro-Trap (Figures 6.1, 6.3) and two modified envirotraps (Figure 6.2) were used. In response to observations made during the BRD experiment (Section 6.4) and the trapping trial in the Lane Cove River (above), alterations were made to the mesh platforms and the inner lining along the tops of the envirotraps designed to improve the ability of turtles to access the escape platforms. During the BRD experiment, turtles had been observed continually poking their heads through the outer mesh covering the trap while moving along the interface between the black liner and the mesh. As the liner extended below the level of the platform entrance, many turtles had moved past the entrance to the BRD and accumulated at the back of the trap. Modifications were:

Escape platforms: the lateral edges of the platform in the original Enviro-Trap were bent upwards at right-angles and secured to the upper frame of the trap forming a chute (see Figure 7.5). The

platforms in the two envirotraps were flattened and the edges secured laterally to the sides of each trap. In both the original and modified traps, the gap between the platform and the top of each trap was about 85 mm at the centre (Figure 7.5).
Upper surface: in one envirotrap, the lateral edge of the smooth plastic flute-board near the escape platform was tapered inwards above the platform and towards the escape ring (Figure 7.9). In the second trap, the flute-board was removed and replaced with fine plastic mesh; this small mesh lined the complete upper half of the trap, eliminating any interface with the outer large mesh in the top of the trap (Figure 7.10). Both modifications were designed to better guide the turtles directly onto the BRD.

Traps were baited with bread and dry dog-food pellets contained in onion bags. Each trap was submerged near the centre of the creek, and set facing down-stream. Traps were set over a period of nine days; they were retrieved on each of six mornings after soaking for 24 hours, and on Monday 14 April, after 72 hours' soak over the weekend. Water temperature was recorded at each site on three mornings. Any fish caught were measured (fork length, FL) and weighed; native fish were then released. Turtles were also measured for carapace length (CL).

7.3.4.4. Results

The few captures are listed in Table 7.1. Across the three sites, water temperature ranged between 16.2 and 19.2 ^{o}C; the greatest variation (almost 3^{o}C) was at Site 2, the shallowest of the three sites.

A single small carp (195 mm FL; 545g) was caught at Site 1. Five Australian bass, ranging in size between 250 and 365 mm FL (350-800 g) were caught, three at Site 1, and one at each of the other sites. Single, small long-neck turtles were captured at Sites 1 and 2. The turtle (139 mm CL) found in the Site 2 trap after the weekend (72 hour soak) was moribund but recovered; it was assumed that this turtle entered the trap the previous night as previous observations suggested that turtles are unlikely to survive more than about 12 hour's entrapment. The second turtle (170 mm CL) caught in the Site 1 trap after an overnight soak was very active and was replaced back in the trap. It was still present the next morning in a moribund state but subsequently recovered and was released back into the creek.

7.3.4.5. Comments

Although medium sized carp were seen in the creek prior to the trapping trials, the only capture was a small juvenile. Water levels in the creek were unusually low (D. Williams, GWS, personal communication) and there was little to no flow. As demonstrated in the Eagle Creek trials, carp trapping is more effective in flowing water when carp actively move and feed into the current. In addition, water temperatures at the three sites were between 16 and 19^{o}C, whereas carp feed more actively in water temperatures greater than about 20^{o}C.

The capture of several Australian bass confirmed their presence in the creek. As the restoration of the riparian zone along the creek proceeds, water quality should improve which, in turn, should result in a healthy bass population.

That only two turtles were caught was probably a result of the relatively low water temperature and it seems that few were actively feeding. Whilst it could not be determined whether any turtles went in and out of the traps during these trials, the two turtles that were caught did not escape from the traps during prolonged soak times and would have drowned if not released. The small number of turtles precluded any quantitative evaluation of the trap modifications.

7.4. General discussion

Trapping provides an alternative, or additional, means of harvesting carp, and field trials in Eagle Creek demonstrated that traps could capture a broad size range of carp from a small waterway, particularly during periods of significant water flow. The unsuccessful trapping in the small waterways around Sydney was probably attributable to the lack of water flow and relatively low carp density. Carp trapping can be successful in still-water locations but is usually preceded by sustained berleying to first habituate and concentrate carp to the vicinity of the trap (see Section 4.4).

Field trials to test the effectiveness of the inbuilt BRD in the envirotrap were inconclusive. Under experimental conditions, about 80% of turtles escaped through the BRD in less than four hours (Section 6.4). In the field, insufficient turtles were caught to conduct quantitative tests. However, it was apparent in the Lane Cove River and South Creek trials that some turtle mortality would occur if envirotraps were fished unattended for periods greater than about 12 hours. Unless the envirotrap turtle BRD can be modified to be totally effective, fully submerged traps should require the fitting of properly shaped netting tubes or codends that are buoyed or staked at the surface. In areas of high turtle density, escape codends would need sufficient capacity to prevent overcrowding leading to turtle mortality.

The carp trap tested here, or other styles of trap fitted with an escape chute, may have a role in commercial fishing. It is more likely, however, that traps would be used in carp control operations, particularly in areas where conventional fishing methods, such as mesh-netting or seining, are not possible. The complete eradication of carp in even relatively small water bodies by commercial fishing is not feasible. This is because, as the carp densities decline in the fished areas, the diminishing economic returns force harvesting operations to move on, usually leaving small carp populations behind. However, the deployment of traps, with their relatively low capital cost, may be sufficient to control carp at a local level. The National Strategy for Carp Control stresses the need to assess carp management within the context of the regional or local catchment management plans. The main role for carp traps may be to provide conservation and carp control groups operating at the catchment level with a viable, cost-effective, low-impact method to control local carp populations.

Table 7.1. Water temperature, fish and turtle captures at the three sites in South Creek.

	Site 1			**Site 2**			**Site 3**		
April	Water Temp (°C)	Fish	Turtle	Water Temp (°C)	Fish	Turtle	Water Temp (°C)	Fish	Turtle
8	-	-	-	-	bass	-	-	-	-
9	-	-	-	-	-	-	-	bass	-
10	-	bass	-	-	-	-	-	-	-
11	17.2	carp	-	16.2	-	-	17.4	-	-
14	19.2	bass (2)	-	19.0	-	long-neck	18.6	-	-
15	18.0	-	long-neck	16.5	-	-	17.0	-	-
16	-	-	-	-	-	-	-	-	-

Figure 7.1. Box-trap with carp catch from Eagle Creek.

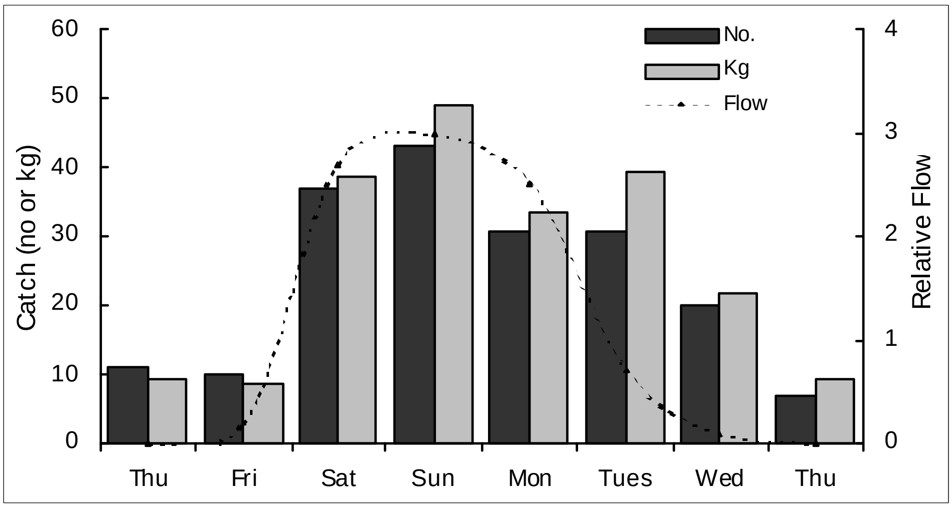

Figure 7.2. Daily carp catch from Eagle Creek (no. and kg; combined for all traps); the dotted line represents relative flow in the creek.

