



Government of South Australia
Primary Industries and Resources SA

SOUTH AUSTRALIAN FISHERIES MANAGEMENT SERIES

DRAFT

Ecological Assessment of the South Australian Lakes and Coorong Fishery

Assessment Report Prepared for the Australian Government Department of Environment and
Heritage, against the *Guidelines for the Ecologically Sustainable Management of Fisheries*

For the purposes of Part 13(A) of the *Environment Protection and Biodiversity Conservation Act 1999*

5 September 2005

Prepared by the Fisheries Division of the Department of Primary Industries and Resources, South Australia

25 Grenfell Street, Adelaide
GPO Box 1625 ADELAIDE SA 5001

Ecological Assessment of the South Australian Lakes and Coorong Fishery

Assessment report prepared for the Australian Government Department of Environment and Heritage, against the *Guidelines for the Ecologically Sustainable Management of Fisheries*. For the purposes of Part 13(A) of the *Environment Protection and Biodiversity Conservation Act 1999*.

5 September 2005

Keith Jones, Sean Sloan and Alice Fistr

Primary Industries and Resources South Australia (Fisheries)
GPO Box 1625
ADELAIDE SA 5001
www.pir.sa.gov.au

ph (08) 8226 0219
fax (08) 8226 2320

e-mail: jones.keith@saugov.sa.gov.au
sloan.sean@saugov.sa.gov.au
fistr.alice@saugov.sa.gov.au

FOREWORD

The marine, estuarine and freshwater fisheries resources of South Australia are community owned resources. The role of the Government, as custodian of these resources on behalf of the broader community and future generations, is to ensure that they are used in an ecologically sustainable and economically efficient manner, while at the same time promoting optimum utilisation and maximising returns to regional and wider South Australian communities.

Experience world-wide has demonstrated that where unrestricted access to fisheries resources is allowed, the incentive for individuals to conserve fish stocks is diminished. The resulting competition among and between user groups often leads to increased fishing effort and excess fleet capacity, which in turn reduces biological, ecological and economic productivity.

In managing fisheries resources, the South Australian Government has the primary responsibility of balancing optimum utilisation with the need to ensure long term resource sustainability. The Government must also ensure that the basis for sharing fisheries resources among all user groups is clearly understood and accepted as equitable, and that the allocation of fisheries resources and their level of utilisation are consistent with the needs of present and future generations.

To facilitate better decision-making in South Australia's fisheries, a number of stakeholder-based fishery management committees have been established to provide expertise-based advice to the Government. These committees may be comprised of Government managers, research scientists, commercial and recreational fishers, fish processors and members of the general community. An independent chairperson is appointed.

Where there are considered to be threats of serious or irreversible damage to fisheries resources, or the environment upon which they depend, a lack of full scientific certainty or insufficient information will not prevent the Government from making decisions. Where resource management decisions must be made in an environment of uncertainty, the Government, in partnership with the fisheries management committees, will take a precautionary approach to the management of South Australia's fisheries resources.

CONTENTS

1.	PURPOSE OF THE ECOLOGICAL ASSESSMENT	6
2.	DESCRIPTION OF THE FISHERY	6
2.1	Geographic and Environmental Context.....	6
2.2	History	10
2.3	Harvest of Key Species	14
2.4	Biology of Key Species.....	20
2.5	Biology of By-product Species	26
3.	MANAGEMENT OF THE FISHERY	27
3.1	The Management Plan for the South Australian Lakes and Coorong Fishery	27
3.2	Operation of the Management Plan	43
3.3	Review of the Management Plan	43
3.4	Consultation and co-management.....	43
4.	ECOLOGICAL ASSESSMENT	44

LIST OF FIGURES

Figure 1:	The South Australian Lakes and Coorong Fishery (A. Doonan, SARDI).....	8
Figure 2:	The Lakes and Coorong barrage network (A. Doonan, SARDI).....	9
Figure 3:	Annual production and value for key species in the Lakes and Coorong Fishery (Data source: Knight et al., 2004).....	14
Figure 4:	Commercial harvest of greenback flounder, black bream, mullet and mulloway by Lakes and Coorong Fishery licence holders from 1984/85 to 2003/04.	15
Figure 5:	Annual commercial harvest of Goolwa cockles by Lakes and Coorong Fishery licence holders from 1984/85 – 2003/04.....	19
Figure 6:	Commercial harvest of bony bream, European carp and golden perch by Lakes and Coorong Fishery licence holders from 1984/85 to 2003/04.	19
Figure 7:	Retained species in the commercial sector of the Lakes and Coorong Fishery ..	47
Figure 8:	Decision-making framework for the South Australian Lakes and Coorong Fishery.	64
Figure 9:	Non-retained species in the commercial and recreational sectors of the Lakes and Coorong Fishery.....	77
Figure 10:	The general ecosystem impacts of fishing in the Lakes and Coorong Fishery ...	85
Figure 11:	Annual research planning process for the Lakes and Coorong Fishery.....	103

LIST OF TABLES

Table 1:	Commercial participation in the Lakes and Coorong Fishery for selected years over time (1906 – 2003).	11
Table 2:	Maximum gear entitlements that may be endorsed on a licence following a licence transfer or amalgamation.	13
Table 3:	Commercial fishing methods	14
Table 4:	Harvest strategy for the South Australian Lakes and Coorong Fishery.....	29
Table 5:	Sampling programs for size and age information on Lakes and Coorong Fishery species	48
Table 6:	Sampling programs for recreational fishing in the Lakes and Coorong region ..	51

Table 7:	Status of Key Species in the Lakes and Coorong Fishery	54
Table 8:	Estimates of all removals for key species in the Lakes and Coorong Fishery in 2000/01	58
Table 9:	Commercial Sector Gear Restrictions.....	68
Table 10:	Spatial and temporal closures in the commercial sector of the Lakes and Coorong Fishery.....	69
Table 11:	Size limits for selected key species in the Lakes and Coorong Fishery.....	70
Table 12:	Permitted recreational fishing methods.....	71
Table 13:	Recreational bag, boat and possession limits in place for the Lakes and Coorong Fishery.....	71
Table 14:	Spatial and temporal closures in the Lakes and Coorong Fishery for the recreational sector *	72
Table 15:	Target and by-product catch of species harvested by commercial fishers in 2000/01	73
Table 16:	Documented reports of bycatch species for all components of the Lakes and Coorong Fishery.....	78
Table 17:	List of marine animals classified as either endangered, vulnerable or protected, and which have the potential for interaction with the Lakes and Coorong fishery.	80
Table 18:	Stock assessment and stock status reporting for key species in the Lakes and Coorong Fishery.....	112

1. PURPOSE OF THE ECOLOGICAL ASSESSMENT

This report has been prepared by the Fisheries Division of the Department of Primary Industries and Resources, South Australia (PIRSA).

The purpose of this report is to provide the Australian Government Department of Environment and Heritage with a detailed assessment of the management arrangements in place for the South Australian Lakes and Coorong Fishery in accordance with the “*Guidelines for the Ecologically Sustainable Management of Fisheries*”, which are administrative guidelines under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

It is intended that this report serve as the first step in the process to have key species taken from the waters of the South Australian Lakes and Coorong fishery placed on the list of exempt native species for export, under Part 13(A) of the EPBC Act.

2. DESCRIPTION OF THE FISHERY

2.1 Geographic and Environmental Context

The lower Murray lakes and Coorong region is situated at the tail end of the largest freshwater catchment in Australia, the Murray-Darling Basin, where the river system meets the Southern Ocean (Figure 1). The entire catchment spans across four state management jurisdictions and has been significantly modified since European settlement because of its importance in supporting human existence and industrial development. The introduction of various water flow management measures, water extraction systems, the associated barriers to fish migration, the proliferation of a number of exotic fish species and pollution from agricultural run-off have collectively served to modify the structure, productivity and function of the entire ecosystem.

The fishery includes area of the waters of three separate, but closely linked, freshwater, estuarine and marine ecosystem components including:

- The lower River Murray lakes (Lake Alexandrina and Lake Albert);
- The Coorong lagoons; and
- Coastal marine waters adjacent to the Sir Richard and Youngusband Peninsulas, out to three nautical miles from the low water mark.

The Lakes and Coorong Fishery (L&CF) is a small-scale, multi-species, multi-method fishery. The fishery operates within an area designated as wetland of international importance under the Ramsar Convention, and within the boundaries of the Coorong National Park, an area recognised primarily for its wetland habitats and importance for a variety of migratory waterbirds.

A range of stakeholder values are attached to the fishery, which include commercial, recreational, indigenous and conservation interests. Commercial fishers are able to transfer effort between the different ecosystem components and species, within and between years in response to changes in fish stock abundance or market conditions. Recreational line fishing access to the fishery is currently unlimited, subject to various gear controls, area closures, bag and boat limits and size limits. There is also a licence limited recreational net fishery in the Coorong lagoon and lakes components of the fishery. Local indigenous communities are able to access the fishery for cultural and educational purposes under a specific arrangement. A

variety of conservation driven activities, including eco-tourism operations are undertaken within the boundaries of the National Park.

The fishery operates within a very dynamic ecosystem, which is influenced by high natural variation in river flooding and periods of extended drought. This presents challenges to management, with respect to matching total harvesting capacity and exploitation rates with annual changes in fish stock abundance, particularly during extended periods of drought.

The natural ecosystems supporting fisheries resources throughout the River Murray and lower lakes and Coorong region have been dramatically modified since early European settlement in South Australia. Most of these modifications have been directed at water flow control and water extraction. An extensive barrage network (Goolwa, Boundary Creek, Mundoo, Ewe Island and Tauwichee – see Figure 2) was constructed near the Murray Mouth in 1940 to:

- Reduce salinity levels in the lower Murray River and lakes;
- Stabilise the river level to provide for irrigation and human consumption; and
- Concentrate releases to the ocean to a small area and so scour a channel for navigation, during periods of low water flow (MDBC, 2005).

Construction of the barrage network transformed about 90% of the original estuary into a freshwater catchment (Lake Alexandrina and Lake Albert), changing the natural flow regime, which has altered the morphology of the Murray Mouth and imposed significant impediments to natural fish passage.

This had a generally negative impact on the overall health of the ecosystem, in particular the habitat available for a range of estuarine dependant fish species, native plants and waterbirds. Use of the barrage network has significantly reduced the flow of water into and out of the river mouth under tidal influence. Because of this, the Murray Mouth approaches closure more frequently than would have occurred naturally. Flow management can result in abrupt changes to salinity levels and overall water quality in the Coorong estuary, which disrupts the natural reproductive cycles and movement patterns of many fish species. The net result of these factors and other external impacts on the fishery is that there are varied and acute pressures placed on fish stocks and the ecosystem that supports them, particularly during periods of drought. Some freshwater species such as golden perch, bony bream and carp have benefited from the creation of larger areas of freshwater habitat in the lower lakes.



Figure 1: The South Australian Lakes and Coorong Fishery (A. Doonan, SARDI)

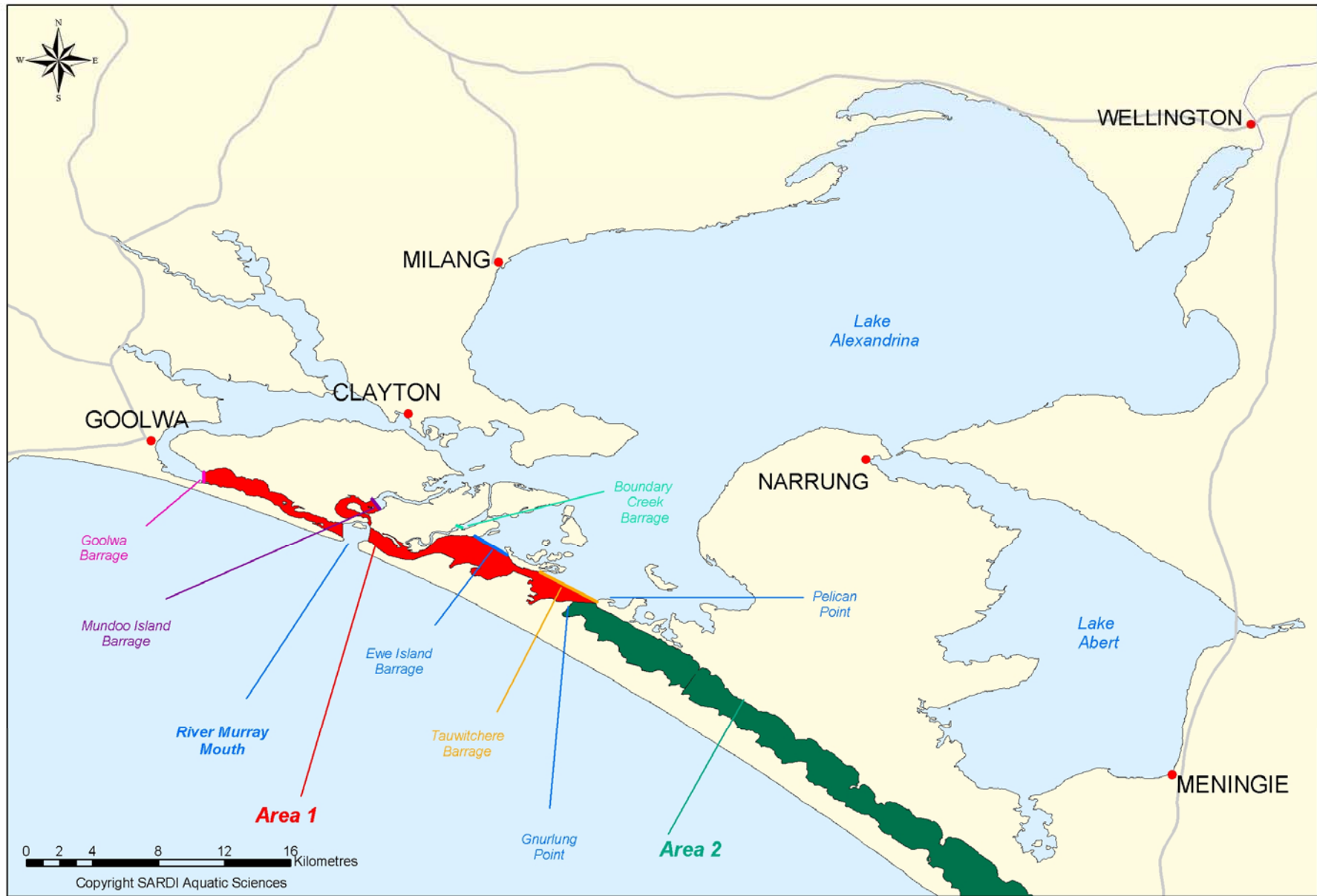


Figure 2: The Lakes and Coorong barrage network (A. Doonan, SARDI).

2.2 History

Fishing enterprises have been carried out in the lower Murray lakes and Coorong region since early European settlement and have been documented from as early as 1846. During this early period of development, the fishery was characterised by artisanal and subsistence operations, with most fishers operating on a seasonal basis. In 1906, a newspaper report (Register, September 1906) documented that two men were fishing on a commercial basis to supply the needs of the local Goolwa community and starting to preserve fish for wider distribution (Olsen, 1991).

Commercial fishing developed slowly during this early period due mainly to the increased focus on agricultural and pastoral activities, but also because of inadequate transport infrastructure and poor storage facilities. Notwithstanding these impediments, large catches of mulloway were recorded during this period, taken mainly for their swim bladders which were dried to produce isinglass for use in early brewing procedures (Olsen, 1991).

The growth of commercial fishing activities in the lakes and Coorong region was stimulated by the development of the steamer-barge trade, which commenced in 1853 through the ports of Goolwa and Milang. Over time, fishing provided full time and part time employment for residents of the local area and for idle steamer crews waiting for cargoes, or during periods of low water levels when their vessels were unable to safely navigate the River Murray. As fishing developed in the region, both ports served as bases for commercial fish landings, where fresh and preserved fish were consigned for sale at the Adelaide fish markets (Olsen, 1991). The main species taken from the region during this period were mulloway, bream, yellow-eye mullet, Australian salmon and tommy-ruff. Fishing equipment used included locally built, naturally aspirated wooden vessels, set lines and various net designs with different lengths and mesh sizes, all constructed from natural fibres (Olsen, 1991).

A number of unique methods have been developed over time by commercial fishers, including swinger nets and cockle rakes used to target mulloway and Goolwa cockles respectively, on the ocean beaches of the Sir Richard and Younghusband Peninsulas. Although modern technologies and materials (such as motor powered aluminium fishing vessels and synthetic fibres used to construct fishing nets) have been adopted, changes to fundamental fishing practices have been relatively superficial, when compared to the advances made in many other commercial fisheries. This reflects the unique characteristics of the lakes and Coorong region and a desire from the commercial industry and Government to contain effective fishing effort levels within historical and sustainable limits.

In 1888, a newspaper report in the Southern Argus documented that approximately 85 tonnes of fish were sent by rail from Goolwa to Adelaide in 1887. This amount increased to 167 tonnes in 1908 and 209 tonnes in 1912, the majority of which was mulloway, yellow-eye mullet and tommy ruff caught in Encounter Bay. By the early 1900s the harvest of fisheries resources from the lakes and Coorong region constituted a significant component of the overall South Australian scalefish production. The total catch taken by 40 fishers in 1935 was estimated to be 191 tonnes. In 1936, this amount increased to 231 tonnes of mulloway and 135 tonnes of yellow-eye mullet, representing approximately 28% of the total South Australian marine scalefish production, estimated to be 1,270 tonnes. In 1939, catches rose to 595 tonnes of mulloway and 447 tonnes of yellow-eye mullet, representing approximately 58% of the South Australian marine scalefish production, estimated to be 1,794 tonnes (Olsen, 1991).

In 1896, there were approximately 30 full time commercial fishers operating in the lakes and Coorong region, based mainly at Goolwa and Milang. The South Australian Government introduced a requirement in 1906 for all commercial fishers to hold a commercial fishing licence. In 1915, there were 15 licensed commercial fishers operating in the lakes and

Coorong region, however, the number of unlicensed fishers may have been significantly greater at times, particularly during the depression years and when the steamer trade through Goolwa slowed due to low river flows.

Table 1: Commercial participation in the Lakes and Coorong Fishery for selected years over time (1906 – 2003).

Historical data source: Olsen (1991); PIRSA Fisheries Licensing records.

Year	Lakes and Coorong		Coorong Only	
	No. of Fishers	No. of Vessels	Full Time Fishers	Part Time Fishers
1906	15	*	*	*
1930	70	*	*	*
1932	63	43	11	26
1937	65	39	13	27
1940	64	46	16	28
1945	52	33	15	26
1950	54	34	17	28
1955	46	31	16	25
1960	34	25	10	10
1965	27	22	9	8
1970	13	13	5	1
1972	106	*	*	*
1982	49	47	**	**
1984	42	42	**	**
1990	41	41	**	**
1992	39	39	**	**
2002	37	37	**	**

* Data unavailable

** Majority of fishers are assumed to have operated on a full time basis.

Prior to construction of the barrage network, up to about 30 commercial fishers operated regularly in the southern Coorong lagoon when conditions were favourable (Hera-Singh, G. 2004, pers. comm.). In 1940, following barrage construction in the Coorong, there were 64 fishing licences issued in the lakes and Coorong region. This number dropped to 13 by 1970, evidently due to military enlistments and regulations on the number of additional agents (persons assisting fishing operations) permitted. Following this, records indicate that the number of licensed commercial fishers in the fishery rose to a maximum of 106 fishers in 1972 (Olsen, 1991), before being substantially reduced with the introduction of new licensing criteria.

From January 1972, all licensed commercial fishers were required to furnish the South Australian Department of Fisheries with monthly catch and effort returns detailing the total weight of each fish species caught, the fishing location (one degree statistical blocks), the method of capture and the duration of fishing time. In 1984/85 the fishery was divided in to 16 areas for the purpose of data collection and more detailed fishing location information was collected from operators. PIRSA is currently in the process of reviewing the logbook and developing arrangements to collect spatial information at a finer scale, in order to improve management of the fishery.

In 1984, the *Scheme of Management (Lakes and Coorong Fishery) Regulations 1984* were introduced to formally manage the Lakes and Coorong Fishery as a distinct fishery, separate

from the Marine Scalefish Fishery (MSF). Prior to the introduction of the Scheme of Management, A and B class licences operated in the fishery. A class licences were issued to full time operators and B class licences were issued to part time operators. When the Scheme of Management was introduced, B class licences were discontinued, which assisted with reducing the number of commercial licences in the fishery. The Scheme of Management was updated in 1991 and the regulations are now called the *Fisheries (Scheme of Management – Lakes and Coorong Fishery) Regulations 1991*.

Licence amalgamations were permitted under the Scheme of Management introduced in 1984 to promote economic efficiency by allowing fishers to rationalise individual gear entitlements from within the existing pool of licences. In 1990, following an agreement between the Fisheries Department and the commercial industry, a policy directive was introduced to formalise a set of guidelines on licence amalgamations and transfers. A key element of the policy is the limitation placed on the amount of gear that may be endorsed on an individual licence upon licence transfer or amalgamation. Under the policy, a maximum of two agents may undertake fishing activity pursuant to each licence, following the transfer of a licence. Specific arrangements apply to licence transfers between members of a family. All applications for licence transfer or amalgamation must be considered in accordance with the *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991*.

The ‘amalgamation scheme’ has allowed for limited structural adjustment of the commercial sector by reducing the number of licences and the amount of gear operating in the fishery over time. Since the introduction of the policy, a number of licences and a substantial amount of gear have been removed from the fishery. The maximum gear entitlements that may be endorsed on any single licence following a licence transfer or amalgamation, in accordance with the Scheme of Management and the policy are shown in Table 2.

Table 2: Maximum gear entitlements that may be endorsed on a licence following a licence transfer or amalgamation.

Type of Device	Number
mesh nets (coastal waters)	1
mesh nets (inland waters)	Maximum of 25 per licence upon transfer; or a maximum of 100 per licence on amalgamation, subject to approval by the Director of Fisheries
swinger nets	1
hauling nets	1
bait net	1
drop/hoop nets	As per licence conditions
dab net	1 per licensee and agent/s
drum net	The number endorsed on the original licence
cockle rake	1 per licensee and agent/s
cockle net	1 per licensee and agent/s
crab rake	1 per licensee and agent/s
yabbie trap	maximum of 50 per licence upon transfer; or a maximum of 100 per licence on amalgamation, subject to approval by the Director of Fisheries
shrimp trap	The number endorsed on the original licence
Set line (long line)	The number endorsed on the original licence, subject to a 400 hook limit when used in coastal waters
razor fish tongs	1 per licensee and agent/s
fish spear	1 per licensee and agent/s
electro-fishing gear	No transfer or amalgamation unless specifically applied for. All applications will be considered on their individual merits, subject to consultation with the Southern Fishermen's Association.

Production levels in the Lakes and Coorong Fishery are primarily driven by variation in natural environmental conditions, in particular the frequency of flooding and the extent of drought periods (Pierce and Doonan, 1999). As such, the biological productivity of most major fish species and the economic productivity of the fishery will continue to fluctuate in line with variations in natural environmental conditions such as freshwater outflows. The following chart (Figure 3) details inter-annual changes in production and value during the recent history of the fishery.

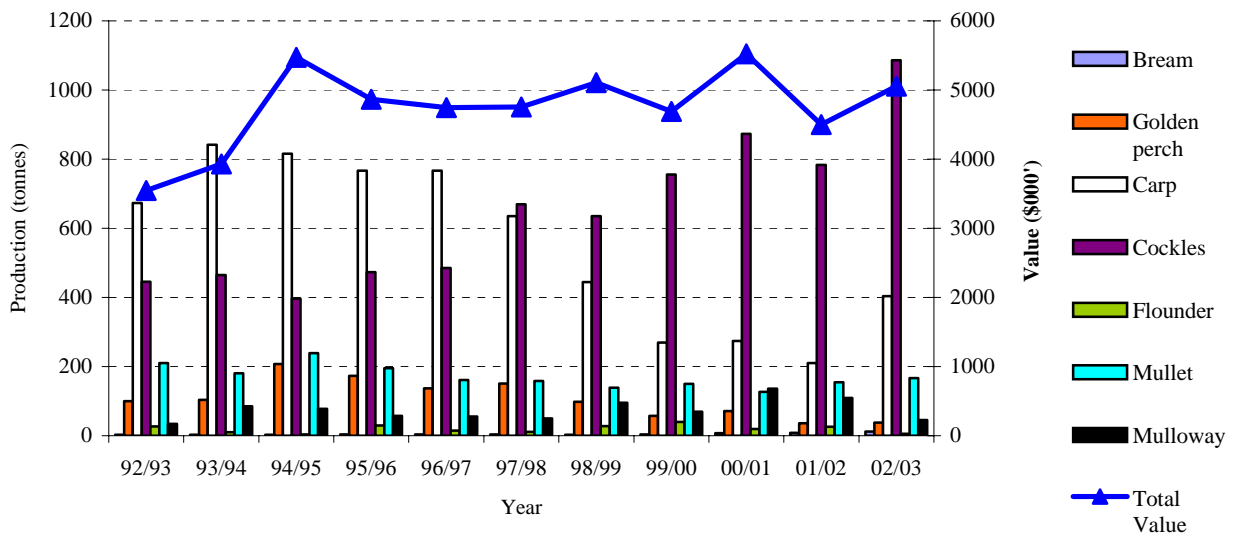


Figure 3: Annual production and value for key species in the Lakes and Coorong Fishery (Data source: Knight et al., 2004).

Since early European settlement, commercial fishing in the lakes and Coorong region has played an important role in establishing and maintaining the adjacent and surrounding coastal settlements. The commercial fishery has provided a significant contribution to regional economies and helped to shape the social structure of coastal communities in the region through the provision of fish products to local consumers, small business enterprise, employment, economic flow on effects and, in more recent times, tourism.

2.3 Harvest of Key Species

Thirty-seven commercial fishers target a diversity of native and exotic finfish species throughout the fishery, predominantly using mesh nets. A species of surf clam (*Donax deltoides*) is harvested from the ocean beaches using manual raking methods. A list of all commercial fishing methods for the fishery are provided at Table 3. The primary species taken in the fishery include mulloway (*Argyrosomus japonicus*), Goolwa cockle (*Donax deltoides*), yellow-eye mullet (*Aldrichetta forsteri*), golden perch (*Macquaria ambigua*), greenback flounder (*Rhombosolea tapirina*), black bream (*Acanthopagrus butcheri*) and bony bream (*Nematalosa erebi*). Important exotic fish taken in the fishery include European carp (*Cyprinus carpio*) and redfin (*Perca fluviatilis*). A number of other marine, estuarine and freshwater species (native and exotic) are also harvested. Refer to Appendix A for the list of permitted species prescribed for the Lakes and Coorong Fishery under Schedule 1 of the *Fisheries (Scheme of Management – Lakes and Coorong Fishery) Regulations 1991*.

Table 3: Commercial fishing methods

Device	Main Target Species
mesh nets	mulloway, golden perch, carp, bream, mullet, flounder and salmon
swinger nets	mulloway
hauling nets	mulloway, salmon, mullet, bream and flounder
bait net	bait species collection
drop/hoop nets	crabs
dab net	garfish, other
drum net	golden perch and Murray cod
cockle rake	Goolwa cockle
cockle net	Goolwa cockle
crab rake	crabs

yabbie trap	yabbies
shrimp trap	shrimp
set line	Murray cod, mulloway
razor fish tongs	razor fish
fish spear	flounder
electro-fishing gear	carp

Lakes and Coorong Fishery licence holders surveyed for the 2003/04 economic indicators report sold their product to the local; Kingston; Adelaide; Sydney; Melbourne; Brisbane; and Perth markets (Clark *et al.*, 2005). Licence holders are currently pursuing opportunities for the export of Goolwa cockles to overseas markets.

Coorong Lagoon and Ocean Beach Fishery (Finfish)

The annual commercial harvest by Lakes and Coorong Fishery licence holders for the target species harvested in the Coorong Lagoon (flounder, black bream, yellow-eye mullet and mulloway) and the ocean beach component (mulloway) is provided in Figure 4. The size of the combined harvest did not change substantially between 1988/89 and 2001/02, however, it has decreased significantly in the past two years. Over the period of stable total harvests, the relative proportion of the harvest of mulloway increased, but mullet, black bream and greenback flounder harvest decreased. In the last two years, the harvest of yellow-eye mullet was proportionally the largest for all finfish species targeted in the Coorong lagoon.

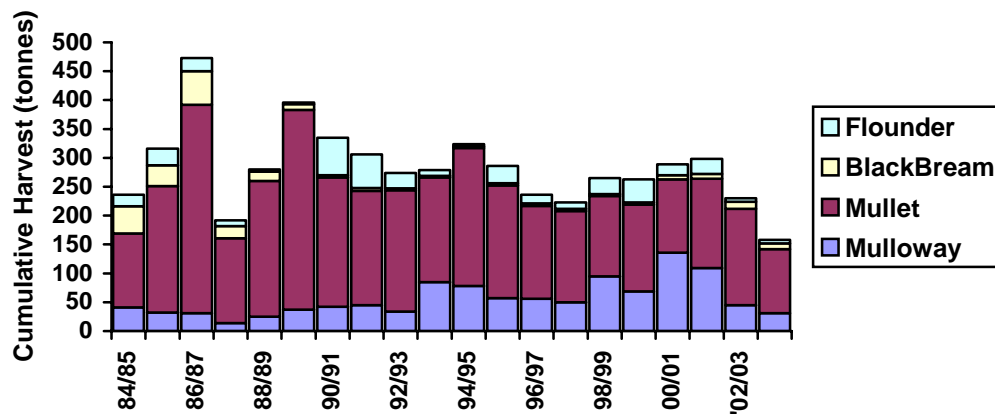


Figure 4: Commercial harvest of greenback flounder, black bream, mullet and mulloway by Lakes and Coorong Fishery licence holders from 1984/85 to 2003/04.

Mulloway

Small mulloway have been harvested within the Coorong estuary since early European settlement. A minimum weight limit of 10 ounces (approximately 32cm) was introduced in 1888 (Wallace-Carter, 1987) and a minimum size limit of 18 inches (approximately 46cm) was introduced under the 1917 Fisheries Act (Trigg, 1940). Controlled harvesting of mulloway above the existing minimum size limit of 46cm, within estuarine waters, is considered to have an acceptable impact on the entire population, provided exploitation rates are appropriately matched with resource availability and taking into account current knowledge of stock structure and the fraction of the total population being harvested. The management plan provides a framework to achieve this. Targeted research into the key biological characteristics of mulloway is being undertaken by SARDI Aquatic Sciences and is expected to resolve key areas of uncertainty associated with this management strategy. This research also aims to examine the significance of freshwater outflows for juvenile and adult

mulloway, with respect to nursery and spawning requirements. It is intended that management arrangements for mulloway will be strengthened as a result of this research.

The commercial and recreational catch of mulloway in South Australia is seasonal, with most of the catch taken in the warmer months during spring and summer. Commercial swinger net catches on the ocean beaches showed a similar periodicity to mean monthly freshwater flows (Ferguson and Ward, 2003).

Historical mulloway population production was far greater than current levels, due mainly to the significant reduction in available nursery habitat following the introduction of the barrage network in the 1940s. The total commercial catch of mulloway in the 2001/02 financial year was 114 tonnes. Of this, 96% was taken by L&CF operators. The remaining 4% was taken in the MSF. In addition to this catch, Commonwealth Southern Shark Fishery operators took an estimated 2.7 tonnes.

Recreational catch and effort levels are better understood since the National Recreational and Indigenous Fishing Survey was undertaken during May 2000 and April 2001 (Henry and Lyle, 2003). Estimates from this survey indicate that about 90.2 tonnes of mulloway were harvested (and retained) by recreational fishers during the period between May 2000 and April 2001 (Henry and Lyle, 2003). Within the lakes and Coorong area of jurisdiction, the harvest (numbers) amounted to 42% of the state harvest (27,004 (+/- 5,156 SE), with 89% of this harvest taken along the ocean beach. A relatively high proportion of the total catch was released (75%), which would have been made up of both undersized and those legal sized fish which fishers caught as part of a catch and release fishery (Jones and Doonan, 2005). Mortalities of line caught and released mulloway taken from high energy beaches are unknown (McLeay et al 2002).

Yellow-eye Mullet

In the Coorong, there appears to be a weak association between the spring and winter months and catches of yellow-eye mullet. This is thought to be mostly related to increased summer temperatures, which affect flesh quality, the seasonal closure of Area 1 to mesh netting and the migration of mullet from Area 2 into marine waters (Hera-Singh, G. 2004, pers. comm.). Discussion with commercial fishers indicates that this results in preferential targeting of mulloway during the summer months, as indicated by Ferguson and Ward (2003) (Higham, Ferguson and Ye, 2005).

The dominant gear type in the commercial fishery, in terms of landed weight, is small mesh gill nets, which account for approximately 96% of the total catch since 1984/85. Minor contributions from large mesh gill nets have also been recorded, whilst contributions from other gear types were negligible in all years except 1984/85 and 1996/97 (Higham, Ferguson and Ye, 2005).

