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Fishery statistics, stock status and performance indicators for the South Australian Lakes and Coorong Fishery

J. Earl

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SARDI Aquatics Sciences
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Report to PIRSA Fisheries and Aquaculture

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The report was formally reviewed by Dr Tony Fowler and Dr Greg Ferguson (SARDI Aquatic Sciences), and Dr Belinda McGrath-Steer (Fishery Manager, PIRSA Fisheries and Aquaculture). The report was approved for publication by Dr Stephen Mayfield (Science Leader, Fisheries, SARDI Aquatic Sciences).

EXECUTIVE SUMMARY

This report summarises the fishery statistics for South Australia's multi-species, multi-gear Lakes and Coorong Fishery (LCF). It provides a summary of the fishery data for key finfish species that are harvested by the three gillnet sectors of the fishery (Estuarine large mesh gillnet; Estuarine small mesh gillnet; and Freshwater large mesh gillnet), as well as for Pipi (*Donax deltoides*), from 1984/85–2017/18. For each species, the report summarises relevant biological information; examines trends in catch and effort data; and assigns status using the National Fishery Status Reporting Framework (NFSRF; Stewardson et al. 2018). The report also assesses the recent condition of the environment in which the finfish sectors operate against a set of reference points, and provides estimates of the biological performance indicators for Pipi. Of the seven species assessed in this report, five are classified as 'sustainable', and two (Black Bream (*Acanthopagrus butcheri*) and Greenback Flounder (*Rhombosolea tapirina*)) are classified as 'depleted'.

<u>Estuarine large mesh gillnet sector (ELMGN)</u>

For Mulloway (*Argyrosomus japonicus*), the total catch of 121 t in 2017/18 was the second highest since 1984/85, and was associated with record-high catch per unit effort (CPUE). These data suggest that the biomass of this stock is at a level sufficient to ensure that future recruitment is adequate, and provide no evidence that current levels of fishing will move the stock towards being recruitment impaired. Consequently, this stock is classified as '**sustainable**' under the NFSRF.

For Black Bream, targeted effort and catch have been historically low in most years since the early 1990s, which continued in 2017/18. These results suggest that the biomass of the stock in the Coorong estuary remains in a recruitment-impaired state. In 2018, management measures were implemented to recover the stock, but have not yet resulted in measurable improvements. As such, the status of '**depleted**' that was applied to this stock in 2016/17 is retained.

Greenback Flounder is considered a 'marine estuarine-opportunist' – a marine species that enters estuaries in substantial numbers, particularly during their first 1–2 years, but uses marine waters as alternative habitat. In the Coorong estuary, low targeted effort and catches since 2012/13 likely reflect low fishable biomass as a consequence of low recruitment over several recent years due to the low freshwater inflows to the estuary (i.e. non-fishing effects). Biomass in the estuary has been reduced primarily through non-fishing effects and, as a consequence recruitment is impaired. On this basis, the Greenback Flounder stock in the Coorong is classified as '**depleted**'.

For the ELMGN, the environmental performance indicator for habitat available to Mulloway in the Coorong for the 2018/19 reporting year (1 February 2018 to 31 January 2019) was 55.04%, which was marginally above the target reference point of 55%.

Estuarine small mesh gillnet sector (ESMGN)

For Yelloweye Mullet (*Aldrichetta forsteri*) in 2017/18, the total catch of 158 t was similar to the previous five-year average (2012/13–2016/17), while targeted CPUE using small mesh gillnets (SMGN) was above the long-term average. This stock is classified as '**sustainable**'.

For the ESMGN, the environmental performance indicator for habitat available to Yelloweye Mullet in the Coorong for the 2018/19 reporting year was 67%, which was above the target reference point of 50%.

Freshwater large mesh gillnet sector (FWLMGN)

For Golden Perch (*Macquaria ambigua*), the total catch of 105 t in 2017/18 was the highest since 2007/08. Annual CPUE has increased since 2009/10 and was among the highest on record in 2017/18. This stock is classified as '**sustainable**'.

Bony Herring (*Nematalosa erebi*) is mainly taken as by-product by LCF fishers targeting other species. The total catch of 362 t in 2017/18 was the lowest catch since 2005/06, but above the low annual catches taken in the early 2000s. This stock is classified as '**sustainable**'.

Common Carp (*Cyprinus carpio*) has been declared noxious under the *Fisheries Management Act 2007*. In the LCF, the species is mostly taken as by-product when other species are targeted. Total catch has been at moderate levels since 2009/10. No stock status is applied to this stock.

For the FWLMGN, the environmental performance indicator for water level in the Lower Lakes for the 2018/19 reporting year was 0.65 m, which was above the target reference point of 0.4 m.

Pipi sector

Since 2009/10, annual catches of Pipi have been constrained by the total allowable commercial catch (TACC). The total catch of 646 t in 2017/18 was the highest since 2009/10. In 2017/18, the estimate of relative biomass (primary biological performance indicator) derived from fishery-independent surveys was among the highest on record. However, pre-recruits (secondary biological performance indicator) were absent (i.e. comprised <30% of size frequency distributions) in November 2017 (26%), but present in February 2018 (46%). On the basis of this information, the stock status of '**sustainable**' that was applied in 2017 is retained.

Keywords: Mulloway, Yelloweye Mullet, Golden Perch, Pipi, Common Carp, Bony Herring, Black Bream, Greenback Flounder, gillnets, habitat, Murray River, estuary.

Key statistics for South Australia's Lakes and Coorong Fishery finfish resources from 2015/16–2017/18, including stock status based on weight of evidence and the National Fishery Status Reporting Framework (Stewardson et al. 2018). X = confidential data.

Species	F/Year	Catch (t)	CPUE (kg.net-day^{-1})	Stock status
Mulloway	2015/16	73	4.33	Sustainable
	2016/17	62	9.35	Sustainable
	2017/18	121	9.89	Sustainable
Black Bream	2015/16	1.9	x	Overfished
	2016/17	1.6	1.31	Overfished
	2017/18	1.3	x	Depleted
Greenback Flounder	2015/16	4.5	1.47	Environmentally-limited
	2016/17	2.1	2.26	Environmentally-limited
	2017/18	0.7	1.67	Depleted
Yelloweye Mullet	2015/16	135	8.99	Sustainable
	2016/17	183	13.01	Sustainable
	2017/18	154	13.14	Sustainable
Golden Perch	2015/16	77	1.38	Sustainable
	2016/17	81	1.36	Sustainable
	2017/18	106	1.55	Sustainable
Bony Herring	2015/16	397	4.80	Not assessed
	2016/17	427	5.30	Not assessed
	2017/18	363	4.46	Sustainable
Common Carp	2015/16	395	4.64	Not assessed
	2016/17	490	6.00	Not assessed
	2017/18	403	4.71	Not assessed

Results from the annual assessments of the environmental performance indicators from 2016/17 to 2018/19 (reporting years) against their target, trigger and limit reference points (RP) for the three finfish sectors. The annual total allowable commercial effort (TACE) is also shown for each sector.

Finfish sector	Performance indicator	Target RP	Trigger RP	Limit RP	Reporting year	PI value	Proposed TACE (net units)
Estuarine LMGN	Habitat available to Mulloway	55	24.9	10	2016/17	63.3%	1,250
					2017/18	57.8%	1,250
					2018/19	55.04%	1,250
Estuarine SMGN	Habitat available to YE Mullet	50	30.9	10	2016/17	69.7%	1,250
					2017/18	67%	1,250
					2018/19	67%	1,250
Freshwater LMGN	Water level in the Lower Lakes	0.4	-0.71	-1.2	2016/17	0.72 m	1,250
					2017/18	0.72 m	1,250
					2018/19	0.65 m	1,250

Key statistics for South Australia's Lakes and Coorong Fishery Pipi resource from 2015/16 to 2017/18, including stock status based on weight of evidence and the National Fishery Status Reporting Framework (Stewardson et al. 2018). TACC = total allowable commercial catch.

	F/year	TACC (t)	Catch (t)	Relative biomass (kg/4.5 m² ±SE)	Pre-recruits present	Stock status
Pipi	**2015/16**	500	492	20.3 (±1.1)	Yes	Sustainable
	2016/17	550	539	21.5 (±1.4)	Yes	Sustainable
	2017/18	650	646	19.1 (±1.1)	Yes	Sustainable

1. INTRODUCTION

This is the thirteenth annual report that summarises the fishery statistics for South Australia's commercial multi-species and multi-gear Lakes and Coorong Fishery (LCF). The aims of the report are to: (1) provide a historical summary of the commercial and recreational fishery statistics for the key species in the LCF up to 30 June 2018, including an assessment of stock status for each species; and (ii) assess the recent condition of the environment in which the fishery operates against several reference points. The requirement for these reports is prescribed in the previous (Sloan 2005) and current management plans for the fishery (PIRSA 2016).

The current management plan ('the management plan') for the LCF includes a harvest strategy for finfish (PIRSA 2016). This harvest strategy aims to manage the sustainable harvest of finfish relative to environmental conditions – specifically the amount of habitat available to key species for three habitat/gear-based sectors. The sectors are: (i) estuarine large mesh gill net (ELMGN); (ii) estuarine small mesh gill net (ESMGN); and (iii) freshwater large mesh gill net (FWLMGN).

This report summarises the fishery data for key finfish species that are taken across the three finfish sectors for each financial year from 1 July 1984 to 30 June 2018. These are distributed across the 'primary' and 'secondary' species categories defined in the management plan and are consistent with those considered in previous fishery statistics reports (e.g. Earl 2018). For each species, a summary of relevant biological information is presented, along with an interrogation of the fishery statistics, and a classification of stock status.

The finfish harvest strategy uses environmental performance indicators and decision rules to guide management of the fishery through adjustment of the annual total allowable commercial effort (TACE) for each of the three sectors. Estimates of the environmental performance indicators for the 2018/19 reporting year (1 February 2018–31 January 2019) relative to target, trigger and limit reference points are presented to ensure that the most up-to-date environmental information is available to inform the setting of the TACE for each sector for the 2019/20 financial year.

This report also summarises relevant biological information, fishery data and assessment of stock status for Pipi (*Donax deltoides*). Pipi is harvested along the ocean beach on Younghusband Peninsula. A total allowable commercial catch (TACC) was introduced under a quota management system for Pipi in 2007/08, with commercial catches constrained since 2009/10 (Ferguson and Hooper 2017). Additionally, a harvest strategy for Pipi was implemented in 2012/13 and subsequently revised in 2015/16 as part of the updated management plan. The revised harvest strategy uses performance indicators and decision rules to inform setting of the annual TACC. The TACC for 2017/18 was 650 t, which was 100 t higher than that for 2016/17.

2. METHODS

2.1 FISHERY STATISTICS

Daily commercial catch and effort data have been collected by LCF fishers since 1 July 1984, which are submitted to SARDI Aquatic Sciences on a monthly basis. Data include catch (kg), effort (net-days, i.e. the number of nets) for targeted and non-targeted species, and location of the fishing activity by fishery reporting block (Figure 2.1).

Annual catch totals for primary, secondary and tertiary species groups (as defined in the management plan) are presented for each financial year from 1984/85–2017/18 to show inter-annual variation in their relative contribution to fishery production. Detailed catch and effort data are presented for the key species within each habitat/gear-based finfish sector, and for Pipi. For each species, a map is presented that shows total catch by reporting block for 2017/18. Then, annual estimates are provided for: (i) total catch; and for the dominant gear type(s); (ii) targeted catch; (iii) targeted effort; and (iv) catch per unit effort (CPUE; targeted catch divided by targeted effort). For species that are not typically targeted, CPUE was determined based on total catch and the amount of effort that produced catches of that particular species. Data relating to less than five licences are not shown, as these are confidential.

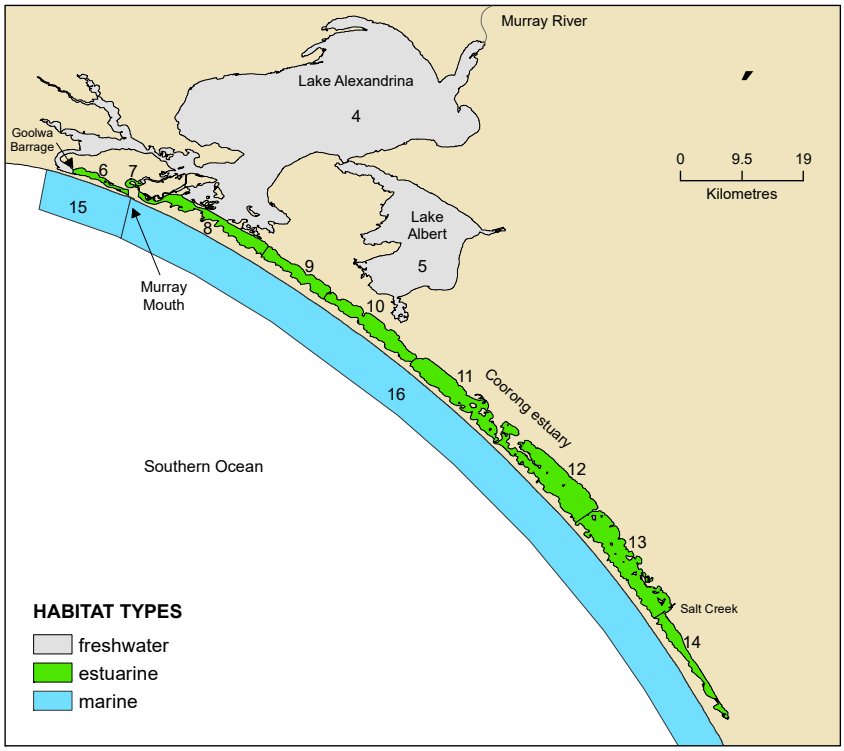

Figure 2.1. Map of the Lakes and Coorong region showing commercial reporting blocks 4–16 across freshwater, estuarine and marine habitats accessible to the LCF.