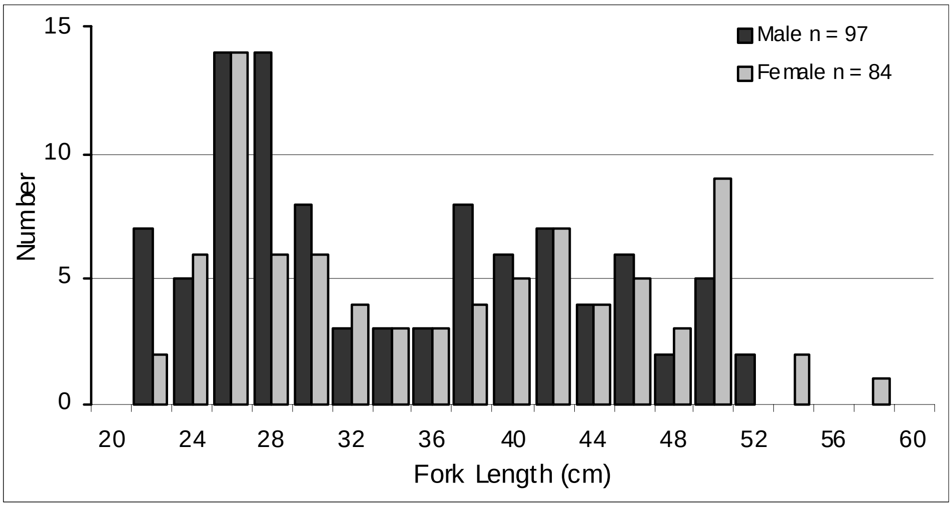

Figure 7.3. Length frequency distribution of carp from Eagle Creek.

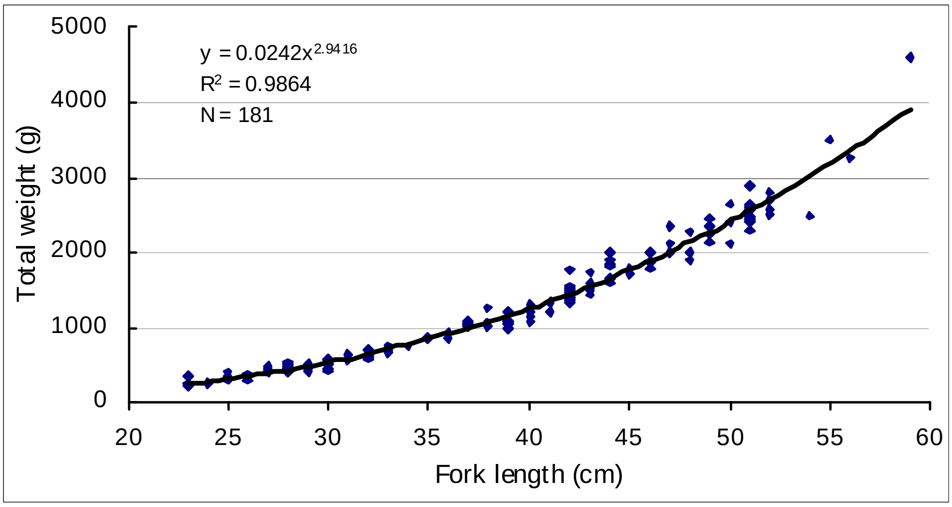

Figure 7.4. Length-weight relationship (sexes combined) for carp from Eagle Creek.

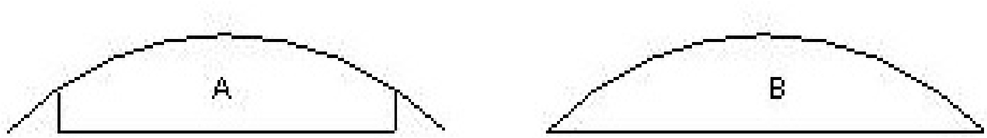

Figure 7.5. Diagrams of upper sections of envirotraps showing escape chute modifications. A = original Enviro-Trap; B = modified chute in envirotraps; in both chutes, the distance between the floor and the top of the trap was 85 mm.

Figure 7.6.
South Creek trapping site 1.

Figure 7.7.
South Creek trapping site 2.

Figure 7.8.
South Creek trapping site 3.

Figure 7.9.

Trap 2 (modified envirotrap) showing the shade board tapered inwards to the exit hole; the rust-coloured platform is seen beneath.

Figure 7.10.

Trap 3: the top half of the trap is lined with small-mesh plastic netting.

8. CONCLUSIONS

Carp continue to spread throughout inland NSW and are now present in several coastal catchments. Despite the widespread distribution and abundance of carp, a number of factors combine to inhibit any expansion of the commercial carp fishery in the near future. The general remoteness of the main carp resource, combined with the lack of market demand and hence low price for any product, make commercial fishing for carp largely unprofitable.

Electro-fishing, hauling, meshing and trapping, with appropriate modifications and deployment procedures, can safely be used for commercial carp fishing with minimal effects on bycatch species. Should the economic viability for carp improve, fishers will be in the best position to adapt and develop the most effective gear for harvesting carp. For government and non-government organisations which frequently contact NSW Fisheries about carp control in public and private waterways, any of the above methods can be adapted to help control carp numbers in relatively small waterways and streams. However, any gear or methods used to catch carp must be environmentally safe and conform to any legislative conservation requirements.

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10. APPENDICES

Appendix 1. Mapping of carp distribution: data sources and metadata.

Table 1. Sources and number of records of point data from the Freshwater Fish Research Database (administered by Conservation Research Section) and Fishfiles Database (Threatened Species Unit) at the Port Stephens Fisheries Centre.

Source	Description	No. of records
Arthur Rylah Institute, Victoria	Section 37 permit/ Scientific collection	9
Aust. Water Technologies, Victoria	Section 37 permit/ Scientific collection	2
Gaia Research Pty Ltd	Publication/Filed data	1
Griffith University	Section 37 permit/ Scientific collection	6
Monash University	Section 37 permit/ Scientific collection	12
Murray Darling Freshwater R. C.	Section 37 permit/ Scientific collection	7
NSW Fisheries	River surveys & Conservation research	1448
NSW Fisheries District Fisheries Officers	Recreational fisher observations	10
NSW National Parks &Wildlife Service	Personal communication	1
Recreational fishers	Personal communications	6
State Water Projects	Section 37 permit/ Scientific collection	1
Streamline Research Pty Ltd	Section 37 permit/ Scientific collection	1
T. R. Grant	Section 37 permit/ Scientific collection	25
University of Sydney	Section 37 permit/ Scientific collection	1
W S Rooney and Associates	Section 37 permit/ Scientific collection	1
Vic. Dept of Natural Resources and Environment	Section 37 permit/ Scientific collection	3

Metadata

The database contains seven tables. Three tables ‘all river lengths’, ‘carp streams’ and ‘carp waterbodies’ all relate to the spatial GIS shapefiles of polyline information for calculating length of stream with presence, absence and expected presence of carp. Most fields in these tables are used only for working with the GIS. The last field ‘lengths2’ in the ‘all river lengths’ table however, is the length of each segment in metres.

