Black bream (*Acanthopagrus butcheri*)

Stock Assessment Report for PIRSA Fisheries

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EXECUTIVE SUMMARY

1 This is the first stock assessment report on the Lakes and Coorong Fishery for black bream.

2 Total annual catch declined steeply from 58.2 t to 4.6 t between 1986-87 and 1991-92. Total annual catch remained below 12 t after this and was 4.5 t in 2006-07. The catch in 2006-07 was 42% below the most recent 5-year average (7.6 ± 1.36).

3 Non-target catch of black bream comprised approximately 50% of total annual catch from 2002-03 to 2006-07.

4 Catches are highly seasonal. From 2002-03 to 2006-07 most of the annual catch (65%) was taken in the three months from August to October.

5 The dominant gear in all years was the large mesh gill net (>70% of catch). Smaller amounts (<24%) were taken using small mesh haul nets.

6 Trends in targeted effort, (fisher days) were similar to those for targeted catch. Peaks in targeted effort of 3 303 and 2 255 fisher days occurred in 1985-86 and 1988-89 respectively. After 1991-92 the highest targeted effort was 473 fisher days in 2002-03. Targeted effort in 2006-07 was 168 fisher days.

7 The highest recorded CPUE was 12.7 kg.fisher day^{-1} in 1984-85 and then declined to 3.0 kg.fisher day^{-1} in 1990-91. CPUE then increased over 16 years to 12.3 kg.fisher day^{-1} in 2006-07.

8 In 2006-07, the performance indicator CPUE (kg.fisher day^{-1}) breached the upper reference limit.

9 In age structures from 2002 the strongest age class was 4 year olds (76% of sample), which then persisted as 5, 6 and 9 year olds in samples from 2003 (85%), 2004 (66%) and 2007 (37%) respectively. In age structures from 2007 an additional year class of 3 year olds was present.

10 Black bream may live to 29 years but age structures from each year had few individuals older than the dominant age class (4 to 9 year olds). This suggests that the older year classes may be absent due to a combination of fishing/natural mortality and poor recruitment.

11 The resource that supports the Lakes and Coorong Fishery for black bream is currently in a weakened state as indicated by trends in catch and effort. From 1990-91 to 2006-07 CPUE increased consistently to breach the upper reference limit in 2006-07 while catches were historically low. Increasing CPUE may be due to increasing catchability of black bream as they aggregate in a decreasing area of suitable habitat.

12 The lack of older (>10 year old) individuals in the age structures further suggest high levels of mortality and poor annual recruitment. It is also likely that black bream require freshwater inflows to achieve successful recruitment. These factors and the potential for the current drought to cause further adverse affects on the black bream population indicate that management action may be warranted.

1 GENERAL INTRODUCTION

1.1 Overview

This is the first stock assessment of black bream (*Acanthopagrus butcheri*) in the South Australian Lakes and Coorong Fishery, and builds on previous stock status reports (Ferguson 2006; Ferguson 2006; Ferguson 2008). The aim of the report is to provide a synopsis of information available for the black bream fishery to assess the current status of the resource.

The report is divided into five sections. Section one provides the General Introduction which; (i) outlines the aims and structure of the report, (ii) describes the history of the black bream fishery, and (iii) provides a synopsis of biological and ecological knowledge of the black bream.

Section two provides a summary of the fishery statistics for the Lakes and Coorong Fishery (LCF) for black bream from 1984-85 to 2006-07. Information presented in this section includes inter-annual patterns in catch, effort and catch-per-unit-effort (CPUE), intra-annual trends in catch and a comparison of effort measures (fisher day, net day) available for the fishery.

Section three presents age/size structures and sex ratios for black bream from the Lakes and Coorong Fishery (LCF).

Section four assesses the performance of the black bream fishery against the biological performance indicators specified for this fishery in the Lakes and Coorong Fishery Management Plan (Sloan 2005).

Section five is the General Discussion. It synthesises information presented in the previous sections of the report, assesses the status of the fishery and the level of uncertainty in the assessment, and outlines future research needs.

1.2 Description of the fishery

1.2.1 Commercial Fishery

Black bream support commercial fisheries in Victoria, South Australia and Western Australia with most catches taken from Victoria (Kailola et al. 1993). Recreational fishers regard black bream as an important species in Victoria, Tasmania, South Australia and Western Australia (Kailola et al. 1993).

Most of the South Australian catch of black bream is taken by the LCF (Kailola et al. 1993; Ferguson 2008) (Figure 1-1). The LCF is a multi species, multi-method fishery and is the only commercial fishery operating in the Coorong lagoons. The dominant gear is the large-mesh gill net (mesh size > 115 mm) which is set on the bottom when targeting black bream (Ferguson 2006). Smaller annual catches are taken by haul seine nets.

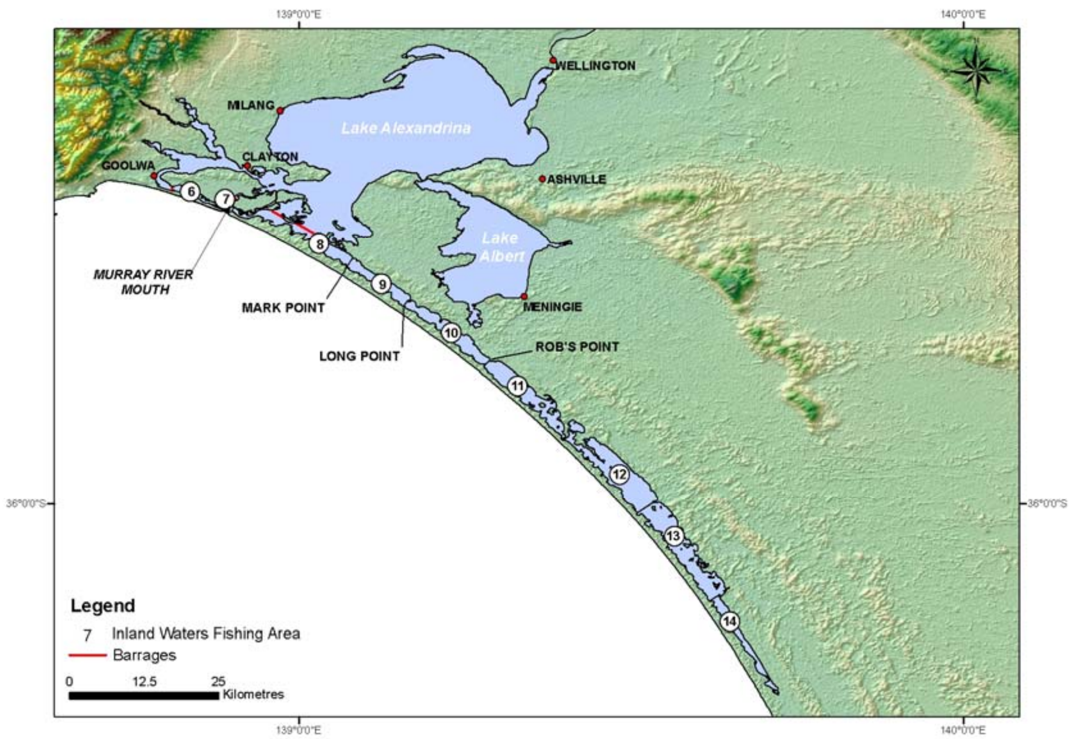

Figure 1-1. Map of Coorong showing commercial reporting blocks 6 to 14 of the Lakes and Coorong Fishery.

1.2.2 Recreational Fishery

Recreational fishers harvest black bream using rod and line (Kailola et al. 1993). However, there is little information available for recreational fishing for black bream in South Australia (Henry and Lyle 2003; Jones and Doonan 2005). A 12 month survey of recreational fishing in South Australia is currently being undertaken and results are expected in early 2009.

