The South Australian Greenback Flounder (*Rhombosolea tapirina*) Fishery

Fishery Assessment Report for PIRSA Fisheries

SARDI Aquatic Sciences

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Data on net selectivity's were available from a current FRDC project (FRDC 2005/061).

The report was formally reviewed by Dr. Shane Roberts and David Schmarr (SARDI Aquatic Sciences) and Alice Fistr (PIRSA Fisheries Policy) and was approved for release by Dr. Tim Ward (SARDI Aquatic Sciences).

EXECUTIVE SUMMARY

1 This report is the first assessment of the South Australian fishery for greenback flounder. The report provides: a synopsis of information available to the fishery; assesses the current status of the resource, including assessment of fishery performance against biological performance indicators prescribed in the Management Plan; and assesses the available information and it's limitations.

2 Limited information is available for the fishery. Consequently, this assessment is heavily reliant on the interpretation of fishery-dependent data from the Lakes and Coorong Fishery (LCF), especially catch per unit effort (CPUE).

3 More than 99% of catches of greenback flounder in South Australia are taken by the LCF. The main gear used to target greenback flounder is the large mesh gill net.

4 Catch from the LCF in 1999-00 was 39.9 t which then declined to 6.5 t in 2005-06 which was 53% below the most recent 5-year average annual catch (10.3 t ± 3.82).

5 Targeted effort (fisher days, large mesh gill nets) was highest in 1991-92 (2292 fisher days), then declined before increasing to a secondary peak in 1999-00 (1252 fisher days). Effort then declined to 624 fisher days in 2005-06.

6 CPUE (kg.fisher day^{-1}) increased from 7.3 kg.fisher day^{-1} in 1994-95 to 23.3 kg.fisher day^{-1} in 1999-00 which was the highest recorded. CPUE then declined to 6.1 kg.fisher day^{-1} in 2005-06 which was the lowest on record.

7 All Performance Indicators were within the range of reference points. Total catch and CPUE (kg.fisher day^{-1}) were close to the lower reference points.

8 The most important knowledge gaps for this fishery concern biological information about the Coorong population of greenback flounder and the size of the recreational catch. A 12 month monitoring program is needed to provide data to estimate size of maturity, age/size structures and sex ratio. Development and validation of an ageing method is also required. An ongoing monitoring program is needed to determine the size of the recreational catch.

9 The recent 6-year decline in catch and CPUE (1999-00 to 2005-06) suggests a decline in biomass.

1 GENERAL INTRODUCTION

1.1 Overview

This is the first stock assessment of greenback flounder, *Rhombosolea tapirina,* in South Australia. The aim of the report is to provide a comprehensive synopsis of information available for the greenback flounder fishery and to assess the current status of the resource.

The report is divided into four sections. The first section is the General Introduction that (i) outlines the aims and structure of the report, (ii) describes the history of the greenback flounder fishery, and (iii) provides a synopsis of biological and ecological knowledge of the greenback flounder.

Section two provides a synopsis of the fishery statistics for the South Australian greenback flounder fishery from 1984-85 to 2005-06. Information presented in this section includes inter-annual patterns in catch, effort and catch-per-unit-effort (CPUE) and a comparison of effort measures available for the fishery.

The third section presents preliminary net selectivity's for several nets in the Lakes and Coorong Fishery (LCF).

The fourth section presents an assessment of the performance of the greenback flounder fishery against the biological performance indicators specified for this fishery in the Lakes and Coorong Fishery management plan (Sloan 2005).

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

1.2 Description of the Fishery

1.2.1 Location

Flounder support commercial and recreational fisheries in south-eastern Australia with smaller catches also taken in Queensland and Western Australia (Kailola *et al.* 1993; PIRSA 1996). Catches of flounder are mainly composed of *R. tapirina* because it is the only flatfish species in southern Australia that is sufficiently large and abundant to be exploited (Edgar 2000).

In South Australia, almost all catches of greenback flounder are from the Coorong lagoons (Figure 1-1). With low volume catches sold primarily on the domestic market (Kailola *et al.* 1993; PIRSA 1996).

1.2.2 Commercial Fishery

The LCF is a multi species, multi-method fishery and is the only commercial fishery operating in the Coorong lagoons. The dominant gear is the large-mesh gill net (mesh size > 115 mm) which is set on the bottom when targeting flounder (Ferguson 2006b).

There is anecdotal evidence that when abundance of Coorong crabs (*Paragrapsis gaimardii*) is high, fishers are less likely to target greenback flounder because damage caused by crabs causes the product to be unsaleable (Pierce and Doonan 1999).

1.2.3 Recreational Fishery

Recreational fishers harvest greenback flounder using spears and gill nets. However, there is little information available for recreational fishing for greenback flounder in South Australia (Henry and Lyle 2003; Jones and Doonan 2005).

1.2.4 Traditional Fishery

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

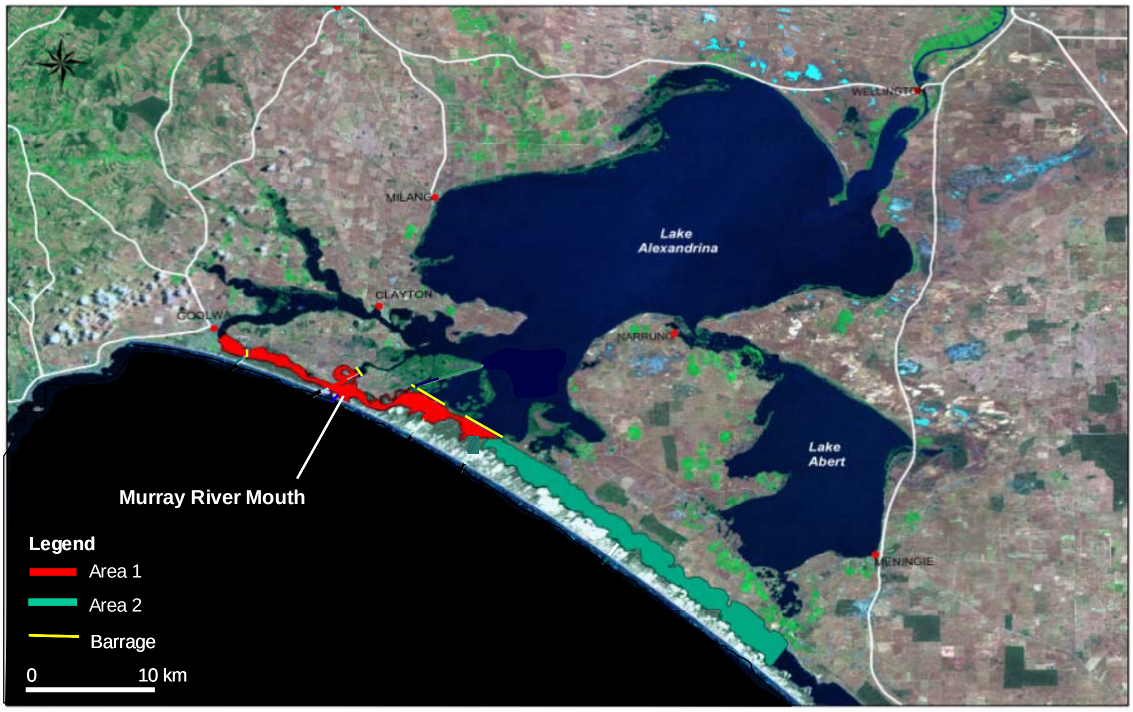

Figure 1-1. Map of Coorong showing Lakes and Coorong Fishery management Areas 1 (red) and 2 (green).

