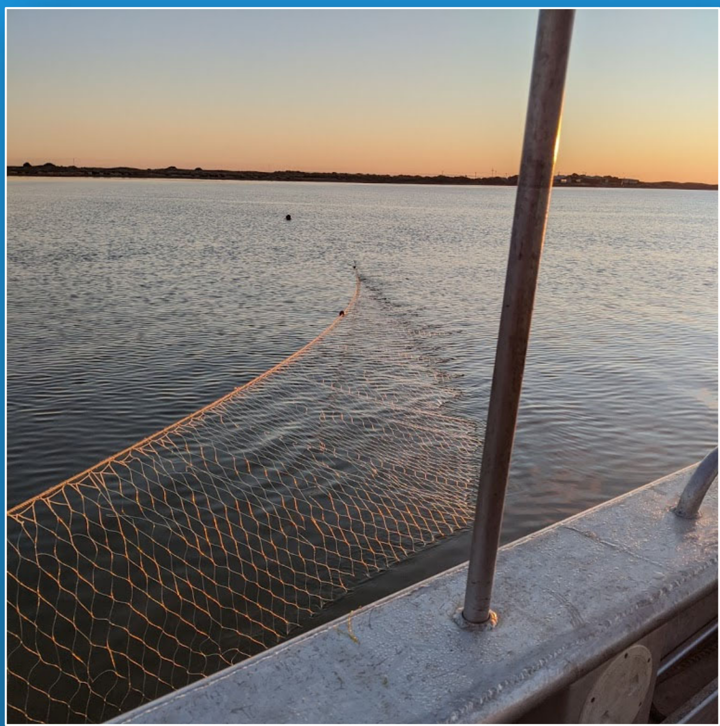
Fisheries

Assessment of the South Australian Lakes and Coorong Fishery in 2019/20



J. Earl and F. Bailleul

SARDI Publication No. F2020/000208-2
SARDI Research Report Series No. 1092

SARDI Aquatics Sciences
PO Box 120 Henley Beach SA 5022

May 2021

Report to PIRSA Fisheries and Aquaculture

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

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We gratefully acknowledge Angelo Tsolos and Milly Boyle of the Fisheries Information Services Group at SARDI Aquatic Sciences for providing the catch and effort data from the Lakes and Coorong Fishery Information System. Thanks to Tom Stewart of the Department for Environment and Water for providing the Coorong Hydrodynamic Model outputs that were used to update the environmental performance indicators for finfish; Jeremy Bussell (SARDI Aquatic Sciences) for support with the laboratory processing of fish samples; Gretta Chaplin (SARDI Aquatic Sciences) for preparing the Yelloweye Mullet otoliths for ageing; Dr Greg Ferguson (SARDI Aquatic Sciences) for providing updated estimates of the biological performance indicators for Pipi; and Dr Jonathan Smart (SARDI Aquatic Sciences) for feedback on earlier versions of the report.

The report was formally reviewed by Dr Craig Noell and Dr Owen Burnell (SARDI Aquatic Sciences), and Kylie Leppa and Keith Rowling (PIRSA Fisheries and Aquaculture). The report was approved for publication by Dr Stephen Mayfield (Science Leader, Fisheries, SARDI Aquatic Sciences).

EXECUTIVE SUMMARY

This report is the second in a new series for South Australia's Lakes and Coorong Fishery (LCF). It provides a description of the dynamics of the multi-species and multi-gear fleet, a stock assessment for Yelloweye Mullet, the catch statistics for Carp (an invasive species) and assigns stock status to a further five native finfish species that are harvested by the three gillnet sectors of the fishery (estuarine large mesh gillnet [ELMGN]; estuarine small mesh gillnet [ESMGN]; and freshwater large mesh gillnet [FLMGN]), and Pipi (a bivalve). The report includes a summary of the species-specific fishery information relating to: population biology, fishing access, management arrangements, and trends in commercial fishery statistics from 1 July 1984 to 30 June 2020. It also provides updated estimates of the performance indicators for the three gillnet sectors and Pipi. Of the seven species assessed here, five are classified as 'sustainable', and two are classified as 'depleted', based on the National Fishery Status Reporting Framework (NFSRF; Stewardson et al. 2018).

Fleet dynamics

The dynamics of the LCF fleet have changed considerably over the last 36 years. Most of the changes relate to the environment and markets, and are reflected in shifts in targeted effort among the fishery's six primary species (Mulloway, Yelloweye Mullet, Golden Perch, Pipi, Carp and Bony Herring). These species have consistently accounted for 94–98% of the fishery's annual targeted effort since 1984/85. Total and Primary Species catches have been increasing over the past decade. In 2019/20, both were at the highest level since 2009/10.

Yelloweye Mullet stock assessment

The assessment of the LCF for Yelloweye Mullet used a weight-of-evidence approach that placed considerable emphasis on analysing commercial catch, effort and catch per unit effort (CPUE) trends, and size and age structures of fishery and research survey catches from the Coorong Estuary.

The LCF has historically been the most productive of South Australia's fisheries for Yelloweye Mullet, and in 2019/20 contributed 98% of the State's total commercial catch. The total catch of Yelloweye Mullet by the LCF in 2019/20 was 458 t, which is the highest catch recorded in the fishery.

The main gear type used by the LCF to target Yelloweye Mullet has been the small mesh gillnet (SMGN; 50–64 mm mesh). In 2019/20, targeted catches taken using SMGN in the Coorong Estuary accounted for 97% of the total catch with most of the remaining catch taken as by-product when other species were targeted.

The recent high catches of Yelloweye Mullet in the LCF have been associated with exceptionally high estimates of mean annual $CPUE_{SMGN}$. In 2019/20, mean annual $CPUE_{SMGN}$ was 37.2 kg.net-day^{-1}, which was the highest on record and likely reflects high abundance of Yelloweye Mullet in the Coorong.

The fishery age structure for Yelloweye Mullet in 2020/21 comprised mostly two and 3-year old fish, and was similar to that of previous years. Older fish were rare despite the potential for this species to reach 10 years of age. The presence of young fish in the size and age structures suggests that recruitment has occurred in recent years.

The above evidence indicates that the biomass of the Yelloweye Mullet stock in the Coorong Estuary 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 stock is classified as **'sustainable'** under the NFSRF.

Yelloweye Mullet is the primary target species in the ESMGN. The environmental performance indicator for habitat available to Yelloweye Mullet in the Coorong Estuary for the 2020/21 reporting year (1 February 2020–31 January 2021) was 62.4%, which was above the target reference point of 50%.

Stock status of other key species

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

Mulloway is the primary target species in the ELMGN. The total Mulloway catch of 120 t in 2019/20 was the third highest catch of this species since 1984/85, and was associated with high CPUE for large mesh gillnets (LMGN; 115–150 mm mesh) in the Coorong Estuary. Targeted effort for Mulloway using swinger nets along the ocean beaches adjacent the Murray Mouth was negligible in 2019/20. This stock is classified as '**sustainable**'.

Black Bream is a secondary species in the ELMGN. Targeted catch and effort for Black Bream have been historically low in most of the last 31 years, and this continued in 2019/20. These results suggest that the biomass of this stock remains in a recruitment-impaired state. In 2018 and 2019, temporary management arrangements, which included 'no take' of Black Bream in several months for the recreational and commercial sectors, were implemented to recover the stock but these have not yet resulted in measurable improvements. This stock is classified as '**depleted**'.

Greenback Flounder is a secondary species in the ELMGN. This species is considered a 'marine estuarine-opportunist' – a marine species that enters estuaries in substantial numbers, particularly as juveniles and young adults, 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 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. This stock is classified as '**depleted**'.

For the ELMGN sector, the environmental performance indicator for habitat available to Mulloway in the Coorong Estuary for the 2020/21 reporting year (1 February 2020–31 January 2021) was 52.3%, which was below the target reference point of 55%.

Freshwater large mesh gillnet sector (FLMGN)

Golden Perch, Bony Herring and Carp are the primary target species in the FLMGN. Decreased demand for Carp and Bony Herring as bait from South Australia's Southern Zone Rock Lobster Fishery contributed to an overall decline in fishing effort in the FLMGN in 2019/20.

For Golden Perch, the total catch of 50.6 t in 2019/20 was the lowest since 2012/13. This low catch reflected low targeted effort (i.e. the second lowest level of targeted effort since the early 1990s) but was associated with near record-high catch rates. This stock is classified as '**sustainable**'.

For Bony Herring, the total catch of 269 t in 2019/20 was the lowest since 2004/05 reflecting the overall decline in fishing effort in the FLMGN, while $CPUE_{LMGN}$ increased and was above the long-term average. This stock is classified as '**sustainable**'.

Carp is listed as a noxious species in South Australia under the *Fisheries Management Act 2007*. Total catches of Carp have been at moderate levels since 2009/10. Status is not assigned to this species.

For the FLMGN, the environmental performance indicator for mean annual water level in the Lower Lakes for the 2020/21 reporting year was 0.71 m (Australian Height Datum), which was above the target reference point of 0.4 m.

Pipi sector

Since 2009/10, annual catches of Pipi have been constrained by annual total allowable commercial catches (TACC). The TACC was reduced to 450 t in 2019/20 (from 650 t in 2018/19), thereby constraining catch to its lowest level since 2012/13. The estimate of fishery-independent relative biomass of legal-sized Pipi (primary performance indicator) of 10.75 kg/4.5 m^2 in 2019/20 was 2% below the target reference point of the 11 kg/4.5 m^2. Pre-recruits (secondary performance indicator) comprised 13% of size structures in November 2019, increased to 40% in February 2020, and were therefore considered present in 2019/20. This stock is classified as '**sustainable**'.

Keywords: multi-species, multi-gear, stock status, Mulloway, Black Bream, Greenback Flounder, Yelloweye Mullet, Golden Perch, Bony Herring, European Carp, Pipi, Goolwa Cockle, gillnets, Coorong Estuary.

Table E-1. Key statistics for South Australia's Lakes and Coorong Fishery finfish resources from 2017/18 to 2019/20, including stock status based on weight of evidence and the NFSRF (Stewardson et al. 2018). Crosses indicate confidential data.

Species	F/Year	Catch (t)	CPUE (kg.net-day^{-1})	Stock status
Yelloweye Mullet	2017/18	154	13.1	Sustainable
	2018/19	285	26.8	Sustainable
	2019/20	458	37.2	Sustainable
Mulloway	2017/18	121	9.9	Sustainable
	2018/19	110	10.2	Sustainable
	2019/20	120	7.8	Sustainable
Black Bream	2017/18	1.3	X	Depleted
	2018/19	0.68	-	Depleted
	2019/20	1.76	X	Depleted
Greenback Flounder	2017/18	0.7	1.7	Depleted
	2018/19	1.85	1.6	Depleted
	2019/20	0.24	X	Depleted
Golden Perch	2017/18	106	1.6	Sustainable
	2018/19	61	1.2	Sustainable
	2019/20	50.6	1.2	Sustainable
Bony Herring	2017/18	363	4.5	Sustainable
	2018/19	294	4.2	Sustainable
	2019/20	269	5.1	Sustainable

Table E-2. Results from the annual assessments of the environmental performance indicators for the three finfish sectors of the LCF from 2018/19 to 2020/21 (reporting years) against their target, trigger and limit reference points (RP). The annual total allowable commercial effort (TACE) for each sector for each financial year from 2017/18 to 2019/20 is also shown.

Finfish sector	Financial year	TACE (net units)	Performance indicator	Limit RP	Trigger RP	Target RP	Reporting year	PI value
Estuarine LMGN	2017/18	1,250	Habitat available to Mulloway	10%	24.9%	55%	2018/19	55.0%
	2018/19	1,175					2019/20	59.6%
	2019/20	1,175					2020/21	52.3%
Estuarine SMGN	2017/18	1,250	Habitat available to YE Mullet	10%	30.9%	50%	2018/19	67.9%
	2018/19	1,175					2019/20	65.1%
	2019/20	1.175					2020/21	62.4%
Freshwater LMGN	2017/18	1,250	Water level in the Lower Lakes (m)	-1.2 m	-0.71 m	0.4 m	2018/19	0.65 m
	2018/19	1,175					2019/20	0.69 m
	2019/20	1,175					2020/21	0.71 m

Table E-3. Key statistics and stock status for South Australia's Lakes and Coorong Fishery Pipi resource from 2017/18 to 2019/20, including the results from the annual assessments of the primary performance indicator (fishery-independent relative biomass of legal-sized Pipi) from 2017/18 to 2019/20 against the target reference point (RP). The annual total allowable commercial catches (TACC) are also shown.

	Financial year	TACC (t)	Catch (t)	Primary performance indicator: relative biomass (kg/4.5 m²)		Pre-recruits present	Stock status
				Target RP	PI value		
Pipi	2017/18	650	646	11	19.1	Yes	Sustainable
	2018/19	650	646		12.6	No	Sustainable
	2019/20	450	430		10.75	Yes	Sustainable

1 GENERAL INTRODUCTION

1.1 OVERVIEW

This is the second report in this series for the South Australian Lakes and Coorong Fishery (LCF) that provides a species-specific summary of information on fisheries biology, fishing access, management arrangements, trends in commercial fishery statistics, and stock status at the biological stock or management unit scale. It also assesses sets of performance indicators against associated reference points for the finfish and Pipi (*Donax deltoides*) sectors of the fishery, as prescribed in the *Management Plan for the South Australian Commercial Lakes and Coorong Fishery* (hereafter referred to as the management plan; PIRSA 2016). As such, this report provides a comprehensive document to support the management of this complex multi-species and multi-gear fishery. The data included in this report extends over a 36-year time series from 1 July 1984 until 30 June 2020.

There are five main sections. The first section, including this overview, provides a description of the LCF, its management arrangements, and details the performance indicators and reference points used to inform management of the finfish and Pipi sectors of the fishery. Section two describes the dynamics of the commercial fishing fleet, catch composition, and spatial and temporal trends in fishing effort.

Section three provides an assessment of the LCF for Yelloweye Mullet (*Aldrichetta forsteri*). This assessment is based on: commercial catch and effort data from 1 July 1984 to 30 June 2020; information on the size and age characteristics of the Yelloweye Mullet in commercial fishery and research survey catches; and an environmental performance indicator that relates to the amount of suitable habitat available for Yelloweye Mullet in the Coorong Estuary.

Section four consists of a series of species-specific sections that are arranged to align with the estuarine and freshwater large mesh gillnet sectors and the Pipi sector of the LCF, as defined in the management plan (PIRSA 2016). For key species of each sector, the relevant biological information is provided, along with a description of the fishery, associated management arrangements, an interrogation of the fishery data, and a classification of stock status using the definitions of the National Fishery Status Reporting Framework (NFSRF; Stewardson et al. 2018). For each finfish sector, environmental conditions are also assessed against reference points defined in the management plan.

The final section, the General Discussion, discusses the overall performance of the fishery, details emerging trends within the fleet, and identifies research priorities that will improve future assessments.

1.2 DESCRIPTION OF THE FISHERY

The LCF is a small-scale, multi-species, multi-gear fishery that operates in the estuary of the Murray River and Coorong lagoons (the Coorong Estuary), the freshwater lower lakes of the Murray River

(Lakes Alexandrina and Albert) and the nearshore marine environment adjacent the Coorong Estuary (Figure 1-1). Currently, there are 36 active licence holders in the fishery, who are permitted to take around 40 species/taxa that include fishes, molluscs, crustaceans, annelid worms, rays, skates and sharks (PIRSA 2016). Fishery production by weight of catch is mainly comprised of Bony Herring (*Nematalosa erebi*), Carp (*Cyprinus carpio*), Yelloweye Mullet, Mulloway (*Argyrosomus japonicus*), Golden Perch (*Macquaria ambigua*) and Pipi. Other species such as Black Bream (*Acanthopagrus butcheri*), Greenback Flounder (*Rhombosolea tapirina*) and Redfin Perch (*Perca fluviatilis*) have historically contributed significantly to the overall catch in some years.

Currently there are around 15 types of fishing gear (or devices) endorsed in the LCF (PIRSA 2016). The use of these gears differs depending on the location of fishing and the species being targeted. Mesh gillnets are the main gear used by fishers targeting finfish species (Ferguson et al. 2013). In the Lower Lakes, large mesh gillnets (115–150 mm mesh) are used to target Golden Perch, Redfin Perch, Bony Herring and Carp. In the Coorong Estuary, large mesh gillnets are used to target Mulloway, and occasionally Greenback Flounder and Black Bream, while small mesh gillnets (50–64 mm mesh) are used to target Yelloweye Mullet. Mulloway are also targeted in the nearshore marine environment adjacent the Murray Mouth using extra-large mesh gillnets (> 150 mm mesh), known as swinger nets. Pipi is harvested using hand-held rakes along the ocean beach on the Younghusband Peninsula. Other methods permitted for use include drum nets, hauling nets and set lines.

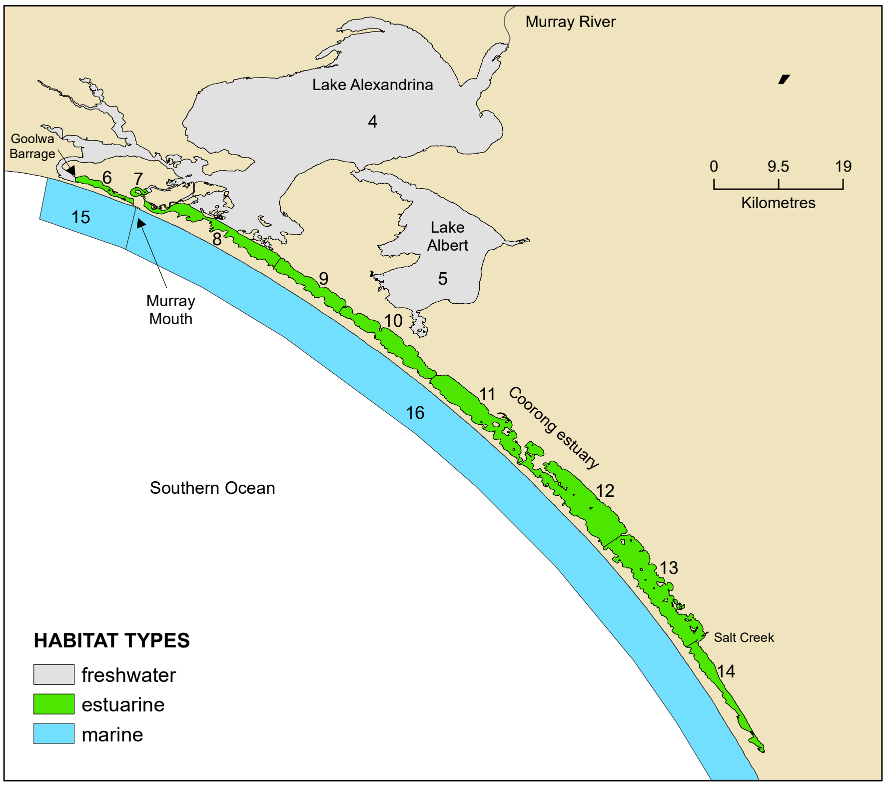

Figure 1-1. Commercial reporting blocks of the LCF showing the different habitats.

The broad mixture of target species, gear types, habitat types and regulations associated with the LCF make the task of assessing the status of the fish stocks challenging. This is compounded by the dynamic nature of fisher behavioural responses to markets, resource availability, environmental conditions, and in recent years, the impacts of Long-nosed Fur Seals (*Arctocephalus forsteri*), as fishers can readily switch their targeted fishing effort between species, gears and areas.

The recreational fishing sector has access to many LCF species. Recreational fishing occurs in freshwater, estuarine and marine waters in the region, with fishers permitted to use several gear types. Recreational fishers can also target finfish in the Coorong Estuary using registered monofilament nylon nets. Recreational net fishing is prohibited in all other coastal waters of South Australia (PIRSA 2016).

1.3 MANAGEMENT ARRANGEMENTS

The LCF is managed by the South Australian Government's Department of Primary Industries and Regions (Fisheries and Aquaculture Division) in accordance with the legislative framework provided within the *Fisheries Management Act 2007*, and subordinate *Fisheries Management (General) Regulations 2017*, *Fisheries Management (Lakes and Coorong Fishery) Regulations 2009* and licence conditions.

The LCF is managed as a limited entry fishery. There are 36 licences with non-exclusive access within the Lakes and Coorong system and the adjacent beach along the Sir Richard and Younghusband Peninsulas. Fishing effort is limited through gear entitlements, with each licence endorsed for the type and number of devices that can be used. Owner-operator provisions and a range of output controls also apply, including a legal minimum size (LMS) for most species and quota management for Pipi.

The management plan provides a strategic policy framework for managing the fishery and an overview of the management changes that have occurred over the last four decades (PIRSA 2016). In 1984, licence amalgamations were permitted under the Scheme of Management introduced to promote economic efficiency by allowing fishers to rationalise individual gear entitlements from within the existing pool of licences. In 1990, following an agreement between PIRSA and the commercial industry, a policy directive was introduced to formalise a set of guidelines on licence amalgamations and transfers. A key element of the policy was the limitation placed on the amount of gear that may be endorsed on an individual licence upon transfer or amalgamation. Under the policy, a maximum of two agents may undertake fishing activity pursuant to each licence, following the transfer of a licence. Specific arrangements apply to licence transfers between members of a family. All applications for licence transfer or amalgamation must be considered in accordance with the *Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991.* This 'amalgamation scheme' has allowed for limited structural adjustment of the commercial sector by reducing the number of licences and the amount of gear operating in the fishery over time.

The recreational fishery is not licenced but is subjected to a range of regulations such as size, boat, bag and possession limits, restrictions on the types of gear that may be used, temporal and spatial closures, and the complete protection of some species.

1.4 HARVEST STRATEGIES

The management plan includes harvest strategies for finfish and Pipi which provide strategic and transparent frameworks to guide annual management decisions on commercial harvesting (PIRSA 2016). The harvest strategy for finfish outlines the process for setting the annual total allowable commercial effort (TACE) for three finfish sectors, which collectively account for > 98% of all finfish catches each year. The three sectors are: (i) estuarine large mesh gillnet (ELMGN); (ii) estuarine small mesh gill net (ESMGN); and (iii) freshwater large mesh gill net (FLMGN). The finfish harvest strategy is different to that of a traditional harvest strategy, because it aims to manage the sustainable harvest of key finfish species relative to the condition of environment within which the fishery operates, which is linked to the availability of the fished resources (PIRSA 2016). It uses an environmental performance indicator and decision rules to inform setting of the annual TACE for each sector. The environmental performance indicator for each sector is: (i) ELMGN - suitable habitat available (%) for Mulloway in the Coorong Estuary; (ii) ESMGN – suitable habitat available (%) for Yelloweye Mullet in the Coorong Estuary; and (iii) FLMGN - mean annual water level (m) in the Lower Lakes. Detailed descriptions of the performance indicators and associated reference points are provided in the management plan.

The second harvest strategy for the LCF for Pipi was developed in 2015/16 and outlines the process for setting the annual total allowable commercial catch (TACC) (PIRSA 2016). The harvest strategy uses performance indicators and decision rules to inform setting of the annual TACC. The biological performance indicators used in the harvest strategy are: (i) fishery-independent mean annual relative biomass (primary performance indicator), and (ii) presence/absence of pre-recruits in size-frequency distributions (secondary performance indicator; Ferguson and Ward 2014; Ferguson et al. 2015; Ferguson and Hooper 2017). Detailed descriptions of the biological performance indicators and associated reference points are provided in the management plan (PIRSA 2016).

1.5 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 and subsequent growth and recruitment is impaired. 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 1-1). PIRSA has adopted this classification system to define the status of South Australian fish stocks.

Table 1-1. 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 FISHING FLEET DYNAMICS

2.1 INTRODUCTION

The dynamics of a fishing fleet are a product of a series of decisions made by the fishers that relate to when and where to fish, what gear to use and what species to target. These decisions can be influenced by a range of factors such as the abundance of the target species, weather and environmental conditions, management arrangements, markets, and other socio-economic considerations. For multi-species, multi-gear fisheries such as the LCF, understanding the dynamics of the fishing fleet is an important first step toward assessing the status of the fish stocks they exploit. Understanding how fishing effort is directed among target species in particular areas over time is important for interpreting trends in fishery catch and effort data. A detailed breakdown of fishing effort by season, location, species and gear is often considered to reveal patterns of fishing activity and fisher behaviour (Hilborn and Walters 1992).

This section of the report provides an overview of the LCF by examining and comparing trends in catches, fishing effort, gear use, fishing areas and seasonality from 1 July 1984 to 30 June 2020. This summary illustrates the dynamic and complex nature of this fishery over different spatial and temporal scales, and the relationships and trends between target species, and provides important context for the assessments of stock status for individual species in sections three and four of this report.

2.2 METHODS

The LCF is divided into 13 fishery blocks for the purpose of data reporting and monitoring of commercial fishing activity (Figure 1-1). All fishers are required to log their daily fishing activities by recording specific details such as the reporting block fished, species targeted, species caught, weight of each species caught, gear type used, and for gillnet fishing, the number of gillnets used. Daily catch and effort data have been collected by LCF fishers since 1 July 1984, and are submitted monthly to SARDI Aquatic Sciences where they are entered into the LCF Information System. This database is routinely reviewed and cross-checked in accordance with quality assurance protocols (Vainickis 2010). The current database is a compilation of catch and effort data collected from 1 July 1984 to the present, and provides the primary source of data used for the assessments of status in this report.

Daily catch and effort data were extracted from the Lakes and Coorong Fisheries Information System for the 36-year period from 1 July 1984 to 30 June 2020. These data were aggregated to provide annual totals of catch (tonnes) by species, and targeted effort (fisher-day) by species, gear, month and location, for each financial year from 1984/85 to 2019/20. These aggregations of data enabled analysis of the major trends in fisher behaviour and fleet dynamics for the fishery.

2.3 RESULTS

2.3.1 Trends in number of active licences

There has been a 19% decline in the number of active fishers licensed to operate in the LCF over the past 36 years, declining from 42 licences in 1984/85 to 34 licences in 2019/20 (Figure 2-1). Since 1992/93, the number of active fishers has varied between 33 and 36 licences each year.

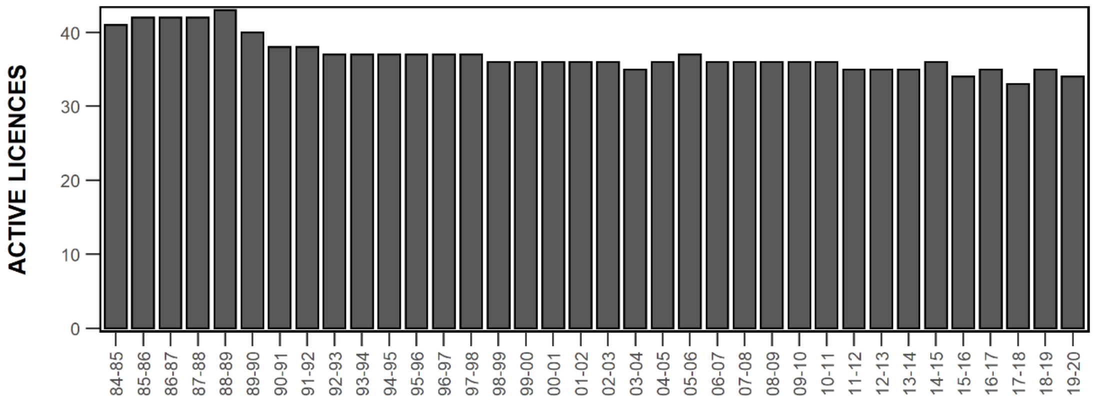

Figure 2-1. Long-term trend in the number of active licence holders that have access to the LCF.

