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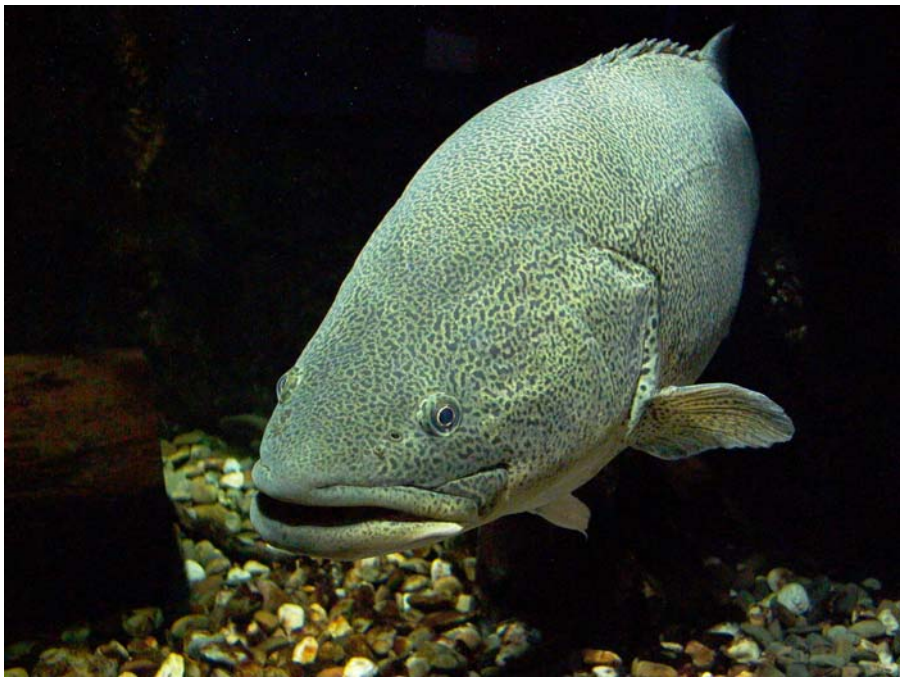
Murray Cod Stock Status –

The Lower River Murray, South Australia



Stock Status Report to PIRSA Fisheries

Q. Ye and B. Zampatti

March 2007

SARDI Aquatic Sciences Publication No. F2007-000211-1
SARDI Research Report Series Number 208

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Table of Contents

List of Tables

List of Figures

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Special thanks to Dr Keith Jones for providing regional information on Murray cod based on the National Recreational and Indigenous Fishing Survey 2000/01. Thanks also to Alice Fistr for comments on the manuscript. Dr Tony Fowler and Dr Jason Tanner formally reviewed a draft of this report. This report is funded by PIRSA Fisheries.

Executive Summary

- In the South Australian River Murray, there is little indication of strong recruitment of Murray cod since 1994.
- There appears to have been some low level recruitment in 2000 associated with flows in the River Murray of approximately 20,000 to 60,000 ML/day.
- Previous stock assessments for Murray cod in SA were primarily dependent on the readily available commercial fishery data. Such data are no longer available since the restructure of the commercial River Fishery in July 2003. Attempts have been made to sample Murray cod through the Native Fish Monitoring Program, nevertheless, information collected so far has been limited and patchy.
- Historical fishery data indicate a strong link between river flow and Murray cod recruitment with a positive relationship.
- Given protracted years without significant high flows, and particularly the critical drought conditions in the last six years in the Murray-Darling Basin, there is a high risk that the stock may decline further unless strong year classes can be added.
- Furthermore, to mitigate the impact of flow regulation on Murray cod, environmental water allocations are essential to maintain/enhance natural recruitment of this species. Effective flow management, habitat rehabilitation and fish passage restoration, in conjunction with fishing regulations to ensure sustainable exploitation, are important measures for the sustainable management and conservation of Murray cod populations.
- The National Recreational and Indigenous Fishing Survey suggested significant recreational harvest of Murray cod in the SA River Murray (22.8 tonnes in 2000/01), with an additional 16.4% released.
- Ensuring an adequate spawning biomass to maximise recruitment from years when environmental conditions are favourable is an important strategy for the management of the Murray cod fishery.
- A precautionary approach to the management of this species should be adopted. Conservation management measures may include: changing size limits; seasonal or area closures; a moratorium on the take of Murray cod.
- Current research indicates that key areas (such as major anabranches) may be important for Murray cod recruitment, particularly during years of sustained low and uniform flows in the River Murray.

1. Introduction

Murray cod (*Maccullochella peelii peelii*) is the icon fish species of the River Murray. It was a key commercial species in the South Australian Inland Waters Fishery and remains an important recreational species. The first fishery assessment report specific to Murray cod was prepared in November 2000. That report provided a detailed review of the fishery biology and ecology of this species and information on biological performance indicators estimated from compulsory catch and effort data and data collected voluntarily by commercial fishers (i.e. size compositions and non-targeted catch rate of Murray cod during the seasonal closure between 1st September and 31st December) (Ye *et al.* 2000). In 2002 an interim report on Murray cod was provided to PIRSA Fisheries, which updated the commercial catch and effort information to June 2002 (Ye *et al.* 2002).

In 2003 Murray cod was listed as a species that was nationally vulnerable to extinction under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). As such, a National Recovery Plan for this species is currently in the final stages of development. Commercial fishing for native fish including Murray cod ceased in the South Australian reaches of the River Murray when the fishery underwent a major restructure to a non-native fishery in July 2003. In January 2005, a fishery independent monitoring program (Native Fish Monitoring Program) was implemented by PIRSA Fisheries and SARDI Aquatic Sciences. This program aims to collect biological information for key native fish species such as Murray cod and golden perch (*Macquaria ambigua*), and measure biological performance indicators for stock assessment.

This document is a stock status report, highlighting key biological information on Murray cod and evaluating current stock status in the lower River Murray, South Australia. Several independent datasets are considered including: commercial catch and effort data updated to June 2003; information on size composition collected by fishers between 1990 and 2003; estimates of recreational harvest and release from the National Recreational and Indigenous Fishing Survey conducted in 2000/01 (Henry and Lyle 2003; Jones and Doonan 2005); and additional information from the Native Fish Monitoring Program (NFM) and Murray-Darling Basin Commission funded projects (e.g. the Tristate Murray River Fishway Assessment Program and the Chowilla Fish Ecology Project). Key biological performance indicators derived from the above data are:

- catch rates (CPUE) from the previous commercial fishery and the fishery independent sampling program (NFM);

- temporal and spatial variability in size composition, as an indirect indicator of recruitment strength, based on data from the previous commercial fishery (measured and released cod during the moratorium and the closed seasons), NFM (netting) and other research projects in this region (electrofishing);
- harvest and release of Murray cod from the recreational fishery.

River flow is also considered, as an environmental performance indicator, because historical fishery data suggest a strong correlation between flow and Murray cod recruitment (Ye *et al.* 2000). The trends for flow-corrected catch rates are also considered to indicate changes in stock abundance.

2. Key Biological Information

Murray cod (*Macculochella peelii peelii*) belongs to the family Percichthyidae, and is the largest freshwater fish in Australia. Its natural distribution is widespread throughout most of the Murray-Darling system (Fig. 1) except for the upper reaches of some tributaries in Victoria and southern New South Wales (Lake 1971).

The habitat of Murray cod varies greatly from small clear rocky streams to the generally turbid, slow-flowing rivers and creeks. Murray cod are generally found in or near deep holes and prefer habitats containing cover such as rocks, fallen trees, stumps, and clay banks or overhanging vegetation (Harris and Rowland 1996).