Post-release survival of undersized black bream was investigated in Victoria (Grixti et al. 2008). Black bream were caught and monitored for initial (≤1 h, n = 1557) and delayed (72 h, n = 923) survival over a 3-year period. The nature of the injury caused by catching fish with hook and line was defined as: (i) "shallow" when the hook was embedded in the mouth or outside body, or (ii) "deep" where the hook had been ingested and was embedded in the gut. Survival was 95% (SE ±0.8%) for shallow–hooked fish and 74% (SE ±3%) for deep-hooked fish. Survival decreased as fish length increased. Deep-hooking increased as fish length increased and occurred more often during warm water compared to cold water trials. Survival of deep-hooked fish was 20% higher when hooks were left in the fish.

1.2.3 Traditional Fishery

The Ngarrindjeri population density is likely to have been the largest of any aboriginal group in Australia with an estimated 3000 people inhabiting the Coorong region in the 1800's, prior to European settlement (Sloan 2005). The Ngarrindjeri people targeted black bream as well as flounder, mulloway and yellow-eye mullet and smoked and dried fish for storage and trading (Jenkin 1979).

1.3 Management of the fishery

1.3.1 Commercial Fishery

The regulations that govern the management of the LCF are the *Fisheries Management (Lakes and Coorong Fishery) Regulations 2006* and the *Fisheries Management (General) Regulations 2007.* The Management Plan for the SA Lakes and Coorong Fishery was finalised in 2005 (Sloan 2005), and provides a strategic policy framework for the management of the fishery (

Table 1-1).

The LCF is managed in the context of a number of international legal instruments including the Ramsar Convention and the United Nations Convention on the Law of the Sea. In addition, the fishery operates within the boundaries of the Lakes and Coorong National Park, an area recognised primarily for its wetland habitats and importance for a variety of migratory waterbirds. The population of black bream in the Coorong is managed as a distinct unit stock (Sloan 2005).

The fishery is managed as a limited entry fishery with 36 licences. Licence holders have non-exclusive access within the Lakes and Coorong system and effort is limited through gear entitlements and owner-operator provisions as designated under the *Scheme of Management (Lakes and Coorong Fishery) Regulations 2006* (Pierce and Doonan 1999; Knight et al. 2000).

The LCF operates in the northern and southern Coorong lagoons, the freshwater lower lakes of Lake Alexandrina and Lake Albert, and the adjacent coastal marine waters along Sir Richard and Younghusband Peninsulas. Effort data for the commercial fishery for black bream in South Australia have been recorded since 1984 (Knight et al. 2001). Daily catch and effort information is provided on a monthly basis to SARDI Aquatic Sciences; catch, effort (days, fisher days, number of nets) and fishing location. Fishing location is reported against LCF fishery reporting blocks (Figure 1-1). Management arrangements for the commercial fishery for black bream comprise general gear restrictions and a legal minimum size (LMS) of 28 cm total length.

Table 1-1. Management milestones for marine scalefish species in South Australia (Anon. 1988; Jones et al. 1990; Rohan et al. 1991; Anon. 2005; Sloan 2005).

Date	Milestone
1971	Introduction of fishing licences for all commercial fishing in South Australia
1972	Licensed commercial fishers required to provide monthly catch data
1984	*Scheme of Management (Lakes and Coorong Fishery) Regulations 1984* *Scheme of Management (Marine Scalefish Fisheries) Regulations 1984* *Scheme of Management (Restricted Marine Scale Fishery) Regulations 1984*
1984-85	The LCF was divided in to 16 areas for the purpose of data collection and more detailed fishing location information was collected from operators.
1986	Restrictions on commercial net type, mesh size, net depth and net length. Prohibition of net use adjacent to the Murray Mouth from November 1 to March 31. Limit of one registered recreational net per person, with 70m total length and maximum of 1m drop. Total prohibition on recreational netting in coastal marine waters from Goolwa Beach Road to Kingston Jetty. Recreational bag limit of 20 flounder per person per day in Coorong waters (boat limit 50 per person per day). Prohibition of all forms of netting in the Coorong, adjacent to the Murray Mouth from December 25 to January 7.
1990	Guidelines formalised to limit the amount of gear that may be endorsed on an individual licence upon licence transfer or amalgamation.
1991	*Fisheries (Scheme of Management—Lakes and Coorong Fishery) Regulations 1991* *Fisheries (Scheme of Management—Marine Scalefish Fisheries) Regulations 1991*
1997	Review of the recreational fishery
2004	Amendments to the Scheme of Management to allow an individual to hold more than one licence.
2005	Management Plan for the South Australian Lakes and Coorong Fishery
2006	*Fisheries (Scheme of Management – Lakes and Coorong Fishery) Regulations 2006* *Fisheries (Scheme of Management – Marine Scalefish Fishery) Regulations 2006*
2007	The *Fisheries Management Act 2007* was assented to by Parliament on 8 March 2007 and commenced during 2007. Fishery Management Committees were discontinued from 31 March 2007.

1.3.2 Recreational Fishery

The recreational fishery is open access and is managed with general gear restrictions, spatial and temporal closures and bag/boat limits (Sloan 2005). The legal minimum size for all *Acanthopagrus* species is 28 cm total length with a personal daily bag limit of 10 bream and a boat limit of 30 bream.

1.3.3 Traditional Fishery

All of the management measures in place for the recreational sector currently apply to indigenous fishers when fishing.

1.3.4 Previous stock assessments

There has been no formal stock assessment of black bream in South Australia. Black bream in the Coorong lagoons have been described as fully exploited and environmentally limited due to the potential for regulation of the Murray River flow to impact on reproduction and recruitment (Pierce and Doonan 1999) (See also Section 1.4). Pierce and Doonan (1999) also recommended that fishery independent surveys of juveniles be conducted to develop a recruitment index for this species.

From 1964-65 to 1999-00 catches of black bream in South Australia ranged from 10 to 75 t (Kailola et al. 1993). The most recent Stock Status Report for the Lakes and Coorong Fishery presented data from 1984-85 to 2006-07 (Ferguson 2008). Catch per unit of effort (CPUE, kg.fisher day^{-1}) for black bream was 3% above the upper reference point defined in the Management Plan (Sloan 2005) although catches were historically low. This may have indicated hyper-stability of CPUE due to aggregation of individuals in response to environmental conditions caused by drought (Ferguson 2008). Ferguson (2008) recommended that a time series of age structures was essential for interpreting trends in CPUE for this species.

The only available estimate of catch of black bream from the recreational sector was from the National Recreational and Indigenous Fishery Survey (NRIFS) (Henry and Lyle 2003; Jones and Doonan 2005). The estimated recreational catch of black bream for South Australia was 31.9 t in 2000-01. However, few fishers from the Coorong region were surveyed (Keith Jones, PIRSA, pers. com.) and few data were collected on size composition of black bream in this study.

1.3.5 Performance indicators for the back bream fishery

Performance indicators and reference points were derived from historical catch and effort data from 1984-85 to 2001-02 (Sloan 2005). Upper and lower reference points for the catch and CPUE performance indicators were estimated from the average of the 3 highest highest and 3 lowest values during the reference period. Upper and lower trend (rate-of-change) performance indicators for Catch and CPUE were estimated from highest and lowest slope of the linear relationships for 4 year periods within the reference period (Sloan 2005).

1.4 Fisheries biology

The literature concerning black bream in Australia was comprehensively reviewed by Norriss et al (1998). This section provides a summary of the relevant literature as well as updated information on this species.

1.4.1 Taxonomy

Black bream (*Acanthopagrus butcheri*) is a member of the family Sparidae. Six sparid species occur in Australian waters; with five belonging to the genus *Acanthopagrus*, and one to the genus *Rhabdosargus* (Munro 1949).

1.4.2 Geographical distribution and habitat

In Australia, *A. butcheri* is distributed in temperate waters from Myall Lake, New South Wales to the Murchison River, Western Australia (Rowland 1984), where it is common in estuaries and river mouths (Norriss et al. 2002). In South Australia it is found in the Coorong lagoons, the Onkaparinga River and the rivers of Kangaroo Island (Norriss et al. 2002). It is unlikely that black bream occur in the Great Australian Bight due to insufficient estuarine and river mouth habitat (Kailola et al. 1993).