A limited number of recreational gill nets are allowed in the lower lakes and Coorong as well as Lake George, under specific conditions. The majority of these recreational nets are used to target yellow-eye mullet. There were 2,258 recreational nets registered with PIRSA Fisheries in 2004. These were not all necessarily used in the fishery during 2004. The National Recreational and Indigenous Fishing Survey estimated that the total recreational catch of yellow-eye mullet in the lakes and Coorong region during May 2001 and April 2002 was 82,519 fish, with a total estimated harvest of 8,830 kg (Henry and Lyle, 2003). Survey estimates indicate that a further 31,763 yellow-eye mullet were released during this period, with 34,343 hours of recreational effort expended for the lakes and Coorong managed area, using a range of recreational fishing techniques. Of this total catch, the majority (95%) was caught from private boats, while approximately 4% was caught from beaches/rocks and less than one percent was caught from other platforms. Of the total catch of yellow-eye mullet,

96% was caught using the line method, while 4% was caught using gill nets (Higham, Ferguson and Ye, 2005). Additionally, 11,319 'unspecified mullet species' were harvested in the lakes and Coorong managed region, and 75 % of the total catch of these were released (Jones & Doonan, 2005).

Black bream

There has been a significant reduction in the total commercial catch of black bream from the Coorong lagoons since the early 1940s when the barrage network was completed. This decrease in production is largely due to reduced spawning success and lower survival rates of larvae caused by limitations on the availability of estuarine habitat, disrupted natural flow regimes and changes to estuarine conditions. At present, the annual commercial catch is below 10 tonnes per year. Annual catches usually reflect by-product landings, rather than targeted catches (Hera-Singh, G. 2004, pers. comm.). Mesh nets are the main commercial gear used to target black bream. For this reason and on the basis that the population is largely resident in the Coorong, total commercial catch and CPUE could be used to provide a useful index of inter-annual changes in stock abundance.

Black bream is a very popular recreational species targeted throughout the State's estuaries, including the lakes and Coorong. Recreational catch and effort levels are better understood since the National Recreational and Indigenous Fishing Survey was undertaken between May 2000 and April 2001 (Henry and Lyle, 2003). This survey estimated that the total statewide recreational catch of black bream was 31.9 tonnes in 2000/01, of which 0.6 tonnes was taken from the lakes and Coorong (Henry and Lyle, 2003). Recreational fishers catch black bream using rods and lines. As previously stated, a limited number of recreational small mesh nets are registered with PIRSA Fisheries, for use in the lakes and Coorong and Lake George in the south east. These nets are mainly used for targeting yellow-eye mullet. A bycatch study will commence in 2005 to, among other things, quantify the catch composition and bycatch levels of bream associated with mesh nets (refer to Appendix F).

Greenback Flounder

There has been a significant reduction in the total catch of greenback flounder from the Coorong lagoons since the early 1940s when the barrage network was completed. This decrease in production is largely due to reduced spawning success and lower survival rates of larvae caused by limitations on the availability of estuarine habitat, disrupted natural flow regimes and changes to estuarine conditions. Since barrage construction, the total commercial catch has varied substantially between years. The commercial catch has varied between 4 to 65 tonnes since 1984/85.

The most common gear used in the commercial fishery is bottom set mesh nets, although hauling nets and fish spears are also permitted. Commercial fishers only target flounder during seasons when stocks reach a level of abundance that makes catching and marketing economically viable; in all other years the catch reflects non-targeted by-product (Hera-Singh, G. 2004, pers. comm.). For this reason and on the basis that the population is resident in the Coorong, total commercial catch and CPUE could be used to provide a useful index of inter-annual changes in stock abundance. Greenback flounder are the most common species caught in the Lakes and Coorong Fishery, but catches are also known to include other flounder species such as the small-toothed flounder (Westlake, 1987).

Recreational catch and effort levels are better understood since the National Recreational and Indigenous Fishing Survey was undertaken between May 2000 and April 2001 (Henry and Lyle 2003). This survey estimated that the total statewide recreational catch of greenback flounder was 2,994 fish in 2000/01 (Henry and Lyle, 2003). Recreational fishers catch flounder with fish spears, rods and lines. As previously stated, a limited number of

recreational small mesh nets are registered with PIRSA Fisheries, for use in the lakes and Coorong and Lake George in the south east. These nets are mainly used for targeting yellow-eye mullet. A bycatch study will commence in 2005 to, among other things, quantify the catch composition and bycatch levels associated with mesh nets (refer to Appendix F).

Goolwa Cockle Fishery

Commercial fishers use cockle rakes (sometimes referred to as cockle nets) to manually harvest Goolwa cockles from the Coorong ocean beaches. No mechanised harvesting methods are permitted in the fishery. The commercial sector has established an industry position opposing the use of mechanised cockle harvesting techniques to minimise the risk of overexploitation. Commercial catch and effort levels have increased substantially since the early 1980s, due mainly to increased demand for cockles associated with the development of a market for human consumption. Goolwa cockles have become the most important species in the Lakes and Coorong Fishery, in terms of both production and value.

Figure 5 shows the increasing trend in annual commercial production, particularly in the decade between 1990/91 and 2000/01. Effort levels have also increased and these trends are a cause for concern to fishery managers. The level of latent effort that exists in a number of other state managed fisheries, including the MSF and Rock Lobster Fisheries (RLF), has also been of concern. Following a major review process, permanent changes to commercial access for Goolwa cockles in Coorong coastal waters have recently been introduced (from the 2005/06 fishing season) to address this issue:

- L&CF licence holders will retain current access to Goolwa cockles and may sell Goolwa cockles taken pursuant to Lakes and Coorong Fishery licences;
- Two MSF licence holders with recognised prior catch history for Goolwa cockles (as part of MSF Restructure review) will retain current access to Goolwa cockles and may sell Goolwa cockles taken pursuant to their MSF licences;
- All remaining Northern Zone Rock Lobster Fishery (NZRLF), Southern Zone Rock Lobster Fishery (SZRLF) and MSF licence holders will retain access to Goolwa cockles for the purposes of bait use only. Goolwa cockles taken by these licences must not be sold, but may be used as bait for other fishing activities undertaken pursuant to the same licence;
- NZRLF, SZRLF and MSF licence holders with cockle gear entitlements will still be able to harvest Goolwa cockles (*Donax deltooides*) from other areas of the State, that are outside Coorong Coastal Waters (ie the Coorong and Goolwa Beaches), subject to any other existing restrictions; and
- At this stage, no catch limit is proposed for bait collection; however, this will be monitored and reviewed if necessary.

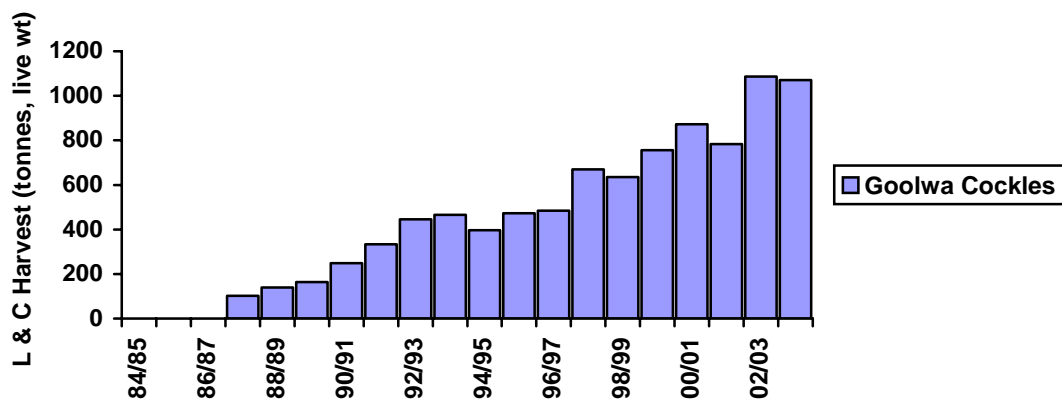


Figure 5: Annual commercial harvest of Goolwa cockles by Lakes and Coorong Fishery licence holders from 1984/85 – 2003/04

Recreational fishers are permitted to use a cockle rake to harvest Goolwa cockles. Many recreational fishers harvest cockles by hand. The majority of the recreational catch is taken from the Sir Richard Peninsula (the Goolwa beach) during the summer months. The National Recreational and Indigenous Fishing Survey recently estimated the statewide recreational catch of Goolwa cockles to be 22.9 tonnes between May 2000 and April 2001 (Henry and Lyle, 2003) and were all harvested from the Goolwa beach (Jones and Doonan, 2005). The recreational catch is estimated to constitute about 2% of the total statewide commercial catch.

A Quality Assurance Program has been introduced in the Lakes and Coorong Fishery to ensure that all cockles harvested from the fishery meet national food safety standards. A stretch of ocean beach, from the Murray Mouth to a point about 62km south east along to the Younghusband Peninsula (the Coorong beach), has been classified as a remote area by the South Australian Shellfish Quality Assurance Program (SASQAP). Ongoing sampling of water quality in this area is undertaken to ensure water quality does not present a risk to human safety. Additional water quality monitoring is undertaken in storage tanks used by commercial fishers and fish processors. Only cockles harvested from the classified area may be sold for human consumption.

Lakes Fishery

Commercial fishing in Lake Alexandrina and Lake Albert largely comprises the target species European carp and bony bream, with the proportion of the harvest of carp increasing and that for bony bream decreasing (Figure 6). During the 1990's, a small but highly valued component of the lakes fishery consisted of golden perch, however the size of this harvest has declined in recent years.

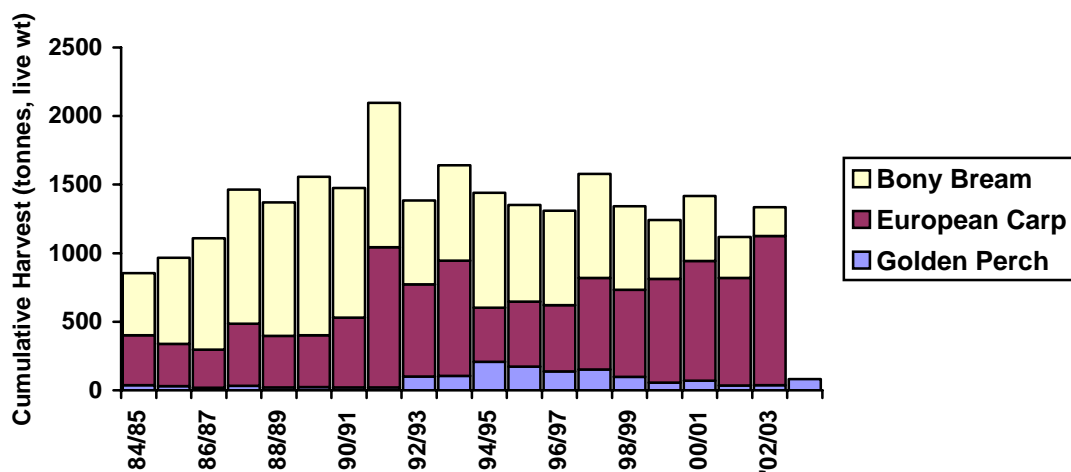


Figure 6: Commercial harvest of bony bream, European carp and golden perch by Lakes and Coorong Fishery licence holders from 1984/85 to 2003/04.

Note: 2003/04 harvest figures for European carp and bony bream will be available shortly, due to confidentiality arrangements with River fishers

Golden perch

In South Australia, golden perch populations support important commercial and recreational fisheries. In the Lakes and Coorong Fishery, golden perch is one of several key species

targeted by commercial and recreational fishers. Until recently, golden perch was also targeted by commercial fishers on the River Murray. Following a commercial restructure process initiated by the South Australian Government in 2002, commercial fishing for native species (including golden perch) is no longer permitted on the River Murray.

Historically, the largest commercial catches of golden perch in South Australia have come from the River Murray and been closely correlated with good flooding in preceding years (Reynolds, 1976b; Pierce and Doonan, 1999). In the late 1970s, the proportion of the total catch taken from the Lakes and Coorong increased to about 50% (Rohan, 1987), due to the increased availability of suitable habitat created by the construction of the barrage network, which converted nearly 90% of the original River Murray estuary into a freshwater impoundment. Static mesh nets are the predominant gear used by the commercial sector to target golden perch, however, drum nets are also used. The total commercial catch of golden perch from South Australia was 97 tonnes in 2001/02, with 36 tonnes taken from the Lakes and Coorong Fishery (Knight, *et al.*, 2004).

The recreational catch of golden perch in South Australia is significant, the majority of which is taken from River Murray waters; however, no golden perch were reported to have been harvested in the lakes area (Jones and Doonan, 2005).

European carp

European carp have been commercially fished in most jurisdictions for many years, as part of strategies aimed at reducing carp numbers and their impact on the environment. Commercial fishers in the Lakes and Coorong Fishery use mesh nets and haul nets to harvest carp from the lower lakes, mainly for sale to rock lobster fishers as bait, but also for the human consumption market. European carp is also taken as a by-product when other freshwater species such as golden perch or bony bream are being targeted. Some L&CF fishers specialise in carp fishing for the rock lobster bait market.

European carp is an exotic species that has been declared a pest across all jurisdictions. Consistent with the National Management Strategy for Carp Control, the overriding management goal for European carp in South Australia is complete eradication (MDBC, 2000). However, complete eradication has long been considered an unrealistic expectation, therefore management strategies are currently focussed on controlling the overall ecological impacts of European carp on native fish species and native fish habitat. European carp is listed as an exotic species under the *Fisheries Act 1982*, meaning it is unlawful to release/return carp into South Australian waters.

European carp have evolved to become an important recreational species because of their large densities and relative ease of capture. Predominantly, recreational fishers catch European carp using rods and lines. Recreational catch and effort levels are better understood since the National Recreational and Indigenous Fishing Survey was undertaken during May 2000 and April 2001 (Henry and Lyle, 2003). This survey estimated that the total statewide recreational catch of European carp was 273.5 tonnes, while the total catch from the Lower Lakes was 3.6 tonnes. The majority of the statewide catch is taken from the River Murray (Henry and Lyle, 2003).

2.4 Biology of Key Species

Mulloway (*Argyrosomus japonicus*)

Mulloway are distributed throughout southern Australia, however, there is currently only a limited understanding of stock structure for the species (Hall, 1986; Ferguson and Ward, 2003). In the absence of reliable quantitative scientific data to support an alternative stock

hypothesis, the South Australian mullocky population is managed using a precautionary approach as a self-recruiting population, with recruitment considered to be dependent upon local spawning within South Australian waters.

Mullocky are a fast-growing, relatively long-lived species attaining a maximum age of about 30-35 years at a maximum size of approximately 1.8m. The size at which approximately 50% of males and females reach sexual maturity has been determined to be about 75cm (Hall, 1986)¹. The life history strategy of mullocky is thought to involve an early phase of rapid growth and delayed maturity, followed by prolonged longevity to ensure sufficient egg production over time (Ferguson and Ward, 2003).

The spawning behaviour and locations used by mullocky in South Australia are unclear, as is the proportion of the total population that use the Coorong estuary as juvenile habitat (Ferguson and Ward, 2003). Adult mullocky aggregate around the River Murray Mouth during the spring and early summer months, attracted by freshwater outflows and an abundance of food (Hall, 1986; Ferguson and Ward, 2003). It is currently unclear to what extent these aggregations form part of a reproductive strategy however females caught from these aggregations show yolked oocytes in the ovaries and males are running ripe. Smaller aggregations are also known to occur on the west coast (Hall, 1986).

Juvenile mullocky are found in the waters of the Coorong estuary, which they utilise as nursery habitat for at least five years. Adjacent nearshore oceanic waters are provide alternative nursery habitat although juveniles appear to show a preference for estuarine waters. After five years they are migrate out of the estuary and into marine waters.

Goolwa cockles (*Donax deltoides*)

Populations of Goolwa cockles are distributed throughout Australia on high energy ocean beaches (Murray-Jones and Johnson, 2003). The population found in the Coorong along the Sir Richard and Youngusband Peninsulas is likely to represent the largest population of the species found in Australia (King, 1976). For the purposes of management, the Coorong population of *D. deltoides* is managed as a self recruiting population distinct from other stocks distributed throughout other South Australian ocean beaches.

Goolwa cockles are a fast growing, short-lived, highly fecund species that attain a maximum size of between 60-80mm and reach sexual maturity at about 13 months of age and about 36mm shell length (Murray-Jones and Johnson, 2003). Maximum age is estimated to be about 4 years. The spawning season is thought to be continuous throughout the year, but with a number of peaks during September-October and in January (King, 1976; Murray-Jones and Johnson, 2003).

Large natural fluctuations in population abundance are a characteristic of cockle populations worldwide (Murray-Jones and Johnson 2003). King (1976) suggested that such fluctuations are likely to be driven by surface winds or hydrological processes, including oceanic upwellings. Goolwa cockles are thought to feed mainly on surf diatoms, which are common on the Coorong ocean beaches (King, 1976). Productivity of the Coorong population of *D. deltoides* is likely to benefit significantly from elevated primary production of phytoplankton due to freshwater outflows from the River Murray (Murray-Jones and Johnson, 2003).

Yellow-eye mullet (*Aldrichetta forsteri*)

¹ The mean size at which 50% of males and females reach sexual maturity is currently being investigated as part of a PhD study.

Populations of yellow-eye mullet are distributed in bays, estuaries and open coastline from Shark Bay in Western Australia, throughout the southern coastline including Tasmania, to Newcastle in New South Wales (Kailola, *et al.*, 1993). Yellow-eye mullet also inhabit shallow bays and inlets around New Zealand (Thomson, 1957; Kailola, *et al.*, 1993; Gorman, *et al.*, 1994; Yearsley, *et al.*, 1999). Yellow-eye mullet live in brackish and inshore coastal waters and beaches over sandy and muddy bottom in depths to about 20m (Kailola, *et al.*, 1993). The estuarine waters of the Coorong offer an ideal habitat for this species. Two separate genetic populations are considered to exist between the western and eastern seaboard (Thomson, 1957). South Australian populations are considered to form part of western stocks (Thomson, 1957; Pellizzari, 2001).

Yellow-eye mullet is fished commercially throughout most of its distribution. Two populations of yellow-eye mullet are believed to exist, an eastern and western population, based on differences in lateral scale and gill raker counts and breeding season (Thomson, 1957; Pellizzari, 2001). The South Australian population is currently thought to form part of the western population, due to similarities in morphological characters although further clarification is required (Thomson, 1957; Pellizzari, 2001).

Yellow-eye mullet are categorised as estuarine opportunists (Whitfield, 1999) because they regularly utilise estuaries during part of their life cycle but do not need access to complete their life cycle (Potter and Hyndes 1994). However, the importance of the Coorong estuarine system to the life history of yellow-eye mullet is currently uncertain due to conflicting information about gonad condition and early life history from the region (Higham, Ferguson and Ye, 2005).

Yellow-eye mullet are a fast growing, short-lived species attaining a maximum age of 5 years and a maximum size of about 40cm caudal fork length (CFL) (Thomson, 1957). Female yellow-eye mullet from the Coorong mature at about 23cm CFL, whilst males mature slightly smaller at 22cm CFL, approximately in their third year of age (Harris, 1968). These figures concur with figures reported by other studies interstate and in New Zealand (Thomson, 1957; Harris, 1968; Webb, 1973). In the Coorong commercially caught fish reach a maximum size of 35cm CFL (Harris, 1968). Harris concluded that females grow to a greater size (in terms of length) than males (Harris, 1968).

The fecundity of yellow-eye mullet ranges from 125,000 to 630,000 eggs per female (Thomson, 1957). Currently, no information is available on the fertilisation rate for yellow-eye mullet or the survival rate of spawned individuals. Generally, yellow-eye mullet are considered to be omnivorous eating detritus, seagrass, micro and macro-algae as well as small animals and epiphytes (Kailola, *et al.*, 1993; McDowall, 1996).

Golden Perch (*Macquaria ambigua*)

Golden perch or callop are a freshwater species that occur in the River Murray and lower lakes (Lake Albert and Lake Alexandrina). The species is distributed throughout most of the Murray-Darling Basin, with the exception of high altitude water bodies. It is also found in the Lake Eyre and Bulloo systems (Lake, 1967a; Lake, 1971). Golden perch prefer warm, turbid, slow flowing inland rivers and their floodplain, lakes and anabranches (Lake, 1971; Merrick and Schmida, 1984). Golden perch favour deep pool habitats because of the refuge and dimensionality provided by dead trees, snags, undercut ledges and river banks. They are well adapted to the dynamic flood conditions of the Murray-Darling system and can withstand significant changes in temperature (4-37°C) and salinity (Harris and Rowland, 1996).

Similar to many other freshwater native species, the natural range of distribution and abundance of golden perch has declined steadily since European settlement (MDBC, 2004). One of the main causes for this decline is habitat degradation, due to the construction of

numerous dams and weirs, causing barriers to natural migration patterns and altering natural water flow and temperature regimes (MDBC, 2004). The first stock assessment for golden perch in South Australia was prepared in 2004 (Ye, 2004).

The population structure of golden perch has been genetically defined throughout its range of distribution (MacDonald, 1978; Musyl and Keenan, 1990, 1992; Keenan, *et al.*, n.d.). There are at least four separate populations of golden perch, which exist in the Murray-Darling Basin, the Lake Eyre Basin, the Bulloo River and the Fitzroy Basin (Musyl and Keenan, 1992). The Lake Eyre population has been identified as a genetically distinct stock at the species level and the Fitzroy and Murray-Darling populations diverge genetically at the sub-species level. Within the Murray-Darling Basin, seven separate stocks (genotypes) have been identified (Keenan, *et al.*, n.d.).

Within South Australia, two separate stocks (genotypes) exist, which are considered to be the 'central stock' and the 'lakes stock' (Keenan, *et al.*, n.d.). Their range overlaps considerably, therefore both stocks are relevant to the management of the Lakes and Coorong Fishery. The lakes stock could represent a separate genotype, which has increased in abundance since barrage construction and the resulting habitat modification (enlargement of freshwater habitat in the lakes). Alternatively, the lakes stock may have evolved to become a separate, self sustaining stock since barrage construction in the 1940s (Ye, 2004). However, due to the similar morphology and overlapping occurrence of the central and lakes stocks, the golden perch resource of the lower Murray River and lakes is managed as a unit stock.

Golden perch is a long lived species that can reach a maximum size of about 760mm. The known maximum age is about 26 years (Ye, 2004). Growth rates are highly variable between individual populations (Anderson, *et al.*, 1992). Samples of golden perch from the River Murray and the lower lakes also indicated considerable variability in growth rates of individual fish. For example, faster-growing one year old fish may be larger than slow growing five year olds (Ye, 2004).

Spawning occurs during spring and summer in response to river flooding or rising water levels, in a temperature range of between 20° to 25°C. Individual fish may spawn more than once in a season if conditions are favourable (Battaglione and Prokop, 1987). If suitable spawning stimuli fail to occur (eg. a change in water level or temperature), females will reabsorb their eggs and defer spawning (Lake, 1967b; Mackay, 1973). The lakes stock is thought to reproduce at base levels even during non-flood years or periods of low river flow (Ye, 2004). Females mature at 4-5 years and males at 2-3 years (Battaglione and Prokop, 1987; Harris and Rowland 1996). Golden perch are highly fecund, with a female of 2.3kg (about 500mm) producing up to 500,000 eggs (Lake, 1967b). Fecundity increases with size and age (Rowland, 1983; Battaglione and Prokop, 1987). Egg development is pelagic and hatching occurs about 24-33 hours after fertilisation at 20° to 31°C (Lake, 1967c; Rowland, 1983). Larvae are able to swim against a gentle current about 96 hours after hatching and commence feeding on zooplankton about five days after hatching (Rowland, 1996).

Black Bream (*Acanthopagrus butcheri*)

Black bream occur in estuarine and coastal waters from Myall Lake in central New South Wales to the Murchison River in Western Australia, including Tasmania and the Bass Strait Islands (Kailola, *et al.*, 1993; Gomon, *et al.*, 1994). In South Australia, black bream are common in estuaries from the Victorian border to Port Lincoln on the west coast, including the small estuaries on Kangaroo Island (Hall, 1984). Movement between estuaries and other sheltered bays is limited and usually only occurs during periods of flooding (Hall, 1984; Kailola, *et al.*, 1993; Cashmore, Conron and Knuckey, 2000). Black bream are considered to be an estuarine resident species that complete their life cycle within estuarine waters (MDBC, 2002).

Black bream are a bottom dwelling species that occur in areas where hard substrates, snags or structures provide shelter (Kailola, *et al.*, 1993), although they are also captured over more exposed sandy bottom and seagrass beds in the Victorian Gippsland Lakes (Cashmore, Conron and Knuckey, 2000). They can withstand a wide range of salinities and often move into the freshwater lower lakes and the lower reaches of the River Murray.

Black bream stock structure has not been studied comprehensively in South Australia. A recent genetic study was undertaken in South Australia and Victoria involving sampling in the Port, Onkaparinga and Hindmarsh Rivers in SA and the Surrey, Hopkins, Yarra, Gippsland and Sydenham estuaries in Victoria (Burrige, *et al.*, 2004). This study suggested that there were genetic similarities in samples from estuaries close to one another and that the greater the spatial separation between populations, the greater the degree of genetic differentiation. Given the known limited movement between the Coorong lagoons, South Australian coastal waters and other estuaries in the state (Hall, 1984), the Coorong population is currently managed as a distinct unit stock, reliant on local spawning events within the Coorong lagoons for successful recruitment.

Black bream are a slow growing, relatively long lived species that reach a maximum age and size of more than 29 years and 40cm, respectively (Cashmore, Conron and Knuckey, 2000). Growth rates are variable between locations (Kailola, *et al.*, 1993). Males reach sexual maturity at 3 years old at lengths of between 14-18 CFL, while females reach maturity at 4 years old at lengths of between 21-25cm CFL (Hall, 1984). In the Coorong, spawning is thought to occur in the deeper channels near the Murray Mouth from November to March (Hall, 1984).

In the Coorong lagoons, temperature dependent freshwater inflows are thought to provide a critical spawning stimulus for black bream and other estuarine dependent species (MDBC, 2003). In addition to spawning success, the magnitude, timing and duration of freshwater flows effect larval survival and development (Hall, 1984; Pierce and Doonan, 1999). There is potential for black bream stock production levels to be significantly improved in the Coorong lagoons under an improved barrage flow strategy (Hall, 1984; Pierce and Doonan, 1999; MDBC, 2003a).

Greenback flounder (*Rhombosolea taparina*)

Greenback flounder belong to the family Pleuronectidae, commonly known as the right-eyed flounders. They occur in sheltered bays, estuaries and coastal waters from southern Western Australia to southern New South Wales and around Tasmania (Kailola, *et al.*, 1993; Gomon, *et al.*, 1994). In New Zealand, greenback flounder occur around the South Island, the Auckland Islands and Campbell Island. Significant genetic differences exist between Australian and New Zealand populations (van den Enden, *et al.*, 2000). In Australia, populations of greenback flounder in western Tasmania are genetically distinct from south eastern and northern Tasmanian populations and Victorian populations (Kurth, 1957).

The stock structure of Western Australian and South Australian greenback flounder populations has not been studied. However, Hall (1984) documented that greenback flounder were rarely captured in marine waters outside of the Coorong, suggesting that the Coorong population is estuarine resident (MDBC, 2002), completing its life cycle in the sheltered waters of the Coorong lagoons. Based on this understanding of movement patterns and the limited information available on stock structure, the greenback flounder population in the Coorong is managed as a distinct unit stock, reliant on local spawning events within the Coorong lagoons for successful recruitment.

Greenback flounder are usually found over non-vegetated, sandy or muddy bottom where they are well camouflaged (Connolly, 1994). Larvae are fully settled on this type of habitat about 65 days after hatching, at less than a centimetre in length (Crawford, 1984; Crawford, 1986). Greenback flounder have a large temperature and salinity tolerance (Kailola, *et al.*, 1993). In their natural state, the Coorong lagoons provide an ideal habitat for greenback flounder. Larvae feed during daylight hours (Chen, *et al.*, 1999; Cox & Pankhurst, 2000), in contrast to juveniles and adults, which feed on rising tides at night on shallow mud banks (Kailola, *et al.*, 1993).

Limited information is available on the growth and age characteristics of greenback flounder populations in South Australia. The small amount of information that exists suggests that greenback flounder are a fast growing species that reach a maximum length of 40cm and weight of 0.6kg, at an age of between 3 and 4 years (Hall, 1984; Kailola, *et al.*, 1993).

In the Coorong lagoons, temperature dependent freshwater inflows are thought to provide a critical spawning stimulus for greenback flounder and other estuarine dependent species (MDBC, 2003). In addition to spawning success, the magnitude, timing and duration of freshwater flows effect larval survival and development (Hall, 1984; Pierce and Doonan, 1999). There is potential for greenback flounder stock production levels to be significantly improved in the Coorong lagoons under an improved barrage flow strategy (Hall, 1984; Pierce and Doonan, 1999; MDBC, 2003a).

European carp (*Cyprinus carpio*)

European carp are a non-native freshwater fish species that were first introduced to freshwater systems in Australia in the early 1900s. However, European carp did not begin to spread throughout Australian rivers until after fish bred at a Victorian hatchery in Boolarra were released into the River Murray in Mildura, Victoria, in 1964. Following this release, European carp populations spread rapidly throughout the Murray-Darling Basin, assisted by good flooding in the early 1970s (Koehn, Brumley and Gehrke, 2000).

European carp are now the most common large freshwater fish species in the Murray-Darling Basin and are widely distributed throughout freshwater systems in south-eastern Australia, Western Australia, Queensland and Tasmania (Kailola, *et al.*, 1993; Koehn, Brumley and Gehrke, 2000; MDBC, 2003b). In South Australia, European carp are distributed throughout the River Murray and the lower lakes. They also occur in other South Australian rivers and streams including the Finnis, Gawler, Light, Marne, Torrens and Wakefield Rivers (Koehn, Brumley and Gehrke, 2000). European carp originated in central Asia.

There are three separate European carp stocks in Australia that are thought to be the result of three separate introductions (Kailola, *et al.*, 1993). These three stocks are defined as the Yanko stock confined to the Murrumbidgee system, the Prospect stock confined to the Prospect Reservoir in NSW and the Boolarra stock, which is distributed throughout the Murray-Darling Basin (Kailola, *et al.*, 1993).

European carp have very flexible habitat requirements and tend to thrive in conditions that most freshwater fish species would not survive. They have a wide tolerance for changes in environmental parameters such as temperature, salinity and dissolved oxygen (Kailola, *et al.*, 1993; Koehn, Brumley and Gehrke, 2000). European carp prefer warmer waters found in shallow lakes and slow flowing rivers. They occur over soft muddy substrates and feed on benthic invertebrates, insects and aquatic plants by filtering small particles from the water or by sieving food from soft sediments (Kailola, *et al.*, 1993; Koehn, Brumley and Gehrke, 2000). European carp are active swimmers that are able to launch from the water to negotiate obstacles.

As for many species, growth rates of European carp can vary significantly between different locations, depending on temperature, food availability and other density dependent factors. European carp have been reported to live for over 20 years, attaining a maximum size of 26 kilograms and 850mm (Kailola, *et al.*, 1993; Koehn, Brumley and Gehrke, 2000). The age and size at which first maturity is reached also varies between locations, however, generally males mature at 2-3 years when about 20cm and females at 3-4 years when about 25cm (Kailola, *et al.*, 1993; Koehn, Brumley and Gehrke, 2000).

2.5 Biology of By-product Species

Bony Bream (*Nematalosa erebi*)

This freshwater species is endemic to Australia and is widely distributed in all mainland warm water catchments. No stock identification studies have been carried throughout its range, and for the purposes of the management of the Lakes and Coorong Fishery, the population occurring in the Murray-Darling Basin should be considered as a unit stock. In the southern catchments of Australia it is locally abundant and spawns from spring to early summer when the water temperature is greater than 21°C. In the lakes, spawning aggregations occur off sandy shores (Kailola *et al.*, 1993).

Bony bream is a highly fecund species, with fecundity increasing with size (90 g females produce 30,000 eggs to 880,000 for a 590 g female). Both male and female fish become sexually mature at age 1 year (16 cm and 20 cm, respectively). Fertilised eggs are relatively small and are initially demersal and adhesive. Hatched larvae and juveniles are pelagic. Fish have been aged at up to 10 years, but growth has only been validated up to 3 years of age.

Juvenile bony bream initially feed on zooplankton and then shift to detritus and algae after reaching 5-6 cm. Adults are primarily herbivorous, feeding on algae and aquatic plants and occasionally insects and small crustaceans.

Bony bream are a very important forage species, with both juveniles and adults being a major part of the diets of birds (pelicans, cormorants), freshwater fish (golden perch, redfin perch and Murray cod) and estuarine fish species (mulloway).