1.3 Management of the Fishery

1.3.1 Commercial fishery

The regulations that govern the management of the LCF are the *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 2006* and the *Fisheries (General) Regulations 2000*. The Management Plan for the SA Lakes and Coorong Fishery was finalised in 2005 (Sloan 2005), and provides a strategic policy framework for the management of the fishery (Table 1-1).

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

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

Date	Milestone
1906	The South Australian Government introduced a requirement for all commercial fishers to hold a commercial fishing licence.
1971	Introduction of fishing licences for all commercial fishing in South Australia
1972	Licensed commercial fishers required to provide monthly catch data
1984	*Scheme of Management (Lakes and Coorong Fishery) Regulations 1984* *Scheme of Management (Marine Scalefish Fisheries) Regulations 1984* *Scheme of Management (Restricted Marine Scale Fishery) Regulations 1984*
1984-85	The LCF was divided in to 16 areas for the purpose of data collection and more detailed fishing location information was collected from operators.
1986	Restrictions on commercial net type, mesh size, net depth and net length. Prohibition of net use adjacent to the Murray Mouth from November 1 to March 31. Limit of one registered recreational net per person, with 70m total length and maximum of 1m drop. Total prohibition on recreational netting in coastal marine waters from Goolwa Beach Road to Kingston Jetty. Recreational bag limit of 20 flounder per person per day in Coorong waters (boat limit 50 per person per day). Prohibition of all forms of netting in the Coorong, adjacent to the Murray Mouth from December 25 to January 7.
1990	Guidelines formalised to limit the amount of gear that may be endorsed on an individual licence upon licence transfer or amalgamation.
1991	*Fisheries (Scheme of Management—Lakes and Coorong Fishery) Regulations 1991* *Fisheries (Scheme of Management—Marine Scalefish Fisheries) Regulations 1991*
1997	Review of the recreational fishery
2004	Amendments to the Scheme of Management to allow an individual to hold more than one licence.
2005	Management Plan for the South Australian Lakes and Coorong Fishery
2006	*Fisheries (Scheme of Management – Lakes and Coorong Fishery) Regulations 2006* *Fisheries (Scheme of Management – Marine Scalefish Fishery) Regulations 2006*
2007	The *Fisheries Management Act 2007* was assented to by Parliament on 8 March 2007 and will commence during 2007. Fishery Management Committees were discontinued from 31 March 2007.

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

The LCF operates in the northern and southern Coorong lagoons, the freshwater lower lakes of Lake Alexandrina and Lake Albert, and the adjacent coastal marine waters along Sir Richard and Younghusband Peninsulas (Figure 1-1).

Effort data for the commercial fishery for greenback flounder in South Australia have been recorded since 1984 (Knight *et al.* 2001). Daily catch and effort information is provided on a monthly basis to SARDI Aquatic Sciences; catch, effort (days), effort (fisher days), effort (number of nets) and fishing location. Target and catch species are recorded as "flounder" but are not differentiated into species. The species present in the Coorong lagoons are greenback (*Rhombosolea tapirina*) and long-snouted flounder (*Ammotretis rostratus*), although almost all commercial catch comprises *R. tapirina*.

Management arrangements for the commercial fishery for greenback flounder comprise general gear restrictions, spatial and temporal closures and a legal minimum size (LMS) of 25 cm total length.

1.3.2 Recreational Fishery

The recreational fishery is open access and is managed with general gear restrictions, spatial and temporal closures and bag/boat limits (Sloan, 2005). The restrictions are applied to flounder generally, which includes both greenback and long-snouted flounder. There is no legal minimum length for flounder taken by recreational fishers in SA.

1.3.3 Traditional Fishery

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

1.4 Stock Assessment

1.4.1 Commercial Fishery

Previous information available for the greenback flounder fishery are (i) general information on catches within the Coorong lagoons (Hall 1984) and (ii) stock status reports for the Lakes and Coorong fishery (Pierce and Doonan 1999; Ferguson 2006b).

In South Australia, the catches of greenback flounder tend to be highest from February to April (Kailola *et al.* 1993), and catches and catch rates have varied greatly among years (Hall 1984; Pierce and Doonan 1999; Ferguson 2006b). In 1976-77 the catch was 232 t, then declined to 6 t in 1982-83 (Hall 1984). During this period, CPUE ranged from 40 $kg.day^{-1}$ in 1976-77 to 10 $kg.day^{-1}$ in 1978-79 then was approximately 2 $kg.day^{-1}$ each year until 1982-83 (Hall 1984).

More recently, the annual catch of greenback flounder by the Lakes and Coorong Fishery ranged from 58 t in 1991-92 to 8 t in 2004-05 (Ferguson 2006b). CPUE increased from 7 to 25 $kg.fisherday^{-1}$ from 1994-95 to 1999-00. CPUE then declined to 12 $kg.fisherday^{-1}$ in 2004-05 (Ferguson 2006b). The abundance of greenback flounder in the Coorong lagoons may be related to freshwater inflow from the Murray River and the available area of estuarine habitat (Hall 1984; Pierce and Doonan 1999). In South Australia, in the 1940's, a series of barrages were constructed between the mouth of the Murray River and Lakes Alexandrina and Albert that effectively reduced the area of estuarine habitat to 11% of its original size. It is likely that this severely reduced the area of habitat available for greenback flounder.

Hall (1984) related CPUE ($kg.day^{-1}$) from commercial catches to the amount of freshwater spill over the barrages for the period from 1976-77 to 1982-83 and found that the maximum correlation coefficient occurred when barrage spill was lagged by 38 months. This implied that spawning and/or recruitment success may have been enhanced during periods of freshwater inflow to the Coorong lagoons.

1.4.2 Recreational Fishery

The only available estimate of the recreational catch of flounder (all species) in South Australia was 2994 kg (± 647, SE) in 2000-01 (Jones and Doonan 2005). There is currently no estimate of the size composition of greenback flounder harvested by the recreational fishery in South Australia.

1.5 Fisheries Biology

1.5.1 Taxonomy

The greenback flounder (*Rhombosolea tapirina* Günther, 1862) belongs to the family Pleuronectidae, commonly known as the right-eye flounders (Last *et al.* 1983). Of the four species in the temperate Australasian genus *Rhombosolea*, *R. tapirina* is the only species that occurs in Australia (Gomon *et al.* 1994). The key diagnostic features for identification of *R. tapirina* are; (i) the absence of ventral fins on the lower body surface, and (ii) a distinctive, pointed snout (Last *et al.* 1983).

1.5.2 Geographical distribution and habitat

Rhombosolea tapirina occur in Australia from southern New South Wales and Tasmania, to Western Australia (Last *et al.* 1983; Kailola *et al.* 1993; Gomon *et al.* 1994). They also occur in New Zealand, around the Auckland and Campbell Islands (Gomon *et al.* 1994).