Habitat preferences for each life stage of *A. butcheri* in Lake Tyers, Gippsland Lakes and Glenelg and Hopkins Rivers (Victoria) were summarised by Nicholson and Gunthorpe (2006, 2008). These authors thought spawning to be pelagic in lower salinity water, and located around the halocline. They suggested that the salinity profile and dissolved oxygen were important for larval survival and that vegetated habitat was important for settlement. Older juveniles were though to be more tolerant of varying salinity and had a preference for hard structure such as snags (Nicholson and Gunthorpe 2008). Similarly, studies in Western Australia described the preferred habitat of juvenile and adult *A. butcheri* as overhanging banks amongst the branches of dead trees which lie on the bottom of deep, low-salinity pools with moderate salinity and high dissolved oxygen (Norriss et al. 1998).

Acanthopagrus butcheri appears to be tolerant of a wide range of salinities and other physical water parameters. In the Blackwood River estuary in Western Australia they were found in habitats with salinity, temperature and dissolved oxygen levels ranging from 0.3 to 36.8 ppt, 9.5 to 25.5°C and 5.18 to 8.64 mg/l, respectively (Lenanton 1977).

1.4.3 Stock Structure

In south-western Australia, tagging experiments have provided no evidence to suggest that of *A. butcheri* move between estuaries (Hoeksema et al. 2006). However, *A. butcheri* in Western Australia rarely leave an estuary unless flushed out by floodwaters (Lenanton 1977; Holt 1978 in Norriss 2002) and studies in NSW and Victoria suggest that coastal movement is limited. Tagging studies in Victoria's Gippsland Lakes indicated that *A. butcherii* exhibit little movement and are confined within the Gippsland Lakes (Butcher and Ling 1962 in Norriss, 2002). These observations suggest that the Gippsland Lakes population is a distinct stock and that mixing of populations of *A. butcheri* from different estuaries is uncommon.

In South Australia 1 383 *A. butcheri* were tagged within the Coorong lagoons in 1982 – 1983 (Hall 1984). All recaptures (7.2%, n=102) were reported within the lagoon area (Hall 1984). Hall (1984) also suggested that *A. butcheri* may move into marine waters in low flow years and may also move between estuaries but this was based on an anecdotal report of a single recaptured fish.

Genetic studies were conducted in Victoria and Western Australia (Farrington et al. 2000; Burridge et al. 2004). An investigation of allozyme variation at 32 loci (n=6 samples) of *A. butcheri* in Victoria was consistent with the existence of a single panmictic population in this region (Farrington et al. 2000). This implied that dispersal between estuaries in Victoria is more extensive than was shown by tagging studies (Farrington et al. 2000). However, a later study in Victoria concluded that gene flow which occurred mostly between adjacent estuaries was evident in south-east Australia, indicating that management of *A. butcheri* should be conducted at the scale of individual or geographically proximate estuaries (Burridge et al. 2004).

In south-western Western Australia high levels of genetic divergence were reported among populations from a total of nine sites representing permanently open and intermittently closed estuaries (Chaplin et al. 1998).

Large distances between estuaries in South Australia indicate that distribution of available habitat is likely closer in character to Western Australia than Victoria. On this basis, it is suggested that movement of *A. butcherii* is likely to be restricted to individual estuaries.

1.4.4 Growth

Growth has been described for Victoria and Western Australian populations of *A. butcherii*, and parameter estimates, based on sectioned otoliths, are summarized in

Table 1-2. Overall, black bream grow slowly and can reach a maximum age of at least 29 years (Morison et al. 1998).

Growth rates of *A. butcheri* in Victoria (Morison et al. 1998) and Western Australia (Morison et al. 1998; Sarre 1999; Hoeksema et al. 2006) vary greatly between estuaries. In Western Australia a study of three estuaries showed marked differences in the growth of *A. butcheri,* during the early years of life (Hoeksema et al. 2006). The differences in growth were shown to be independent of diet and that the lowest growth rate was recorded from an estuary with the highest population density suggesting that growth may be suppressed with increasing densities. Anecdotal evidence from populations in estuaries on Kangaroo Island, South Australia, supports the hypothesis of an inverse relationship between population density and growth.

Table 1-2. Estimates of von Bertalanffy growth parameters for *Acanthopagrus butcherii* in Australia.

Source	Location	Sex	L_∞ (mm CFL)	K (yr^{-1})	t_0 (years)	n
(Morison et al. 1998)	Gippsland Lakes (Vic)	F	545	0.04	-5.21	na
"		M	382	0.08	-3.70	na
"		F, M	402	0.07	-4.09	747
(Coutin et al. 1997 in Norriss 2002)	Gippsland Lakes (Vic)	F, M	360	0.09	-3.00	414
(Coutin et al. 1997 in Norriss 2002)	Lake Tyers (Vic)	F, M	716	0.03	-8.46	140
(Sarre and Potter 1999)	Swan River Estuary (WA)	F	438	0.30	-0.13	733
"		M	419	0.31	-0.15	894
"	Moore River (WA)	F	452	0.11	-0.54	345
"		M	429	0.11	-0.61	387
"	Nornalup Walpole (WA)	F	367	0.16	-0.60	346
"		M	323	0.21	-0.31	265
"	Wellstead (WA)	F	378	0.25	–0.17	324
"		M	345	0.27	-0.18	331
"	Lake Clifton (WA)	M	445	0.32	-0.46	85

1.4.5 Size at maturity

Estimates of age and size at maturity for *A. butcheri* from estuaries in Victoria, South Australia and Western Australia are shown in Table 1-3.

Estimates, by Sarre and Potter (1999), of the age at which 50% of fish are sexually mature (A_{50}) are likely the best currently available; these ranged from 1.9 to 4.3 years for estuaries in southern

Western Australia. Size at maturity for females from the Swan/Moore Rivers and Walpole/Nornalup area were 156 to 201 mm CFL respectively. Males generally matured at a smaller size than females, with sizes at maturity of 129 and 169 mm CFL in the Swan and Moore Rivers respectively.

The age at maturity for *A. butcheri* from the Onkaparinga estuary, South Australia, was 3+ years, although the method used to estimate the age is unknown (Harbison 1973).

Table 1-3. Age and size at maturity of *Acanthopagrus butcheri* in Australia.

Source	Location	Sex	Size at maturity (LD_{50} mm CFL)	Age at maturity (yr or A_{50})
(Harbison 1973 in Norriss 2002)	Onkaparinga Estuary (SA)	F,M	na	3+
(Butcher 1945 in Norriss 2002)	Gippsland Lakes (Vic)	F, M	216	2+
(Scott et al. 1974 in Norriss 2002)	Gippsland Lakes (Vic)	F	na	4+
"		M	na	3+
(Sarre and Potter 1999)	Swan River (WA)	F	156	2+
"		M	169	2+
"	Moore River (WA)	F	156	3.3
"		M	129	2.6
"	Welstead Estuary (WA)	F	157	1.9
"		M	145	1.8
"	Walpole Nornalup	F	201	4.3
"		M	158	2.8

1.4.6 Reproduction

Spawning of *A. butcheri* generally occurs from spring to summer, with reproductively mature fish in the Onkaparinga estuary, South Australia, occurring from August to December with peak spawning activity during October (Harbison 1973 in Norriss 2002). A similar spawning season occurred in populations from the Gippsland Lakes and Glenelg Rivers in Victoria, where spawning was generally in late October and November (Coutin et al. 1997; Norriss et al. 2002). In Western Australian populations reproductive development commenced in late September with the first spent gonads were observed in January (Lenanton 1977) with high mean monthly GSI's from September to December and a peak for females in October (Sarre and Potter 1999).

In Victoria black bream form dense aggregations in deeper water during winter. Just prior to spawning in October-November, adults move from the deeper water and form single sex schools

(Hobday and Moran 1983). Spawning continues over summer and females may spawn more than once (Cashmore et al. 1998).

In Western Australia *A. butcheri* may also spawn more than once in the same spawning season (Sarre and Potter 1999) and fecundity increases considerably with the length of the fish (Coutin et al. 1997 in Norriss 2002). The mean fecundity for females from the Swan River estuary just prior to the onset of spawning was 1 58 x10^6 yolked oocytes (Sarre and Potter 1999). With the highest recorded fecundity estimated as 7.09 x10^6 yolked oocytes from a 470 mm TL individual.