Yabbies (*Cherax destructor*)

This freshwater crustacean is endemic to Australia. It is naturally occurring in flood plain areas characterised by a turbid, still-water environment (NSW Fisheries, 2005). With the construction of weirs on the River Murray and the barrages, still water conditions have favoured this species (Walker, 1981). Research in South Australia indicates wide tolerances in water temperature (4-36°C) and salinity (up to 14 ppt). Breeding occurs in summer months and yabbies are capable of repetitive spawning during the breeding season. Yabbies reach sexual maturity at about 9-10 cm (measured from the tip of the rostrum to the end of the tail-fan), and studies elsewhere suggest that females aged 2 years contribute most to the number of recruits in the population. There are relatively few yabbies older than 2 years of age in the population (NSW Fisheries, 2005). The number of juveniles produced by females varies proportionally with the size of the female (from 50-1,200). Yabbies are known to grow to at least 20 cm length.

Yabbies feed on aquatic plants and are scavengers of decaying plant and animal material. They are an important component of the diet of native fish species, such as golden perch and Murray Cod and water birds, including cormorants and white ibis (NSW Fisheries, 2005).

In the past, yabby populations in the lakes have been known to fluctuate markedly in abundance (Reynolds, 1979). These fluctuations are believed to be linked to fluctuating water

levels. Although yabbies are targeted by licence holders in the fishery, they have been included as a by-product species for the purposes of this assessment report due to the low historical catch levels.

3. MANAGEMENT OF THE FISHERY

The *Fisheries Act 1982* (the Fisheries Act) provides the broad statutory framework to ensure the ecologically sustainable management and development of South Australia's marine, estuarine and freshwater fisheries resources. In the administration of the Fisheries Act, the Minister for Agriculture, Food and Fisheries, the Director of Fisheries and all established Fisheries Management Committees must operate in accordance with the following objectives, outlined in Section 20 of the Act:

- (a) ensuring, through proper conservation, preservation and fisheries management measures, that the living resources of the waters to which this Act applies are not endangered or overexploited;
- (b) achieving the optimum utilisation and equitable distribution of those resource; and
- (c) insofar as this Act applies to the River Murray, seeking to further the objects of the River Murray Act 2003 and the objectives of a healthy River Murray under that Act.

3.1 The Management Plan for the South Australian Lakes and Coorong Fishery

A management plan has been finalised for the Lakes and Coorong Fishery. This plan provides a strategic policy framework to address the diverse and complex issues facing the future management of the fishery. The plan will provide a foundation for the fishery to continue moving towards a more integrated, ecosystem-based approach to fisheries management.

The plan sets out a formal harvest strategy for the fishery and provides direction for the formulation of regulations contained within the *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991* and the *Fisheries (General) Regulations 2000*. The harvest strategy (refer to Table 4) incorporates critical environmental factors such as the timing and volume of freshwater flows, barriers to fish passage and river mouth opening. As part of the harvest strategy, key performance indicators and biological reference points have been developed to allow for regular and structured assessment of the degree to which management objectives are being achieved.

The plan covers all fishing activity undertaken within the lower Murray lakes and Coorong region including commercial, recreational, traditional and any illegal fishing. The powers contained in Section 14 of the *Fisheries (Management Committees) Regulations 1995* (the FMC regulations) provide the legal basis for the preparation of the management plan. The responsibility for the preparation of the plan for the Lakes and Coorong Fishery lies with the Inland Fisheries Management Committee (Inland FMC).

The regulations that govern the management of the Lakes and Coorong Fishery are the *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991* and the *Fisheries (General) Regulations 2000*. The Management Plan should be read in conjunction with these regulations. The management plan does not form part of the *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991* and does not have any statutory basis. The management framework outlined in this assessment document is based on information contained in the management plan and the existing regulations mentioned above.

Management of the Lakes and Coorong Fishery is implemented in the context of a number of international legal instruments including the Ramsar Convention and the United Nations Convention on the Law of the Sea². The existing management regime complies with these international conventions. 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 waterbird habitats of the lower Murray lakes and Coorong region were designated as a wetland of international importance under the Ramsar Convention in 1985. These wetlands provide habitat for many local species as well as for migratory wading birds. A Ramsar Management Plan for the Lower Lakes and Coorong was prepared in 2000 to fulfil the Australian Government obligations under the Convention agreement. The 'Coorong and Lakes Alexandrina and Albert Ramsar Management Plan' provides an integrated management framework to promote wise use and conserve the ecological character in the lakes and Coorong wetlands, while taking into account the social, cultural and economic values attached to the area (DEH 2000).

The objectives and strategies of the Lakes and Coorong Fishery Management Plan have been developed to take the management framework and objectives provided by the Ramsar Management Plan into account. Goals of sustainable harvest, minimising fishery impacts on the ecosystem, collection of biological, environmental and ecological information, equitable access, participative governance and the concept of 'wise use' are pursued through the objectives and management strategies of the Lakes and Coorong Fishery Management Plan.

Acknowledging that the commercial exploitation of fish is permitted inside a national park, the objectives of the National Park Management Plan have been taken into account in the development of the harvest strategy for the Lakes and Coorong Fishery, to achieve where possible, complementarity between management of the fishery and the Coorong National Park.

While the Management Plan aims to provide a firm basis for the long-term sustainability of the fisheries resources of the lower Murray lakes and Coorong region, it does not aim to return the ecosystem to its original, unmodified state. To do this would require substantial re-engineering of the water flow management system along the entire length of the River Murray system, which is beyond the scope of the Management Plan. However, there are ways that the productivity of the existing ecosystem can be improved and enhanced (Pitcher, 2001). The Management Plan provides direction and strong support for a range of Government, industry and community based programs aimed at habitat restoration (eg. barrage fish passage-ways).

² Information on the United Nations Convention on the Law of the Sea is available at the United Nations website www.un.org

Table 4: Harvest strategy for the South Australian Lakes and Coorong Fishery.

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 1. Sustainable harvesting of fisheries resources</i>				
a. Fishing is conducted at a level that maintains ecologically viable stock levels and protects fish stocks from overfishing.	<ol style="list-style-type: none"> 1. Restrict total catch and effort in the fishery. 2. Restrict the number of commercial fishing licences in the fishery to no more than 37. 3. Restrict the fishing methods that may be used in the commercial and recreational sectors. 4. Restrict the amount of fishing gear that may be used in the commercial and recreational sectors. 5. Restrict commercial and recreational fishing in certain areas at certain times to protect key species during critical stages of their life cycle. 6. Restrict the minimum and/or maximum size at which fish may be captured. 7. Maintain a capacity for commercial fishers to transfer harvesting effort between species and between ecosystem components in the fishery, within and between years. 	<ol style="list-style-type: none"> 1. Total annual commercial catch for each key species. 2. Total annual commercial fishing effort level for each fishing method in each area of the fishery. 3. The total number of active commercial fishing licences operating in the fishery. 4. Total annual commercial catch per unit effort (CPUE) for each key species. 5. Annual commercial catch composition. 6. Age/size composition of key species populations. 7. Annual pre-recruit abundance of key species. 8. Estimated total annual recreational catch of key species. 	<p>PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA / In periodic stock assessment</p> <p>PIRSA / In periodic stock assessment</p> <p>PIRSA / In periodic recreational surveys.</p>	<ol style="list-style-type: none"> 1. The annual total commercial catch (all sectors) is above or below the upper or lower reference values for each key species.* 2. There is a greater than 25% change between years in the total target commercial fishing effort level for any fishing method in each area of the fishery. 3. Annual average commercial CPUE for each key species is above or below the upper or lower reference values.* 4. The rate of change in the annual total catch of each key species (over a three to four year period) is greater than (\pm) the reference value.* 5. The rate of change in the annual total average CPUE for each key species (over a three to four year period) is greater than (\pm) the reference value.*

* Biological reference points are provided in Appendix V

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 1. Sustainable harvesting of fisheries resources</i>				
a. Fishing is conducted at a level that maintains ecologically viable stock levels and protects fish stocks from overfishing.	<p>8. Develop fishing methods to minimise incidental mortality of undersized catches associated with commercial and recreational fishing operations.</p> <p>9. Develop management strategies to minimise incidental fishery interactions with undersized fish.</p> <p>10. Restrict the quantity of each species that may be harvested by the recreational sector using bag and boat limits and possession limits.</p> <p>11. Reduce latent effort in other South Australian commercial fisheries, which could threaten future sustainability of key species in the Lakes and Coorong Fishery.</p> <p>12. Exercise a precautionary approach to management, should serious or irreversible threats to fish stocks or the wider ecosystem become apparent – particularly during periods of extended drought.</p> <p>13. Develop a package of management measures to control the targeted harvest of black bream in relation to fresh water outflows.</p>	9. The level of latent effort in other South Australian commercial fisheries that impact on the Lakes and Coorong Fishery.	PIRSA Fisheries & Inland FMC / Annual	<p>6. There is a greater than 50% change over a four year period in the total commercial fishing effort level for any fishing method in each of the four areas of the fishery.</p> <p>7. A significant change in the species composition of the commercial catch between years.</p> <p>8. A significant reduction in the abundance of pre-recruits for key species.</p> <p>9. Latent effort levels in other South Australian commercial fisheries impacting on the Lakes and Coorong Fishery are not reduced below 2004 levels during the life of this Management Plan.</p> <p>10. Surveys indicate recreational catch and effort levels are higher than the levels identified in the 2001 National Recreational & Indigenous Fishing Survey (Henry and Lyle 2003).</p>

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 1. Sustainable harvesting of fisheries resources</i>				
b. Sufficient biological and environmental information is collected and analysed to make informed management decisions.	<p>1. Establish baseline biological information for all key species.</p> <p>2. Monitor the performance of key species populations, through the production of independent scientific stock assessment and status reports.</p> <p>3. Review and update the strategic research and monitoring strategy annually, to ensure that research programs address management priorities.</p> <p>4. Periodically review and update the information collected through commercial fishing logbooks.</p> <p>5. Develop an industry-based catch sampling program for all user groups - to collect biological information on key species.</p> <p>6. Explore the costs and benefits of developing a fishery-independent monitoring program.</p> <p>7. Explore options to monitor recreational catch and effort levels and implement data collection systems, when available.</p>	<p>3. Availability of baseline biological information for all key species.</p> <p>4. Production of stock assessment reports or status reports to inform management.</p> <p>5. Annual update of the strategic research and monitoring plan.</p> <p>6. Periodic review and update of the commercial logbook .</p> <p>7. Scope of industry-based catch sampling programs for all sectors.</p> <p>8. Scope of fishery-independent monitoring.</p> <p>9. Availability of information on recreational catch and effort.</p>	<p>Inland FMC & PIRSA / Annual</p> <p>Inland FMC & PIRSA / Annual, in line with strategic plan.</p> <p>Inland FMC / Annually updated</p> <p>Inland FMC, PIRSA Fisheries & PIRSA / At least every five years</p> <p>Inland FMC & PIRSA / Annual</p> <p>PIRSA & Inland FMC / Annual</p> <p>PIRSA / Annual</p>	<p>1. Baseline biological information is not available for all key species, in line with timeframes set out in the strategic research and monitoring plan.</p> <p>2. Stock assessment reports and status reports are not produced, in line with the strategic research and monitoring strategy</p> <p>3. Strategic research and monitoring strategy is not updated annually.</p>

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 1. Sustainable harvesting of fisheries resources</i>				
c. For fish stocks that are determined to be operating outside of established reference levels, the fishery will be managed to promote recovery to ecologically viable stock levels, within agreed timeframes.	<p>1. Undertake investigation of reasons for one or more reference value being reached.</p> <p>2. Where performance is considered to be unacceptable, review existing management strategies and develop and implement stock recovery plans for individual species, with established timeframes and targets for stock recovery.</p>	<p>1. A full investigation of the reasons why one or more reference value has been reached is undertaken immediately upon advice being formally provided to the FMC.</p> <p>2. A stock recovery plan is developed within 4 months, including proposed management actions, timeframes and targets for stock recovery.</p> <p>3. Rate of stock recovery, relative to established targets in recovery plan.</p>	<p>Inland FMC / Annual</p> <p>Inland FMC / Annual</p> <p>Inland FMC / Annual</p>	<p>1. Stock recovery rates do not meet the targets identified in the recovery plan.</p>

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 2. Optimum utilisation and equitable distribution of fisheries resources, within the constraints of sustainability imperatives</i>				
a. Maintain a flow of economic benefit from the fishery to the broader community through the wise use of Lakes and Coorong fisheries resources.	<p>3. Develop and implement arrangements that allow commercial operators to maximise operational flexibility and economic efficiency.</p> <p>4. Develop and implement arrangements that promote optimum utilisation and minimise waste.</p> <p>5. Maintain mechanisms to allow for autonomous fleet adjustment (eg. licence amalgamation scheme).</p> <p>6. Develop and implement methods to assess the economic benefits of alternative harvest strategies.</p> <p>7. Monitor interstate market prices for all key species.</p>	<p>4. Trend in Gross Value of Production (G.V.P) of the commercial fishery.</p> <p>5. Trend in market prices for key species.</p> <p>6. Trend in the average annual commercial licence value.</p> <p>7. Trend in annual return on investment in the commercial fishery.</p> <p>8. Trend in annual total economic impact of the commercial fishery.</p> <p>9. Trend in the number of commercial fishing licenses.</p> <p>10. Trend in the amount of commercial fishing gear available to the fishery.</p>	<p>PIRSA via Economic Survey / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA via Economic Survey / Annual</p> <p>PIRSA via Economic Survey / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA / Annual</p>	<p>1. A decreasing trend in annual return on investment over a three year period.</p>

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 2. Optimum utilisation of fisheries resources, within the constraints of sustainability imperatives</i>				
b. Maintain equitable public access and recreational fishing opportunities.	1. Ensure appropriate recreational bag and boat limits are in place. 2. Develop and implement a program to periodically monitor participation trends in the recreational sector. 3. Restrict commercial and recreational fishing at certain times, in certain areas. 4. Identify potential for conflict between marine resource users and develop strategies to reduce conflict. 5. Explore the development and implementation of methods to identify and address resource allocation disputes between user groups.	1. Scope of recreational access and recreational fishing opportunities. 2. Trend in recreational participation in the fishery. 3. Scope of policies aimed at addressing allocation disputes between user groups.	PIRSA, Inland FMC / Annual PIRSA & Inland FMC / Annual PIRSA & Inland FMC / Annual	
c. Provide opportunities for indigenous communities to access fish stocks for traditional purposes.	1. Allow teachers and students at 'Camp Coorong' to access fish stocks using traditional methods for educational purposes. 2. Develop and implement a longer term strategy to provide for indigenous communities to access fish stocks for traditional purposes. 3. Provide fisheries management advice in relation to resolution of native title claims.	1. Scope of traditional fishing activities. 2. Trend in traditional participation in the fishery.	PIRSA Fisheries / Annual PIRSA / Annual	

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 2. Optimum utilisation of fisheries resources, within the constraints of sustainability imperatives</i>				
d. Maintain equitable levels of commercial access and the regional development nature of the commercial fishery.	<p>1. Develop and implement methods to obtain information on the overall contribution to regional communities made by the commercial sector.</p> <p>2. Maintain management arrangements that promote owner-operations in the commercial sector.</p>	<p>1. Availability of baseline information on the overall contribution to regional communities made by the commercial fishery.</p> <p>2. Trend in the number of owner-operators in the commercial fishery.</p> <p>3. Trend in the total number of people employed in commercial fishing operations.</p>	<p>Inland FMC / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA via economic survey / Annual</p>	1. A decreasing trend in the total number of people employed in commercial fishing operations over a three year period.
e. Economic information exists to make informed management decisions.	<p>1. Undertake annual economic surveys of the commercial sector.</p> <p>2. Develop and implement methods to improve estimates of the total value of recreational fishing to regional economies and the wider community.</p>	<p>1. Availability of accurate and up to date economic data on the commercial sector.</p> <p>2. Participation rates in the annual economic survey process for the commercial fishery.</p> <p>3. Availability of estimates on the value of recreational fishing to regional economies and the wider community.</p>	<p>PIRSA & Inland FMC via economic surveys / Annual</p> <p>PIRSA via economic surveys / Annual</p> <p>PIRSA & Inland FMC / Annual</p>	

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 3. Impacts on the structure, productivity, function and biological diversity of the ecosystem are minimised</i>				
a. Minimise any external impacts on fish stocks associated with broader environmental or ecosystem health.	<p>1. Monitor external impacts on the fishery.</p> <p>2. Ensure that state and National water flow strategies take into account impacts on Lakes and Coorong fish stocks.</p> <p>3. Monitor net freshwater flow into South Australia and into the Coorong estuary (over the barrage network).</p> <p>4. Monitor the Status of the River Murray Mouth.</p> <p>5. Develop and implement strategies to improve the opportunity for natural fish passage.</p> <p>6. Improve coordination between Government agencies responsible for water flow management and natural resource management.</p> <p>7. Encourage adoption of the principles outlined in the commercial sector Environmental Management Plan.</p>	<p>1. Net freshwater flows into South Australia and into the Coorong estuary (over the barrage network).</p> <p>2. Status of River Murray Mouth opening.</p> <p>3. Capacity for natural fish passage through the barrage network and the River Murray Mouth.</p> <p>4. The level of coordination between the Government agencies responsible for water flow management and natural resource management.</p>	<p>PIRSA, in consultation with other relevant state agencies / Annual</p> <p>PIRSA, in consultation with other relevant state agencies / Annual</p> <p>PIRSA & The Inland FMC / Annual</p> <p>PIRSA / Annual</p>	<p>1. The annual net freshwater flow over the barrage network falls below 500GL/year for three consecutive years.</p> <p>2. The barrage network remains closed for a 12 month period.</p> <p>3. The River Murray Mouth opening becomes restricted to a point that is considered unsuitable for maintaining adequate fish passage or wider ecosystem health - in any given year.</p> <p>4. During the life of this plan, infrastructure changes do not take place to improve opportunities for natural fish passage.</p>

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 3. Impacts on the structure, productivity, function and biological diversity of the ecosystem are minimised</i>				
b. Minimise fishery impacts on bycatch species and the ecosystem.	<p>1. Quantify the impact of fishing operations on bycatch species through targeted research projects.</p> <p>2. Improve data recording systems to capture baseline information on bycatch species interactions and bycatch species catch composition.</p> <p>3. Undertake a risk analysis to assess the vulnerability of bycatch species to fishing operations.</p> <p>4. Develop and implement a bycatch action plan for the fishery.</p> <p>5. Introduce measures to restrict the catch and mortality of bycatch species.</p> <p>6. Develop and implement methods to reduce the environmental impact of certain gear types.</p> <p>7. Encourage and support the uptake of the commercial and recreational industry Codes of Practice.</p>	<p>1. Availability of data to undertake analysis of impacts of fishing operations on bycatch (non-retained) species populations.</p> <p>2. Availability of risk analysis to assess the vulnerability of bycatch (non-retained) species to fishing operations.</p> <p>3. Trend in the relationship between the catch of retained and non-retained (bycatch) species.</p> <p>4. Implementation of a bycatch action plan for the fishery.</p>	<p>Inland FMC & PIRSA / Annual</p> <p>Inland FMC & PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>Inland FMC / PIRSA / By 2006</p>	<p>2. The amount of bycatch (discards) in commercial mesh net fishing operations, relative to the total catch of retained species is greater than 20% (in weight) in any given year.**</p> <p>3. An increasing trend in discard rates in the commercial or recreational fishing sectors over a three year period.</p>

** This reference point will be reviewed following the completion of the risk assessment and by-catch study

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 3. Impacts on the structure, productivity, function and biological diversity of the ecosystem are minimised</i>				
c. Avoid the incidental mortality of endangered, threatened and protected species.	<p>1. Quantify the impact of fishing operations on endangered, threatened and protected species through targeted research projects.</p> <p>2. Improve data recording systems to collect baseline information on fishery interactions with endangered, threatened and protected species.</p> <p>3. Undertake a risk analysis to assess the vulnerability of endangered, threatened and protected species to fishing operations.</p> <p>4. Develop and implement measures to avoid the catch and mortality of endangered, threatened and protected species.</p> <p>5. Promote the uptake of the commercial and recreational sector codes of practice.</p>	<p>1. Availability of baseline data to undertake an analysis of the fishing related impacts on endangered, threatened and protected species.</p> <p>2. Availability of risk analysis to assess the vulnerability of endangered, threatened and protected species to fishing operations.</p> <p>3. Annual trend in the level of interaction between fishing operations and endangered, threatened and protected species.</p>	<p>Inland FMC & PIRSA / Annual</p> <p>Inland FMC & PIRSA / Annual</p> <p>PIRSA / Annual</p>	<p>1. An increasing trend in the level of interaction between fishing operations and endangered, threatened and protected species over a three year period.</p>

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 3. Impacts on the structure, productivity, function and biological diversity of the ecosystem are minimised</i>				
d.Reduce the population size and ecological impact of non-native fish species.	1.Monitor non-native species population levels through commercial catch statistics. 2.Develop and implement strategies to eradicate or control non-native species populations. 3.Continue to support controlled commercial harvesting of non-native species, as part of a broader control system. 4.Continue to support national initiatives aimed at developing effective control and eradication methods for non-native species populations. 5.Promote market/product development for non-native species.	1.Trend in non-native species relative population size. 2.The scope of strategies developed to address non-native species ecological impacts. 3.Trend in commercial catch levels of non-native species. 4.Progress of national initiatives aimed at developing effective non-native species control mechanisms.	PIRSA / Annual Inland FMC / Annual PIRSA / Annual PIRSA / Annual	1.An increasing trend in non-native species population levels.

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 4. Cost-effective and participative governance of the fishery</i>				
<p>b. Have regard to the range of social, cultural and wider community values attached to the fishery.</p>	<p>1. Promote stakeholder involvement in the management of the fishery, through established co-management processes.</p> <p>2. Ensure that social and cultural issues are given appropriate consideration when developing new management strategies.</p> <p>3. Provide an information service to the public and communicate management developments to the wider community.</p>	<p>1. Fisheries Management Committee membership reflects the stakeholder interests in the fishery.</p> <p>2. Scope of stakeholder involvement and community consultation in the development of new management strategies.</p> <p>3. Scope of information available to the public on the management of the fishery.</p>	<p>Inland FMC and PIRSA Fisheries / Annual</p> <p>Inland FMC and PIRSA Fisheries / Annual</p> <p>Inland FMC and PIRSA Fisheries / Annual</p>	

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
<i>Goal 4. Cost-effective and participative governance of the fishery</i>				
c. Promote compliance with management controls.	<ol style="list-style-type: none"> 1. Undertake annual compliance risk assessment. 2. Implement a cost-effective compliance and monitoring program to address identified risks. 3. Develop and implement methods to quantify illegal catch levels. 4. Promote high levels of stakeholder stewardship through established management processes and Fishwatch activities. 5. Increase public awareness on the management of the fishery. 6. Encourage the community to report fisheries offences to Fishwatch. 7. Conduct a review of existing regulations and commercial licence conditions. 	<ol style="list-style-type: none"> 1. Risk Assessment is updated annually to take account of changes in the risk profile for the fishery. 2. Trend in the number of compliance checks undertaken by Fishwatch each year. 3. Trend in the number of reports of illegal activity, relative to the number of compliance actions each year (eg. expiations, formal briefs, cautions etc). 4. Trend in the number of Fishwatch reports each year. 	<p>PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA / Annual</p> <p>PIRSA Fishwatch / Annual</p>	<ol style="list-style-type: none"> 1. Increasing trend in the level of illegal activity detected in the fishery over a three year period.

3.2 Operation of the Management Plan

The plan will operate for a five year period from 2005 to 2010 inclusive, subject to annual review and amendments that are considered necessary by the Inland FMC, the Director of Fisheries or the Minister for Agriculture, Food and Fisheries. The Inland FMC will use the management plan to guide annual processes for providing advice to the Minister and Director of Fisheries on management and research for the fishery. The Inland FMC will use the reporting framework established in the harvest strategy to prepare an annual report on the performance of the fishery against all performance indicators and reference points. An annual stock status report will provide the basis for this annual assessment of fishery performance. All stock assessment reports for individual species will address the key performance indicators outlined in the management plan. This process has been designed to deliver improved public accountability on the management of the fishery.

3.3 Review of the Management Plan

The management plan will be periodically reviewed and improved over time as major advances in knowledge are made. In 2010, PIRSA Fisheries will undertake a major review of the management plan, including the strategic research and monitoring plan, in association with the Inland FMC and key stakeholders.

It is important to note that PIRSA is currently undertaking a comprehensive review of the *Fisheries Act 1982*, in consultation with key stakeholder groups and the broader community. This review is likely to result in significant changes to the broad sustainability framework established for administering and managing South Australia's fisheries resources. If necessary, the management plan will be updated to make it consistent with the requirements of the new legislation.

3.4 Consultation and co-management

Section 46 of the Fisheries Act establishes a set of regulation-making powers to formalise a co-management process for fisheries management in South Australia. The *Fisheries (Management Committees) Regulations 1995* outline a set of co-management principles and establish a number of Fisheries Management Committees (FMCs) for key fisheries or groups of fisheries, including the Inland FMC. The Fisheries Act requires that the Minister, the Director of Fisheries and the FMCs to operate in accordance with the principal objectives outlined in the Fisheries Act.

The Inland FMC provides the principle forum for stakeholder consideration of fisheries management and research issues relevant to the inland fisheries of South Australia.. FMCs are designed to assist the Minister, the Director of Fisheries and fishery managers in the administration of the Fisheries Act, consistent with the objectives of the Fisheries Act and the designated management plans for each fishery. The regulations prescribe the advisory role and function of all FMCs. The Fisheries Act also provides a capacity for the Minister or the Director of Fisheries to delegate decision-making functions to an FMC.

The role and function of FMCs has evolved over time. Membership of the Inland FMC consists of a Government fisheries manager, a Government scientist, commercial fishers and recreational fishers, appointed by the Minister. An independent Chairperson is appointed by the Minister to facilitate meetings. A committee support officer provides secretarial support to the committees. The Minister appoints non-Government members of the committee after calling for applications from relevant parties and interest groups and undergoing a transparent selection process involving relevant stakeholder representation.

The FMC regulations assign responsibility for the preparation of management plans to individual FMCs. The necessary tasks required to complete management plans are undertaken by PIRSA Fisheries. Key stakeholder and community input to the development of management arrangements and strategic research and monitoring priorities for the Lakes and Coorong Fishery are facilitated through the Inland FMC process and during public consultation on draft management plans.

A review of the Fisheries Act is currently being undertaken which may result in changes to broader FMC membership structure and operation. In the interim, agreement has been reached to broaden the membership of the Inland FMC to more accurately reflect stakeholder group interests and move towards a more community-based approach to management. This involves participation by members of the indigenous community and non-Government conservation groups. Increased participation of representatives from the South Australian Department of Environment and Heritage (National Parks) through FMC processes has started to more closely link natural resource management decision-making across Government agencies.

The Inland FMC is required to produce an annual report to the Minister and to hold a public meeting each year to provide an opportunity for the FMC to publicly report on its yearly activities and allow for members of the broader community to discuss relevant issues with FMC members. Observers are welcome to attend meetings, with agreement from the chairperson. The operating costs of the Inland FMC are currently funded through a combination of fees paid by commercial fishery licence holders and Government funds. The Inland FMC meets approximately four to six times per year.

The Fisheries Act requires the Minister or a delegate to consult with licence holders who may be adversely affected by a change to licence conditions, in particular the removal of a species or gear entitlement from a commercial fishing licence. No formal requirements currently exist in the Fisheries Act to consult with the broader community concerning fisheries management decision-making. However, as a matter of policy PIRSA Fisheries consults with key stakeholder groups and the broader community through public comment processes when significant management changes or developments are being considered. For example, all Fisheries Management Plans undergo a public consultation process. Formal community consultation and accountability provisions are being considered as part of the Fisheries Act review process.

All new fishing regulations or Fisheries Act amendments are subject to the disallowance provisions set out under the *Subordinate Legislation Act 1978* and as such can be disallowed by either house of parliament. New regulations or Fisheries Act amendments are also scrutinised by the parliamentary legislative review committee.

The South Australian Government has management jurisdiction for the full suite of species taken in the Lakes and Coorong Fishery. The one exception to this is school and gummy shark. The Australian Fisheries Management Authority (AFMA) has primary responsibility for the management of school and gummy shark under an Offshore Constitutional Settlement (OCS) agreement between the South Australian and Commonwealth governments. However, bycatch trip limits apply to authorised state-based fishers.

4. ECOLOGICAL ASSESSMENT

The *Guidelines for the Ecologically Sustainable Management of Fisheries* (the Guidelines) consist of two overarching principles and a series of objectives. They require that data collection, assessment and management of responses in place for target species, by-product, bycatch and the broader environment are adequate to demonstrate that a commercial fishery is

managed in an ecologically sustainable manner. The Guidelines are addressed below in relation to the Lakes and Coorong Fishery.

Principle 1:

A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks that are overfished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover.

Objective 1:

The fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability.

Information requirements

Guideline 1.1.1:

There is a reliable information collection system in place appropriate to the scale of the fishery. The level of data collection should be based upon an appropriate mix of fishery independent and dependent research and monitoring.

Strategic Research and Monitoring Plan

The Lakes and Coorong Fishery can be classified as a data poor fishery, with only limited quantitative information available to managers during annual decision-making processes. A strategic research and monitoring plan has been developed as part of the fishery management plan. The primary focus of the strategic research and monitoring plan (refer to Appendix C) is to increase the amount of quantitative information available for management of the fishery. This plan aims to ensure that all research and stock assessment undertaken in the Lakes and Coorong Fishery is carried out to address established management priorities and information gaps.

The annual process undertaken by the Inland FMC to direct research at priority areas for the fishery has been developed as part of the strategic research and monitoring plan and is outlined in Figure 11.

There are significant gaps in the information concerning basic biological parameters for many of the key species in the Lakes and Coorong Fishery. Research must be directed at addressing these information gaps to underpin reliable quantitative stock assessment and future management decision-making. The strategic research and monitoring plan has identified biological research priorities for each priority species in the fishery (refer to Appendix C).

The fishery-wide research priorities are also listed in the strategic research and monitoring plan and are aimed at addressing fishery-wide issues over the life of the Management Plan. These priorities will be updated annually by the Inland Fisheries Management Committee to address emerging issues and changing priorities.

The collection systems for fishery dependent and independent data have been summarised below:

Fishery Dependent Information

Commercial catch and effort log books

The primary source of data used to underpin all stock assessment work is fishery-dependent. At this stage, this approach is considered appropriate, given the scale of the fishery and its stage of development. The collection of fishery-dependent data is facilitated by a commercial logbook program, which requires all commercial fishers to compulsorily record daily information on catch and effort levels and other details on daily fishing operations. This information is submitted monthly and entered into a database, which is managed by SARDI Aquatic Sciences. SARDI fisheries statistics staff carry out data validation by querying catch, effort and fishing block information.

A copy of the inland waters catch and effort return is at Appendix B. These forms have been in place since 1984/85. Prior to this, licence holders were required to complete general fishery catch and effort forms as far back as 1976/77.

Information collected through the logbook program is periodically reviewed to ensure data collection meets management and research needs. The common unit of effort currently used to measure CPUE in the fishery is a fisher day. This broad unit of effort will be refined during the life of the Management Plan to improve CPUE estimates.

Because of the inherent limitations associated with fishery-dependent data sets, it is recognised that the information required to generate accurate estimates of some fishery performance indicators may require additional fishery-independent data. It is also recognised that it may be necessary for fishery-dependent data sets to be periodically validated by independent means to ensure accuracy of the data collected. The strategic research plan included in Appendix C establishes a process to evaluate the costs and benefits of a fishery-independent monitoring program for the fishery.

As part of the FRDC funded research project “Gear interaction of non-targeted species in the Lakes and Coorong commercial and recreational fisheries of SA”, to be conducted during 2005–07, the existing catch and effort data from the commercial fishery in the Coorong lagoons by gear type and targeted species will be reviewed and analysed to delineate spatial temporal and gear related differences in catch composition. As part of this project, onboard catch sampling will be conducted from commercial vessels operating in the Coorong lagoons and will include both retained and non-retained species. Refer to Appendix F for further information on this research project.

Figure 7 shows a component tree for the retained species in the commercial sector of the Lakes and Coorong Fishery, including target and by-product species.