Adult *R. tapirina* prefer sand, silt and muddy substrates in sheltered bays, estuaries, and inshore coastal waters (Last *et al.* 1983; Kailola *et al.* 1993; Gomon *et al.* 1994). They may also be found in the deeper channels of estuaries and to depths of 100 m (Last *et al.* 1983; Edgar 2000). In Tasmania, adults sexually partition habitat, with females more abundant in shallow water (5-10 m depth), and males more abundant in deeper water (10-25 m depth) (Kurth 1957; Crawford 1984a).

Post-settlement and juvenile *R. tapirina* tend to be found in shallower water and prefer unvegetated sand and mudflat habitat where they are well camouflaged (<1 m) (Connolly 1994b; a; Edgar and Shaw 1995; Jenkins et al. 1997; Jenkins and Wheatley 1998). Juveniles tolerate a wide range of changes in salinity and are often found in the upper reaches of estuaries and occasionally upstream in rivers (Last *et al.* 1983).

1.5.3 Stock structure

Significant genetic differences exist between the Australian and New Zealand populations of *R. tapirina* based on polymorphic allozyme loci (van den Enden *et al.* 2000). Within Australia, *R. tapirina,* from western Tasmania are genetically isolated from the population in Victoria, and northern and south-eastern Tasmania, although to a much lesser extent than from the population in New Zealand. The separation of western and eastern Tasmanian populations is supported by morphometric data, and has been suggested to have occurred as a consequence of the closure of Bass Strait during the last ice age (Kurth 1957).

The stock structure of Western Australian and South Australian populations of *R. tapirina* is not known. *R. tapirina* are rarely found in marine waters adjacent to the Coorong lagoons and it has been suggested that the Coorong population is estuarine-resident and completes it's life cycle within the Coorong (Hall 1984).

1.5.4 Growth

Most ageing work on *R. tapirina* has been done on the larvae and juveniles. Daily growth increments begin to form in the sagittal otoliths as exogenous feeding commences approximately 5 days after hatching (Jenkins 1987a; Stewart and Jenkins 1991). After 35 days a transition zone forms, corresponding with metamorphosis and settlement, and causes the rings to become indiscernible (May and Jenkins 1992). Visible daily increments resume after this transition zone.

The growth of early larval *R. tapirina* is exponential, ranging from 0.1 to 0.23 $mm.day^{-1}$ (Jenkins 1987a). During metamorphosis, growth is slow, and from post-settlement is linear at 0.29 mm d^{-1} (May and Jenkins 1992). In Victoria, growth rates of juveniles were shown to be higher when the food supply was higher (Jenkins *et al.* 1993). No ageing work has been done on juveniles longer than 40 mm total length (TL) in Australia.

Adult *R. tapirina* in Australia appear to be fast growing (Edgar *et al.* 1982; Last *et al.* 1983; Gomon *et al.* 1994). The maximum length of 36 to 45 cm occurs at approximately 600 g in Tasmania, although the average size for adults was generally less than 30 cm (Jordan *et al.* 1998).

Otolith-based ageing studies were conducted in New Zealand on several species of the genus *Rhombosolea* showing that they had fast growth rates and low maximum ages (Colman 1974; Francis 1988; Paul 1992; Stevens *et al.* 2005). The maximum age of *R. tapirina* in New Zealand was 6 years (D.W. Stevens unpublished data, in, Stevens *et al.* (2005)), although the ages reported in these studies may have been underestimated because they were based on whole otoliths (Stevens *et al.* 2005). Stevens *et al* (2005) used thin sections of sagittal otoliths to estimate the ages of the Pleuronectids, brill (*Colistium guntheri*) and turbot (*C. nudipinnis*). Formation of annuli were validated, for younger fish, using marginal increments. This latter method may potentially be used to characterise age and growth patterns of *R. tapirina* in South Australia.

In New Zealand, adult stocks of Pleuronectid species generally appeared to be made up of one or two year classes and the stock size appeared to be recruitment driven for most species (Annala *et al.* 2003).

1.5.5 Size of Maturity

In Tasmania, the size of maturity (SOM) was estimated to be 218.6 and 190 mm TL for female and male *R. tapirina,* respectively (Crawford 1984a) (Table 1-2). The estimate of SOM for males was consistent with that of Kurth (1957), although that for females was not, possibly due to the use of different criteria to determine female maturity. There are no estimates of SOM for greenback flounder in South Australia.

Table 1-2. Size of maturity for greenback flounder (*Rhombosolea tapirina*) in Tasmania.

Source	Method	Sex	Size of maturity (mm TL)
(Crawford 1984a)	LD_{50} (macroscopic gonad staging)	F	218.6 (± 36)
"	"	M	190.4 (± 75)
(Kurth 1957)	Oocyte diameters (60% of fish mature)	F	240
"	"	M	190

1.5.6 Reproduction

Based on gonadosomatic indices, the spawning season in Tasmania occurs when the water temperature is low, from late autumn to spring (June to October) (Kurth 1957; Crawford 1984a). Larval abundances are also greatest between June and August (Crawford 1984b; Jenkins 1986).

Females move from the shallows, prior to spawning which occurs in the deeper areas of tidal rivers and estuaries as well as offshore (Kurth 1957; Crawford 1984a).

Instantaneous fecundity ranged from 820,880 to 1,969,070 eggs and was linearly related to length for females from 247 to 343 mm TL (LR: Fecundity = -1053.65 + 85.85*Length (cm), $r^2 = 0.72$, Crawford 1984a). Oocyte development is multiple group-synchronous with the capacity for multiple ovulations within a reproductive season (Kurth 1957; Crawford 1984a; Barnett and Pankhurst 1999). However, neither the spawning fraction nor total fecundity have been quantified (Hunter et al. 1985; Hunter et al. 1992).

The reproductive strategy of *R. tapirina* involves serial spawning and relatively high fecundity, over a prolonged spawning season (Crawford 1984a). This strategy may maximise reproductive potential and appears best suited to survival of newly metamorphosed juveniles which have a narrow distributional range in the intertidal zone (Crawford 1984a). Recruitment over several months may enhance the opportunity for larvae and juveniles to find favourable environmental conditions and thus alleviate crowding in nursery areas (Crawford 1984a).

1.5.7 Early Life History

The fully developed eggs of *R. tapirina* are buoyant, pelagic, 0.7-1.0 mm in diameter, and hatch between 82 and 93 hours after fertilisation at 11-14°C (Crawford 1986; Hart 1994). They also contain oil droplets and are transparent (Crawford 1984a).

Larvae hatch, at 1.9 mm, between May to November and float passively at the surface with yolk sac uppermost (Crawford 1984a). Five days after hatching, yolk absorption is complete and feeding commences. Larvae remain in the plankton for over 30 days where they attain a length of approximately 6 mm (Jenkins *et al.* 1993).

