Victorian Fisheries AUTHORITY

Review of key Victorian fish stocks — 2019

S. D. Conron, J. D. Bell, B. A. Ingram & H. K. Gorfine
November 2020, First Edition
Victorian Fisheries Authority Science Report Series No. 15

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Printed by VFA

Edited by Simon Conron

Approved for release by Dallas D'Silva (06–01–2021)

ISSN 2203-3122 (print)

ISSN 2204-6933 (online)

ISBN 978-0-6488979-4-1 (print)

ISBN 978-0-6488979-5-8 (pdf/online/MS word)

For more information, contact the Customer Service Centre on 136 186.

Accessibility
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Executive Summary

The Victorian Fisheries Authority (VFA) is the State agency responsible for managing the more than 90 wild fish stocks that are fished by recreational and/or commercial fishers. The VFA does this using a risk-based approach to prioritise the allocation of resources for monitoring, assessing and managing the impacts of fishing.

This report endeavours to:

- Review the status of key Victorian fish stocks to determine their exploitation status;
- Provide fisheries managers and policy makers with the information and advice they need to guide their decisions, work prioritisation and policy development;
- Identify the information requirements to improve future assessments;
- Streamline reporting requirements such as those for obtaining and maintaining export approval under the Federal *Environment Protection and Biodiversity Conservation Act 1999*, the Victorian *Commissioner for Environmental Sustainability Act 2003,* and Victorian fisheries cost recovery policy in accordance with the *Fisheries Act 1995* and the *Fisheries (Fees, Royalties and Levies) Regulations 2008*; and
- Align stock assessments with Victoria's stock reporting and the Commonwealth Status of Key Australian Fish Stocks (SAFS).

This review updates previous assessments of stock status during 2017–19 for non-quota managed species in terms of their biological performance. Importantly it does not consider the expected success/failure or otherwise of current or alternative management approaches, or foreseeable changes in management of fishing effort. Consideration of future or previously implemented management responses to stock status issues would be expected to occur as part of follow up discussions/integrated risk assessments. Relative importance of each species/stock based primarily on consideration of relative catch, gross value of production (GVP) and or assumed relative catch or social value (i.e. recreational dominated species). Where available the most recent Status of Australian Fish Stocks classifications (https://fish.gov.au/) are also included together with key points about each species' performance.

Abalone (blacklip and greenlip), giant crab and southern rock lobster fisheries, for which assessments have been outsourced and are reported separately, are not covered by this report.

Thirty-one species each comprising one or more stocks totalling of 40 were assessed as follows:

- Relative importance of the stocks in accordance with an internal VFA index was evenly distributed among categories with 13 high, 10 moderate and 13 low, and the remaining four (2 × octopus and 2 × sea urchin species) classed as developing or recently developed;
- More than half of the 31 species among the 40 stocks (55%) were classed as sustainable in accordance with the SAFS classification system;
- Only two species from two stocks, Gippsland Lakes Black Bream and Banded Morwong in eastern Victoria, were classed as depleting and three (Murray Cod, Southern Sand Flathead and Yelloweye Mullet) were considered as recovering for the 2018 SAFS assessment, noting that this is an external process where SAFS classifications in a limited number of instances may be at variance with VFA classifications, especially where a stock is shared among jurisdictions; and,
- Ten stocks comprising six species in this report were not included in the SAFS assessment.

Two species of eels (long-fin and short-fin) that have not been included in this report are included in the SAFS assessment, as well as three geographically marginal species (Cobia, Bronze Whaler Shark, and Striped Trumpeter) that naturally occur in only low abundance in Victorian waters. These last three are not classified in SAFS but instead are described qualitatively by a simple generic statement. As more species are included in SAFS (in the 2020 SAFS report there will be 200 stocks comprising 157 species) the number of data poor stocks that will be classified as undefined or less commonly negligible will invariably increase despite the development of a data limited modelling software package that only requires a reliable times series of catch (fishing mortality) and CPUE (stock biomass) together with assumed values of biological parameters.

The outcomes of this review of the status of Victorian fish stocks will be used to meet the requirements of State and Commonwealth stock status reporting and to inform Victorian and interstate fisheries managers and scientists of the status of key cross-jurisdictional stocks. Options for increasing the number of individual stocks reviewed are also discussed. Implementing regular stock status reviews as opposed to a pre-determined assessment schedule may provide a more adaptive and resource -efficient approach to managing Victoria's fisheries while ensuring sustainability of the stocks.

Introduction

The Victorian Fisheries Authority (VFA) is the agency responsible for managing the State's fisheries resources under the guiding principles of ecological sustainable development consistent with the obligations under the *Fisheries Act 1995* and the *Victorian Fisheries Authority Act 2016*.

Recreational, commercial and Indigenous fishing provide a wide range of social and economic benefits to Victorians. Many of Victoria's fisheries are complex, involving multi-sector, multi-species, multiple fishing methods and gears. They are also subject to competing consumptive use as seafood and non-consumptive uses such as tourism and provision of ecosystem services. Furthermore, environmental factors can exert strong influences on production of most inshore and estuarine species. In recent times, access and impacts on finfish stocks have also become increasingly weighted towards the recreational sector. This provides additional challenges for assessment of fish population status and the impacts of fishing, because in general catch and effort for recreationally dominated fisheries is not routinely reported as is the case for most commercial fisheries.

Managing complex, wild fisheries to ensure long-term sustainability and satisfactory fishery performance in the face of naturally varying fish populations, climate change, expanding human population, increased urbanisation and competing stakeholder interests (recreation, commerce, conservation, water extraction, land reclamation) is demanding. To ensure that resources are managed sustainably and maximise the economic, social and cultural benefits, a strong evidence base, informed by knowledge of the stock status, is required.

The VFA prioritises the allocation of resources for the monitoring and assessment activities required to inform management of fisheries based on importance to the community and risk to the resource. High value, commercially dominated fisheries for abalone and rock lobster have well developed and resourced annual stock assessment and data collection programs. They also have management plans with formal harvest strategies and quota systems to which assessments are aligned. Giant crab is less intensively monitored, but like rock lobster and abalone has an established annual assessment and quota setting system. Abalone species, rock lobster and giant crab are not included in this assessment which focusses on species/fisheries that are i) not under quota management, ii) or are recreationally dominated, and/or iii) are emerging without established assessment processes or management plans, and in many cases have limited data.

It is important to recognise that information available to assess the status of species/stocks or management units is variable among species and locations. For example, Port Phillip Bay and Western Port snapper and King George whiting, and Gippsland Lakes black bream fisheries are subject to comprehensive monitoring programs. Smaller, lower value and lower risk fisheries, such as the recreational fisheries in regional Victorian rivers and estuaries, are assessed using simpler and less resource intensive approaches such as an Angler Diary program. Investment in new and cost-effective electronic data collection methods is a priority of the VFA, for example a trial of a phone application catch-reporting system for recreational fishers (GoFishVic app) and installation of boat ramp cameras to track effort. The assessments in this report are based on available information considered to be informative about the recent biological status of the specific species/stock/management units.

Non-quota Victorian fisheries do not have formal management plans, harvest strategies or defined management objectives with agreed performance indicators and reference points. In lieu of such prescribed approaches to management, this annual review uses available and relevant information to provide evidence-based advice on the status of species and their stocks or management units, uncertainties in status, and issues over performance of associated recreational and commercial fisheries. As the amounts and types of information vary among species assessed, so expert opinion and knowledge about each fishery and its data is important in interpreting variation and trends. Although data extraction and production of graphic summaries can be automated, this does not extend to processes of data interpretation.

Expert interpretation of available data is refined through internal discussions among VFA scientists, managers and policy specialists about problematic species/stocks/management units. Discussion in each species section of this report provides a synopsis that aligns with terminology in the classification scheme used by SAFS (Stewardson et al. 2018), i.e. depleting, depleted, recovering, with the use of 'uncertain' rather than 'undefined' as is used in SAFS. Uncertainty encompasses not only stocks lacking in data, but also those for which data are sufficiently variable to preclude identification of trends. It is expected that the species summaries provided in this report will underpin the biennial SAFS classifications for 2020. This report is more expansive in scope than SAFS and includes species and spatial scales not reported in SAFS but nevertheless relevant to localised operational fisheries management in Victoria. Where a species/stock/management unit has also been assessed in the most recent 2018 SAFS assessment, that classification is indicated in the review table (Table 1) for easy reference.

Purpose

The purpose of this report is to:

- Extract, refine, summarise and present key data on the status and performance of selected non-quota species/stocks/management units;
- Review the status of selected non-quota species/stocks/management units and to indicate levels of any issue or uncertainty over status;
- Provide fisheries managers and policy makers with information to help inform their decisions about work prioritisation, and identification of emerging management issues; and
- Provide a summary of key information that can be used for other related reporting requirements including:
    - Development of external stakeholder communication products;
    - SAFS reporting;
    - Cost recovery reporting for commercial fisheries; and
    - Recreational Fishing Licence (RFL) funded monitoring programs (i.e. creel survey and angler diary).

Methods

Most of the reviews in this report are based on multiple lines of evidence covering four key aspects of stock condition and fishery sustainability:

- *Biomass* status using catch per unit effort (CPUE) as a proxy;
- *Fishing pressure* using total catch and effort or proxies;
- *Fishing mortality* trends inferred using length composition data;and,
- *Recruitment* measured using fishery independent sampling of pre-recruits.

Data sources include:

- Fishery dependent commercial catch and effort data and length compositions collected by industry and or VFA staff;
- Fishery dependent creel surveys of recreational catch and effort, and length compositions;
- Angler Diary Program that involves structured data collection on catch, effort and length compositions by volunteer angler diarists; and
- Annual fishery independent pre-recruit (young-of-year) surveys.

Detailed methods for the creel survey and angler diary programs are described in PoMC (2008), and Conron and Oliveiro (2016).

Fishery dependent CPUE is the most commonly used proxy for biomass trends in fisheries assessments and is mostly available from catch and effort data reported by commercial fisheries. In more limited instances where recreational fishing dominates, and/or commercial data may be insufficient for analysis, recreational angler CPUE was used as an alternative or supplement to assess trends in stock biomass. Victorian commercial fishers have reported catch and effort information since 1978 but corresponding information has only been consistently collected for selected recreational species and locations using creel surveys since 2002, although some earlier creel survey data are available for some areas. Wherever earlier creel survey data are available these have been included. There are no time series for total recreational catches and limited effort data for any Victorian recreational fishery. The only State-wide recreational catch surveys that included several key species assessed in this report were conducted in 2000/01 (Henry and Lyle 2003) and 2006/07 (Ryan *et al.* 2009) so as these reports are outdated they were not used in this report.

For commercial CPUE trends, only gear types that account for most of the harvests have been considered in this report. Choice of gear types for use in analysing CPUE was made by inspecting plots of harvest by gear type by year for key fishery areas. For most species/stocks catch by area is presented, but if relevant, i.e. major shifts in gear types used to target species, catches by gear types are also included. The CPUE for some fisheries/gear types was standardised using General Linear Mixed Modelling (GLMM) (Appendix 1) to reduce the influence of factors that are known to affect CPUE but are unrelated to real changes in biomass. In this review standardised CPUE is presented along with nominal CPUE wherever possible, however for some CPUE data series, standardisation is problematic due to the involvement of very few fishers (i.e. diary anger data for small estuaries), and poor/unsatisfactory model fits. Generalized Additive Models (GAMS) are used to indicate trends in CPUE time series (Appendix 1).

As a guide to assist with interpretation of CPUE patterns, averages have been used to facilitate discussion of CPUE trends and stock status. Where CPUE is approaching an all-time low the stock will likely be in a depleted state and should be subject to heightened scrutiny by managers and stakeholders. Nevertheless, CPUE decline may reflect change in the way the fishery is operating that has altered the relationship between CPUE and biomass. This, for example, may involve a change in targeting or retention and reporting. The main issue in this situation is it means that recent and future data will no longer be readily relatable to historic series. Average CPUE may be viewed as a benchmark below which the stock and fishery is considered as underperforming, depleting or perhaps at risk of becoming depleted. While periodic drops below the long-term average may not necessarily be indicative of a persistent depleting trend, they nevertheless provide grounds for greater scrutiny and an alternative explanation of the data patterns.

Although standardisation of CPUE data can remove some of the confounding influences when inferring biomass changes, there is always a need to consider any changes that are evident in how a fishery operates, such as modifications to gear, introduction of new technology, targeting preferences, and management changes that can affect efficiency and catchability. Each fishery dependent CPUE time series is carefully examined by VFA scientists within the scope of their knowledge and the operational context of the respective fishery.

Furthermore, some stocks exhibit long-term trends without clear periods of stability, and others show strong cyclical variation or regimes that may be driven by factors other than fishing, such as environmentally induced recruitment variation and prolonged poor recruitment phases. Interpretation of CPUE variation and trends in these instances requires knowledge of the underlying process driving the dynamics independently of fishing. This knowledge is available in some cases, but not others, and where it exists it is brought into the discussions of data trends. However, low understanding of the environmental/ecological drivers of cycles or long-term trends in the indicators can increase the level of uncertainty in stock status, even for higher value species.

The default reference period used for interpreting CPUE trends is **1986–2015 inclusive**. This default period was selected because:

1) It was consistent with previous assessments to the extent that these three decades lies within the 38-year time-period of 1978–2015;

2) It omits the eight years of data from 1978–1985 because the early years of data acquired after commercial catch and effort reporting was introduced are of lower quality/reliability than subsequent years, presumably due to commercial fishers' unfamiliarity or lack of compliance with the reporting scheme that was introduced in 1978 as well as the time it can take for the CPUE for the various fleets to become consistent in terms of the measurement of effort; and

3) Most of Victoria's major fisheries had been operating for decades before the introduction of catch and effort reporting meaning that there is no possibility to benchmark current CPUE against CPUE during the development of the fishery on a 'virgin stock'.

In some cases, declining trends in CPUE are driven by changes in fishing operations, such as differential targeting of species or uptake of technology. If sufficient confirmation is available, then the reference period may be modified to only encompass a period where targeting was occurring, and operational processes were consistent. In this instance, recent CPUE may be well below the lowest point in the reference period, and the reasons for this will need to be discussed when formulating assessment to advise managers. Shorter reference periods may also be used where, for example, the fishery has only been developed recently; management arrangements have changed (e.g. wrasse licences being made transferable); the time series of data is limited (e.g. recreational fisheries in Port Phillip Bay, Western Port and the Gippsland Lakes); or where a clear step change has occurred, caused either by increased fishing power (i.e. gear change and uptake of technology) or environmental regime change.

Summary of use of CPUE as fishery performance measures:

- Default reference period 1986––2015
- Reference period average (RPA) = Average of annual nominal or standardised CPUE for reference period
- Reference period low (RPL) = lowest annual CPUE for reference period

The 31 species and their 40 stocks or management units included in the most recent review are:

1. Snapper (*Chrysophrys auratus*): Western and Eastern Victorian Stocks
2. King George Whiting (*Sillaginodes punctatus*): State-wide
3. Southern Sand Flathead (*Platycephalus bassensis*): Port Phillip Bay
4. Black Bream (*Acanthopagrus butcheri*): Gippsland Lakes, Glenelg Estuary, Hopkins River, Mallacoota Inlet, Lake Tyers
5. Southern Sea Garfish (*Hyporhamphus melanochir*): Corner Inlet-Nooramunga
6. Pipi (*Donax deltoides*): State-wide
7. Yellow-Eye Mullet (*Aldrichetta forsteri*): State-wide
8. Rock Flathead (*Platycephalus laevigatus*): Corner Inlet-Nooramunga
9. Southern Calamari (*Sepioteuthis australis*): State-wide
10. Blue Throat Wrasse (*Notolabrus tetricus*) and Purple Wrasse *N. fucicola*): State-wide, coastal waters
11. Gummy Shark (*Mustelus antarcticus*): State-wide
12. Silver Trevally (*Pseudocaranx georgianus*): State-wide
13. Southern Bluespotted Flathead (*Platycephalus speculator*): State-wide
14. Sand Crab (*Ovalipes australiensis*): State-wide
15. Australian Salmon (*Arripis trutta*): Eastern Australian and (*A. truttaceus*): Western Australian Stocks
16. Tailor (*Pomatomus saltatrix*): Gippsland Lakes
17. Elephant Fish (*Callorhinchus milii*): State-wide
18. Dusky Flathead (*Platycephalus fuscus*): Gippsland Lakes, Lake Tyers and Mallacoota Inlet
19. Sea Urchins, Long-spined (*Centrostephanus rodgersii*): Eastern Victoria and Short-spined (*Heliocidaris erythrogramma*): Central and Eastern Victoria
20. Estuary Perch (*Maquaria colonorum*): Glenelg and Hopkins Rivers
21. Octopus, Maori (*Macroctopus maorum*): State-wide and Pale (*Octopus pallidus*): Eastern Victoria
22. Banded Morwong (*Cheilodactylus spectabilis*): Eastern Victoria
23. Commercial Scallop (*Pecten fumatus*): Port Phillip Bay
24. Mulloway (*Argyrosomus japonicus*): Glenelg River
25. Murray Cod (*Maccullochella peelii*): State-wide
26. Snook (*Sphyraena novaehollandiae*): State-wide
27. Golden Perch (*Macquaria ambigua*): State-wide
28. Greenback Flounder (*Rhombosolea tapirina*): Corner Inlet-Nooramunga

Stock Review Summary

This review updates previous assessment of stock status for non-quota managed species in terms of their biological performance. Importantly it does not consider the expected success or failure of current or alternative management approaches, or foreseeable changes in management of fishing effort. Consideration of future or previously implemented management responses to stock status issues would be expected to occur as part of follow up discussions/integrated risk assessments. Relative importance of each species/ stock based primarily on consideration of relative catch, GVP and/or assumed relative catch or social value (i.e. recreationally dominant species), is indicated in Table 2. Where available the most recent Status of Australian Fish Stocks classifications (https://fish.gov.au/) are also included together with key points about each species' performance.

Thirty-one species comprising 40 stocks were assessed (Table 1). Relative importance of the stocks had a roughly even distribution among categories with 13 high, 10 moderate and 13 low, and the remaining four (octopus and sea urchin species) classed as developing.

Two years ago seventeen species (55%) in this report were classed as sustainable in accordance with the 2018 SAFS classification systems and one fifth were not included in that assessment. Out of those not classed as sustainable, only two stocks, Gippsland Lakes Black Bream and Banded Morwong in eastern Victoria, were classed as depleting, two (Southern Sand Flathead and Yelloweye Mullet) were considered as recovering from previous depletion and four species (Murray Cod, , Pale Octopus, Pipi and Mulloway) were classed as undefined i.e. uncertain, due to insufficient or highly variable data. The Eastern Snapper stock was also undefined, but the Western Snapper stock was classed as sustainable. In the current submission for the 2020 SAFS assessment two thirds of Victorian stocks have been assigned to the sustainable category, one fifth are considered undefined or negligible, two percent are recovering, and eight percent are depleted or depleting. The remaining six percent (3 species) are geographically marginal and so seldom taken from Victorian waters and were not classified for Victorina in the respective SAFS species chapters for 2020.

The analyses of recent performance of stock status indicators suggest no marked changes since the SAFS 2018 status classifications with the exception of Murray Cod. Analysis, of CPUE data for five of six indicator riverine populations of Murray Cod have shown increases since the early 2010s suggesting that stocks are improving state-wide (Table 1).

Seven stocks reviewed in this report which were not assessed for the SAFS 2018 report showed evidence of:

- Recent increasing or stable CPUE trends being evident in Estuary Perch stock in the Glenelg and Hopkins rivers and Golden Perch (for five of six indicator rivers)
- A downward trend in CPUE being evident in Rock Flathead in Corner Inlet-Nooramunga and a major increase in mesh net effort over the last two years
- No clear trends in CPUE being evident in Southern Bluespotted Flathead in Corner Inlet-Nooramunga, Maori Octopus (State-wide) and Sand Crab (State-wide).

Table 1 Summary of current stock classifications and recent key changes in performance indicators.

Species	Management Unit/Stock	Relative importance	SAFS 2018 classification	VFA assessment of recent performance (2018-2020)
Snapper	Western stock	High	Sustainable	Very strong recent juvenile recruitment suggests major increase in biomass expected over the next five years. Recently stable CPUE, after decreases from 2014.
	Eastern stock	Moderate	Undefined	Now a stand-alone Victorian jurisdiction stock, no information to assess status, anecdotal stakeholder reports about high recreational pressure on spawning aggregations.
King George Whiting	State-wide	High	Sustainable	Strong post-larval recruitment over last three years will result in a major increase in biomass in bays and inlets from 2018/19. CPUE is recruitment driven.
Southern Sand Flathead	Port Phillip Bay	High	Recovering	Continued relatively low recruitment means the stock will remain stable but at a depleted level well below the reference period average for creel survey CPUE.
Black Bream	Gippsland Lakes	High	Depleting	Recent downward trends in commercial and recreational CPUE are apparent, and commercial CPUE is now below the reference period minimum. Stronger juvenile recruitment in recent years and the removal of commercial fishing pressure over is expected to drive stock recovery over the next 5 years.
Rock Flathead	Corner Inlet-Nooramunga	High	Not assessed	Major increase in mesh net effort over last two years accompanied by downward trend in CPUE. No recruitment data available.
Southern Calamari	State-wide	High	Sustainable	CPUE is well above reference period average, short-lived highly dynamic population.
Blue throat Wrasse	Coastal waters	High	Sustainable	Uncertainty in how CPUE is responding under new licence arrangements, i.e. consistency of the indicator. Potential for catch to increase quickly if licences all become active.
Purple Wrasse				
Dusky Flathead	Gippsland Lakes	High	Sustainable: (State-wide)	Catch rates stabilised just below reference period average, but no information on recruitment or length composition. Improved monitoring required through angler diary or creel survey programs.
	Lake Tyers	High	Sustainable: (State-wide)	Recent low recruitment may impact on larger fish abundance in future. Current length composition shows larger female fish are common. Improved monitoring required through angler diary or creel survey programs.
	Mallacoota Inlet	High	Sustainable: (State-wide)	Possible growth-overfishing; uncertainty in status of the larger female population component; lack of reliable CPUE data due to the angler diarists mostly targeting bream.
Murray Cod	State-wide	High	Undefined	Although there is limited long-term estimates of population abundances and recreational harvest for Murray cod across the State, CPUE estimates for five of six indicator riverine populations (Broken Creek and River, Campaspe River, Goulburn River, Gunbower Creek, Loddon River and Ovens River) have increased since the early 2010s suggesting that State-wide stocks are improving. Changes in CPUE for some populations may be influenced by stocking of hatchery-bred fish.
Golden Perch	State-wide	High	Undefined	State-wide stock status was based on assessment of six indicator riverine populations. CPUE is increasing in four rivers, stable in one and declining in another. All rivers are stocked annually. It is anticipated that the stock will progressively improve under favourable environmental conditions.
Short-spined Urchins	Port Phillip Bay	Developing	Sustainable	Stable.
	Eastern Zone	Developing	Sustainable	Stable.
Long-spined Urchins	Eastern Zone	Developing	Sustainable	Stable.
Gummy Shark	State-wide	Moderate	Sustainable	Stable.
Eastern Australian Salmon	Eastern Victoria	Moderate	Sustainable	Stable.

Species	Management Unit/Stock	Relative importance	SAFS 2018 classification	VFA assessment of recent performance (2018-2020)
Western Australian Salmon	Western Victoria	Moderate	Sustainable	Stable.
Black Bream	Mallacoota Inlet	Moderate	Sustainable	Diary angler targeted CPUE has declined to below the reference period average in recent years, but in 2018 was above the reference minimum. Uncertainty over recruitment and decreased diary angler reporting.
	Lake Tyers	Moderate	Sustainable	Diary angler targeted CPUE has declined to below the reference period average in recent years but in 2018 was above the minimum. A lower number of sampling trips has been recorded in recent years due to less diary anglers and CPUE data is become unreliable.
	Glenelg River	Moderate	Sustainable	For the last decade CPUE trend has been stable at about or above reference period average with the exception 2018.
	Hopkins River	Moderate	Sustainable	Diary angler targeted CPUE has fluctuated in recent years above or just below the reference period average.
Southern Garfish	State-wide	Moderate	Sustainable	Recent increase in CPUE for Corner Inlet, now above the reference period average.
Pipi	State-wide	Moderate	Undefined	Not enough fishery data for making inferences from CPUE to assess the sustainability of current catches. Improved effort reporting via e-Catch will be important.
Yellow-eye Mullet	State-wide	Low	Recovering	Reduced catches due to low retention. Low catch risk. In this instance commercial CPUE is not an accurate proxy for biomass.
Silver Trevally	State-wide	Low	Sustainable	Suggestion that broader stock might be depleted, but it is unlikely that the Victorian fishing is a major contributor given the low catch. No change in status.
Southern Bluespotted Flathead	Corner Inlet	Low	Not assessed	Catches have increased significantly in recent years in due to combination of increased mesh netting effort and repeatedly increasing CPUE cycles.
Sand Crab	State-wide	Low	Not assessed	Low risk, but not enough fishery data for making inferences from CPUE or on the sustainability of current catches.
Tailor	Gippsland Lakes	Low	Sustainable	Broader stock is considered stable.
Elephant Fish	State-wide	Low	Sustainable	Current low catch appears stable. Western Port fishery remains unproductive. Lack of recovery after 10 years. Possible habitat/environmental influences depressing recruitment.
Estuary Perch	Glenelg River	Low	Not assessed	Catch rates have been high in recent years. However, a lack of juveniles among observations could mean poor recruitment in recent years. More targeted sampling is required to determine whether there has been a lack of recruitment, or alternatively that the fisher's practices are responsible for the lack of juveniles in the sample.
	Hopkins River	Low	Not assessed	Catch rates have, on average, increased throughout the time series and have remained relatively stable for the last three years at historic highs well above the reference period average. However, like the Glenelg River, there is a lack of data on juveniles. This could also be more due to the selective fishing practices of the angler collecting the data in recent years than to recent poor recruitment.
Pale Octopus	Eastern Victoria	Developing	Undefined	Developing fishery, sustainable catch levels unclear.
Maori Octopus	State-wide	Low	Not assessed	Low risk. Relative stability in the CPUE trend suggests that the abundance of stock is stable.
Banded Morwong	Eastern Victoria	Low	Depleting	Declines in CPUE to below the reference period average in the last two years are associated with increasing fishing effort. Evidence indicates that the fishery is depleting but not recruitment impaired.
Commercial Scallop	PPB	Low	Sustainable	Low risk.
Snook	State-wide	Low	Sustainable	No indication of recruitment impairment and generally appears to be stable throughout the State.
Mulloway	Glenelg River	Low	Undefined	Currently insufficient evidence to reliably assess.
Greenback Flounder	Corner Inlet-Nooramunga	Low	Sustainable	If haul seine CPUE is considered reflective of biomass and mesh net CPUE reflects targeting then the is no indication of depletion.

Snapper (*Chrysophrys auratus*): Western and Eastern Stocks

Stock Structure and Biology

The Victorian snapper population is comprised of two stocks (Figure 1).

- *Western Victorian stock*: Wilsons Promontory (VIC) to Investigator Strait (SA)
- *Eastern Victorian stock*: Wilsons Promontory to southern NSW

Snapper can live to at least 39 years and grow to at least 110 cm total length (TL). Length at 50% maturity is 42 cm TL (legal minimum length, LML = 28 cm) which is reached at approximately 5 years of age. Snapper have high fecundity and a slow-moderate growth rate reaching the LML of 28 cm in 3-4 years.

The main spawning period is from November to January, with Port Phillip Bay the main spawning area responsible for most of the western stock replenishment. The spawning aggregations that occur along inshore reefs between Corner Inlet-Nooramunga and Lakes Entrance are thought to be important for replenishing the eastern Victorian stock.

Management/Assessment Unit

The western and eastern Victorian snapper stocks support recreational and commercial fisheries. The largest fisheries are in Port Phillip Bay (commercial and recreational) and Western Port (recreational), both of which are based on the western Victorian stock. The western stock fisheries account for most of the Victorian snapper harvest and receive most of the assessment and management attention. This report considers each stock separately, although there is limited information to inform assessment of the eastern stock, despite its perceived growth as a recreational fishery over the last decade.

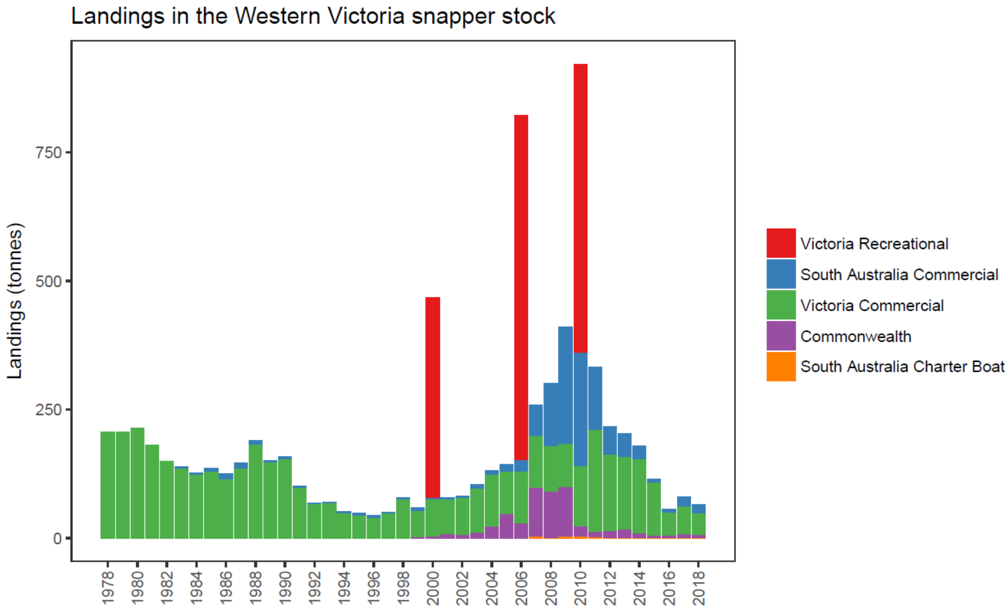


Figure 1 Total catch of snapper from the Western Victorian stock, financial years 1978–2018.

Assessment Summary

Western Victorian Stock

The status of the Western Victorian snapper stock and associated fisheries were evaluated using:

- Available harvest information for the commercial and recreational sectors
- Nominal and standardised CPUE for commercial long-line in Port Phillip Bay (reference period 2000-2015)
- Nominal and standardised CPUE for the recreational fishery from annual creel surveys in Port Phillip Bay and Western Port for adult (October-December) and juvenile/sub-adult (January-April) snapper (reference period 2002–2015)
- Length composition of long-line fishery catches in Port Phillip Bay
- Length composition of recreational fishery catches in Port Phillip Bay and Western Port from creel survey samples and diary anglers
- Snapper pre-recruit (0+ age) abundance from fishery independent trawl surveys in Port Phillip Bay.

This assessment found:

- *Fishing pressure* – most of the commercial harvests are from Port Phillip Bay and have dropped considerably since 2010-11, with recent harvests of less than 50 t/y being among the lowest recorded since 1978 (Figure 2). Since 2009/10 harvests by non-Victorian licensed operators from the western stock region have also declined to very low levels (Figure 3). Commercial effort using haul seine is now very low due to removal of most of the netting from Port Phillip Bay and long-line effort has reduce substantially in recent years due to a reduction of licences and the introduction of catch caps (Appendix 2). There is no recent information on recreational harvest or effort.
- *Biomass* – Standardised CPUE of adult snapper by the commercial long-line fishery (Figure 4) and recreational anglers (October-December surveys; Figure 5) have decreased since the late 2000s - early 2010s in Port Phillip Bay. The decrease in the recreational catch rate in Port Phillip Bay was rapid from 2013 to 2014 but has since stabilised and remained above the lowest point observed during the reference period, however, it is currently below the reference period average for standardised CPUE (Figure 5). The long-line standardised CPUE is now at the reference period average (Figure 4). Standardised CPUE for recreational anglers in Western Port for the October-December period was approximately half way between the reference period average and the reference period low point in 2018 (Figure 6). Standardised CPUE for the recreational creel surveys in January-May was about half-way between the average and minimum for the reference period in Port Phillip Bay (Figure 7), and just above the reference period low point for Western Port in 2018 (Figure 8). The recreational CPUE for January-April is indicative of the biomass of smaller juvenile and sub-adults and is typically highly variable across years due to the passage of weaker and stronger cohorts through the fishery.
- *Length compositions* – The various length composition data display no long-term trends or signs of increasing truncation (Figure 10, Figure 11, Figure 12, Figure 13, Figure 14 and Figure 15). However, the median length for the October-December period has been lower since 2014 for the Port Phillip Bay recreational fishery (Figure 12). This appears due to lower numbers of larger fish being caught since 2013 by the surveyed anglers (Figure 13a). However, the diary angler length compositions showed that the upper range of the length compositions has been consistent at approximately 100 cm since 2013 (Figure 13b).
- *Recruitment* – Recruitment of 0+ age snapper was low from 2015-2017 after moderate recruitments in 2014 and 2015 (Figure 9).. In 2018, recruitment of of 0+ age snapper was the highest recorded since trawl surveys began in 1993 (Figure 9).

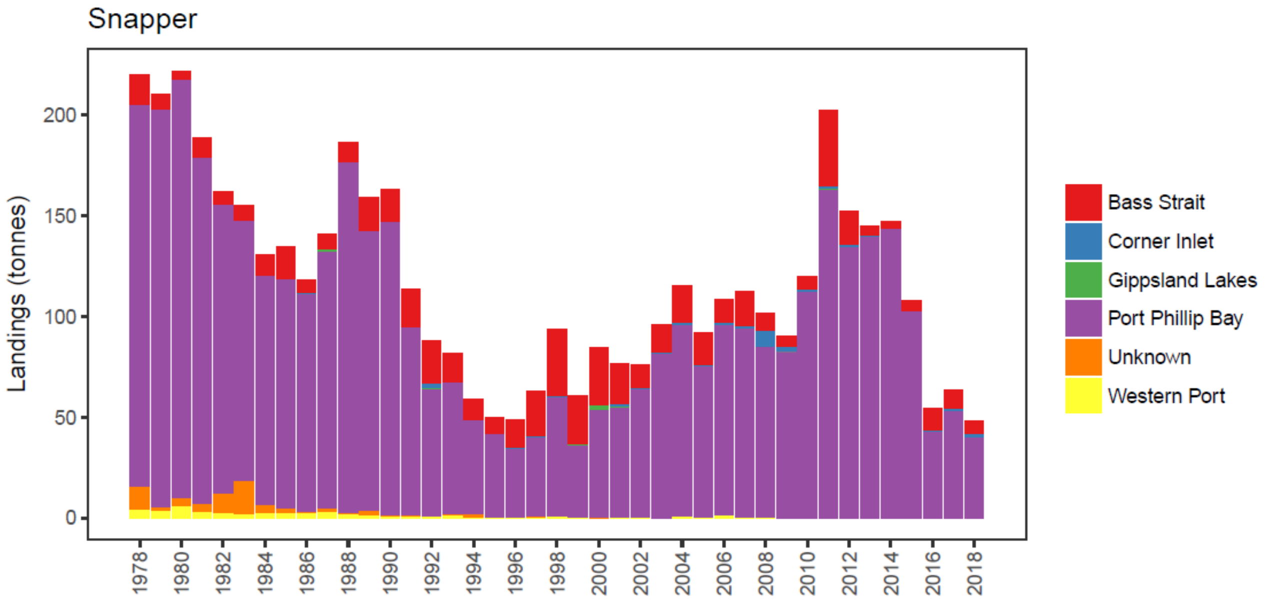


Figure 2 Snapper harvest by Victorian licenced commercial operators by fishing areas, financial years 1978–2018.

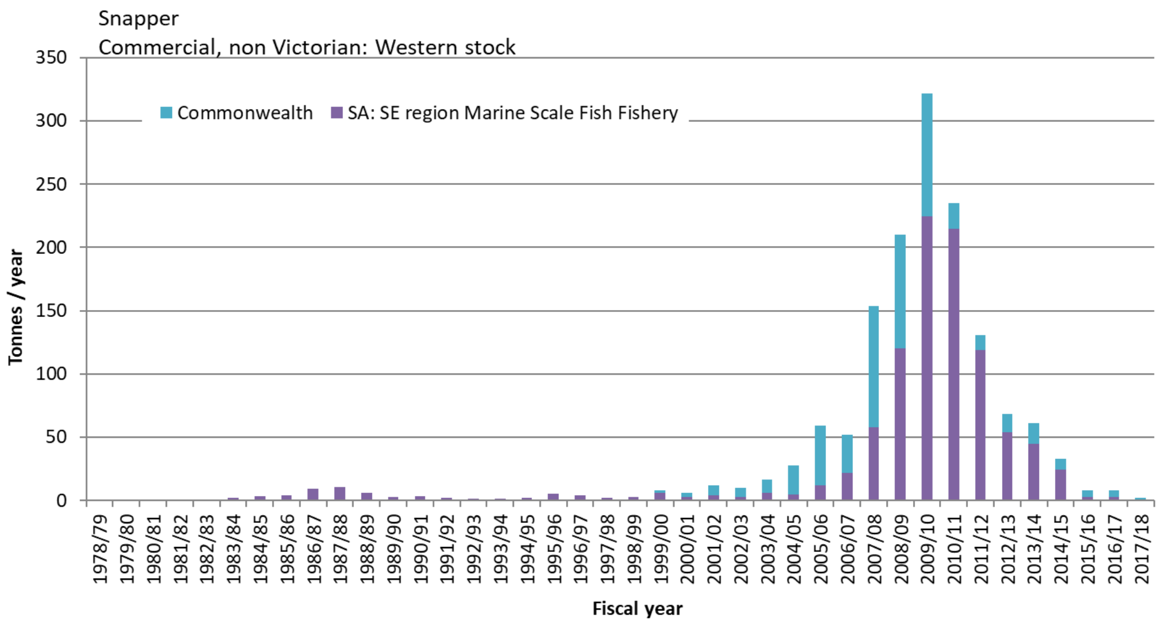


Figure 3 Snapper harvest by Commonwealth and South Australian (SA: SE region) licenced commercial operators from the western Victorian stock, financial years 1978–2018.

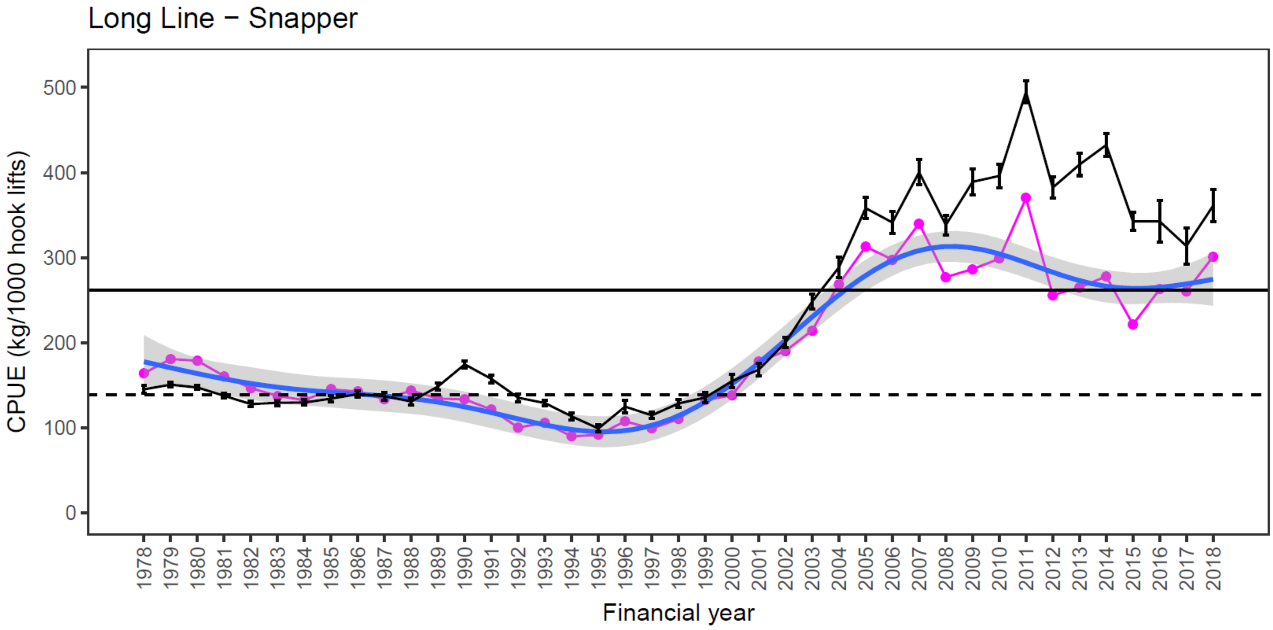


Figure 4 Catch-per-unit effort (CPUE) of snapper by commercial long-line fishers in Port Phillip Bay from 1978–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model GAM of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (2000–2015) and the dashed black line is the minimum standardised CPUE within the reference period.

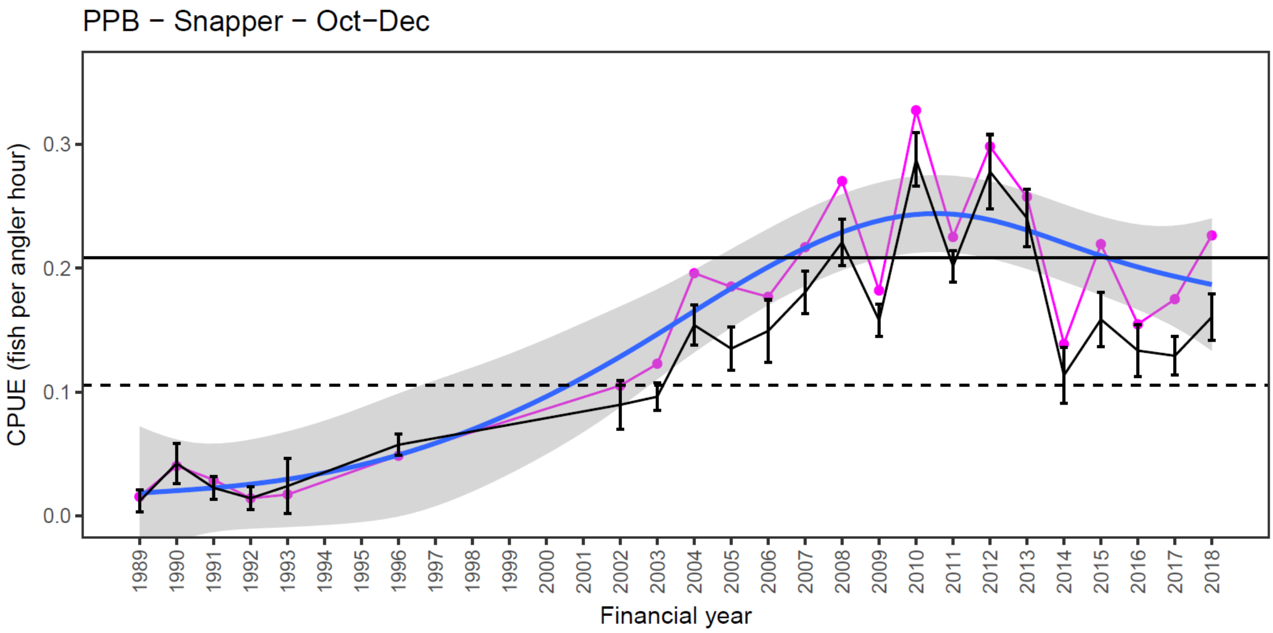


Figure 5 Catch-per-unit effort (CPUE) of snapper by recreational anglers interviewed in creel surveys undertaken in Port Phillip Bay PPB) between October – December during 1989–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model GAM of the standardised trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (2002–2015) and the dashed black line is the minimum standardised CPUE within the reference period.

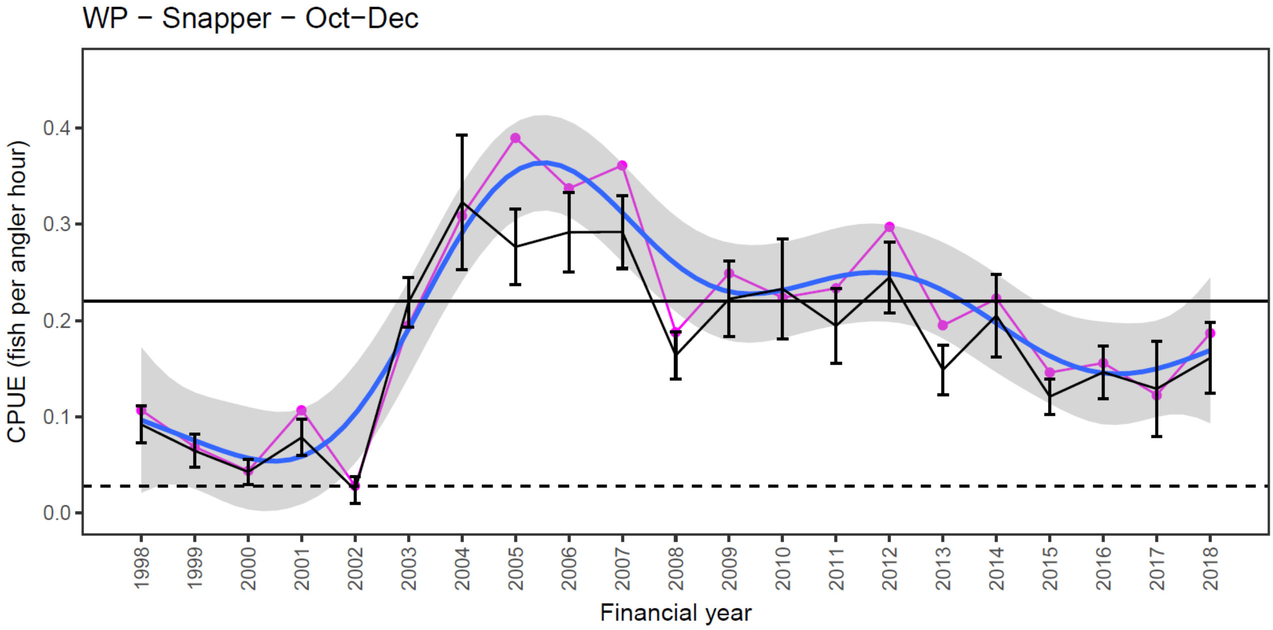


Figure 6 Catch-per-unit effort (CPUE) of snapper by recreational anglers interviewed in creel surveys undertaken in Western Port between October – December during 1998 – 2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model GAM of the standardised trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (2002-2015) and the dashed black line is the minimum standardised CPUE within the reference period.

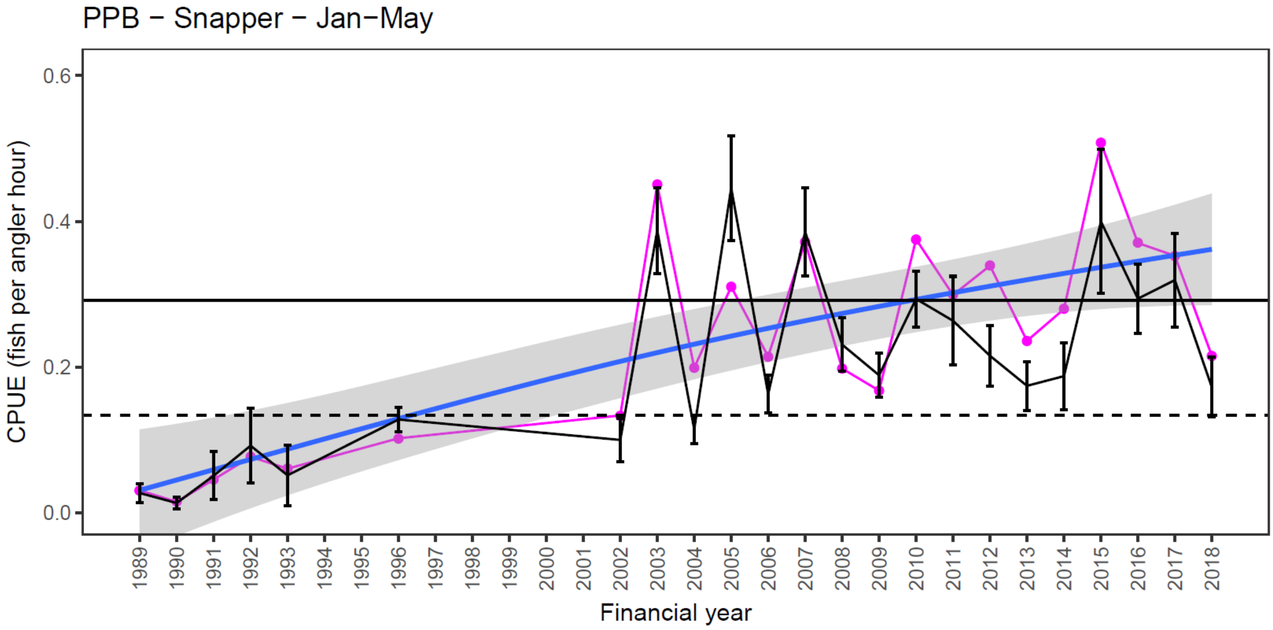


Figure 7 Catch-per-unit effort (CPUE) of snapper by recreational anglers interviewed in creel surveys undertaken in Port Phillip Bay (PPB) between January – April during 1998–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a GAM of the standardised trend with the shaded grey area representing the 95% confidence interval of the generalised additive model GAM. Horizontal black line is the mean standardised CPUE during the reference period and the dashed black line is the minimum standardised CPUE within the reference period.

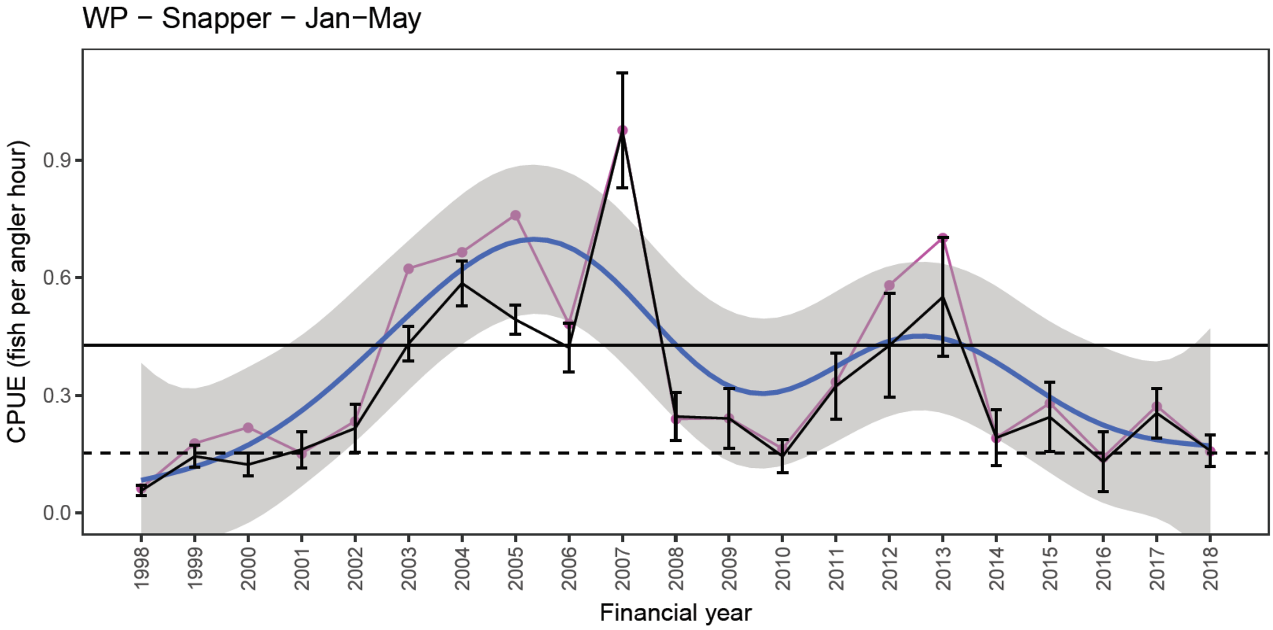


Figure 8 Catch-per-unit effort (CPUE) of snapper by recreational anglers interviewed in creel surveys undertaken in Western Port (WP) January – April during 1998–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model GAM of the standardised trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period and the dashed black line is the minimum standardised CPUE within the reference period.

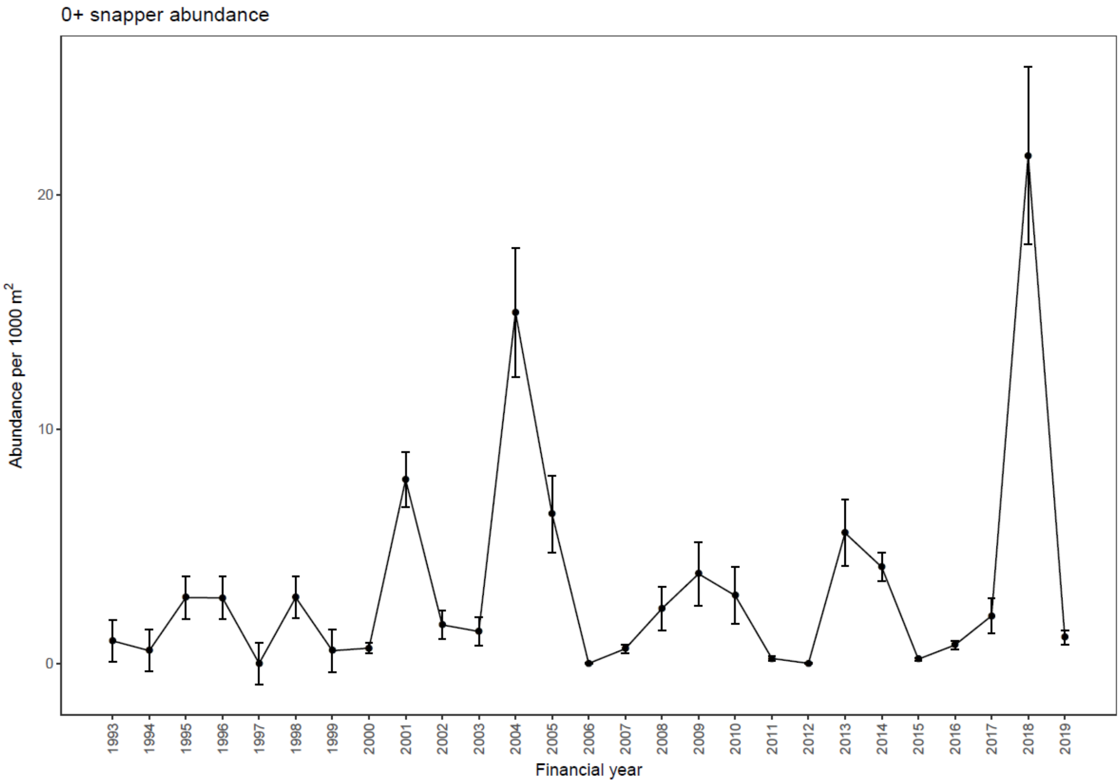


Figure 9 Port Phillip Bay snapper pre-recruit (0+ age) trawl survey catch rates (±SE) 1993–2019. Note: SE can only be calculated from 2000 onwards, data prior is based on extrapolation of beam trawl to earlier otter trawl data using a regression relationship from 11 years when the otter trawl and beam trawl surveys overlapped.

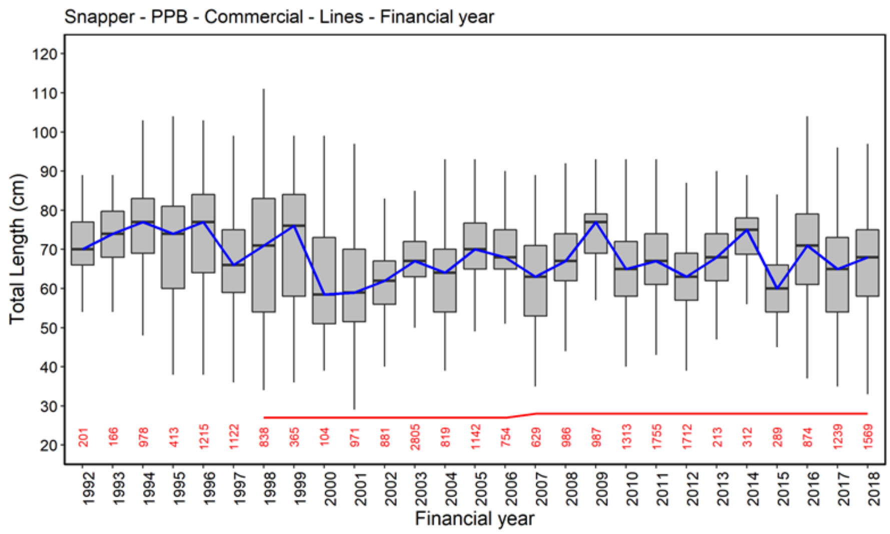


Figure 10 Box-plots of Port Phillip Bay (PPB) commercial long-line snapper length composition 1992–2018. Red numbers on the x-axis indicate numbers of fish measured scaled to sampled catch weights. Blue line = median length. Red line = LML.

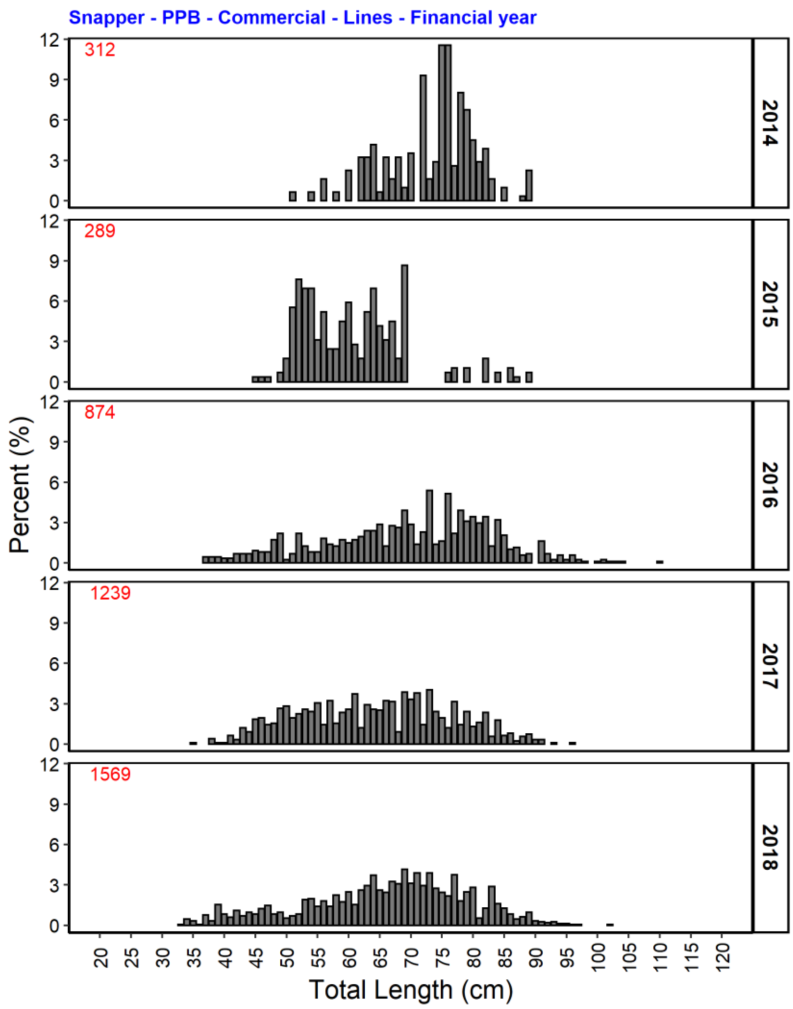


Figure 11 Length frequency histograms for Port Phillip Bay long-line snapper catches for 2014–2018 fiscal years. Red numbers on x-axis indicate numbers of fish measured scaled to sampled catch weights.

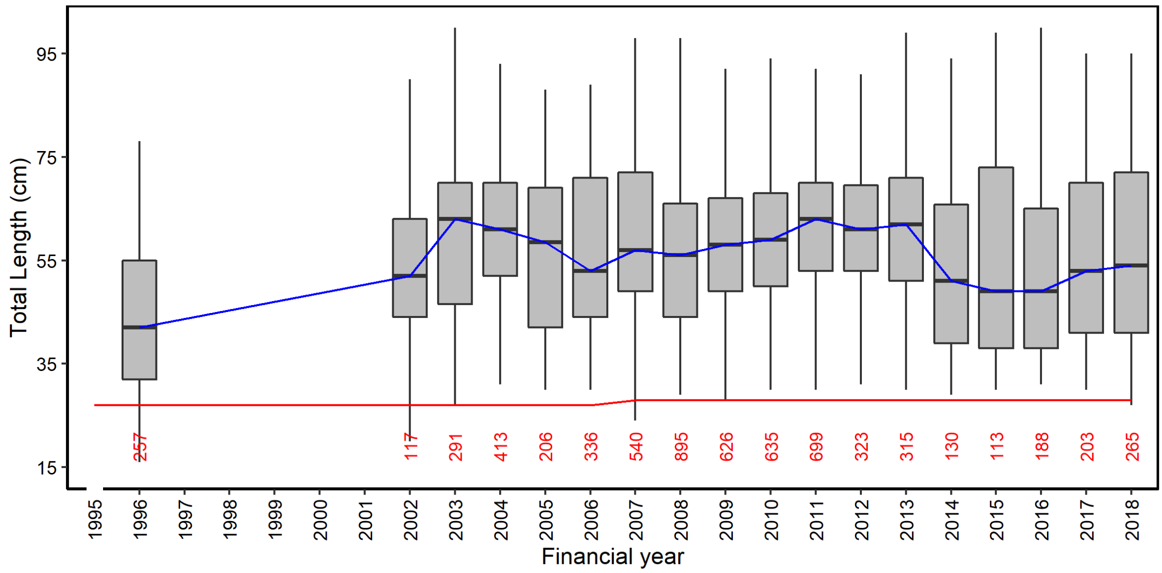
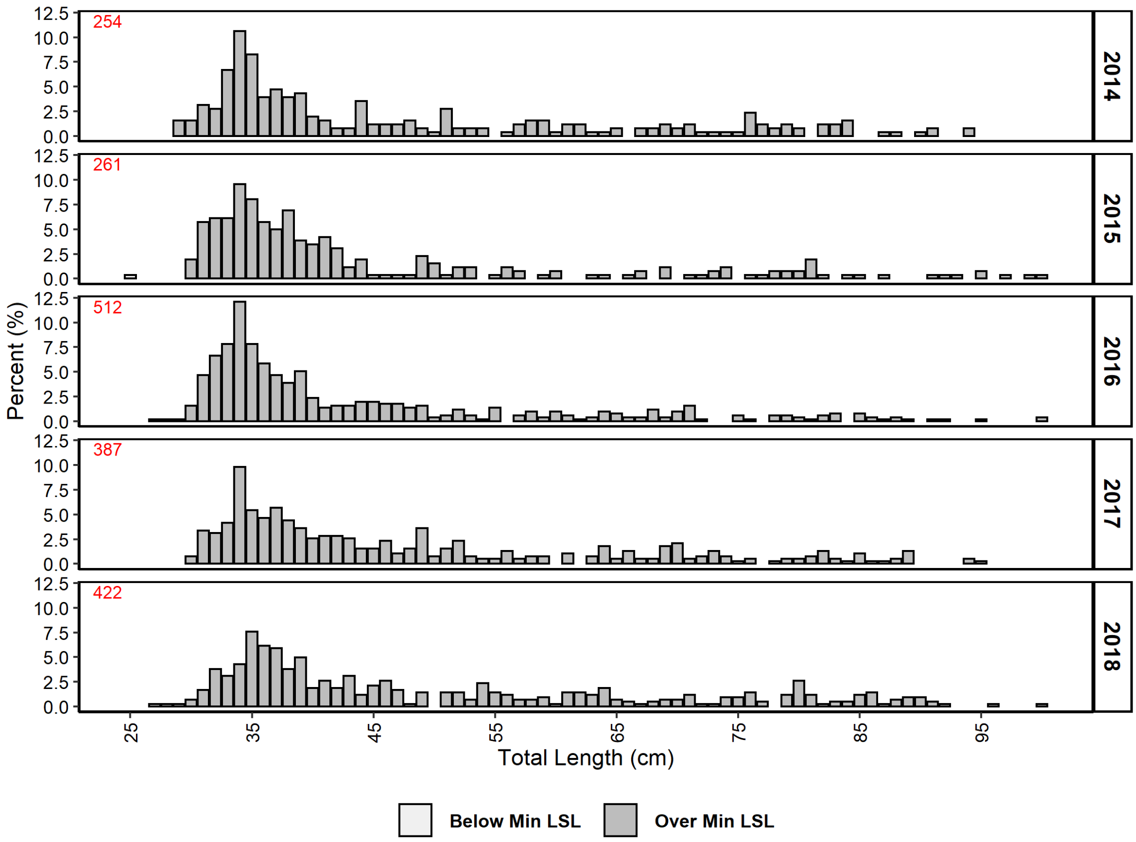


Figure 12 Box-plots of Port Phillip Bay (PPB) recreational snapper length composition for creel surveys October-December 1996–2018. Red numbers on x-axis indicate numbers of fish measured. Blue line = median length. Red line = legal size limit (LSL).

(a)



(b)

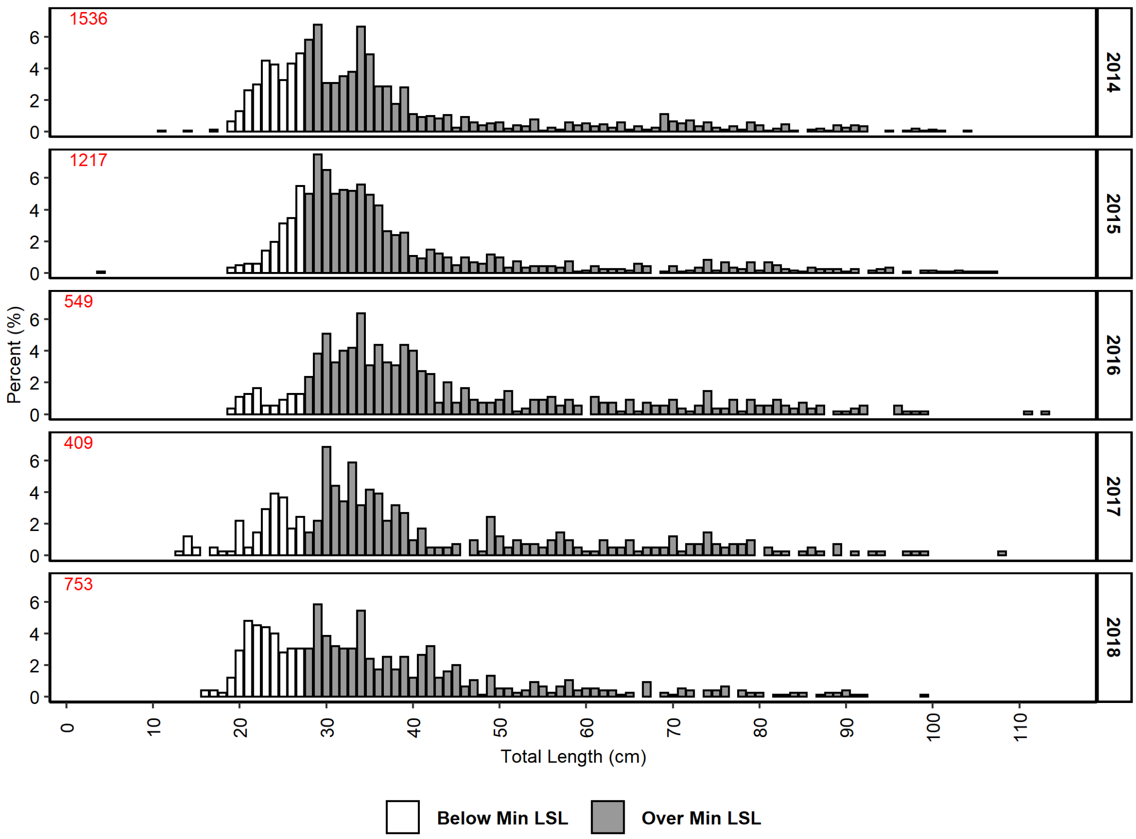


Figure 13 Frequency histograms of Port Phillip Bay recreational snapper length composition (a) creel surveys all months, (b) diary angler all months, fiscal years 2014–2018. Red numbers indicate numbers of fish measured. LSL = legal size limit.

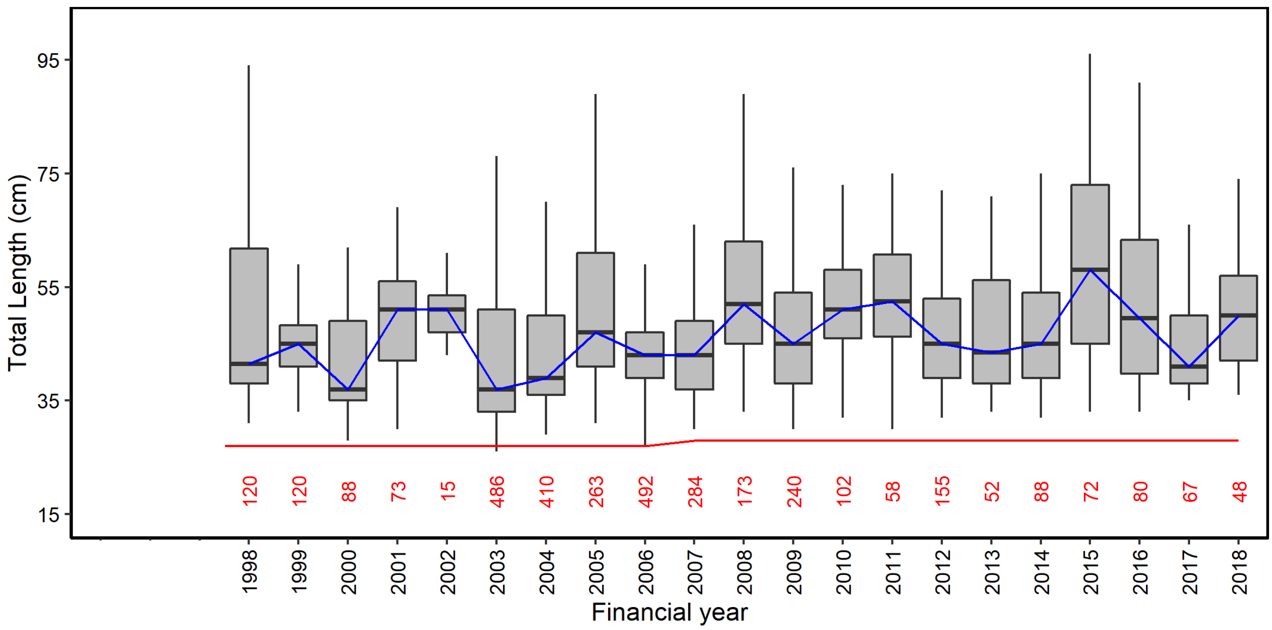


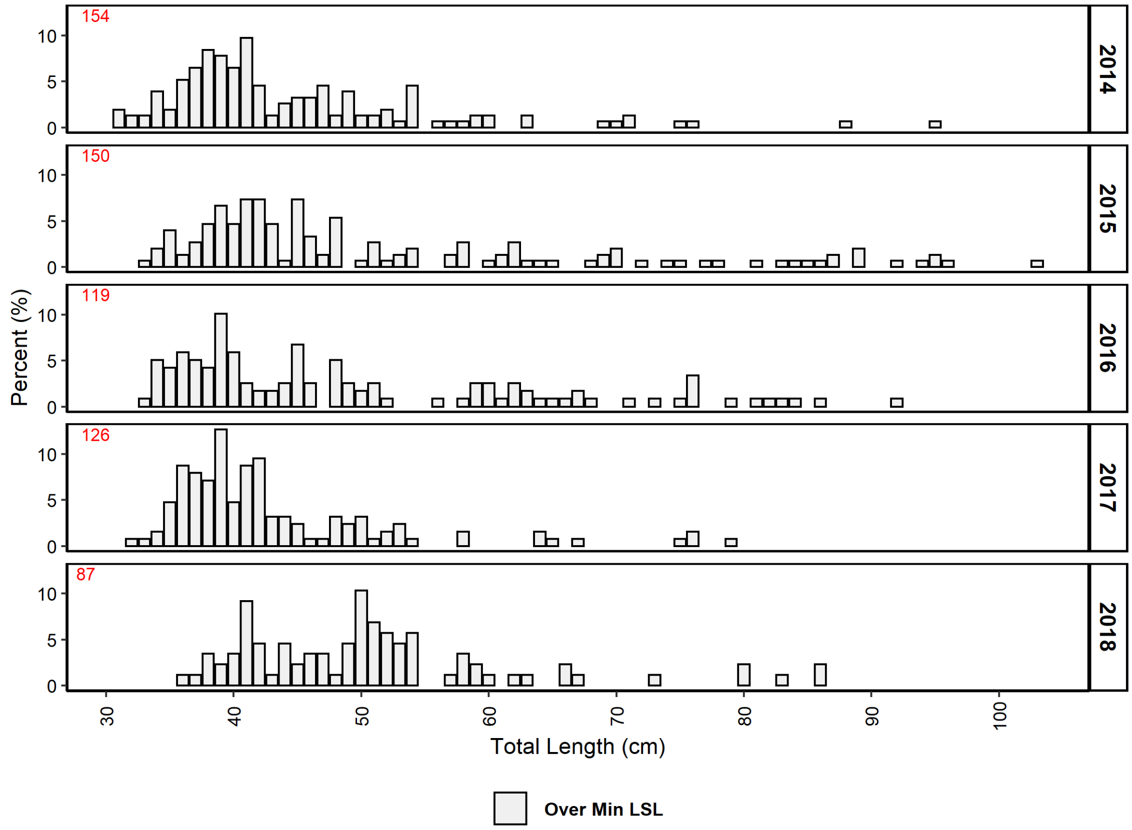
Figure 14 Box-plots of Western Port recreational snapper length composition for October-December 1998–2018. Red numbers on x-axis indicate numbers of fish measured. Blue line = median length. Red line = legal size limit (LSL).