2.3.2 Trends in commercial catch

Since 1984/85, there have been considerable changes in the composition of the commercial catches within the LCF, which have contributed to high inter-annual variation in fishery production (Figure 2-2). The variation in production is mainly attributable to variation in catches of the primary species, which have consistently made up 94–98% of total annual production. In 2019/20, production was dominated (98.1%) by the six primary species, with the secondary (0.11%), tertiary (0.06%) and other permitted species (1.73%) contributing the remaining catch.

Total catch of the primary species peaked at 2,667 t in 1991/92, with a secondary peak of 2,420 t in 2005/06 (Figure 2-2). Total catch then declined to 1,379 t in 2011/12 and has since steadily increased to 1,831 t in 2019/20. Among the primary species, catches of Bony Bream, Carp and Pipi have collectively accounted for most (> 80%) of the annual catches since 1984/85, with smaller contributions from Yelloweye Mullet, Golden Perch and Mulloway.

Total catch of the secondary and tertiary species peaked at 85 t in 1991/92. Since then it has been highly variable but has steadily declined to an historic low of 3.05 t in 2019/20. The trends in fishery production for these species groups reflects the temporal trends in catches of Greenback Flounder and Black Bream (secondary species), and to a lesser extent Western Australian Salmon (*Arripis truttaceus*; tertiary species).

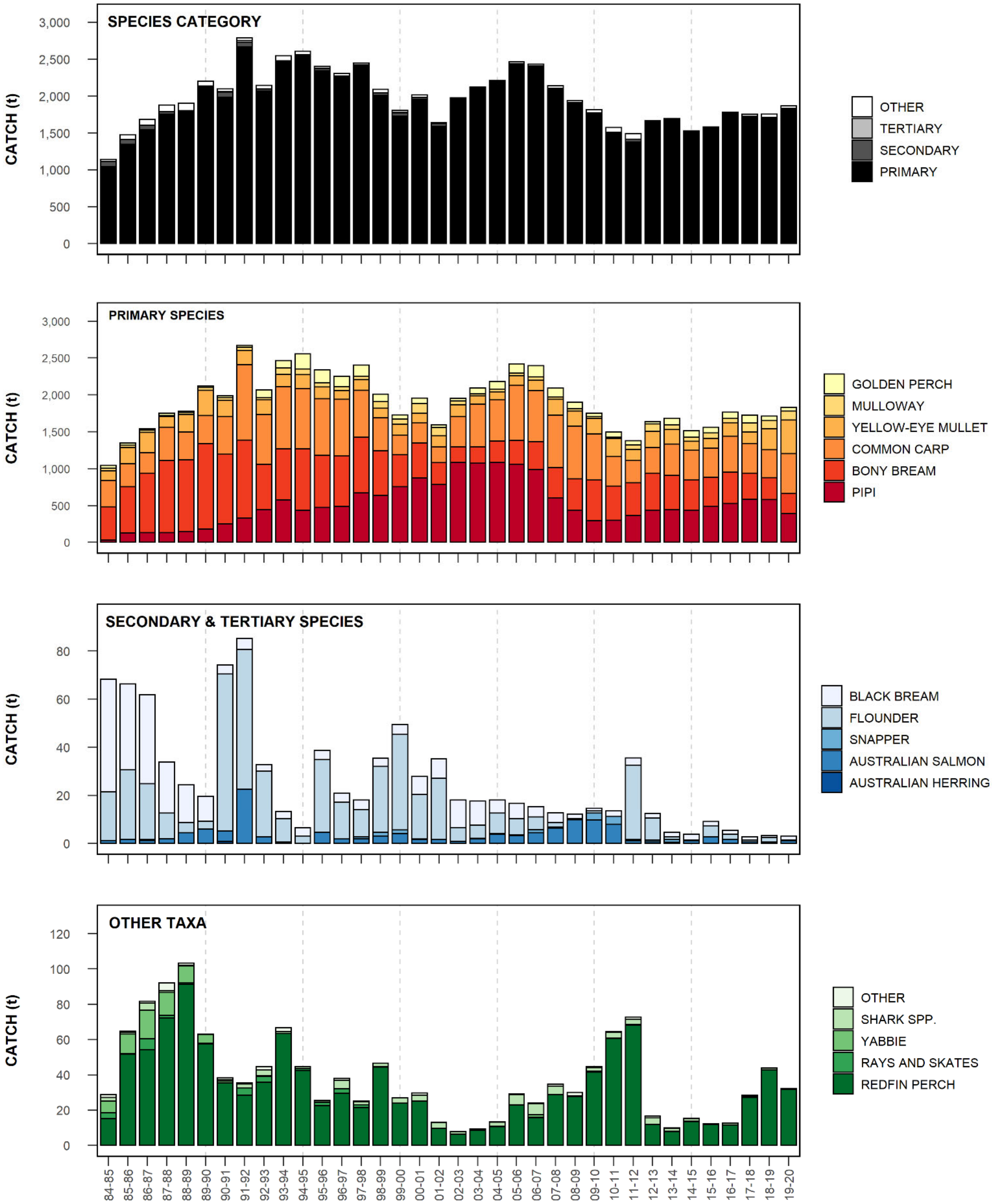

Figure 2-2. Long-term trends in total catch (t) in the commercial LCF from 1984/85 to 2019/20, presented by species category, primary species, secondary and tertiary species, and all other permitted species.

Annual catches of all other permitted LCF species peaked at 103 t in 1988/89, with a secondary smaller peak of 72 t in 2011/12. Among the “other” species that have contributed to the commercial harvest since 1984/85, Redfin Perch have dominated catches, accounting for 79–98% of annual catches of species/taxa in this group. A summary of total annual catches for twelve LCF species from 1984/85 to 2019/20 is shown in Appendix 1.

2.3.3 Trends in commercial fishing effort

2.3.3.1 Species

Annual estimates of total fishing effort in the LCF peaked at 10,081 fishing days in 1988/89 (Figure 2-3). This peak represented a 16.8% increase in annual effort since 1984/85, after which, there has been a 40.2% reduction in effort to 6,024 fishing days in 2010/11. This decline in effort occurred over a long period, although a substantial annual reduction occurred in early 2000s coinciding with the initial stages of the Millennium Drought, when a large part of the Coorong Estuary was uninhabitable for fish due to persistent hypersaline environmental conditions associated with a lack of freshwater inflows from the Murray River (Webster 2010). In the last decade, annual effort increased to 7,573 fishing days in 2014/15 and then steadily declined to a historic low of 5,553 fishing days in 2019/20, with around 80% of the effort being targeted to a particular species.

Of the reported targeted effort since 1984/85, the primary species have consistently accounted for the highest proportion (78–98%), of which Yelloweye Mullet and Golden Perch have historically dominated (Figure 2-3). During the 1980s, Yelloweye Mullet and Carp accounted for the largest proportions of the targeted effort among the primary species. There was a shift in fishing activity during the early 1990s, as fishers directed some of their effort away from Yelloweye Mullet and Carp towards Golden Perch and Mulloway. The relative proportion of effort targeted towards Pipi also increased during the 1990s and was highest during the mid-2000s. Over the past five years, the relative proportions of effort directed toward each of the primary species has been stable, with Yelloweye Mullet (29%), Golden Perch (25%), Pipi (17%) and Mulloway (18%) accounting for most.

Prior to 1992/93, the secondary species attracted up to 21% of the total fishing effort in some years, most of which was directed toward Black Bream and Greenback Flounder (Figure 2-3). Of these species, Black Bream accounted for most of the targeted effort during the 1980s, before there was a distinct shift in fishing activity in 1990/91 away from Black Bream toward Greenback Flounder. Since then, targeted fishing for secondary species has been highly variable and accounted for < 5% of total effort in most years. The variation is largely attributable to changes in targeting of Greenback Flounder, as targeting of Black Bream has been negligible. Most of the remaining targeted effort over the last 26 years has been directed toward Redfin Perch.

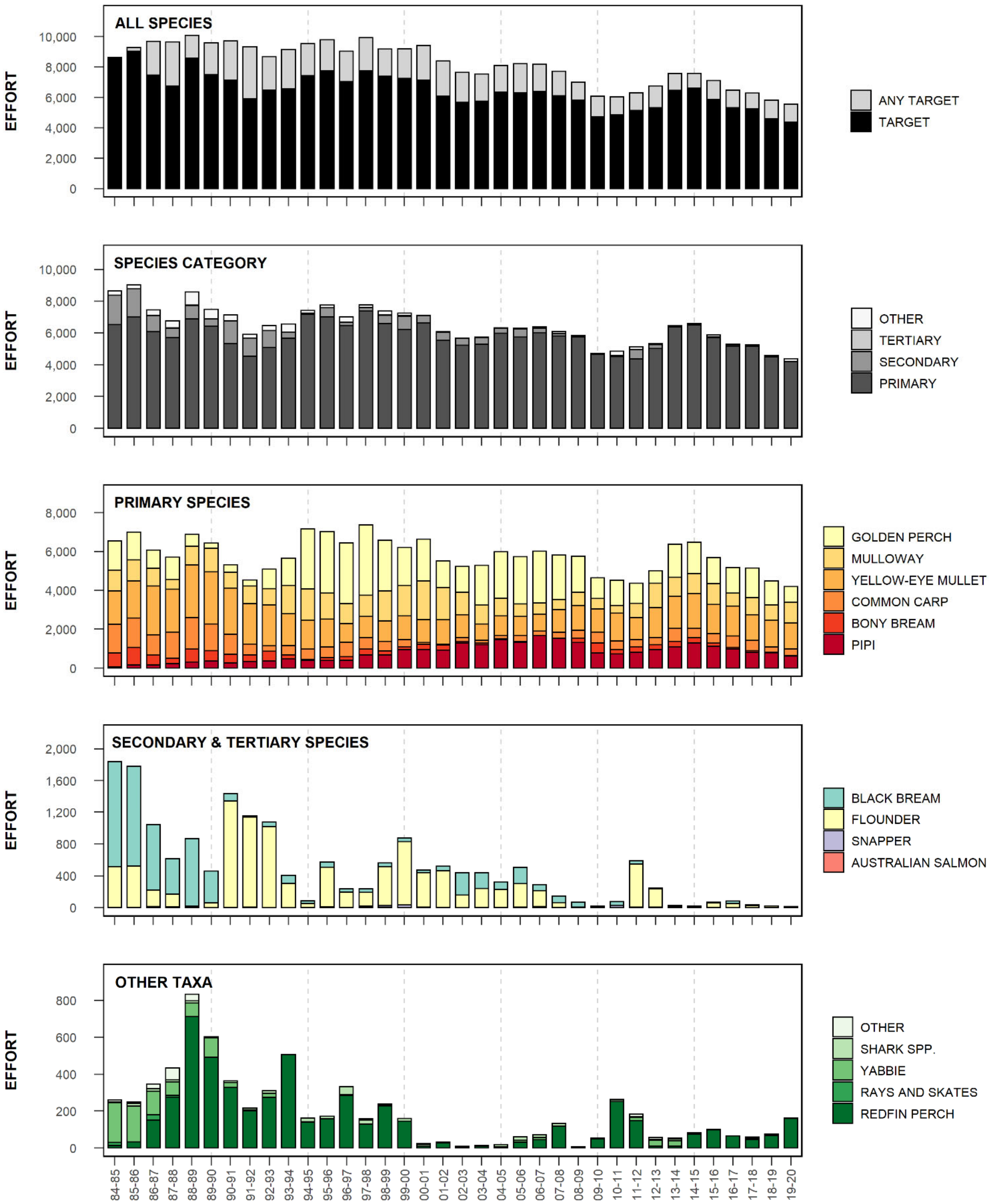

Figure 2-3. Long-term trends in total effort in the LCF from 1984/85 to 2019/20 presented by targeted and non-targeted ('any target') effort (top graph), and by species category, primary species, secondary and tertiary species, and all other permitted species.

2.3.3.2 Gear

Large mesh gillnets have consistently been the dominant gear type used in the fishery, accounting for 60–80% of the total fishing effort each year. Small mesh gillnets have been the second most utilised gear type since 1984/85 (Figure 2-4). The relative use of cockle rakes steadily increased from < 3% during the 1980s to 20% in 2006/07 before stabilising at 12–15% during the last decade. Swinger nets have accounted for most of the remaining fishing effort in the fishery, with negligible contributions from hauling nets, and other gears such as drum nets, set lines and yabbie pots.

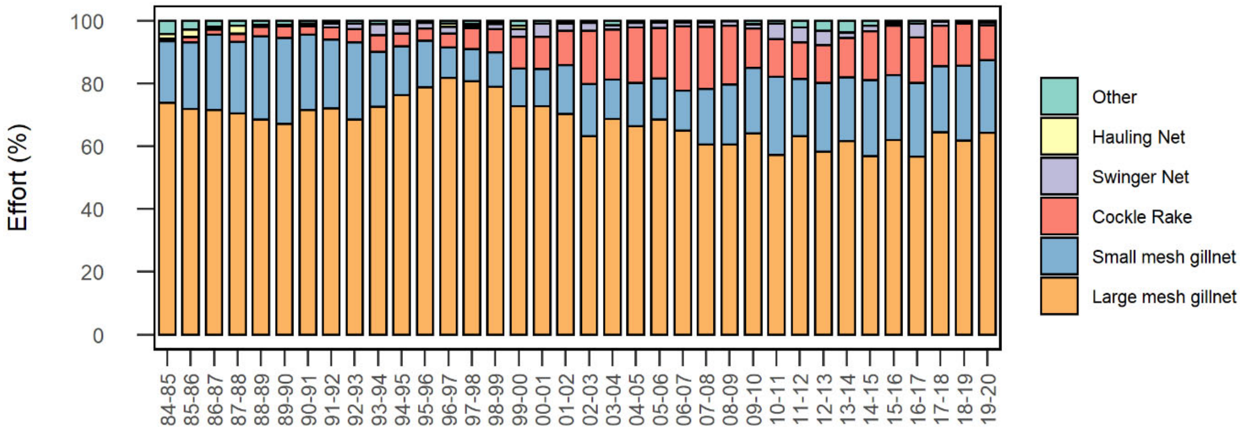

Figure 2-4. Gear usage (% of total fishing effort in fishing days) within the LCF.

2.3.3.3 Season

The multi-species nature of the LCF provides fishers with flexibility in terms of the species they can target at different times of the year (Figure 2-5). Among the six primary species over the last five years, Yelloweye Mullet was targeted throughout the year although average monthly targeted effort was highest during the cooler months with a peak of around 139 (SE ± 6.6) fishing days in August. The seasonal pattern for Golden Perch was similar, with a relatively high level of fishing effort throughout the year and peaks of around 120 fishing days in July and March. Conversely, targeted effort for Mulloway was highest in late spring, peaking at around 147 (± 11.5) fishing days in November. Fishing effort for Pipi was highest during January–March, which is when weather conditions are most favourable for targeting the species. Carp were targeted across the year, while fishing for Bony Herring was generally limited to between July and January.

For the secondary species, fishing for Greenback Flounder was seasonal with on average, around 92% of targeted effort occurring from November to April (Figure 2-5). In contrast, targeted effort for Black Bream was highest in July, with lower levels of targeting from September to November likely attributable to the Black Bream fishery closure during these months in the 2018/19 and 2019/20 fishing seasons. Targeted fishing for Black Bream was negligible from January to June.

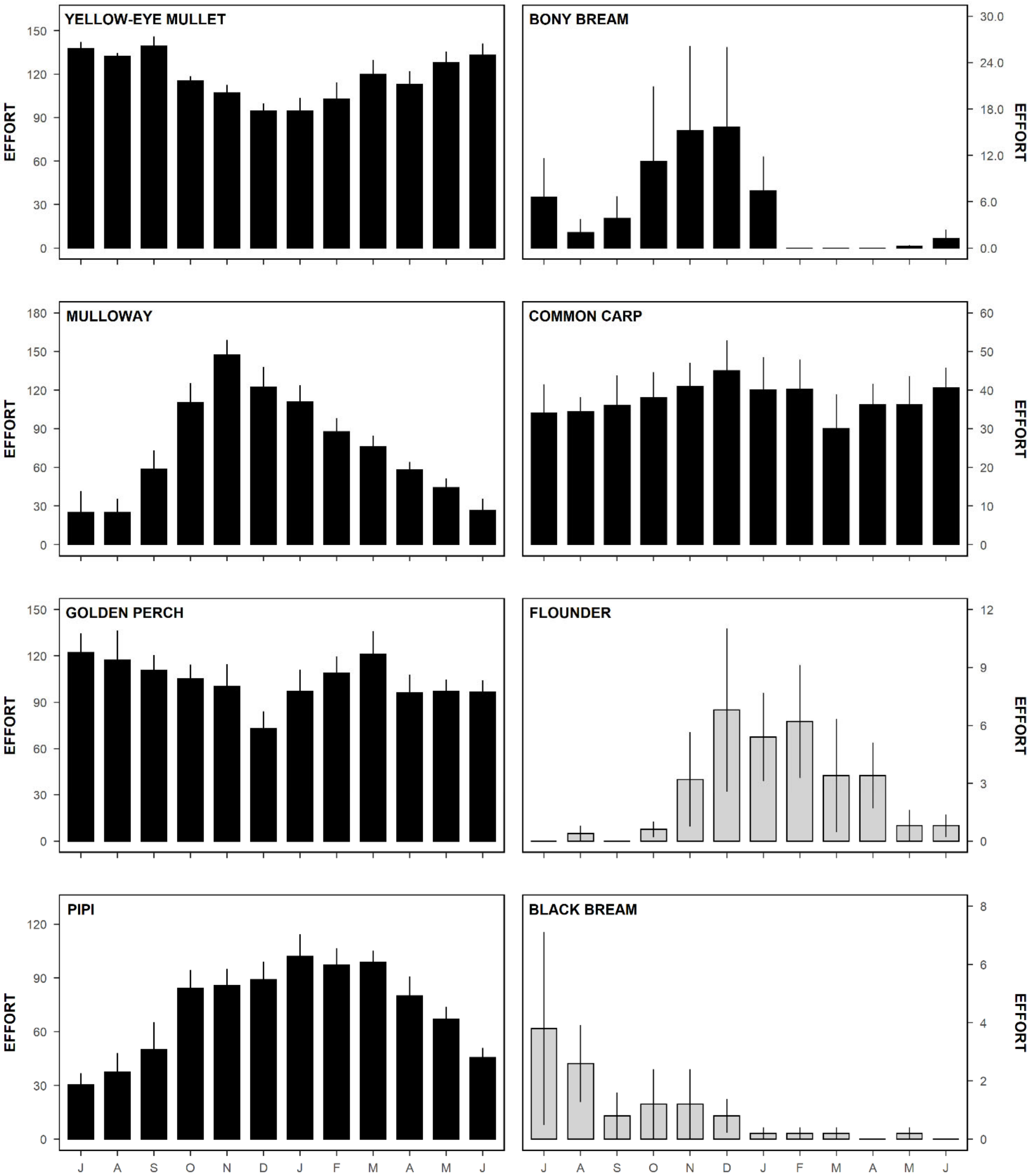

Figure 2-5. Monthly pattern of targeted fishing effort (fishing-days averaged, ± se) from 2015/16 to 2019/20 for each species/taxon assessed in this report. The different shades denote species category; primary (black) and secondary (grey).

2.3.3.4 Location

During the mid-1980s, the spatial distribution of fishing effort in the LCF was largely limited to the Lower Lakes (blocks 4, 5) and Coorong Estuary (blocks 6–12), with low levels of fishing along the adjacent ocean beaches (blocks 15, 16). During this time, effort was most intense in Lake Alexandrina (block 4) with moderate levels of targeting in the upper estuary (blocks 8–10). During the 1990s and 2000s, there was a progressive increase in fishing activity along the ocean beach of the Younghusband Peninsula (block 16) associated with increased targeting of Pipi, while Lake Alexandrina (block 4) continued to account for most of the effort. During the 2000s, there was a gradual contraction of the fishing ground in the Coorong Estuary associated with the Millennium Drought, with minimal fishing in the south lagoon (blocks 12–14). Drought-breaking river flows in 2010/11 led to improved environmental conditions in the estuary and a subsequent expansion of the fishing ground. The historically low level of fishing effort across the fishery in 2019/20 (Figure 2-3) related to reduced effort in Lakes Alexandrina and the Coorong Estuary from the preceding five-year period.

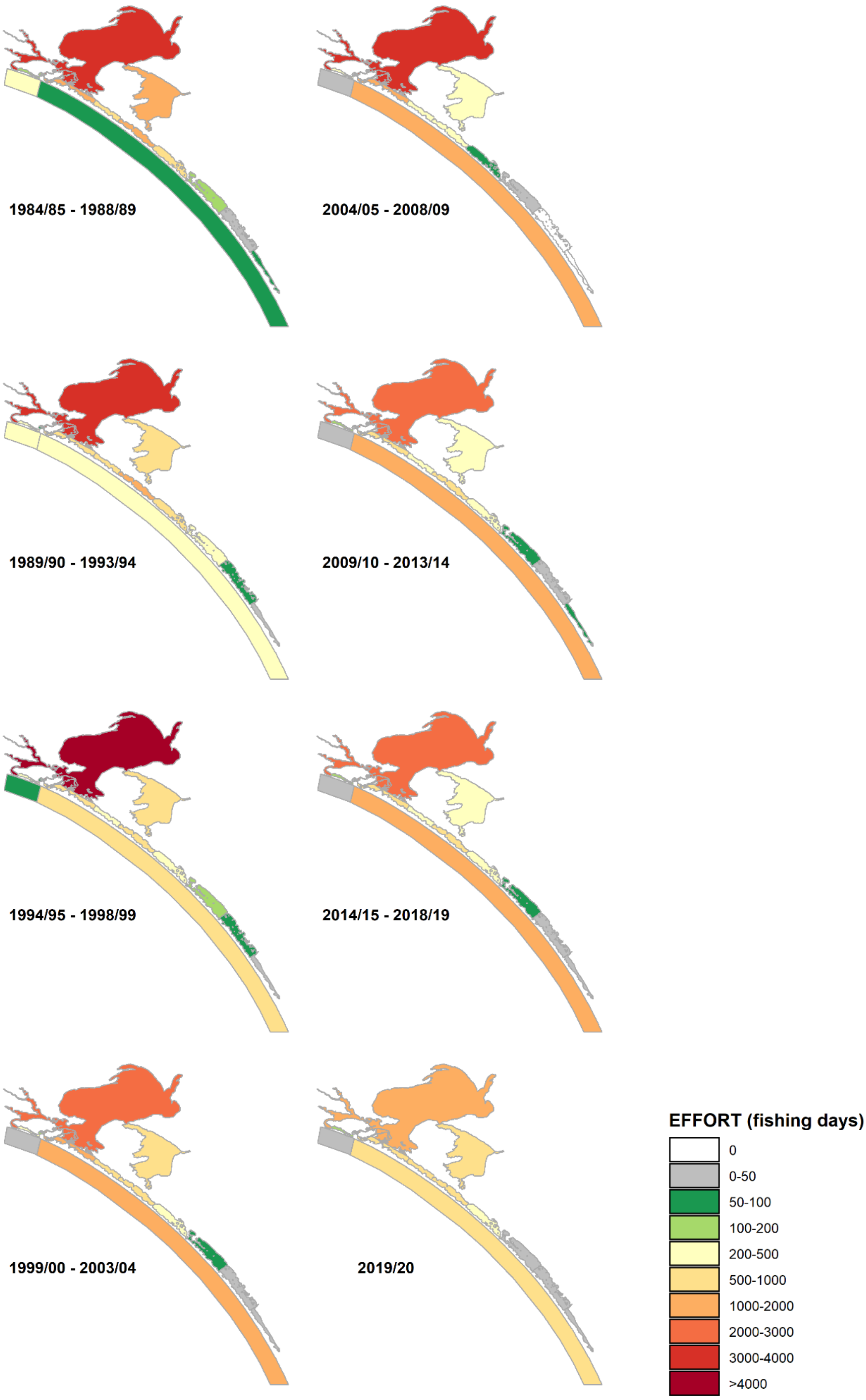

Figure 2-6. Spatial and temporal distribution of annual fishing effort (fishing days) in the LCF averaged over five-year periods from 1984/85 to 2018/19, and for 2019/20.

2.4 DISCUSSION

The dynamics of the LCF fleet have changed considerably over the last 36 years with most of the changes relating to market shifts and environmental conditions. While the primary species have consistently accounted for most of the reported targeted effort in the fishery since 1984/85, the most obvious changes in fisher behaviour have related to shifts in targeting among the primary species.

In the 1980s, a large proportion of the fleet's targeted effort was directed to Yelloweye Mullet, Mulloway and Carp. These primary species continue to be key targets for the fishery to the present day, with Yelloweye Mullet and Mulloway sold for human consumption and Carp primarily supplied as bait to local Rock Lobster fisheries, with small and increasing volumes reportedly sold for human consumption. During the 1990s, there was an increase in targeting of Golden Perch, and this species is now a primary target for the fishery due to its high wholesale value for human consumption. There was also a substantial increase in targeting of Pipi during the 1990s and 2000s, when most of the catch was supplied as relatively low-value product to the bait market. The introduction of a TACC under a quota management system for Pipi in 2007/08 has effectively constrained commercial harvest since 2009/10 (Ferguson and Hooper 2017), and since then, the fishery has increased its proportionate supply of Pipi for human consumption which has subsequently increased its wholesale market value (EconSearch 2020).

Environmental conditions associated with freshwater inflow from the Murray River have a major influence on the function and productivity of the Lakes and Coorong ecosystem, including the abundance and distribution of most of the species that support the LCF. Over the last 36 years, there have been several key environmental events that have resulted in Lakes and Coorong fishers modifying their fishing activities to optimise fishery production. An example was during the Millennium Drought (between 2002 and 2010), when a lack of freshwater inflows resulted in the intensification of a longitudinal salinity gradient in the Coorong Estuary where extremely high salinities (> 140 ppt) in parts of the south lagoon (blocks 12–14) made it uninhabitable for fish. Consequently, the fishable area in the estuary contracted considerably, with fishing effort all but disappearing from the south lagoon and becoming confined to areas adjacent the Murray Mouth and the north lagoon (blocks 6–11). This spatial contraction of the fishery reflected reductions in the amount of suitable estuarine habitat for many species. A flood event in late 2010 led to reduced salinities in the upper south lagoon, and fishing activity in these areas has since resumed. These environmentally-driven changes in fisher behaviour, along with the day-to-day behavioural responses of fishers to other factors such as markets, management arrangements, weather and the presence of Long-nosed Fur Seals (EconSearch 2020), highlight the complex and dynamic nature of the LCF fleet.

3 YELLOWEYE MULLET STOCK ASSESSMENT

3.1 INTRODUCTION

3.1.1 Overview

This section of the report provides an assessment of the LCF for Yelloweye Mullet, which builds on previous stocks assessments completed in 2005 and 2013, and assessments of stock status in 2015, 2016, 2018, 2019 and 2020 (Higham et al. 2005; Earl and Ferguson 2013; Earl and McPhail 2015; Earl et al. 2016; 2018; Earl 2019; 2020). It provides a synopsis of information available for this species and an assessment of the current status of LCF for Yelloweye Mullet, based on: (i) commercial fishery catch and effort statistics from 1 July 1984 to 30 June 2020; (ii) results from State-wide recreational fishing surveys done in 2000/01, 2007/08 and 2013/14 (Henry and Lyle 2003; Jones 2009; Giri and Hall 2015); (iii) information on the size and age characteristics of Yelloweye Mullet from commercial catches and research survey catches to inform on population structure and recent recruitment; and (iv) information on the recent condition of the environment in which the Yelloweye Mullet fishery operates against reference points prescribed in the management plan (PIRSA 2016).