Where available, the estimates of total commercial catches for each species are supplemented with estimates of State-wide recreational catch, sourced from the: (i) National Recreational and Indigenous Fishing Survey from May 2000–April 2001 (Henry and Lyle 2003), and State-wide telephone/diary surveys of South Australian residents from (ii) November 2007–October 2008 (Jones 2009) and (iii) December 2013–November 2014 (Giri and Hall 2015).

2.2 STOCK STATUS CLASSIFICATION

A national stock status classification system has been developed for the consistent assessment of key Australian fish stocks (Stewardson et al. 2018). It considers whether the current level of fishing pressure is adequately controlled to ensure that spawning stock abundance is not reduced to a point where the production of juveniles is significantly compromised. The system combines information on both the current stock size and the level of catch into a single classification for each stock against defined biological reference points. Each stock is then classified as either: ‘sustainable’, ‘depleting’, ‘recovering’, ‘depleted’ or ‘undefined’ (Table 2.1). PIRSA has adopted this classification system to define the status of South Australian fish stocks.

The finfish harvest strategy lacks an index that defines stock status for individual species. Consequently, emphasis is placed on analysing trends in fishery-dependent data and available information on fishery age structures to support a weight-of-evidence assessment of stock status. No catch sampling has been undertaken for LCF species since 2015, and so assessments of stock status for finfish species in this report are based on commercial catch and effort data.

The harvest strategy for Pipi outlines two biological performance indicators which inform setting of the annual TACC (PIRSA 2016), and provide the primary information for assessment of stock status for this species in this report. The biological performance indicators used in the harvest strategy are: (i) fishery-independent mean annual relative biomass (primary biological performance indicator); and (ii) presence/absence of pre-recruits in size frequency distributions (i.e. pre-recruits are considered present when they comprise greater than 30% of size frequency distributions in the November sub-survey) (secondary biological performance indicator) (Ferguson and Hooper 2017). Detailed methods used to provide estimates of these biological performance indicators are described in Ward et al. (2010) and further evaluated in Ferguson et al. (2015). Associated reference points are detailed in the harvest strategy for Pipi in the management plan (PIRSA 2016).

Table 2.1. Classification scheme used to assign fishery stock status. The description of each stock status and its potential implications for fishery management are also shown (Stewardson et al. 2018).

	Stock Status	Description	Potential implications for management of the stock
	Sustainable	Biomass (or proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (recruitment is not impaired) and for which fishing mortality (or proxy) is adequately controlled to avoid the stock becoming recruitment impaired (overfishing is not occurring)	Appropriate management is in place
	Depleting	Biomass (or proxy) is not yet depleted and recruitment is not yet impaired, but fishing mortality (or proxy) is too high (overfishing is occurring) and moving the stock in the direction of becoming recruitment impaired.	Management is needed to reduce fishing mortality and ensure that the biomass does not become depleted.
	Recovering	Biomass (or proxy) is depleted and recruitment is impaired, but management measures are in place to promote stock recovery, and recovery is occurring.	Management is in place, and there is evidence that the biomass is recovering.
	Depleted	Biomass (or proxy) has been reduced through catch and/or non-fishing effects, such that recruitment is impaired. Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements.	Management is needed to recover this stock; if adequate management measures are already in place, more time may be required for them to take effect.
	Undefined	Not enough information exists to determine stock status	Data required to assess stock status are needed

2.3 ENVIRONMENTAL PERFORMANCE INDICATORS

For each of the three finfish sectors, the recent condition of the environment in which the fishery operated is assessed by comparing the environmental performance indicator for the 2018/19 reporting year (1 February 2018–31 January 2019) against target, trigger and limit reference points from the reference period of 1984/85–2012/13 (PIRSA 2016).

The environmental performance indicators for the ELMGN and ESMGN sectors represent annual estimates of the proportions of habitat in Coorong estuary that were available to Mulloway (*Argyrosomus japonicus*) and Yelloweye Mullet (*Aldrichetta forsteri*), respectively. These metrics are determined based on the salinity tolerances of each species, and modelled estimates of salinity at 1 km increments along the longitudinal gradient of the estuary from the Goolwa Barrage to Salt Creek. The environmental performance indicator for the FWLMGN is mean annual water level in the Lakes Alexandrina and Albert (Lower Lakes), and represents the amount of available habitat for finfish, including Golden Perch (*Macquaria ambigua*). Detailed descriptions of the environmental performance indicators and the associated reference points are provided in the harvest strategy for finfish (PIRSA 2016).

2.4 QUALITY ASSURANCE PROCESSES

Various quality assurance processes were implemented in the development of this report:

1. Commercial catch and effort data were validated by SARDI's Fisheries Information Services Group based on:
    i. random cross-checking of raw data transferred from commercial catch returns,
    ii. random cross-checking of data entered to the database by trained personnel, and
    iii. automated filters and structured queries built into the fisheries statistics database;
2. Extracted catch and effort data for each species were graphed into their appropriate species/gear/time categories and cross-checked with the time-series presented in previous fishery statistics reports (e.g. Earl 2018);
3. Tabulated fishery data were cross-checked against the computer output;
4. Fishery catch and effort data and their interpretation were discussed with peers, PIRSA and LCF licence holders;
5. The report was formally reviewed by two independent SARDI scientists in accordance with the SARDI report review process, and by PIRSA to ensure it is consistent with their needs and objectives for the fishery, before approval for publication.

3. RESULTS

3.1 TRENDS IN COMMERCIAL CATCH

Total production of the LCF has varied cyclically over time (Figure 3.1). This variation is mainly attributable to inter-annual variation in catch of the six primary species, which have consistently contributed >94% of annual production since 1984/85. Total catch of the primary species peaked at 2,671 t in 1991/92 with a secondary peak of 2,419 t in 2005/06. It declined to 1,379 t in 2011/12 and subsequently increased to 1,723 t in 2017/18. Among the primary species, catches of Bony Herring (*Nematalosa erebi*), Common Carp (*Cyprinus carpio*) and Pipi have consistently accounted for most (>78%) of the annual catches, with smaller contributions from Yelloweye Mullet, Golden Perch and Mulloway.

Total catch of secondary and tertiary species peaked at 85 t in 1991/92. Since then it has progressively declined to a low of 2.7 t in 2017/18. The decline and subsequent variation in production for these species categories reflects the catch trends of Greenback Flounder (*Rhombosolea tapirina*) and Black Bream (*Acanthopagrus butcheri*) (secondary species), and to a less extent Australian Salmon (*Arripis truttaceus*) (tertiary species). A summary of total annual catches for twelve LCF species from 1984/85–2017/18 is shown in the Appendix (Table A.1).

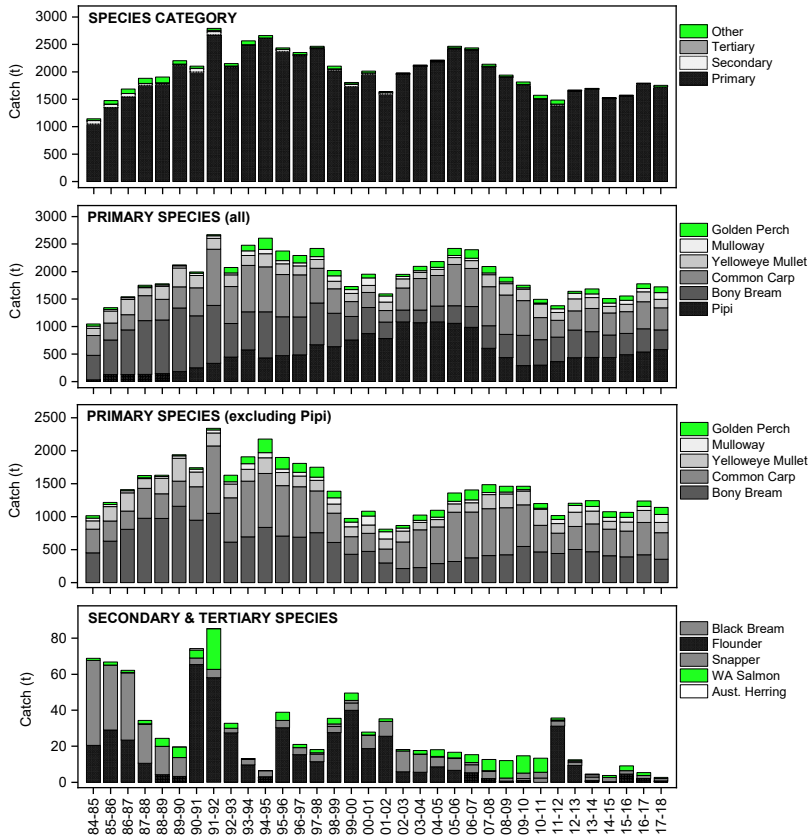

Figure 3.1. Annual catches in the LCF from 1984/85–2017/18, by species category, primary species, primary species excluding Pipi (i.e. finfish species only), and secondary and tertiary species.

3.2 ESTUARINE LARGE MESH GILLNET SECTOR

3.2.1 Mulloway (*Argyrosomus japonicus*)

Biology

Mulloway (*Argyrosomus japonicus*) is a member of the Sciaenidae family of fishes (Gomon et al. 2008). It has a wide distribution in Australia, from the Gascoyne region on the west coast of Western Australia (WA), around the southern coasts of the continent, and up to the Wide Bay–Burnett region on the east coast of Queensland (Kailola et al. 1993). Within this distribution, juveniles are often abundant in estuaries while adults are mainly found in nearshore coastal waters (< 100 m depth), including the surf zone and around the mouths of rivers.

Mulloway is a large-bodied, long-lived, late-maturing species that can grow to 2000 mm total length (TL) and live to 42 years of age. In South Australia (SA), Mulloway mature at around 780 mm TL and 5 years of age for males, and 850 mm TL and 6 years of age for females. Spawning occurs from October to January (Ferguson et al. 2014).

Regional differences in genetics, and otolith morphology and chemistry suggest distinct populations of Mulloway along the eastern and western coasts of SA (Ferguson et al. 2014; Barnes et al. 2016). There is evidence that the Coorong population is part of a biological stock that occurs from Gulf St. Vincent to Western Port Bay, Victoria (Veale et al. 2017). Here, assessment of stock status is undertaken at the management unit level – the LCF.

Fishery statistics

Estimates of total annual catches for Mulloway increased from 13 t in 1987/88 to a peak of 136 t in 2000/01 (Figure 3.2). Catches progressively declined during the 2000s to 19 t in 2010/11. This decline was concomitant with declines in targeted effort and low CPUE for the dominant gear types (i.e. large mesh gillnets (LMGN; 115–150 mm mesh); and swinger nets (>150 mm mesh)). Since then, annual catches have been considerably higher with peaks of 103 t in 2012/13 and 121 t in 2017/18, the latter of which is the second highest recorded since 1984/85. Targeted catches taken using LMGN in the estuary have accounted for most catches in most years, with smaller catches taken in marine waters using swinger nets contributing most of the remainder.

Estimates of CPUE for LMGN have been variable over the years, but have increased to unprecedented high levels in recent years (Figure 3.2). The LMGN CPUE of 9.8 kg.net-day^{-1} in 2017/18 was the highest on record. The numbers of fishers who reported taking Mulloway declined slightly over the long-term at a similar rate as the lower numbers of fishers that reported targeting the species.