Recreational catch

Recreational harvest in 2000/01 and 2006/07 for the Victorian region of the western stock were estimated at approximately 400 and 670 t respectively (Henry and Lyle 2003; Ryan et al. 2009; VFA unpublished data). For the South Australian region of the western stock, recreational harvests were estimated at between 10–20 t for the three most recent surveys 2000/01, 2007/08, 2013/14 (Fowler et al. 2016).

Stock status summary: Adult biomass for the Western Victorian snapper stock has been depleting since a recent peak in the late 2000s – early 2010s. The rapid drop in recreational CPUE from 2013 to 2014 indicates that rapid depletion of strong cohorts may occur in the near future. Nevertheless, fishery performance remains generally good (CPUE is close to the reference period average) for the long-line fishery where nominal CPUE has not declined as much as for the recreational fisheries, likely due to the high skill and effectiveness of the small number of long-line fishers who have been operating since 2010. The recreational fishery for adult snapper in Port Phillip Bay is considered sustainable at its current level, appearing to have stabilised since 2014, but a declining trend in Western Port persists. The decline in Western Port is thought to be related to local dynamics rather than deterioration in overall stock status. Recent strong recruitment is expected to reverse any declining biomass trends and drive a rebuilding of adult biomass and improved fishery performance over the next 5–10 years. Length compositions are not showing signs of truncation, and commercial fishing pressure has reduced substantially in recent years due to the Port Phillip Bay buy-outs and reduced targeting by South Australian operators.

(a)



(b)

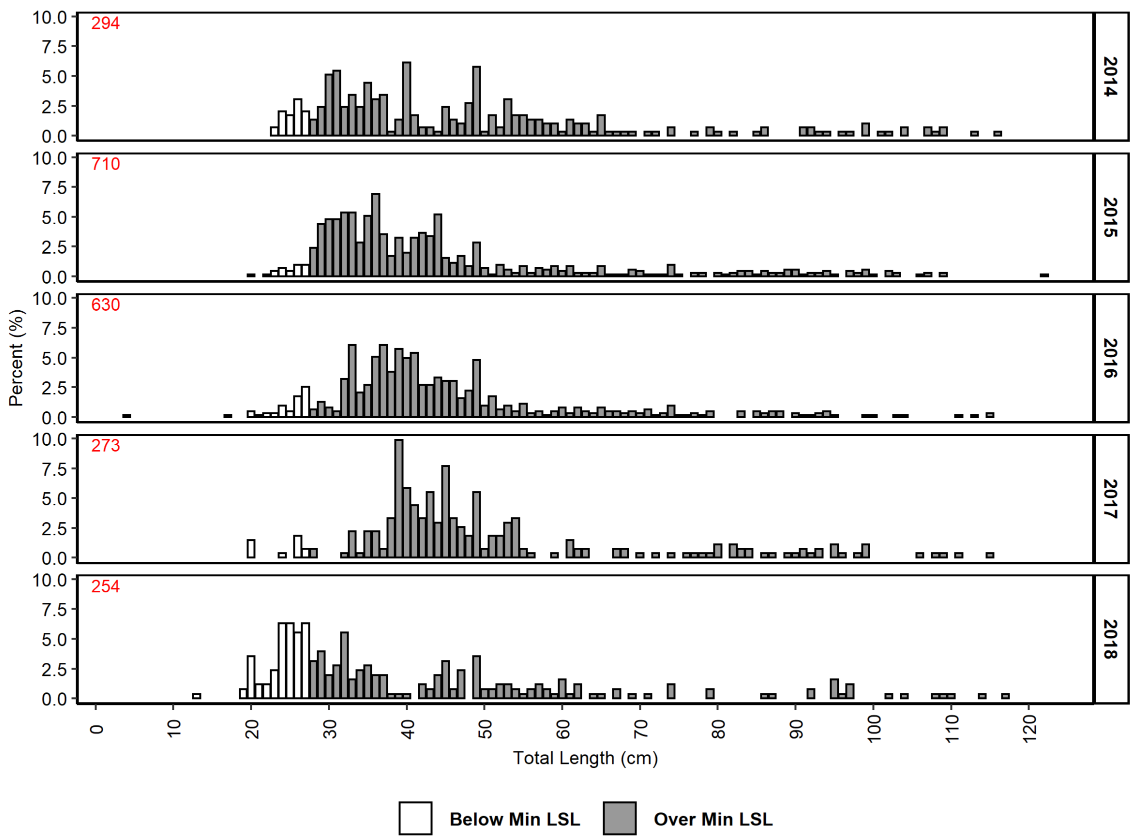


Figure 15 Frequency histograms of Western Port recreational snapper length composition (a) creel surveys all months, (b) diary angler all months, fiscal years 2014-2018. Red numbers are numbers sampled. LSL= legal size limit.

Eastern Victorian snapper stock

There are no suitable proxy measures for stock biomass or pre-recruit abundance of the eastern Victorian snapper stock. Commercial catch is mostly taken by Commonwealth operators and has decreased since a peak in 2011/12 in response to Commonwealth industry-imposed rules to limit snapper harvest (Figure 16). There are no recent data on recreational harvest or any data on effort trends for the eastern Victorian stock. Recreational catch estimates in 2000/01 and 2006/07 indicated catches were in the order of around 30 t/year (Henry and Lyle 2003; Ryan et al. 2009), but anectdotal information suggests that increased fishing pressure on spawning aggregations close to Lakes Entrance is an emerging issue among local stakeholders.

Stock status summary: Recent recognition of the eastern Victorian stock as a stand-alone stock for SAFS reporting and a lack of information to make any confident judgement of status, along with reports of increased fishing pressure on spawning aggregations by local stakeholders, imply that the current status of eastern Victorian snapper stock is uncertain.

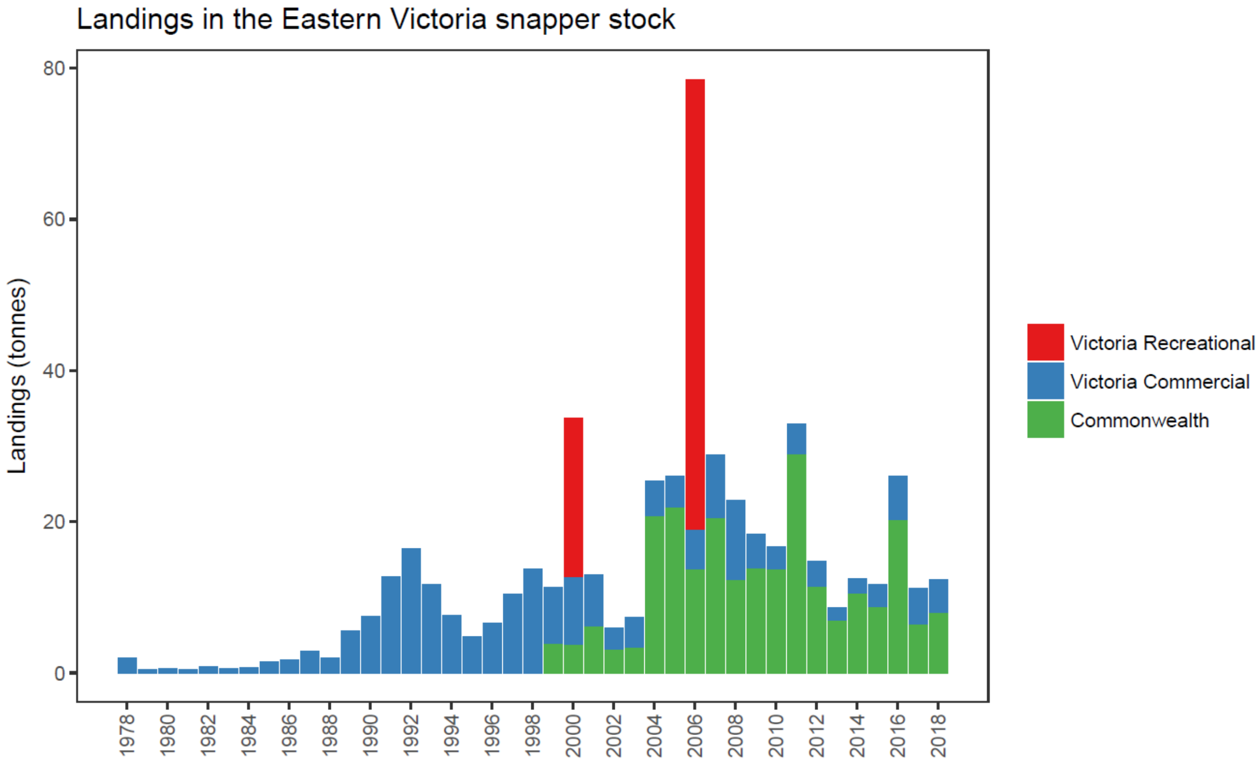


Figure 16 Total catch of snapper from the Eastern Victorian stock, fisccal years 1978–2018.

King George Whiting (*Sillaginodes punctatus*): State-wide

Stock Structure and Biology

The Victorian King George whiting population is considered to comprise a State-wide stock that extends into eastern South Australia. The main fisheries are in Port Phillip Bay, Western Port and Corner Inlet, with both commercial and recreational components in Port Phillip Bay and Corner Inlet (Figure 17). In Victorian bays and inlets most King George whiting are harvested as immature fish < 4 yr of age. Juvenile whiting migrate out of bays and inlets at 3 – 5 years of age to complete their adult lives in coastal waters where they can live to approximately 20 years old and reach lengths of at least 60 cm. It is thought that the majority of King George whiting that recruit into Victorian bay and inlet fisheries originate from spawning events in coastal waters off far western Victoria and south-east South Australia. King George whiting are highly fecund and have a moderate to high growth rate, reaching the LML of 27 cm in approximately 2 years. Offshore spawning and a long-larval dispersal phase prior to settlement in bay and inlet nursery areas mean that settlement rates of larvae are highly variable from year to year depending on ocean currents. This variability coupled with a short residence time for juveniles within bay and inlet nursery areas (i.e. two-three years when most fish are available for harvest) means that fisheries production and catch rates are naturally highly variable.

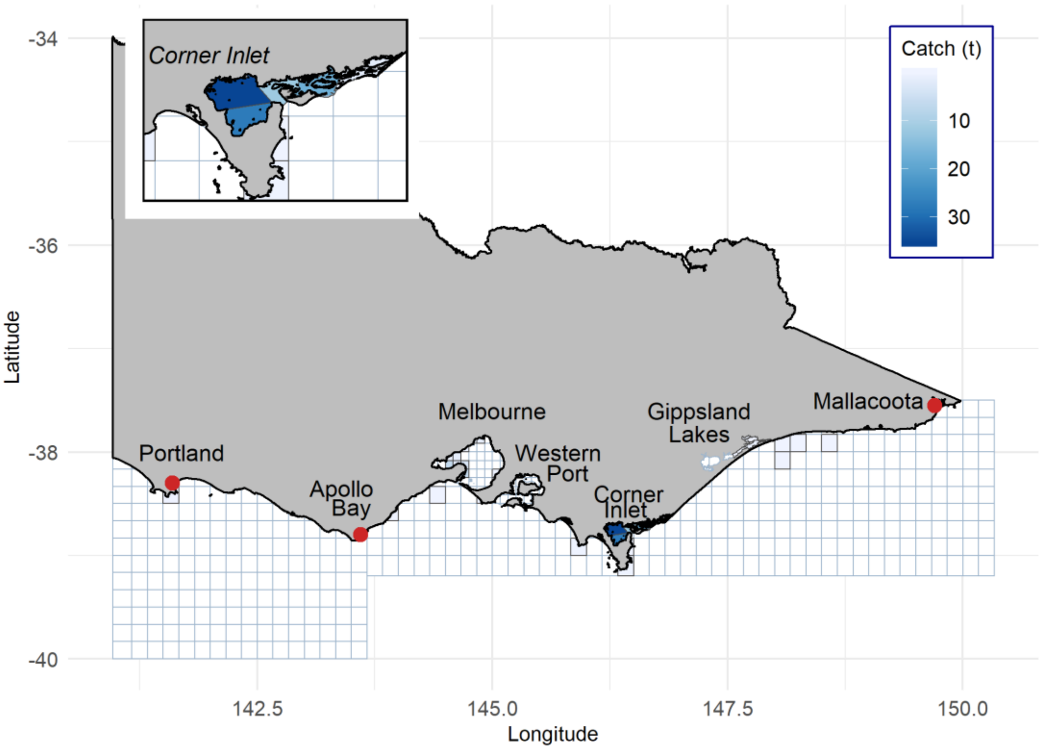


Figure 17 Victorian King George whiting commercial catch distribution for 2018/19 financial year.

Assessment Summary

The status of the Victorian King George whiting stock and associated fisheries were evaluated using:

- Available harvest information for the commercial and recreational sectors
- Nominal CPUE for commercial haul seine in Port Phillip Bay and Corner Inlet-Nooramunga (reference period 1986–2015) (Note: nominal CPUE is used because standardisation has minor influence on levels, trends and variability in seine net CPUE)
- Nominal and standardised CPUE for the recreational fishery from annual creel surveys in Port Phillip Bay and Western Port (reference period 2002–2015)
- Length composition of haul seine fishery catches in Corner Inlet-Nooramunga
- Length composition of recreational fishery catches in Port Phillip Bay and Western Port from creel survey and diary anglers
- Pre-recruit (post-larval) abundance from fishery independent netting surveys in Port Phillip Bay.

This assessment found:

- *Fishing pressure* – commercial harvests have dropped considerably since 2016, mostly driven by a reduction in netting effort due to commercial licence buy-outs in PPB (Appendix 2), and reduced catch rates in Corner Inlet-Nooramunga can be attributed to natural fluctuations in availability (Figure 18). There is no recent information on recreational harvest or effort.
- *Biomass* – Nominal CPUE of King George whiting by commercial haul seine in Port Phillip Bay and Corner Inlet-Nooramunga both increased to 2018/19 (Figure 19). These were inconsistent with results from the Port Phillip Bay recreational creel survey that showed CPUE with a shallow overall decline (Figure 20). This difference might be related to the implementation of licence buy-outs in Port Phillip Bay in April 2016. The creel survey CPUE for Western Port plateaued and then slowly declined from 2015 (Figure 21). Overall, CPUE indicators suggest stable to improving stock biomass of King George whiting in Victorian bays and inlets over the last few years after the most recent peak in 2015/16. There are no specific indicators of adult biomass status for King George whiting in coastal waters.
- *Length compositions* – The various length composition data display no long-term trends or signs of increasing truncation, consistent with the transient nature of King George whiting in bays and inlets. A recent increase followed by a decrease (2015–2018) in median lengths observed for all length frequency data (Figure 23, Figure 24, Figure 25, Figure 26, Figure 27 and Figure 28) are consistent with the passage of the strong 2013 cohort (Figure 22) through the bay and inlet fisheries.
- *Recruitment* – Recruitment of post-larval King George whiting to Port Phillip Bay has been relatively strong for the last three years (Figure 22). The Port Phillip Bay survey data are generally indicatve of post-larval recruitment to other Victorian bays and inlets. These three cohorts will drive increased availabilty and catch rates for bay and inlet fisheries over the next 3 years.

Stock status summary: Indicators of stock status for King George whiting are all directly related to juvenile life stages, and are highly variable being primarily driven by recruitment dynamics. However, none of the fishery CPUE or pre-recruit time series show persistently declining trends.This provides reassurance that the poorly known and lightly fished adult stock in coastal waters is continiung to be replenished at rates that are sufficient to prevent declines in recruitment potential/egg production. Recent strong post-larval recruitment is expected to drive a rapid increase in CPUE over the next few years so the stock should remain sustainable.

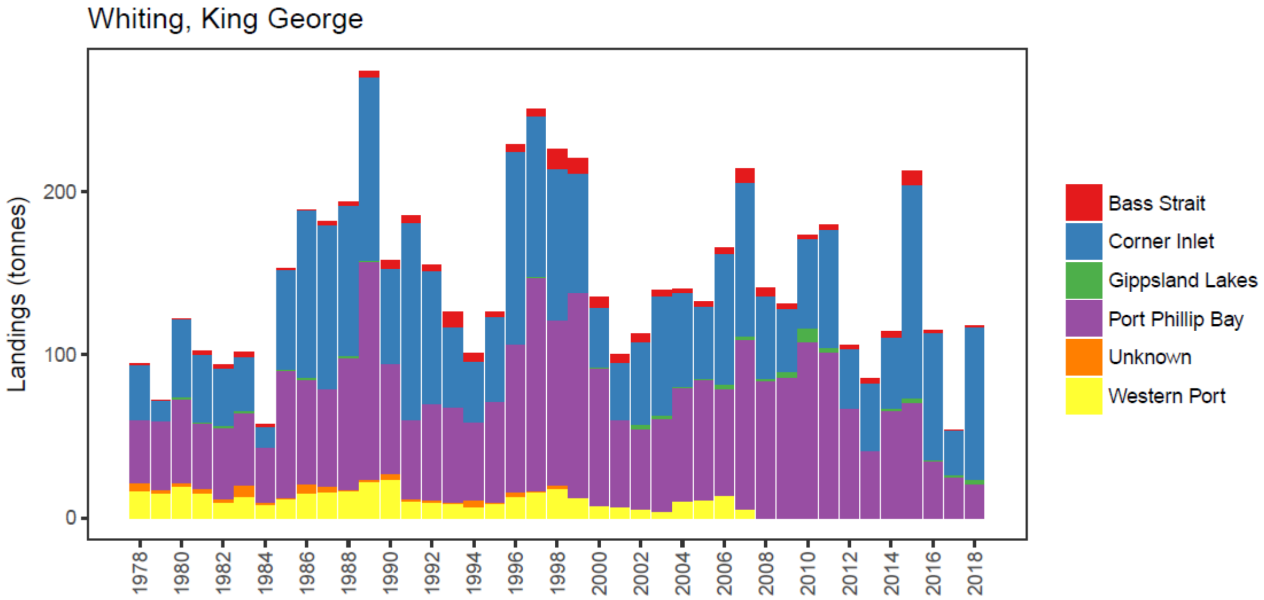
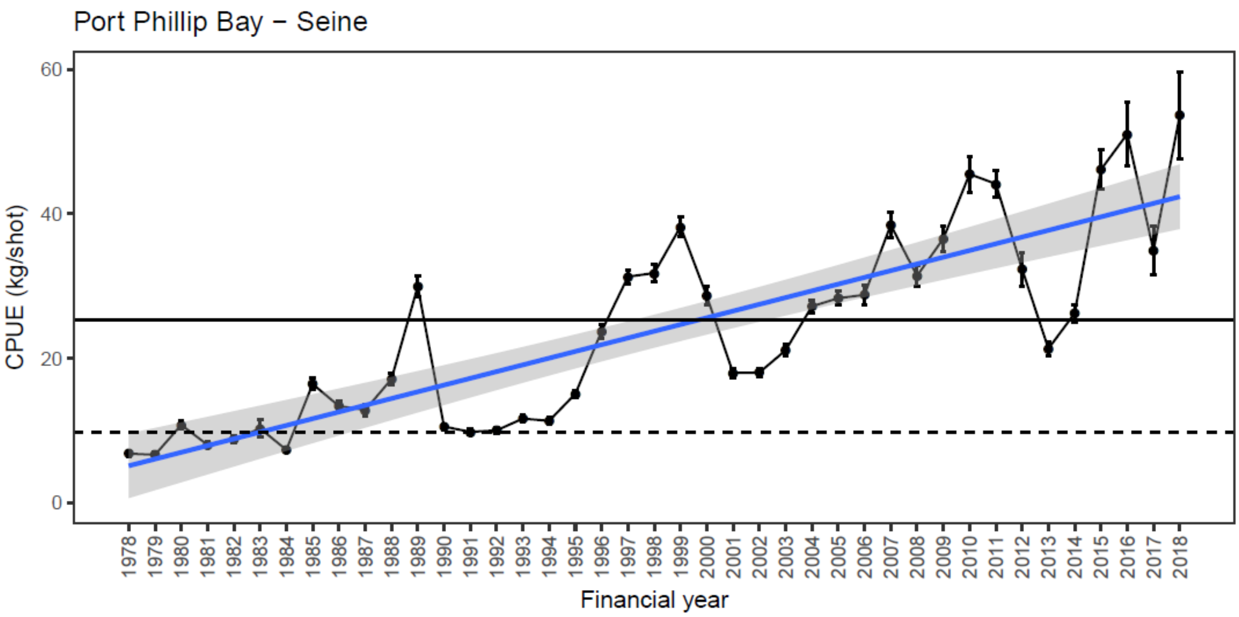


Figure 18 Commercial catch of King George whiting by area in Victorian waters, financial years 1978–2018.

(a)



(b)

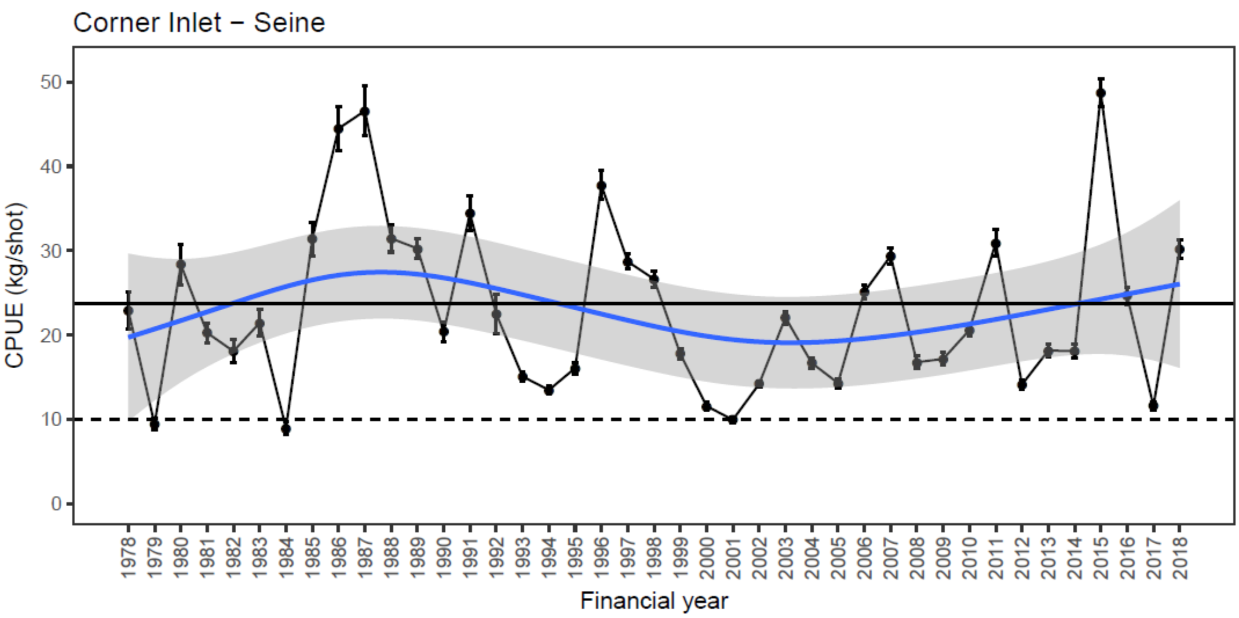


Figure 19 Commercial haul seine catch-per-unit-effort CPUE (nominal) for King George whiting in (a) Port Phillip Bay (PPB) and (b) Corner Inlet (CI), 1978–2018. Horizontal black line is the mean nominal CPUE during the reference period (1985–2015) and the dashed black line is the minimum CPUE within the reference period. The blue line is a generalised additive model GAM of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

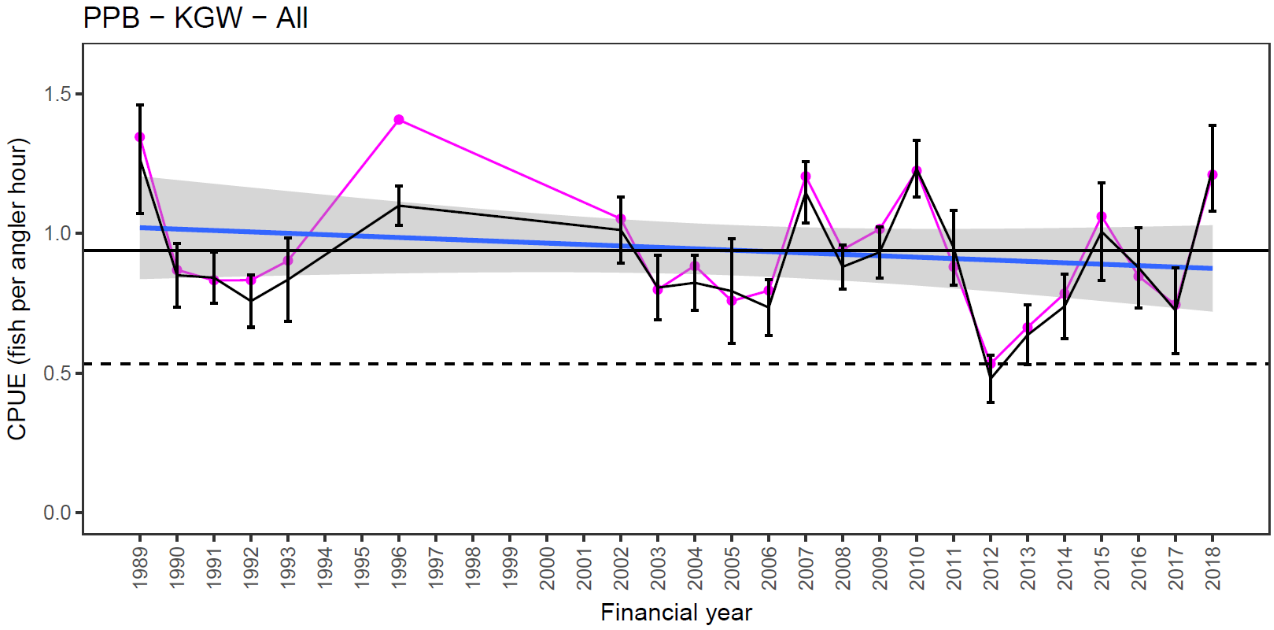


Figure 20 Catch-per-unit-effort **(**CPUE) of King George whiting (KGW) by recreational anglers interviewed in creel surveys undertaken in Port Phillip Bay (PPB) from 1989–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (i.e. 1989 – 2015) and the dashed black line is the minimum standardised CPUE within the reference period.

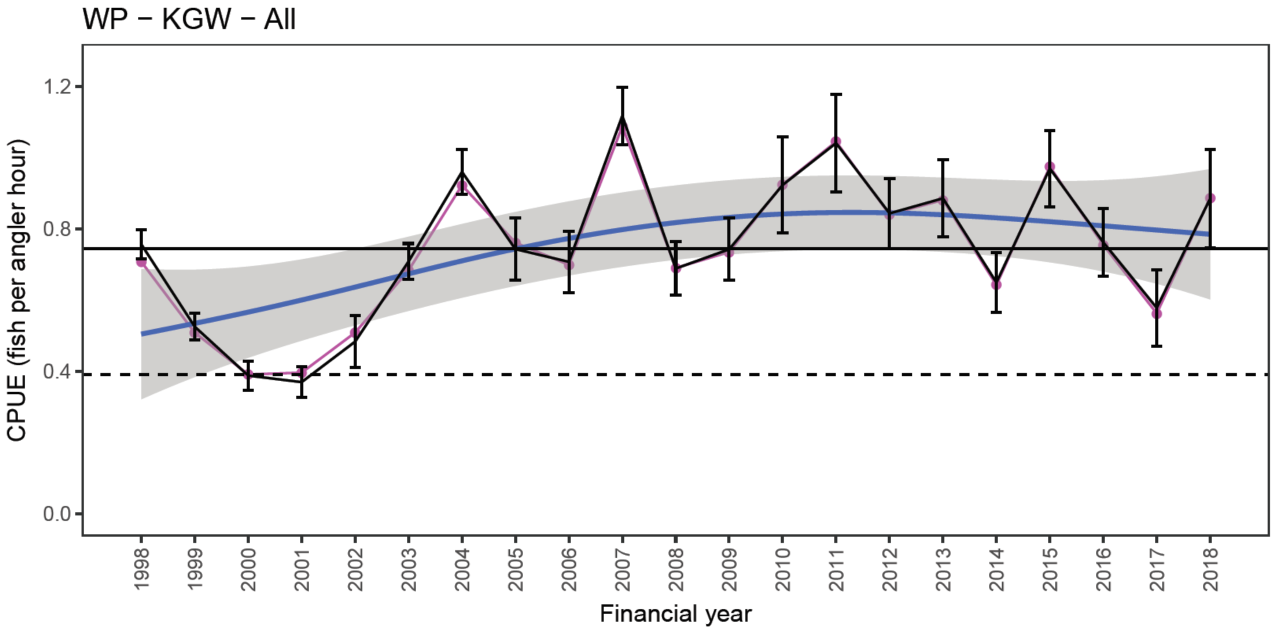


Figure 21 Catch-per-unit-effort **(**CPUE) of King George whiting (KGW) by recreational anglers interviewed in creel surveys undertaken in Western Port Bay (WP) from 1998–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (1998–2015) and the dashed black line is the minimum standardised CPUE within the reference period.

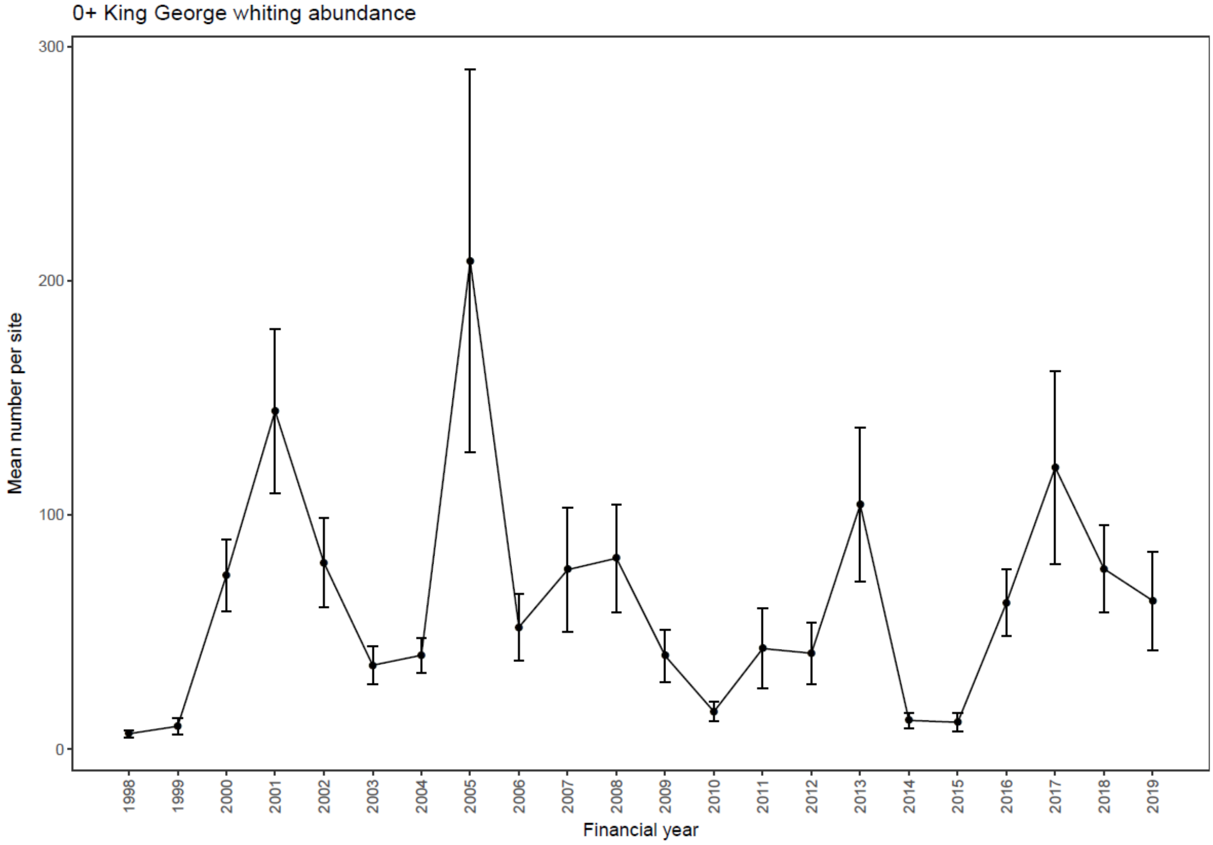


Figure 22 Port Phillip Bay King George whiting pre-recruit (0+ age) trawl survey catch rates (±SE) 1998–2019.

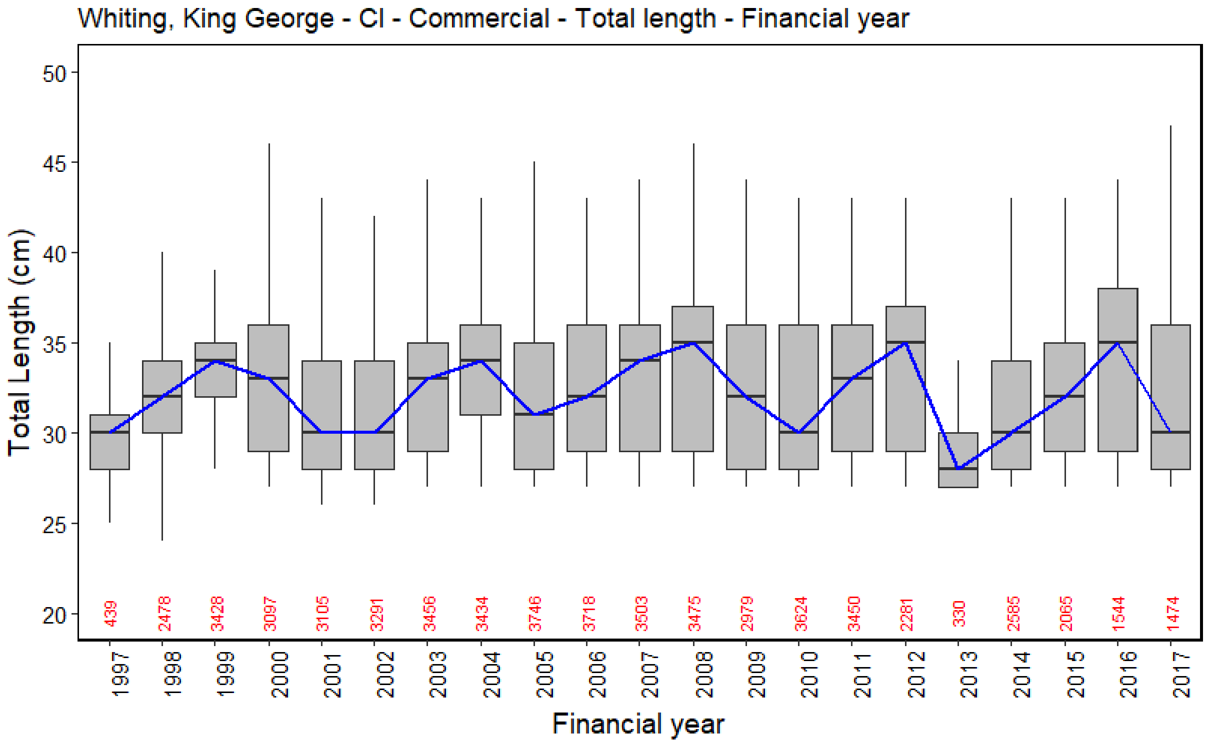


Figure 23 Box-plots of Corner Inlet (CI) King George whiting commercial haul seine length composition 1997–2017. Red numbers on x-axis indicate numbers of fish measured scaled to sampled catch weights. Blue line = median length.

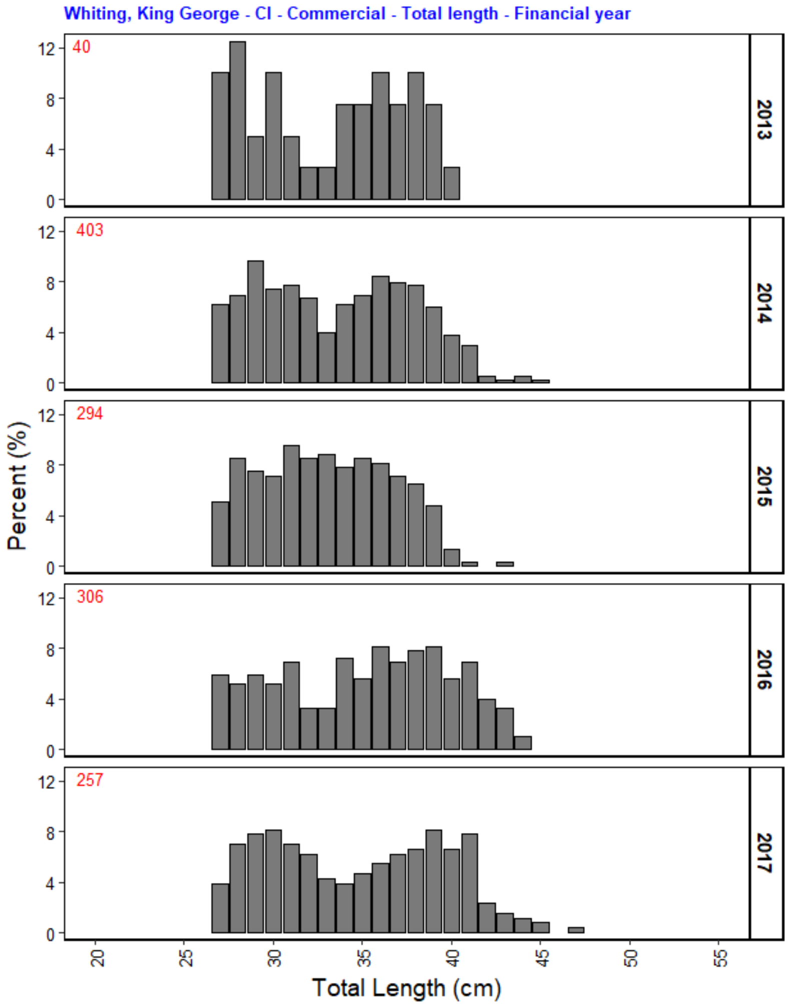


Figure 24 Length frequency histograms for Corner Inlet (CI) King George whiting haul seine catches from 2013–2017 fiscal years. Red numbers on x-axis indicate numbers of fish measured scaled to sampled catch weights.

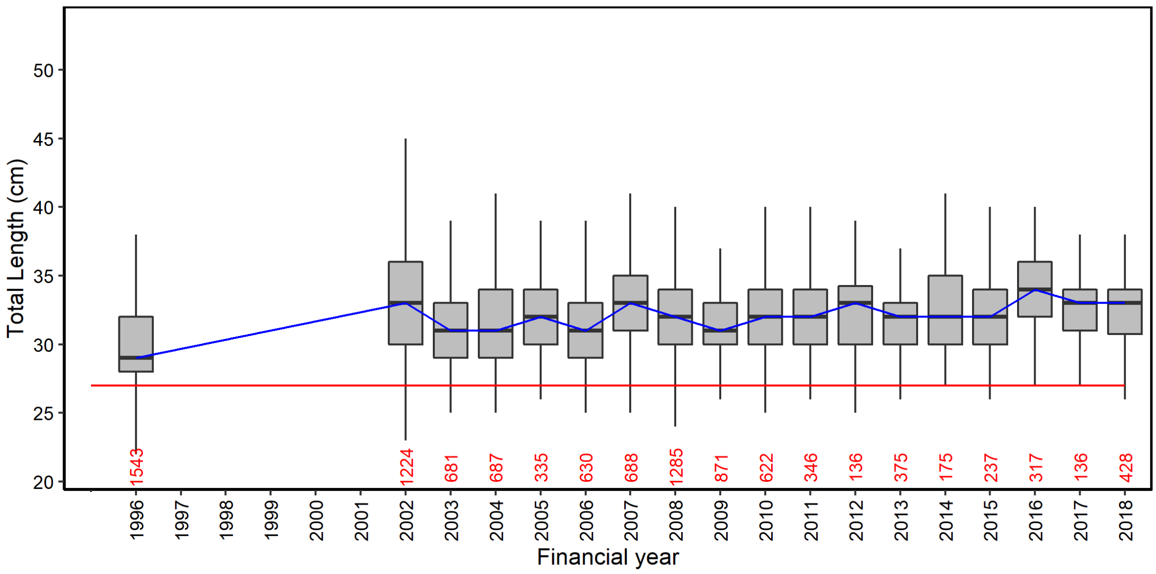
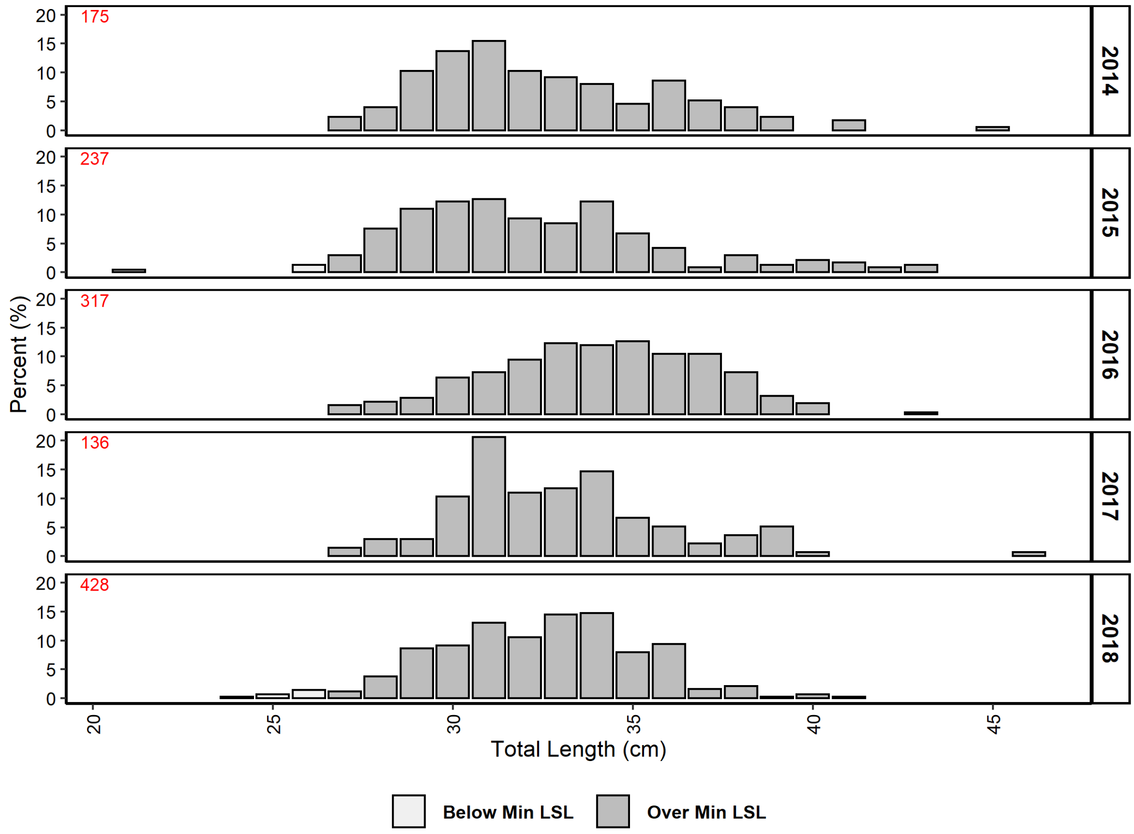


Figure 25 Box-plots of Port Phillip Bay recreational King George whiting creel survey length composition 1996–2018. Red numbers on x-axis indicate numbers of fish measured. Blue line median length. Red line = legal size limit.

(a)



(b)

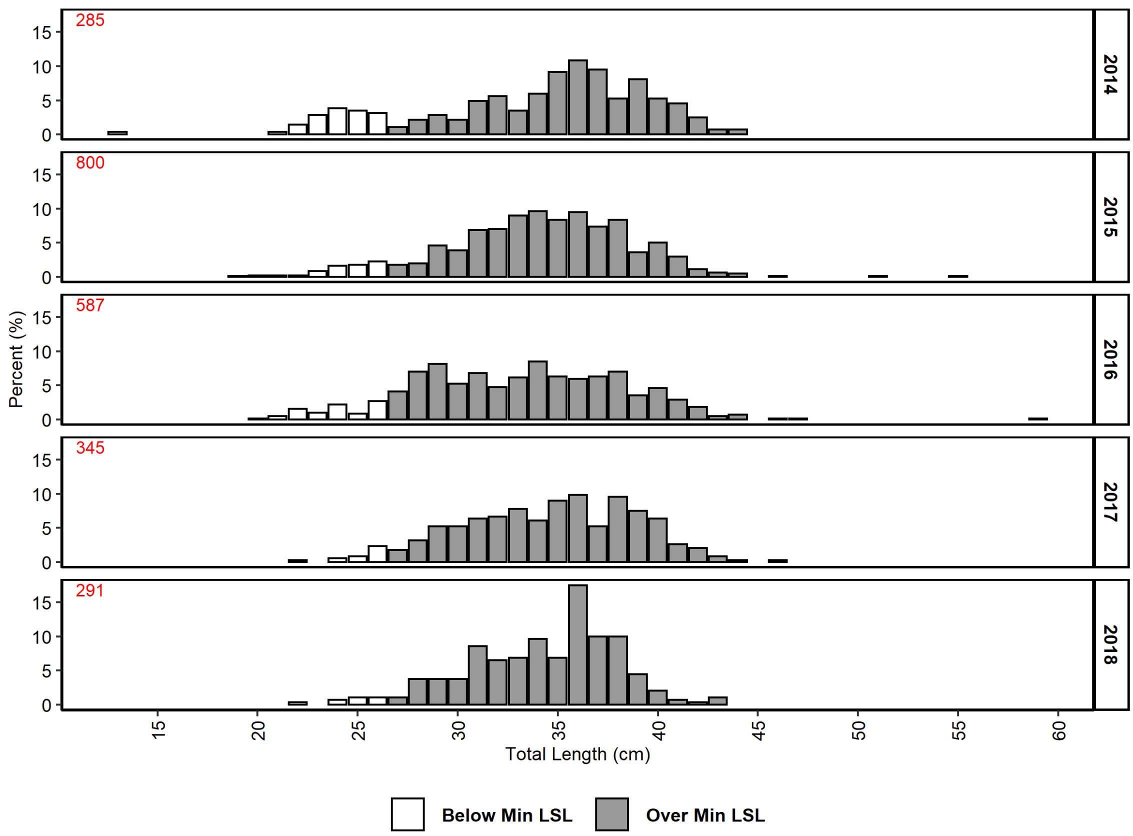


Figure 26 Frequency histograms of Port Phillip Bay recreational King George whiting length composition (a) creel surveys, (b) diary angler, fiscal years 2014–2018. Red numbers indicate numbers of fish measured. Grey bars are those fish equal to or larger that the Legal Size Limit (LSL) and white bars are sub-legal sized fish less than the LSL.

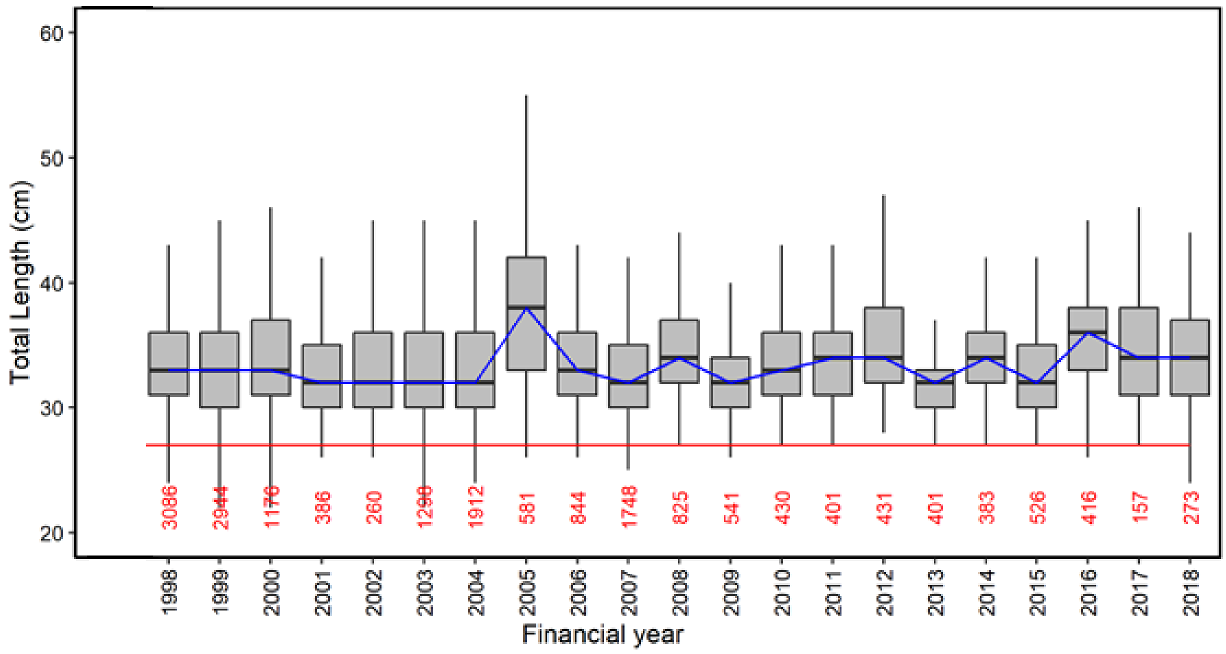
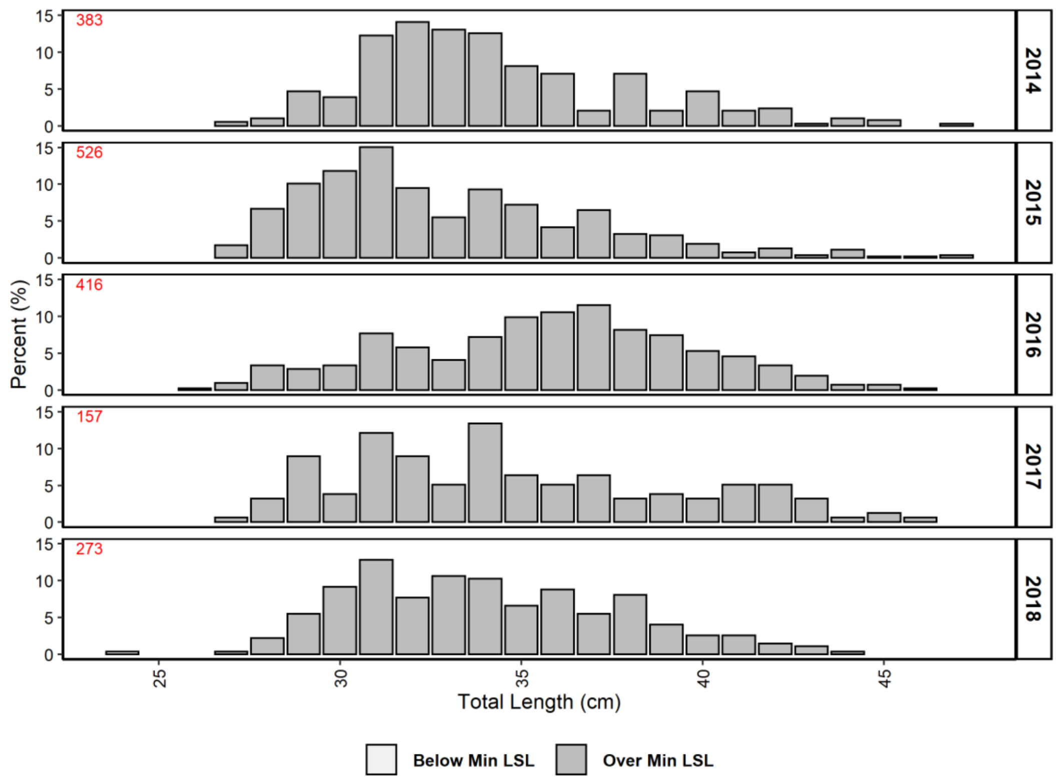


Figure 27 Box-plots of Western Port recreational King George whiting creel survey length composition 1998-2018. Red numbers on x-axis indicate numbers of fish measured. Blue line = median length; red line = LML

(a)



(b)

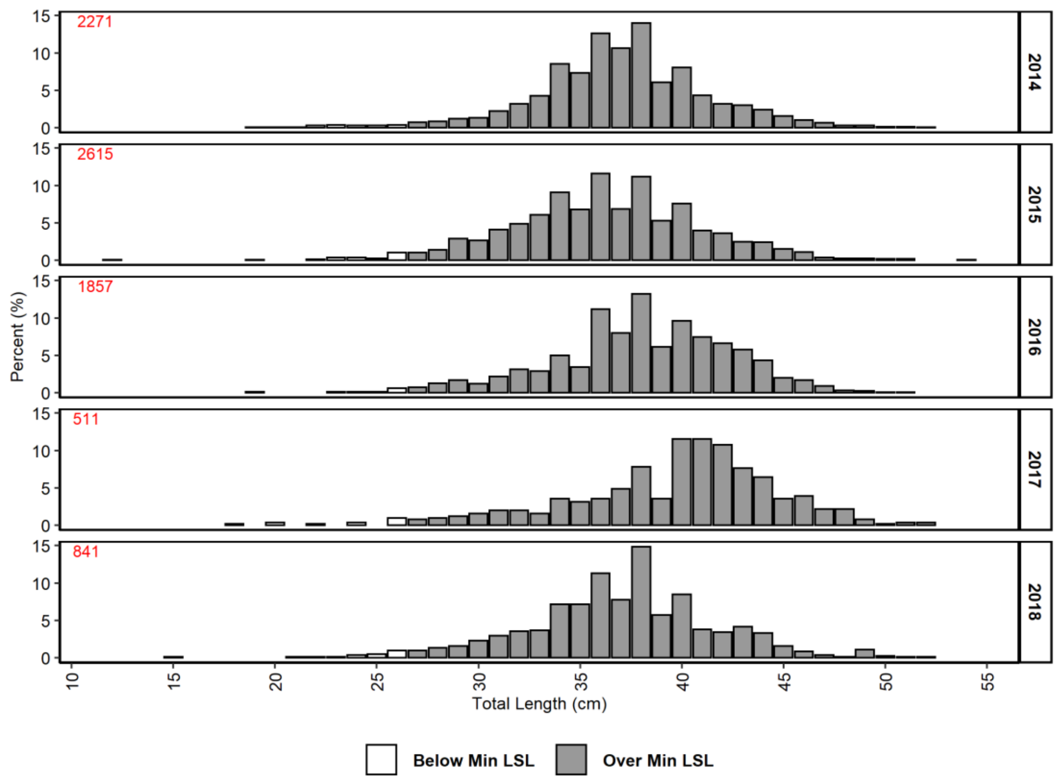


Figure 28 Frequency histograms of Western Port recreational King George whiting length composition (a) creel surveys, (b) diary angler, fiscal years 2014–2018. Red numbers indicate numbers of fish measured. Grey bars are those fish equal to or larger that the Legal Size Limit (LSL) and white bars are sub-legal sized fish less than the LSL.

Southern Sand Flathead (*Platycephalus bassensis*): Port Phillip Bay

Stock Structure and Biology

Southern Sand flathead are distributed along the entire Victorian coast in coastal waters and in all bays and inlets. The most important fishery for this species is in Port Phillip Bay, with smaller fisheries in Western Port, Corner Inlet, and coastal waters (Figure 29). Most of the Victorian sand flathead catch is taken by recreational anglers with only minor commercial harvesting.

The main Port Phillip Bay component of the sand flathead stock is a predominantly self-replenishing sub-population. The primary spawning period for sand flathead is during October to March.

Sand flathead in Port Phillip Bay can live to at least 23 years and grow to a size of 40 cm TL, although fish over 35 cm are relatively uncommon. Length at 50% maturity is reached at two to five years of age at a TL between 22 and 25 cm. Sand flathead growth rate and maximum sizes are lower for Port Phillip Bay than for coastal populations. Importantly, female sand flathead grow faster, and reach larger sizes, than males. Most sand flathead above the 27 cm LML in Port Phillip Bay are females. This assessment focusses on the main fishery in Port Phillip Bay.

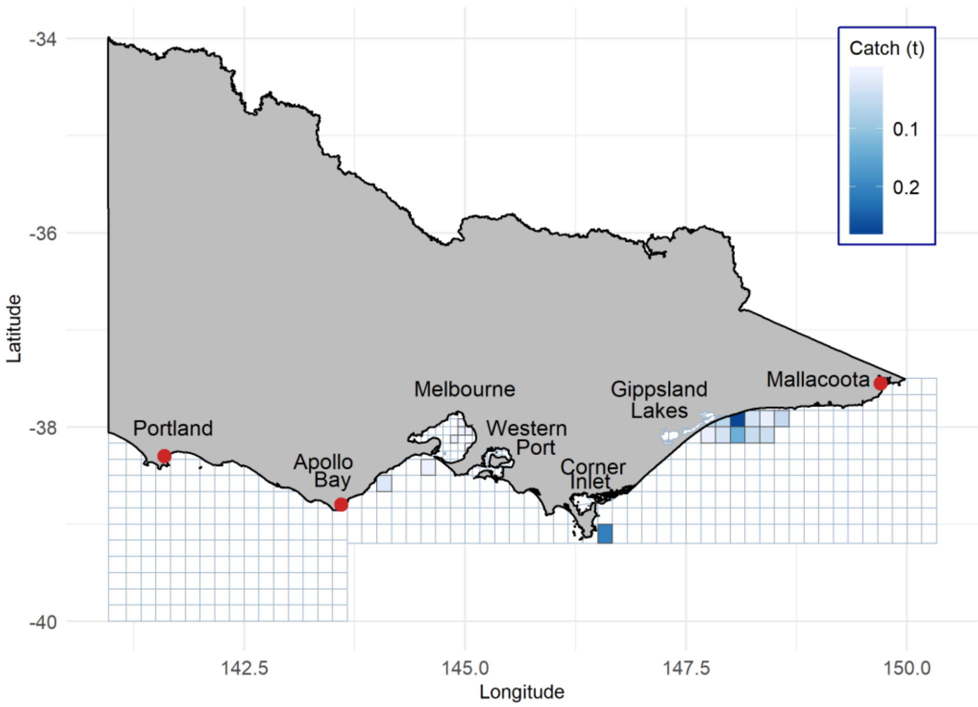


Figure 29 Victorian sand flathead commercial catch distribution 2018/19.

Assessment Summary

The status of sand flathead was evaluated using:

- Available harvest information for the commercial and recreational sectors
- Nominal CPUE for long-line in Port Phillip Bay (reference period 1986-2015)
- Nominal and standardised CPUE for the recreational fishery from annual creel surveys in Port Phillip Bay (reference period 1989-2015)
- Nominal CPUE for diary angler targeted sand flathead trips in Port Phillip Bay
- CPUE of mature sized sand flathead (>25 cm TL) in Port Phillip Bay from fishery independent trawl surveys
- Length composition of recreational fishery catches in Port Phillip Bay from creel surveys and diary anglers
- Pre-recruit (0+ age) abundance from fishery independent trawl surveys in Port Phillip Bay.

This assessment found:

- *Fishing pressure* – There is currently negligible commercial fishing pressure on southern sand flathead in Port Phillip Bay (Figure 29) with virtually all of the commercial catch being taken from Bass Strait during the past two years (Figure 30). Changes in, or current status of, recreational fishing pressure are unclear. Length composition data from creel surveys has been stable over the last 15 years (Figure 31).
- *Biomass* – Standardised CPUE from the creel surveys has remained relatively low (compared to historical levels) since the mid-2000s and was approximately midway between the reference period minimum (i.e. 2013/14) and reference period average in 2018/19 (Figure 32). The creel CPUE data indicate that the availability of legal sized sand flathead has stabilised since 2008 and shown signs of an increase from the lowest point in 2013, particularly in the last year (Figure 32). Consistent with creel CPUE, diary angler targeted CPUE showed a decline from the mid 2000s to the late 2000s, but since 2011 its postive trend is more pronounced than the trend in creel survey CPUE, and is above the reference period average (Figure 33). Unlike creel CPUE, diary angler CPUE represents catch rates of fish both above and below the LML, and the recent increasing trend is influenced by greater abundance of pre-recruit sand flathead below the LML since 2011 (Figure 36) that do not contribute to the creel survey catch rates. Long-line CPUE (Figure 35) is not considered indicative of stock status since 2015 due to the exceptionally low reported catches, but is nevertheless included for historical context along with the otter trawl survey data of mature biomass (ceased in 2011). These indicators of mature biomass show a period of higher biomass from the mid-1990s to the early 2000s (Figure 35). The ongoing small beam trawl CPUE for mature fish (> 25 cm TL) indicates a drop in biomass from 2004 to 2006 similr to that in long-line and trawl biomass, and shows an increasing trend since 2012 consistent with the diary angler data (Figure 32). Again this increasing trend is influenced by fish less than the LML being included in th beam trawl survey data. Overall, the various CPUE data indicate sand flathead abundance is slowly increasing from an historic low during the late 2000s, however, the current increase in abundance is due to recent recruitment with the population now dominated by small fish just below the LML.
- *Recruitment* – Pre-recruit survey data clearly show that the high biomass during the mid-1990s to early 2000s was due to exceptionally strong recruitment during the late 1980s to mid-1990s (Figure 34) (note: sand flathead take about 4–5 years to recruit to the fishery). Recruitment levels since 2000 have been much lower, driving the biomass declines observed from the early 2000s to 2010. It appears tht the stock has now stablised at a lower biomass under this lower recruitment regime, and recruitment has been sufficient to balance natural and fishing mortality at this lower level. Recent recruitment events (i.e. 2009, 2013) have been important in preventing ongoing decline, and indeed driving some increase in biomass. The 2018 recruitment is expected to contribute to the stability of the stock and may be sufficient to support continuation of a slowly increasing trend.

Stock status summary: On balance, the multiple lines of available evidence indicate that the Port Phillip Bay sand flathead population has been stable over the last decade at lower levels of abundance than during the 1990s. This indicates that recent recruitment has been sufficient to balance natural mortality and fishing impacts and that overfishing is unlikely to be occurring. There are recent signs of slow recovery in recreational catch rates, however, due to lack of recent strong recruitment events, any ongoing recovery in stock biomass is expected to remain slow.

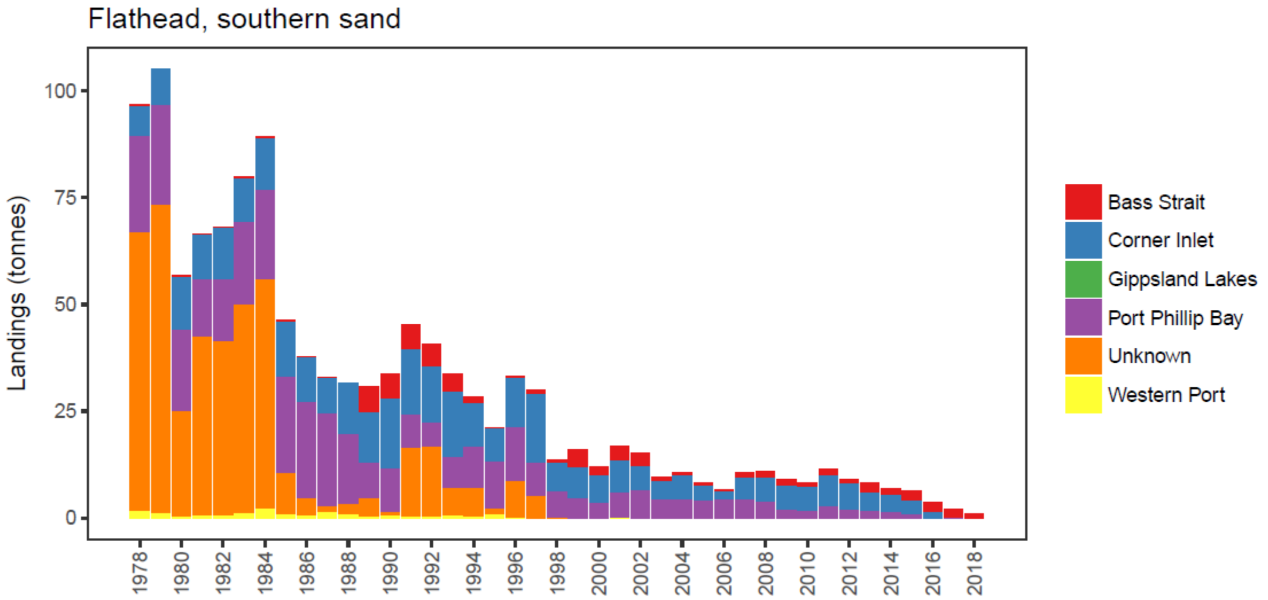


Figure 30 Victorian southern sand flathead commercial catches, financial year 1978–2018. Note: most of the catch classified as "unknown" is from Danish seine or trawl fishing in Bass Strait waters prior to the Danish seine/trawl fishery coming under Commonwealth management in 1998. Recent Commonwealth harvests are not included.

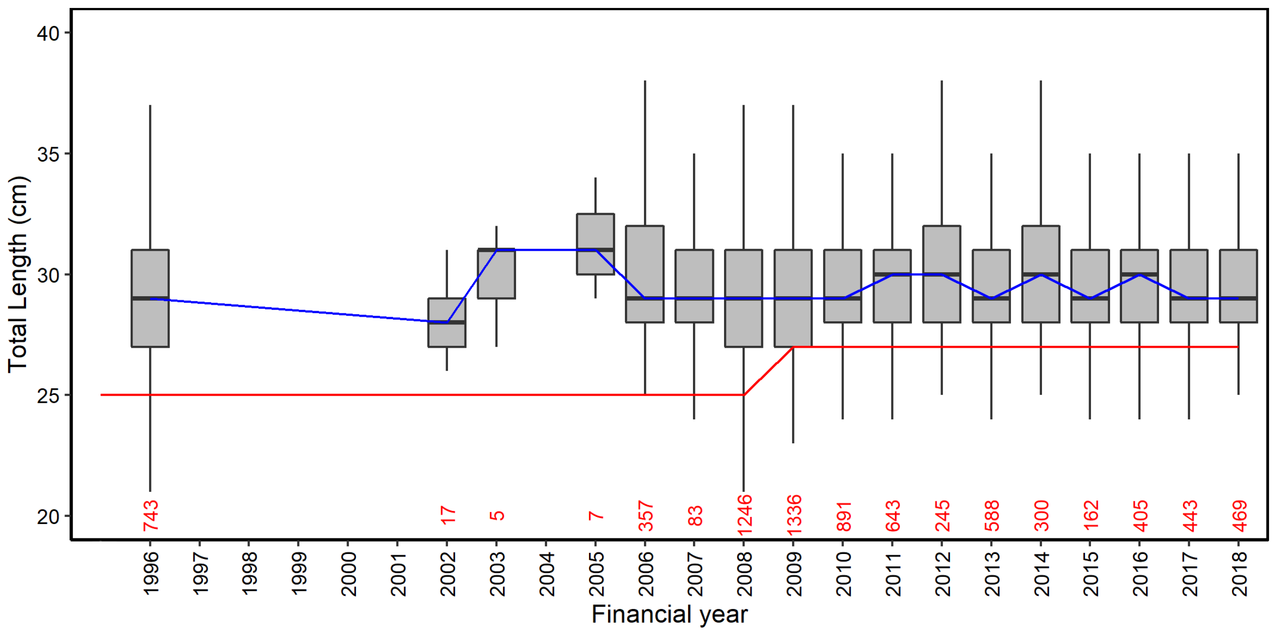


Figure 31 Box-plots of Port Phillip Bay sand flathead recreational creel survey length composition 1996–2018. Red numbers on x-axis indicate numbers of fish measured. Blue line = median length. Red line = legal minimum length (LML).

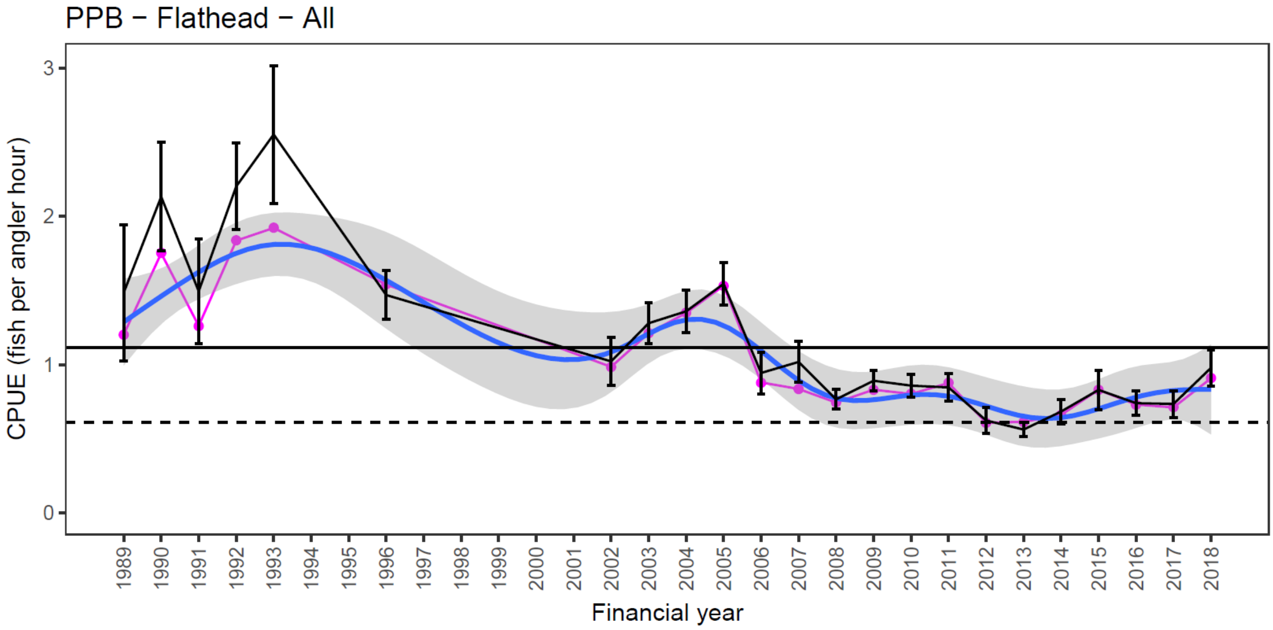


Figure 32 Catch-per-unit-effprt (CPUE) of southern sand flathead by recreational anglers interviewed in creel surveys undertaken in Port Phillip Bay (PPB) during 1989 – 2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (i.e. all years up to and including 2015) and the dashed black line is the minimum standardised CPUE within the reference period. Note: Catch rates were standardised prior to 2009 when the size limit was increased from 25 to 27 cm using the proportion of fish >27 cm in the catches of fishers interviewed during creel surveys in earlier years.