3.1.2 Biology

Yelloweye Mullet is a member of the Mugilidae family (Gomon et al. 2008). It is characterised by a silvery, slender, cigar-shaped small–medium bodied adult form that can reach around 440 mm total length (TL) and 10 years of age (Thomson 1957; Gaughan et al. 2006). It occurs in bays, estuaries and coastal waters in New Zealand and along the southern coast of Australia, from Murchison River in Western Australia to the Hunter River in New South Wales, and around Tasmania (Kailola et al. 1993). They typically occur in schools in brackish and inshore coastal waters over sandy and muddy substrates to depths up to 20 m. Larger fish show a preference for deeper habitats such as channels or gutters, whereas juveniles tend to occupy shallow habitats (Higham et al. 2005). This species is well adapted to the dynamic environmental nature of estuaries and the nearshore coastal environment. They have a wide tolerance of water temperatures, e.g. from 14 to 33°C, and have been recorded in salinities up to 95 ppt in the Coorong Estuary (Ye et al. 2015).

Yelloweye Mullet is considered a marine estuarine-opportunist, i.e. it spawns at sea; regularly enters estuaries, particularly as juveniles, but uses coastal waters as alternative nursery habitat (Potter et al. 2015; Bice et al. 2018). For the Coorong population, macroscopic staging of gonads and gonadosomatic indices indicated a protracted reproductive season that extended from winter to early-autumn (Harris 1968; Ye et al. 2013). The estimated size at maturity (L_{50}) for Yelloweye Mullet in the Coorong Estuary is around 245 mm TL (Earl and Ferguson 2013).

Biological stock structure for Yelloweye Mullet is uncertain. It has been suggested that populations in Australia form two stocks, i.e. the western and eastern stocks, based on the number of lateral scales and gill rakers (Pellizzari 2001). The Western Stock comprises populations in Western Australia and western South Australia (Smith et al. 2008), while the Eastern Stock comprises populations in South Australia's Spencer Gulf, Gulf St Vincent and South East, and extends eastwards to Victoria, New South Wales and Tasmania (Pellizzari 2001). While there is limited evidence that fish in the Coorong Estuary may be part of the Eastern Stock, further work is required to confirm biological stock delineation. This assessment of stock status is undertaken at the management unit level – the LCF.

3.1.3 Fishery

In Australia, Yelloweye Mullet support commercial fisheries in Victoria, South Australia, Western Australia and Tasmania (Kailola et al. 1993). It is an important recreational species in these States, as well as New South Wales. In South Australia, commercial and recreational catches are taken in most nearshore coastal areas around the State, including the Coorong Estuary.

The commercial fishery for Yelloweye Mullet in South Australia has two main sectors: the LCF, and the Marine Scalefish Fishery (MSF). Over the past 25 years, the majority of the State's commercial catch has been taken by fishers in the LCF who target the species using small mesh gillnets. The Northern Zone Rock Lobster Fishery (NZRLF) and Southern Zone Rock Lobster Fishery (SZRLF) also have limited access to Yelloweye Mullet, though catches from these sectors are low and not considered in this assessment.

Recreational fishers harvest Yelloweye Mullet using rod and line in semi-protected nearshore coastal waters of South Australia (Kailola et al. 1993). They can also target the species using registered monofilament nylon nets in the Coorong Estuary and Lake George (PIRSA 2016). Recreational net fishing is prohibited in all other coastal waters of South Australia. In 2013/14, an estimated 100,598 mullet were captured by the recreational sector, of which 29,598 fish were released, leaving 71,278 fish retained (Giri and Hall 2015). This provided a total estimated State-wide harvest of 19.4 t.

3.1.4 Harvest strategy

The management plan (PIRSA 2016) includes a harvest strategy for finfish. The harvest strategy uses environmental performance indicators and decision rules to inform setting of the annual TACE for three finfish sectors of the LCF, which collectively account for > 98% of the fishery's total finfish catch each year. These sectors are: (i) estuarine large mesh gillnet (ELMGN); (ii) estuarine small mesh gill net; and (iii) freshwater large mesh gill net. Yelloweye Mullet is the primary target in the ESMGN sector (Earl 2019). The environmental performance indicator for the ESMGN sector is the amount (%) of suitable habitat available for Yelloweye Mullet in the Coorong Estuary. This indicator was developed as a surrogate metric for fishable biomass of Yelloweye Mullet in the Coorong Estuary (Knuckey et al. 2015; PIRSA 2016).

3.1.5 Management arrangements

For the commercial sector of the LCF, management arrangements are in place to manage targeted fishing effort and limit the take of Yelloweye Mullet. These comprise general gear restrictions, spatial and temporal closures and a legal minimum size (LMS) of 210 mm TL. The recreational sector is managed through a combination of input and output controls, aimed at ensuring the total catch is maintained within sustainable limits and to ensure that recreational access to the fishery is equitably distributed between recreational participants (PIRSA 2016). Bag and boat limits apply to all State waters. The personal daily bag limit is 60 fish, and there is a boat limit (when three or more people are onboard) of 180 fish. The LMS of 210 mm TL applies to the recreational sector. Management arrangements also comprise general gear restrictions. A small number of registered mesh net owners can use nylon gillnets to target finfish in the Coorong Estuary. Recreational mesh nets must be less than 75 m long with 50–64 mm mesh, and the registered net owner must be within 50 m of the net at all times when fishing. Temporal and spatial closures apply to the use of recreational nets in the region.

3.2 METHODS

The data sources considered in this stock assessment were: commercial fishery statistics; recreational fishery catch estimates; annual fishery size and age structures from commercial catch sampling; annual population size structures from fishery-independent sampling; and estimates of the environmental performance indicator for the ESMGN sector. These data were considered at the management unit scale for the LCF.

3.2.1 Fishery statistics

The commercial fishery data for Yelloweye Mullet were extracted from the commercial Lakes and Coorong Fishery Information System for the 36-year period of 1984/85 to 2019/20. These data were aggregated to provide annual totals of total catch across all gear types, and targeted catch, targeted effort and CPUE for small mesh gillnets ($CPUE_{SMGN}$) in financial years. $CPUE_{SMGN}$ was estimated by dividing annual targeted catch by annual targeted effort in terms of the number of nets that were deployed (net-days). Effort in fisher days is not considered in this assessment, because it does not account for the variation in the number of nets deployed on each fishing day. Estimates of total catch, by month and reporting block (Figure 1-1), for each of the past 36 years is also presented to describe the fine-scale spatial and temporal trends in fishery production. Estimates of total annual State-wide recreational catches of Yelloweye Mullet obtained from telephone/diary surveys done in 2000/01, 2007/08 and 2013/14 (Henry and Lyle 2003, Jones 2009, Giri and Hall 2015) are also presented.

3.2.2 Size and age structures

Biological samples of Yelloweye Mullet were collected in the financial years 2012/13, 2016/17, 2019/20 and 2020/21, from several sources. Samples were available from commercial catches taken using small mesh gillnets (50–64 mm mesh) in the Coorong Estuary in 2012/13 and 2020/21. Commercial catches were accessed at fish processing facilities in Meningie, Goolwa and Hindmarsh Island. No commercial catch samples were available from 2013/14–2018/19, inclusive. Additional samples were available from multi-panel gillnet (38–150 mm mesh) catches from research sampling done in 2012/13, 2016/17 and 2019/20, which provided a wider size range of fish. No multi-panel gillnet samples were available from 2013/14–2015/16, 2017/18, 2018/19 and 2020/21.

On each commercial catch sampling occasion, fish were randomly sub-sampled (10–25 fish) from the catch and stored for processing. In the laboratory, each sampled fish was measured to the nearest mm, weighed to the nearest 0.1 g, and then dissected for the removal of its otoliths that were later used to determine fish age using an established ageing protocol (Earl and Ferguson 2013). The additional samples available from research sampling were measured for TL to the nearest mm before being returned to the water. Subsequently, estimates of annual size and age structures were generated. The age structures based on commercial catch samples for 2012/13 and 2020/21 were compared using the Kolmogorov-Smirnov (K-S) 2-samples goodness of fit test. This test was done using SPSS® 26.

3.2.3 Environmental performance indicator

One performance indicator was considered in this assessment for Yelloweye Mullet, i.e. the environmental performance indicator used in the finfish harvest strategy for the ESMGN sector. The environmental performance indicator for this sector is the amount (%) of suitable habitat available for Yelloweye Mullet in the Coorong Estuary. Annual estimates of this performance indicator were determined based on: (i) modelled daily salinity for 109 locations, at 1-km intervals, along longitudinal gradient of the Coorong Estuary from Goolwa Barrage to Salt Creek, as determined by the Coorong Hydrodynamic Model (Webster 2010); and (ii) the salinity tolerance of Yelloweye Mullet (68 ppt), as determined by McNeil et al. (2013). The annual performance indicator values represent the proportion (%) of the 109 locations in the Coorong Estuary for which modelled salinity was below the tolerance threshold of the species.

For this assessment, a time series of annual environmental performance indicator values was calculated from 1984/85 to 2020/21. The value for the 2020/21 reporting year (1 February 2020–31 January 2021), was compared to the target, trigger and limit reference points from the reference period of 1984/85–2012/13 (PIRSA 2016). A salinity contour graph based on modelled daily estimates of salinity for the 109 locations in the Coorong Estuary during the 2020/21 reporting year is presented to show how the amount of habitat available for Yelloweye Mullet varied over the last 12 months.

3.3 RESULTS

3.3.1 Fishery statistics

3.3.1.1 State-wide

Total annual State-wide catches of Yelloweye Mullet increased from 223 t in 1984/85 to a historical peak of 519 t in 1989/90 (Figure 3-1). Annual catches then steadily declined to 156 t in 2003/04. From then, catch increased to 271 t in 2010/11 before declining to 138 t in 2014/15. It remained relatively low during 2015/16–2017/18, and increased sharply in 2018/19 and 2019/20. The total State-wide catch of 469 t in 2019/20 was the second highest on record.

The commercial LCF has been the main contributor to annual catches of Yelloweye Mullet in South Australia, and from 1984/85 to 2004/05 contributed between 49% and 78% of the catch (Figure 3-1). Since then, the contribution from the LCF has gradually increased. In 2019/20, the LCF contributed 98% (458 t) of the total State-wide catch, while the remaining 2% (11 t) was taken by the MSF.

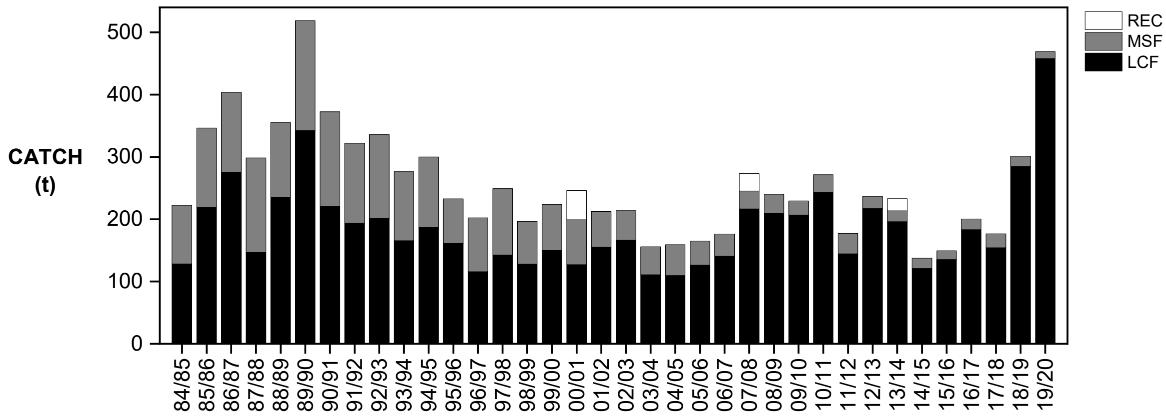

Figure 3-1. State-wide catch of Yelloweye Mullet from 1984/85 to 2019/20, showing contributions by the commercial LCF and MSF, and the recreational sector (available for 2000/01, 2007/08 and 2013/14 only).

Estimates of recreational catch for Yelloweye Mullet in South Australia are available for three years: 2000/01, 2007/08 and 2013/14 (Figure 3-1). In 2000/01, the estimated harvested catch was 47 t, which accounted for 19% of the State's combined commercial and recreational catch. In 2007/08, the harvested catch declined to 28 t. In 2013/14, the estimated number of Yelloweye Mullet captured by recreational fishers in South Australia was 100,876 fish, of which 29,598 fish were released, leaving 71,278 fish harvested. The estimated total weight of these harvested fish was 18 t, which accounted for 8% of the State's combined commercial and recreational harvest. The proportion of the total Statewide recreational catch taken in areas of the LCF is not known.

3.3.1.2 Lakes and Coorong Fishery

Trends in total catch, effort and CPUE

Total annual catch of Yelloweye Mullet in the LCF increased from 128 t in 1984/85 to 346 t in 1989/90 (Figure 3-2). From then, catch progressively declined to a low of 110 t in 2004/05. It then increased and ranged between 206–243 t between 2007/08 and 2010/11, before declining to 121 t in 2014/15. Catches have gradually increased since 2015/16, with sharp increases in 2018/19 and 2019/20. The total catch of 458 t in 2019/20 was the highest annual catch recorded in the fishery since 1984/85.

The dominant gear type used to target Yelloweye Mullet in the LCF has been the small mesh gillnet, which has accounted for an average of 90% (landed weight, ± 6.1% S.D) of the annual catch over the past 36 years. Most of the remaining catch in each year was taken using haul nets, or as by-product when other species were targeted. In 2019/20, 97% of the total catch was taken as targeted catch using small mesh gillnets.

Estimates of annual $CPUE_{SMGN}$ were variable during the 1980s (range: 4.5–12.2 kg.net-day^{-1}); stable at moderate levels during the 1990s (6.3–8.5 kg.net-day^{-1}); and then increased to around 14 kg.net-day^{-1} in 2008/09. $CPUE_{SMGN}$ declined to 5.22 kg.net-day^{-1} in 2014/15, reflecting a possible decline in fishable biomass in the Coorong. Since then, catch rates have increased to unprecedented high levels. The $CPUE_{SMGN}$ of 37.2 kg.net-day^{-1} in 2019/20 was the highest catch rate on record.

Spatial and temporal trends in catch

Reporting blocks 9–11 have consistently contributed most to the annual catches of Yelloweye Mullet in the LCF since 1984/85 (Figure 3-3). Over this time, the most notable change in the spatial distribution of catches occurred during the 2000s (i.e. the Millennium Drought) when there was an increase in the relative contributions of catches from blocks 8–9 to total annual catch. This spatial contraction of the fishery was associated with a reduction in the amount of suitable estuarine habitat available for the species in the Coorong Estuary (Earl 2020). In 2018/19, most of the catch was taken in reporting blocks 9 and 10. Historically, the Yelloweye Mullet fishery was seasonal with higher catches taken between May and November. In 2019/20, catches were highest from May to March, and lowest during April and May.

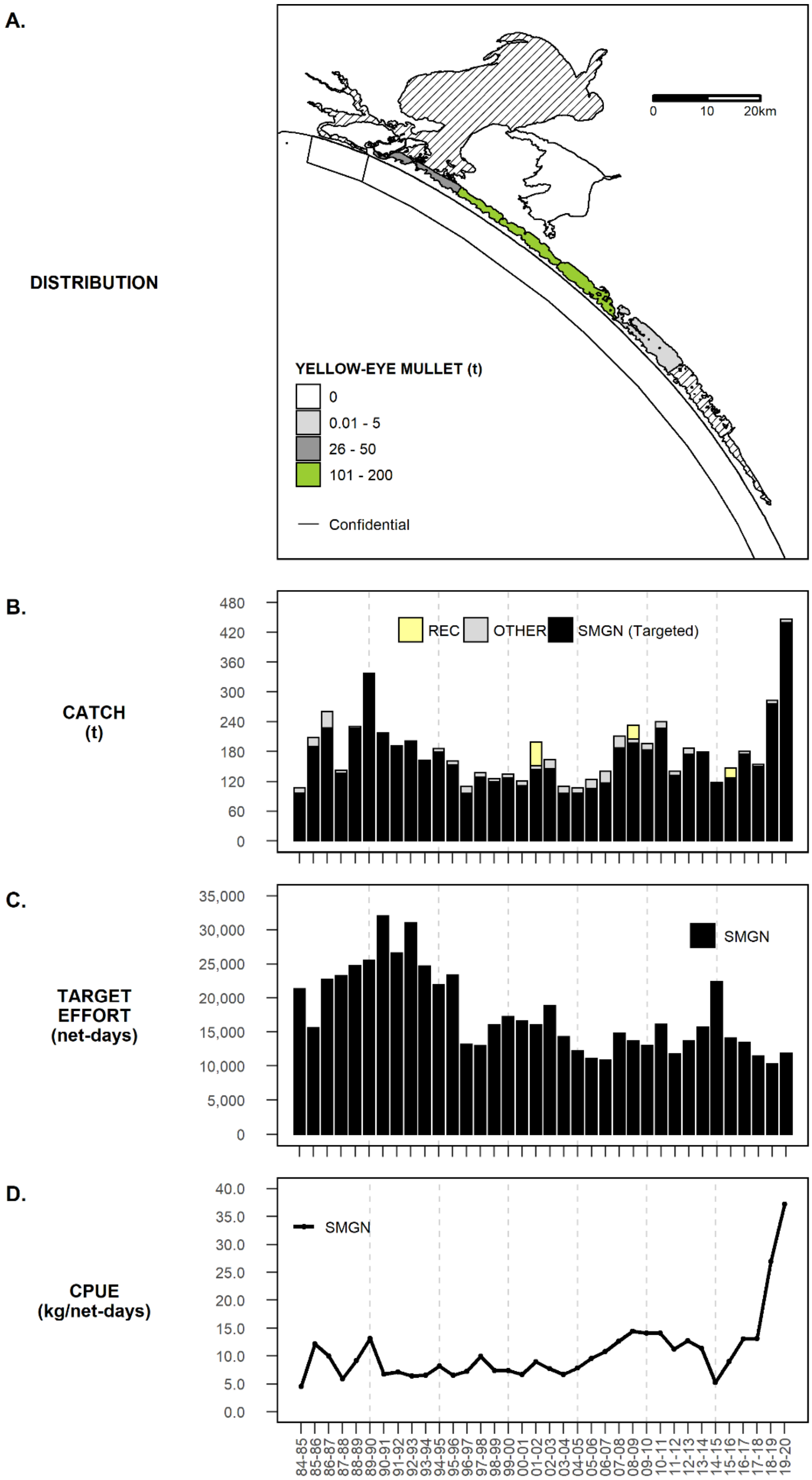

Figure 3-2. Fishery statistics for Yelloweye Mullet. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20; long term trends in: (B) total catch for main gear types (small mesh gillnets (SMGN), other); (C) targeted effort for SMGN; and (D) targeted CPUE for SMGN.

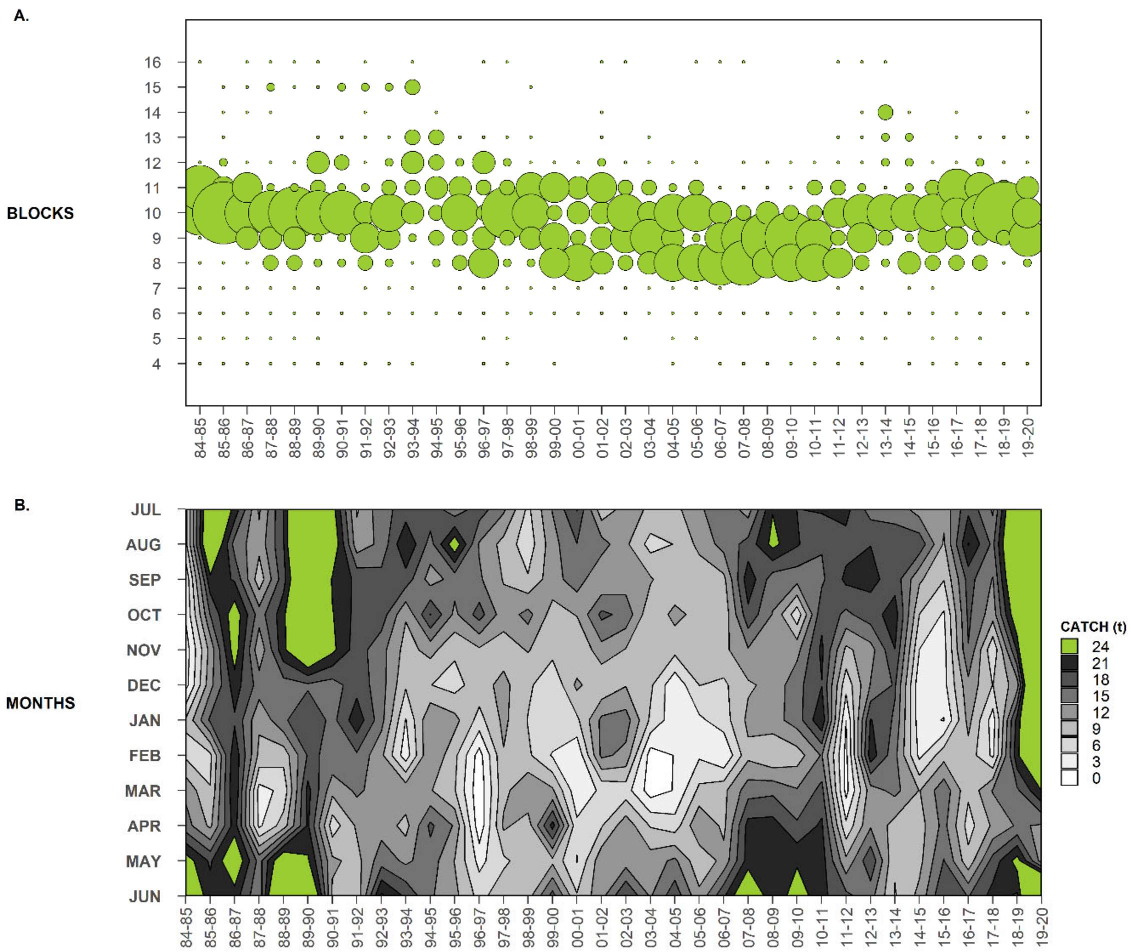

Figure 3-3. Fishery statistics for Yelloweye Mullet. Long-term trends in (A) the annual distribution of catch among LCF reporting blocks (diameter of the bubbles represent the relative contribution of each reporting block to total annual catch); and (B) the annual distribution of catch among months.

3.3.2 Size and age structures

3.3.2.1 Commercial fishery gillnet catches

The size structure for Yelloweye Mullet from small mesh gillnet catches taken in the Coorong Estuary in 2020/21 was similar to that in 2012/13, i.e. it involved mostly fish from the LMS of 220 mm TL to 320 mm TL, and comprised a dominant narrow mode at 250–260 mm TL (Figure 3-4). The size structure for 2012/13 included fish up to 346 mm TL, whereas the largest fish collected in 2020/21 was 322 mm TL. In both years, > 95% of fish in the size structure were > 240 mm TL.

The age structures for Yelloweye Mullet from commercial catches in 2012/13 and 2020/21 had similar distributions (K-S D = 0.781, P = 0.575) (Figure 3-4). In both years, the age structure involved four young age classes and included fish from 1–4 years of age. In 2012/13, the age structure comprised mostly two and 3-year old fish which accounted for 32% and 62% of the fish sampled, respectively. Small numbers of one and 4-year old fish were also sampled. Similar to 2012/13, the age structure in 2020/21 comprised mostly 2 year old (47%, i.e. the 2018/19 year class) and 3 year old fish (43%, i.e. the 2017/18 year class) from the 2018/19 and 2017/18 year classes, respectively, with 4 year olds accounting for 9% of the fish sampled.

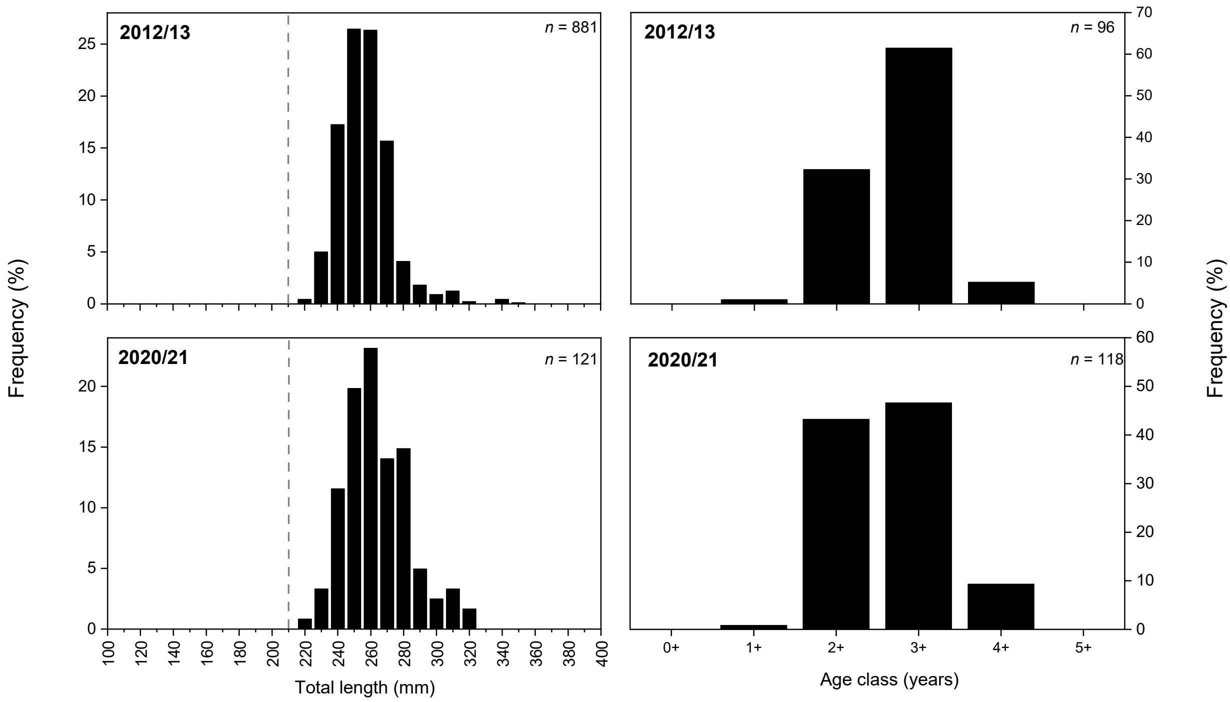

Figure 3-4. Size (left) and age (right) structures for Yelloweye Mullet from commercial fishery catches taken by the LCF using small mesh gillnets in the Coorong Estuary in 2012/13 and 2020/21. The numbers (n) of fish processed are shown. Note the different y-axis scales. Black dashed vertical line represents the LMS of 210 mm TL.

3.3.2.2 Fishery-independent multi-panel gillnet catches

The size structure of Yelloweye Mullet from multi-panel gillnet samples in 2019/20 was similar to those in 2012/13 and 2016/17, and considerably wider than those from commercial gillnet catches in 2012/13 and 2020/21 (Figure 3-5). In each year, the size distributions comprised a large mode at 250–260 mm TL, and a smaller mode at around 190–210 mm TL with most fish between 165–300 mm TL. A small number fish from 300–350 mm TL were collected in 2020/21.