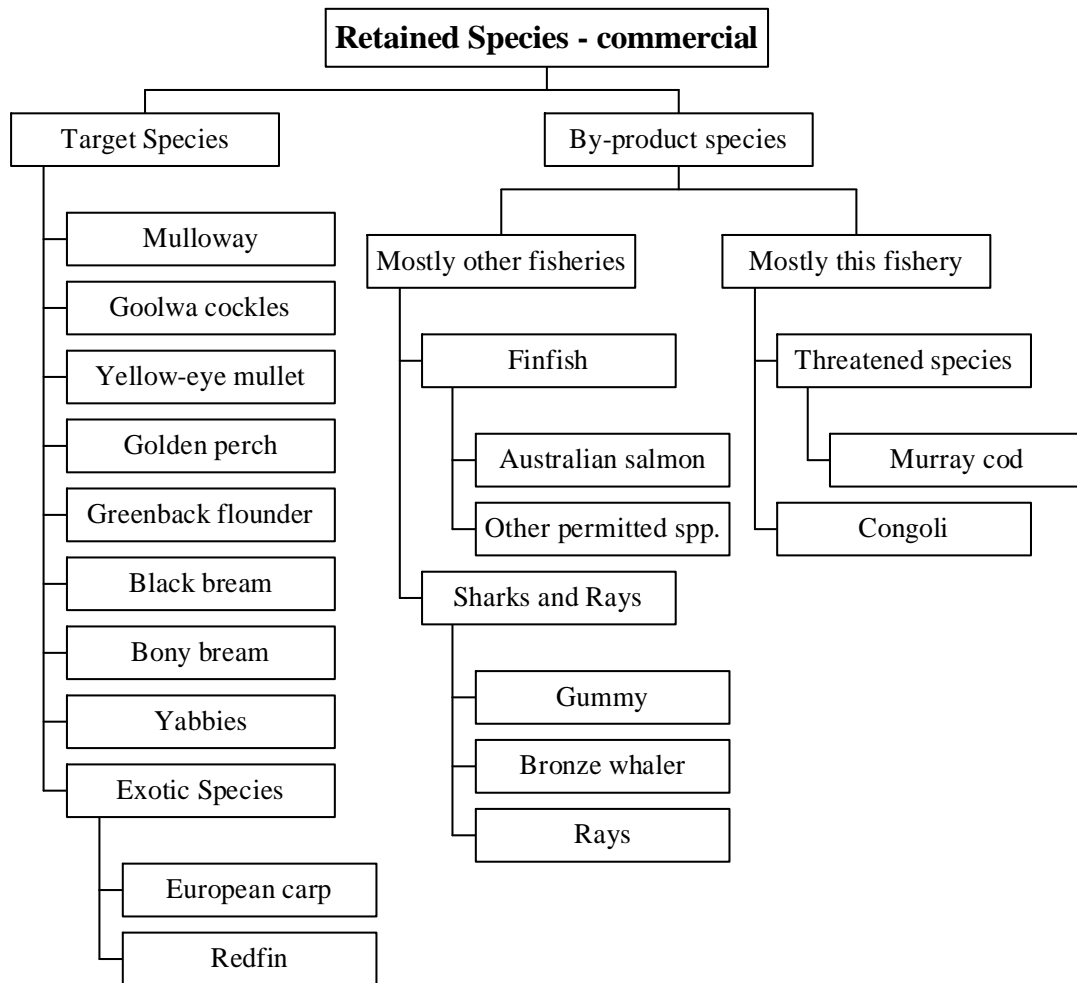


Figure 7: Retained species in the commercial sector of the Lakes and Coorong Fishery

Since 1968, some fish measuring and age determination programs have been in place to collect information on size and age structure of the commercially fished component of several species caught in the Lakes and Coorong Fishery. These studies are summarised below:

Table 5: Sampling programs for size and age information on Lakes and Coorong Fishery species

Sampling period	Species measured /aged	Region	Reference
1966	Yellow-eye mullet	Coorong Lagoons	Harris, 1968
1968/9	Black bream	Coorong Lagoons	Weng, 1971
1982-84	Mulloway Yellow-eye mullet Greenback flounder Black bream	Ocean Beach, Coorong Lagoons	Hall, 1984
2002 - ongoing	Mulloway	Coorong Lagoons, Ocean Beach	Ferguson and Ward, 2003
2003 - ongoing	Golden perch	Lakes	Ye, 2005

Mulloway (Coorong lagoon and ocean beach fisheries)

In 1982 - 84, monitoring of size and age composition of the commercial catch was undertaken through a fish measuring and scale collection programme at the Adelaide Fish Market. However, the information was inconclusive due to gear selectivity, spatial variation in age composition and fishing effort and low sample sizes (Hall, 1986).

Since October 2001, size compositions of mulloway, derived from the commercial fishery in the Coorong lagoon and the ocean beach fisheries have been monitored directly from fishers operating in those areas, and from the Adelaide Fish market (Ferguson and Ward, 2003). Also, some information on size composition of mulloway caught by recreational line fishers in the Coorong Lagoon and Beaches, combined have become available from the National Recreational and Indigenous Fishing Survey in 2000/01. Both sets of information have been incorporated into the most recent fishery assessment report (Ferguson and Ward, 2003).

Black bream (Coorong lagoon fishery)

A number of fish measuring programs have been undertaken on black bream from the Coorong Lagoon. Weng (1971) regularly collected data on the size and age compositions of black bream from the SA commercial fishery in 1969-70, which at the time was believed to mainly take place in the Coorong Estuary / Lagoon. Fish sampled from the fishery ranged in size from 26 – 38 cm LCF, with a mode at 32 cm LCF. Fish were aged using both scales and otoliths (97 % agreement), resulting in the observation of 3 relatively strong year classes occurring in the commercial catch. The age groups represented 3, 6 and 9 year old fish, which can be related to the 1967, 63 and 59 year classes.

Hall (1984) collected information on the monthly and annual size composition of commercially harvested black bream between November 1982 – September 1983, prior to the increase in minimum size limit from 25 to 28 cm TL in the late 1980's. Although, size distribution of harvested fish was wide during this period (250 – 410 mm, TL), the bulk of the fish sampled occupied a relatively narrow size range (270 – 320 mm), possibly belonging to one age group (see Hall, 1984).

Geddes (2005) collected size and age composition of black bream caught by commercial fishers in the Coorong Lagoon in a number of months during 2002, 3 and 4, suggesting that the fishery over that period was highly dependent on the 1998 year class. Fish up to 23 years of age were detected, however, a large proportion of the harvest consisted of the 1998 year class (3, 4 and 5 yrs of age, respectively in 2002, 2003 and 2004).

Yellow-eye mullet (Coorong lagoon fishery)

Two significant monitoring programs on commercially caught yellow eye mullet have been undertaken in the past (196? : Harris, 1968; and 1982 – 83; Hall (1984). Both fish measuring programs occurred at the Adelaide Fish Market. Pellizzari (2001) collected limited information on the size and age composition of *A. forsteri* from the Coorong lagoon fishery for the month of February, 2001; however, that program was not aimed at collecting information on the size and age structure of the fished component of the mullet stock in the lagoon.

Golden perch (lakes fishery)

Since 2002, with the assistance of commercial fishers, golden perch harvested in the lakes fishery have been regularly sampled for size frequencies, and otoliths collected for age determination. Information will be used for determination of age structure of the commercial harvest (Ye, 2004), and provided in the stock assessment reports for this species.

Fishery Independent Data

Goolwa cockles

Between Jan, 1973 and Dec, 1974, a fishery-independent sampling program on Goolwa cockles was undertaken monthly along the Coorong Beach, specifically investigating the growth, and reproductive biology of the species (King, 1976). By temporally following the modes of the population size distributions and their reproductive stages, King reported that *P. deltoides* became reproductively mature at 36 mm (13 months of age), and there followed two adult age groups. Their maximum size of 60 mm in this region was reached after about 3 years of age. Although reproductive activity occurred throughout the year, peaks in spawning activity occurred in September – October in the two years of study. There appeared to be high variability in settlement time, growth, and abundance between the two years of the study.

Inter-annual variation in relative abundance was also observed in another fishery-independent opportunistic sampling program during 1992, 1997 and 1998 (Murray-Jones and Johnson, 2003); however, both studies have highlighted a high degree of uncertainty in using such surveys for monitoring annual variation in abundance of the cockle population along the Coorong beach, without a greater understanding of a) their movements up and down the beach with tides, and, b) the high degree of patchiness in their distribution along the beach.

Mulloway

Pre-recruit surveys: Between January and March 1985, Hall used beach-seine nets (5 cm mesh) in the Coorong lagoon to successfully sample 1 and 2 year old mulloway, demonstrating that this gear type may be a suitable one for ongoing pre-recruit surveys for this species (Hall, 1986).

Movement of juvenile and sub-adult mulloway: Between 1981 and 1985, Hall (1986) tagged six thousand 1 and 2 year old mulloway in the Coorong lagoon, adjacent to the barrages (Mundoo Channel and Ewe Island). Very small numbers of fish were recaptured. Up to one year later, some mulloway were caught within the northern part of the lagoon, during summer months; however, thereafter, a significant number of the recaptured tagged fish were reported outside the Coorong, either in eastern Gulf St. Vincent or the south-east of SA during winter months (Hall, 1986).

In 2001/02, Ferguson deployed multi-panel gill nets (40, 50, 70, 113 and 153 mm stretched mesh) in the Coorong lagoon for the purpose of fishery-independent mesh selectivity trials on

the mulloway population in this area. This work demonstrated that small mulloway < 30cm were present in the Coorong lagoons in all months. The size distributions of mulloway taken from 51, 64, 89 and 102 mm monofilament nets were described by Hall (1986). Ferguson and Ward (2003) described size distributions for mesh sizes 50 and 70 mm. All distributions showed that the mesh nets were highly size selective.

Monthly monitoring of the reproductive biology was also undertaken from the fishery independent multi-panel net sampling in the Coorong lagoons, as well as from the swinger-net fishery along the ocean beach between October 2001 to March, 2001. No sexually mature fish were reported from the fish sampled within the Lagoon. For the fish sampled from the ocean beach, few data were available in the size range 650 – 800 mm TL, hence, size at maturity (L50) was not estimated at that stage.

Several attempts to understand the relationship between freshwater flow from the River Murray into the Coorong lagoon and the ocean beach ecosystems and the catch and effort have been attempted for mulloway (Hall, 1986; Ferguson and Ward, 2003). Hall (1986) found a weak positive correlation between commercial mulloway catch (1951 – 84) and the flow of water through Lock 1 on the River Murray, (with a 2 year lag); however, a significant positive correlation existed between water flow through the barrage and the Coorong mulloway catch (1976 – 85), also two years later. Ferguson and Ward investigated the link between barrage flow and the mulloway fishery by correlating monthly barrage flow rates with the monthly mulloway harvest and CPUE's from both the commercial gill net fishery in the Coorong Lagoon and the swinger net fishery along the Coorong Ocean Beach between 1984 – 2003 (Ferguson and Ward, 2003). Both flows and catches exhibited similar seasonality. For the mulloway in the Coorong Lagoon, and with fish fully recruited to that fishery after 5 years, the highest lagged correlation at 63 months implies that, "following a freshwater flow, catches remain high for three years until exploitation or migration result in fish leaving the lagoon " (Ferguson and Ward, 2003). For the swinger net fishery, highest correlations occurred without any time lag, suggesting that adult mulloway were attracted to the freshwater flow. These trends will be investigated further and validated with data from age structures of mulloway.

Black bream

Between January, 1969 and April, 1970, Weng (1971) independently sampled black bream in the Goolwa Channel using a 3.2 cm net of 60 m length and 2.5 m depth. The sizes of fish ranged between 12 and 29 cm LCF, with a number of size modes observed at 15, 21 and 27 cm LCF. The fish were not aged, so it was not known whether these modes represented age groups.

Attempts to sample juvenile black bream in Nov, 2003 and Jan, 2004 using a wide range of research gear types in the Coorong Lagoon proved to be unsuccessful (Geddes, 2005), however, as key nursery areas in this area have not been identified, and further research is necessary before fishery independent surveys can be developed to monitor pre-recruit indices.

To determine movements of Black Bream in the Coorong, Hall (1984) tagged over 1,300 fish in 1982-83 within the Lagoon. All recaptures (7.4%) occurred within the Murray Mouth; however, smaller-scale tagging voluntary tagging projects in the late 1970's reported one bream tagged in the Coorong Lagoon, was re-captured in an adjacent estuary (Hindmarsh) (see Hall, 1984).

Yellow-eye mullet

The early life history of yellow-eye mullet in The Coorong Lagoon, mainly adjacent to the Murray Mouth was investigated by Pelizzari (2002). By counting and backdating the daily

rings laid down on the otoliths of newly settled juveniles, Pelizarri identified spawning dates and settlement patterns of juvenile fish sampled with small mesh beach seine nets. Spawning activity was identified as occurring throughout the year, but with summer and winter peaks; however, it was not possible to identify the relative levels of reproductive activity inside and outside the Coorong. This contrasts with Harris' (1968) conclusion that yellow-eye mullet caught in the Coorong Lagoon were essentially summer spawners.

Recreational catch and effort

Three sets of data are available on recreational fishing participation and catch and effort levels in the lakes and Coorong lagoons, and Coorong beach and are summarised below:

Table 6: Sampling programs for recreational fishing in the Lakes and Coorong region

Sampling Period	Region Studied	Type of study	Reference
March, 1982 – March 1983	Lakes & Coorong, Ocean Beach (Kingston – Newland Head)	Recreational fishing participation / quarter during 1982 – 83.	Philipson et al, 1986
1995 - onwards	Lakes and Coorong Lagoon	Annual number of recreational net registrations	Higham et al, 2004
May, 2000 – April, 2001	Lakes, Coorong Lagoon, Ocean Beach (Goolwa Beach – Kingston)	National Recreational Fishing Survey – participation, catch and effort on target species, by gear type. (Separated for Lakes, Coorong Lagoon and Ocean Beach).	Henry and Lyle, 2003; Jones and Doonan, 2005

The National Recreational and Indigenous Fishing Survey (NRIFS) was undertaken during May 2000 – April 2001. Prior to this, no accurate estimates of the size of harvest or fishing effort applied by recreational fishers specifically to the lakes and Coorong area were available (Henry and Lyle, 2003). Regional data from the NRIFS can now be used to distinguish the catch and effort by major gear types, between the lakes, Coorong lagoon and the Coorong beach. These regional sets of data have and are currently being incorporated into the stock assessment reports for mulloway (Ferguson and Ward, 2003), yellow-eye mullet (Higham et al, 2004) and Golden Perch (Ye, 2004). The annual catch (harvest and released numbers) of the major species and associated target and non-target effort for the lakes, Coorong lagoon and Coorong beach are provided in Jones and Doonan, 2005.

From the NRIFS, Jones and Doonan (2005) have also provided data on the release rates (numbers released as a percentage of the total catch), for several of the key species, (mulloway, golden perch, mullet (yellow-eye and unspecified species) and Goolwa cockles) and the by-product species (Australian salmon and whaler sharks) for the three regions of the Lakes and Coorong Fishery.

All data available on recreational catch and effort levels will be taken into account when assessing the performance of the fishery through stock assessment. In the absence of other survey data, the data provided by the National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) will be used as the main source of information on catch and effort levels in the recreational sector. Development of cost-effective methods to continue the collection of accurate recreational catch and effort data is identified as a priority in the strategic research plan.

Assessment

Guideline 1.1.2:

There is a robust assessment of the dynamics and status of the species/fishery and periodic review of the process and the data collected. Assessment should include a process to identify any reduction in biological diversity and/or reproductive capacity. Review should take place at regular intervals but at least every three years.³

History of Assessment and Review

Goolwa cockles

Year of assessment	Type of assessment	Reference
1976	Fishery biology of Goolwa cockles along the Coorong beach, fishery independent survey of size composition of stock, reproductive biology.	King, 1976
1999	Commercial catch and effort trends to 1997/98. CPUE relatively poor indicator of stock abundance. Stock fully exploited.	Pierce and Doonan, 1999
2003	Review biology of species. Analysis of commercial catch, effort and CPUE data from L&CF and MSF fisheries to 2001/02.	Murray-Jones and Johnson, 2003
2000/01	NRIFS survey, harvested and released numbers of Goolwa cockles harvested by recreational fishers during May, 2000 – April, 2001.	Jones and Doonan, 2005

Mulloway

Year of assessment	Type of assessment	Reference
1976 – 85.	a) Fishery biology of mulloway in Coorong area, b) commercial catch, effort, CPUE trend analyses lagged with river flow through barrages. c) yield per recruit model to assess optimum size limits.	Hall, 1986
1984/85 – 1997/98	Commercial catch, effort trends.	Pierce and Doonan, 1999
1984/85 – 2001/02	Update fishery biology of mulloway, Commercial catch, effort and CPUE trend analyses by gear type and lag correlated with river flow through barrages. Preliminary information on recreational harvest.	Ferguson and Ward, 2003
2000/01	NRIFS survey	Jones and Doonan, 2005

³ Review should be undertaken by the relevant management authority in a transparent way

Yellow-eye mullet

Year of assessment	Type of assessment	Reference
1960	Commercial catch trend, Fishery biology of mullet in Coorong	Harris 1968
1975/76 – 1984/85	Review fishery biology of yellow-eye mullet in Coorong, Catch, effort and CPUE trend analyses.	Hall, 1984
1984/84 – 1997/98	Commercial catch, effort trend in Coorong fishery	Pierce and Doonan, 1999
1984/85 – 2002/03	Coorong fishery assessment. Review of fishery biology. Commercial catch, effort and CPUE trend analyses. Recreational catch, effort and CPUE for 2000/01.	Higham et al, (2004).
2000/01	NRIFS	Jones and Doonan, 2005

Greenback flounder

Year of assessment	Type of assessment	Reference
1985	Review of fishery biology, Coorong commercial catch and effort trend analyses	Hall, 1984
1984/85 – 97/98	Coorong commercial catch, effort trends	Pierce and Doonan, 1999

Black bream

Year of assessment	Type of assessment	Reference
1971	Fishery biology of black bream in Coorong	Weng (1971)
1985	Review of fishery biology, Coorong commercial catch and effort trend analyses	Hall, 1984
1984/85 – 97/98	Coorong commercial catch, effort trends	Pierce and Doonan, 1999

Overall fishery

Year of assessment	Type of assessment	Reference
1846 – 1983/84	Review of history of commercial harvest in the L&CF fishery pre- and post barrages	Olsen (1991)
1984/85 – 1997/98	Review of commercial catch and effort by gear type	Pierce and Doonan, 1999
1984/85 – 2002/03	Review of fishery in Management Plan	Sloan 2005

Where available, some fishery-independent and recreational fishery data have and are being incorporated into stock assessments (eg see Ferguson and Ward, 2003; Higham et al, 2004).

Stock Assessment and Stock Status Reporting

A fundamental requirement for the sustainable management of fish populations is knowledge of the basic biological and ecological parameters of fish stocks. This fundamental information must be available in order to assess the status of fish stocks and also to evaluate the costs and benefits of alternative fisheries management strategies. A key priority for management of the Lakes and Coorong Fishery is the establishment of baseline information on the status of all commercially and recreationally exploited fish stocks.

The strategic research and monitoring program (Appendix C) outlines the current staged approach to establishing stock assessment and stock status information for all commercially and recreationally important species in the Lakes and Coorong Fishery. Species to which a high priority has been assigned will have a full stock assessment report produced at least every two to three years. Lower priority species will have a full stock assessment report produced every three years.

In years when full stock assessment reports are not produced, stock status reports will be produced. These status reports will provide a brief assessment of fish stocks, as measured by stock performance against established management objectives and reference values outlined in this Management Plan.

The Inland FMC will use the reporting framework established in the harvest strategy to prepare an annual report on the performance of the fishery against all performance indicators and reference points. An annual stock status report will provide the basis for this annual assessment of fishery performance. All stock assessment reports will provide a full literature review and comprehensively analyse the status of fish stocks, as measured by performance against established management objectives and reference values outlined in the Management Plan. This process has been designed to deliver improved public accountability on the management of the fishery.

Estimates of the fishable biomass and the current proportion of that biomass being harvested are unknown for all target species in this fishery. Therefore, the potential productivities of these species can, at the moment, only be determined on the trends in the commercial CPUEs, coupled with some key environmental indicators such as trends in flow rates through the barrages and/or the Murray Mouth. Table 7 summarises the current understanding on the status of the key species, based on their most recent stock assessments.

Table 7: Status of Key Species in the Lakes and Coorong Fishery

Species	Status	Reference
Goolwa cockles	Fully exploited (precautionary, as assessment was fishery-dependent, only).	Murray-Jones and Johnson, 2003
Mulloway	Current fishing practices and levels of harvest appear sustainable under current (2002/03) flow conditions; however, continued extraction of water from the River Murray could alter this condition.	Ferguson and Ward, 2003
Yellow-eye mullet	All fishery performance indicators are within or positively outside the fishery reference points.	Higham et al, (2004)
Flounder	Unknown status, however, due to un-natural outflow management during spawning period, production potential is currently reduced.	Pierce and Doonan, (1999)
Black Bream	Fully exploited. Reduced production capacity due to flow management not coordinated with spawning period for this species.	Pierce and Doonan, (1999)
Golden Perch	Fully exploited, recent decline in commercial harvest, however, CPUE's have remained higher	Ye (2004)

Guideline 1.1.3:**The distribution and spatial structure of the stock(s) has been established and factored into management responses.**

A series of biological reference points have been established for key performance indicators to enable managers to determine whether fishery performance is sustainable (refer to Table 4 on page 29 and Guideline 1.1.6 on page 60 for further information). The reference points have been designed to provide clear guidance to management decision-making processes by defining how performance indicator estimates should be interpreted. More meaningful and robust performance measures will be developed over time, as the population dynamics of each species and their relationship to environmental conditions becomes better understood.

Target species**Mulloway**

Mulloway are distributed throughout southern Australia; however, there is currently only a limited understanding of stock structure for the species (Ferguson and Ward, 2003). In the absence of reliable quantitative scientific data to support an alternative stock hypothesis, the SA mulloway population is managed using a precautionary approach as a self-recruiting population, with recruitment considered to be dependent upon local spawning within SA waters. An unknown proportion of the mulloway population occurs in waters, which are accessible only to Commonwealth operators (Gillnet, Hook and Trap Sector of the Southern and Eastern Scalefish and Shark Fishery). A mulloway trip limit of 100 kg has been set for Commonwealth operators.

Black bream

This southern Australian sparid is, by definition, an estuary-dependent species (Jones et al, 1996). Some mixing of bream populations occurs between adjacent estuaries; however, with greater distance between estuaries, black bream populations become more genetically distinct (Coutin *et al*, 2003). Results from tagging experiments on black bream in the Coorong Lagoon between 1979 and 1983 confirm this hypothesis, as there was extremely limited movement of fish out of the estuary (Hall, 1984). Therefore, for the purposes of management, the black bream population occurring in the Lakes and Coorong Fishery is regarded as a single self recruiting population (Leigh, 2004: Barrage releases workshop, 15 May 2004).

Yellow-eye mullet

Populations of yellow-eye mullet inhabit sheltered bays and coastal beaches throughout southern Australia (WA through to sthn NSW and Tas), as well as NZ. Two genetically distinct populations occur between the western and eastern seaboard of Australia, based on morphometric studies as well as temporal differences in spawning activity (Thomson, 1957). The population occurring in waters associated with this fishery has some characteristics of the eastern population (summer spawning; Harris, 1962), however, other more recent morphometric studies suggest fish in this region are more closely associated with the western population (Pellizzari, 2001; Higham et al, 2004).

Goolwa cockles

Populations of Goolwa cockles are distributed throughout Australia on high energy beaches (Murray-Jones and Johnson, 2003); however, the number of genetically distinct populations throughout its range have not been investigated. Murray-Jones and Ayre (1997) found no

genetic differentiation between populations of *D. deltoides* over 1200 km of eastern coast of Australia from southern Queensland to southern NSW. The population along the Coorong Beach is likely to represent the largest population of the species in Australia, and for the purposes of management, the Coorong population is managed as a self recruiting population distinct from other stocks found throughout other South Australian ocean beaches.

Greenback flounder

The number of species of flounder harvested in the Lakes and Coorong Fishery is presently unknown. There is the perception that the harvest comprises mainly greenback flounder (*Rhombosolea taparina*). This species occurs throughout southern Australian coastal waters (tidal flats of bays and estuaries) between eastern WA and southern NSW, including Tasmania, and is also known throughout NZ inshore waters (Gomon et al, 1994). In SA, it has been reported from the Eyre Peninsula (Glover and Olsen, 1983), Gulf St. Vincent (Jones et al, 1996; Jackson and Jones, 2000), Kangaroo Island waters (Glover, 1982) and the south east (Glover, 1985; Ye et al, 2003). It is regarded as an estuary dependent species (Jones et al, 1996). Other species of flounder are known to occur in the Coorong estuary (short-toothed flounder (*Pseudorhombus jenynsii*; Westlake, 1997); but the significance of this latter species in the overall harvest of flounder in the area of the Lakes and Coorong Fishery is unknown. Until further monitoring of the species composition of the harvest is conducted, a single species (*R. taparina*) comprising a single stock within the Coorong has been assumed for the purposes of management.

Golden perch

Golden perch is a freshwater species that exists in Lake Albert and Alexandrina. The species is distributed throughout the most of the Murray-Darling Basin, except at higher latitudes (Reynolds, 1975). Genetic studies have discriminated a number of populations within the Murray-Darling system, and one of these populations is distributed in the waters of the lakes and lower Murray River (Keenan, cited in Ye, 2004). However, as the populations are not morphologically distinguishable, for the purposes of management, the species has been managed as a single self recruiting population throughout the Murray-Darling system (Ye, 2004)

Bony bream

This species occurs throughout the Murray-Darling basin, however, it is unknown whether there are any subpopulations within this area. Thus, for management purposes, it is assumed that the fish occurring in the lakes and Coorong area contribute to the whole population within the basin.

European carp

This species has been legislated as a noxious species, live translocations of this species and releasing of live carp bycatch is not permitted.

By-product species

Sharks and rays

The main shark species harvested as by-product in the Lakes and Coorong Fishery are gummy and whaler sharks, occurring mainly in the oceanic component of the fishery (ie the swinger net and recreational surf fisheries). **Gummy sharks** (*Mustellus antarcticus*) are distributed throughout southern Australian waters from estuaries to depths of 400 m (Yearsley et al, 1999), and consist of a single stock. **Whaler sharks** probably comprise two species

(dusky (*Carcharhinus obscurus*) and bronze (*C. brachyurus*), although all are reported as bronze whalers. **Bronze whalers** are distributed globally, but the number of stocks within its overall distribution is unknown. **Dusky whalers** also have a world wide distribution and in Australia are found from northern Australia westwards and south to be found throughout the year in the GAB and sthn Tasmania. (Gomon *et al.*, 1994; and Jones (unpublished data), 2005). All by-product shark species are managed as single stocks throughout SA. Significant management arrangements are in place for Commonwealth and state managed gummy sharks, but, currently, there is no specific management on whaler sharks in SA or adjacent commonwealth managed waters.

Australian salmon

Two species of Australian salmon are known to occur in the lakes and Coorong area of jurisdiction (Lagoon and Oceanic fisheries) (Jones and Westlake, 2003). The western species, (*Arripis truttacea*), is distributed from the west coast of WA throughout SA coastal waters, and as far east as Port Phillip Bay, Vic and the north coast of Tasmania, based on tagging and research sampling throughout its range. The eastern species, *Arripis trutta*, has been found as far west as the Coorong lagoon (juveniles) and beach (sub-adults), and occurs in mixed species schools with *A. truttacea* (Jones and Westlake, 2003). Within SA, the same regulations exist for managing both species.

All other marine by-product species are not considered in this report, as the size of their harvest is minimal, relative to their overall harvest in other commercial fisheries.

Congolli

Pseudophritis urvillii may be caught occasionally as a by-product species in the hauling or small mesh fishery of the Coorong lagoon; however, it was not reported as a species commercially harvested in 2000/01. This estuary-dependent species occurs between Streaky Bay, SA and sthn NSW, including Tasmania (Gomon *et al.*, 1994). Although it occasionally occurs in open coastal waters, the number of stocks throughout its distribution is unknown.

Yabbies

Yabbies are widely distributed throughout central and southern inland Australia and there is a translocated population in south west Western Australia. Despite being distributed throughout a wide area, they are not highly mobile and many isolated populations exist (Kailola *et al.*, 1993). Many of these populations were originally described as different species but more recent research suggests that many may be local variations of the same species (Morrissey *et al.*, 1990 in Kailola *et al.*, 1993). Although yabbies are targeted by licence holders from time to time, they comprise a very small component of the total catch.

Murray cod

According to Ye *et al.* (2000), the commercial fishery for Murray cod was dominated by the River Fishery, which accounted for 94% of the total landings since 1985. River Fishery licence holders had their access to native fish removed in 2003 (except yabbies and bony bream), as part of a State Government restructure of the fishery. Commercial catches of Murray cod from the Murray lakes (Lake Alexandrina and Lake Albert) are minimal.

According to Ye *et al.* (2000) in the Murray Cod Fishery Assessment Report; “*Murray cod constitute one genetic stock throughout the Murray River system in South Australia (Pierce and Doonan, 1999). Murray cod is the largest freshwater fish in Australia. Its natural distribution is widespread throughout most of the Murray-Darling system except for the upper reaches of some tributaries in Victoria and southern New South Wales (Lake 1971).*

Murray cod were originally extremely common and supported a substantial commercial fishery in the nineteenth century and in the early decades of the twentieth (Rowland 1989). Extensive flow regulation and habitat modification of the majority of the rivers in the Murray-Darling basin have resulted in a great reduction in Murray cod abundance throughout its range since the 1950s (Reynolds 1976, Cadwallader 1978, Cadwallader and Gooley 1984, Rowland 1989, Walker and Thoms 1993)."

"During the mid 1950's, the commercial catch in the River Murray in South Australia underwent a dramatic decline from over 140 tonnes in 1958/59 to 2 tonnes in 1975/76. From that time until 1989 catches remained below 10 tonnes, with the exception of 1978/79 and 1981/82.

Murray cod depend on flooding for successful recruitment, and given the low flood frequency it was felt that there was inadequate recruitment to maintain the population. As a result the fishery managers took a precautionary approach and imposed a moratorium on the taking of Murray cod in January 1990 within the South Australian sector of the River Murray Basin.

In the years following 1989, the lower river had regular annual floods, which it is believed, helped the stocks to rebuild (Pierce 1994). Consequently the Scalefish Management Committee decided to support limited harvest of Murray cod in SA, and the moratorium was lifted in January 1994."

Guideline 1.1.4:

There are reliable estimates of all removals, including commercial (landings and discards), recreational and indigenous, from the fished stock. These estimates have been factored into stock assessments and target species catch levels.

Table 8 below provides known estimates of removals of key species in the Lakes and Coorong Fishery by all the different sectors. Currently there are no estimates available of the size of bycatch from any of the commercial sectors, nor the harvest and bycatch by indigenous fishers. A research program to assess the composition and magnitude of retained and discarded catches and rates of capture of retained and discarded species in the main types of gear used by commercial and recreational fishers in the Coorong lagoons, in order to establish a risk assessment framework for bycatch management, will commence in 2005 (refer to Appendix F).

Table 8: Estimates of all removals for key species in the Lakes and Coorong Fishery in 2000/01

Species	L&CF commercial harvest (kg, live wt)	MSF & RLF * commercial harvest (kg, live wt)	Common-wealth Managed net and hook harvest (kg, live wt)	Recreational harvest (kg) and release rate (% numbers of total rec harvest)
Goolwa cockles	857,148	367,804	Nil	22,900 (19.3%)
Mulloway	139,665	5,276	~ 5,500**	37,800 (74.5%)
Yellow-eye Mullet	142,496	58	Nil	12,127 (18.1%)
Flounder	19,322	0	Nil	Not available
Black bream	7,062	0	Nil	Not available
Golden Perch.	66,381	Not applicable	Not applicable	Nil

Bony Bream	check	Not applicable	Not applicable	Not available
European carp	274,000	Not applicable	Not applicable	3,600 (Not available)
Yabbies	474,000	Not applicable	Not applicable	66 (20%)

* For confidentiality reasons, the harvest by MSF and RLF licence holders has been combined, as there are less than 5 RLF licence holders reporting on mullocky harvest. For all other species reported in this column, MSF were the only licence holders who reported harvest levels.

** The Commonwealth net and line fishery for the by-product species, mullocky harvested approx. 5,500 kg, live wt in the waters between 136 E and 141 E, which includes the L&CF area of jurisdiction, (Ferguson and Ward, 2003).

All data available on recreational catch and effort levels will be taken into account when assessing the performance of the fishery through stock assessment. In the absence of other survey data, the data provided by the National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) will be used as the main source of information on catch and effort levels in the recreational sector.

Illegal harvest

Goolwa cockles

According to Murray-Jones and Johnson (2003), illegal harvest for sale of Goolwa cockles is known to exist, even though few compliance matters have been recorded with respect to this species. Individuals have been observed collecting cockles on Goolwa and Middleton Beaches in November, during the closed season (B Pierce, pers comm.). The participation and level of harvest derived from this illegal activity has not been quantified, but is likely to represent an additional and unregulated mortality. The growing popularity of this species for human consumption may also see an increase in illegal activity.