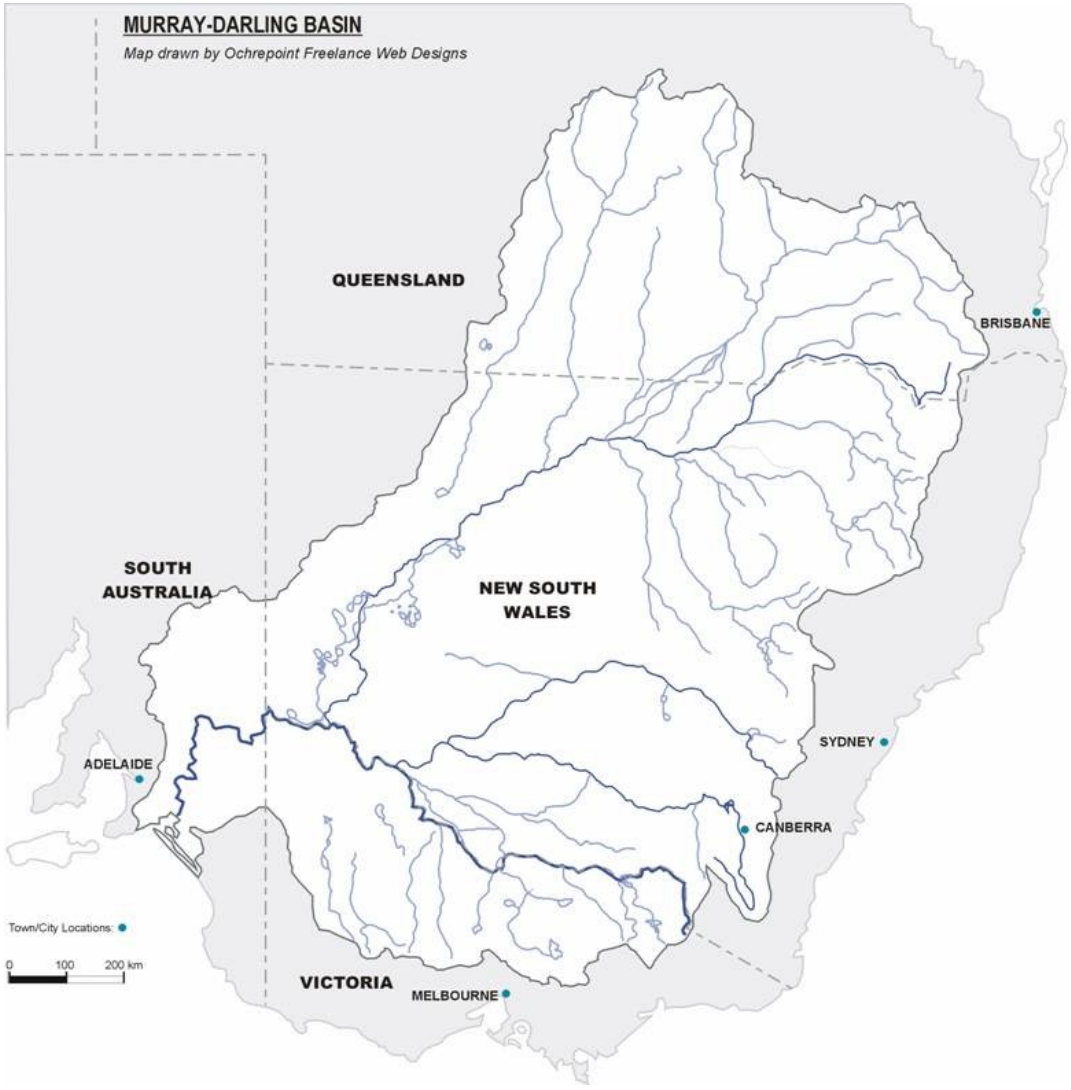

Figure 1. Map of the Murray-Darling Basin (source: MDBC).

Murray cod has a relatively short, well-defined breeding season. Spawning occurs in spring and early summer cued by increasing photoperiod and water temperature (recorded range 15 – 23.5 ºC) (Lake 1967; Langtry in Cadwallader 1977; Rowland 1983, 1985; Gooley *et a*l., 1995; Koehn and Harrington 2006). Murray cod deposits large (3 mm) adhesive eggs onto solid surfaces such as logs, rocks or clay, and relative fecundity is approximately 5000 eggs per kg of body weight (Rowland 1985). Murray cod spawn annually (Humphries *et al.* 2002; Humphries 2005), but in the lower River Murray, Edward, Wakool and Murrumbidgee Rivers relatively strong year classes may only be established when the breeding season coincides with high river flows both within channel and overbank (Rowland 1998; Ye *et al.* 2000). The South Australian historical fishery data suggest a strong correlation between the recruitment of Murray cod and river flows (Ye *et al.* 2000).

The estimates of size and age of Murray cod at first maturity from various studies are extremely variable, and depend on a range of factors that include ambient climatic conditions and natural productivity of the water (Rowland 1985; Gooley *et al.* 1995; Rowland 1998). The various estimates of mature size and age are shown in Table 1. Note that this important biological information is still lacking for Murray cod in the South Australian reaches of the River Murray.

Table 1. The estimates of size and age at first maturity of Murray cod from different studies conducted in different regions in Australia.

Sex	**Total length (mm)**	**Weight (kg)**	**Age (years)**	**Maturity status**	**Region**	**Reference**
Both	381	1.14	NA	first	South-western N.S.W.	Whitley 1937
Both	432 457 483	NA	NA	first 50% 70%	Bringagee, Victoria	Langtry, in Cadwallader 1977
Both	560	1.8-2.3	4	first	N.S.W.	Lake 1967
Female Male	610 625	5.0 5.4	4 4	first first	Lake Mulwala, NSW	Rowland 1985
Female Male	480-590 530-585	2.1-3.9 2.3-3.4	4-5 3-5	first first	Murray, Edward, Wakool, Murrumbidgee and Gwydir Rivers, NSW	Rowland 1985
Female Male	480 NA 590 530 NA 585	2.1 NA 3.9 2.3 NA 3.4	NA 4 NA 3 4 NA	First 77% 100% 15% 70% 100%	Edward, Wakool, Murray and Gwydir Rivers, NSW	Rowland 1998
Female Male	500 400	2.0 0.7	6 3-4	first first	Lake Charlegrark, Victoria	Gooley *et al.* 1995

Murray cod is a long-lived species with a life span that extends to at least 48 years (Anderson *et al.* 1992). Growth rates and body forms may vary significantly between populations from different regions and different habitats within the Murray-Darling Basin (Rowland 1985; Anderson *et al.* 1992; Nicol *et al.* 2005). In general, growth is characterised by mostly increasing weight when Murray cod are older than 10 years (Harris and Rowland 1996).

A limited number of otoliths from Murray cod have been collected on an ad hoc basis during 1992 and from 2001 to 2007, from the lower River Murray in South Australia. The age estimates of fish were determined from transverse-sections (Anderson *et al.* 1992) or the break and burn method (Gooley 1992). A length-at-age relationship has been developed for Murray cod from the South Australian River Murray (Fig. 2). Additional data collected from the River Murray in Victoria indicate considerable variation in length in several age classes (Fig. 3). Morphometric relationships between the total and standard length, and the total length and weight, have also been determined for South Australian fish (Figure 4).

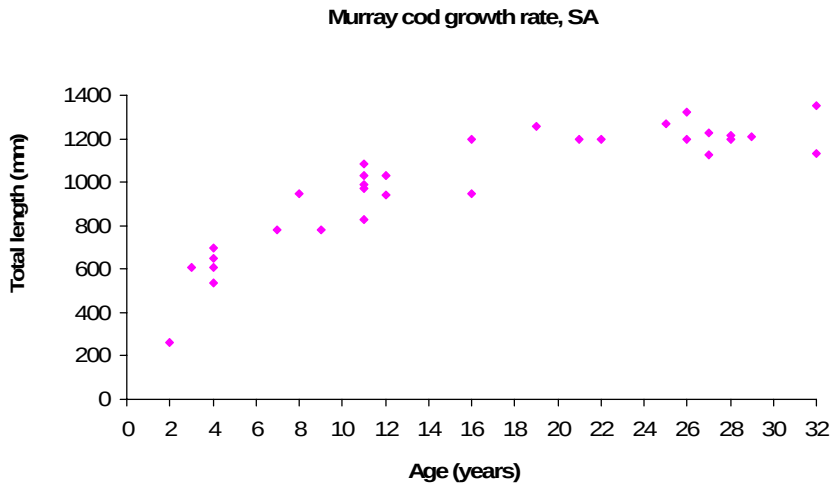

Figure 2. Lengths at age of Murray cod from the lower River Murray, South Australia.

