Management Plan for the South Australian

Lakes and Coorong Fishery

Sean Sloan
Fisheries Division
Primary Industries and Resources South Australia

July 2005

The South Australian Fisheries Management Series

Paper No. 44

Prepared for the purposes of Section 14 of the *Fisheries (Management Committees) Regulations 1995* by the Fisheries Division of Primary Industries and Resources, South Australia in Association with the Inland Fisheries Management Committee

Agriculture, Food and Fisheries
(A Division of Primary Industries and Resources South Australia)
GPO Box 1625
ADELAIDE SA 5001
www.pir.sa.gov.au

Tel: (08) 8226 2316
Fax: (08) 8226 0434

Disclaimer

This management plan has been prepared as a policy document. The information contained in this document is current at the time of publication. However, government policy may change at any time. Persons should not act in reliance on the information contained in this document when making business decisions without seeking independent advice first.

This document also contains information in relation to the *Fisheries Act 1982* and associated regulations. This information has been prepared as a summary of the fisheries management arrangements that are in place at the time of publication, and does not replace the legislation. Legislation may change from time to time. It is the responsibility of each individual to ensure that they are aware of the law that applies and to comply with it.

The South Australian Fisheries Management Series

Paper number 44: Management Plan for the South Australian Lakes and Coorong Fishery

ISBN 0 7590 1359 4
ISSN 1322-8072

Cover photos PIRSA would like to acknowledge and thank the following people for contributing their photographs: Michael Bell, Murray-Darling Basin Commission, Tom Robinson, Andrew Dalgetty, Greg Ferguson, Jason Higham and SARDI Aquatic Sciences.

FOREWORD

Management of the Lakes and Coorong Fishery

The marine, estuarine and freshwater fisheries resources of South Australia's Lakes and Coorong region 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.

The South Australian Lakes and Coorong Fishery is a small scale, multi-species fishery that operates within a highly modified very dynamic environment, recognised internationally for its unique ecological character. The fishery contributes to the socio-economic well being of regional coastal communities in the Lakes and Coorong region through commercial and recreational activity and harbours significant cultural and spiritual significance for the Ngarrindjeri people.

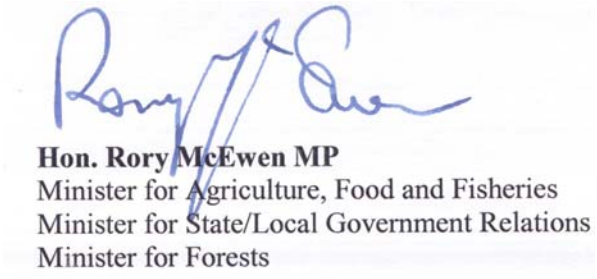
Experience world-wide has demonstrated that where unrestricted access to fisheries resources is allowed, the incentive for individuals to conserve fish stocks is diminished. The resulting competition among and between user groups often leads to increased fishing effort and excess fleet capacity, which in time 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 is 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. The Inland Fisheries Management Committee is the principle forum established to allow for stakeholder input to the management of South Australia's inland fisheries, which includes the Lakes and Coorong Fishery.

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.

This Management Plan provides a framework to address key challenges facing the future management of the Lakes and Coorong Fishery over the next five years.



Hon. Rory McEwen MP
Minister for Agriculture, Food and Fisheries
Minister for State/Local Government Relations
Minister for Forests

18 / 7 / 2005

ACKNOWLEDGEMENTS

The Inland Fisheries Management Committee (FMC) coordinated a process to finalise this Management Plan. All members of the Inland FMC are acknowledged for their individual and collective contributions. The following organisations are acknowledged for specific contributions: SARDI Aquatic Sciences; the Southern Fishermen's Association; the South Australian Fishing Industry Council; and the South Australian Recreational Fishing Advisory Council. The South Australian Department of Water, Land and Biodiversity Conservation provided technical information on water flows. Mr Jason Higham provided information on fish passage modified from Thorncraft & Harris (2000) and on yellow-eye mullet. Ms Kelly Crosthwaite assisted in documenting historical information on commercial sector gear restrictions. Ms Annette Doonan assisted with the preparation of maps. Dr Qifeng Ye and Dr Keith Jones reviewed the sections describing the biological characteristics of key species. Ms Alice Fistr edited the document following the public comment period. Mr Ken Meek chaired the Inland FMC through the development of the Management Plan.

Contents

List of Figures

List of Tables

1 PURPOSE

The purpose of this Management Plan is to provide a detailed outline of the strategic policy framework that has been established to provide for the ecologically sustainable management of the South Australian Lakes and Coorong Fishery. This 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*. This Plan is intended to provide greater certainty in day-to-day and longer term management decision-making, for all stakeholder groups.

Access to fisheries resources, managed by the Government on behalf of the broader community and future generations, comes with certain obligations for commercial licence holders, recreational participants and traditional fishers regarding the proper management and care of fisheries resources. These obligations are set out in the Management Plan. Information in this document provides a reference for the broader community in relation to the management measures that have been introduced to ensure the long-term sustainability of Lakes and Coorong fisheries resources.

In accordance with the objectives of the *Fisheries Act 1982* (the Fisheries Act), a key goal of this Management Plan is to ensure that an appropriate balance exists between the need to ensure long term sustainability of the marine, estuarine and freshwater fisheries resources of the Lakes and Coorong region, and the optimum utilisation and equitable distribution of these resources, for all stakeholder groups and future generations. This Management Plan sets out key performance measures to allow for assessment of the degree to which these objectives are being achieved.

This Management Plan formalises a long-standing, informal ecosystem-based approach to the management of the Lakes and Coorong Fishery. It also aims to provide a foundation for management of the fishery to continue moving towards a more integrated management framework, incorporating environmental management principles with standard species and gear based fisheries management.

2 SCOPE OF THE MANAGEMENT PLAN

2.1 General

The Fisheries Act provides a broad statutory framework to ensure the ecologically sustainable management 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 the Fisheries Management Committees must operate in accordance with the following objectives:

(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; and

(b) achieving the optimum utilisation and equitable distribution of those resources.

(c) insofar as this Act applies to the River Murray, seeking to further the objects of the River Murray Act 2003 and the Objectives for a Healthy River Murray under that Act.

This Management Plan covers all fishing activity undertaken within the Lower Murray Lakes and Coorong region including commercial, recreational, traditional and any illegal fishing. This 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 powers contained in Section 14 of the *Fisheries (Management Committees) Regulations 1995* (the FMC regulations) provide the legal basis for the preparation of this Management Plan. The FMC regulations assign responsibility for the preparation of Management Plans to individual FMCs. The responsibility for the preparation of this Management Plan lies with the Inland FMC.

This Management Plan is an expression of the policy that applies in relation to the Lakes and Coorong Fishery that will inform the exercise of any discretionary decision-making powers in the legislation, as they apply to the fishery. The area of waters to which this Management Plan applies includes the waters of three separate, but closely linked, ecosystems, including:

- The lower River Murray Lakes;
- The Coorong lagoons; and
- Coastal marine waters adjacent to the Sir Richard and Younghusband Peninsulas, out to three nautical miles from the low water mark.

Figure 1. The lower Murray, Lakes and Coorong region, South Australia.

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. 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 and the proliferation of a number of exotic fish species have collectively served to modify the structure, productivity and function of the entire ecosystem and had a generally negative impact on fish habitat.

While this 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 this Management Plan. However, there are ways that the productivity of the existing ecosystem can be improved and enhanced (Pitcher, 2001). This 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).

The Lakes and Coorong Fishery is a multi species, multi-method fishery. The primary species to which this Management Plan applies include mulloway (*Argyrosomus japonicus*), Goolwa cockle (*Donax deltoides)*, yellow-eye mullet (*Aldrichetta forsteri*), golden perch (*Macquaria ambigua*), greenback flounder (*Rhombosolea tapirina*) and black bream (*Acanthopagrus butcheri*). Important exotic fish species covered by this Plan include European carp (*Cyprinus carpio*) and redfin (*Perca fluviatilis*). A number of other marine, estuarine and freshwater species (native and exotic) are also covered by this Management Plan (Appendix I).

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*. This Management Plan should be read in conjunction with these regulations. 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, by-catch trip limits apply to authorised state-based fishers.

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 Sea. 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.

2.2 Operation of the Management Plan

This Management 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 Fisheries Management Committee (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.

2.3 Review of the Management Plan

This Management Plan will be periodically reviewed and improved over time as major advances in knowledge are made. In 2009, PIRSA Fisheries will undertake a major review of this 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, in consultation with key stakeholder groups and the broader community. This review is likely to result in significant changes to the broad framework established for administering and managing South Australia's fisheries resources. If necessary, this Management Plan will be updated to make it consistent with the requirements of the new legislation.

2.4 Key Policy Drivers

This Management Plan aims to achieve outcomes that are consistent with broader Government objectives for the management of the Lakes and Coorong region. Other important policy drivers that have been taken into account in the development of this Management Plan are:

- The National Strategy for Ecologically Sustainable Development;
- The Precautionary Principle, as set out in the Intergovernmental Agreement on the Environment;
- The Australian Government 'Guidelines for the Ecologically Sustainable Management of Fisheries', which relate to the requirements of the *Environment Protection and Biodiversity Conservation Act 1999*;
- The Native Fish Strategy for the Murray-Darling-Basin 2003-2013;
- The National Policy on Fisheries By-catch;
- The Coorong and Lakes Alexandrina and Albert Ramsar Management Plan; and
- The Coorong National Park Management Plan.

2.4.1 National Strategy for Ecologically Sustainable Development

The principles of Ecologically Sustainable Development (ESD) have been incorporated into fisheries legislation and management frameworks throughout Australia. The Australian Government defined the concept of ESD in the National Strategy for ESD as 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased' (the National Strategy for Ecologically Sustainable Development, 1992, p.6).

The overriding goal of the National Strategy for ESD is 'development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'. The following core objectives were developed as part of the National Strategy for ESD (the National Strategy for Ecologically Sustainable Development, 1992, p.8):

- To enhance individual and community wellbeing and welfare by following a path of economic development that safeguards the welfare of future generations;
- To provide for equity within and between generations; and
- To protect biological diversity and maintain essential ecological processes and life-support systems.

The following guiding principles are outlined in the National Strategy for ESD (the National Strategy for Ecologically Sustainable Development, 1992, p.8):

- Decision making processes should effectively integrate both long and short term economic, environmental, social and equity considerations;
- Where there are threats of serious irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- The global dimension of environmental impacts of actions and policies should be recognised and considered;
- The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised;
- The need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;
- Cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms; and
- Decisions and actions should provide for broad community involvement on issues which affect them.

The broad national objectives and guiding principles outlined in the National Strategy for ESD have shaped the way in which natural resources are currently being managed throughout Australia. In 2000, the Australian Standing Committee on Fisheries and Aquaculture initiated a process to develop a national ESD reporting framework for all Australian fisheries (Fletcher *et al.*, 2002). The national ESD reporting framework provides for a consistent national approach to reporting on fishery performance against all elements of ESD.

The National ESD reporting framework highlights that implementing ESD in the day-to-day management of fisheries requires consideration of not only the impacts of fishing on target species, but also the impacts of fishing on non-target species and the wider ecosystem. Linked to this is a recognition that the economic health of a fishery also relies on maintaining essential ecological processes. In addition, governments and key stakeholder groups must be able to satisfy the wider community that the management systems in place are adequate and that fisheries are providing sufficient socio-economic benefits to justify any negative impacts they may have (Fletcher *et al.*, 2002).

This Management Plan takes into account the approach suggested in the National ESD Reporting Framework and aims to provide for regular assessment of fishery performance against all aspects of ESD.

2.4.2 The Precautionary Approach

Principle 15 of the Rio Declaration of the United Nations Conference on Environment and Development states that *"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."* (FAO 1996, p.3).

The FAO International Code of Conduct for Responsible Fisheries prescribes a precautionary approach to the management of all fisheries, in all aquatic ecosystems, and regardless of their jurisdictional nature, recognises that most problems affecting the management of fisheries results from a lack of precaution in management regimes when faced with high levels of uncertainty (FAO 1996, p.3).

The precautionary approach to fisheries management recognises that changes in fisheries systems are only slowly reversible, difficult to control, not well understood and subject to changing environmental and human values (FAO 1996, p.6). The implications of adopting a precautionary approach to fisheries management are summarised as follows (FAO 1996, p.6):

"*The precautionary approach involves the application of prudent foresight. Taking account of the uncertainties in fisheries systems and the need to take action with incomplete knowledge, it requires inter-alia:*

- *Consideration of the needs of future generations and avoidance of changes that are not potentially reversible;*
- *Prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly;*
- *That any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, on a time scale not exceeding two or three decades;*
- *That where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource;*

- *That harvesting and processing capacity should be commensurate with estimated sustainable levels of resource, and that increases in capacity should be further contained when resource productivity is highly uncertain;*
- *All fishing activities must have prior management authorisation and be subject to periodic review;*
- *An established legal and institutional framework for fishery management within which management plans implement the above points are instituted for each fishery; and*
- *Appropriate placement of the burden of proof by adhering to the requirements above*."

The Commonwealth and State governments formed an agreement in 1994 to implement a precautionary approach to all facets of policy development and decision-making concerning the environment. This agreement is embodied in section 6 of the *National Environment Protection Council Act 1994* (the NECP Act), which sets out the Intergovernmental Agreement on the Environment. Clause 3.5.1 of the Australian Intergovernmental Agreement on the Environment defines the precautionary principle as:

"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decision-making should be guided by:

- *careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and*
- *an assessment of the risk-weighted consequences of various options.*

This Management Plan seeks to promote a precautionary approach to the management of the Lakes and Coorong Fishery through its harvest strategy. For the purposes of this Management Plan, the precautionary principle has the same meaning as in clause 3.5.1 of the Australian Intergovernmental Agreement on the Environment.

2.4.3 Australian Government Environment Legislation

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) establishes reporting requirements against the 'guidelines for the sustainable management of fisheries'. All State and Commonwealth fisheries must undergo a comprehensive independent ecological assessment process, which is subject to public consultation, prior to fishery products being considered for export approval under Parts 13 and 13A of the EPBC Act.

The two key principles of the EPBC Act 'guidelines for the ecologically sustainable management of fisheries' are as follows:

- A fishery must be conducted in a manner that does not lead to overfishing, or for those stocks that are over-fished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover; and
- Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.

PIRSA Fisheries will prepare a submission during 2004, to allow for the Australian Government Department for the Environment and Heritage to undertake an assessment of the management framework in place for the Lakes and Coorong Fishery, against the EPBC Act 'guidelines for the ecologically sustainable management of fisheries'.

2.4.4 The Native Fish Strategy for the Murray-Darling Basin

The Murray-Darling Basin Commission (MDBC) Native Fish Strategy aims to ensure there is a coordinated national response to key threats to the sustainable management of native fish populations across the whole Basin. The main objective of the Native Fish Strategy is to rehabilitate native fish communities across the whole Basin back to 60% of estimated pre-European settlement levels, after 50 years of implementation.

The key threats to native fish populations are identified by the Native Fish Strategy as:

- Flow regulation;
- Habitat degradation;
- Reduced water quality;
- Barriers to fish passage
- Introduction of alien fish species;
- Fisheries exploitation (commercial, recreational and illegal);
- Spread of disease; and
- Inappropriate translocation and stock enhancement.

The Native Fish Strategy suggests that native fish populations have declined significantly because of these combined threats, and are currently at about 10% of pre-European settlement levels.

The Native Fish Strategy is an important national policy that has been taken into account in the development of this Management Plan. The range of management, research and monitoring strategies set out in this Plan are consistent with the objectives of the Native Fish Strategy.

2.4.5 National Policy on Fisheries By-catch

The Ministerial Council on Forestry, Fisheries and Aquaculture endorsed the National Policy on Fisheries By-catch in April 1999 to ensure a unified national response to the problem of by-catch across all Australian fisheries. The overall goal of the policy is to ensure that the direct and indirect fishery impacts on ecosystems are taken into account in the development and implementation of fisheries management regimes. An overarching objective of the policy is to ensure that by-catch species and populations are maintained at sustainable levels. Supporting this are the following sub-objectives (National Policy on Fisheries By-catch 1999):

- To reduce by-catch;
- To improve protection for vulnerable/threatened species; and
- To minimise adverse impacts of fishing on the aquatic environment.

The National Policy on Fisheries By-catch defines fisheries by-catch at its broadest level, to include all material, living and non-living, other than targeted species which is caught while fishing. However, for practical purposes, the National Policy defines by-catch to include discards (that part of the catch returned to the water) and also that part of the catch that is not landed but is killed as a result of interactions with fishing gear. By-product is defined as non-targeted catch that is commercially valuable and therefore retained by fishers. For the purposes of this Management Plan, by-catch and by-product have the same meaning as the definitions set out in the National Policy on Fisheries By-catch.

2.4.6 The National Park Management Plan

The Lower Murray Lakes and Coorong provide one of the most significant wetland habitats in Australia. The area provides an important refuge for migratory waders and waterfowl, particularly during periods of drought. A National Park Management Plan for the Coorong was finalised in 1990, in accordance with the *National Parks and Wildlife Act 1972* to deliver conservation outcomes consistent with the following broad National Park objectives (DEP 1990):

- Preservation and management of wildlife;
- Preservation of historic sites, objects and structures of historic or scientific interest;
- Preservation of features of geographical, natural or scenic interest;
- Destruction of dangerous weeds and the eradication or control of noxious weeds and exotic plants;
- Control of vermin and exotic animals;
- Control and eradication of disease and injurious affection of animals and vegetation;
- Prevention and suppression of bushfires and other hazards;
- Encouragement of public use and enjoyment of reserves and education in, and a proper understanding and recognition of, their purpose and significance; and
- Generally, the promotion of the public interest.

In addition to these objectives, the following specific objectives currently apply to the management of the Coorong National Park:

- Protect endangered, vulnerable and rare species;
- Control fire so as to minimise threats to life, property and the natural and cultural resources of the reserves;
- Provide a range of recreation facilities in selected areas so as to enhance visitor access and enjoyment;
- Develop interpretation and education programmes and prepare information about recreation opportunities, resources and management; and
- Contribute to regional and State tourism while protecting the natural values of the park.

The commercial fishery operates within the boundaries of the Coorong National Park. The above objectives 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 management of the National Park. The Coorong National Park Management Plan will be revised during the life of the Lakes and Coorong Fishery Management Plan.

2.4.7 Coorong, and Lakes Alexandrina and Albert Ramsar Management Plan

The waterbird habitats of the Lower Murray Lakes and Coorong region were designated as 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 of the plan are:

- Integrated environmental management of the Coorong and Lower Lakes Ramsar Wetlands with monitoring of biotic indicators to ensure the sustainable, multiple use of the region; and monitoring of management performance against the plan objectives.
- Increased opportunities for participation by the Ngarrindjeri people in the planning and management of the Coorong and Lower Lakes Ramsar Wetlands, subject to South Australian Government policy relating to the resolution of native title claims.
- Improved awareness among all key stakeholders, including the wider community, of the natural values of the Coorong and Lower Lakes Ramsar Wetlands and Ramsar principles expressed in the Management Plan.
- Protection of the full range of wetlands habitats and restoration of degraded habitats in the Ramsar area and their conservation for future generations.
- Increased environmental benefits from the improved management of existing water entitlements and improved water quality and flows.
- Ongoing funds and resources to achieve the objectives of the management plan.

3 MANAGEMENT OF THE FISHERY

3.1 Historical Overview

3.1.1 Traditional Fishing

The lower Murray Lakes and Coorong region has been important to Aboriginal people throughout the entire period of their habitation of Australia. The aboriginal (Ngarrindjeri) history associated with the Lakes and Coorong region extends over at least 45,000 years. Archaeological evidence to support this is provided by middens containing cockle shells and the remains of fish and terrestrial animals, traditional camp sites, meeting places, rock formations and burial sites (Leubbers, 1981). These sites are found throughout the Lakes and Coorong region in a greater frequency than other locations throughout Australia (Leubbers, 1981).

The high abundance and diversity of natural aquatic and terrestrial resources in the Lakes and Coorong region provided a rich sustenance for the Ngarrindjeri people and formed the basis of large semi-permanent settlements in the region. The Ngarrindjeri population density is likely to have been the largest of any aboriginal group in Australia, with an estimated 3,000 inhabiting the region in the early 1800's, prior to European settlement. These numbers declined significantly to only five or six hundred following European settlement due largely to the spread of diseases such as smallpox (Linn, 1988).