Indigenous fishing

Goolwa cockles

According to Murray-Jones and Johnson (2003) in the Goolwa cockle (*Donax deltooides*) Fishery Assessment Report, section 2.1 'Traditional Fishery'; "Australian Aborigines have been harvesting *D. deltooides* for at least 10,000 years (Godfrey, 1989). The original inhabitants of the Coorong region depended on the Goolwa cockles for food and trade, particularly during the spring and summer (Luebbbers, 1978). Middens in the vicinity of the River Murray mouth are composed almost exclusively of the shells of adult Goolwa cockles (Bourman and Murray-Wallace, 1991). The estimated population of more than 3000 inhabitants at this site represented Australia's largest permanent Aboriginal population (Jenkins, 1979), reflecting the productive capacity of this ecosystem. Traditional inhabitants have occupied the Coorong region for upwards of 16,000 years, and carry on through to the present time (Horton, 1994). Goolwa cockle stocks at this site have been subject to significant exploitation during this period, making estimation of "unexploited" virgin biomass inappropriate. Aboriginal fishers managed the Goolwa cockle and other natural resources through an integrated system of territorial use rights and verbally communicated rules. The descendants of traditional fishers do not currently possess independent artisanal or commercial access to the Goolwa cockle resource."

Guideline 1.1.5:

There is a sound estimate of the potential productivity of the fished stock/s and the proportion that could be harvested.

Production levels in the Lakes and Coorong Fishery are primarily driven by variation in natural environmental conditions, in particular the frequency of flooding and the extent of drought periods (Pierce and Doonan, 1999). As such, the biological productivity of most major fish species and the economic productivity of the fishery will continue to fluctuate in line with variations in natural environmental conditions such as freshwater outflows.

Estimates of the fishable biomass and the current proportion of that biomass being harvested are unknown for all target species in this fishery. Therefore, the potential productivities of these species can, at the moment, only be determined on the trends in the commercial CPUEs, coupled with some key environmental indicators such as trends in flow rates through the barrages and/or the Murray Mouth.

Goolwa cockles

According to Murray-Jones and Johnson (2003), Goolwa cockle is a highly fecund species with an almost continuous spawning period, so it should be capable of recovery from periods of extremely low stock abundance. In South Australia, River Murray outflows are likely to support elevated primary production of phytoplankton and allow high densities of Goolwa cockles to be reached.

Management responses

Guideline 1.1.6:

There are reference points (target and/or limit), that trigger management actions including a biological bottom line and/or a catch or effort upper limit beyond which the stock should not be taken.⁴

Performance Indicators

The extent to which the Management Plan is achieving the range of established management objectives will be assessed using a combination of performance indicators, designed to measure the performance of the fishery, the status of individual key species and the overall condition of the environment. Due to the multi-species nature of the fishery, not all of the performance indicators established in the Management Plan will be suitable for assessing all of the species or fishing impacts associated with the fishery.

Performance indicator values will be estimated using conventional stock assessment methods, models and more empirically based practical methods, which are outlined in the Plan. These methods will be refined during the life of the Management Plan as advances in knowledge are made. Where there is another fishery that has an impact on fish stocks managed under this Management Plan, those impacts will be taken into account when estimating fishery performance (eg. mullocky and Goolwa cockles). Additional indicators of fishery performance may be developed over time as advances in knowledge are made and as stock assessment methods are refined.

Performance Measures

A series of biological reference points have been established for key performance indicators to enable managers to determine whether fishery performance is acceptable (sustainable) or

⁴ Reference points can allow for seasonal fluctuations in stock recruitment and other areas of uncertainty

not. The reference points have been designed to provide clear guidance to management decision-making processes by defining how performance indicator estimates should be interpreted. Commercial catch and CPUE biological reference points have been defined using:

- Historical commercial catch and effort data collected over a reference period (1984/85 to 2001/02 – financial year);
- A reference range (upper and lower limits) for selected key performance indicators (both at the fishery-wide level and for individual key species); and
- A reference rate of change (rate of increase or decrease) for selected key fishery performance indicators, to measure trends over a three to four year period depending on the species⁵.

Upper and lower limit biological reference points have been determined for total commercial catch and commercial catch per unit effort (CPUE) for six primary species (mulloway, Goolwa cockle, yellow-eye mullet, golden perch, greenback flounder and black bream). CPUE reference points were derived using information from daily targeted effort (fisher days)⁶. Reference points have been determined using estimates of the total commercial catch and mean annual CPUE for each species over the three highest and three lowest years during the reference period (1984/85 – 2001/02 – financial year). Total catch and CPUE trend reference points were determined using the greatest rate of change (\pm) during the reference period in total catch and targeted CPUE - over a four year period for scalefish and a three year period for Goolwa cockles.

For mulloway and Goolwa cockles, commercial catch limit reference points have been determined using the total commercial catch from all sectors (eg. the L&CF, MSF and RLF). CPUE reference points for these two species have been determined using targeted catch and effort data from the Lakes and Coorong Fishery only. For mulloway, separate upper and lower CPUE reference points have been determined for commercial mesh nets and swinger nets.

In recognition of the developing nature of the commercial fishery for Goolwa cockles and the current poor understanding of population dynamics, upper and lower catch and CPUE reference limits have been derived using data from a shorter ten-year period between 1990/91 and 2000/01. Commercial catch and effort data collected from this period is more representative of the current scale of the fishery. The upper total catch biological reference limit for Goolwa cockles has been determined using an empirically based precautionary approach, aimed at protecting the resource from overfishing or stock collapse.

The lower reference points and reference rates of change (\pm) represent unacceptable (unsustainable) fishery performance that the Management Plan aims to avoid. The Management Plan also aims to avoid reaching upper reference points for total catch that result from large effort shifts to a particular species. The intention of the upper limits is to cap the total catch of each species. However, it is acknowledged that reaching these upper reference points may also reflect improved fishery performance. The distinction between these two possible interpretations will be assessed through stock assessment.

A number of reference points have been established to guide decision-making at the fishery-wide level. These measures address total commercial effort levels in each sector of the

⁵ Trends will be measured over a 4 year time period for all finfish species. Goolwa cockles will be measured over a 3 year time period, in recognition of their shorter life span.

⁶ The majority of black bream and flounder taken during the reference period reflect non-targeted by-product catches, due to low stock abundances.

fishery, changes in the species composition of the commercial catch, bycatch levels, recreational effort levels and significant environmental disturbances.

- Overall fishery performance will be measured by evaluating:
- Annual estimates of performance indicators, relative to established upper and lower biological reference points; and
- Longer term trends, as determined by the rate of change in annual performance indicator estimates over a three to four year period, relative to the established reference rates of change.

More meaningful and robust performance measures will be developed over time, as the population dynamics of each species and their relationship to environmental conditions becomes better understood. The reference period (1984 to 2001) was selected for the following reasons:

- Reliable commercial catch and effort data are available for the fishery during this period;
- The commercial fishery had stabilised after experiencing an extended period of drought, which resulted in Murray Mouth closure in 1981;
- There was relative stability in the management arrangements and commercial licence numbers following the introduction of the Scheme of Management in 1984; and
- It is representative of fishery performance over the recent history of the fishery.

Management Responses

When annual estimates of one or more performance indicators (refer to Table 4) suggests that the fishery is performing outside of the reference range established in the Management Plan (i.e. if a reference point is reached), PIRSA Fisheries and the Fisheries Management Committee will take the following actions:

1. Notify the Minister for Agriculture, Food and Fisheries and participants in the fishery as appropriate;
2. Undertake a detailed review including an examination of the causes and implications for all key species of reaching one or more reference values;
3. Consult with key stakeholder groups regarding the need for alternative management strategies for each sector, which may include changes or improvements to:
 - Limitations on total effort levels;
 - The type and amount of fishing gear that may be used;
 - The design of fishing gear (eg. mesh sizes or configurations);
 - Temporal and spatial closures;
 - Moratoria on the take of individual species;
 - Size limits for individual species;
 - Recreational bag and boat limits and possession limits;
 - Limits on the total catch of an individual species (output controls);
 - Limitations on the number of participants; and
 - Processes that influence environmental performance.
4. Provide a report to the Minister, within three months of the initial notification, on the effects of reaching one or more limit reference values, including any recommendations on alternative management strategies.

Given the highly dynamic nature of the Lakes and Coorong Fishery, the inherent uncertainty in assessment processes and the range of external factors that can influence assessment

outcomes, this non-prescriptive approach to management review and response is considered appropriate. A more structured approach to decision-making may be considered in the future if management tools become available that provide a capacity to evaluate the level of biological risk and uncertainty associated with alternative management strategies.

When a management review is undertaken it does not mean that management arrangements will automatically be altered. If a review reveals that unsatisfactory performance can be explained by factors other than those directly related to resource sustainability (eg. market forces), then it may be recommended that no management action be taken or that further monitoring be undertaken. In extreme circumstances, the Minister may use the powers in section 43 of the Fisheries Act to protect a fishery or an individual species by removing access to a species or limiting fishing activities in a fishery, for a specified period while a long-term management response is being formulated. This same measure can be used when total allowable catch limits are reached within a fishing season.

Biological reference points for key species are at Appendix D.

Guideline 1.1.7:

There are management strategies in place capable of controlling the level of take.

Harvest Strategy

The harvest strategy for the fishery aims to provide a strategic framework to guide annual decision-making on harvesting rates for all sectors of the fishery. In a practical sense, the harvest strategy describes the linkages between management objectives, strategies, performance indicators, reference points, management triggers and agreed management actions to be introduced, upon reaching reference points or triggers. The harvest strategy also describes how fishery data should be collected, how the data should be analysed and how the results of data analyses should be interpreted and used to determine management actions. A formal harvest strategy strengthens the link between annual fishery stock assessment processes and management decision-making.

The harvest strategy framework integrates a set of basic environmental management principles into the day-to-day management of the fishery to ensure that management decision-making incorporates critical environmental factors, such as the timing and volume of freshwater flows, barriers to fish passage and river mouth opening. This approach aims to ensure that fundamental environmental processes are maintained or, where necessary, restored to maximise benefits for fish stocks. Under this integrated approach, instead of simply measuring the performance of individual fish stocks against management objectives, critical environmental drivers will be explicitly taken into account when assessing the overall health of the fishery and in decision-making processes. If water flow rates or other key environmental parameters fall outside of reference levels in any given period, the Management Plan will require a management response to be initiated, to ensure fish stocks are not left unmanaged during periods of low ecosystem health, such as extended periods of drought or low water flow.

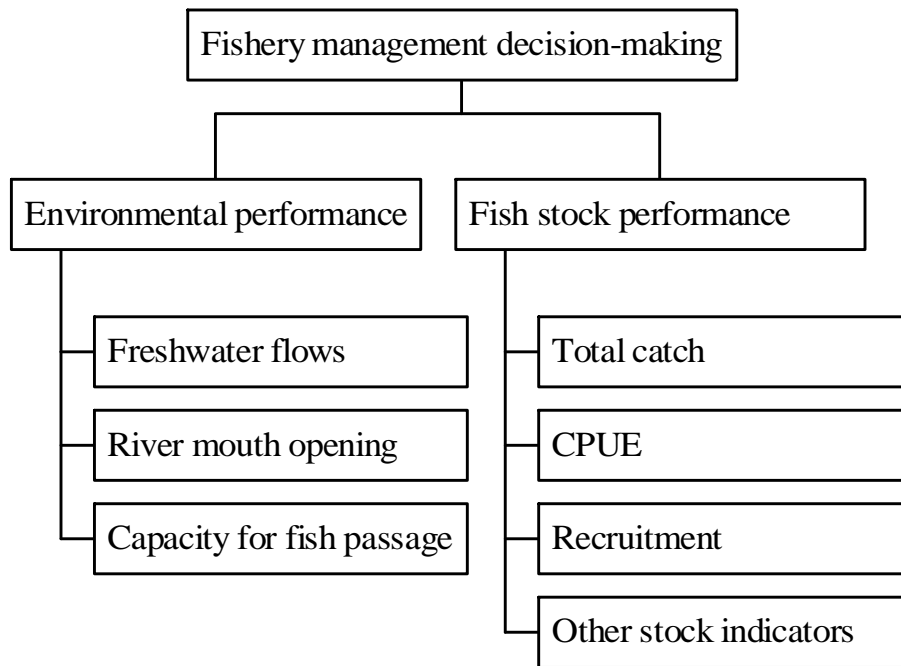


Figure 8. Decision-making framework for the South Australian Lakes and Coorong Fishery.

Management Goals and Objectives

The *Fisheries Act 1982* provides an overarching framework to ensure long-term sustainability of South Australia's marine, estuarine and freshwater fisheries resources. The following broad management goals and objectives provide a focus for the long-term sustainable management of the Lakes and Coorong Fishery and are complementary to the objectives outlined in the Fisheries Act.

Consistent with the objectives of the Fisheries Act, a key goal of the Management Plan is to ensure that an appropriate balance exists between the need to ensure long term sustainability of lakes and Coorong fisheries resources and the optimum utilisation and equitable distribution of these resources between all stakeholder groups and future generations. For this reason, the stock sustainability and environmental management objectives set out in this Management Plan provide the baseline against which all other objectives will be pursued. Economic and social objectives will be pursued to the extent possible, where stock sustainability imperatives have been demonstrably achieved.

The following management goals aim to address key challenges facing the fishery and take into account key policy drivers set out in section 2.4 such as the 'principles of ecologically sustainable development', the 'precautionary principle', the 'guidelines for the ecologically sustainable management of fisheries' set out in the Australian Government *Environment Protection and Biodiversity Conservation Act 1999*, the National Policy on Fisheries Bycatch, the Coorong National Park Management Plan, the Coorong and Lakes Alexandrina and Albert Ramsar Management Plan and the Murray-Darling Basin Commission Native Fish Strategy. A series of objectives have been established to ensure management goals are actively pursued.

Goal 1. Sustainable harvesting of fisheries resources.

- a. *Fishing is conducted at a level that maintains ecologically viable stock levels and protects fish stocks from overfishing;*
- b. *Sufficient biological and environmental information is collected and analysed to make informed management decisions; and*
- c. *For fish stocks that are determined to be operating outside of established reference levels, the fishery will be managed to promote recovery to ecologically viable stock levels, within agreed timeframes.*

Goal 2. Optimum utilisation and equitable distribution of fisheries resources, within the constraints of sustainability imperatives.

- a. *Maintain a flow of economic benefit from the fishery to the broader community through the wise use of Lakes and Coorong fisheries resources;*
- b. *Maintain equitable public access and recreational fishing opportunities;*
- c. *Provide opportunities for indigenous communities to access fish stocks for traditional purposes;*
- d. *Maintain equitable levels of commercial access and the regional development nature of the commercial fishery; and*
- e. *Sufficient economic information exists to make informed management decisions.*

Goal 3. Minimise impacts on the structure, productivity, function and biological diversity of the ecosystem.

- a. *Monitor any external impacts on fish stocks associated with broader environmental or ecosystem health;*
- b. *Minimise fishery impacts on bycatch species and the ecosystem;*
- c. *Avoid the incidental mortality of endangered, threatened and protected species; and*
- d. *Reduce the population size and ecological impact of non-native fish species.*

Goal 4. Cost-effective and participative governance of the fishery.

- a. *Promote cost-effective and efficient management of the fishery;*
- b. *Have regard to the range of social, cultural and wider community values attached to the fishery; and*
- c. *Promote compliance with management controls.*

Management Strategies

The management strategies outlined in Table 4 reflect the multi-species, multi-method nature of the fishery and have been designed to ensure that management objectives are effectively pursued. Collectively, these strategies are aimed at management of the whole fishery, however, a number of strategies have been directed specifically at either the commercial or recreational sector, or at an individual species or group of species.

An important element of the Lakes and Coorong Fishery commercial harvest strategy is the flexibility that commercial fishers have to transfer harvesting effort between species and ecosystem components, within and between years. This strategy is fundamental to the management of the commercial sector as it allows commercial fishers to respond to natural changes in environmental conditions, which drive the abundance and availability of fish within and between seasons. This strategy reduces the risk of commercial overfishing of an individual species during most conditions. This strategy also provides scope for fishers to adjust fishing practices in response to changes in market conditions.

The range of strategies outlined in Table 4 provides the necessary scope and flexibility required to manage the fishery and its impacts on fish stocks and the broader ecosystem, within a natural system that is characterised by high variability in environmental conditions and fish stock abundances. The strategies outlined in this Management aim to provide the capacity to facilitate any changes that are required to implement National Park management strategies.

Management Arrangements

The Management Plan aims to provide a foundation for the fishery to continue moving towards a more integrated, ecosystem-based approach to management. The first step in this process is to integrate environmental management principles with conventional species and gear based fisheries management. This will ensure that management decision-making incorporates critical environmental factors such as the timing and volume of freshwater flows, barriers to fish passage and Murray Mouth opening.

There has been a long standing informal ecosystem-based approach to management of the fishery, which is underpinned by the capacity commercial fishers have to transfer effort between a diversity of species in the marine, estuarine and freshwater ecosystem components of the fishery. These unique characteristics allow commercial fishers the necessary individual flexibility to respond to inter and intra-annual variations in overall ecosystem health and fish stock abundance, or to changes in the market. In addition, a range of flexible management measures can be introduced in response to fish stock declines or significant environmental disturbances, such as extended periods of drought, low freshwater flow or closure of the River Murray Mouth.

The existing management arrangements have evolved through necessity over a long period of time in response to changes in the physical structure, productivity and function of the diverse and interdependent ecosystems encompassed by the fishery, evolving community expectations and competing stakeholder interests. Management approaches will continue to evolve as knowledge of the interaction between environmental variables and fishing operations is better understood.

Commercial fishing

The commercial fishery is managed using a complex mix of input and output controls aimed at matching harvesting capacity with resource availability and controlling growth in aggregate harvesting capacity. Existing controls include limitations on the number of licences, a wide range of gear restrictions, spatial and temporal closures, restrictions on the number of commercial agents permitted to assist fishing operations and legal size limits for individual species. The majority of the management controls used today have been in place for many years. The primary species targeted in the Lakes and Coorong Fishery are outlined in section two of this document. A full list of the species, which may be taken for the purpose of trade or business by commercial licence holders is at Appendix I.

Access to the Lakes and Coorong Fishery

Lakes and Coorong Fishery

Access to the fishery is limited to holders of a current Lakes and Coorong Fishery licence, renewed annually by the Director of Fisheries under section 34 of the Fisheries Act, subject to certain requirements. The *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991* preclude the Director of Fisheries from granting any additional fishing licences in the fishery. There are currently 37 licences issued in the Lakes and Coorong

Fishery, all of which have a variety of different gear entitlements. All licences issued in the fishery are fully transferable. Prior to February 2004, the scheme prevented the Director from granting more than one licence to an individual operating in the fishery. A review of all State fisheries legislation against National Competition Policy guidelines led to amendments to the Scheme of Management to allow the Director of Fisheries to grant multiple licences to an individual.

All licence holders must be present when fishing operations are being undertaken, consistent with the owner operator provisions in place for the fishery, except in circumstances where the holder of a licence also holds another licence in the Lakes and Coorong Fishery or another fishery. In this case, the licence holder must be the registered master on at least one of the licences. Historically, the owner operator provisions have had the dual role of limiting effort expansions and maintaining the regional development nature of the fishery. All licence holders may nominate a relief master for up to 28 days each year.

Other Fisheries

An underlying issue pertinent to the long-term sustainable management of the Lakes and Coorong Fishery is the substantial latent effort that exists in other sectors of the commercial fishing industry in South Australia. If activated, this latent effort has the potential to have impacts on the sustainability of key species, particularly mulloway and Goolwa cockles. Other state commercial fisheries with restricted access to the Lakes and Coorong Fishery include the MSF and RLF. These state fisheries have a 1,000kg annual limit per licence on catches of mulloway and have the potential to take large quantities of Goolwa cockles under existing access arrangements. Management measures have been developed to remove latent effort from the Goolwa cockle fishery and limit all other state based fisheries to access the species for personal bait use only, within the Lakes and Coorong Fishery. These arrangements will be implemented through a change in licence conditions from July 2005. Commonwealth shark fishers have a 100kg mulloway bycatch trip limit to cover catches taken during operations adjacent to the Coorong ocean beaches.

Gear Restrictions

A wide and complex range of restrictions is in place to control the use of all commercial fishing methods in the Lakes and Coorong Fishery, which reflects the multi-species nature of the fishery. These restrictions are in place to limit the amount of effort expended in the fishery, in order to limit total catches to sustainable levels. Some measures are designed to protect fish stocks during specific stages of their life cycle, while others are in place to restrict gear conflict between sectors. Current commercial gear restrictions are set out in Table 9 below.

Table 9: Commercial Sector Gear Restrictions

Device	Restriction	Dimensions	
Mesh nets (Coorong Area 1)		<i>Small mesh monofilament</i>	<i>Large mesh monofilament</i>
	Max length	50m, with a combined total length of 500m	50m, with a combined total length of 500m.
	Min mesh size	50mm	115mm
	Max mesh size	64mm	150mm
	Maximum drop	33 meshes	2m
	Min break strain	5.5kg	7kg
	Max number	The number endorsed on a licence, subject to: <ul style="list-style-type: none"> - A maximum of 11 mesh nets (50m) may be joined together and used a single net; and - If a net with a mesh size greater than 150mm is used, only 5 may be used at any one time. 	
Mesh nets (Coorong Area 2)		<i>Small mesh monofilament</i>	<i>Large mesh monofilament</i>
	Max length	50m, with a combined total length of 550m	50m, with a combined total length of 550m.
	Min mesh size	50mm	115mm
	Max mesh size	64mm	None
	Maximum drop	50 meshes	2m
	Min break strain	5.5kg	7kg
	Max number	The number endorsed on a licence, subject to: <ul style="list-style-type: none"> - A maximum of 11 mesh nets (50m) may be joined together and used a single net; and - If a net with a mesh size greater than 150mm is used, only 5 may be used at any one time. 	
Mesh nets (Coorong coastal waters)		<i>Small mesh monofilament</i>	<i>Large mesh monofilament</i>
	Max length	50m, with a combined total length of 600m	
	Min mesh size	50mm	115mm
	Max mesh size	64mm	None
	Maximum drop	Max depth of 1m below water surface	2m
	Min break strain	5.5kg	7kg
	Max number	The number endorsed on a licence, subject to: <ul style="list-style-type: none"> - One mesh net may be used at any one time. 	
Mesh nets (Lakes Alexandrina, Albert)	Max length	50m, with a combined total length of 550m	
	Min mesh size	50mm	
	Max mesh size	None	
	Maximum drop	5m	
	Min break strain	None	
	Max number	The number endorsed on a licence (max of 100)	
Swinger nets (Coorong coastal waters)	Max length	100m	
	Min mesh size	120mm	
	Max mesh size	None	
	Min break strain	9kg	
	Max rope length	600m	
	Max number	1	

Device	Restriction	Dimensions	Device
		<i>Small mesh multifilament</i>	<i>Large mesh multifilament</i>
Hauling nets - Coorong Area 1 - Coorong Area 2 - Coorong coastal waters	Max length	400m	- Coorong Area 1 – 240m - Coorong Area 2 – 400m - Coorong coastal waters - 600m
	Min mesh size	50mm	95mm
	Max mesh size	64mm	None
	Min ply	15	21
	Max rope length	100m	50m
	Max number	1	
	Maximum drop	None	
	Power hauling	Not permitted	
Hauling nets (Lakes Alexandrina, Albert)	Max length	- Power hauling net - 600m - Manual hauling net - none	
	Min mesh size	None	
	Max mesh size	None	
	Maximum drop	10m	
	Max number	1	
Cockle nets	Max number	Number endorsed on licence; 1 per licensee and agent/s	
Cockle rakes	Max number	Number endorsed on licence; 1 per licensee and agent/s	
Crab rake	Max number	Number endorsed on licence; 1 per licensee and agent/s	
Dab nets	Max number	Number endorsed on licence	
Drum nets	Max number	Number endorsed on licence	
Drop/hoop nets	Max number	Number endorsed on licence	
Bait net	Max number	1	
Yabbie trap	Max number	Number endorsed on licence, maximum of 100	
Shrimp trap	Max number	Number endorsed on licence	
Set line	Max Length	None	
	Max no. of hooks	400 hooks	
Razor fish tongs	Maximum number	Number endorsed on licence; 1 per licensee and agent/s	
Fish spear	Maximum number	Number endorsed on licence; 1 per licensee and agent/s	
Electro-fishing gear	Maximum number	Only a limited number of licences (5) are currently endorsed to allow the use of electro-fishing gear. Can only be used in Lake Alexandrina and Lake Albert to catch European carp and bony bream.	

Spatial and Temporal Closures

Similar to the current set of gear restrictions, a series of spatial and temporal closures have been introduced, which are in many cases explicitly linked to a restriction on the use of a particular fishing method. Closures are used to restrict catch levels, to protect fish stocks during specific stages of their life cycle or to reduce gear conflict between the commercial and recreational sectors.

Table 10. Spatial and temporal closures in the commercial sector of the Lakes and Coorong Fishery (refer to Appendix II for other gear restrictions and closures).

Species or Gear	Area	Time Closure Period
Goolwa cockles	Ocean beaches (Area 4)	1 June to 31 October
Murray cod	Lake Alexandrina and Lake Albert (Area 3)	1 September to 31 December
All nets	Area 1 of the Coorong	25 December to 7 January
Small mesh nets (set and haul)	Area 1 of the Coorong	1 November to 31 March
All nets	Within 500m of the Murray Mouth	All year round
All nets	Goolwa channel	Between midnight on Friday and sunset on the following Sunday

Size Limits for Key Species

Size limits have been applied to individual fish species in the fishery for many years, primarily to maximise the opportunity for individual fish to reproduce at least once before capture, which is intended to protect fish stocks from recruitment overfishing. Other reasons for including size limits as part of fisheries management strategies include efforts to maximise the biological or economic yield per-recruit for a species or efforts to protect fish populations from growth overfishing.

Table 11. Size limits for selected key species in the Lakes and Coorong Fishery.

Species	Minimum Legal Length
Mulloway	Within Coorong estuary: 46cm Outside Coorong estuary: 75cm
Goolwa cockle	3.5cm
Yellow eye mullet	21cm
Greenback flounder	25cm (currently for commercial sector only)
Black bream	28cm
Murray cod	50cm (minimum) – 100cm (maximum)
Golden perch	33cm
Australian salmon	21cm
Yabbies	No size limit
Bony bream	No size limit
Congolli	No size limit
Carp	No size limit

Recreational Fishing

The recreational sector is managed through a combination of input and output controls, aimed at ensuring the total catch is maintained within sustainable limits and to ensure that recreational access to the fishery is equitably distributed between recreational participants. Similar to the commercial sector, these controls include limitations on the type and amount of fishing gear that may be used, spatial and temporal closures, legal size limits for individual species (which are consistent with those in place for the commercial sector) and bag and boat limits for individual species. The majority of management controls currently used to manage the recreational sector have been in place for many years. Please refer to the existing set of regulations for specific recreational management controls.

Access to the Fishery

The South Australian recreational community currently has unlimited access to the State's fisheries resources, including the Lakes and Coorong Fishery, subject to various management controls listed in this section. Some fishing methods are limited to certain numbers (eg. recreational mesh nets).

Recreational Fishing Methods

The recreational sector is permitted to use a wide variety of methods, which includes specified combinations of fishing rods, hand lines, hand nets, cockle rakes, shrimp and yabbie traps, hoop and drop nets. A limited number of recreational mesh nets are permitted for use in the waters of the Lakes and Coorong and in Lake George, under specified conditions. The number of recreational mesh nets registered for these waters in 2004 was 2,258. Of these, 2,238 may be used in the waters of the Lakes and Coorong and 1,780 may be used in Lake George. Recreational mesh nets must be registered with PIRSA Fisheries each year. When

recreational nets are used, registered net users must be within 50m of nets at all times. Recreational net registrations are non-transferable. Details related to the gear specifications of the following devices are set out in the *Fisheries (General) Regulations 2000*.

Table 12. Permitted recreational fishing methods.

Device	Permitted number of devices
Fishing rod, handline	up to 2 fishing rods per person; or up to 2 handlines per person; or one of each
Fishing hooks	up to 3 hooks attached; or up to 5 hooks attached eye to shank, or threaded together
Mesh nets	1 per person (restrictions apply – registered users only)
Hand net	1 per person
Hoop nets	10 per person (in the estuarine waters of the Coorong), if no other device is used 3 per person (in the estuarine waters of the Coorong), if a hand net or mesh net is used 3 per person (in the waters of Lake Alexandrina and Lake Albert) Specific requirements apply to coastal waters
Drop Net	3 per person
Cockle rake, crab rake	1 per person
Shrimp trap	1 per person
Yabbie trap	3 per person
Spear gun, hand fish spear	Not permitted in Lake Alexandrina or Lake Albert Not permitted within 100m of landings and wharves, including foreshore areas.
Bow and arrow (but not a crossbow)	May be used to target carp only, when at least 50m away from other persons
Bait pump	None specified
Bait fork or spade	None specified
Razorfish tongs	None specified

Bag and Boat Limits

Bag and boat limits are an output control used to cap the total catch in the recreational sector to ensure catch levels remain within sustainable limits. Bag limits, boat limits and possession limits help to ensure that recreational fishers catch only what they need for their immediate needs and also assist with ensuring the catch is equitably shared between recreational participants in the fishery. If a possession limit is exceeded, it may be assumed under existing fisheries legislation that the catch is a commercial quantity being taken for illegal purposes.

Table 13. Recreational bag, boat and possession limits in place for the Lakes and Coorong Fishery.

Species	Daily Bag Limit	Daily Boat Limit	Possession Limits
Mulloway 46cm – 75cm (within Coorong only)	10	–	25
Mulloway 75cm or larger (all state waters)	2	6	10
Greenback flounder	20	60	50
Goolwa cockle	600	-	-
Yellow eye mullet	60	180	-
Bream (<i>Acanthopagrus spp.</i>)	10	30	-
Murray cod	2	6	-
Golden Perch	5	15	-
Yabbies	200	-	-

Salmon (21cm – 35cm)	20	60	-
Salmon (larger than 35cm)	10	30	40
Flathead	10	30	-
Shark, school & gummy combined	2	6	-

Spatial and Temporal Closures

A number of spatial and temporal closures have been introduced for the recreational sector of the Lakes and Coorong Fishery, primarily to ensure sustainability of fish stocks. Some closures are consistent with those in place for the commercial sector. These closures are usually focussed on a given species, but may be explicitly linked to a restriction on the use of a particular fishing method.

Table 14. Spatial and temporal closures in the Lakes and Coorong Fishery for the recreational sector *

Species/Device	Area	Time Closure Period
Goolwa cockle	Marine component - Ocean beaches	1 June to 31 October
Murray cod	Lake Alexandrina and Lake Albert	1 September to 31 December
Mesh nets	Area 1	1 November to 31 March
Mesh nets	Coastal waters	All times
Mesh nets	Within a 500m radius of the River Murray Mouth	All times
Mesh nets	Within 150m of all barrages	All times
Mesh nets	Goolwa Channel*	Between midnight Friday and sunset on Sunday
Mesh nets	Between Murray Mouth and Mundoo Island	All times
Mesh nets	Within 200m of any other net	All times

* Refer to the relevant *Fisheries (General) Regulations 2000* or the Recreational Fishing guide published by PIRSA Fisheries to confirm specifications for all netting closures and other seasonal restrictions.

Traditional Fishing

All of the management measures in place for the recreational sector currently apply to indigenous fishers when undertaking traditional fishing practices. This is because the Fisheries Act does not currently recognise traditional or customary fishing as a separate type of fishing. However, a general exemption notice has been in place for many years to allow teachers and students of 'Camp Coorong' to use a single mesh net in the Lakes and Coorong Fishery to participate in the Aboriginal studies course coordinated by the Ngarrindjeri Land and Progress Association Inc. This exemption notice is subject to certain conditions.

In a broader context, access to South Australia's fisheries resources by indigenous communities is being considered as part of the current review of the Fisheries Act. It is anticipated that the new legislation will specifically recognise traditional or customary fishing. Furthermore, the State is currently engaged in negotiations with native title claimant representative bodies and the commercial fishing industry in relation to resolving native title claims through negotiated agreements. Both the Act review process and the agreement negotiation process will inform the way that access to fisheries resources by Aboriginal communities is defined and implemented in the Lakes and Coorong Fishery. PIRSA will work closely with the Ngarrindjeri people in the development of any future arrangements.

Compliance

An annual risk assessment in terms of compliance of all management regulations undertaken by PIRSA Fishwatch, in association with the Inland Waters Management Committee has been in place since 2002/03. Appendix E shows the priorities for the commercial Lakes and Coorong Fishery for 2003/04.

Guideline 1.1.8:

Fishing is conducted in a manner that does not threaten stocks of by-product species.

(Guidelines 1.1.1 to 1.1.7 should be applied to by-product species to an appropriate level)

Table 15 shows the total catches of target and by-product species harvested by commercial fishers in the Lakes and Coorong Fishery, Marine Scalefish Fishery and Rock Lobster Fisheries in 2000/01. Species harvested predominantly as by-product species (marked "BP") for the lagoon and ocean components of the fishery include: Australian salmon, sharks (bronze whalers and gummy), rays, school whiting, trevally, garfish, snapper and other un-named species. By-product species for the lakes fishery include yabbies, Murray cod and other un-named species. Fishers report either single target species or multiple target species on the catch and effort forms (Appendix B).