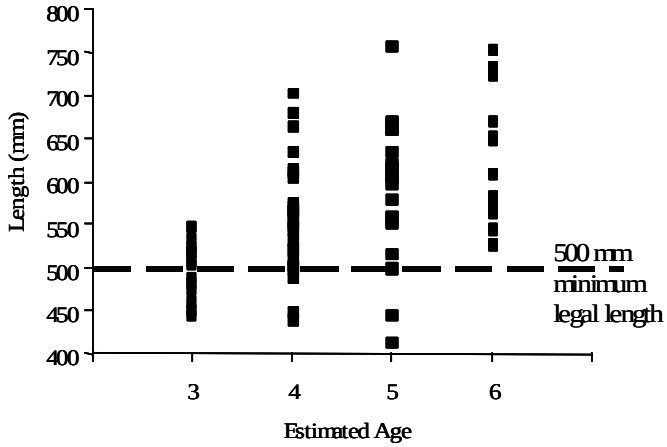

Figure 3. Lengths at age of Murray cod from the River Murray, Victoria (Nicol *et al.* 2005).

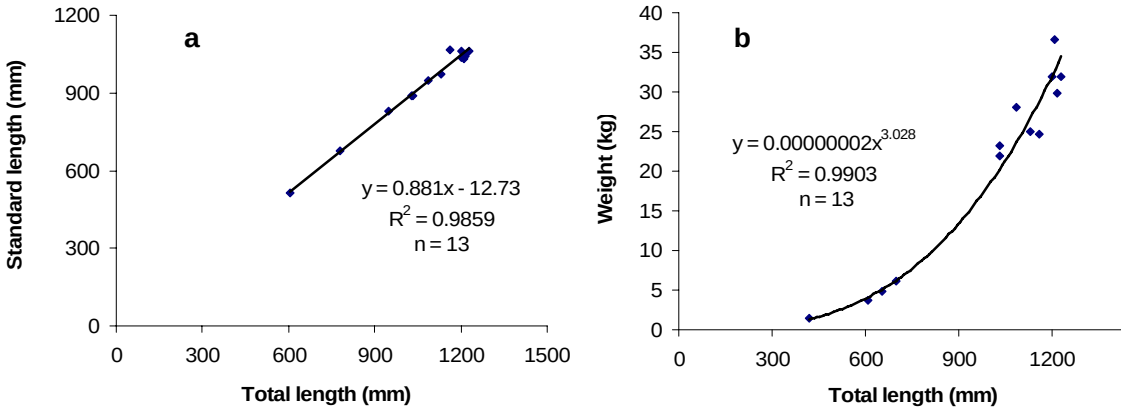

Figure 4. Morphometric relationships for Murray cod from the lower River Murray, South Australia. **a**. Relationship between total and standard length. **b**. Relationship between total length and weight.

3. Stock Status

3.1 Commercial Catch and Effort

Overall landings

The South Australian commercial catch of Murray cod declined dramatically through the 1960s from 140 tonnes at the end of 1950s to an average of less than 10 tonnes per annum in the early 1970s (Fig. 5). The annual landings remained under 10 tonnes in the following years except for 1981/82; consequently, a moratorium was instituted in 1990. The fishery recommenced in 1994 after which the landed catch increased gradually to the relatively high level of 28.5 tonnes in 2001/02. This was followed by the considerably lower catch of 7.1 tonnes in 2002/03. Commercial fishing for Murray cod ceased in South Australia in July 2003 when the River Fishery was restructured to a non-native fishery.

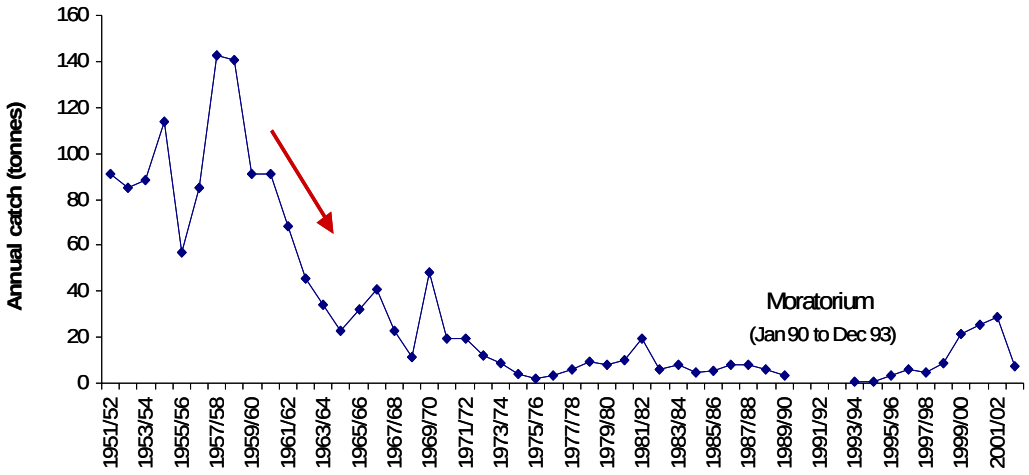

Figure 5. Murray cod commercial landings from the South Australian inland fisheries between 1951/52 and 2002/03.

River fishery

Prior to 2003, commercial catches of Murray cod were mainly taken by the River Fishery with only a small proportion of catch coming from the Lakes and Coorong Fishery. After 1984, more than 95% of the state catch was taken from the River Murray (upstream of Wellington), and from 1994 to 2003 the river catch accounted for 99.7% of the total harvest. This report therefore focuses on the River Fishery.

Estimates of catch, effort and CPUE are only available from July 1984 onwards as this was when mandatory catch reporting was introduced. Annual commercial landings (tonnes), fishing effort (fisher-days) and catch per unit of effort (kg/fisher-day) for Murray cod from the River Fishery from 1985 to 2003 are presented on a calendar year basis in Fig. 6. From 1985 to 1989 the annual landing was <10 tonnes.year^{-1}. After the end of the moratorium in 1994, the annual landing increased significantly to a peak of 28.8 tonnes in 2001 (Fig. 6a). Nevertheless, it declined considerably in 2002 and 2003 with catches of 18.9 tonnes and 4.8 tonnes up to 30 June 2003.

Catch rates (CPUE) increased substantially from 1998 and peaked in 2001 at 21.2 kg/fisher-day (Fig. 6b). This suggests that strong recruitment of Murray cod associated with increased flows in 1989 and the early 1990's (Fig. 6c) facilitated an increase in stock size. Nevertheless, CPUE declined slightly in 2002 and more significantly in 2003. It is of concern that since 2001 there have been no significant flows in the SA River Murray (Figure 6 c).