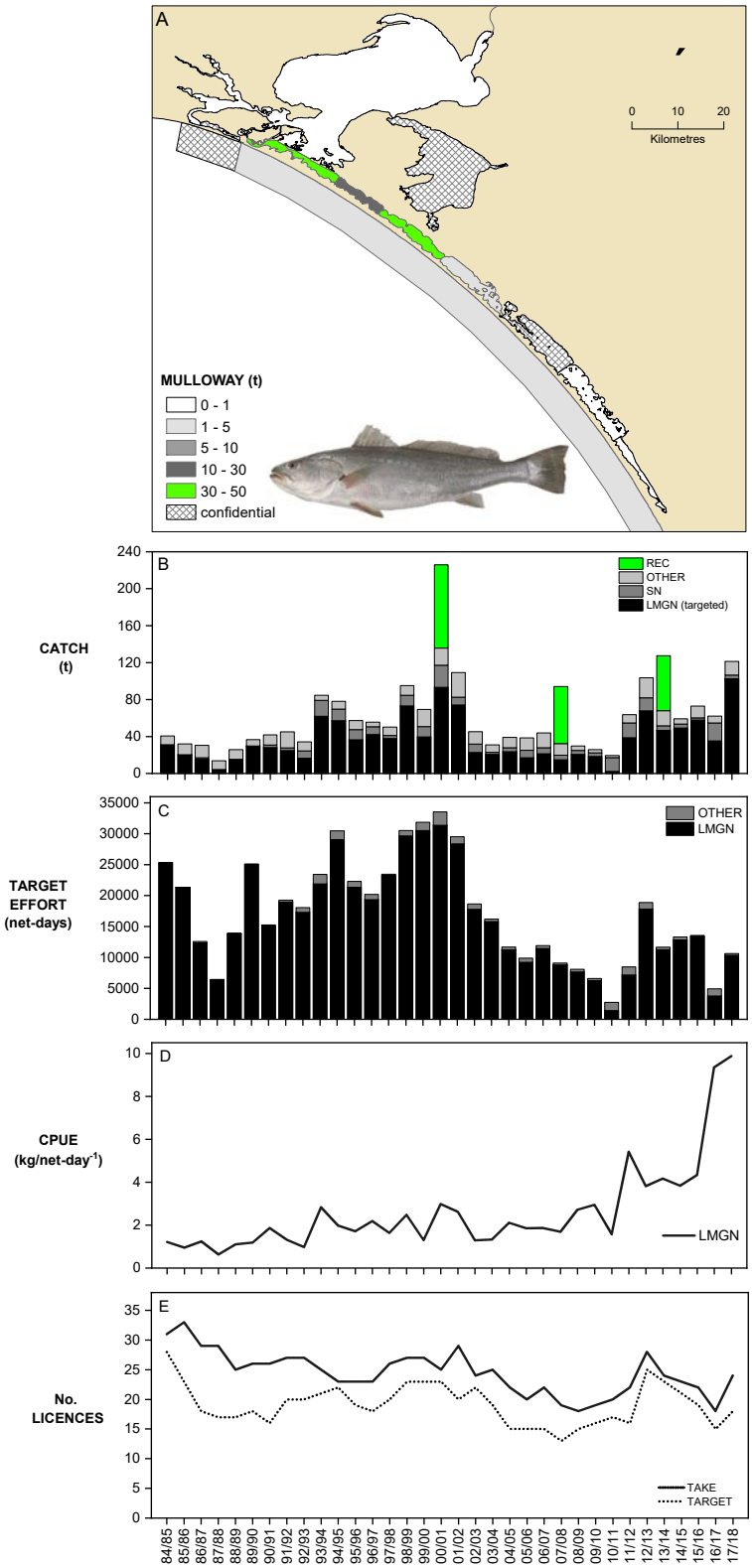

Figure 3.2. Fishery statistics for Mulloway. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the main gear types (large mesh gillnets (LMGN), swinger nets (SN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) targeted effort for LMGN and all other gears; (D) targeted CPUE for LMGN; and (E) the number of active licence holders that reported taking or targeting the species.

Stock status

Mulloway is a primary species for the commercial sector of the LCF (PIRSA 2016). This likely reflects its history of relatively high catches of this species in some years and its relatively high wholesale value compared to some other species available to the fishery (EconSearch 2017). The most recent stock assessment for Mulloway in the LCF was undertaken in 2014 and used a weight-of-evidence approach that considered commercial catch and effort data and fishery age structures to the end of June 2014 (Earl and Ward 2014). There has been no catch sampling for Mulloway since 2015.

Commercial landings of Mulloway in the LCF peaked in 2000/01 and then progressively declined to an historical low point in 2010/11. This decline was associated with a decline in targeted effort and low CPUE during the Millennium Drought (2002–10) and likely reflected a decline in fishable biomass in the Coorong estuary. Since 2010/11, higher catches and record-high catch rates likely reflected a substantial increase in biomass in the Coorong estuary. These results suggest that the biomass of this stock is unlikely to be depleted, recruitment is unlikely to be impaired, and that that the current level of fishery performance is unlikely to move the stock in the direction of becoming recruitment impaired. On this basis, the LCF for Mulloway is classified as **sustainable** stock.

3.2.2 Black Bream (*Acanthopagrus butcheri*)

Biology

Black Bream (*Acanthopagrus butcheri*) is a member of the Sparidae family of fishes (Gomon et al. 2008). It has a wide distribution in estuaries and coastal waters of southern Australia, from central New South Wales (NSW) to central west coast WA, including Tasmania, where it is a popular target species for commercial and recreational anglers (Kailola et al. 1993).

Black Bream is a medium-bodied, slow-growing and long-lived species that can grow to 600 mm TL and live to 32 years of age. In SA, male and female Black Bream mature at around 340 mm TL and 289 mm TL, respectively (Cheshire et al. 2013). Spawning is usually confined to estuarine habitats and occurs from August to December each year.

Black Bream is an estuarine-dependent species, completing much of its life-cycle within a single estuary (Chaplin et al. 1998). Results of tagging studies done in estuaries in SA (Hall 1984), WA (Norriss et al. 2002) and Victoria (Butcher and Ling 1962; Hindell et al. 2008) found limited or no evidence of migration among estuaries.

Growth and recruitment of Black Bream within estuaries are strongly influenced by environmental conditions associated with freshwater inflows (Williams et al. 2013). Thus, it is likely that at the local scale at least, annual recruitment strength is dependent on environmental conditions, with substantial inter-annual variation in recruitment affecting local stock demographics and biomass. Here, the assessment of status is undertaken at the biological stock level - the Coorong Stock.

Fishery statistics

The highest total annual catch of Black Bream was 47.3 t in 1984/85 (Figure 3.3). Annual catches remained >35 t until 1986/87 and then declined to 3.7 t in 1990/91 and have been historically low in most years since. From 1990/91–2016/17 the average annual catch was 4.3 t. The total catch of 1.3 t in 2017/18 was among the lowest on record. The low catches since the early 1990s have been associated with low targeted fishing effort.

Historically, the dominant gear type used to target Black Bream is the LMGN (Figure 3.3). However, targeted fishing for Black Bream has been low since the early 1990s, with the most of the annual catches taken by fishers when targeting other species. Mean annual CPUE for LMGN peaked at 2.3 kg.net-day^{-1} in 2003/04 and then declined to an historical low of 0.5 kg.net-day^{-1} in 2013/14. The estimate of CPUE for 2017/18 is confidential. The catch rates for Black Bream should be interpreted with caution due to considerable uncertainty around CPUE (kg.net-day^{-1}) as a measure of relative abundance. This is because spatial contraction of the fishery for Black

Bream, particularly during low inflow years, may increase their catchability and thus confound interpretation of CPUE as an indicator of population abundance (Earl et al. 2016). Given the high wholesale value of Black Bream (EconSearch 2017), catch is considered a more appropriate indicator of abundance for this species in the Coorong.

Stock status

Black Bream is a secondary species for the commercial LCF (PIRSA 2015). The most recent stock assessment for Black Bream in the Coorong estuary was done in 2016 and used a weight-of-evidence approach that considered fishery catch and effort data and fishery age structures to 30 June 2015 (Earl et al. 2016). No catch sampling has been done for Black Bream since 2015.

Analysis of the long-term chronology of fishery production for Black Bream in the Coorong estuary indicated high variability in biomass. In the late 1980s, fishery production plummeted to historically low levels and have not recovered. The low catches since the 1980s have been associated with low targeted effort. Given the high wholesale value of Black Bream compared to other species available to the LCF (EconSearch 2017), the lack of targeting and low catches since the 1980s likely reflects low biomass in the Coorong estuary.

Annual fishery age structures from 2007/08–2015/16 comprised fish between four and 17 years, although fish older than 10 years were rare (Earl et al. 2016), despite the potential for this species to reach 32 years of age (Ye et al. 2017). Within any year, relatively few age classes contributed most to the catch, reflecting the relative strength of these year classes. This variation in year class strength relates to inter-annual variation in recruitment. Larger year classes appear to be linked to freshwater releases to the Coorong estuary in 1997/98, 2003/04, 2006/07, 2009/10 and 2012/13, confirming that environmental conditions associated with freshwater inflow are important for successful reproduction of Black Bream in the Coorong estuary (Earl et al. 2016; Ye et al. 2017). The recruitment of these year classes to the fishable biomass since the mid-1990s indicates that environmental conditions in the Coorong estuary supported successful spawning in those years. Despite this recruitment, fishery production has remained low compared to historical levels. Recruitment levels over the past 25 years have not been strong enough to support recovery of the stock following the decline in the 1980s.

The above evidence indicates that the biomass of this stock has been reduced through fishing mortality, such that recruitment is impaired. Management measures have been put in place to recover the stock but have not yet resulted in measurable improvements. More time is required for the management measures to take effect. On this basis, the Black Bream stock in the Coorong estuary is classified as a **depleted** stock.

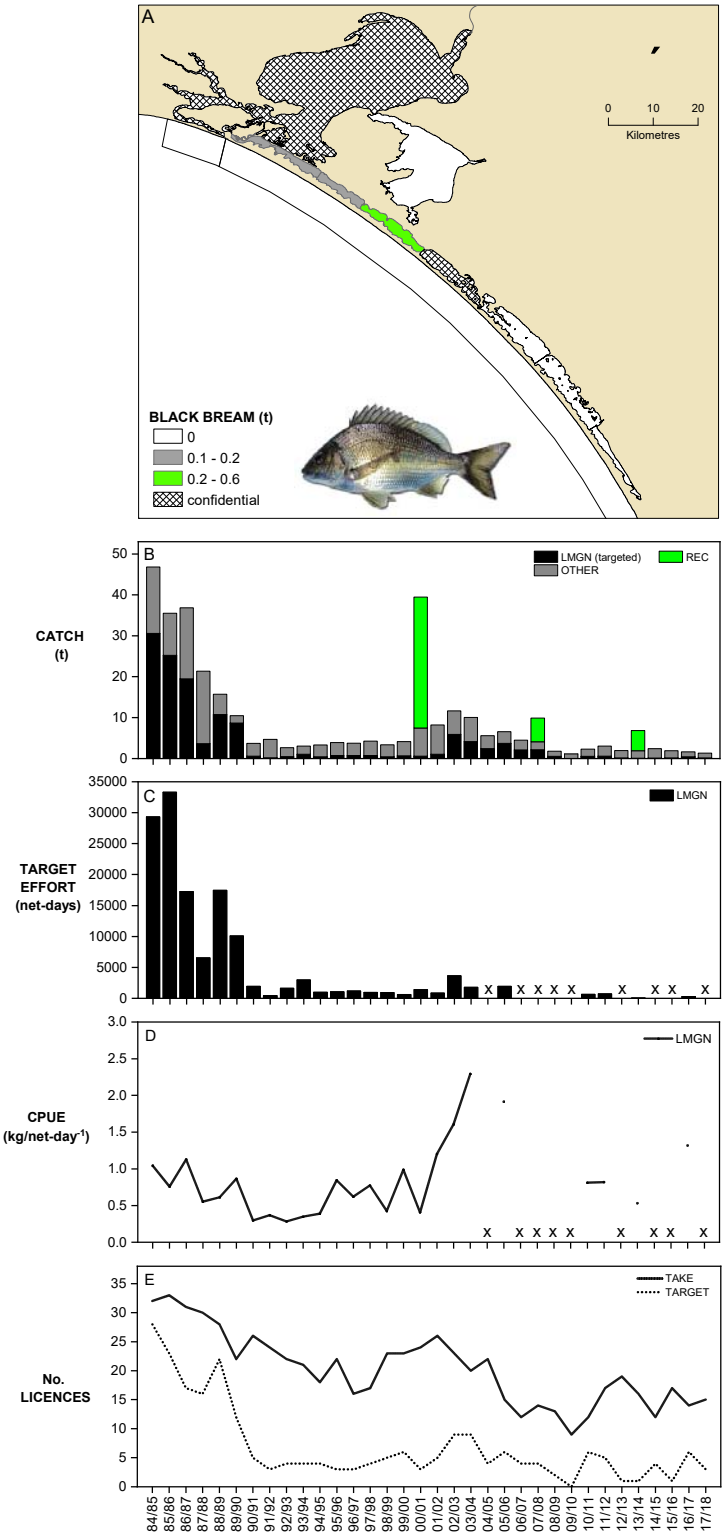

Figure 3.3. Fishery statistics for Black Bream. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) targeted effort for LMGN; (D) targeted CPUE for LMGN; and (E) the number of active licence holders that reported taking or targeting the species. Crosses indicate confidential data.

3.2.3 Greenback Flounder (*Rhombosolea tapirina*)

Biology

Greenback Flounder (*Rhombosolea tapirina*) is a member of the Rhombosoleidae family of fishes (Gomon et al. 2008). Its distribution in Australia extends from south-eastern WA, around the southern coasts of the continent and Tasmania, and up to southern NSW (Kailola et al. 1993). It also occurs in New Zealand (Sutton et al. 2010). Juveniles and adults mainly occur over unvegetated substrates in coastal waters (< 100 m depth) and are often abundant in estuaries.

Greenback Flounder can grow to 450 mm TL and live to 10 years of age (Sutton et al. 2010). It is fast growing, reaching around 220 mm TL in its first year of life (Earl et al. 2014). The estimated size at maturity for females and males in the Coorong estuary is 198 and 211 mm TL, respectively (Earl 2014). Spawning occurs in the deeper areas of estuaries as well as offshore, and is most frequent from March to August (Kurth 1957; Crawford 1984; Earl 2014).

In SA, the species is considered a 'marine estuarine-opportunist' (Earl 2014) – a marine species that enters estuaries in substantial numbers, particularly during the juvenile and early adult life stages, but use marine waters as alternative habitat. This is supported by a recent acoustic telemetry study that showed that the Coorong population is most likely part of a broader population that encompasses the adjacent marine environment (Earl et al. 2017). Nevertheless, the stock structure of Greenback Flounder in SA is uncertain. Specifically, the extent of the portion of the population in the marine environment adjacent to the Coorong estuary is not known. Here, the assessment of stock status is undertaken at the management unit level – the LCF.

Fishery statistics

Total annual catch has been highly variable since 1984/85. It increased to a peak of 65 t in 1990/91 and subsequently declined to < 1 t during 2007/08–2010/11 (Figure 3.4). In 2011/12, catch increased sharply to 31 t and then declined to 0.72 t in 2017/18. Catches taken using LMGN (targeted and non-targeted) typically account for >95% of annual catches.