Traditional tribal and clan boundaries extended into the marine, estuarine and freshwater environments and were valued with the same importance as terrestrial boundaries (Smyth, 1994). The terrestrial, freshwater, estuarine and marine resources of the Lakes and Coorong region were harvested by a number of Ngarrindjeri tribes, as a basis to sustain the large communities that existed throughout the region. The Ngarrindjeri use of water-based resources was sophisticated, with the use of a number of different net designs (for fish and bird capture), spears and specialist boomerangs. Rock enclosures were also constructed to capture fish or hold excess catches for later use (Leubbers, 1981).

The main fish species targeted by the Ngarrindjeri people during this period included mulloway, bream, flounder and yellow-eye mullet. Goolwa cockles also formed an important staple dietary component. Evidence that fish and cockles were prominent in the Ngarrindjeri diet is demonstrated by the high abundance of otoliths and cockle shells found in middens throughout the region. Smoked and dried fish were stored and traded (along with other commodities such as nets, clothing, baskets and mats) with other Aboriginal settlements in the region (Jenkin, 1979).

Charles Sturt discovered the River Murray Mouth in 1830. By 1834, land in the Lakes and Coorong region was being sold in Britain for agricultural use including sheep and cattle grazing. By 1839, European settlement in South Australia had extended to the shores of the northern Coorong lagoon. This settlement was first named Port Pullen and subsequently renamed Goolwa, which has the Aboriginal meaning 'elbow of river'. Milang was first settled in 1847. The township of Meningie, which has the Aboriginal meaning 'mud', was established in 1844 as an

out-station for graziers who settled in the area. Goolwa and Milang soon became the main centres for business and trade in the region and served as ports for the Murray River steamer trade and as bases for shipbuilding and fishing interests (Olsen, 1991). The early European explorers and settlers on the Adelaide Plains and in the Lakes and Coorong region caught fresh fish to supplement their food supplies and began to compete with aboriginal communities for access to the fish resources throughout the region (Olsen, 1991).

The physical character, natural resource base and overall health of the Lakes and Coorong region, including the River Murray Mouth, harbours significant cultural and spiritual importance for the Ngarrindjeri people (Hemming, Trevorrow and Rigney, 2002). Ngarrindjeri people still practice traditional fishing and food gathering in the Lakes and Coorong region. Camp Coorong also engages in cultural and traditional fishing for educational purposes.

3.1.2 Habitat Modifications

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 was constructed near the Murray Mouth in 1940 to stabilise water levels, prevent saltwater intrusion into the lower Lakes and provide for irrigation and human consumption (MDBC, 2005a). This action reduced the River Murray estuary to about 10% of its original size and created a large 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. These issues are expanded upon in section 4.

3.1.3 Commercial Fishing

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

artisinal 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.

	Lakes and Coorong		Coorong Only	
Year	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. 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 following maximum gear entitlements may be endorsed on any single licence following a licence transfer or amalgamation, in accordance with the Scheme of Management and the policy:

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 details inter-annual changes in production and value during the recent history of the fishery.

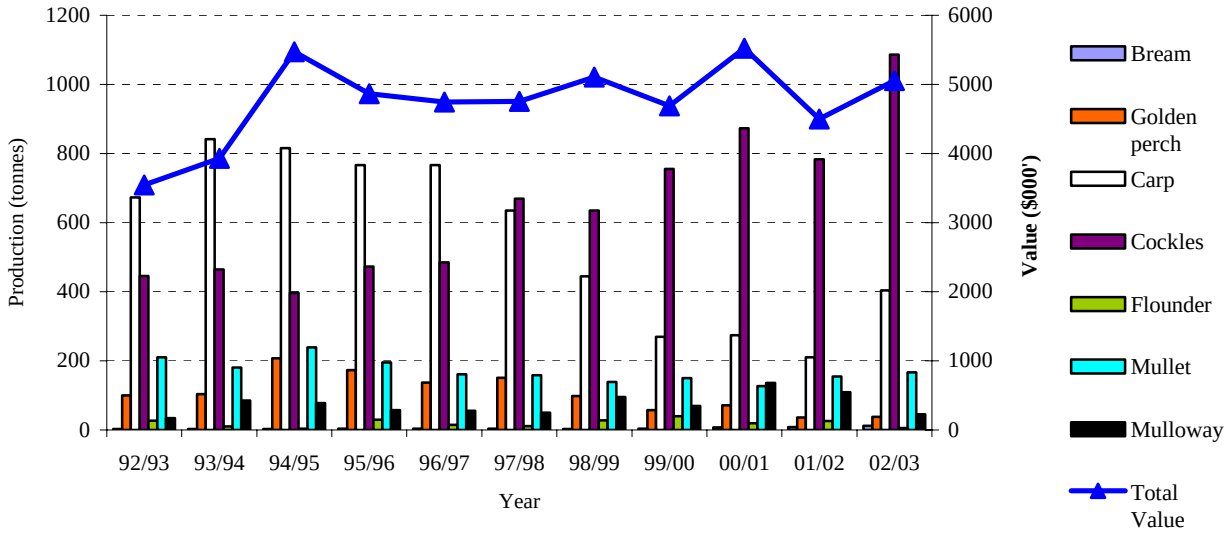


Figure 2. Annual production and value for key species in the Lakes and Coorong Fishery (Data source: Knight *et al*., 2003; Anon, 2004).

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. The following table outlines the current regional distribution of commercial licence holders in the Lakes and Coorong Fishery. Other towns where commercial fishers reside include Murray Bridge, Wellington, Middleton, Strathalbyn, Clayton, Coonalpyn and Kingston (SE).

Table 3. Residential locations of licence holders in the Lakes and Coorong Fishery (as at June 2004).

Location	Number of licence holders
Meningie	23
Goolwa	6
Other	8
Total	37

Commercial Industry Initiatives

The Southern Fishermen's Association (SFA) was established in 1939 to represent the interests of commercial Lakes and Coorong fishers (Hera-Singh, G. 2004, pers. comm.). The SFA has been pro-active in promoting improved environmental management practices in the fishery across a number of areas, which include:

- Developing an Environmental Management Plan;
- Developing industry best practice guidelines to minimise by-catch;
- Advocating for improved water flow strategies and fish passage;
- Developing markets for the human consumption of exotic species;
- Supporting changes to mesh size regulations to improve net selectivity;
- Promoting the introduction of regulations for mesh net ply ratings and breaking strains;
- Supporting the prohibition of power hauling nets in the Coorong lagoons;
- Supporting size limits increases for black bream and flounder; and
- Maintaining the use of manual harvesting methods for Goolwa cockles.

The SFA is currently seeking independent third party accreditation of the fishery's operation under the Marine Stewardship Council (MSC) assessment framework. The MSC is an independent, global, non-profit organisation whose role is to recognise, via a certification program, well-managed fisheries and to harness consumer preference for seafood products bearing the MSC label of approval (MSC, 2002). Successful accreditation of the fishery under the MSC assessment framework may provide improved opportunities for commercial fishers to increase domestic and overseas market demand for species harvested from the fishery.

3.1.4 Recreational Fishing

Fishing has provided an important recreational and sporting activity throughout South Australia since European settlement. Many early accounts of fishing in South

Australia refer to fish being taken as part of recreational pursuits, to supplement food supplies and to trade for other goods and services. The Lakes and Coorong region has evolved to become an important location for recreational fishers due to its picturesque natural environment, its close proximity to the capital city of Adelaide and the presence of iconic species such as mulloway.

Initially controls such as size limits and measures aimed at controlling total harvesting capacity (eg. gear restrictions and spatial and temporal closures etc.) were generally introduced to be consistent with those in place for commercial fishers and were not specifically targeted at the recreational sector. However, over time the need for specific management arrangements for recreational activity developed due to increases in the popularity of fishing, improvements in recreational opportunities and the growing number of people living or holidaying on or near the coast.

Mulloway and yellow-eye mullet are the most sought after species by recreational fishers in the Lakes and Coorong region. Larger mulloway are targeted by recreational fishers on the ocean beaches of the Sir Richard and Younghusband Peninsulas, particularly adjacent to the River Murray Mouth during the warmer months of spring and summer when mulloway aggregate around the Mouth. Smaller mulloway are targeted in the Coorong estuarine lagoons all year round. Yellow-eye mullet are targeted by recreational fishers all year round using rod and line and a limited number of small mesh nets. Goolwa cockles are harvested by recreational fishers on the ocean beaches of the Coorong, but predominantly along the Sir Richard Peninsula (the Goolwa beach). Previously, cockles were mainly targeted for bait purposes but in more recent times cockles have been harvested for personal consumption.

Updated information on participation rates on recreational fishing activities throughout Australia was recently provided through the National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003). The results of this survey have indicated that the South Australian recreational sector catch a significant proportion of the total catch of many major marine scalefish species throughout the State, including species important to the Lakes and Coorong Fishery. The total state-wide catch of mulloway during the period May 2000 to April 2001 was estimated to be about 90.2 tonnes (Henry and Lyle, 2003). The total state-wide commercial catch of mulloway (Lakes and Coorong, marine scalefish and Commonwealth southern shark fisheries) during this period is estimated to be about 150 tonnes (Ferguson and Ward, 2003).

Today, recreational fishing opportunities provided by the Lakes and Coorong region and throughout the state contributes to the overall well being of many South Australians. As well, the recreational community contributes significantly to state and regional economies through tourism, the purchase of fishing equipment, vessels, bait supplies and fuel etc. In recognition of the importance of recreational fishing to the community of South Australia, a strategic plan for recreational fishing was developed in 2001 to set a number of future directions for management and development of recreational fishing throughout the state.

Recreational Industry Initiatives

The South Australian Recreational Fishing Advisory Council Inc. was established in February 1975 to represent the interests of the recreational angling community in all fisheries in South Australia (Watts, T. 2005, pers. comm.). SARFAC advocates on behalf of all anglers in SA promoting sustainable recreational fishing practices, including:

- Development of a number of recreational fishing policy papers;
- Development of a code of conduct for recreational anglers in South Australia;
- Development of a guide for the survival of released line caught fish;
- Development of a five-year research and development strategy 2003 – 2008;
- Supporting the minimum size increases of all species to match sexual maturity;
- Supporting increased environmental flow management and strategies;
- Supporting net mesh size increases to prevent by-catch and undersize mortality;
- Retaining a proportion of harvested Goolwa cockles for recreational bait; and
- Supporting fish passage initiatives.

3.1.5 Fish Processing

In 1863, there were 12 fish mongers in Adelaide providing fresh and preserved fish to the Adelaide community. Prior to the mid 1880s, all Lakes and Coorong fish sold on Adelaide markets were transported from the Murray Mouth by horse and cart. In the early 1870s, a fish processing plant was established near the River Murray Mouth providing constant employment for approximately thirty permanent fishers in Goolwa and eleven in Milang. During the same period, ship building yards commenced operation at the ports of Goolwa and Milang to service the steamer trade and the local commercial fishing industry. The shipbuilding industry provided steady employment for local residents. The number of people employed in the commercial fishery, ship building and fish processing industries increased substantially during low river levels when steamer crews were forced to remain in port (Olsen, 1991).

The amount of fish caught in the Lakes and Coorong region and sold on the Adelaide fish markets increased substantially following the completion of a rail link to Adelaide in 1885. From the mid 1880s onward, the majority of fish caught in the Lakes and Coorong region was sold on the Adelaide fish markets. The remainder was sold to the local communities of Goolwa and Milang (Olsen, 1991). Early reports indicate that seafood consumers purchasing through the Adelaide fish markets had a preference for snapper, mulloway, whiting, flounder and Murray cod over flathead, snook, garfish, yellow-eye mullet, sweep and a range of other locally caught species. During this same period, the preferred species on the Melbourne fish market were whiting, snapper and garfish (Olsen, 1991).

During the early development of the fishery, fish did not travel well over long distances due to poor refrigeration. While many other fisheries in South Australia explored the interstate markets of Melbourne and Sydney, particularly the Melbourne fish market following the construction of a rail link, Lakes and Coorong fishers continued to supply local consumers and the Adelaide fish market. The Adelaide fish market therefore evolved to become the single largest market for species such as

mulloway and yellow-eye mullet caught in the Lakes and Coorong region. While this same trend continues today, developments in refrigerated transport and improvements in market knowledge have allowed fishers to monitor interstate fish prices more closely, with some regularly supplying product to the Melbourne and Sydney fish markets when market conditions are favourable.

Reduced fishery production resulting from habitat modifications has led to industry-driven innovations in product and market development. A market has developed over time for the human consumption of carp and carp products. In addition, carp is sold in significant quantities for bait in state-based rock lobster fishing operations. In recent times, the emergence of a developing market for the human consumption of Goolwa cockles within Australia has driven a shift away from sales to the traditional bait market and increased the landed value of production. Some operators are exploring export markets. This market development has been associated with a marked incremental increase in targeted effort and landed catch for the species over time.

3.2 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 and the Fisheries Management Committees 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 all 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.

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 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. In addition, an Inland FMC research sub-committee has been established to provide for more coordinated input from key stakeholder groups to the development and review of strategic research priorities, research projects and stock assessment reports.

The Fisheries Act requires the Minister or a delegate to consult with licence holders who may be affected by a change to licence conditions, in particular if the change will result in 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.

3.3 Current Management Arrangements

This 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.

3.3.1 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.

3.3.1.1 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 marine scalefish and rock lobster fisheries. 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 by-catch trip limit to cover catches taken during operations adjacent to the Coorong ocean beaches.

3.3.1.2 Area of the Fishery

The area of water encompassed by the Lakes and Coorong Fishery include the waters of three separate, but closely linked, ecosystem components. These are: (i) the northern and southern lagoons; (ii) the freshwater lower lakes of Lake Alexandrina and Lake Albert; and (iii) the adjacent coastal marine waters along the Sir Richard and Younghusband Peninsulas. The fishery boundaries are described in detail in the *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991*. For the purposes of management, the fishery is divided into four main areas (Figs. 1, 3 and 5):

Area 1
Defined as the waters of the Coorong separated from the lower Murray and Lake Alexandrina by the Goolwa, Mundoo, Boundary Creek, Ewe Island and Tauwitchere Barrages and by a straight line drawn westerly from Pelican Point to Gnurlung Point and separated from the ocean by the Murray Mouth;

Area 2
Defined as the waters of the Coorong commencing from a straight line drawn westerly from Pelican Point to Gnurlung Point, then extending south easterly to the most southerly limit of the southern Coorong lagoon;

Area 3
Defined as the freshwater component, which includes Lake Alexandrina and Lake Albert, downstream from the punt at Wellington to the barrages; and

Area 4
Defined as the Coorong coastal waters, extending out to three nautical miles from the low water mark, from the Goolwa beach road (latitude 35º 31.3' south, longitude 138º 46.3' east) and south easterly along the Sir Richard and Younghusband Peninsulas to the Kingston jetty (latitude 36º 49.7' south, longitude 139º 51.1' east).

Figure 3. Fishing areas defined for the South Australian Lakes and Coorong Fishery.

3.3.1.3 Commercial Fishing Methods

Over many decades, commercial fishers in the Lakes and Coorong Fishery have developed a number of unique fishing methods. Many of these methods and associated fishing practices reflect the diversity of habitat types and fish species in the fishery. Commercial fishers are permitted to use the fishing devices that are registered and endorsed on their licence, subject to various regulations, conditions and industry codes of practice. The range of available methods is outlined in the following table.

Table 4. 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

3.3.1.4 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 Appendix II.

3.3.1.5 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 5. 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

3.3.1.6 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 6. 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

3.3.2 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.

3.3.2.1 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).

3.3.2.2 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 7. 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

3.3.2.3 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 8. 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 (*Acanthopagrus spp.*)	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	-

3.3.2.4 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 9. 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.

3.3.3 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.

3.3.4 Stock Enhancement and Translocation

Regulations

There has been no stock enhancement program in the Lakes and Coorong Fishery. The South Australian *Fisheries Act 1982* currently prohibits the release of any exotic fish, farmed fish or any fish that have been kept apart from their natural habitat into any "waters". The Act defines "waters" to mean any sea or inland waters including any body of water or watercourse of any kind occurring naturally or artificially created. It is therefore an offence to release any cultured fish (restocking) or translocate fish from their natural habitat unless the Director of Fisheries has issued a permit in accordance with section 50 of the Act for this activity to occur.

Current Stocking Policy

At present there is no formal articulation of a policy for the management of fish stocking programs and translocation of fish throughout the waters of South Australia. Generally, fish stocking programs are not encouraged but are considered on a case-by case basis. There are no Government owned hatcheries for stocking purposes, although hatchery facilities exist within a number of Government agencies (South Australian Research and Development Institute) and universities. There are a number of privately owned hatcheries, predominantly used for aquaculture businesses.

Exemptions have been approved for projects to establish artificial refuge populations and/or for enhancing local populations of critically endangered small native fish species. In recent years, these have been approved for programs developed by the

Cooperative Research Centre (CRC) for Freshwater Ecology with the Department of Environmental Biology, University of Adelaide.

Broodstock Collection

A policy is currently being prepared by PIRSA to guide decision-making on the collection of broodstock for aquaculture purposes across all of South Australia's fisheries. Associated with this are a set of strict guidelines and protocols developed for the aquaculture industry that prohibit the re-release and translocation of broodstock, the prevention of escapements of cultured fish, and the management of disease and parasites.

3.4 Harvest Strategy

The following section outlines a harvest strategy which 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 following 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.

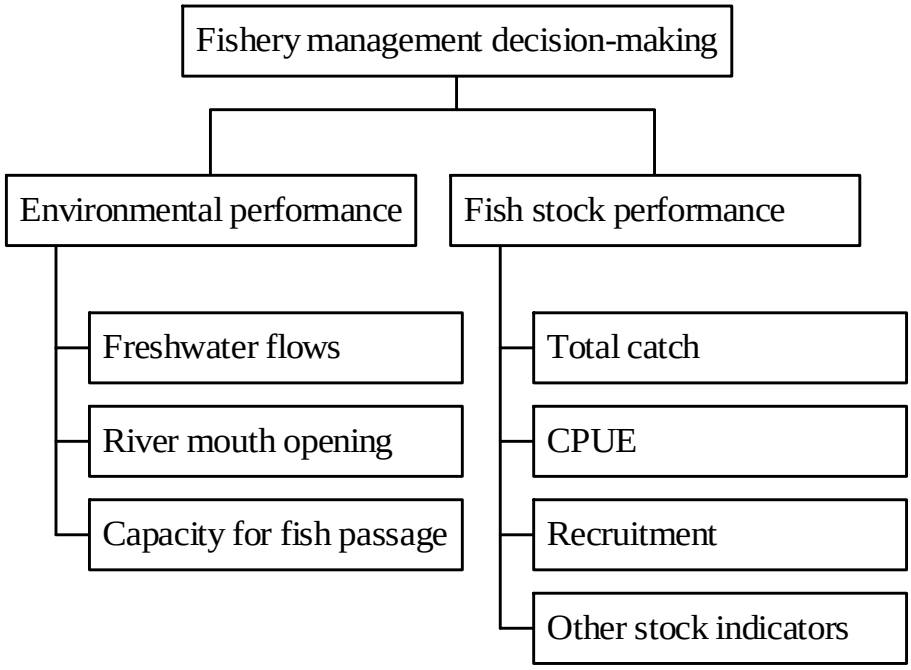


Figure 4. Decision-making framework for the South Australian Lakes and Coorong Fishery.

3.4.1 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 this 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 By-catch, 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 by-catch 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.*

3.4.2 Management Strategies

The management strategies outlined in Table 10 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 10 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.

3.4.3 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. mulloway 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.

3.4.4 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 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 species[1].

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)[2]. 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 (±) 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 lakes and Coorong, marine scalefish and rock lobster fisheries). 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 (±) 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 fishery, changes in the species composition of the commercial catch, by-catch levels, recreational effort levels and significant environmental disturbances.
Overall fishery performance will be measured by evaluating:

[1] 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.

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

- 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.

3.4.5 Management Responses

When annual estimates of one or more performance indicators (refer to Table 10) 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.

3.4.6 Data Collection and Analysis

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 entered into a database, which is managed by SARDI Aquatic Sciences.

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 III establishes a process to evaluate the costs and benefits of a fishery-independent monitoring program for the 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.

Table 10. Harvest Strategy for the Lakes and Coorong Fishery.