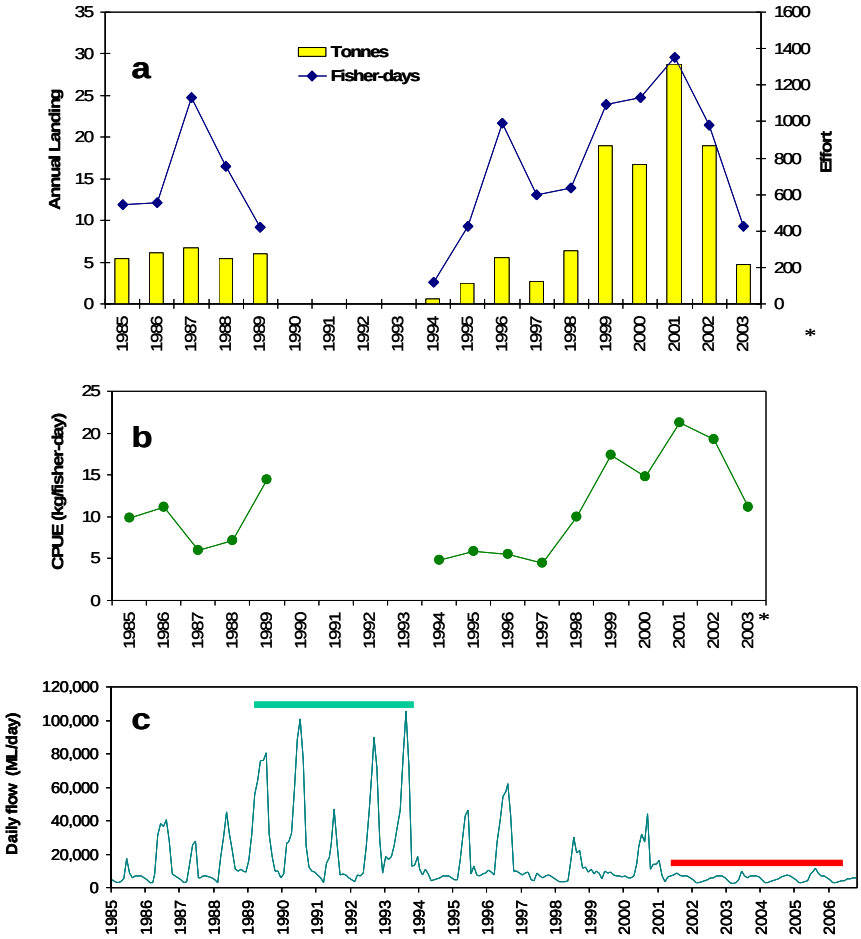

Figure 6. **a.** Annual commercial landings and fishing effort for Murray cod in the South Australian River Fishery from 1985 to 2003; **b**. Catch per unit of effort (CPUE kg/fisher-day); **c**. River Murray daily flow rate (ML/day) to South Australia at the border (data source: DWLBC). *Note 2003 data are only for the period of January-June. Green line: high flow years; Red line: low flow years.

River catch and effort by gear

The dominant fishing methods for Murray cod in the River Fishery were gillnets, drum nets, and set lines, which accounted for 57%, 37%, and 5%, respectively, of the total River catch from 1985 to 1989 (Fig. 7). After the lifting of the moratorium in 1994, gillnets and drum nets accounted for 68% and 30%, respectively, of the total catch. Generally, during low flow years gillnet effort and proportional catch by this method increased. Drum net catches of Murray cod are strongly influenced by river flows with low flows reducing the effectiveness of this method.

The trends for catch rates and flow-corrected catch rates are shown in Fig. 8 to indicate changes in stock abundance. CPUE by drum net and gillnet are also standardised by flow volume to take into account the bias due to flow-dependent catchability (Ye *et al.* 2000). The CPUE and flow-corrected CPUE (CPUE-FC) from both gear types show a general trend of decline between 1985 and 1989. After the fishery reopened, the CPUE and CPUE-FC increased significantly from 1996, which probably suggests that the high flows/flood in 1989 and the early 1990's helped the stock to recover from its relatively low state in the late 1980's. The drum net CPUE and CPUE-FC show a continuous increase from 1997 (Fig. 8) until a slight drop in 2003, which may be partially due to the relatively lower catchability of Murray cod during the January – June period as Ye *et al.* (2000) suggested that the average monthly catch rates for Murray cod between 1985 and 2000 peaked in July and August.

The gillnet CPUE and CPUE-FC decreased over the last 4 years of the fishery (Fig. 8), which is possibly due to a combination of the following factors:

- growth (size increase) of the few strong year classes from 1989 and the early 1990's reduces the Murray cod's catchability by gillnets;
- a reduction in the maximum legal size from 110 cm to 100 cm in July 2001, which resulted in a smaller size range of Murray cod that could be landed and these smaller fish constituted a low proportion of the catchable stock; and
- the 2003 commercial fishery data do not include a complete year, and missed the part of the year that produced the highest catch rates.

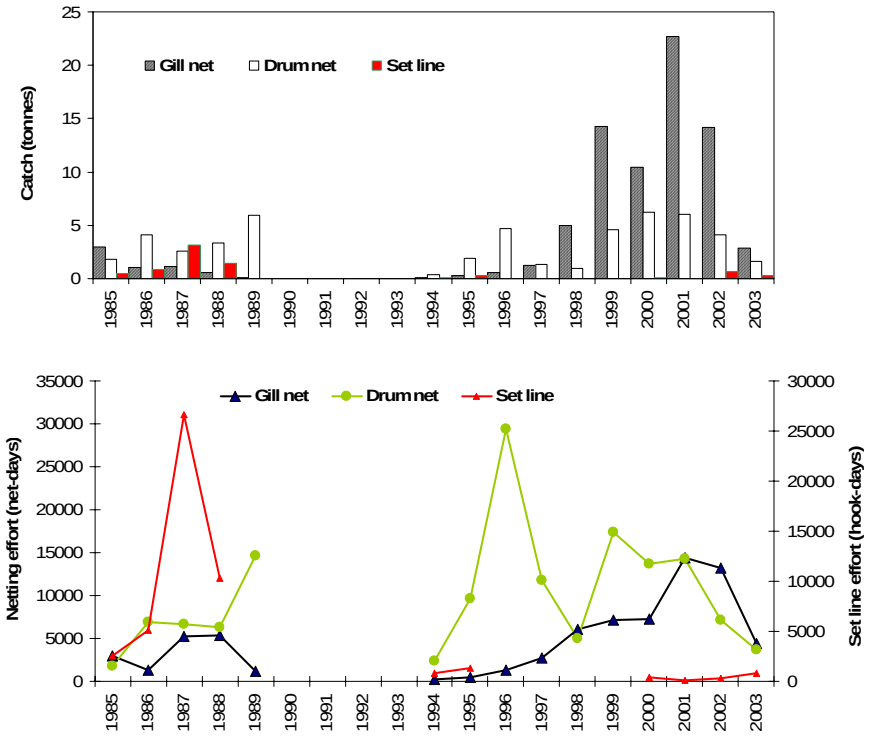

Figure 7. Annual commercial catch and fishing effort for Murray cod by gear type in the South Australian River Fishery from 1985 to 2003.

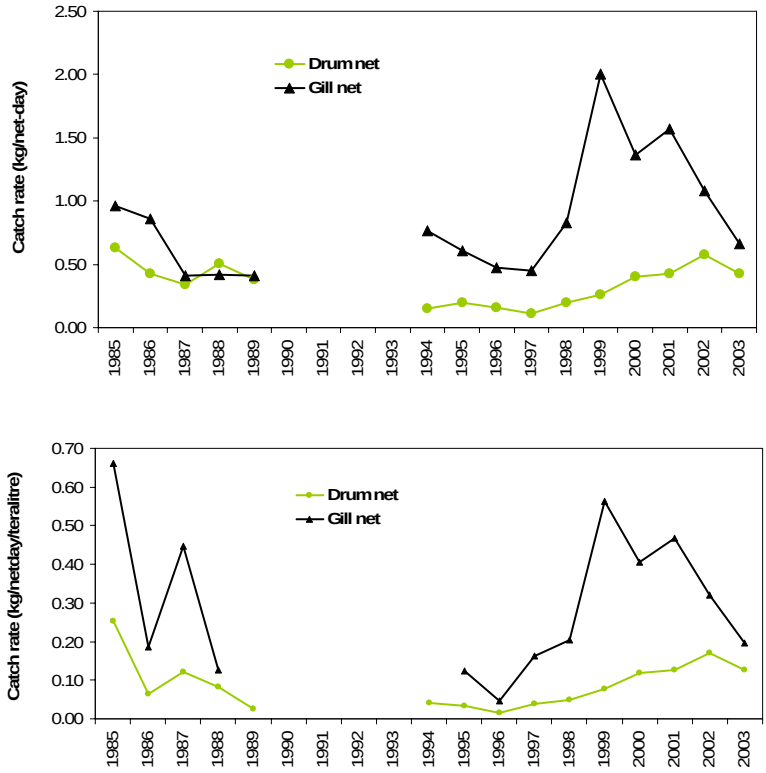

Figure 8. Catch rates and flow adjusted catch rates by gear for Murray cod in the South Australian River Fishery from 1985 to 2003.