The trends in total catch reflect the trends in targeted fishing effort. In recent years, annual targeted effort declined from a peak of 9,773 net-days in 2011/12 to 76 net-days in 2013/14 and has since remained low. Trends in CPUE also followed those of total catch, although catch rates in recent years have been more variable. The catch rates should be interpreted with caution due to considerable uncertainty around CPUE (kg.net-day^{-1}) as a measure of relative abundance resulting from likely (potential) environmental influences on catchability (Earl and Ye 2016). Given its high wholesale value (EconSearch 2017), catch is considered a more appropriate indicator of abundance for Greenback Flounder in the Coorong.

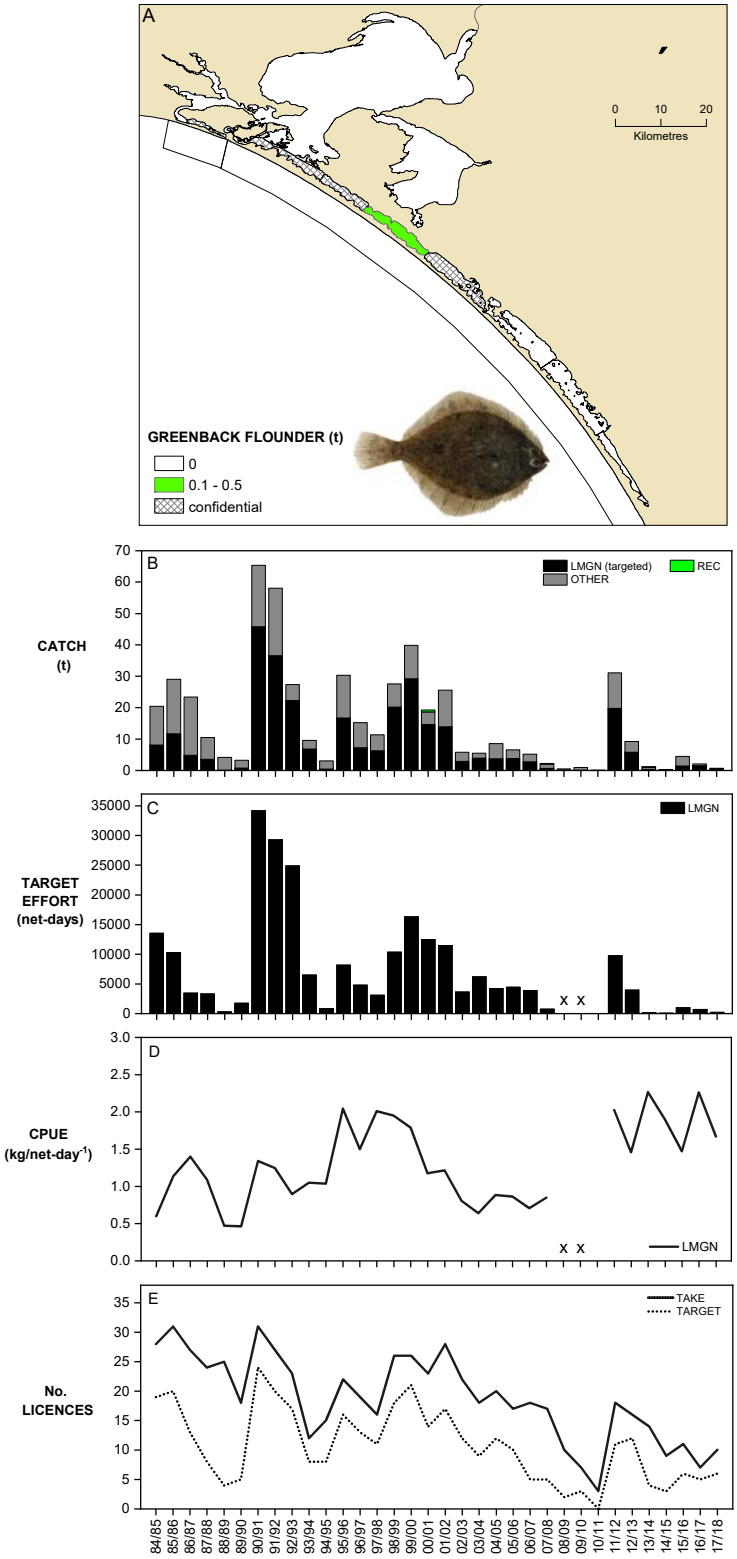

Figure 3.4. Fishery statistics for Greenback Flounder. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) targeted effort for LMGN; (D) targeted CPUE for LMGN; and (E) the number of active licence holders taking or targeting the species. Crosses indicate confidential data.

Stock status

Greenback Flounder is a secondary species for the LCF (PIRSA 2015). The most recent stock assessment for this species was completed in 2016 and used a weight-of-evidence approach that considered fishery data and fishery age structures to the end of June 2015 (Earl and Ye 2016).

Long-term trends in fishery production for Flounder indicate extreme inter-annual variability in fishable biomass in the Coorong estuary (Earl and Ye 2016). Annual catches were highly variable during the 1980s–early 2000s, and subsequently declined to historically low levels during the Millennium Drought. In 2011/12, (i.e. the year after drought-breaking Murray River flows reached the Coorong estuary), a large biomass of large Flounder moved into the estuary from the adjacent marine environment (Earl et al. 2017), and catch increased abruptly to 31 t. This sudden increase in biomass was not consistent with a spawning biomass that was in a recruitment-overfished state (Earl and Ye 2016). The lack of targeted fishing effort and low catches in recent years have been associated low freshwater inflows and likely reflect a low biomass in the Coorong estuary.

The high inter-annual variation in Flounder abundance in the Coorong estuary has been strongly associated with variation in freshwater inflow to the estuary, with a lag of 1–2 years (Earl and Ye 2016). This is because large areas of estuarine habitat that support high abundances of Flounder are only available after years of high freshwater inflow (1990/91, 1996/97, 2010/11). Alternatively, during periods of low inflow (2001/02–2009/10, 2012/13–2015/16, 2017/18), abundance in the estuary is typically very low. It is likely that low flow conditions reduce the favourable habitat for Flounder in the estuary, during which time, some individuals move from the estuary to the ocean where they remain and can possibly return when estuarine conditions improve (Earl et al. 2017). This was evidenced by the large biomass of Flounder in the estuary in 2011/12, after the most recent high inflow event as indicated by trends in catch (Earl and Ye 2016). The current low biomass in the Coorong estuary appears to relate to the lack of freshwater inflow to the system in recent years, rather than a depleted spawning stock biomass.

Low targeted effort and catches since 2012/13 likely reflect low fishable biomass in the Coorong estuary as a consequence of low recruitment over several recent years due to the low freshwater inflows to the estuary (i.e. non-fishing effects). Biomass in the Coorong estuary has been reduced through non-fishing effects and, as a consequence, recruitment is impaired. On this basis, the Greenback Flounder fishery is classified as a **depleted** stock.

3.2.4 Environmental performance indicator

Modelled daily salinity concentrations for the Coorong estuary between Goolwa Barrage and Salt Creek for the 2018/19 reporting year indicated that the amount of suitable habitat for Mulloway was stable at 60–70% from February–August, declined during September–October and subsequently remained low (34–50%) through to 31 January 2019 (Figure 3.5). The ELMGN performance indicator for habitat available to Mulloway in the Coorong estuary was 55.04% for the 2018/19 reporting year, which was marginally above the target reference point of 55% (Figure 3.6).

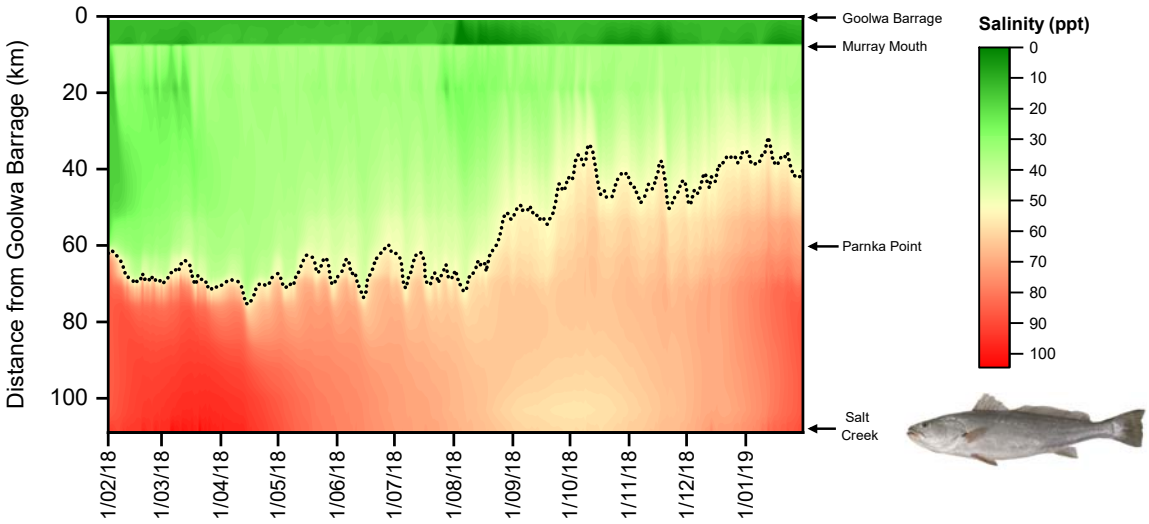

Figure 3.5. Modelled salinity concentration with distance from the Goolwa Barrage for the 2018/19 reporting year, with the approximate salinity threshold for Mulloway (51 ppt) shown as a dotted line. Salinity threshold is the level of salinity that was lethal for 10% of test fish, as determined by Ye et al. (2013).

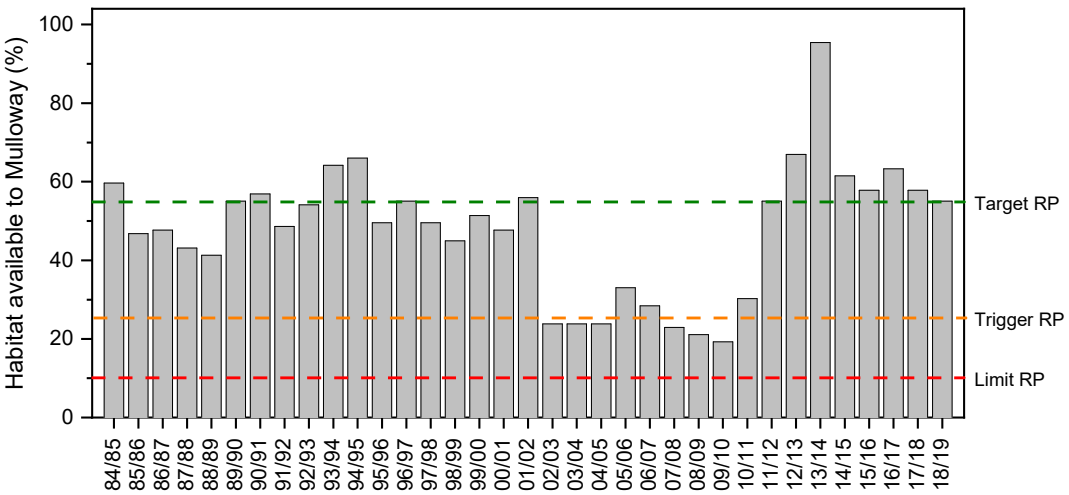

Figure 3.6. Estimates of the ELMGN performance indicator for habitat available to Mulloway in the Coorong estuary from 1984/85–2018/19 (reporting years), showing target, trigger and limit reference points (RP).

3.3 ESTUARINE SMALL MESH GILLNET SECTOR

3.3.1 Yelloweye Mullet (*Aldrichetta forsteri*)

Biology

Yelloweye Mullet (*Aldrichetta forsteri*) is a member of the Mugilidae family of fishes (Gomon et al. 2008). It occurs along the southern coasts of Australia, from Murchison River in WA to the Hunter River in NSW, and around Tasmania. Yelloweye Mullet typically occur in schools in coastal waters (< 20 m depth), and are often abundant in estuaries (Kailola et al. 1993). The species is considered a marine estuarine-opportunist, i.e. it spawns at sea; regularly enters estuaries, particularly as juveniles, but use, to varying degrees, coastal waters as alternative nursery areas (Potter et al. 2015).

Yelloweye Mullet can grow to 440 mm TL and live to 10 years of age (Earl and Ferguson 2013). Females mature at around 240 mm TL, while males mature at around 250 mm TL. Spawning occurs from early spring to early autumn, and is most frequent during December–February.

Biological stock structure for Yelloweye Mullet throughout southern Australia is uncertain. It has been suggested that the populations of this geographic region form two stocks, i.e. the Western and Eastern Stocks. The populations on SA's far West Coast are thought to contribute to the Western Stock (Smith et al. 2008), while populations in Spencer Gulf, Gulf St Vincent and the South East, including the Coorong estuary, are thought to be part of the Eastern Stock (Pellizzari 2001). Here, the assessment of stock status is undertaken at the management unit level – LCF.

Fishery statistics

The highest total annual catch of Yelloweye Mullet was 353 t in 1989/90 (Figure 3.7). From then, catch progressively declined to a low of 122 t in 2004/05. It increased and ranged between 223–260 t from 2007/08–2010/11, before abruptly declining to 124 t in 2014/15. The recent decline in catch was associated with a decline in targeted CPUE for SMGN (i.e. the dominant gear type used to target this species) from a peak of 14.4 kg.net-day^{-1} in 2008/09 to 5.2 kg.net-day^{-1} in 2014/15. In the three years since 2014/15, estimates of annual catch and CPUE have been higher. The total catch of 158 t in 2017/18 was related to moderate CPUE of 13.1 kg.net-day^{-1}.