Metamorphosis occurs after approximately 35 days and coincides with migration of the left eye which is completed approximately 65 days after hatching (8.8 mm) (Crawford 1984b; 1986; Jenkins 1986; May and Jenkins 1992). During metamorphosis there is an ontogenetic shift in preferred salinity and position in the water column, as well as a preference for fine sand, which may play a role in guiding the larvae towards settling on shallow estuarine sandflats which provide nursery habitat (Crawford 1984a). The larvae are weak swimmers and rely on water currents or wind-induced surface water movements to drift inshore to settle (Crawford 1984a). Metamorphosis is completed about 65 days after hatching (Crawford 1986). Settlement occurs during late winter to early summer and substrate type and salinity preferences appear to be the major determinants of the distribution of recently settled juveniles (Burchmore 1982). Estuaries are important nursery grounds for *R. tapirina* although low salinities may be a preferred, but not essential, requirement (Crawford 1984a).

Newly metamorphosed juveniles of *R. tapirina* were observed in most months (Crawford 1984a), and the widespread distribution of *R. tapirina* across southern Australia is probably related to the duration of the planktonic larval stage in the open ocean (Gomon et al. 1994).

1.5.8 Diet

Larval *R. tapirina* feed mainly on bivalve veligers, tintinnids, invertebrate eggs, and copepod nauplii (Jenkins 1987b) during daylight hours (Chen *et al.* 1999; Cox and Pankhurst 2000). As the larvae grow, larvaceans, cladocerans, and harpacticoid nauplii become an increasingly important part of the diet (Jenkins 1987a). Newly metamorphosed juveniles are also daytime feeders and eat mostly amphipods, harpacticoid copepods and polychaetes (Crawford 1984a). Older juveniles consume epibenthic harpacticoids, harpacticoid nauplii, and gammaridean amphipods and polychaetes (Crawford 1984a; Shaw and Jenkins 1992).

Adult *R. tapirina* feed nocturnally, as the tide rises, by digging for benthic crustaceans and polychaetes on shallow mud or sand banks (Edgar *et al.* 1982; Edgar 2000).

2 FISHERY STATISTICS

Two commercial sectors catch greenback flounder in South Australia: the Lakes and Coorong Fishery (LCF) and the Marine Scale Fishery. Annual catches from the LCF comprised >98% of the total catch in all years since 1995-06.

2.1 South Australian Total Catch

The highest total catch of greenback flounder in South Australia was 65.6 t in 1990-91. Catches subsequently declined to 6.6 t in 2005-06. The recreational catch was 2.9 t in 2000-01 which was 13% of the total South Australian recreational and commercial catches combined (Jones and Doonan 2005). The LCF comprised > 99% of the total catch in all years since 2001-02 and consequently this report is focussed on that sector.

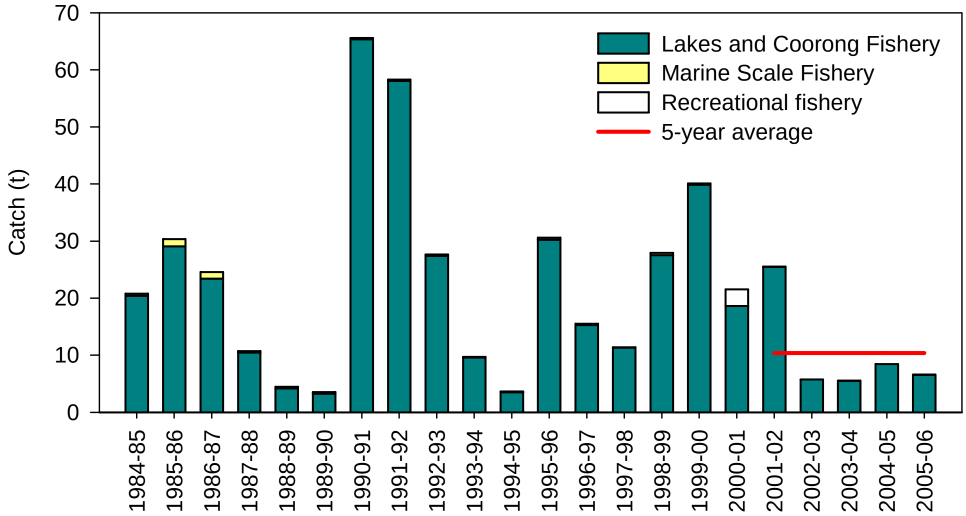

Figure 2-1. Total South Australian catch of greenback flounder.

2.2 Lakes and Coorong Fishery Catch, Effort and CPUE

2.2.1 Catch

The highest catch of greenback flounder by the LCF was 65.4 t in 1990-91. Catches then declined to 3.5 t in 1994-95 before increasing to 39.9 t in 1999-00 (Figure 2-2). Since then catches declined to 6.5 t in 2005-06 which was 53% below the 5 year average annual catch of 10.3 t (± SE 3.82).

The dominant gear was the large mesh gill net which accounted for >96% of catches from 2001-02.

Catches were seasonal with most of the catch taken between Spring-Summer (September to February) Figure 2-3). In 2005-06 75% of the catch was taken in Spring-Summer and >70% in each of 2001-02, 2002-03, and 2003-04.

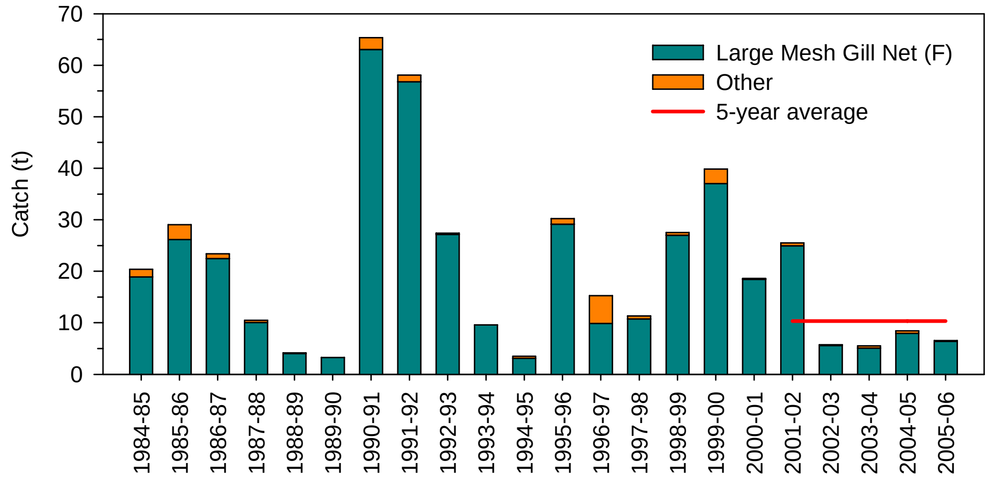

Figure 2-2. Catches of greenback flounder by the Lakes and Coorong Fishery, showing gear.