3.2 Size Composition

From 1990 information on the size composition of Murray cod was collected voluntarily by commercial fishers. Most of the data were from caught (non-targeted) and released fish during the moratorium between 1990 and 1994 and the annual seasonal closure between 1st September and 31st December. Before 1994, fish were generally measured throughout the year, but with a relatively low sample size. From 1995 more length data were provided for the period between September and December with a good number of fish being measured in most years (Fig. 9). About 90% of these fish were caught in drum nets rather than gillnets.

With more consistent data collection from 1995, there was a prominent yearly progression of size frequency modes (Fig. 9). The most distinct size class first appears at 350-399 mm in 1995, then progresses to around 450-499, 550-599, 600-649, 700-749, and 800-849 mm in 1996, 1997, 1998, 1999, and 2000, respectively. Based on the limited data from SA (Fig. 2) and age-growth studies in Victoria (Anderson *et al.* 1992; Nicol *et al.* 2005), these fish were most likely produced in 1992 and 1993 when major floods occurred in the lower River Murray. The modal progression in size composition also explains the increasing catch rates after 1996/1997 (Fig. 6b, Fig. 8). A weaker size class, probably from spawning success in 1989 and 1990, showed similar growth from 1995 onwards, with modes at 550-599, 650-699, and 700-749 mm in 1995, 1996, and 1997, respectively. Nevertheless, the mode became indistinct in 1998, as the change in size increment between years slowed down as fish got older leading to the merging of year classes. Since 2002, a considerable proportion of fish from those strong cohorts have gradually moved out of the fishery (> 1000 mm TL), which is reflected in the significant decline of CPUE, particularly in the gillnet sector (Fig. 6b, Fig. 8).

There were no distinct size classes of relatively small Murray cod (< 450 mm TL) between 1997 and 2002, suggesting no or low levels of recruitment in the years between 1994 and 1999. In 2003, a noticeable group of fish that were 350-550 mm became apparent, indicating some recruitment success that probably occurred in 2000, which would coincide with river flows of approximately 20,000 to 60,000 ML/day.

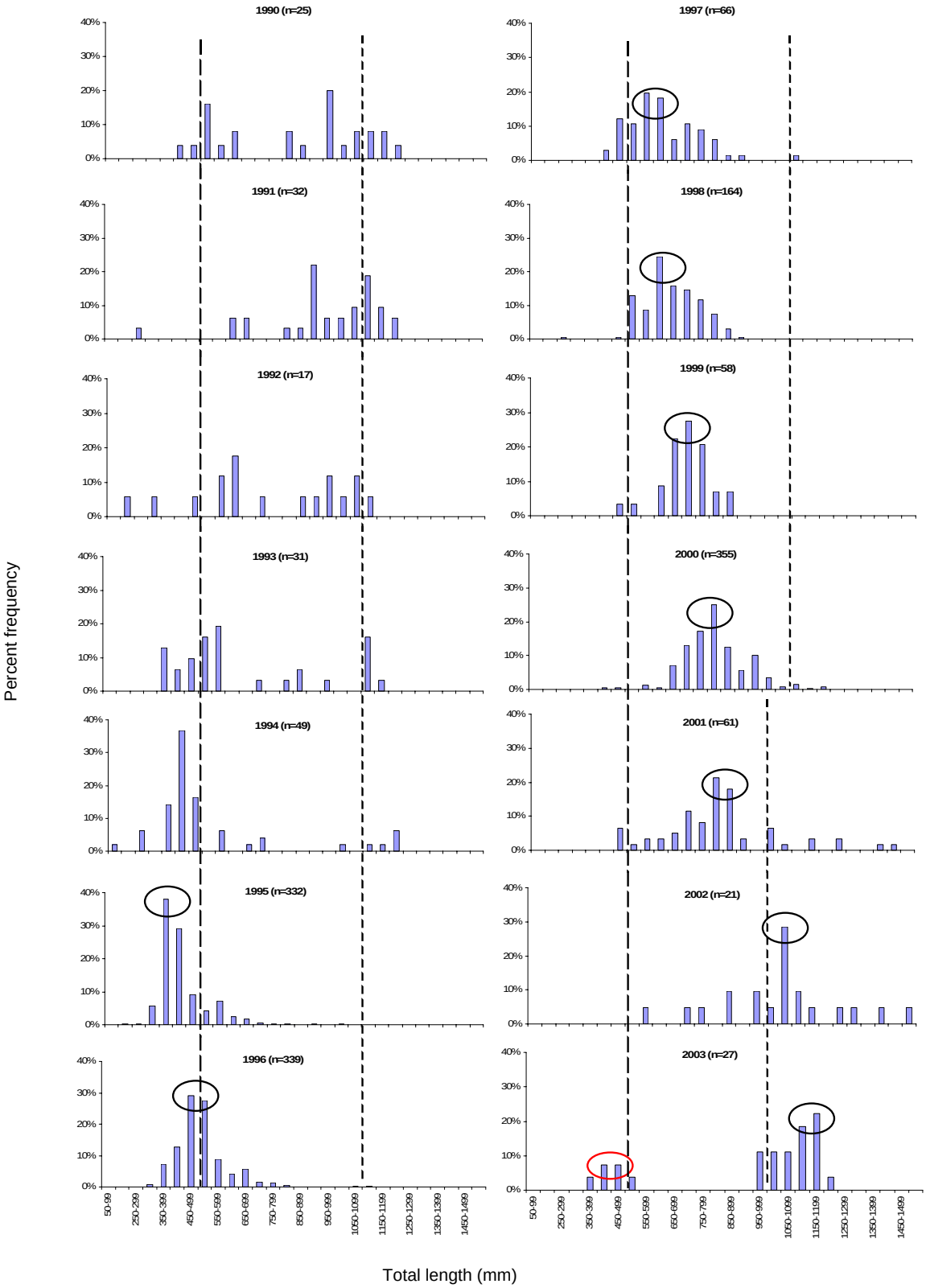

Figure 9. Length frequency distributions (percent frequency) of Murray cod in South Australia from 1990 to 2003. Most of the data were from caught and released fish measured voluntarily by commercial fishers during the moratorium and seasonal closure, and about 90% of these fish (by number) were caught by drum nets rather than gillnets. Dashed lines indicate minimum and maximum size limits. Black circles track progression of size frequency modes; red circle indicates a potential new cohort.

3.3 Recreational and Indigenous Fishing Survey

The National Recreational and Indigenous Fishing Survey, conducted between May 2000 and April 2001, suggested that the recreational harvest of Murray cod from South Australian inland waters was 22.8 tonnes (Table 2) (Henry and Lyle 2003). All harvest of Murray cod came from the River Murray system (Jones and Doonan 2005), and the level is similar to commercial harvest (25.5 tonnes) in the same year. The survey also indicated that an additional 16.4% of the recreational catch of Murray cod from the River Murray was released (Table 2). Nevertheless, the estimates are based on minimal records, and the standard error is very high relative to the harvest level.

During the 2000/01 survey, there were a total of 20 fishing events reporting the harvest or release of Murray cod in SA, and a total of 9 households fished in these events. Of the 9 households, 3 were from interstate (Victory, Tasmania and Western Australia), and the remaining 6 were SA households.

Table 2. Estimates of the recreational harvest (+/- standard error) and release of Murray cod in 2000/01 from the South Australian River Murray and total inland waters (Jones and Doonan 2005).