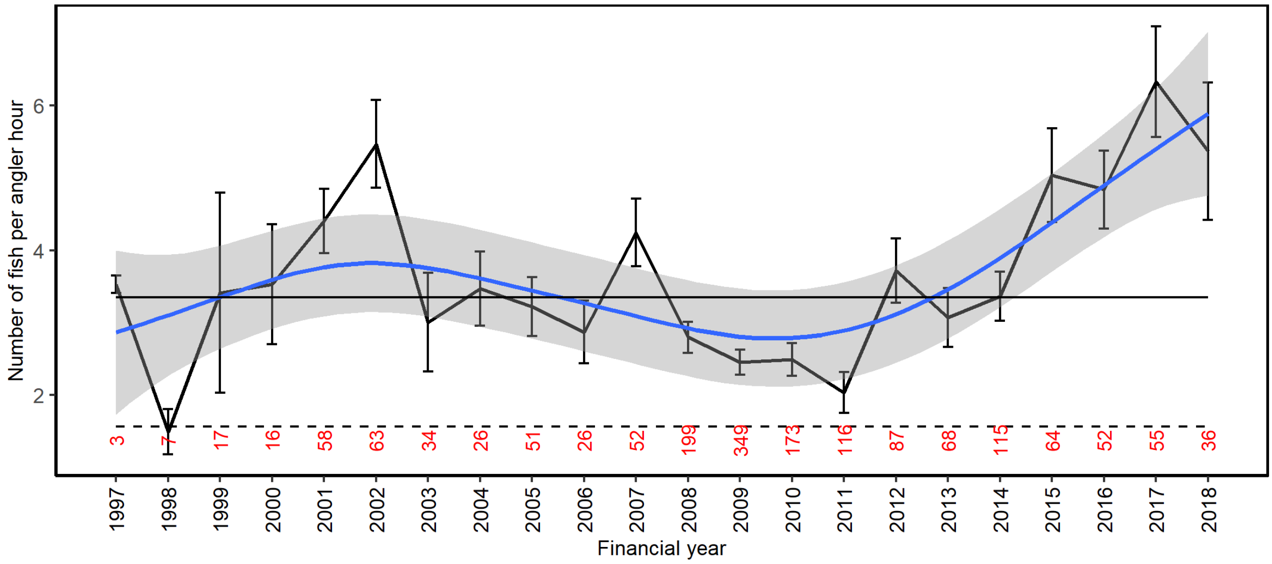


Figure 33 Nominal catch-per-unit-effort (CPUE) (±SE) (black line) for diary angler targeted flathead trips, all sizes, in Port Phillip Bay (PPB) during 1997–2018. Blue line is a generalised additive model (GAM)of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean CPUE during the reference period (1997–2015) and the dashed black line is the minimum CPUE within the reference period.

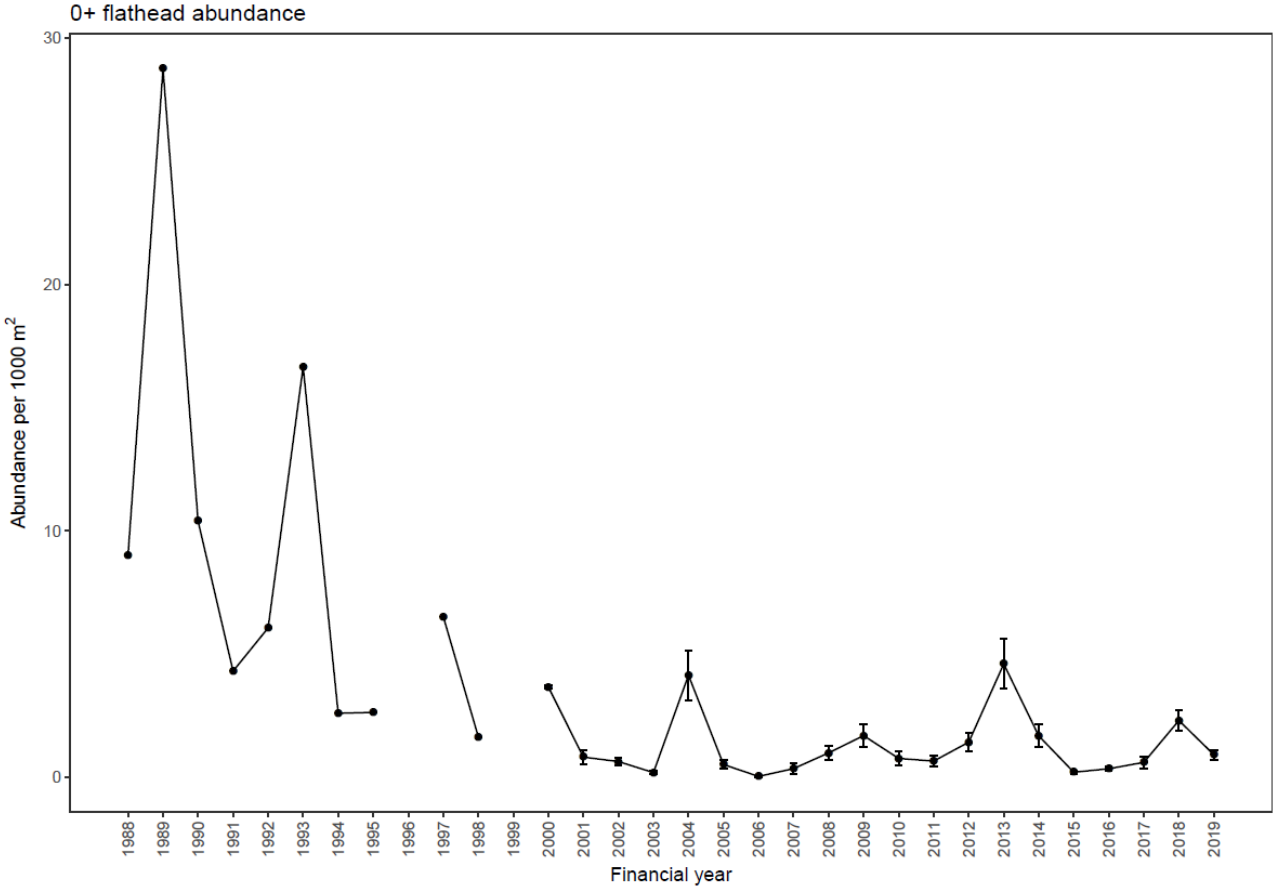


Figure 34 Port Phillip Bay sand flathead pre-recruit (0+ age) beam trawl survey catch rates (±SE) 1988–2019. Note: SE can only be calculated from 2000 onwards, data prior is based on extrapolation of beam trawl to earlier otter trawl data using a regression relationship from 11 years when the otter trawl and beam trawl surveys overlapped.

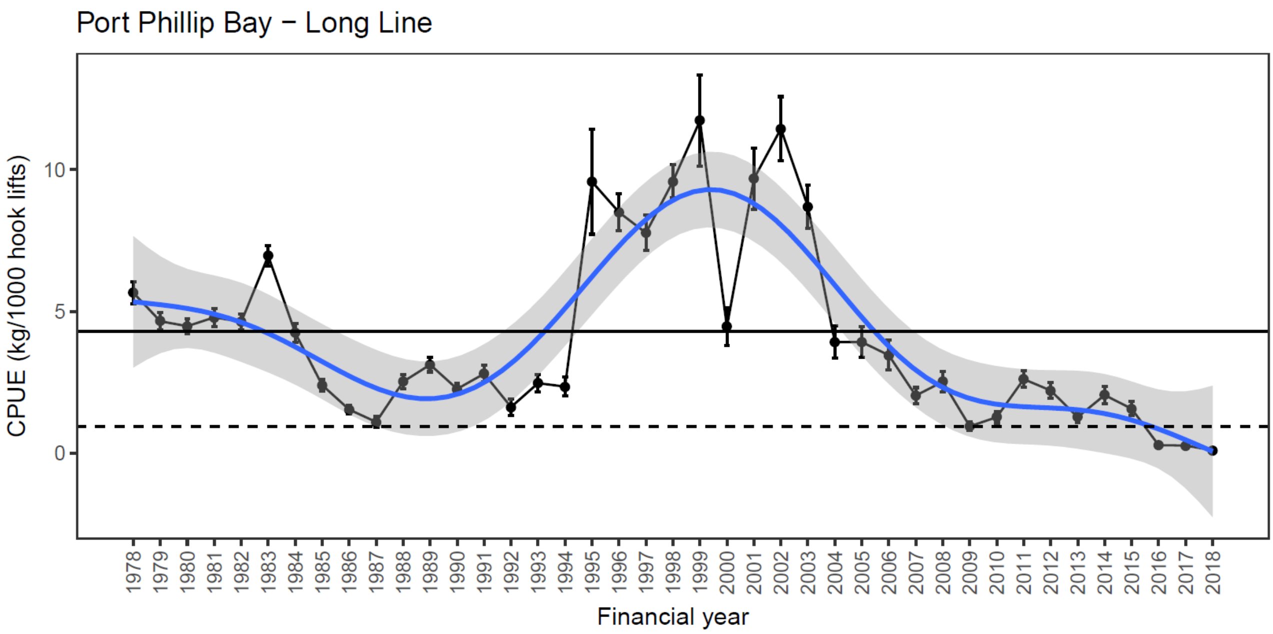
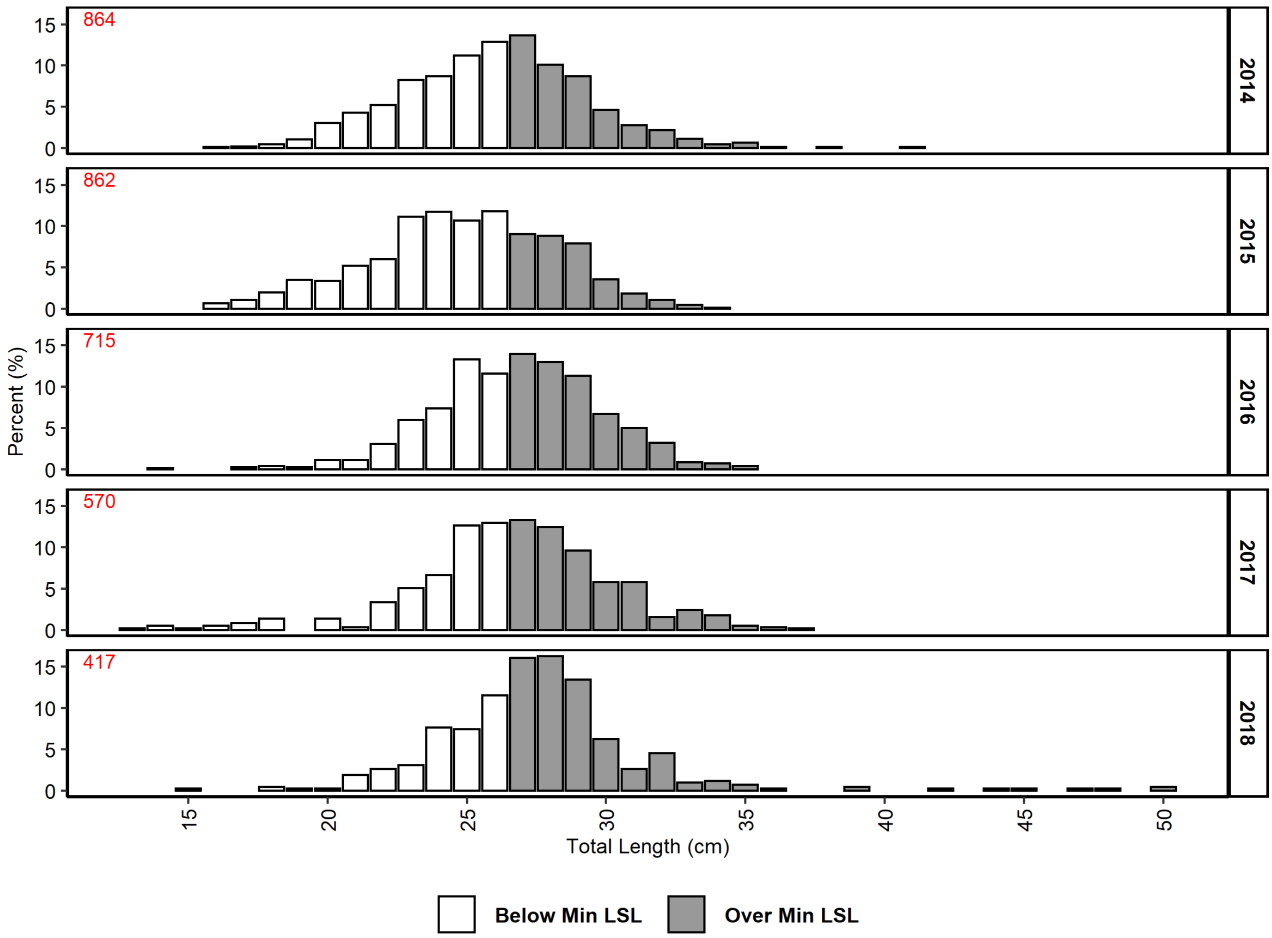


Figure 35 Nominal catch-per-unit-effort (CPUE) (±SE) (black line) for sand flathead by commercial long-line in Port Phillip Bay (PPB) during 1978–2018. Blue line is a generalised additive model (GAM) of the CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean CPUE during the reference period (1985–2015) and the dashed black line is the minimum CPUE within the reference period.

(a)



(b)

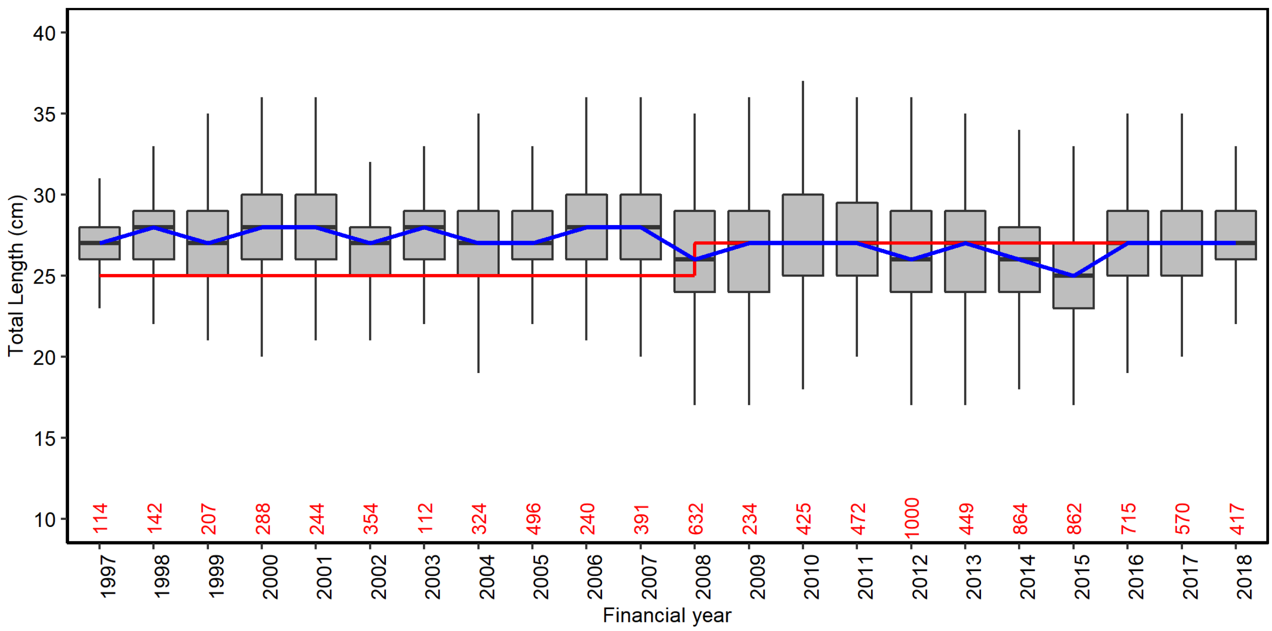
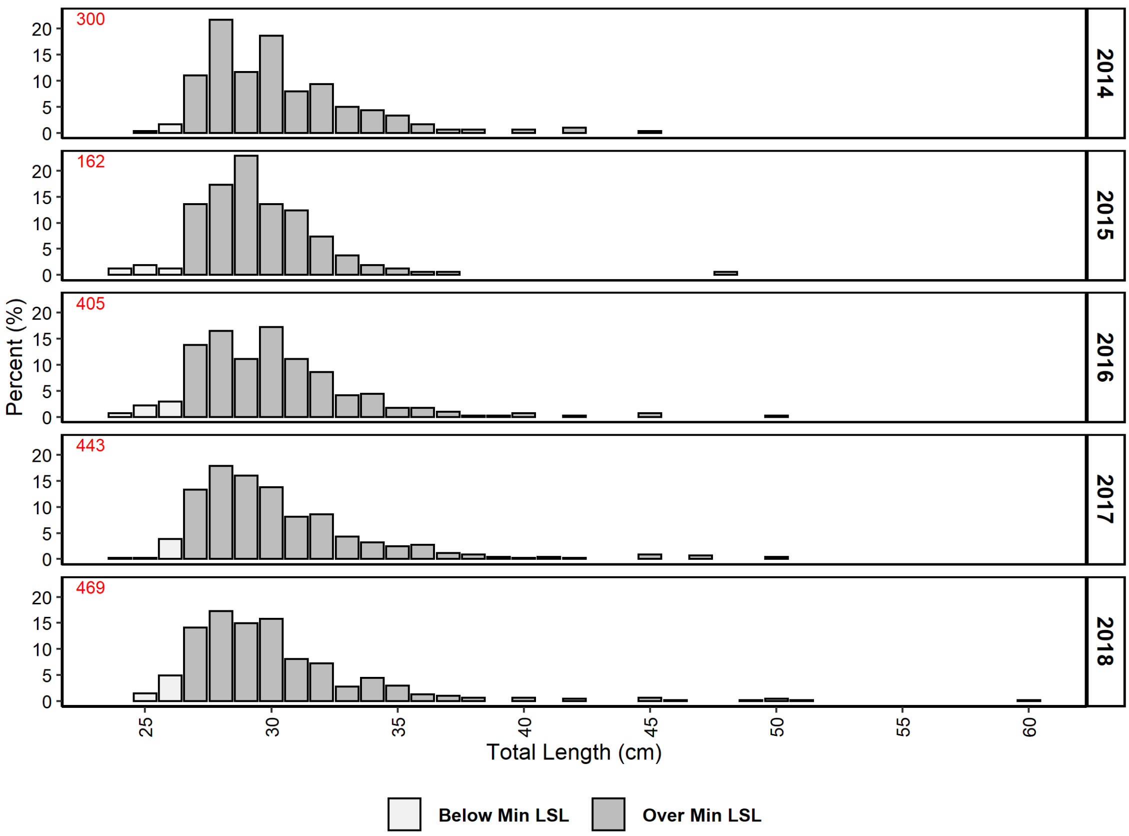


Figure 36 Distribution of Port Phillip Bay sand flathead angler diary length composition a) as proportions 2014–2018, and b) as box plots (1997–2018) . Red numbers on x-axis indicate numbers of fish measured. Blue line = median length. Red line = legal size limit (LSL).

(a)



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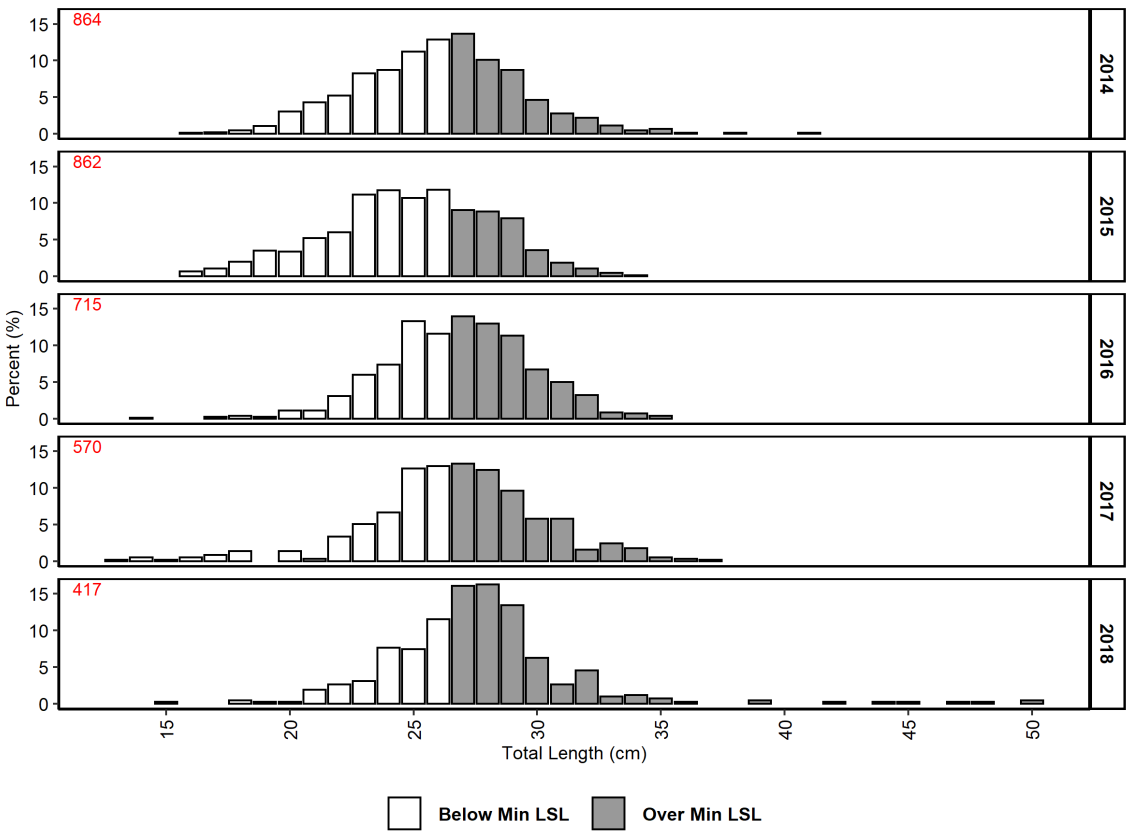


Figure 37 Frequency histograms of Port Phillip Bay recreational sand flathead length composition (a) creel surveys, (b) angler diary, fiscal years 2013–2018. Red numbers indicate numbers of fish measured. LSL = legal size limit.

Black Bream (*Acanthopagrus butcheri*)

Stock Structure and Biology

Black bream populations in the Gippsland Lakes, Lake Tyers, Mallacoota Inlet, the Hopkins and Glenelg Rivers, and other minor inlets and river estuaries are considered to be self-replenishing discrete stocks, with limited mixing among adjacent estuaries (Figure 38 and Figure 39). Commercial harvests occurred in the Gippsland Lakes and Port Phillip Bay in 2018/19 (Figure 38).

Black bream can live for at least 29 years and grow to a size of at least 60 cm TL. Size at 50% maturity is reached at two years of age and 20 cm TL (LML = 28 cm). Black bream is characteristically variable in its fecundity and growth rate, taking three to eight years to reach the current LML. The main spawning period is during October to February, and occurs in estuaries, often associated with a salt-wedge.

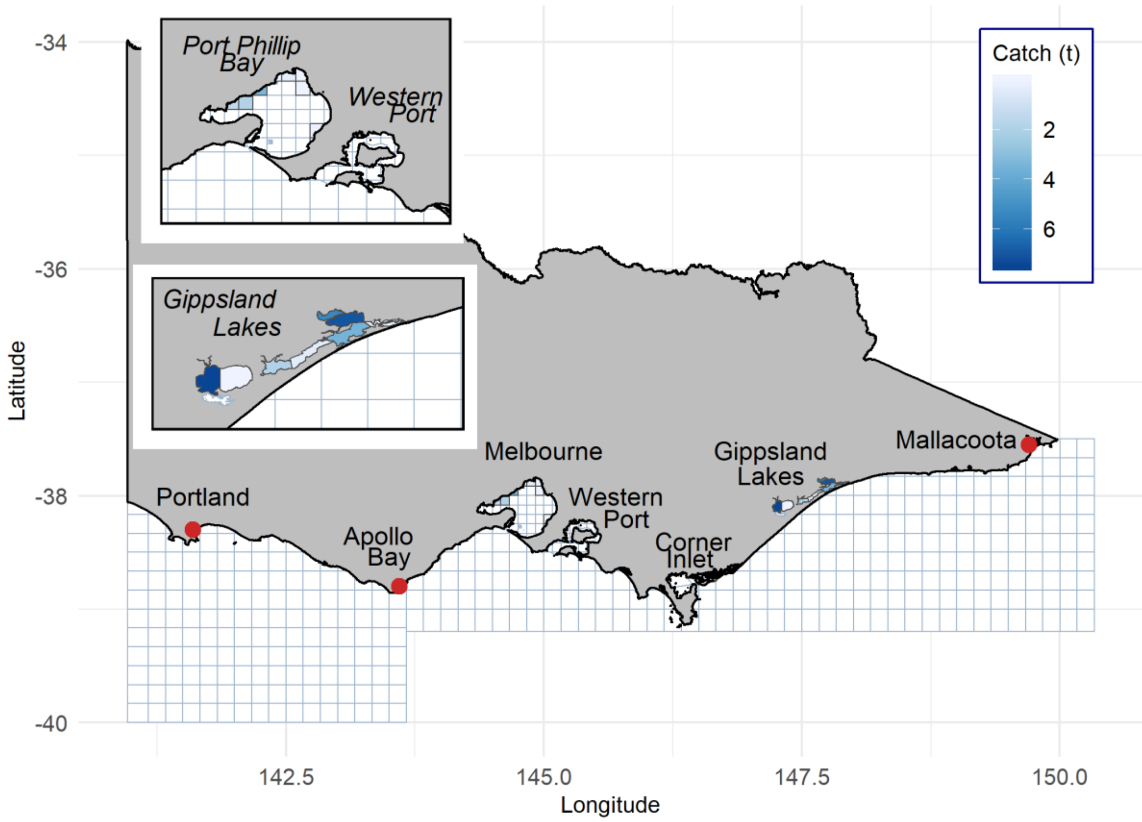
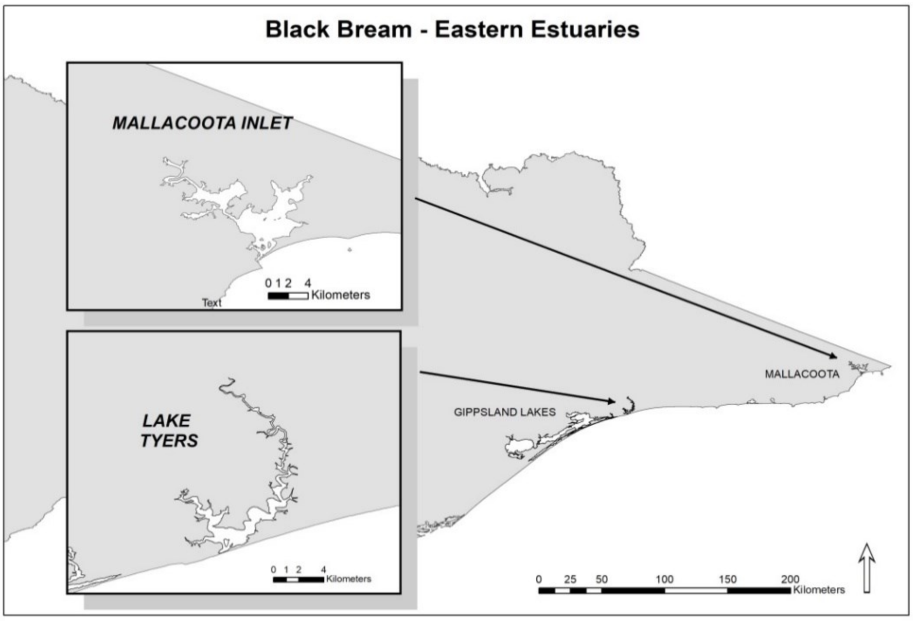


Figure 38 Victorian Black Bream commercial catch distribution 2018/19.



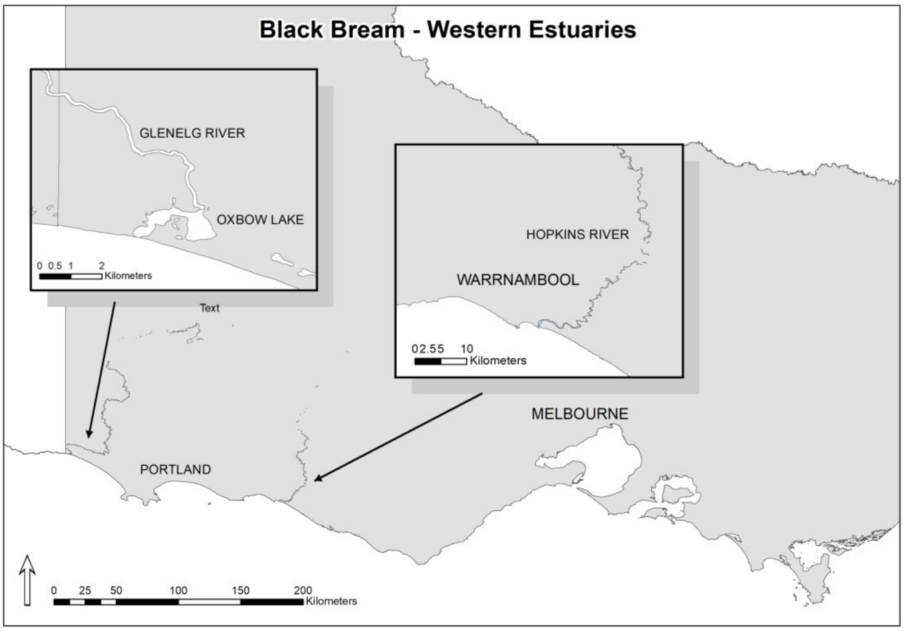


Figure 39 Victorian black bream recreational estuaries in eastern and western Victoria.

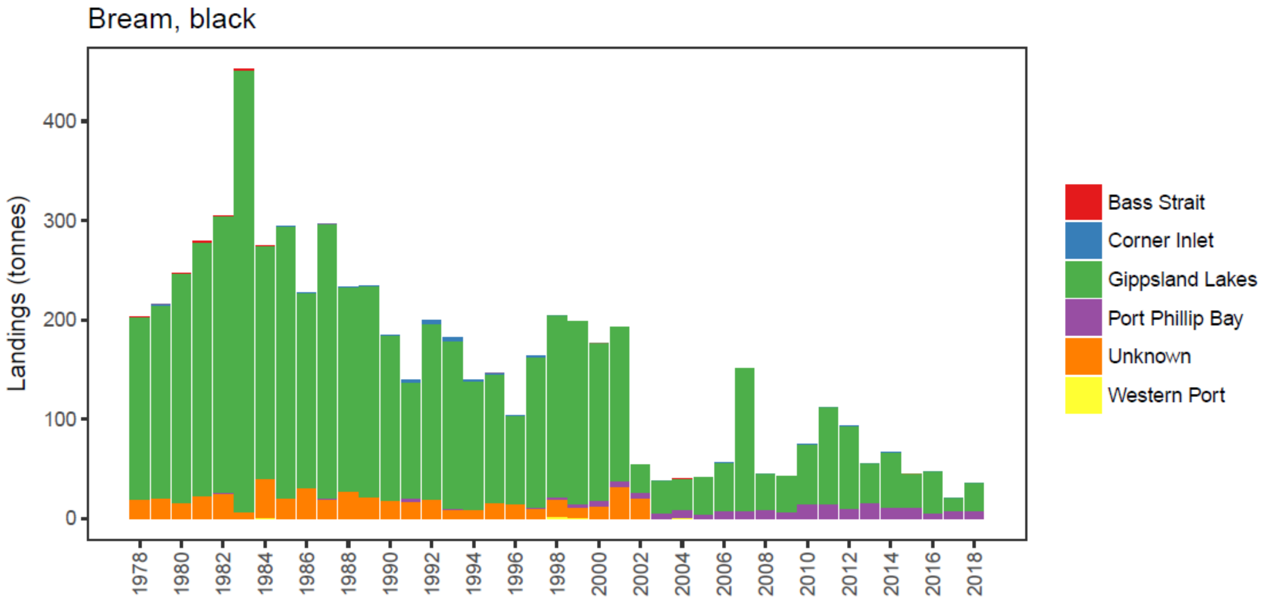


Figure 40 Commercial harvests of black bream from Victorian waters by area during fiscal years 1978—2018.

Assessment Summary

Gippsland Lakes

Gippsland Lakes comprise a series of interconnected temperate coastal lagoons in eastern Victoria which drain to the sea via a single permanent narrow entrance located at the town of Lakes Entrance. Three main river systems, the Mitchell, Nicholson and Tambo, discharge into the Gippsland Lakes system, which is almost 70 km long and is the largest navigable network of inland waterways in Australia. The Gippsland Lakes commercial net fishery is restricted to the lakes area and fishing is not permitted in the rivers or within 400 m from any part of the mouth of any river flowing into the Gippsland Lakes which limits access of the fishery to black bream. The majority of the commercial black bream harvest from the Gippsland Lakes is by mesh nets. Mesh nets are also used to harvest the majority of dusky flathead, yellow-eye mullet, sea mullet, luderick and tailor. Because the fishery includes multiple species and fishing activities that are spatially restricted there is some uncertainty in the accuracy of estimates of catch rates as an indicator of relative abundance for black bream.

Shore- and boat-based recreational anglers frequent the Gippsland Lakes and the estuarine reaches of the inflowing rivers where they target black bream. There is no recent information about the total recreational catch, however recreational fishery catch-rate and size composition monitoring programs for black bream have been in place for the last 20 years.

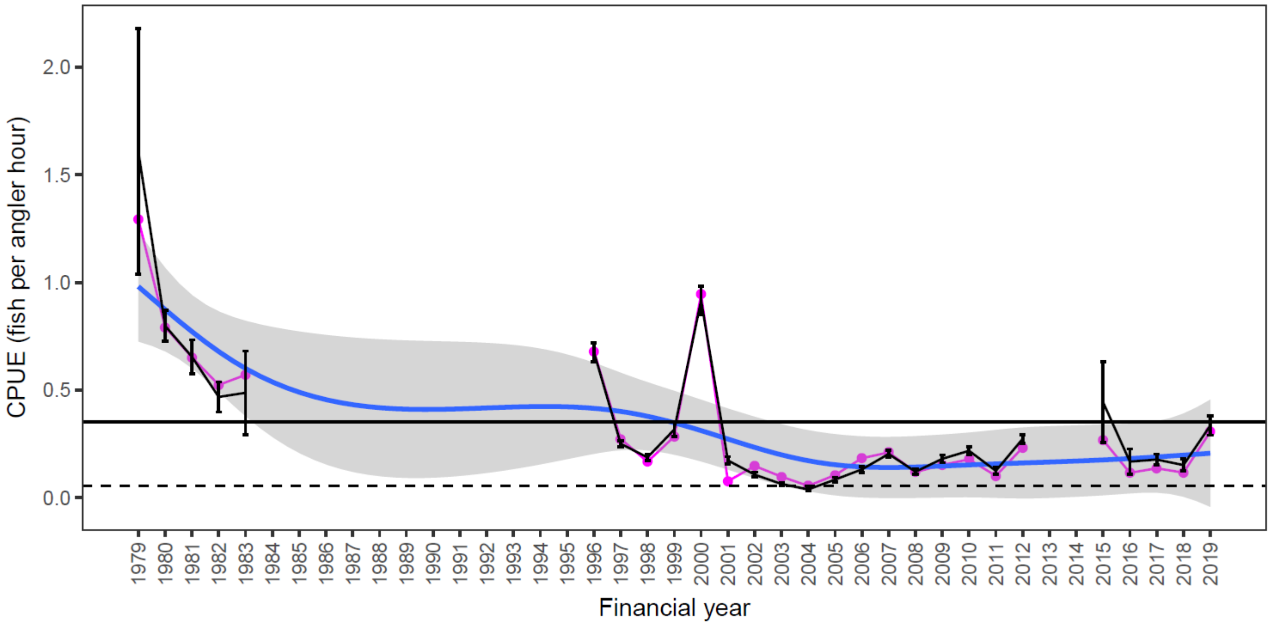
The status of the black bream in the Gippsland Lakes was evaluated using:

- Available harvest information for the commercial and recreational sectors
- CPUE (standardised and nominal) for commercial mesh net (reference period 1986–2015)
- CPUE (standardised and nominal) for the recreational fishery from annual creel surveys (reference period 1979—2015)
- CPUE (nominal) for the diary angler program
- Length composition of diary angler catches
- Length composition of recreational fishery creel survey
- Pre-recruit (post-larval) abundance from fishery independent netting surveys (2010—2018).

This assessment found:

- *Fishing pressure* – Commercial harvests have dropped considerably since the 1980s (Figure 40), and more recently have declined substantially in reponse to declining netting effort due to commercial licence reductions since 2010 (Appendix 2). Most of the catch since the early 2000s has been by mesh net . There is no recent information on recreational harvest or effort.

Biomass **– Standardised CPUE from mesh nets has declined continuously from 2011 to below the reference period lowest point in 2017/18 and 2018 (Figure 41). Standardised CPUE from the creel surveys has remained low (compared to historical levels) since the early 2000s, and was below the reference period average and only just above the reference period lowest point from 2016-2018 (Figure 42**



- Figure 42). The creel CPUE data indicates that the availability of legal size black bream appears to have stabilised in recent years.

  Diary angler targeted CPUE, which includes catches of fish above and below the LML, shows peaks in 2006 and 2012–2013, similar to the timing of peaks in the mesh net and creel survey CPUE (Figure 43). Diary angler CPUE declined from 2013 to 2016, also similar to mesh net and creel survey CPUE, however has increased in the most recent year to be just below the reference period average in 2018 (Figure 43).

  Length composition data for creel surveys has been stable over the last 15 years with signs of an increase in the median size of fish harvested from 2009 to 2018 (Figure 45a). There has been increased proportions of smaller fish in diary angler catches in 2017 and 2018, suggesting recent increased recruitment rates as evidenced by the smaller sub-legal fish in 2016 (Figure 46).

- *Recruitment* – Recruitment of 0-age black bream has been relatively stronger for the last two years (Figure 44). These two cohorts will grow to legal size over the next 4-5 years. However, because of the short length of the recruitment time series it remains unclear how the recruitment index relates to replenishment of adult biomass.

Stock status summary: Due to the recent mesh net CPUE trending below the reference period minimum; the lower bound of the 95% confidence interval creel survey CPUE being close to the low point; and uncertainty as to the relationship between the pre-recruit index and replenishment of the adult stock, the Gippsland Lakes Black Bream stock has been assessed as depleting.

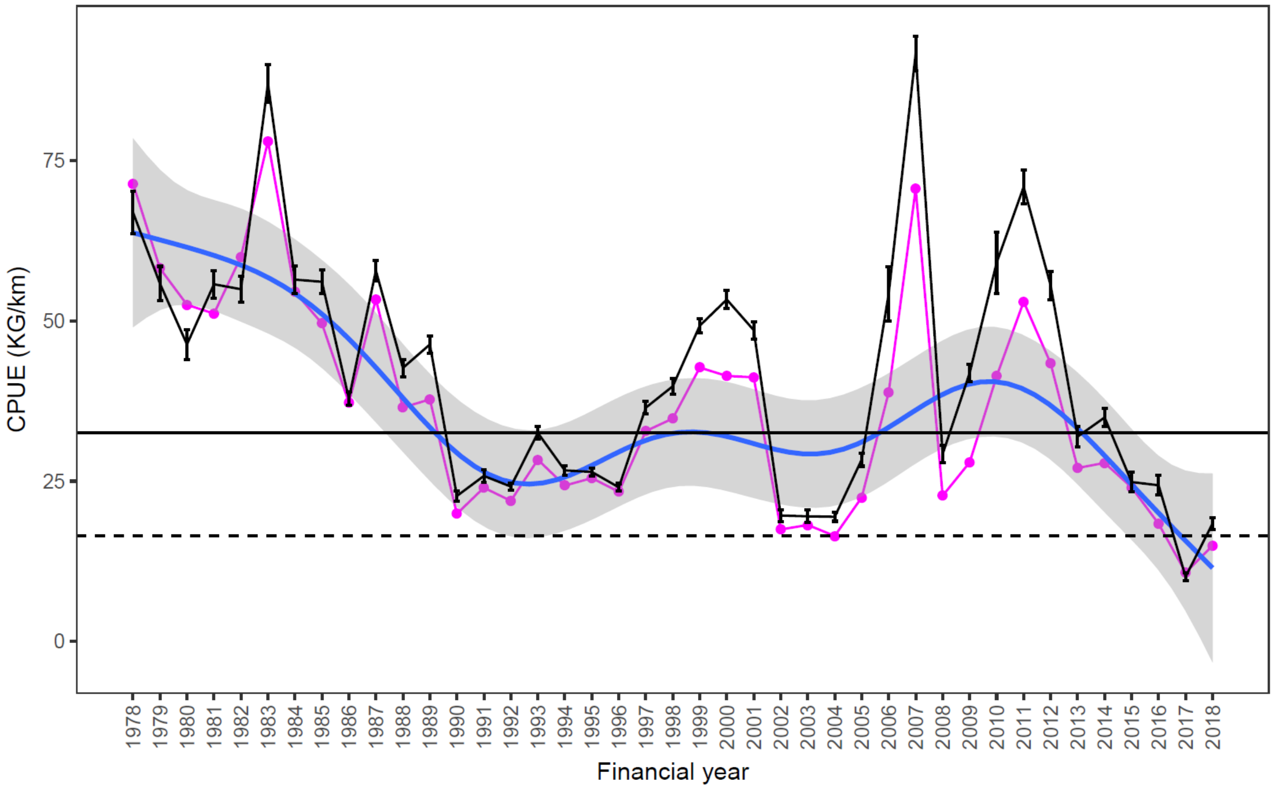


Figure 41 Catch-per-unit-effort **(**CPUE) of black bream by commercial mesh net fishers in the Gippsland Lakes during 1978 – 2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (1985–2015) and the dashed black line is the minimum standardised CPUE within the reference period. Note: CPUE is calculated as Kg/km as no soak time data were available prior to 1998 and mesh net fishers in the Gippsland Lakes tend to soak their gear overnight meaning soak time is relatively uniform through time.

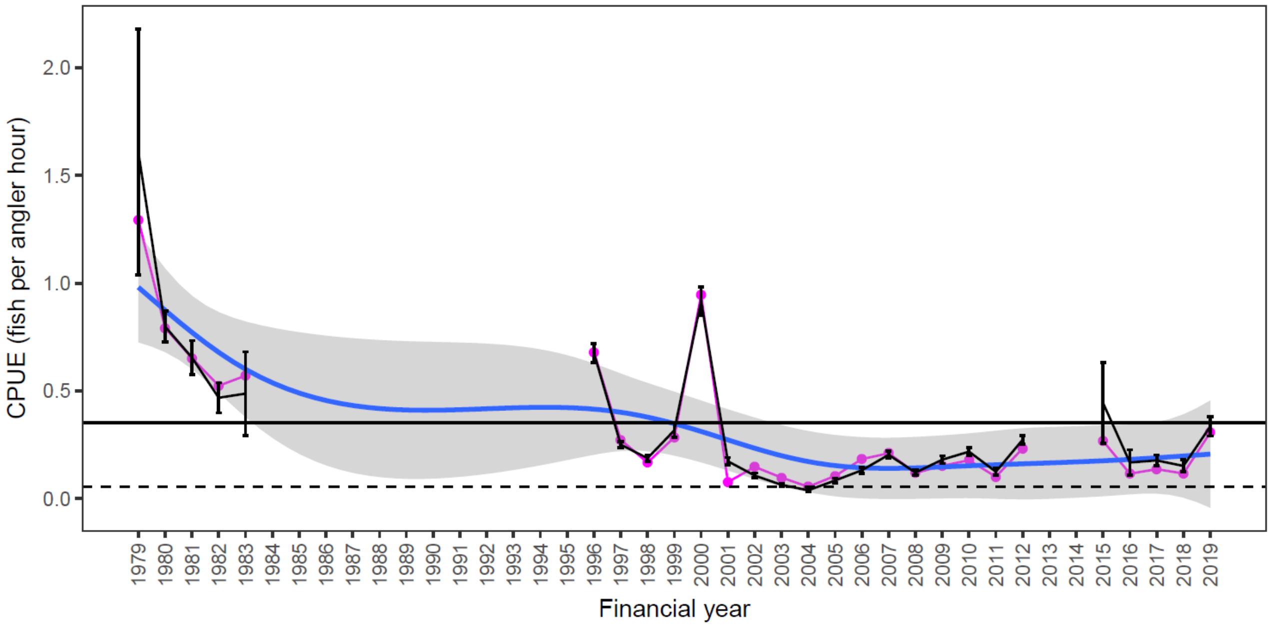


Figure 42 Catch-per-unit-effort **(**CPUE) of black bream by recreational anglers interviewed in creel surveys undertaken in the Gippsland Lakes during 1979–2019. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (i.e. all years up and including 2015) and the dashed black line is the minimum standardised CPUE within the reference period.

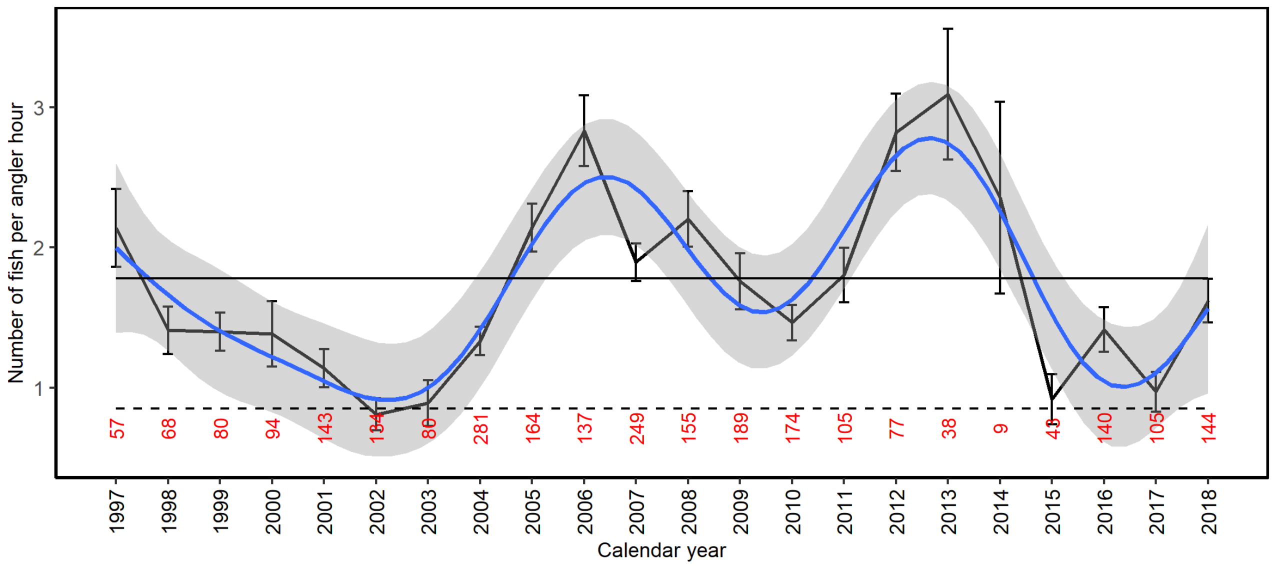


Figure 43 Diary angler mean nominal (±SE) catch-per-unit-effort **(**CPUE) of black bream from the Gippsland Lakes, 1997-2018 calendar years. Horizontal black line is the mean CPUE during the reference period (1997 - 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

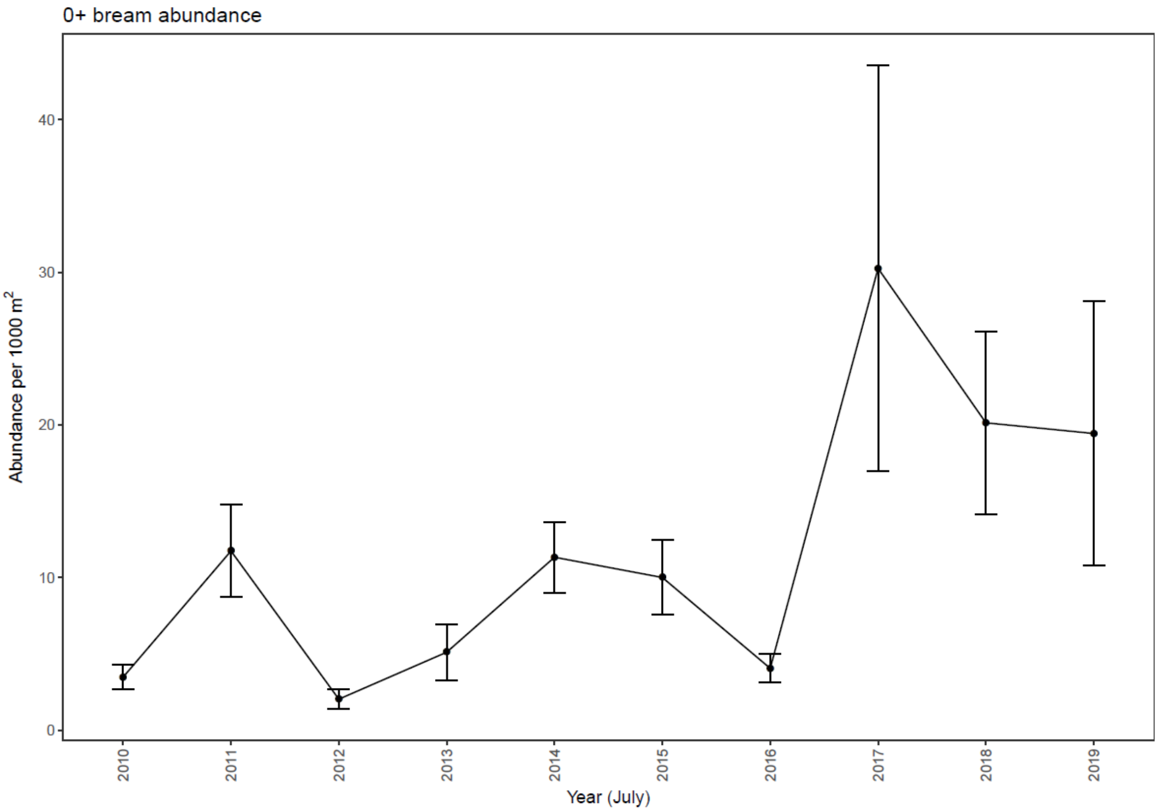
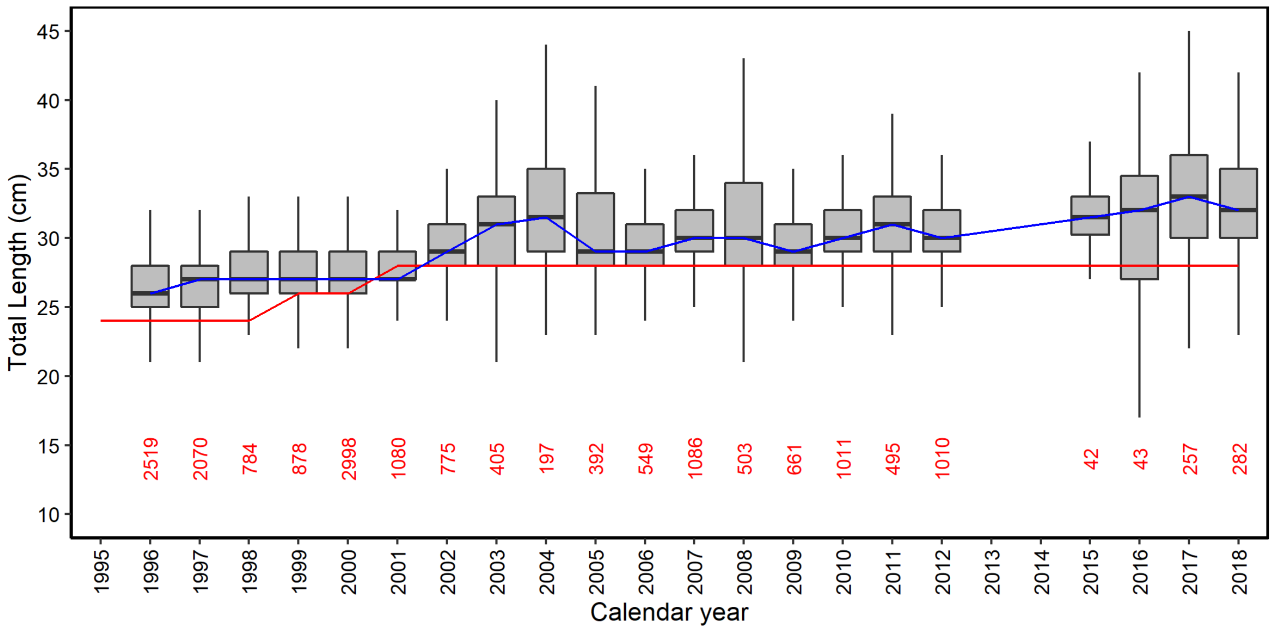


Figure 44 Pre-recruit survey abundance of 0+ black bream in the Gippsland Lakes (mean ±SE). Pre-recruit surveys comprise ~50 demersal trawl shots throughout the rivers and lakes of the system.

(a)



(b)

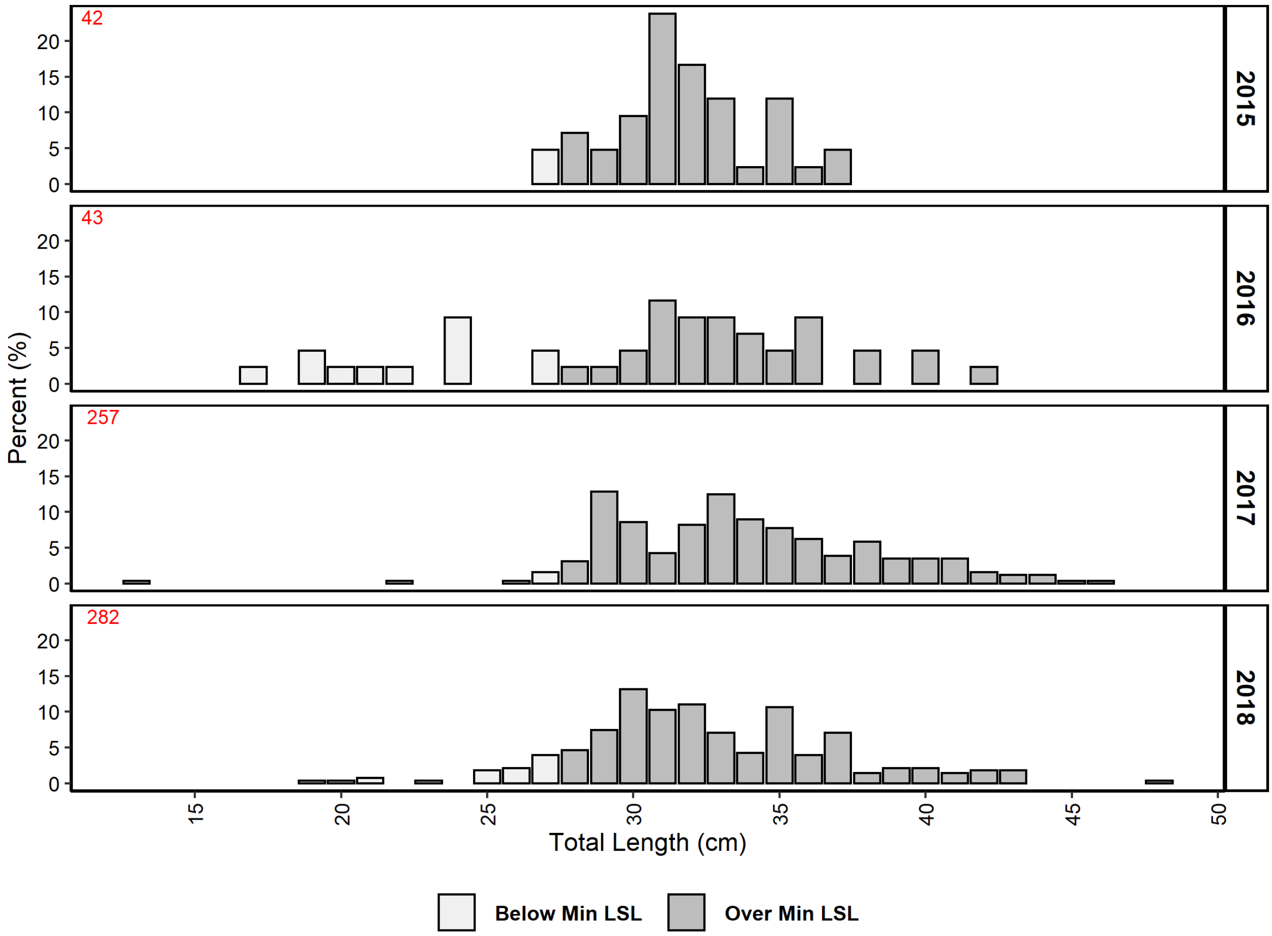


Figure 45 (a) Box-plots of Gippsland Lakes black bream length composition from recreational creel surveys for calendar years 1996–2018, red numbers on x-axis indicate numbers of fish measured, blue line = median length, red line = legal minimum length (LML). (b) Frequency histograms of Gippsland Lakes black bream length composition for recreational creel survey calendar years 2015—2018. Red numbers indicate numbers of fish measured.

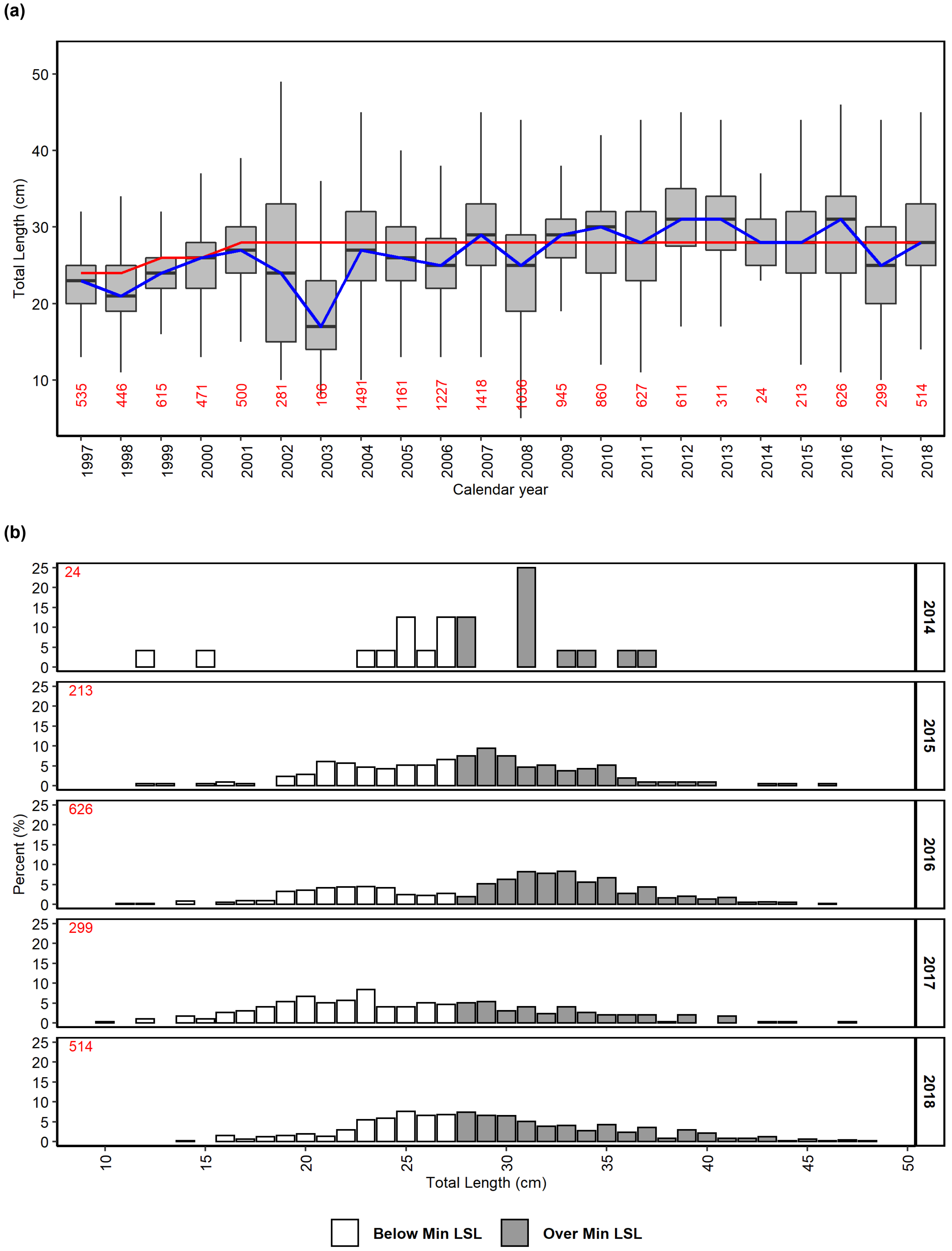


Figure 46 (a) Box-plots of Gippsland Lakes black bream length composition from diary anglers for calendar years 1997-2018, red numbers on x-axis indicate numbers of fish measured, blue line median length, red line is the legal minimum length (LML). (b) Frequency histograms of Gippsland Lakes black bream length composition from diary anglers for calendar years 2014–2018. Red numbers indicate numbers of fish measured.

Western Victorian Estuaries

The status of stock biomass and impact of fishing pressure was evaluated using CPUE and size compostion from fishers paticipating in an angler fishing diary program. There is no commercial fishing for black bream in the smaller estuaries.

Glenelg River

This review found:

- *Fishing pressure* – There is no direct information on the amount of fishing pressure on the black bream population in the Glenelg River. Size composition data shows that larger fish (>35 cm) are consistently recorded in the catches (Figure 48) suggesting fishing mortality is likely to be relatively low. There have also been consistent catches of undersize fish suggesting recent spawning success with the exception of 2018 (Figure 48a). The lack of undersize fish recorded by angler diarists in 2018 is suprising given there prevalence in the previous years and this may be due to changes in the fishing gear use or the locations fished.
- *Biomass* – Diary angler targeted CPUE was just below the reference period average in 2018 but above the low point (Figure 47). For the last decade CPUE has had a stable trend at about or above the reference period average with the exception 2018.

Stock status summary: Based on the above lines of evidence the Glenelg River black bream stock is considered to be sustainable.

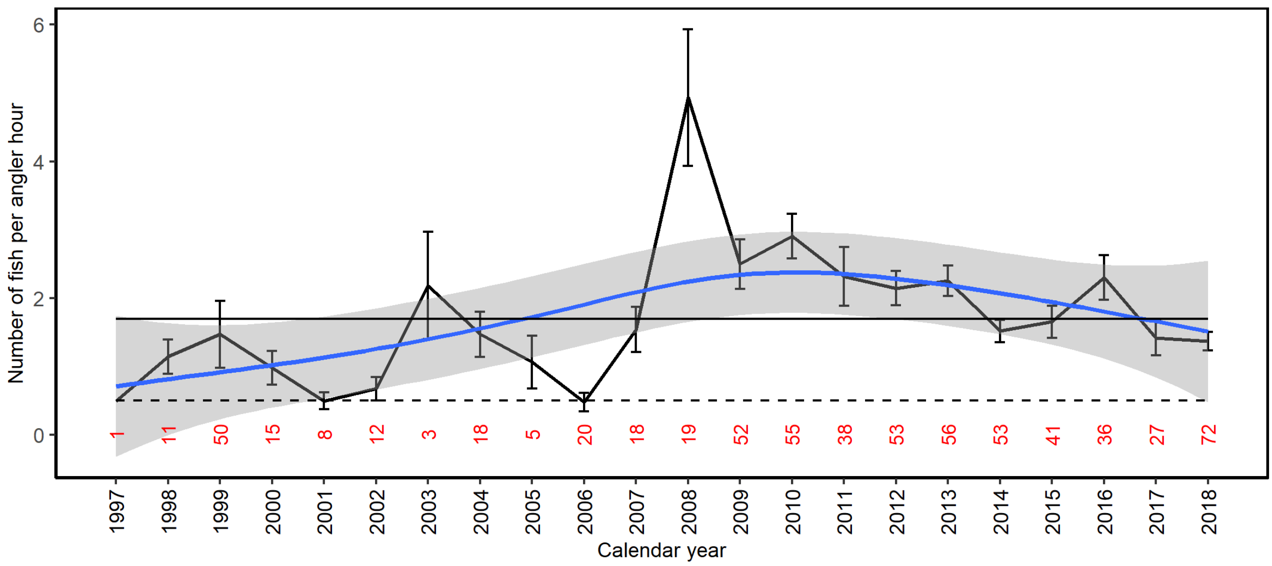


Figure 47 Nominal catch-per-unit-effort **(**CPUE) (±SE) for black bream caught by diary program anglers in the Glenelg River (1997–2018). Horizontal black line is the mean CPUE during the reference period (1997- 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

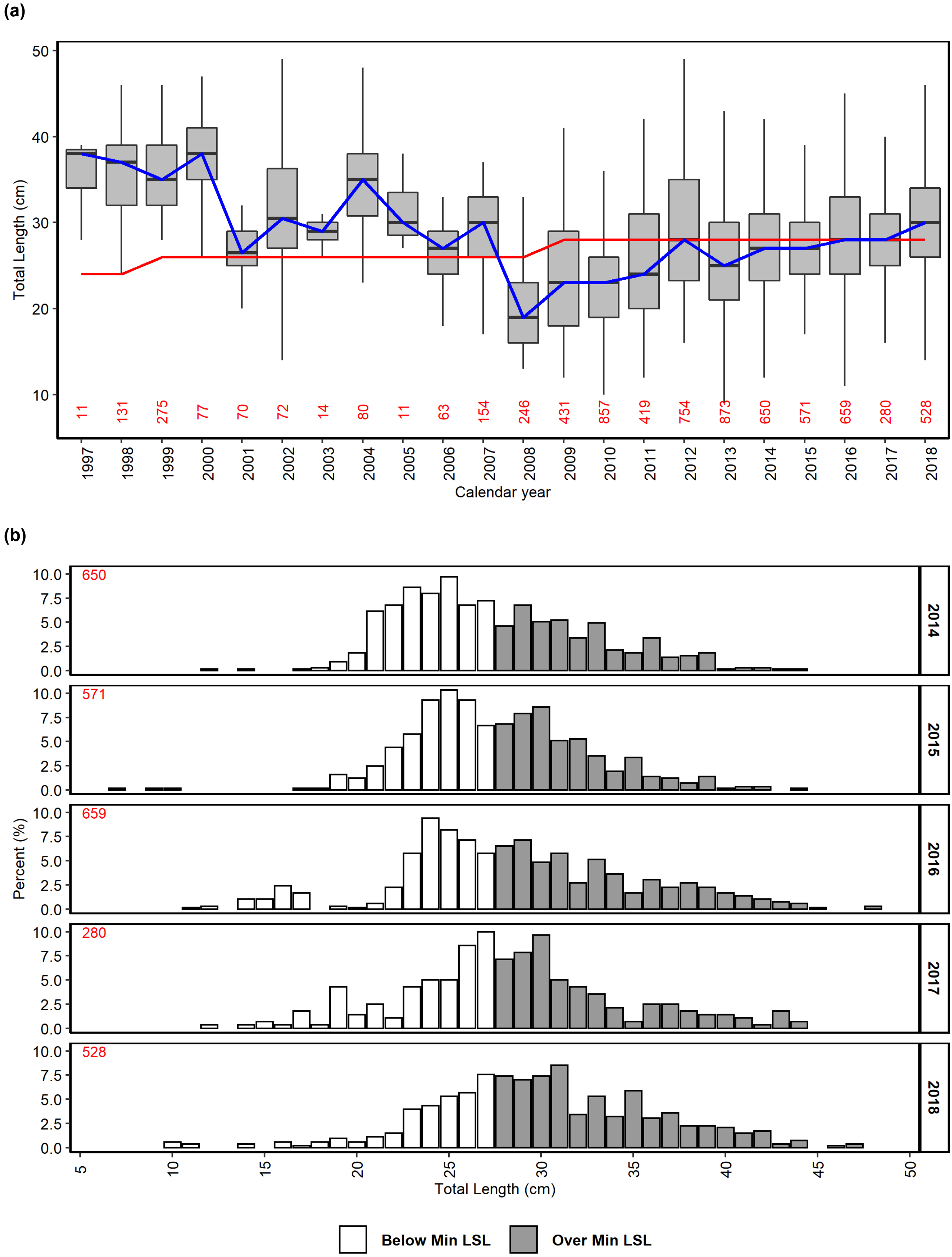


Figure 48 (a) Box-plots of Glenelg River black bream length composition from diary anglers for calendar years 1997—2018. Red numbers on x-axis indicate numbers of fish measured, blue line is median length, red line is the legal minimum length (LML). (b) Frequency histograms of Glenelg River black bream length composition from diary anglers for calendar years 2014—2018. Red numbers indicate numbers of fish measured.

Hopkins River

The status of stock biomass and impact of fishing pressure was evaluated using CPUE and size composition data from fishers participating in an angler diary program.

This assessment found:

- *Fishing pressure* – There is no direct information on the amount of fishing pressure on the black bream population in the Hopkins River. Size composition data shows that larger fish (>35 cm) are consistently recorded in catches (Figure 50) suggesting fishing mortality is likely to be relatively low. There have also been consistent catches of undersize fish suggesting recent spawning success.
- *Biomass* – Diary angler targeted CPUE have fluctuated in recent years above or just below the reference period average with a small number of sampling trips being recorded (Figure 49).

Stock status summary: Based on the above lines of evidence the Hopkins River black bream stock has been assessed as sustainable.