In the Hopkins River, Victoria, peak concentrations of *A. butcheri* eggs and larvae were found during November and December (Newton 1996). At this location eggs were found in pools at depths of 2-4 m, and in salinities ranging from 13 – 28 ppt. Salinities at each location were 20 to 25 ppt (15.5°C) and 13 ppt (17°C) during November 25 to 28 ppt and 21 to 22 ppt, respectively in December (Newton 1996).

In the estuaries of the Glenelg and Hopkins Rivers (southwestern Victoria) the spawning of *A. butcheri* was restricted by the seasonal fluctuation in the fresh water flow rate of these rivers (Sherwood and Backhouse 1982 in Norriss 2002). The authors of that study suggested that *A. butcheri* moves downstream with the winter freshwater inflow then follow the salt wedge as it advances upstream in spring and early summer. By maximizing the time spent in favourable salinities, dissolved oxygen content and suitable habitat, spawning may be stimulated and extended. These results were supported by Newton (1996) who found that the eggs of *A. butcheri* were restricted to the middle and upper sections of the river during the post-flood period and reformation of the salt wedge, between November and January.

Nicholson et al (2008) compared the distribution and abundance of *A. butcheri* eggs and yolk-sac larvae between two rivers in south-western Victoria. The riverine flow into the Glenelg estuary was around eight times the flow volume into the Hopkins estuary (Nicholson et al. 2008). Eggs occurred in a wide range of dissolved oxygen levels but yolk-sac larvae were less common at the lowest levels. Egg mortality was higher in the Hopkins than the Glenelg estuary, which may be associated with the hypoxic conditions characteristic of low-flow conditions (Nicholson et al. 2008). These results have significant implications for populations of *A. butcheri* in terms of climate change that is predicted to lead to warmer, drier conditions in south-eastern Australia, potentially increasing stratification and subsequent hypoxic zones (Nicholson et al. 2008).

1.4.7 Recruitment

Various studies have indicated that temporal variation is a consistent feature of the recruitment of *A. butcheri* (Hobday and Moran 1983; Morison et al. 1998).

In Victoria, year class strength in the Gippsland Lakes was highly variable with weaker year classes coinciding with high spring river flows and below average temperatures while dominant year classes resulted from spawning during relatively dry springs (Hobday and Moran 1983). An environment–recruitment model, based on age structures, was developed for black bream in the Gippsland Lakes (Walker et al. 1998). Results of this model suggested that summer temperature during the spawning period was an important factor in year class strength. Large gaps in year classes were reported Gippsland Lakes (Victoria) from a study in 1995 (Nicholson and Gunthorpe 2006). These authors suggested that unfavorable environmental conditions had resulted in consecutive years of unsuccessful spawning/recruitment.

Peak numbers of larvae occur in November in Victoria and correspond with the re-establishment of calanoid copepod populations after flooding which form the main food supply (Newton 1996). Timing of spawning to coincide with the food supply is likely an important part of the spawning strategy of *A. butcheri* (Newton 1996). Newton (1996) hypothesized that the highly variable level of recruitment between years may depend to a large extent on food supply and correct timing of the spawning season.

In the Hammersley and Culham inlets in southwestern Australia high recruitment and successful year classes were reported after periods of increased rainfall (Chapman 1995 in Norriss et al. 1998). An age based study in Western Australia showed that the population of *A. butcheri* in Stokes Inlet bred successfully in all but one of the years between 1992 and 2003 and that recruitment of juveniles was greatest in years when moderate flows were recorded in the months preceding and during the spawning period (Hoeksema et al. 2006).

1.4.8 Diet

There is no information on the diet of *A. butcheri* in South Australia. In a study of five water bodies in Western Australia *A. butcheri* was shown to be an opportunistic carnivore with significantly different diets in different water bodies (Sarre 1999; Hoeksema et al. 2006). For example, a larger proportion of the diet of *A. butcheri* from the Moore River Estuary, on the lower east coast, comprised the macroalgae *Cladophora sp.* whilst amphipods and decapods dominate the diet for fish from the Swan River Estuary. The diet of *A. butcheri* in the Nornalup/Walpole Estuary on the south coast contained atypically large volumes of the seagrass *Ruppia megacarpa* and teleosts. The diet also varied across different habitats within the same estuary. Sarre et al. (2000) suggest that *A. butcheri* prefers to feed on or above the substratum, rather than within the substratum.

1.4.9 Sex ratio

Sex ratios for *A. butcheri* in the Swan River Estuary were 1.19:1.00 (n_m:n_f)with male bias higher in the spawning season (about 2:1) possibly due to spawning aggregations of males (Sarre 1999 in Norriss 2002) although the length and age distributions were the same for both sexes.

Hermaphroditism i.e. simultaneous occurrence of male and female gonad tissue in an individual, has been reported for *A. butcheri*, (range 265 to 290 mm SL) has been reported from Hoyers Lake in Victoria and the male:transitional:female sex ratio was 5:7:7 (Rowland and Snape 1994). Larger fish tended to be male whilst smaller fish were female. In contrast, no hermaphrodites were found in the Gippsland Lakes. Rowland and Snape (1994) suggested that protogynous hermaphroditism may be labile in *A. butcheri*: selective pressures from environmental conditions or intense fishing pressure have induced the expression of this condition in Hoyers Lake. Hermaphroditism has also been reported from Tasmania (Haddy and Pankhurst 1998) but not from Western Australia (Sarre and Potter 1999 in Norriss 2002)

2 FISHERY STATISTICS

2.1 Lakes and Coorong Fishery: Catch, Effort and CPUE

The highest total annual catch of black bream was 58.2 t in 1986-87 (Figure 2-3). This declined to 2.6 t in 1992-93 and remained below 5 t until 2000-01 when it was 7.4 t. Annual catches increased to 11.6 t in 2002-03 then declined to 4.5 t in 2006-07. The catch in 2006-07 was 42% below the most recent 5-year average (2003-04 to 2006-07, 7.6 ± SE 1.36).

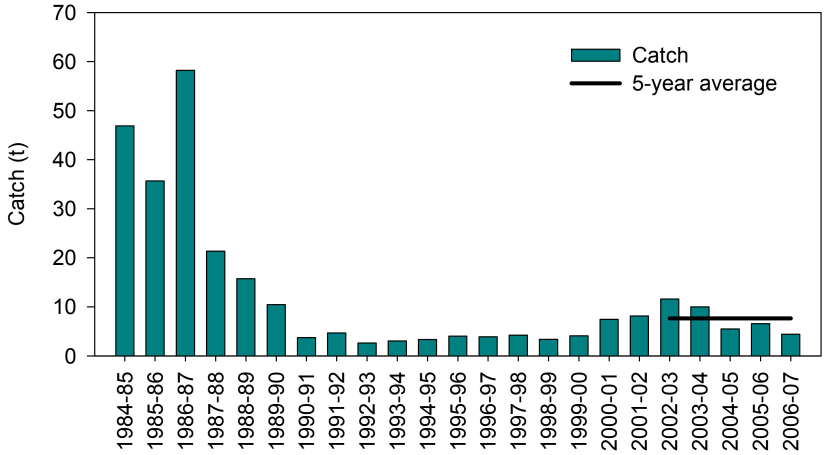

Figure 2-1. Annual catches of black bream taken by the LCF, by type of gear.

Catches were highly seasonal with most of the annual catch taken in the three month period from August to October (65%) in the years 2002-03 to 2006-07. Highest catches (31%) were recorded in September (Figure 2-2).

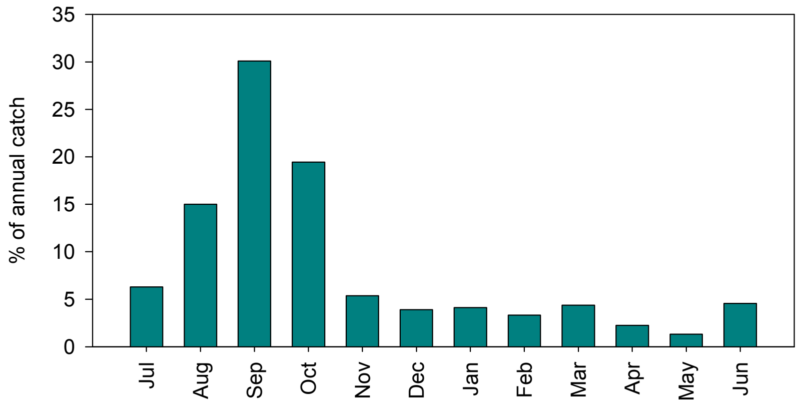

Figure 2-2. Monthly catches of black bream as a percentage of annual catch from 2002-03 to 2006-07.