Table 15: Target and by-product catch of species harvested by commercial fishers in 2000/01 (L&CF, MSF and RLF combined)

Species	Mesh and hauling nets in Lagoon	Large mesh nets, swinger nets, shark nets	Line (set and handline)	Rakes and cockle nets	Other gear
Coorong Lagoon and Ocean Beach Fisheries					
Goolwa Cockles	0	0	0	1,219,952	0
Mulloway	116,173	24,224 (State), 217 (Commonwealth)	4,028	0	93
Black Bream	7,005	40	0	0	17
Yellow-eye Mullet	138,668	185	58	0	3,642
Flounder	18,980	0	0	0	342
Australian salmon (BP)	4,415	0	0	0	146
Sharks/rays (BP)	112	1,925	1,862	0	0
Other marine species (BP)	184	0	667	0	4
Lakes Fishery					
Golden Perch	66,361	0	0	0	20
European carp	279,103	955	0	0	7,689
Bony Bream	496,447	0	0	0	0
Redfin perch	24,072	0	0	0	8
Other freshwater species (BP)	1,120	0	0	0	0
Total (kg, live wt)	1,152,642	32,829	6,615	1,219,952	11,831

Australian salmon

This by-product of commercial net and recreational line fishing in the Coorong lagoon and estuary comprises the juveniles of both eastern and western species. Both species use the estuary as a nursery area (1 yr old fish), and both are approaching the geographic extremities of their distributions (Jones and Westlake, 2003). The annual commercial harvest of salmon

by L&CF fishers is minimal (2 – 3 tonnes), compared with the total harvest of the stocks (3,000 t for western species and approx. 800 t for eastern species. Although larger, sub-adult salmon form schools along parts of the Coorong ocean beach, they are not harvested by L&CF commercial fishers (mesh size restrictions), and the harvest by recreational line fishers is small in comparison with the statewide harvest of the stocks. Both species are known to occur along these ocean beaches in mixed schools (Jones and Westlake, 2003).

Gummy and bronze whaler sharks

Trip limits of 5 gummy shark carcasses have been applied to all L&CF, MSF and RLF commercial licence holders harvesting this species in state managed waters. Min size limits (45 cm, trunk length) apply for both the commercial and recreational fisheries. The netting closure around the Murray mouth (refer to Table 14) will lessen the potential for over fishing aggregations of sharks at the mouth during seasons of high flow (see Jones, in prep).

Currently, apart from the limited entry L&CF, MSF and RL fisheries, no other restrictions exist on the harvesting of whaler sharks. A review of the status of whaler sharks in fisheries, in adjacent to SA waters commenced in July, 2004, and will include an ecological risk assessment of all operations directed towards whaler sharks (FRDC research grant 2004/067).

Murray cod

Since January 1994, a legal minimum size of 500 mm and a legal maximum size of 1100 mm total length have applied to all Murray cod landings in South Australia. There is a closed season from 1 September to 31 December inclusive. Recreational effort is further regulated by a bag limit of two Murray cod per fisher per day, with gear restrictions including two rod/handline limits and "in attendance" requirements. Prior to the moratorium (January 1990 to December 1993), there was a minimum size limit of 460 mm and a three-month seasonal closure between 1 September and 30 November.

Guideline 1.1.9:

The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.

The extent to which the Management Plan is achieving the range of established management objectives will be assessed using a combination of the performance indicators, designed to measure the performance of the fishery, the status of individual key species and the overall condition of the environment. The linkages between management objectives, strategies, performance indicators, reference points, management triggers and agreed management actions to be introduced, upon reaching reference points or triggers have been described earlier in this report.

Objective 2.

Where the fished stock(s) are below a defined reference point, the fishery will be managed to promote recovery to ecologically viable stock levels within nominated timeframes.

Management responses

Guideline 1.2.1:

A precautionary recovery strategy is in place specifying management actions, or staged management responses, which are linked to reference points. The recovery strategy should apply until the stock recovers, and should aim for recovery within a specific time period appropriate to the biology of the stock.⁷

In the event that annual estimates of one or more performance indicators (refer to Table 4) suggest that the fishery is performing outside of the reference range established in the Management Plan (i.e. if a reference point is reached), there are a number of actions that PIRSA Fisheries and the Fisheries Management Committee will take. This process is described on page 62. There are no species that have been assessed as being over-exploited.

Guideline 1.2.2:

If the stock is estimated as being at or below the biological and / or effort bottom line, management responses such as a zero targeted catch, temporary fishery closure or a 'whole of fishery' effort or quota reduction are implemented.

When a management review is undertaken it does not mean that management arrangements will automatically be altered. If a review reveals that unsatisfactory performance can be explained by factors other than those directly related to resource sustainability (eg. market forces), then it may be recommended that no management action be taken or that further monitoring be undertaken. In extreme circumstances, the Minister may use the powers in section 43 of the Fisheries Act to protect a fishery or an individual species by removing access to a species or limiting fishing activities in a fishery, for a specified period while a long-term management response is being formulated. This same measure can be used when total allowable catch limits are reached within a fishing season.

Should annual estimates of performance suggest the fishery is performing outside the reference range, alternative management strategies may include changes or improvements to:

- Limitations on total effort levels;
- The type and amount of fishing gear that may be used;
- The design of fishing gear (eg. mesh sizes or configurations);
- Temporal and spatial closures;
- Moratoria on the take of individual species;
- Size limits for individual species;
- Recreational bag and boat limits and possession limits;
- Limits on the total catch of an individual species (output controls);
- Limitations on the number of participants; and
- Processes that influence environmental performance.

⁷ Strategies require that recovery should take place within specified times with certain degrees of probability

Principle 2:

Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.⁸

Objective 1.

The fishery is conducted in a manner that does not threaten bycatch species.

Information requirements**Guideline 2.1.1:**

Reliable information, appropriate to the scale of the fishery, is collected on the composition and abundance of bycatch.

The bycatch species associated with the Lakes and Coorong Fishery are outlined in Figure 9. The recognition that these species are released as bycatch is based on observations from commercial fishers in written reports, fisheries compliance officers, and fishery researchers, and for the recreational fishery, the reports associated with the National Recreational and Indigenous Fishing Survey and are documented in Table 16. Estimates of the release rates in the recreational sector for the key species have been given in Table 6.

There is a need for reference data on bycatch by the commercial and recreational fisheries that operate in the Coorong lagoons. The FRDC-funded project “Gear interaction of non-targeted species in the Lakes and Coorong commercial and recreational fisheries of South Australia” aims quantify bycatch in the Lakes and Coorong Fishery and to develop methods to further reduce the effects fishing interactions on bycatch species. The active participation of the commercial and recreational fishers will be fundamental to this project, with researchers undertaking on-board sampling and surveys to collect data on gear, and target and non-target species. In addition, recreational fishers will participate through voluntary logbook and interviews.

These data will be used to identify management issues, prioritise management actions, and enable targets/solutions to be established in accordance with principles of ecological sustainable development. A summary of this research project is at Appendix F.

⁸ The issues addressed under the principle are those that define components of ecosystem integrity

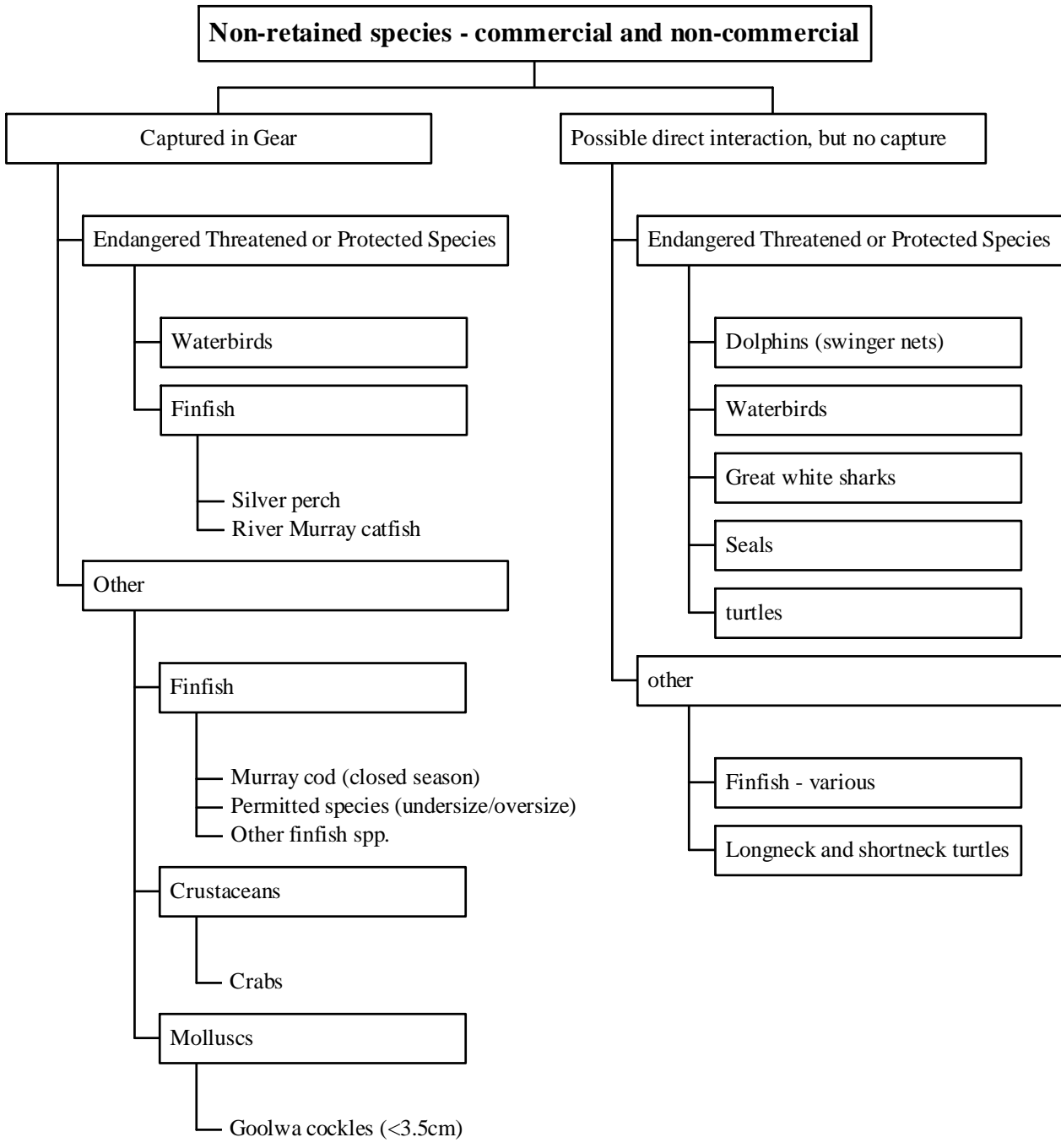


Figure 9: Non-retained species in the commercial and recreational sectors of the Lakes and Coorong Fishery.

Table 16: Documented reports of bycatch species for all components of the Lakes and Coorong Fishery

Component of the Lakes and Coorong Fishery	Bycatch Species	Reference
Goolwa cockle commercial and recreational fisheries	Undersized Goolwa cockles	Murray-Jones and Johnson, 2003; Jones and Doonan, 2005.
	Undersized sand crabs	Murray-Jones and Johnson, 2003
	Beach worms	Murray-Jones and Johnson, 2003
Mullet commercial net fishery	Undersized mullet	Hall, 1986; Heyes, 2002
	Shore crabs	Heyes, 2002
Flounder commercial net fishery	Undersized mullet.	Hall, 1986
Bream commercial net and recreational fisheries	Undersized mullet	Hall, 1986;
Recreational flounder fishery	Small flounder, or those over bag limit	
Lakes commercial net fishery	Unwanted bony bream, undersized golden perch, m. cod in closed season.	Ye, 2005
Recreational mullet net and line fisheries	Undersized and legal sized mullet over bag/boat limit (combined), Undersized mullet	Higham <i>et al</i> , 2004; Jones and Doonan, 2005
Recreational mullet line fishery	Undersized and legal sized over bag/boat limit Whaler sharks in ocean beach fishery	Ferguson and Ward, 2003; Jones and Doonan, 2005

Assessments

Guideline 2.1.2:

There is a risk analysis of the bycatch with respect to its vulnerability to fishing.⁹

No estimates of the fate of the bycatch species in Figure 9, or Table 16 or the effect on the sustainability of the stocks are currently available.

In some mesh selectivity studies on mullet in the Coorong lagoon, Hall (1986) reported relatively large numbers of 1 yr old mullet were caught and killed in 5 cm mesh nets (fishery-independent), but no quantitative assessment was carried out. Hall equated the mesh size of these nets to the mullet nets used in the commercial and recreational net fisheries in this region.

The national review on the survival of released line caught finfish (McLeay *et al*, 2002) incorporated a semi-quantitative risk assessment in the review. Mullet caught by line fishing operations in both the Coorong lagoon as well as along the high energy Coorong beach were recommended as the second highest priority species for SA waters, (after snapper,

⁹ The vulnerability of a bycatch species may be its vulnerability to fishing technology (eg its catchability), or its vulnerability in terms of ecological impact (eg loss of predators or prey)

Pagrus auratus), for further assessment and development of improved techniques to enhance survival.

The vulnerability of non-target species and regulated undersized species to current fishing operations will be assessed following a study of the interactions between current fishing operations and non-target species, including endangered, threatened and protected species (see Appendix F). The study will allow for a risk assessment to be undertaken and provide a basis for future consideration of the need for management actions to address non-target species sustainability.

Management responses

Guideline 2.1.3:

Measures are in place to avoid capture and mortality of bycatch species unless it is determined that the level of catch is sustainable (except in relation to endangered, threatened or protected species). Steps must be taken to develop suitable technology if none is available.

The Southern Fishermen's Association (Heyes, 2002) has provided advice to net fishers on measures to avoid or minimise bycatch of juvenile mulloway when targeting yellow-eye mullet in the small mesh net fishery of the Coorong lagoon. These include:

- The use of floating nets;
- Reduction in net depth;
- Ensuring nets are slung correctly and the optimal mesh size and ply rating is used;
- Avoiding areas of high bycatch; and
- Timing of setting and hauling of nets.

'Coorong' crabs (*Paragrapsis gaimardii*) are a significant bycatch species identified by fishers using mesh nets in the lagoon. Minimisation of this bycatch species in mesh nets is recommended by the Southern Fishermen's Association (Heyes, 2002) through the use of floating set nets, and the avoidance of setting nets in areas of high crab abundance.

SARFAC (2004) has recently released a pamphlet, describing recommended methods for improving the survival of released line caught fish in South Australia. Key species highlighted include Murray cod. An FRDC funded project (2001/099), "National Strategy for the survival of released line caught fish: Planning, project management and communications" is in place to develop and implement a communication and extension program on the best available knowledge for releasing line caught fish by recreational fishers.

The management plan makes a commitment to develop and implement a bycatch action plan for the fishery by 2006 (refer to Table 4).

Guideline 2.1.4:

An indicator group of bycatch species is monitored.

The strategic research and monitoring plan (refer to Appendix C), developed as part of the draft Lakes and Coorong Fishery Management Plan, has recommended a high priority for monitoring the bycatch and its fate for both the commercial and recreational sectors of the fishery. Recommended species include undersized mulloway in the Coorong Lagoon. The SARDI bycatch project (funded by FRDC) commencing in 2005/06 will develop potential performance indicators and reference points related to bycatch of the main fishing gear used in the Coorong lagoons

Guideline 2.1.5:

There are decision rules that trigger additional management measures when there are significant perturbations in the indicator species numbers.

The management plan details the management strategies and performance indicators developed to pursue the goal of ‘minimising fishery impacts on bycatch species and the ecosystem’ (see Table 4). The two reference points specifically focused on bycatch are:

- The amount of bycatch (discards) in commercial mesh net operations, relative to the total catch of retained species is greater than 20% (in weight) in any given year¹⁰; and
- An increasing trend in discard rates in the commercial or recreational fishing sectors over a three year period.

The management response actions are described on page 62.

Guideline 2.1.6:

The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.

The extent to which the Management Plan is achieving the range of established management objectives will be assessed using a combination of the performance indicators, designed to measure the performance of the fishery, the status of individual key species and the overall condition of the environment. The linkages between management objectives, strategies, performance indicators, reference points, management triggers and agreed management actions to be introduced, upon reaching reference points or triggers have been described earlier in this report.

Objective 2.

The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.¹¹

Information requirements**Guideline 2.2.1:**

Reliable information is collected on the interaction with endangered, threatened or protected species and threatened ecological communities.

The following marine and estuarine animals have been considered in this part of the assessment as they are listed under either the EPBC Act or South Australian legislation under the Fisheries (General) Regulations 2000; and are geographically distributed in part or all of the waters under jurisdiction for the Lakes and Coorong Fishery. They are classified as endangered, vulnerable or protected and Table 17 lists those species that have the potential to interact with the fishery.

Table 17: List of marine animals classified as either endangered, vulnerable or protected, and which have the potential for interaction with the Lakes and Coorong fishery.

¹⁰ This reference point will be reviewed following the completion of the risk assessment and bycatch study.

¹¹ “Protected” species are those which warrant a higher degree of conservation and for which explicit legislative or other mechanisms exist, eg they may be categorised under separate legislation as “endangered”, “threatened”, “protected”

Marine Animals	Fisheries (General) Regulations 2000	EPBC Act 1999
Great White shark (<i>Charcarodon carcharias</i>) (ocean beach fishery)	Protected	Vulnerable
Syngnathids (Family <i>Syngnathidae</i>) (incl. common seadragon, big bellied seahorse) (lagoon fishery)		Listed
Freshwater catfish (<i>Tandanus tandanus</i>) (lakes fishery)	Protected	
Silver perch (<i>Bidyanus bidyanus</i>) (lakes fishery)	Protected	
Murray cod (lakes fishery – by-product species)	Protected (Sept – Dec, incl.)	Vulnerable

Under South Australian legislation, all marine mammals and sea birds are protected under the *National Parks and Wildlife Act 1972* and are listed as endangered, vulnerable or rare. Under this Act the following marine animals have the potential for interaction with the Lakes and Coorong Fishery.

Australian fur seal (<i>Arctocephalus pusillus doriferus</i>)	Rare
Australian sea-lion (<i>Neophoca cinerea</i>)	Rare
Southern Right whale (<i>Eubalaena australis</i>)	Vulnerable
Dolphins – bottlenose and common	Vulnerable
Australian Pelican (<i>Morus serrator</i>)	Vulnerable
Cormorants (incl, little black and pied) (<i>Phalacrocorax</i> spp.)	Vulnerable

Sea birds

According to Murray-Jones and Johnson (2003) in the Goolwa cockle (*Donax deltoides*) Fishery Assessment Report, section 5.3.5 ‘Bird Species Impacts’ p45; “A potential indirect impact associated with access to the Goolwa cockle fishery is associated with the nesting period of the hooded plover. During the nesting season, this species reacts to the presence of humans by attempting to hide in shallow depressions, as are typically formed through the footprint of a vehicle tyre track in the sand. As a result, this bird is vulnerable to mortality from vehicles following older tyre tracks. Commercial operators in this region are aware of this issue, and most cockle fishers voluntarily drive on the wet sand at low water to avoid the plovers.

The South Australian National Parks and Wildlife Service restricts access to the Coorong Beach during the key plover reproductive period, which considerably limits beach traffic over the season (DEP, 1989). Vehicle use of the Youngusband Peninsula component of the Coorong Beach (North from Tea Tree Crossing) is closed to all but commercial fishers and permitted (usually SA National Parks and Wildlife Service) vehicles from 25 October to 25 December of each year (inclusive, by regulation). Commercial cockle fishers operating over this period typically employ wide balloontype tyres on their transport vehicles, which materially reduce the depression left in beach sand and hence lessen potential impact on this vulnerable species.”

Ramsar management of the Lakes and Coorong region

The water-bird habitats of this region were designated as wetland habitats of international importance under the Ramsar convention in 1985, and in 2000 the “Coorong and Lakes Alexandrina and Albert Ramsar Management Plan” was prepared.

Assessments

Guideline 2.2.2:

There is an assessment of the impact of the fishery on endangered, threatened or protected species.

The vulnerability of non-target species and regulated undersized species to current fishing operations will be assessed following a study of the interactions between current fishing operations and non-target species, including endangered, threatened and protected species (see Appendix F). The study will allow for a risk assessment to be undertaken and provide a basis for future consideration of the need for management actions to address non-target species sustainability.

As part of their reporting on their fishing operations on their catch and effort forms, commercial fishers will be requested to report on the number and size of Murray cod returned to the water during the closed season (September to December), and the protected species, freshwater catfish and silver perch throughout the year. Information on numbers and size (length) of Murray cod for the rest of the year will also be reported by commercial fishers.

The new catch and effort forms, which are currently being developed for the entire Lakes and Coorong commercial fishery, which will include the compulsory provision to report on their forms, and sightings or interactions with any marine mammals, sea-birds and great white sharks.

Guideline 2.2.3:

There is an assessment of the impact of the fishery on threatened ecological communities.

Bryars (2003) has identified the following major threats to the estuarine river and coastal lagoon components of the lakes and Coorong region:

- Increased level of nutrients caused by agricultural run-off from the River Murray catchment;
- Decreased freshwater flows caused by abstraction from the River Murray catchment;
- Altered patterns of freshwater flows caused by Murray River locks and the Goolwa barrages;
- Increased sedimentation caused by a lack of freshwater flows; and
- Decreased tidal flows caused by increased sedimentation inside the Murray mouth.

Bryars (2003) also identified ‘stock depletion of greenback flounder caused by overfishing for the species’ as a potential threat to these components.

Management responses

Guideline 2.2.4:

There are measures in place to avoid capture and/or mortality of endangered, threatened or protected species.

The management plan makes a commitment to develop and implement a bycatch action plan for the fishery by 2006 (refer to Table 4).

Sea-birds (Pelicans and Cormorants)

The Southern Fishermen's Association (Heyes, 2002) have provided advice to all commercial Lakes and Coorong fishers for reducing interactions with birds, including:

- Setting mesh nets at night;
- Attending mesh nets regularly (reducing soak time); and
- Avoiding setting nets near bird rookeries or colonies.

Murray cod

Commercial catches of Murray cod from the Murray lakes (Alexandrina and Albert) are minimal. Since January 1994, a legal minimum size of 500 mm and a legal maximum size of 1100 mm total length have applied to all Murray cod landings in South Australia. There is a closed season from 1 September to 31 December inclusive. Recreational effort is further regulated by a bag limit of two Murray cod per fisher per day, with gear restrictions including two rod/handline limits and "in attendance" requirements. Prior to the moratorium (January 1990 to December 1993), there was a minimum size limit of 460 mm and a three-month seasonal closure between 1 September and 30 November.

Guideline 2.2.5:

There are measures in place to avoid impact on threatened ecological communities.

Management strategies in the management plan to address this guideline include:

- Exercise a precautionary approach to management, should serious or irreversible threats to fish stocks or the wider ecosystem become apparent – particularly during periods of extended drought;
- Monitor external impacts on the fishery;
- Ensure that state and National water flow strategies take into account impacts on Lakes and Coorong fish stocks;
- Monitor net freshwater flow into South Australia and into the Coorong estuary (over the barrage network);
- Monitor the Status of the River Murray Mouth;
- Develop and implement strategies to improve the opportunity for natural fish passage;
- Improve coordination between Government agencies responsible for water flow management and natural resource management;
- Encourage adoption of the principles outlined in the commercial sector Environmental Management Plan; and
- Develop and implement methods to reduce the environmental impact of certain gear types.

Refer to Table 4 for further information.

Guideline 2.2.6:

The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.

The extent to which the Management Plan is achieving the range of established management objectives will be assessed using a combination of the performance indicators, designed to measure the performance of the fishery, the status of individual key species and the overall condition of the environment. The linkages between management objectives, strategies,

performance indicators, reference points, management triggers and agreed management actions to be introduced, upon reaching reference points or triggers have been described earlier in this report.

Objective 3:

The fishery is conducted in a manner that minimises the impact of fishing operations on the ecosystem generally.

Information requirements

Guideline 2.3.1:

Information appropriate for the analysis in 2.3.2 is collated and/or collected covering the fisheries impact on the ecosystem and environment generally.

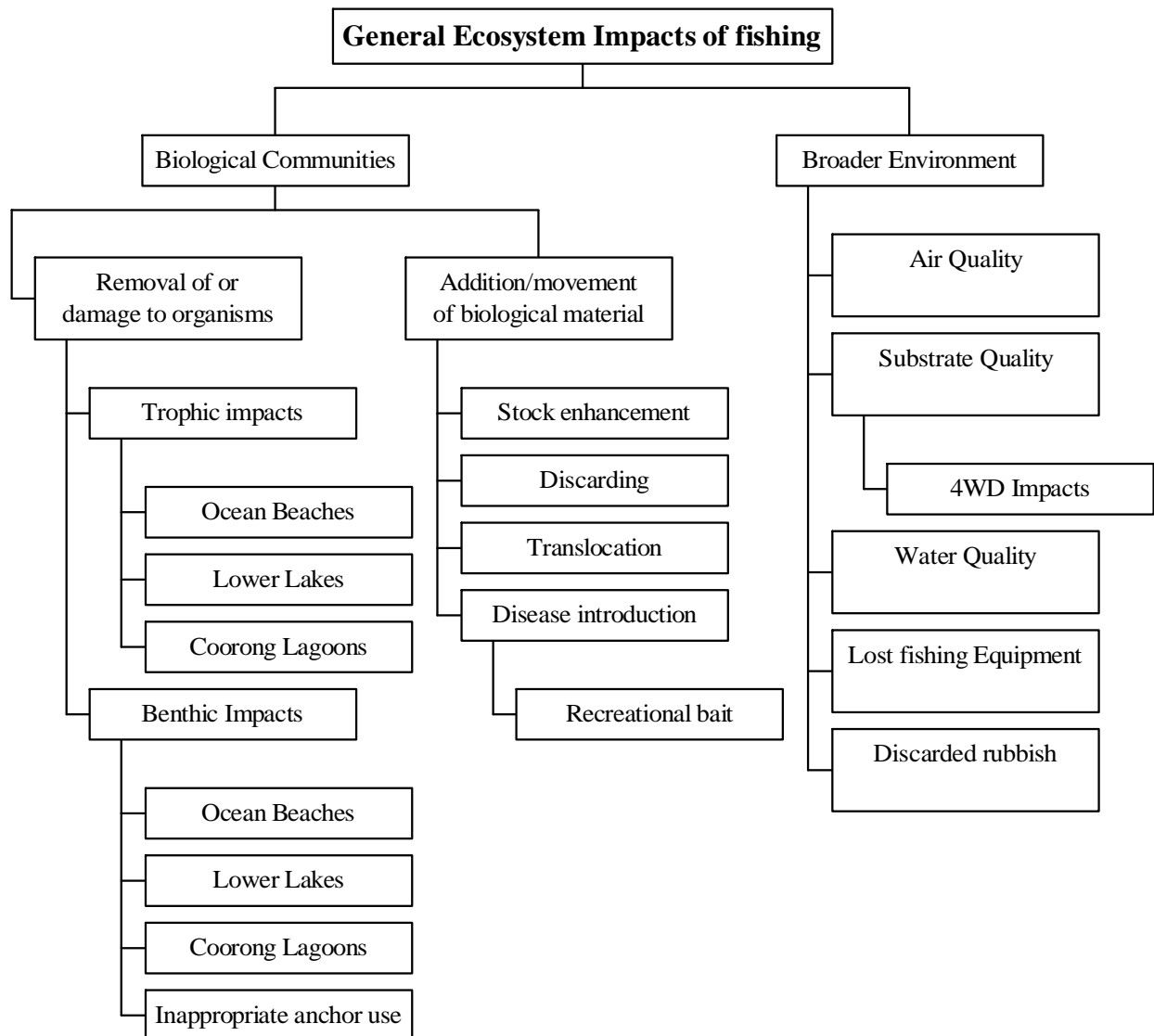


Figure 10: The general ecosystem impacts of fishing in the Lakes and Coorong Fishery

Figure 10 provides an overview on the likely or potential effects that the Lakes and Coorong fishery has on their associated ecosystems and environment generally. The following information is available according to the three major ecosystems:

Coorong Ocean Beach Ecosystem.

Biological communities

Fishing (trophic impacts)

Most of the trophic levels of this ecosystem are fished by commercial and recreational fishers (King and Shepherd, 1982). Primary production (surf diatoms) is believed to be generated from nutrient rich water derived from the River Murray and upwelling of nutrient rich water from the south-east of SA (McLaughlin and Hesp, 1984; Geddes, 1984; Scharhinger, 1987, resp.), and Goolwa cockles filter-feed on the surf diatoms, *Asterionella* spp. (King, 1976). The sand crab (*Ovalipes australiensis*), which is a bycatch species in the Goolwa cockle rake fishery, is a primary predator of the cockles (Jones, 1999). The secondary predators, mulloway, have been reported to feed on *O. australis* (Hall, 1986). However, no research has been undertaken to determine whether the effects of fishing on Goolwa cockles or mulloway have had any significant effects on the abundances of predators or prey.

Adult mulloway are known to aggregate at the mouth of the River Murray to feed on fish (both native species – bony bream, and exotic species – European carp), when these species accompany fresh water flows from the open barrages through the mouth and to the ocean beach ecosystem. It is not known whether the introduction of European carp into the River Murray since the 1960's has meant that there has been an increase in tendency for mulloway to aggregate. If this is the case, an increase in the vulnerability of these aggregations to fishing must be considered.

According to Murray-Jones and Johnson (2003) in the Goolwa cockle (*Donax deltoides*) Fishery Assessment Report; “*There may be impacts on wading birds if the resource were to be seriously depleted. For example, pied oystercatchers rely heavily on D. deltoides for food, and preferentially target large cockles (S. Murray-Jones, unpublished data).*”

Benthic and open water communities

This ocean beach ecosystem of sand substrate is a highly dynamic one, with strong long-shore drift, medium tidal amplitude, and strong oceanic ground swells (Bryars, 2003). Both the benthic and open water communities associated with this ecosystem are mainly mobile (eg patches of *D. deltoides* are mobile; Murray-Jones and Johnson, 2003), and so the impact of fishing gear on these communities is believed to be minimal.

Translocation (pest species)

This applies to European carp and is addressed in the Fishing (trophic levels) component for this ecosystem.

Bait collection

Although the proportion of Goolwa cockles harvested for human consumption is believed to be increasing, the greatest proportion harvested is currently for bait purposes (commercial and recreational line fishing for KG whiting and other marine finfish species) (Murray-Jones and Johnson, 2003). The assessment and management of the Goolwa cockle fishery has been fully addressed in other parts of this report.

Berleying

Commercial (MSF) and recreational line fishers targeting adult mulloway along the Coorong ocean beach, at times deploy berley bags (chopped pilchards) in the surf zone to attract the

target species (P. Rogers, SARDI, pers. obs.). Other by-product and bycatch species, including whaler sharks and rays, are also known to be attracted.

Broader Environment

Substrate Quality

Assessment of habitat damage caused by Goolwa cockle harvesting due to manual netting activity has been broadly assessed. Given the nature of the high energy beach zone, the highly mobile substrates are re-sorted on each tidal cycle. Hence no habitat damage is likely from cockle fishing in the intertidal zone (Murray-Jones and Johnson, 2003).

Vehicles on ocean beaches

According to Murray-Jones and Johnson (2003) in the Goolwa cockle (*Donax deltooides*) Fishery Assessment Report, section 5.3.4 'Vehicular Impacts' p44; the impact of vehicular activity along the ocean beaches is a factor that needs to be addressed in assessing the Goolwa cockle fishery. *"One of the few published studies addressing recreational 4WD impacts, conducted on a mid-Atlantic beach, did not find any significant mortality or shell damage in fauna associated with traffic (Wolcott and Wolcott, 1984). Digging out Goolwa cockles by hand after deliberately driving over a section of beach did not show shell damage in 220 individuals across the full size spectrum, (B. Pierce, unpublished data, Jan. 1998). On the east coast of Australia, cockles move upwards when vehicles pass over them (the trigger is likely to be acoustic shock, sensu Ellers 1995). If cockles are in the swash zone when disturbed, they will surf downwards on the next wave. If they are stranded in the mid-intertidal where the sand is hard packed, this upward movement of the cockles results in very visible "bumps" in the sand, which can in fact be used for rapid rough assessment of densities (Murray-Jones, 1999) and is used by fishers to locate fishing sites. No mortality from vehicles was observed during a six-year study on D. deltooides in NSW, although the hooves of horses being exercised on the beach were seen to cause shell damage (Murray-Jones, pers. obs.)."*

In the case of the Coorong beach fishery, some fishers suggest that vehicular activity on the beach causes a behavioural reaction in adjacent cockle stocks resulting in disaggregation and reduced catchability of the resource. This impact has not been quantitatively examined, although it is likely to enhance rather than reduce sustainability of the resource by lowering harvest efficiency. Any such behavioural impact is likely to be associated with potential increased predation or reduced reproductive success. No such change has been reported elsewhere for Donacid bivalves. Disturbed cockles simply tend to re-aggregate on the next tidal cycle. The distribution of the cockles includes areas with no vehicle access and therefore the overall impact is not likely to be major, although further research is needed to quantitatively address vehicular impacts."