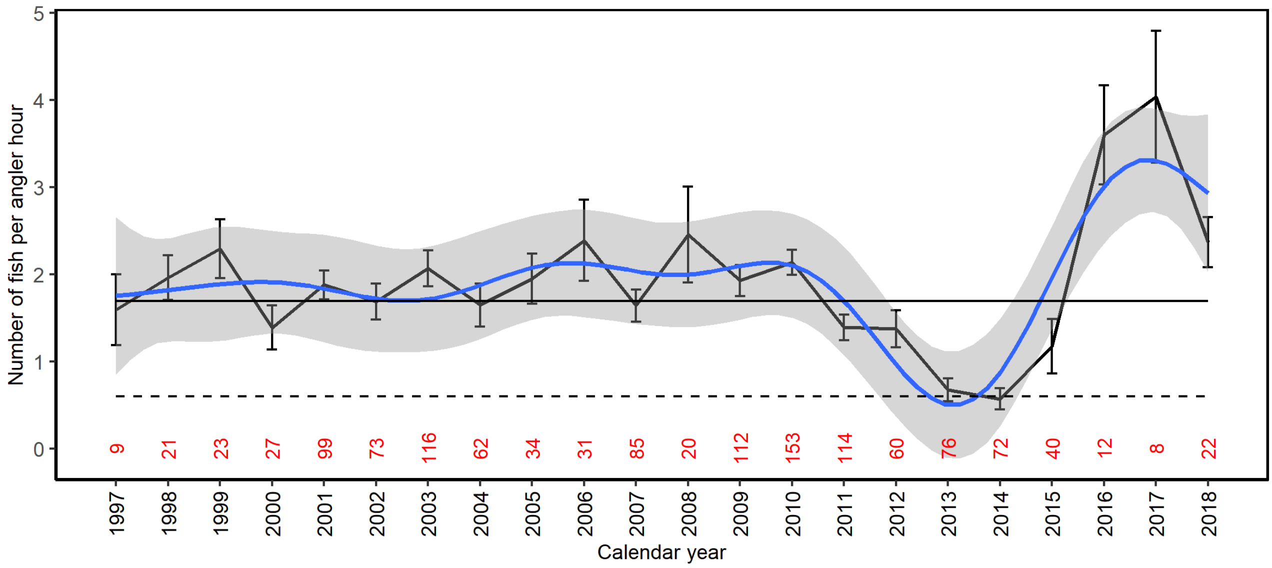
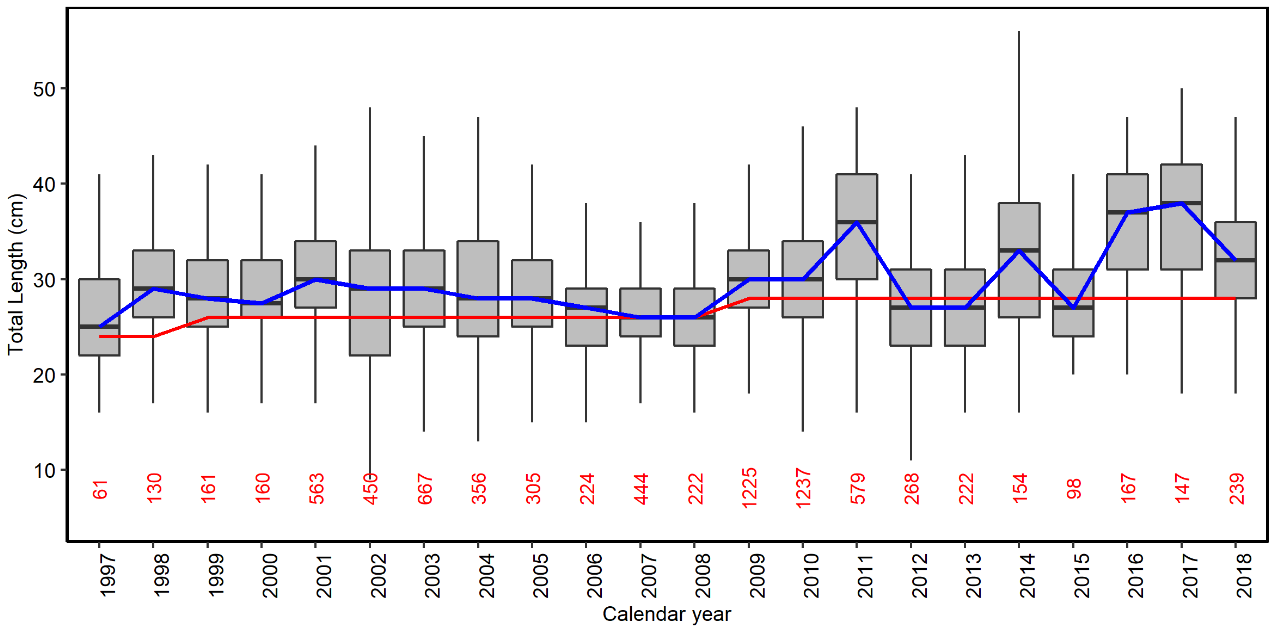


Figure 49 Nominal catch-per-unit-effort **(**CPUE) (±SE) of black bream for diary anglers in the Hopkins River (1997–2018). Horizontal black line is the mean CPUE during the reference period (1997–2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

(a)



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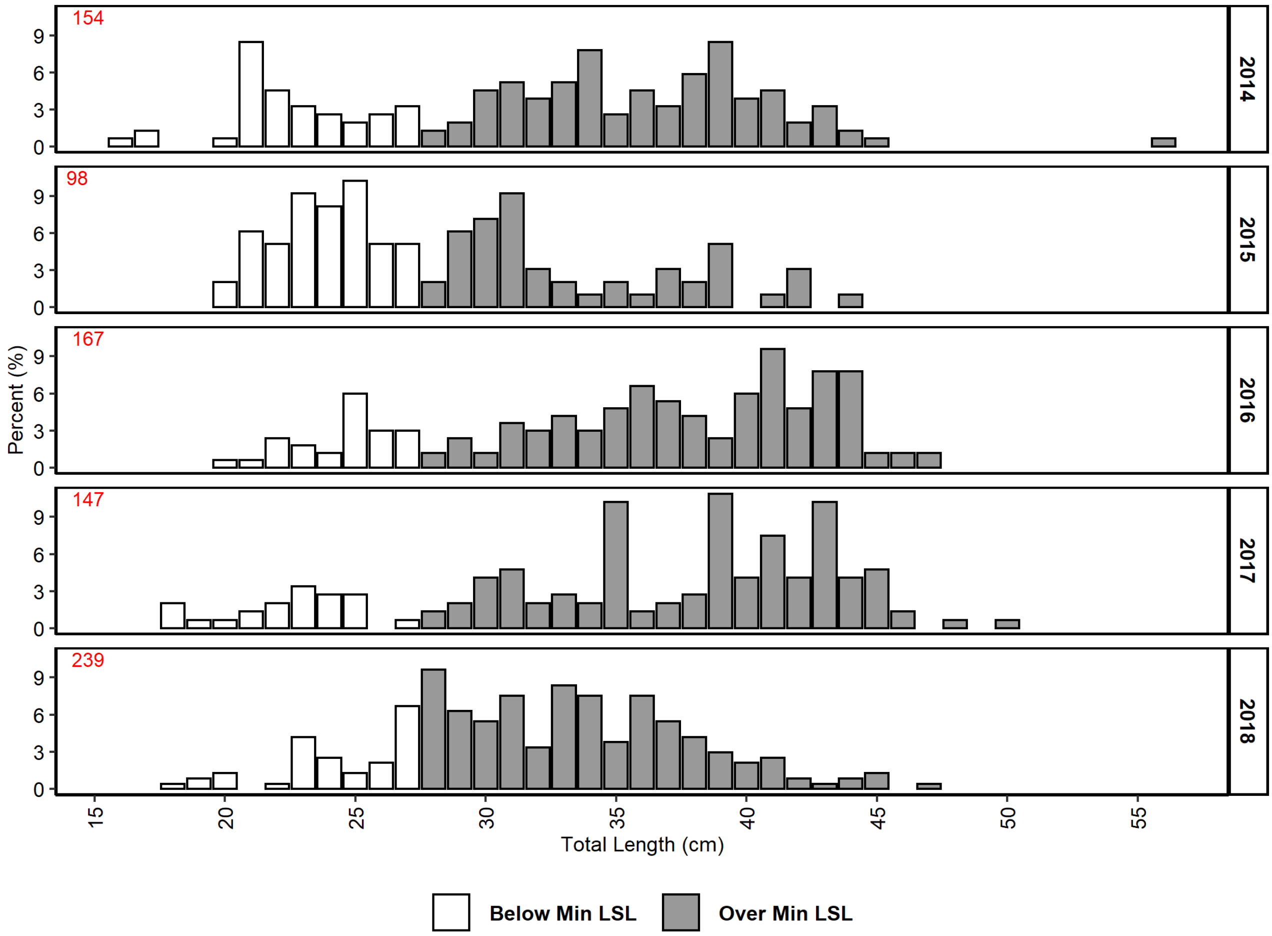


Figure 50 (a) Box-plots of Hopkins River black bream length composition from diary anglers for calendar years 1997–2018. Red numbers on x-axis indicate numbers of fish measured, blue line is median length, red line is the legal minimum length (LML). (b) Frequency histograms of Hopkins River black bream length composition from diary anglers for calendar years 2014–2018. Red numbers indicate numbers of fish measured.

Lake Tyers

The status of stock biomass and impact of fishing pressure was evaluated using CPUE and size composition data from fishers participating in an angler diary program.

This assessment found:

- *Fishing pressure* – There is no recent information about the amount of fishing pressure on the black bream population in the Lake Tyers. Size composition data shows that larger fish (>35 cm) remain in the catches (Figure 52) suggesting fishing mortality is likely to be relatively low. There have been also consistent catches of undersize fish suggesting recent spawning success.
- *Biomass* – Diary angler targeted CPUE has declined to below the reference period average in recent years but in 2018 was above the minimum for the period (Figure 51). Fewer sampling trips were recorded during recent years which is consistent with reduced angler participation in the angler diary program. This has created uncertainty in the reliability of recent diary angler CPUE.

Stock status summary: Uncertainty in the diary angler decline in CPUE and an overall paucity of recent biomass data means there is no evidence to suggest that this stock is not sustainable. The indication of recent spawning success and larger fish in catches, suggesting that the stock is not recruitment impaired, corroborates a view that this stock is sustainable.

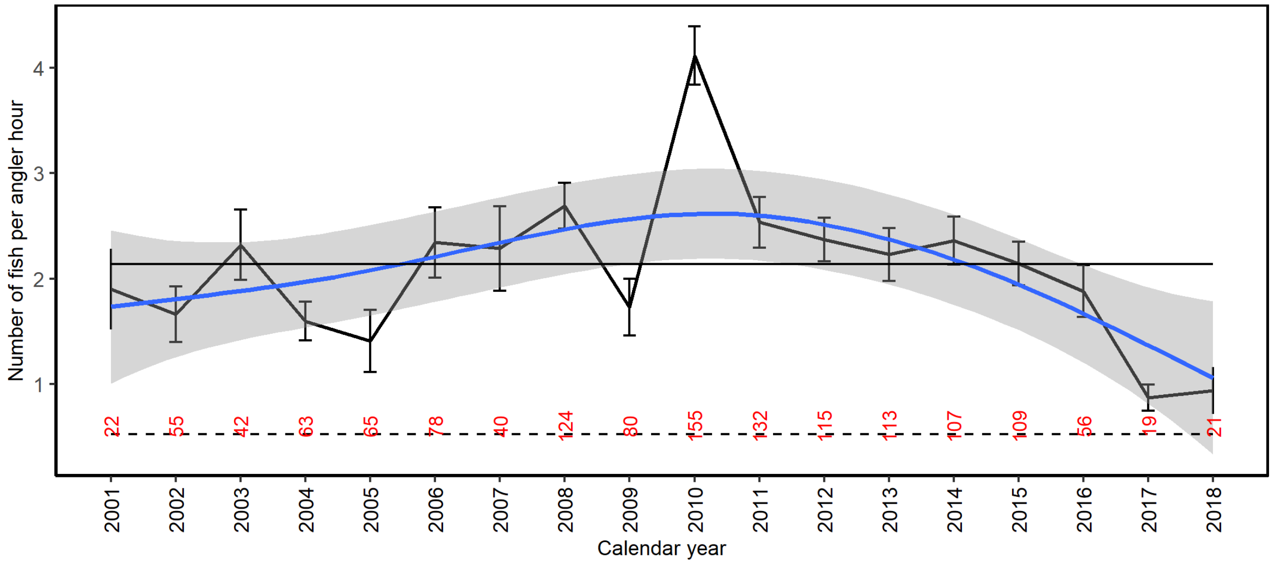


Figure 51 Nominal catch-per-unit-effort **(**CPUE) (±SE) of black bream for diary anglers in Lake Tyers (2001–2018). Horizontal black line is the mean CPUE during the reference period (2001- 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

(a)

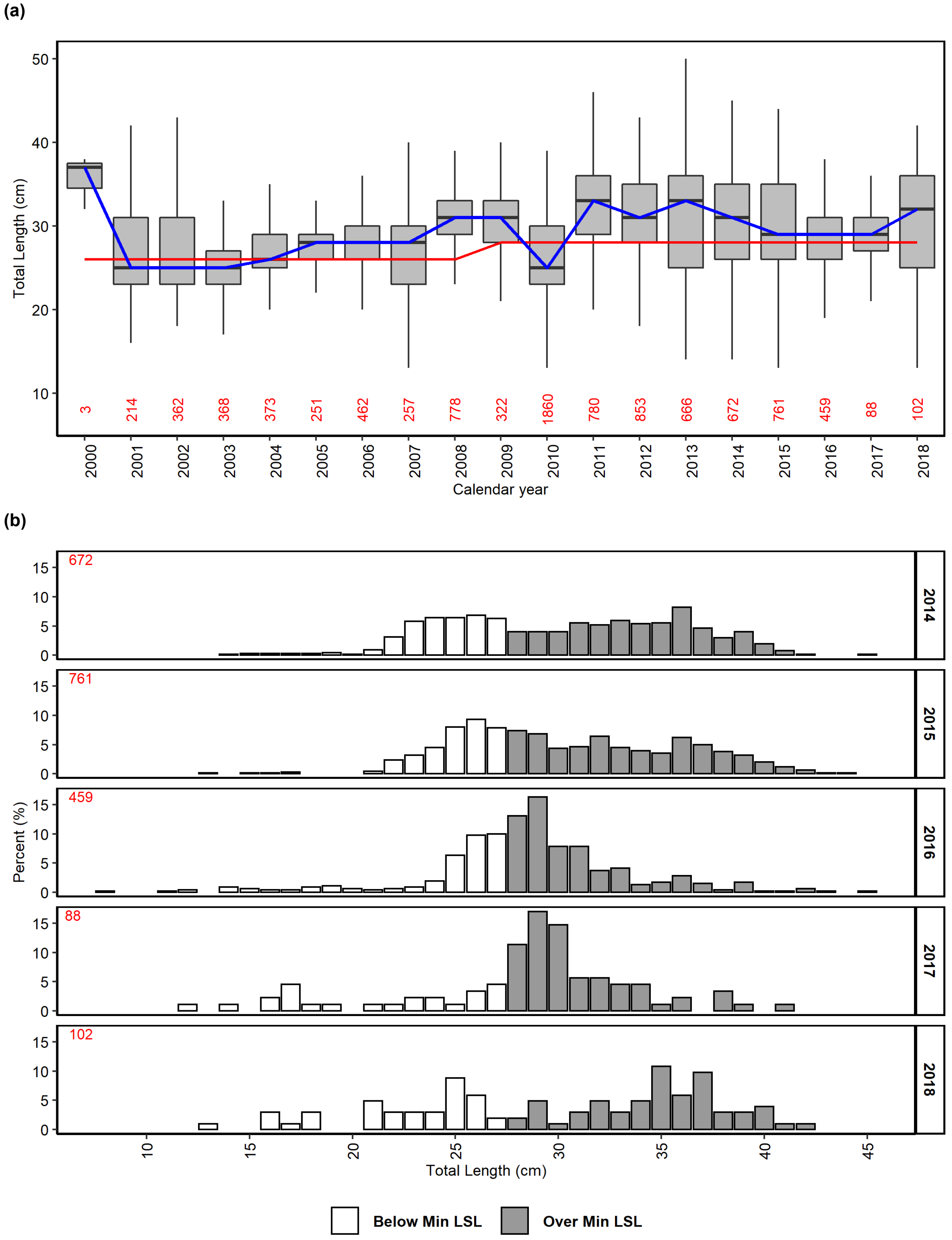


Figure 52 (a) Box-plots of Lake Tyers black bream length composition from diary anglers for calendar years 2000—2018. Red numbers on x-axis indicate numbers of fish measured, blue line is median length, red line is the legal size limit LSL. (b) Frequency histograms of Lake Tyers black bream length composition from diary anglers for calendar years 2014—2018. Red numbers indicate numbers of fish measured.

Mallacoota Inlet

The status of stock biomass and impact of fishing pressure was evaluated using CPUE and size composition data from fishers participating in an angler diary program. Thers is no commercial fishery for black bream in Mallacoota Inlet.

This assessment found:

- *Fishing pressure* – There is no direct recent information on the amount of fishing pressure on the black bream population in the Mallacoota Inlet. Size composition data shows that larger sizes (>35 cm) are consistently recorded in the catches (Figure 54) suggesting fishing mortality is likely to be relatively low. There have also been consistent catches of undersize fish suggesting recent spawning success.
- *Biomass* – Diary angler targeted CPUE has declined to below the reference period average in recent years, but in 2018 was above the reference period low point (Figure 53). A lower number of sampling trips were recorded in 2018 which is due to less angler participation in the angler diary program, and there are issues about the recent reliability of CPUE.

Stock status summary: Uncertainty in the diary angler decline in CPUE and an overall paucity of recent biomass data means there is no evidence to suggest that this stock is not sustainable. The indication of recent spawning success and larger fish in catches, suggesting that the stock is not recruitment impaired, corroborates a view that this stock is sustainable.

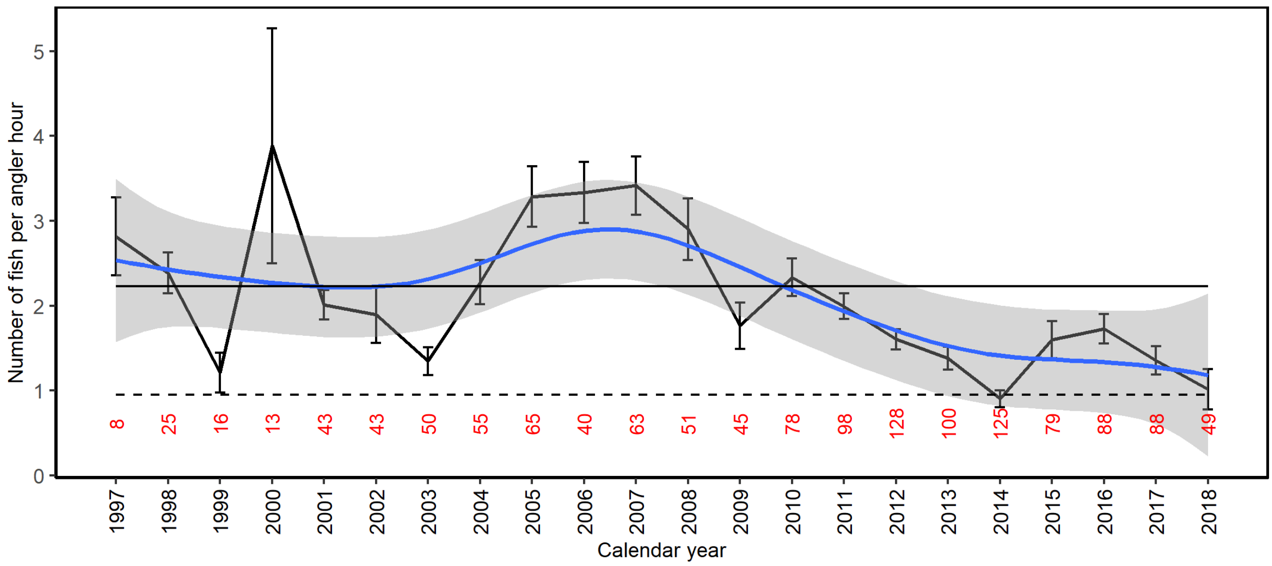
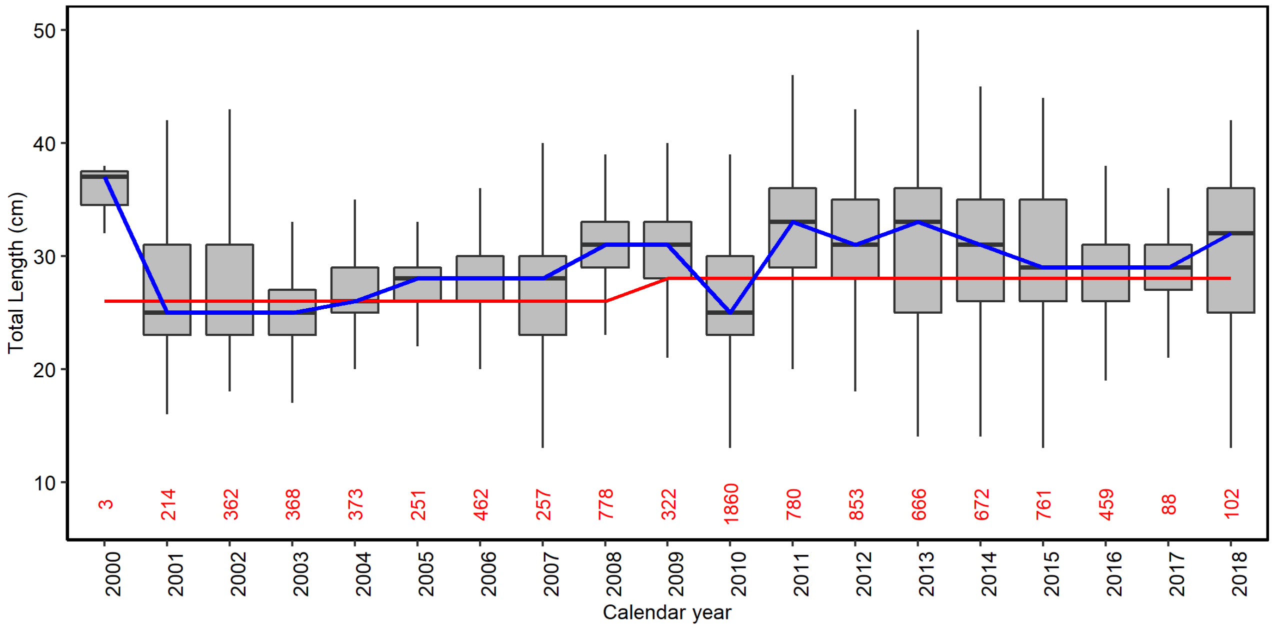


Figure 53 Nominal catch-per-unit-effort **(**CPUE) (±SE) of black bream for diary anglers in Mallacoota Inlet (1997–2018). Horizontal black line is the mean CPUE during the reference period (1997–2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

(a)



(b)

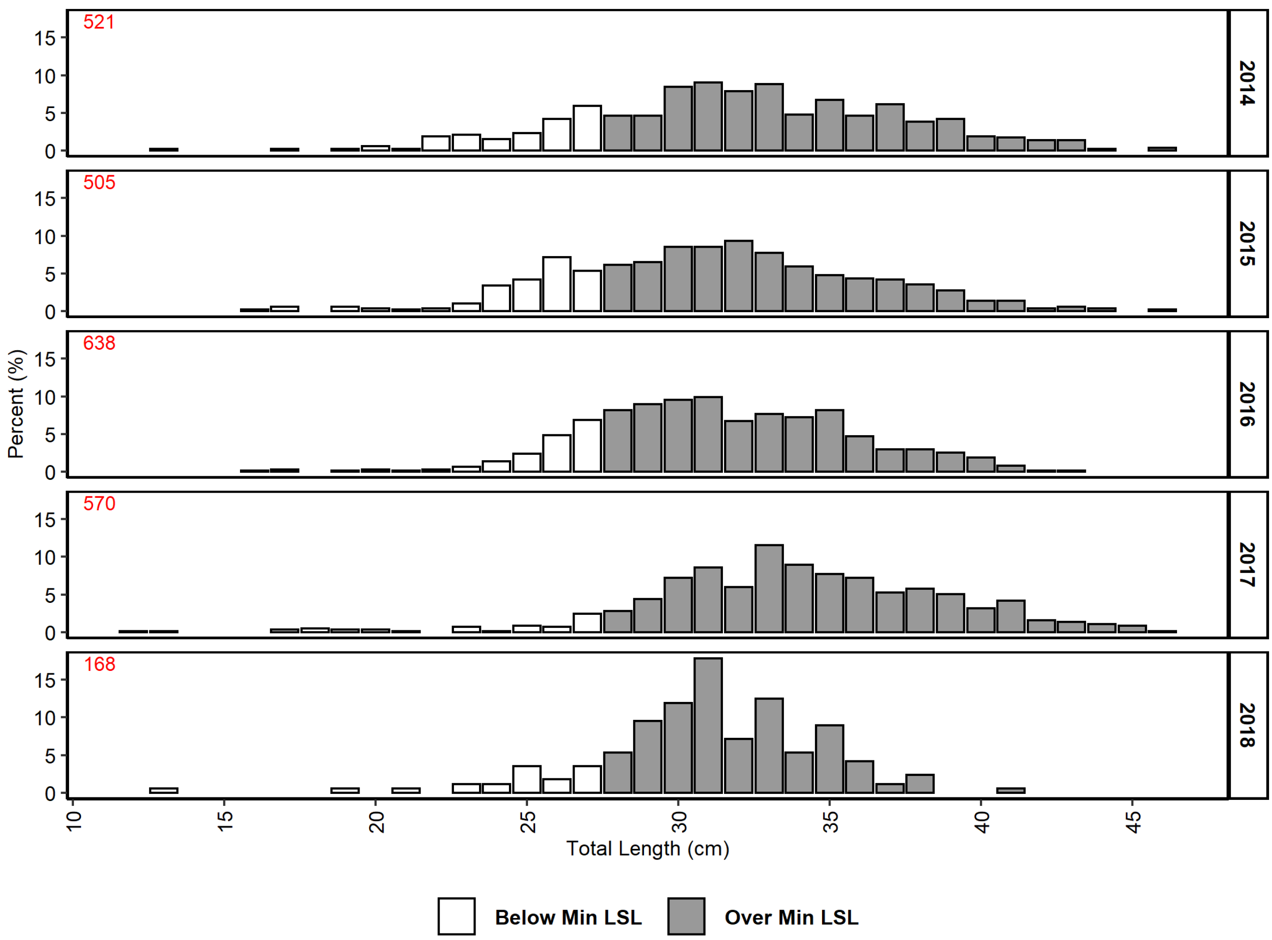


Figure 54 (a) Box-plots of Mallacoota Inlet black bream length composition from diary anglers for calendar years 2000—2018. Red numbers on x-axis indicate numbers of fish measured, blue line is median length, red line is the legal minimum length (LML). (b) Frequency histograms of Mallacoota Inlet black bream length composition from diary anglers for calendar years 2014-2018. Red numbers indicate numbers of fish measured.

Southern Garfish (*Hyporhamphus melanochir*): State-wide

Stock Structure and Biology

The Victorian southern sea garfish population is considered to comprise a single stock that is genetically similar to southern sea garfish in the South Australian gulfs but is distinct from the Tasmanian stock.

Garfish can live to 12 years and grow to 46 cm total length (TL). Size at maturity (50 percent) is reached at approximately 19 months of age and 21 cm TL. There is no LML in Victoria. Garfish have low fecundity and a medium growth rate. The main spawning period is October to March. Bays and inlets are the main spawning areas.

Management/Assessment Unit

Southern sea garfish support recreational and commercial fisheries, with the largest commercial fishery now located in Corner Inlet-Nooramunga (Figure 55) after the removal of most net fishing from Port Philip Bay from 2016. Southern Sea Garfish are an important recreational species in Port Phillip Bay, particularly for land-based anglers fishing from piers. Smaller fisheries are located in Western Port (recreational) and the Gippsland Lakes (recreational and commercial) (Figure 56). This report considers Victorian southern sea garfish as a single stock.

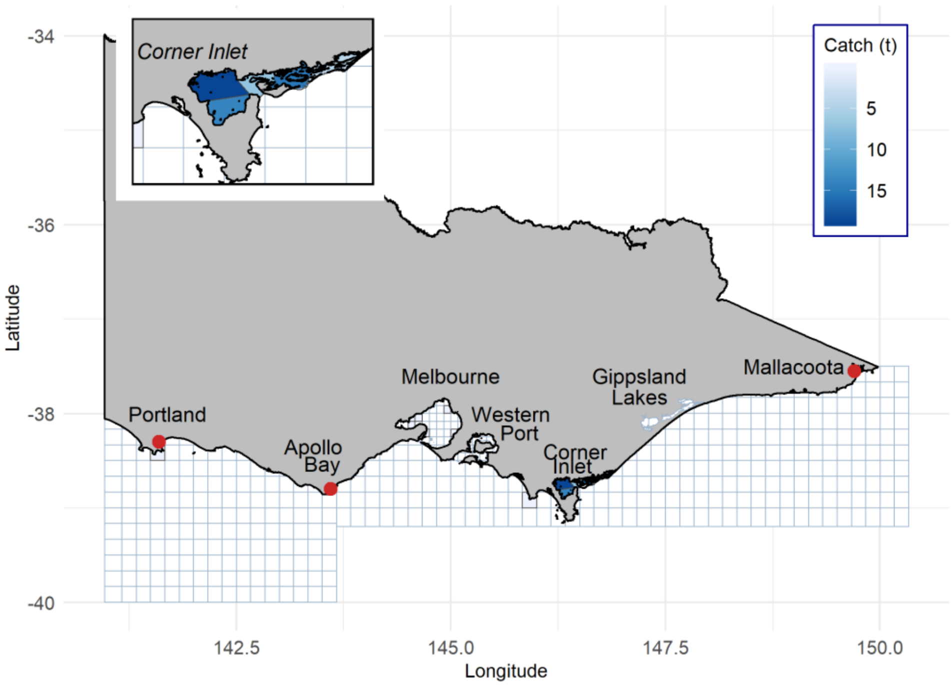


Figure 55 Distribution of commercial catches of southern sea garfish from Victorian waters in 2018/19.

Assessment Summary

State-wide stock

For this assessment the status of the southern garfish stock was evaluated using:

- Nominal CPUE for commercial haul seine harvests in Corner Inlet-Nooramunga and Port Phillip Bay. The performance of the CPUE biomass proxies were assessed in relation to the specified reference level and limit points using a default reference period (1979–2015)
- Commerial catch and effort data.

Recreational fishery data was not available.

This assessment found:

- *Fishing pressure* – Southern garfish are predominantly caught by seine in Corner Inlet-Nooramunga and Port Phillip Bay and the amount of effort has declined in both bays with a switch to more mesh netting in Corner Inlet and a decline in the number of fishers in Port Phillip Bay due to buy-outs (Appendix 2). As a result, southern garfish landings have delined through time (Figure 56) and it is also likely that southern garfish are now discarded by seine fishers in Port Phillip Bay as they are fishing within a mixed species quota management system and southern garfish are less valuable than the main target species. Catches have, however, increased over the last two years in Corner Inlet-Nooramunga, due to increased CPUE (Figure 56 and 57).
- *Biomass* – Due to the issues with retention rates in Port Phillip Bay outlined above, Corner Inlet is used as the primary performance measure for the Victorian southern garfish fishery. CPUE appears to follow a cyclical pattern in which a single year of high catch rate is followed by 2-7 years of low catch rate rate. This is somewhat surprising given the species has relatively low fecundity and is therefore unlikely to show a boom-and-bust population strategy as do short lived highly fecund species. In this instance, the GAM is useful in elliminating some of the variation around this cycling and it indicates there was a general decline in CPUE from 1978-1996 before a stabilisation around the reference period average that has persisted through until 2017 (Figure 57).

Stock status summary: There has been decreasing fishing effort with gears for which southern garfish are susceptible to capture that is unrelated to southern garfish abundance and a relatively stable temporal CPUE trend suggesting that the southern garfish is performing adequately, and stocks are unlikely to be recruitment impaired. CPUE trend is stable and the last two years of CPUE are above the reference period average in the main fishery of Corner Inlet-Nooramunga. Based on the above summary southern sea garfish in Victoria is assessed as sustainable.

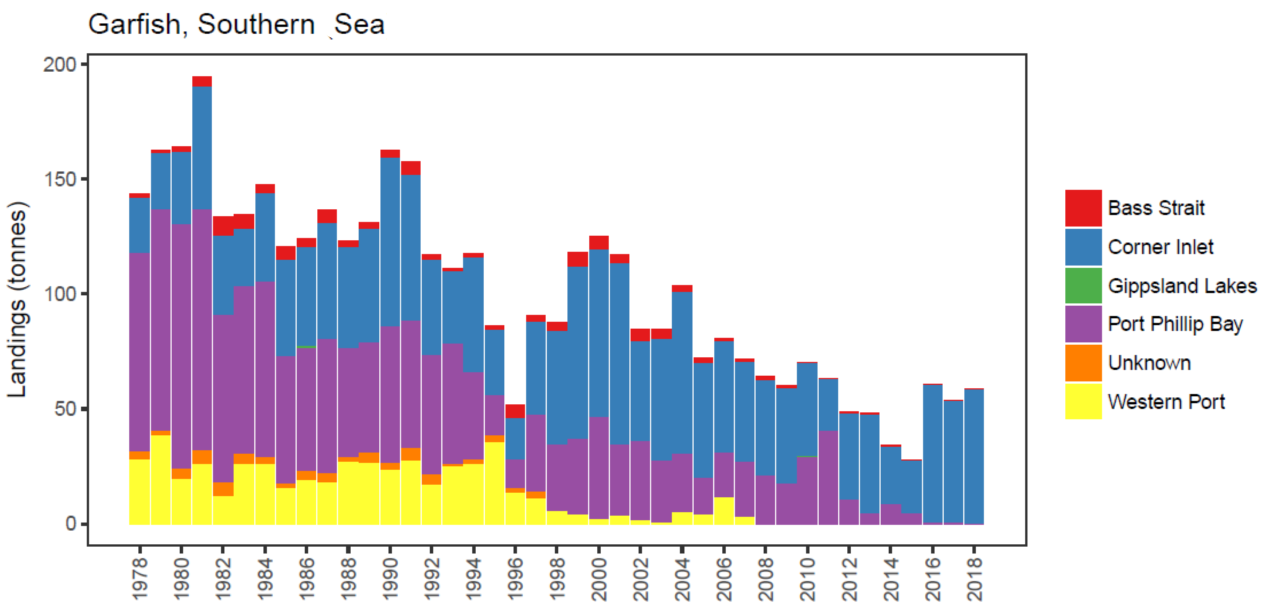
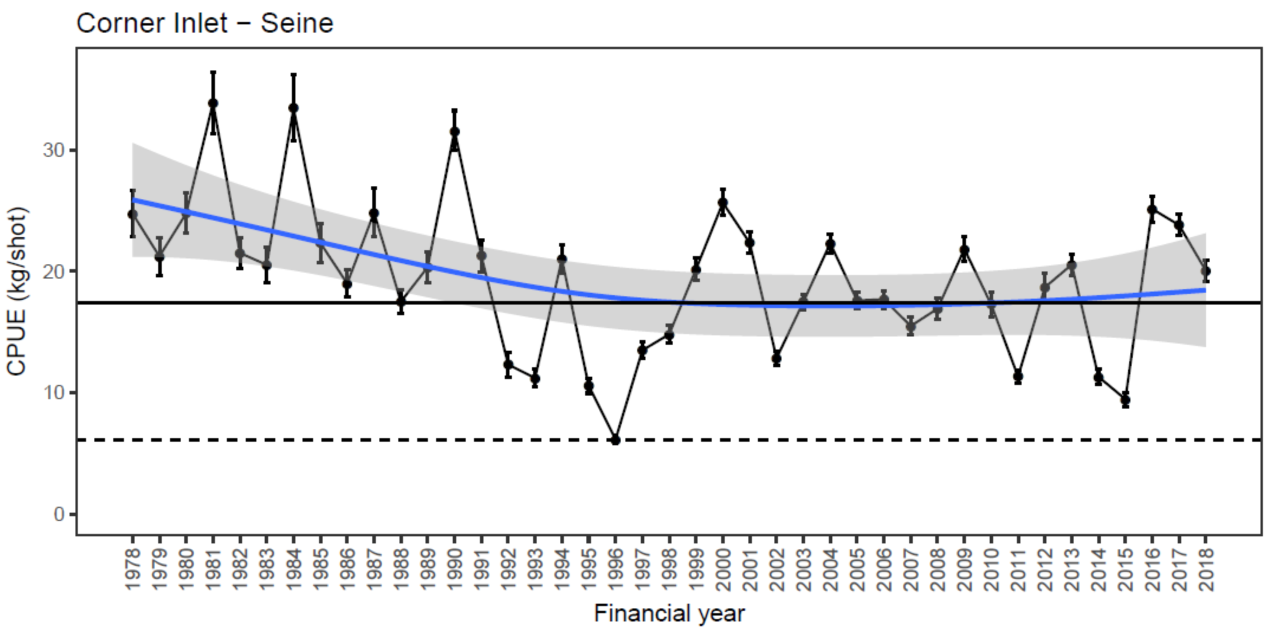


Figure 56 Total commercial harvests of southern sea garfish from Victorian waters, financial years 1978–2018.

(a)



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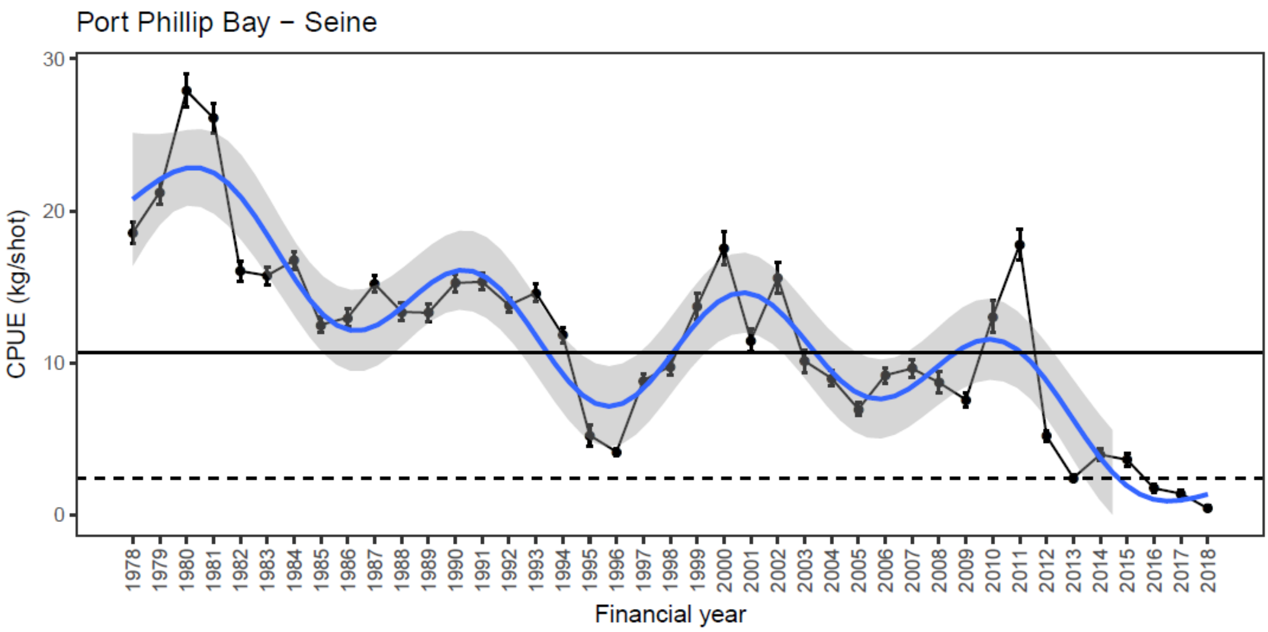


Figure 57 Southern sea garfish nominal catch-per-unit-effort (CPUE) (±SE) for the (a) Corner Inlet haul seine fishery, and (b) Port Phillip Bay haul seine fishery (1978-2018 financial years). Horizontal black line is the mean CPUE during the reference period (1985-2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM)of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

Pipi (*Donax deltoides*): State-wide

Stock Structure and Biology

Genetically, the Victorian pipi population comprises of at least two biological stocks at either end of Bass Strait, centred around Discovery Bay in the west and Venus Bay in the east (Figure 58). There is no biological population parameter information available for Victorian pipi. Locally the biological stock delineation of Pipi remains unclear, by recruits are likely to be self-seeded or to come from nearby, adjacent beaches (Murray-Jones and Ayre 1997). In South Australia, pipi can live to 3–5 years of age and grow to 61 mm SL (shell length) compared with New South Wales populations, where they live to 1–2 years of age and grow to 75 mm SL. In South Australia, maturity (50 percent) is reached at 10 months of age and 28 mm SL and in New South Wales maturity is reached at 1 year of age and 37 mm SL. Pipi are highly fecund and are widely dispersed in the larval stage.

Management/Assessment Unit

Victorian pipi stocks support recreational and commercial fisheries in several main areas. Commercial fisheries occur mainly in Discovery Bay and Venus Bay (Figure 58) and are restricted to four areas across the state. Recreational fisheries occur across the state including coastal beaches, bays and inlets, although the predominant recreational harvest areas are also at Venus and Discovery Bay. This report considers Victorian pipi as a single stock but only Discovery Bay supports a significant fishery, so this location is used to assess the state of the stock.

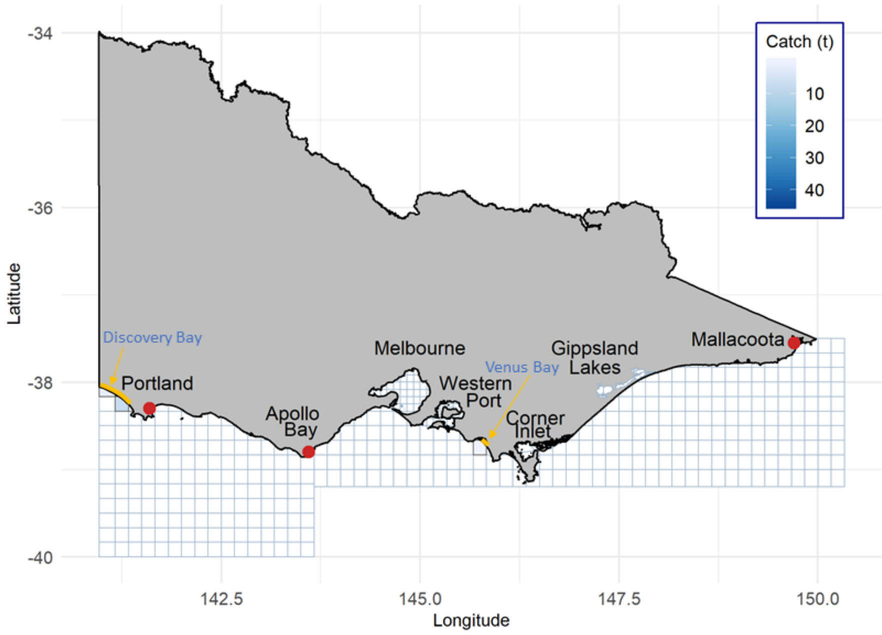


Figure 58 Distribution of commercial pipi catches from Victorian waters during the 2018/19 financial year.

Assessment Summary

State-wide

For this assessment the status of the pipi stock was evaluated using:

- Nominal CPUE trends for the commercial fishery based in the Discovery Bay area. The performance of the CPUE biomass proxy was assessed in relation to the specified reference level and limit points using the reference period 2011–2015.
- Commercial catch and effort data.

Recreational fishery data were unavailable.

This assessment found:

- *Fishing pressure* – The overwhelming majority of pipis are landed from Discovery Bay (Figure 58). Infrequent, small, catches of pipi have been reported since 1990, however it was not until 2011 that the fishery developed and substantial quantities began to be landed (Figure 59). Pipi catch in the 2013/14 year was maintained at 90 tonne, but decreased to 82 tonnes in 2014/15, followed by 58 tonnes in 2015/16 and 42 tonnes in 2016/17 and 2017/18. The reduction in catch was due to the spatial and catch restrictions imposed from 2013 onwards. Upper catch limits were introduced for Discovery Bay in September 2017. Fishing effort increased markedly with the development of the fishery though decreased in 2015 and 2016 before returning to high levels in 2017. It must be noted, however, that inconsistent reporting of gears because the ocean access logbook is poorly designed to record pipi fishing, and the fact that the number of fishers operating on a given day has been incosistently reported, means that fishing effort within this fishery may be inaccurate.
- *Biomass* – CPUE was the lowest on record in 2010 when the commercial pipi fishery was developing, thus the first year was not included in the reference period over which CPUE was averaged. There was then four years of relatively high CPUE followed by a decline in 2015–2016 before an increase over the past two years (Figure 60). During the brief duration of this fishery there have been relatively large shifts in CPUE from >100 kg/hr to ~50 kg/hr suggesting that there have either been large changes in the biomass of pipis in Discovery Bay, or that fishing practices have changed. Either hypothesis is plausible: pipis are a short-lived species and could be expected to exhibit large natural variation in their abundance depending on recent presumably localised recruitment; the reporting of effort for this fishery has varied through time with fishers not initially required to report the number of participants taking part in fishing operations, which may have changed through time thereby confounding the interpreation of CPUE (Figure 61). Additionally, given the brief history of this fishery, the current reference period is liekly to be too short to encompass all of the natural variation over time in the Discovery Bay pipi stocks. Further years of montoring will be required to clearly reveal patterns and trends.

Stock status summary: There is a possibility that effort, and hence CPUE, is inaccurate due to differences over time in what has been reported meaning that there is a possibility that changing fishing practices (e.g. additional people catching pipis under a license) could be masking changes in biomass. Now that the number of fishers is reported in ocean access logbooks it will be important to continue monitor CPUE into the future in conjunction with industry consultation to ascertain whether fishing practices have changed through time. This will assist with determining whether historic CPUE are likely to be biased. Additionally, a significant recreational fishery exists, particularly in Venus Bay and the landings from this fishery are currently unknown. Based on the available information the ciurrent status of the Victorian pipi stock uncertain.

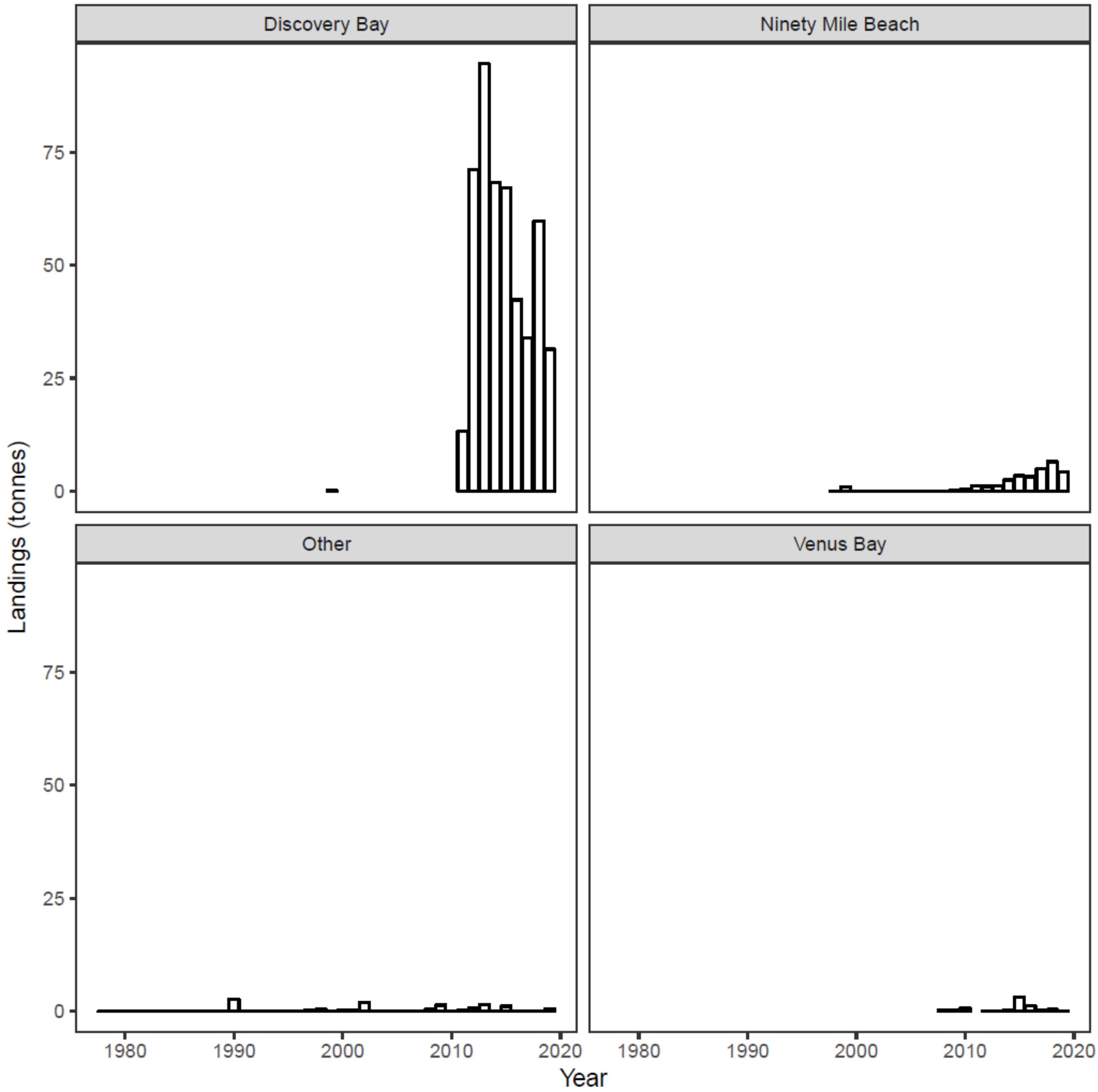


Figure 59 Total Victorian commercial catches of pipi by area, financial years 1978–2018.

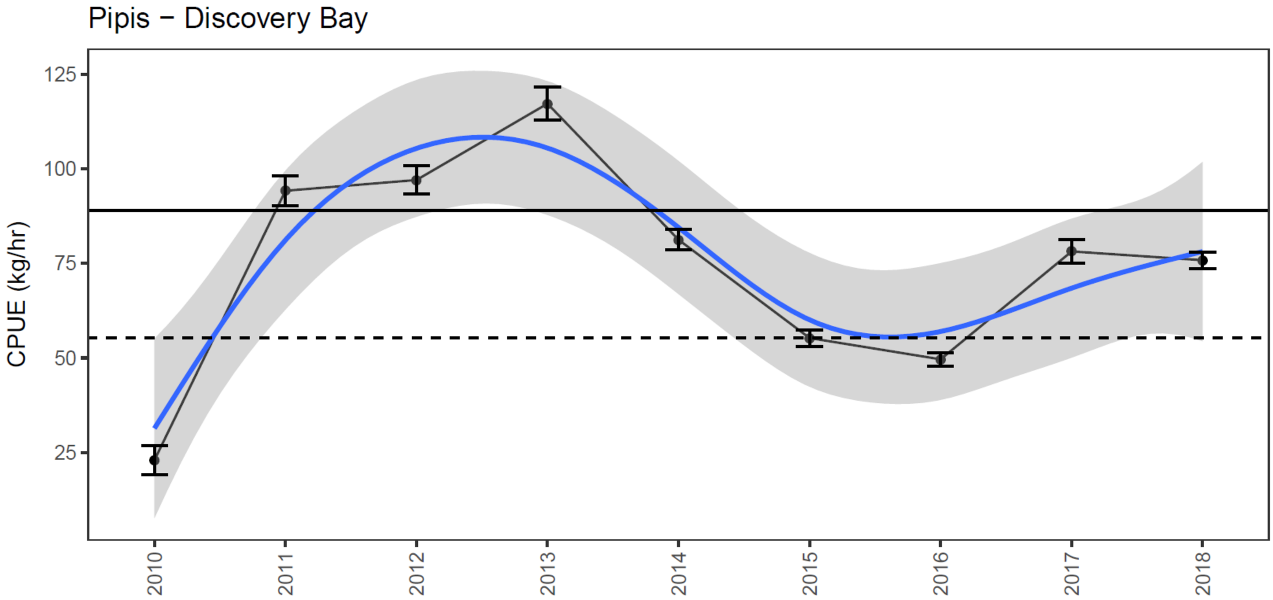


Figure 60 Catch-per-unit-effort (CPUE) in Discovery Bay from 2010–2018 financial years. Black line is nominal CPUE (±SE), blue line is a generalised additive model (GAM) of the CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal solid black line is the mean CPUE during the reference period (2010–2015) and the dashed black line is the minimum standardised CPUE within the reference period. Note: although there was a small catch of pipis by trawl/seine fishers prior 2010, a targeted fishery only began to develop in 2009 in Discovery Bay and during this year there was minimal effort that was not reflective of catch rates in later years, so it was omitted from the time series.

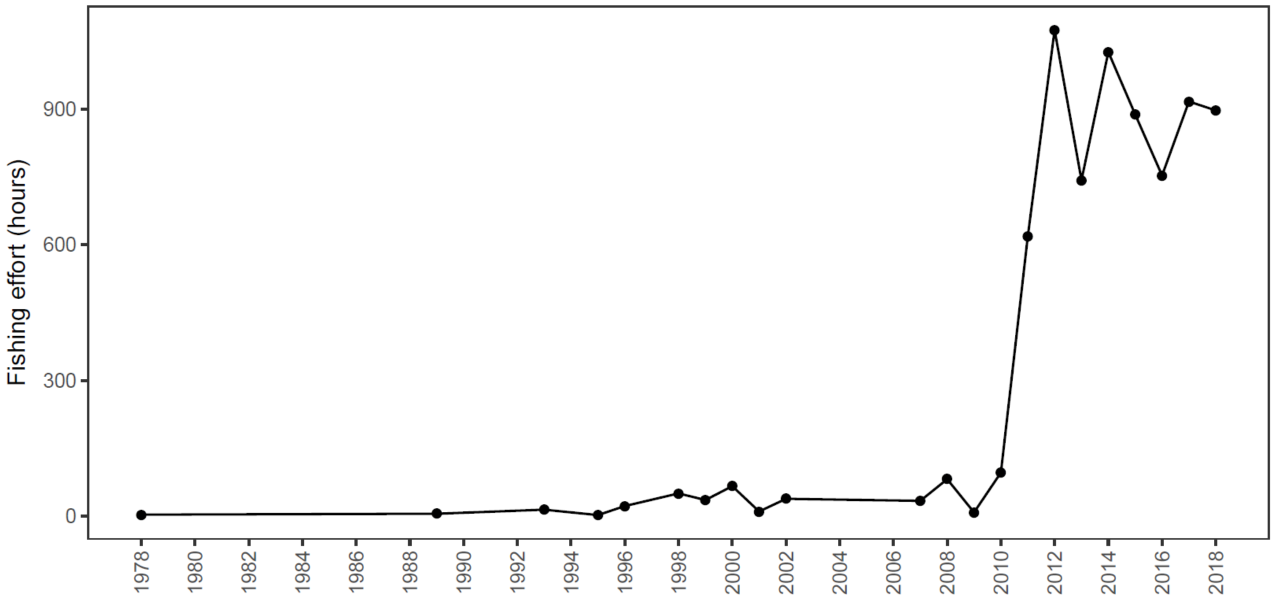


Figure 61 Commercial fishing effort for pipi by the bait and ocean access licenced commercial fisheries (1978–2018 financial years).

Yellow-eye Mullet (*Aldrichetta forsteri*): State-wide

Stock Structure and Biology

Genetically, the Victorian yellow-eye mullet population is considered part of a broader eastern Australian stock. Yellow-eye mullet live to ten years and grow to 44 cm TL. Maturity (50 percent) is reached at 2 to 3 years of age and 20–26 cm TL. Yellow-eye mullet are highly fecund with fast growth. The main spawning period is summer/autumn in inshore coastal regions and the larval stages are widely dispersed.

Management/Assessment Unit

The Victorian component of the eastern Australian yellow-eye mullet stock supports recreational and commercial fisheries. Commercial fisheries occur mainly in Corner Inlet and the Gippsland Lakes (Figure 62). This report considers Victorian yellow-eye mullet as single stock.

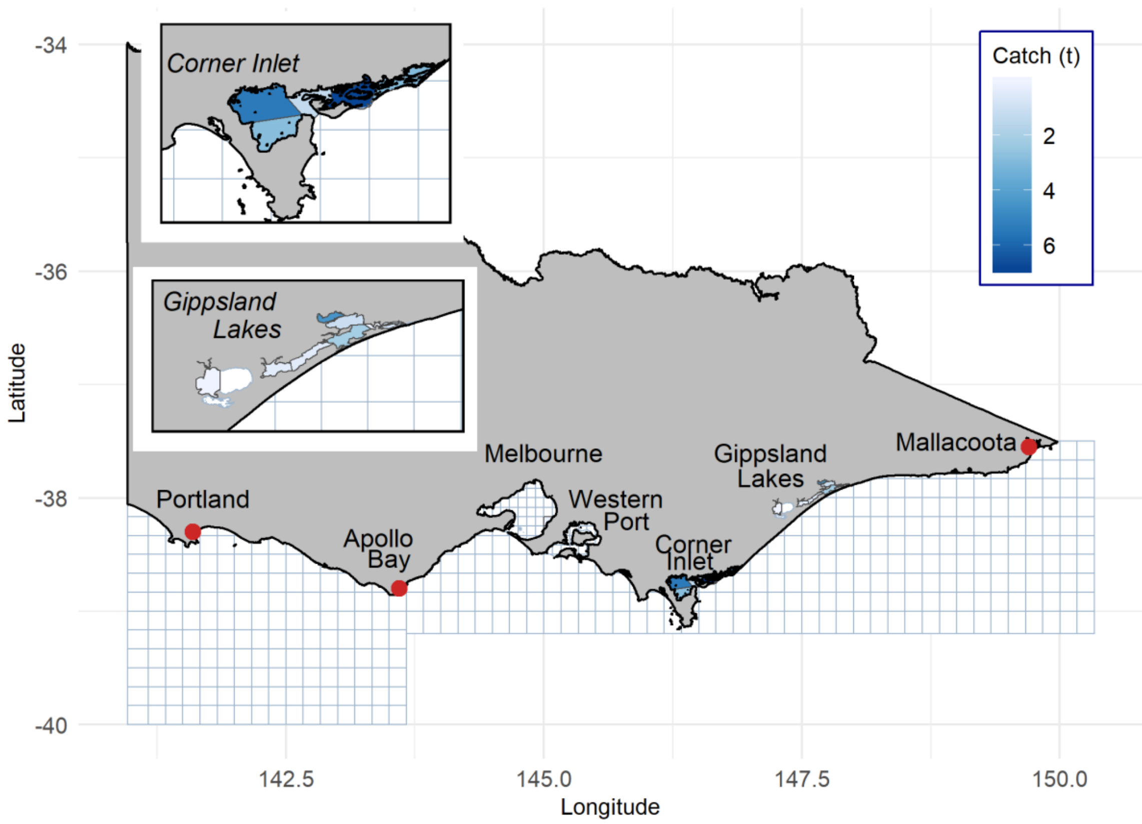


Figure 62 Distribution commercial catches of yellow-eye mullet in Victorian for the 2018/19 financial year.

Assessment Summary

State-wide stock

For this assessment the status of the yellow-eye stock biomass and fishing pressure were evaluated using:

- Nominal CPUE for commercial haul seine and mest net fishing in Port Phillip Bay, Corner Inlet, and Gippsland Lakes (default reference period 1986–2015),
- Commercial catch and effort data.

This assessment found:

- *Fishing pressure* – Commercial catch of yellow-eye mullet has declined to about 10% of its peak in the 1980s (Figure 63). Effort using mesh nets and haul seine, the predominant methods for catching yellow-eye mullet, have also declined in all Victorian commercial fisheries (Appendix 2), and will cease in Port Phillip Bay and Gippsland Lakes in the near future. Recreational harvest is unknown, however, they are not a key target species for recreational anglers in Victoria.
- *Biomass* – Haul seine and mesh net CPUE in Port Phillip Bay had a peak period during the 1980s, but declined from the mid-late 1980s until the early 2000s, and has since stablised and now appears to be increasing. It is currently slightly above the average for 1986–2015 (Figure 64 and 65). A similar pattern with a peak in the early-mid 1980s ocurred for haul seine CPUE in Corner Inlet, with a similar decline until the CPUE stabilised from the early 2000s and is since increased to be slightly below the average for 1986–2015 (Figure 64). In contrast CPUE for haul seine in the Gippsland Lakes, while showing a peak during 1987–1989, has not shown the same long-term declining trend from the late 1980s as observed for Port Phillp Bay and Corner Inlet, but is now showing a steep decline over the past five years to be close to the minimum for the reference period (Figure 64). Mesh net CPUE for Corner Inlet and Gippsland Lakes is higly variable with no long-term trends (Figure 65). Overall, CPUE time series for yellow-eye mullet are highly variable and have been influenced to an unknown degree by variation in the level of harvest retention and reporting. It is thought that in recent decades, due to the low value of yellow-eye mullet, they have often been discarded and therefore the reported CPUE may have been under-estimating abundance.

Stock status summary: The status of yellow-eye mullet in Victoria is problematic to assess due to uncertainty in the interpretation of CPUE and the fact that yellow-eye mullet in Victoria are part of a broader eastern Australian stock. Yellow-eye mullet were classified as 'sustainable' in recent SAFS assessments for Western Australia, South Australia and Tasmania, and as 'recovering' for Victoria. Overall this would suggest the stocks in southern and eastern Australia are in good condition, and coupled with reduced commercial catch and effort in Victoria, mean that yellow-eye mullet in Victoria should recover over time. Nevertheless, whereas Port Phillip Bay from which there has been virtually no commercial catch for the past three years could be considered to be sustainable, and Corner Inlet appears to be recovering, Gippsland Lakes is depleted. Although these differences in trends create some uncertainty in the assessment overall, on balance with the impending cessation of commercial fishing in Gippsland Lakes the state-wide stock status is considred to be recovering.

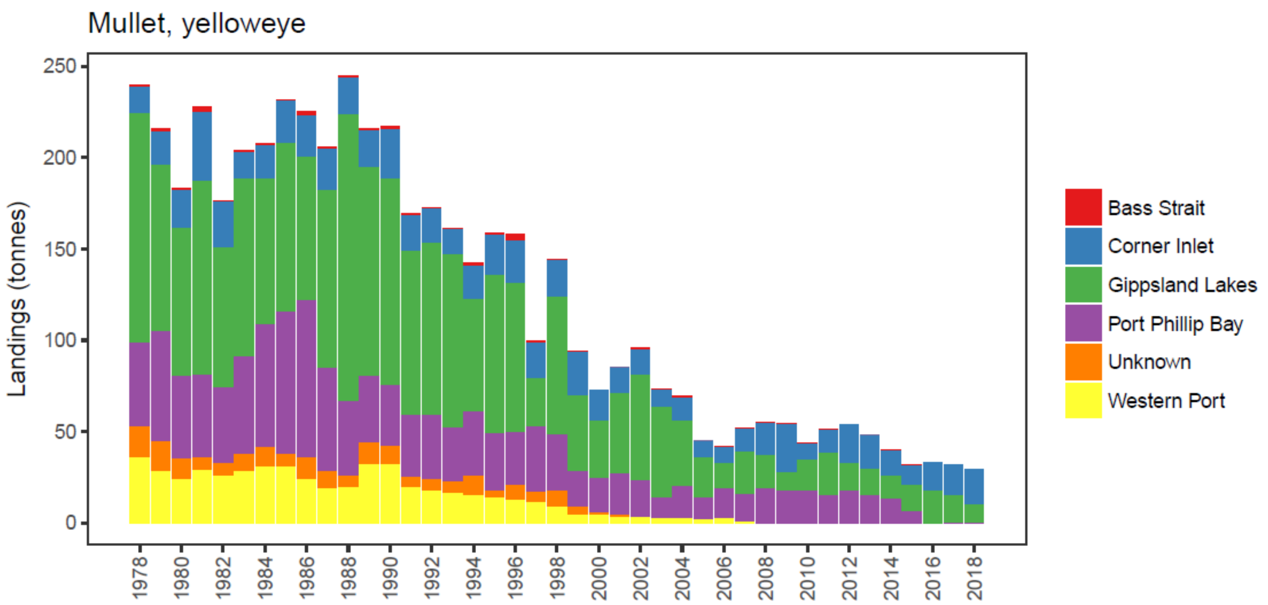
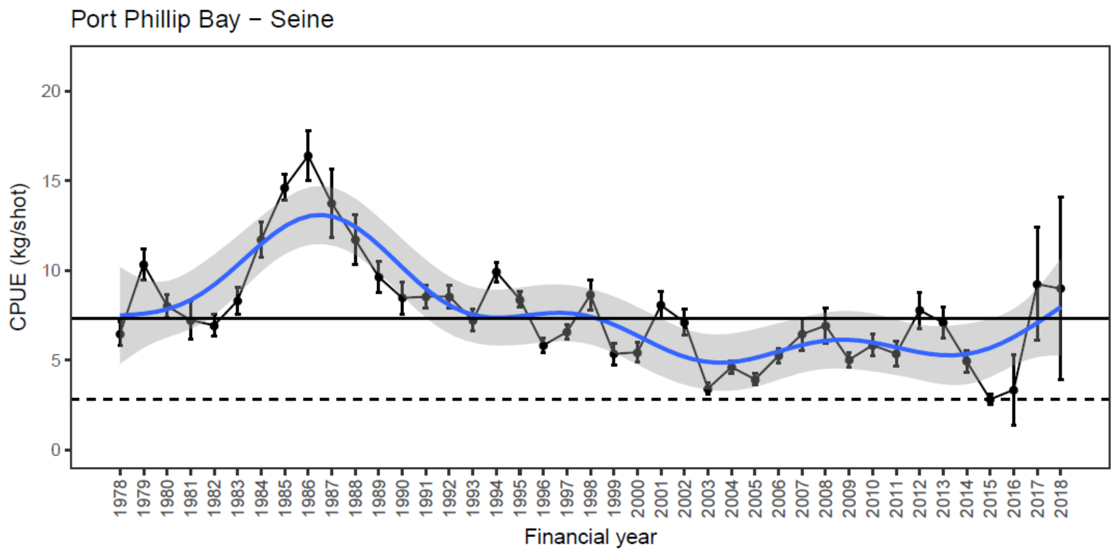
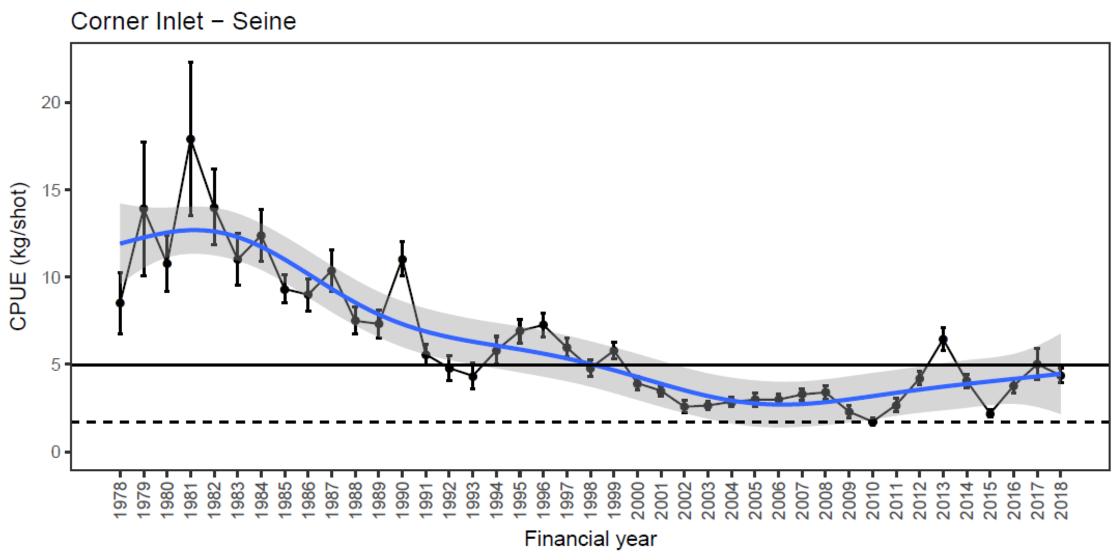


Figure 63 Total Victorian commercial catches of yellow-eye mullet by area, financial years 1978–2018.

(a)



(b)



(c)

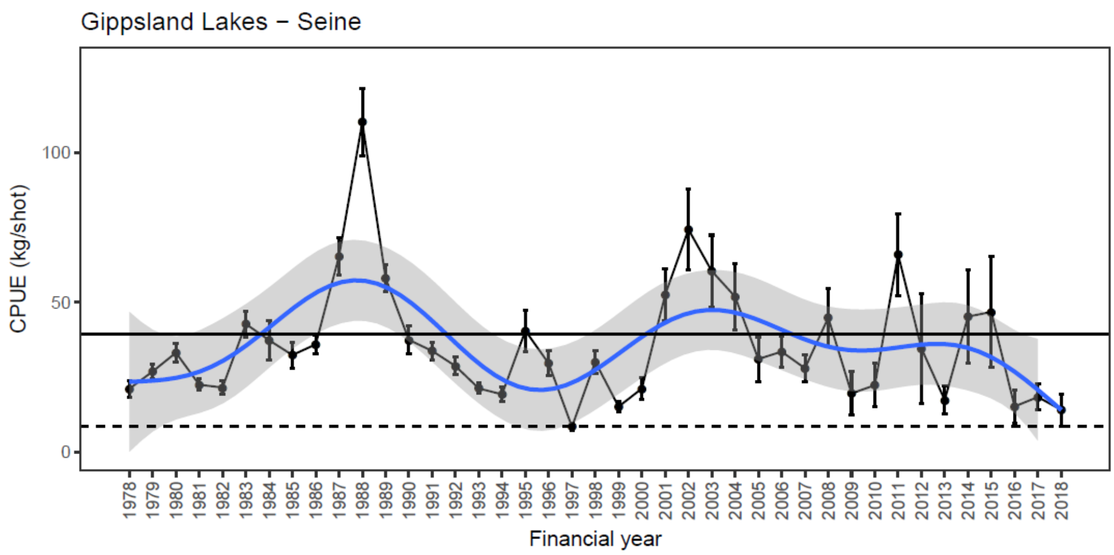
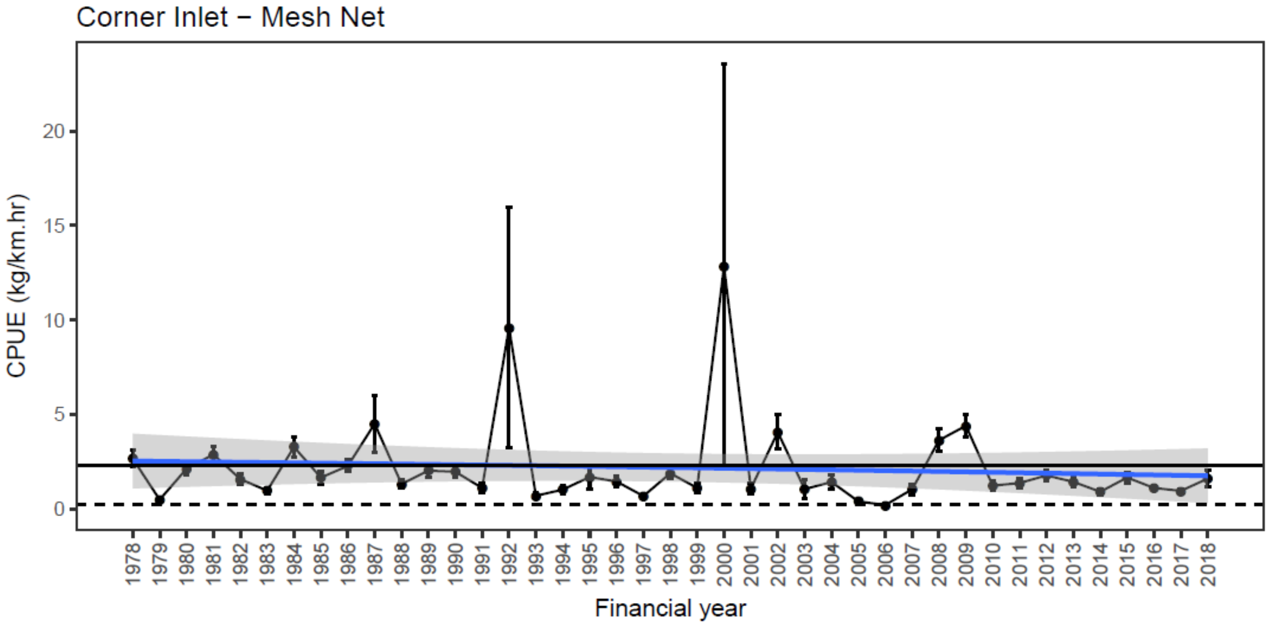


Figure 64 Yellow-eye mullet nominal catch-per-unit-effort (CPUE) (±SE) for; (a) Port Phillip Bay haul seine, (b) Corner Inlet haul seine, and (c) Gippsland Lakes haul seine (1978–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1986–2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

(a)



(b)

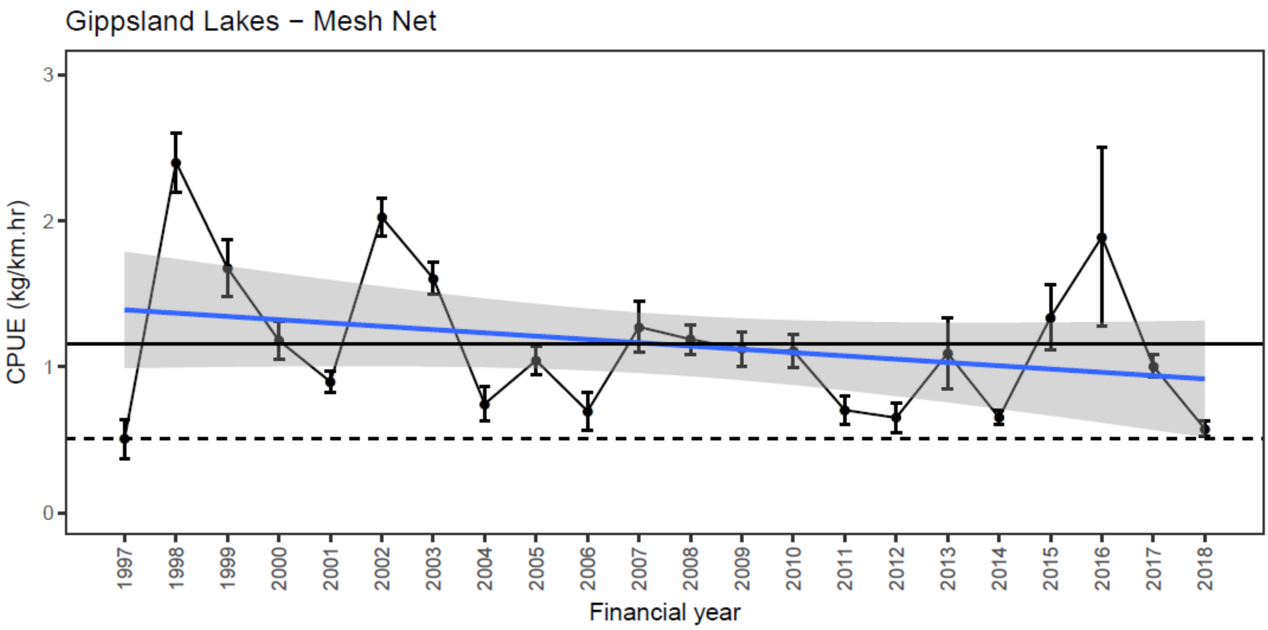


Figure 65 Yellow-eye mullet nominal catch-per-unit-effort (CPUE) (±SE) for; (a) Corner Inlet mesh net, and (b) Gippsland Lakes mesh net (1978–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1986–2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. There has been almost no yelloweye mullet landed in Port Phillip Bay during the last three years.