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
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.	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.	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.	PIRSA / Annual PIRSA / Annual PIRSA / Annual PIRSA / Annual PIRSA / Annual PIRSA / In periodic stock assessment PIRSA / In periodic stock assessment PIRSA / In periodic recreational surveys.	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 (±) 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 (±) the reference value.*

* Biological reference points are provided in Appendix V

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
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.	8. Develop fishing methods to minimise incidental mortality of undersized catches associated with commercial and recreational fishing operations. 9. Develop management strategies to minimise incidental fishery interactions with undersized fish. 10. Restrict the quantity of each species that may be harvested by the recreational sector using bag and boat limits and possession limits. 11. Reduce latent effort in other South Australian commercial fisheries, which could threaten future sustainability of key species in the Lakes and Coorong Fishery. 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. 13. Develop a package of management measures to control the targeted harvest of black bream in relation to fresh water outflows.	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	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. 7. A significant change in the species composition of the commercial catch between years. 8. A significant reduction in the abundance of pre-recruits for key species. 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. 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).

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

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
Goal 1. Sustainable harvesting of fisheries resources				
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.	1. Undertake investigation of reasons for one or more reference value being reached. 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.	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. 2. A stock recovery plan is developed within 4 months, including proposed management actions, timeframes and targets for stock recovery. 3. Rate of stock recovery, relative to established targets in recovery plan.	Inland FMC /Annual Inland FMC / Annual Inland FMC / Annual	1. Stock recovery rates do not meet the targets identified in the recovery plan.

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
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.	1. Develop and implement arrangements that allow commercial operators to maximise operational flexibility and economic efficiency. 2. Develop and implement arrangements that promote optimum utilisation and minimise waste. 3. Maintain mechanisms to allow for autonomous fleet adjustment (eg. licence amalgamation scheme). 4. Develop and implement methods to assess the economic benefits of alternative harvest strategies. 5. Monitor interstate market prices for all key species.	1. Trend in Gross Value of Production (G.V.P) of the commercial fishery. 2. Trend in market prices for key species. 3. Trend in the average annual commercial licence value. 4. Trend in annual return on investment in the commercial fishery. 5. Trend in annual total economic impact of the commercial fishery. 6. Trend in the number of commercial fishing licenses. 7. Trend in the amount of commercial fishing gear available to the fishery.	PIRSA via Economic Survey / Annual PIRSA / Annual PIRSA / Annual PIRSA via Economic Survey / Annual PIRSA via Economic Survey / Annual PIRSA / Annual PIRSA / Annual	1. A decreasing trend in annual return on investment over a three year period.

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

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

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

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

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
Goal 3. Impacts on the structure, productivity, function and biological diversity of the ecosystem are minimised				
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
Goal 4. Cost-effective and participative governance of the fishery				
a. Promote cost-effective and efficient management of the fishery.	1. Develop and implement arrangements that are effective at achieving management objectives, while minimising costs. 2. Determine the annual total real costs of management, research and compliance for the fishery. 3. Recover an economic return from commercial licence holders, sufficient to cover the attributed costs of fisheries management, research and compliance, in line with established cost recovery principles. 4. Explore methods for all stakeholder groups to share the costs of managing the fishery.	1. Trend in the annual total real costs of management, research and compliance for the fishery. 2. Trend in the total costs of management, research and compliance in the fishery, attributed to the commercial industry, relative to GVP.	PIRSA / Annual PIRSA / Annual	

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

Management Objectives	Management Strategies	Performance Indicators	Responsibility / Schedule	Reference Points/Triggers
Goal 4. Cost-effective and participative governance of the fishery				
c. Promote compliance with management controls.	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.	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.	PIRSA / Annual PIRSA / Annual PIRSA / Annual PIRSA Fishwatch / Annual	1. Increasing trend in the level of illegal activity detected in the fishery over a three year period.

4 ENVIRONMENTAL CHARACTERISTICS

4.1 The Murray-Darling Basin

The Murray-Darling Basin is the largest freshwater catchment in Australia, spanning an area of about 1,060,000 km^2 and extending into Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory. The entire system has evolved in an environment of extremes, characterised by periodic flooding and extended periods of drought (Crabb, 1997). Because of its critical importance to human existence and industrial development, the entire system has been dramatically modified since European settlement. The introduction of various flow management and water diversion systems, the associated barriers to fish migration, the proliferation of many exotic fish and plant species and pollution from agricultural run-off have collectively had a significant negative impact on the overall environmental health of the entire riverine and estuarine environment.

In a jurisdictional sense, the most relevant part of the Murray-Darling Basin to South Australia is the River Murray and its large estuary at the Murray Mouth. There are six broad ecosystem components that can be identified within the South Australian section of the River Murray. These include the River Murray Mouth, the Lower Lakes (Lake Albert and Lake Alexandrina), the Coorong, the River channel, the wetlands and the floodplain. The remainder of this section will focus on the environmental characteristics of the Murray Mouth, the Lower Lakes and the Coorong lagoons as these ecosystems support the Lakes and Coorong Fishery.

4.2 The Murray Mouth, Lower Lakes and Coorong

In the wider context of the Murray-Darling Basin, the River Murray Mouth, Lower Lakes and Coorong form what was historically the River Murray estuary. Throughout this area, a diversity of important interrelated wetland habitats exist, including the hyper-saline waters of the southern Coorong lagoon (the Coorong proper), a narrow lagoon that extends about 100km south east from the Murray Mouth adjacent to the coastline, the freshwater Lower Lakes, the estuarine waters of the northern lagoon and the coastal marine waters adjacent to the ocean beaches and dune system.

The River Murray enters Lake Alexandrina and Lake Albert at Wellington in South Australia and then separates into five channels that lead to the Murray Mouth. Historically, these channels allowed River Murray water to either mix with the saline waters of the Coorong or enter the Southern Ocean through the Murray Mouth. However, natural flows have been controlled since the early 1940s when a network of five barrages (Goolwa, Boundary Creek, Mundoo, Ewe Island and Tauwitchere) were constructed across each of the five channels 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, 2005a).

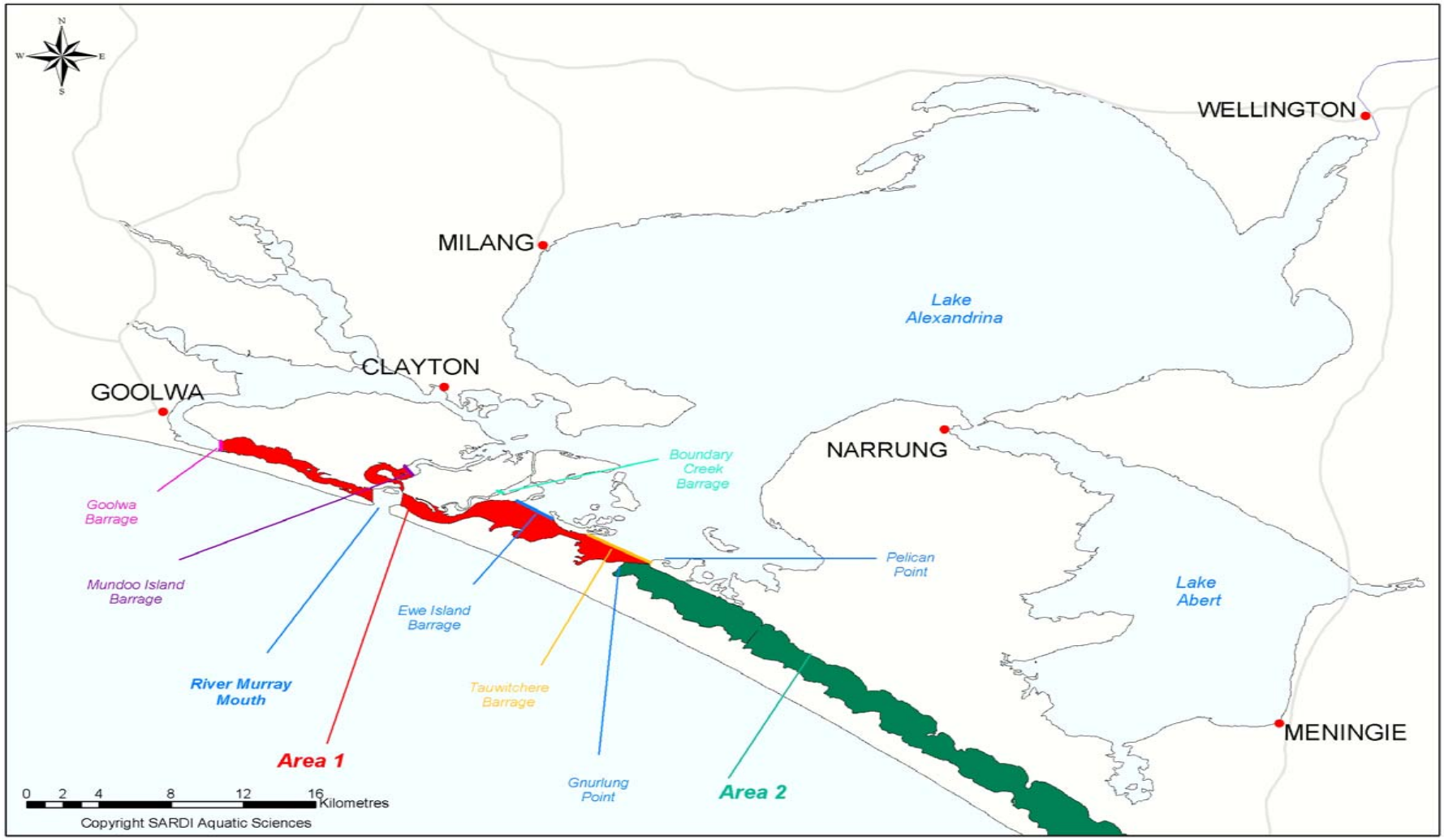


Figure 5. The Lakes and Coorong barrage network

Construction of the barrage network (Fig. 5) transformed about 90% of the original estuary into a freshwater catchment (the Lower Lakes) and had a generally negative impact on the overall health of the Lakes and Coorong ecosystem, in particular the habitat available for a range of estuarine dependant fish species, native plants and birds. The barrage network has significantly reduced the flow of water into and out of the Murray Mouth under tidal influence and restricted natural fish passage. The range of flow regulation measures introduced throughout the Murray-Darling Basin has caused the Murray Mouth to approach closure more frequently than would have occurred naturally. As a result, there are varied and acute pressures placed on the environment, many of which are exposed during periods of extended drought or reduced water flow. During periods of low River Murray flow or non-flow, suitable winds, tide and swell could result in closure of the Murray Mouth. The potential impacts of a long-term Murray Mouth closure on the fish stocks of the Lakes and Coorong are severe (Higham *et al*., 2002, p.53). Important environmental issues for the future management of fish stocks in the Lakes and Coorong Fishery include:

- Restoration of natural flow regimes, through improvements to environmental flow strategies;
- Maintenance of the Murray Mouth opening;
- Improvements to fish passage;
- Improved water quality; and
- Minimising the ecological impacts of exotic fish species.

The unique ecological character of the Lakes and Coorong wetlands are recognised both internationally and nationally for their significance to waterbirds. High conservation status is afforded to the area as a South Australian National Park and as a wetland area listed under the international Ramsar convention. The Murray-Darling Basin Commission has recognised the importance of the Murray Mouth, by identifying it as one of six 'significant ecological assets' in the Basin.

4.3 Environmental Flows

The fish assemblages in most major river systems in the world have been negatively affected by river flow regulation, the associated barriers to fish migration, habitat modification, the introduction of exotic flora and fauna, pollution from agricultural runoff and reduced water quality (Humphries, *et al.*, 1999). The amount of water flowing into the Lower Lakes, then into the Coorong and through the Murray Mouth to the ocean, has decreased dramatically since water flow control measures were introduced throughout the Murray-Darling Basin and in the Coorong. On average, the annual flow through the Murray Mouth is limited to about 27% of the natural median flow recorded before water flow regulation (MDBC, 2002). Prior to flow regulation, flows through the Murray Mouth ceased about every twenty years. This now occurs every two years on average (Jensen, *et al.*, 2000). Reduced river flows and less frequent flooding have changed the morphology of the Mouth, causing sand to build up in and around the Mouth. The Murray Mouth closed in 1981 during a period of extended drought and would almost certainly have closed again in 2003 had extensive dredging operations not been undertaken. The following figure shows the estimated freshwater outflows through the Coorong barrage network since 1963.

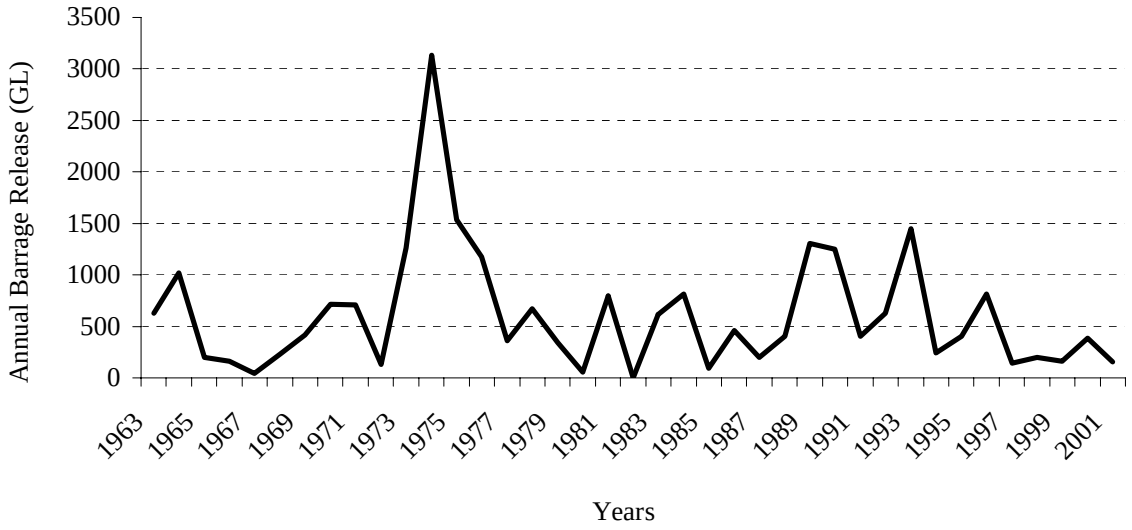


Figure 6. Annual barrage water releases into the Coorong since 1963 (Data source: SA DWLBC).

The evolution of a particular life history pattern, including growth rates, mortality rates and reproductive strategies is the result of a complex mix of selective forces imposed on a species by its environment. Many native freshwater, estuarine and marine fish species have adapted to synchronise life cycle events such as growth and reproduction to changes in environmental conditions such as water temperature, water levels, salinity levels, food availability, lunar phase, photoperiod, and water flow rates (King, 1995). These adaptations occur over long periods of time and although individual events influencing all of these parameters are difficult to predict, fish are likely to adapt to the long term average timing of events such as water flows, if they occur with sufficient predictability (Lytle and Poff, 2004).

The majority of fish spawning events in the Lakes and Coorong are thought to coincide with high flow periods, which have historically occurred in spring and summer (Ferguson and Ward, 2003; MDBC, 2003a; Ye, *et al.*, 2000; Pierce and Doonan, 1999). Due to the individual environmental needs of many native fish species in the Lakes and Coorong, the volume, timing, duration, frequency and quality of water released into the lower Lakes and Coorong is critical to spawning success, overall population health and productivity levels. Combined with other environmental impacts, modifications to natural flow regimes have had severe impacts on many native fish populations and the range of habitats that support them (Pierce and Doonan, 1999).

For some fish species, particularly estuarine dependent species, such as black bream and greenback flounder, barrage water flow regimes can significantly impact on the degree of reproductive success between years and therefore have a significant impact on production status (MDBC, 2003a). The degree to which freshwater outflows impact on the reproductive strategies or productivity levels of other key species such as mulloway and cockles is less clear. However, recent studies confirm that peaks in freshwater flow through the Murray Mouth are correlated with peaks in seasonal commercial catches of mulloway inside and outside the Coorong estuary (Ferguson and Ward, 2003). Freshwater outflows enhance nutrient levels, which elevates primary production and provides a more abundant food supply of phytoplankton for Goolwa cockles (King, 1976; Murray-Jones and Johnson, 2003).

The Murray-Darling Basin Commission Native Fish Strategy (NFS) identifies flow regulation as one of eight key threats to native fish management across the Basin. The NFS aims to promote a coordinated Basin-wide approach to address these issues (MDBC, 2003b). To address this issue, the South Australian Department of Water, Land and Biodiversity Conservation Environmental Flows Program is currently developing a barrage operating strategy as part of The Living Murray Asset Management Plan for the Lower Lakes, Coorong and Murray Mouth. This operating strategy will take into account the diverse environmental needs of the Lakes and Coorong environment, including fish stocks.

The Department of Water, Land and Biodiversity Conservation Environmental Flows Program develops policy and initiates projects for the management and use of environmental flows. Environmental flows are flows for the specific purpose of maintaining and enhancing ecological assets of the river.

At present, the main operating rule for the Lower Lakes is to maintain an average water level of 0.75 metres above sea level. Prior to the beginning of the irrigation season, the Lakes are surcharged to a level of 0.85 metres above sea level. Sufficient barrage gates are opened or closed to maintain this level. As river flow increases, more gates are opened to maintain EL 0.75 metres. The barrage staff use the flows over Lock 1 at Blanchetown, some 250 km upstream, together with the current weather conditions, as a guide to how many gates to operate (West, A. 2004, pers. comm.).

Maintaining water levels at this height increases lakeshore erosion and permanently inundates lake edge habitat. In addition, under current operating rules, water is not released from the barrages until the Lakes are full, which can delay potential releases into the Coorong for a number of months, possibly having a detrimental effect upon the ecology of the Coorong. A project is underway to establish a new operating strategy for the Lakes. This strategy will be built upon the principle of releasing water through the barrages as the Lakes fill, rather than when they are full. This will allow for estuarine conditions in the Coorong at the time its ecology requires this water, as well as reduce the amount of lakeshore erosion caused by long term elevated water levels (West, A. 2004, pers. comm.).

The Murray-Darling Basin Agreement guarantees a minimum flow into South Australia of 1 850 GL per year. This water is divided between irrigation and other users with a portion being left in the river as a maintenance/environmental flow. River Murray Water ensures the delivery of this minimum flow and SA Water manages river operations including the maintenance and operation of the locks and barrages. The barrage structures are owned by the Murray Darling Basin Commission.

Implementation of the Upper South East Dryland Salinity and Flood Management Scheme will lead to regular outflows from Salt Creek to the southern lagoon of the Coorong. There is potential that the southern lagoon will exhibit characteristics of a marine / hypermarine aquatic ecosystem and be more attractive for commercial fish species. The need for further management of the fishery as a result of this will be monitored.

Maximising benefits for fish stocks

In mid-2002, the Murray-Darling Basin Ministerial Council established the Living Murray Initiative in response to substantial evidence that the health of the River Murray system is in

decline. The Council's concern was that the decline would threaten the Basin's industries, communities, and natural and cultural values (MDBC, 2005b).

In 2003, as part of the Living Murray Initiative, the MDBC established a regional evaluation group to assess the overall environmental outcomes for the Lower Lakes, Coorong and Murray Mouth region from a range of revised flow regimes. This process assessed the benefits for fish stocks as one indicator of the overall environmental outcomes. Three reference flows identified in the Living Murray Initiative were evaluated (350GL, 750GL and 1,500GL). Three scenarios for each of these reference flows were tested (MDBC, 2003a).

The outcomes from the regional evaluation group assessment process provide the best available information with which to establish a policy position on the most suitable flow strategy to maximise benefits for fish stocks in the Lower Lakes and Coorong (MDBC, 2003a). On this basis, the information has been used as a starting point for the development of a flow strategy aimed at maximising fish spawning opportunities in the Lower Lakes and Coorong. This position will be refined during the life of this Management Plan as more information becomes available. However, in the meantime, the following flow characteristics reflect PIRSA Fisheries policy in relation to delivering water to maximise benefits for fish stocks in the Lower Lakes and Coorong.

The regional evaluation group process assessed the benefits of improved flow regimes for three categories of fish species: wetland specialists; freshwater species (golden perch); and estuarine (bream and flounder). The regional evaluation group process did not specifically assess the benefits from improved flow regimes for catadromous species such as mulloway or filter feeding bivalves on the ocean beaches (cockles). These two species are the most important species for the commercial sector of the Lakes and Coorong Fishery.

Wetland Specialists

These species include, among others, southern pygmy perch, hardy heads, galaxias and bony bream. Such species are generally associated with the lake edge and wetland habitats with dense or overhanging aquatic riparian vegetation. The spawning period for these species is in early spring and summer, meaning flows timed with these periods will maximise fish spawning opportunities. However, steady flows and lake levels are required all year round to maintain suitable habitats (MDBC, 2003a, p.31).