Another potential effect from fishers' vehicles on the ocean beach ecosystem, is the vulnerability of nesting shore sea-birds, eg hooded plover to vehicles (Murray-Jones and Johnson, 2003).

Water quality

The main factor affecting water quality along the Coorong ocean beach ecosystem is the quality of water derived from the River Murray, salinity and pathogens. Mass mortalities of Goolwa cockles have occurred at times in the past, and have been explained through extended periods of low salinity water from outflows from the mouth (Murray-Jones and Johnson, 2003). As Goolwa cockles are filter-feeders, there is a risk that pathogens are introduced

during periods of high rainfall and when agricultural runoff is at its highest and outflows through the mouth could translocate these pathogens to this ecosystem.

Coorong Lagoon and Estuary Ecosystem

All fishery habitats found within the Coorong lagoon are regarded as threatened (Bryars, 2003). The lagoon has been separated into two ecosystems, a) the estuarine river adjacent to the seaward side of the barrages, and b) the lagoon, south of the estuarine river.

For the estuarine river ecosystem, major threats are due to:

- Increased levels of nutrients caused by agricultural runoff from Murray River catchment;
- Decreased freshwater flow caused by abstraction from Murray River catchment;
- Altered patterns of freshwater flow caused by locks and barrages;
- Increased sediment caused by lack of flow; and
- Decreased tidal flows caused by increased sedimentation inside the Murray Mouth (Bryars, 2003).

For the Coorong lagoon ecosystem, major threats are due to:

- Decreased tidal flows caused by sedimentation and closure of the Murray mouth; and
- Decreased freshwater flows caused by abstraction from the River Murray catchment. (Bryars, 2003).

These threats to the communities within the lagoon have been highlighted through the closure of the Murray mouth in 1982 and, more recently, in 2003.

Effects of these threatening issues and implications to the fishery and the sustainability of the fish stocks include the diminution of optimum habitat for several of the estuary dependent species (ie lower salinities for mullocky, flounder and black bream). With diminished flows through the barrages, there is a risk that a significant proportion of the populations of these species occurring in the Coorong Lagoon will aggregate in the vicinity of water of the lower salinity (ie adjacent to the barrages), thus increasing their vulnerability to targeted fishing.

Fishing (trophic impacts)

Primary productivity is primarily derived from nutrients from the River Murray – see Geddes, 1984), whereas in other sheltered coastal waters of SA, seagrasses play a dominant role in primary production for those ecosystems (McArthur et al, 2003). The trophic levels of this ecosystem are the least well understood of all the ecosystems in the Lakes and Coorong region. Hall (1986) reported on the diets of juvenile mullocky, and found that finfish dominated their diet, whereas, amphipods and *Macrobrychium* shrimps, made up relatively small proportion of their diet, by weight. With increasing size of mullocky, the prey size increased too; thus, in 1 yr old mullocky, their diet was dominated by small Atherinids (hardyheads), whereas, the diet of two year old mullocky consisted mainly of the freshwater species, bony bream. Hall speculated that in years of low flow of water through the barrage, the proportion of bony bream in their diet would be minimal (Hall, 1986).

Weng (1971) found that black bream in the Coorong lagoon were benthic omnivores, feeding on mud crabs, tubicolous worms and filamentous algae (*Enteromorpha*). Although the diets of black bream, flounder and mullet are well known outside the Coorong region (see Ye et al, 2003; Kailola et al, 1993), no comprehensive investigation of the diets of these species and their relative positions in the food chain has been studied for this region.

The impact of fishing one target species on the abundance or productivity of another target species is currently not known.

Benthic communities

The effects of selective fishing on key species, which in turn feed on macro-fauna of sediments may, in turn, influence the distribution and abundance of wading birds (Ramsar Convention). Potential fish species which may compete with wading birds include flounder; however, there is currently no available information.

Open water communities

Species composition of open water communities include the finfish species: juvenile salmon, sandy sprats, larval stages of bream, mullet, flounder and seabirds, which feed on open water finfish: these include: terns, cormorants and pelicans. However, the relative abundances and trophic position of these species is unknown.

Stock enhancement

Mulloway has been considered as a potential species for stock enhancement in the Coorong Lagoon, however, the current Fisheries Act 1982 prohibits the release of any farmed fish into any waters.

Pests

The exotic species, European carp is the main pest species that may impact the ecosystems of the Coorong lagoon. In years of high water flow through the barrages and high carp abundance in the lakes, significant strandings of dead and dying carp occur in waters of the lagoon where salinities match those of the ocean (Anon, 1977).

The other pest species known to occur in the Coorong Lagoon is the European shore crab (*Concinus maenas*), however, this has only been recorded once in this area (Zeidler, 1988), and so effects are considered to be minimal.

Bait collection

There are few reports of bait being collected by fishers within the Coorong lagoon and this activity is believed to be minimal.

Berleying

In similarity with the ocean beach line fishery for mulloway, sub-adult mulloway are attracted to baited line fishing operations in the lagoon through the use of berley bags deployed from the shore or fishing vessels (P. Rogers, SARDI, pers. obs.). Therefore, there is an increased chance of attracted unwanted species, such as rays, during these operations.

Fishways

The construction of the barrages formed a barrier between the fresh water Lakes and Coorong estuary and prevented fish from moving between freshwater and sea water as part of their natural life cycle, except when the barrage gates were open. The frequency of barrage gate opening has been reduced over time due to the ongoing competing demands for water use, reducing the habitat available for fish to complete their life cycle.

Natural fish passage in the Lakes and Coorong is affected by the barrage network, which restricts fish passage between the Lakes and the Coorong Lagoons and the Murray mouth. When the mouth is threatened by closure, this can restrict natural movement between the ocean and the Coorong lagoons and hence between the River Murray Lakes and the Sea.

The following species will be directly affected by Mouth closure due to an interrupted life cycle (Higham, *et al.*, (2002):

- Climbing galaxias (*Galaxias brevipinnis*);
- Common galaxias (*Galaxias maculatus*);
- Pouched lamprey (*Geotria australis*);
- Short-headed lamprey (*Mordacia mordax*);
- Shortfin eel (*Anguilla australis*);
- Estuary perch (*Macquaria colonorum*);
- Congolli (*Pseudaphritis urvilli*);
- Jumping mullet (*Liza argentea*);
- Yellow-eye mullet (*Aldrichetta forsteri*);
- River Garfish (*Hyporhamphus regularis*);
- Mulloway (*Argyrosomus japonicus*); and
- Sea mullet (*Mugil cephalus*).

This list includes many of the species harvested by commercial and recreational fishers in the Coorong and a sizeable contribution to the diversity and abundance of Lower Lakes fauna. Higham, *et al.*, (2002) suggested that further, secondary consequences of Mouth closure relate to elevated salinities and possible reduced dissolved oxygen concentration in the Coorong, as well as the effect of reduced food availability and increased predator-prey interactions due to the impact of salinity increases reducing suitable habitat for all species.

The Murray-Darling Basin Ministerial Council have recognised the impact that barriers to fish passage have caused and have funded a \$25m project to provide fish passage from the Sea to Hume Dam, through the Living Murray Implementation Program. Part of this program includes fish passage at the River Murray barrages. Four fish passages are being trialled to test their effectiveness under estuarine conditions, two at the Goolwa Barrage and two at the Tauwichee Barrage.

Habitat modification

Habitat modification by fishers may occur through disturbance of shore habitat from wave wash, anchor drag over bottom habitat and the scarring of bottom habitat from propellers of vessels. None of these effects have been investigated for the Coorong lagoon.

Lakes Alexandrina and Albert Ecosystem

Fishing (trophic impacts)

As reported above, the construction of the barrages converted this area of the Lakes and Coorong Fishery from one of the most extensive estuaries along the southern Australian coast, to largely freshwater lakes, with minimal variation in lake level (Reynolds, 1976). This has resulted in significant changes to the fish community structure as well as the bottom and open water communities. Additionally, a number of exotic pest species have been introduced to this ecosystem, again influencing the community structure and associated trophic dynamics.

Reynolds (1976) outlined the trophic relationships for the key economically important species in these waters. In the years after the construction of the barrages and prior to the introduction of European carp, yabbies (*Cherax destructor*) were believed to be an important herbivore and detritus feeder (Anon, 1979), and key prey species for golden perch (Reynolds, 1976). Due to the adverse effects of carp on the critical habitat utilized by yabbies, yabbie abundance has dropped, and juvenile carp now occupy a significant proportion of the diet of golden perch.

The schooling open water species, bony bream (*Nematalosa erebi*) are detritus (plant material and aquatic insects) feeders (Briggs, 1989), and are prey to golden perch and Murray Cod (Reynolds, 1976).

Benthic and open water communities

The lakes ecosystem has been highly modified, since the construction of the barrages (see above). Any effects by the current fishery on the benthic or open water communities in this region are considered to be minimal, in comparison with that of the barrages.

Translocation

Stocking of trout in some of the rivers flowing into the lakes occurs but numbers of trout found in the actual lakes is believed to be relatively small.

Exotic pests and diseases

A number of exotic fish species are now common in the Lakes ecosystem. These include European carp (*Cyprinus carpio*), redfin perch (*Perca fluviatilis*), mosquito fish (*Gambusia* sp.). Trout (brown and rainbow) also occur in the lakes ecosystem, however, are more common in the streams flowing into the lakes. The effect of carp on the native fish species has already been highlighted (see above). Redfin perch are known to prey on juvenile native species (Reynolds, 1976), and *Gambusia* sp. Feed on the eggs and larvae of native species (Reynolds, 1976).

The introduced virus (Epizootic Haematopoietic Necrosis (EHN) was detected in redfin perch in the lakes ecosystem in 1990. Significant mortalities of redfin perch resulted in that year (Pierce et al, 1991). Although lesser effects are known on native fish species, they are still believed to be carriers of the disease.

Fishways

With the construction of the fishways at the barrages, it is highly likely that the species composition of the fish communities in the lakes ecosystem will change. Some baseline information on the fish community structure prior to the fish ways are available (Ye et al, 2003, 4?).

All other potential impacts outlined in Figure 10 are believed to be minimal for the lakes ecosystem.

Assessment

Guideline 2.3.2:

Information is collected and a risk analysis, appropriate to the scale of the fishery and its potential impacts, is conducted into the susceptibility of each of the following ecosystem components to the fishery.

1. Impacts on ecological communities
 - Benthic communities
 - Ecologically related, associated or dependent species
 - Water column communities
2. Impacts on food chains
 - Structure
 - Productivity/flows
3. Impacts on the physical environment
 - Physical habitat
 - Water quality

Bait collection

Commercial catch, effort and CPUE data on Goolwa cockles is currently being collected for the Lakes and Coorong Fishery and bait collection by RLF and MSF licence holders will be monitored. Part of the harvest by commercial and recreational fishers in the L&CF is for bait purposes.

The NRIFS survey of size of baitfish harvest for the Coorong Lagoon is not currently available, but this is considered to be minimal as size of baitfish harvest by recreational fishers on a statewide basis is minimal (Jones and Doonan, 2005).

Fishing trophic levels

No assessments are currently being undertaken.

Benthic / open water communities

Berleying

Attraction of unwanted species. No current monitoring.

Translocation and pests

- Target species – policy paper currently being written by PIRSA.
- Fish ways – base line information currently being collected.
- Pests – commercial catch and effort for carp, redfin perch monitoring. No current fishery-independent surveys.
- Water quality – SASQAP survey for Goolwa cockles.

Vehicles on ocean beaches

An potential effect from fishers' vehicles on the ocean beach ecosystem, is the vulnerability of nesting shore sea-birds, eg hooded plover to vehicles (Murray-Jones and Johnson, 2003; Weston, 2003).

Management responses

Guideline 2.3.3:

Management actions are in place to ensure significant damage to ecosystems does not arise from the impacts described in 2.3.1.

The management plan has specific management strategies, performance indicators and reference points to achieve the goal of 'minimising any external impacts on fish stocks associated with broader environmental or ecosystem health' (refer to Table 4 on page 36)

Bait fisheries

For the Goolwa cockle fishery there is a seasonal closure from 1 June to 31 October and a minimum size limit of 35 mm. The number of fishing licences with access to Goolwa cockles for sale is limited to 29 in the Lakes and Coorong Fishery and 2 in the MSF. Other licence holders in the MSF and RLF have access to Goolwa cockles for personal bait purposes. There is a recreational bag limit of 600 cockles per person per day, which intends to allow for a bucket of cockles to be collected. PIRSA will undertake a review of size and bag limits in 2005/06.

Food chain effects

No consideration at present.

Berleying

Attraction of protected species, such as white sharks – regulations against berleying from wharves and vessels to attract sharks (Great white shark, regulations, 1999).

Translocation

PIRSA is currently developing a policy for stock enhancement. Translocation is currently not permitted.

Pests

Carp and redfin are not permitted to be returned to the water.

Vehicle use on Coorong Beach

Seasonally closed to all users, except commercial fishers who use "balloon" tyres to minimise effects on the hooded plover population.

Guideline 2.3.4:

There are decision rules that trigger further management responses when monitoring detects impacts on selected ecosystem indicators beyond a predetermined level, or where action is indicated by application of the precautionary approach.

The management plan details the management strategies and performance indicators developed to pursue the goal of 'minimising fishery impacts on bycatch species and the ecosystem' and 'minimising any external impacts on fish stocks associated with broader environmental or ecosystem health' (see Table 4). There are currently no reference points specifically focussed on the impacts of the fishery on the broader ecosystem; however, there are reference points for indicators of ecosystem health, such as environmental flows, Murray mouth closure and fish passage.

Guideline 2.3.5:

The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.

The extent to which the Management Plan is achieving the range of established management objectives will be assessed using a combination of the performance indicators, designed to measure the performance of the fishery, the status of individual key species and the overall condition of the environment. The linkages between management objectives, strategies, performance indicators, reference points, management triggers and agreed management actions to be introduced, upon reaching reference points or triggers have been described earlier in this report.

References

- Anderson, J.R., Morison, A.K. & Ray, D.J. (1992) Validation of the use of thin-sectioned otoliths for determining the age and growth of golden perch, *Macquaria ambigua* (Perciformes: Percichthyidae), in the lower Murray-Darling basin, Australia. *Aust. J. Mar. Freshwat. Res.* 43 (5), 1103 – 1128.
- Anon (1977) Carp killed. *SAFIC Magazine*, Feb, 1977, No. 11. p. 13.
- Anon (1979) Studies on diet of the yabbie. *SAFIC magazine*, Vol, 3 (2), 13 – 5.
- Battaglione, S. & Prokop, F. (1987) Golden Perch. NSW Dept. Agriculture AGFACTS A3.2.2.
- Burridge, C.P., Hurt, A.C. Farrington, L.W., Coutin, P.C. & Austin, C.M. (2004) Stepping stone gene flow in an estuarine dwelling sparid from south-eastern Australia. *J. Fish. Biol.* 64, 815 – 19.
- Briggs, I. (1989) Family Clupeidae. Herrings. In “ Freshwater fishes of south-eastern Australia.” Ed. R. McDowell, publ. Reed. P. 48 – 9.
- Bryars, S. (2003) An inventory of important coastal Fisheries Habitats in South Australia. Fish Habitat Program PIRSA. NHT Project No. 99069. Fisheries habitat – a strategy for sustainability. 909 pp.
- Cashmore, S., Conron, S. & Knuckey, I. (eds) (2000) Black bream – 1998. Compiled by the Bay and Inlet Fisheries Stock Assessment group. Fisheries Victoria Assessment Report. No. 24. (MAFRI, Queenscliff).
- Chen, W-M., Purser, J. & Blyth, P. (1999) Diel feeding rhythms of greenback flounder *Rhombosolea taparina* (Gunther 1862): the role of light-dark cycles and food deprivation. *Aquaculture Research* 30, 529 – 537.
- Connolly, R.M. (1994) A comparison of fish assemblages from seagrass and unvegetated areas of a southern Australian estuary. *Aust. J. Mar. Freshwat. Res.* 45, 1033 – 1044.
- Cox, E.S. & Panhurst, P.M. (2000) Feeding behaviour of greenback flounder larvae, *Rhombosolea taparina* (Gunther) with different exposure histories to live prey. *Aquaculture* 183, 285 – 97.
- Crawford, C.M. (1984) Preliminary results of experiments on the rearing of Tasmanian flounders, *Rhombosolea taparina* and *Ammotretis rostratus*. *Aquaculture* 42, 75 – 81.
- Crawford, C.M. (1986) Development of eggs and larvae of the flounders *Rhombosolea taparina* and *Ammotretis rostratus*(Pisces: Pleuronectidae). *J. Fish Biol.* 29, 325 – 334.
- Department of Environment & Heritage (2000) Coorong and Lakes Alexandrina and Albert Ramsar Management Plan. South Australian Dept. Environment and Heritage 63 p.
- Department of Environment and Planning (1990) Coorong National Park Management Plan. National Parks and Wildlife Service. A Division of the South Australian Dept. Environment & Planning 54 p.

- Ferguson, G. and Ward, T. (2003) Mulloway (*Hololepidotus japonicus*). Fishery Assessment Report to PIRSA (Fisheries) for the Inland Fisheries FMC. SARDI Aquatic Sciences Publication No. RD 03/0040. 55pp.
- Geddes, M.C. (2005) Ecological outcomes for the Murray Mouth and Coorong from the managed barrage release of September-October 2003. Final Report April, 2005. SARDI Aquatic Sciences Publ. No. RD03/0199-2. 69pp.
- Glover, C.J.M. (1982) Fishes. In: Natural History of Kangaroo Island. Ed Tyler, M.J., Twidale, C.R., and Ling, J.K. publ. Roy. Soc. SA pp. 139 – 153.
- Glover, C.J.M. (1985) Fishes. In: Natural History of the South East. Ed Tyler, M.J., Twidale, C.R., Ling, J.K. and Holmes, J.W. publ. Roy. Soc. SA pp. 157 – 67.
- Glover, C.J.M. & Olsen, A.M. (1983) Fishes and Fisheries. In: Natural History of Eyre Peninsula.
- Gomon, M.F., Glover, J.C.M. and Kuitert, R.H. (1994) The fishes of Australia's south coast. SA State Print, 922 pp.
- Hall, D. (1984) The Coorong: biology of the major fish species and fluctuations in catch rates 1976 – 1984. SAFIC 8 (10, 3 – 17).
- Hall, DA. (1986) An assessment of the mulloway (*Argyrosomus hololepidotus*) fishery in South Australia with particular reference to the Coorong Lagoon. Discussion Paper. SA Dept. Fisheries. 41 pp.
- Harris, J.A. (1968) Age structure, growth rate and spawning cycle of a population of yellow-eye mullet *Aldrichetta forsteri* (Cuv. Et Val.) from the Coorong Lagoon, South Australia. Trans. Roy. Soc. SA 92, 37 – 50.
- Harris, J.H. & Rowland, S.J. (1996) Australian freshwater cods and basses. In: Freshwater Fishes of south-eastern Australia. R.M. McDowell (Ed.) Reed Books, NSW 247 pp.
- Henry, G.W. and Lyle, J.M. (2003) The National Recreational and Indigenous Fishing Survey. FRDC Project No. 99/158. 188 pp.
- Heyes, C. (2002) Lakes and Coorong Fishery. Best practices to minimise interaction of juvenile mulloway, crabs and birds with fishing gear. Southern Fishermen's Association/Seanet Unpublished Report. 9 pp.
- Higham, J. Ferguson, G. and Ye, Q. (2005) Lakes and Coorong Yellow-eye mullet (*Aldrichetta forsteri*) fishery. Fishery Assessment report to PIRSA (Fisheries) for the Inland Fisheries Management Committee. SARDI Aquatic Sciences Publ. No. RD04/0162. 43 pp.
- Jackson, G. and Jones, G.K. (2000) Spatial and temporal variation in nearshore fish and macro-invertebrate assemblages from a temperate Australian estuary over a decade. Marine Ecology Progress Series. 182 – 268.
- Jones, G.K., Baker, J.L., Edyvane, K. and Wright, G.J. (1996) The nearshore fish community of the Port River-Barker Inlet Estuary, South Australia. 1. The effect of thermal effluent on the fish community structure and distribution and growth of economically important fish species. Mar. Freshwat. Res. 47 (6), 785 – 799.

- Jones, G.K. & Doonan, A.M. (2005) National Recreational & Indigenous Fishing Survey 2000/01 South Australian Regional Information. South Australian Fisheries Management Series Paper No. 46. 100 pp.
- Jones, G.K and Westlake, M.G. (2003) Marine Scalefish and Miscellaneous Fisheries. Australian salmon and herring. Fishery Assessment report to PIRSA for the MSF Fishery management Committee. South Australian Fisheries Assessment Series 01/18. 1 – 25.
- Kailola, P.J., Williams, M.J. Stewart, P.C. Reichelt, R.E. McNee, A. & Grieve, C. (eds). (1993) Australian Fisheries Resources Canberra, Bureau of Resource Sciences, DPIE and FRDC.
- King, M.G. (1976) The life history of the Goolwa cockle *Donax (Plebidonax) deltoides* (Bivalvia: Donacidae), on an ocean beach, South Australia. Fisheries Branch, South Australian Department of Agriculture and Fisheries Internal report. (85): 16 pp.
- King, M. & Shepherd, S.A. (1982) Food webs (ch. 2) In: Shepherd, S.A. & Thomas, I.M. Marine Invertebrates of South Australia. Part 1. SA Govt. Printer.
- Knight, M.A., Tsolos, A., Doonan, A.M. (2004) South Australian Fisheries and Aquaculture Information and Statistics Report. SARDI Research Report Series No. 60, 82 pp.
- Koehn, J., Brumley, A. & Gehrke, P. (2000) Managing the impacts of carp. Bureau of Rural Sciences (Dept. Agriculture, Fisheries & Forestry – Australia), Canberra.
- Kurth, D.(1957) An investigation of the greenback flounder, *Rhombosolea taparina*, Gunther. PhD Thesis. University of Tasmania.
- MacDonald, C.M. (1978) Morphological and biochemical systematics of Australian freshwater and estuarine percichthyid fishes. Aust. J. Mar. Freshwat. Res. 29 (5), 667 – 98.
- McArthur, L.C., Boland, J.W., Brown, B. & Jones, G.K. (2003) Investigation of the influence of seagrass on fisheries catch level using isotonic regression. Environmental modelling & Assessment, 8, 285 – 290.
- McDowell, R.M. Ed. (1986) Freshwater fishes of south-eastern Australia. Sydney, Reed Books, Australia. Chatswood, NSW.
- Mackay, N.J. (1973) Histological changes in the ovaries of the golden perch, *Plectroplites ambiguus*, associated with the reproductive cycle. Aust. J. Mar. Freshwat. Res. 24, 95 – 101.
- McLeay, L.J., Jones, G.K. and Ward, T. M. (2002) National Strategy for the survival of released line-caught fish: A review of research and fishery information. FRDC Final Report Project No. 2001/101. 122 pp
- Merrick, J.R. & Schmida, G.E. (1984) Australian Freshwater Fishes, biology and management. Griffin Press Ltd, Netley, South Australia. 409 pp.
- Morrissy, et al, (1990)
- Murray-Darling Basin Commission (2002) The Murray Mouth: Exploring the implications of closure or restricted flow. Canberra. 96 pp.

Murray-Darling Basin Commission (2003) Regional Evaluation Group Assessment Report to the Scientific Reference Panel: Lower Lakes and Coorong. Murray Darling Basin Commission Living Murray Initiative. Canberra 31 pp.

Murray-Darling Basin Commission (2005). The Barrages. World wide web electronic resource: http://www.mdbc.gov.au/river_murray/river_murray_system/barrages/barrages.htm. Date accessed: 3 February 2005.

Murray-Jones, S. and Ayre, D.J. (1997) High level of gene flow in the surf bivalve *Donax deltoides* (Bivalvia: Donacidae) on the east coast of Australia. Mar. Biol. 128 (1), 83 – 9.

Murray-Jones, S. and Johnson, J.A. (2003) Goolwa cockles (*Donax deltoides*) Fishery Assessment Report to PIRSA (Fisheries) for the Inland Waters Fisheries Management Committee. South Australian Fisheries Assessment Series 2002/21. 54 pp.

Musyl, M.K. & Keenan, C.P. (199) Population genetics and zoogeography of Australian freshwater golden perch (*Macquaria ambigua*) (Richardson 1845) (Teleostei: Percichthyidae) and electrophoretic identification of a new species from the Lake Eyre Basin. Aust. J. Mar.Freshwat. Res. 43, 1485 – 1601.

New South Wales Fisheries (2005) The freshwater yabby. NSW website: http://www.fisheries.nsw.gov.au/aquaculture/freshwater2/the_freshwater_yabby.

Olsen, A.M. (1991) The Coorong: A Multi-species Fishery. Part 1. – A history and development. Fish. Res. Pap. Dep. Fish. (S.Aust.) No. 22, 1 – 37.

Pellizzari, M. (2001) Discrimination of populations of yellow-eye mullet (*Aldrichetta forsteri*) in southern Australia, using morphometric analyses, growth of adults and their reproductive biology. (SARDI (Aquatic Sciences) Unpubl. Report, pp.

Pellizzari, M. (2002) The early life history of yellow-eye mullet (*Aldrichetta forsteri*), in the Coorong Lagoon South Australia, determined via analysis of otolith microstructure. B.Sc (Hons) thesis, University of Adelaide, Dept. of Environmental Biology., 43 pp.

Phillipson, M., Byrne, J. & Rohan, G. (1986) Participation in recreational fishing in South Australia Fish. Res. Pap. (S.Aust) Dep. Fish. No. 16.

Pierce, B.E., Phillips, P.H. and Jackson, G. (1991) Redfin Virus (EHD) Fish disease confirmed in South Australia. Safish Magazine, Vol. 15 (3), 5 – 6.

Pierce, B.E. and Doonan, A. (1999) A summary report on the status of selected species in the River Murray and Lakes and Coorong Fisheries. South Australian Fisheries Assessment Series 99/1. SARDI.

Pitcher, T.J. (2001) Fisheries managed to rebuild ecosystems ? Reconstructing the past to salvage the future. Ecological Applications. 11 (2), 601 – 617.

Potter, I.C., & Hyndes, G.A. (1984) Composition of the fish fauna of a permanently open estuary on the southern coast of Australia, and comparisons with a nearby seasonally closed estuary. Mar. Biol. 121 199 – 209.

Reynolds, L.F. (1976) Decline of the native fish species in the River Murray. SAFIC. No. 8, 19 – 24.

- Rohan, G. (1987) River Fishery (South Australia) – review of management arrangements. Green Paper. South Australian Dept. Fisheries 31 pp.
- Rowland, S. J. (1983) The hormone-induced ovulation and spawning of the Australian freshwater fish golden perch, *Macquaria ambigua* (Richardson) (Percichthyidae) *Aquaculture* 35, 221 – 38.
- SARFAC (2004) Guide for the survival of released line caught fish. Pamphlet published and released in March, 2004 by the South Australian Recreational Fishing Advisory Council Inc.
- Sloan, S. (2005) Management Plan for the South Australian Lakes and Coorong Fishery. South Australian Fisheries Management Series. Primary Industries and Resources, South Australia. South Australian Fisheries Management Series. Paper No. 44, 135 pp.
- Thomson, J. M. (1957) Biological studies of economic significance of the yellow-eye mullet, *Aldrichetta forsteri* (Cuvier & Valenciennes) Mugilidae) *Aust. J. Mar. Freshwat. Res.* 8, 1 – 13.
- Trigg, F. (1940) Fisheries Act, 1917 – 1938.: Regulations and Proclamations Government Printer, Adelaide, SA: 27 pp.
- Van den Enden, T., White, R.W. & Elliot, N.G. (2000) Genetic variation in the greenback flounder *Rhombosolea taparina* Gunther (Teleostei, Pleuronectidae) and the implications for aquaculture. *Mar. Freshwat. Res.* 51, 21 – 33.
- Wallace-Carter, E. (1987) For they were fishers: The history of the fishing industry in South Australia. Amphitrite Publ. House, Adelaide, S.A.
- Webb, B.F. (1973) Fish populations of the Avon-Heathcote Estuary. 1. General ecology, distribution and length frequency. *NZ J. Mar. Freshwat. Res.* 7 (1 & 2), 45 – 66.
- Weng, H. T-C. (1971) The black bream (*Acanthopagrus butcheri* (Munro)); its life history and its fishery in South Australia. MSc Thesis, University of Adelaide. 97 pp, 21 figs, 26 tables.
- Westlake, M.G. (1997) Early life history of small-toothed flounder in Coorong Estuary, South Australia. BSc(Hons) Thesis University of Adelaide. pp.
- Westlake, M. & Jones, G.K. (1999) Sand Crabs (*Ovalipes australiensis*). Fishery Assessment Report to PIRSA for the Marine Scalefish Fishery Management Committee. SA Fisheries Assessment Series 99/15. 25 pp.
- Weston, M.A. (2003) Managing the Hooded plover *Thinordis rubricollis* – a critical review.. Abstract to 4th Australasian Shorebird Conference “Status and conservation of shorebirds in the east Asian-Australasian Flyway.” Dec 13 – Dec, 2003, ANU, Canberra.
- Whitfield, A.K. (1999) Ichthyological assemblages in estuaries: A South African case study. *Rev. in Fish Biology & Fisheries.* 9, 151 – 86.
- Ye, Q., Jones, G.K. & Pierce, B.P. (2000) Murray cod (*Maccullochella peelii peelii*) Fishery Assessment Report. Series 2000/17.
- Ye, Q. et al (2003) Lake George Fishery Assessment.

Ye, Q. (2004) Golden Perch (*Macquaria ambigua*). Fishery Assessment Report to PIRSA Fisheries. SARDI Aquatic sciences Publ. No. RD04/0167. 75 pp.

Yearsley, G.K., Last, P.R. (eds) (1999) Australian Seafood Handbook. An identification guide to domestic species. Hobart, CSIRO Marine Research.

Zeidler, W. (1988) The European shore crab, *Carcinus maenas* in hre Coorong – a potential threat to local fisheries. Trans. Roy. Soc. S.A. 112 (4), 181 – 2.

Appendix A: South Australian Inland Waters Catch and Effort Return

The following fish are specified for the Lakes and Coorong Fishery in the *Fisheries (Scheme of Management – Lakes and Coorong Fishery) Regulations 1991*:

Scalefish

Anchovy (*Engraulis australis*)
Barracouta (*Thyrsites atun*)
Bluethroated wrasse (*Notolabrus tetricus*)
Bony bream (*Nematalosa erebi*)
Black bream (*Acanthopagrus butcheri*)
Carp (all species) (Family Cyprinidae)
Freshwater catfish (*Tandanus tandanus*)
Cod (marine species) (Family Moridae)
Congolli (*Pseudaphritis urvilli*)
Dory (Family Zeidae)
Flathead (Family Platycephalidae)
Flounder (Family Pleuronectidae)
Southern sea garfish (*Hyporhamphus melanochir*)
River garfish (*Hyporhamphus regularis*)
Mullet (all species) (Family Mugilidae)
Mulloway (*Argyrosomus japonicus*)
Murray cod (*Maccullochella peeli*)
Nannygai, Red snapper, Swallowtail (Family Berycidae)
Perch, golden (callop) (*Macquaria ambigua*)
Redfin (*Perca Fluviatilus*)
Silver perch (*Bidyanus bidyanus*)
Pilchard (*Sardinops neopilchardus*)
Salmon (*Arripis truttacea*)
Snapper (*Chrysophrys auratus*)
Snook (*Sphyræna novaehollandiae*)
Sole (*Aserragodes haackeanus*)
Sweep (*Scorpiæ aequipinnis*)
Tommy ruff (*Arripis georgiana*)
Trevalla (*Hyperoglyphe antarctica*)
Trevally (*Usacaranx georgianus*)
Trout, brown (*Salmo trutta*)
Rainbow (*Oncorhynchus mykiss*)
Whiting (Family Sillaginidae)

Crustaceans

Freshwater shrimp (*Macrobrachium australiensis*)
Crabs (Family Portunidae)
Yabbies (*Cherax destructor*)

Molluscs

Cockle (Suborder Teledonta)
Squid, calamary (*Sepioteuthis australis*)
Squid, arrow (*Nototodarus gouldi*)
Mussels (Family Hyriidae)
Mussels (*Mytilus* spp.)