The numbers of fishers taking and targeting Yelloweye Mullet each year are closely linked, which indicates that the species is mostly taken by fishers who are targeting the species, rather than taken as by-product. The number of fishers targeting the species has declined from 34 in 1986/87 to 18 in 2017/18.

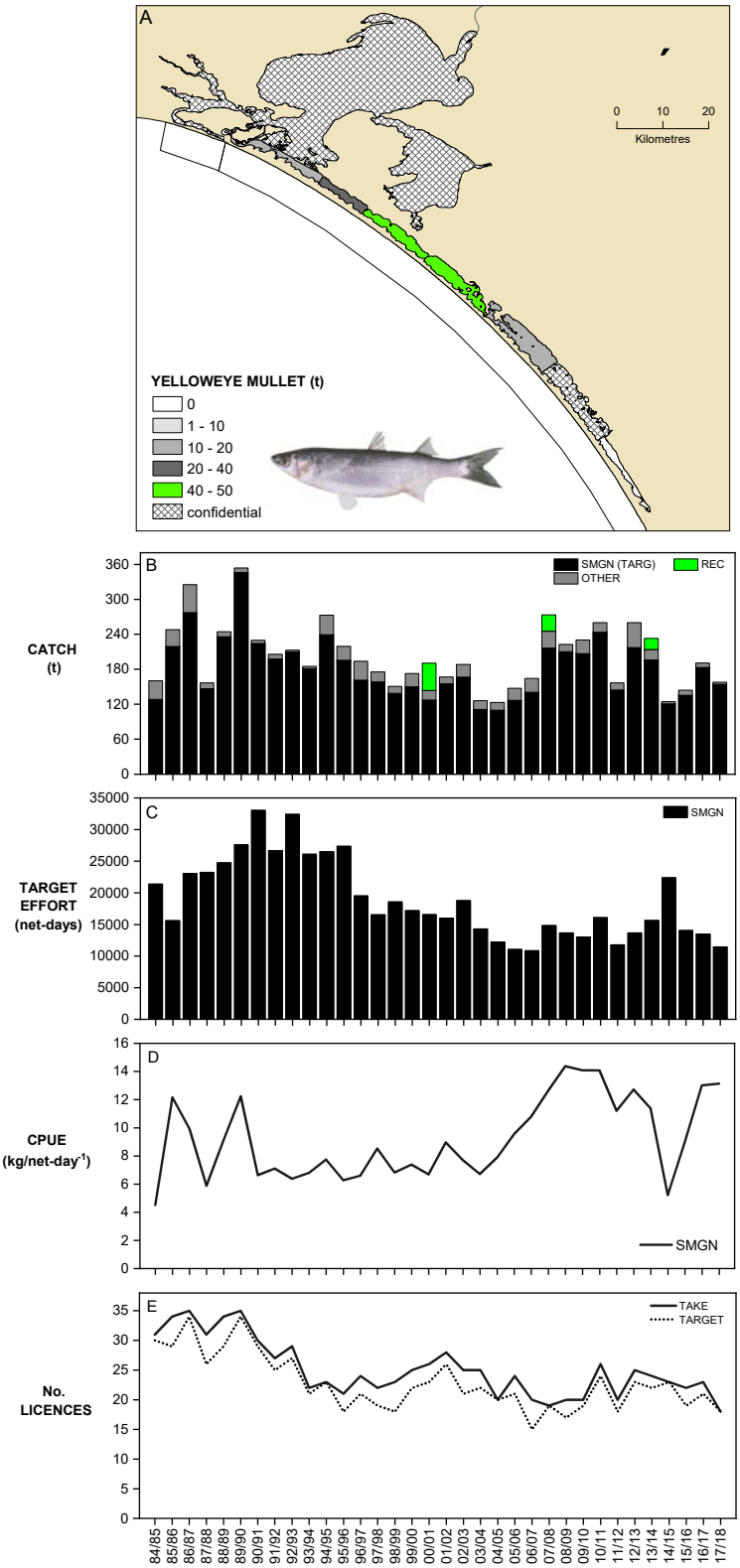

Figure 3.7. Fishery statistics for Yelloweye Mullet. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the main gear type (small mesh gillnets (SMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) targeted effort for SMGN; (D) targeted CPUE for SMGN; and (E) the number of licence holders that reported taking or targeting the species.

Stock status

Yelloweye Mullet is a primary species for the commercial LCF (PIRSA 2015). This fishery has traditionally been the most important of SA's fisheries for Yelloweye Mullet, typically accounting for around 90 per cent of the State's total commercial catch. The most recent assessment for Yelloweye Mullet in the LCF was completed in 2013, and used a weight-of-evidence approach that considered fishery catch and effort data and fishery age structures to the end of June 2012 (Earl and Ferguson 2013).

Commercial landings of Yelloweye Mullet in the LCF peaked in 1989/90 and then progressively declined to a historical low in 2004/05. This long-term decline likely reflects redirection of targeted fishing effort to higher value species rather than a declining biomass, because estimates of annual gillnet CPUE steadily increased during and after this period to an historic peak in 2008/09. The subsequent decline in catch rates through to 2014/15 was indicative of a possible decline in fishable biomass in the Coorong estuary. However, the high catch rates and moderate catches in recent years suggests that the biomass of this stock is unlikely to be depleted, recruitment is unlikely to be impaired, and that the current level of fishing mortality is unlikely to cause the stock to become recruitment impaired. On this basis, the LCF for Yelloweye Mullet is classified as a **sustainable** stock.

3.3.2 Environmental performance indicator

Modelled daily salinity concentrations for the Coorong estuary for the 2018/19 reporting year indicated that the amount of suitable habitat for Yelloweye Mullet was stable at around 75% from February to July. Based on model outputs, the entire estuary was available for the species in August and the amount of suitable habitat remained high through to November, before declining during December and January (Figure 3.8). The ESMGN performance indicator for habitat available to Yelloweye Mullet in the Coorong estuary was 67% for the 2017/18 reporting year, which was above the target reference point of 50% (Figure 3.9).

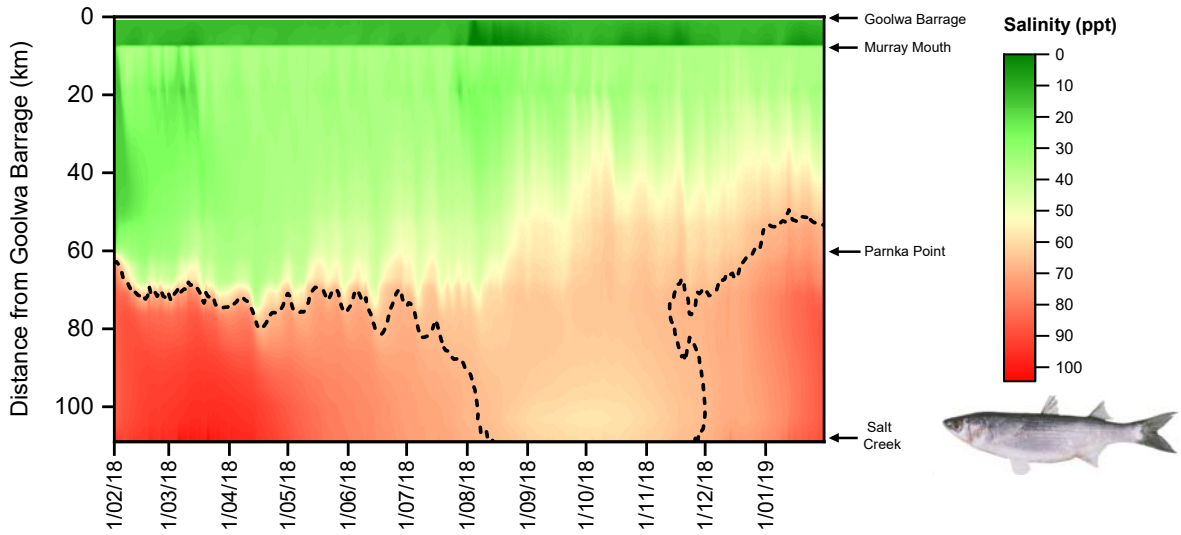

Figure 3.8. Estimated salinity concentration with distance from the Goolwa Barrage for the 2018/19 reporting year, with the approximate salinity threshold for Yelloweye Mullet (68 ppt) shown as a dashed line. Salinity threshold is the level of salinity that was lethal for 10% of test fish, as determined by Ye et al. 2013.

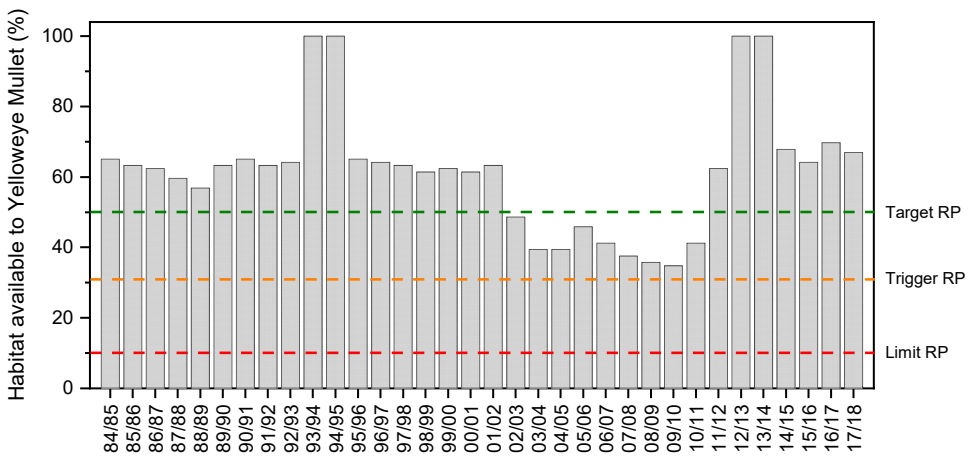

Figure 3.9. Estimates of the ESMGN performance indicator for habitat available to Yelloweye Mullet in the Coorong estuary from 1984/85–2018/19 (reporting years), showing target, trigger and limit reference points (RP).

3.4 FRESHWATER LARGE MESH GILLNET SECTOR

3.4.1 Golden Perch (*Macquaria ambigua*)

Biology

Golden Perch (*Macquaria ambigua*) is a member of the Percichthyidae family of fishes (Gomon et al. 2008). It occurs throughout most of the Murray-Darling Basin (MDB), as well as numerous other freshwater systems in NSW, SA, Victoria and southern Queensland (Battaglene and Prokop 1987). In SA, it is common throughout the lower Murray River, including the Lower Lakes.

Golden Perch can grow to 760 mm TL and live to 26 years of age (Mallen-Cooper and Stuart 2003). In the lower Murray River, individuals usually mature at 2–4 years of age. No estimate of size-at-maturity exists for the Lower Lakes stock. Spawning occurs mainly during spring and summer (Battaglene and Prokop 1987).

Several biological stocks of Golden Perch occur in the MDB (Keenan et al. 1995). This includes two main stocks: (1) the Central Stock, which is situated in the lower–mid basin waters (i.e. NSW, Victoria and SA); and (2) the Lakes Stock, which occurs in the Lower Lakes, and extends upstream to Renmark. Here, the assessment of stock status is undertaken at the management unit level – the LCF.

Fishery statistics

Total annual catches of Golden Perch have fluctuated cyclically since the early 1990s (Figure 3.10). Annual catches were below 40 t from 1984/85–1991/92 and then increased steeply to an historic peak of 206 t in 1994/95. Catches subsequently declined to 36 t in 2001/02 then increased to a second smaller peak of 152 t in 2006/07. Then, catches declined to 34 t in 2012/13, before increasing to 88 t in 2013/14 and remaining between 79–84 t per year until 2016/17. The total catch in 2017/18 was 105 t.

Targeted catches from LMGN in Lake Alexandrina comprised 69% (5-year average to 2017/18) of catches and followed the same temporal trends as total catch (Figure 3.10). Annual CPUE for LMGN also followed a similar temporal trend with peaks of 1.48 kg.net-day^{-1} in the early 1990s and 1.21 kg.net-day^{-1} in 2006/07. In recent years, CPUE has increased from 0.62 kg.net-day^{-1} in 2009/10 to an historic peak of 1.55 kg.net-day^{-1} in 2017/18. The numbers of fishers who reported taking Golden Perch declined over the last 20 years at a similar rate as the lower numbers of fishers that reported targeting the species.