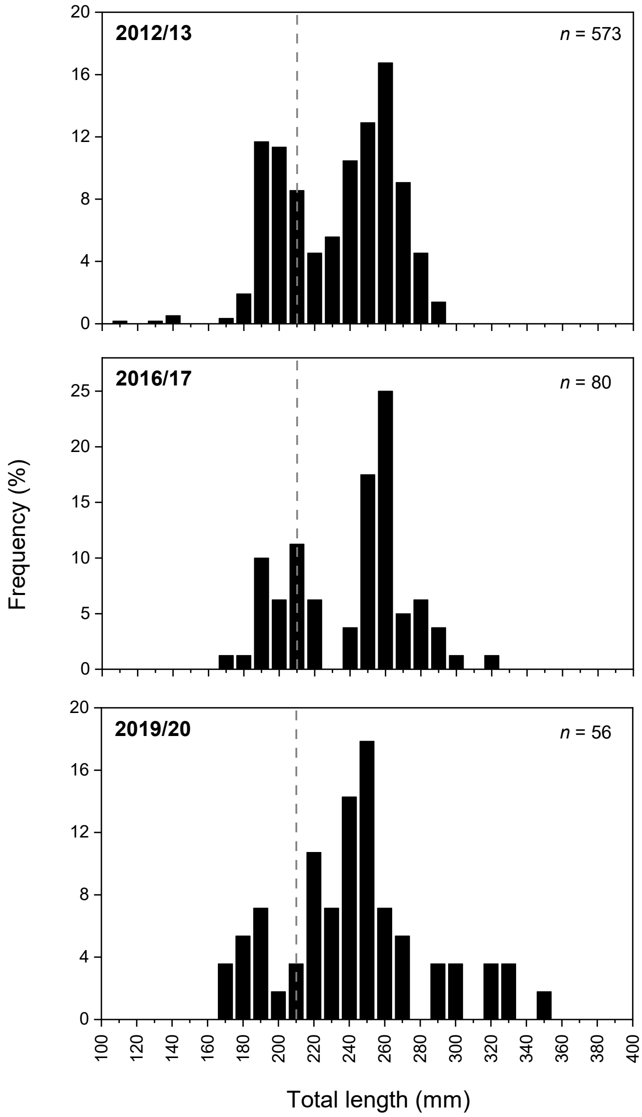

Figure 3-5. Size structures for Yelloweye Mullet from fishery-independent sampling done at various locations in the Coorong Estuary using multi-panel gillnets in 2012/13, 2016/17 and 2019/20. The numbers (*n*) of fish measured in each year are also shown. Note the different y-axis scales. Black dashed vertical line represents the LMS of 210 mm TL.

3.3.3 Environmental performance indicator

Modelled daily salinity concentrations for the Coorong Estuary indicated that the amount of suitable habitat for Yelloweye Mullet was relatively stable throughout the 2020/21 reporting year (Figure 3-6). The ESMGN performance indicator for habitat available to Yelloweye Mullet in the Coorong Estuary was 62.4% for the 2020/21 reporting year, which was above the target reference point of 50% (Figure 3-7).

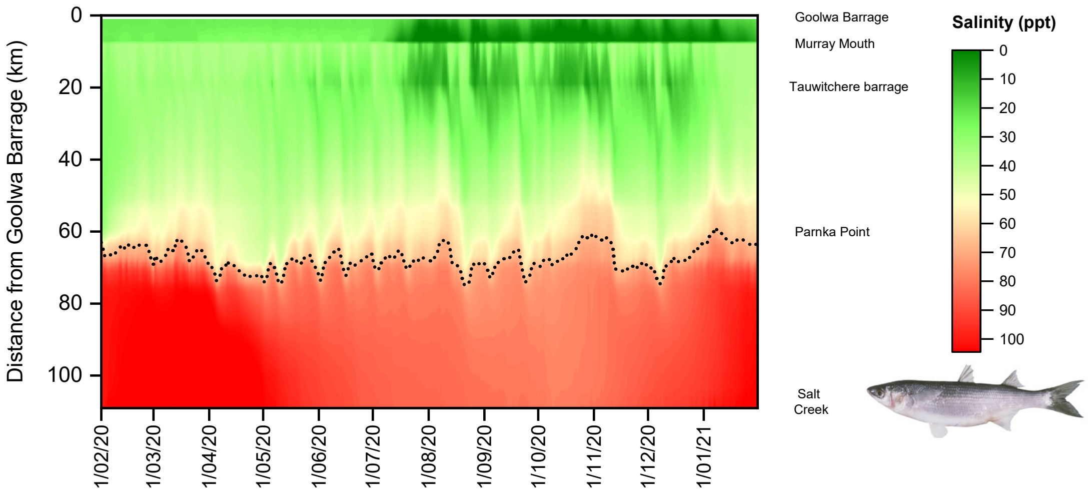

Figure 3-6. Estimated salinity concentration with distance from the Goolwa Barrage for the 2020/21 reporting year, with the approximate salinity threshold for Yelloweye Mullet (68 ppt) shown as a dashed line. Salinity threshold represents the level of salinity that was lethal for 10% of test fish, as determined by Ye et al. (2013).

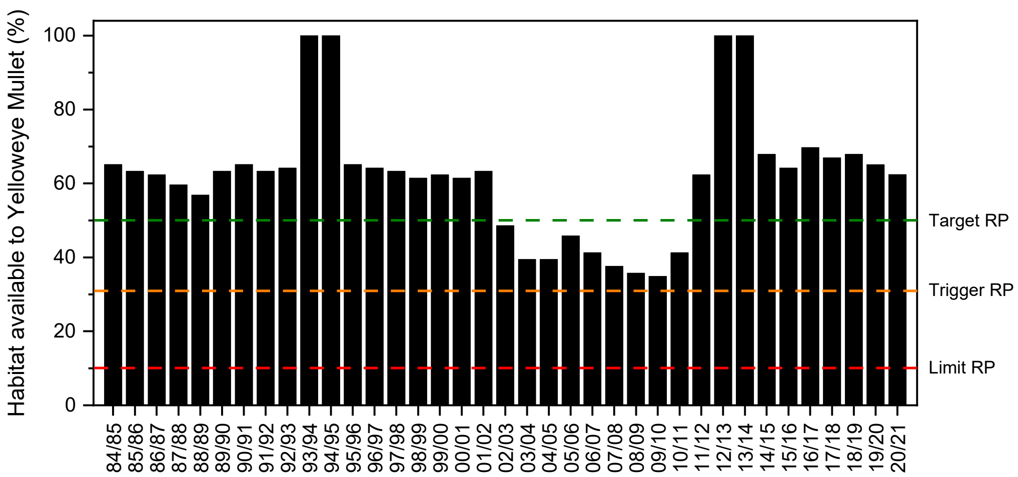

Figure 3-7. Estimates of the ESMGN performance indicator for habitat available to Yelloweye Mullet in the Coorong Estuary from 1984/85 to 2020/21 (reporting years), showing target, trigger and limit reference points (RP).

3.4 DISCUSSION

3.4.1 Context of this assessment

The previous Yelloweye Mullet stock assessment, which considered commercial catch and effort statistics up to 30 June 2012, classified the stock as “sustainably fished” (Earl and Ward 2014). All subsequent assessments of stock status (Earl and McPhail 2015; Earl et al. 2016; 2018; Earl 2019; 2020), which were based solely on analyses of commercial fishery data, resulted in a classification of ‘sustainable’.

Since 2009, the number of interactions between Long-nosed Fur Seals and LCF gillnet fishers have increased and impacts to the Yelloweye Mullet fishery through depredation of fish caught in gillnets have been reported (Goldsworthy and Boyle 2019). The impacts occur as seals attempt to remove fish caught in gillnets which can result in catch losses and gear damage (Earl et al. 2021). Reliable, quantitative information on the impacts of seals on the fishery in terms of catch losses, as well as possible changes to fisher behaviour in response to the presence of seals is not available. Nevertheless, seal depredation of Yelloweye Mullet caught in gillnets is likely to have resulted in modified fisher behaviour as well as lower catches and catch rates than would otherwise have been realised. The need for quantitative information on the impacts of seals on the fishery will be addressed by the Fisheries Research and Development Corporation (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 2019.

3.4.2 Determination of stock status

The status of the LCF for Yelloweye Mullet was assigned using the NFSRF (Table 1-1; Stewardson et al. 2018). The current harvest strategy for finfish (PIRSA 2016) does not provide a pre-defined limit reference point that determines when the Yelloweye Mullet stock is depleted (i.e. when recruitment is impaired because the adult biomass no longer has the reproductive capacity to replenish itself), and therefore lacks an index that explicitly defines stock status. Consequently, the assignment of stock status for Yelloweye Mullet used a weight-of-evidence approach that placed considerable emphasis on trends in commercial catch and effort data from 1984/85 to 2019/20, and the size and age structures from commercial fishery catches and fishery-independent multi-panel gillnet catches from research surveys for a number of years since 2012/13. This weight-of-evidence approach is consistent with that used in the Status of Key Australian Fish Stocks Reports (Stewardson et al. 2018).

3.4.3 Stock status

The LCF has historically been the most significant fishery for Yelloweye Mullet in South Australia, and in 2019/20 contributed 98% of State’s total commercial catch of this species. Commercial landings in the LCF peaked in 1989/90 and then progressively declined to a historical low in 2004/05. This long-term decline likely reflected redirection of targeted fishing effort to higher value species (i.e. Mulloway) rather than a declining biomass, because $CPUE_{SMGN}$ was stable during this period. Catch rates declined from 2010/11 to 2014/15 suggesting a possible decline in fishable biomass in the Coorong Estuary. Since then, catches and catch rates have been considerably higher. The total catch of 458 t in 2019/20 was the highest catch recorded in the fishery. The recent high catches have been associated with historically high $CPUE_{SMGN}$ and likely reflect high abundance of Yelloweye Mullet in the Coorong Estuary.

The State-wide recreational catch of Yelloweye Mullet was estimated at 18 t in 2013/14, which represented around 8% of the State's combined commercial and recreational harvest (Giri and Hall 2015). The proportion of the State-wide recreational catch taken in the Coorong region is not known.

The environmental performance indicator for the ESMGN of the LCF was developed as a surrogate metric for fishable biomass for Yelloweye Mullet in the Coorong Estuary (Knuckey et al. 2015; PIRSA 2016). The ESMGN performance indicator for habitat available for Yelloweye Mullet in the Coorong Estuary for the 2020/21 reporting year was 62.4%, which was above the target reference point of 50%.

Annual size and age structures for Yelloweye Mullet in commercial catches from the Coorong Estuary in 2020/21 were similar those in 2012/13 (i.e. dominated by two and 3-year old fish) and consistent with those developed for the Coorong population in the 1960s (Harris 1968). The 2020/21 fishery age structure included 1–4-year old fish and was dominated by two (47%) and 3-year olds (43%) which originated from spawning that occurred in 2018/19 and 2017/18, repsectvely. Fish older than three years were rare despite the potential for this species to reach 10 years of age (Gaughan et al. 2006). Whether the truncated age structures related to the removal of older fish by fishing, gear selectivity, the impacts of environmental conditions, and/or the emigration of larger/older individuals to the adjacent marine environment, is not known. The presence of young fish in the fishery size and age structures suggests that recruitment has occurred in recent years.

The regular recruitment to the fishable biomass in the Coorong Estuary in recent years, stable size and age structures and recent record-high annual catches and catch rates indicate that the biomass of this stock is unlikely to be depleted, recruitment is unlikely to be impaired, and the current level of fishing mortality in unlikely to cause the stock to become recruitment impaired. On this basis, and using the definitions from the NFSRF, the LCF for Yelloweye Mullet is classified as a **sustainable** stock.

The LMS for Yelloweye Mullet in South Australia is 210 mm TL, which is around 35 mm lower than the estimated size at maturity (SAM_{50}) for this species in the Coorong Estuary (Ye et al. 2013). While size structures for Yelloweye Mullet from commercial catches in 2019/20 indicated that the LCF generally target and capture fish above the SAM_{50}, a small proportion of the catch comprised sexually immature fish. An increase in the proportion of immature fish harvested by the fishery would reduce the number of fish recruiting to the spawning biomass of the population and subsequently reduce egg production. One potential solution is to increase the LMS from 210 mm to the SAM_{50}, i.e. 245 mm.

3.4.4 Uncertainty in the assessment

The main uncertainty in this stock assessment for Yelloweye Mullet relates to the correlation between fishable biomass and $CPUE_{SMGN}$. It is assumed that the patterns in commercial catch and $CPUE_{SMGN}$ are influenced by the biomass of Yelloweye Mullet in the Coorong Estuary. However, there are other factors relating to fisher behaviour that may also influence these relationships. Fishers can switch their fishing effort between different target species and move between different areas of the fishery to optimise their fishing efficiency and profitability. Furthermore, in recent years some LCF fishers have adapted their fishing practices to try and avoid interactions with Long-nosed Fur Seals (e.g. reduced soak times; fishing in suboptimal areas), and so the measure of a unit of fishing effort, i.e. 'net-day', has changed over time. These changes in fisher behaviour, over time, complicate interpreting fishing effort and CPUE in terms of fishable biomass.

Environmental variability contributes to additional uncertainty around the relationships between fishable biomass and the commercial fishery data. Variation in the timing and magnitude of freshwater inflows to the Coorong Estuary influences salinity levels along the system, and ultimately the size of the area of habitat available for Yelloweye Mullet (Ye et al. 2013). For example, low freshwater inflows during the Millennium Drought resulted in hypersaline conditions in the southern Coorong and this caused populations of many fish species, including Yelloweye Mullet to aggregate into a reduced area of favourable habitat near the Murray Mouth (Ferguson and Ward 2011). Such changes in the range of Yelloweye Mullet in the Coorong Estuary may affect their catchability and potentially confound interpretation of $CPUE_{SMGN}$ as an indicator of fishable biomass.

A further uncertainly relates to the lack of information on spatial trends in Yelloweye Mullet catch by the recreational sector in South Australia. State-wide telephone/dairy surveys done in 2000/01, 2007/08 and 2013/14 estimated that Yelloweye Mullet catches by the recreational sector in South Australia accounted for between 8–19% of the State's combined commercial and recreational catch (Jones and Doonan 2005; Jones 2009; Giri and Hall 2015). Nevertheless, the proportion of the total recreational catch taken in, or adjacent to the Coorong Estuary is not known. This is of particular concern for the Coorong population because recreational fishers can target Yelloweye Mullet using registered gillnets. Understanding the spatial and temporal trends in Yelloweye Mullet catch by the recreational sector would improve future stock assessments for this species.

Although this study provided size and age structure information from commercial gillnet catches and fishery-independent multi-panel gillnet catches it should be noted that these are from an exploited population that has likely also been impacted by environmental changes. Further, the size range of fish collected using these methods will have been limited by the mesh sizes of the gillnets. Additional fishery-independent sampling using small-mesh haul nets may provide a wider size/age range of fish and the use of gillnets with different mesh sizes would allow gear selectivity to be estimated.

Finally, a key uncertainty in this stock assessment relates to the levels of fishing mortality that are not accounted for in the commercial fishery statistics. Levels of incidental mortality of sub-legal sized Yelloweye Mullet discarded by commercial and recreational fishers in the Coorong Estuary are poorly understood. Estimates of discarding are only available for the ESMGN sector from limited sampling undertaken during the Millennium Drought (Ferguson 2010). For the commercial sector, this could be addressed by validated monitoring of discards from gillnets by incorporating discard information into the Inland Waters Catch and Effort return. Another potential source of fishing-related mortality that is not accounted for in the fishery data but is frequently spoken about by fishers, relates to Yelloweye Mullet that were caught in gillnets and subsequently removed by Long-nosed Fur Seals before they could be landed. As such, fishing mortality of Yelloweye Mullet in the Coorong Estuary is likely to be higher than the levels reported in this assessment. The current FRDC project (2018-036) will provide estimates of the proportions of the commercial gillnet catches of Yelloweye Mullet (and other species) that are lost due to seal depredation.

3.4.5 Research priorities

The most important research needs for the Yelloweye Mullet fishery and its management include: (i) ongoing development of a time series of annual age structures from the Coorong Estuary, based on fishery and research survey catches; (ii) independent ongoing monitoring of discarding of sub-legal sized individuals from gillnets in the Coorong Estuary; (iii) regular surveys to estimate recreational harvest of Yelloweye Mullet in the Coorong Estuary; (iv) collecting more refined data on fishing effort from the commercial sector (e.g. soak time of gear); and (v) information on the proportion of the Yelloweye Mullet catch that is lost to depredation of fish caught in commercial gillnets.

4 STOCK STATUS OF OTHER KEY FISHERY SPECIES

4.1 INTRODUCTION

Assessing the status of fish stocks can be challenging, especially for stocks that have limited data. In these situations, a weight-of-evidence approach is required to support status determination. This approach involves the systematic consideration of a range of available biological and fisheries information, each used to provide a measure or proxy for fishable biomass and levels of fishing mortality to support a status determination. Additional information about the species' stock structure, biology and management arrangements can contribute to the decision-making process. This weight-of-evidence approach is the standard approach used in the Status of Australian Fish Stocks Reports (Stewardson et al. 2018) for complex multi-species/gear fisheries and data-poor stocks, i.e. stocks for which sophisticated stock assessment models are not available.

This section of the report uses a weight-of-evidence approach to assign stock status for six LCF species that are distributed across the 'primary' and 'secondary' species categories defined in the management plan (PIRSA 2016). It consists of species-specific sections, which are arranged to align with the ELMGN and FLMGN sectors of the fishery. For key species in each sector, the relevant biological information is provided, along with a description of the fishery, associated management arrangements, an interrogation of the fishery data from 1984/85 to 2019/20, and a classification of stock status using the definitions from the NFSRF (Table 1-1; Stewardson et al. 2018). The report also provides an assessment of the recent condition of the environment in which the ESMGN and FLMGN sectors operate, using environmental performance indicators and reference points defined in the management plan. Assessment of the environmental performance indicator for the ESMGN sector is provided in Section 3.3.3. This section also summarises relevant biological information, fishery data and assessment of stock status for Pipi, including an assessment of biological performance indicators against reference points defined in the management plan.

4.2 METHODS

4.2.1 Fishery statistics

Daily commercial catch and effort data are the primary data considered in this section. These 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 (fishing days; net-days, i.e. the number of nets) for targeted and non-targeted species, and location of the fishing activity by reporting block (Figure 1-1).

The appropriate data for each species were extracted from the SARDI Aquatic Sciences' commercial LCF Information System. For Pipi, data on catches by the MSF are also included. The data span a 36-

year time series from 1984/85 to 2019/20 and were aggregated to provide annual estimates of catch and effort for the main gear types.

The fishery data are presented by financial year from 1984/85 to 2019/20. For each species, a map is presented that shows total catch by reporting block for 2019/20. 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. The presentation of data was limited by constraints of confidentiality, i.e. data could only be presented when aggregated for five or more fishers. Where available, estimates of recreational catch obtained from three telephone/diary surveys (Jones and Doonan 2005; Jones 2009; Giri and Hall 2015) are also presented.

4.2.2 Performance indicators

4.2.2.1 Finfish

The harvest strategy for finfish uses environmental performance indicators and decision rules to inform setting of the annual TACE for the three finfish sectors (PIRSA 2016). The environmental performance indicator for each sector is: (i) ELMGN - suitable habitat available (%) for Mulloway in the Coorong Estuary; (ii) ESMGN – suitable habitat available (%) for Yelloweye Mullet in the Coorong Estuary; and (iii) FLMGN - mean annual water level (m) in the Lower Lakes. These indicators were developed as surrogate metrics for fishable biomass for the key target species within each sector (Knuckey et al. 2015). In this section, estimates of the environmental performance indicators for the ELMGN and FLMGN sectors relative to their target, trigger and limit reference points for the 2020/21 reporting year (1 February 2020–31 January 2021) are presented (PIRSA 2016). Detailed descriptions of the performance indicators and associated reference points are provided in the management plan (PIRSA 2016).

4.2.2.2 Pipi

The harvest strategy for Pipi uses biological performance indicators and decision rules to inform setting of the annual total allowable commercial catch (TACC) (PIRSA 2016). The biological performance indicators used in the harvest strategy are: (i) fishery-independent mean annual relative biomass (primary performance indicator), and (ii) presence/absence of pre-recruits in size frequency distributions (secondary performance indicator; Ferguson and Ward 2014; Ferguson et al. 2015; Ferguson and Hooper 2017). Estimates of these performance indicators relative to target, trigger and limit reference points for the 2019/20 financial year are presented to support status determination for Pipi. Detailed descriptions of the biological performance indicators and associated reference points are provided in the management plan.

4.3 RESULTS

4.3.1 Estuarine large mesh gillnet sector

4.3.1.1 Mulloway

Biology

Mulloway (*Argyrosomus japonicus*) is a member of the Sciaenidae family (Gomon et al. 2008). It is broadly distributed throughout the Indo-Pacific region including Australia, where it occurs from the Gascoyne region on the west coast of Western Australia, around the southern coasts of the continental mainland, and up to the Wide Bay–Burnett region on the east coast of Queensland (Kailola et al. 1993). Within this distribution, Mulloway occur in bays, tidal creeks, estuaries and marine waters to depths of at least 100 m. In South Australia, juveniles are abundant in the Coorong Estuary, while larger Mulloway are common in exposed marine habitats, such as the surf beaches.

Mulloway has a complex life-history that involves ontogenetic changes in habitats that are linked by movement at different life history stages (Ferguson et al. 2014). In South Australia's southeast, temporal analysis of gonadosomatic indices indicated that Mulloway has a prolonged spawning season that extends from October to January. Spawning occurs in aggregations that form during spring/summer in the marine waters at the Murray Mouth. Young juveniles then enter the Coorong Estuary when environmental conditions are favourable and utilise estuarine habitat as juveniles, before returning to the marine environment as 5–6 year olds. Such movement results in a significant ontogenetic shift from protected estuarine habitats to more exposed marine habitats. As a result, population size and age structures vary among habitats. The Coorong Estuary generally supports a population with only a few young age classes, whereas the population in the adjacent marine environment generally involves multiple age classes of larger, older fish and has included individuals up to 41 years old (Ferguson et al. 2014). The estimated size at maturity (L50) for Mulloway in South Australia is 850 mm total length (TL) for females and 778 mm TL for males, which is equivalent to the mean age of approximately 6 years and 5 years, respectively (Ferguson et al. 2014).

Attempts to understand the stock structure of Mulloway in Australia have yielded different results. It has been suggested that a single panmictic population occurs in Australia (Archangi 2008), but this is not supported by recent studies that suggest sub-structuring between populations in New South Wales, South Australia and Western Australia is more likely (Ferguson et al. 2011; Barnes et al. 2016). These recent studies suggested that two stocks occur in South Australia. The eastern stock occupies marine and estuarine waters of the State's south-east including the Coorong Estuary and coastal waters along the Younghusband Peninsula, while the western stock occurs on the State's far west coast and may have some association with populations in southern Western Australia (Barnes et al. 2016). While there is evidence that fish in Gulf St. Vincent may be part of the eastern stock and fish in Spencer Gulf may be part of the western stock, further research is required to confirm biological stock delineation for the species in South Australia. This assessment of stock status is undertaken at the management unit level–the LCF.

Fishery

Mulloway is a significant inshore fishery species of southern Australia with fisheries in Western Australia, South Australian, New South Wales and Queensland (Kailola et al. 1993). Historically, the national commercial catch for this species has been dominated by that from South Australia, with moderate contributions from New South Wales and small contributions from Western Australia and Queensland (Earl et al. 2018). Mulloway is also a popular target amongst recreational fishers in these States, as well as Victoria (Henry and Lyle 2003).

In South Australia, Mulloway is heavily targeted by commercial and recreational fishery sectors (PIRSA 2016). Several life history stages are targeted: juveniles in the Coorong Estuary; and mature adults in nearshore marine waters across the State, including on the far west coast (Earl and Ward 2014; Rogers et al. 2014). As such, during their ontogenetic development the fish run the gauntlet of fishing lines and mesh nets that are used by both sectors to target them in different habitats. Because of this, South Australia's fishery for Mulloway can currently be described as a 'gauntlet' fishery (Smith 2013).

In the commercial sector of the LCF, licence holders target juvenile Mulloway using large mesh gillnets in the Coorong Estuary, while adults are targeted using swinger nets in the adjacent nearshore marine environment. Three other South Australian commercial fisheries have limited access to Mulloway in SA: the MSF; NZRLF; and SZRLF, although catches from these sectors are low and not considered in this report. For the recreational sector, Mulloway is an iconic species that is targeted using rod and line (Jones 2009).

Management arrangements

The commercial LCF for Mulloway has undergone a number of management changes over the past 36 years that have seen the introduction of general gear restrictions, spatial and temporal restrictions and size limits. The most significant recent change occurred in 2016, when the LMS for Mulloway taken in all State waters outside of the Coorong Estuary was increased from 750 mm TL to 820 mm TL. This increase was made to ensure that at least 50% of the Mulloway at that size would be sexually mature and had the opportunity to spawn at least once before capture (Ferguson et al. 2014). The LMS for Mulloway in the Coorong Estuary was kept at 460 mm TL, which is 54% and 59% of the size--at-maturity for females and males, respectively.

The recreational sector of the LCF is managed through a combination of input and output controls, aimed at ensuring the total catch is maintained within sustainable limits and to ensure that recreational access to the fishery is equitably distributed between recreational participants (PIRSA 2016). Bag and boat limits apply, and vary geographically and with fish size. In the Coorong Estuary, the daily bag limit is 10 fish for the size range of 460–750 mm TL, and there is a boat limit (when three or more people are onboard) of 30 fish. For fish > 750 mm TL, a bag limit of two fish and a boat limit of six fish applies. In all waters outside the Coorong Estuary, a daily bag limit of two fish, and a boat limit of six fish applies. Management arrangements also comprise general gear restrictions. A small number of registered mesh net owners can also use nylon gillnets to target finfish in the Coorong Estuary. Recreational mesh nets must be less than 75 m long with 50–64 mm mesh, and the registered net owner must be within 50 m of the net at all times when fishing. Temporal and spatial closures apply to the use of recreational nets in the region.

Commercial fishery statistics

Trends in total catch, effort and CPUE

Total annual catches for Mulloway in the LCF increased from a low of 13.8 t in 1987/88 to a historic peak of 135.7 t in 2000/01 (Figure 4-1). After this, catches fell sharply to 45.4 t in 2002/03 and continued to decline, although at a slower rate, to a low of 19 t in 2010/11. This decadal decline in catch was associated with a decline in targeted effort and low CPUE for the dominant gear types, i.e. large mesh gillnets and swinger nets. Since 2010/11, annual catches have been considerably higher, ranging from 59 t in 2014/15 to 121 t in 2017/18. The total catch of 120 t in 2019/20 was the third highest annual catch since 1984/85.

Since 1984/85, the main gear type used to target Mulloway in the LCF has been the large mesh gillnet. On average, targeted catches taken using large mesh gillnets in the Coorong Estuary have accounted for 64% of the annual catch, while those taken using swinger nets along the ocean beaches adjacent the Murray Mouth have accounted for around 13%. The remaining catches have been taken as by-product when other species were targeted. In 2019/20, targeted catches using large mesh gillnets accounted for 88% of all catches, while those taken using swinger nets accounted for around 2%.