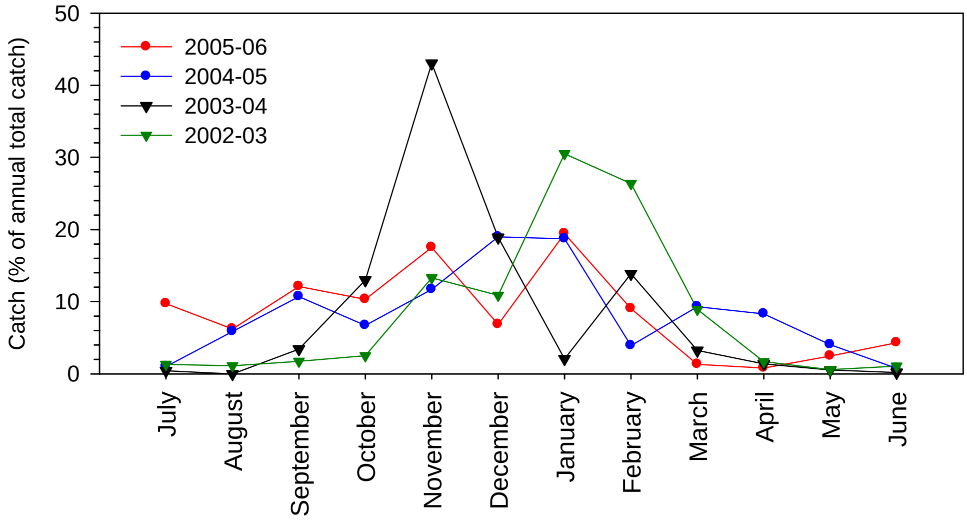

Figure 2-3. Monthly catches of greenback flounder in the Lakes and Coorong Fishery from 2002-03 to 2005-06.

2.2.2 Effort

Comparison of Effort Measures

Three measures of total annual fishing effort are available for large mesh gill nets in the LCF: (i) days, (ii) fisher days, and (iii) number of nets. The first measure (days) is the number of days fished. The second measure (fisher days) is the number of individuals engaged in fishing, multiplied by the number of days fished. Finally, net days, represents the number of nets set, multiplied by the number of days fished.

Targeted effort and targeted catches had similar temporal trends (Figure 2-4 A, B). There was a linear relationship between catch and effort (fisher days) (Linear regression, LR: $r^2 = 0.75$, $F_{1,20} = 60.55$, $p < 0.0001$). Similarly, catch was linearly related to (i) effort in units of net days (LR: $r^2 = 0.78$, $F_{1,20} = 70.69$, $p < 0.0001$), and (ii) effort in units of days (LR: $r^2 = 0.81$, $F_{1,20} = 85.62$, $p < 0.0001$).

All three measures of effort show similar trends over time. The trend for fisher days was similar to that for days (Pearson Correlation Co-efficient, CC: $r = 0.98$, $p < 0.001$). Similarly, the trend in net days reflected that of fisher days (CC: $r = 0.97$, $p < 0.001$).

Temporal Patterns in Effort

The highest targeted effort using large mesh gill nets occurred in 1991-92 when it was 2292 fisher days (Figure 2-4 B). Effort then declined to 118 fisher days in 1994-95 before increasing to 1252 fisher days in 1999-00. After 1999-00 effort declined to 253 fisher days in 2002-03, then increased to 624 fisher days in 2005-06.

2.2.3 Catch-per-unit effort (CPUE)

Comparison between CPUE estimates

Estimates of CPUE were available for each of the 3 measures of effort: days, fisher days and net days (Figure 2-4 C). The temporal trend for each estimate of CPUE was similar with peaks in 1990-91 and 1999-00 although CPUE (kg.net day^{-1}) was more variable between years. CPUE (kg.fisher day^{-1}) was similar to (i) CPUE (kg.day^{-1}) (CC: $r = 0.98$, $p < 0.000$) and (ii) CPUE (kg.net day^{-1}) (CC: $r = 0.87$, $p < 0.000$).

Temporal trends in CPUE

CPUE (kg.fisher day^{-1}) increased from 6.3 to 22.8 kg.fisher day^{-1} from 1984-85 to 1990-91. CPUE then declined to 7.3 kg.fisher day^{-1} in 1994-95 and subsequently increased to the highest estimate of 23.3 kg.fisher day^{-1} in 1999-00. CPUE then declined to 6.1 kg.fisher day^{-1} in 2005-06 which was the lowest on record (LR: r^2 = 0.95, $F_{1,6}$ =114.09, p < 0.001).

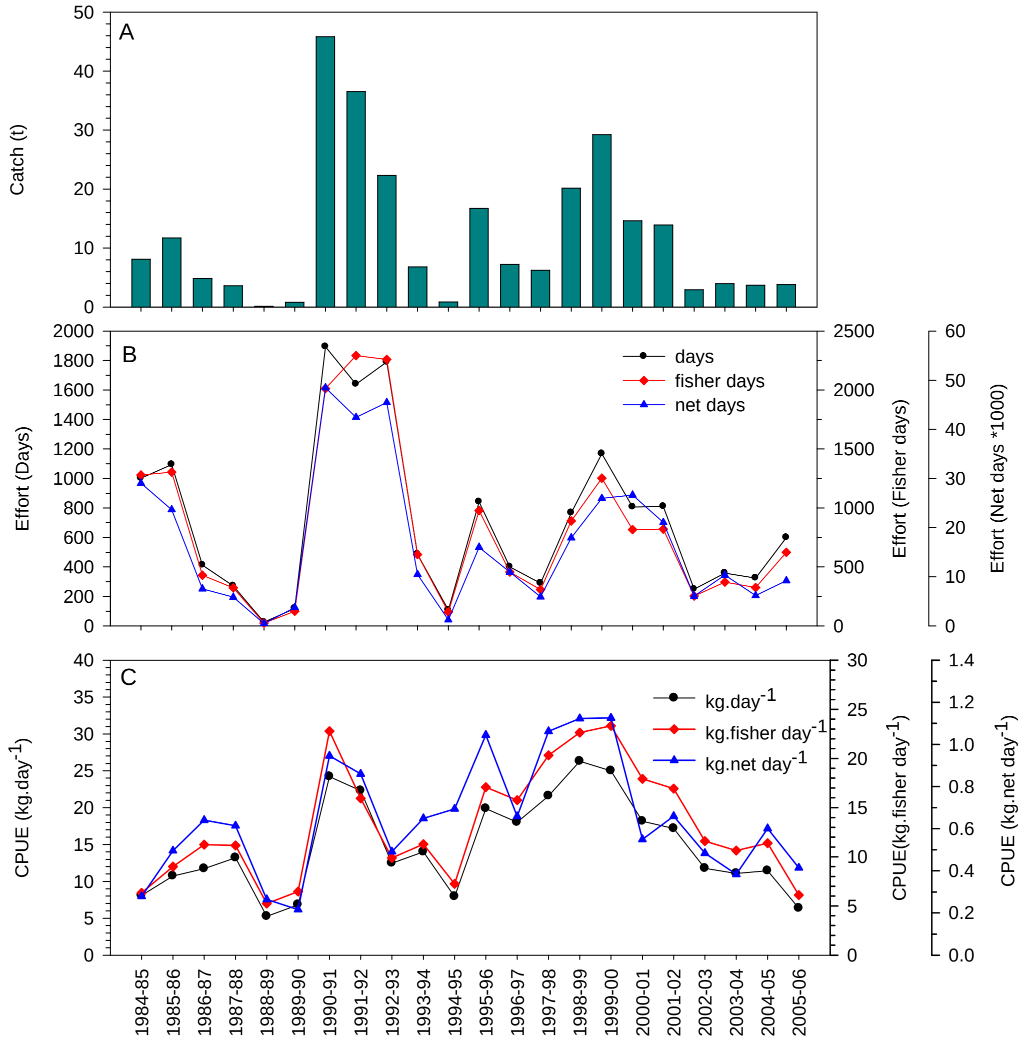

Figure 2-4. Fisheries statistics in the Lakes and Coorong Fishery. (A) targeted catch (large mesh gill net), (B) three measures of effort, and (C) CPUE estimated from three measures of effort.