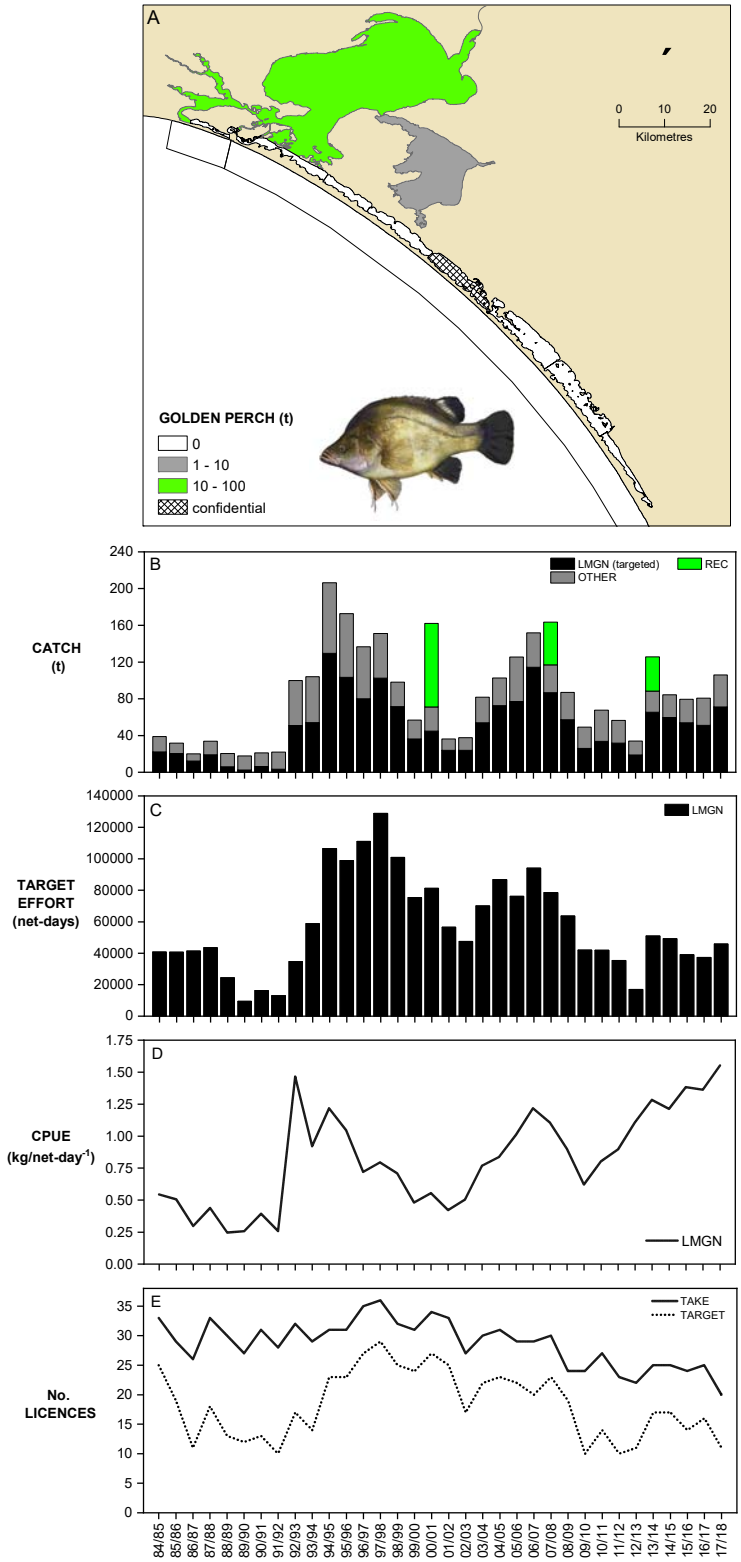

Figure 3.10. Fishery statistics for Golden Perch. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) targeted effort for LMGN; (D) targeted CPUE for LMGN; and (E) the number of licence holders that reported taking or targeting the species.

Stock status

Golden Perch is a primary species for the commercial sector of the LCF (PIRSA 2016). This likely reflects its history of relatively high catches in some years and its exceptionally high wholesale value, particularly compared to other freshwater species available to the fishery (EconSearch 2017). The most recent stock assessment for Golden Perch in the Lower Lakes was completed in 2012, and used a weight-of-evidence approach that considered fishery catch and effort data and fishery age structures to the end of June 2012 (Ferguson and Ye 2012). No fishery catch sampling has been done for this species since February 2012.

The most obvious long-term trend in the fishery statistics for Golden Perch is the cyclical nature of the variation in total catch, which has been closely linked to the trends in targeted effort and CPUE. The high catches and exceptionally high catch rates over the past 5 years likely reflect high fishable biomass in the Lower Lakes. The biomass of this stock is unlikely to be depleted, recruitment is unlikely to be impaired, and the current level of fishing mortality is unlikely to cause the stock to become recruitment impaired. On this basis, the LCF for Golden Perch is classified as a **sustainable** stock.

3.4.2 Bony Herring (*Nematalosa erebi*)

Biology

Bony Herring (*Nematalosa erebi*) is a member of the Clupeidae family of fishes (Classon and Booth 2002). It occurs throughout the MDB, in the Lake Eyre drainage system and across Queensland, most of the Northern Territory and parts of north-western WA. In SA, the species is abundant in the Murray River, including the Lower Lakes. It often occurs in large shoals near the bottom, but is also common in the shallows of still or slow-flowing areas.

Bony Herring is a deep-bodied fish with a small head and blunt snout. It can grow to 470 mm TL but is commonly 150–200 mm TL (Classon and Booth 2002). Bony Herring spawn in spring and summer after reaching maturity at a size of ~80 mm TL. Stock structure in SA is uncertain. Here, the assessment of stock status is undertaken at the management unit level – the LCF.

Fishery statistics

Total annual catches of Bony Herring have exceeded 1,100 t twice in the past 34 years: 1,172 t in 1989/90 and 1,128 t in 1991/92, before consistently declining to a record low of 215 t in 2002/03 (Figure 3.11). This represents an 81% decline over ~10 years. This decline corresponded with a 49% decline in LMGN effort that produced catches of Bony Herring and a 62% decline in CPUE. After 2002/03, catch and CPUE increased to smaller secondary peaks in 2009/10, while effort remained relatively stable. The total catch of 362 t in 2017/18 was associated with moderate CPUE of 4.45 kg.net-day^{-1}. The numbers of fishers who reported taking and targeting Bony Herring have been vastly different over time, suggesting the species is typically taken as by-product when other, or a suite of species are targeted.

Stock status

Bony Herring is a primary species for the LCF (PIRSA 2015). This reflects the relatively high catches of this species taken compared to other species. Most of the catch is taken as by-product by the gillnet fishers targeting Golden Perch in the Lower Lakes. This was reflected by the relatively high numbers of fishers who reported taking the species and the few who targeted it.

Annual catches of Bony Herring declined considerably during 1990s, which largely reflected the decline in LMGN effort that occurred over that period. Catch rates also declined during this time, but subsequently increased and have been relatively high since 2010/11. Catches have also been consistent at moderate levels since 2010/11. These fishery-dependent data suggest that the biomass of this stock is unlikely to be depleted and recruitment is unlikely to be impaired. The recent moderate levels of fishing mortality are unlikely to cause the stock to become recruitment impaired. On this basis, the LCF for Bony Herring is classified as a **sustainable** stock.

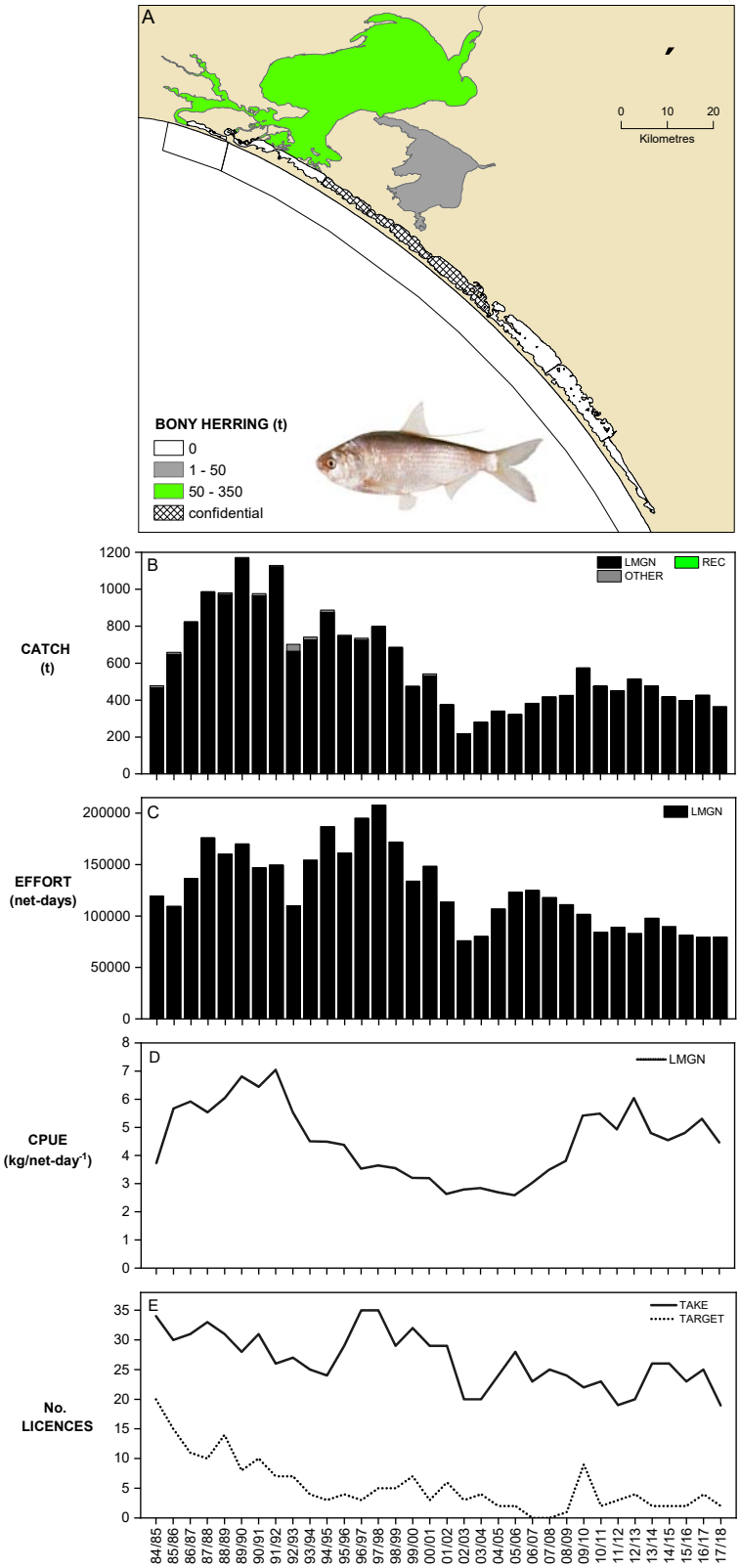

Figure 3.11. Fishery statistics for Bony Herring. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only); (C) total effort that produced catches of Bony Herring for LMGN; (D) CPUE for LMGN; and (E) the number of licence holders that reported taking the species.

3.4.3 Common Carp (*Cyprinus carpio*)

Biology

Common Carp (*Cyprinus carpio*) (hereafter 'Carp') is a member of Cyprinidae family of fishes (Classon and Booth 2002). The species is native to Asia, and is a major pest in Australia, threatening native fishes due to environmental damage and competition for resources. In SA, Carp is declared noxious under the *Fisheries Management Act 2007*.

Carp can grow to 1,200 mm TL but are typically <500 mm TL (Classon and Booth 2002). Individuals mature at 1–3 years of age. Females have high fecundity and each large female is able to produce up to one million eggs. Spawning occurs during spring and summer. Here, assessment of stock status is undertaken at the management unit level – the LCF.

Fishery statistics

Total annual catches of Carp have fluctuated cyclically over the last 30 years (Figure 3.12). They ranged from 277–360 t during 1984/85–1986/87 and then increased to a peak of 1,021 t in 1991/92. Catches subsequently declined to 208 t in 2001/02 before increasing to a second smaller peak of around 700 t in 2005/06 and then remained stable until 2008/09. In 2017/18, the total catch was 402 t, of which 99% was taken in the Lower Lakes using LMGN.

Total annual LMGN effort that produced catches of Carp has been stable at moderate levels over the last 10 years. It was ~83,000 net-days during 2015/16–2017/18, which is considerably lower than reported levels during the 1980s and 1990s, when it ranged from 117,580–236,804 net-days. Annual CPUE followed a similar temporal trend as total catch with peaks in the early 1990s and 2000s. In 2017/18, CPUE was 4.7 kg.net-day^{-1}, which was around 22% above the long-term average. The numbers of fishers who reported taking and targeting Carp each year have been very different, suggesting the species was mostly taken as by-product when other species were targeted.

Stock status

No stock status is assigned for this species.