Freshwater Species

These species are not classified as wetland specialists, but reside in the freshwater Lower Lakes (golden perch and Murray cod). Freshwater inflows which result in lake level rises provide a cue for spawning migrations and/or spawning events for these species. These species spawn during spring and summer meaning that flows timed to occur during this period will maximise spawning opportunities for freshwater species (MDBC, 2003a, p. 31). In addition to flow timing and volume, flow duration is an important consideration in the development of flow strategies aimed at maximising spawning opportunities for these species.

Estuarine Species

These species are resident in the Coorong estuarine lagoons or utilise estuarine waters for annual spawning events (black bream, flounder, yellow-eye mullet). Freshwater inflows

through the barrage network into the Coorong lagoons allow for freshwater to mix with marine water resulting in estuarine conditions. Temperature dependent freshwater inflows during spring and summer provide a critical stimulus for spawning activity in estuarine species. However, as for freshwater species, flow duration is also very important. A protracted flow period extending into late summer is essential to maintain estuarine conditions and low salinity levels to ensure the survival of larval and juvenile fish. Barrage opening and freshwater flows are also important for diadromous species such as lampreys and eels (MDBC, 2003a, p. 31).

The information above outlines the current best knowledge regarding the requirements of native fish and provides direction to the 'Asset Environmental Management Plan: Lower Lakes, Coorong and Murray Mouth Significant Ecological Asset' when developing future guidelines for management.

4.4 Water Quality

The Murray-Darling Basin Native Fish Strategy identifies reduced water quality as one of eight threats to native fish management in the Murray-Darling Basin. Reduced water quality can arise as a result of increased nutrient levels, turbidity, sedimentation, salinity, artificial changes in water temperature, pesticides and other contaminants (MDBC, 2003b). These threats are of particular importance for the Lakes and Coorong Fishery because it exists at the end of the Murray-Darling Basin and is heavily influenced by environmentally damaging practices and low water quality up-stream and throughout the Basin.

The main factors that will impact on water quality in the Lower Lakes and Coorong region are the quality of water arriving from upstream, density stratification, salinity and pathogens. Density stratification can lead to several hazards including cyanobacterial blooms, oxygen depletion and nutrient release from sediments. The highest risk from pathogens generally arises during periods of high rainfall when agricultural runoff is highest. Salinity levels are affected by periods of low freshwater flow from the Lakes into the northern and southern Coorong lagoons, water entering the Coorong lagoons through the Murray Mouth and evaporation (MDBC, 2002) All of these water quality issues present potential threats to native fish species in the Lakes and Coorong.

4.5 Exotic Species

A total of 43 exotic fish species have been established and recorded on mainland Australia (Koehn and Mackenzie, 2004). The Murray-Darling Basin contains at least 11 established exotic fish species (MDBC, 2003b). The abundance, distribution and characteristics of some exotic species continue to cause damage to native fish populations and habitats. The most attention has been given to European carp because of its highly visible presence throughout the Murray-Darling system. However, there are many other exotic fish species which can have significant impacts through predation, competition and disease introduction. The following exotic fish species are established in the Lower Lakes (Lake Alexandrina and Lake Albert):

- European carp and hybrids (*Cyprinus carpio*);
- Goldfish (*Carassius auratus*);
- Gambusia (*Gambusia holbrooki*);
- Rainbow trout (*Oncorhynchus mykiss*);

- Redfin perch (*Perca fluviatilis*);
- Brown trout (*Salmo trutta*); and
- Tench (*Tinca tinca*).

The Murray-Darling Basin Native Fish Strategy identifies exotic fish species as one of eight key threatening processes to native fish management in the Basin. The main threats to native fish management posed by exotic species are related to predation, competition, disease introduction, habitat destruction and reduced water quality. There are also threats posed by future introductions of other exotic species, especially from the aquarium fish trade (MDBC, 2003b). The focus of exotic species management is on minimising and controlling impacts rather than on complete eradication. This Management Plan aims to support the integrated management approach suggested in the Murray-Darling Basin Native Fish Strategy, which could include a range of strategies such as commercial harvesting, rehabilitating wetting and drying cycles for floodplain wetlands and the use of fish screens and traps to prevent adult migrations (MDBC, 2003b).

European carp are harvested commercially from the waters of Lake Alexandrina and Lake Albert, as well as in the South Australian section of the River Murray. Commercial harvesting is currently the most direct method available to minimise the ecological impact of carp populations in the Lakes and Coorong region. However, when considered within the context of the integrated management approach proposed in the Native Fish Strategy, commercial harvesting is only one component of a broader strategy aimed at reducing the overall ecological impact of carp populations. Other carp population control methods will be adopted and integrated as part of a broader carp control strategy, as they become available.

4.6 Fish Passage

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.

Implications of mouth closure

During periods of reduced or low river flow and low rainfall, the Murray Mouth is of central importance because seawater becomes the major source of water to 'freshen' the Coorong and to maintain water quality in the Murray Estuary and Coorong lagoons (Geddes and Hall, 1990). If a range of factors, including weather conditions, tides, sea state and processes such as littoral drift combine in a suitable form, complex sand bars may develop across the Mouth, greatly impeding water exchange and effectively isolating the estuary and the Coorong from the sea (Harvey, 2001).

Closure of the Murray mouth would have multiple effects on the plants and animals of the Coorong and Murray Estuary. Not only would Mouth closure largely prevent fish and other

organisms from migrating between the Coorong and the sea, thereby effecting life cycle processes, but sand deposited inside the Mouth will also smother the productive mudflats in the local area of the Mouth, affecting food resources and water quality for birds and fish. Hall (1984) stated that closures during the period of November to April are most likely to affect migration, whilst water quality and salinity are most likely to rapidly change during the summer period if the Mouth is closed, and hence represents the period of greatest risk (Higham, *et al.*, 2002).

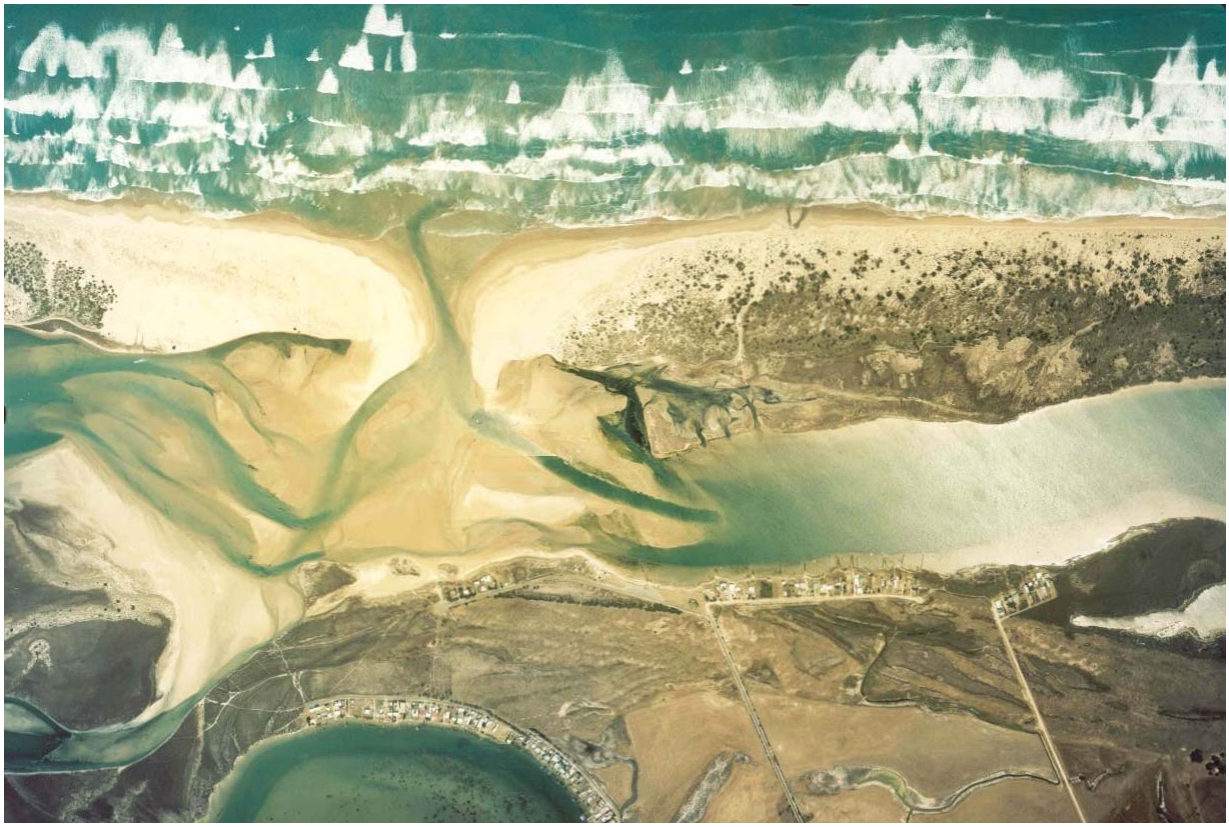


Figure 7. The Murray Mouth approaching closure in November 2002. (Photo: Brenton Erdmann).

Using the categorisation system of Whitfield (1999), the fish species from the Murray Mouth, Lower Lakes and Coorong can be classified into eight groups. This allows clear determination of the relative importance of free access to estuarine habitats with regard to species life history, reflecting those fishes most affected by closure of the Mouth. Marine migrants, marine stragglers, estuarine migrants, catadromous and anadromous species are those that will be directly affected by mouth closure through impacts on population size or particular life cycle stages.

As the marine stragglers do not rely upon the estuary to complete their lifecycle, they will persist locally with the Mouth closed and hence will not be affected in the long term by Mouth closure. The prevention of migration into the estuary for these species will result in a short-term reduction of biodiversity in the Coorong, but it is expected that this would return to present levels following the opening of the Mouth to the sea and re-establishment of suitable water quality.

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.

Species that will be indirectly affected by Mouth closure due to degraded water quality and salinity impacts include black bream (*Acanthopagrus butcheri*) and greenback flounder (*Rhombosolea tapirina*), while an important prey species for many piscivorous fish and other animals the small-mouthed hardyhead (*Atherinosoma microstoma*) would also be significantly affected (Higham, *et al*., 2002).

The Goolwa cockle (*Donax Deltoides*), although not residing inside the Coorong, is distributed along the surf beaches just outside the Mouth. Recruitment levels may be linked to Murray River outflow (Murray-Jones and Johnson, 2003) and oceanic upwelling. With the closure of the mouth, the recruitment of Goolwa cockles may be depressed in the next season due to a reduction in food availability. From recent studies during periods of near-continual river flow during 2001/02, it was found that there is always a proportion of the local cockle population able to spawn and when flow is released, food availability increases triggering the 'ripe' animals to spawn (Murray-Jones and Johnson, 2003). As most fish are two or more years of age before reaching minimum legal length, the effects of lifecycle interruption will initially be masked. Over time, the effect is likely to be reflected as a decrease in catch per unit of fishing effort in the commercial returns supplied to SARDI by commercial fishers (Higham, *et al*., 2002). Sudden, large freshwater outflows can also cause significant mortality of Goolwa cockles because of reduced salinity levels in the surf zone adjacent to the Mouth (Murray-Jones and Johnson, 2003).

Complete Mouth closures have happened many times in the past, but have not been paralleled by a River Murray as restricted in flow as witnessed today. Prior to the short-term freshwater release across the barrages during September/October 2003, the barrages had remained closed for the longest period ever at over 600 days. Previous recent and historic closures have fortunately been short in duration, with the Mouth being re-opened by flow or a combination of flow and human intervention (excavation), as in 1981 before significant degradation in water quality occurred.

The recent period of no flow across the barrages has necessitated dredging operations to ensure suitable water quality and connectivity with the sea is preserved and the health of fish populations is maintained (Fig. 8).

Figure 8. Dredging operations undertaken during 2002/03 to maintain an opening at the Murray Mouth. (Photo: Brenton Erdmann)

Fish passage between the Lakes and Coorong/Sea

Murray-Darling Basin fish movements and migrations can vary in distance from small localised movements (<1 km) up to 1000 km depending on both the species and the purpose of the movement. There are two main classifications of migrations:

- potamodromous - fish that migrate wholly within fresh water;
- diadromous - fish that migrate between fresh water and the sea.

Within the latter group there are a further three subdivisions:

- anadromous - diadromous fish that spend most of their life in the sea and migrate to fresh water to breed;
- catadromous - diadromous fish that spend most of their life in fresh water and migrate to the sea to breed;
- amphidromous - diadromous fish that migrate between the sea and fresh water, but not for the purpose of breeding.

For fish that have large-scale migrations in their life cycles, particularly anadromous and catadromous species, the prevention of fish passage causes local extinctions above barriers and can greatly reduce population numbers downstream of those barriers (Faragher & Harris, 1994; Marsden, *et al.,* 1997; Harris, *et al.,*. 1998; Pethebridge, *et al.,* 1998). For all fish species, major barriers isolate and can modify previously continuous fish communities, resulting in changes in the faunal community structure in that river system (Harris & Mallen-Cooper, 1994; McDowall, 1996; Stuart 1997; Harris, 1997; Harris, *et al.,* 1998).

Barriers to upstream fish passage, such as large dams, have the most obvious effect on fish migrations. Partial barriers to fish migration such as low weirs can be passable at certain stream flows, or may be removed at certain times (Mallen-Cooper & Edwards, 1991; Harris, *et al*., 1992; Mallen-Cooper & Thorncraft, 1992; Williams, *et al.,* 1996; Pethebridge, *et al.,* 1998). Partial barriers have less immediately noticeable impact on fish populations than total barriers. If conditions allowing fish passage occur only infrequently, they may not correspond to the natural timing of fish migration each year, or suitable conditions may not extend over a long enough period to permit movement by a sufficient portion of the population. In these situations recruitment to upstream areas is reduced; mortalities increase, because of predation for example; fish congregate below the barrier; and the overall productivity of the system decreases (Harris, 1984a; Harris & Mallen-Cooper, 1994; Mallen-Cooper, *et al.,* 1995).

Barriers to fish migrations in the lower reaches of a river usually have the greatest impact on fish populations. Catadromous and potamodromous life cycles are both common among fish species in the Murray-Darling basin, so both adult and juvenile fish commonly attempt to migrate past barriers. In coastal lowland reaches, especially at the tidal limit where larval and juvenile catadromous fish require upstream passage, even very small barriers can totally bar the weaker-swimming fish (Harris, 1984a; Mallen-Cooper, 1992, 1994), resulting in recruitment failure to all upstream habitats in that catchment (Harris, 1984a; Stuart ,1997; Harris, 1988).

For the species mentioned earlier as being directly affected by mouth closure and to a lesser extent catadromous and anadromous species, fish passage across the barrages between the estuary and the Lower Lakes/Lower Murray is of more relevance with regard to inhibition of lifecycle stages.

Fish passage is critical in allowing:

- adult fish access to and from spawning habitats;
- dispersal of juvenile fish to new habitats;
- access to feeding habitats;
- re-colonisation of new habitats;
- exploratory movements and habitat selection; and
- access to and from refuge areas during droughts or floods.

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 Tauwitchere Barrage.

At the Tauwitchere barrage, a rock ramp fish ladder has been constructed in the barrage adjacent to the shore to allow passage for the smaller fish species. A vertical slot fish passage has been constructed in the deepest section of the barrage to allow passage for the larger fish species. Operating guidelines for the barrages are currently being developed. Under these guidelines, the barrage gates containing fish ladders will be the first ones opened when water is to be released. The barrage gates adjacent to the fish passage will be the next to be opened to draw fish to the fish ladder.

A vertical slot fish ladder and a 'Denil' fish ladder are being constructed at the Goolwa barrage. All three types of fish passage will be monitored and evaluated to determine which types are the most effective for the Coorong and Lower Lakes. Additional fish ladders may be installed after the first four have been evaluated.

The South Australian Research and Development Institute is currently involved in the MDBC Barrage Fish Passage Monitoring and Assessment Program. Following the completion of fishway installation, an intensive monitoring and assessment program will be carried out by SARDI to compare the relative efficiency of the fishway options. Specific fishway experiments will also be conducted to optimise final fishway design, placement and operation. The monitoring program will gauge the success of the fish ladders at the Murray Mouth barrages.

5 BIOLOGICAL CHARACTERISTICS OF KEY SPECIES

The following descriptions provide brief background information on the biological characteristics, commercial production statistics and recreational catch and effort levels for each key species in the Lakes and Coorong Fishery. More detailed information on stock status is provided in stock assessment reports prepared by the South Australian Research and Development Institute (SARDI), Aquatic Sciences. All completed stock assessment reports are available on the PIRSA Fisheries website at www.pir.sa.gov.au/fisheries.

5.1 Mulloway

Mulloway, *Argyrosomus japonicus* (Teminck and Schlegel, 1843) 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 mulloway 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. The first stock assessment of *Argyrosomus japonicus* in South Australia was completed in 2003 (Ferguson and Ward, 2003).

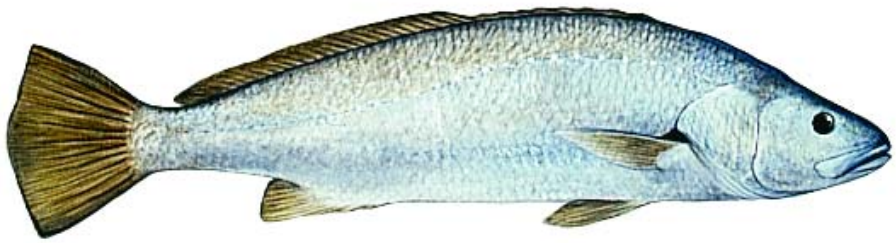


Figure 9. Mulloway (*Argyrosomus japonicus*)

Mulloway 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)[3]. Females grow faster than males and hence reach a size where they recruit to the swinger net component of the fishery at a younger age than males (Ferguson and Ward 2003). The life history strategy of mulloway 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 mulloway 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 mulloway aggregate around the River Murray Mouth

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

during the 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. Smaller aggregations are also known to occur on the west coast (Hall, 1986).

Juvenile mulloway utilise the waters of the Coorong estuary as a nursery habitat for at least five years after which time they are thought to migrate out of the estuary and into marine waters. At present, separate size limits are in place for mulloway taken inside estuarine waters and outside estuarine waters on the ocean beaches. This management strategy was implemented to provide greater protection for the adult breeding stock in coastal waters, which was becoming increasingly more vulnerable to commercial and recreational fishing pressure (Hall, 1986). Hall (1986) suggested that mulloway do not reach a size of sexual maturity until five years of age or a size of 75cm. These findings are consistent with the preliminary findings of recent studies (Ferguson and Ward, 2003). Size of maturity for mulloway in Western Australia has been estimated at approximately 92cm for males and 95cm for females (Farmer, 2003).

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 are correlated well with mean monthly freshwater flow data. Time lagged freshwater flows correlate with commercial mesh net catches inside the Coorong estuary (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. Figure 10 represents the total commercial catch of mulloway by all sectors in South Australia over the period 1984 to 2001. The total commercial catch of mulloway in the 2001/02 financial year was 114 tonnes. Of this, 96% was taken by Lakes and Coorong fishers. The remaining 4% was taken in the marine scalefish fishery. In addition to this catch, Commonwealth southern shark fishery licence holders took an estimated 2.7 tonnes.

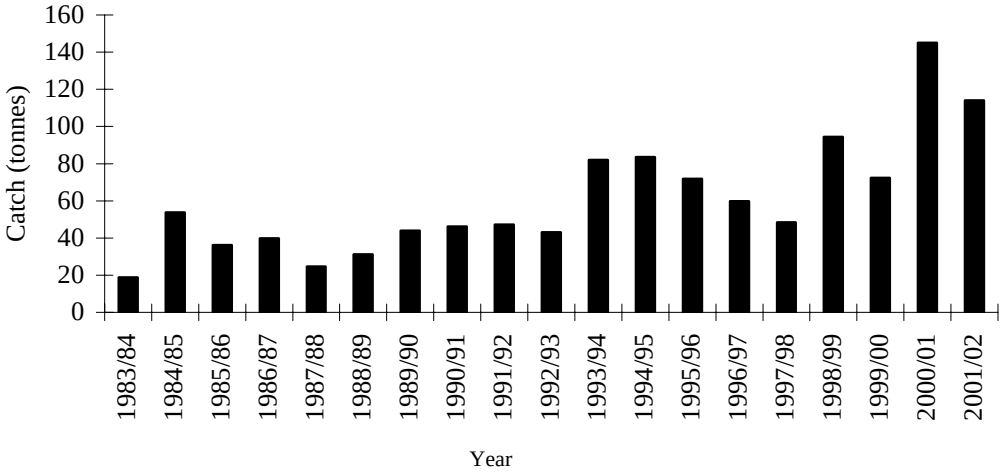


Figure 10. Inter-annual commercial catch of mulloway by all sectors in South Australia.