3 MESH SELECTIVITY'S

Greenback flounder are targeted with large mesh gill nets (> 115 mm), typically a 152 mm (6 in) mesh net that is set on the bottom in the shallows, left in the water overnight then retrieved in the morning. The mesh selectivity's for greenback flounder from several nets were estimated from an on-board observer survey conducted in 2005-06. The modal size of greenback flounder caught in 6 in (152 mm) mesh was 320 mm TL which is 14.2% above the LMS of 280 mm TL.

The modal size of greenback flounder caught in 4 ½ in (114 mm) mesh nets was 225 mm TL (n=22) which was 10% below the LMS of 250 mm TL, however the sample size for this mesh size was small (Figure 3-1). For 121 mm mesh the modal length was 236 mm TL (n=55) which was 5.6% below the LMS. For 152 mm nets the modal size was 320 mm TL (n=108).

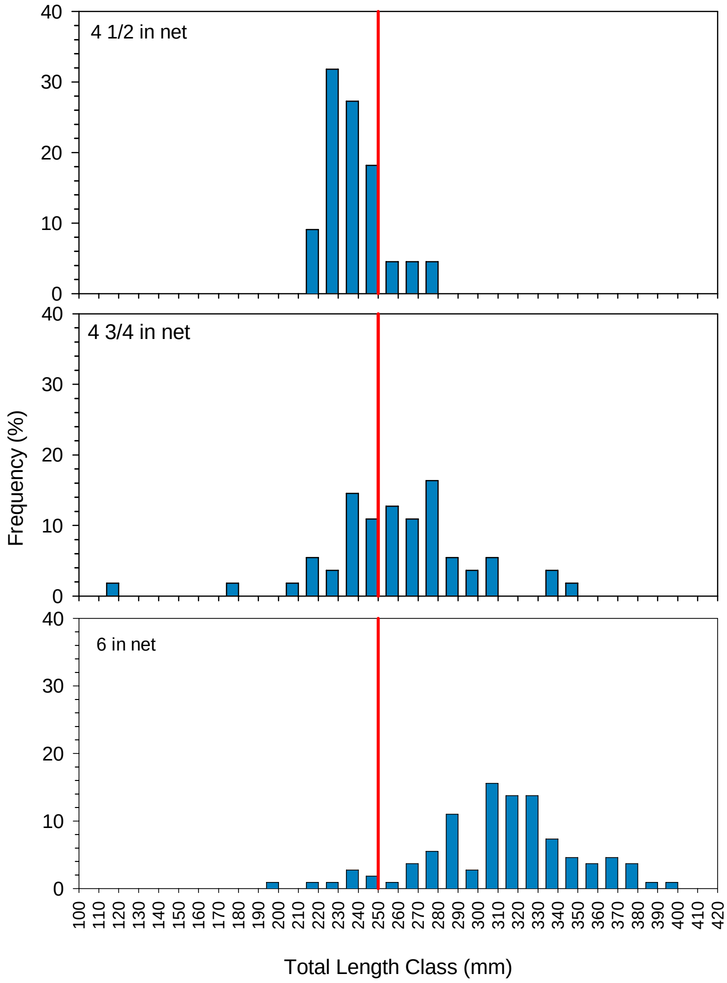

Figure 3-1. Mesh selectivity's for 3 gill nets used to target flounder in the Lakes and Coorong Fishery. (vertical red line is legal minimum length)

4 PERFORMANCE INDICATORS

4.1 Introduction

This section provides a report on the performance of the fishery for greenback flounder against the biological performance indicators defined in the Management Plan (Sloan 2005). Biological reference points are defined for each performance indicator, on the basis of historical data from 1984-85 to 2001-02 (Sloan 2005).

4.2 Biological Performance Indicators

There are four biological performance indicators for greenback flounder in 2005-06. All performance indicators were within the range of reference points. Total catch was 6.5 t which was close to the lower reference point (4 t). CPUE was 6.1 kg.fisher day^{-1} which was 2% above the lower reference point.

Both total catch and CPUE (kg.fisher day^{-1}) were within the range of reference points although close to the lower reference point.

Catch and CPUE trends were within the range of reference points.

Table 4-1. Biological performance indicators and reference points for greenback flounder from the South Australian Lakes and Coorong Fishery, 2004-05.

	Lower reference point	Upper reference point	2005-06	Within range of reference points
Total Catch (t)	4	54	6.5	Y
CPUE (kg.fisher day^{-1})	6	23	6.1	Y
4-year total catch trend ($t.year^{-1}$)	-22	+22	1.0	Y
4-year CPUE trend (kg.fisher day^{-1})	-5	+5	-1.5	Y

4.3 Active Licences Between 2001-02 and 2005-06

In 2005-06 there were 37 licences operating in the LCF. Over the last 5 years (2001-02 to 2005-06, the number of active licence holders ranged from 17 in 2001-02 to 9 in 2005-06.

Table 4-2. The number of Lakes and Coorong commercial licences against which greenback flounder were reported during the last five years.

Year	No licences reporting catches of greenback flounder
2001-02	17
2002-03	13
2003-04	9
2004-05	13
2005-06	9

5 GENERAL DISCUSSION

5.1 Information Available for the Fishery

Assessment of the fishery for greenback flounder, is aided by three stock status reports (Pierce and Doonan 1999; Ferguson 2006b; c), a literature review (Ferguson 2006a) and the Management Plan (Sloan 2005), which describes the current management arrangements, biological performance indicators and associated reference points for the fishery. However, information available for assessing the status of the fishery is limited due to heavy reliance on commercial catch and effort data, and the associated estimates of CPUE, from 1984-85 to 2005-06. The quality of these data is poorly understood.

The temporal trends in three measures of effort (days, fisher days, net days) were similar. Trends in mean annual CPUE (kg.day^{-1}, kg.fisher day^{-1}, kg.net day^{-1}) derived from these effort measures were also similar. CPUE (kg.fisher day^{-1}) provided the most useful measure of relative abundance.

Information on the biology of greenback flounder is limited. As a consequence the underlying mechanisms affecting the high inter-annual variability in catch and CPUE are poorly understood.

The key knowledge gaps for greenback flounder in the Coorong lagoons are (i) the size of maturity, (ii) size/age structure of the commercial and recreational catches, and (iii) the amount of recreational catch.

Additional knowledge gaps are (i) the role of environmental factors in determining year class strength, and (ii) the extent to which the greenback flounder population depends on habitat within the Coorong lagoons. Freshwater flows from the Murray River into the Coorong lagoons have been suggested as one factor that may explain variability in the abundance of greenback flounder (Hall 1984). This relationship may be investigated using regression methods to relate environmental variables to residuals from catch curve analysis (Hall 1984; Staunton-Smith *et al.* 2004; Robbins *et al.* 2005).