In the table ‘carp streams’, the third last field ‘carp’ is a numerical code for carp distribution; the field ’status’ is an alpha description of the previous field; the last column ‘region’ is a description of the inspectoral region each segment lies within. This data is also mapped spatially and has a polyline shapefile titled ‘carp distribution streams 94’.

The table ‘carp waterbodies’ is similar to the previous table ‘carp streams’ except that it describes and maps the polygon shapefile ‘carp distribution waterbodies 94’.

The table ‘comcatch sites’, ‘fishfiles sites’ and ‘fishkills’ all provide point data and are mapped spatially in the GIS database.

The table ‘comcatch sites’ is a list of all sites of commercial catches of carp and the total weight caught from July 1984 to March 2001. The fields ‘lat’ and ‘long’ are given to place a point on the GIS on the river of origin, in the general vicinity and are not necessarily the exact point of capture.

The table ‘fishfiles sites’ is a subset of carp listed from a database titled ‘Fishfiles’ managed by the Threatened Species Unit at Port Stephens. Table 4.3 lists fields and a description of their content.

Table 2. Database fields and descriptions.

Title	Description
Genus	Genus name
Species	Species name
CommonName	Common name
Reference Category	Study or survey which donated the data
Description	Section or team which donated the data
Organisation/Company Name	Membership to organisation or individual
Latitude	In decimal degrees
Longitude	In decimal degrees
Nearest Town	To sample site
Stream or Dam Name	Waterbody
Bioregion	Region to which waterway belongs derived from “?”
Sum of Total Number Caught	Total number of animals in database caught at the site

The coordinates given are accurately mapped locations of where the animals were caught.

The table ‘fishkills’ is a subset of carp data from the Fishkills database administered by Alan Lugg, Senior Conservation Manager at Nowra. The table houses data from 1977 to 2001 on the precise location including GPS coordinates of the site of the fishkill.

The table ‘DWR’ is a list of the drainage basins in NSW and has a numerical code linked to the tables ‘fishkills’ and ‘comcatch sites’.

Table 3. Metadata for Carp Distribution shapefiles.

Title	Carp distribution streams94 and Carp distribution waterbodies94
Custodian	NSW Fisheries
Jurisdiction	New South Wales
Abstract	The Carp Assessment and Reduction Program (CARP) was established to manage the impact of carp on the State's inland waterways in the lead up to implementation of a National Management Strategy for Carp Control. One of the primary objectives of the program was to document the distribution of carp.
Search Word(s)	CARP DISTRIBUTION
Geographic Extent Name	NSW
Geographic Extent Polygon(s)	*Left bounding coordinate: 141.001139 *Right bounding coordinate: 153.632093 *Top bounding coordinate: -28.156468 *Bottom bounding coordinate: -37.496997
Beginning Date	February 2002
Ending Date	May 2003
Progress	Complete
Maintenance and update	Not planned
Stored Data Format	DIGITAL ESRI shapefiles under Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4
Access Constraint	No restrictions.
Available Format Type	DIGITAL -ESRI shapefiles; DIGITAL – jpeg; NONDIGITAL – A4 printout; NONDIGITAL – report
Lineage	1:250,000 vector shapefiles supplied by AUSLIG were copied and modified by adding new fields to show the distribution of carp. The original shapefile was split into smaller, more compact regional sections and then reconstructed into one file which covers the entire state.
Positional Accuracy	The shapefiles are a composite product and the positional accuracy depends on the source data.
Attribute Accuracy	The Fisheries Officers were requested to provide details of reported carp sightings along the waterways in their region, and/or to record waterways known to be free of carp. A protocol for interpreting and entering the data was developed to standardise the mapping procedure. The carp distribution information for each waterway was coded as follows: 0 = carp absent 1 = carp present 2 = no information 3 = likely presence of carp
Logical Consistency	The digitised data has been visually verified by the Fisheries Officers for each region
Completeness	The classification of each polyline and polygon is based on the accuracy of the source data at a scale of 1:250,000
Contact Organisation	NSW Fisheries
Contact Position	Trudy Walford
Mail Address 1	Port Stephens Fisheries Centre, Private Bag 1 Nelson Bay 2316
Mail Address 2	Taylors Beach Rd, Taylors Beach, Australia 2315
Telephone & Facsimile	02 4982 1232; 02 4982 2265
Electronic Mail Address	Trudy.Walford@fisheries.nsw.gov.au
Metadata Date	May 2003

Appendix 2. Inland production areas

Table 1. NSW inland areas used to summarise historical carp production (region codes and drainages from Reid *et al*. 1997, ComCatch).

West and Northwest		**Southwest**		**Central north**	
Code	Drainage	Code	Drainage	Code	Drainage
4004	Far northwest	4401	Upper Murray R.	4416	McIntyre R.
4011	Bulloo R.	4409	Murray Riverina	4417	Moonie R.
4012	Lake Bancannia	4410	Murrumbidgee R (general)	4418	Gwyder R.
4424	Paroo R , Copago L.	4411	Murrumbidgee R (Balranald)	4419	Namoi R.
4425	Darling R, Menindee Lakes	4412	Lachlan R.	4420	Castlereagh R.
4426	Lower Murray, L. Victoria	4413	Murrumbidgee Riverina	4421	Macquarie R., Bogan R.
				4422	Barwon, Condamine, Culgoa Rs, Narran L.
				4423	Warrego R.

Appendix 3. Morphmetric data for short-necked turtles from Botany Pond.

Table 1. Carapace length, carapace width, and girths of short-necked turtles from Botany Pond (Lakes Golf Course) used in envirotrap BRD trials.

Length	Width	Girth	Length	Width	Girth	Length	Width	Girth
106	93	208	163	132	288	190	149	337
112	98	217	167	136	289	191	157	338
112	98	219	167	127	284	195	151	330
113	101	221	170	137	305	196	148	330
118	105	230	170	137	302	198	158	360
121	106	232	172	138	305	200	160	347
121	103	230	172	138	294	204	160	345
128	108	243	172	128	288	206	167	358
131	110	254	172	145	314	207	150	332
133	114	252	175	134	299	207	168	373
138	110	250	176	143	318	208	161	372
139	117	254	179	141	314	209	168	320
143	125	272	179	146	322	210	158	353
153	130	287	183	152	330	211	158	344
154	134	298	183	143	325	236	185	415
155	126	275	183	136	310	244	188	418
158	134	287	185	152	334			
160	126	280	185	144	316			

Appendix 4. Titles and abstracts of published papers detailing envirotrap experiments.

1. Grant, T.R., Lowry, M.B., Pease, B., Walford, T.R. and Graham, K. (2004). Reducing the by-catch of platypuses (*Ornithorhynchus anatinus*) in commercial and recreational fishing gear in New South Wales. Proceedings of the Linnean Society of New South Wales 125, 259-272.

Reducing the by-catch of platypuses (*Ornithorhynchus anatinus*) in commercial and recreational fishing gear in New South Wales

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Abstract

The problem of platypus by-catch mortality in the eel, yabby and carp trap fisheries in New South Wales is reviewed, and the results of several experiments to determine the effectiveness of gear modifications to reduce platypus by-catch are presented. Entrance screens with 50-60 mm openings prevented the entry of platypuses into eel or yabby traps. Larger screens were not effective as a deterrent to platypuses entering traps. By-catch of platypuses in the eel fishery can be minimised by restricting traps to estuarine areas, where platypuses seldom occur, and by providing air spaces in the cod ends of traps used in impoundments and farm dams. Prohibiting the use of yabby traps in areas where platypuses are known to occur provides the most practical protection against by-catch of platypuses in this fishery. Platypuses were unable to exit from prototype carp traps, designed to permit escape of air-breathing species, but the provision of appropriately-sized openings at the base of the entrance funnels in these drum traps permitted platypuses to escape.