Rock Flathead (*Platycephalus laevigatus*): Corner Inlet-Nooramunga

Stock Structure and Biology

The stock structure of rock flathead in Victorian waters is unknown. Female rock flathead can live for 21 years and grow to at least 50 cm TL. Male rock flathead only live for 16 years but likewise grow to 50 cm TL. Maturity (50 percent) is reached at 2 years and 23 cm TL (LML = 27 cm TL). Rock flathead are highly fecund and with rapid rates of growth. The main spawning period is spring/summer in inshore coastal regions.

Management/Assessment Unit

Rock flathead primarily supports the commercial mesh-net and haul seine fishery in Corner Inlet (Figure 66). Up until 2016, when the removal of netting was implemented, the species was also important to the Port Phillip Bay commercial fishery. There are very small recreational catches in Port Phillip Bay and Corner Inlet. This report only considers the population of rock flathead in Corner Inlet-Nooramunga, as a single management unit, although the species is also important in Tasmania and the stock structure is not well known.

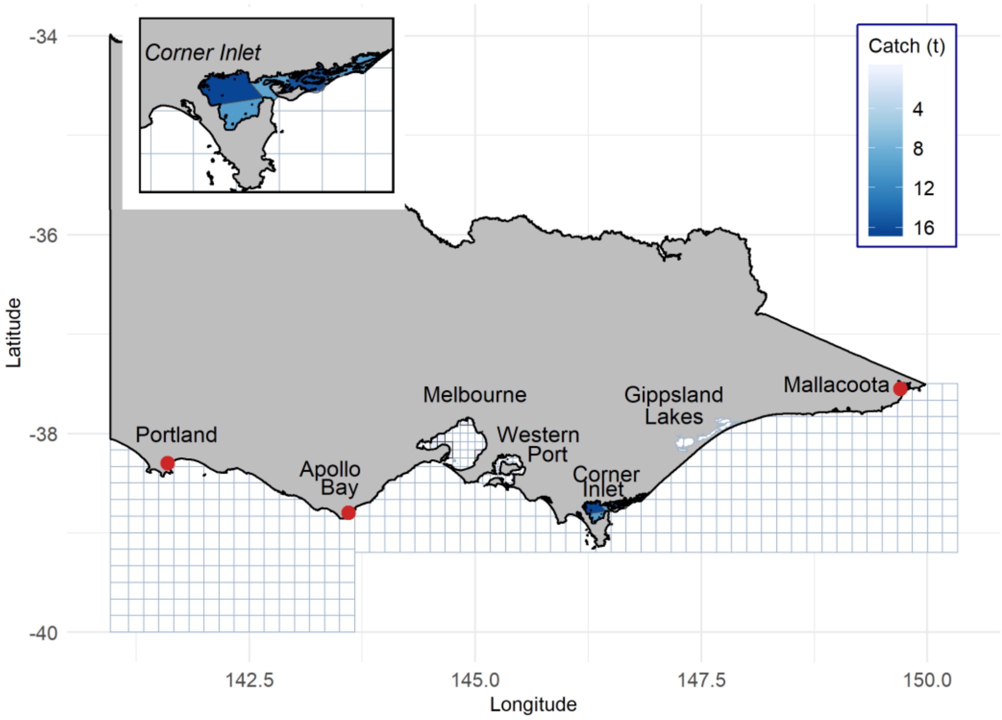


Figure 66 Distribution of commercial catches of rock flathead in Victorian waters during the 2018/19 financial year.

Assessment Summary

Corner Inlet

For this assessment, the status of the Corner Inlet rock flathead population was evaluated using:

- Nominal and standardised CPUE for commercial mesh-net, and nominal CPUE for haul seine,
- Length composition data from haul seine catches,
- Catch and effort data for the Corner Inlet commercial fishery.

This assessment found:

- *Fishing pressure* – At the state-wide scale, harvest of rock flathead has decreased since the peak harvest recorded in 2010 (Figure 67). Over 70% of the peak harvest in 2010 was from Corner Inlet-Nooramunga, and most of the decline in catch, at least until 2016, is due to declines in catch from Corner Inlet-Nooramunga (Figure 67a). While seine net effort has been relatively stable over the last 10 years, after declining to about 50% of the peak level observed in the early 2000s, mesh net effort has increased considerably since the lowest levels in the early 2000s (Appendix 2). Mesh net effort in 2017/18 was similar to previous peak levels observed in 1979/80 (Appendix 2). Length composition of seine net catches, which are less affected by selectivity bias than mesh nets, have been relatively stable, with fish up to 55 cm still being captured, and the dominant length categories being in the 28-31 cm length range (Figure 69a, b).
- *Biomass* – CPUE by mesh net is highly variable, with regular peaks at approximate 5-year intervals, and an underlying increasing trend from the early 1980s to the mid-2000s (Figure 68a). Since the mid-late 2000s the underlying trend has been decreasing, and after a short-lived increase in 2015, recent mesh net standardised CPUE is halfway between the reference period average and low point (Figure 68a). Seine net CPUE had a major peak from 2009 to 2011 (also observed in mesh net CPUE), but similar to mesh nets, has since declined and has recently been stable at around the reference period average (Figure 68b).

Stock status summary: Overall, while regular peaks in CPUE likely relate to recruitment variation, the underlying trend of a declining mesh net CPUE is noteworthy, more so because of recent increases in mesh net effort and catch. While the length composition has been stable with a consistent presence of large fish in the catches, the combination of decreasing CPUE, increasing effort and increasing catch of rock flathead in Corner Inlet-Nooramunga may result in further stock decline.

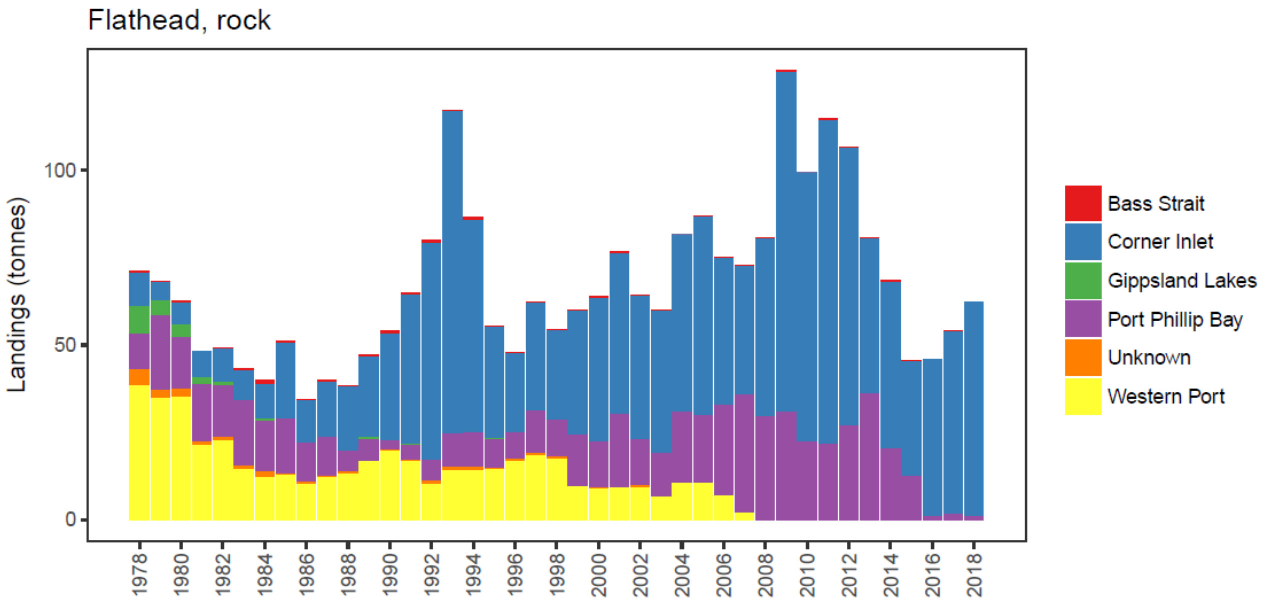
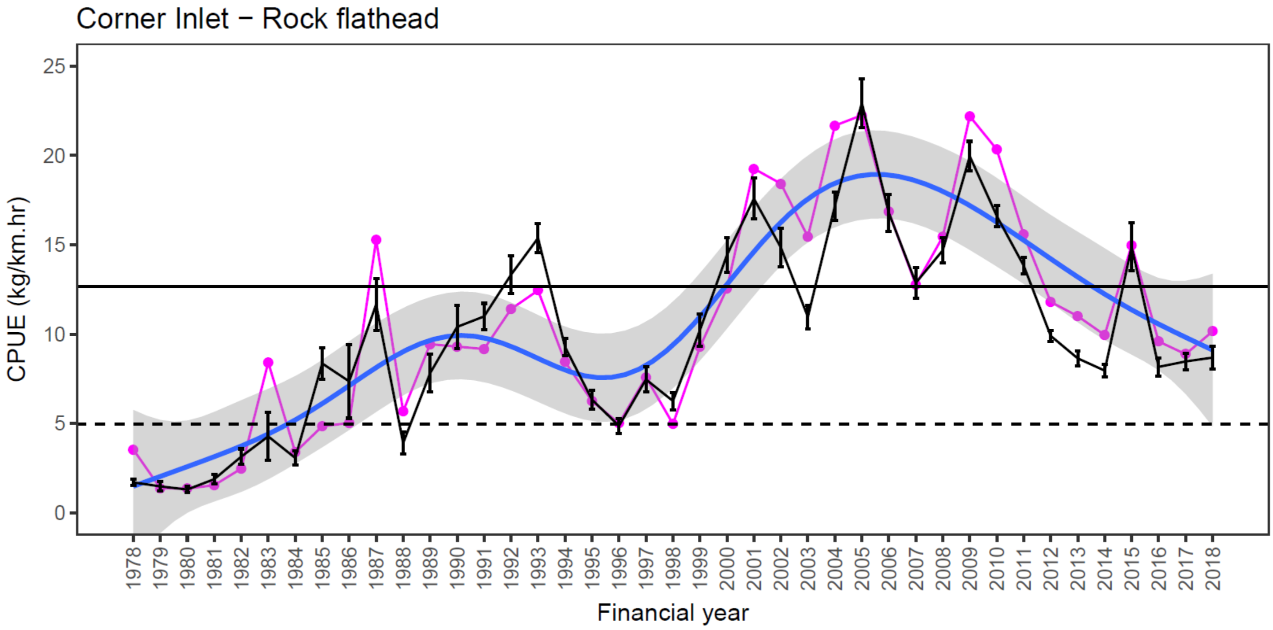


Figure 67 Total Victorian commercial catches of rock flathead by (a) area and (b) gear types, financial years 1978–2018.

(a)



(b)

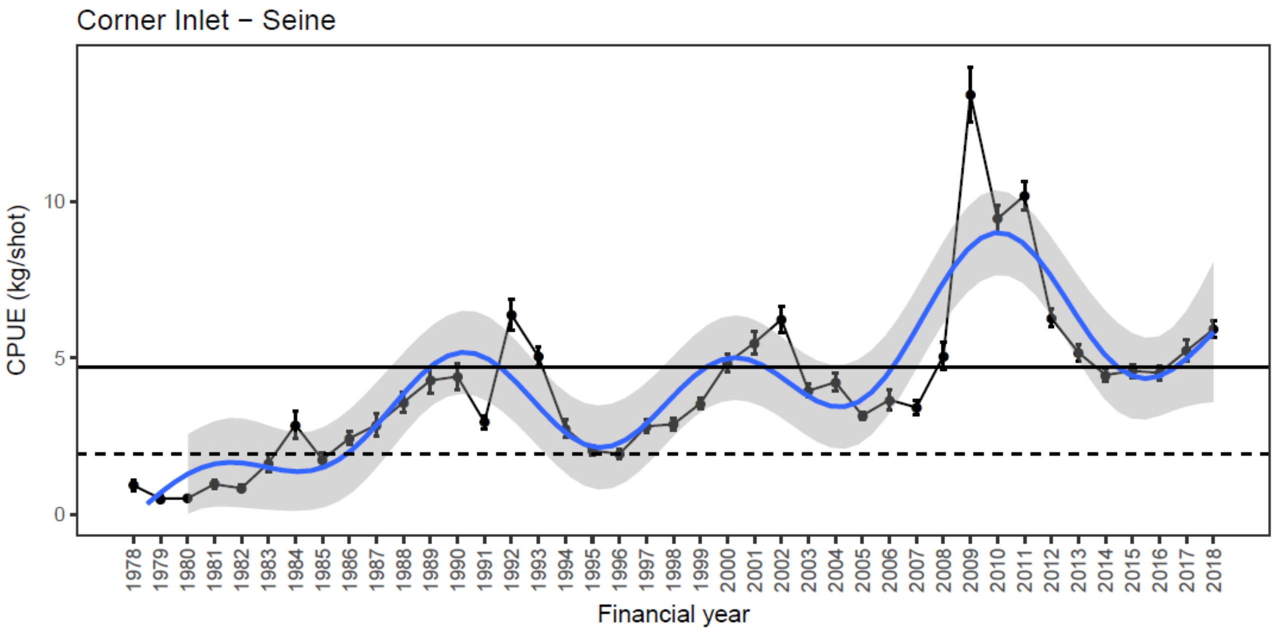
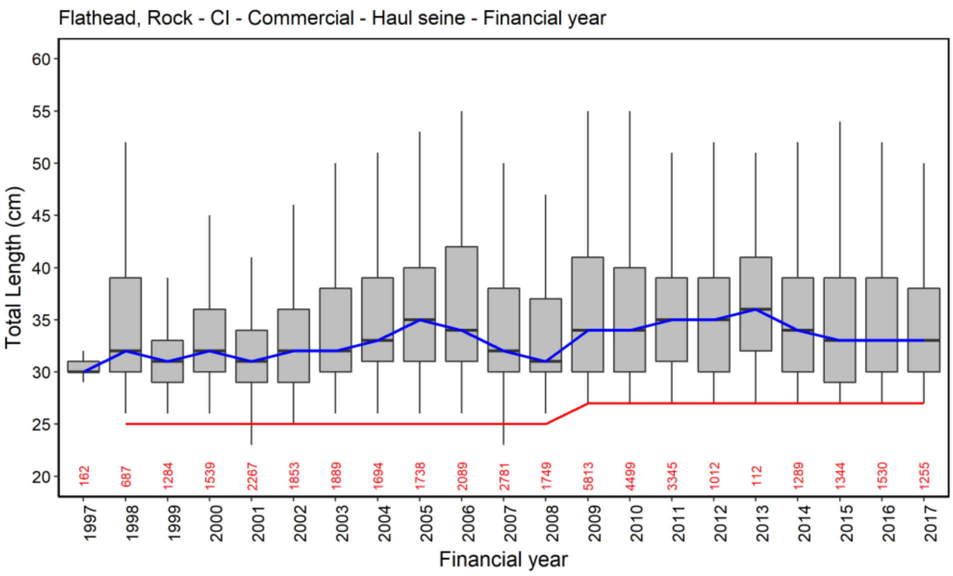


Figure 68 Catch-per-unit-effort (CPUE) of rock flathead by (a) commercial mesh net, and (b) seine net in the Corner Inlet during 1978–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (1986–2015) and the dashed black line is the minimum standardised CPUE within the reference period.

(a)



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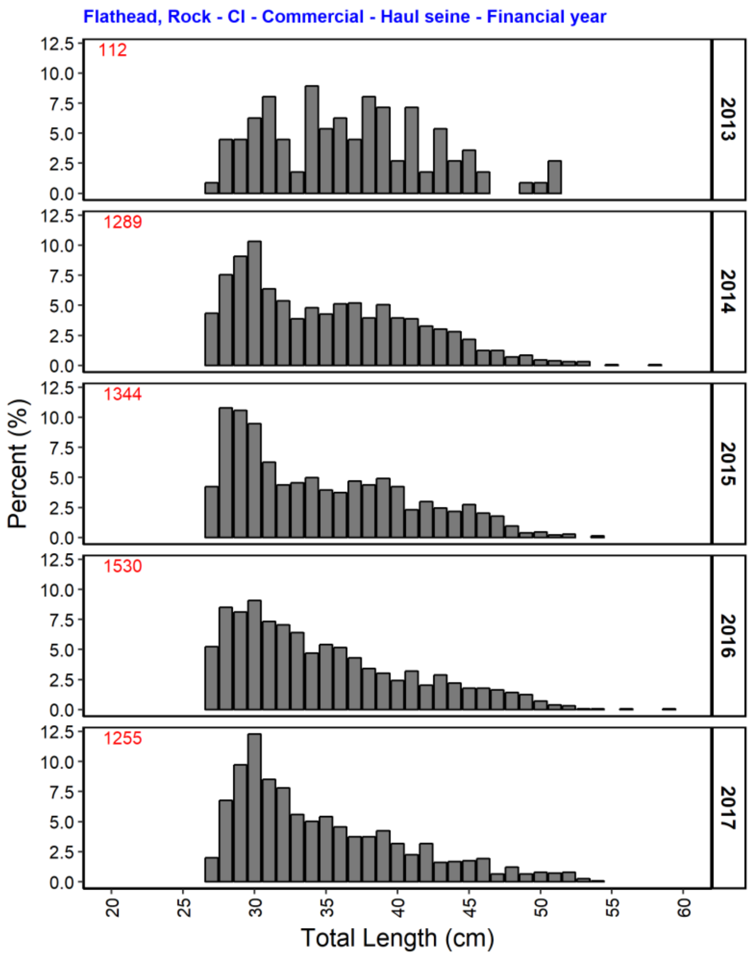


Figure 69 (a) Box-plots of Corner Inlet rock flathead length composition from haul seine catches financial years 1997-2018. Red numbers on x-axis indicate numbers of fish sampled. Blue line = median length, red line = LML. (b) Frequency histograms of Corner Inlet length composition from haul seine catches financial years 2013–2018. Red numbers indicate numbers of fish measured scaled to catch sample weight.

Southern Calamari (*Sepioteuthis australis*): State-wide

Stock Structure and Biology

The population of southern calamari in Victorian waters is genetically similar and considered a single stock with phenotypic variation. Southern calamari live for less than 1 year and grow to 55 cm mantle length (ML). Maturity (50 percent) is reached at 3 to 6 months /15-20 cm ML (LML = 27cm TL). Calamari are moderately fecund and are fast growers. The main spawning period is spring/summer in inshore coastal regions with eggs laid in seagrass and reef algal habitats.

Management/Assessment Unit

The Victorian southern calamari population supports commercial fisheries in Corner Inlet and Port Phillip Bay (Figure 70). There are also recreational fisheries in Port Phillip Bay, Corner Inlet, Western Port and coastal waters. This report considers the Victorian population calamari a state-wide stock.

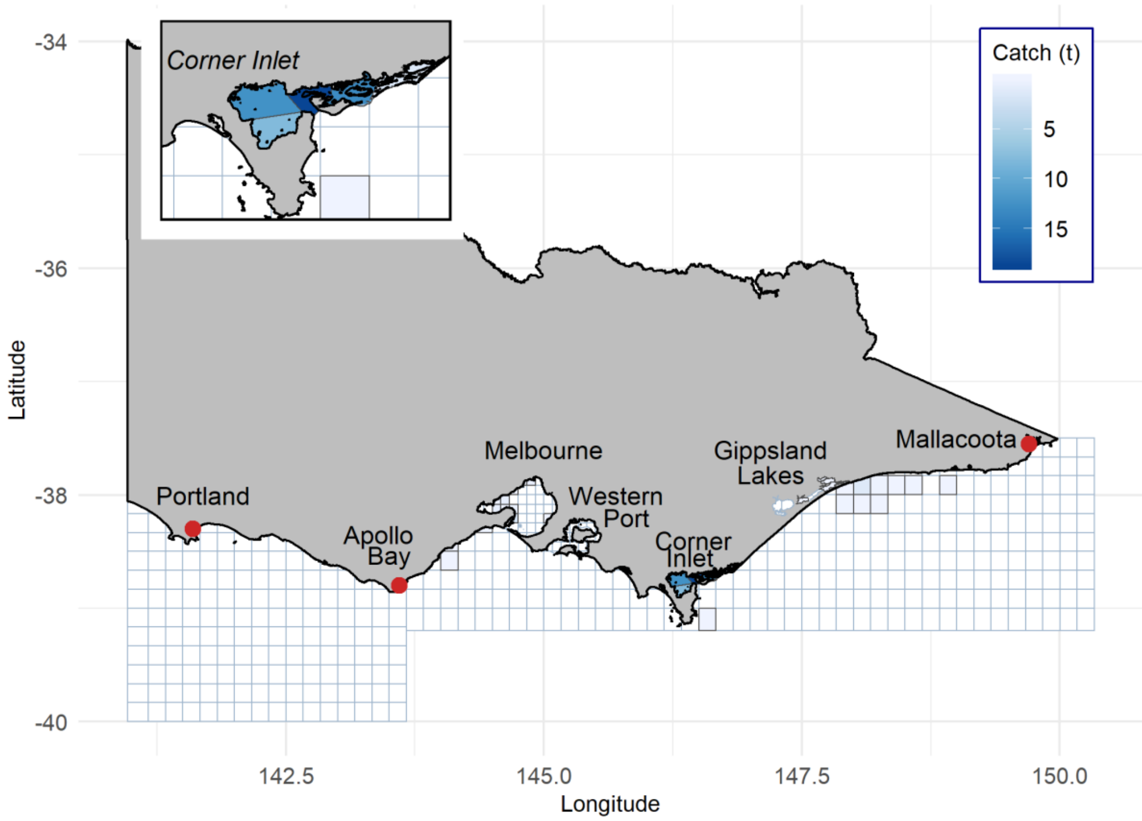


Figure 70 Distribution of commercial southern calamari catches from Victorian waters during the 2018/19 financial year.

Summary of the Assessment

Corner Inlet

For this assessment, the status of the Corner Inlet southern calamari population was evaluated using:

- Nominal CPUE for commercial fishery haul seine in Port Phillip Bay and Corner Inlet. The performance of the haul seine CPUE biomass proxies was assessed in relation the specified reference level and limit points using the reference period 1979–2015 for the haul seine fishery
- Nominal CPUE for recreational fishers targeting calamari in Port Phillip Bay. The performance of the recreational CPUE biomass proxies was assessed in relation to the average and minimum values of standardised CPUE during reference period.
- Commercial catch, and effort data.
- Calamari size composition from surveyed samples of recreational fishery catches.

This assessment found:

- *Fishing pressure* – Commercial catches of calamari are almost entirely taken by seine net. Prior to the 1990s squid jig was also important, but effort by squid jig has virtually ceased in all bays and in Bass Strait (see Appendix 2). There has been a decline in seine effort in all bays and inlets with Corner Inlet-Nooramunga the only fishery continuing to use this gear for much of the fishing effort, and now accounting for most of the commercial catch (Figure 71). State-wide the commercial catches have declined by over 60% from a peak period during the early 2000s.
- *Biomass* – CPUE of commercial seines has remained above the reference period average for the last 3–4 years in both Corner Inlet-Nooramunga and Port Phillip Bay (Figure 72). Recreational CPUE from creel surveys has generally been between the reference period average and minimum since 2006, with the 2007 catch rate marginally above the reference period average (Figure 73).

Stock status summary: There has been decreasing commercial seine effort in most fisheries, which is associated with buy outs in Port Phillip Bay and Western Port and a transfer of effort in Corner Inlet from seining to mesh netting (see Appendix 2). This decreasing seine effort is not associated with declining southern calamari catch rates. Given southern calamari only live for a maximum of one year, the available stock within any given year is reflective of annual spawning success and interannual changes in catch rate likely reflect this aspect of their population biology. There is no evidence to suggest recruitment impairment and in the context of their biology and the relatively low level of fishing pressure the stock is expected to remain sustainable into the future.

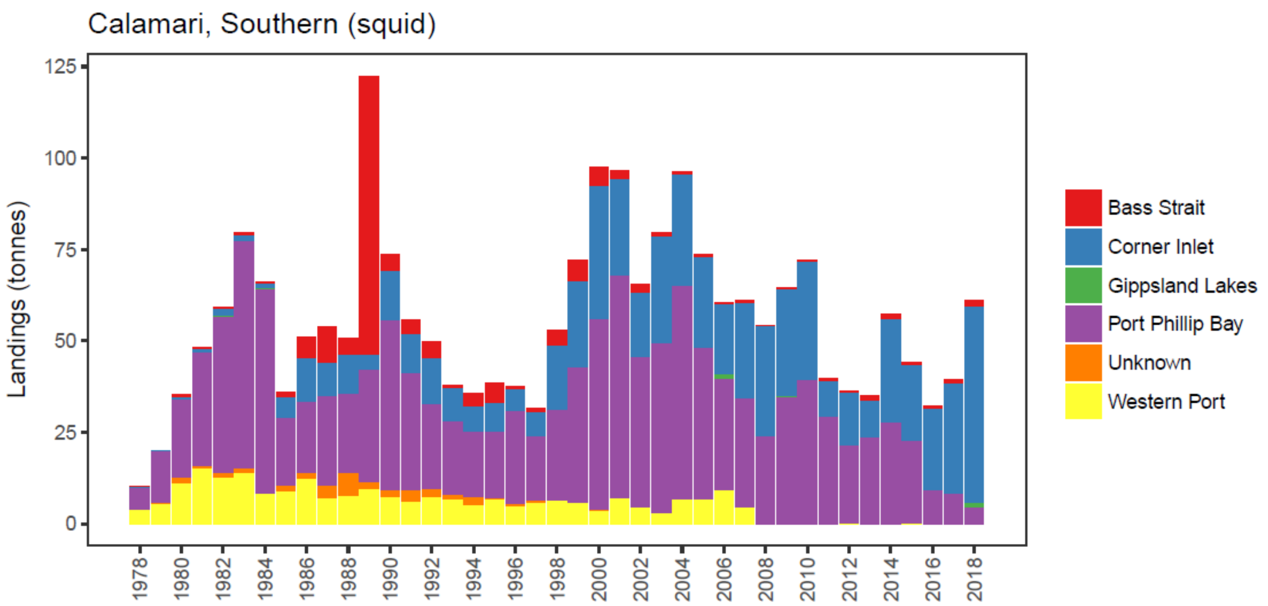
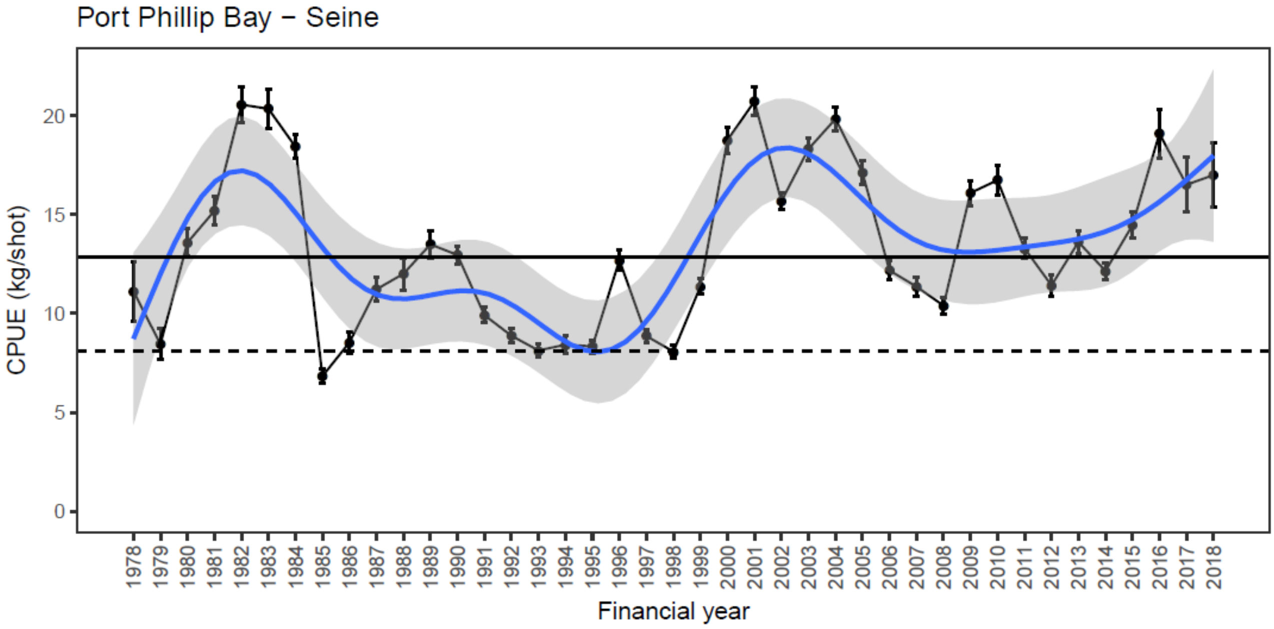


Figure 71 Total commercial catches of southern calamari by area in Victorian waters, 1978–2018 financial years.

(a)



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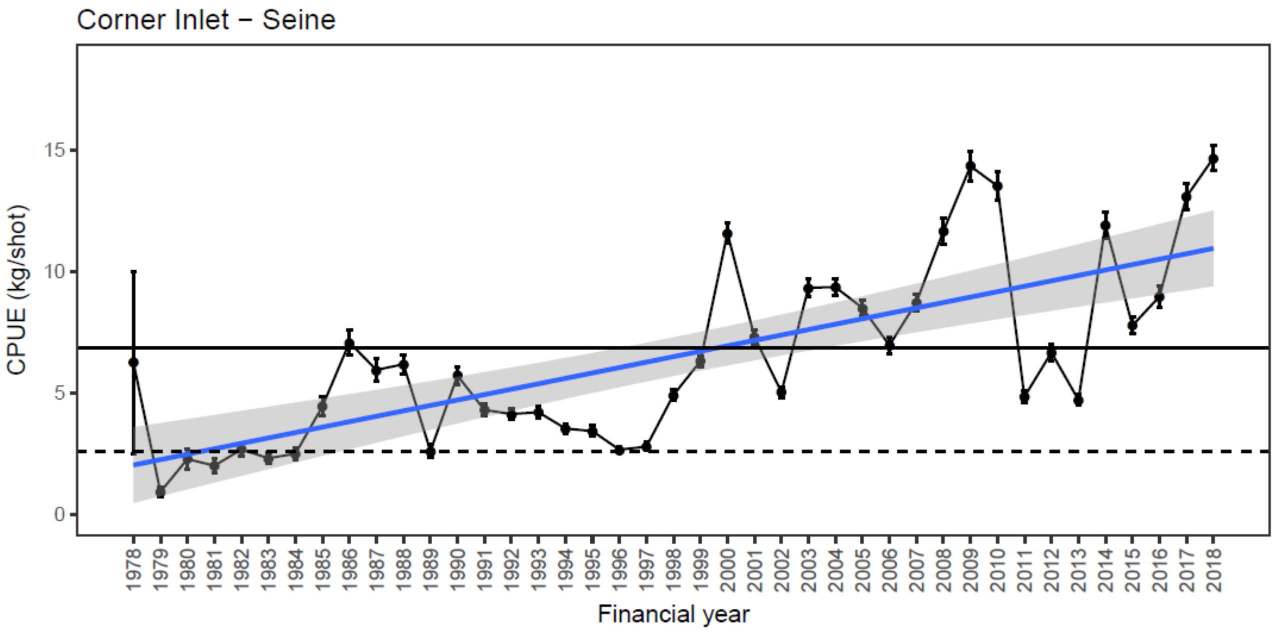


Figure 72 Southern calamari nominal catch-per-unit-effort (CPUE) (±SE) for (a) Port Phillip Bay haul seine, and (b) Corner Inlet haul seine (1978–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1985–2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

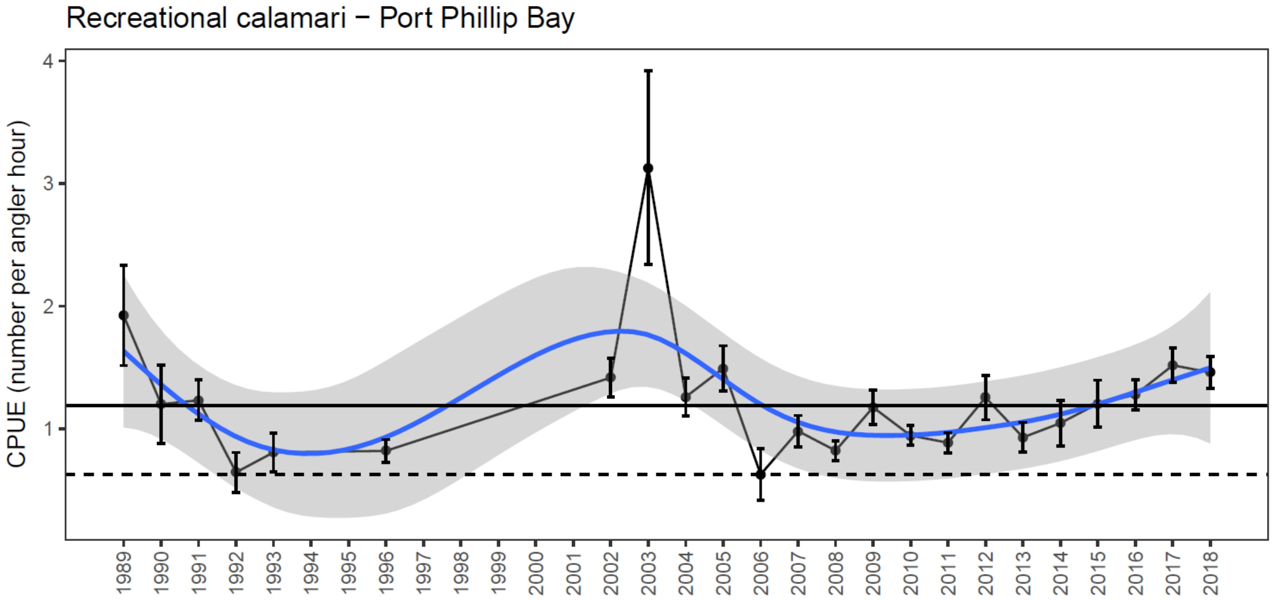


Figure 73 Southern calamari nominal catch-per-unit-effort (CPUE) (±SE) for the Port Phillip Bay recreational fishery from boat ramp creel surveys (financial years 2004–2016). Horizontal black line is the mean CPUE during the reference period (1989–2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

Bluethroat and Purple Wrasse (*Notolabrus tetricus* and *N. fucicola*): Coastal Waters

Bluethroat Wrasse **Purple Wrasse**

Stock Structure and Biology

Wrasse are reef dwelling species with a single male dominating a “harem” of females. Aside from this aspect of biology where females of some species greatly outnumber males, stock structure of wrasse in Victorian waters is uncertain. Bluethroat Wrasse live to 23 years and males can grow to over 50 cm total length (TL). Purple Wrasse live for up to 24 years and grow to over 45 cm total length (TL). Maturity (50 percent) for blue throat wrasse is reached at four to eight years (20–30 cm TL), and for Purple Wrasse at three years (18 cm TL). Bluethroat wrasse can change sex (female to male) from 5 years of age in response to the loss of a dominate male. Purple wrasse do not change sex and males and female reach similar sizes. Wrasse are highly fecund and are fast growers. The main spawning period is spring. Wrasse are territorial inhabiting specific reefs.

Management/Assessment Unit

Victorian wrasse populations support mostly local port-based commercial fisheries (Figure 74). The Victorian fishery predominantly uses hook and line to harvest wrasse from in-shore waters (<30m depth) year-round for the live fish restaurant market. There is also a small recreational fishery. This report considers the Victorian wrasse fishery as western, central and eastern assessment zones, although the fishery is managed at a state-wide scale.

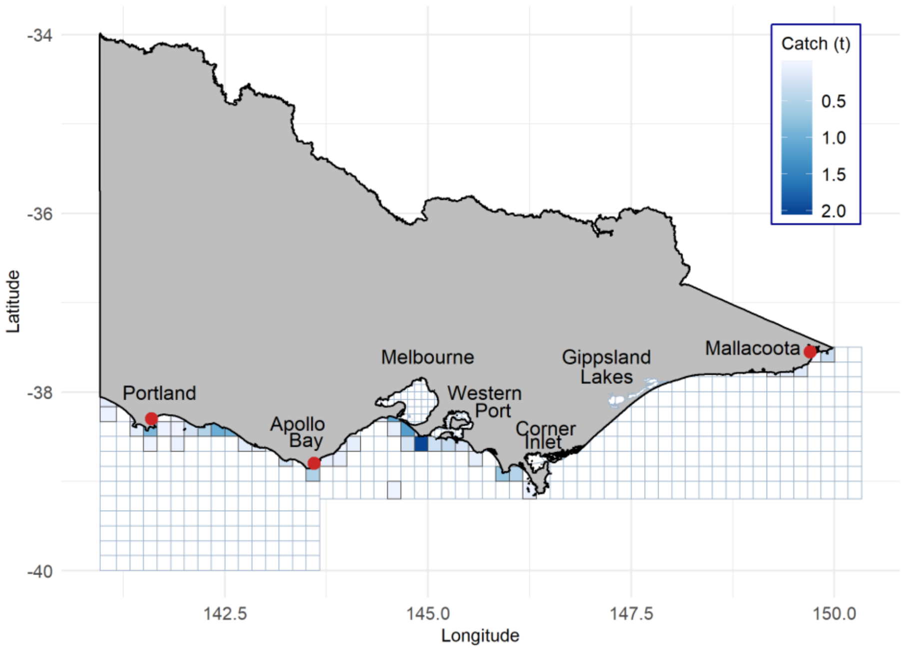


Figure 74 Spatial distribution of state-wide landings of wrasse (Bluethroat & Purple Wrasse only) from Victorian fisheries during the 2018/19 financial year.

Assessment Summary

For this assessment, the status of the Victorian wrasse commercial fishery (both blue throat and purple wrasse combined) was evaluated using:

- Nominal and standardised CPUE by hand-line for the commercial fishery separated into western, central and eastern zones.

  NOTE: CPUE is based on catches combined across species as reporting at the species was unreliable during earlier years. Nevertheless, most of the catch (~90%) was Bluethroat Wrasse. The reference period used for wrasse is 1998–2015, avoiding the initial peak in harvests, much of which was marketed dead under 'Offshore Fishery Access Licences (OFAL)', and consequently does not reflect the current fishery operations and stand-alone 'Ocean Wrasse (OW)' licence arrangements.

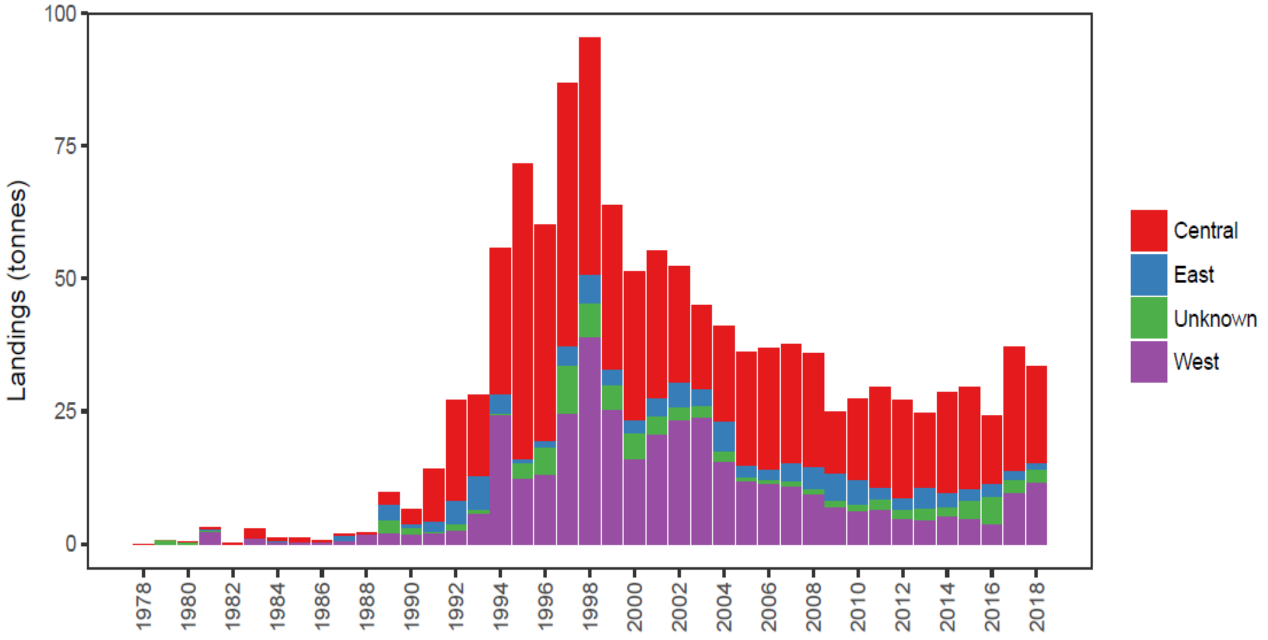
- Commercial catch and effort data.

This assessment found:

- *Fishing pressure* – Harvests of wrasse increased rapidly to around 90 tonnes/year when a market for wrasse established in the early 1990s. However, the challenging nature of wrasse fishing, and the market preference for live fish, saw many OFAL fishers cease to target them. By 2010 state-wide harvest had declined to the current levels of 20–30 tonnes/year. The harvest in 2017/18, immediately after the 22 transferable 'Ocean Wrasse' licences were issued in April 2017, was the highest since 2009 (Figure 75a). Over the last two years 10-15% of the wrasse harvest has been by pots (Figure 75b), and most of the catch has be taken in the central zone (Figure 75a).
- *Biomass* – The standardised CPUE in all three assessment zones was below the reference period average in 2017/18 (Figure 76), however, for the central and western zones it has fluctuated above and below the reference period average since the early 2000s (Figure 76b, c). For the eastern zone, nominal and standardised CPUE have been consistently between the reference period average and low point since 2010 (Figure 76a). Overall, the CPUE variation and trends would appear to indicate relative stability of biomass rather than clear increases or decreases. One caveat is that the relationship between CPUE and stock wide biomass is unclear, as CPUE for this fishery may be prone to hyper-stability due to the highly resident behaviour of wrasse on reef areas and fishers regularly move between different reef areas to maintain acceptable catch rates.

Stock status summary: The limited licences (22) and limited number of fishing days/year due to swell and weather impose constraints on harvest for most areas. However, substantial potential for increased effort and catch exists because most of the 22 licences are not yet fully utilised and the catch is unconstrained. The main risk for the fishery has been previously identified as a potential for localised depletion on individual reefs. The current harvest and effort appear to present a low risk for the stock becoming recruitment overfished state-wide, bearing in mind the depleting trend in the east which was occurring prior to licence transferability. State-wide, fishing for blue throat and purple wrasse appears to be sustainable.

(a)



(b)

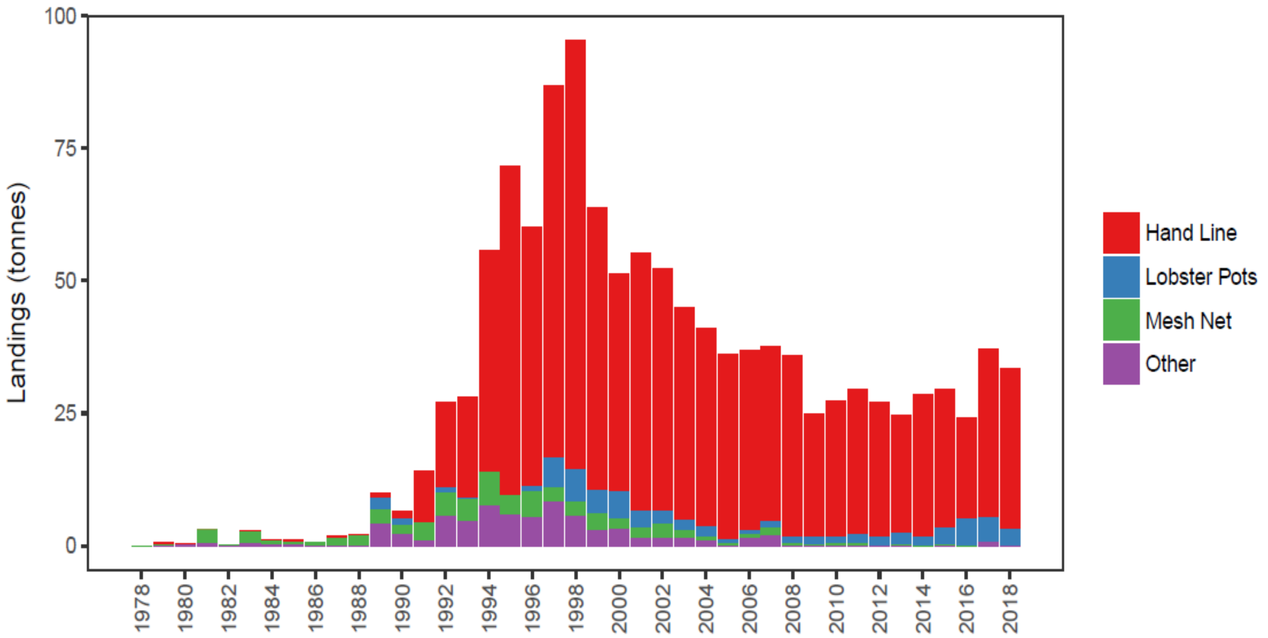
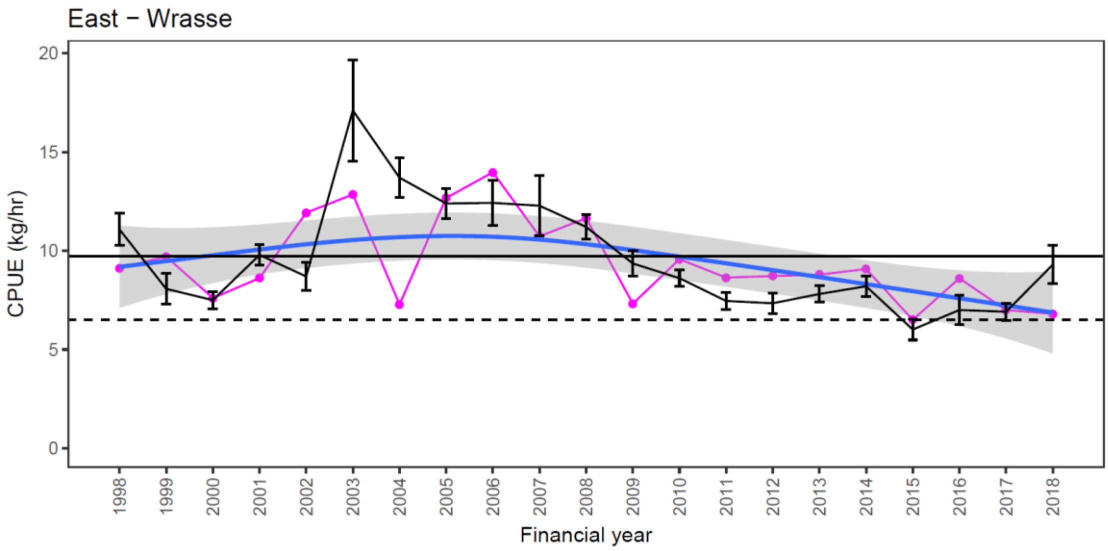


Figure 75 Total commercial catches of wrasse by (a) zone and (b) gear type from Victorian waters (1978–2018 fiscal years).

(a)



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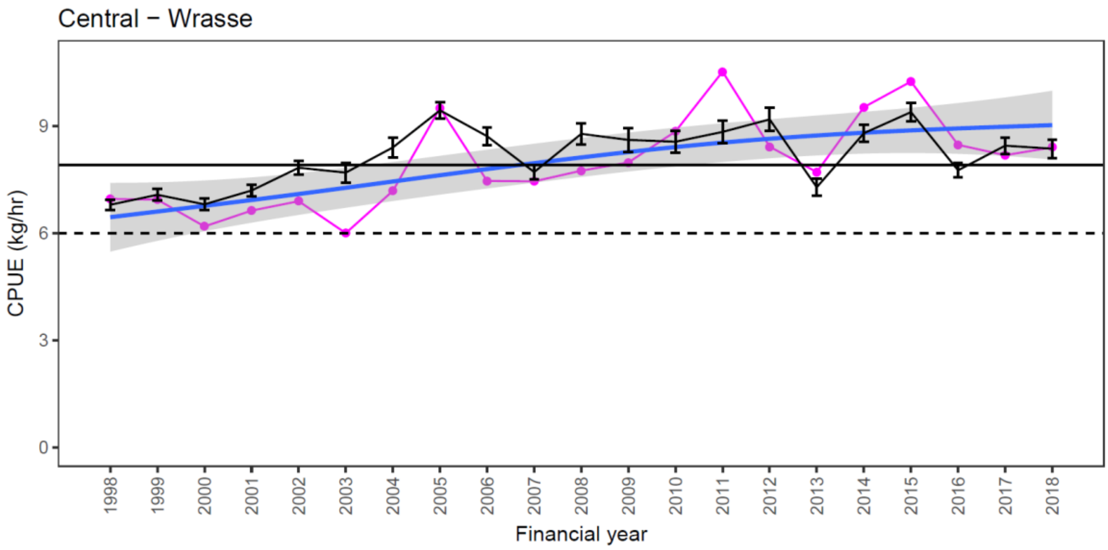


(c)

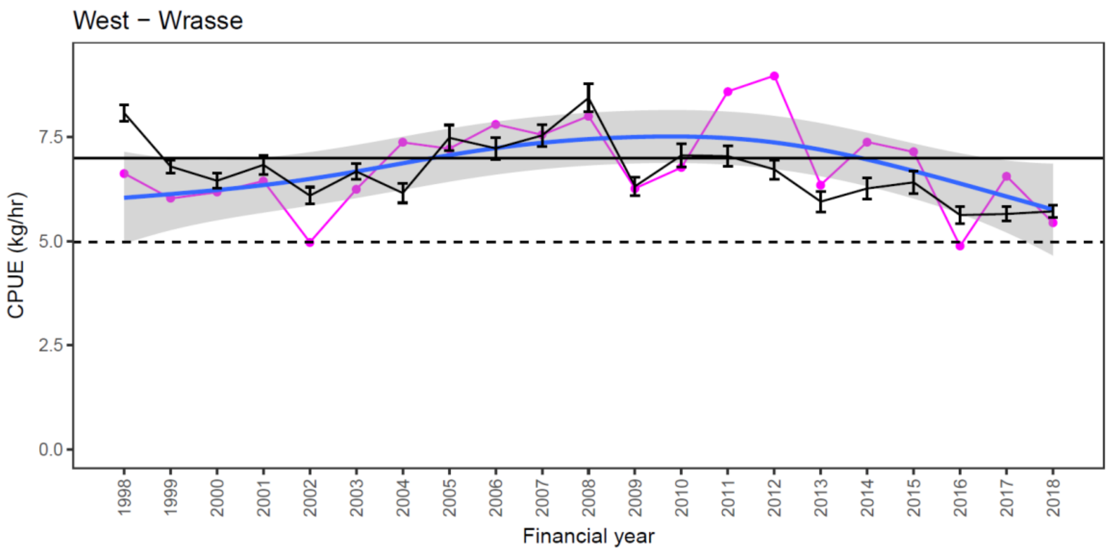


Figure 76 Catch-per-unit-effort (CPUE) of wrasse (all species) by commercial handline fishers in the (a) Eastern, (b) Central and (c) Western assessment zones during 1998–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period (2000–2015) and the dashed black line is the minimum standardised CPUE within the reference period.

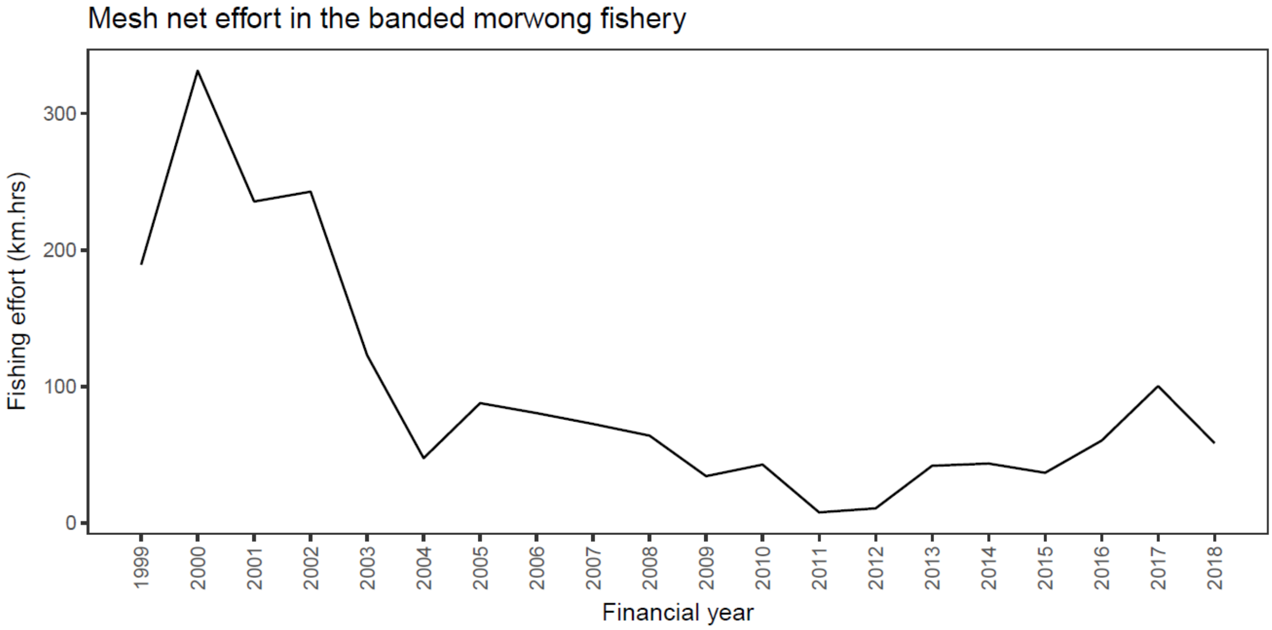


Figure 77. Catch-per-unit-effort (CPUE) of wrasse (all species) by commercial mesh net fishers state-wide during 1998–2018 fiscal years.

Gummy Shark (*Mustelus antarcticus*): State-wide

Stock Structure and Biology

Gummy shark populations in Victorian waters are a component of a single biological stock for south-eastern Australia. Gummy shark can live to 16 years and grow to over 180 cm total length (TL) (25 kg total body mass). Maturity (50 percent) for females is at 110–125 cm TL and for males is at 95–115 cm TL. Gummy shark have low fecundity (an average of 14 pups per breeding cycle) and an 11 to 12 month gestation period. The growth rate of male gummy shark higher than for females. The peak parturition period is November to December with shallow coastal waters, including sheltered bays, the preferred pupping habitat.

Management/Assessment Unit

The gummy shark populations in Victorian waters support commercial gillnet and hook fisheries as well as recreational fisheries in Port Phillip Bay, Western Port, Corner Inlet and other inshore coastal waters (Figure 78). The Commonwealth Southern and Eastern Scalefish and Shark Fishery harvests by far the largest component of the gummy shark catch and is managed by the Commonwealth of Australia using a harvest strategy that includes age structured and pup production outputs to inform quota setting decisions. This report considers the Victorian gummy shark population in Victorian waters as a state-wide stock.

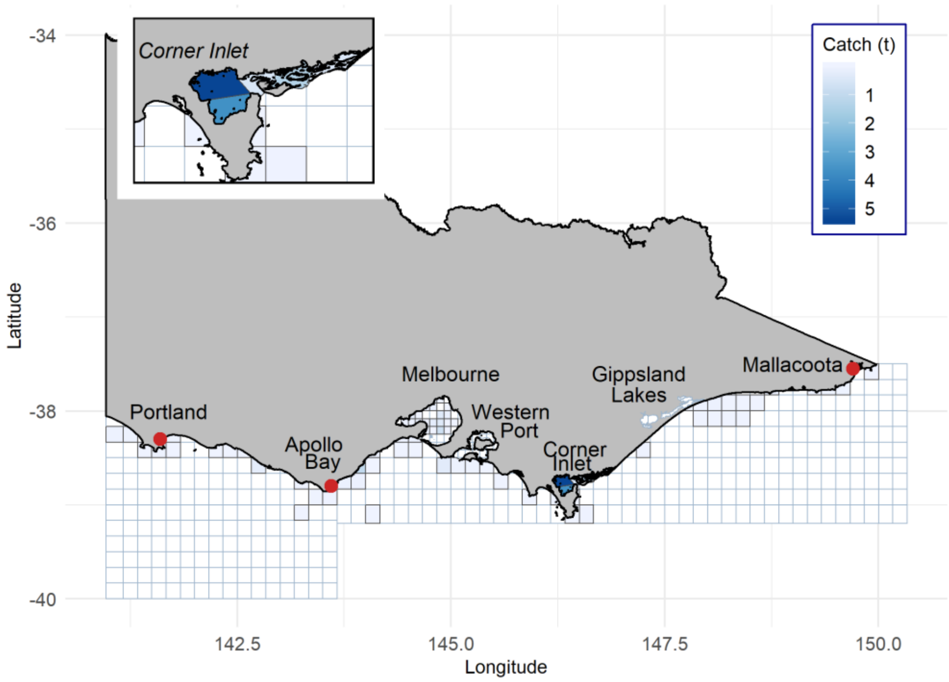


Figure 78 Spatial distribution of state-wide landings of Gummy Shark from Victorian fisheries during the 2018/19 financial year.

Assessment Summary

For this assessment, the status of the state-wide Gummy Shark population was evaluated using:

- Total commercial gummy shark catch and modelled gummy shark catch output for the Southern and Eastern Scalefish and Shark Fishery,
- Nominal CPUE trends for the Victorian commercial Gummy Shark fishery from Corner Inlet-Nooramunga using mesh nets (reference period 1998–2015) and Port Phillip Bay long-line (reference period 1986–2015),
- Nominal recreational CPUE from creel survey in the Western Port recreational fishery (reference period 1998–2015).
- Time series of commercial catch and recreational fishery size composition data.

This assessment found:

- *Fishing pressure* – Gummy shark landings were high (500–1000 t) in Victoria from 1978–1997, after which trip limits were introduced for most state fisheries and the Commonwealth formally created the Southern Shark Fishery (now a component of the South East Scalefish and Shark Fishery; SESSF) (Figure 79). This is reflected by the large decline in Bass Strait mesh net effort post-1998 (see Appendix 2). In recent years, fishing effort using the gears that capture the majority of gummy shark in Victorian state fisheries have both increased (Corner Inlet) and decreased (Port Phillip Bay), with the latter a result of license buy-outs. Subsequent to this, gummy shark CPUE increased in Victoria's bay and inlets (Figure 80 and 81) potentially because targeted fishing occurred following the closure of offshore gummy shark Victorian fisheries.
- *Biomass* – Gummy shark long line CPUE in Port Phillip Bay has been among historic highs in recent years in Port Phillip Bay and is well above the reference period average, potentially as a result of targeting this species due to the decreasing abundance of snapper (see snapper section). Conversely, CPUE has been declining in Corner Inlet since about 2006, dropping below the reference period average in 2012 where it has remained ever since, but has not fallen below the reference period minimum (Figure 81). Recreational catch rates in Western Port have remained relatively consistent throughout the time period analysed (Figure 82) and there has been a relatively consistent size composition of the catch (Figure 83) indicating that recruitment has been ongoing and fishing mortality is not high enough to decrease the proportion of larger fish in the population.

Stock status summary: The Gummy Shark fishery component of the SESSF comprises multiple populations with varying reproductive characteristics (Walker, 2007), however, the Victorian fishery comprises of catches from a single biological stock (i.e. Bass Strait), and this stock is modelled independently in formal quantitative stock assessments (Tuck, 2018). Tuck (2018) found that the Bass Strait stock was above the 48% of unfished pup production limit and therefore sustainable at current catches. This study also projected future sustainable catches and the landings from the Commonwealth and state fisheries have remained below these projections. The information available in this current assessment reinforces that the gummy shark population is performing adequately with recreational CPUE in Western Port and commercial longline CPUE in Port Phillip Bay increasing through time in line with the Commonwealth stock assessment. Although trends in commercial mesh net CPUE in Corner Inlet were contrary to the positive trends elsewhere, gummy shark represent a by-product in this region of the fishery with increased fishing effort in recent years predominantly targeting King George whiting using mesh sizes that are unlikely to select effectively for gummy sharks (see King George whiting section). Based on the multiple lines of evidence available it can be concluded that the Victorian gummy shark population is sustainable.

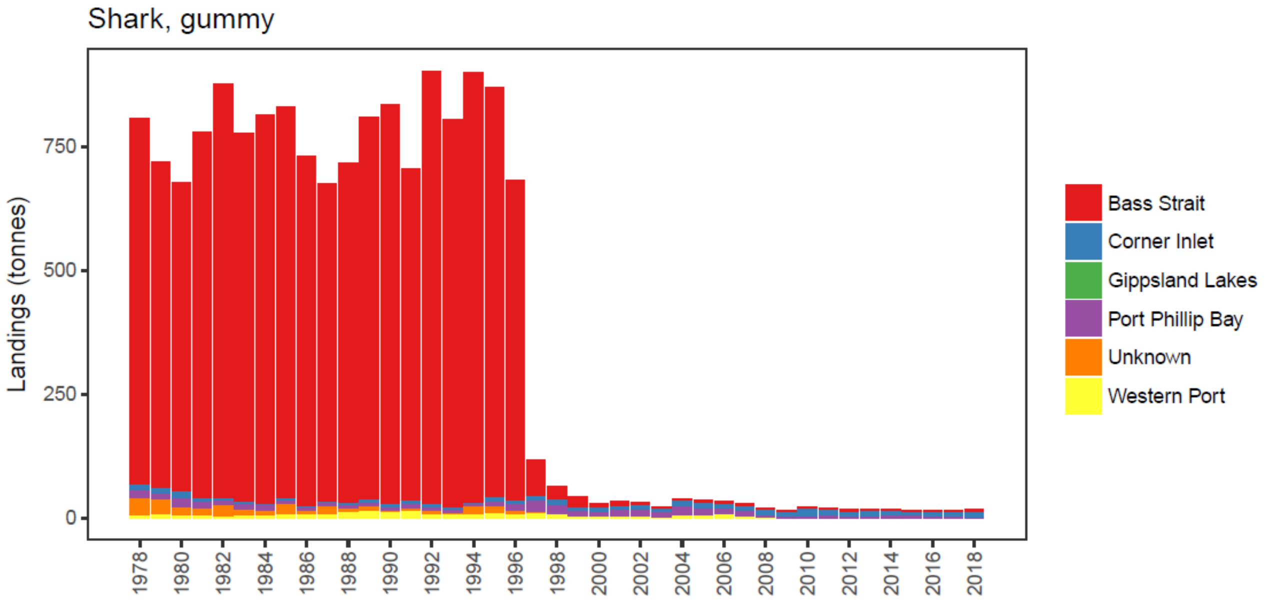


Figure 79 Total catch from the Victorian commercial Gummy Shark fishery by area. Note from 1997 gummy shark in coastal waters transferred to Commonwealth management. Since 1997 most Gummy Shark harvested adjacent to Victoria were taken under Commonwealth issued licences and are not represented in this figure.

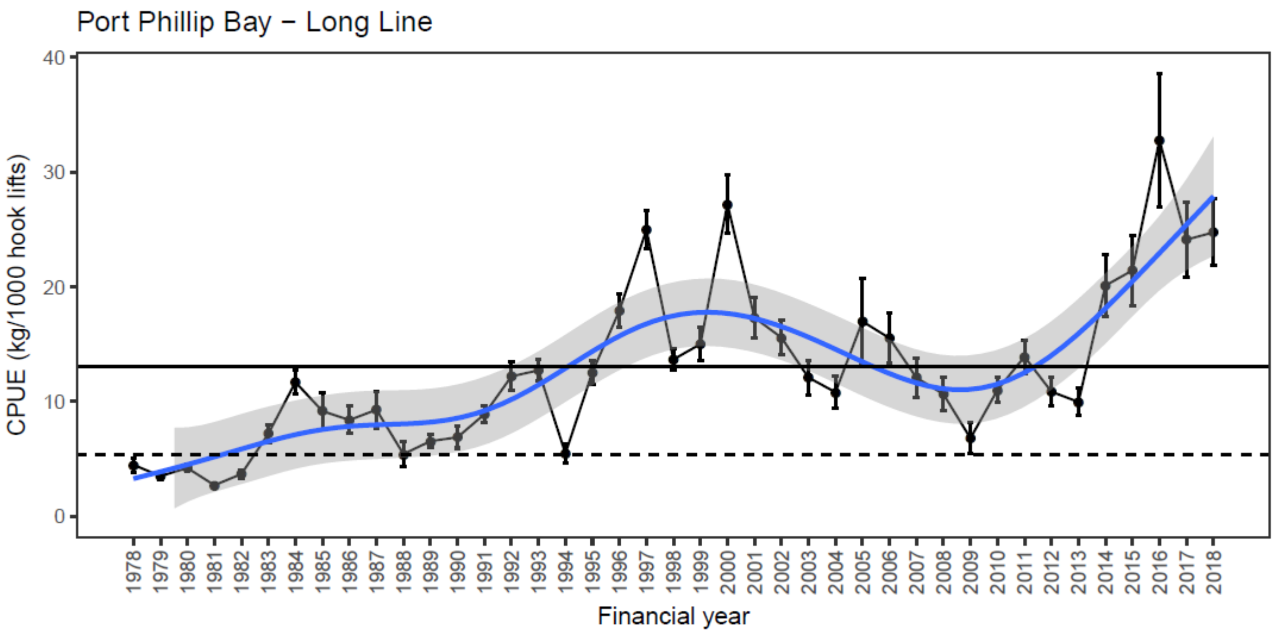


Figure 80 Nominal catch-per-unit-effort (CPUE) (±SE) of gummy shark by commercial long-line for Port Phillip Bay (1978–2015). Horizontal black line is the mean nominal CPUE during the reference period (1985–2015) and the dashed black line is the minimum standardised CPUE within the reference period. Blue line is a generalised additive model (GAM) of the CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

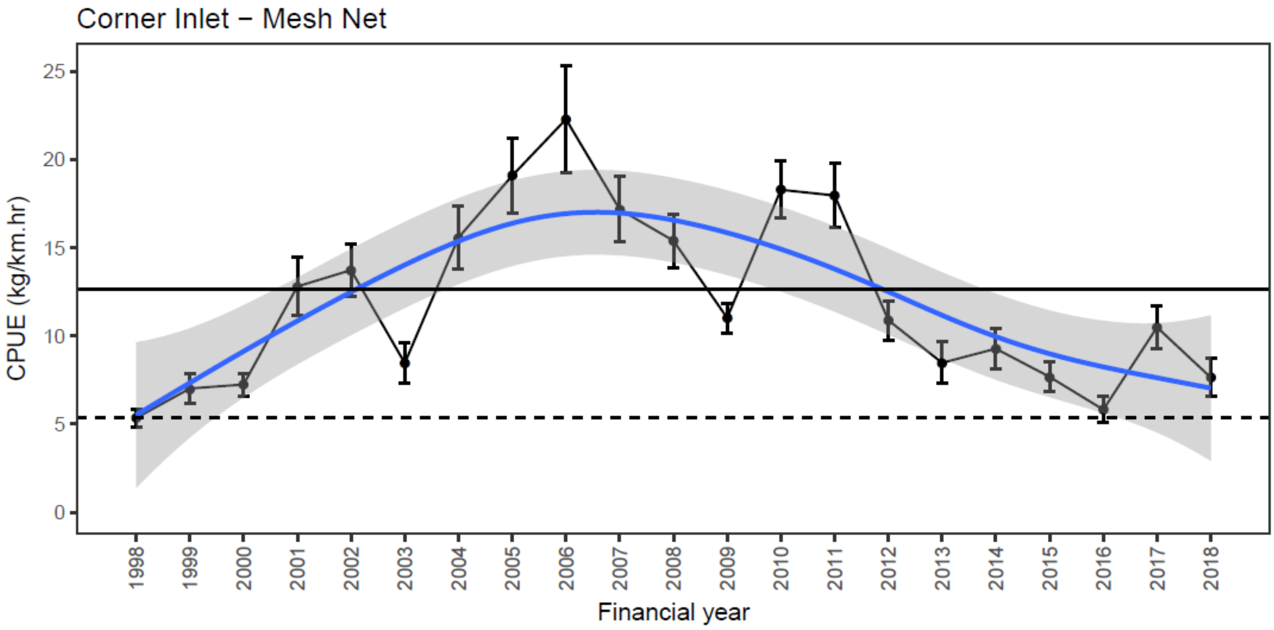


Figure 81 Nominal catch-per-unit-effort (CPUE) (±SE) of gummy shark by commercial mesh net for Corner Inlet (1998–2018). Horizontal black line is the mean nominal CPUE during the reference period (1998–2015) and the dashed black line is the minimum standardised CPUE within the reference period. Blue line is a generalised additive model (GAM) of the CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Note: data prior to 1998 are not presented as catch rates were extremely low suggesting a lack of targeting gummy shark in this region of the fishery.

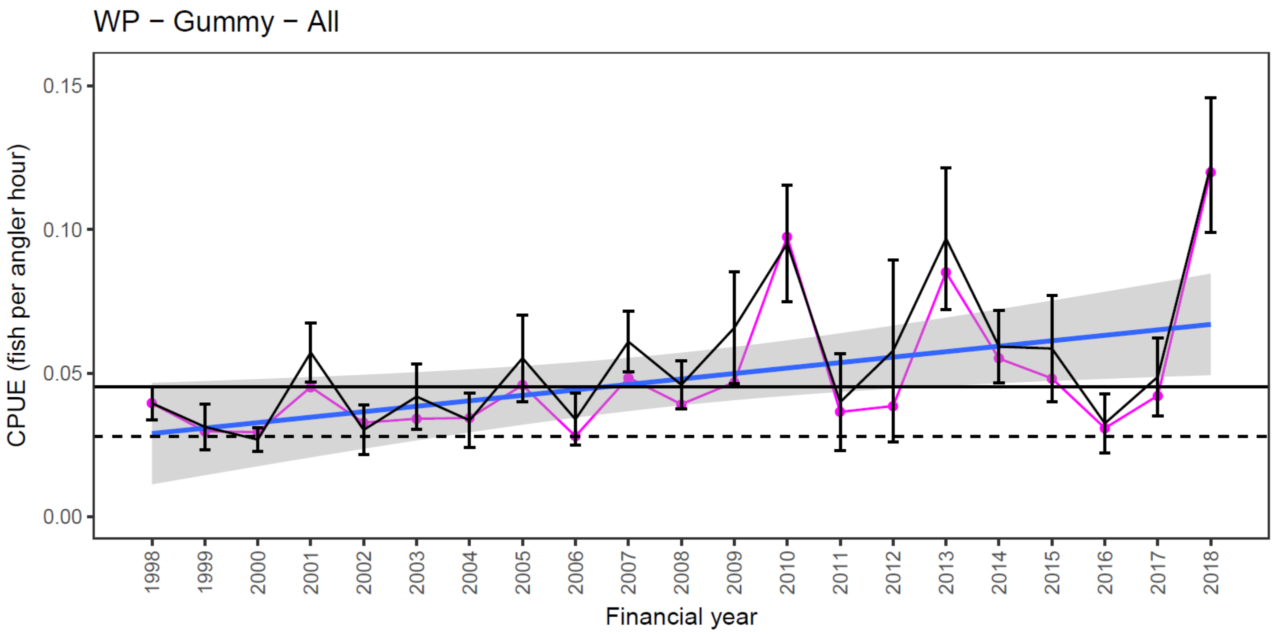


Figure 82 Catch-per-unit-effort (CPUE) of gummy shark by recreational anglers interviewed in creel surveys undertaken in Western Port (WP) from 1998–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period and the dashed black line is the minimum standardised CPUE within the reference period.