Region	**Harvest (nos.)**	**SE +/-**	**Average weight (kg)**	**Harvested Biomass (kg)**	**Released (nos.)**	**% Released**
SA	2,278	1,362	10.0	22,780	1,088	32.3
River Murray System	2,278	1,362	10.0	22,780	448	16.4

3.4 Native Fish Monitoring

Sampling by drum nets and gillnets

Previous stock assessments for native fish species such as Murray cod and golden perch in SA were mainly dependent on readily available commercial fishery data. Since the restructuring of River Fishery in July 2003, commercial fishery data are no longer available to inform research. In January 2005, PIRSA Fisheries and SARDI Aquatic Sciences implemented a long-term fishery independent monitoring program. The aim of this sampling program is to collect biological information for key native fish species (Murray cod and golden perch) and to measure biological performance indicators for stock assessment. The sampling program is

undertaken with the assistance of two former River Fishery licence holders. The data presented in this report were collected from January 2005 to April 2006.

Following initial support and training from SARDI, monthly sampling has been carried out by commercial fishers at six sites along the lower River Murray below Locks 1-6 (Fig. 10). Three of the sites were within the gorge section (above Wellington and below Overland Corner) and three in the floodplain section (between the SA/NSW border and Overland Corner). A standard set of sampling gear (provided by SARDI) was used at each site, with nets set and checked over three consecutive nights. The set of gear included:

- 10 small-mesh drum nets (January 2005 to April 2006);
- 4 multi-panel gillnets (45 x 2 m, 38, 51, 70, 114, 152 mm meshes) (January to April 2005)

Additional methods were used to specifically target Murray cod including

- 5 large funnel/mesh drum nets (August 2005 to April 2006)
- 4 large mesh gillnets (50 x 2 m) with various mesh sizes i.e. 203, 254, 305 and 356 mm (August and September 2005)

All fish captured from each net were identified to species, counted, and total lengths measured for all Murray cod and golden perch and a sub-sample of 20 individuals per species for other species for each gear type. A research log was provided by SARDI to record all relevant information.

Figure 10. Native Fish Monitoring Program sampling sites along the lower River Murray, South Australia.

The results of netting from January 2005 to April 2006 are presented in Table 3. A total of 95 Murray cod were sampled over sixteen months, of which 75 were from targeted gillnetting (large mesh) during August and September 2005. No fish was caught in 203 mm gillnets; all 75 fish were captured in the larger mesh nets (254, 305 and 356 mm), and 90% came from 305 and 356 mm meshes. The catch rates for relatively small Murray cod were low despite the significant sampling effort by drum nets and multi-panel gillnets. These data suggest that the Murray cod population in the lower River Murray is generally dominated by larger individuals, probably associated with recruitment success from 1989 and the early 1990s.

Length frequency distributions (Fig. 11) indicate different size structures of Murray cod in the floodplain and gorge sections of the River Murray. In the gorge section, fish 900-1099 mm TL dominate the population, whilst along the floodplain section the size distribution is broader, i.e. from 400 to 1500 mm TL. With limited data from drum nets, a distinct size class

of smaller fish appears in the floodplain section, suggesting that there may have been some recruitment in recent years possibly associated with anabranch systems that provide hydrological and habitat diversity in this region.

Table 3. A summary table of the number of Murray cod sampled, fishing effort and CPUE through the Native Fish Monitoring Program between January 2005 and April 2006.

	Gorge			Floodplain			Total		
Gear type	**Effort**	**Cod**	***CPUE***	**Effort**	**Cod**	***CPUE***	**Effort**	**Cod**	***CPUE***
	net-days	**#**	***#/10 net-days***	**net-days**	**#**	***#/10 net-days***	**net-days**	**#**	***#/10 net-days***
Drum net (small mesh)	1334	3	*0.02*	1169	10	*0.09*	2503	13	*0.05*
Drum net (large mesh)	200	1	*0.05*	160	5	*0.31*	360	6	*0.17*
Gillnet (MP)	128	0	*0.00*	111	1	*0.09*	239	1	*0.04*
Gillnet (large mesh)	65	38	*5.85*	72	37	*5.14*	137	75	*5.47*

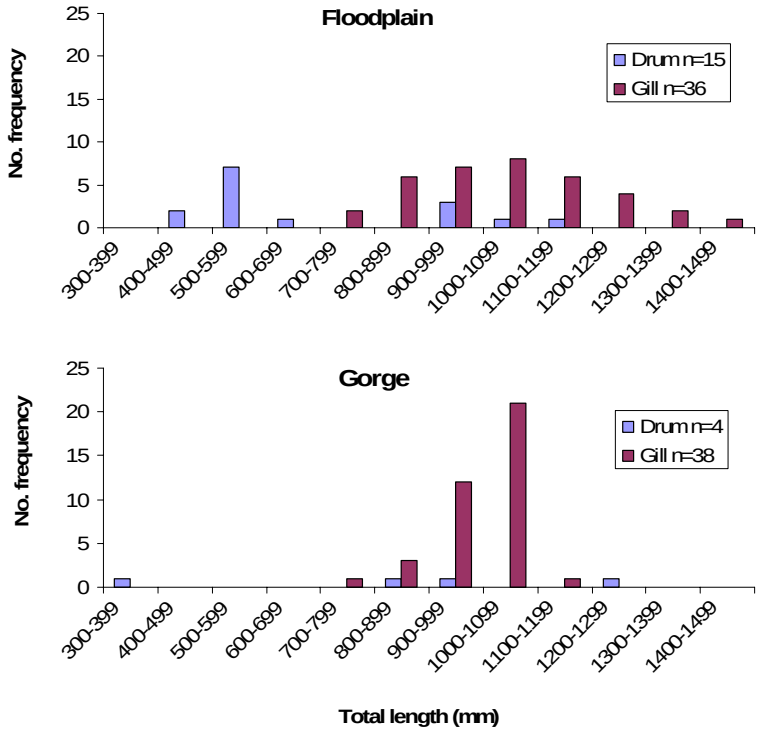

Figure 11. Size frequency distributions of Murray cod sampled through the Native Fish Monitoring Program between January 2005 and April 2006.

Boat electrofishing

On 3-7 April 2006, standardised quantitative boat electrofishing was undertaken at selected reaches in the lower River Murray. Sites were selected with the assistance of experienced commercial fishers who previously targeted native fish (Fig. 12). At each site, electrofishing (Fig. 13) was conducted to specifically target habitats preferred by Murray cod (i.e. large woody debris, cliff edge/clay bank) (Fig. 14), along each bank (depth 0.5-5 m). Sites were electrofished using replicated (5 – 20 replicates), standardised time (90 seconds, power on time) electrofishing shots. Distances travelled were also recorded. The results are presented in Table 4.

Only six Murray cod were sampled by boat electrofishing in April 2006, during 15,420 seconds power-on time of electrofishing, and a total distance travelled of 26,418 m. Three fish were collected near snags between Locks 2 and 3, and three were from the cliff edge/clay banks below Lock 1. The size of fish ranged from 780-1200 mm TL.

Boat electrofishing is an effective means of sampling large and small bodied fishes in flowing and shallow (< 3 m) waters. Nevertheless, much of the main channel of the River Murray in South Australia is characterised by deep, lentic weir pools where electrofishing may be less efficient. Ongoing monitoring of Murray cod using boat electrofishing may be most efficient when undertaken in lotic environments such as the tail waters of weirs and anabranch environments.

Table 4. Number of Murray cod sampled by boat electrofishing and fishing effort during April 2006.

Sites	E fishing (sec.)	Dist (m)	Murray Cod No.	Callop* No.
Above Lock 6	3810	6939	0	20
Mid Locks 5&6	473	590	0	4
Pike Creek	1884	3248	0	11
Lake Bonney	1426	4117	0	0
Below Lock 3	5230	7691	3	28
Below Lock 1	2597	3833	3	34
Overall	15420	26418	6	102
	257 min.	**26 km**		

* Note: The numbers of callop sampled are presented, indicating the effectiveness of boat-electrofishing in sampling large-bodied fish species in the lower River Murray.