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). This catch represents about 38% of the total catch (commercial and recreational) of the species across South Australia.

This estimate was derived from national recreational survey results, which estimated a total of 27,004 (± 5,156 SE) mulloway, with an estimated mean weight of 3.34 kg, were caught by recreational fishers during this period (Henry and Lyle, 2003). Across Australia, 46% of all mulloway caught by recreational fishers are discarded, which means the total mortality associated with recreational fishing may be higher. The post release mortality associated with line caught mulloway returned to the water after capture is currently unknown (Ferguson and Ward, 2003).

5.2 Goolwa Cockles

Populations of *Donax deltoides* 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 Younghusband 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. The first stock assessment of *D. deltoides* in South Australia was completed in 2003 (Murray-Jones and Johnson, 2003).

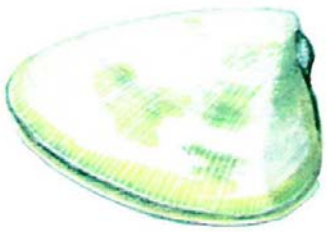


Figure 11. Goolwa cockle (*Donax deltoides*).

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 upwelling. 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).

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 12 shows the increasing trend in annual commercial production, particularly in the decade between 1990 and 2000. This trend in increased catch and effort levels is a cause for

concern to fishery managers. Also of concern is the level of latent effort which exists in a number of other state managed fisheries including the marine scalefish and southern rock lobster fisheries. Strategies to address these issues are outlined in this Management Plan.

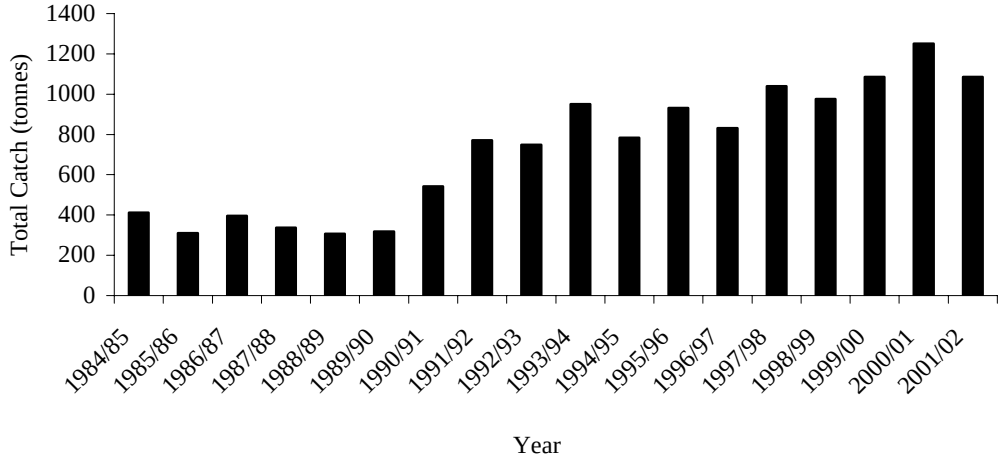


Figure 12. Inter-annual commercial catch of Goolwa cockles by all sectors in South Australia.

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 less than 30 tonnes between May 2000 and April 2001 (Henry and Lyle, 2003). 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.

5.3 Yellow-eye Mullet

Populations of yellow-eye mullet, *Aldrichetta forsteri* 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 overs 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).

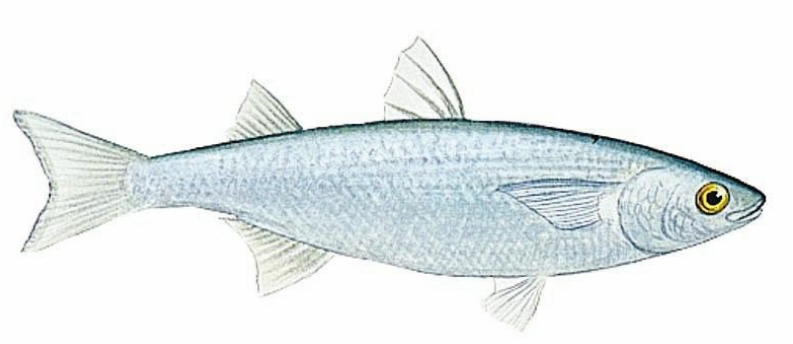


Figure 13. Yellow-eye mullet (*Aldrichetta forsteri*).

Yellow-eye mullet are categorised as estuarine opportunists (Wakefield, 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).

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).

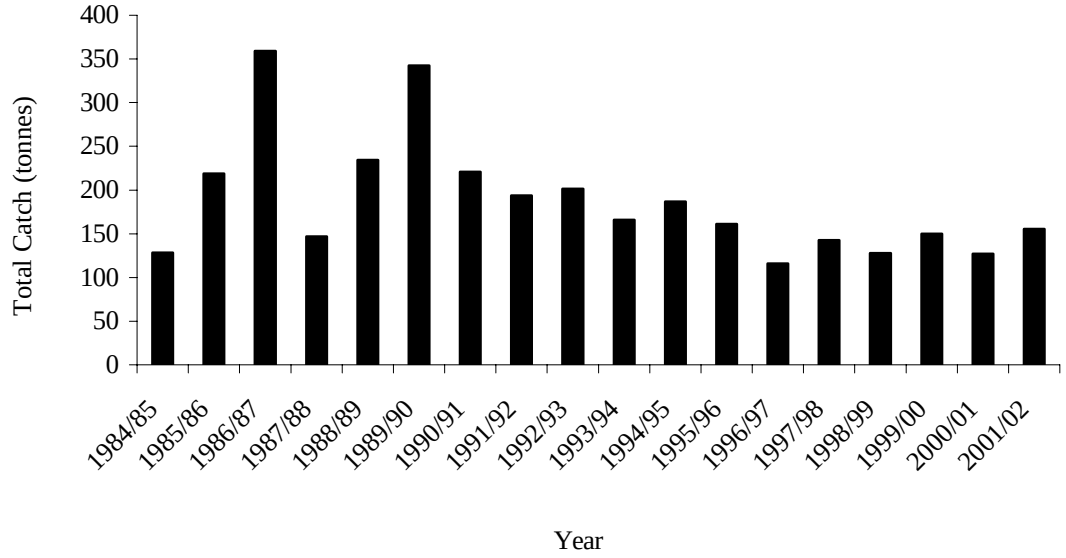


Figure 14. Inter-annual commercial catch of yellow-eye mullet in the Lakes and Coorong Fishery.

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).

5.4 Golden Perch

Golden perch or callop, *Macquaria ambigua* 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, except at high altitudes. 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 (4-37ºC) 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).

Figure 15. Golden perch (*Macquaria ambigua*).

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.*, 1992b). 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 20º to 25ºC. Individual fish may spawn more than once in a season if conditions are favourable (Battaglene 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 (Battaglene 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; Battaglene and Prokop, 1987). Egg development is pelagic and hatching occurs about 24-33 hours after fertilisation at 20º to 31ºC (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).

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. Figure 16 shows the commercial catch of golden perch from the Lower Murray Lakes between 1984 and 2002.

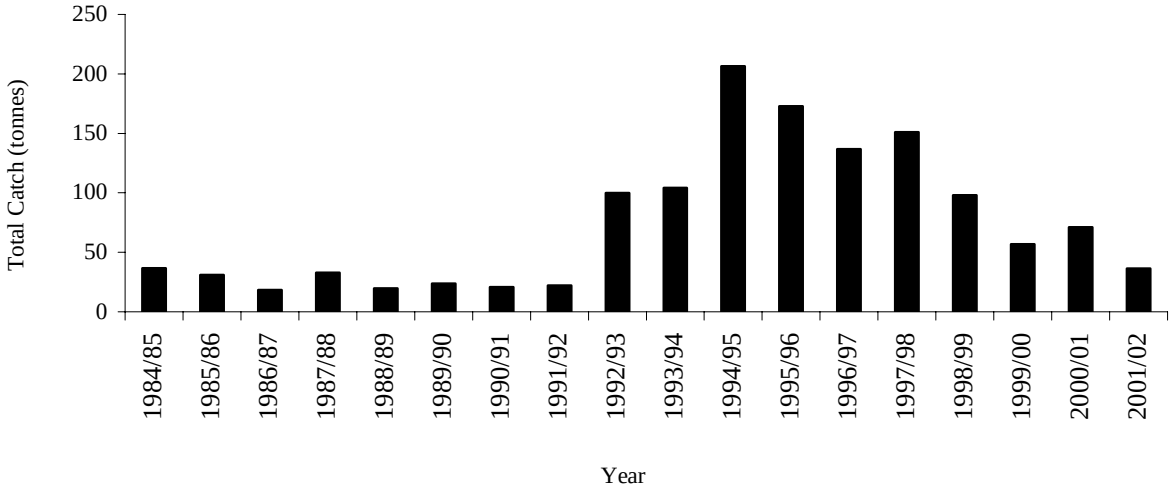


Figure 16. Inter-annual commercial catch of golden perch in the Lakes and Coorong Fishery.

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.*, 2003).

The recreational catch of golden perch in South Australia is significant, the majority of which is taken from River Murray waters. In relative terms, the total recreational catch taken from the Lakes and Coorong is thought to be small. The National Recreational and Indigenous Fishing Survey undertaken between May 2000 and April 2001 estimated that the total recreational catch of golden perch from South Australian waters was 91.1 tonnes (Henry and Lyle 2003). Recreational fishers target golden perch mainly using rod and line, however, a limited number of recreational net registrations exist in South Australia, which are permitted to be used in Lake Alexandrina and Lake Albert. Anecdotal evidence exists to suggest the recreational catch of Lake Eyre golden perch is also significant, but this has not been quantified. There are concerns over the extent of the illegal catch of golden perch from the River Murray and the Cooper Creek system. The illegal catch is unquantified.

5.5 Black Bream

Black bream *Acanthopagrus butcheri* (Munro 1949) 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 (Burridge, *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.

Figure 17. Black bream (*Acanthopagrus butcheri*).

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). Future management of this species must focus on increasing the number of successful annual spawning events and maximising the opportunities for larvae survival and development, through improved barrage flow manipulation.

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 (Fig. 18). 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.

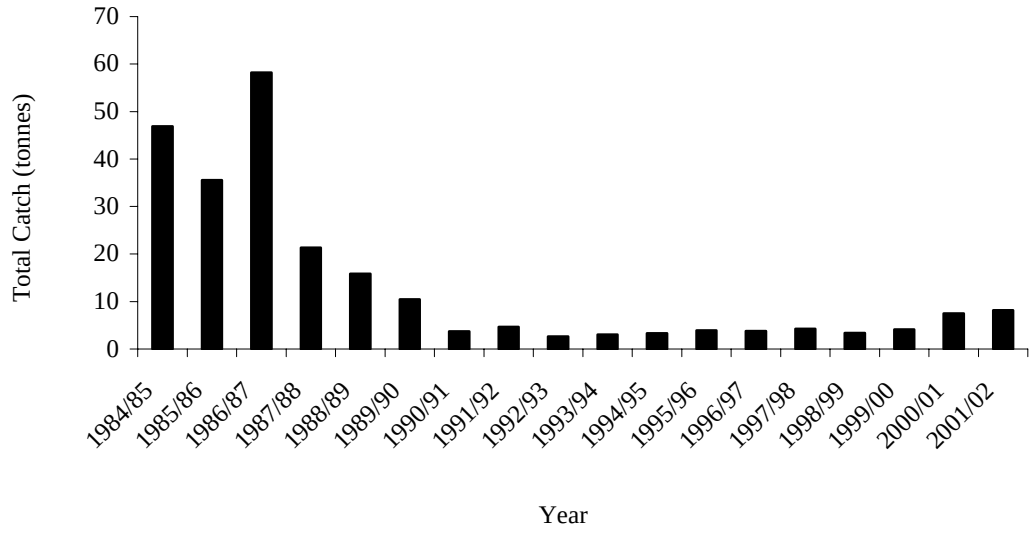


Figure 18. Inter-annual commercial catch of black bream in the Lakes and Coorong Fishery.

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 by-catch study is currently being undertaken to, among other things, quantify the catch composition and by-catch levels associated with mesh nets.

5.6 Greenback Flounder

Greenback flounder, *Rhombosolea tapirina* (Günther, 1862) 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.

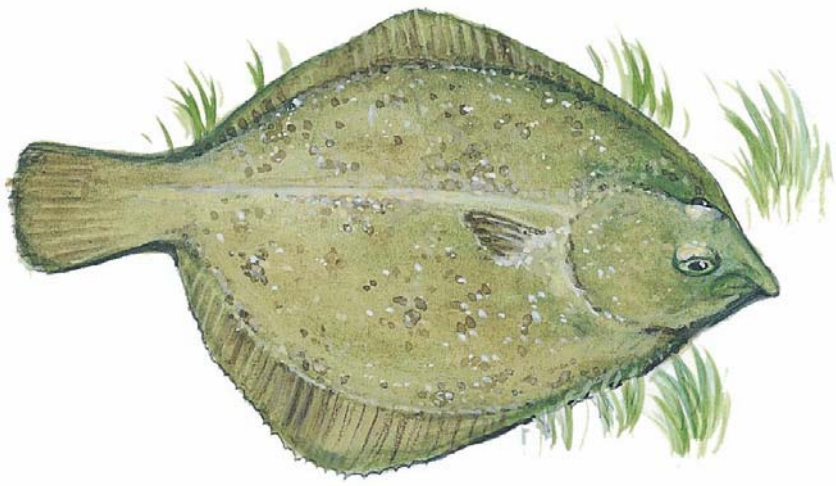


Figure 19. Greenback flounder (*Rhombosolea tapirina*).

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).

Limited information is available of the reproductive biology of greenback flounder in South Australia. A Tasmanian study indicated that the species has a protracted spawning season from March to October and that spawning occurs in the deeper regions of estuaries, tidal rivers and offshore waters (Kurth, 1957). Maturity is reached at between 19 and 30cm (Kailola, *et al.,* 1993). Female greenback flounder are capable of ovulating several times within a reproductive season (Barnett and Pankhurst, 1999).

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). Future management of this species must focus on increasing the number of successful annual spawning events and maximising the opportunities for larvae survival and development, through improved barrage flow manipulation.

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 (Fig. 20).

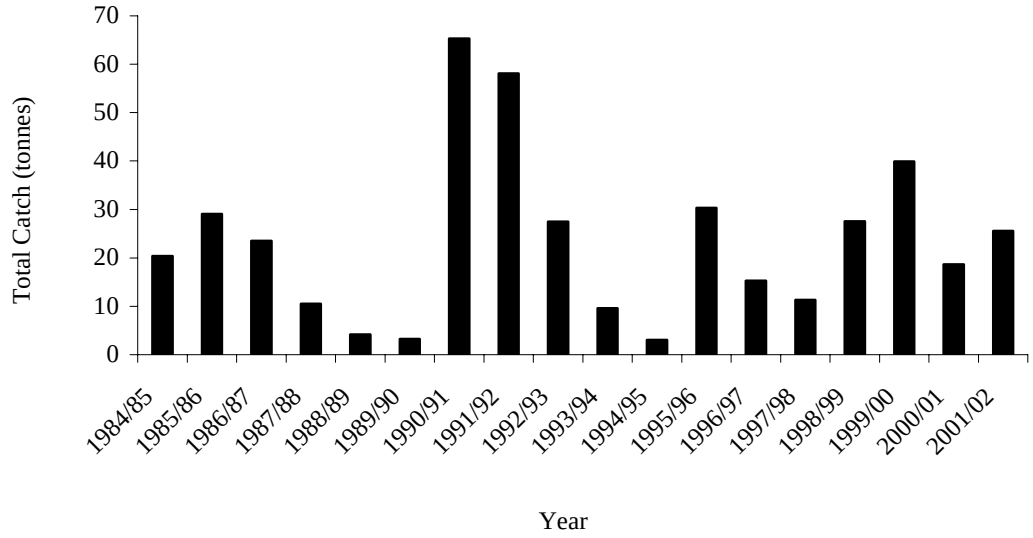


Figure 20. Inter-annual commercial catch of greenback flounder in the Lakes and Coorong Fishery.

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 include other flounder species such as the small-toothed flounder (Jones, K. 2004, pers. comm.).

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 by-catch study is currently being undertaken to, among other things, quantify the catch composition and by-catch levels associated with mesh nets.

5.7 European Carp

European carp *Cyprinus carpio* (Linnaeus) 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.

Figure 21. European carp (*Cyprinus carpio*).

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, 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).

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 Lakes and Coorong fishers specialise in carp fishing for the rock lobster bait market.

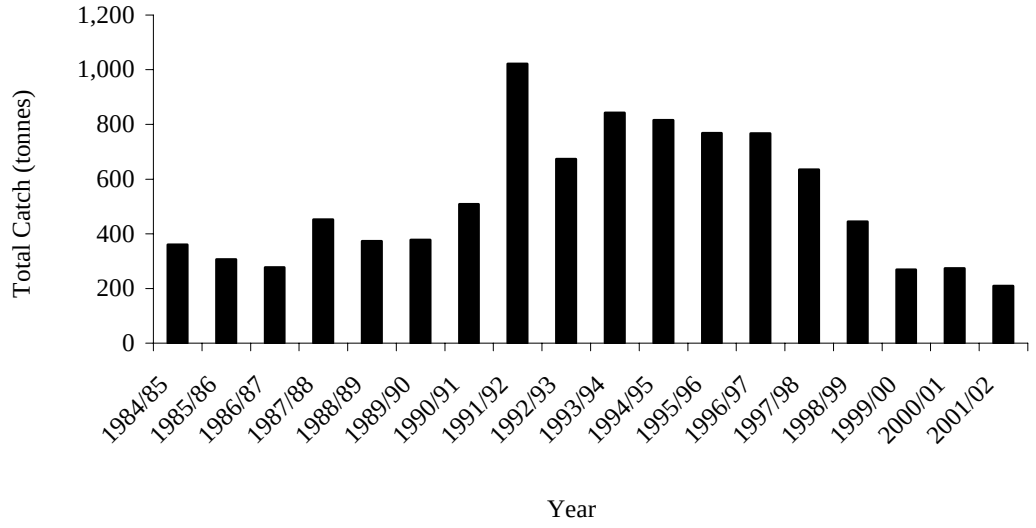


Figure 22. Inter-annual commercial catch of European carp in the Lakes and Coorong Fishery.

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).

6 STOCK ASSESSMENT AND RESEARCH

The Lakes and Coorong Fishery can currently be classified as a data poor fishery, with only limited quantitative information available to managers for annual decision-making processes. A strategic research and monitoring plan has been developed to guide research and monitoring activities and increase the amount of quantitative information available for management of the fishery. The research and monitoring 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. A key priority for the Lakes and Coorong Fishery is the preparation of quantitative stock assessment reports for all key species. A strategic research and monitoring plan for the fishery is at Appendix III.

7 ECOSYSTEM IMPACTS

One of three core objectives of the National Strategy for Ecologically Sustainable Development (ESD) is to 'protect biological diversity and maintain essential ecological processes and life support systems'. The National Strategy for ESD was a key policy driver in the development of the Australian Government 'guidelines for the ecologically sustainable management of fisheries' set out in the *Environment Protection and Biodiversity Conservation Act 1999.* These guidelines mandate the need to ensure that fisheries management frameworks aim to minimise the impacts of fishing on the structure, productivity, function and biological diversity of ecosystems.

This Management Plan aims to address broad ecosystem impacts at two levels: impacts related to fishing operations (eg. trophic impacts related to exploitation rates and by-catch); and external impacts on the environment (eg. barriers to fish passage and water flow regulation). Broader ecosystem impacts have only recently been taken into account in fisheries management systems and stock assessment (Fletcher, *et al.,* 2000). As a result, there is generally a higher level of uncertainty associated with the potential consequences of these impacts.

The national ESD reporting framework (Fletcher, *et al.,* 2000) outlines a process to identify fishery-related ecosystem impacts and evaluate the level of risk associated with fishing activities. An outline of fishery related impacts on the ecosystem and external (non-fishery related) impacts on the ecosystem are presented in Appendix V as a series of component trees. These component trees will be used to undertake a qualitative assessment of the risks to individual species and the wider ecosystem posed by fishing activities and the risks to the fishery from external factors.

8 COMPLIANCE AND MONITORING

PIRSA Fisheries uses a risk management approach to the development of compliance strategies across all fisheries in South Australia. This approach is designed to improve the cost-effectiveness of compliance and monitoring activity in all sectors by prioritising key activities, based on a formal semi-quantitative assessment of the risks in all fisheries.