The dominant gear in all years was the large mesh gill net (>70% of catch). Smaller amounts (<24%) were taken using small mesh haul nets. In 2003-04 and 2005-06 haul nets (large mesh) were used to catch 13 and 11% of the total annual catch respectively. In 2006-07 large mesh haul nets accounted for 9% of the total annual catch.

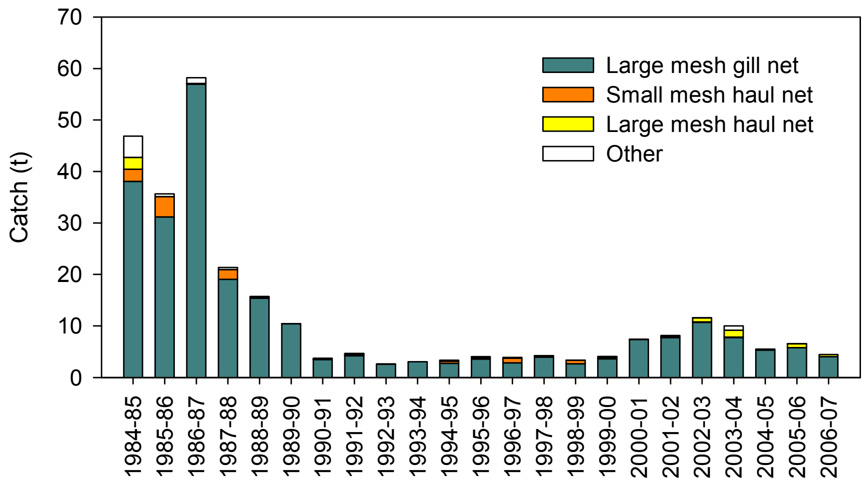

Figure 2-3. Annual catches of black bream taken by the LCF, by type of gear.

Targeted catch and effort for black bream taken by large mesh gill nets is shown in Figure 2-4. The highest targeted catch was 29.8 t in 1984-85 (Figure 2-4 A). This declined to 0.2 t in 1991-92. After 1991-92 the highest targeted catch was 4.0 t in 2003-04. This declined to 2.0 t in 2006-07. The contribution of target catch to total catch varied greatly between years. In 1989-90 targeted catch comprised 83% of the total catch. However from 1990-91 to 2001-02 targeted catch contributed between 3 and 34 % of the total catch. From 2002-03 to 2006-07 target catch contributed between 41 and 51% of the total catch.

Trends in targeted effort, (fisher days) were similar to those for targeted catch with peaks in effort of 3303 and 2255 fisher days in 1985-86 and 1988-89 respectively (Figure 2-4 B). Effort then declined to 50 fisher days in 1991-92. After 1991-92 the highest effort was 473 fisher days in 2002-03 and 403 fisher days in 2005-06. Effort in 2006-07 was 168 fisher days.

Trends in effort (net days) were similar to those for effort (fisher days) with the two measures linearly related (LR: $r^2 = 0.96$, $F_{1,21}$, = 564.058, $p < 0.01$). Variability in effort (fisher days) explained 90% of the variability in catch (LR: $r^2 = 0.86$, $F_{1,21}$ = 128.458, $p < 0.001$), while effort (net days) explained 85% of the variability in catch (LR: $r^2 = 0.85$, $F_{1,21}$, = 118.922, $p < 0.01$).

The highest recorded CPUE was 12. 7 kg.fisher day^{-1} in 1984-85. CPUE then declined to 2.9 kg.fisher day^{-1} in 1990-91 before increasing to 9.1 kg.fisher day^{-1} in 2001-02. Since 2000-01

CPUE has remained above 9.0 kg.fisher day^{-1} and was 12.3 kg.fisher day^{-1} in 2006-07. Trends in CPUE (kg.net day^{-1}) were generally similar to those for CPUE (kg.fisher day^{-1}) (Figure 2-4 C).

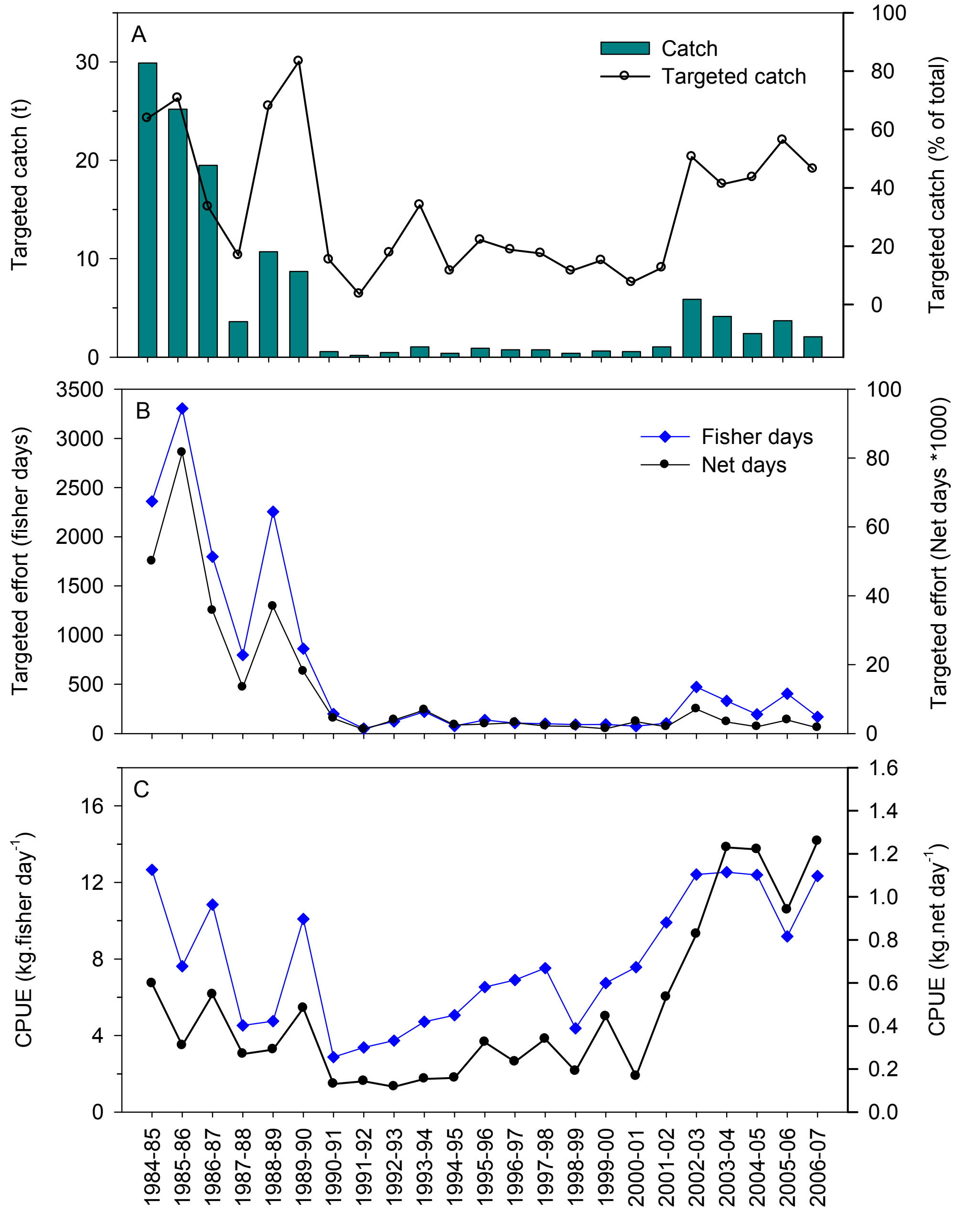

Figure 2-4. Annual targeted catch and effort for black bream taken by large mesh gill nets. (A) Targeted catch shown in tonnes, and as percentage of total catch, (B) Comparison of two measure of effort, and (C) Comparison of two estimates of CPUE.