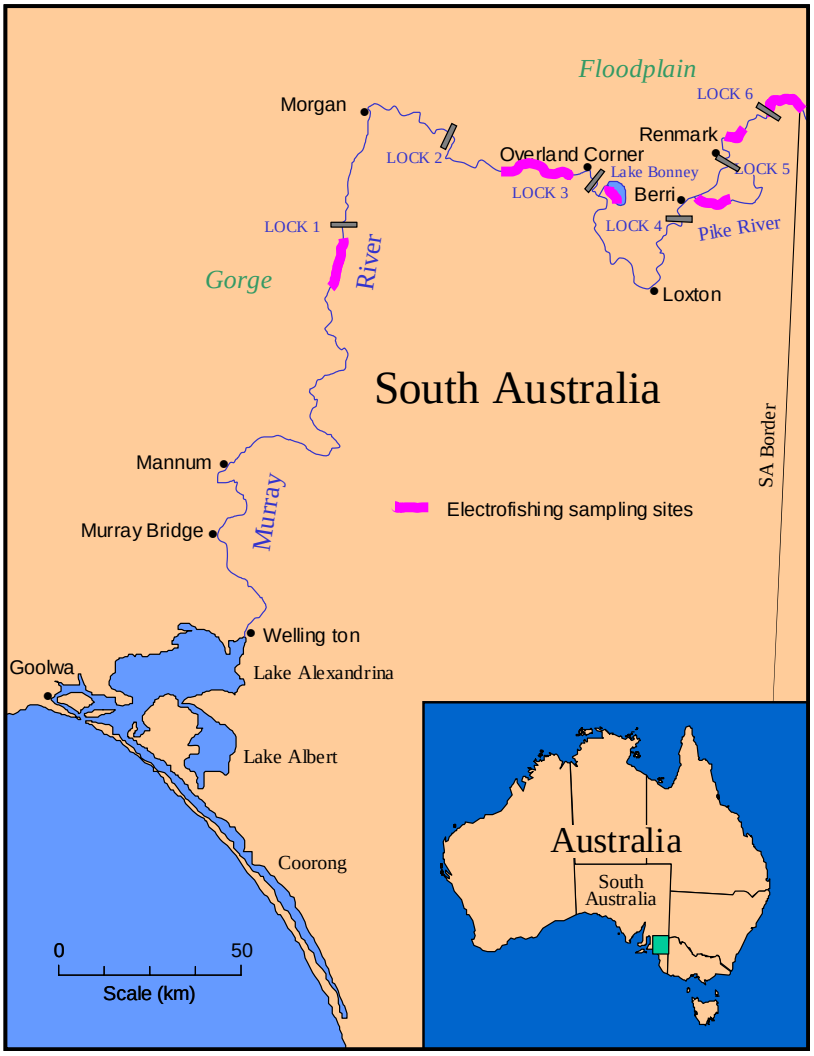

Figure 12. Native Fish Monitoring electrofishing sites during April 2006 along the lower River Murray, South Australia.

Figure 13. Boat electrofishing in April 2006 along the lower River Murray, South Australia.

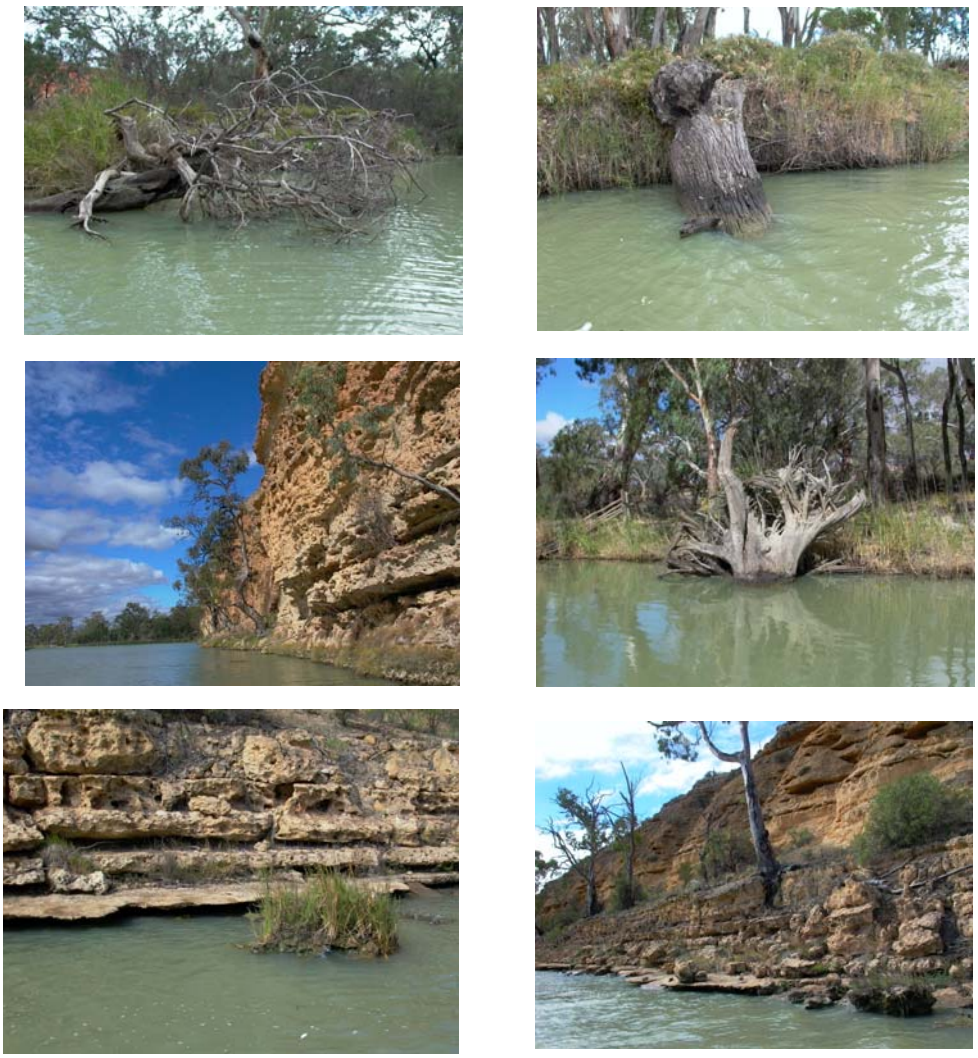

Figure 14. Typical habitats that were sampled using electrofishing for Murray cod along the lower River Murray during 3-7 April 2006.

3.5 Other research

Two Murray-Darling Basin Commission (MDBC) funded projects are collecting long-term data on fish assemblages in the South Australian catchment of the lower River Murray, including distribution, spawning and length-frequency data for Murray cod. The 'Sea to Hume Dam' fish passage project has facilitated the collection of six years of data (2001-2007) on fish assemblages downstream of Locks 1-3 and considerable data on fish assemblages in the vicinity of Locks 7-9 (New South Wales immediately upstream of the South Australian border). In addition, the Chowilla Fish Ecology project has investigated the spatial and temporal distribution of fish assemblages, and the spawning and recruitment of Murray cod in the Chowilla Anabranch system and adjacent River Murray.

To determine spatial and temporal variation in fish assemblages both projects use standardised quantitative boat electrofishing which means that data are comparable between the projects. Sites are electrofished using replicated (12 – 16 replicates), standardised time (90 – 120 seconds, power-on time) electrofishing shots.

Length-frequency data based on sampling undertaken to March 2006 indicate three scenarios in the lower River Murray (Fig. 15). In the River Murray downstream of Lock 7 there appears to be considerable recent recruitment or stocking of juvenile fish. The length frequency distribution for fish collected in this region is also truncated, potentially as a result of high angling pressure. In the Chowilla Anabranch system there appears to have been some recruitment in recent years although there are no particularly strong cohorts. In the River Murray in the vicinity of Locks 1-3 (Blanchetown to Waikerie) there appears to have been minimal recruitment with the majority of fish collected being greater than 700 mm.