Estimates of mean annual targeted CPUE for large mesh gillnets ($CPUE_{LMGN}$) have been highly variable since 1984/85, but have increased to unprecedented high levels in recent years (Figure 4-1). From 1984/85 to 1992/93, annual $CPUE_{LMGN}$ was ≤ 1.85 $kg.net\text{-}day^{-1}$ before increasing to 2.97 $kg.net\text{-}day^{-1}$ in 2000/01. Catch rates were low during the 2000s before increasing to 5.4 $kg.net\text{-}day^{-1}$ in 2010/11. Since then, annual $CPUE_{LMGN}$ has increased to historically high levels of > 9 $kg.net\text{-}day^{-1}$ in 2016/17, 2017/18 and 2018/19. The $CPUE_{LMGN}$ declined to 7.8 $kg.net\text{-}day^{-1}$ in 2019/20 which is the fourth highest on record.

Estimates of mean annual CPUE for swinger nets ($CPUE_{SN}$) have also been highly variable (Figure 4-1). Since declining to a historic low of 8 $kg.net\text{-}day^{-1}$ in 1988/89, $CPUE_{SN}$ has fluctuated periodically at higher levels with peaks of between 71–82 $kg.net\text{-}day^{-1}$ in the late 1990s, late 2000s and 2016/17. The $CPUE_{SN}$ of 50.9 $kg.net\text{-}day^{-1}$ in 2019/20 was associated with minimal targeted effort (51 net-days) and so should be interpreted with caution.

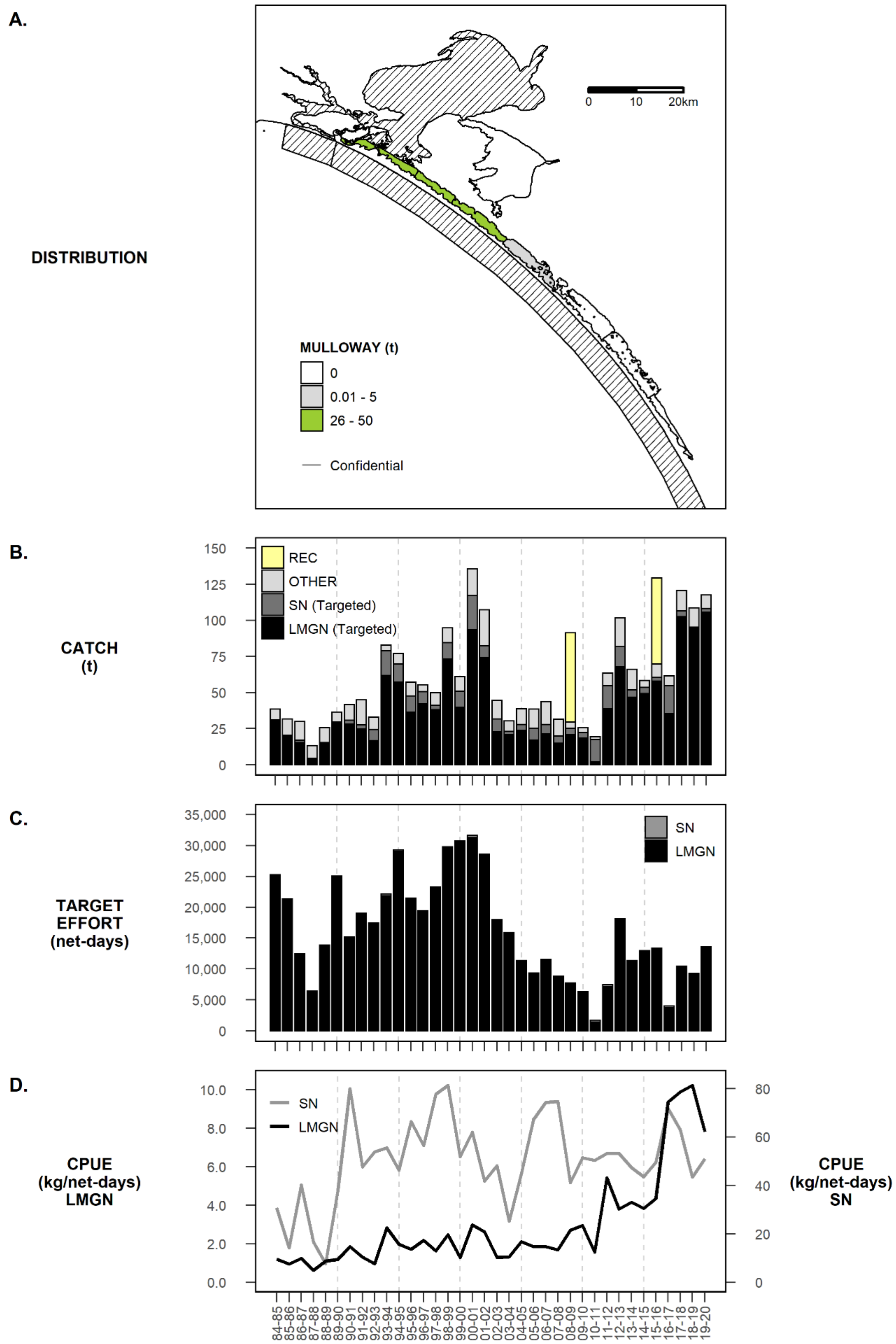

Figure 4-1. Fishery statistics for Mulloway. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20; long term trends in: (B) total catch for the main gear types (large mesh gillnets (LMGN), Swinger nets (SN), other)) and the recreational sector (from all State waters for 2007/08 and 2013/14; (C) targeted effort for LMGN and SN; and (D) targeted CPUE for LMGN and SN.

Spatial and temporal trends in catch

Since 1984/85, reporting block 8 (i.e. upper Coorong Estuary) has consistently contributed most to the annual catches of Mulloway in the LCF (Figure 4-2). An exception was in 2010/11, when 77% of the catch was taken in reporting block 16 (i.e. along the ocean beach). This anomaly reflects the historically low level of targeted fishing effort in the Coorong Estuary in 2010/11, i.e. the final year of the Millennium Drought, when the amount of suitable habitat in the Coorong Estuary was at an all-time low (Earl 2019). The spatial distribution of catches during 2017/18–2019/20 was also slightly different to that of most years. Reporting block 10 contributed most to the total catches in 2017/18 and 2018/19, while reporting block 9 contributed most to the catch in 2019/20. The fishery for Mulloway has been seasonal with the highest catches taken in the warmer months from October to March (Figure 4-2).

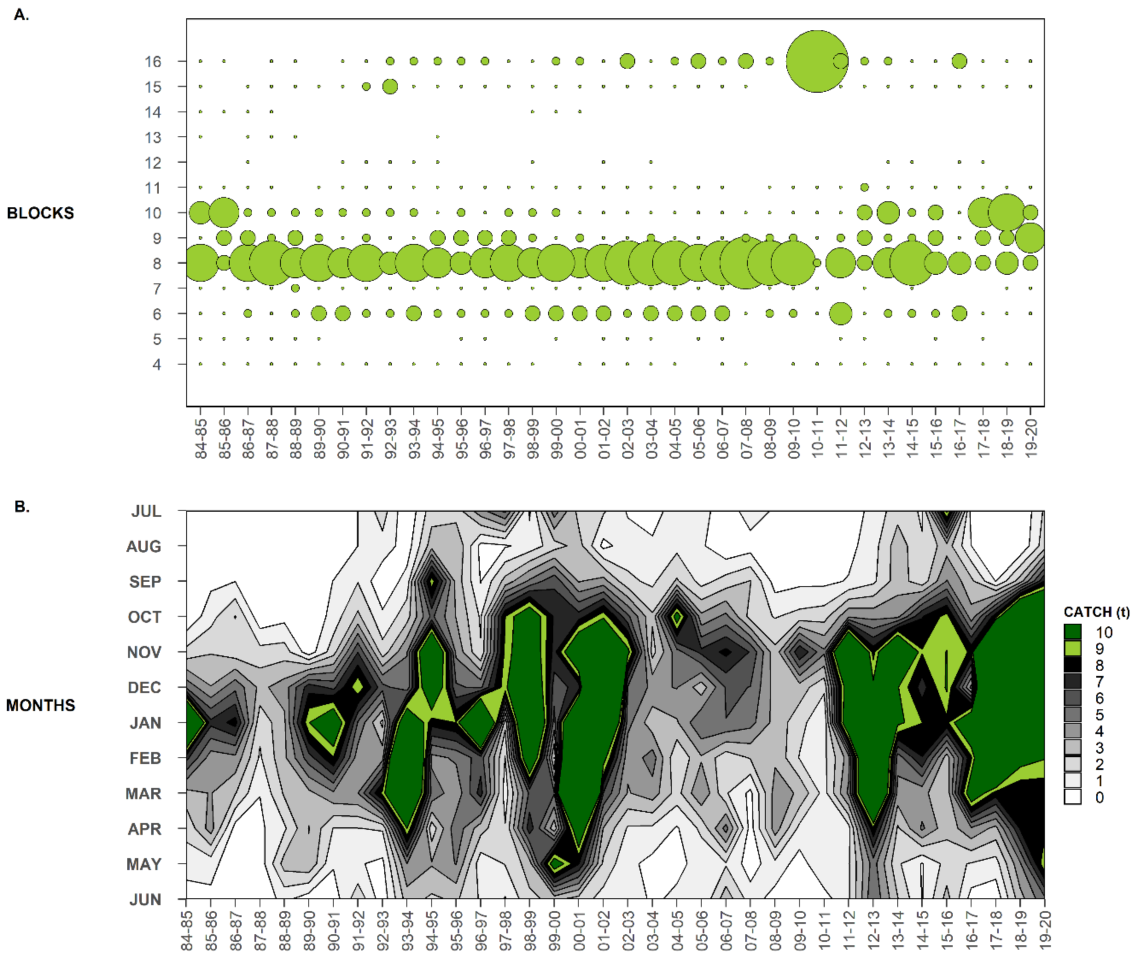

Figure 4-2. Fishery statistics for Mulloway. Long-term trends in (A) the annual distribution of catch among LCF reporting blocks (diameter of the bubbles represent the relative contribution of each reporting block to total annual catch); and (B) the annual distribution of catch among months.

Stock status

Mulloway is a primary species for the commercial LCF (PIRSA 2016). This reflects its history of relatively high catches and wholesale value compared to most other species available to the fishery

(EconSearch 2020). The most recent stock assessment for Mulloway was done in 2020 and used a weight-of-evidence approach that considered commercial catch and effort data to the end of June 2019 and fishery size and age structures to the end of June 2020 (Earl 2020).

The highest total annual catch of Mulloway for the LCF was 136 t in 2000/01. From then, catch declined to an historic low of 19 t in 2010/11. This decline in catch was associated with a decrease in targeted fishing effort and low $CPUE_{LMGN}$ during the Millennium Drought (2002/03–2010/11), and likely reflected a decline in fishable biomass in the Coorong Estuary. Since 2010/11, annual catches have been considerably higher, increasing to 121 t and 120 t in 2017/18 and 2019/20, respectively. The recent high catches have been associated with historically high $CPUE_{LMGN}$ and likely reflect high abundance of Mulloway in the Coorong Estuary (Earl 2020). These results suggest 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, and using the definitions from the NFSRF, the LCF for Mulloway is classified as a **sustainable** stock.

4.3.1.2 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 for commercial and recreational fishers (Kailola et al. 1993).

Black Bream is an estuarine-dependent species, completing much of its life cycle within a single estuary (Chaplin et al. 1998). It is slow-growing, long-lived and can grow to 600 mm TL and live for 32 years. In SA, males and females mature at around 340 mm TL and 289 mm TL, respectively (Cheshire et al. 2013). Spawning is confined to estuaries and occurs between August and December. 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

Black Bream supports recreational and commercial fisheries in SA. Historically, the LCF has been SA's main commercial fishery for Black Bream. In recent years, around 70% of the State's annual catches have been taken by LCF fishers, who target the species using large mesh gillnets (Earl et al. 2016b). Black Bream has a high market value and is a premium product of the LCF (EconSearch

2020). The MSF, NZRLF and SZRLF also have access to this species, although catches from these sectors are negligible and are not considered in this assessment.

South Australian recreational fishers target Black Bream in coastal waters using rod and line, particularly in estuaries and the lower reaches of rivers (Kailola et al. 1993). The State-wide recreational survey in 2013/14 estimated that 197,848 Black Bream were captured, of which 91% were released (Giri and Hall 2015). The retained fish contributed to an estimated harvest weight of 4.97 t.

Management arrangements

Black Bream is a secondary species of the LCF, making a relatively low contribution to the total production value over the last 25 years (PIRSA 2016). For the commercial sector, management arrangements are in place to manage targeted fishing and limit the take of Black Bream. These include temporal and spatial netting closures, restrictions to net lengths and mesh sizes, and a LMS of 300 mm TL.

There are multiple management arrangements in place for Black Bream in the recreational sector. Input and output controls ensure the total catch is maintained within sustainable limits and that access is distributed equitably among fishers. These include gear restrictions, spatial closures and a daily bag limit of 10 fish and boat limit of 30 fish. The LMS of 300 mm TL also applies.

Temporary management arrangements were implemented in 2018 and 2019 to recover the Black Bream stock in the Coorong, after it was classified as 'overfished' in 2016 (Earl et al. 2016b) and 'depleted' in 2017 (Conron et al. 2018). The temporary arrangements applied to Black Bream in the Lower Lakes and Coorong Estuary from 1 September until 30 November in 2018, and from 21 September until 30 November in 2019. Under the arrangements, commercial and recreational fishing nets could not be used within 300 metres of barrages located in the Coorong Estuary, including Goolwa, Mundoo, Boundary Creek, Ewe Island and Tauwitchere barrages; and Black Bream could not be targeted, and all incidental catch of Black Bream had to be released by both the recreational and commercial sectors.

Commercial Fishery statistics

Trends in total catch, effort and CPUE

Over the past 36 years, the highest total annual commercial catch of Black Bream in the LCF was 46.8 t in 1984/85 (Figure 4-3). Annual catches were around 35 t in 1985/86 and 1986/87 and then declined to 3.7 t in 1990/91. They remained low during the 1990s, averaging 3.7 $t.yr^{-1}$, before increasing to 11.6 t and 10 t in 2002/03 and 2003/04, respectively. Catches gradually declined to 1.7 t in 2008/09 and have been < 2 t in most years since. The total catch of 1.76 t in 2019/20 was similar to the average annual catch from 2009/10–2018/19.

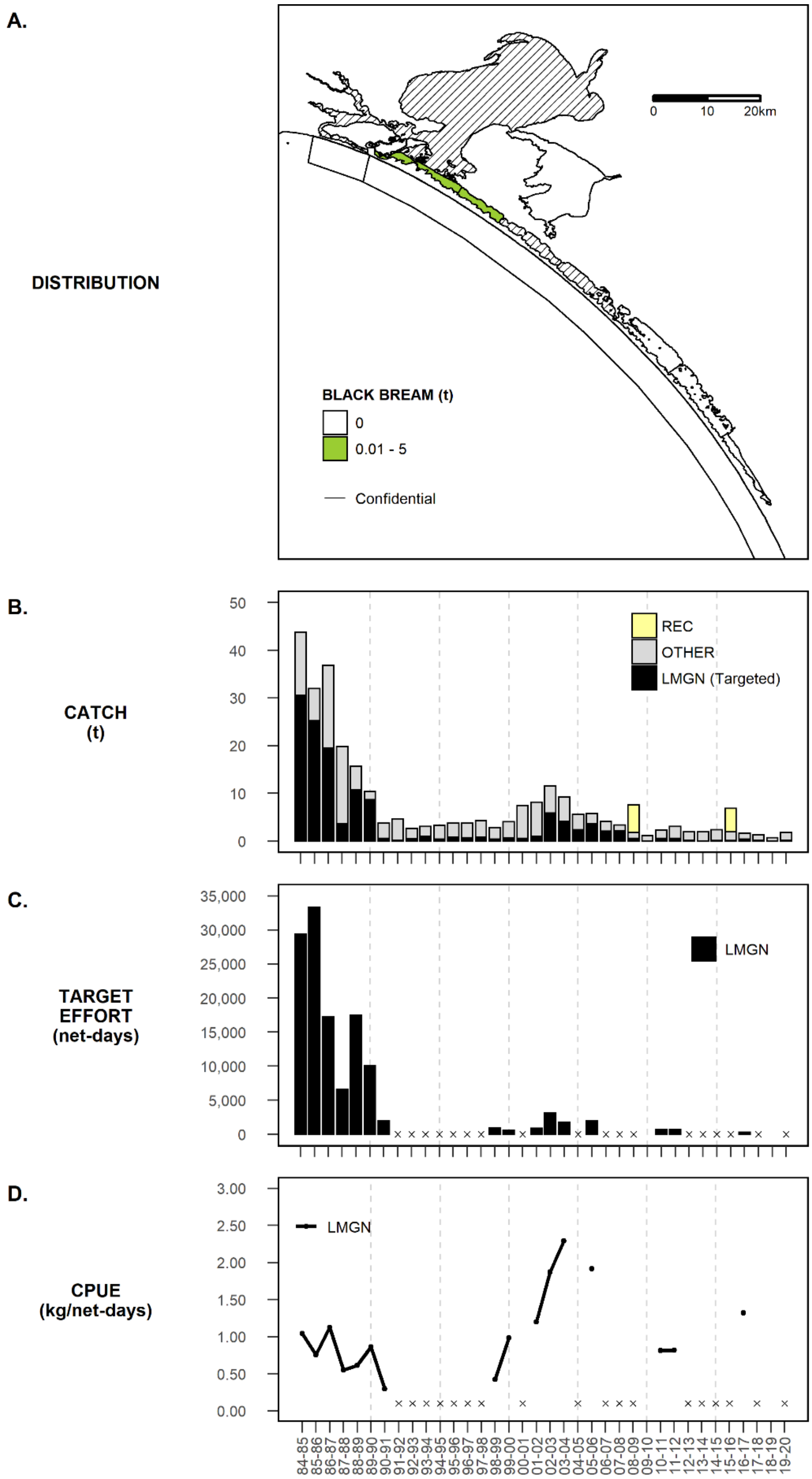

Figure 4-3. Fishery statistics for Black Bream. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20; long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2007/08 and 2013/14; (C) targeted effort for LMGN; and (D) targeted CPUE for LMGN. Crosses indicate confidential data (i.e. from < 5 fishers).

Historically, the main gear type used to target Black Bream has been the large mesh gillnet (Figure 4-3). The low catches since the early 1990s have been associated with low targeted effort, with most of the catches taken as by-product when other species were targeted. Consequently, estimates of annual targeted effort and targeted CPUE for large mesh gillnet are confidential for most of the past 15 years, including 2019/20.

The catch rates for Black Bream should be interpreted with caution due to considerable uncertainty around CPUE as a measure of relative abundance. This is because spatial contraction of the fishery for this species, 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 2020), catch is considered a more appropriate indicator of abundance for this species in the Coorong.

Spatial and temporal trends in catch

Between 1984/85 and 1998/99, reporting blocks 9–11 provided the highest catches of Black Bream (Figure 4-4). The fishery contracted to blocks 6–8 (those adjacent the Murray Mouth) during the 2000s, when low freshwater inflows associated with the Millennium Drought reduced the amount of suitable habitat available for Black Bream in the estuary. The drought-breaking floods in 2010/11 led to a freshening of the estuary and an increase in the size of the fishable area for Black Bream with catches coming from blocks 6–11 during recent years. Historically the fishery for Black Bream in the Coorong Estuary was seasonal with catches generally concentrated between July and December, with peaks in September and October.

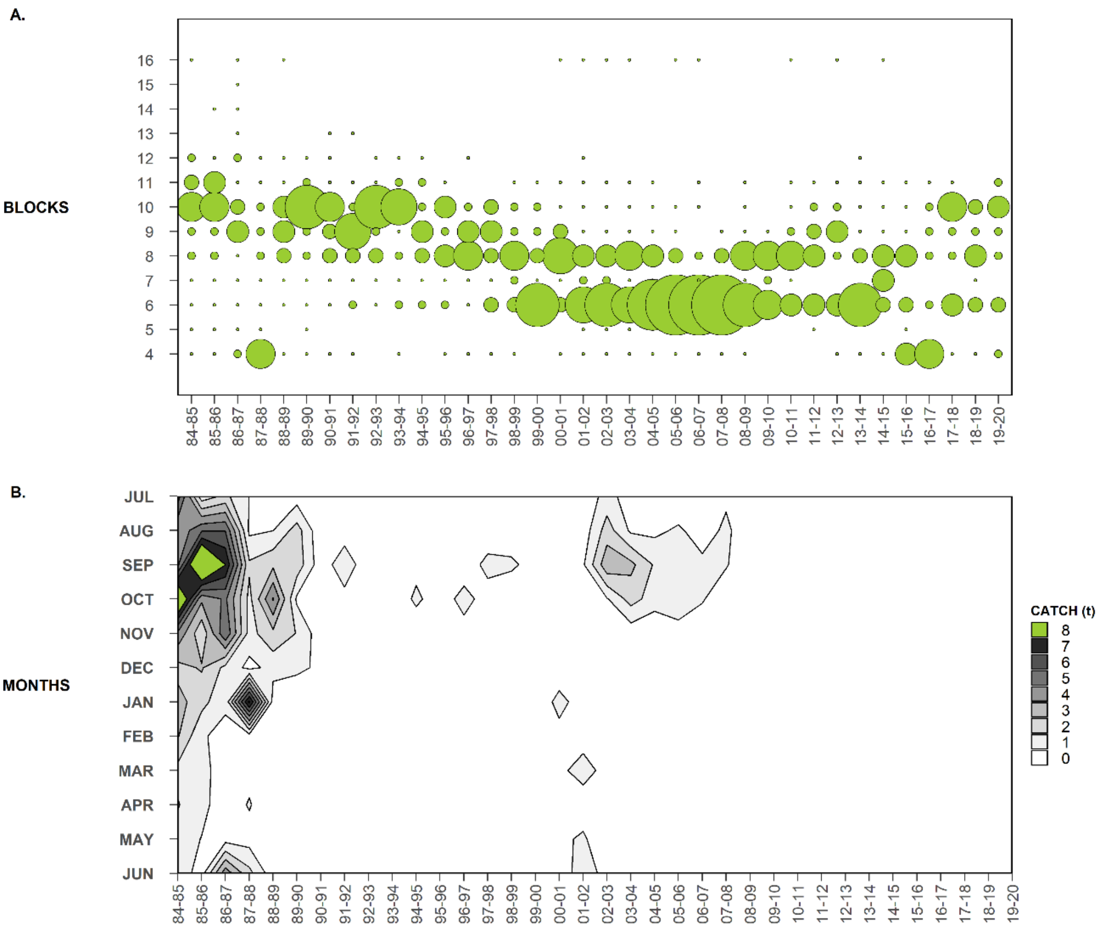

Figure 4-4. Fishery statistics for Black Bream. Long-term trends in (A) the annual distribution of catch among LCF reporting blocks (diameter of the bubbles represent the relative contribution of each reporting block to total annual catch); and (B) the annual distribution of catch among months.

Stock status

Black Bream is a secondary species for the commercial LCF (PIRSA 2016). The most recent stock assessment for this species in the Coorong Estuary was in 2016 and used a weight-of-evidence approach that considered fishery catch and effort data and fishery age structures up to 30 June 2015

(Earl et al. 2016b). Since then, limited catch sampling has been done as part of the Coorong Fish Condition Monitoring program to develop fishery age structures for Black Bream (Ye et al. 2020).

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 catches dropped to historically low levels and have remained low. The low catches since the 1980s have been associated with low targeted effort. Given the high wholesale value of Black Bream compared to other LCF species (Econsearch 2020), the lack of targeting and low catches since the 1980s likely reflects low biomass. The lack of targeting in recent years may also relate to the presence of Long-nosed Fur Seals in the region, which has reportedly resulted in fishers avoiding the long gillnet soak times required to effectively target this species (Econsearch 2020).

Annual fishery age structures from 2007/08 to 2018/19 comprised mostly 4–17 year old fish, although fish older than 10 years were rare, despite the potential for this species to live to at least 32 years of age (Earl et al. 2016b; Ye et al. 2020). Within any year, 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, suggesting that environmental conditions associated with freshwater inflow are important for successful reproduction of Black Bream in the system (Ye et al. 2020). 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 historically low. Recruitment levels over the past 25 years have not been strong enough to support recovery of the stock following the decline in the 1980s. In 2018, successful recruitment of Black Bream in the Coorong Estuary was evident by the detection of higher than average abundances of young-of-year (Ye et al. 2019). Recruitment of these juveniles to the fishable biomass has not yet occurred and is expected to take at least several years (Ye et al. 2020).

The above evidence indicates that the biomass of this stock has been reduced through fishing mortality, such that recruitment is impaired. Whilst management measures have been put in place in 2018 and 2019 aimed at recovering the stock, there are not yet any data to demonstrate measurable improvements to the stock. For example, recent fishery age structures do not show an increase in recruitment (Ye at al 2020). Consequently, Black Bream is classified as a '**depleted**' stock.

4.3.1.3 Greenback Flounder (*Rhombosolea tapirina*)

Biology

Greenback Flounder (*Rhombosolea tapirina*) is a member of the Rhombosoleidae family of fishes (Gomon et al. 2008). Its Australian distribution extends from southern WA, around the southern coasts of the continent and Tasmania, and up to southern NSW (Kailola et al. 1993). Juveniles and adults occur over unvegetated substrates in coastal waters and are often abundant in bays and estuaries.

Greenback Flounder can grow to 450 mm TL and live to 10 years of age (Sutton et al. 2010). It exhibits fast growth, reaching around 220 mm TL in its first year of life (Earl et al. 2014a). The estimated size at maturity for females and males in the Coorong Estuary is 198 and 211 mm TL, respectively (Earl 2014). Spawning occurs from March to October (Kurth 1957; Crawford 1984; Earl 2014). In SA, Greenback Flounder is considered a 'marine estuarine-opportunist' – 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 (Earl 2014). This is supported by an acoustic telemetry study that showed that the population in the Coorong Estuary is likely part of a broader population that encompasses the adjacent marine environment (Earl et al. 2017). Nevertheless, 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

Greenback Flounder is an important species for commercial and recreational fisheries throughout its distribution (Kailola et al. 1993). In Australia, most commercial catches are taken in Tasmania and SA, with smaller landings taken in NSW, Victoria and WA. In SA, the LCF accounts for most of the commercial catch of this species, which is targeted and taken as a by-product using large mesh gillnets in the Coorong Estuary. The MSF, NZRLF and SZRLF also have limited access to the species, although catches from these sectors are negligible and therefore not considered in this assessment. Recreational fishers target Greenback Flounder using hand-held spears in estuaries and protected coastal waters across SA. The estimated harvest of flounder by the recreational sector in 2013/14 was 0.27 t (Giri and Hall 2015).

Management arrangements

Greenback Flounder is a secondary species of the commercial LCF, making a relatively low contribution to the total production value (PIRSA 2016). For this sector, management arrangements are in place to manage fishing effort and limit the take of Greenback Flounder. These include temporal and spatial netting closures, restrictions to net lengths and mesh sizes, and a LMS of 250 mm TL (PIRSA 2016).

The recreational sector is managed through a combination of input and output controls, aimed at ensuring that the total catch is maintained within sustainable limits and to ensure that recreational access to the fishery is equitably distributed between recreational participants. Management restrictions apply to all flounder species collectively, including Greenback Flounder. A daily bag limit of 20 flounder per person, and a daily boat limit of 60 flounder, applies to this fishery. Management arrangements also comprise general gear restrictions (PIRSA 2016). No LMS applies for this sector.

Commercial Fishery statistics

Trends in total catch, effort and CPUE

Total annual catch has been highly variable since 1984/85. It peaked at 65 t in 1990/91 and subsequently declined to < 1 $t.yr^{-1}$ during 2007/08–2010/11 (Figure 4-5). In 2011/12, catch increased to 31 t, and then declined to 0.27 t in 2014/15. Catches have averaged 1.88 $t.yr^{-1}$ over the last five years. The total catch of 0.24 t in 2019/20 was the second lowest catch recorded in the fishery.