Annelids

Bloodworm (Class Polychaeta)
Tubeworm

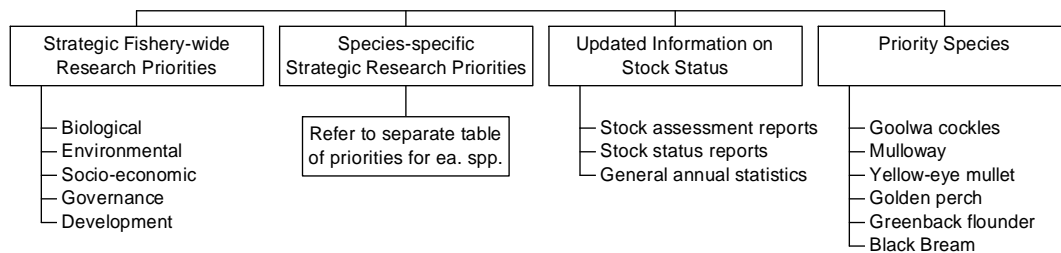
Shark, Skate and Rays

All species other than white pointer shark (*Carcharodon carcharias*) (Class Elasmobranchii)

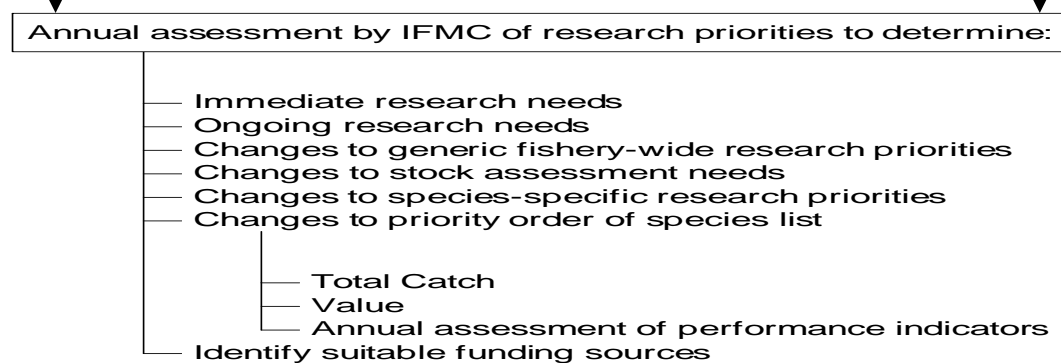
Appendix C: Strategic Research and Monitoring Plan for the Lakes and Coorong Fishery

The Lakes and Coorong Fishery can be classified as a data poor fishery, with only limited quantitative information available to managers during annual decision-making processes. The primary focus of the strategic research and monitoring plan is to increase the amount of quantitative information available for management of the fishery. This plan aims to ensure that all research and stock assessment undertaken in the Lakes and Coorong Fishery is carried out to address established management priorities and information gaps. The following diagram outlines the annual process undertaken by the Inland FMC to direct research at priority areas for the fishery.

1. Strategic Inputs to Annual Research Planning Process



2. Annual Research Planning Process



3. Outputs from annual research planning process

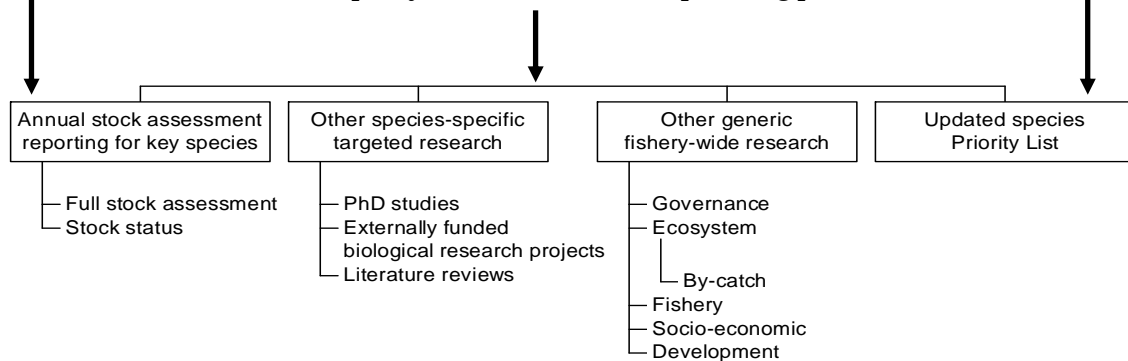


Figure 11. Annual research planning process for the Lakes and Coorong Fishery.

1. Fishery-wide Research Priorities

The following research priorities are aimed at addressing fishery-wide issues over the life of the Management Plan. These priorities will be updated annually by the Inland Fisheries Management Committee to address emerging issues and changing priorities. This set of priorities covers the following broad areas:

- Fisheries assessment and biology;
- Habitat and ecology;
- Governance/Management;
- Socio-economics; and
- Industry development.

Research priorities have been rated using the following scale:
5 = Essential. 4 = High. 3 = Moderate. 2 = Low. 1 = Very low.

1.1 Fisheries Assessment and Biology

1.1	Fisheries Assessment and Biology	Priority
1	Refinement of commercial fishery monitoring techniques.	5
2	Collection of basic biological information for all key species to facilitate stock assessment (Refer to species-specific priorities).	5 - ongoing
3	Development of cost-effective and robust methods to estimate non-commercial catch and effort levels	5
4	Continued refinement of quantitative stock assessment approaches for all key species, incorporating recreational catch and effort data.	4
5	Development of a industry-based catch-sampling program for biological information on key species	4
6	Development of cost-effective fishery-independent monitoring techniques	3
7	Post release survival rates for relevant recreational line caught fish species	4
8	Relationship between freshwater outflows and fish production levels and spawning success.	5
9	Stock recruitment relationships and connectivity between juvenile fish in estuarine waters and adult populations in coastal waters.	4

1.2 Habitat and Ecology

Environmental conditions influence health and productivity of all major fish stocks in the Lakes and Coorong Fishery. Many of these influences are unique to the Lakes and Coorong Fishery because of the significant modifications to the ecosystem, brought about by water flow regulation and other habitat modifications. These impacts need to be taken into account when assessing the status of fish stocks.

<i>1.2</i>	<i>Habitat and Ecology</i>	<i>Priority</i>
<i>1</i>	Development and refinement of robust ecological health indicators	<i>3</i>
<i>2</i>	Improved fishery-dependent and independent data collection and quantitative assessment of by-product, bycatch, threatened, endangered and protected species interactions.	<i>5</i>
<i>3</i>	Assessment of fishery and non-fishery related risks to by-product, bycatch, threatened, endangered and protected species.	<i>5</i>
<i>4</i>	Refinement of water flow strategies to maximise spawning opportunities and recruitment success for key fish species.	<i>4</i>
<i>5</i>	Modifications to infrastructure to provide opportunities for fish passage between the three ecosystem components of the fishery.	<i>5</i>
<i>6</i>	Quantify the impacts of exotic species on native fish populations and the ecosystem. Develop and refine management options to minimise exotic species impacts on native fish populations.	<i>4</i>

1.3 Governance

The following priorities recognise that fisheries management is a process of continual improvement that needs to be regularly evaluated to identify better ways of managing fish stocks.

<i>1.3</i>	<i>Governance</i>	<i>Priority</i>
<i>1</i>	Continued development of management methods that incorporate environmental and socio-economic principles	<i>4</i>
<i>2</i>	Continue to refine biological performance indicators	<i>3</i>
<i>3</i>	Development of resource allocation methods to address user group conflicts	<i>5</i>
<i>4</i>	Development of adaptive management techniques.	<i>4</i>
<i>5</i>	Periodic assessment of community awareness of management programs	<i>3</i>
<i>6</i>	Methods to improve communication on management activities between FMCs and relevant stakeholder groups: <ul style="list-style-type: none"> ▪ Commercial fishers; ▪ Recreational fishers; ▪ Indigenous communities; ▪ Government agencies; and ▪ Wider community. 	<i>4</i>
<i>7</i>	Quantify the biological and economic impact of illegal fishing	<i>5</i>
<i>8</i>	Human capital development, including development of leadership capacity.	<i>3</i>

1.4 Socio-economic and Cultural

The Lakes and Coorong Fishery has important commercial, recreational and traditional fishing sectors that need to be taken into account when management decisions are made. Accurate socio-economic information is required on these sectors to inform management decision-making and to ensure management strategies maximise the flow of socio-economic benefits to the wider community. Socio-economic information on the commercial fishery is collected through annual economic surveys. However, the scope and quality of the information collected through this process needs to be improved.

<i>1.4</i>	<i>Socio-economic and Cultural</i>	<i>Priority</i>
<i>1</i>	Refinement of socio-economic and cultural performance indicators	<i>4</i>
<i>2</i>	Assess the influence of market changes on commercial fishing activities and behaviour	<i>4</i>
<i>3</i>	Monitor and assess changes in industry structure, i.e. trends in ownership of licenses	<i>2</i>
<i>4</i>	Assess the socio-economic importance of the commercial fishery to regional communities in South Australia.	<i>5</i>
<i>5</i>	Determine the non-fishing related community support activities provided by the commercial industry.	<i>3</i>
<i>6</i>	Assess the socio-economic importance of recreational and traditional fishing to regional communities	<i>5</i>
<i>7</i>	Develop methods to collect information on the importance of fishing to Ngarrindjeri culture.	<i>3</i>
<i>8</i>	Benchmark current market prices for key species in the Lakes and Coorong Fishery with comparable species on the world market.	<i>2</i>

1.5 Industry Development

Industry development priorities should primarily be addressed by industry sectors, in partnership with Government where appropriate.

<i>1.5</i>	<i>Industry Development</i>	<i>Priority</i>
<i>1</i>	Third party audit and accreditation processes	<i>5</i>
<i>2</i>	Market development	<i>5</i>
<i>3</i>	Product development	<i>5</i>
<i>4</i>	Assess the costs, benefits and impacts of stock enhancement programs	<i>5</i>
<i>5</i>	Quality Assurance Programs	<i>4</i>

2. Species-specific Biological Research Priorities

There are significant gaps in the information concerning basic biological parameters for many of the key species in the Lakes and Coorong Fishery. Research must be directed at addressing these information gaps to underpin reliable quantitative stock assessment and future management decision-making. The priority species in the fishery are as follows (not in priority order):

- Mulloway;
- Goolwa cockles;
- Yellow-eye mullet;
- Golden perch;
- Greenback flounder;
- Black bream; and
- European carp.

The following biological research priorities have been identified for each priority species in the fishery:

Mulloway (Argyrosomus japonicus)

	<i>Knowledge Gaps</i>	<i>Priority Level</i>
1	Information on the reproductive strategy and mode for Mulloway from studies at the cellular level to give a clearer understanding of fecundity (estimates of the spawning fraction and spawning frequency)	5
2	Interaction between flows and reproduction success	5
3	The location(s) of mulloway spawning in South Australia	5
4	Larval mulloway surveys	3
5	Habitat use by larval and juvenile mulloway	5
6	Contribution to the mulloway stock of that proportion of the population that utilise the Coorong as juvenile habitat. (Interactions between 'West Coast' and 'Coorong' fish)	4
7	Accurate estimates of growth parameters, (using otoliths)	4
8	Age structure of recreational line catches	5
9	Age structure of commercial swinger net catches	5
10	Catch and effort information from the recreational fishery	5
11	Levels of incidental mortality in small mesh gill nets, both recreational and commercial (high due to length of juvenile phase)	5
12	Refinement of performance indicators for the fishery: <ul style="list-style-type: none"> ▪ CPUE; ▪ Age structure; ▪ Sex ratio; ▪ Recruit abundance / index; ▪ Freshwater flows; ▪ Murray Mouth opening; and ▪ Others. 	2
13	Post-release survival rates of line caught mulloway from the ocean beaches and the Coorong lagoons.	4

Information on the age, growth and reproductive development is needed to understand the life history of mulloway and the capacity to sustain fishing. These data are being collected as part of a current PhD study.

Yellow-eye Mullet (Aldrichetta forsteri)

	<i>Knowledge Gaps</i>	<i>Priority Level</i>
1	Determine the importance of the Coorong estuarine system to the life history of yellow-eye mullet	4
2	Determine spawning location and timing in relation to the Coorong estuary for yellow-eye mullet	4
3	Develop a recruitment index for yellow-eye mullet	4
4	Determine the time, life stage, and size at which yellow-eye mullet migrate into and out of the Coorong	4
5	Investigate the stock structure of yellow-eye mullet, (possibly through genetics) comparing adjacent populations in SA to populations in the Eastern and Western states of Australia	3
6	Age, sex and length frequency information: <ul style="list-style-type: none">▪ Population▪ Commercial catch▪ Recreational catch	5
7	Refine performance indicators for the fishery	2

Goolwa Cockles (Donax deltoides)

	<i>Knowledge Gaps</i>	<i>Priority Level</i>
1	Investigation of the basic biological parameters of <i>Donax deltoides</i> : <ul style="list-style-type: none"> ▪ Life history; ▪ Stock structure; ▪ Age; ▪ Growth; ▪ Reproduction; ▪ Mortality; ▪ Diet. 	5
2	Investigation of the spatial and temporal distribution and abundance of cockles on the Coorong and Goolwa beaches: <ul style="list-style-type: none"> ▪ Density dependant factors; ▪ Age/Growth; and ▪ Movement. 	5
3	Development of robust stock assessment tools for the Coorong Goolwa cockle population.	5
4	Spatial and temporal determination of recreational catch and effort levels	4
5	Investigation of the spatial distribution of commercial harvesting on the Coorong beaches	4
6	Determine factors affecting reproduction, recruitment strength and growth rates: <ul style="list-style-type: none"> ▪ Timing, duration, quantity and quality of River Murray outflows; ▪ Density dependant factors; ▪ Surf diatom production; and ▪ Oceanic upwelling. 	5
7	Impact of vehicular movement along the Goolwa and Coorong beaches on the spatial and temporal distribution of cockles.	3
8	Investigation of the level of bycatch from commercial and recreational harvesting (i.e. undersize cockles) – size structure of catches.	3
9	Development of methods to improve gear selectivity (avoid bycatch of u/size cockles) in the commercial sector, including investigations of different mesh sizes and configurations or variations in the spatial distribution of effort.	3
10	Refine performance indicators for the fishery: <ul style="list-style-type: none"> ▪ CPUE (hours not days and more discrete reporting of harvesting location on the beach); ▪ Size structure; ▪ Recruitment; ▪ Freshwater flows; ▪ Oceanic upwelling; and ▪ Others. 	2

Carp (Cyprinus carpio)

	<i>Knowledge Gaps</i>	<i>Priority Level</i>
1	Development of biological performance indicators to assess the impact of carp populations on native fish species and the ecosystem in the Lower Murray.	4
2	Refinement of effective and efficient methods for carp control (including commercial removal) in different habitats with minimum impact on native fish species.	2
3	Recreational catch and effort levels, as part of a broader monitoring program.	5
4	Basic biological/ecological information for SA carp populations: <ul style="list-style-type: none"> ▪ Population structure (age/size and sex ratio) of carp and spatial and temporal variation across different habitats (e.g. main channel, anabranches, floodplain/wetland, lakes, etc) ▪ Habitat use, key spawning sites and nursery areas, and the importance of off-stream or lake habitats in the recruitment ecology of carp ▪ Environmental triggers and movement patterns of juvenile and adult carp (dispersal & spawning migration, and critical access points). ▪ Relationship between the environmental factors (and adult biomass/numbers) and annual variations in carp recruitment year-class strength. 	2

Golden Perch (*Macquaria ambigua*)

	<i>Knowledge Gaps</i>	<i>Priority Level</i>
1	Basic biological parameters for Lower Lakes (e.g. spawning site/time, growth rate, size/age at first maturity, fecundity and length/age relationships, etc).	5
2	Age/size composition of spawning stock in the Lower Lakes.	4
3	Factors influencing spawning success and recruitment in the lower Lakes: <ul style="list-style-type: none"> ▪ algal blooms; ▪ exotic species impacts; ▪ freshwater flows; ▪ lake level; and ▪ water quality and temperature. 	5
4	Size and age composition of the commercial and recreational catch.	2
5	Improved information on recreational catch and effort levels.	5
6	Improved understanding of ecology, including: <ul style="list-style-type: none"> ▪ population response to flow management; ▪ importance of lake, channel, and floodplain habitats in relation to different life stages; ▪ water quality requirements, environmental triggers and movement patterns; ▪ critical environmental factors influencing recruitment; and ▪ interaction/impact by exotic fish species. 	3

Greenback Flounder (*Rhombosolea tapirina*)

	<i>Knowledge Gaps</i>	<i>Priority Level</i>
1	Literature review	4

Black Bream (*Acanthopagrus butcheri*)

	<i>Knowledge Gaps</i>	<i>Priority Level</i>
1	Literature review	4

3. Stock Assessment and Stock Status Reports

3.1 Target Species

A fundamental requirement for the sustainable management of fish populations is knowledge of the basic biological and ecological parameters of fish stocks. This fundamental information must be available in order to assess the status of fish stocks and also to evaluate the costs and benefits of alternative fisheries management strategies. A key priority for management of the Lakes and Coorong Fishery is the establishment of baseline information on the status of all commercially and recreationally exploited fish stocks.

Species to which a high priority has been assigned will have a full stock assessment report produced at least every two to three years. Lower priority species will have a full stock assessment report produced every three years. All stock assessment reports will provide a full literature review and comprehensively analyse the status of fish stocks, as measured by performance against established management objectives and reference values outlined in this Management Plan.

In years when full stock assessment reports are not produced, stock status reports will be produced. These status reports will provide a brief assessment of fish stocks, as measured by stock performance against established management objectives and reference values outlined in this Management Plan. The following table outlines the current staged approach to establishing stock assessment and stock status information for all commercially and recreationally important species in the Lakes and Coorong Fishery.

Table 18: Stock assessment and stock status reporting for key species in the Lakes and Coorong Fishery.

Species	2004/05	2005/06	2006/07	2007/08	2008/09
Mulloway	SA	ST	ST	SA	ST
Cockles	ST	SA	ST	SA	ST
Mullet	SA	ST	ST	ST	SA
Golden Perch	SA	ST	ST	ST	SA
Black bream	LIT	ST	SA	ST	ST
Flounder	LIT	SA	ST	ST	ST

SA (full stock assessment report): A full stock assessment report comprises a detailed analysis of fishery status and includes a review of all biological research undertaken on the species/fishery, covering all sectors and generally including a fieldwork component. A mix of fishery-dependent and fishery-independent data should be incorporated. A detailed scientific interpretation of all results is provided to address all relevant performance indicators outlined in the Management Plan. Management implications and future research needs are taken into account.

ST (status report): A status report comprises a desktop study of fishery status, reporting only on key performance indicators outlined in the Management Plan. A limited data analysis is provided without detailed scientific interpretation. Generally no fieldwork component would be undertaken.

LIT (Literature review): A literature review involves undertaking an exhaustive search of all published literature available for a species to assist in the process of prioritising future biological research.

3.2 Non-target Species

The vulnerability of non-target species and regulated undersized species to current fishing operations will be assessed following a study of the interactions between current fishing operations and non-target species, including endangered, threatened and protected species. The study will allow for a risk assessment to be undertaken and provide a basis for future consideration of the need for management actions to address non-target species sustainability.

3.3 Exotic Species

Non-native species population numbers and ecosystem impacts will continue to be monitored through commercial catch statistics. A key priority for non-native species management outlined in this Management Plan is for a broad policy framework to be developed to guide non-native species management and monitoring.

4. Data Collection

4.1 Fishery-Dependent

All stock assessment carried out on Lakes and Coorong fish species is heavily reliant on fishery-dependent data sets collected through commercial catch and effort logbooks. The Inland Fisheries Management Committee is currently reviewing the existing commercial logbook for the fishery, as a priority. This review process will expand the scope of the data collected and refine the spatial and temporal scales currently used, to improve the robustness of the data analyses currently performed.

The costs and benefits of an industry-based catch sampling program aimed at collecting biological information for key species will be investigated. The type of data that could be collected through such a program includes length frequency samples, otolith samples and gonad samples etc. This data could be used to assist the generation of estimates for some performance indicators (eg. index of the population size structure). This information would be particularly useful if it is complemented by fishery-independent sampling programs.

4.2 Fishery-independent

The limitations of fishery-dependent stock assessments are well understood, particularly with respect to the uncertainty associated with population abundance estimates. However, the costs of fishery-independent monitoring may exceed the benefits in a small-scale fishery such as the Lakes and Coorong Fishery. Therefore, development of cost-effective methods to ensure robust and reliable stock assessments are available is a priority for the fishery. The costs and benefits of a fishery-independent monitoring program for the Lakes and Coorong Fishery will be evaluated as a priority in the research and monitoring strategy.

Appendix D: Biological Reference Points for Key Species

Species	Total catch (tonnes)		CPUE (kg/day)*		Total catch trend (t)	CPUE trend (kg/day)**
	Upper	Lower	Upper	Lower	3-4 years	3-4 years
Mulloway total catch (all sectors)***	118	31	-	-	(±) 27 (4 yrs)	-
Mulloway (mesh nets)	-	-	28	5	-	(±) 7
Mulloway (swinger nets)	-	-	57	6	-	(±) 16
Goolwa cockles****	1,500	800	1,200	850	(±) 226 (3 yrs)	(±) 240
Yellow-eye mullet	312	124	93	47	(±) 45 (4 yrs)	(±) 13
Golden perch (lakes)	177	20	13	2	(±) 56 (4 years)	(±) 4
Black bream	47	3	12	3	(±) 15 (4 years)	(±) 4
Flounder	54	4	23	6	(±) 22 (4 years)	(±) 5

* Catch per unit effort (CPUE) estimates were derived using estimates of kilograms per fisher day for all species (using daily targeted effort data for most species - the data used to generate these estimates for black bream and flounder reflects non-targeted effort predominantly). These estimates will be refined during the life of this Management Plan, through improvements to commercial catch and effort data collection methods.

** CPUE trend reference points were derived using the greatest rate of change during the reference period in targeted CPUE - over a four year period for scalefish and a three year period for Goolwa cockles. CPUE trend reference points were derived using targeted effort for most species (except for black bream and flounder - as above).

*** Separate CPUE upper and lower biological reference limits are in place for mesh nets and swinger nets used to target mulloway in the Lakes and Coorong Fishery. The total catch reference points for mulloway include the combined total catch taken by mesh nets and swinger nets and the catch taken in other fisheries.

**** The upper and lower catch biological reference limits for Goolwa cockles were set empirically using total catch data (including the combined total catch of cockles taken by other fisheries) from the period between 1990/91 and 2000/01, as catch and effort data from this period is more representative of the current scale of the fishery. CPUE biological reference limits for Goolwa cockles were set using Lakes and Coorong Fishery data from the period between 1990/91 and 2000/01 and using the same approach applied for all other species (i.e. average of the three highest and lowest years).

Refer to '3.4 Harvest Strategy' pages 40-61 of the Management Plan for detailed information on the harvest strategy, management goals and objectives, management strategies, performance indicators, performance measures, management responses and data collection and analysis in the Lakes and Coorong Fishery.

Appendix E: Compliance Risk Assessment

Note that the following risk profile was developed for the 2003/04 fishing season. It will be audited and updated annually.

Fishery sector	Risks (What can happen)	Risk Rating	Possible actions (mitigating strategies)
Commercial	Unregistered / illegal / excess gear	High	<ul style="list-style-type: none"> • Investigate alternative methods to detect & remove illegal gear • Conduct awareness program - talking to fishers about gear requirements • Conduct vessel patrols • Conduct licence holder inspections • Liaison and networking with industry members to increase intel • Conduct intel driven operations • Conduct random observations of fishers retrieving gear • Follow-up and investigate possible illegal activity
	Fail to supply to log book data	High	<ul style="list-style-type: none"> • Respond to SARDI requests to follow-up missing forms • Promote prosecutions for offences via appropriate media • Raise awareness of issue and penalties at industry & association meetings
	Interference with commercial gear <i>(Note: links to Gear interference in Non-Commercial sector)</i>	Moderate	<ul style="list-style-type: none"> • Liaison and networking with industry members • Conduct random checks, targeting high risk periods • Conduct covert operations
	Use excess agents (inc. Licence holder not present)	Moderate	<ul style="list-style-type: none"> • Liaison and networking with industry members to increase intel • Conduct awareness program - talking to fishers about licence conditions • Conduct licence holder inspections • Conduct covert operations
	Taking undersized / oversized fish	Moderate	<ul style="list-style-type: none"> • Respond to and follow-up Fishwatch reports • Conduct awareness program - talking to fishers about size requirements • Conduct licence holder inspections • Liaison and networking with markets to increase intel

Fishery sector	Risks (What can happen)	Risk Rating	Possible actions (mitigating strategies)
Non commercial	Illegal sales	High	<ul style="list-style-type: none"> • Liaison and networking with local fishers and groups to encourage reporting of offences • Conduct random uniformed patrols • Liaison and networking with markets to increase intel • Conduct education program targeting retail outlets to raise awareness of requirements • Conduct intel driven operations/investigations • Conduct covert operations/investigations • Conduct overt operations • Benchmark Compliance activities with other inland fishery states • Follow-up and investigate possible illegal activity
	Unregistered / illegal gear	High	<ul style="list-style-type: none"> • Investigate methods to better detect & remove illegal gear • Conduct awareness program - talking to fishers about gear requirements • Conduct vessel patrols • Liaison and networking with industry members to increase intel • Conduct intel driven operations • Conduct random observations of fishers retrieving gear • Follow-up and investigate possible illegal activity
	Take over bag	High	<ul style="list-style-type: none"> • Conduct awareness program - talking to fishers about bag and size limits • Conduct random uniformed patrols • Conduct landing inspections • Liaison and networking with industry members, local rec fishers and allied agencies to increase intel • Conduct covert operations • Follow-up and investigate possible illegal activity
	Take undersized / oversized fish	High	<ul style="list-style-type: none"> • Conduct awareness program - talking to fishers about bag and size limits • Conduct random uniformed patrols • Liaison and networking with industry members, local rec fishers and allied agencies to increase intel • Conduct covert operations
	Gear interference	Moderate	<ul style="list-style-type: none"> • Liaison and networking with industry members • Conduct random checks, targeting high risk periods • Conduct covert operations

Fishery sector	Risks (What can happen)	Risk Rating	Possible actions (mitigating strategies)
Processor	Purchase / sales from non-commercial fishers	High	<ul style="list-style-type: none"> • Conduct random processor checks • Conduct intel based investigations • Conduct processor audits • Follow-up and investigate possible illegal activity
	Unregistered processor	High	<ul style="list-style-type: none"> • Conduct awareness campaign aimed at unregistered fish processors • Conduct random processor checks • Follow-up and investigate possible illegal activity
	Fail to keep correct records	High	<ul style="list-style-type: none"> • Conduct awareness program with processors to raise awareness about requirements • Conduct random processor checks • Conduct processor audits
Other	Habitat destruction (eg. creation of illegal fish barriers, removal of habitat)	High	<ul style="list-style-type: none"> • Provide feedback in relation to proposed exemptions • Referral and investigation of incidents in conjunction with other agencies (River Murray Act)
	Inadequate levels of compliance	High	<ul style="list-style-type: none"> • Liaise with Fishcare volunteer patrols to educate fishers • Use Fishwatch to better target illegal activity • Liaise with local fishers, groups and relevant agencies • Conduct intel driven operations and patrols • Investigate additional cross-authorisation opportunities
	Pest / disease incursion (eg introduction / release of exotic species)	High	<ul style="list-style-type: none"> • Conduct awareness campaign - talking to fishers about exotic fish issues • Respond to reported incidents • Actively contribute to development of incident response plans & training • Investigate viability of border protection program to address fish translocation
	Take fish for aquaculture / aquarium sectors without a permit (eg Illegal take of brood stock for aquaculture; illegal take of fish for aquarium sector)	High	<ul style="list-style-type: none"> • Ensure compliance with broodstock permit conditions • Liaise with aquaculture industry • Liaise with aquarium wholesale outlets • Respond to reported incidents • Follow-up and investigate possible illegal activity
	Illegal sales <i>ornamental</i>	High	<ul style="list-style-type: none"> • Conduct random aquarium wholesaler checks • Liaise with aquarium wholesale outlets • Conduct intel driven operations • Follow-up and investigate possible illegal activity
	Breach of exemptions (S. 59's) ⁶	High	<ul style="list-style-type: none"> • Compliance to provide input into drafting S 59s • Conduct targeted checks • Follow-up and investigate possible breaches of conditions • Prior reporting (inc. destination of product eg processor) • Processor checks as appropriate

Appendix F: Project summary for “Gear interaction of non-targeted species in the Lakes and Coorong commercial and recreational fisheries of South Australia”

Organisation	South Australian Research and Development Institute, Aquatic Sciences
Principle Investigator	Greg Ferguson Senior Research Scientist SARDI, Aquatic Sciences
Co-investigators	Tim Ward Senior Research Scientist SARDI Aquatic Sciences
	Garry Hera-Singh President, Southern Fishermen's Association Inc.
	Qifeng Ye Senior Research Scientist SARDI Aquatic Sciences
Start Date	01 July 2005
End Date	30 June 2007
Total Budget	\$365,936
Primary funding source	Fisheries Research and Development Corporation
Objectives	<ol style="list-style-type: none"> 1. Assess the (i) composition and magnitude of retained and discarded catches and (ii) rates of capture of retained and discarded species in the main types of gear used by commercial and recreational fishers in the Coorong lagoons in order to establish a risk assessment framework for bycatch management. 2. Assess the survival of key species (e.g. mulloway, yellow-eye mullet) discarded for each of the main gear types employed by the commercial (large mesh gill net, haul net) and recreational sectors (line, small mesh gill net). 3. Identify mechanisms for reducing bycatch in the main fishing gear used in the Coorong lagoons and provide extension of these ideas to industry. 4. Develop potential performance indicators and reference points related to bycatch of the main fishing gear used in the Coorong lagoons.
Performance Indicators	<ol style="list-style-type: none"> 1. Development and implementation of a revised logbook for commercial fishers to record more detailed information on bycatch. 2. Collection of quantitative data on bycatch catch rates in the Coorong Lagoon which will be used to meet schedule 4 of the Ecological Assessment of fisheries with DEH and meeting the ESD reporting guidelines outlined by the Standing Committee on Fisheries and Aquaculture (SCFA). 3. Results from recreational fishing survey and voluntary logbooks collated. 4. The identification of main bycatch issues with respect to gear type and area for both commercial and recreational sectors. 5. The regular collection of bycatch data from onboard commercial fishing vessels. 6. Completion of a preliminary assessment of survival of discards of key species from the main recreational and commercial gear. 7. The incorporation of new developments in fishing gear or practices

	<p>for comparison with existing ('optimal') and risky ('worst') fishing practices with respect to bycatch.</p> <p>8. Further development of a code of practice for mitigation of bycatch in the Lakes and Coorong fishery.</p> <p>9. Training courses and/or workshops conducted for implementation of the code of practice and innovations for bycatch reduction.</p> <p>10. Completion of FRDC final report.</p>
Milestones	<p>30 June 2006</p> <p>12 months of observer-based sampling onboard commercial fishing vessels completed. Recreational fishing survey completed. Modified commercial logbook trialled and revised. Modified commercial logbook trialled and revised. Modified logbook implemented by SeaNet. Experiment to assess survival of discarded species completed.</p>
	<p>31 December 2006</p> <p>Experiment for comparing different fishing practices completed. Report on risk assessment completed.</p>
	<p>30 June 2007</p> <p>Code of practice completed and extended to commercial fishers and other relevant stakeholders. Data analysed and final report submitted.</p>

AppendixG: List of Acronyms

<i>AFMA</i>	Australian Fisheries Management Authority
<i>CPUE</i>	Catch Per Unit Effort
<i>CRC</i>	Cooperative Research Centre
<i>CSIRO</i>	Commonwealth Scientific Industry Research Organisation
<i>DEH</i>	Department of Environment and Heritage
<i>EPBC Act</i>	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
<i>EEZ</i>	Exclusive Economic Zone
<i>ESD</i>	Ecologically Sustainable Development
<i>FMC</i>	Fisheries Management Committee
<i>FRDC</i>	Fisheries Research and Development Corporation
<i>ITQ</i>	Individually Transferable Quota
<i>L&CF</i>	Lakes and Coorong Fishery
<i>MDBC</i>	Murray-Darling Basin Commission
<i>MPA</i>	Marine Protected Area
<i>MSC</i>	Marine Stewardship Council
<i>MSF</i>	Marine Scalefish Fishery
<i>MEY</i>	Maximum Economic Yield
<i>MSY</i>	Maximum Sustainable Yield
<i>NFS</i>	Native Fish Strategy
<i>NRIFS</i>	National Recreational and Indigenous Fishing Survey
<i>NZRLF</i>	Northern Zone Rock Lobster Fishery
<i>PIRSA</i>	Department of Primary Industries and Resources, South Australia
<i>RLF</i>	Rock Lobster Fisheries
<i>SAFIC</i>	South Australian Fishing Industry Council
<i>SARDI</i>	South Australian Research and Development Institute
<i>SARFAC</i>	South Australian Recreational Fishing Advisory Council

<i>SASQAP</i>	South Australian Shellfish Quality Assurance Program
<i>SFA</i>	Southern Fishermen's Association
<i>SZRLF</i>	Southern Zone Rock Lobster Fishery
<i>TAC</i>	Total Allowable Catch
<i>TACC</i>	Total Allowable Commercial Catch