The main priority risks to sustainable management of the fishery are broken down into three main categories each year: commercial risks, non-commercial risks and fish processor risks. Risk levels are rated using semi-quantitative estimations of:

- The *likelihood* of identified risks occurring; and
- The *consequences* if the identified risks occur; and
- The degree to which existing management *controls* and *compliance programs* limit the likelihood of risks occurring.

The risk profile prepared for the Lakes and Coorong Fishery for the 2004/05 fishing season is provided in Appendix VI. The risk priorities contained in Appendix VI will be the focus of compliance activity for the Lakes and Coorong Fishery during 2004/05. Other risks will be addressed outside of the planned programme for 2004/05, as circumstances require. The focus of compliance activity may change during the course of the year on the basis of information received. Activity and outcome information is collected in relation to compliance activities to address priority risks and is reported to the Fisheries Management Committee on a quarterly basis. The risk profile for the fishery is audited and updated each year to take account of any changes to arrangements or emerging issues.

9 REFERENCES

Anderson, J. R., A. K. Morison and D. J. Ray. (1992a). Age and growth of Murray cod, *Maccullochella peelii* (Mitchell) (Perciformes: Percichthyidae), in the lower Murray-Darling basin, Australia, from thin-sectioned otoliths. Australian Journal of Marine and Freshwater Research 43, 983-1013.

Anon. (2004). Lakes and Coorong Fishery: "Wild Fisheries with a Future" Value-adding Opportunities. Final report prepared by EconSearch Pty Ltd for the Southern Fishermen's Association Inc.

Australian Fisheries Management Authority (2001). Glossary of Terms and Acronyms. World wide web electronic resource: http://www.afma.gov.au/glossary.php. Date accessed: 7 February 2005.

Baker, D. and Pearce, B. (Eds.) (1998). Environmental Management Plan of the Southern Fishermen's Association for the Lakes and Coorong Fishery.

Barnett, C. W. & Pankhurst, N. W. (1999). Reproductive biology and endocrinology of greenback flounder *Rhombosolea tapirina* (Günther 1862). *Marine and Freshwater Research* 50, 35-42.

Battaglene, S. and F. Prokop. (1987). Golden perch. N.S.W. Department of 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-east Australia. J. Fish Biol. 64, 815 - 19.

Bureau of Rural Sciences (2002). 'Glossary of fisheries terms'. World wide web electronic resource: http://www.affa.gov.au/content/output.cfm?ObjectID=D2C48F86-BA1A-11A1-A2200060B0A06448. Date accessed: 4 February 2005.

Cashmore, S., Conron, S. and Knuckey, I. (Eds.) (2000). Black Bream – 1998. Compiled by the Bay and Inlet Fisheries Stock Assessment Group. Fisheries Victoria Assessment Report No. 24. (Marine and Freshwater Resources Institute: Queenscliff).

Chen, W-M., Purser, J. & Blyth, P. (1999). Diel feeding rhythms of greenback flounder *Rhombosolea tapirina* (Günther 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. *Australian Journal of Marine and Freshwater Research* 45, 1033-1044.

Cox, E. S. & Pankhurst, P. M. (2000). Feeding behaviour of greenback flounder larvae, *Rhombosolea tapirina* (Günther) with differing exposure histories to live prey. *Aquaculture* 183, 285-297.

Crabb, P. (1997). Murray-Darling Basin Resources: Murray-Darling Basin by Numbers. The Murray-Darling Basin Commission. Canberra. 300p.

Crawford, C. M. (1984). Preliminary results of experiments on the rearing of Tasmanian flounders, *Rhombosolea tapirina* and *Ammotretis rostratus*. *Aquaculture* 42, 75-81.

Crawford, C. M. (1986). Development of eggs and larvae of the flounders *Rhombosolea tapirina* and *Ammotretis rostratus* (Pisces: Pleuronectidae). *Journal of Fish Biology* 29, 325-334.

Department of Agriculture, Fisheries and Forestry Australia (1999). National Policy on Fisheries By-catch. Ministerial Council on forestry, Fisheries and Aquaculture. Canberra.

Department of Environment and Planning (1990). Coorong National Park Management Plan. National Parks and Wildlife Service. A Division of the South Australian Department of Environment and Planning. 54p.

Department of Environment and Heritage (2000). Coorong and Lakes Alexandrina and Albert Ramsar Management Plan. South Australian Department of Environment and Heritage. 63p.

FAO. (1996). Precautionary approach to capture fisheries and species introductions. Elaborated by the Technical Consultation on the Precautionary Approach to Capture Fisheries (Including Species Introductions). Lysekil, Sweden, 6-13 June 1995. *FAO Technical Guidelines for Responsible Fisheries.* No. 2. Rome, FAO. 1996. 54p.

Farmer, B. (2003). Biology of the mulloway *Argyrosomus japonicus* in Western Australia. School of Biological Sciences and Biotechnology. Perth, Murdoch University: pp 85.

Ferguson, G. and Ward, T., M. (2003). Mulloway (*Argyrosomus japonicus*) Fisheries Assessment Series 2002/20. pp 56.

Fletcher, W.J., Chesson, J., Fisher, M., Sainsbury, K.J., Hundloe, T., Smith, A.D.M. and B. Whitworth (2002). *National ESD Reporting Framework for Australian Fisheries: The 'How To' Guide for Wild Capture Fisheries.* FRDC Project 2000/145, Canberra, Australia.

Geddes, M. C. and Hall, D. (1990). The Murray Mouth and Coorong. In 'The Murray'. (Eds. N. Mackay and D. Eastburn.). Murray Darling Basin Commission. (pp 200-213)

Gomon, M. F., Glover, C. J. M. & Kuiter, R. H. (Eds.) (1994). The Fishes of Australia's South Coast. Adelaide: State Print.

Goodwin, N. and Bennett, S. (Eds.) (2002). The Murray Mouth: Exploring the Implications of Closure or Restricted Flow. Murray-Darling Basin Commission, Level 5, 15 Moore Street, Canberra City, ACT, 2600. 96p.

Hall, D. (1984). The Coorong: Biology of the major fish species and fluctuations in catch rates 1976 - 1984. SAFIC 8(1): 3 -17.

Hall, D., A (1986). An Assessment of the Mulloway (*Argyrosomus hololepidotus*) Fishery in South Australia with Particular Reference to the Coorong Lagoon. Discussion Paper. Department of Fisheries. 41p.

Halliday, I., Ley, J., Tobin, A., Garrett, R., Gribble, N. and D. Mayer (2001). The effects of net fishing: addressing biodiversity and bycatch issues in Queensland inshore waters. 95p.

Harris, J. A. (1968). Age structure, growth rate and spawning cycle of a population of Yellow-eye mullet *Aldrichetta forsteri* (Cuv. and Val.) from the Coorong Lagoon, South Australia. Transactions of the Royal Society of South Australia 92: 37-50.

Harris, J. H. and S. J. Rowland. (1996). Australian freshwater cods and basses. In 'Freshwater Fishes of South-eastern Australia'. R. M. McDowall (Ed.). Reed Books, NSW. 247pp.

Hemming, S., Trevorrow, T. and Rigney, M. (2002). Ngarrindjeri Culture and the Closure of the Murray Mouth. The Murray Mouth: Exploring the implications of closure or restricted flow. Murray-Darling Basin Commission. Canberra. 96p.

Henry, G.W. and Lyle, J.M. (Eds.) (2003). The National Recreational and Indigenous Fishing Survey. FRDC Project No. 99/158. 188p.

Higham, J., Hammer, M. and Geddes, M. (2002). Implications of Murray Mouth Closure: Fish and Invertebrates. The Murray Mouth: Exploring the implications of closure or restricted flow. Murray-Darling Basin Commission. Canberra. 96p.

Higham, J. Ferguson, G. and Ye, Q. (2005). Lakes and Coorong Yellow-eye Mullet (*Aldrichetta forsteri*) Fishery. Fisheries Assessment Series. Department of Primary Industries and Resources, South Australia.

Humphries, P., King, A., J. and J., D. Koehn (1999). Fish, flows and flood plains: Links between freshwater fishes and their environment in the Murray-Darling River system, Australia. Environmental Biology of Fishes. 56: 129-151.

Jenkin, G. (1979). The conquest of the Ngarrindjeri. 2nd Edition. Published at Point McLeay, South Australia, 302 p.

Jensen, A., Good, M., Harvey, P., Tucker, P. and M. Long (2000). River Murray Barrages Environmental Flows. Report to Murray-Darling Basin Commission, Canberra, ACT. Wetlands management Program, Department of Environment and Natural Resources, Adelaide, South Australia.

Kailola, P. J., Williams, M. J., Stewart, P. C., Reichelt, R. E., McNee, A. and C. Grieve (Eds). (1993). Australian Fisheries Resources. Canberra, Bureau of Resource Sciences, Department of Primary Industries and Energy and the Fisheries Research and Development Corporation.

Keenan, C. P., Watts, R. J. and L. G. Serafini. (No Date). Population genetics of golden perch (*Macquaria ambigua*), silver perch (*Bidyanus bidyanus*) and eel-tailed catfish

(*Tandanus tandanus*) within the Murray-Darling basin. Final Report. MDBC NRMS Project M262. Murray-Darling Basin Commission; Canberra. 113p.

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):16p.

King, M. G. (1995). Fisheries Biology, Assessment and Management. Fishing Book News. 340p.

Knight, M., A., Tsolos, A. and A., M. Doonan (2003). South Australian Fisheries and Aquaculture Information and Statistics Report. South Australian Research and Development Institute, Aquatic Sciences. Research Report No. 58.

Koehn, J., Brumley, A. and Gehrke, P. (2000). Managing the impacts of carp. Bureau of Rural Sciences (Department of Agriculture, Fisheries and Forestry – Australia), Canberra.

Koehn, J., D. and Mackenzie, R., F. (2004). Priority management actions for alien freshwater fish species in Australia. *New Zealand Journal of Marine and Freshwater Research, 2004.* Vol. 38.

Kurth, D. (1957). An investigation of the greenback flounder, *Rhombosolea tapirina* Günther. PhD thesis, University of Tasmania.

Lake, J. S. (1967a). Principal fishes of the Murray-Darling River system. In 'Australian Inland Waters and Their Fauna'. A. H. Weatherley (Ed.). Australian National University Press, Canberra. Pp 192-213.

Lake, J. S. (1967b). Rearing experiments with five species of Australian freshwater fishes. I. Inducement to spawning. Australian Journal for Marine and Freshwater Research 18:137-53.

Lake, J. S. (1967c). Rearing experiments with five species of Australian freshwater fishes. II. Morphogenesis and ontogeny. Australian Journal for Marine and Freshwater Research 18:155-73.

Lake, J. S. (1971). Freshwater fishes and rivers of Australia. Thomas Nelson, Sydney.

Leubbers, R. A. (1981). The Coorong Report: An archaeological survey of the southern Younghusband Peninsula. Report prepared for the Department of Environment and Planning, South Australia.

Linn, R. (1988). A Diverse Land: A History of the Lower Murray Lakes and Coorong. Published by the Meningie Historical Society Inc.

Lytle A. and Poff L. (2004). Adaptation to natural flow regimes. *Trends in Ecology and Evolution*. Vol 19. No. 2. pp 94-100.

MacDonald, C. M. (1978). Morphological and biochemical systematics of Australian freshwater and estuarine percichthyid fishes. Australian Journal of Marine and Freshwater Research 29(5): 667-698.

Mackay, N. J. (1973). Histological changes in the ovaries of the golden perch, *Plectroplites ambiguus*, associated with the reproductive cycle. Australian Journal of Marine and Freshwater Research 1973, 24: 95-101.

Marine Stewardship Council (2002). Welcome to MSC online. World wide web electronic resource: http://www.msc.org/html/content_458.htm. Date accessed: 9 April 2005.

McDowall, R. M., Ed. (1996). Freshwater fishes of South-Eastern Australia. Sydney, Reed Books Australia, Chatswood, NSW.

Merrick, J. R. and G. E. Schmida. (1984). Australian freshwater fishes, biology and management. Griffin Press Ltd., Netley, South Australia. 409pp.

Murray-Darling Basin Commission (2000). National Management Strategy for Carp Control 2000-2005. Murray-Darling Basin Ministerial Council. Canberra 41p.

Murray-Darling Basin Ministerial Council (2000). The Living Murray: A discussion paper on restoring the health of the River Murray. Murray-Darling Basin Commission. Canberra.

Murray-Darling Basin Commission (2002). The Murray Mouth: Exploring the implications of closure or restricted flow. Canberra. 96p.

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

Murray-Darling Basin Commission (2003b). Native Fish Strategy for the Murray Darling Basin 2002 – 2012. Murray-Darling Basin Commission. Canberra. 20p.

Murray-Darling Basin Commission (2005a). 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-Darling Basin Commission (2005b). The Living Murray. World wide web electronic resource: http://www.thelivingmurray.mdbc.gov.au/. Date accessed: 21 February 2005.

Murray-Jones, S., M. and Johnson, J. (2003). Goolwa Cockle (*Donax deltoides*). Fishery Assessment Report Series 2002/21. 54p.

Musyl, M.K. and C. P. Keenan. (1990). Biochemical genetics of Australian yellowbelly (*Macquaria ambigua*). Summary. Newsletter - Australian Society for Fish Biology 20(1): 12.

Musyl, M. K. and C. P. Keenan. (1992). 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. Australian Journal of Marine and Freshwater Research 43: 1585-1601.

Noye, J. (1973). The Coorong. Past, Present and Future. Department of Adult education, the University of South Australia.

Noye, J. (1974). The Coorong. Department of Adult education, the University of South Australia.

Olsen, A. M. (1991). The Coorong: A Multi-species Fishery. Part 1 – A History and Development. Fisheries Resources Paper. Department of Fisheries, South Australia. No.22 pp 1 – 37.

Pellizzari, M. (2001). A preliminary investigation of the biology of yellow-eye mullet in South Australian waters. Adelaide, SARDI Aquatic Sciences**.** 22p.

Phillipson, M., Byrne, J. and Rohan, G. (1986). Participation in recreational fishing in South Australia. Fisheries Research paper16, Department of Fisheries, South Australia.

Pierce, B. E. (1995). Coorong and Murray Mouth Fisheries. In 'Proceedings of the Murray Mouth Biological Resource Assessment Workshop'. (Eds. K. Edyvane and P. Arvallho). SARDI Aquatic Sciences, South Australia. 43-49 pp

Pierce, B. E. and Doonan, A. M. (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. South Australian Research and Development Institute.

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

Potter, I. C. and G. A. Hyndes (1994). Composition of the fish fauna of a permanently open estuary on the southern coast of Australia, and comparisons with a nearby seasonally closed estuary. Marine Biology 121: 199-209.

Restrepo V. (1999). Annotated Glossary of Terms in Executive Summary Reports of the International Commission for the Conservation of Atlantic Tunas´ Standing Committee on Research and Statistics (SCRS). ICCAT .

Reynolds, L. F. (1976b). Decline of native fish species in the River Murray. SAFIC 8: 19-24.

Roberts, K., Horst, J., Roussel, J. and Shephard, J. Defining Fisheries: A User's Glossary. World wide web electronic resource: http://www.ncfisheries.net/stocks/glossary.htm. Date accessed: 10 March 2005. North Carolina Department of Environment and Natural Resources.

Rohan, G. (1987). River fishery (South Australia) - review of management arrangements. Green paper. South Australian Department of Fisheries. 31pp

Rowland, S. J. (1983). The hormone-induced ovulation and spawning of the Australian freshwater fish golden perch, *Macquaria* ambigua (Richardson) (Percichthyidae). Aquaculture 35: 221-238.

Rowland, S. J. (1996). Development of techniques for the large-scale rearing of the larvae of the Australian freshwater fish golden perch, *Macquaria ambigua* (Richardson, 1845). Marine and Freshwater Research 1996, 47:233-42.

Sloan, R., S. (2004). Integrating environmental management principles with fish stock management in a small scale, multi-species fishery: The South Australian Lakes and Coorong Fishery. Poster presentation. *Proceedings of the 4th World Fisheries Congress,* Vancouver, Canada.

Smyth, D. (1994). Understanding Country. The Importance of Land and Sea in Aboriginal and Torres Strait Islander Societies. Council for Aboriginal Reconciliation: Key Issues Paper No. 1, Australian Government Publishing Service, Canberra.

Southern Fishermen's Association (2002). Best Practices to Minimise Interaction of Juvenile Mulloway, Crabs and Birds with Fishing gear. 9p.

Thomson, J. M. (1957a). Biological studies of economic significance of the Yellow-eye mullet, *Aldrichetta forsteri* (Cuvier & Valenciennes) (Mugilidae). Australian Journal of Marine and Freshwater Research 8: 1-13.

Thomson, J. M. (1957b). Interpretation of the scales of the Yellow-eye mullet, *Aldrichetta forsteri* (Cuvier & Valenciennes) (Mugilidae). Australian Journal of Marine and Freshwater Research 8: 14-28.

Thomson, J. M. (1957c). The Food of Western Australian Estuarine Fish. Perth, Fisheries Department, Western Australia: 13pp.

Thomson, J. M. (1957d). The size at Maturity and spawning times of some Western Australian Estuarine Fishes. Perth, Fisheries Department, Western Australia: 8pp.

Thomson, J.M. (1966). The Grey Mullets. Oceanography and Marine Biology, Annual Review 4:301-355

Thorncraft, G. and Harris J. H. (2000). Fish Passage and Fishways in New South Wales: A Status Report. Cooperative Research Centre for Freshwater Ecology, Fyshwick, ACT: 32pp.

Trigg, F. (1940). Fisheries Act, 1917-1938: Regulations and Proclamations. Government Printer, Adelaide, SA: 27pp.

van den Enden, T., White, R. W. G. & Elliott, N. G. (2000). Genetic variation in the greenback flounder *Rhombosolea tapirina* Günther (Teleostei, Pleuronectidae) and the implications for aquaculture. *Marine and Freshwater Research* 51, 21-33.

Wallace-Carter, E. (1987). For They Were Fishers: The history of the fishing industry in South Australia. Amphrite Publishing House, Adelaide, SA.

Webb, B. F. (1973a). Fish Populations of the Avon-Heathcote Estuary. 1. General ecology, distribution and Length-Frequency. New Zealand Journal of Marine and Freshwater Research 7 (1&2): 45-66.

Webb, B. F. (1973b). Fish Populations of the Avon-Heathcote Estuary. 2. Breeding and Gonad Maturity. New Zealand Journal of Marine and Freshwater Research 7 (1&2): 45-66.

Webb, B. F. (1973c). Fish Populations of the Avon-Heathcote Estuary. 3. Gut Contents. New Zealand Journal of Marine and Freshwater Research 7 (3): 223-234.

Ye, Q., Jones, K. and B., E. Pierce (2000). Murray Cod (*Maccullochella peelii peelii*). Fisheries Assessment Report Series 2000/17. Department of Primary Industries and Resources, South Australia. 47p.

Ye, Q. (2004). Golden perch (*Macquaria ambigua*). Fisheries Assessment Report Series No. 71. Department of Primary Industries and Resources, South Australia.

Yearsley, G. K., P. R. Last, *et al.*, Eds. (1999). Australian Seafood Handbook an identification guide to domestic species. Hobart, CSIRO Marine Research.

10 APPENDIX

10.1 Schedule 1 – Permitted Species

The following fish are specified for the Lakes and Coorong Fishery:

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 (*Sphyraena novaehollandiae*)
- Sole (*Aserragodes haackeanus*)
- Sweep (*Scorpis 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)

10.2 Commercial Sector Gear Restrictions

Device	Restriction	Dimensions	
Mesh nets (Coorong Area 1)		*Small mesh monofilament*	*Large mesh monofilament*
	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: - 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)		*Small mesh monofilament*	*Large mesh monofilament*
	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: - 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)		*Small mesh monofilament*	*Large mesh monofilament*
	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: - 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	

Commercial sector gear restrictions cont.

Device	Restriction	Dimensions	Device
		Small mesh multifilament	*Large mesh multifilament*
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.	

10.3 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. 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.