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, with a further decline to 20 net-days in 2018/19. Some recent estimates of targeted effort and $CPUE_{LMGN}$ are confidential, including for 2019/20. Catch rates for this species should be interpreted with caution due to considerable uncertainty around CPUE as a measure of relative abundance resulting from likely environmental influences on catchability (Earl and Ye 2016). Given the high wholesale value of Greenback Flounder from the Coorong estuary (EconSearch 2020), catch is considered a more appropriate indicator of abundance for this species.

Spatial and temporal trends in catch

In most of the past 36 years, catches taken in reporting blocks 8–10 have contributed most to total annual catches of Greenback Flounder (Figure 4-6). In the years that produced the highest catches of this species, the period between October and April was generally the most productive for the fishery.

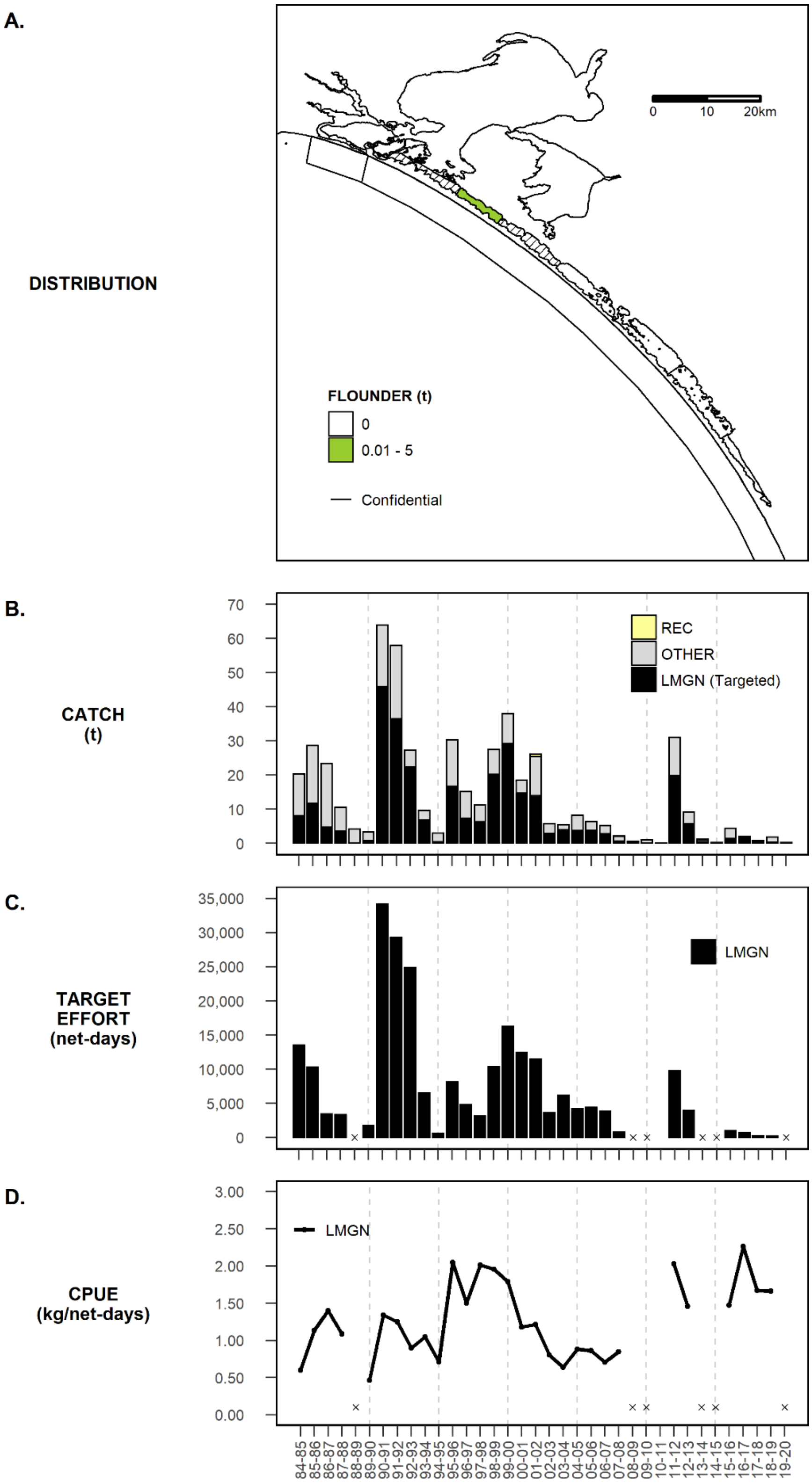

Figure 4-5. Fishery statistics for Greenback Flounder. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) targeted effort for LMGN; and (D) targeted CPUE for LMGN. Crosses indicate confidential data (i.e. from < 5 fishers).

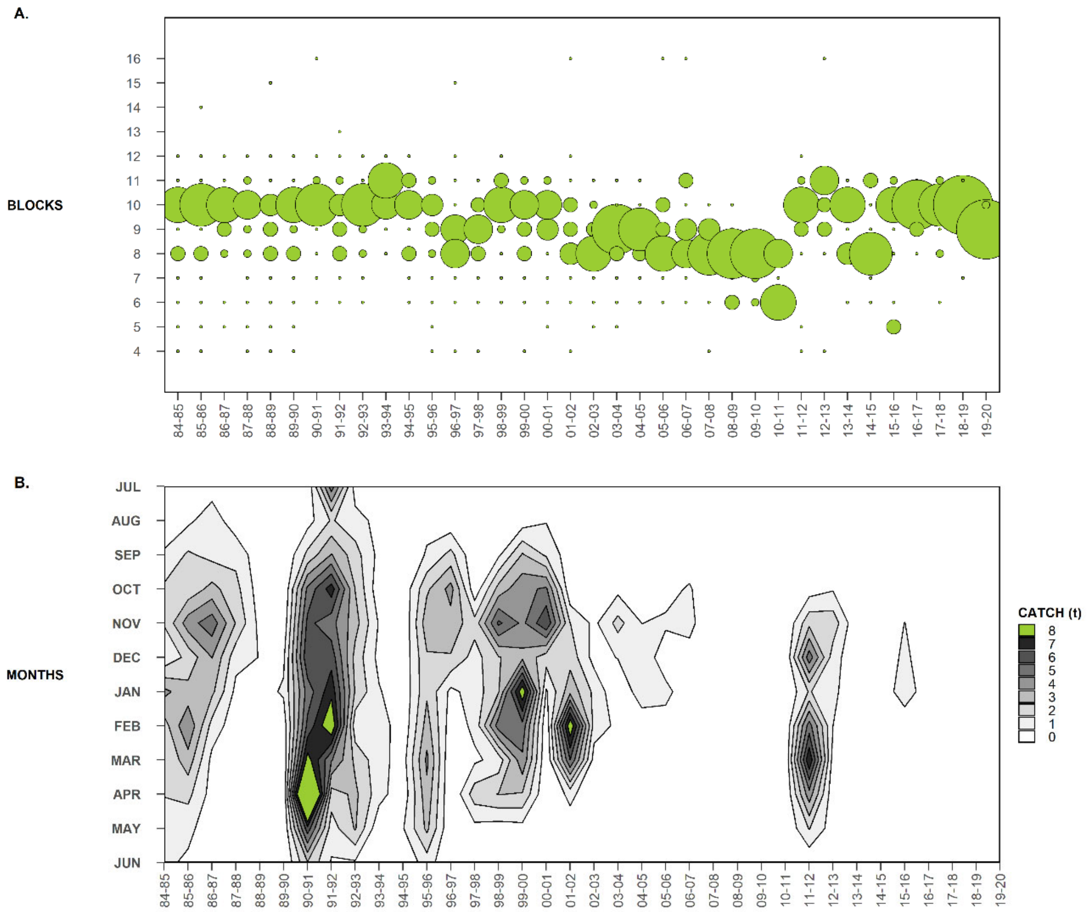

Figure 4-6. Fishery statistics for Greenback Flounder. Long-term trends in (A) the annual distribution of catch among LCF reporting blocks (diameter of the bubbles represent the relative contribution of each reporting block to total annual catch); and (B) the annual distribution of catch among months.

Stock status

Greenback Flounder is a secondary species for the LCF (PIRSA 2016). 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). Since then, limited catch sampling has been done as part of the Coorong Fish Condition Monitoring program to develop fishery age structures for Greenback Flounder (Ye et al. 2020).

Long-term trends in fishery production for Flounder indicate high 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 Greenback 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, which also occurred in 1990/91, 1995/96, 1998/99 following years of elevated freshwater inflows, 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 fishable biomass in the Coorong Estuary.

The high inter-annual variation in Greenback Flounder abundance in the Coorong Estuary since the 1970s 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 (e.g. 1990/91, 1996/97, 2010/11). Alternatively, during periods of low inflow (2001/02–2009/10, 2012/13–2015/16, 2017/18–2018/19), 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 1990/91, 1995/96, 1998/99 and 2011/12, approximately 1-2 years after high inflow events, as indicated by trends in commercial catch (Earl and Ye 2016). The current low biomass in the estuary appears to relate to the lack of freshwater inflow to the system in recent years, rather than a depleted spawning stock biomass (i.e. the spawning biomass is not considered to be recruitment overfished). The lack of targeting of Greenback Flounder by the fishery in recent years may also relate to the presence of Long-nosed Fur Seals in the region, which has reportedly resulted in fishers avoiding the long gillnet soak times required to effectively target this species (Econsearch 2020). Nevertheless, low targeted effort and catches of Greenback Flounder since 2012/13 likely reflect low fishable biomass in the Coorong Estuary as a consequence of low recruitment to the fishable biomass over several recent years due to the low freshwater inflows (i.e. non-fishing effects). Biomass in the Coorong Estuary has been reduced primarily through non-fishing effects and, as a consequence, recruitment is impaired. Consequently, Greenback Flounder is classified as a '**depleted**' stock.

4.3.1.4 Environmental performance indicator

Modelled daily salinity concentrations for the Coorong Estuary indicated that the amount of suitable habitat for Mulloway was highly variable during the 2020/21 reporting year, with periods of increased freshwater inflows to the estuary generally resulting increases in habitat, e.g. from July to December 2020 (Figure 4-7). Nonetheless, the ELMGN performance indicator for habitat available to Mulloway in the Coorong Estuary for the 2020/21 reporting year was 52.3%, which was below the target reference point of 55% (Figure 4-8).

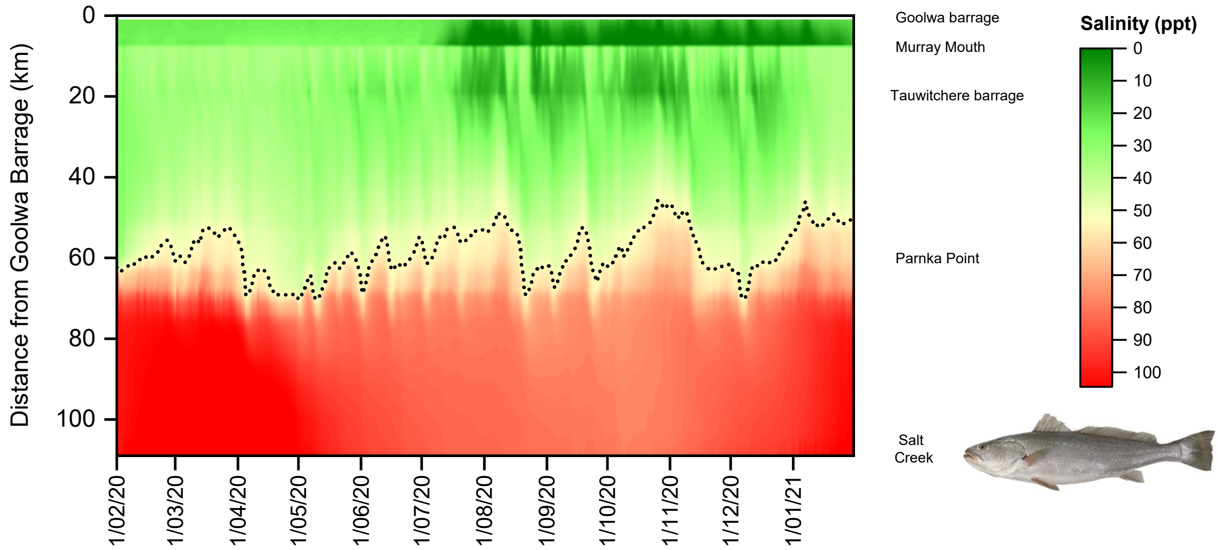

Figure 4-7. Modelled salinity concentration with distance from the Goolwa Barrage for the 2020/21 reporting year, with the approximate salinity threshold for Mulloway (51 ppt) shown as a dotted line. Salinity threshold represents the level of salinity that was lethal for 10% of test fish, as determined by Ye et al. (2013). The dark green contours (i.e. < 10 ppt) indicate periods of freshwater inflows through the barrage system.

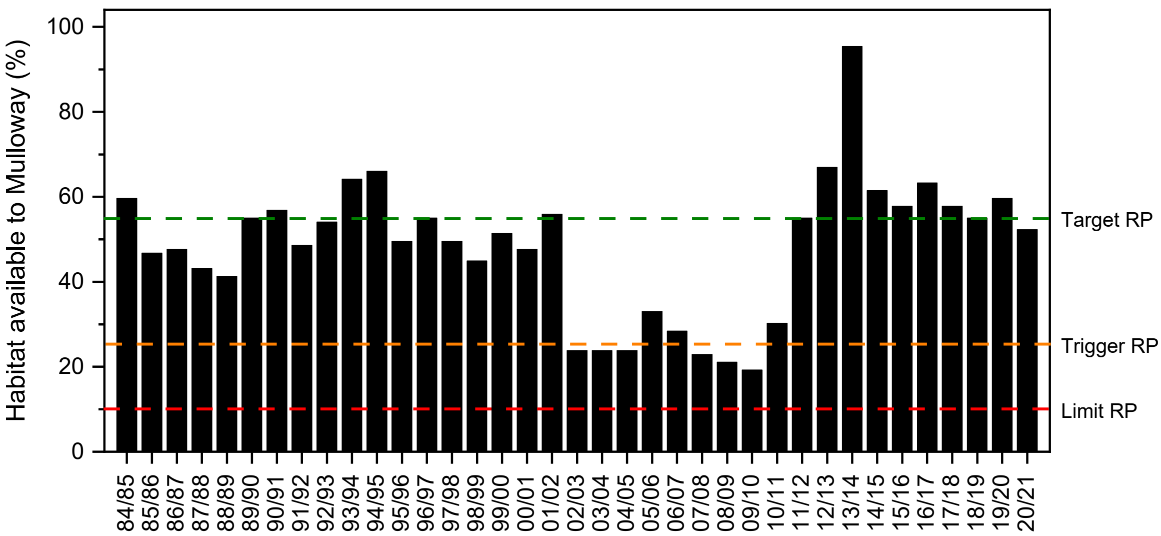

Figure 4-8. Estimates of the ELMGN performance indicator for habitat available to Mulloway in the Coorong Estuary from 1984/85 to 2020/21 (reporting years), showing target, trigger and limit reference points (RP).

4.3.2 Freshwater large mesh gillnet sector

4.3.2.1 Golden Perch (*Macquaria ambigua*)

Biology

Golden Perch (*Macquaria ambigua*) is a member of the Percichthyidae family of fishes (Classon and Booth 2002). It occurs throughout most of the Murray-Darling Basin, except at high altitudes, as well as in the Lake Eyre and Bulloo drainage systems of Queensland, New South Wales and South Australia, and the Dawson-Fitzroy river system in Queensland (Lintermans 2007). Translocated fish occur in numerous other waterways and impoundments throughout south-eastern Australia.

Golden Perch can grow to 760 mm TL and live to 27 years of age (Mallen-Cooper and Stuart 2003). In the lower Murray River, individuals usually mature at 2–4 years of age, although the size-at-maturity for South Australia's Lower Lakes population is not known. Spawning occurs mainly during spring and summer (Battaglene and Prokop 1987).

Golden Perch in the Murray-Darling Basin are genetically distinct from those in the Lake Eyre, Bulloo and Fitzroy systems (Faulks et al. 2010a, b; Beheregaray et al. 2017). Murray-Darling Golden Perch form a well-connected metapopulation with low-level basin-wide population structure, reflecting their ability to migrate and disperse long distances (Attard et al. 2018; Zampatti et al. 2018). However, subtle genetic differences and regional differences in population structures driven by unique recruitment sources suggest sub-structuring across some regions. Examples include the Lower Lakes (Earl et al. 2015) and Paroo River (Attard et al. 2018), and potentially the physically disconnected and hydrologically impacted Victorian tributaries of the Murray River and some NSW tributaries of the Barwon-Darling, e.g. Lachlan River (Shams et al. 2020). The assessment of stock status in this report is undertaken at the management unit level – the LCF.

Fishery

Golden Perch is an important species for commercial and recreational fisheries in South Australia. Historically, the commercial fishery had three main sectors: the LCF; the River (or Reach) Fishery; and the Lake Eyre Basin Fishery (LEBF). The LCF is the main commercial fishery for Golden Perch in the State. The LCF uses large mesh gillnets to target the species in the Lower Lakes and the Murray River between the Lake Alexandrina and Wellington. The commercial River Fishery was established in 1923 and operated along the main channel of the Murray River, before it was closed in 2003 (Earl et al. 2015). The LEBF was established 1992, and has one licensed fisher that operates on the pastoral holding of Mulka Station. The LEBF is a unique fishery due to the harsh environment in which it operates and its dependence on the dispersion of Golden Perch to the region during large scale flood events within the Cooper Creek system. As such, the fishery has operated and reported catches of Golden Perch in only seven of the past 28 years, including in 2012/13. Catch and effort data for the River Fishery and LEBF are not considered in this report.

Currently, Golden Perch is the only native fish species that is permitted to be taken by recreational fishers along the Murray River in South Australia. Recreational fishers target Golden Perch using rod and line. In 2013/14, the estimated State-wide retained recreational catch of Golden Perch was 37.4 t (Giri and Hall 2015).

Management arrangements

Golden Perch is a primary species of the commercial LCF, making a relatively high contribution to the total production value (PIRSA 2016). For the commercial sector, management arrangements are in place to manage targeted fishing effort and limit the take of Golden Perch. These include temporal and spatial netting closures, restrictions to net lengths and mesh sizes, and a LMS of 330 mm TL.

There are multiple management arrangements in place for Golden Perch in the recreational sector. Input and output controls ensure the total catch is maintained within sustainable limits and that access is distributed equitably among fishers. These include gear restrictions and a daily bag limit of five fish and boat limit of 15 fish. The LMS of 330 mm TL also applies.

Commercial fishery statistics

Trends in total catch, effort and CPUE

Total annual catches of Golden Perch have fluctuated cyclically over the past 36 years (Figure 4-9). They ranged from 17.8–36.3 t during the late 1980s, then increased to a peak of 206 t in 1994/95, before declining to 36 t in 2001/02. Catch increased to a smaller peak of 152 t in 2006/07 and then declined to 34 t in 2012/13. Between 2013/14 and 2016/17, annual catches ranged between 79 and 88 t, before increasing to 105 t in 2017/18. Total catch was 50.6 t in 2019/20.

Targeted catches taken using large mesh gillnets have accounted for >75% of the total catch in most years since 1984/85 (Figure 4-9). Trends in targeted effort using large mesh gillnets have been similar to those of total catch with peaks of 128,896 and 94,006 net-days in 1997/98 and 2006/07, respectively. Effort has been considerably lower over the past 10 years, and declined to 19,494 net days in 2019/20, which was among the lowest recorded in the fishery. The recent declines in total catch and targeted effort have been associated with declines in $CPUE_{LMGN}$ from the historical peak of 1.55 kg.net-day^{-1} in 2017/18. Nevertheless, the $CPUE_{LMGN}$ of 1.18 kg.net-day^{-1} in 2019/20 was 42% above the long-term average of 0.8 kg.net-day^{-1}.

Spatial and temporal trends in catch

Catches taken in reporting block 4 (Lake Alexandrina) have consistently accounted for > 90% of annual total catches since 1984/85, with block 5 (Lake Albert) contributing most of the remaining catches (Figure 4-10). There has been no clear seasonality in fishery catches during the past decade.

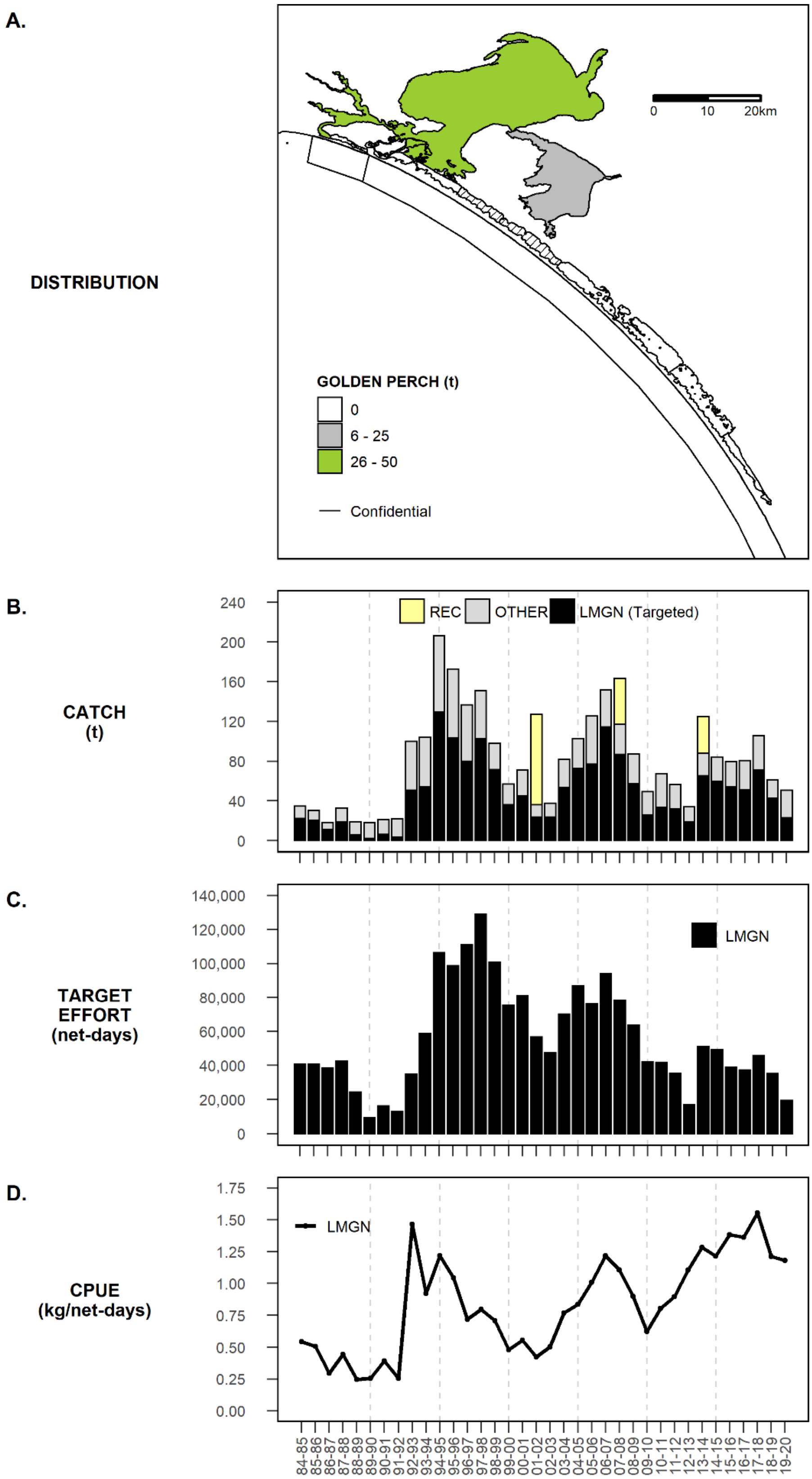

Figure 4-9. Fishery statistics for Golden Perch. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) targeted effort for LMGN; and (D) targeted $CPUE_{LMGN}$.

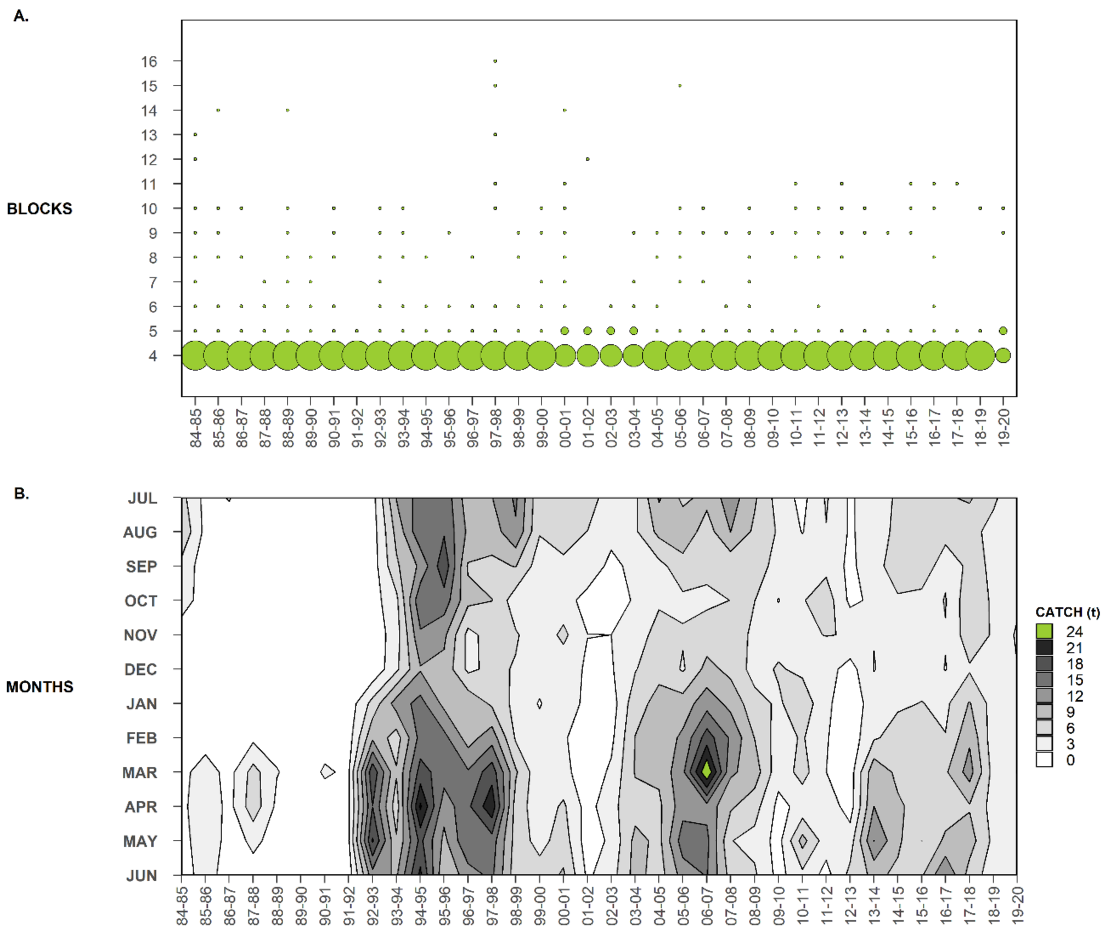

Figure 4-10. Fishery statistics for Golden Perch. Long-term trends in (A) the annual distribution of catch among LCF reporting blocks (diameter of the bubbles represent the relative contribution of each reporting block to total annual catch); and (B) the annual distribution of catch among months.