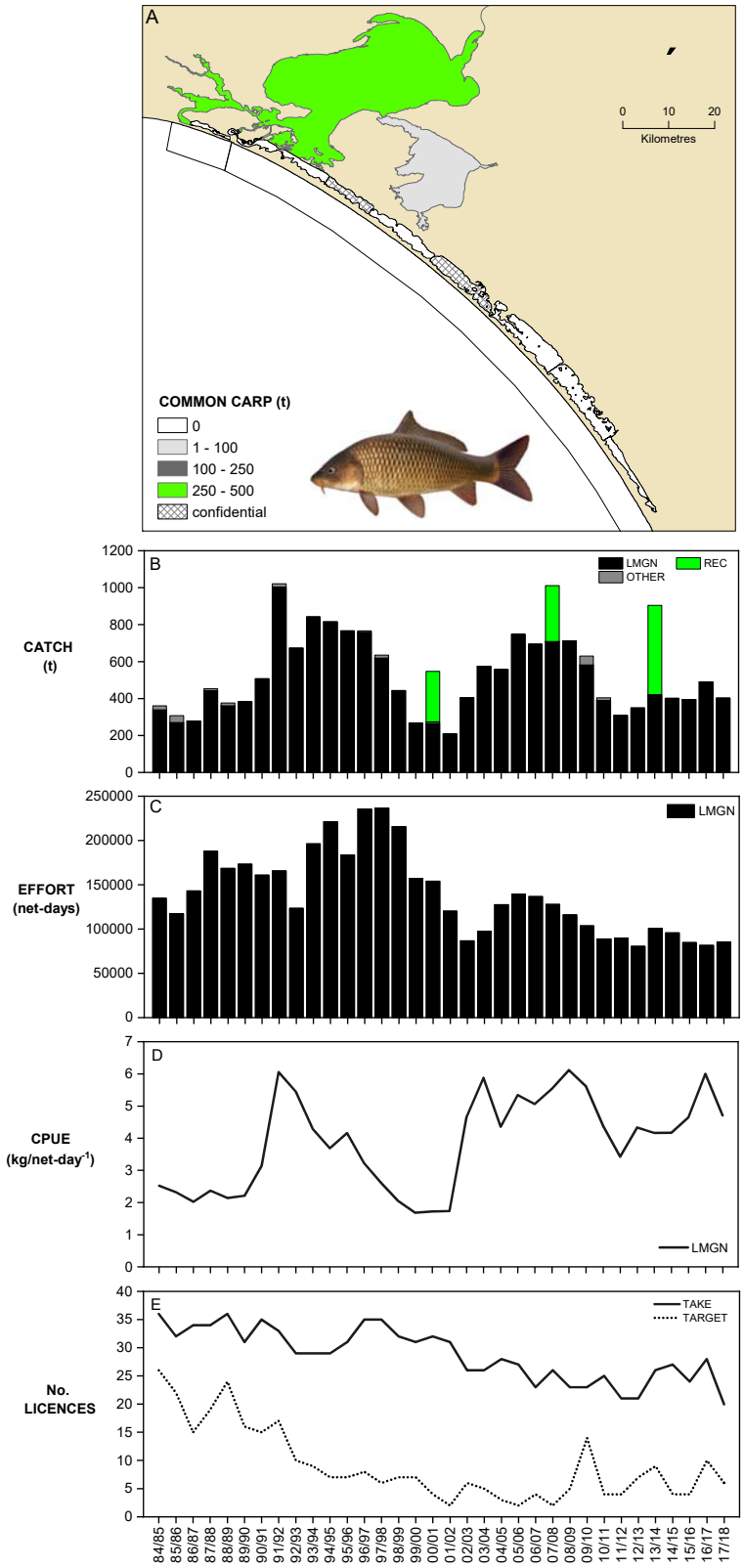

Figure 3.12. Fishery statistics for Common Carp. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) total effort that produced catches of Common Carp for LMGN; (D) CPUE for LMGN; and (E) the number of licence holders that reported taking the species.

3.4.4 Environmental performance indicator

The FWLMGN performance indicator for mean water level in the Lower Lakes was 0.65 m for the 2018/19 reporting year, which was above the target reference point of 0.4 m (Figure 3.11).

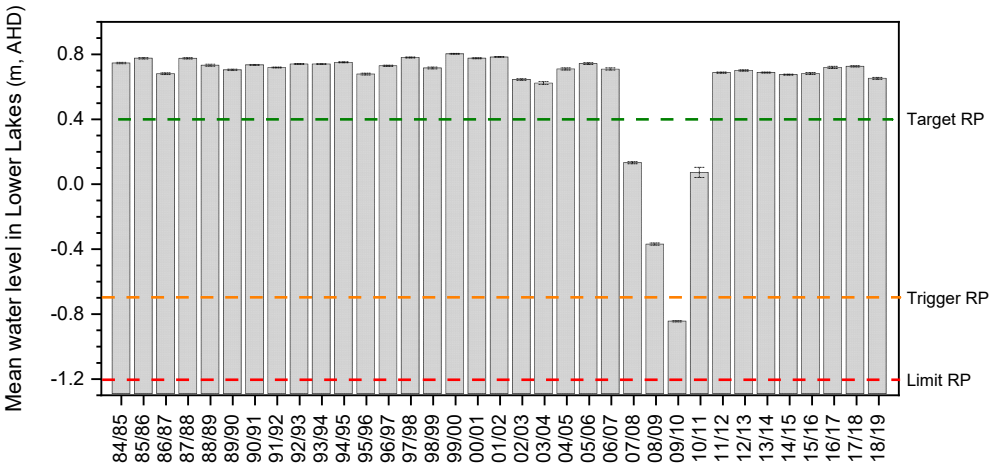

Figure 3.13. Estimates of the FWLMGN performance indicator for mean water level in the Lower Lakes (± S. E.) from 1984/85–2018/19 (reporting years), showing target, trigger and limit reference points (RPs).

3.5 PIPI SECTOR

3.5.1 Pipi (*Donax deltoides*)

Biology

Pipi (*Donax deltoides*) is a member of the Donacidae family of marine bivalve molluscs (Edgar 2000). It is common on high-energy sandy beaches from southern Queensland to the mouth of the Murray River in SA (Murray-Jones and Ayre 1997). The Coorong beaches adjacent to the Murray Mouth, particularly along Younghusband Peninsula, provide high quality habitat for Pipi, and it is likely that the population of Pipi in the Coorong region represents the largest single stock abundance of this species in Australia (King 1976).

For the population of Pipi on Younghusband Peninsula, the size at which 50% and 95% were sexually mature were 28.35 mm and 32.48 mm, respectively (Ferguson and Mayfield 2006). Spawning typically occurs from September–November (Ferguson and Ward 2014). Despite numerous studies, the biological stock delineation of Pipi remains unclear. Here, assessment of stock status is presented at the management unit level –the LCF.

Fishery statistics

Pipi are harvested along the ocean beach of Younghusband Peninsula by commercial fishers using hand-held rakes (Figure 3.14). Concerns about high annual catches (~1000 t) and effort from 1999/00 to 2005/06, concurrent with a steep decline in catch rates and the existence of considerable latent effort (Ferguson and Mayfield, 2006), resulted in a move to quota management in 2007/08, with catches constrained from 2009/10. The total catch of 646 t in 2017/18, which includes small contributions by the Marine Scalefish Fishery (MSF), was the highest since 2007/08, reflecting increases in the annual TACC over the past decade. Annual CPUE was low (<500 kg.fishing day^{-1}) during 2007/08–2015/16, and subsequently increased to 709 kg.fishing day^{-1} in 2017/18. However, catch rates should be interpreted with caution due to considerable uncertainty around CPUE (kg.fisher day^{-1}) as a measure of relative abundance resulting from differences in reporting effort among individual licence holders and changes in fisher practices when targeting different size classes of pipi for bait and human consumption markets (Ferguson and Ward 2014; Ferguson et al. 2015). Data on catch by the MSF are not presented due to data confidentiality.

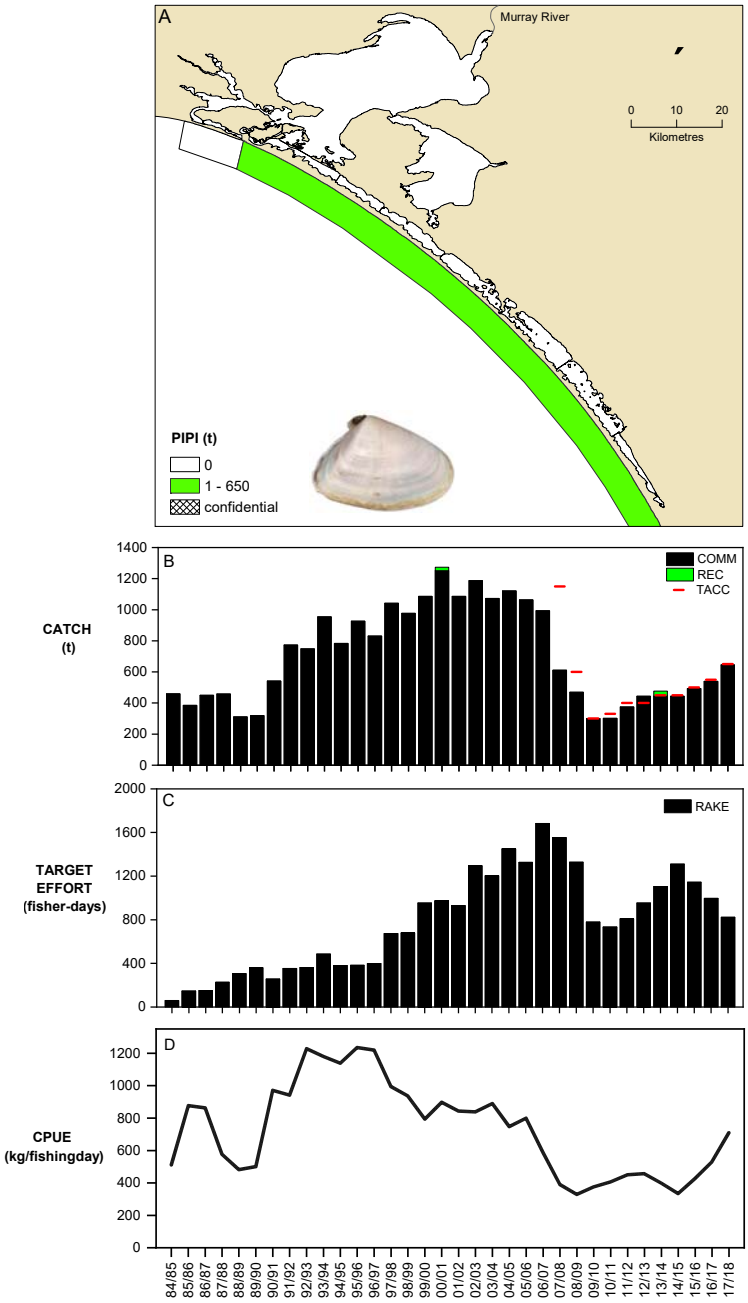

Figure 3.14. Fishery statistics for Pipi. (A) Map of the LCF reporting blocks showing the catch distribution for 2017/18; Long term trends in: (B) total catch for the LCF and MSF combined and the recreational sector (for 2000/01, 2007/08, 2013/14); (C) targeted effort for cockle rakes; and (D) CPUE for cockle rakes. Note: (i) total catch has been constrained by the TACC since 2009/10; (ii) total catch for 2012/13 was higher than the TACC due to a shift in the quota period from calendar years to financial years; and (iii) catch rates should be interpreted with caution due to considerable uncertainty around CPUE (kg.fisher day^{-1}) as a measure of relative abundance (see Ferguson and Ward 2014; Ferguson et al. 2015).

Biological performance indicators

The harvest strategy for Pipi aims to maintain mean annual relative biomass of Pipi above a target reference point of 11 kg/4.5 m² and not less than the trigger reference point of 9 kg/4.5 m² (PIRSA 2016). The estimate of mean annual relative biomass in 2017/18 was 19.1 kg/4.5 m² which was 74% above the target reference point of 11 kg/4.5 m² (Figure 3.15).

Considerable changes in the distribution of sizes of Pipi occurred between November 2017 and February 2018 (Figure 3.16). Pre-recruits comprised 26% of the overall size frequency distribution in November 2017, which was below the target reference point of 30%. In February 2018, pre-recruits comprised 46% of the overall size frequency distribution, which was above the target reference point of 30%.

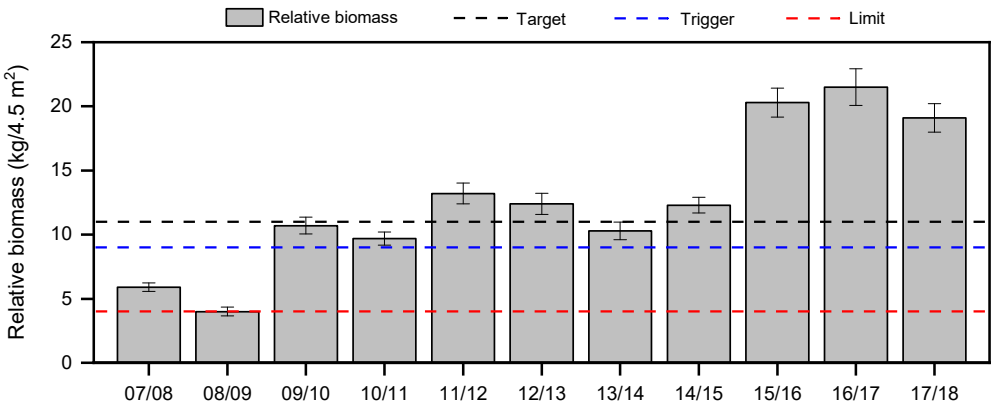

Figure 3.15. Estimates of fishery-independent mean annual relative biomass of Pipi from 2007/08–2017/18 showing target, limit and trigger reference points. The harvest strategy aims to maintain relative biomass above a target of 11 kg/4.5 m² (black dashes) and not less than the trigger reference point of 9 kg/4.5 m² (blue dashes). The lower limit reference point (red dashes) represents a historically low mean annual relative biomass of 4 kg/4.5 m² below which there may be risk of recruitment overfishing.