Manuscript received 4 September 2003, accepted for publication 24 November 2003.
KEYWORDS: by-catch, carp, eel, fishing, *Ornithorhynchus anatinus*, platypus, yabby.

2. **Lowry, M.B., Pease, B.C., Graham, K. & Walford, T.R. (2005). Reducing the mortality of freshwater turtles in commercial fish traps. *Aquatic Conserv: Mar. Freshw. Ecosyt.* 15: 7-21.**

Reducing the mortality of freshwater turtles in commercial fish traps

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Abstract

Mortality of air-breathing vertebrates has been recognised for some time as a significant risk in Australian inland fisheries. There has often been conflict between the desires of fishers to maximize catches of their target species and the implementation of effective methods to reduce nontarget bycatch.

Two trials were conducted to evaluate the effectiveness of modifications to fish traps designed to prevent the capture of freshwater turtles *(Emydura macquarii)* and to facilitate their release. The first study evaluated the use of 100 mm exclusion rings to prevent turtles entering eel traps. The second study assessed two configurations of a carp trap designed to release the accidental catch of turtles.

Eel traps fitted with 100 mm exclusion rings significantly reduced the turtle bycatch, with no significant difference being observed between mean size of eels captured in traps fitted with exclusion rings and traps without rings.

The trials on the modified carp trap confirmed that they effectively retained carp and released a majority (77%) of turtles over a 4h period. Turtles retained in the carp traps were significantly longer than those that found their way out of the trap.

This study demonstrates the different approaches that can be taken to achieve a reduction in non-target bycatch associated with traps, and illustrates the importance of exploiting both the physical and behavioural differences of the target and non-target species in order to develop appropriate gear designs which effectively restrict the entry, or facilitate the release, of bycatch species.

KEY WORDS: eels; turtles; bycatch; exclusion rings; traps

Appendix 5. Report on carp trapping in Eagle Creek.

(Report to Senior Fisheries Manager (inland fisheries) and Eagle Creek Pumping Syndicate, May 2003)

Report on carp trapping in Eagle Creek, December 4-12, 2002

KEN GRAHAM, SCIENTIFIC OFFICER, CRONULLA FISHERIES CENTRE

Introduction

Several members of the Eagle Creek Pumping Syndicate (ECPS) attended the Carp Workshop held in Barham on May 13, 2002. They believed that carp were one of the major contributors to siltation and bank erosion in Eagle Creek, and this local example of environmental damage by carp was used as a discussion topic in the workshop. Subsequently, the Deputy Chairman of the ECPC wrote to NSW Fisheries with the view that appropriately designed fish traps may provide an adequate level of carp control in Eagle Creek. The syndicate requested further help from NSWF in the development of a plan of action to harvest carp, including advice on trap design and location.

Eagle Creek is typical of many small streams and waterways infested with carp. These streams are relatively shallow, slow moving, often heavily silted, and turbid. The streambeds are strewn with snags such as tree trunks and branches, and the banks are frequently tree-lined and/or overgrown with bush or other vegetation. As such, there are limited fishing methods that can be employed to reduce carp numbers. Methods available for carp control include electro-fishing, hauling, mesh-netting and trapping. While many stretches of Eagle Creek appear suitable for electro-fishing, the infrastructure is expensive and the exercise labour-intensive. The numerous snags preclude hauling and mesh-netting. Trapping is a relatively inexpensive means of harvesting fish in restricted waterways, but is reliant on traps that are effective for carp while not adversely affecting other species.

During 2002, the NSWF Carp Reduction Program began trials with a carp trap designed in South Australia. The ‘Enviro-Trap’ is a drum-shaped trap fitted with an escape aperture in the top designed to allow air-breathing animals (e.g. turtles, water-rats) to escape while retaining carp. Initial trials with the envirotrap showed that turtles readily escaped through the top aperture, while almost all carp were retained. Trials with platypus were more equivocal, with most failing to find the escape aperture. However, the addition of small openings around the intersection of the entrance funnel and the front of the trap proved effective for the release of platypus. A more conventional rectangular trap, similar to that designed by professional carp fishers, was also built; this trap has no means for air-breathers to escape and is consequently fished with its top above the water surface.

The request by the ECPS provided an opportunity to test both these traps in the field. The trials would determine whether carp could be trapped in small waterways such as Eagle Creek, demonstrate the utility of the two trap designs, ascertain preferred fishing sites and conditions, and see what impact trapping may have on other species.

Objectives

Initial objectives for the Eagle Creek carp trapping exercise were:

- to determine that carp can be effectively trapped in confined waterways such as Eagle Creek
- to determine best locations/conditions within creek for carp capture
- to determine any diurnal/nocturnal pattern of carp availability
- to determine optimal rig for traps (wings etc.)
- to observe capture rates of native fish and/or air-breathing animals

Description of Eagle Creek

A detailed description of Eagle Creek and its environs is contained in the Eagle Creek Management Plan prepared by J. Lander (2000). Originally, Eagle Creek was an ephemeral creek system but is now a permanent waterway, approximately 31 km long, fed by an artificial cutting from the Murray River at Barham (Figure 1). The creek is typically 10-20 m wide, and 1-2 m deep. For the most part, the creek banks are lined with river red gums; there are also many instances of large trees now isolated within the creek where the bank has eroded from around the tree. Large numbers of logs, branches and tree roots were evident in the creek.

The creek provides irrigation water to the dairy and citrus farms, and market gardens along its length. Usually, water is pumped from the Murray into the creek each weekend. From Saturday to Monday or Tuesday there is noticeable water flow along much of the creek.

Gear and Methods

Traps

Three enviro-traps and one box-trap were used.

The envirotrap (Figure 2) is cylindrical in shape, 90 cm diameter x 1.7 m long, and covered by black plastic mesh (55 mm x 40 mm). The entrance funnel of the original enviro-trap was constructed from the same plastic material as the outer cover; the other two traps were fitted with entrance funnels made from 90 mm mesh trawl netting (braided 3 mm diameter polyethylene twine). A round-cornered rectangle of stainless steel rod 230 mm x 115 mm was secured to the bottom of the funnel where it opened into the trap. A circular escape aperture of 230 mm diameter was located at the top of the trap at the end opposite the entrance funnel (see Figure 2). A wire mesh ramp was positioned beneath the aperture as a guide for escaping animals. To provide a smooth surface and to highlight the escape aperture (for escaping animals), the upper surface inside the top of the trap was lined with black plastic 'fluteboard'. A rope bridle was rigged from each end and met at a single point above the centre; a large polystyrene float attached to the bridle kept the trap upright while fishing.

The dimensions of the box-trap were 2.3 m x 1.5 m x 0.8 m (Figure 3). It was constructed of 20 mm square steel tubing bolted at each corner. The trap was covered in black 36 ply polyethylene trawl netting. The single side entrance was shaped from netting to give an opening similar in size to the envirotraps.

Three of the four traps were fished with wings running from the mouth of the trap to the banks at about a 20-30^{o} angle. The wings were made from lengths of 130 mm mesh trawl netting hung on 8 mm rope with a number of mesh-net floats along the top and small lead weights along the bottom.

A 3.5 m flat-bottomed punt was used at three sites to set and lift the traps.

Bait

Light mesh bait bags (onion bags) were filled with old bread and smaller quantities of dry dog food. Two or three bait bags were suspended in the back half of each trap. Bait was replenished once or twice in each trap during the course of the week’s fishing. Some bait bags were also replaced when they disintegrated during the period of strong current.