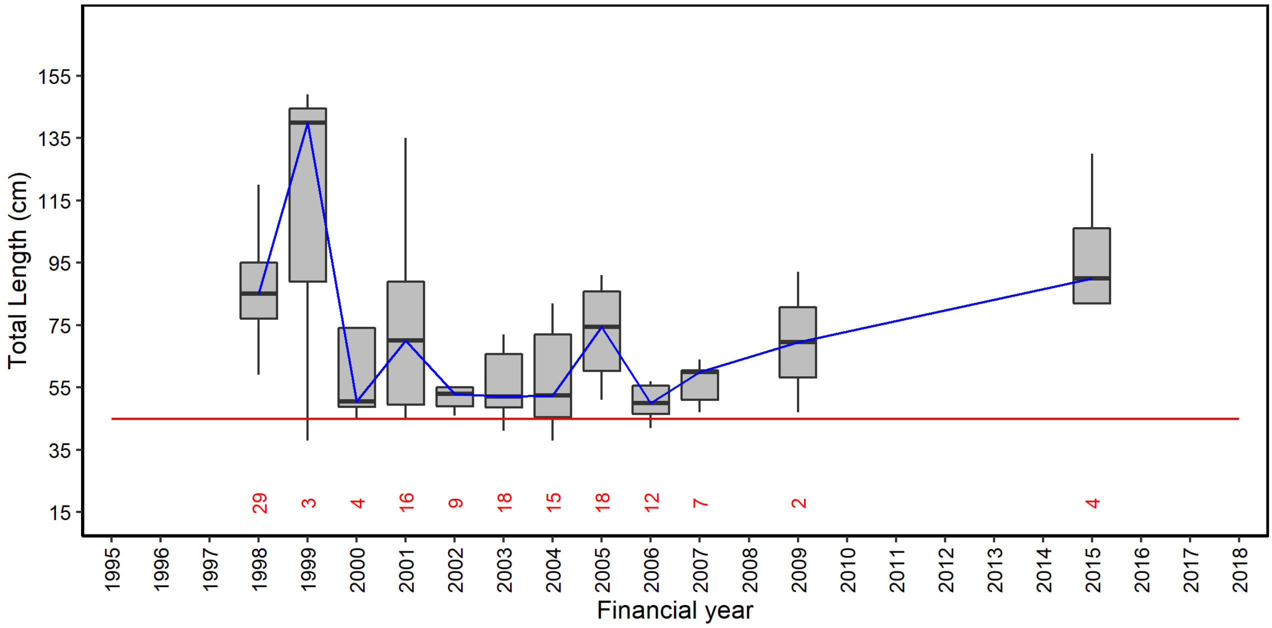


Figure 83 Box-plots of the size frequency of gummy sharks caught by recreational fishers interviewed for creel surveys in Western Port.

Silver Trevally (*Pseudocaranx georgianus*): State-wide

Stock Structure and Biology

The Victorian silver trevally population is part of a broader south-eastern Australian stock. Silver trevally live to 25 years and grow to 60 cm TL. Silver trevally reach maturity (50 percent) at 25–30 cm TL, are highly fecund, and have a slow-moderate grow rate (K = 0.1–0.4). The main spawning period is spring-autumn in coastal waters.

Management/Assessment Unit

The Victorian component of the silver trevally stock supports recreational and commercial fisheries. Commercial fisheries occur mainly in Corner Inlet and the Gippsland Lakes (Figure 84), but recreational fisheries occur throughout the state's bays, inlets and coastal waters. This report considers Victorian silver trevally as single state-wide management unit.

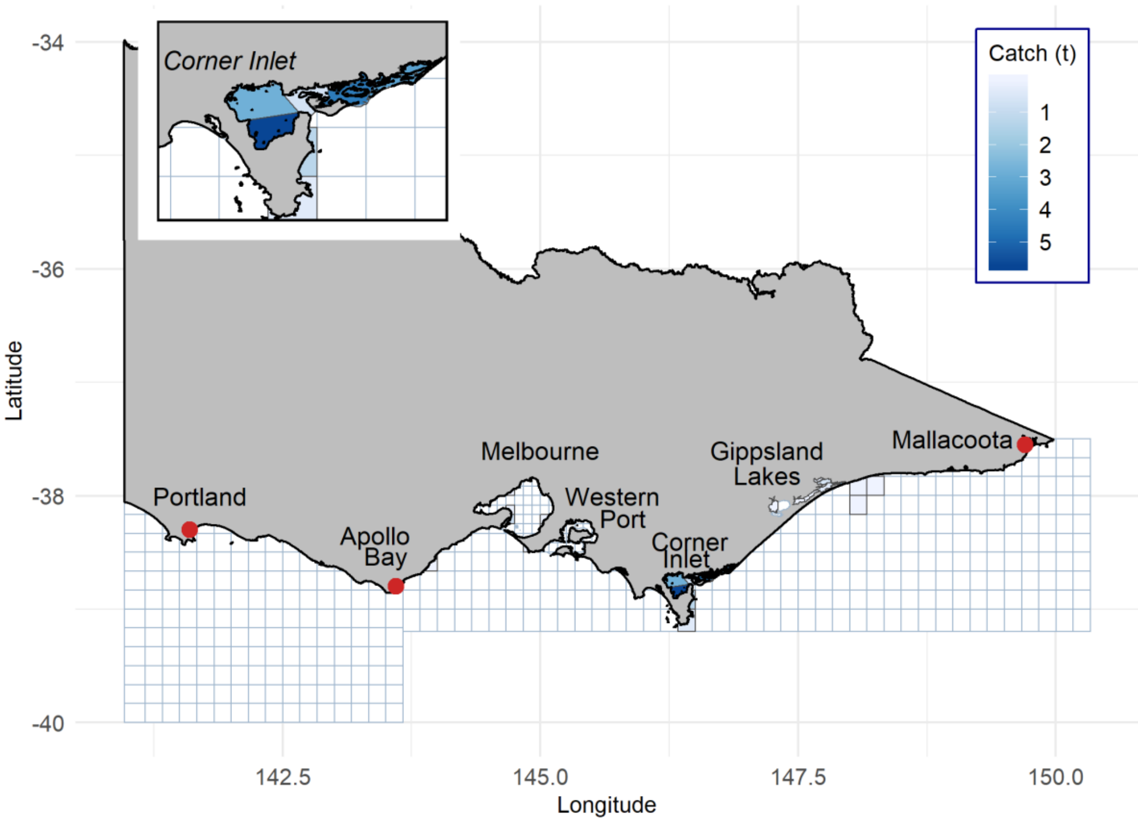


Figure 84 Distribution of commercial catches of silver trevally from Victorian waters during the 2018/19 financial year.

Assessment Summary

For this assessment, the status of the silver trevally population was evaluated using:

- Nominal CPUE trends for the Corner Inlet-Nooramunga and Gippsland Lakes haul seine fisheries. The performance of the CPUE biomass proxies was assessed in relation to the average and minimum values of standardised CPUE during reference period 1998–2015.
- The impact of fishing pressure was assessed using time series of commercial catch and effort.

This assessment found:

- *Fishing pressure* – Very large quantities of silver trevally were landed in Bass Strait using mesh nets up until 1991 (Figure 85), however the offshore mesh net fishery is now managed by the Commonwealth and has largely ceased. Since then, landings have been predominantly from seine nets in Gippsland Lakes and Corner Inlet-Nooramunga with a declining trend through time as effort with this gear has declined in both fisheries (see Appendix 2).
- *Biomass* – There has been high variability in silver trevally CPUE using seines in both the Gippsland Lakes and Corner Inlet-Nooramunga (Figure 86a, b). This is likely to be a combination of varying abundance in inshore waters as this species also frequents waters offshore, and generally represents a by-product while targeting other species. Additionally, there has been very low seine fishing effort in the Gippsland Lakes in recent years (see Appendix 2) and the high catch rate in 2017/18 may not be representative of stock abundance as it is influenced by the catches of a single fisher who landed >2000 kg on multiple occasions. Nevertheless, in both Gippsland Lakes and Corner Inlet, CPUE is above the reference period average meaning there is no local signs of depletion.

Stock status summary: The low silver trevally catches in recent years, and low seine fishing effort, in Victorian fisheries means that fishing operations are unlikely to cause impaired recruitment under current practices. However, there is uncertainty surrounding the interconnectivity of silver trevally stocks and the most recent SAFS classification of silver trevally in New South Wales found that the species was depleting in their jurisdiction. The most recent Commonwealth stock assessment (Tuck, 2018), using data to 2013, showed that standardised CPUE had increased from low levels during the early 2000s, but was still below its long-term average. Given the high catch rates in Victoria waters in recent years and low levels of effort, it is unlikely that the Victorian silver trevally stock is depleted or is at risk of becoming recruitment impaired and becoming depleted. Based on the above information it is concluded that the Victorian silver trevally stock is sustainable.

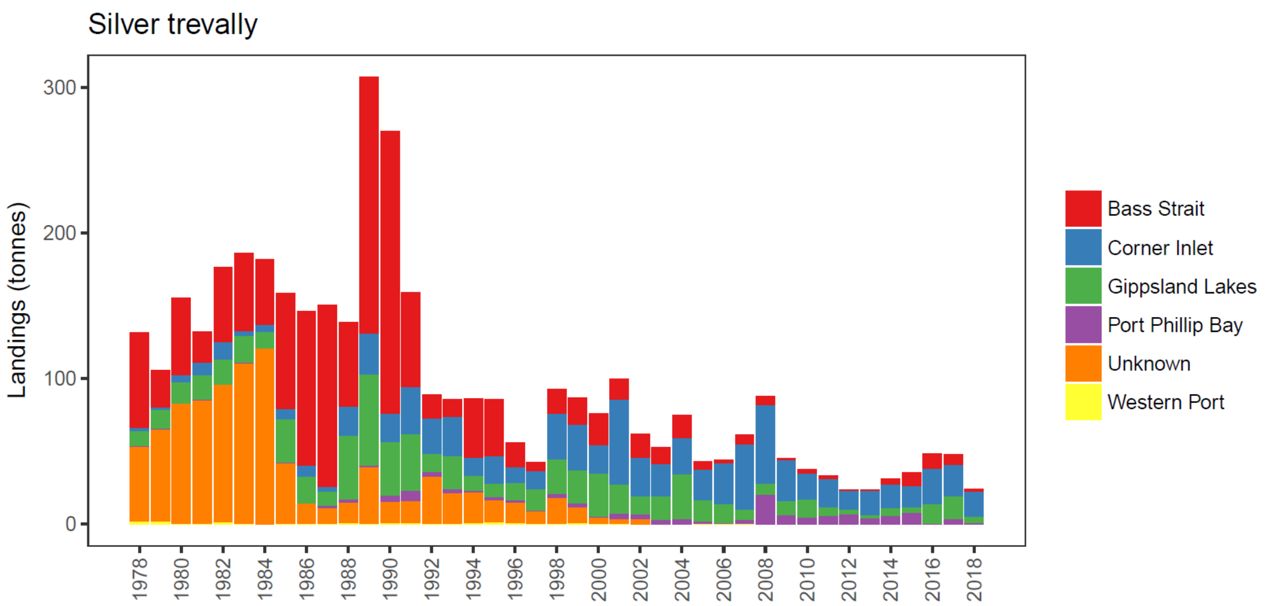
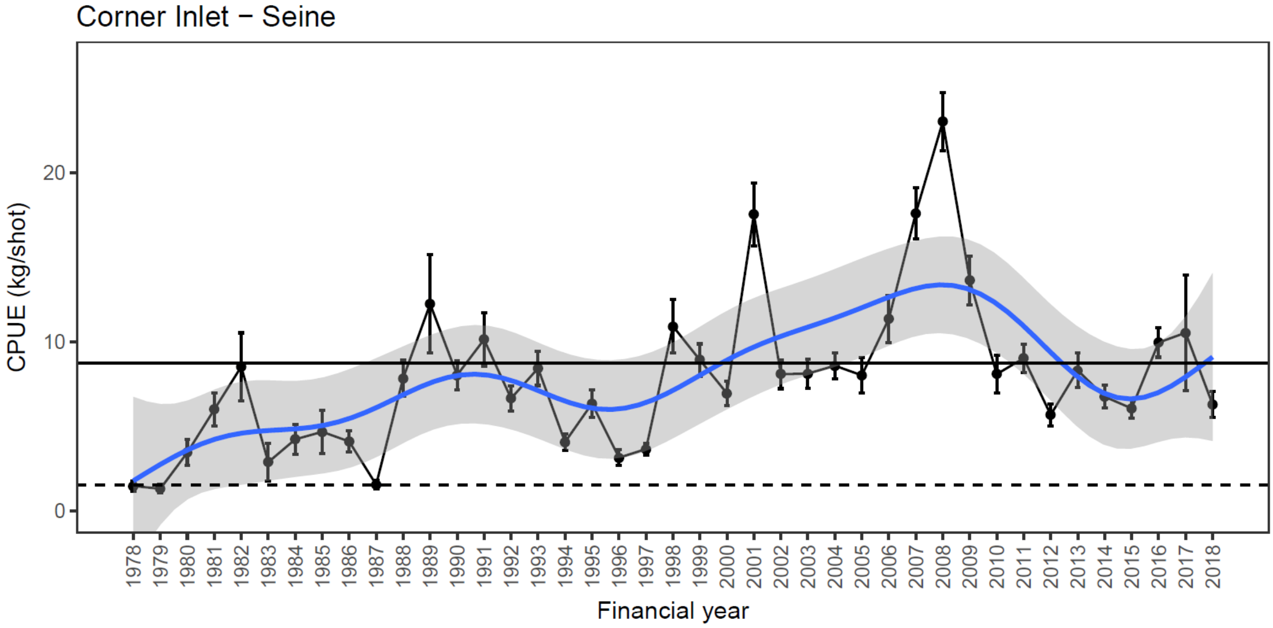


Figure 85 Total commercial catches of silver trevally by area in Victorian waters, 1978–2018 financial years.

(a)



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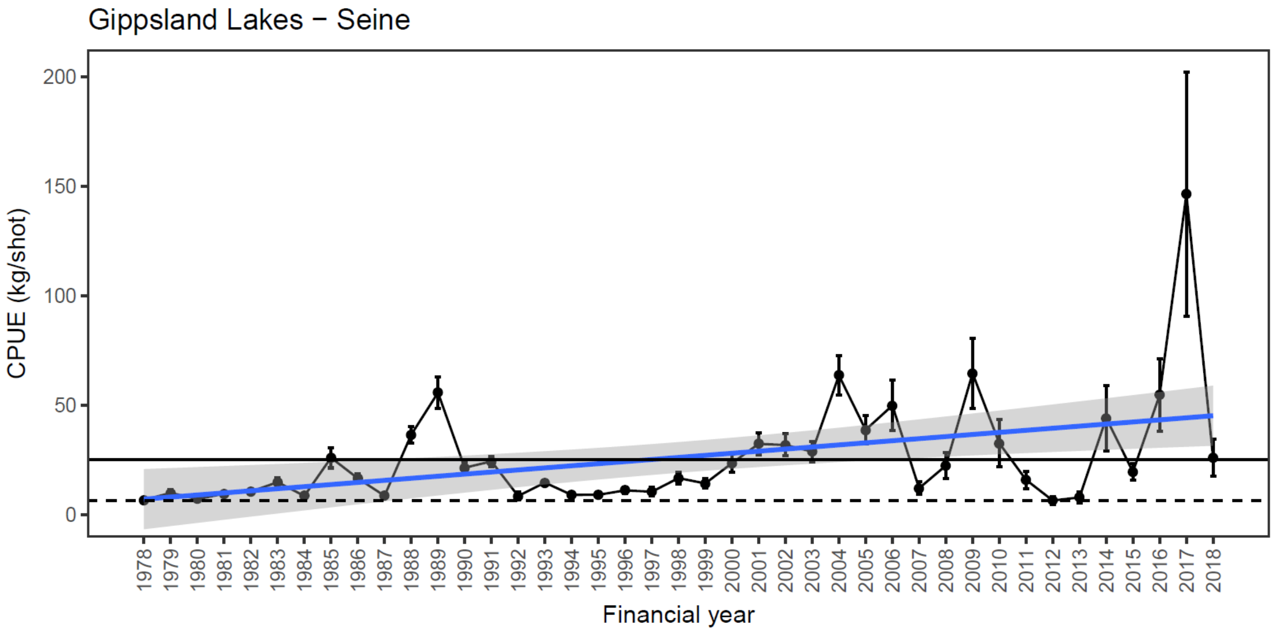


Figure 86 Nominal catch-per-unit-effort CPUE (±SE) of silver trevally by haul seine in; (a) Corner Inlet, and (b) Gippsland Lakes (financial years 1978–2015). Blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period and the dashed black line is the minimum standardised CPUE within the reference period.

Southern Bluespotted Flathead (*Platycephalus speculator*): Corner Inlet-Nooramunga

Stock Structure and Biology

The stock structure of southern bluespotted flathead in Victorian waters is unknown. In Western Australian waters this species can live to at least 12 years and grow to 90 cm TL. Southern bluespotted flathead mature (50 percent) at 1–2 years (males 25 cm, females 32 cm), are highly fecund and are have a moderate growth rate. Their main spawning period is spring/summer in marine bays and coastal waters. There is another closely related species, also named blue spotted flathead (*Platycephalus cearuleopunctatus*) reported to occur from southern Queensland to eastern Victoria. This species is not thought to contribute to the fishery in Corner Inlet-Nooramunga, however, there has been no recent assessment of the species composition of catches to confirm this perception.

Management/Assessment Unit

The Victorian component of the southern bluespotted flathead population supports a commercial fishery in Corner Inlet-Nooramunga. Commercial harvests from Port Phillip Bay have been negligible since 2016, when the removal of netting was instigated. There are also recreational fisheries for this species in Port Phillip Bay, Western Port and Corner Inlet. In 2017/18 the commercial harvest of southern bluespotted flathead was virtually all taken from Corner Inlet-Nooramunga (Figure 87), and this assessment only considers this region of the stock.

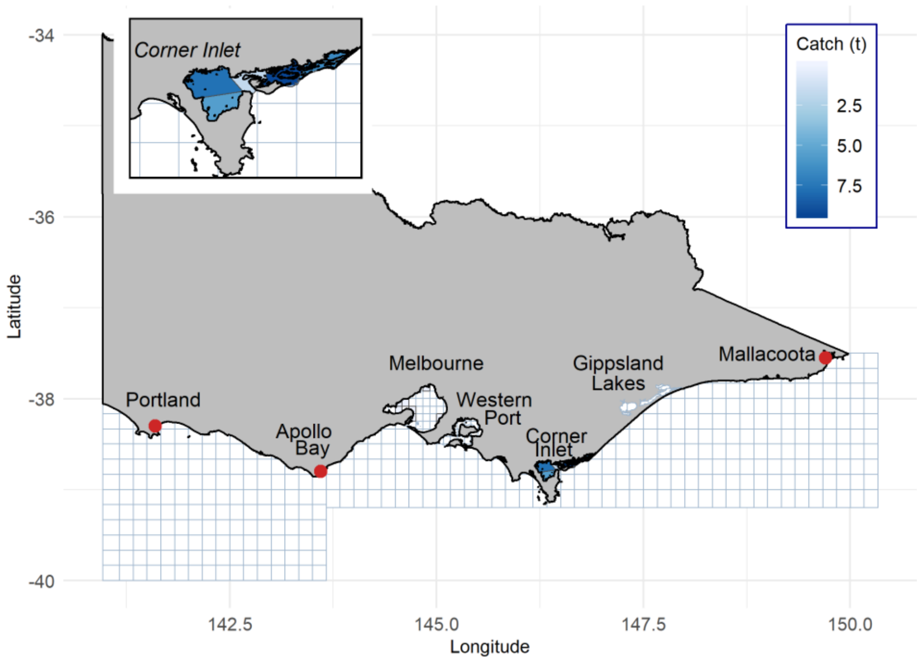


Figure 87 Spatial distribution of state-wide landings of southern bluespotted flathead from Victorian commercial fisheries during the 2018/19 financial year.

Assessment Summary

For this assessment, the status of the southern bluespotted flathead population was evaluated using:

- Nominal CPUE trends for mesh net and seine net methods in the Corner Inlet-Nooramunga, from 2000 onwards. Data prior to 2000 have been excluded because of inconsistent reporting of flathead to species level. The reference period used in this instance is 2000–2015.
- Commercial catch and effort.

This assessment found:

- *Fishing pressure* – Commercial harvests of southern bluespotted flathead have almost entirely been taken from Corner Inlet-Nooramunga since 2015/16, and have increased by approximately 10 tonnes from 2016/17 to 2017/18 (Figure 88) in response to increases in CPUE and greater mesh net effort (Appendix 2). The reported catches of southern bluespotted flathead from Corner Inlet-Nooramunga over the last two years are the highest reported since 1978. Prior to 2015/16 at least half of the reported annual statewide commercial harvest of blue spotted flathead came from Port Phillip Bay (Figure 88). The recent increase in harvest represents a notable increase in fishing pressure.
- *Biomass* – CPUE for mesh net and seine net in Corner Inlet-Nooramunga have displayed similar patterns of variation since 2000, and both have increased since 2013 to be above the reference period average in 2017/18 (Figure 89a, b).

Stock status summary: The recent increases in CPUE for both mesh and seine nets might be reflecting an increase in biomass in Corner Inlet-Nooramunga. However, increased mesh net effort has likely been associated with increased targeting of flathead species and this may be influencing the upward trends in mesh net CPUE. Continued increases in mesh net effort and catch of southern bluespotted flathead would be expected to eventually precipitate a decline in CPUE. There are a number of uncertainties around the harvest and CPUE time series among the different flathead species in Corner Inlet. In particular, the accuracy of species and effort reporting. Uncertainty in catch history for southern bluespotted flathead makes it difficult to assess the risk associated with the recent historically high harvests, and primarily for this reason, there is uncertainty about stock status of southern bluespotted flathead in Corner Inlet-Nooramunga.

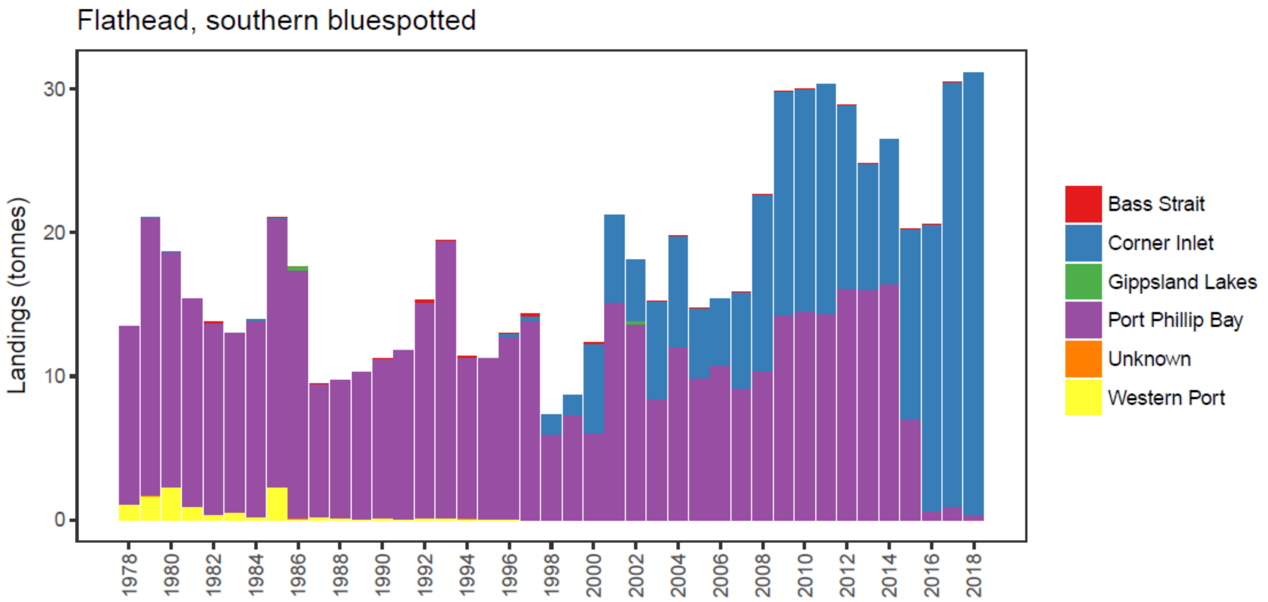
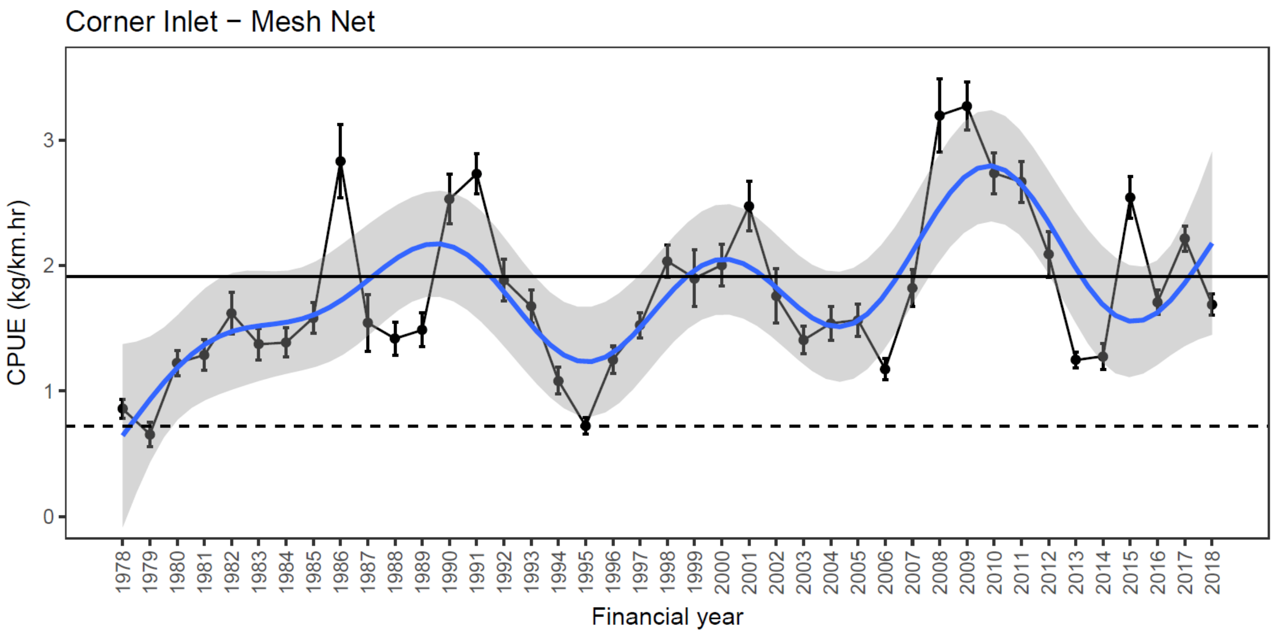


Figure 88 Total commercial catches of southern bluespotted flathead by area in Victorian waters, financial years 1978–2018.

(a)



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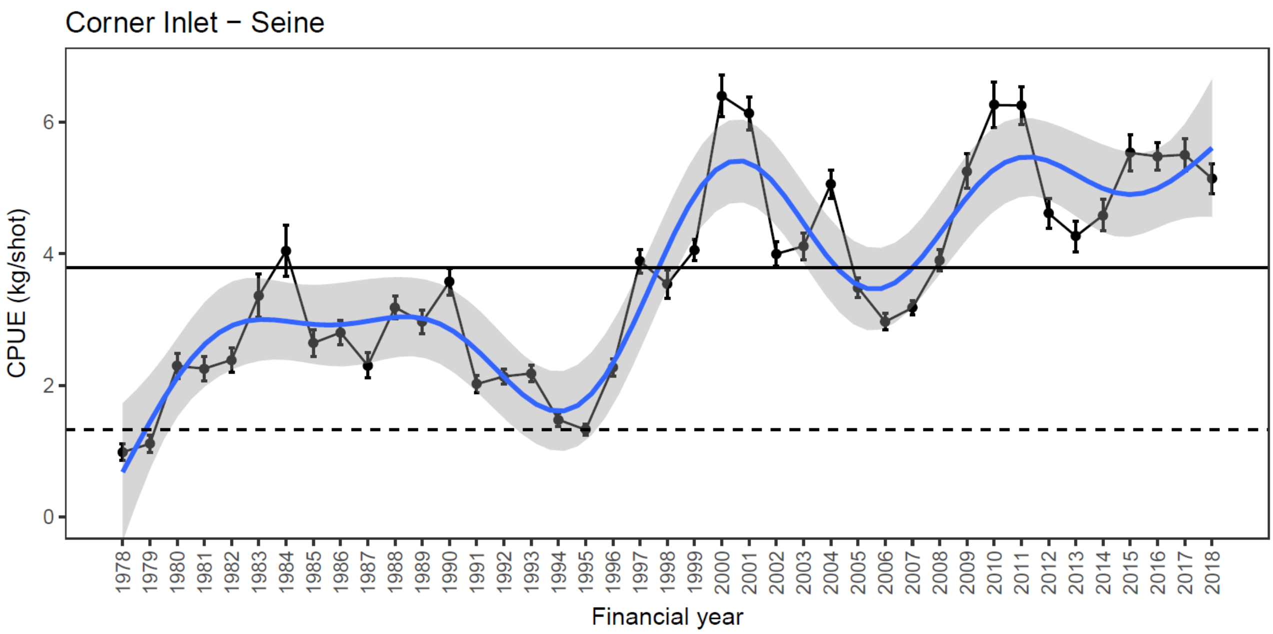


Figure 89 Catch-per-unit-effort (CPUE) (±SE) of southern blue spotted flathead (a) commercial mesh net and (b) commercial seine net Corner Inlet-Nooramunga (financial years 1978–2015). Blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period and the dashed black line is the minimum standardised CPUE within the reference period.

Sand Crab (*Ovalipes australiensis*): State-wide

Stock Structure and Biology

The stock structure of sand crab in Victorian waters is unknown. Sand crab can grow to a carapace width (CW) of up to 20 cm.

Management/Assessment Unit

The Victorian sand crab populations support a commercial inshore trawl fishery in Bass Strait, mainly off Gippsland (Figure 90). The extent of the recreational fishery is unknown. This report considers the population of sand crab in Victorian waters as a state-wide management unit.

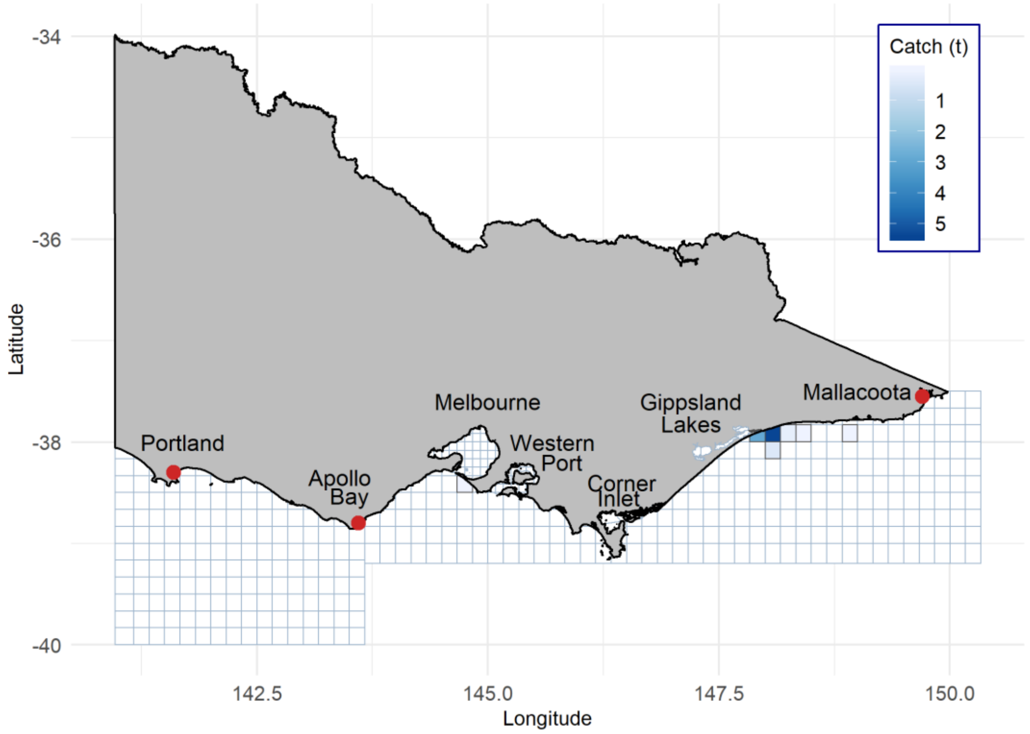


Figure 90 Spatial distribution of state-wide landings of sand crab from Victorian fisheries during the 2018/19 financial year. Most sand crab are taken by trawl method in the Victorian Inshore Trawl fishery.

Assessment Summary

For this assessment, the status of the sand crab biomass was evaluated using:

- CPUE trends for the commercial inshore trawl fishery. Due to changing discard practices, the data were filtered to only include trawl shots with a catch of >0 kg to ensure that fishers were retaining sand crabs when caught. The performance of the CPUE biomass proxy was assessed in relation the average and minimum values for the reference period of 1998–2015.
- The impact of fishing pressure was assessed using time series of commercial catch and effort.

This assessment found:

- *Fishing pressure* – Landings of sand crab peaked in the late 1990s to early 2000s and again in the last five years with the earlier peak coinciding with peak fishing effort in the inshore trawl fishery (Figure 91) (see Appendix 2). The peak landings in recent years coincided with relatively stable fishing effort and are a result of greater proportion of targeting and retention of this species compared with other species.
- *Biomass* – CPUE of sand crabs has varied considerably with some years (1998, 2014) being more than double the mean CPUE of the reference period and others (2008, 2012) approaching the minimum observed in the reference period (Figure 92). However, there were occasions when sand crabs have been discarded due to low market value (e.g. mid-2000s to mid-2010s) rendering CPUE potentially unreliable as an indicator of biomass. Nevertheless, the relatively high landings in recent years are consistent with that a large proportion of those caught being landed and CPUE remains well above its historic low, although it is currently trending downward and is below the reference period average, warranting future monitoring.

Stock status summary: The inshore trawl fishery effort is about half of the historic level and CPUE remains relatively high, albeit slightly below the average during the reference period. Sand crabs are abundant throughout the state, including the bays and inlets, and while there is some possibility of local depletion in the relatively small area they are fished, there is minimal possibility that the current inshore trawl fishery represents a risk to the Victorian stock as a whole. Additionally, recreational catchces are likely to be relatively small and localised. Based on the limitation posed by sporadic changes in retention rates there is uncertainty in interpreting stock status from the available evidence.

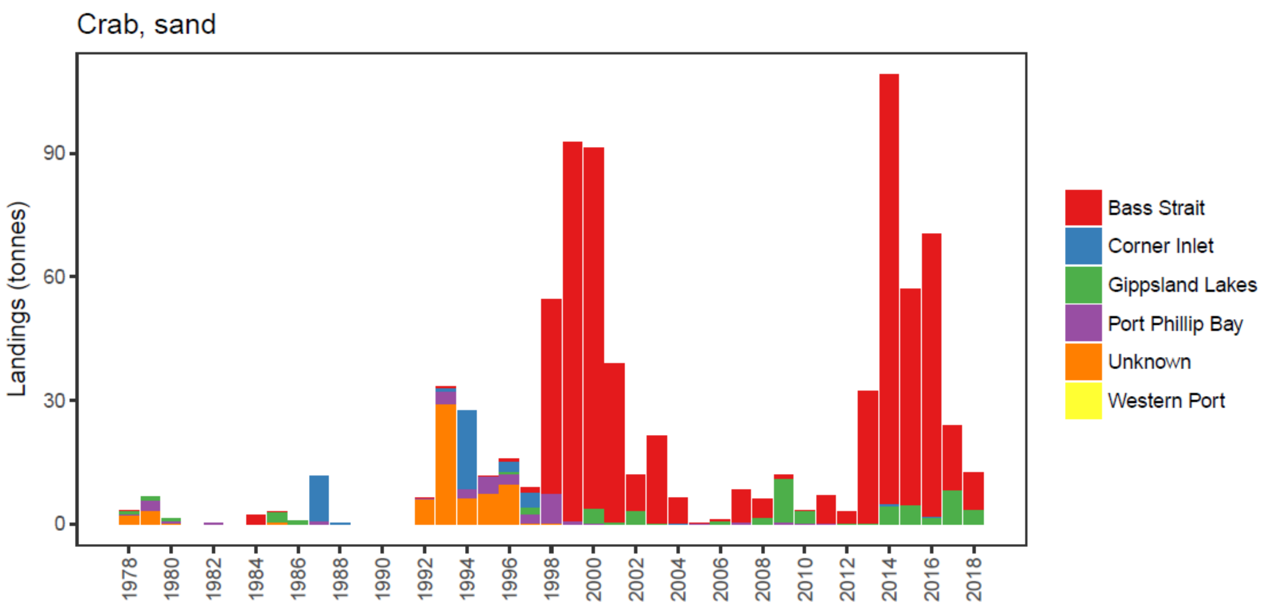


Figure 91 Total commercial catches of sand crab in Victoria by area, financial years 1998–2018 fiscal years.

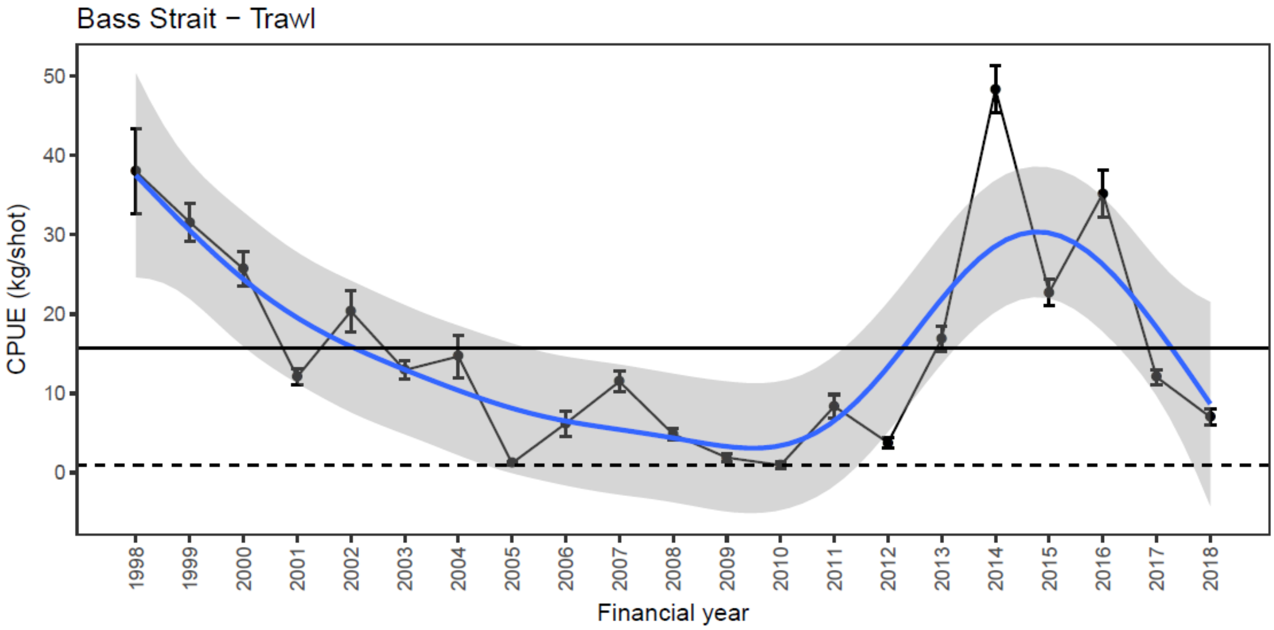


Figure 92 Catch-per-unit-effort (CPUE) (±95% SE) of sand crab for the commercial inshore trawl fishery from 1998–2018 fiscal years (black line). The blue line is a generalised additive model (GAM) of the CPUE trend with the shaded area representing 95% confidence intervals of the model. The black horizontal line is the average of the reference period (1998–2015) and the dashed line is the minimum observed value during the reference period. Note: prior to 1998 there was minimal inshore trawl effort and there was some inconsistent reporting meaning these data were deemed insufficiently accurate to derive biomass trends using CPUE so were thus omitted.

Australian Salmon (*Arripis trutta*, *A. truttaceus*): Eastern and Western Victorian Stocks

Stock Structure and Biology

In Victorian waters there are straddling stocks of eastern and western Australian salmon. Eastern and western Australian salmon can live to at least 12 years of age and reach 81 cm fork length (FL). Eastern Australian salmon mature (50 percent) at 2–4 years (30–40 cm FL). Western Australian salmon mature (50 percent) at 3–5 years (60–65 cm FL). The main spawning period for eastern Australian salmon occurs from November to February in near coastal waters along the east coast of Australia. Western Australian salmon migrate from Victoria back to Western Australia, where spawning occurs in near coastal waters during April–May.

Management/Assessment Unit

The Victorian component of the Australian salmon stocks supports the commercial purse seine ocean fishery, mostly off eastern Victoria, with small catches also taken from Corner Inlet. Recreational fisheries occur in Port Phillip Bay, Western Port, Corner Inlet, many estuaries and along coastal beaches. Although two separate stocks occur in Victorian waters, only the eastern stock is exploited (Corner Inlet and the ocean purse seine fishery; Figure 93) in sufficient quantities to warrant analysis. For this assessment, the status of the eastern Australia salmon stock was evaluated using nominal CPUE trends for the commercial purse seine ocean fishery off eastern Victoria. Australian salmon are frequently discarded by bay and inlet fishers which means that CPUE estimates generated by their catches are unlikely to provide a reliable proxy for stock biomass.

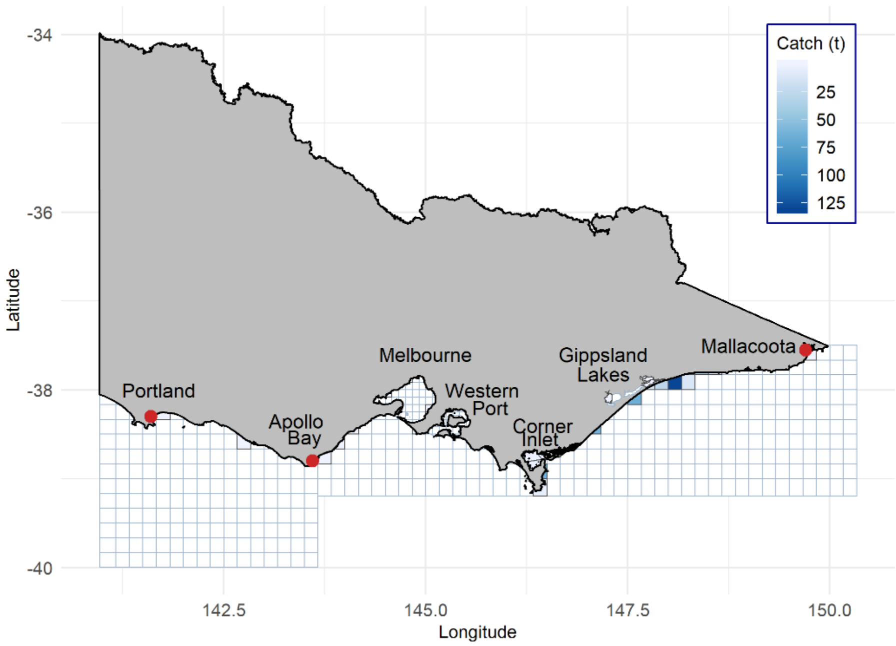


Figure 93 Spatial distribution of state-wide landings of Australian salmon from Victorian fisheries during the 2018/19 financial year.

Assessment Summary

For this assessment, the status of the eastern Australian salmon stock was assessed using:

- Nominal trends in CPUE of the Bass Strait purse seine fishery that operates in eastern Victoria. These data were filtered to only include shots with >100 kg of Australian salmon to effectively exclude purse seine shots targeted at other small pelagic species. The performance of the CPUE biomass proxies was assessed in relation to the average and minimum CPUE during the reference period of 1986–2015.
- The impact of fishing pressure was assessed using time series of commercial catch and effort.

Insufficient data are available from Victorian commercial or recreational fisheries to assess the status of the western Australian salmon stock. However, anecdotal information exists from a variety of recreational fisheries (surf and estuarine). In addition, the western Australian salmon stock extends from Western Australia to Victoria and it is possible to draw inferences from South Australian and Western Australian monitoring to inform the status of the stock.

This assessment found:

Eastern Australian salmon

- *Fishing pressure* – Ocean purse seine fishing effort has remained relatively consistent since the development of the fishery in the mid-1990s (Appendix 2). Australian salmon landings from the eastern stock have been variable (Figure 94) with fluctuations likely driven by market demand and purse seiners targeting a variety of other schooling pelagic species.
- *Biomass* – CPUE was high during the early years of this fishery before fishing ceased temporarily between 1988 to 1995. Upon recommencing, CPUE was lower than it was previously and remained consistently below the reference period average for around a decade. During the last decade CPUE has been above the average for the reference period (Figure 95). Reasons for the low CPUE period are likely to be related to the larger number of operators who may have been less efficient and were targeting species apart from salmon. In recent years gear efficiency and specific targeting are likely to have ensured that CPUE remained above the reference average. These changes in fishing behaviour make it somewhat problematic to interpret CPUE trends within the context of biomass, particularly because this species schools heavily and purse seine shots are only undertaken when a school is located. Nevertheless, the fact that such large quantities are being taken in each shot (10–20 t) means that the size of Australian salmon schools has not declined noticeably since the development of the fishery in the 1980s, implying that biomass is likely to still be relatively high.

Stock status summary: The available evidence indicates that the eastern Australian salmon biomass has remained relatively stable since around 2005 and landings have been low to moderate during the last seven years, presumably due to low market demand for this species, which is predominantly used for rock lobster bait. Based on this evidence the Eastern Victorian Australian salmon stock is considered to be sustainable.

Western Australian salmon

Stock status summary: Insufficient data are available from Victorian commercial or recreational fisheries to assess the status of the western Australian salmon stock. The western Australian salmon stock is subject to very low exploitation by commercial fisheries in Victoria. The species is not a common target in the major Victrorian bay and inlet fisheries; for example, "Salmon" were listed as the primary target species in only 0.38% of recreational fishers interviewed in creel surveys in Port Phillip Bay. Western Australian salmon are targeted in small scale recreational fisheries elsewhere (e.g. in estuaries and along the coast), however these are small within the context of the species wide ranging behaviour and the diversity of habitats where they are found. The mature stock resides exclusively in Western Australia and a variety of modelling techniques indicate that the stock biomass is around target levels and unlikely to be recruitment impaired (Stewart *et al*., 2018). Based on the above, western Australian salmon in Victoria is considered to be sustainable.

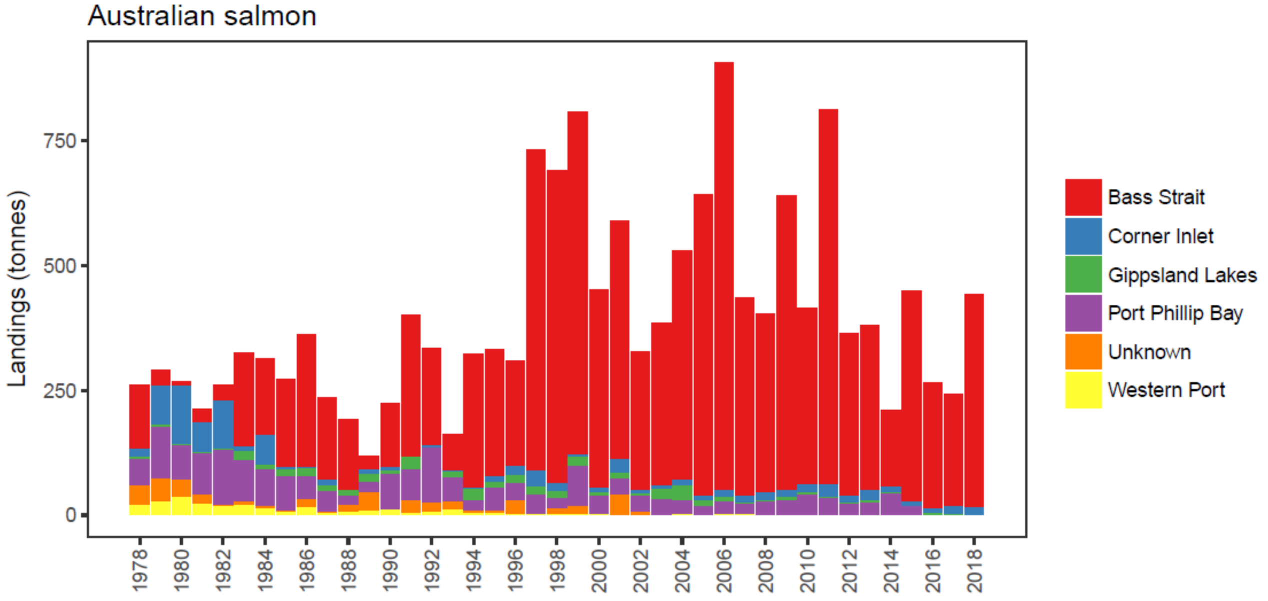


Figure 94 Total catch of Australian salmon in Victoria from the commercial fishery by area, financial years 1978–2018.

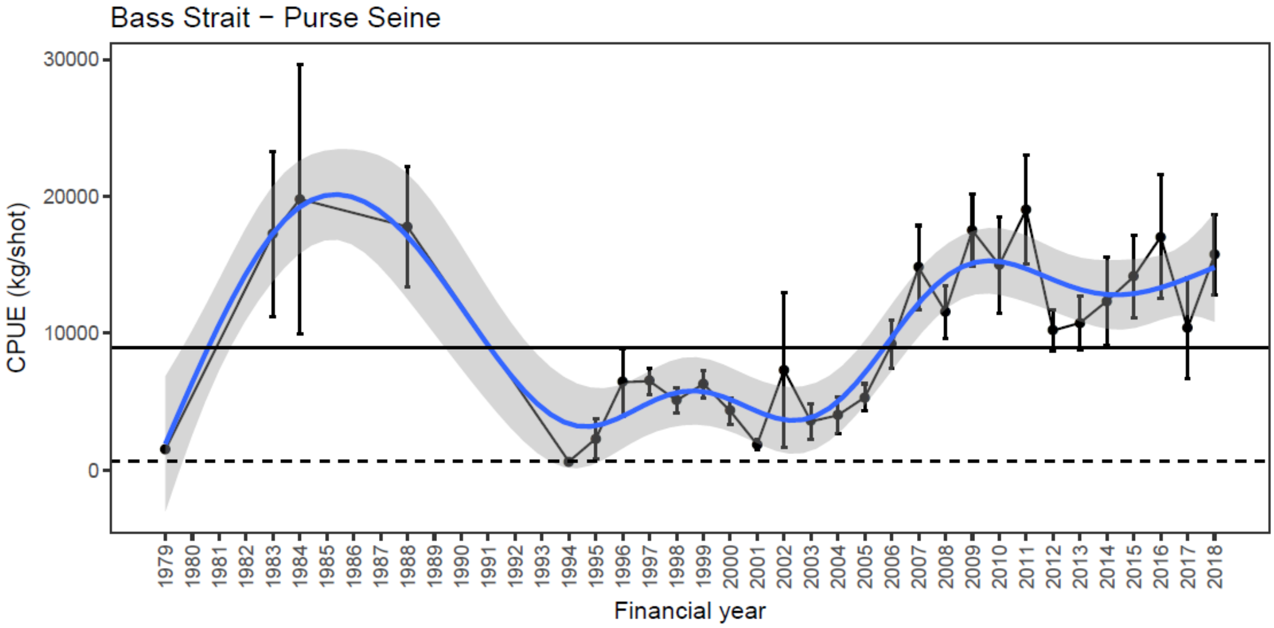


Figure 95 Nominal Catch-per-unit-effort (CPUE) (±95% CL) of catches of eastern Australian salmon for the commercial purse seine ocean fishery (1997–2018 financial years). The blue line is a generalised additive model (GAM) of the CPUE trend with the shaded area representing 95% confidence intervals of the model. The black horizontal line is the average of the reference period (1986–2015) and the dashed line is the minimum observed value during the reference period.

Tailor (*Pomatomus saltatrix*): Gippsland Lakes

Stock Structure and Biology

Information about the stock structure of tailor populations is limited, although there is considerable genetic divergence between eastern and western Australian populations. In Gippsland Lakes, tailor is part of a straddling, south-eastern Australian stock shared with New South Wales and Queensland. Tailor can live to 11–13 years of age and reach 120 cm TL. Tailor mature (50 percent) at 1–2 years of age (males 29 cm TL; females 31 cm TL) and are highly fecund and are fast growers. The main spawning period for the south-eastern Australian tailor stock occurs in winter/spring in coastal waters.

Management/Assessment Unit

The Victorian component of the south-eastern Australian stock supports a commercial fishery and a small recreational fishery in Gippsland Lakes (Figure 96). This report only considers populations in Gippsland Lakes. It is important to note that commercial catches of tailor from Gippsland Lakes, and Victoria more generally, are an order of magnitude lower than in New South Wales and Queensland, and the impact of the Gippsland Lakes fishery is likely to have negligible influence on overall stock status.

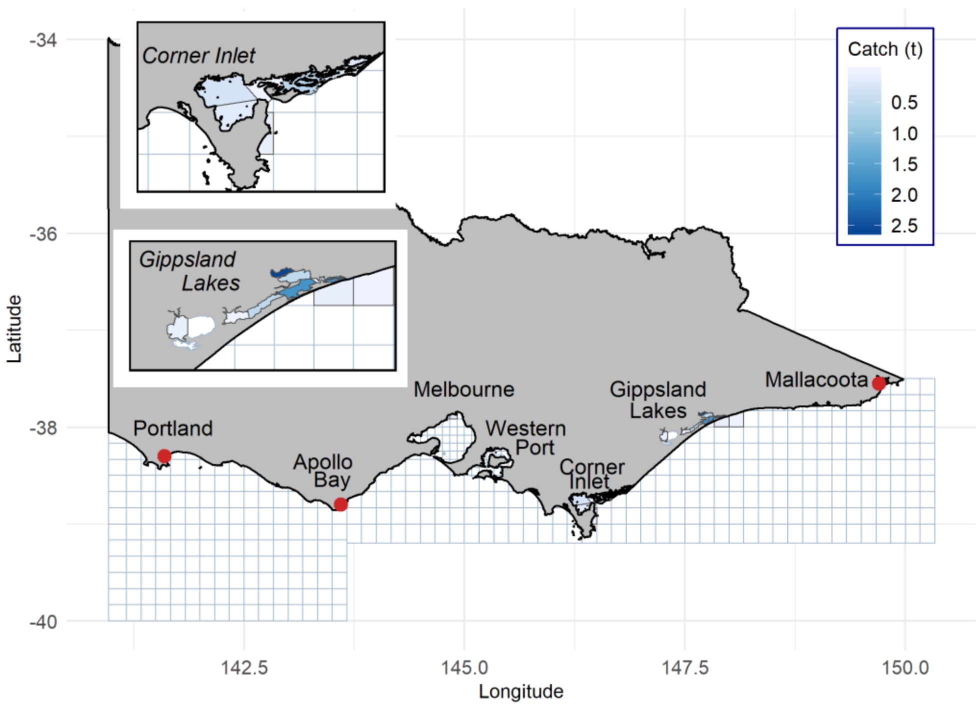


Figure 96 Spatial distribution of state-wide landings of tailor from Victorian fisheries during the 2018/19 financial year.

Assessment Summary

The status of tailor stocks in Victoria was evaluated using:

- Nominal CPUE for the commercial mesh-net fisheries in the Gippsland Lakes. Tailor are also infrequently captured by fishers in Corner Inlet and by purse seine fishers offshore, however there were insufficient data available from these fisheries to inform temporal abundance trends.

This assessment found:

- *Fishing pressure* – State-wide commercial tailor harvest have been variable from <20 t to nearly 100 t representing changes in targeting, retention rates and availability of this highly mobile species (Figure 97). Landings in the last ten years have also been variable but well within the bounds of historical peaks observed during the 1980s to 2000s.
- *Biomass* – Nominal CPUE of tailor from the Gippsland Lakes mesh net fishery has been variable, again likely as a result of variation in targeting, retention rates and availability (Figure 98). Although there appears to be an overall slow decline in CPUE the very high spikes in 1998 and 2003 with large associated variance contrast markedly with greater stability in the last decade where in most years values have been close to the average and variance in the data has been noticeably small.

Stock status summary: There is no evidence that recruitment to the stock has ever been impaired by the Gippsland Lakes fishery and the available evidence suggests that the fishery in Gippsland Lakes is sustainable under current and future conditions.

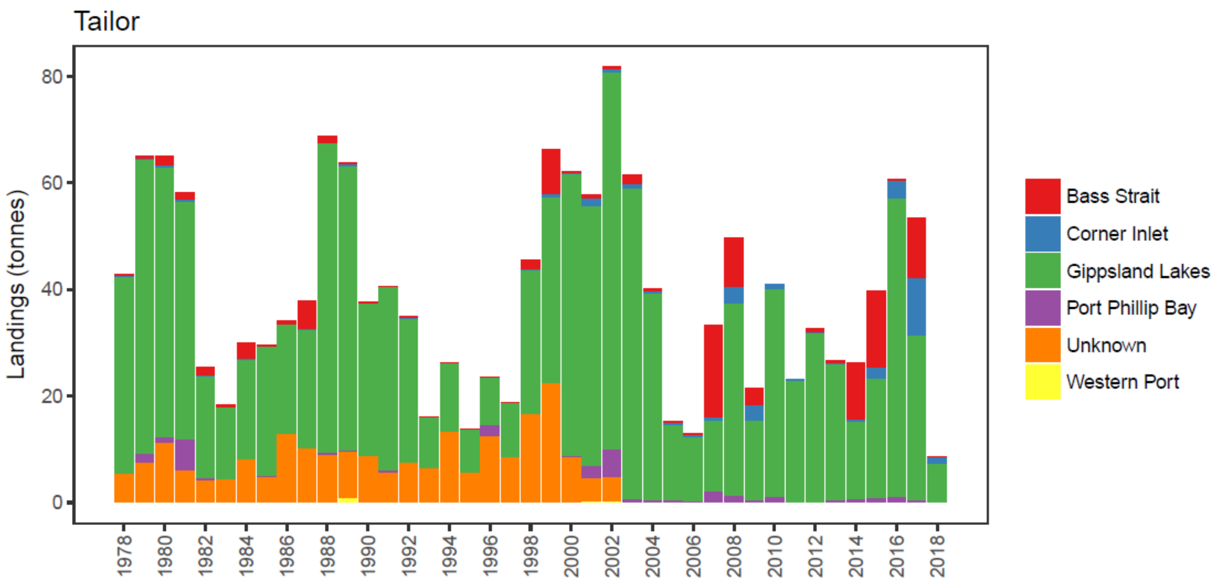


Figure 97 Total commercial catch of tailor in Victoria, financial years 1978–2018.

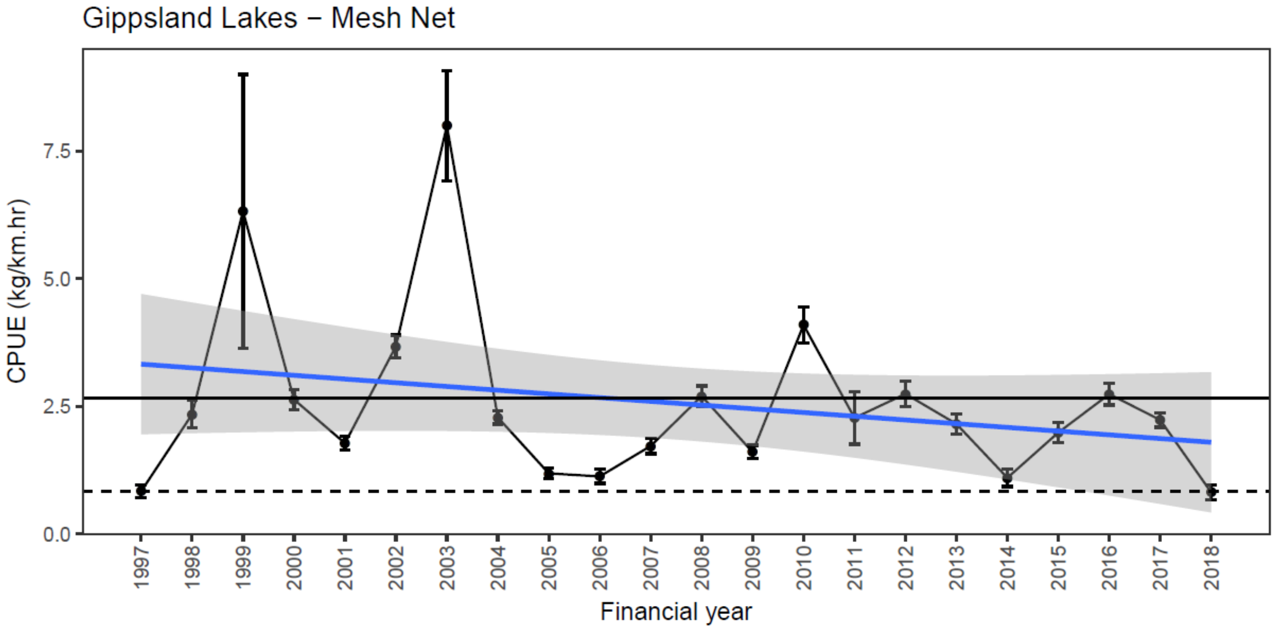


Figure 98 Nominal Catch-per-unit-effort (CPUE) for the Gippsland Lakes commercial mesh-net tailor fishery (1997–2018). The blue line is a generalised additive model (GAM) of the CPUE trend with the shaded area representing 95% confidence intervals of the model. The black horizontal line is the average of the reference period (1997–2015) and the dashed line is the minimum observed value during the reference period.

Elephant Fish (*Callorhinchus milii*)

Image source: Status of Australian Fish Stocks 2018

Stock Structure and Biology

Elephant fish populations in Victorian waters comprise a portion of a single biological stock for south-eastern Australia. Elephant fish live to ~20 years (Bell, 2012) and sexual maturity is attained at 59 and 54 mm fork length for females and males respectively (Bell, 2012). Based on the ovarian cycle, elephant fish lay 20 – 30 eggs per year from February – May, which are deposited on soft sediment habitats (Bell, 2012) and hatch after around 5 – 6 months. Known egg laying areas include Western Port, Port Phillip Bay, Corner Inlet, and the Barwon River (Bell, 2012) but elephant fish are also found in many other Victorian coastal areas, bays and estuaries during their reproductive season suggesting a proportion of the population lays eggs throughout much of the state. Western Port was the major known egg laying habitat for the species within Victoria with the species being so abundant that they once were the target of a relatively large recreational fishery.

Management/Assessment Unit

Elephant fish were historically landed in low to moderate quantities by commercial bay and inlet fisheries, particularly in Western Port. However, due to buy backs in Western Port and Port Phillip Bays, there have been no landings in recent years, and the landings from Corner Inlet are insufficient to support quantitative analyses. As a result, the status of the Victorian stock is estimated using catch and effort information from the recreational fishery in Western Port, supplemented by information from the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF).

Assessment Summary

The performance of the CPUE biomass proxies from creel surveys of the recreational fishery in Western Port Bay were assessed in relation to the average and minimum values for the reference period 1998–2015.

This assessment found:

- *Fishing pressure* – The buy-out of commercial fishing licences in Western Port and, to a lesser extent, Port Phillip Bay, has largely removed any commercial take of elephant fish from Victorian waters. Elephant fish were once a popular target of recreational fishers in Western Port, however, in recent years there is almost no targeted effort toward this species. A study found that in 1998 ~45 t of elephant fish was landed in Western Port by recreational fishers and ~70% of the recreational catch was comprised of mature females that had moved inshore to reproduce (Braccini et al. 2008). When combined with State and Commonwealth landings this was unlikely to be sustainable. As a result, daily bag limits were reduced to one elephant fish per angler to reduce fishing mortality.
- *Biomass* – Standardised recreational CPUE trends among recreational fishers in Western Port were relatively stable from 1998–2007 before declining markedly (Figure 99). It is believed that this reduction in CPUE resulted from both declining availability and a reduction in effort related to the reduced in bag limit. Standardised CPUE from the Commonwealth fleet shows relatively stable trends throughout from 2006–2013 and an increasing trend when this analysis was undertaken with the inclusion of discards (Tuck, 2018).

Stock status summary: Standardised CPUE is now below the minimum observed during the reference period and the recreational fishery is not performing adequately. This could be caused for several reasons: 1) the reduction in daily bag limit has meant that elephant fish are rarely targeted; 2) there may be fine scale population structuring and the stock that once supported the recreational fishery in Western Port is currently depleted to relatively low abundance but is not a major component of the SESSF meaning that this reduction is not reflected in analytical results based on data from the SESSF; 3) changes in discard rates within the Commonwealth fishery have masked the reduction in biomass of the stock; and 4) although elephant fish have very high post capture mortality, the recommended biological catch from the Commonwealth fishery does not incorporate this into its analysis meaning that the retained catch is unlikely to be an effective assessment measure.

As elephant fish are a bycatch/byproduct of the Commonwealth gillnet fleet targeting sharks (predominantly gummy shark) the CPUE of this fleet was greatly changed by the inclusion of discards (Tuck, 2018). Discard rates are estimated using onboard observation information from 1998 to the 2006 as there was some major changes to the operational parameters of the fishery after this time. There was also an increasing trend in discards in 2011 and 2012, which greatly altered the trend in CPUE. Changing patterns in retention rates has a major influence on this analysis and could mean that CPUE is an unreliable index for abundance. These factors create uncertainty about the current status of the Victorian component of the stock.

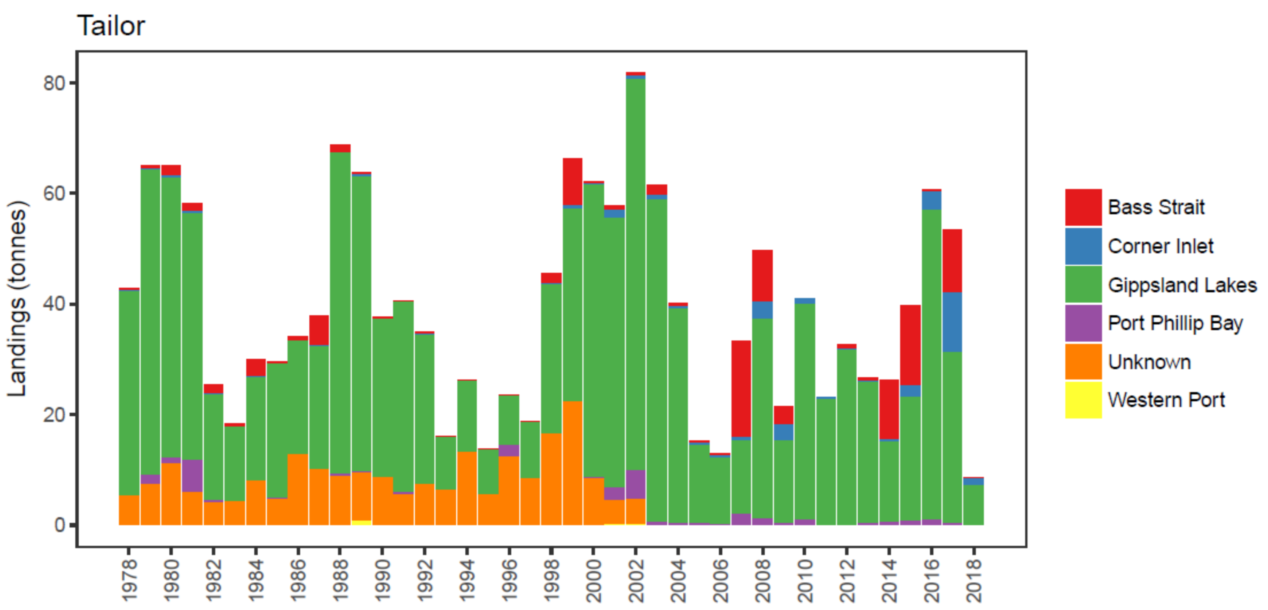


Figure 99 Catch-per-unit Effort (CPUE) of elephant fish by recreational anglers interviewed in creel surveys undertaken in Western Port Bay from 1998–2018 financial years. Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Horizontal black line is the mean standardised CPUE during the reference period and the dashed black line is the minimum standardised CPUE within the reference period.

Estuary Perch (*Macquaria colonorum*)

Stock Structure and Biology

Estuary Perch inhabit estuaries throughout Victoria, although they are only highly abundant in several of these: the Glenelg, Hopkins, Tarwin and Bemm rivers. In these estuaries they support predominantly recreational fisheries, with only low commercial catches taken as by-product from the Gippsland Lakes. Estuary Perch live for over 40 years, but their populations are often comprised of very few year classes (Walsh, 2010). This is thought to occur because the highly variable estuarine environments they inhabit are infrequently conducive to successful recruitment and their long lifespan ensures a proportion of the population survives for enough years to encounter suitable spawning conditions to perpetuate the population.

Management/Assessment Unit

Estuary perch, as their name suggests, inhabit estuarine systems and therefore it would be illogical to assess their status on a state-wide basis. As such, the status of estuary perch is assessed for individual estuaries for which sufficient data are available.

Assessment Summary

There are insufficient data from commercial fisheries to enable assessment of Estuary Perch populations. As such, recreational angler diary programs are used to derive the data required to calculate CPUE in the estuaries where the major estuary perch fisheries exist in western Victoria. This excludes the Tarwin and Bemm rivers and other small estuaries for which data were inadequate or unavailable.

The performance of the CPUE biomass proxies were assessed in relation to the specified reference period (2001–2015 and 1999–2015 for Glenelg and Hopkins rivers respectively).

Glenelg River

This assessment found:

- *Fishing pressure* – There is no direct information on the amount of fishing pressure on the estuary perch population in the Glenelg River. However, they are reaching very large sizes with more than half of the catch being >40 cm in 2017/18 (Figure 102b) suggesting fishing mortality is likely to be relatively low. Given the Glenelg River is relatively remote, and recreational anglers often release the estuary perch that they catch, the current level of fishing pressure is unlikely to be pose a risk to estuary perch populations in this system.
- *Biomass* – Catch rates of estuary perch in the Glenelg River have been well above the reference period average in recent years, and the interannual trend has been increasing, but the sample size is low prior to 2012 meaning there is minimal information upon which to benchmark current catch rates (Figure 101). The available evidence suggests that there has been poor recruitment of estuary perch in the Glenelg River in recent years because; 1) undersized (juvenile) estuary perch were prevalent in catches during 2013 and 2014 but then became scarce in 2015 and have been non-existent in the last two years (Figure 102a, b), and 2) there has been a truncation in the size range of the catch at its lower end with most fish being 30 – 50 cm in length. However, the angler diarist responsible for providing most of the recent data in recent years predominantly fishes well upstream and targets large fish meaning the lack of juveniles may be a biased result which does not reflect of poor recruitment.

Stock status summary: Catch rates have been high in recent years in the Glenelg River and given the proportion of large fish in the system, fishing mortality is likely to be relatively low. However, a lack of juveniles in the data could mean poor recruitment in recent years. Estuary perch are a long-lived species, with this strategy thought to be required to bridge the gap between successful recruitment events, which are less prevalent in highly variable estuarine environments. A more targeted sampling regime is required to determine whether there has been a lack of recruitment, or the fisher's practices are responsible for the lack of juveniles in the sample. Ageing data would be very useful to estimate the number of successful recruitment events that the fishery is reliant upon. It would also enable the level of fishing mortality to be estimated more accurately. Given there is minimal historic information, and it is possible that there has been poor recruitment in recent years, there is some risk that the fishery could become depleted in the future. Based on the evidence available the status of the Glenelg River estuary perch stock remains uncertain.