2.2 Spatial distribution of catches

Fishery catch and effort from the Coorong lagoons is reported against ten spatial blocks (Figure 1-1). Block numbers increase from north to south i.e. Goolwa (block 6) to Salt Creek (block 14). Prior to 1993-94, catches were dominated by the contribution from reporting blocks located south of Long Point (Blocks 10, 11, 12, 13, 14). (Figure 2-5A). For example, in 1984-85 71% of catches were from blocks 12, 13 and 14.

After 1993-94, total catches were increasingly dominated by the contribution from reporting blocks north of Long Point (Blocks 6, 7, 8, 9, 10), particularly reporting blocks 6 and 8 which include the Goolwa and Tauwitchere barrages, respectively.

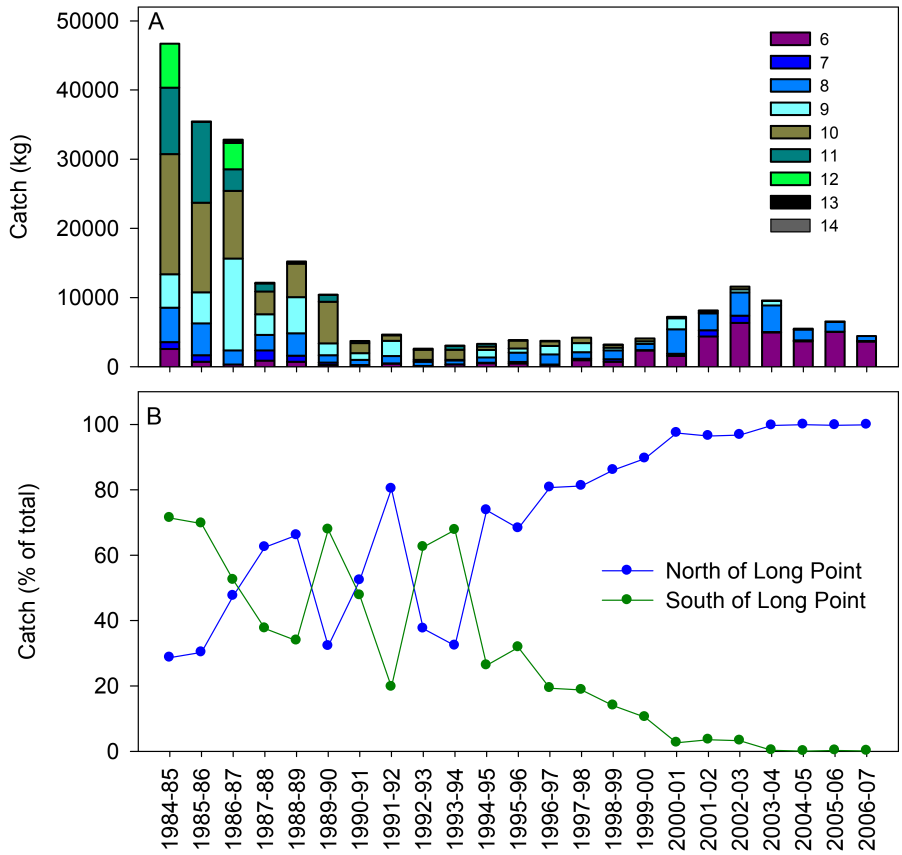

Figure 2-5. Catches from (A) reporting blocks within the Coorong lagoons, and (B) contribution to total catch by areas north and south of Long Point.

Prior to 1993-94 the contribution from the area south of Long Point ranged between 30 and 70% of the total catch (Figure 2-5B). After 1993-94 the contribution from reporting blocks south of Long Point declined, while that from blocks north of long point increased. From 2000-01 the area north of Long point contributed >97% of the total catch. Trends in catches from north of Long Point were influenced mostly by fishery reporting block 6 (circa Goolwa barrages) which contributed 81% of the total catch in 2006-07.

Freshwater inflows to the Coorong lagoons were obtained from the regression based Murray hydrological model (MSM BIGMOD, Murray-Darling Basin Commission) for financial years from 1984-85 to 2006-07. The highest annual freshwater inflows occurred between 1989-90 and 1993-94 and were approximately 11 000 gl (giga litres). Annual inflows generally declined from 1993-94 to 2006-07. In 1998-99 and 2000-01 inflows were 3 000 and 5 000 gl respectively and thereafter less than 700 gl.

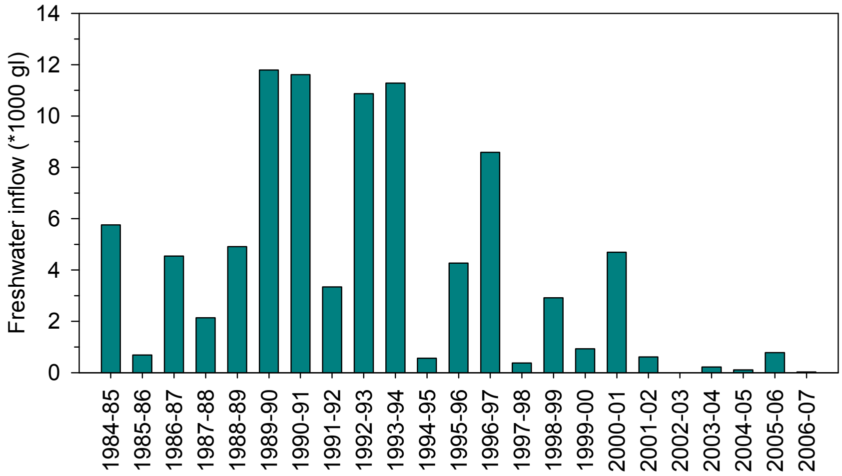

Figure 2-6. Annual freshwater inflow to the Coorong lagoons.

Freshwater inflows to the Coorong lagoons explained 48% of variability in the contribution catches from south of Long Point made to the total catch (LR: $r^2=0.48$, $F_{1,21}=19.682$, $P<0.000$, Figure 2-7A. Freshwater inflows explained 20% of the variability in the area of the Coorong lagoons that catch was reported from (LR: $r^2=0.20$, $F_{1,21} = 5.353$, $P=0.031$, Figure 2-7B).

There was no detectable relationship between freshwater inflows to the Coorong lagoons and catches of black bream (LR: $r^2 = 0.06$, Time lag = -3 years, age of recruitment to fishery). However, the positive relationship between freshwater inflow to the Coorong lagoons and contribution of catches from south of Long Point suggests that the available fishing grounds are reduced during periods of low freshwater inflow. The spatial distribution of catches over time further suggests that the population of black bream in the Coorong lagoons has contracted northwards since 1993-94 and, in recent years occurs mostly in the area near Goolwa barrage (block 6).