5.2 Current Status of the Greenback flounder Fishery

There are limited data available for assessment of this fishery. Catches have declined since 1999-00 while effort also declined after 1999-00 then increased after 2002-03.

CPUE (kg.fisher.day^{-1}) declined consistently from 1998-99 to 2005-06 and is close to the lower performance indicator. This decline suggests declining biomass.

Considerable latent effort also exists within the LCF and the recreational fisheries.

Greenback flounder are known to sexually partition habitat in Tasmania (Kurth 1957; Crawford 1984a) and this may be the case in the Coorong lagoons. Thus the potential exists that catches comprised mostly of females may lead to loss of egg production.

The extent to which the greenback flounder recruit to the Coorong lagoons from inshore marine waters is unknown. However, recruitment from the inshore marine habitat may be unlikely because (i) greenback flounder have not been observed in inshore marine habitat (Hall 1984) and (ii) are known to have a requirement for sheltered habitat (Last *et al.* 1983; Kailola *et al.* 1993; Gomon *et al.* 1994).

5.3 Future Research Needs

The most important research need for greenback flounder is to develop a sampling program to collect demographic information for the population of greenback flounder based in the Coorong lagoons. Sampling reproductive material and otoliths from commercial catches, over a 12 month period, could provide estimates of: size of maturity (SOM), gonad-somatic indices (GSI), size/age structures, and growth rates. This would enhance future stock assessments.

Adult greenback flounder sexually partition habitat in Tasmania (Kurth 1957; Crawford 1984a) and anecdotal information suggests that commercial catches from the Coorong lagoons comprise mostly female flounder. Consequently, fishery independent sampling may be necessary to determine SOM and size/age structures for males. Research sampling using a small seine net has the potential to provide this information. This method could also provide data on the abundance of juveniles which could provide (i) annual recruitment indices, (ii) estimates of juvenile mortality, and (iii) confirm the presence, or absence, of strong adult size/year classes that recruit to the fishery. Development of a recruitment index would provide further opportunity to investigate the role that environmental factors such as freshwater inflow have on the abundance of greenback flounder in the Coorong Lagoons.

There is no validated ageing method available for greenback flounder from South Australia. The ageing methodology developed for other Pleuronectid species in New Zealand may be successful in South Australia but would require validation for the South Australian population (Stevens *et al.* 2005). Once an appropriate ageing method is developed an age-length key could be used to estimate ages of flounder from length measurements taken at either the Adelaide Fish Market or the point of landing, thus reducing the cost of monitoring in subsequent years. Validation of growth could be achieved by (i) marking otoliths in captive fish i.e. oxy-tetracycline and monitoring growth over two months or (ii) by a mark and release study. A tagging study may provide additional information on (i) migration and (ii) and if migration is found to be limited, an estimate of mortality.

The magnitude of the illegal and recreational catches is not known for greenback flounder. This prevents reliable estimation of the total catch and, hence, impedes assessment of the fishery (Jones and Doonan 2005). Regular surveys to estimate the recreational harvest (*e.g.* every five years) would assist the assessment, and could be done in conjunction with surveys of other recreational fisheries.

The above research would substantially decrease the uncertainty that limits the assessment of stock status, particularly due to the difficulties associated with using CPUE as an index of relative abundance.

6 CONCLUSION

The assessment of the current status of the fishery is based on the interpretation of CPUE which provide the only estimate of relative abundance available for the fishery. CPUE has declined significantly since 1999-00 and is close to (+2%) the lower reference point. The decline over time suggests a decline in abundance. The extent to which this decline may have been affected by the current drought is unknown.

The extent of recreational catches of greenback flounder are known only for one year (2000-01). The size composition of recreational catches is not known at all but the requirement for recreational nets to float when set implies that hand spears are probably the main gear used to target greenback flounder. Currently the absence of a LMS for recreational catches of greenback flounder, and the likely reliance on hand spears, may mean that significant numbers of immature flounder are harvested.Currently there is no size of maturity estimate for greenback flounder in South Australia. The most important need for the fishery is a 12 month monitoring program to provide: (i) estimates of size of maturity, (ii) a validated ageing methodology, (iii) size-age structures, and (iv) an age length key for ongoing monitoring of size structures.

7 REFERENCES

Annala, J. H., K. J. Sullivan, C. J. O'Brien, S. N. W. McL. and S. L. Grayling (2003). Report from The Fishery Assesment Plenary may 2003: stock assessments and yield estimates. Wellington, National Institute of Water and Atmospheric Research.

Anon. (1988). "New restrictions for mulloway fishery." Australian Fisheries 47 (8): 9-10.

Anon. (2005). Assessment of the ecological sustainability of management arrangements for the South Australian Lakes and Coorong Fishery. Adelaide, Department of Environment and Heritage: 31.

Barnett, C. W. and N. W. Pankhurst (1999). "Reproductive biology and endocrinology of greenback flounder *Rhombosolea tapirina* (Günther 1862)." Mar. Freshw. Res. 50: 35-42.

Burchmore, J. J. (1982). The comparative ecology of sympatric flatfish species (Pleuronectiformes) in Botany Bay, New South Wales. Sydney, University of Sydney.

Chen, W.-M., J. Purser and P. Blyth (1999). " Diel feeding rhythms of greenback flounder *Rhombosolea tapirina* (Günther 1862): the role of light-dark cycles and food deprivation." Aquac. res. 30: 529-537.

Colman, J. A. (1974). "Growth of two species of flounders in the Hauraki Gulf, New Zealand." NZ. J. Mar. Freshw. Res. 8: 351-370.

Connolly, R. M. (1994a). "A comparison of fish assemblages from seagrass and unvegetated areas of a South Australian estuary." Aust. J. Mar. Freshw. Res. 45: 1033-44.

Connolly, R. M. (1994b). "The role of seagrass as preferred habitat for juvenile *Sillaginodes punctata* (Cuv. & Val.) (Sillaginidae, Pisces): habitat selection or feeding." Journal of Experimental Marine Biology and Ecology 180: 39-47.

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

Crawford, C. M. (1984a). An ecological study of Tasmanian flounder. Hobart, University of Tasmania.

Crawford, C. M. (1984b). "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)." J. Fish Biol. 29: 325-334.

Edgar, G. J. (2000). Australian Marine Life: The Plants and Animals of Temperate Marine Waters. Sydney, Reed New Holland.

Edgar, G. J., P. R. Last and M. W. Wells (1982). Coastal Fishes of Tasmania and Bass Strait. Hobart, Cat and Fiddle Press.

Edgar, G. J. and C. Shaw (1995). "The production and trophic ecology of shallow-water fish assemblages in southern Australia I. Species richness, size-structure and production of fishes in Western Port, Victoria." Journal of Experimental Marine Biology and Ecology 194: 53-81.

Ferguson, G. (2006a). Fisheries biology of the greenback flounder *Rhombosolea tapirina* (Günther 1862) (Teleostei: Pleuronectidae) in South Australia Adelaide, SARDI: 18.

Ferguson, G. (2006b). The South Australian Lakes and Coorong Fishery: Fishery Stock Status Report for PIRSA Fisheries. Adelaide, South Australian Research and Development Institute (Aquatic Sciences): pp12.