Trapping sites

There was no prior knowledge of carp abundance in the creek. The traps were located at sites where the creek was relatively narrow and clear of large snags (so wings could be run from the trap to the banks). Other criteria for site selection were easy access to the bank for the vehicle, and easy entry into the creek for the punt.

Traps were set in the middle of the creek, initially at four sites (see map):

1. envirotrap with wings, set in an open stream site at the southern end of Eagle Creek; water level was initially about 10 cm below the top of the trap, but rose to be level with the trap top during the pumping period.
2. envirotrap with wings, set immediately downstream of the second regulator; the trap was fully submerged at all times, 0.5 to 1 m below the surface.
3. envirotrap without wings, set beneath the footbridge at the back of the Mather house; the trap was fully submerged at all times, approx. 0.5 m below the surface.
4. box-trap with wings, set immediately downstream of the vehicular bridge on Mather farm; the top of the trap projected 20-30 cm above water level.

After day 5, the trap from site 1 was relocated to site 5:

5. envirotrap with wings, set in an open cutting made recently for a new road crossing; water level was about level with the top of the trap.

Fishing

Traps at sites 1, 2 and 5 were set and retrieved from the punt. The trap at site 3 was set and lifted from the footbridge, while the box-trap at site 4 was deployed from a small pontoon tethered to the bank. All traps were set facing downstream. After initial baiting, all traps were inspected daily between 6 a.m. and 8 a.m. The envirotraps were also cleared most evenings between 6 and 8 p.m. to give comparative day-night catch data.

Biological data

Fork length (FL), weight (g) and sex data were collected for all carp. Gonad development stage was also recorded.

Results

Creek conditions

Little or no water flow was evident at any site when the traps were set on Wednesday (Dec. 4). Pumping from the Murray into the creek began on Friday night, and continued until Sunday resulting in flow through most of the creek system. No direct flow measurements were taken but from visual observations, the relative water flow at each of the sites was recorded (Table 1).

Table 1. Relative water flow at each trapping site as observed each morning when traps were cleared.

Site	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.
1	none	slow	mod.	mod.	slow	-	-	-
2	slow	none	fresh	strong	strong	strong	mod.	slow
3	none	none	mod.	mod.	mod.	slow	none	none
4	-	none	mod.	mod.	slow	none	none	none
5	-	-	-	-	mod.	slow	none	-

Catches

A total of 194 fish weighing 210 kg was caught. These comprised 181 carp (203 kg), 4 goldfish, 5 carp/goldfish hybrids, 2 redfin perch, and 2 bony bream. The carp catch included a single ‘mirror’ carp (49 cm FL). No air-breathing vertebrates were caught in the traps, although a long-necked turtle was found unharmed clinging to one of the trap wings when the gear was retrieved from Site 2 at the end of the trials.

Carp were caught at all sites. All goldfish, the two bony bream, four of the five hybrids, and one redfin were caught at Site 4. The other redfin was taken at Site 3, and the fifth hybrid at Site 2.

Details of carp catches are shown in Table 2. Figure 4 shows the total carp catch per day; relative flow is also indicated on the graph. Daily catches for each of the traps at Sites 2, 3 and 4 are shown in Figure 5.

Catches in all traps increased markedly on Saturday, coinciding with the beginning of pumping on Friday evening and the onset of flow in the creek. Catches were greatest and most consistent at Site 2 (envirotrap with wings) averaging about 11 carp / 15 kg per day. The mean catch rate of the envirotrap fished without wings at Site 3 (about 5 carp / 5 kg per day) was less than half that of Site 2, but similar to the box-trap catches at Site 4. Apart from Saturday and Sunday, catches in the trap set initially at Site 1, then at Site 5 were negligible.

Day-night catch data were available from the traps at Sites 2 and 3 for all days except Tuesday afternoon-Wednesday morning (Figure 6). Overall, about 75% of carp were caught during the night. Of the catch taken during daylight hours, almost all was taken during Saturday, immediately after the onset of pumping.

Table 2. Daily carp catches from each site (E = envirotrap; B = boxtrap). Catches are for the 24 hours (0900-0900) preceding the morning trap clearance.

A. Number of carp per trap

		December 5-12								Total	Average
Site	Trap	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	(no.)	(no/day)
1	E	1	2	7	7	0	-	-	-	17	3.4
2	E	9	8	10	17	13	18	6	7	88	11.0
3	E	1	0	6	10	15	11	0	0	43	5.4
4	B	-	0	14	9	3	1	14	0	41	5.9
5	E	-	-	-	-	-	1	0	-	2	1.0
Total		11	10	37	43	31	31	20	7	190	

B. Weight (kg) of carp per trap

		December 5-12								Total	Average
Site	Trap	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	(kg)	(kg/day)
1	E	0.5	1.7	4.8	4.4	0	-	-	-	11.4	2.3
2	E	8.2	7.1	10.3	22.5	19.0	28.2	14.2	9.2	118.7	14.8
3	E	0.5	0	5.1	11.9	13.1	10.3	0	0	40.9	5.1
4	B	-	0	18.4	10.3	1.4	0.5	7.6	0	38.2	5.5
5	E	-	-	-	-	-	0.3	0	-	0.3	0.2
Total		9.2	8.8	38.6	49.1	33.5	39.3	21.8	9.2	209.5	

Biological data

A total of 97 males and 84 females were caught. Female carp ranged in size from 22 to 58 cm fork length (FL), and males 23-53 cm FL. The length-distributions (Figure 7) show an even spread of males and females between 20 and 50 cm; most carp larger than 50 cm were females. Individual weights of carp ranged from about 200 g to 4.6 kg (Figure 8).

Most males and females of all sizes had developing or mature gonads. About 60% of males had well developed testes and another 20% were 'running-ripe'. The ovaries in more than half of the females (55%) were close to or were mature, but only two were running-ripe.

Discussion

Trapping operations

With good access to the creek bank, there were no problems with the transport and deploying of the traps. Two people easily handled the envirotraps and, at suitable sites, it is likely that a single person could manage them. With the punt, the traps were lifted *in situ*, usually with the wings left attached to the banks. However, it was often necessary to re-tighten the wings after the trap was reset. There were obvious advantages with sites adjacent to the creek crossings, particularly when the creek was flowing. For example, at Site 2 the back of the trap was tethered to the regulator by a rope. It was then possible to lift and reset the trap from the punt without releasing the wings and not be carried downstream by the current. After the trap was reset, the wings were re-tightened by pulling the trap back with the rope from the regulator. In the manner of traditional drum nets, the envirotrap may also be effective if fished close to one bank, either with or without wings.

The construction materials of the box trap made it light to handle, but its shape required a smooth bank and creek bed so that it could be easily slid in and out of the water. The small pontoon at Site

4 was ideal for deploying this trap. Traps such as this have been used successfully in larger water impoundments after carp have been attracted into the area with berley. However, compared to the box trap, the robust construction and shape of the envirotrap make it easier to transport and handle in areas where access is difficult, and to deploy from the punt.

Drum traps such as the envirotrap, or larger box-traps, have sufficient capacity to hold substantial numbers of carp and could be fished on a weekly or bi-weekly basis. For Eagle Creek, with its regular pumping regime, a practical scenario may be for traps to be handled twice a week. Traps would be baited and set on Fridays before pumping commences, cleared on Sunday or Monday when most of the catch is expected, then rebaited again the next Friday. For the harvested carp to be sold, a contractual arrangement with a licensed commercial fisher would be required.