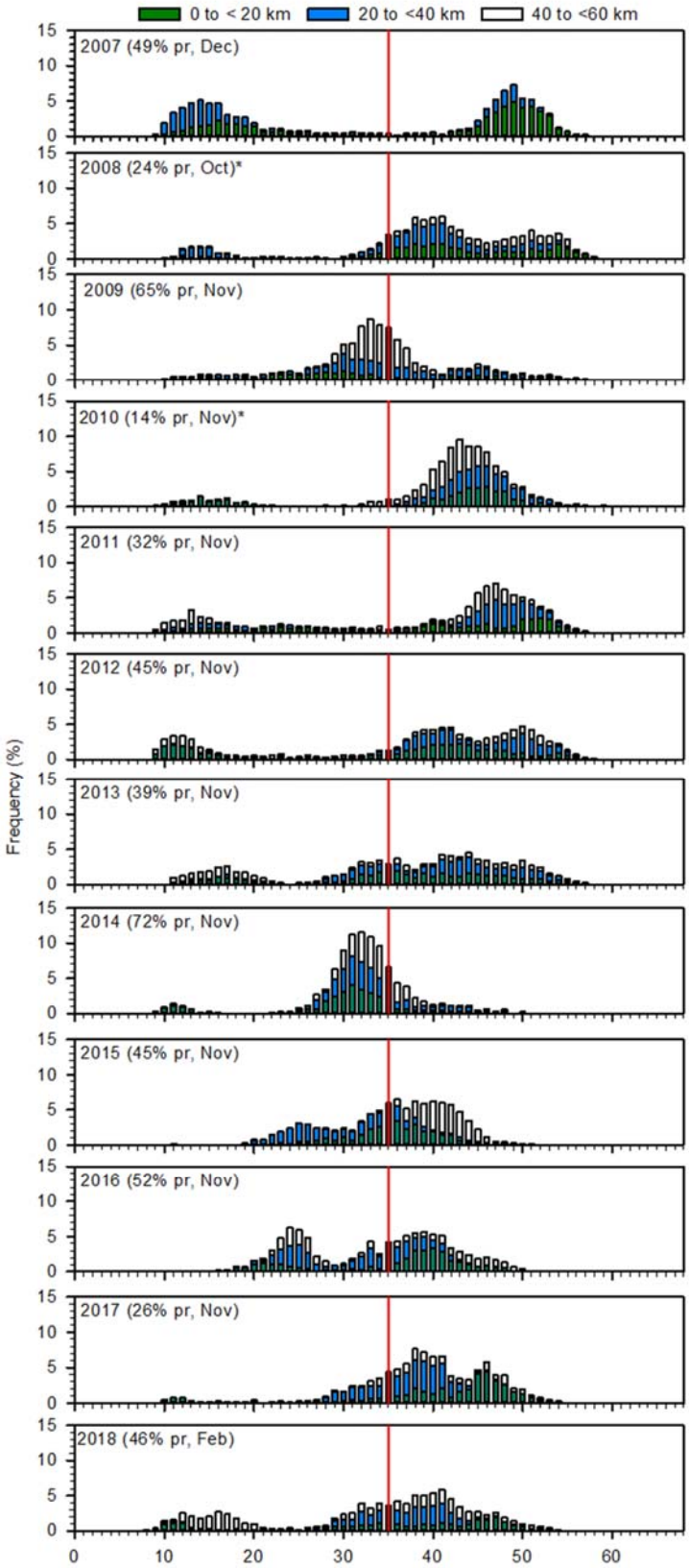

Figure 3.16. Estimates of the secondary biological performance indicator for Pipi: presence/absence of pre-recruits (pr) during November from 2007/08–2017/18 and in February 2018. Vertical red line represents legal minimum size of 35 mm.

Stock status

Pipi is a primary species for the commercial sector of the LCF (PIRSA 2015). The most recent stock assessment for Pipi was completed in 2017 and reported up to the conclusion of 2015/16 (Ferguson and Hooper 2017). The status of the LCF for Pipi is determined primarily from the ongoing fishery-independent research program that undertakes structured surveys to determine the relative biomass and size structure of the Pipi population along Younghusband Peninsula (Ferguson and Hooper 2017). The overall objective of these surveys is to collect the biological information required to inform the harvest strategy for Pipi (PIRSA 2016), which is used to set the annual TACC.

The primary measures for biomass and fishing mortality for Pipi are fishery-independent estimates of mean annual relative biomass (Ferguson et al. 2015) and population size structure. From 2009/10, increasing mean annual relative biomass and increasing complexity of size structures indicated recovery of the resource after a period of low catches and catch rates in the mid-2000s (Ferguson 2013; Ferguson et al. 2015). In 2017/18, the estimate of relative biomass of 19.1 kg/4.5 m^2 was the second highest on record. During 2017/18, pre-recruits were absent in the November 2017 (26% of the size frequency distribution) sub-survey but were present in February 2018 (46%). The above evidence indicates that the biomass of this stock is unlikely to be depleted, and recruitment is unlikely to be impaired. The current level of fishing mortality is unlikely to cause the stock to become recruitment impaired. On this basis, the LCF for Pipi in 2017/18 is classified as a **sustainable** stock.

4. SYNTHESIS

This report provided a summary of the annual fishery statistics for South Australia's multi-species, multi-gear Lakes and Coorong Fishery (LCF) from 1984/85–2017/18, assigned stock status for key finfish species and Pipi, and evaluated the recent condition of the environment in which the finfish fishery operates against a set of reference points.

The long-term variation in fishery production of the LCF has been mainly attributable to inter-annual variation in catch of the six primary species – Bony Herring, Carp, Mulloway, Yelloweye Mullet, Golden Perch and Pipi. These species persisted as the dominant catch species in 2017/18, collectively accounting for 95% of total fishery production. Catches of Bony Herring, Carp and Pipi accounted for most of the catch, with smaller contributions from Yelloweye Mullet, Golden Perch and Mulloway, and negligible contributions from Flounder and Black Bream.

Of the seven LCF species assessed in this report, five (71%) were classified as 'sustainable', and two were classified as 'depleted' (Table 4.1). For each species, the stock status classification from the most recent assessment was retained. Carp was not assigned a stock status as it is a noxious species under the *Fisheries Management Act 2007*.

Table 4.1. Status of South Australia's Lakes and Coorong Fishery resources at the end of 2017/18, based on weight of evidence and the National Fishery Status Reporting Framework (Stewardson et al. 2018).

Species	Stock	2017/18 Status
Mulloway	LCF	Sustainable
Black Bream	Coorong	Depleted
Greenback Flounder	LCF	Depleted
Yelloweye Mullet	LCF	Sustainable
Golden Perch	LCF	Sustainable
Bony Herring	LCF	Sustainable
Pipi	LCF	Sustainable

For the ELMGN sector, the total Mulloway catch in 2017/18 was the second highest catch since 1984/85, and was associated with record-high CPUE. For Flounder, low annual targeted effort and catches have persisted since 2012/13, likely reflecting low fishable biomass in the Coorong estuary. The current low biomass in the estuary likely relates to low freshwater inflows to the estuary during recent years (i.e. non-fishing effects).

The poor fishery performance of the Black Bream stock in the Coorong over the past two decades has persisted, with historically low levels of catch and targeting continuing in 2017/18. Temporary management arrangements were introduced in 2018 to recover the stock, but have not yet

resulted in measurable improvements. The temporary arrangements applied to Black Bream in the Lower Lakes and Coorong estuary from 1 September 2018 until 30 November 2018. Under the arrangements:

i. Commercial and recreational fishing nets cannot be used within 300 metres of barrages located in the Coorong estuary, including Goolwa, Mundoo, Boundary Creek, Ewe Island and Tauwitchere barrages; and
ii. Black Bream cannot be targeted, and all incidental catch of Black bream must be released by both the recreational and commercial sectors.

Any benefit from these arrangements within the population would likely take at least several years to develop. This is because Black Bream is a long-lived species and the Coorong Stock has historically been characterised by irregular recruitment events, the magnitude of which has depended on levels of egg production and appropriate environmental conditions relating to freshwater inflows to support the survival and growth of eggs and larvae. Moreover, juvenile Black Bream that originated from spawning in 2018 (i.e. during the closure) will take 3-4 years to recruit to the fishable biomass, and to contribute to egg production.

The low fishable biomass of Greenback Flounder in the Coorong estuary over recent years also continued in 2017/18. The lack of targeted fishing effort and low annual catches for this species during the past five years – a period of relatively low freshwater inflows to the estuary; is consistent with the significant long-term correlation between fishery production and freshwater inflow to the estuary (Earl and Ye 2016). Since the 1970s, the spawning biomass of this stock has repeatedly demonstrated its capacity to replenish the Coorong population in the 1-2 years that followed a year of high freshwater inflow (e.g. 1990/91, 1996/97, 2010/11). The sustainable management of the Greenback Flounder population in the Coorong estuary would benefit from an ecosystem-based management approach that would seek to:

i. provide a regime of consistent seasonal freshwater inflow to restore and maintain extensive areas of favourable estuarine habitat for the species; and
ii. maintain connectivity between the estuary and the marine environment to facilitate fish passage and accommodate the opportunistic use of the system by the species.

Yelloweye Mullet has been the sole target species of the ESMGN sector since 1984/85, which continued in 2017/18. The moderate catch of 158 t in 2017/18 was associated with moderate annual gillnet CPUE.

In the FWLMGN sector, the total catch of Golden Perch in 2017/18 increased to its highest level in 11 years and was associated with high CPUE, while the catches of the low-value Bony Herring and Carp were stable at moderate levels.

For each finfish sector, the environmental performance indicator for the 2018/19 reporting year was assessed against the reference points used in the finfish harvest strategy and will help set the TACE for the 2018/19 fishing season. All three performance indicators for 2018/19 were above their respective target reference points.

For Pipi, the total catch of 646 t in 2017/18 was the highest since the introduction of annual TACCs in 2007/08. There is no evidence in the fishery data or the two biological performance indicators used in the harvest strategy for Pipi to suggest that the biomass of this stock is depleted or that the current level of fishing mortality will cause the stock to become recruitment impaired.

Since 2009/10, the number of interactions between Long-nosed Fur Seals (*Arctocephalus forsteri*) and LCF gillnet fishers have increased and impacts to the fishery through depredation of gillnet catches and damage to fishing gear have been reported (Mackay 2018). While the economic impacts of seals on the fishery have not been quantified, seal depredation on fish caught in gillnets is likely to have resulted in lower catches and catch rates than would otherwise have been realised for some species. There is a need for reliable, quantitative information on the extent of the economic impacts of seals in the LCF to support the development of strategies to manage seal numbers and mitigate their impacts. This need will be addressed by FRDC Project 2018-036 'Seal-fisher-ecosystem interactions in the Lower Lakes and Coorong: understanding causes and impacts to develop longer-term solutions', which commenced in April 2019.

The weight-of-evidence approach used to determine stock status for the finfish species considered in this report relied heavily on fishery-dependent data. Currently the most significant gap in our knowledge relevant to the assessment of the status of LCF fish stocks relates to the lack of contemporary demographic information (e.g. size and age structures) for key species. There has been no sampling of commercial catches of LCF species since 2015. A targeted catch sampling program is needed to inform stock assessments and to facilitate appropriate fishery management.

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6. APPENDIX

Table A.1. Summary table showing total commercial catches by financial year for twelve LCF species defined as ‘primary’, ‘secondary’, ‘tertiary’ or ‘other’ species in the Management Plan (PIRSA 2016). Total catches for Pipi includes LCF and MSF catches. Crosses indicate confidential data.

	Primary						Secondary		Tertiary			Other
	Mulloway	Yelloweye Mullet	Golden Perch	Bony Bream	Common Carp	Pipi	Greenback Flounder	Black Bream	Snapper	Australian Salmon	Australian Herring	Redfin Perch
84/85	41	128	89	449	370	459	20	47	0	1	0	15
85/86	32	219	62	629	311	385	29	36	x	2	0	52
86/87	31	277	64	808	292	449	23	37	0	1	0	54
87/88	14	147	63	977	456	457	10.5	22	0	2	0	72
88/89	26	235	95	972	378	308	4.2	16	x	4	0	92
89/90	37	346	133	1157	383	311	3.3	10	0	8	x	59
90/91	42	224	164	947	508	533	65	3.7	0	4	x	37
91/92	45	198	157	1053	1021	758	58	4.7	0	23	x	32
92/93	34	210	279	612	673	737	27	2.6	0	3	0	40
93/94	85	181	299	695	842	942	10	3.1	0	1	x	69
94/95	78	239	286	838	816	783	3	3.3	x	x	0	44
95/96	57	195	292	706	767	927	30	4	0	5	0	24
96/97	56	161	235	688	767	829	15	3.9	0	3	0	30
97/98	50	158	190	757	635	1041	11	4.3	1	4	0	22
98/99	95	139	154	609	444	932	28	3.4	1	3	0	45
99/00	69	150	97	429	269	1024	39.9	4.1	2	4	0	24
00/01	136	127	173	474	274	1211	18.6	7.5	0	2	0	25
01/02	109	155	97	299	210	1046	25.6	8.2	0	1	0	10
02/03	45	167	64	212	404	1180	5.8	11.6	0	1	x	6
03/04	31	111	82	228	575	1073	5.5	10	x	2	0	9
04/05	39	110	103	287	558	1108	8.5	5.5	0	4	0	11
05/06	39	127	125	319	749	1062	6.6	6.6	0	3	0	23
06/07	44	141	152	376	694	990	5.2	4.7	1	4	0	16
07/08	32	216	117	411	709	607	2	4	0	6	0	29
08/09	30	210	87	422	713	470	0.5	1.8	0	10	0	28
09/10	26	207	49	550	630	301	1	1.1	3	10	0	41
10/11	19	243	68	464	404	301	0.1	2.3	3	8	0	61
11/12	64	144	57	443	308	374	31.1	3	1	1	0	68
12/13	103	217	34	502	349	443	9.2	1.9	x	1	0	12
13/14	68	196	88	469	422	444	1	1.9	x	0	0	8
14/15	59	121	85	407	403	443	0.3	2.4	0	1	0	14
15/16	73	135	77	397	395	492	4.5	1.9	0	3	0	12
16/17	62	183	81	427	490	539	2.1	1.6	0	0.3	0	12
17/18	121	154	106	363	403	646	0.7	1.3	0	0.6	0	27