Ferguson, G. (2006c). The South Australian Lakes and Coorong Fishery: Fishery Stock Status Report for PIRSA Fisheries. Adelaide, SARDI: 13.

Francis, R. I. C. C. (1988). "Recalculated growth rates for sand flounder, *Rhombosolea plebia*, from tagging experiments in Canterbury, New Zealand, 1964-66." NZ. J. Mar. Freshw. Res. 22: 53-56.

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

Hall, D. (1984). "The Coorong: Biology of the major fish species and fluctuations in catch rates 1976-1983." SAFIC 8 (1): 3-15.

Hart, P. R. (1994). "Tasmanian flounder research - the story so far." Austasia Aquaculture 8 (6): 37-39.

Henry, G. W. and J. M. Lyle (2003). The National Recreational and Indigenous Fishing Survey. Canberra, Fisheries Research and Development Corporation: 188.

Hunter, J. R., N. C. H. Ho and R. J. H. Leong (1985). Batch fecundity in multiple spawning fishes. An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy *Engraulis mordax.*: 67-77.

Hunter, J. R., B. J. Macewiecz, N. C. Lo and C. A. Kimbrell (1992). "Fecundity, spawning, and maturity of female Dover sole *Microstomus pacificus*, with an evaluation of assumptions and precision." Fish. Bull. 90: 101-128.

Jenkin, G. K. (1979). Conquest of the Ngarrindjeri. Adelaide, Rigby Ltd.

Jenkins, G. P. (1986). "Composition, seasonality and distribution of ichthyoplankton in Port Phillip Bay, Victoria." Australian Journal of Marine and Freshwater Research 37: 507-520.

Jenkins, G. P. (1987a). "Age and growth of co-occurring larvae of two flounder species, *Rhombosolea tapirina* and *Ammotretis rostratus*." Mar. Biol. 95: 157-166.

Jenkins, G. P. (1987b). "Comparative diets, prey selection, and predatory impact of co-occurring larvae of two flounder species." Journal of Experimental Marine Biology and Ecology 110: 147-170.

Jenkins, G. P., H. M. A. May, M. J. Wheatley and M. G. Holloway (1997). "Comparison of fish assemblages associated with seagrass and adjacent unvegetated habitats of Port Phillip Bay and Corner Inlet, Victoria, Australia, with emphasis on commercial species." Estuarine, Coastal and Shelf Sci. 44: 569-588.

Jenkins, G. P., M. Shaw and B. D. Stewart (1993). "Spatial variation in food-limited growth of juvenile Greenback Flounder, *Rhombosolea tapirina*: Evidence from otolith daily increments and otolith scaling." Canadian Journal of Fisheries and Aquatic Science 50: 2558-2567.

Jenkins, G. P. and M. J. Wheatley (1998). "The influence of habitat structure on nearshore fish assemblages in a southern Australian embayment: comparison of shallow seagrass, reef-algal and unvegetated sand habitats, with emphasis on their importance to recruitment." Journal of Experimental Marine Biology and Ecology 221: 147-172.

Jones, G. K., D. A. Hall, K. L. Hill and A. J. Staniford (1990). The South Australian Marine Scale Fishery: Stock Assessment, Economics and Management. Green Paper. Adelaide, South Australian Department of Fisheries: 186.

Jones, K. and A. M. Doonan (2005). 2000-01 National Recreational and Indigenous Fishing Survey: South Australian Regional Information. Adelaide, Primary Industries and Resources SA: 1-99.

Jordan, A. R., D. M. Mills, G. Ewing and J. M. Lyle (1998). Assessment of inshore habitats around Tasmania for life-history stages of commercial finfish species. , . Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

Kailola, P. J., M. J. Williams, P. C. Stewart, R. E. Reichelt, A. McNee and C. Greive (1993). Australian Fisheries Resources. Canberra, Australia. Brisbane, Bureau of Resource Sciences, Fisheries Research and Development Corporation. Australian Fisheries Resources: 318-320.

Knight, M. A., A. Tsolos and A. M. Doonan (2000). South Australian Fisheries and Aquaculture Information and Statistics Report. Adelaide, South Australian Research and Development Institute: 1-67.

Knight, M. A., A. Tsolos and A. M. Doonan (2001). South Australian Fisheries and Aquaculture Information and Statistics Report. Adelaide, South Australian Research and Development Institute: 69.

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

Last, P. R., E. O. G. Scott and F. H. Talbot (1983). Fishes of Tasmania. Hobart, Tasmanian Fisheries Development Authority.

May, H. M. A. and G. P. Jenkins (1992). "Patterns of settlement and growth of juvenile flounder, *Rhombosolea tapirina*, determined from otolith microstructure." Mar. Ecol. Prog. Ser. 79: 203-214.

Paul, L. J. (1992). "Age and growth studies of New Zealand marine fishes, 1921-90: A review and bibliography." Aust. J. Mar. Freshw. Res. 43: 879-912.

Pierce, B. E. and A. M. Doonan (1999). A summary report on the status of selected species in the River Murray and Lakes and Coorong fisheries. Adelaide, SARDI Aquatic Sciences: 1-14.

PIRSA (1996). Market overview: Greenback Flounder (*Rhombosolea tapirina*). Adelaide, Primary Industries and Resources South Australia: 26.

Robbins, J. B., I. A. Halliday, J. Staunton-Smith, D. G. Mayer and M. J. Sellin (2005). "Freshwater flow requirements of estuarine fisheries in tropical Australia: a review of the state of knowledge and application of a suggested approach." Mar. Freshw. Res. 56: 343-360.

Rohan, G., G. K. Jones and D. McGlennon (1991). The South Australian Marine Sclaefish Fishery: Supplementary Green Paper. Adelaide, South Australian Department of Fisheries: 1-169.

Shaw, M. and G. P. Jenkins (1992). "Spatial variation in feeding, prey distribution and food limitation of juvenile flounder *Rhombosolea tapirina* Günther." Journal of Experimental Marine Biology and Ecology 165: 1-21.

Sloan, S. (2005). Management Plan for the South Australian Lakes and Coorong Fishery. Adelaide, Primary Industries and Resources South Australia: 122.

Staunton-Smith, J., J. B. Robins, D. G. Mayer, M. J. Sellin and I. A. Halliday (2004). "Does the quantity and timing of freshwater flowing into a dry tropical estuary affect year-class strength of barramundi (*Lates calcarifer*)." Mar. Freshw. Res. 55: 787-797.

Stevens, D. W., M. P. Francis, P. C. Shearer, R. P. McPhee, R. W. Hickman and M. J. Tait (2005). "Age and growth of two endemic flatfish (*Colistium guntheri*) and (*C. nudipinnis*) in central New Zealand waters." Mar. Freshw. Res. 56: 143-151.

Stewart, B. D. and G. P. Jenkins (1991). "Daily growth increments in the otoliths of juvenile greenback flounder, *Rhombosolea tapirina* Günther, 1862." Journal of Fish Biology. 39: 605-608.

van den Enden, T., R. W. G. White and N. G. Elliott (2000). "Genetic variation in the greenback flounder *Rhombosolea tapirina* Günther (Teleostei, Pleuronectidae) and the implications for aquaculture." Mar. Freshw. Res. 51: 21-33.