Stock status

Golden Perch is a primary species for the commercial sector of the LCF (PIRSA 2016). 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 catch sampling has been done since 2012/13.

The most obvious long-term trend in the fishery data for Golden Perch is the cyclical nature of the interannual variation in total catch, which has been closely linked with variations in targeted fishing effort and $CPUE_{LMGN}$. The moderate catches and historically high $CPUE_{LMGN}$ from 2013/14 to 2017/18 were indicative of high fishable biomass in the Lower Lakes during that period. In 2019/20, CPUE declined slightly from the previous year but remained high in an historical context. On this basis, 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.

4.3.2.2 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 Murray-Darling Basin, in the Lake Eyre drainage system and across Queensland, most of the Northern Territory and parts of north-western Western Australia. In South Australia, the species is abundant in the Murray River, including in the Lower Lakes. It is the only large native fish species in the lower River Murray whose abundance appears not to have declined since the advent of flow regulation in the 1940s (Puckridge and Walker 1990).

Bony Herring is a medium-sized, laterally compressed, deep-bodied fish with a small head and blunt snout (Lintermans 2007). It can grow to 470 mm TL but is commonly 150–270 mm TL (Classon and Booth 2002). Bony Herring spawn in spring and summer after reaching maturity at a size of around 80 mm TL and an age of around two years. Stock structure in South Australia is uncertain. The assessment of stock status in this report is undertaken at the management unit level–the LCF.

Fishery

Despite its relatively low wholesale market value, Bony Herring is a primary species for the LCF (PIRSA 2016). This reflects the high catches of this species taken by the commercial sector compared to other species. Most of the catch is taken as by-product by gillnet fishers targeting Golden Perch and Carp in the Lower Lakes, which is sold as bait to the SZRLF and NZRLF. This species is not generally targeted by recreational fishers in South Australia.

Management arrangements

For the commercial sector of the LCF, management arrangements are in place to manage targeted fishing effort and limit the take of Bony Herring. These include temporal and spatial netting closures, and restrictions to net lengths and mesh sizes (PIRSA 2016). No specific management arrangements are in place for Bony Herring in the recreational sector.

Commercial fishery statistics

Trends in total catch, effort and CPUE

Total catches of Bony Herring increased to a peak of 1,157 t in 1989/90, before steadily declining to a low of 212 t in 2002/03 (Figure 4-11). This decline corresponded with a decline in fishing effort that produced catches of Bony Herring and decreasing $CPUE_{LMGN}$. Catch increased to 550 t in 2009/10 and then progressively declined to 269 t in 2019/20, which was the lowest catch since 2004/05. This decline in catches has been associated with a decline in fishing effort to a historical low of 52,840 net-days in 2019/20. $CPUE_{LMGN}$ has been relatively stable at moderate–high levels since 2009/10. The $CPUE_{LMGN}$ of 5.1 kg.net-day^{-1} in 2019/20 was 20% higher than the previous year and well above the long-term average for the fishery.

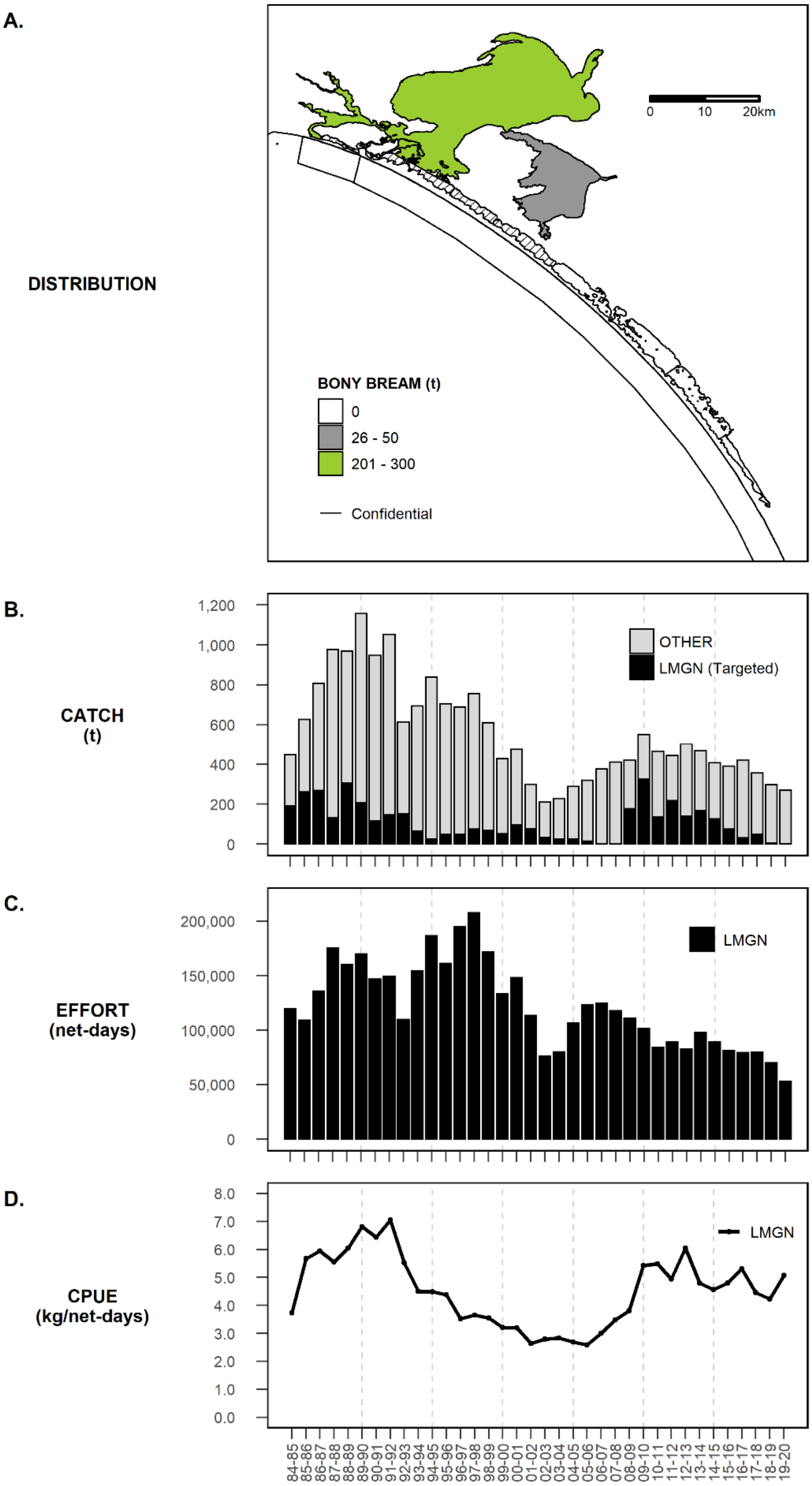

Figure 4-11. Fishery statistics for Bony Herring. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20; Long term trends in: (B) total catch by gear type: large mesh gillnets (LMGN) and ‘other’; (C) total effort that produced catches of Bony Herring for LMGN; and (D) CPUE for LMGN, based on total catch and total effort that produced catches of Bony Herring. Note: no estimates of recreational catch are available for Bony Herring.

Spatial and temporal trends in catch

Catches taken in reporting block 4 (Lake Alexandrina) have consistently accounted for > 90% of annual total catches since 1984/85, with smaller quantities taken in block 5 (Lake Albert) (Figure 4-12). Over the last 20 years, spring and summer have been the most productive seasons for the fishery.

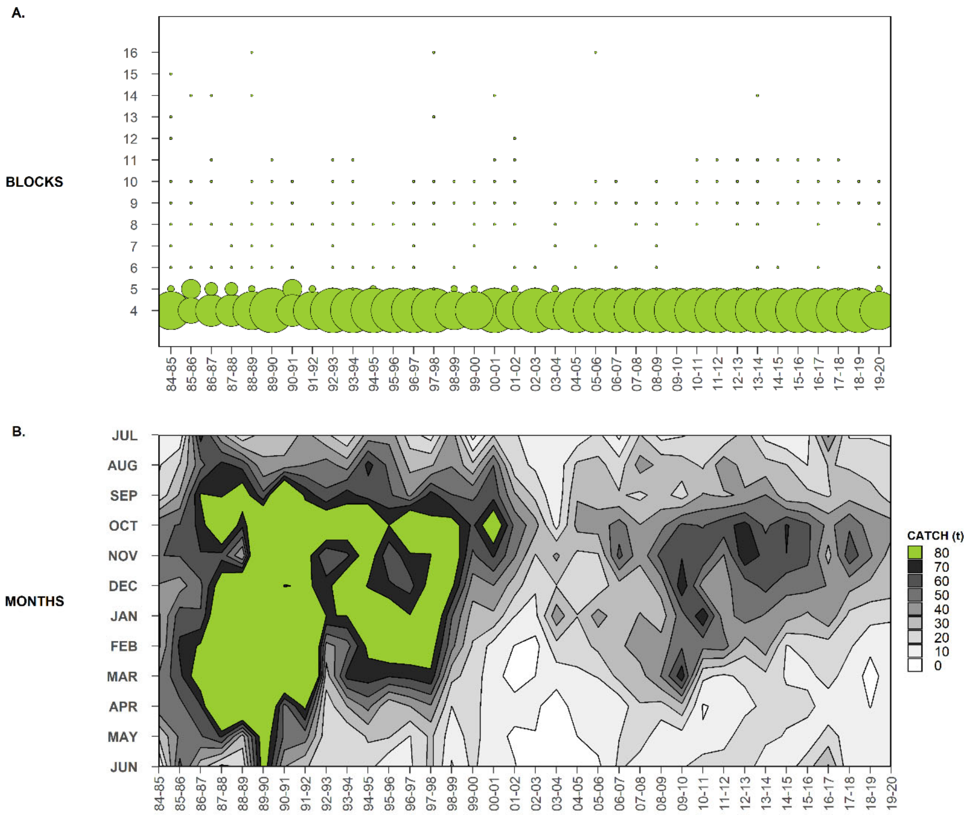

Figure 4-12. Fishery statistics for Bony Herring. Long-term trends in (A) the annual distribution of catch among LCF reporting blocks (diameter of the bubbles represent the relative contribution of each reporting block to total annual catch); and (B) the annual distribution of catch among months.

Stock status

Bony Herring is a primary species for the commercial LCF (PIRSA 2016). This reflects the relatively high catches of this species taken compared to other species that support the fishery. Most of the catch is taken as by-product by the fishers targeting Golden Perch and Carp.

Annual catches of Bony Herring declined considerably during the 1990s, owing to declines in gillnet fishing effort and catch rates over that period. Since then, catches have been higher in most years but have progressively declined over the last decade. The recent low catches have been associated with low gillnet fishing effort in the Lower Lakes. Catch rates have been stable at moderate–high levels since the 2000s. The relatively high catch rate in 2019/20 suggests that 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 Bony Herring is classified as a **sustainable** stock.

4.3.2.3 Carp (*Cyprinus carpio*)

Biology

Carp (*Cyprinus carpio*) is a member of Cyprinidae family of fishes (Classon and Booth 2002). Native to China, Carp was introduced to Australian waterways in the 1850s and has since established populations in every state and territory, except the Northern Territory. It spread rampantly throughout the Murray-Darling Basin in the 1980s and is now considered one of Australia's major aquatic pests. In South Australia, the species has been declared noxious under the *Fisheries Management Act 2007*.

Carp can tolerate a wide range of conditions including warm, low-oxygen and brackish water. Individuals can grow to 1,200 mm TL but are typically < 500 mm TL, and mature at 1–3 years of age. Spawning occurs during spring and summer in shallow, slow-flowing areas such as wetlands, with each large female able to produce and release up to one million eggs each year.

Fishery

In Australia, commercial fishing for Carp occurs in Victoria, South Australia, and NSW. The species is a popular target for recreational fishers in these States, as well as Queensland and the Australian Capital Territory. The LCF is the main commercial fishery for Carp in South Australia. The LCF targets Carp using large mesh gillnets in the Lower Lakes, with most of the catch sold as bait to local rock lobster fisheries, while a small and increasing proportion of the catch is sold for human consumption (EconSearch 2020). Recreational fishers harvest Carp using rod and line along the length of the River Murray in South Australlua, as well as from numerous other freshwater catchments around the State. In 2013/14, the estimated State-wide recreational harvest of Carp was 482.7 t (Giri and Hall 2015).

Management arrangements

Carp is a primary species of the commercial LCF, making a relatively high contribution to the total commercial production value of the fishery (PIRSA 2016). For the commercial sector, management arrangements are in place that limit targeted fishing effort for finfish. These include general gear restrictions, and spatial and temporal closures. For the recreational sector, management arrangements are limited to general gear restrictions. No LMS applies to Carp. Carp must not be returned to the water if caught.

Commercial fishery statistics

Trends in total catch, effort and CPUE

Total annual catches of Carp have fluctuated considerably over the last 36 years (Figure 4-13). They ranged from 278 to 360 t from 1984/85 to 1986/87 and then increased to a peak of 1,021 t in 1991/92. Catches subsequently declined to 209 t in 2001/02 before increasing to a second smaller peak of around 750 t in 2005/06 and remained around that level until 2008/09. Catch declined to 308 t in 2011/12 before increasing to 538 t in 2019/20.

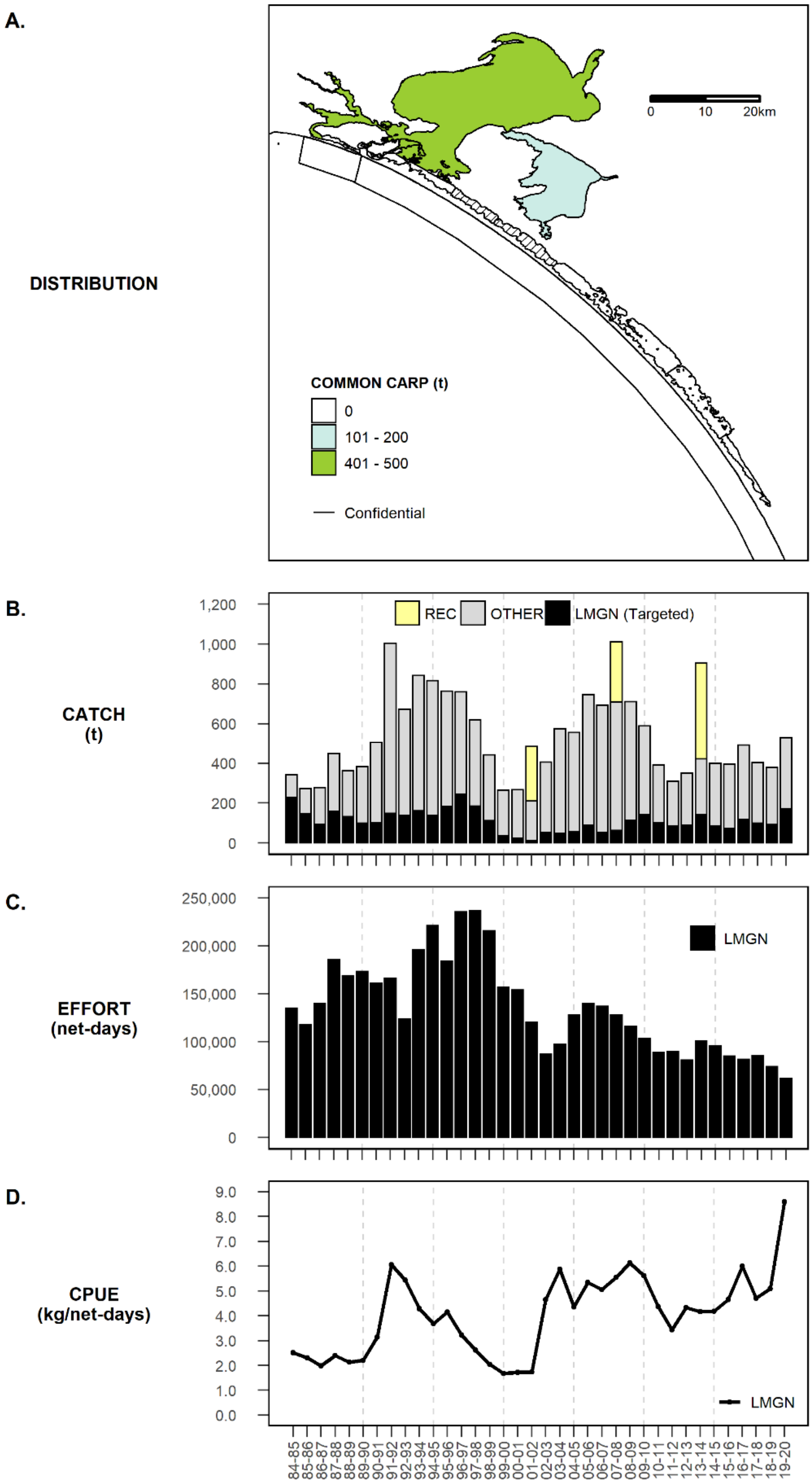

Figure 4-13. Fishery statistics for Carp. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20; Long term trends in: (B) total catch for the main gear type (large mesh gillnets (LMGN), other) and the recreational sector (from all State waters for 2000/01, 2007/08, 2013/14 only; (C) total effort that produced catches of Carp for LMGN; and (D) CPUE for LMGN, based on total catch and total effort that produced catches of Carp.

The temporal trends in total annual LMGN effort that produced catches of Carp have followed those of total catch since 1984/85, with a peak of 236,804 net-days in 1997/98 and a subsequent decline to 86,785 net-days in 2002/03 (Figure 4-13). From 2010/11 to 2017/18, total effort was relatively stable and ranged between 80,588 and 100,462 net-days, before it declined to a historical low of 73,932 net-days in 2018/19. Annual CPUE also followed a similar temporal trend. An exception was in 2019/20, when CPUE increased to 8.8 kg.net-day^{-1}, which was the highest catch rate recorded in the fishery.

Spatial and temporal trends in catch

The commercial fishery for Carp is mostly limited to the Lower Lakes, with most of the catch taken in Lake Alexandrina (block 4) (Figure 4-14). Catches of Carp are taken throughout each year, with the largest quantities harvested usually during the warmer months from September to March.

No stock status is assigned to Carp.

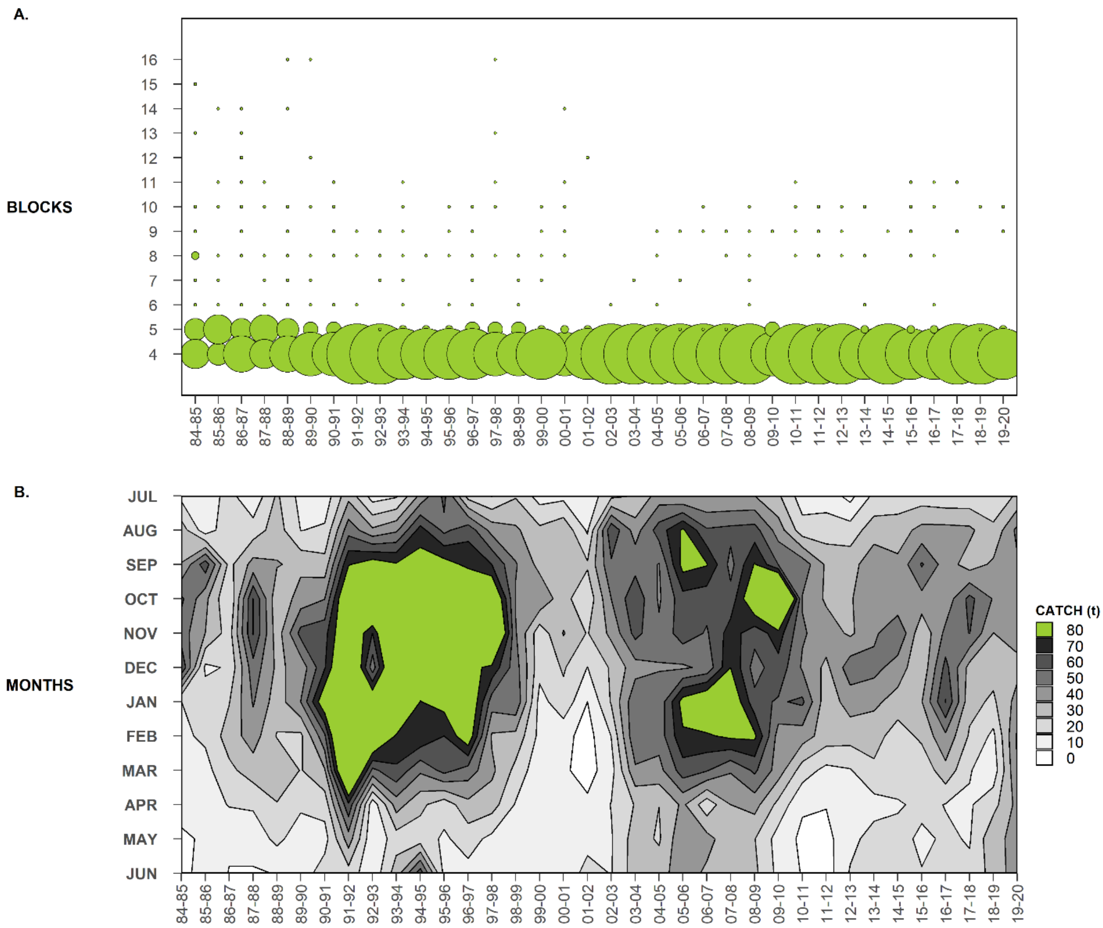

Figure 4-14. Fishery statistics for Carp. Long-term trends in (A) the annual distribution of catch among LCF reporting blocks (diameter of the bubbles represent the relative contribution of each reporting block to total annual catch); and (B) the annual distribution of catch among months.

4.3.2.4 Environmental performance indicator

The FLMGN performance indicator for mean water level in the Lower Lakes was 0.71 m for the 2020/21 reporting year, which was above the target reference point of 0.4 m (Figure 4-15).

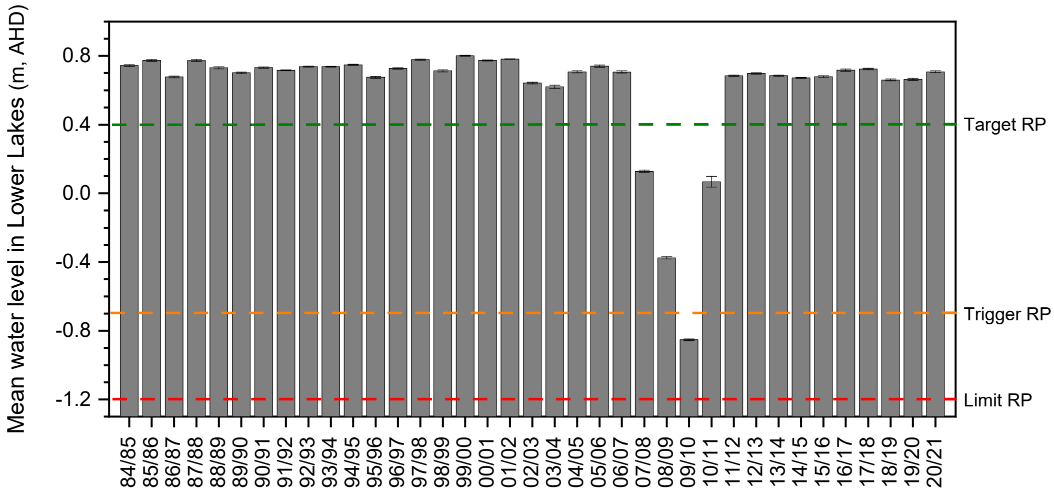

Figure 4-15. Estimates of the FLMGN performance indicator for mean water level in the Lower Lakes (± S. E.) from 1984/85 to 2020/21 (reporting years), showing target, trigger and limit reference points (RPs).

4.3.3 Pipi sector

4.3.3.1 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 South Australia (Murray-Jones and Ayre 1997). The Coorong beaches adjacent to the Murray Mouth, particularly along the Younghusband Peninsula, provide high quality habitat for Pipi, and it is likely that the stock in the Coorong region represents the largest single population of this species in Australia (King 1976).

For the population of Pipi on the Younghusband Peninsula, the sizes at which 50% and 95% were reproductively mature were 28.4 mm and 32.5 mm, respectively (Ferguson and Mayfield 2006). Spawning typically occurs between September and November (Ferguson and Ward 2014). Despite several genetic studies, the biological stock delineation for Pipi is unclear. Here, assessment of stock status is presented at the management unit level–the LCF.

Fishery

Pipi is an important target species for the commercial and recreational fishery sectors in South Australia. The commercial Pipi fishery is located on the ocean beach of the Younghusband Peninsula and comprises three sectors: (i) the LCF; (ii) MSF; and (iii) SZRLF. The commercial fishery harvests Pipi manually using cockle rakes, which consist of a pole and frame with a net attached. As of June 2019, there were 16 licence holders with Pipi catch quota entitlements (14 from the LCF and two from the MSF). Other licence holders in the MSF and SZRLF have access to 10 kg of Pipi per day for personal bait use only.

There is little information on the recreational fishery for Pipi in South Australia. Anecdotal information suggests that most recreational fishers who harvest Pipi harvest most of their catch from Sir Richard Peninsula (Goolwa Beach) during summer (Murray-Jones and Johnson 2003; Giri and Hall 2015).

Management arrangements

Pipi is a primary species of the commercial LCF, making a relatively high contribution to the total production value of the fishery (PIRSA 2016). The commercial sector is managed using a combination of input and output controls including: (i) restrictions on the number of operators and agents; (ii) gear restrictions; (iii) a LMS of 35 mm; and (iv) spatial and temporal closures. Since 2007/08 the fishery has been managed under a total allowable commercial catch (TACC) with individual transferable quotas. The TACC has effectively constrained commercial catches since 2009/10. Under current fisheries regulations, the Pipi season is from 1 November to 31 May, although exemptions have been allowed for commercial fishers to harvest year-round since 2010/11.

The management plan includes a harvest strategy for Pipi (PIRSA 2016). The harvest strategy uses two biological performance indicators and a set of decision rules to inform setting of the annual TACC: (i) primary biological performance indicator – mean annual relative biomass of legal-sized Pipi (harvestable biomass); secondary biological performance indicator – presence/absence of pre-recruits in size distributions from November to February of the previous year (Ward et al. 2010; Ferguson et al. 2015). The objectives of the harvest strategy are to: (i) maintain mean annual relative biomass of legal-sized Pipi above the target reference point of 11 kg/4.5 m^2; but (ii) not less than the trigger reference point of 9 kg/4.5 m^2; and (iii) to ensure that mean annual relative biomass does not fall below the limit reference point of 4 kg/4.5 m^2.

The recreational sector for Pipi is managed through a combination of input and output controls, aimed at ensuring the total catch is maintained within sustainable limits and to ensure that recreational access to the fishery is equitably distributed between recreational participants (PIRSA 2016). Daily bag and vehicle limits apply, and vary geographically. For areas east of longitude 136^{o}E, which includes Goolwa Beach, a personal daily bag limit of 300 Pipi applies, and there is a vehicle limit (when three or more people are present) of 900 Pipi. For areas west of longitude 136^{o}E, the daily bag limit is 100 Pipi and a vehicle limit (when three or more people are onboard) of 300 Pipi applies. A temporal closure applies from 1 June to 31 October each year (inclusive) and recreational fishing for Pipi is prohibited on the Younghusband Peninsula between the Murray Mouth and 28 Mile Crossing. The LMS of 35 mm (across the widest part of the shell) also applies to the recreational sector.