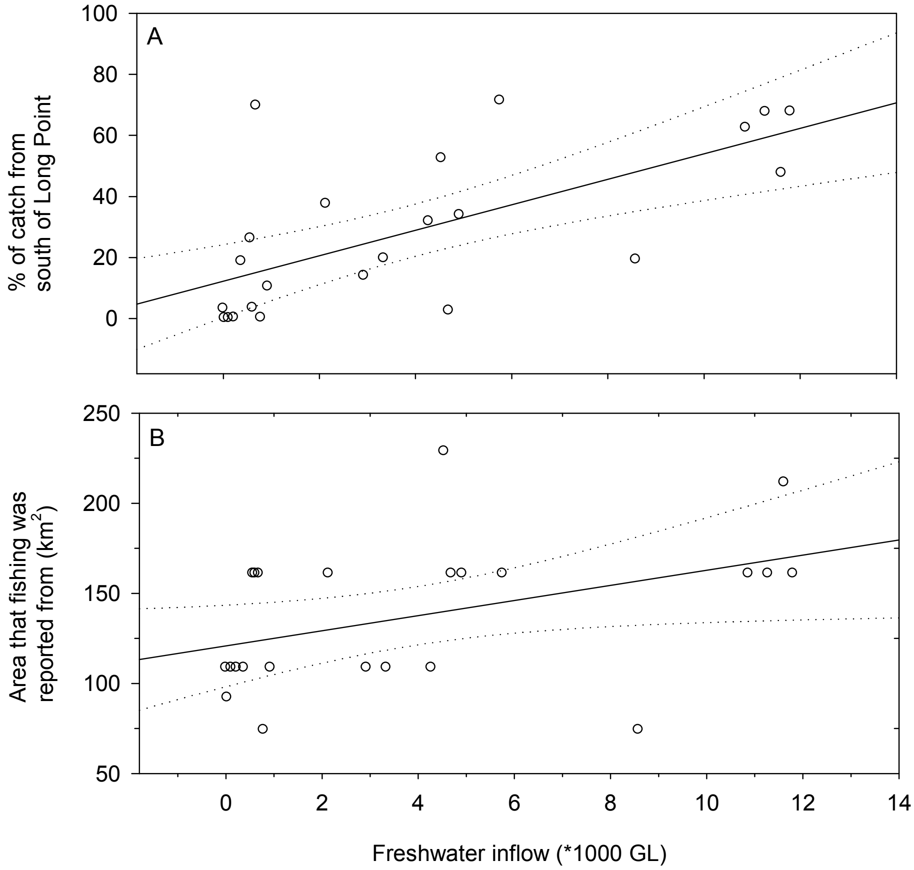

Figure 2-7. The relationship between freshwater inflow to the Coorong lagoons and (A) contribution to the total catch from the area south of Long Point and, (B) area of the lagoons from which catch was reported.

3 AGE/SIZE STRUCTURES AND DEMOGRAPHIC INFORMATION

3.1 Methods

Morphometric data and sagittal otoliths from black bream were obtained from commercial catches. Most catches were from large mesh gill nets with occasional catches from large mesh seine nets. Sampling was done at the point of landing in the Coorong lagoons in October 2003, August to October 2004, and March to November 2007.

In addition to sampling otoliths the caudal fork length (CFL) of each fish was measured and, for a sub-sample of these fish, total weight, sex and gonad maturation stage were also recorded.

3.2 Results

3.2.1 Age/size structures

The age structures for male and female black bream are shown in Figure 3-1. Ages, from the 2002 sample, ranged from 3 to 6 years and 3 to 24 years for and males and females respectively. The age structures for males and females were from the same unimodal distribution (K-S: D=0.133, p=1) with a mode at 4 years (76% of sample, pooled sexes, n=42).

In 2003 ages ranged from 4 to 24 years and 4 to 21 years for males and females respectively. The age structures for males and females were from the same unimodal distribution (K-S: D=0.165, p=1), with a mode at 5 years (85% of sample, pooled sexes, n=124,).

In 2004 ages ranged from 4 to 8 years and 3 to 8 years for males and females respectively. The age structures for males and females were from the same unimodal distribution (K-S: D=0.165, p=1), with a mode at 6 years (66% of sample, pooled sexes, n=96). Five year olds comprised a further 20% of the pooled samples. The maximum age of 8 years was younger than for age structures in 2002, 2003 or 2007 (see below) and may be truncated.

In 2007 the youngest age was 3 years for both sexes with maximum ages of 25 and 17 years for males and females respectively. The age structures of males and females were from the same bimodal distribution (K-S: D=0.480, p=0.975). The dominant mode occurred at 3 years (37% of sample, pooled sexes, n=143) with a secondary mode at 9 years (26% of sample, pooled sexes, n=143).

Overall, the strongest year class originated from 1998 and was present as 4 year olds in samples from 2002. The 1998 year class persisted as 5, 6 and 9 year olds in samples from 2003, 2004 and 2007 respectively. In 2007 a stronger year class, originating from 2003, was also present.

Size structures for black bream reflect the modal progression visible in the age structures (Figure 3-1). The modal size for males and females from 2002 was 260 - 280 mm CFL. This increased in 2003 when it was 300-320 and 280 -300 mm CFL for males and females respectively. In 2004 the modal size for males and females was 280-300 mm CFL. In 2007 the modal size for males and females was 320-340 mm CFL. Size structures in all years were unimodal.

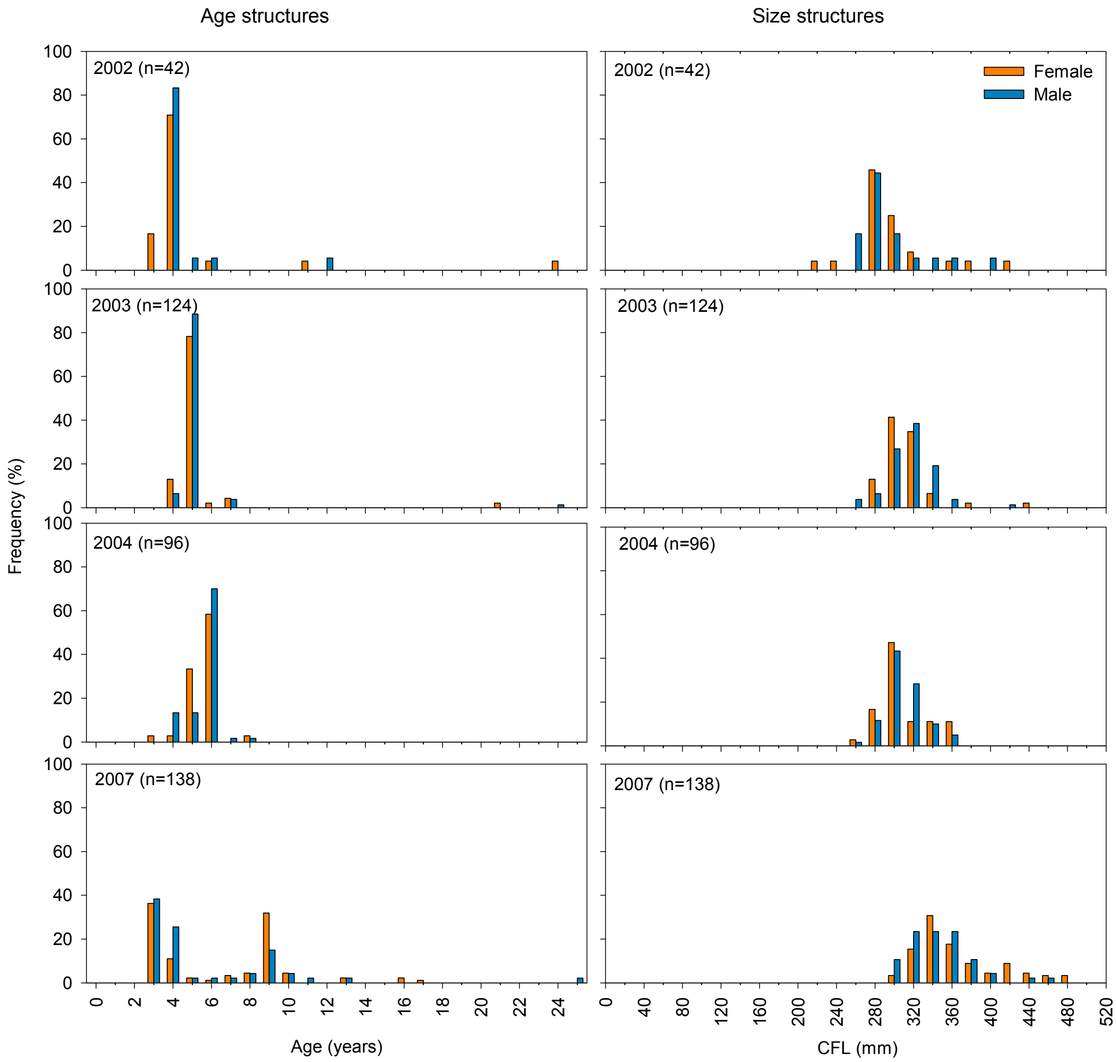

Figure 3-1. Age (left) and size (right) structures of black bream from sub-samples of commercial catches in 2002, 2003, 2004 and 2007.