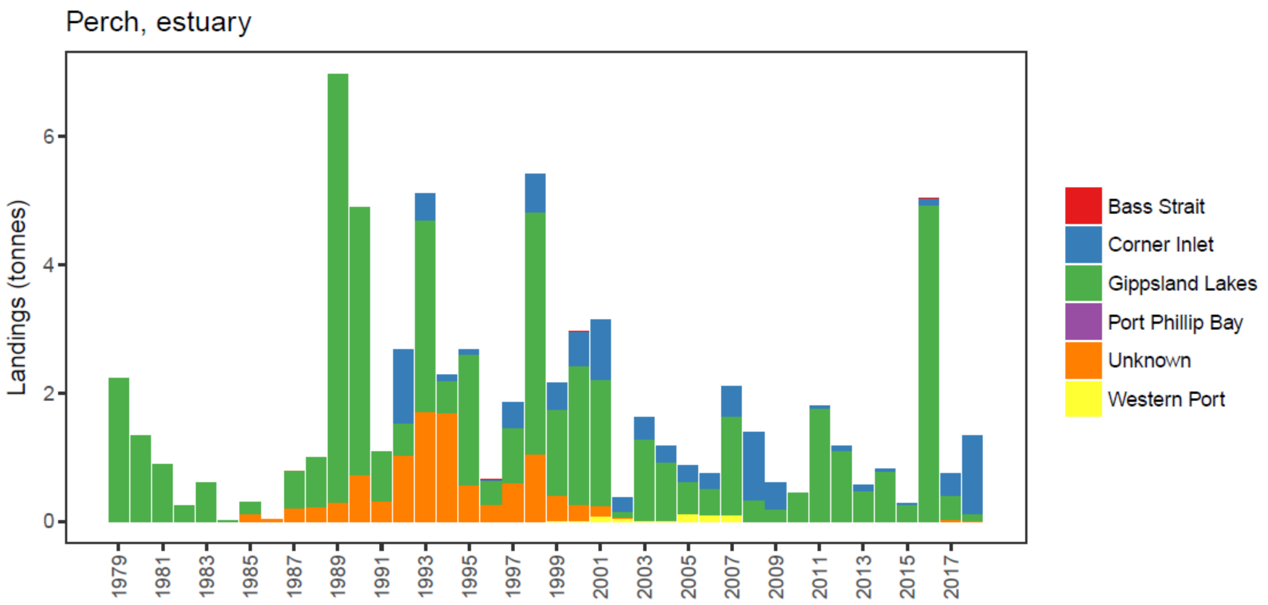


Figure 100 Total catch of estuary perch from the Victorian commercial fisheries, financial years 1978–2018.

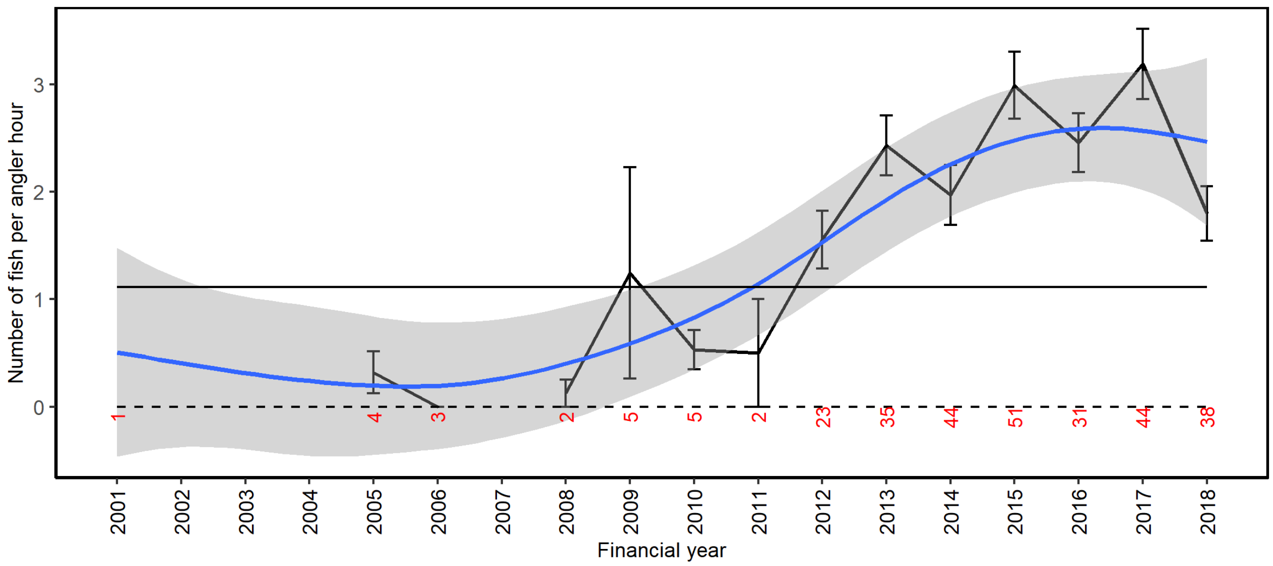
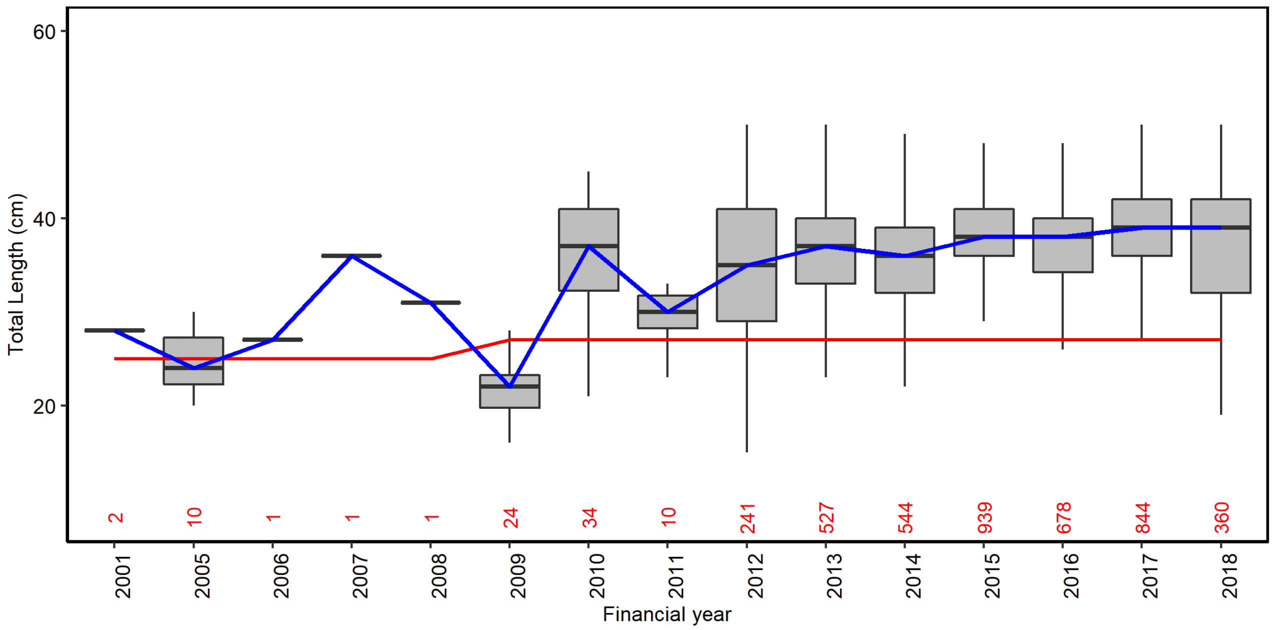


Figure 101 Nominal Catch-per-unit-effort (CPUE) (±SE) of estuary perch for diary anglers in Glenelg River (2001–2018 fiscal years). Horizontal black line is the mean CPUE during the reference period (2001–2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

(a)



(b)

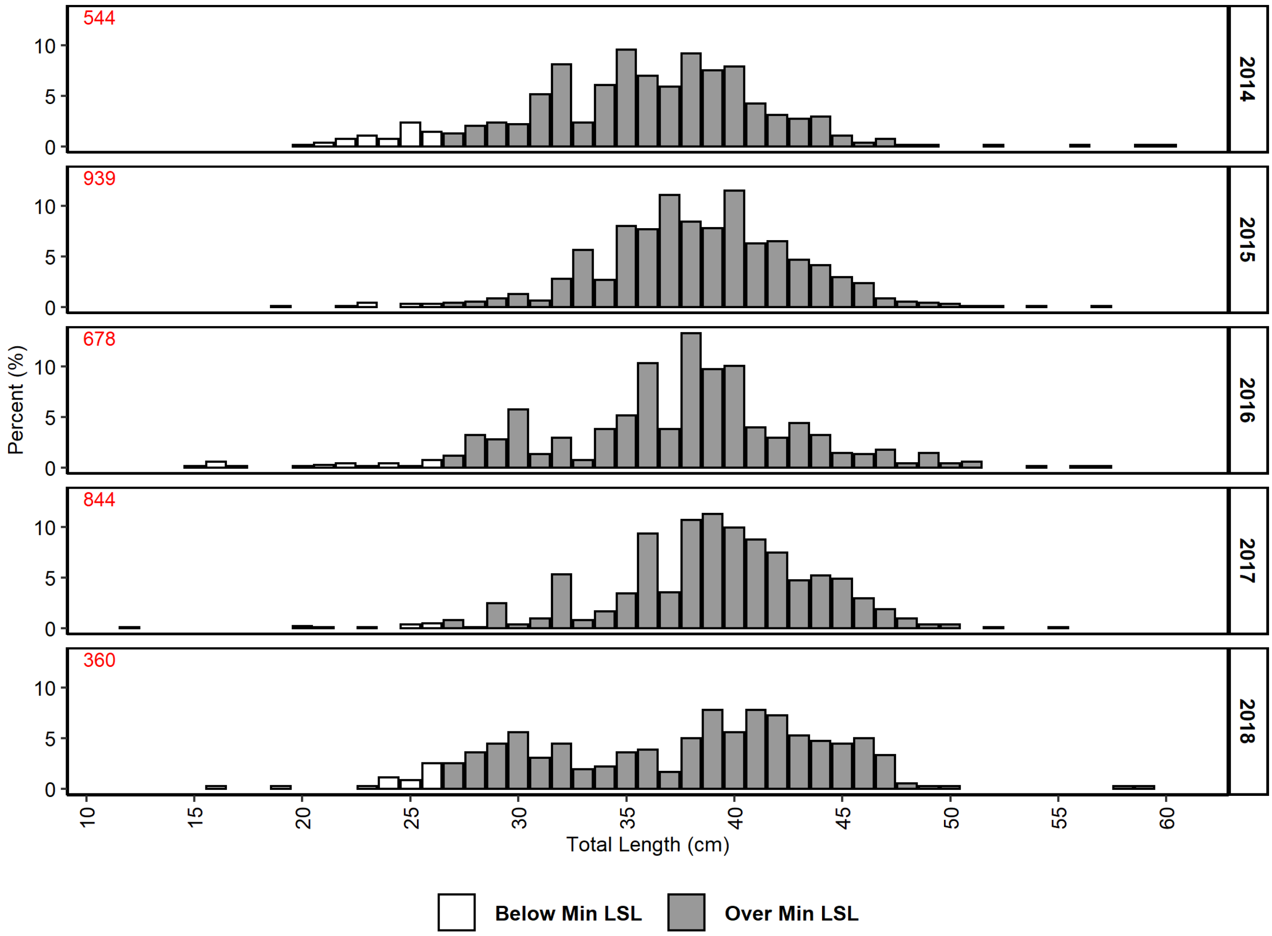


Figure 102 (a) Box-plots of Glenelg River estuary perch length composition from diary anglers for fiscal years 1999–2018. Red numbers on x-axis indicate numbers of fish sampled. Blue line = median length, red line = LML. (b) Frequency histograms of Glenelg River estuary perch length composition from diary anglers for fiscal years 2013–2018. Red numbers indicate numbers of fish measured.

Hopkins River

This assessment found:

- *Fishing pressure* – There is no direct information available on the amount of fishing pressure on estuary perch in the Hopkins River. The length frequency data provides a limited indication of the level of fishing mortality. In this case, the size frequency of the catch is consistent with relatively low fishing mortality, although large perch represent a smaller proportion of the catch than they do in the Glenelg River. This perhaps reflects that the Hopkins is a far smaller estuary located at the much more populous provincial city of Warrnambool. Nevertheless, the prevalence of large fish in the catch indicates that perch are surviving well beyond maturation.
- *Biomass* – A relatively long angler diary CPUE time series is available to assess the biomass of estuary perch in the Hopkins River. Catch rates have, on average, increased throughout the time series and have remained relatively stable for the last three years at historic highs well above the reference period average. Interpretation of the long-term trend needs to be undertaken with the caveat that there have been some significant changes in angling behaviour during this time; particularly the development, and widespread uptake, of lure fishing, which greatly increases the catchability of estuary perch. Additionally, the angler diarist responsible for the last few years of data uses live bait and solely targets very large fish. Based on the length frequency of the catch, the last successful recruitment event appears to have been around 2011/12 as there is a distinct lack of juveniles in the catch. However, like the Glenelg, this could be more due to the fishing practices of the angler in recent years than to poor recruitment.

Stock status summary: The available evidence suggests that fishing mortality is likely to be relatively low for estuary perch in the Hopkins River. However, like the Glenelg River, there appears to have been several years of poor recruitment with juveniles being rare, although this may be an artefact of the angler diarist specialising in targeting large fish. If not, perhaps it is unsurprising that both rivers share similarities in recruitment given their geographic proximity. Estuary perch are a long-lived species, with this strategy thought to be required to bridge the gap between successful recruitment events, which are less prevalent in highly variable estuarine environments. Ageing data would be very useful to estimate the number of successful recruitment events that the fishery is reliant upon. It would also enable the level of fishing mortality to be estimated more accurately. Based on the evidence available the status of the Hopkins River estuary perch stock remains uncertain.

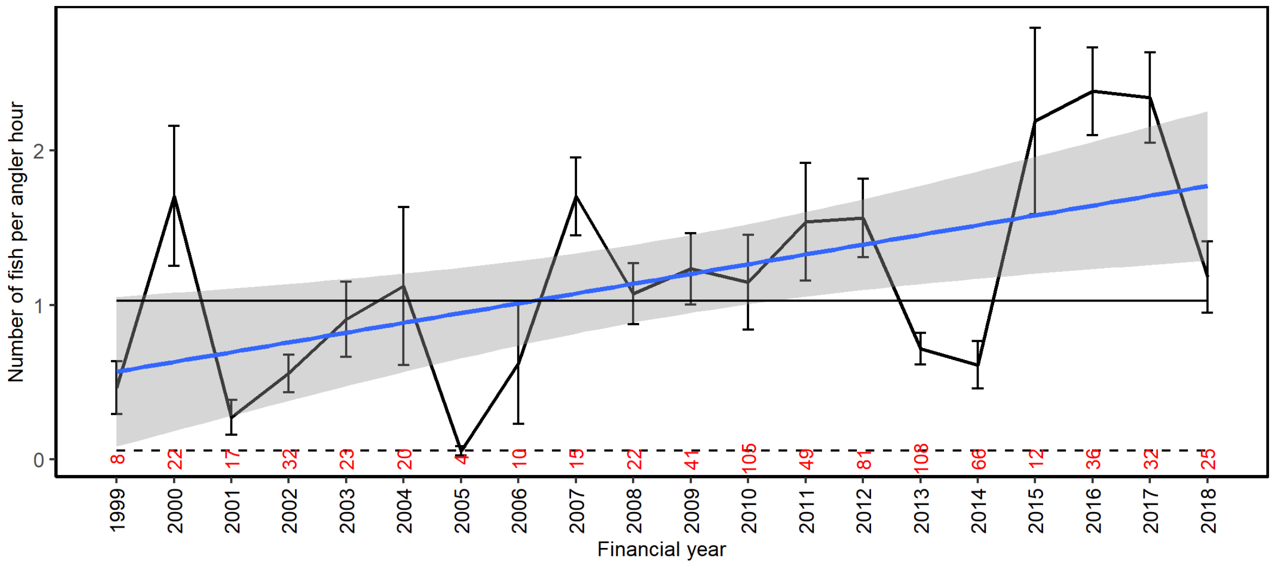


Figure 103 Nominal Catch-per-unit-effort (CPUE) (±SE) of estuary perch for diary anglers in Hopkins River (1999–2018 fiscal years). Horizontal black line is the mean CPUE during the reference period (1999 - 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

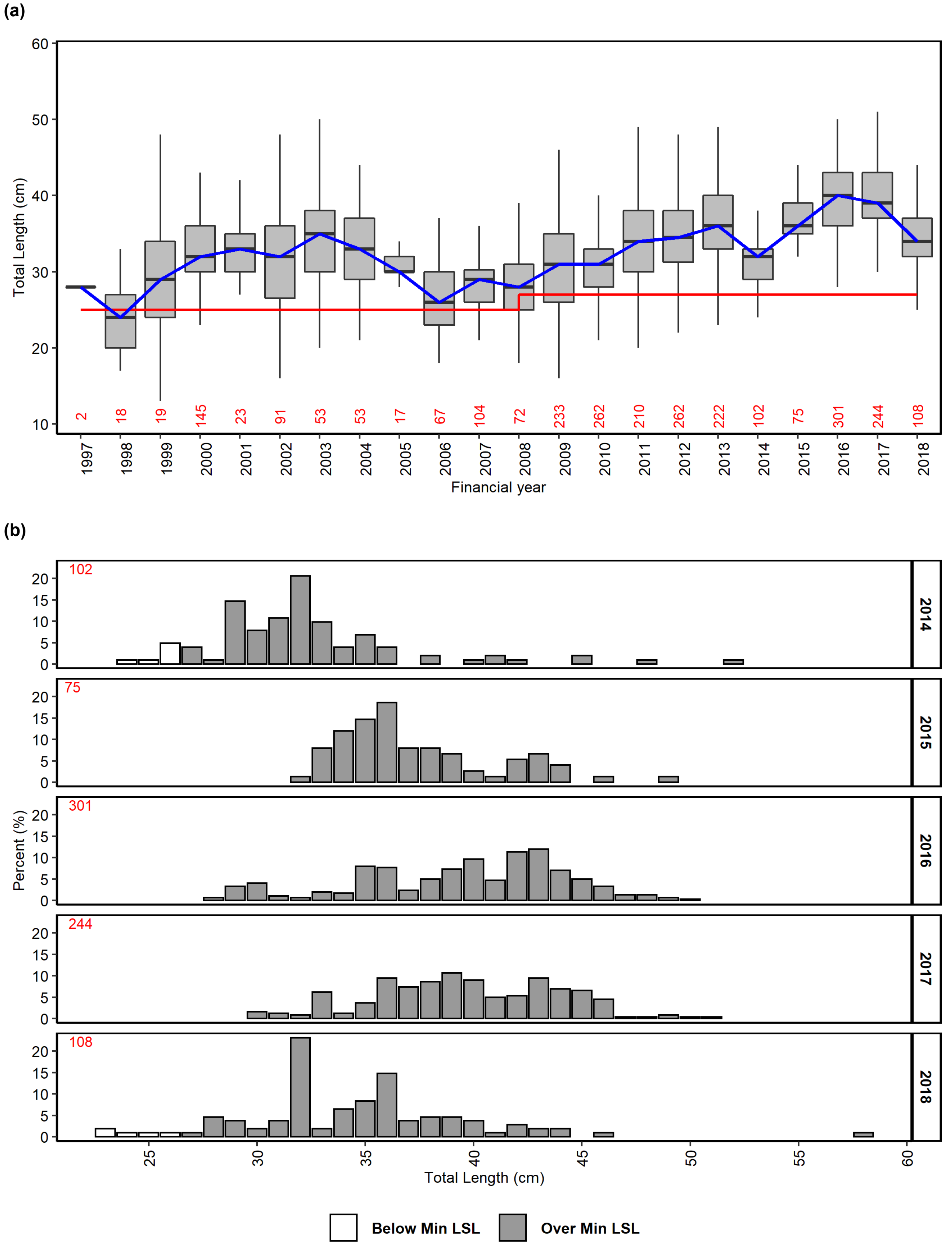


Figure 104 (a) Box-plots of Hopkins River estuary perch length composition from diary anglers for fiscal years 1999-2018. Red numbers on x-axis indicate numbers of fish sampled. Blue line = median length, red line = LML. (b) Frequency histograms of Hopkins River estuary perch length composition from diary anglers for fiscal years 2013-2018. Red numbers indicate numbers of fish measured.

Dusky Flathead (*Platycephalus fuscus*)

Stock Structure and Biology

Dusky Flathead are predominantly an estuarine species captured by commercial fishers in Gippsland Lakes and by recreational anglers in the estuaries of eastern Victoria. Contrary to the popular belief that Dusky Flathead are protandrous and change sex from male to female, studies have found that they are rudimentary hermaphrodites with sex determined at an early juvenile stage (Pollock, 2014). Females do, however, grow much larger than males. This species lives to at least 16 years of age (Gray and Barnes, 2015), though there are no published studies of the age of this species at its maximum reported size. Dusky Flathead have a protracted spawning period throughout summer, with multiple spawning events taking place near the entrance of estuaries (Pollock, 2014; Gray and Barnes, 2015). The relatively short lifespan for this species coupled with potentially high, albeit highly variable, fecundity implies that environmental conditions will have the greatest influence over the stock recruitment (Hicks et al. 2015).

Management/Assessment Unit

Dusky flathead predominantly inhabits estuaries, with each estuary likely to support a relatively isolated stock. Considering their isolation, each estuary for which data are available is assessed independently. Commercial harvests have been restricted to Gippsland Lakes since the creation of recreational only fishing reserves in Lake Tyers in 2007 and Mallacoota Inlet in 2004 (Figure 105). The 20-year time series of data available does not rule out a decadal cycle given the pattern of recruitment expected under natural, unfished, conditions. Under these circumstances, future performance of the stock will remain uncertain until there is a much longer time series available for assessment.

Assessment Summary

The performance of the CPUE biomass proxies were assessed in relation to their average and minimum values during the reference period 1999 – 2015 for commercial fishing in Gippsland Lakes, and during 1999–2015 for creel or angler diary surveys undertaken in Gippsland Lakes, Lake Tyers and Mallacoota Inlet.

Gippsland Lakes

This assessment found:

- *Fishing pressure* – Dusky flathead have historically been a by-product of commercial fishers targeting more valuable species with landings remaining around 10 – 20 t for the last few years (Figure 105), as they have been solely taken from Gippsland Lakes since the buyout of commercial licences from other estuarine commercial fisheries. Mesh netting effort in Gippsland Lakes is currently at about half of historic high values that occurred in the 1980s and seining effort is at historic low values (see Appendix 2). There is some indication that dusky flathead has been targeted commercially in Gippsland Lakes since the mid-2000s, possibly as a response to reduced availability of black bream.

- *Biomass* – Mesh net commercial CPUE increased during the 2000s, reaching a maximum in the mid-2000s that was well above the reference period average, before declining again to levels similar to the start of the series close to the reference period minimum. There was a moderate increase towards the end of this CPUE series (Figure 107). Despite its limitations in coverage i.e. low number of observations outside the period 2006 - 2010, and absence of data in 2011 in 12, CPUE from recreational anglers showed a clearly declining trend over almost two decades from well above the reference period average to below the minimum for that reference period(Figure 107).

Stock status summary: Current levels of fishing pressure (both mesh net and seine) are below historic highs. Mesh net CPUE remains around halfway between the reference period average and the minimum suggesting that the stock is within historic bounds. Notwithstanding the overall trend in angler diarist CPUE, and bearing in mind the limited observations, the pattern among recent nominal values has been relatively stable around the minimum. However, with the impending closure of the commercial fishery future data available to assess this species will be limited to diary angler and creel surveys which currently lack coverage for dusky flathead in Gippsland Lakes. These most recent data suggest that although future is uncertain, there is some expectation that given the life history characteristics of dusky flathead and an absence of commercial fishing, further recruitment to the stock is likely when environmental conditions are favourable. Based on the above summary the Victorian Gippsland Lakes dusky flathead stock is depleting.

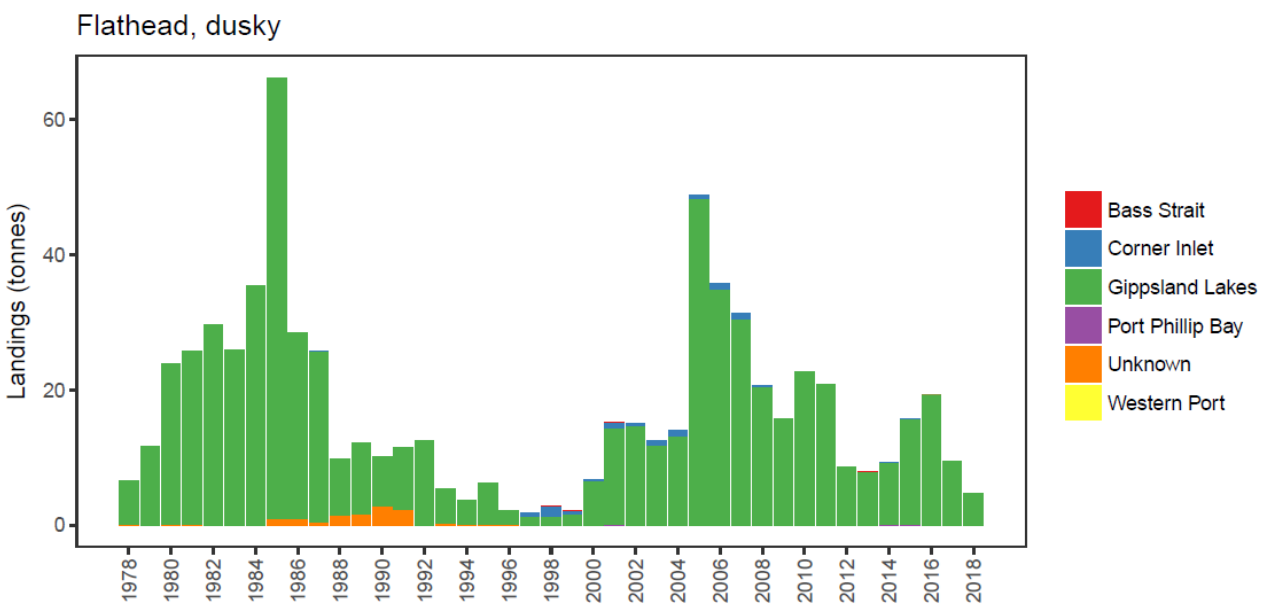


Figure 105 Total catch of dusky flathead from Gippsland Lakes by gear type, financial years 1978–2018. Note: Commercial harvests have been restricted to the Gippsland Lakes since creation of recreational only estuaries in Lake Tyers in 2007 and Mallacoota Inlet in 2004.

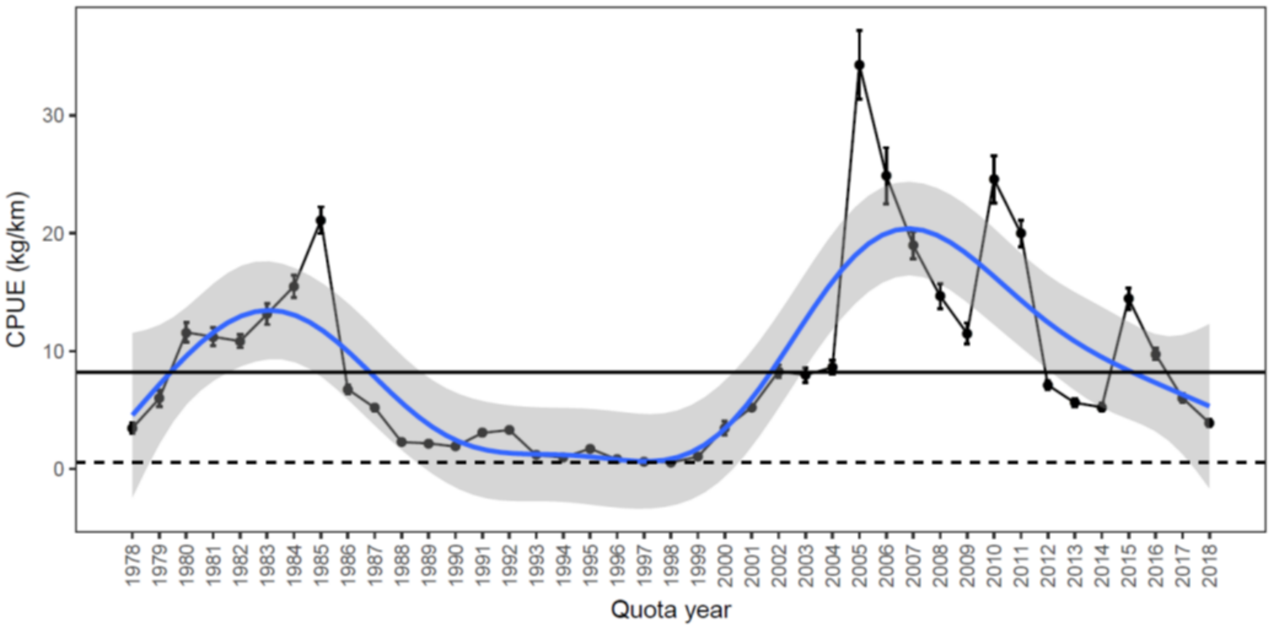


Figure 106 Dusky flathead nominal Catch-per-unit-effort (CPUE) (±SE) for a) for commercial mesh netting in Gippsland Lakes (1978–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1985 - 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

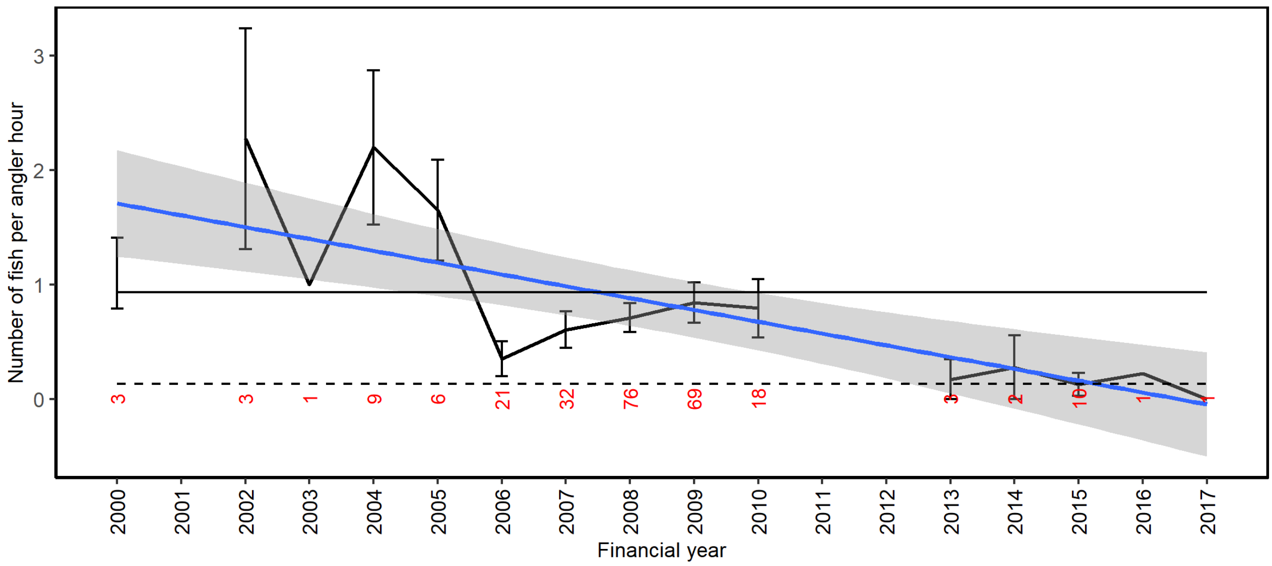


Figure 107 Dusky flathead nominal angler diarist catch-per-unit-effort (CPUE) (±SE) for a) in the Gippsland Lakes (1978–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1985 - 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

Mallacoota

This assessment found:

- *Fishing pressure* – There is no direct measure of fishing pressure for dusky flathead in the Mallacoota estuarine system. There is some possibility that fishing mortality may be relatively high given there is a lack of very large dusky flathead in all years of the length frequency sample (Figure 109b) and the median size, and upper quantile, have declined since the late 1990s and early 2000s (Figure 109a).
- *Biomass* – There has been a variable, but increasing, trend in angler diarist CPUE during the first 5 years of the time series followed by five years at levels at or above the reference period average, before a decline since 2009 to level out at bit over one third of the rate during the preceding five years (Figure 108) (Hamer et al 2019).

Stock status summary: The higher levels of CPUE during 2004 – 2009 from angler diarists fishing for dusky flathead at Mallacoota was likely reflective of a strong recruitment event. The time series is not long enough to determine if this is part of the boom-bust cycle of recruitment which characterises this species (Hamer et al 2019; Hicks et al. 2015) or represents an ongoing depleted state in which recruitment has become impaired due to changing environmental conditions. The fishing slot introduced in 2010 is regarded as generally protecting female spawning biomass from fishing and the relatively short lifespan coupled with potentially high, albeit highly variable, fecundity implies that environmental change poses the greatest threat to the stock. Although the last decade shows a pattern of depletion, this is inconclusive as the 20-year time series does not rule out a decadal cycle. Under these circumstances stock status, at least in terms of future performance, remains uncertain.

Catches have predominantly been comprised of smaller fish due the main diary angler mostly targeting bream. The diary angler CPUE is not thought to represent larger female fish, and the status of the important large female component is uncertain. While increasing use of soft plastics could be masking reductions in biomass and may explain the increasing temporal trend in CPUE, it is reasonable to assume that this would not be affecting the trend during the last 5 – 10 years and that the component of the stock within the ‘slot limit’ range (i.e. 30-55 cm) is relatively stable or increasing. There is, however, some risk that fishing mortality may be too high given relatively few very large individuals are now caught. While the relative consistency of small individuals throughout the time series suggests that recruitment is relatively consistent and remains unimpaired it may possible that growth overfishing is occurring. Growth overfishing will only reduce angling success and not compromise the sustainability of the stock.

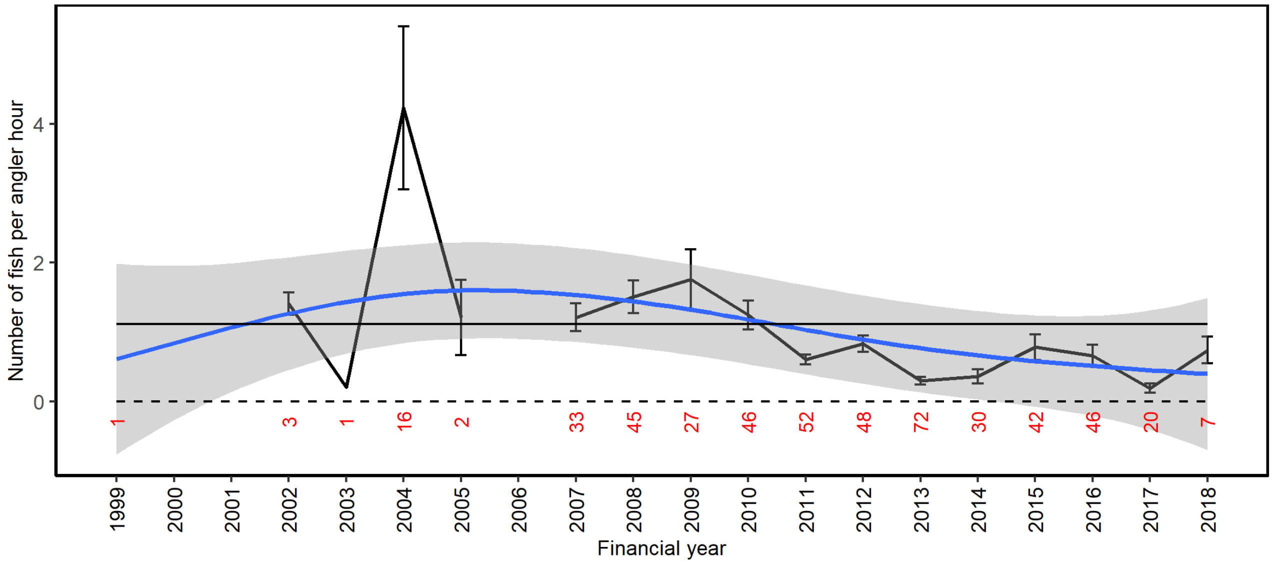


Figure 108 Nominal Catch-per-unit-effort (CPUE) (±SE) of dusky flathead for diary anglers in Mallacoota Inlet (1999–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1999 - 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

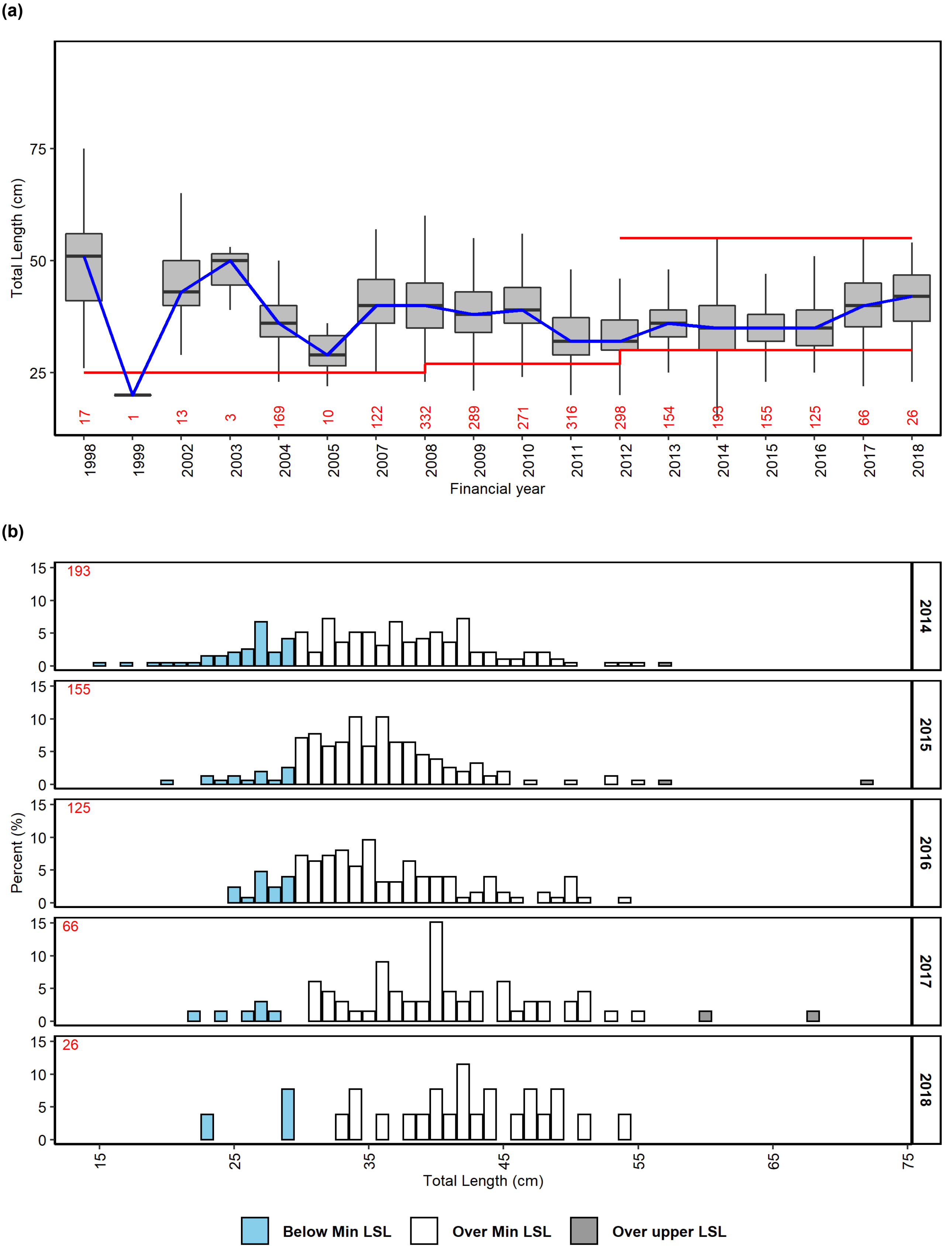


Figure 109 (a) Box-plots of Mallacoota Inlet dusky flathead length composition from diary anglers for financial years 1999-2018. Red numbers on x-axis indicate numbers of fish sampled. Blue line = median length, red line = LML. (b) Frequency histograms of Mallacoota Inlet dusky flathead length composition from diary anglers for fiscal years 2013-2018. Red numbers indicate numbers of fish measured.

Lake Tyers

This assessment found:

- *Fishing pressure* – There is no direct measure for fishing pressure in the Lake Tyers dusky flathead fishery. Based on the size composition of the angler diarists catches, there has been no long-term change in the median, or range, of sizes (Figure 111). Additionally, large individuals are present in the catch suggesting that fishing mortality is low enough to enable some females to grow through the slot limit and gain protection (Figure 111).
- *Biomass* – The CPUE of angler diarists for dusky flathead in Lake Tyers increased from 1999 – 2004 and was highly variable throughout the 2000s. From 2010 there was a consistent decline in catch rate from around 2.5 fish per hour to less than 1.0 fish per hour (Figure 110). Juveniles were present in the catch during each year suggesting recruitment has been consistent and is ongoing.

Stock status summary: The CPUE of angler diarists reduced to less than a quarter by 2018 of what it was in 2010. Although the large sample size during this period represents many more trips per diarist there was only a weakly positive relationship (20% association) between the trip count and CPUE, and there have been no major changes in fishing practices. This and the low variability in the estimates due to the large number of trips, implies that CPUE since 2010 is likely to be relatively representative of actual stock biomass. The size frequency of the catch has remained consistent and included both very large and very small fish, indicating that fishing mortality has not been so high as to prevent females from growing through the slot limit. Despite the decline in CPUE and it approaching the minimum value observed during the reference period, there is evidence for recent recruitment in the length frequency data. Based on this evidence the Lake Tyers dusky flathead stock is considered to be sustainable. The likelihood of recuitment impairment is low with the main risk being that heavy fishing pressure may limit catches until a subsequent cohort recruits to the stock.

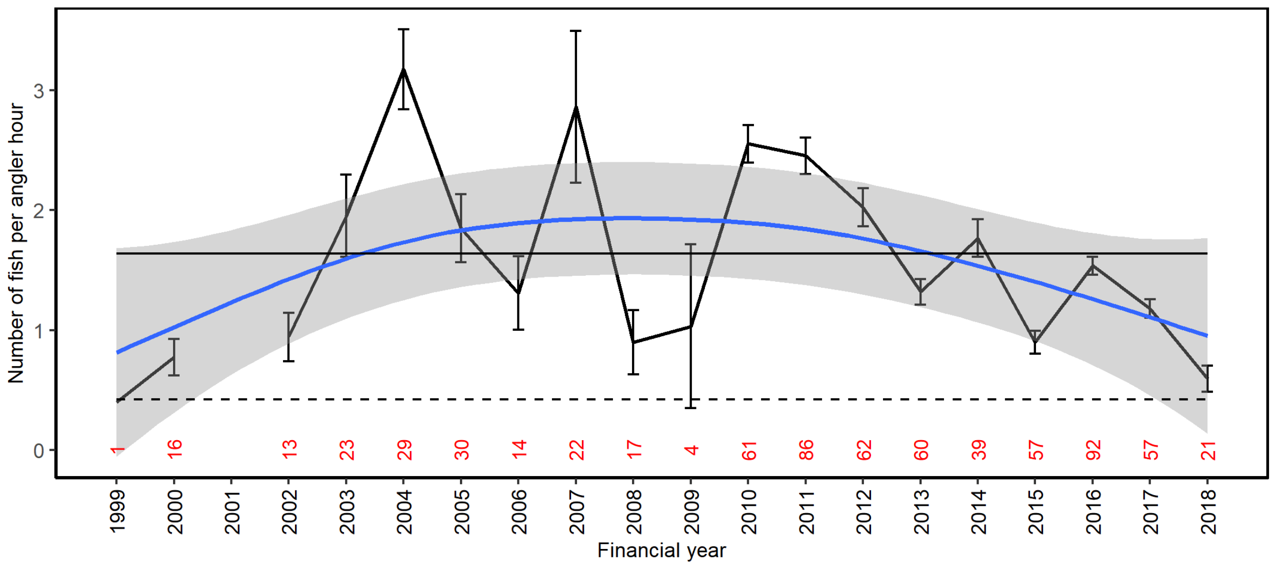
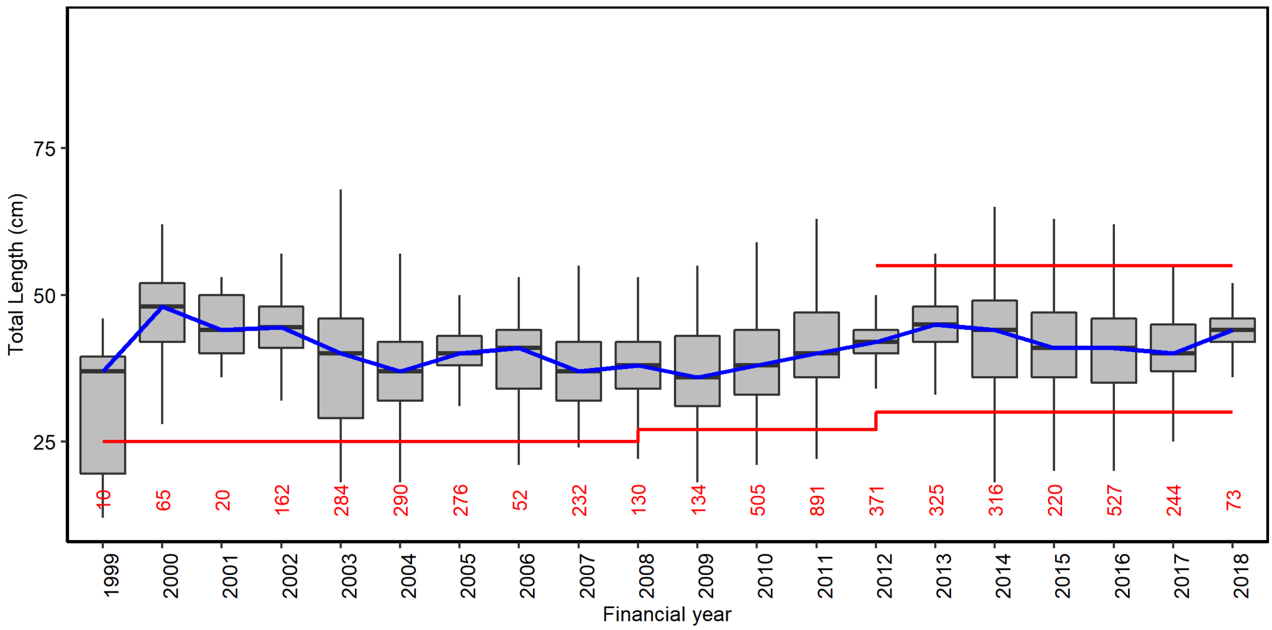


Figure 110 Nominal Catch-per-unit-effort (CPUE) (±SE) of dusky flathead for diary anglers in Lake Tyers (1999–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1999 - 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of diary angler trips.

(a)



(b)

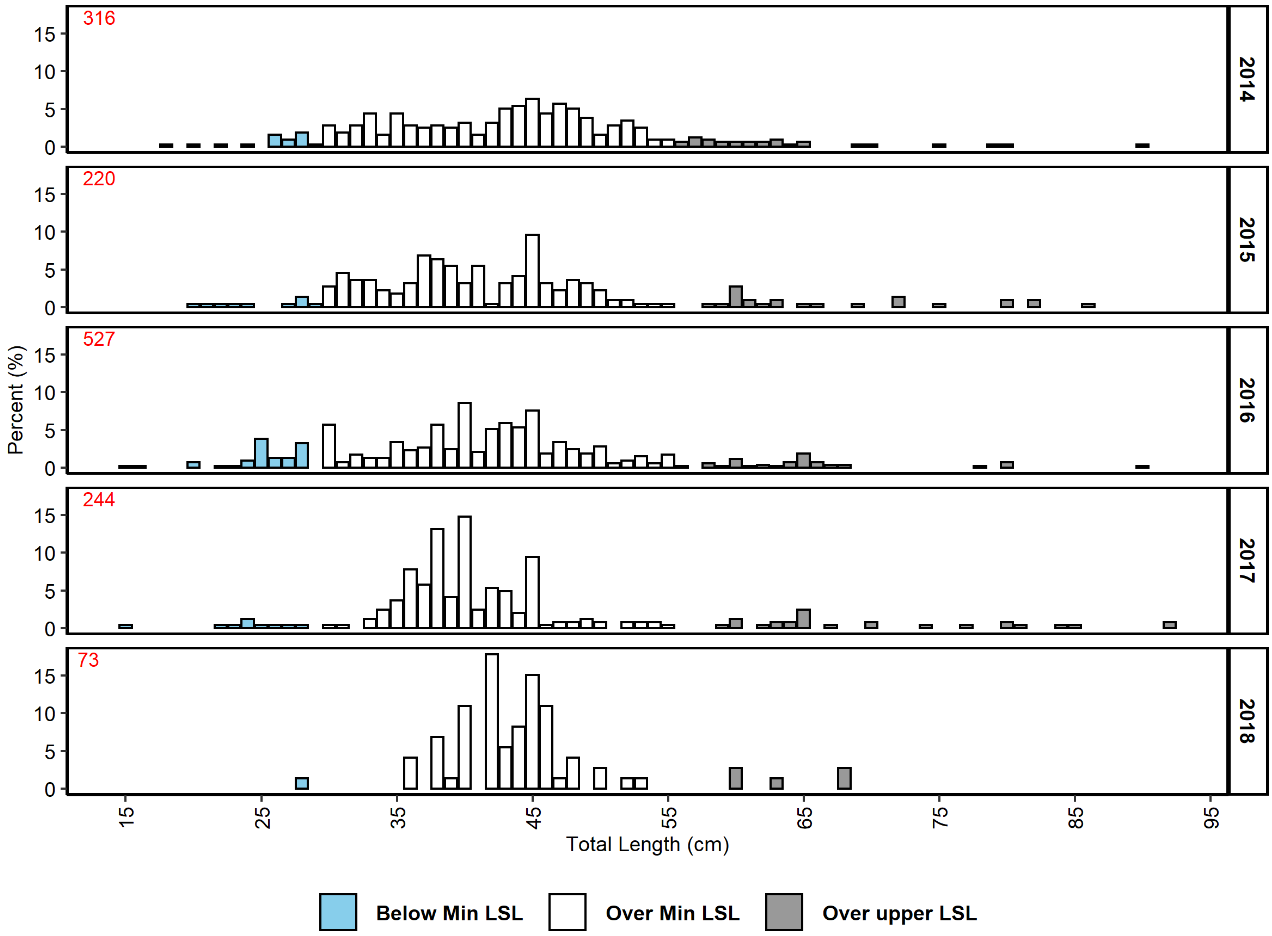


Figure 111 (a) Box-plots of Lake Tyers dusky flathead length composition from diary anglers for financial years 1999-2018. Red numbers on x-axis indicate numbers of fish sampled. Blue line = median length, red line = LML. (b) Frequency histograms of Lake Tyers dusky flathead length composition from diary anglers for financial years 2013–2018. Red numbers indicate numbers of fish measured.

Sea Urchins (*Centrostephanus rodgersii* and *Heliocidaris erythrogramma*)

Stock Structure and Biology

Two species of sea urchin are abundant in Victoria: the long-spined sea urchin (*Centrostephanus rodgersii*) and the short-spined sea urchin (*Heliocidaris erythrogramma*). Except for several isolated specimens found occasionally during the past two decades, the long-spined urchin is mostly confined to the reef habitats of East Gippsland where changing environmental conditions, predominantly due to strengthening of the East Australian Current, have led to them proliferating and denuding reefs of overstorey macroalgae to form barrens. Short-spined urchins can also form barrens, but these have mostly affected seagrass meadows in Corio Bay and Corner Inlet.

Short-spined sea urchins spawn from December – March and produce lecithotrophic offspring (i.e. larvae with their own yolk sac enabling direct development) that develop, and settle, rapidly in about 3–5 days (Williams and Anderson, 1975). No information exists about their maximum age, however it appears that they are likely to be relatively slow growing and long lived (Pederson and Johnson, 2008; Ebert, 1982).

Long-spined sea urchins live to around ten years of age (Pecorino *et al.* 2012) and have an extended spawning period from May – October (Byrne et al. 1999). The long-spined sea urchin is prolific in eastern Victoria and has been responsible for denudation of reef habitats in waters deeper than about 10 m, which has negatively impacted the Eastern Zone abalone fishery through reduction in available habitat. As a result, ongoing culling takes place on barrens habitat where roe is typically substandard (Byrne *et al*. 1999) and the urchin fishery is subsidized at times to encourage increased harvesting of urchins in areas important to the abalone fishery.

Management/Assessment Unit

The fishery is managed as two separate areas, with specific access licences for the Port Phillip Zone and Eastern Zone. Given the geographic separation between areas where short-spined sea urchins are caught (i.e. far east Gippsland and Port Phillip Bay) and the likely lack of larval dispersal due to the short larval phase of several weeks they are considered to be individual stocks. Nevertheless, because historic reporting of short-spined urchin catches from the Eastern Zone has been sporadic and at times unreliable the assessment for this species focusses on the Port Phillip Zone.

Long-spined sea urchins are only caught along the coast of far eastern Victoria and, given the extensive larval dispersal potential of this species over several months (Ling et al. 2008), it is reasonable to assume that the stocks of this species represent a single panmictic population. Long-spined sea urchins are hence assessed as a single, eastern Victorian, stock.

Both species are also culled under permit to varying extents by commercial abalone divers to prevent overgrazing and denudation of reef and seagrass habitats where they are overly abundant. The objective is to rehabilitate the habitat and restore abalone populations diminished by loss of habitat. This complicates the overall assessment in the sense that the aim of fisheries management is generally to prevent depletion rather than curb increasing biomass.

Assessment Summary

For this assessment, the status of short spined and long spined sea urchins was evaluated using:

- Nominal CPUE trends for the commercial dive fishery. The performance of the CPUE biomass proxy was assessed in relation the specified reference level and limit points throughout the entire time series.
- The impact of fishing pressure was assessed using time series of commercial catch and effort.

Eastern Zone short-spined sea urchin

This assessment found:

- *Fishing pressure* – Landings, and fishing effort, for short-spined sea urchins remain relatively low in Eastern Victoria (Figure 112 and 113). Conversations with industry suggest this is because the species is naturally in relatively low abundance.
- *Biomass* – Catch rates have been variable during the time series investigated, which is likely due to the small number of fishers, and small amount of fishing effort targeting this species in Eastern Victoria (Figure 114). In contrast, estimates from fishery independent surveys show a prolonged decline during 2003–2016 in which abundance halved (Figure 115).

Stock status summary: Catch and effort remain low for short-spined sea urchins in Eastern Victoria. CPUE is variable, but relatively high, and industry has indicated that the relatively low abundance of this species in Eastern Victoria, and long distance to markets, means the fishery is limited. Based on the above summary Eastern Victorian short spined sea urchin is considered sustainable.

Port Phillip Bay Zone short-spined sea urchin

This assessment found:

- *Fishing pressure* – Landings were consistent between 20 and 30 t for the three years 2017 and then halved in 2018 (Figure 112). Effort has remained more stable during this period with a slight decrease in 2018 (Figure 113).
- *Biomass* – CPUE has remained stable at ~40 kg/hr during the four years examined (Figure 116). However, in this instance, catch rate is likely to reflect the availability of those short-spined sea urchins with marketable roe more so than total abundance because short-spined urchins are in very high abundance throughout much of Port Phillip Bay.

Stock status summary: Catch, effort and CPUE remain relatively stable within this fishery. Conversations with industry suggest that market demand and/or price are the primary factors dictating the amount of fishing effort and hence catch. Interpretation of CPUE is complicated by the fact that this species is very abundant, but only a proportion of the stock is of acceptable quality for processing. As such, it is possible that the fishery could reach maximum production (i.e. catch as many urchins with marketable roe as is financially viable) without posing a risk to the stock as a whole. There is no information to suggest that the stock is in any danger of depletion. Based on the available evidence the Port Phillip Bay Zone short spined sea urchin stock is sustainable.

Eastern Zone long-spined sea urchins

This assessment found:

- *Fishing pressure* – landings, and fishing effort, have both showed an increasing trend in recent years (Figure 112 and 113), since a low in the 2015 quota year.
- *Biomass* – CPUE has remained very stable at ~175 kg/hr for the last four quota years with a slight decrease over the last year (Figure 117). However, CPUE is likely to be more reflective of the availability of urchins with roe of marketable quality rather than overall abundance of the species. This is illustrated by an increase in abundance of about 80% observed from fishery independent surveys over the same period following a decrease (probably as a result of culling to mitigate range expansion and restore kelp habitat from barrens) of about one third over the preceding two years (Figure 118). This species is very abundant on barrens in deeper waters where the roe is largely unmarketable due to food limitations associated with higher densities.

Stock status summary: Catch, effort, and CPUE trends, are largely reflective of market demand and can be influenced by changes in the availability of urchins with marketable roe. As such, it is possible that the fishery could reach maximum production (i.e. catch as many urchins with marketable roe as is financially viable) without posing a risk to the stock as a whole. There is no information to suggest that the stock is in any danger of depletion. Based on the available evidence the Eastern Victorian long-spined sea urchin is sustainable.

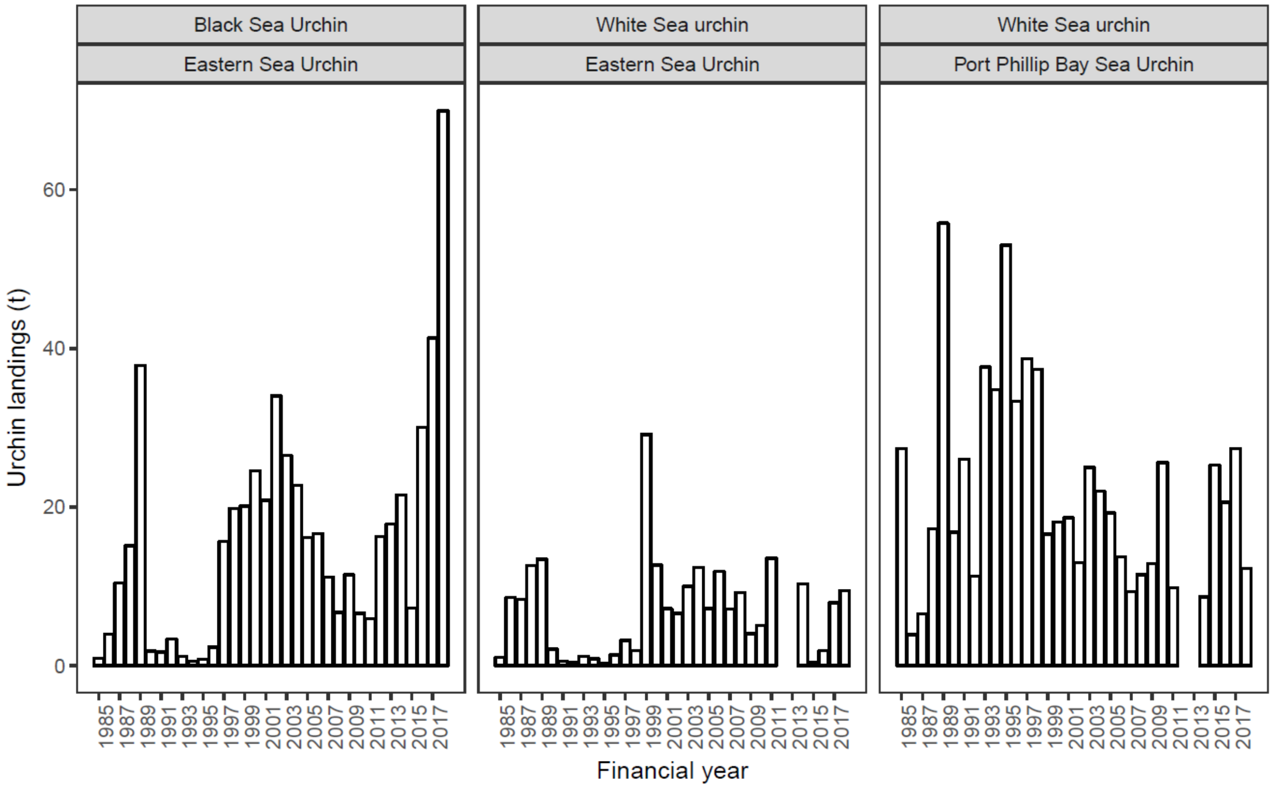


Figure 112 Annual long-spined (Black) and short-spined (White) sea urchin landings from Eastern Victoria and Port Phillip Bay.

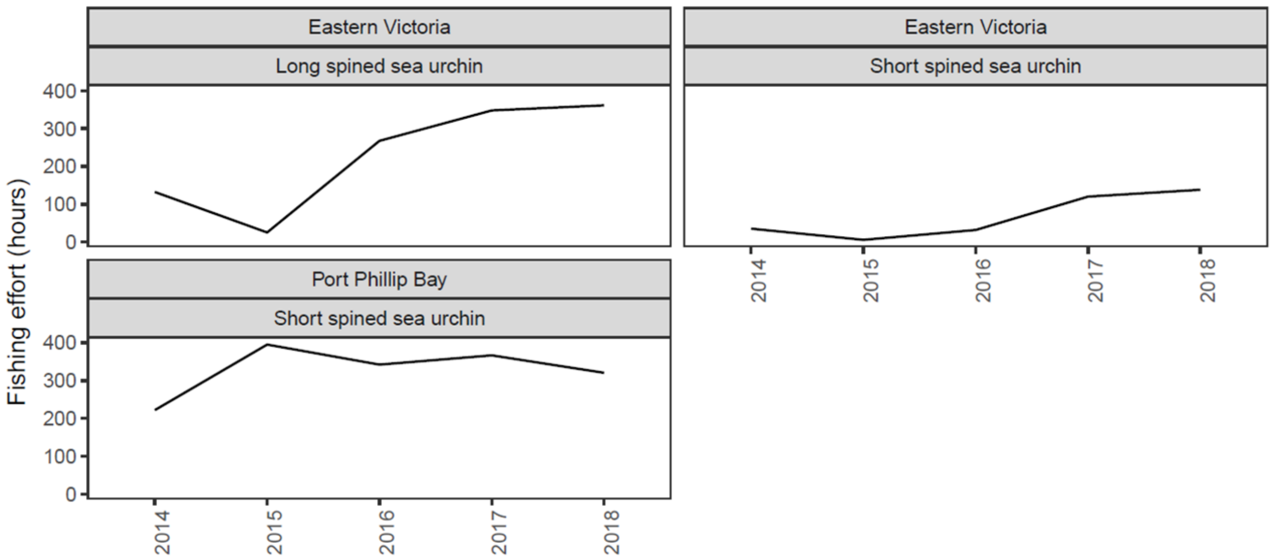


Figure 113 Annual fishing effort targeting long-spined, and short-spined, sea urchin landings in Eastern Victoria and Port Phillip Bay.

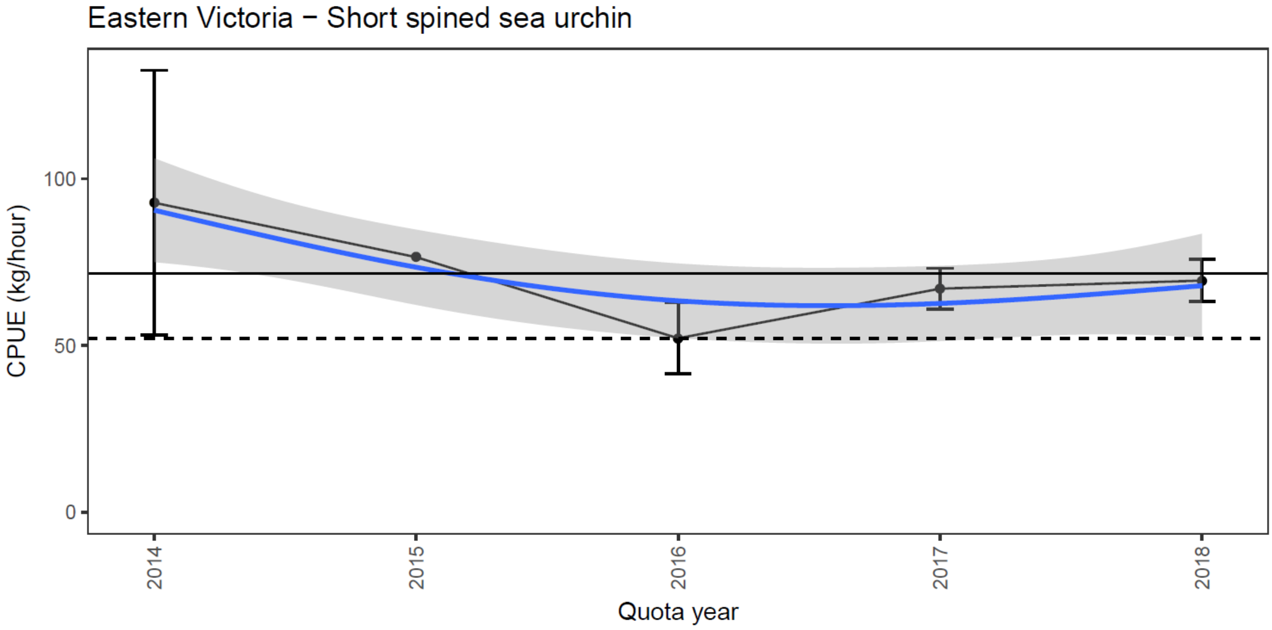


Figure 114 Nominal Catch-per-unit-effort (CPUE) of short-spined sea urchins (± SE) in Eastern Victoria (black line). Solid black horizontal line in the mean and horizontal dashed line is the minimum. Blue line is a generalised additive model (GAM) of the annual mean CPUE with the shaded area representing 95% confidence intervals of the GAM.

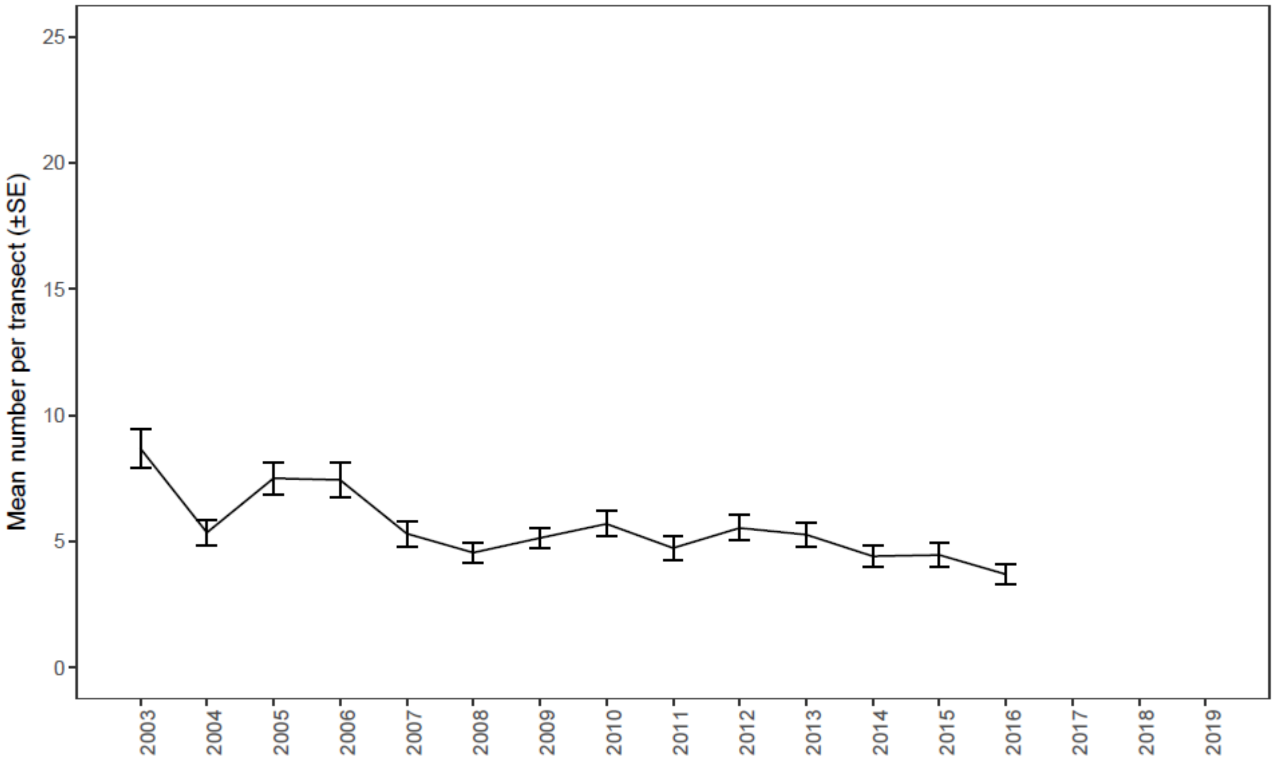


Figure 115 Temporal trend in the abundance of short-spined urchins (±SE) within the Eastern Zone. Note: analyses were limited to sites surveyed throughout entire time period, other than 2004 when Marlo was not surveyed (see results for explanation). A transect is 30 m^2.

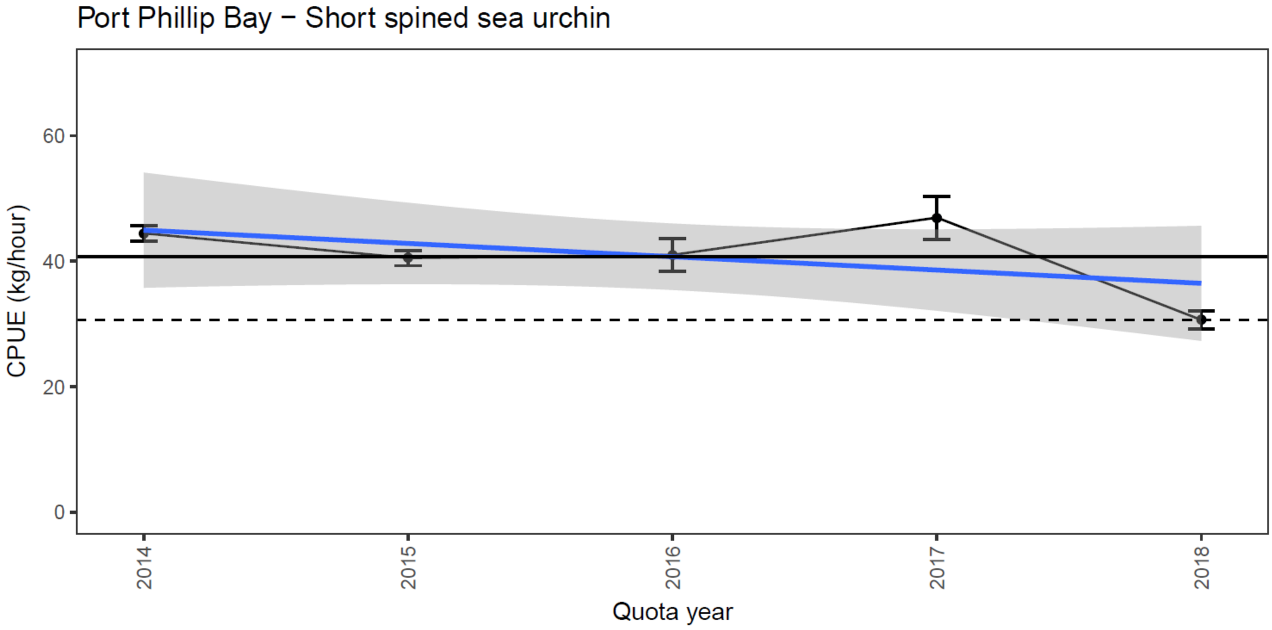


Figure 116 Nominal catch-per-unit-effort (CPUE) of short-spined sea urchins (± SE) in Port Phillip Bay (black line). Solid black horizontal line in the mean and horizontal dashed line is the minimum. Blue line is a generalised additive model (GAM) of the annual mean CPUE with the shaded area representing 95% confidence intervals of the GAM.

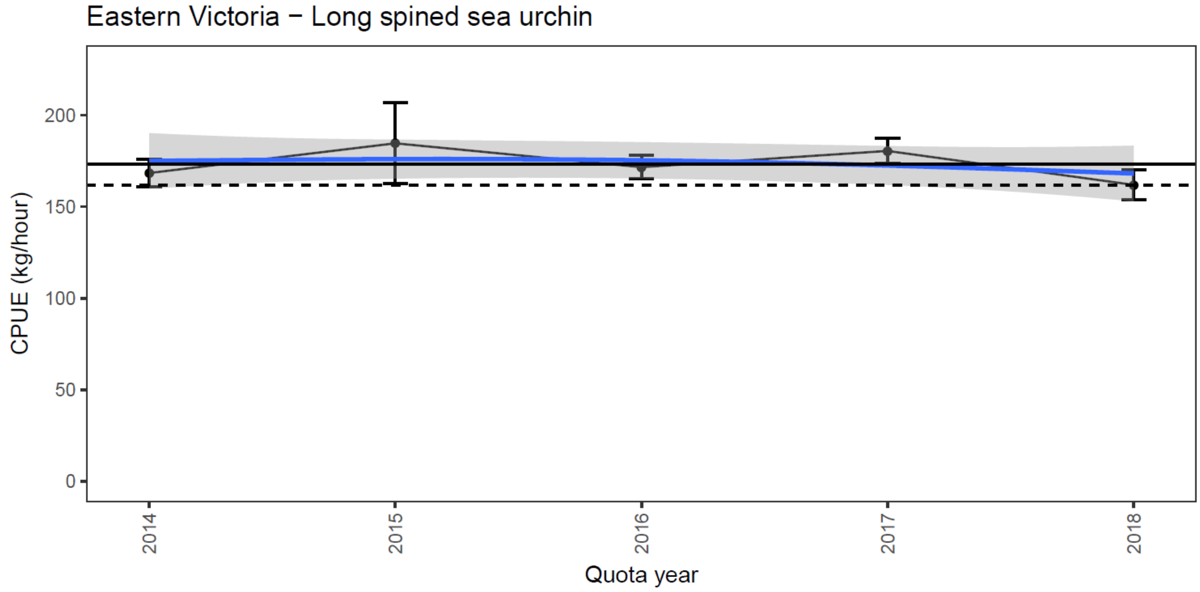


Figure 117 Nominal catch-per-unit-effort (CPUE) of long-spined sea urchins (± SE) in Eastern Victoria (black line). Solid black horizontal line in the mean and horizontal dashed line is the minimum. Blue line is a generalised additive model (GAM) of the annual mean CPUE with the shaded area representing 95% confidence intervals of the GAM.