These preliminary data indicate that hydrologically diverse anabranch systems may maintain some level of Murray cod recruitment during periods of sustained low flows and hence low hydrological variability in the main channel of the River Murray. Consequently these anabranch systems may be an important source of low numbers of recruits to the River Murray during years of limited recruitment in the main stem of the River. Other significant anabranch systems for Murray cod recruitment in the lower River Murray include the Lindsay Mullaroo system (Meredith *et al.* 2002) and potentially the Pike Mundic (bypasses Lock 5) and the Katarapko Creek systems (bypasses Lock 4).

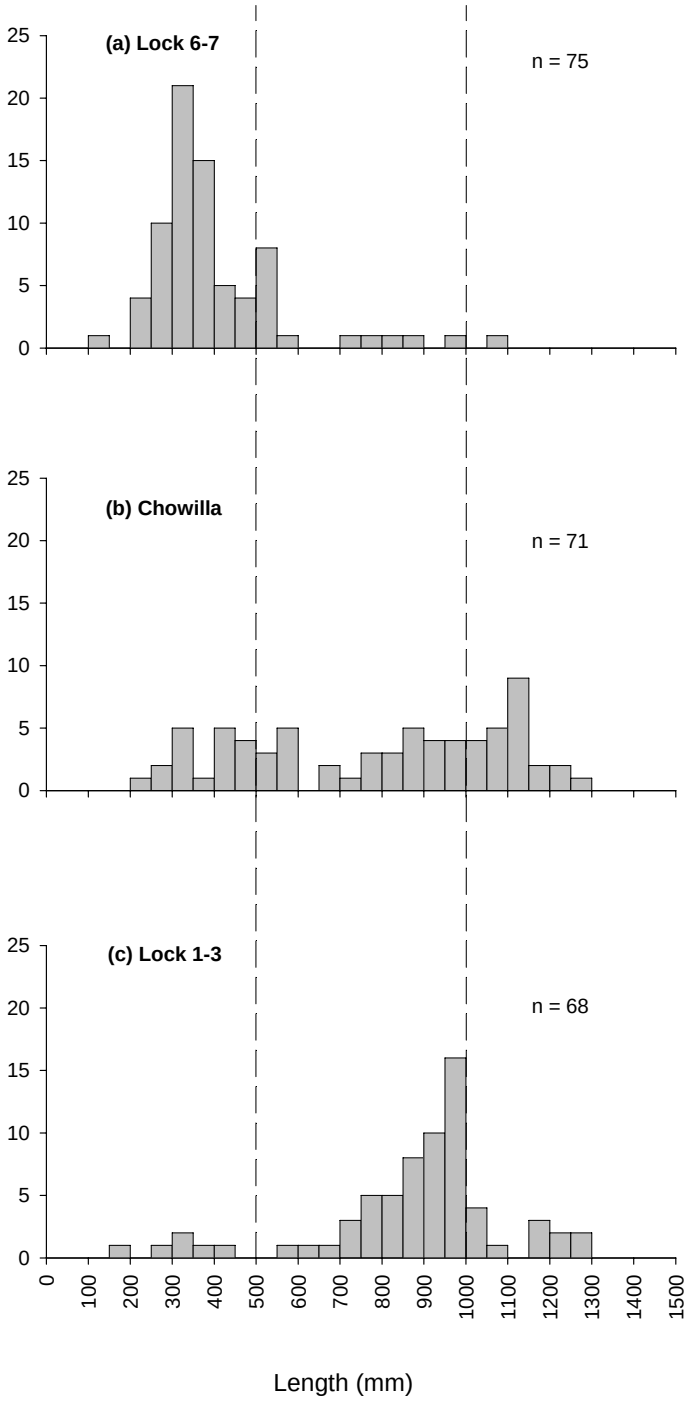

Figure 15. Length-frequency distribution of Murray cod boat electrofished (a) downstream of Lock 7, (b) in the Chowilla Anabranch system and (c) immediately downstream of Locks 1, 2 and 3 (Blanchetown to Waikerie). Dashed lines indicate minimum and maximum size limits in SA and NSW. As an indication of catch per unit effort, the Lock 6-7 data were collected in one week of sampling, the Chowilla data in 6 weeks and the Lock 1-3 data in 20 weeks.

4. General Discussion

CPUE from the previous commercial fishery and the fishery independent sampling program (NFM) have been used to indicate the stock abundance of Murray cod. In the last two years of the River Fishery (2002 and 2003) there was a decline in the overall CPUE (kg/fisher-day). Both CPUE (kg/net-day) and CPUE-FC (kg/net-day/teralitre) from the gillnet sector decreased over the last 4 years of the fishery, and that from the drum net sector decreased in the last year. These data suggest a decline of the fishable stock of Murray cod (legal size 500-1000 mm TL), most probably due to the growth of the few strong year classes from 1998 and the early 1990's. More recent fishery independent sampling (NFM) produced low catch rates of Murray cod from drum nets, multi-panel gillnets and electrofishing, despite considerable fishing effort from January 2005 to April 2006. Nevertheless, there was a reasonable CPUE when gillnets with larger meshes (305 and 356 mm) were used to target Murray cod. This further suggests that larger individuals dominate the lower Murray population.

As an indirect indicator of recruitment strength, the temporal changes in the size composition of the Murray cod measured and released by commercial fishers during the moratorium and closed seasons between 1990 and 2003 were examined. A distinct size class could be tracked over time, showing a prominent yearly progression of size frequency modes from 1995 to 2000. This size class is most likely linked to recruitment success during the high flows/flood years in the early 1990s. Since 1994, there is little indication of strong recruitment of Murray cod in the SA lower River Murray. The appearance of a group of 350-550 mm fish in 2003 indicates there may have been some low level recruitment in 2000 associated with river flows of approximately 20,000 to 60,000 ML/day, nevertheless the sample size was small (n=27).

Spatial differences in size composition of Murray cod between the gorge and floodplain sections of the River Murray, based on limited data from the NFM, further suggest that low level recruitment in recent years may have occurred along the floodplain section of the River Murray. There are major anabranch systems along this geo-morphic zone, providing habitat and hydrological diversity in contrast to the river channel. Preliminary data from the MDBC funded Chowilla Fish Ecology Project also support the notion that significant anabranch systems such as Chowilla may be an important source of Murray cod recruits to the River Murray during low flow years when there is low hydrological variability and limited recruitment in the main stem of the River.

River flow is considered a potential environmental performance indicator of Murray cod stock status. It is of most concern that there have been protracted years without significant high flows, and critical drought conditions have persisted for more than six years in the Murray-Darling Basin. The SA historical commercial fishery data (Ye *et al.* 2000) and previous NSW studies (Rowland 1998) suggest a strong link between river flows and Murray cod recruitment. Under current conditions, there is a high risk that the stock may decline further unless strong year classes can be added.

Ensuring an adequate spawning biomass to maximise recruitment success from years when environmental conditions are favourable is an important strategy for the management of the Murray cod fishery. Given the estimate of significant catch from the recreational fishery, and lack of strong years classes of new recruits over protracted drought years, a precautionary approach to the management of Murray cod should be adopted. Conservation management measures may include:

- changing size limits (a minimum size of 600 mm will ensure greater confidence that fish reach reproductive maturity before being removed from the stock. Nevertheless, this measure may be ineffective unless new strong year classes are added to the stock);
- extended seasonal closures (e.g. August to December) to protect Murray cod before and during the spawning season;
- spatial closures to protect reaches/areas which may be significant spawning sites;
- a moratorium on the take of Murray cod.

5. Future Research and Monitoring Needs

- In the absence of commercial fishery data, an effective monitoring program is needed to measure stock status and recruitment success;
- Assessment of the catch and potential impact of the recreational fishery on the stock is essential;
- Basic biological and ecological information is required for Murray cod populations in SA;
- Other research projects (eg Murray Fishway Program and Chowilla Fish Ecology project) contribute invaluable data to the stock assessment of Murray cod in SA. Nevertheless, this is currently an unfunded component of these projects.

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