3.2.2 Sex ratios

Sex ratios from samples of commercial catches of black bream are shown in Table 3-1. In 2007 samples from both seine and gill net catches comprised approximately twice as many females as males. Samples from 2003 and 2004, however, comprised mostly males.

Table 3-1 . Sex ratios of black bream from commercial catches.

Sample	Gear	n_f	n_m	n_f/n_m	χ^2	*p*
2002	Gill net	24	18	1.33	0.60	0.440
2003	Gill net	46	78	0.59	7.75	0.005
2004	Unknown	37	61	0.61	5.40	0.020
2007	Gill net	87	46	1.89	12.03	0.001
2007	Seine net	8	1	2.04	16.11	0.000

4 PERFORMANCE INDICATORS

This section provides a report on the performance indicators of the fishery for black bream against the biological performance indicators defined in the Management Plan (Sloan 2005). Biological reference points are defined for each performance indicator, on the basis of historical data from 1984-85 to 2001-02 (Sloan 2005). These data were also presented in the Stock Status report for the Lakes and Coorong Fishery (Ferguson 2008).

The performance indicators for black bream are shown in Table 4-1. The performance indicator CPUE (kg.fisher day^{-1}) was historically high and breached the upper limit reference.

Table 4-1. Performance indicators for black bream and current status levels for 2006-07 (yellow shading indicates biological performance indicator outside range of reference points).

Performance Indicator	Upper reference point	Lower reference point	2006-07	Within range of reference points
Total catch (t)	47	3	4.5	Y
CPUE (kg.fisher day^{-1})	12	3	12.3	N
4-year total catch trend ($t.year^{-1}$)	+15	-15	-2.8	Y
4-year CPUE trend (kg.fisher day^{-1})	+4	-4	-0.1	Y

5 GENERAL DISCUSSION

5.1 Information available for the fishery

Assessment of the fishery for black bream is aided by several stock status reports (Pierce and Doonan 1999; Ferguson 2006; Ferguson 2006; Ferguson 2008), and the Management Plan for the LCF (Sloan 2005), which describes the current management arrangements, biological performance indicators and associated reference points for the fishery. Commercial catch and effort data, and the associated estimates of CPUE, from 1984-85 to 2006-07 provide the only available estimates of relative abundance.

Age structure data were available for black bream from commercial catch sampling from 4 years (2002, 2003, 2004 and 2007). Estimates of growth and size at maturity for black bream that are specific to the population located in the Coorong lagoons are currently unavailable.

The magnitude of the illegal catch of black bream is unknown and recreational catch is only known for one year (<2.3% of the total catch in 2000-01; Jones and Doonan 2005). Regular surveys to estimate the recreational harvest (*e.g.* every five years) of black bream in the Coorong lagoons would assist the assessment and could be done in conjunction with surveys of other recreational fisheries.

Sex ratios varied greatly between samples suggesting that black bream genders are spatially or temporally separated. Additionally, protogynous hermaphroditism has been described for black bream in Western Australia, Tasmania and Victoria (Hoeksema et al. 2006). Consequently, sex ratio of black bream may be inappropriate as a biological performance indicator.

5.2 Current status of the fishery for black bream

The highest total annual catch of black bream was 58 t in 1986-87 and this declined steeply over 5 years to 1990-91. In the 16 years from 1990-91 to 2006-07 catches were less than 20% of the peak in 1986-87. Although catches were historically low mean annual CPUE (kg.fisher day^{-1}) increased consistently over this period. In 2006-07 CPUE (kg.fisher day^{-1}) breached the upper reference limit.

The area over which the fishery operates declined concurrently with the increase in CPUE (kg.fisher day^{-1}) that occurred from 1990-91 to 2006-07. This may reflect an increase in catchability of black bream as the population contracted into a reduced habitat due to poor environmental conditions.

Catches of black bream are highly seasonal with 65% taken from August to October which is also the annual spawning period (Norriss et al. 2002).

Uncertainty exists around estimates of total annual catch because the annual recreational catch from the Coorong lagoons is unknown. Additionally, aggregation of the black bream population in the northern part of the Coorong lagoons reduces the effectiveness of CPUE as an index of relative abundance.

Age structures from 2002 were dominated by 4 year olds and these persisted in 2003 and 2004 as 5 and 6 year olds respectively and likely represented successful recruitment in spring-summer of 1998-99. Samples from 2007 were bimodal suggesting persistence of the 1998 year class in addition to a new class of 3 year old fish from 2003. The strong year classes may be linked to relatively high freshwater inflows in 1998 and to an experimental flow across Goolwa barrages in 2003, suggesting that freshwater inflow to the lagoons is important for establishment of a relatively strong year class. This is supported by several studies that have related recruitment success to freshwater inflow and associated factors i.e. establishment of a salinity gradient, maintenance of favourable dissolved oxygen levels and the availability of larval food (Newton 1996; Norriss et al. 2002; Nicholson and Gunthorpe 2008).

The requirement of black bream for freshwater inflows to achieve successful recruitment may mean that development of a new strong year class will not occur without appropriately timed freshwater inflows to the Coorong lagoons. Movement of black bream is known to be very limited and immigration into the Coorong lagoons from elsewhere is unlikely (reviewed in Norriss et al. 2002).

The 1998 year class comprised 66 and 75% of age structures from 2002 to 2004 respectively. The maximum age of black bream from the Coorong lagoons was significantly less than maximum ages of 29 and 21 years old reported from Victoria and Western Australia respectively (Morison et al. 1998; Sarre 2000). The absence of older, larger individuals may reduce the capacity of the population to withstand unfavourable environmental conditions such as those relating to the current drought (Palumbi 2004; Hseih et al. 2006).

5.3 Future research needs

Key knowledge gaps for this fishery are; (i) an estimate of annual recreational catch, (ii) validation of the ageing protocol, (iii) estimates of size at maturity, (iv) characterisation of growth, and (v) an index of recruitment.

An estimate of annual recreational catch may be provided by a current 12 month survey of recreational fishing in South Australia. Results from this survey are expected in early 2009.

The timing of formation of opaque bands in the otoliths of black bream requires a dedicated validation study. Due to the seasonality of catches the best approach may be to use tetracycline marking of otoliths in captive fish held over a 12 month period (Fowler and Short 1998).

Estimates of age at length and size of maturity are highly variable between estuaries (Norriss et al. 1998) and a specific study is required for the Coorong lagoons. These knowledge gaps may potentially be addressed with data from the FRDC funded "Flow related fish and fisheries ecology in the Coorong, South Australia" being conducted by SARDI from 2006-07 to 2008-09.

Ongoing sampling of otoliths from male and female black bream in commercial catches, using a range of net sizes, would provide a useful indicator of the status of the stock. It is important to generate age structures separately for males and females due to possible hermaphroditism and habitat partitioning between sexes. Regular, seasonal age frequency sampling would provide improved understanding of mortality and confirm the presence, or absence, of strong year classes that recruit to the fishery. This would potentially improve understanding of the effect of environmental factors on this population.

The fishery reporting blocks against which the LCF reports catch and effort data may be refined to provide spatial reporting on a smaller scale. Smaller fishery reporting blocks may be particularly beneficial for the northern part of the lagoons (6, 7) where most the catch is currently taken.

A dedicated study of seasonal habitat usage by black bream within the Coorong lagoons could also inform management of appropriate areas for protection of spawning aggregations.

5.4 Conclusion

The resource that supports the Lakes and Coorong Fishery for black bream is currently in a weakened state as indicated by trends in catch and effort. From 1990-91 to 2006-07 CPUE increased consistently to breach the upper reference limit in 2006-07 while catches were historically low. Increasing CPUE may be due to increasing catchability of black bream as they aggregate in a decreasing area of suitable habitat.

The lack of older (>10 year old) individuals in the age structures further suggest high levels of mortality and poor annual recruitment. It is also likely that black bream require freshwater inflows to achieve successful recruitment. These factors and the potential for the current drought to cause further adverse affects on the black bream population indicate that management action may be warranted.

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