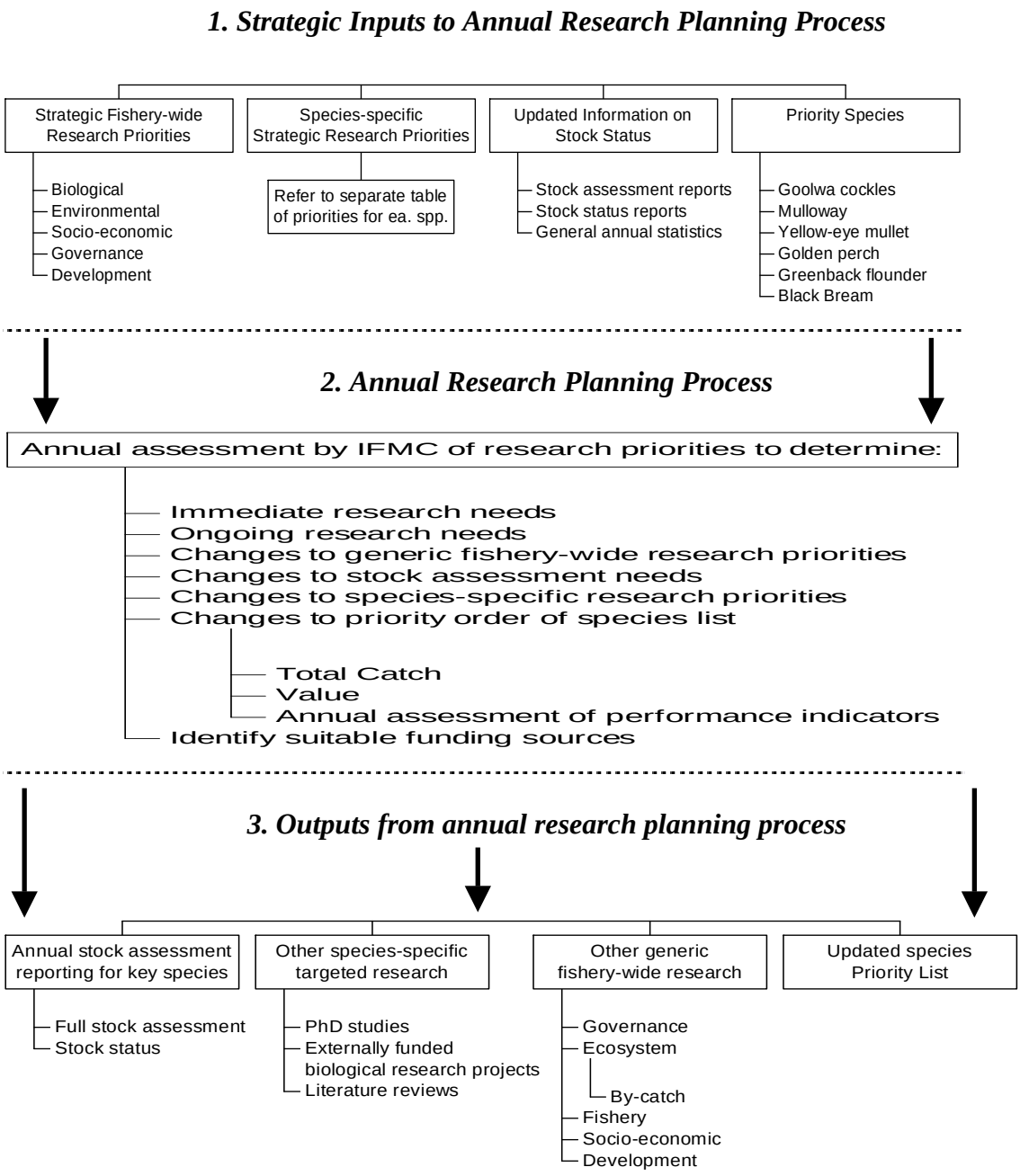


Figure 23. Annual research planning process for the Lakes and Coorong Fishery.

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.

1.2	***Habitat and Ecology***	***Priority***
1	Development and refinement of robust ecological health indicators	*3*
2	Improved fishery-dependent and independent data collection and quantitative assessment of by-product, by-catch, threatened, endangered and protected species interactions.	*5*
3	Assessment of fishery and non-fishery related risks to by-product, by-catch, threatened, endangered and protected species.	*5*
4	Refinement of water flow strategies to maximise spawning opportunities and recruitment success for key fish species.	*4*
5	Modifications to infrastructure to provide opportunities for fish passage between the three ecosystem components of the fishery.	*5*
6	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.	*4*

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.

1.3	***Governance***	***Priority***
1	Continued development of management methods that incorporate environmental and socio-economic principles	4
2	Continue to refine biological performance indicators	*3*
3	Development of resource allocation methods to address user group conflicts	*5*
4	Development of adaptive management techniques.	*4*
5	Periodic assessment of community awareness of management programs	*3*
6	Methods to improve communication on management activities between FMCs and relevant stakeholder groups: ▪ Commercial fishers; ▪ Recreational fishers; ▪ Indigenous communities; ▪ Government agencies; and ▪ Wider community.	*4*
7	Quantify the biological and economic impact of illegal fishing	*5*
8	Human capital development, including development of leadership capacity.	*3*

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.

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

1.5 Industry Development

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

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

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)

	Knowledge Gaps	***Priority Level***
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: ▪ 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)

	Knowledge Gaps	***Priority Level***
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: ▪ Population ▪ Commercial catch ▪ Recreational catch	*5*
7	Refine performance indicators for the fishery	*2*

Goolwa Cockles (Donax deltoides)

	Knowledge Gaps	***Priority Level***
1	Investigation of the basic biological parameters of *Donax deltoides:* ▪ 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: ▪ 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: ▪ 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 by-catch from commercial and recreational harvesting (i.e. undersize cockles) – size structure of catches.	*3*
9	Development of methods to improve gear selectivity (avoid by-catch 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: ▪ 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)

	Knowledge Gaps	***Priority Level***
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: ▪ 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)

	Knowledge Gaps	***Priority Level***
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: ▪ 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: ▪ 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)

	Knowledge Gaps	***Priority Level***
1	Literature review	*4*

Black Bream (Acanthopagrus butcheri)

	Knowledge Gaps	***Priority Level***
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 11. 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.

10.4 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 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.

10.5 Ecosystem Impacts

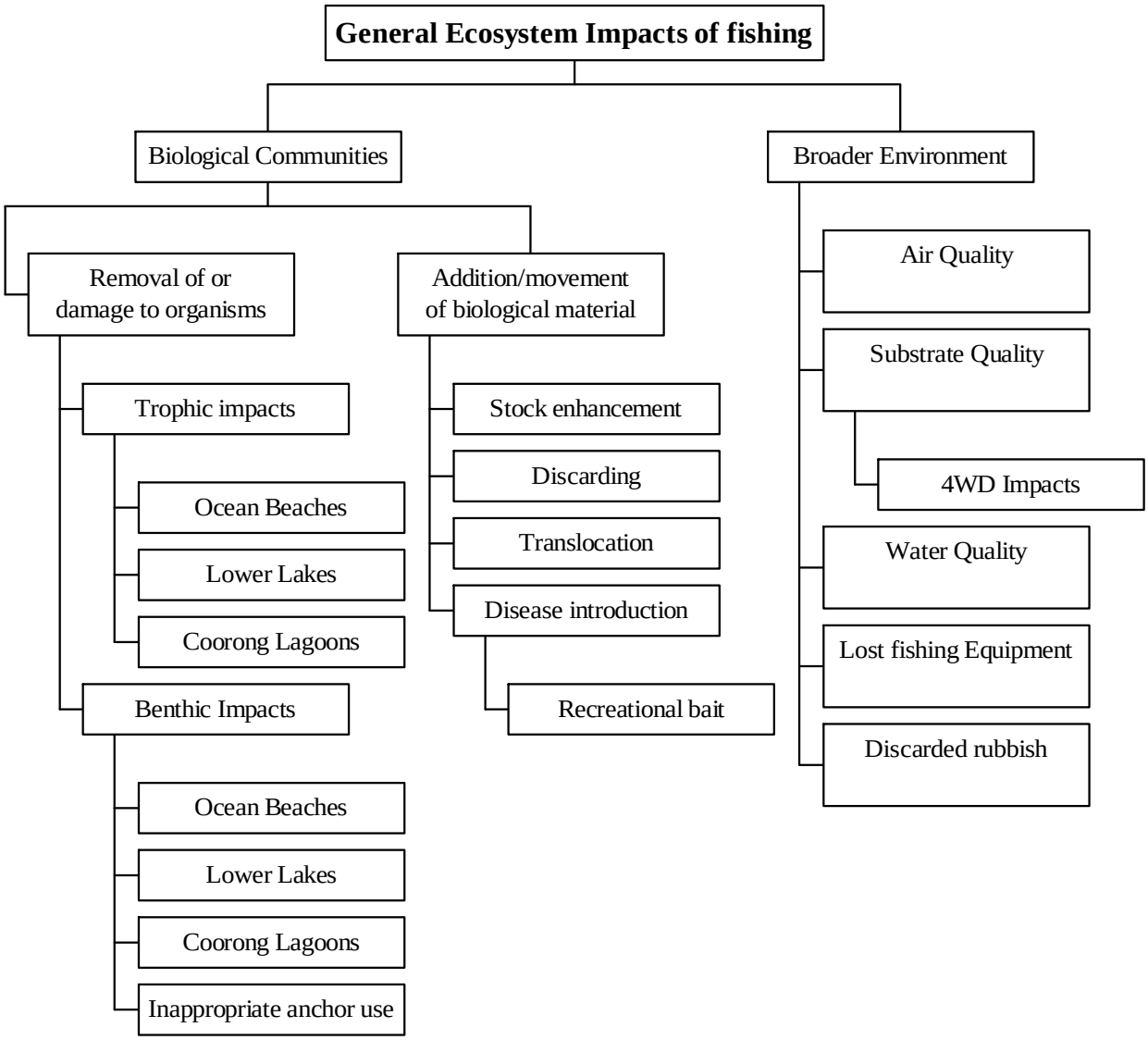


Figure 24. The general ecosystem impacts of fishing in the Lakes and Coorong Fishery.

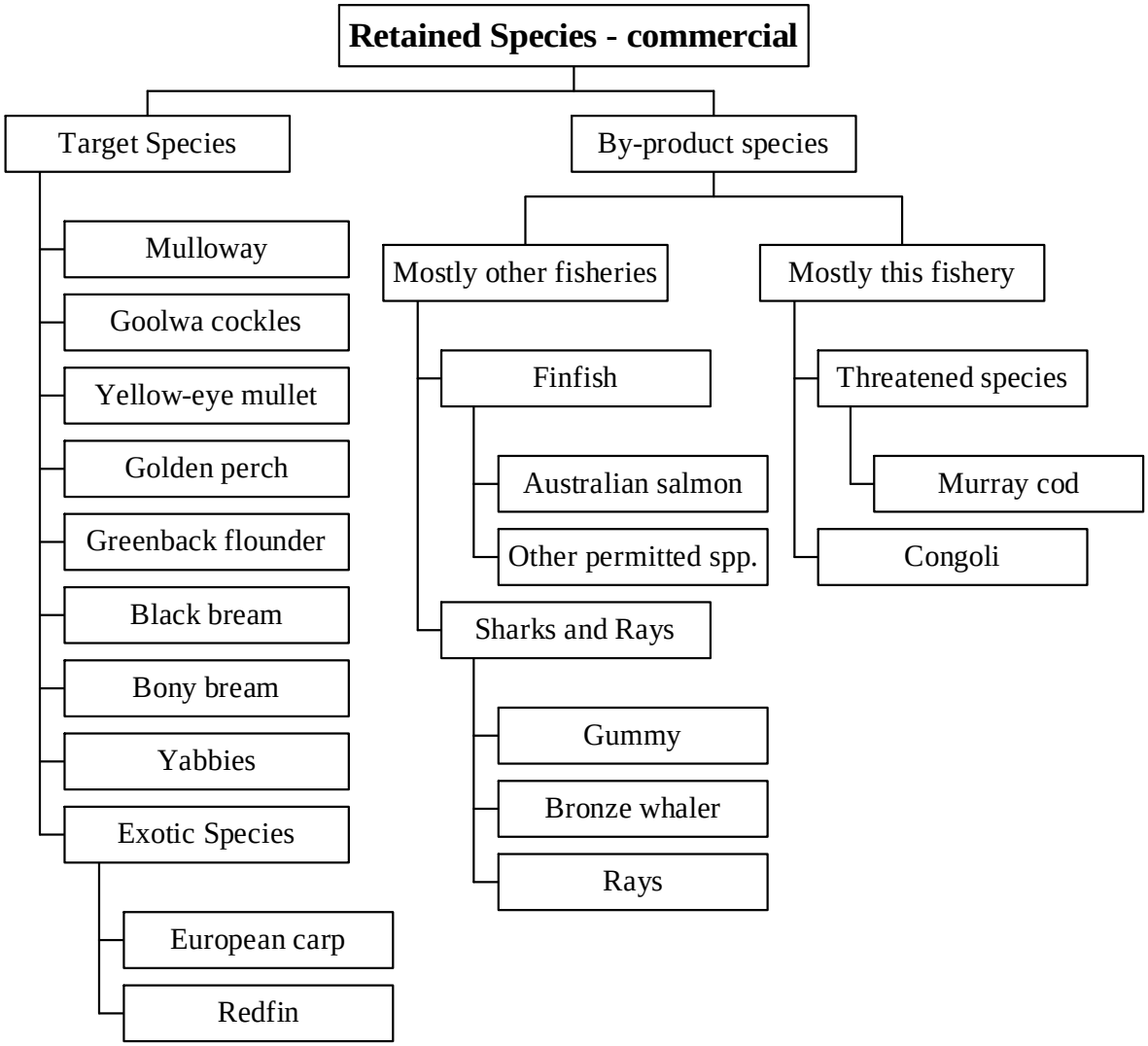


Figure 25. Retained species in the commercial sector of the Lakes and Coorong Fishery.

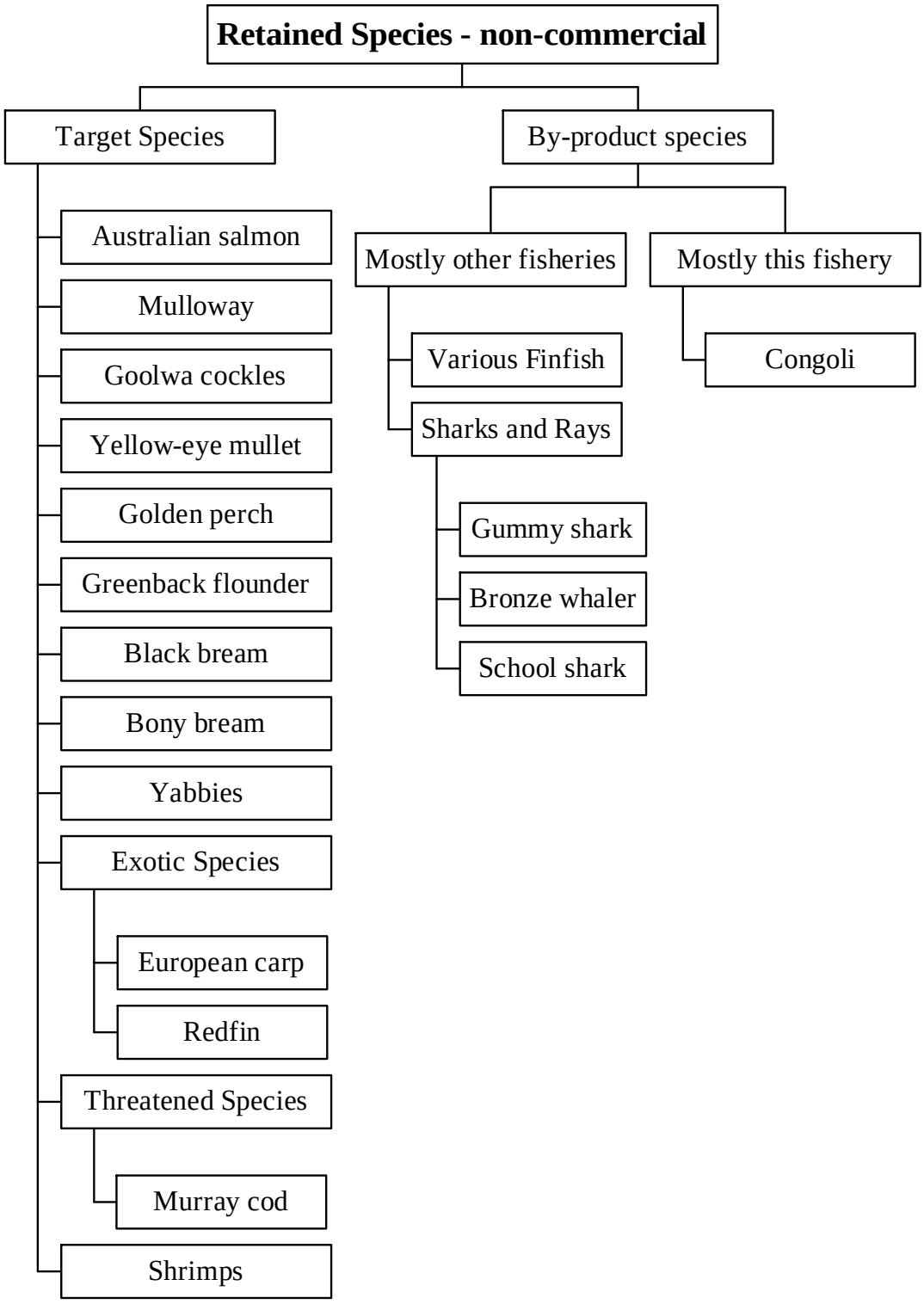


Figure 26. Retained species in the non-commercial sector of the Lakes and Coorong Fishery.

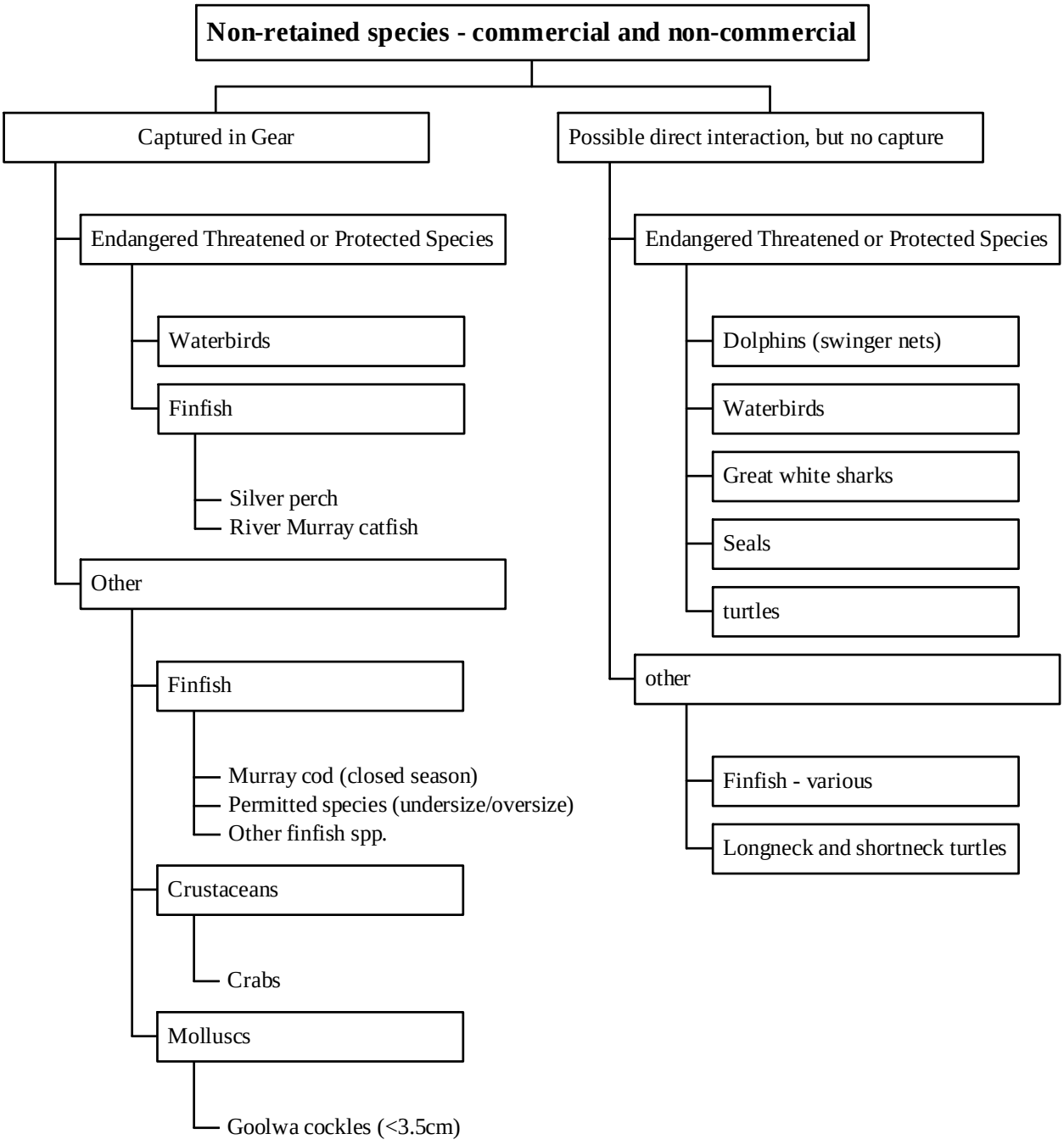


Figure 27. Non-retained species in the commercial and recreational sectors of the Lakes and Coorong Fishery.