Carp catches

Both types of traps were effective but the scope of the trials did not allow direct comparisons between traps or the effectiveness of wings. With no knowledge of carp abundance along the creek, the differences in catch rates may have reflected local density rather than a better trap or trap set-up at any particular site. However, it was clear that catches were related to water flow. Carp catch rates increased immediately after the onset of pumping, and good catch rates continued particularly at Site 2 where water continued to flow the longest.

Carp up to 10 kg are relatively common in southeastern Australia but fish between 50 g and 5 kg are more common (Koehn *et al*. 2000). Although very large carp were absent from the trapped sample, the size range of 200-4600 g was not abnormal. As there was no physical barrier to larger carp entering the traps, it seems that very large specimens were absent from the trapping areas. The age-length key in Koehn *et al*. (2000) show that the peak in abundance between 25 and 30 cm FL comprise carp about 2 years old, and most of the catch were probably less than 6 years old. Several of the large females were close to spawning or had recently spawned which is consistent with the known spawning period of October-December.

Bycatch

Any mortality of air-breathing vertebrates during trapping operations is undesirable. However, traps fitted with effective escape avenues for air-breathers can be fully submerged, and soak times extended to several days. Although turtles are known to inhabit the Murray River/Eagle Creek environs (one long-necked turtle was observed at Site 2), none was caught during these trials suggesting that any turtles that did enter the envirotraps subsequently escaped. However, it seems more likely that none actually entered any trap as none was caught in the box trap, and because subsequent field trials in waterways near Sydney found that significant numbers of turtles failed to escape from envirotraps during extended soak times. This suggests that additional escape gaps in these traps are required to prevent any turtle mortality.

As only two native fish (bony bream) and no air-breathing animals were caught, potential bycatch in Eagle Creek would appear to be minimal. If freshwater turtles are subsequently found to be a problem during more extensive carp trapping in Eagle creek, box traps or modified envirotraps could be utilised. In most parts of the creek, a box trap similar in size to that trialed could be set at a depth where sufficient air-space is maintained above the water surface for turtles to breathe. Alternatively, any box or drum-shaped traps fished fully submerged would need to have a netting codend staked or buoyed above the water surface, in the manner required for eel fykes. Commercial fishers are reluctant to attach above-surface devices as they attract interference, but this would not be a problem in Eagle Creek as it mostly runs through private property.

Summary and Recommendations

1. Both the drum-shaped envirotraps and the box trap successfully caught carp (and goldfish) while the creek was flowing.

2. Bycatch was minimal during the Eagle Creek trapping trials, but freshwater turtles maybe a potential bycatch problem during prolonged trapping.

3. Carp can be harvested commercially from Eagle Creek by a licensed fisher, possibly under contract to the Eagle Creek Pumping Syndicate.

4. If turtle mortality occurs, all fully submerged traps would need to be fitted with codends staked or buoyed above the surface; any native fish would be released.

Reference

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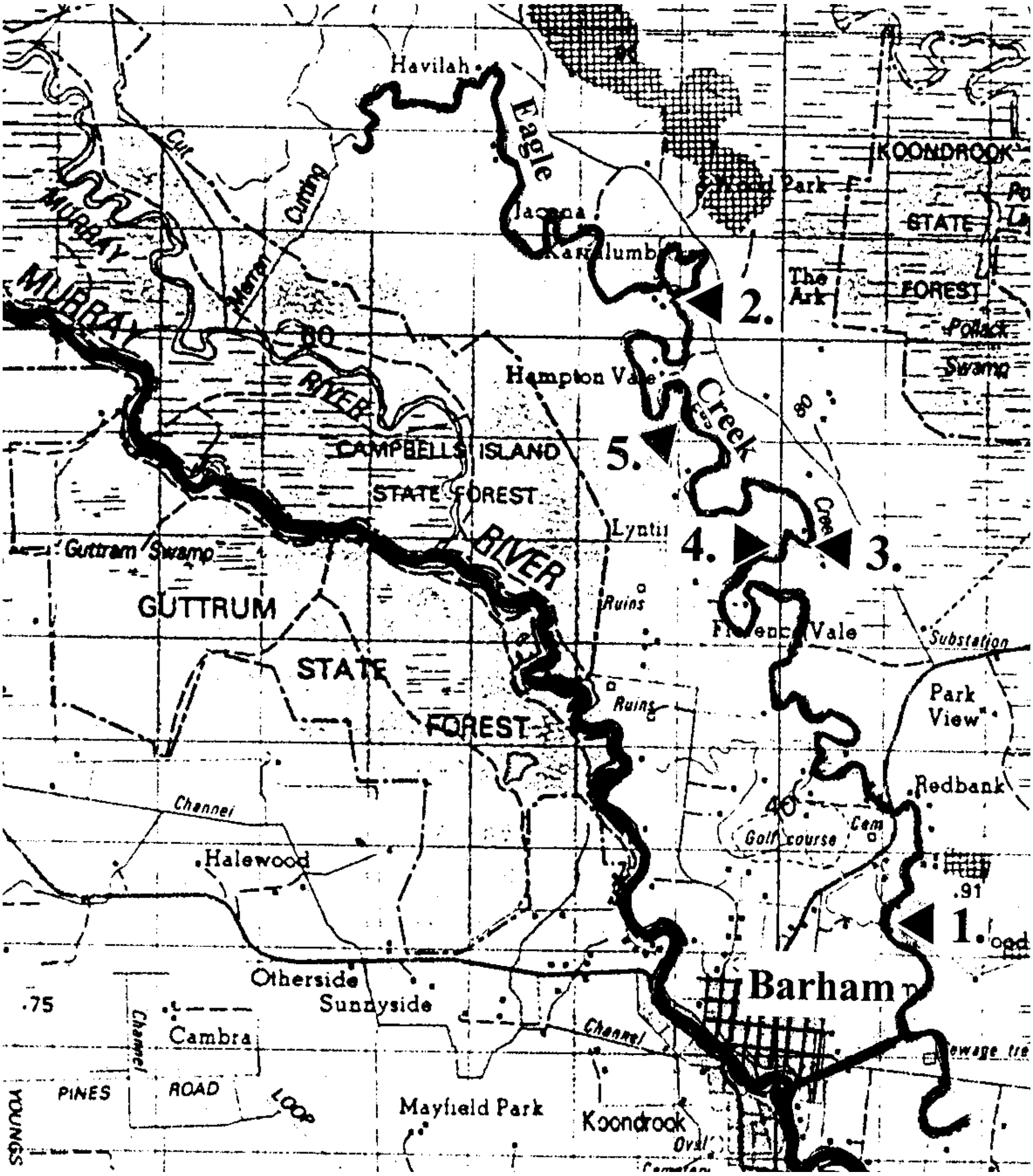


Figure 1. Barham and Eagle Creek environs showing the five trapping sites (black triangles).

Figure 2. Envirotrap showing escape aperture for air-breathing animals.

Figure 3. Box-trap with carp catch from Eagle Creek.