Commercial fishery statistics

Trends in total catch, effort and CPUE

Total annual commercial catches (combined catches from LCF and MSF) of Pipi ranged from 310 to 457 t between 1984/85 and 1989/90, and then increased progressively to an historic peak of 1,251 t in 2000/01 (Figure 4-16). Catches exceeded 1,000 $t.yr^{-1}$ between 1999/00 and 2006/07 and then declined steeply to 470 t in 2008/09. From 2009/10, catches were constrained by annual TACCs, which steadily increased from 300 t in 2009/10, to 650 t in 2017/18 and 2018/19. In 2019/20, the annual TACC was reduced to 450 t, thereby constraining catch to its lowest level since 2012/13.

Annual CPUE for cockle rakes (LCF only) increased from 483 kg.fisher-day^{-1} in 1988/89 to a historic peak of 1,235 kg.fisher-day^{-1} in 1995/96 (Figure 4-16). From then, CPUE declined consistently to 329 kg.fisher-day^{-1} in 2008/09 and remained low (334–456 kg.fisher-day^{-1}) until 2016/17. Over the last four years, CPUE increased to 720 kg.fisher-day^{-1} in 2018/19 and then fell to 633 kg.fisher-day^{-1} in 2019/20.

The estimates of CPUE for Pipi 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 et al. 2015; Ferguson and Hooper 2017). Data on catch and CPUE for the MSF are not presented due to data confidentiality (i.e. reported by < 5 fishers).

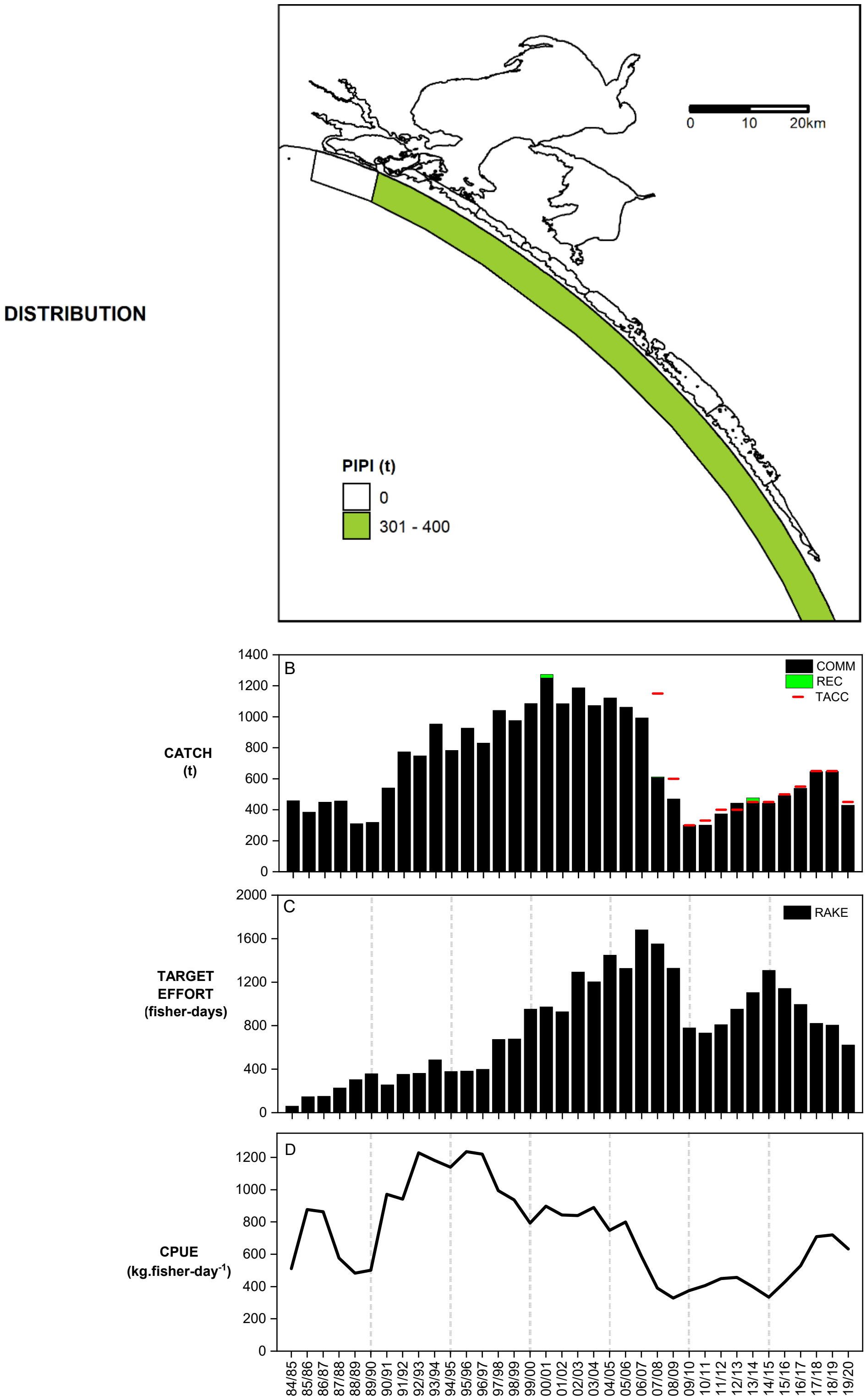

Figure 4-16. Fishery statistics for Pipi. (A) Map of the LCF reporting blocks showing the catch distribution for 2019/20 (LCF only); Long term trends in: (B) total catch for the LCF and MSF combined and the recreational sector (for 2000/01, 2007/08, 2013/14); (C) targeted effort for cockle rakes; and (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).

Seasonal trends in catch

Prior to 2010/11, the fishery for Pipi was closed from 1 May to 30 September each year, with the months of November to April being the most productive for the fishery. Since 2010/11, fishing has occurred throughout the year under Ministerial Exemption (Ferguson and Hooper 2017). In 2018/19, catches taken between November and April accounted for around 70% of the total catch.

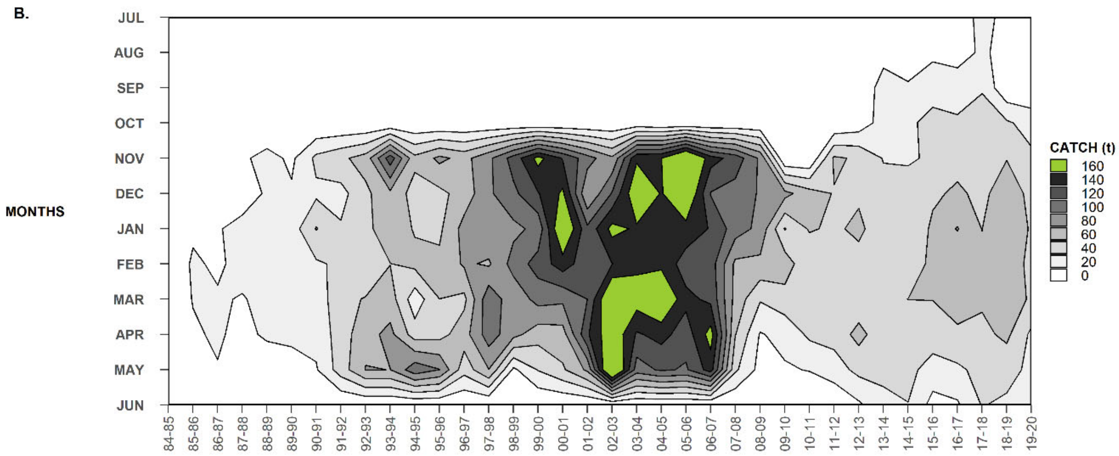

Figure 4-17. Fishery statistics for Pipi. Long-term annual distribution of catch among months of the year.

Biological performance indicators

The harvest strategy for Pipi aims to maintain mean annual relative biomass above a target reference point of 11 kg/4.5 m^2 (PIRSA 2016). In 2019/20, the estimate of mean annual relative biomass was 10.75 kg/4.5 m^2 which was 2% below the target reference point of 11 kg/4.5 m^2 (Figure 4-18).

Pre-recruits comprised less than 30% of size structures in November 2018 (12%), and February 2019 (16%), and therefore were considered absent in 2018/19 (Figure 4-19). In 2019/20, pre-recruits comprised 13% of size structures in November 2019, with this increasing to 40% in February 2020. Therefore, pre-recruits were considered present in 2019/20.

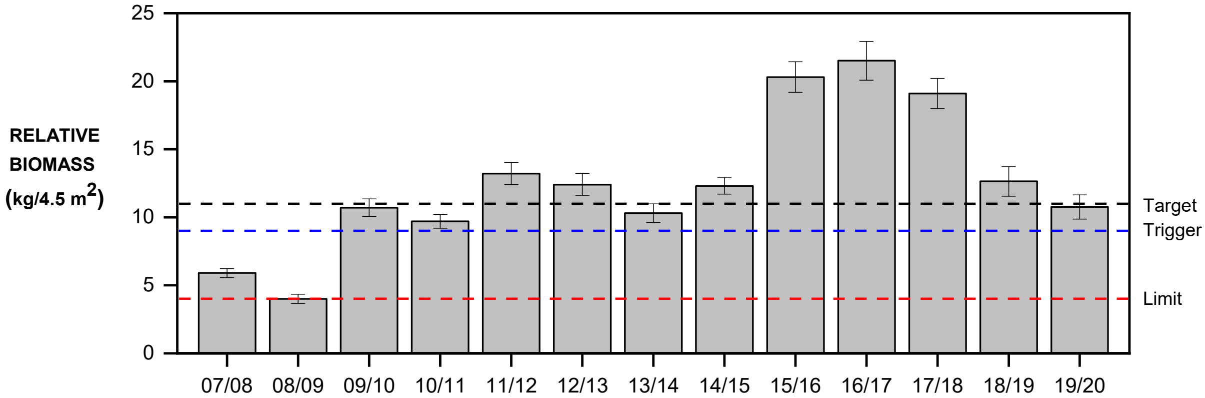

Figure 4-18. Estimates of fishery-independent mean annual relative biomass of Pipi from 2007/08 to 2019/20 showing target, limit and trigger reference points. The harvest strategy aims to maintain relative biomass above a target of 11 kg/4.5 m² (black dashes) and not less than the trigger reference point 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.

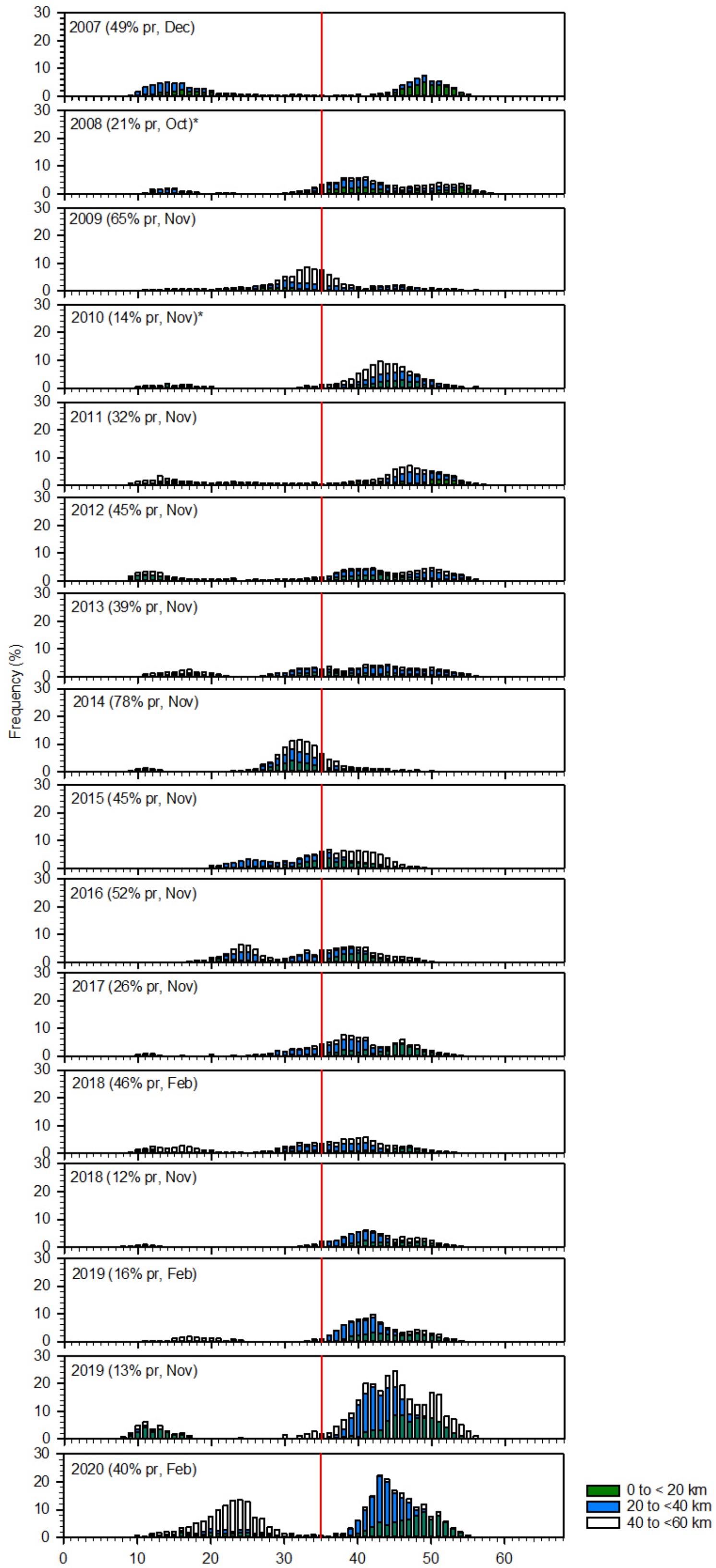

Figure 4-19. Estimates of the secondary biological performance indicator for Pipi: presence/absence of pre-recruits (pr) during November from 2007/08 to 2019/20, and in February 2018, 2019 and 2020. Vertical red line represents legal minimum size of 35 mm.

4.3.3.2 Stock status

Pipi is a primary species for the commercial sector of the LCF (PIRSA 2016). 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 Pipi fishery 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 resource across the fishing ground on the Younghusband Peninsula (Ferguson and Hooper 2017). The key 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 et al. 2015). From 2015/16 to 2017/18, following several years of successful recruitment, estimates of mean annual relative biomass were the highest on record. From then, relative biomass declined and in 2019/20 was 2% below the target reference point in the harvest strategy (PIRSA 2016). Pre-recruits were present (40%) in the population size structure in 2019/20. The above evidence indicates that 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 Pipi is classified as a **sustainable** stock.

4.4 SUMMARY

This section of the report used a weight-of-evidence approach to assign stock status for six key species of the commercial LCF and describes trends in the commercial fishery statistics for Carp. The assessment of each stock relied heavily on fishery-dependent data, and placed considerable emphasis on analysing trends in catch, effort and CPUE from 1984/85 to 2019/20. Additional information about the species' stock structure, biology and management arrangements also contributed to the determination of stock status.

Of the six LCF species assessed in this section, four (Yelloweye Mullet, Mulloway, Golden Perch and Bony Herring) are classified as 'sustainable', and two (Black Bream and Greenback Flounder) are classified as 'depleted'. For each species, the stock status classification was the same as that for 2018/19 (Earl 2020).

This section of the report also provided an assessment of the recent condition of the environment in which the fishery's ELMGN and FLMGN sectors operate, based on the environmental performance indicators and reference points used in the harvest strategy for finfish (PIRSA 2016). For the ELMGN, the performance indicator for habitat available to Mulloway in the Coorong Estuary for the 2020/21 reporting year was 52.3%, which was below the target reference point of 55% and above the trigger reference point of 24.9%. For the FLMGN, the environmental performance indicator for water level in the Lower Lakes for the 2020/21 reporting year was 0.71 m, which was above the target reference point of 0.4 m. An assessment of the environmental performance indicator for the ESMGN sector is presented Section 3.3.3, as part of the stock assessment for Yelloweye Mullet. The ESMGN performance indicator for habitat available to Yelloweye Mullet in the Coorong Estuary for the 2020/21 reporting year was 62.4%, which was above the target reference point of 50%.

5 GENERAL DISCUSSION

5.1 SYNTHESIS

This report for South Australia's multi-species, multi-gear LCF provided an overview of the dynamics of the fishery's fleet and catches from 1984/85 to 2019/20, a stock assessment for Yelloweye Mullet, and assigned stock status to a further six species using the NFSRF (Stewardson et al. 2018). The assessments of stock status undertaken for each species used a weight-of-evidence approach that considered a range of species-specific information relating to: population biology; fishing access; management arrangements; and trends in commercial fishery data from 1 July 1984 to 30 June 2020. Updated estimates of the environmental performance indicators for the three gillnet sectors of the fishery, as well as the biological performance indicators for Pipi were also provided.

Of the seven stocks assessed in this report, five (71%) were classified as 'sustainable', and two (29%) were classified as 'depleted'. For each stock, the status classification in 2019/20 was the same as that from 2018/19 (Earl 2020). The five 'sustainable' stocks are those of the primary species—Mulloway, Yelloweye Mullet, Golden Perch, Bony Herring and Pipi, which along with Carp (also a primary species) have consistently accounted for > 95% of the fishery's total annual catches since 1984/85. This continued in 2019/20, with the six primary species accounting for 97% of the fishery's total catch. The two 'depleted' stocks relate to the secondary species – Black Bream and Greenback Flounder. Catches of these two species remained low in 2019/20.

The stock assessment for Yelloweye Mullet in this report was the first since 2013 (Earl and Ferguson 2013). The stock is classified as 'sustainable', as it was in 2019/20 (Earl 2020), on account of: (i) the unprecedented, record-high annual catches and $CPUE_{SMGN}$ in the Coorong Estuary in 2019/20; (ii) the recruitment of successive year classes of juveniles to the fishable biomass in the Coorong Estuary in recent years; and (iii) the presence of multiple age classes in the population age structure, which was consistent with previous years.

The recent high catch rates for Yelloweye Mullet are indicative of high fishable biomass in the Coorong Estuary, but may also reflect changes in the relative efficiency of the fleet in recent years. Representatives from the fishing industry have indicated that many fishers, including those that target Yelloweye Mullet, have modified their fishing practices to try and avoid interactions with Long-nosed Fur Seals. These interactions occur as seals attempt to eat fish caught in gillnets, which results in catch losses and damage to nets. Some of the operational changes made by fishers have included: reducing the number of gillnets used per fishing day which has allowed them to attend their nets more regularly (i.e. reduce soak time of individual gillnets); changing the time of the day that nets are in the water; and more regularly shifting between fishing areas to try and be less predictable to foraging seals

(EconSearch 2020). The influence of such changes in fisher behaviour on estimates of $CPUE_{SMGN}$ is difficult to assess because most of the changes are not currently able to be recorded in fishery logbooks. This could be partially addressed by incorporating additional reporting fields (e.g. soak time) in the Inland Waters Catch and Effort return. The next stock assessment for Yelloweye Mullet in the LCF is planned for 2023/24.

Mulloway continued to be the main target species of the ELMGN sector of the LCF in 2019/20. The high levels of fishery production for Mulloway from 2017/18 to 2019/20 have been associated with record high estimates of CPUE. Catch rates declined slightly in 2019/20 but remained high in a historical context, and were indicative of high fishable biomass in the Coorong Estuary. As is the case for Yelloweye Mullet, the unprecedented high catch rates in recent years could also relate to changes in fishing strategy as fishers continue to adapt to the presence of Long-nosed Fur Seals. A comprehensive stock assessment for Mulloway in the LCF in planned for 2022/23.

The poor fishery performance of the Black Bream stock in the Coorong since the early 1990s has persisted, with historically low levels of catch and targeting continuing in 2019/20. The temporary management arrangements introduced in 2018 and 2019 to recover the stock have not yet resulted in measurable improvements. Any benefit from these management 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 (Jenkins et al. 2015; Earl et al. 2016b; Ye et al. 2017, 2019). Moreover, juvenile Black Bream that originated from spawning in 2018 and 2019 (i.e. when the temporary management arrangements were in place) will take several years to recruit to the fishable biomass and contribute to egg production (Ye et al. 2020). A comprehensive stock assessment for Black Bream that builds on the previous stock assessment (Earl et al. 2016b) and evaluates the effectiveness of the temporary management arrangements should be considered within the next 2–4 years.

The low fishable biomass of Greenback Flounder in the Coorong Estuary over recent years also continued in 2019/20. The lack of targeted effort and low annual catches during the past seven 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, which likely extends beyond the spatial constraints of the LCF and into the Southern Ocean (Earl et al. 2017), has repeatedly demonstrated its capacity to replenish the Coorong population in the 1–2 years after 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 aims 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.

For the FWLGN sector in 2019/20, an overall decline in fishing effort contributed to declines in catches of Golden Perch and Bony Herring. This sectoral decline in effort likely reflected a weaker market demand for Bony Herring and Carp, which are primarily supplied as bait to commercial fishers in the SZRLF. Rock Lobster fishing in South Australia effectively ceased in February 2020 in direct response to the weakening of export markets, particularly in China, due to the COVID-19 pandemic. While commercial Rock Lobster fishing resumed in March 2020, the pandemic continued to impact the LCF, with some fishers reluctant to catch and store large volumes of bait due to ongoing market uncertainty.

In 2019/20, the total catch of Golden Perch declined to its lowest level since 2012/13, although $CPUE_{LMGN}$ remained high, annual CPUE for the low-value Bony Herring remained at a moderate level. Golden Perch and Bony Herring stocks were classified as '**sustainable**' in 2018/19 (Earl 2020) and 2019/20. While no stock status was assigned to Carp, the increase in catch (despite the effort sectoral reductions in fishing effort) and record-high catch rates in 2019/20 suggest that the biomass of this stock is unlikely to be depleted.

For each of the three finfish sectors, the environmental performance indicator for the 2020/21 reporting year (1 February 2020 to 31 January 2021) was assessed against the reference points used in the finfish harvest strategy. The results of these comparisons will guide setting of the annual TACE for each sector for the 2021/22 fishing season. The environmental performance indicator for two of the three finfish sectors were above their respective target reference points. These sectors were the FLMGN and ESMGN sectors. The environmental performance indicator for the ELMGN sector was 4.9% below the target reference point.

For Pipi, 2017/18 and 2018/19 were the most productive years for the commercial fishery in terms of total catch since a TACC was introduced under a quota management system for the species in 2007/08. The estimate of fishery-independent relative biomass of legal-sized Pipi (primary performance indicator) in 2019/20 was marginally below the target reference point but well above the trigger reference point used in the harvest strategy for Pipi (PIRSA 2016). This indicates that the biomass of the Pipi stock along the ocean beach of the Younghusband Peninsula is unlikely to be depleted. In fact, the Pipi fishery was subjected to a 22% increase in TACE for the 2020/21 fishing season, after fishery-independent surveys identified a relatively high proportion (40%) of pre-recruits in the population in February 2020. The next stock assessment for Pipi is planned for 2020/21.

5.2 RESEARCH PRIORITIES

The weight-of-evidence approach used to determine stock status for the LCF stocks considered in this report relied heavily on fishery-dependent data. The assessments placed considerable emphasis on analysing trends in catch, effort and CPUE for the primary gear types used to target each species. These data will continue to form the basis of the assessments of LCF stocks. For most species considered in this report, the primary measure of fishable biomass is targeted CPUE from gillnets. For these species, CPUE is assumed to be proportional to abundance and is therefore used as relative index of abundance. However, the CPUE likely also reflects changes in the relative efficiency of the fleet in recent years because many fishers have modified their fishing practices to try and avoid negative interactions with Long-nosed Fur Seals. In addition, for several species, especially those that are taken in low quantities (e.g. Black Bream, Greenback Flounder) and for which most of the recent annual catches have been taken as by-product, targeted CPUE is considered a poor indicator of relative abundance. Catch per unit effort standardisation may help improve the usefulness of CPUE as a relative index of abundance, including by accounting for differences in the relative contributions of targeted and non-targeted catches to the total catch. Improving the reliability of CPUE as an indicator of biomass would improve the confidence in assessments of stock status.

Consideration of contemporary information on the size and age composition of exploited populations is also fundamental for assessments of stock status, particularly for long-lived species (King and McFarlane 2003). The life histories of Mulloway, Black Bream and Golden Perch are characterised by longevity (i.e. 41 years for Mulloway; 32 years for Black Bream; and 26 years for Golden Perch) and delayed maturity. Such a life history (periodic strategist) generally relies on the establishment of one or several strong year classes at regular intervals to maintain the population (Winemiller and Rose 1992). Currently the most significant gap in our knowledge relevant to the assessments of stock status for these species relates to the lack of demographic information (e.g. size/ age structures) for populations that support the LCF. A catch sampling program to support development of a time series of annual age structures for Mulloway, Black Bream and Golden Perch would improve assessments of stock status and facilitate better informed fishery management.

A key gap in our knowledge for assessing the status of the stocks that support the LCF is determining the relative contribution of the recreational fishing sector to total State-wide catch. The total harvest by the recreational sector has traditionally been determined through telephone/diary surveys that are undertaken on a five-year cycle (Henry and Lyle 2003, Jones 2009, Giri and Hall 2015). Although these surveys adopt a standard methodology that allows the results to be compared through time, their estimates of catch and effort are typically imprecise, and even more so at the regional scale for the Lakes and Coorong. This imprecision has implications for the assessments of Mulloway, Golden Perch, Black Bream and Pipi, for which the relative recreational contribution to overall State-wide catch is significant. Improving the precision of the estimates of the recreational catches, either through more frequent surveys or increased participation rates, will improve assessments of stock status. The 2021/22 Recreational Fishing Survey commenced in February 2021 and will continue until 28 February 2022. The survey involves a traditional telephone/diary survey, State-wide onsite sampling and dedicated survey for Pipi. To increase participation rates, a smartphone application has been made available for all recreational fishers to contribute information on where they fished and their catch.

Levels of incidental mortality of sub-legal sized individuals of key LCF species discarded by commercial and recreational fishers in the Coorong Estuary and Lower Lakes are poorly understood. This is because estimates of discarding are only available for the commercial fishery from limited sampling undertaken during the Millennium Drought (Ferguson 2010). For the commercial sector, this could be addressed by ongoing monitoring discards from gillnets.

Conflict between LCF fishers and Long-nosed Fur Seals has been an important issue for the fishery over the last 11 years (EconSearch 2020). Despite recent mitigation initiatives (e.g. implementation of seal crackers as a management tool), reports from industry suggest that the seal-fisher conflict and associated economic impacts continued in 2019/20. A key gap in our knowledge for assessing the status of LCF stocks is quantitative information on the extent of the impacts of seals on the fishery with respect to catch losses and damaged discarded catch, both of which represent a source of fishing mortality that is not currently able to be accounted for in fishery assessments. A FRDC-funded Project (2018-036 'Seal-fisher-ecosystem interactions in the Lower Lakes and Coorong: understanding causes and impacts to develop longer-term solutions') is seeking to acquire this information. The utility of the data will be heavily dependent on the engagement of the LCF commercial fishers in the data collection process.

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APPENDIX

Appendix 1. Summary table showing annual total commercial catches (tonnes) 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	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	421	490	539	2.1	1.7	0	1.6	0	12
17/18	121	154	106	356	403	646	0.7	1.3	0	0.6	0	27
18/19	109	284	61	296	376	646	1.8	0.7	0.3	0.3	0	43
19/20	120	458	50.6	269	538	430	0.24	1.76	0	1.1	0	32