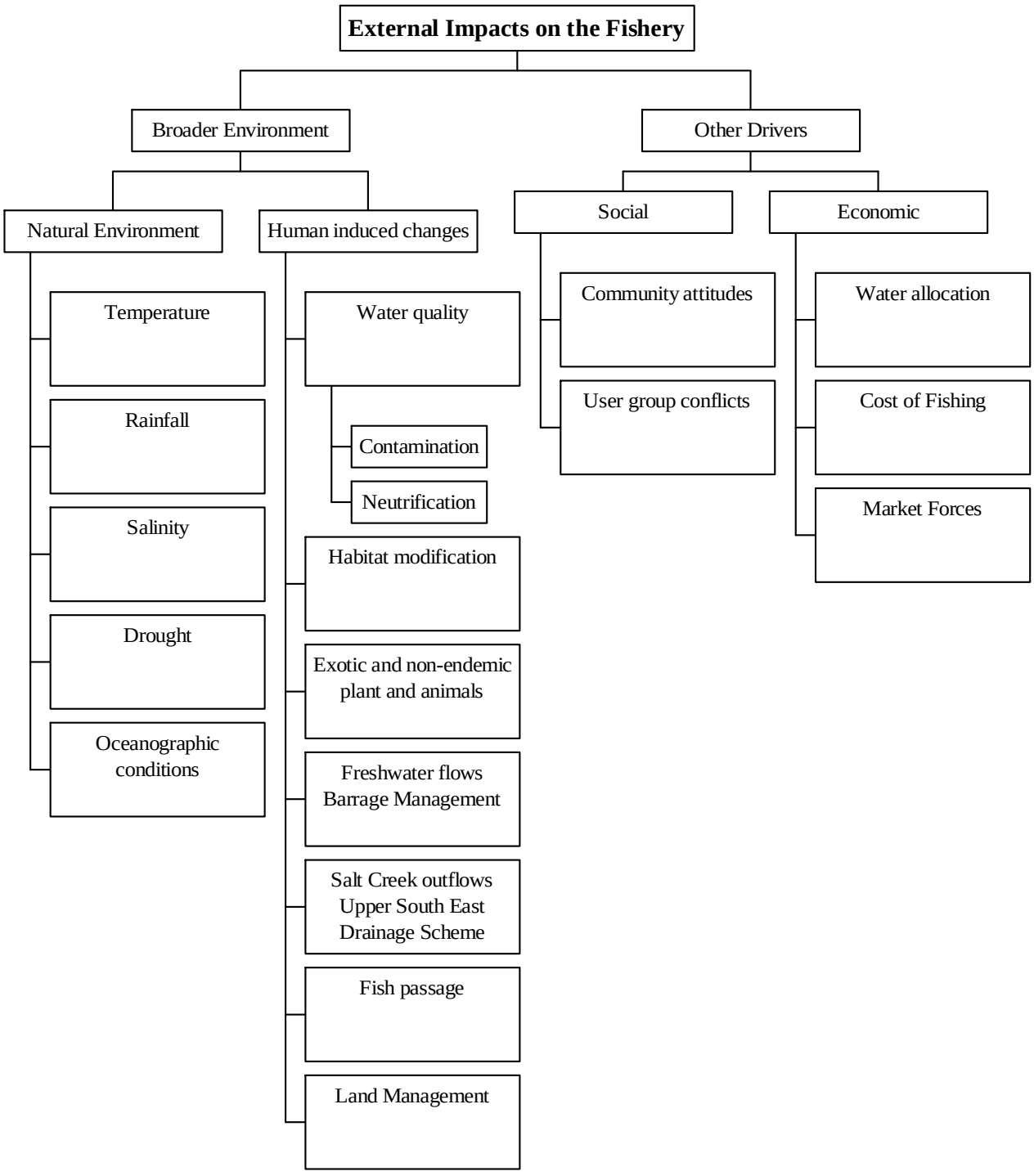


Figure 28.. External impacts on the Lakes and Coorong Fishery.

10.6 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	• 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	• 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 *(Note: links to Gear interference in Non-Commercial sector)*	Moderate	• 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	• 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	• 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	• 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	• 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	• 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	• 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	• 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	• Conduct random processor checks • Conduct intel based investigations • Conduct processor audits • Follow-up and investigate possible illegal activity
	Unregistered processor	High	• 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	• 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	• 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	• 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	• 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	• 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 *ornamental*	High	• 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	• 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

10.7 Links to Other Policy, Legislation and Codes of Practice

- The South Australian *Fisheries Act 1982*
- The South Australian *Fisheries (General) Regulations 2000*
- The *Fisheries (Scheme of Management - Lakes and Coorong Fishery) 1991*
- The Management Plan for the South Australian Marine Scalefish Fishery
- The Commonwealth Southern and Eastern Scalefish and Shark Fishery Management Plan
- The Murray-Darling Basin Commission Native Fish Strategy
- The Coorong and Lakes Alexandrina and Albert Ramsar Management Plan
- The Coorong National Park Management Plan
- The National Strategy for Ecologically Sustainable Development
- The Australian Intergovernmental Agreement on the Environment
- The *South Australian River Murray Act 2003*
- The Living Murray Strategy
- The National Policy on Fisheries By-catch
- The Australian Government *Environment Protection and Biodiversity Conservation Act 1999*
- *Native Title Act 1993* (Australian Government)
- *Native Title (South Australia)(Act) 1994*
- Southern Fishermen's Association commercial fishery code of practice
- Code of Conduct for Recreational Anglers in SA
- The Environmental Management Plan of the Southern Fishermen's Association
- The National ESD Reporting Framework (Fletcher, *et al.,* 2002)

10.8 Glossary of Common Fisheries Management Terms

These terms are intended to be used for the purposes of this management plan only and are not intended to be inconsistent with fisheries legislation.

Adaptive management Management involving active responses to new information or the deliberate manipulation of fishing intensity or other aspects in order to learn something of their effects. Within a stock, several sub-stocks can be regarded as experimental units in which alternative strategies are applied.

Age structure A breakdown of the different age groups within an individual population, or population sample.

Allocation Distribution of the opportunity to access fisheries resources, within and between stakeholder groups.

Aquatic reserve An area of water, or land and water, established as an aquatic reserve by proclamation under the *Fisheries Act 1982*.

Anadromous Fish that migrate from saltwater to freshwater to spawn.

Artisinal fishery A small-scale, low-cost and labour intensive fishery in which the catch is consumed locally.

Bag limit The maximum number of a species that can be legally taken by a person per day or per fishing trip, as specified.

Benthic Describes animals that live on, in or near the substrate.

Biodiversity The variability among living organisms from all sources (including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part) and includes: (a) diversity within species and between species; and (b) diversity of ecosystems.

Biological reference point An indicator of the status of an exploited stock and a standard for comparison between years. Two types are often used when sufficient biological data are available: those based on fishing mortality and those based on the sustainability of recruitment. In data poor fisheries, other BPIs related to estimates of relative biomass may be used (i.e. total catch and catch per unit effort). Reference points can be either desirable targets (target reference points) or minimum biologically acceptable limits (limit reference points).

Biomass The total weight or volume of individuals in a fish stock.

Boat limit The maximum number of a species that can be legally taken by persons on a boat per day or per fishing trip, as specified.

By-catch At a broad level, fisheries by-catch includes all material, living and non-living, other than targeted species which is caught while fishing. It includes discards (that part of the catch returned to the water) and also that part of the catch that is not landed but is killed as a result of interaction with fishing gear.

By-product Non-targeted catch that is commercially valuable and retained by fishers.

Catadromous Fish that migrate from freshwater to saltwater to spawn.

Catch The total amount (weight or number) of a species captured from within a specified area over a given period of time. The catch includes any animals that are released or returned to the water.

Catch per unit effort (CPUE) The weight or number of a species caught by a specified amount of effort. Typically, effort units are defined using a combination of the following factors: gear type; gear size; the amount of gear; the amount of time the gear is used ; and the number of people operating the gear. CPUE is often used as an index of relative abundance in fisheries stock assessment. In modern assessments, CPUE is standardised to account for the diverse range of factors that can affect CPUE.

Closures Prohibition of fishing during particular times or seasons (temporal closures) or in particular areas (spatial closures), or a combination of both.

Cohort A group of fish spawned during a specified period, usually within a year. A cohort is also referred to as an age class.

Co-management Arrangements between governments and stakeholder groups to allow joint responsibility for managing fisheries resources on a cooperative basis. Co-management arrangements can range from a consultative model, where stakeholders have an advisory role to government, to an informative model where co-managers have decision-making powers.

Commercial fishing Fishing undertaken for the purposes of trade or business.

Common property resource A resource that is determined to be owned by the community, or by the State on behalf of the community, and to which no individuals or user groups have exclusive access rights.

Critical habitats Habitats that are crucial in at least part of the life cycle of a species, which typically includes nurseries such as estuaries, mangroves, seagrass beds, reefs and defined spawning areas.

Data poor fishery A fishery where limited data are available to inform management. For example, fisheries for species where baseline biological data such as size at maturity, fishing mortality and growth rates are unknown.

Ecologically sustainable development Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

Economic efficiency The maximisation of the value of the net benefits derived from fishery resources.

Ecosystem A dynamic complex of plant, animal, fungal, and micro-organism communities and the associated non-living environment interacting as an ecological unit.

Effort Amount of fishing taking place, usually described in terms of gear type and frequency or period during which the gear is in use; for example, 'hook-sets', 'trawl-hours', 'searching hours'.

Effective fishing effort Measures of fishing effort (such as hooks per day of fishing) that have been standardised so that the measure is proportional to the fishing mortality rate that the gear(s) impose on the stock of fish. Management measures to limit effective effort imply that the fishing mortality rate is to be limited.

Fecundity Number of eggs an animal produces each reproductive cycle; the potential reproductive capacity of an organism or population.

Fishery A term used to describe the collective enterprise of taking fish. A fishery is usually defined by a combination of the species caught (one or several), the gear and/or fishing methods used, and the area of operation.

Fishery dependent data Information collected about a fishery or fish stock by the participants of a fishery, eg. catch and effort information from fishery log sheets.

Fishery independent data Information collected about a fishery or fish stock by researchers, independent of the fishery, eg. scientific surveys, observer reports.

Fisheries Management Committee *(FMC)* A statutory advisory body established by the Minister to provide a forum for consideration of management issues relevant to a specific fishery, by stakeholders in that fishery. FMCs are designed to allow for stakeholder input to fisheries management.

Fishing capacity The amount of fishing effort that a fishing boat, or a fleet of fishing boats, could exert if utilised to its/their full potential.

Fishing mortality The rate of deaths of fish due to fishing.

Fully exploited This describes a fish stock for which current catches and fishing pressure are close to optimum (the definition of which may vary between fisheries; for example, catches are close to maximum sustainable yield). Categorising a species as 'fully fished' suggests that increasing fishing pressure or catches above optimum (allowing for annual variability) may lead to overfishing.

Gear restriction A type of input control used as a management tool to restrict the amount and/or type of fishing gear that can be used by fishers in a particular fishery.

Growth overfishing A level of fishing pressure beyond that required to maximise the yield (or value) per recruit; a level of fishing where young recruits entering the fishery are caught before they reach an optimum marketable size.

Habitat The place or type of site in which an organism naturally occurs.

Harvest The total number or weight of fish caught and kept from an area over a period of time.

Indicator species A species whose presence or absence is indicative of a particular habitat, community or set of environmental conditions.

Individually transferable quota A management tool by which portions of the total allowable catch are allocated among licence holders (individual fishers or companies) as units of quota. Quota entitlements can be made to be temporarily or permanently transferable between these licence holders.

Input controls Limitations on the amount of fishing effort; restrictions on the number, type, and size of fishing vessels or fishing gear, or on the fishing areas or fishing times in a fishery.

Latent effort The potential for effective effort within a fishery to increase over time (i.e. inactive fishing licences that may be used in the future).

Length Frequency An arrangement of recorded lengths of a species of fish, which indicates the number of times each length or length interval occurs in a population or sample.

Limited entry Fishing effort is controlled by restricting the number of operators. It usually requires controlling the number of licences in a fishery. It can also include restrictions on the number and size of vessels, the transfer of fishing rights, and the replacement of vessels

Logbook An official record of catch and effort data made by fishers.

Marine protected area An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, and managed through legal or other effective means.

Marine park An area of water, or land and water, considered to be of national significance because of the aquatic flora or fauna of those waters or the aquatic habitat, and established as a marine park by proclamation under the *Fisheries Act 1982* and/or the *National Parks and Wildlife Act 1972*.

Minimum mesh size The smallest size of mesh permitted in nets and traps; imposed on the basis that smaller individuals will escape unharmed.

Mortality Rate of deaths (usually in terms of proportion of the stock dying annually) from various causes. Comprises (i) Natural Mortality - deaths in a fish stock caused by predation, pollution, senility, etc., but not fishing and (ii) Fishing Mortality - deaths in a fish stock caused by fishing.

Nominal fishing effort 'Nominal' means quantities as they are reported, before any analyses or transformations. Nominal effort refers to measures of fishing effort or vessel carrying capacity that have not been standardised.

Non-target species Any part of the catch, except the target species, and including by-catch and by-product.

Non-retained species Species that are taken as part of the catch but are subsequently discarded, usually because they have low market value or because regulations preclude them being retained.

Offshore Constitutional Settlement (OCS) An agreement between the State(s) and the Commonwealth whereby the State or the Commonwealth (or in some cases a Joint Authority) is given jurisdiction for a particular fishery occurring in both coastal waters and the Australian Fishing Zone. When no OCS agreement has been reached, the fishery remains under the jurisdiction of the State out to 3 nm, and the Commonwealth from 3 to 200 nm.

Output controls Limitations on the weight of the catch (quota), or the allowable size, sex or reproductive condition of individuals in the catch.

Over-exploited *or overfished* A fish stock in which the amount of fishing is excessive or for which the catch depletes the biomass too much; or a stock that still reflects the effects of previous excessive fishing.

Parameter A 'constant' or numerical description of some property of a population.

Parental stock The weight of the adult population of a species.

Population A group of individuals of the same species, forming a breeding unit and sharing a habitat.

Possession limit A possession limit under the *Fisheries Act 1982* is a prescribed number of fish for a species that represents what is considered a commercial quantity of that species. If a person has the prescribed amount of fish in their possession, then the onus of proof is reversed in any prosecution relating to taking those fish illegally.

Precautionary principle This concept asserts that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decision-making should be guided by: (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and (ii) an assessment of the risk-weighted consequences of various options.

Quota A limit on the weight or number of fish that may be caught of a particular stock or from specified waters.

Quota entitlement The proportion of a quota that is allocated to a particular licence, which limits the total amount of a species that is permitted to be taken pursuant to that licence.

Recreational fishing Fishing for a purpose other than trade or business, where the catch is released or used for personal consumption or taken for sport.

Recruitment The addition of new individuals to a stock.

Recruitment overfishing Occurs when excessive fishing effort or catch reduces recruitment to the extent that the stock biomass falls below the pre-defined limit reference point.

Relative abundance An index of fish population abundance used to compare fish populations from year to year. This does not measure the actual numbers of fish, but shows changes in the population over time.

Retained species The species within the catch that are not discarded.

Sample A proportion or a segment of a fish stock which is removed for study, and is assumed to be representative of the whole. The greater the effort, in terms of both numbers and magnitude of the samples, the greater the confidence that the information obtained is a true reflection of the status of a stock (level of abundance in terms of numbers or weight, age composition, etc.).

Seasonal closure The closure of a fishing ground for a defined period of time, usually used to protect a stock during a spawning season.

Selectivity The ability of a type of gear to target and catch a certain size or species of fish.

Socio-economic Relating to both social and economic considerations.

Spatial Of or relating to space.

Species A group of organisms capable of interbreeding freely with each other but not with members of other species.

Size limits A minimum or maximum size limit determines the legal size at which a given species can be retained.

Size of maturity Length or weight of the fish when it attains reproductive maturity.

Slot size limit Refers to a situation where both a minimum and maximum size limit has been determined for a given species.

Stakeholder An individual or a group with an interest in the conservation, management and use of a resource.

Stock A group of individuals of a species occupying a well defined spatial range independent of other groups of the same species, which can be regarded as an entity for management or assessment purposes.

Stock assessment A detailed analysis of stock status (abundance, distribution, age structure, etc.) to support the management of the species/fishery.

Target species The most highly sought component of the catch taken by fishers.

Target effort Effort that is directed at a particular species.

Traditional fishing Fishing for the purposes of satisfying personal, domestic or non-commercial communal needs, including ceremonial, spiritual and educational needs and utilising fish and other natural marine and freshwater products according to relevant indigenous custom.

Temporal Of or relating to time.

Threatened A species or community that is vulnerable, endangered or presumed extinct.

Total allowable catch (TAC) For a fishery, a catch limit set as an output control on fishing. The total amount of a species that may be taken during a specified time period.

Total allowable commercial catch (TACC) For a fishery, a catch limit set as an output control specifically on commercial fishing. The total amount of species that may be taken by commercial fishing during a specified time period.

Trigger points Events or measures that, if they occur or if they reach specified levels, are used to determine when a response should be made. Not usually used as a criterion for overfishing, but to indicate the need for review of management.

Uncertain A fish stock that may be underfished, fully fished or overfished, but for which there is inadequate or inappropriate information to make a reliable assessment of its status.

Under-exploited *or underfished* A fish stock that has potential to sustain catches higher than those currently taken.

Vulnerable species Under endangered species protection legislation, a species that within 25 years will become endangered unless mitigating action is taken.

Yield Total weight of fish harvested from a fishery.

Yield per recruit Analysis of how growth and natural mortality interact to determine the best size of animals for harvest.

10.9 List of Acronyms

AFMA	Australian Fisheries Management Authority
CPUE	Catch Per Unit Effort
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific Industry Research Organisation
DEH	Department of Environment and Heritage
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EEZ	Exclusive Economic Zone
ESD	Ecologically Sustainable Development
FMC	Fisheries Management Committee
FRDC	Fisheries Research and Development Corporation
ITQ	Individually Transferable Quota
MDBC	Murray-Darling Basin Commission
MPA	Marine Protected Area
MSC	Marine Stewardship Council
MEY	Maximum Economic Yield
MSY	Maximum Sustainable Yield
NFS	Native Fish Strategy
NRIFS	National Recreational and Indigenous Fishing Survey
PIRSA	Department of Primary Industries and Resources, South Australia
SAFIC	South Australian Fishing Industry Council
SARDI	South Australian Research and Development Institute
SARFAC	South Australian Recreational Fishing Advisory Council
SFA	Southern Fishermen's Association
TAC	Total Allowable Catch
TACC	Total Allowable Commercial Catch

10.10 Contacts

Primary Industries and Resources South Australia, Fisheries
GPO Box 1625
ADELAIDE SA 5000
Tel: (08) 8226 0219
Fax: (08) 8226 0434
FISHWATCH: 1800 065 522
www.pir.sa.gov.au/fisheries

South Australian Research and Development Institute, Aquatic Sciences
Po Box 120
HENLEY BEACH SA 5022
Tel: (08) 8200 2400
Fax: (08) 8200 2481
www.sardi.sa.gov.au

Southern Fishermen's Association
Box 263
MENINGIE SA 5264
Tel: (08) 8575 1680

South Australian Fishing Industry Council
60 London Road
MILE END SOUTH SA 5031
Tel: (08) 8234 8622
Fax: (08) 8234 8633
www.safic.com.au

Seafood Council (SA)
Level 1, 16 Unley Road
UNLEY SA 5061
Tel: (08) 8272 7766
Fax: (08) 8272 7767
www.seafoodsa.com

South Australian Recreational Fishing Advisory Council Inc.
1 Boskenna Avenue
NORWOOD SA 5067
Tel: (08) 8132 0430
Fax: (08) 8363 6455
www.sarfac.com

Inland Fisheries Management Committee
C/- PIRSA
GPO Box 1625
ADELAIDE SA 5000
Tel: (08) 8226 0219
Fax: (08) 8226 0434