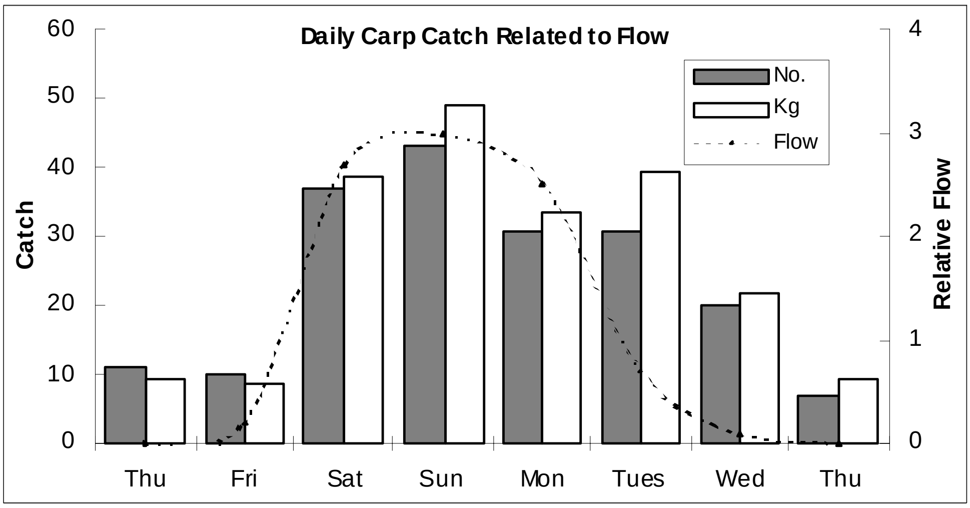


Figure 4. Daily carp catch pooled for all sites and related to flow. Catch is for the 24 hour period starting 0900 the previous day.

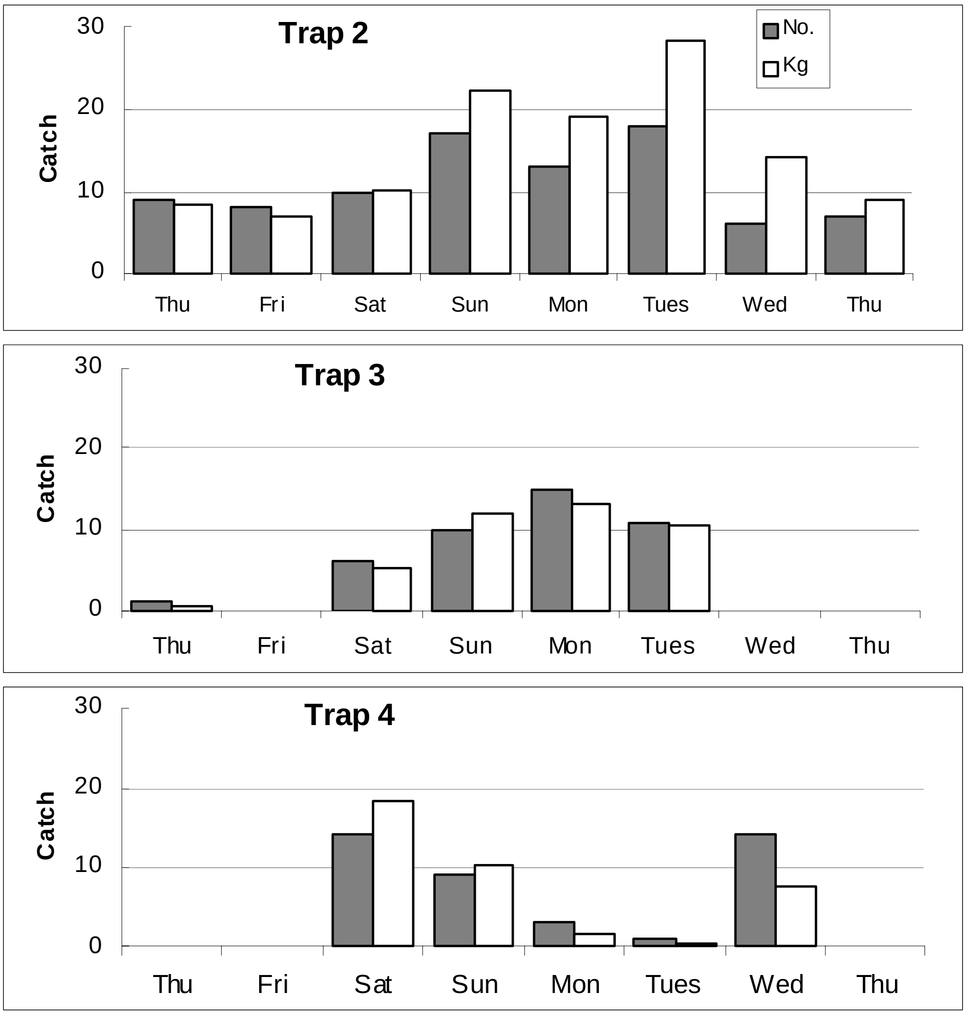


Figure 5. Daily carp catches (no. and kg) in traps at Sites 2-4.

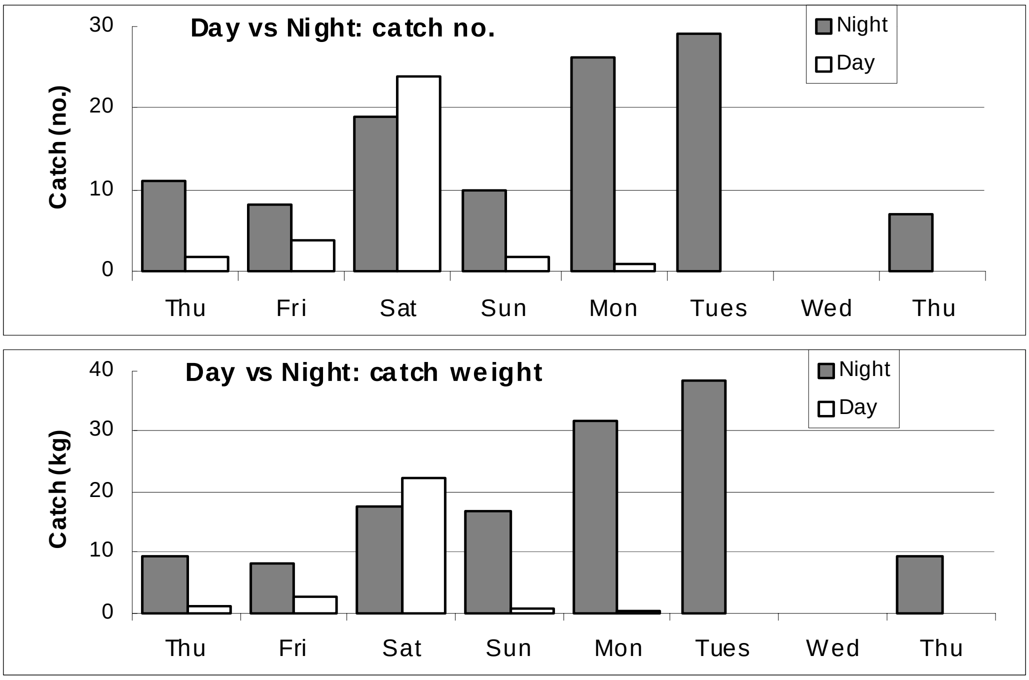


Figure 6. Day and night carp catches from traps at Sites 2 and 3. (Traps were not cleared on Tuesday evening, so no night catch is given for Wednesday; there was no daytime catch on Wednesday.)

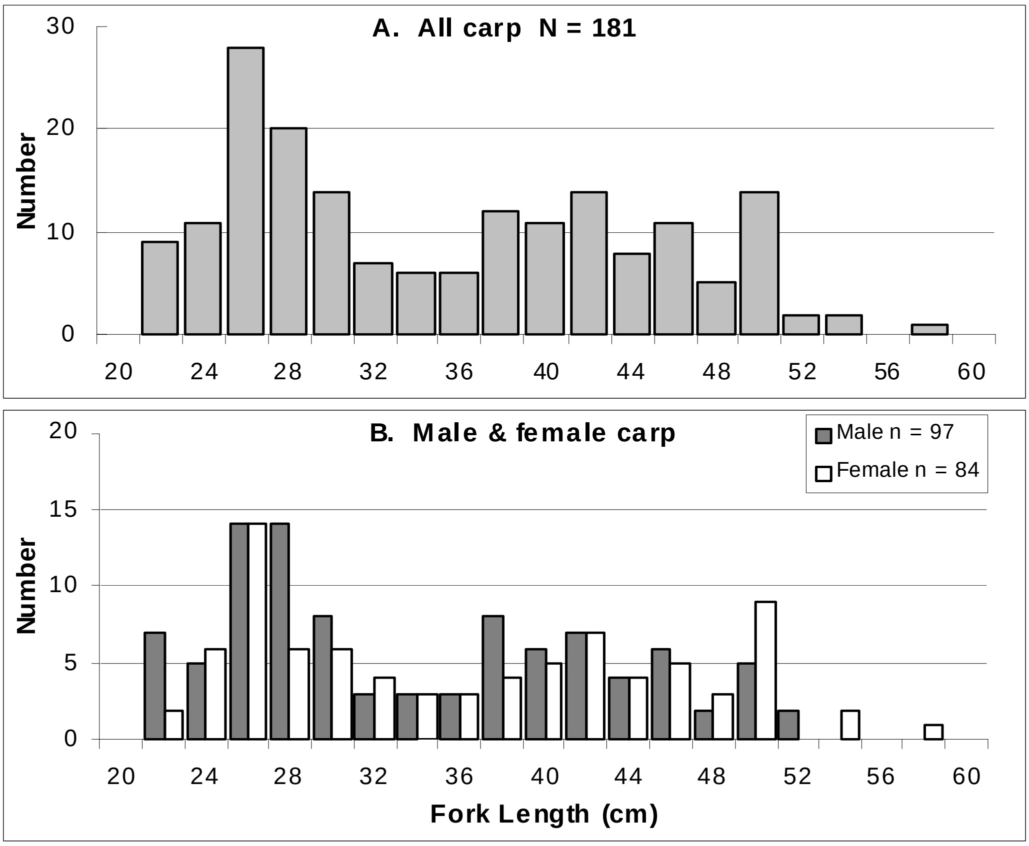
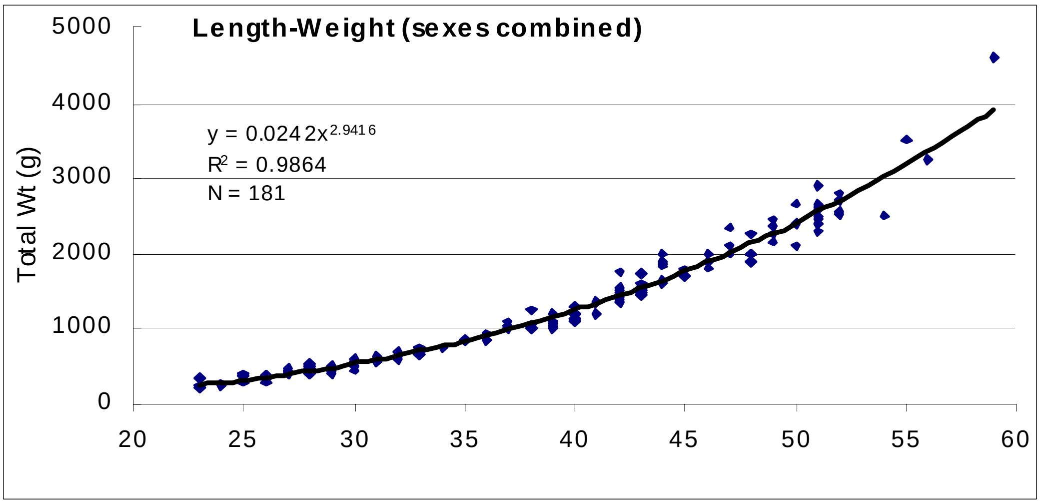


Figure 7. Length-frequency distributions of carp from Eagle Creek.



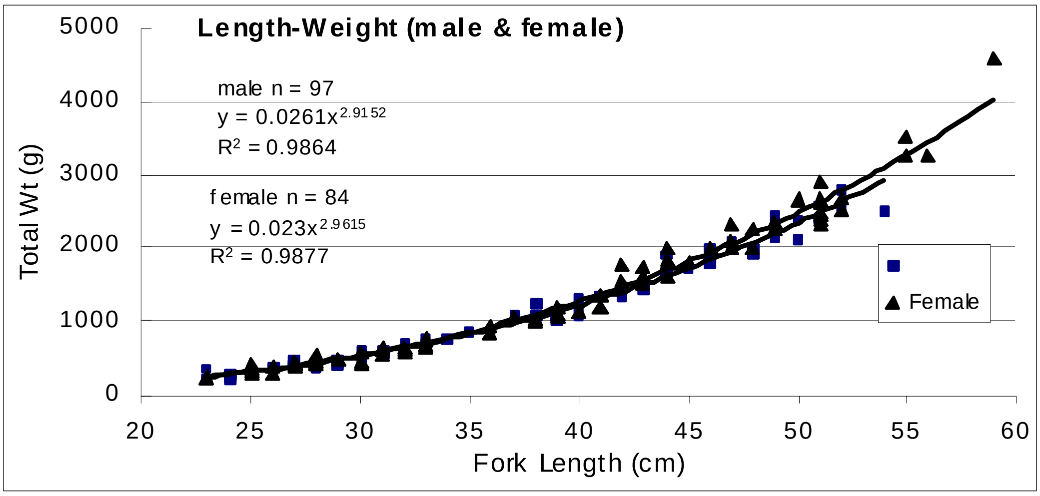


Figure 8. Length-weight relationships for carp from Eagle Creek.

Figure 9. Carp catch from Site 2 on final day of trials. Size range 25 - 51 cm; 0.4 - 2.4 kg.

Trapping Site 1. The creek was wide and shallow at this site. The trap was set in the centre of the creek opposite to where the photograph was taken.

Trapping Site 2. The regulator is in the background and the floats (centre, left) show the position of the trap. Most carp were caught at this site.

Trapping Site 3. The trap at this site was set and lifted from the bridge; no wings were attached.

Trapping Site 4. The box-trap was deployed from the pontoon (background). Bags of bait (bread) are floating in the trap.

Trapping site 5. Only one small carp was caught in this recently cut channel.

Appendix 6. Capture details and size data for bass and turtles caught in the Lane Cove River.

Table 1. Daily catches of bass, long-necked and short-necked turtles. Traps were inspected each morning (am) and evening (pm) during 11-20 March 2003.

		Trap 1			Trap 2			Trap 3		
March	Time	bass	long-neck	short-neck	bass	long-neck	short-neck	bass	long-neck	short-neck
11	am					1	1			
11	pm									
12	am				1					
12	pm									
13	am						1			
13	pm			1			2			
14	am									3
17	pm					2				1
18	am									1
18	pm				2				1	2
19	am				1	1				1
19	pm		1				1			4
20	am					1				

Table 2. Length and weight data for bass.

Fork length (cm)	Total weight (g)
31	580
38	1100
38	1110
39	1080

Table 3. Length measurements for turtles (CL = carapace length, CW = carapace width, PL=plastron length).

Short-necked			Long-necked		
CL (mm)	CW (mm)	PL (mm)	CL (mm)	CW (mm)	PL (mm)
156	129	123	133		
158			150	120	129
169		137	162	127	136
171		136	186	142	165
175			195	142	165
177		148	198	160	158
178	165	147	213	164	177
183		160			
184	140	148			
188	135	154			
196		153			
196	163	160			
214	168	170			
216	165	172			
217	177	179			
244	202	196			
245	188	195			
260	210	208			

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