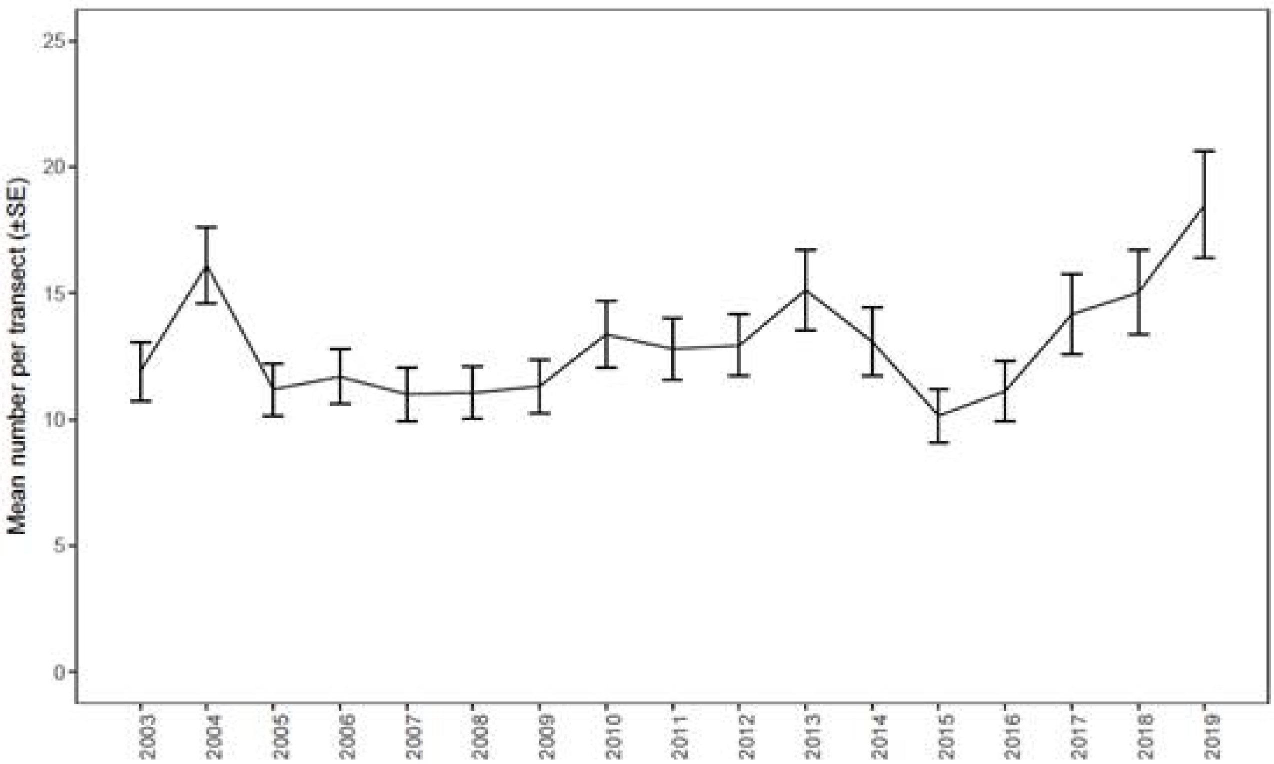


Figure 118 Temporal trend in the abundance of long-spined urchins (±SE) within the Eastern Zone. Note: analyses were limited to sites surveyed throughout entire time period, other than 2004 when Marlo was not surveyed (see results for explanation). A transect is 30 m^2.

Octopus (*Macroctopus maorum* and *Octopus pallidus*)

Stock Structure and Biology

Two species of octopus are predominantly landed in Victorian commercial fisheries: 1) the Maori octopus (*Macroctopus maorum*) and 2) the pale octopus (*Octopus pallidus*). Octopus are a by-product of the southern rock lobster fishery and are landed in relatively low quantities throughout the geographic range of the fishery (Figure 119). Species is not recorded by this fishery, but it is generally accepted that Maori octopus predominate, as is the case in Tasmania (Bradshaw *et al.* 2018). Additionally, a fishery targeting pale octopus is developing in eastern Victoria over soft sediment habitats using octopus traps (Figure 119). Maori octopus and gloomy octopus (*Octopus tetricus*) are also landed within this fishery but the proportions of each species are unquantified at present. If the species composition of the Victorian catch is similar to that off northern Tasmania (Bradshaw *et al*. 2018), then the pale octopus is likely to be predominant with the remaining two species comprising a small proportion of the catch.

Attempts to age Maori octopus have proved unsuccessful (Doubleday *et al*. 2011) but they are thought to live for around three years. Maori octopus are semelparous, spawning once before laying up to 7000 eggs and subsequently dying (Anderson, 1999). Maori octopus eggs incubate benthically with maternal protection and after they hatch the larvae enter a planktonic phase. This means they have relatively high dispersal potential resulting in minimal genetic structuring (Higgins *et a*l. 2013).

Pale octopus predominantly inhabit soft sediment habitats and are also semelparous (spawn once then die) living for 12 – 18 months (Leporati *et al.* (2009). They produce relatively few (450 – 800) very large eggs and there is no larval phase after hatching with hatchlings resembling adults in both appearance and behaviour (Leporati 2007). This reproductive strategy means that this species has limited dispersal giving rise to considerable genetic population structuring (Higgins *et al*. 2013).

Management/Assessment Unit

Given Maori octopus are likely to dominate the octopus by-product of the rock lobster fishery, and pale octopus are likely to dominate landings of the octopus trap fishery in eastern Victoria, these two species are the focus of this assessment and the gloomy octopus was not assessed.

Soak time has minimal effect on the weight, or number, of octopus caught so the CPUE proxy for biomass used herein is the weight of the catch divided by the number of pots/traps (i.e. soak time is not factored in).

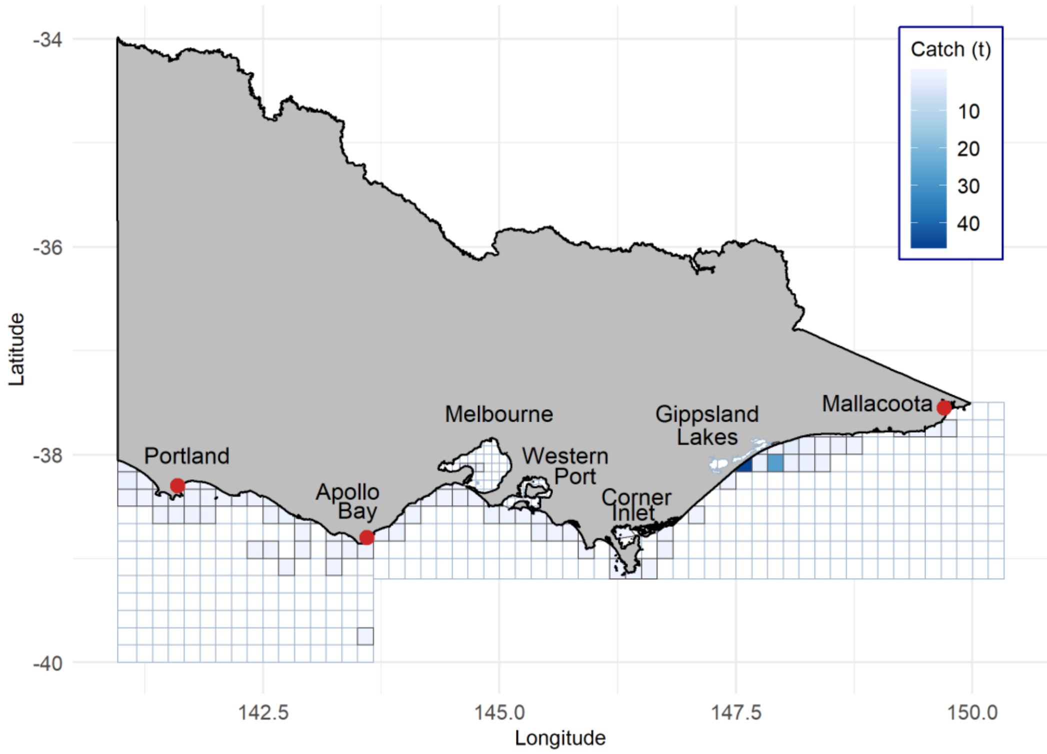


Figure 119 Spatial distribution of state-wide landings of octopus (all species) from Victorian fisheries during the 2018/19 financial year.

Assessment Summary

Maori octopus

This assessment found:

- *Fishing pressure* – Fishing effort in the rock lobster fishery increased from the late 1980s to late 1990s. There has been a consistent decline in effort since in line with rock lobster quota reductions meaning there has also been less effort directed at Maori octopus. Landings, however, have remained relatively consistent, which may indicate that a proportion of the octopus by-product may have been discarded during earlier years, presumably due to a lack of market demand. Considering this likelihood, the reference period was adjusted to 1998 – 2015.
- *Biomass* – Given the issues with discarding, CPUE trends prior to about 1998 may not be reflective of abundance. Nevertheless, CPUE was very high in the earlier time period, decreasing by the early to mid-1980s. Since then, CPUE has been relatively stable and above the reference period average for five out of the last eight years. In 2017, however, CPUE was close to the reference period minimum and it will be important to ensure that it increases in the near future.

Stock status summary: Decreasing trends in effort within the rock lobster sector have resulted in decreasing landings of Maori octopus, despite it being likely that this species is now retained most of the time it is captured. Relative stability in CPUE for >30 years suggests that there has been no long-term depletion of the stock and, provided the low value in 2017 is established to be within the bounds of natural variation and there is an increase in the near future, there is minimal reason to believe that this species is at risk of depletion under current fishing practices. This implies that the Victorian Maori octopus stock is sustainable.

Pale octopus

This assessment found:

- *Fishing pressure* - Pale octopus have likely been caught, and retained, by a variety of gears and fisheries operating in eastern Bass Strait (Figure 120). Landings of 'octopus' were recorded by Danish seine vessels up until the mid-1990s. Trawl vessels also report landings of around 10 t in some years but analysis of CPUE data indicated that there was likely to be a relatively high rate of discarding in earlier years (the reference period was adjusted to 1997 – 2015 to account for this). In recent years, many of these vessels are predominantly targeting species managed by the Commonwealth and reporting their landings to AFMA. A fishery using octopus traps was operational from 1998 – 2003 and it is likely that some octopus were caught prior to this time but the gear was not accurately reported. Small amounts of octopus were subsequently caught using traps up until 2015 when landings began to increase, and they have remained high since (Figure 121b). This coincided with a very notable increase in octopus trap effort (Figure 122).
- *Biomass* - Octopus trap CPUE has been relatively variable and was notably higher during the period of time the fishery initially developed (1999 – 2002) but declined soon after (Figure 123, Figure 124 and Figure 125). This may be related to the type of traps used in this period or it may represent a high available biomass during that time-period. Catch and effort were so low during the period up until the recent expansion of the fishery that it is unlikely that CPUE represents a reliable proxy for biomass. Octopus trap CPUE has been relatively stable in the last few years but the time series is too brief to determine current abundance and the low level of fishing effort in earlier years means it is difficult to determine long term trends from these data alone (Figure 124). CPUE from the trawl fishery presents a longer time period, but it is much lower during earlier time periods indicating a degree of discarding. In more recent years the trend is variable but the average catch rate, as indicated by the GAM, has remained around the average from the reference period indicating the stock is roughly at historic levels.

Stock status summary: All the gears that are likely to be able to be used to estimate the stock status (trawl, Danish seine and octopus trap) of pale octopus show high variability in annual landings and CPUE. The type of gear that would most likely reflect abundance is octopus traps as these are highly selective and are not subject to changes in fishing practices or selectivity. The trend in octopus trap CPUE is nevertheless variable, likely due to the low effort during much of the time-period and possibly due to changes in the type of trap. There is some risk that current fishing practices could result in local depletion given that 1) there is no long term data available for this species in eastern Victoria to use as a benchmark; 2) the fishery is expanding rapidly within a small spatial area; 3) the biology of the species means it is easily depleted over small spatial scales; and 4) the catch off of Lakes Entrance is similar to, or exceeds, catches off northern Tasmania that have shown to be fully exploiting and depleting the resource which is at risk of localised depletion. This means that there is uncertainty about the stock status of Victorian pale octopus.

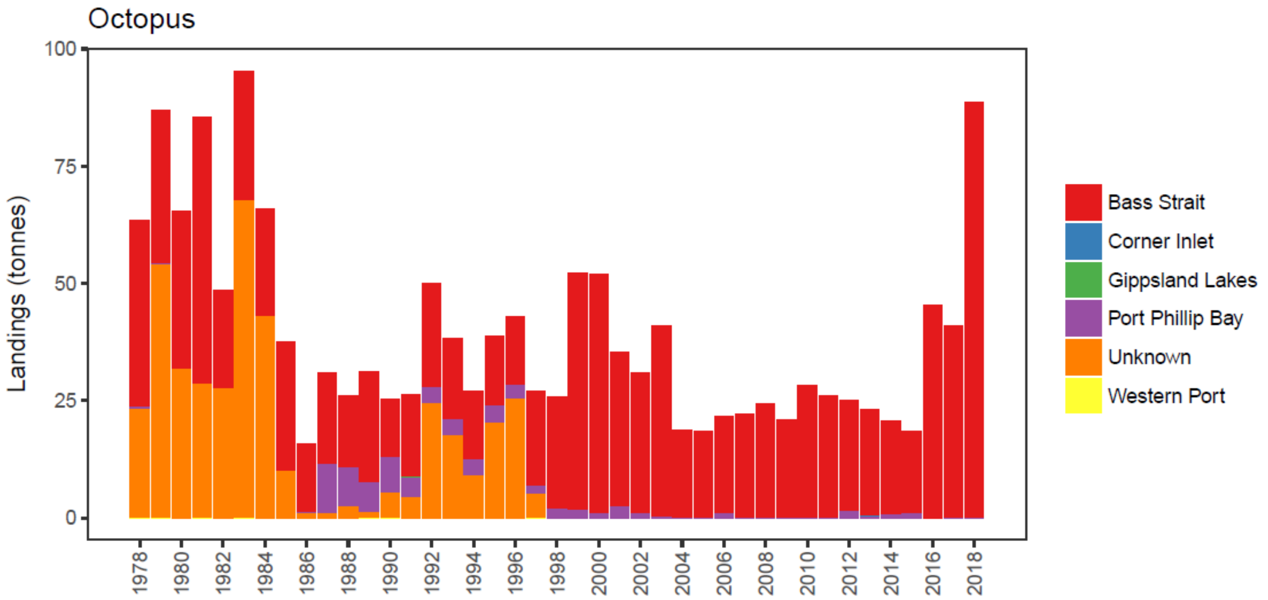
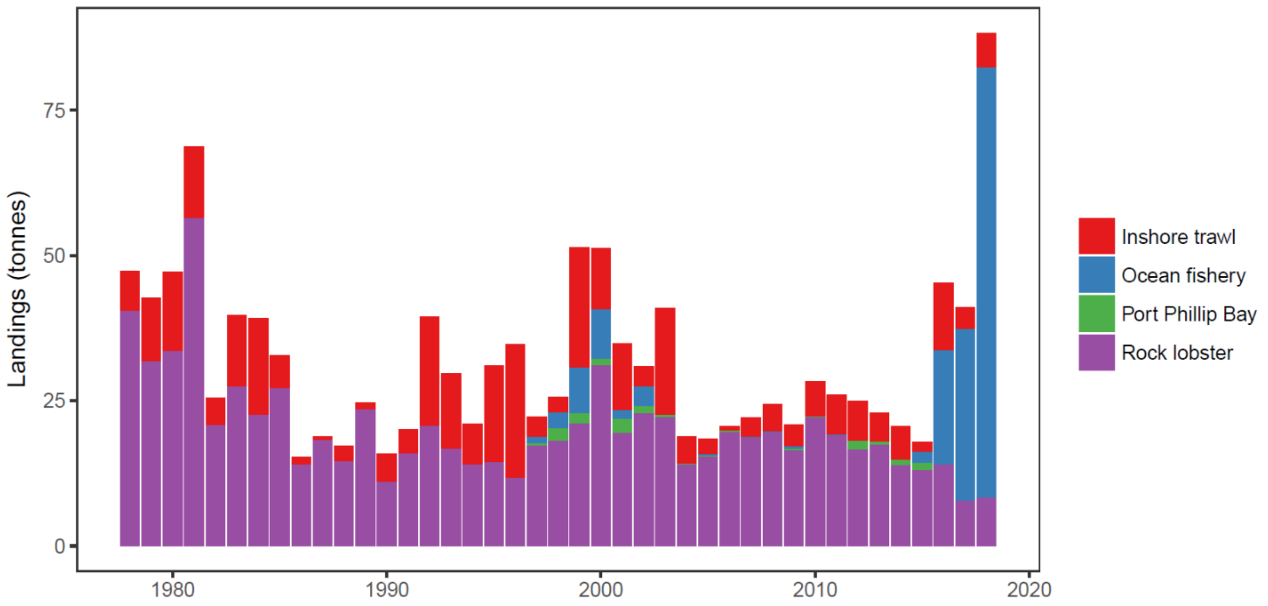


Figure 120 Total catch of octopus (all species) from the commercial fishery by area for financial years 1978–2018.

(a)



(b)

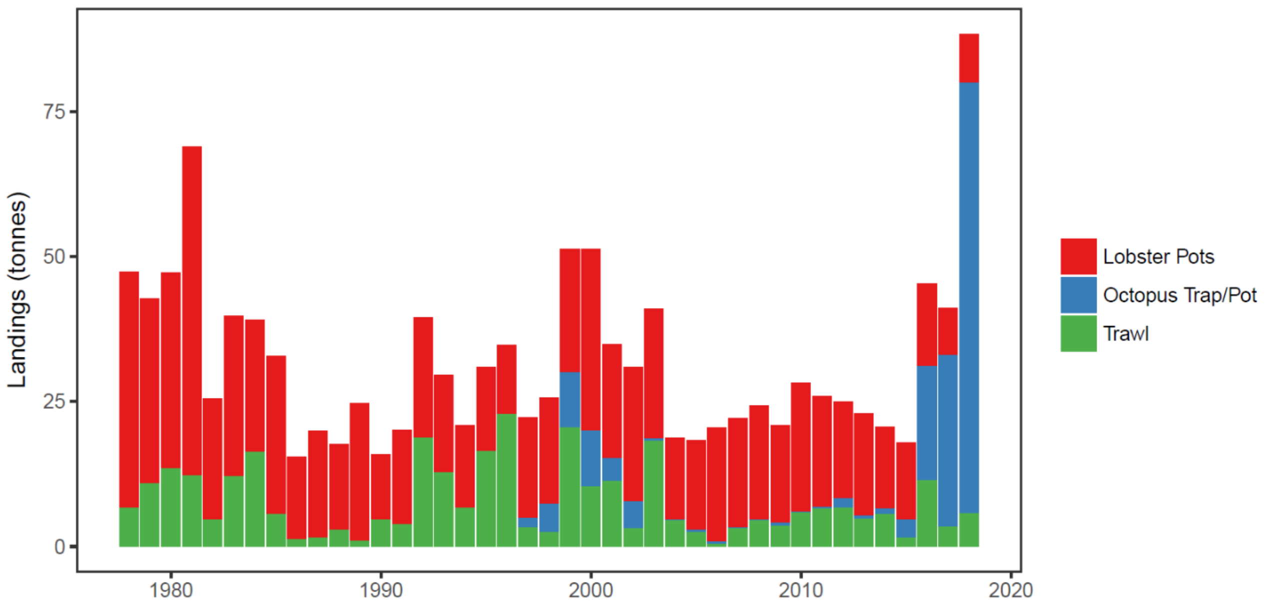


Figure 121 Total catch of octopus (all species) from the commercial fishery (a) by fishery, and (b) by gear, financial years 1978–2018.

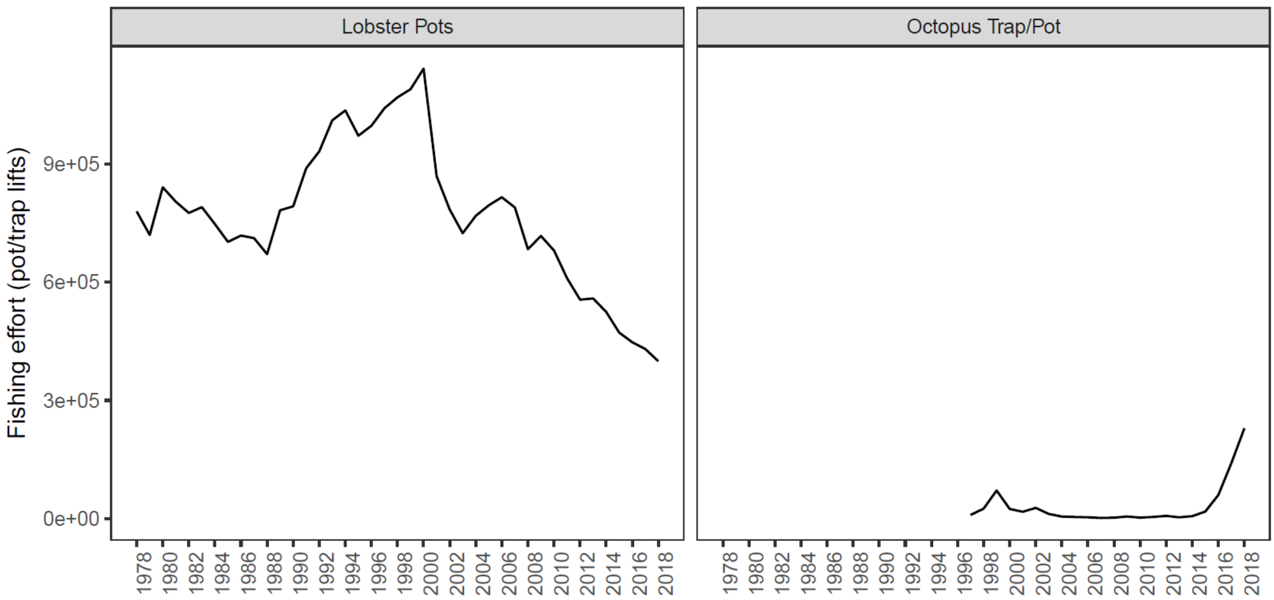


Figure 122 Annual fishing effort using lobster pots and octopus traps (1978–2018 financial years).

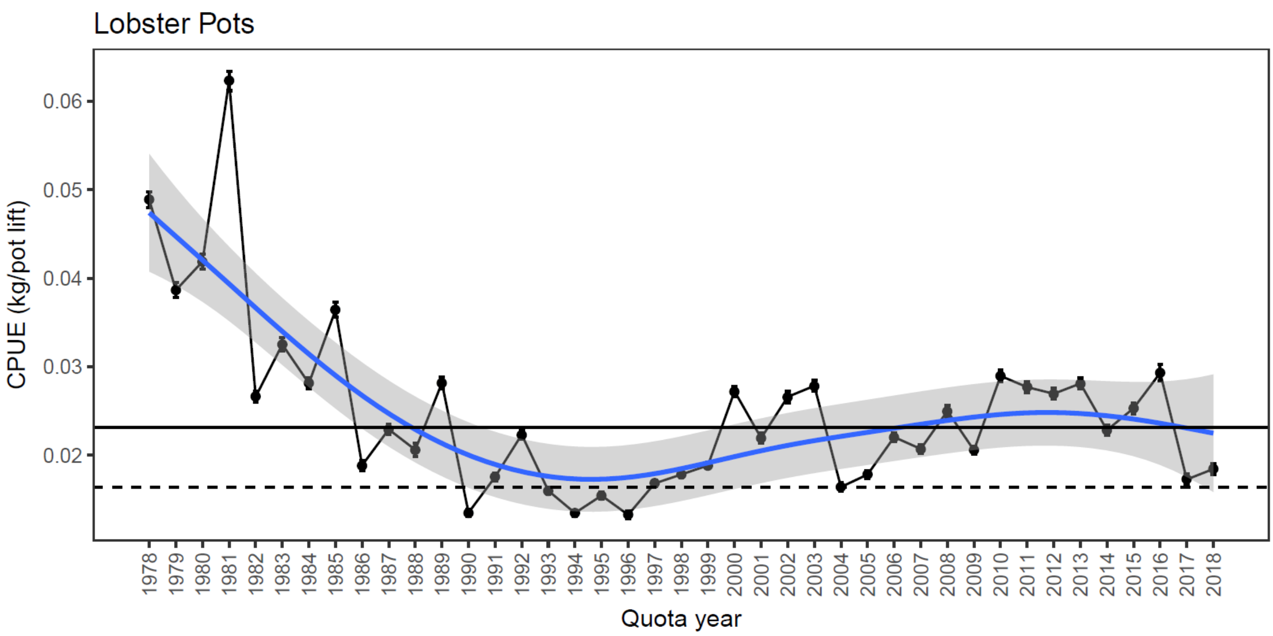


Figure 123 Catch-per-unit-effort (CPUE) of octopus from the southern rock lobster fishery (1978–2018 financial years).

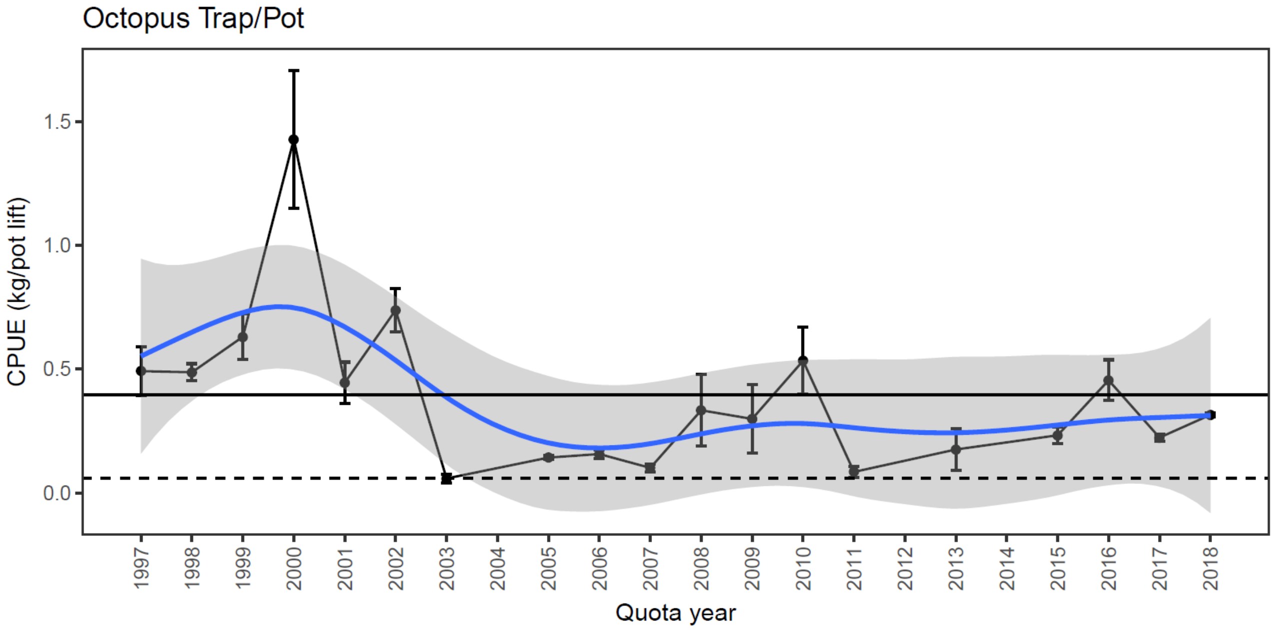


Figure 124 Catch-per-unit-effort (CPUE) of octopus from the southern rock lobster fishery (1997–2018 financial years).

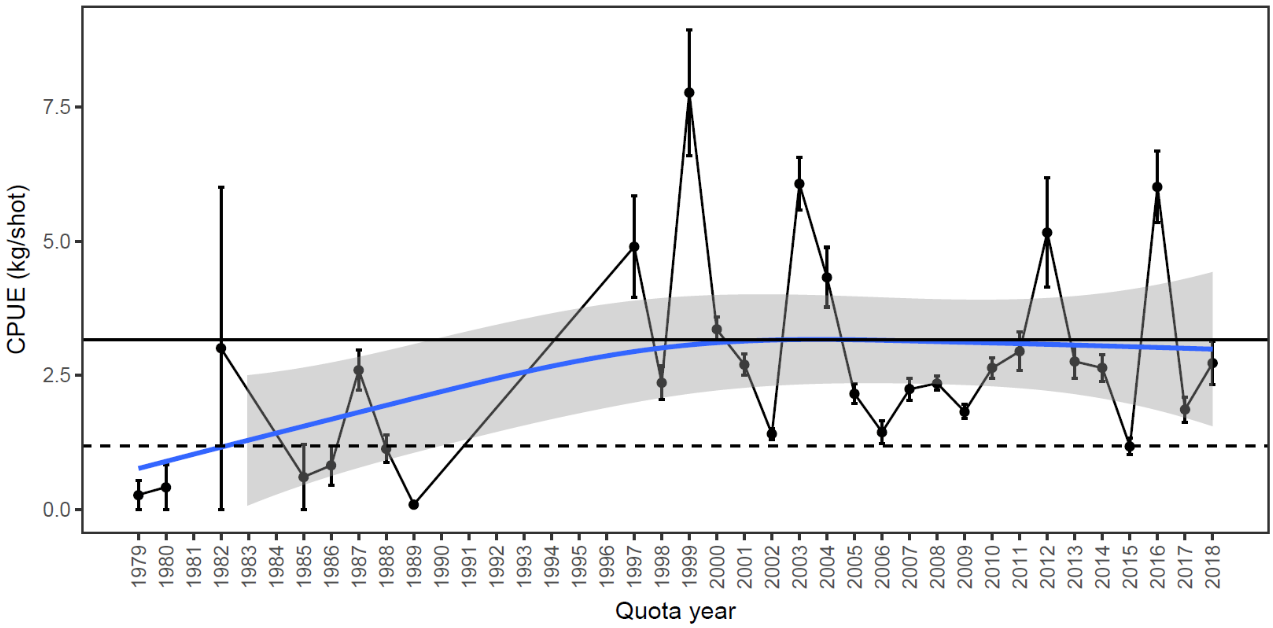


Figure 125 Catch-per-unit-effort (CPUE) of octopus from the trawl fishers (1979–2018 financial years). Note: the reference period used was 1997–2015 to account for the fact that there appears to have been discarding during years prior to this.

Banded Morwong (*Cheilodactylus spectabilis*)

Attr: Photographer: Mark Norman

Stock Structure and Biology

In Australia, banded morwong (*Cheilodactylus spectabilis*) inhabit temperate reefs from around Sydney to south-eastern South Australia, including all of Tasmania (Gomon et al. 1994). The species also inhabits waters around New Zealand. Banded morwong are very long lived, with a maximum reported age of 97 years (Ewing, 2007). There are notable differences between the sexes with males growing much faster than females and to a much larger size (Ziegler, et al. 2007). Little is known about the stock structure of banded morwong but it has been hypothesised that, due to an extended larval phases (~6 months) that it is unlikely that there is fine scale genetic differentiation (Moore et al. 2018).

Banded morwong were historically a by-product or discard species, however, in the early 1990's, fisheries developed in Tasmania, and later eastern Victoria, to supply the domestic live fish market. In both states, banded morwong are targeted using mesh nets over inshore reefs as the species has exceptionally high post release survival (Bell et al. 2016) and rarely displays scarring from where it was in contact with the net.

Management/Assessment Unit

The banded morwong fishery operates exclusively out of eastern Victoria with fishers utilising highly mobile planning hull vessels. The Victorian banded morwong fishery is therefore considered a single stock for management purposes.

A specific banded morwong licence was implemented in 2000 because of increasing catch by ocean general licences and licences were allocated to two fishers based on catch history. As such, this analysis only includes data since the implementation of the target fishery (i.e. from 2000 onward). Fishing is now only undertaken by mesh netting so this gear is used to calculate CPUE given that it is more likely to be a reliable proxy for abundance of the species than CPUE from other gear types used in the past was included.

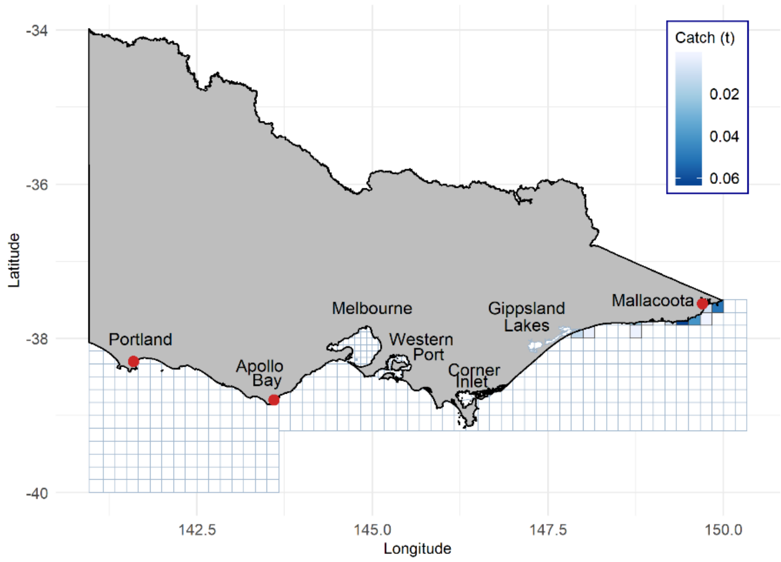


Figure 126 Spatial distribution of state-wide landings of banded morwong from Victorian fisheries during the 2018/19 financial year.

Assessment Summary

This assessment found:

- *Fishing pressure* – Fishing effort, and catch, in the commercial live banded morwong fishery reached a peak from 2001–2003 soon after the banded morwong licence was implemented (Figure 127 and 128). Both fishing effort and catch began to decline soon after and have remained relatively consistent since 2005.
- *Biomass* – The decrease in catch and effort were brought about by localised depletion of stocks (fisher's observations), but fishers were able to maintain relatively high CPUE by spreading their effort throughout the extensive inshore reef systems in eastern Victoria (Figure 129). Nevertheless, catch rates began to decline after 2006, falling below the reference period average, and reaching a low in 2010, which was associated with a decline in fishing effort. The two active operators in the fishery have maintained relatively low levels of fishing effort in recent years, resulting in an increase in CPUE from the low in 2010 until 2016, which was well above the reference period average. However, CPUE has declined during the last two years, with the 2018/19 financial year being below the reference period average. It will be important to monitor this fishery during the coming years to ensure this is not an indication of stock depletion. It is important to note, however, that with <50 days of fishing effort in most years driving the trend in recent years (some <20 days), CPUE may not be a reliable indicator of biomass across the entire breadth of the fishery.

Stock status summary: The banded morwong fishery was likely fully exploited by Ocean Access License holders before it was licensed as a specialised target fishery with two operators. This is corroborated by observations by fishers during the mid-to-late 2000's when further declines were observed. This is consistent with the longevity of this species and the pattern observed in Tasmania where a full quantitative stock assessment of the fishery is undertaken. As a result, fishers decreased fishing effort with consequent increases in CPUE. However, declines in CPUE to below the reference period average in the last two years are associated with increasing fishing effort and it will be important to monitor how this fishery performs in the coming years. The available evidence indicates that the commercial banded morwong fishery in eastern Victoria is depleting but not recruitment impaired.

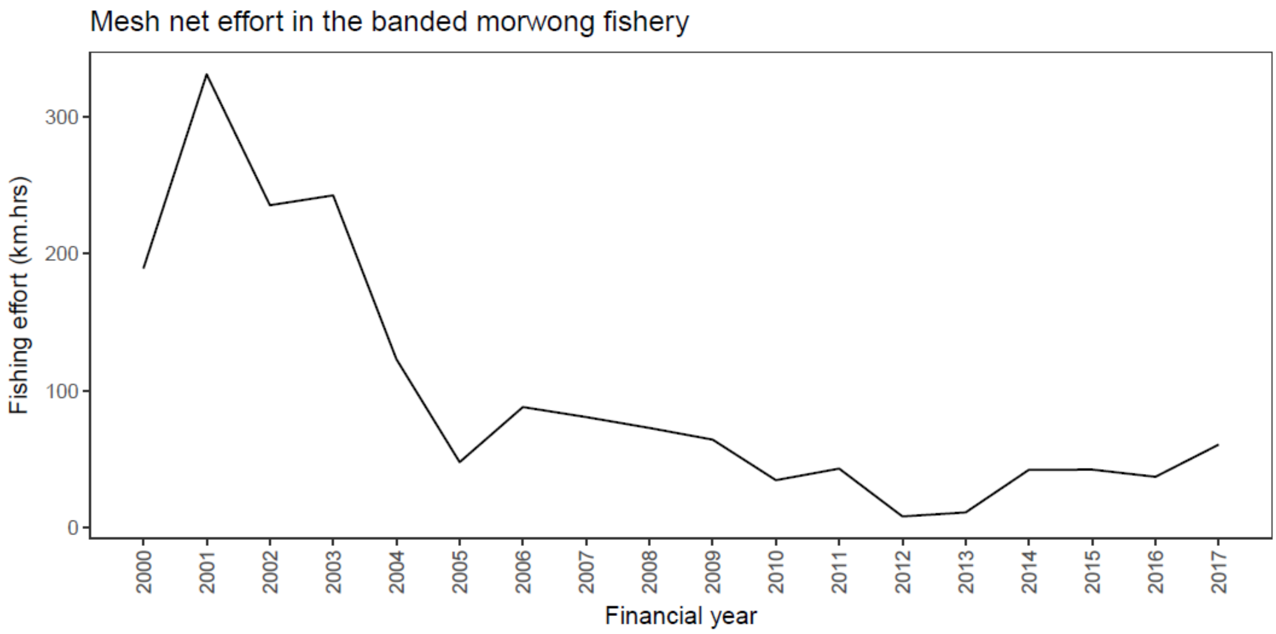


Figure 127 Annual fishing effort in the commercial live banded morwong fishery (2000–2018 financial years).

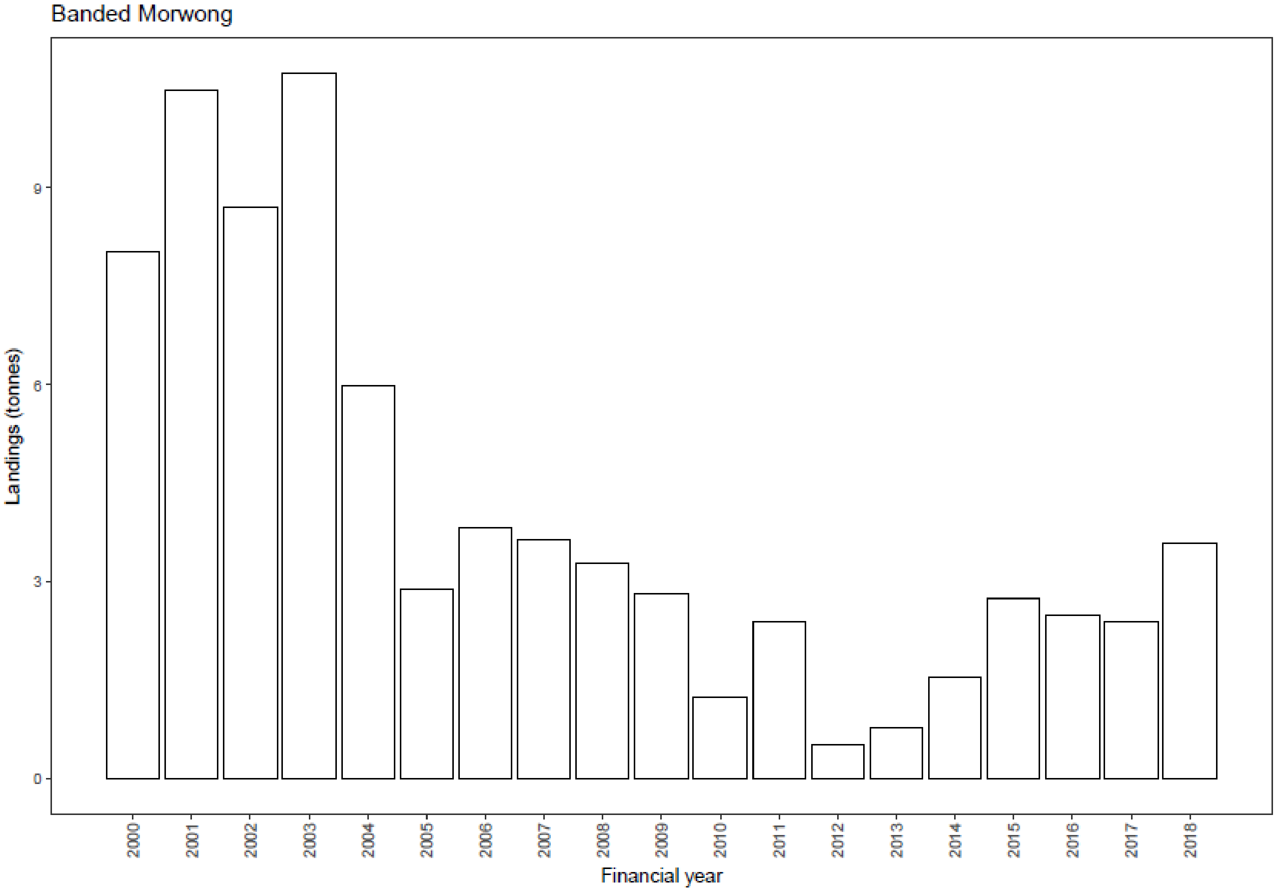


Figure 128 Annual landings of commercial live banded morwong fishery (2000–2018 financial years).

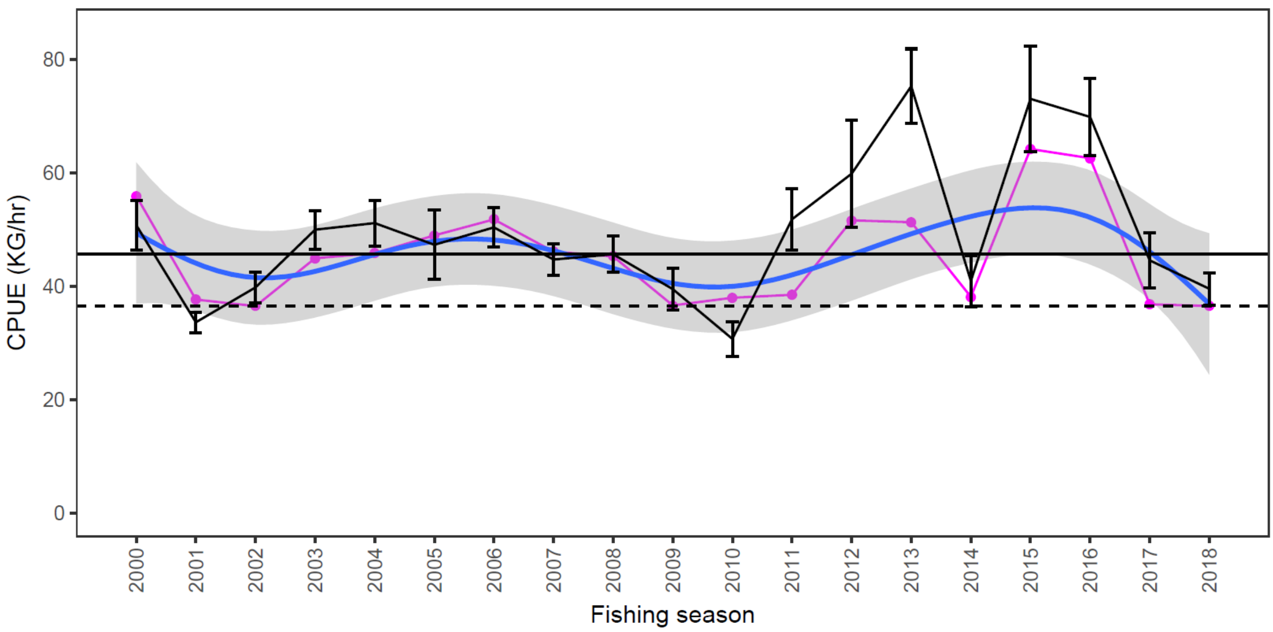


Figure 129 Nominal catch-per-unit-effort (CPUE) (±SE) of live banded morwong for the commercial mesh net fishery (2000–2018 financial years). The blue line is a generalised additive model (GAM) of the CPUE trend with the shaded area representing 95% confidence intervals of the model. The black horizontal line is the average of the reference period (2000–2015) and the dashed line is the minimum observed value during the reference period.

Port Phillip Bay Commercial Scallop (*Pecten fumatus*)

Stock Structure and Biology

The commercial scallop (*Pecten fumatus*) is a large mollusc that inhabits soft sediment habitats throughout southern Australia from Shark Bay in Western Australia to central Queensland, including Tasmania (Edgar et al. 2008). The commercial scallop, as its name implies, is the major target of scallop fisheries in southern Australia with fisheries historically operating throughout eastern Tasmania, Bass Strait and Port Phillip Bay with several localised fisheries in New South Wales and South Australia and being taken as by-product in fisheries operating for other species in West Australia (Kailola, *et al*. 1993).

Scallops are fast growing, maturing after just 1–2 years and reaching a harvestable size in around three years, but growth can vary spatially (Kailola, *et al*. 1993). Scallops can live for >10 years but are prone to large die-offs leading to large natural fluctuations in abundance (Coleman, 1998).

Commercial scallops in the D'Entrecasteaux Channel and Port Phillip Bay are genetically distinct from most other regions with beds in northeast Bass Strait also being different from central and southern Bass Strait (Ovenden, et al., 2016). This implies that there are likely at least two genetically distinct commercial scallop populations in Victoria: 1) Port Phillip Bay, and 2) northeast Bass Strait.

Management/Assessment Unit

There has been minimal commercial scallop fishing in Victorian-managed waters of northeast Bass Strait, thus, the current assessment will only consider the Port Phillip Bay dive fishery. Note that there have been no doughboy scallops landed since the development of the Port Phillip Bay dive fishery so only results pertaining to commercial scallops are presented.

Commercial scallops are only permitted to be hand caught in Port Phillip Bay and because they tend to live in waters >5 m, compressed air diving (i.e. Hookah or SCUBA) is necessary to access the beds. Thus, the current assessment uses the number of diver hours as the effort metric for CPUE calculation in this assessment.

Assessment Summary

This assessment found:

- *Fishing pressure* – Fishing commenced in the Port Phillip Bay commercial scallop dive fishery in 2014, the year after the single exclusive license was issued, and effort increased gradually over the next two years reaching a maximum in 2016 and 2017 (Figure 130). Effort then decreased slightly in 2018. Catch has followed a similar trend, increasing from 2014 through to highs in 2016 and 2017, but decreased substantially in 2018 (Figure 131).
- *Biomass* – CPUE increased from 2014 to 2016, with nominal CPUE reaching 93 kg/hr, and remained relatively stable in 2017 (Figure 132). In 2018, however, nominal CPUE almost halved to 54 kg/hr, because of the slight decline in effort coupled with a large decline in the total catch landed. Importantly, the standardised results were higher but followed a similar pattern, indicating that bias in the data was consistent over time and that the somewhat symmetrical pattern of increase followed by decrease reflected the actual biomass.

Stock status summary: Commercial scallop abundance naturally fluctuates by several orders of magnitude, which has been well documented in Port Phillip Bay (Coleman, 1998). As a result, the decrease in CPUE observed in 2018 is not necessarily a sign of overfishing and is unlikely to be so given the very conservative landings (<60 t) within the context of the total abundance, which was estimated to be >11,000 t in 2015 (Gwyther, 2015) i.e. ~0.5% of the total biomass. As a result, it is likely that the decrease in CPUE observed in 2018 is largely due to naturally lower scallop abundance, which has resulted in a decrease in fishing effort as fishers are receiving lower returns for their effort. As time progresses it will become apparent how the natural variation in scallop abundance effects the dive fishery, but at present, given the very conservative landings, it is highly unlikely that the Port Phillip Bay commercial scallop dive fishery will cause recruitment impairment and the stock can be considered as sustainable.

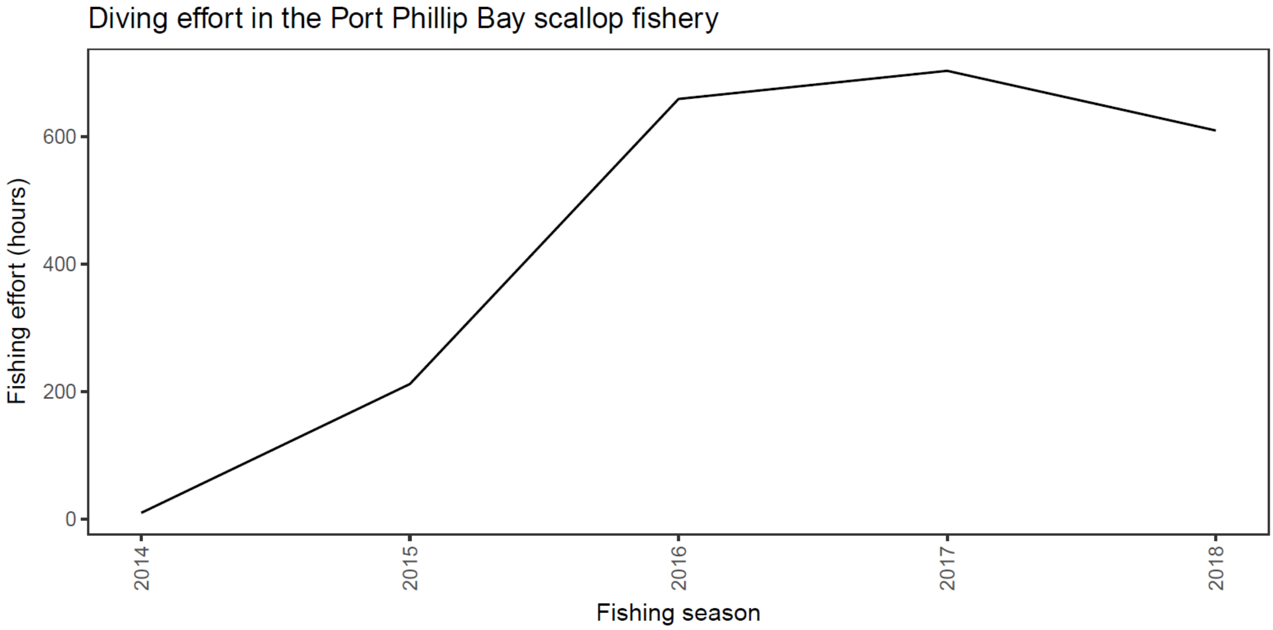


Figure 130 Annual fishing effort in the Port Phillip Bay commercial scallop dive fishery (2014–2018 fishing seasons).

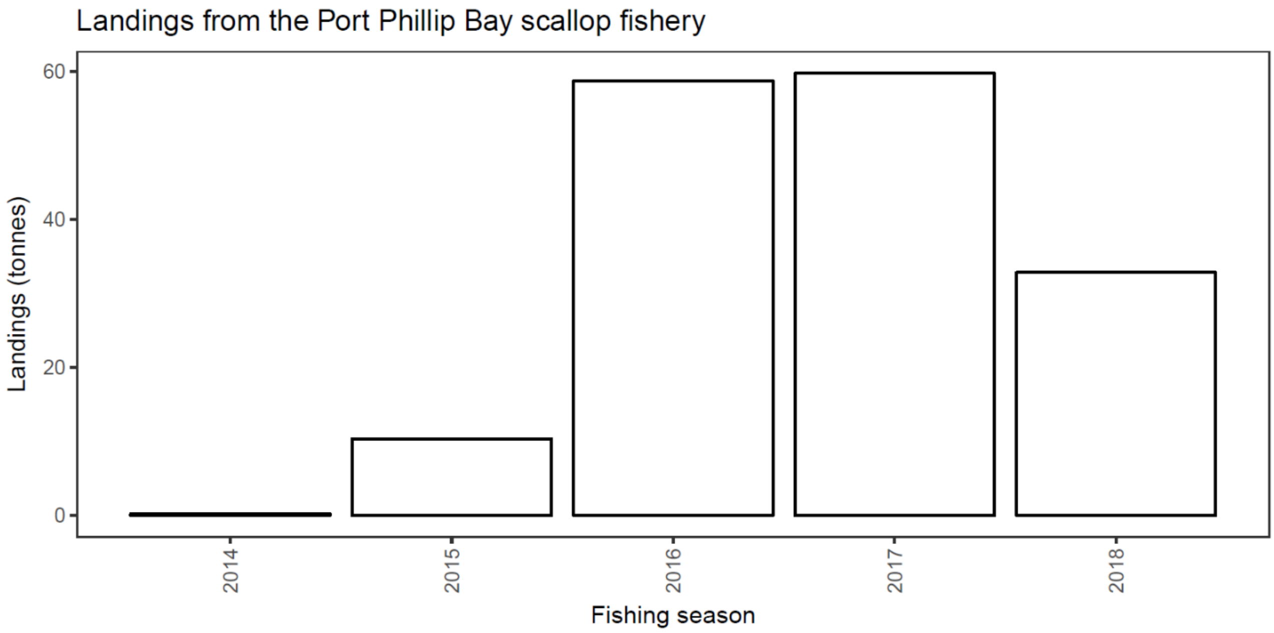


Figure 131 Annual landings of commercial scallops from the Port Phillip Bay commercial scallop dive fishery (2014–2018 fishing seasons).

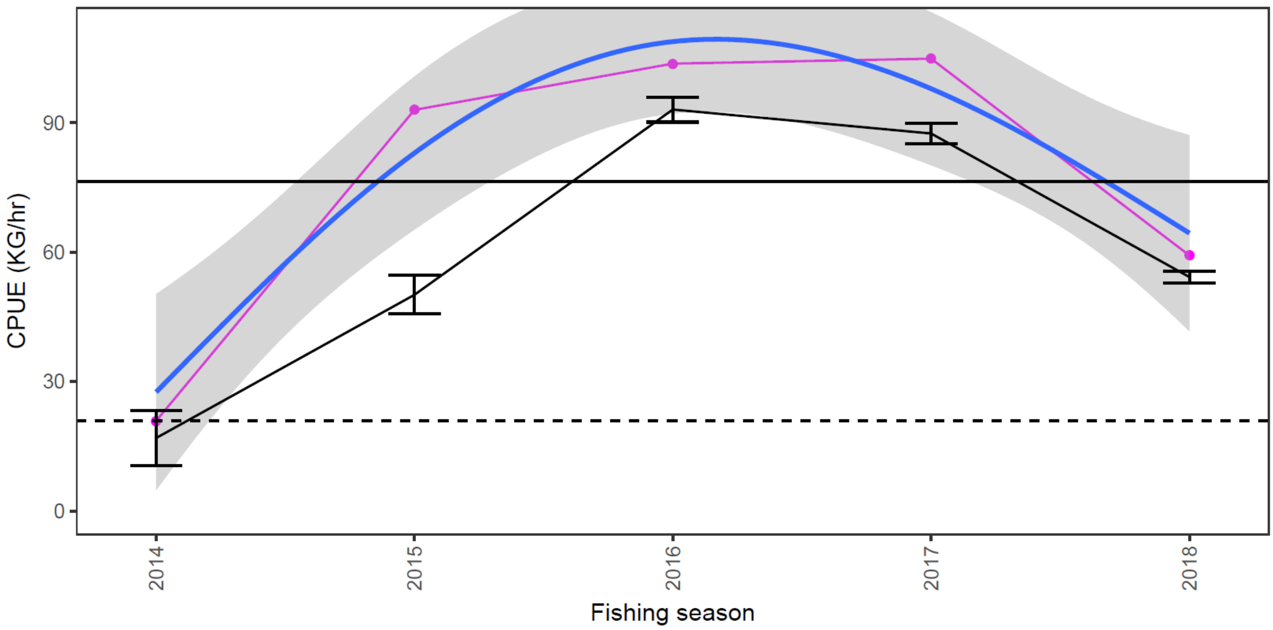


Figure 132 Catch-per-unit-effort (CPUE) (±95% CL) in the Port Phillip Bay commercial scallop dive fishery (2014–2018 fishing seasons). Black line is nominal CPUE (±SE), magenta line is standardised CPUE, blue line is a generalised additive model (GAM) of the standardised CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. The black horizontal line is the average CPUE and the dashed line is the minimum observed during the time series. No reference period used due to the short period the fishery has been operating.

Mulloway (*Argyrosomus japonicus*)

Stock Structure and Biology

Mulloway (*Argyrosomus japonicus*) are widely distributed in temperate waters of the Atlantic, Indian and Pacific Oceans. In Australian they are distributed from Bundaberg in Queensland, throughout southern Australia, excluding Tasmania, to North West Cape in Western Australia (Kailola *et al*. 1993).

Mulloway are relatively fast growing, with males reaching 50% maturity in 5 years at 78 cm and females in 6 years at 85 cm respectively (Ferguson *et al.* 2014) but this varies spatially. Mulloway are relatively long lived, living to >40 years of age (Ferguson et al. 2014). Mulloway spawn in marine environments from October to January (Ferguson *et al.* 2014; Griffiths, 1996), with evidence suggesting that spawning takes place near the entrance of estuaries that subsequently act as nurseries for the juveniles (Ferguson *et al*. 2014). Juveniles remain in estuaries until they around the size of maturation, after which they predominantly inhabit coastal waters and are capable of relatively large migrations (Griffiths, 1996).

Nothing is known of the stock structure of mulloway in Victorian waters. In South Australia, otolith microchemistry and shape analysis revealed at least two distinct stocks with the central region showing similarities to both the east and western stocks, potentially representing a third stock (Ferguson *et al*., 2011). Molecular analyses support this notion with two additional separate Australian stocks: the first in New South Wales and another in West Australia. As such, it is reasonable to assume that multiple stocks exist in Victoria with it being most likely that the western part of the state shares a stock with eastern South Australia and the eastern part of the state shares a stock with New South Wales, as is the case for a variety of other species (e.g. Australian salmon, snapper, white sharks). Preliminary results from a study in western Victoria indicated that mulloway in the Glenelg River are likely to be a component of the south-eastern South Australia population, which includes the Coorong (Lauren Brown, unpublished data).

Management/Assessment Unit

Less than 3 t of mulloway (<50 individual catches) has been landed by all Victorian commercial fisheries (predominantly Port Phillip/Western Port Bays and the Gippsland Lakes) during the last 20 years, which is insufficient to facilitate meaningful analyses. The only data with which to assess the status of Victorian mulloway stocks comes from angler diarists fishing in the Glenelg River in western Victoria. As such, this assessment will use catch rates, and length frequency, from those anglers to evaluate the status of this part of the south-eastern South Australia stock likely to also encompass other coastal and estuarine habitats in western Victoria. As a formal stock assessment has been undertaken for the south-eastern South Australian stock (Earl and Ward, 2014), albeit six years ago, this information was used to augment information from the Glenelg River.

Assessment Summary

This assessment found:

- *Fishing pressure* – Less than 3 t of mulloway have been landed in Victorian commercial fisheries in 20 years suggesting there is minimal fishing pressure from commercial fisheries. There is no quantitative information on the fishing pressure of recreational anglers targeting mulloway in Victoria. Anecdotal reports from fishers suggest there has been an increase in recreational fishing pressure in the Glenelg River in recent years, with charter operators also running guided tours in the system.
- *Biomass* – Catch rates of mulloway in the Glenelg River have been variable through time but increased from relatively low levels during the 1990s with a peak from 2012/13 to 2015/16 at over 0.5 fish per angler hour (Figure 133). This was followed by a slight reduction before increasing again in 2018/19. High recent catch rates, along with length frequency data (detailed below), indicate that there has been relatively strong recruitment in recent years. Additionally, anglers report that mulloway have been abundant and the fishery performing well. This is consistent with findings of a stock assessment undertaken in the Coorong, South Australia, in which catch rates of commercial mesh net fishers targeting mulloway has increased from the mid-1980s through until 2013/14 when the study was undertaken (Earl and Ward, 2014). Furthermore, in the Coorong, there was a distinct peak in catch rate in 2012/13 and 2013/14, which corresponds with similarly high catch rates in the Glenelg River.
- *Length compositions* – There is some evidence that a particularly strong year class entered the Glenelg River fishery in 2014 at around 40 cm TL, with individuals growing to around 55 cm over the subsequent two years (Figure 134). During 2018, a wide range of sizes were present in angler diary catches suggesting additional recruitment to the system. The lack of large individuals is not unexpected, or necessarily representative of high fishing mortality, as mature mulloway tend to inhabit oceanic waters.

Stock status summary: A wide range of sizes were observed in angler diary catches in 2018 suggesting there has been regular successful recruitment. However, this alone is insufficient to conclude that recruitment is unimpaired despite the Glenelg being only one small part of a stock that incorporates multiple estuaries and hundreds of kilometres of coastline. Additionally, there is no information available about the adult proportion of the stock and no stock assessment has been undertaken in South Australia for >5 years. While there are positive signs for the Glenelg River mulloway fishery in terms of increasing catch rates and some regular recruitment, there is currently insufficient evidence to reliably assess the status of the stock, therefore, the stock status for Victorian mulloway remains uncertain.

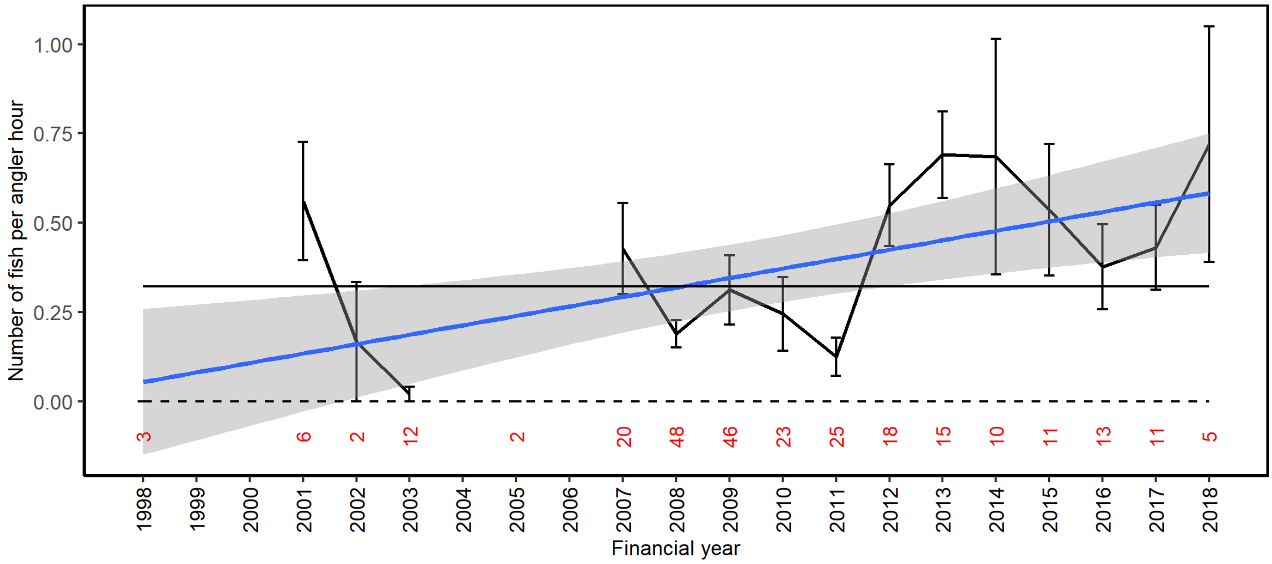
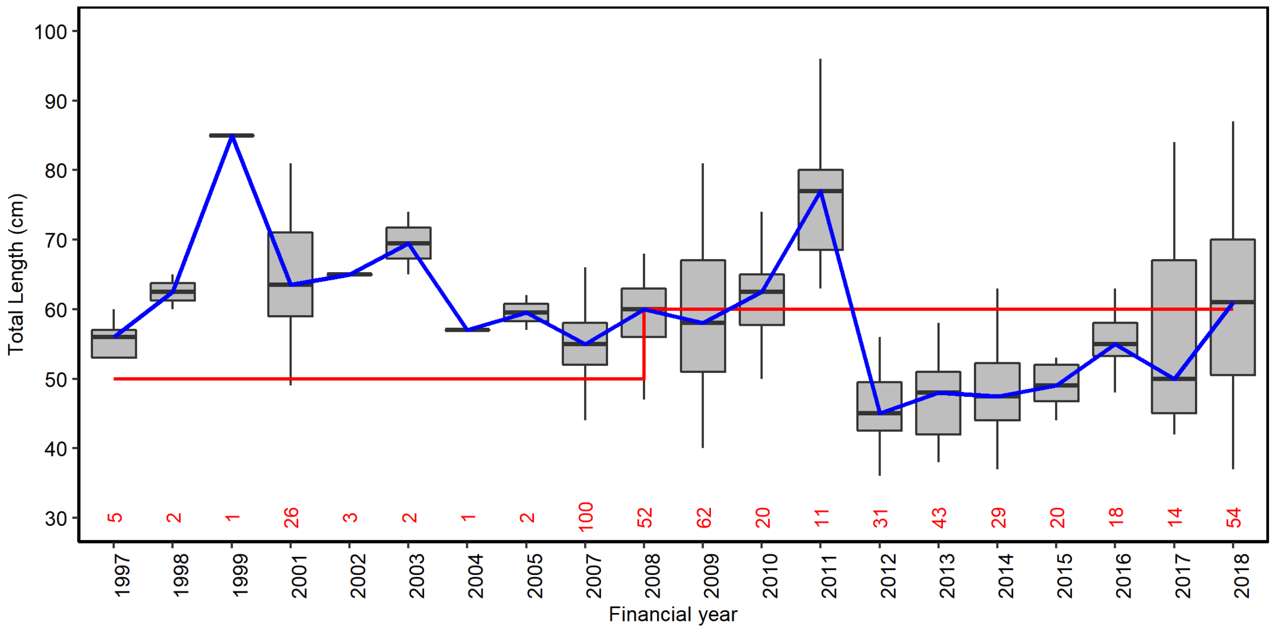


Figure 133 Mulloway nominal catch-per-unit-effort (CPUE) (±SE) for a) in the Glenelg River (1998–2018 financial years). Horizontal black line is the mean CPUE during the reference period (1998 - 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM.

(a)



(b)

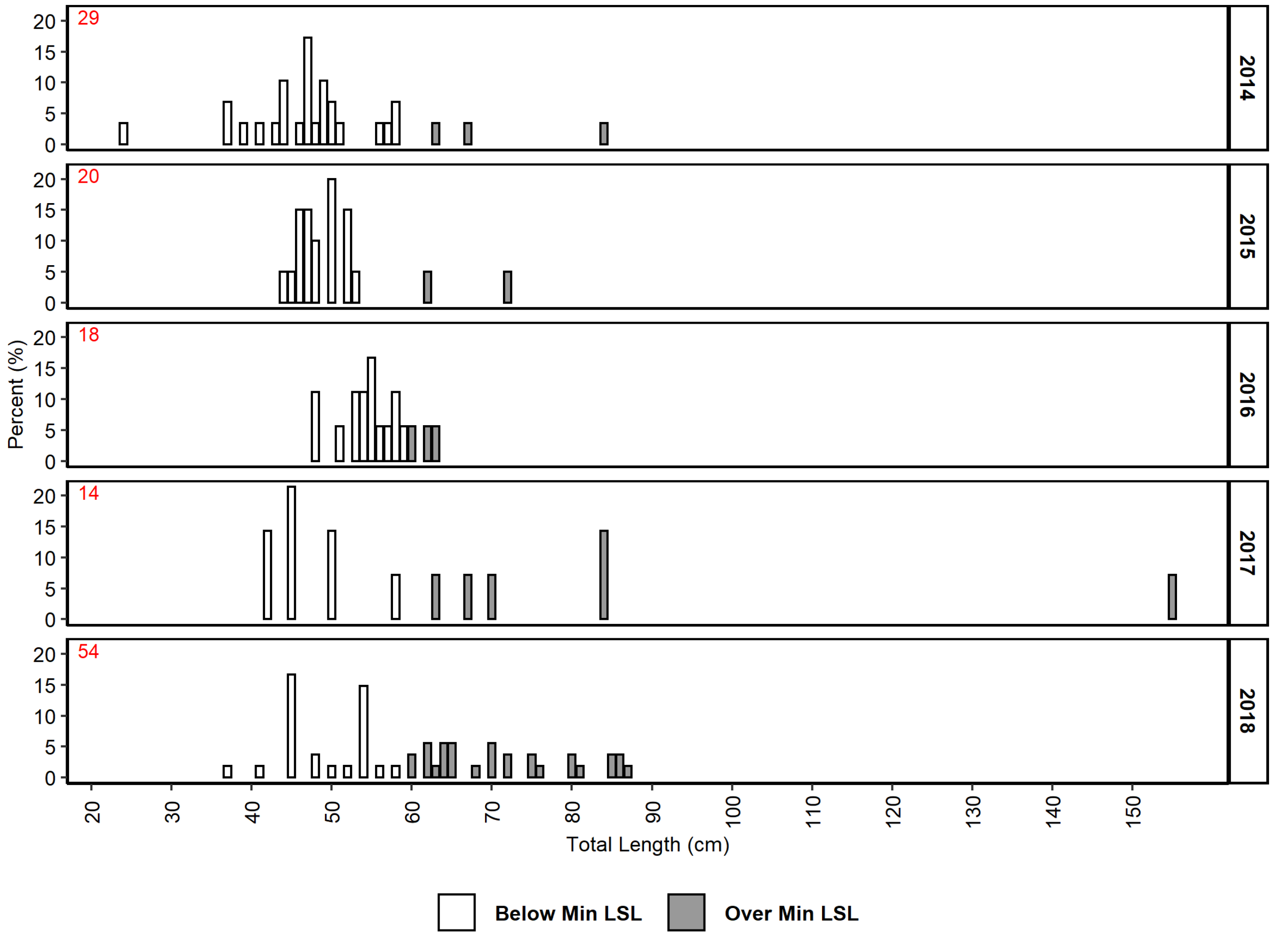


Figure 134 (a) Box-plots of Glenelg River mulloway length composition from diary anglers for financial years 1998-2018. Red numbers on x-axis indicate numbers of fish sampled. Blue line = median length, red line = LML. (b) Frequency histograms of Glenelg River mulloway length composition from diary anglers for fiscal years 2013-2018. Red numbers indicate numbers of fish measured.

Murray Cod (*Maccullochella peelii*): State-wide

Stock Structure and Biology

Murray Cod occurs throughout most of the Murray–Darling system of south-eastern Australia, with the exception of the upper reaches of some tributaries. In Victoria, the Murray cod population is considered to comprise a state-wide stock that occurs in the lower sections of river catchments north of the Great Dividing Range (Figure 135). These represent one genetically panmictic biological stock (Rourke *et al.* 2011). Murray cod have been translocated into waters outside their natural range and self-sustaining populations have established in some waters, including the Wimmera and Yarra rivers (Figure 135). Hatchery-bred juvenile Murray cod are also stocked into selected waters, mainly within its natural range and mainly within impoundments, to maintain and enhance the recreational fishery (Figure 135). Murray cod completes its lifecycle solely within freshwater. Spawning in Victoria occurs from late-September to mid-January, in response to rising temperature. Populations in rivers are mostly self-replenishing whereas populations in impoundments are sustained by stocking. Maturity occurs at about 4–6 years and 40 for males and 60 cm for females, although this is variable across geographic regions. Murray cod supports a highly valuable and popular recreational fishery. There is no commercial harvest of Murray cod in the state, but the species is grown in aquaculture operations for human consumption. The recreational fishery is managed through strict recreational bag and size (slot) limits, restrictions on fishing methods such as set lines and supplementation by stocking hatchery-bred fish.

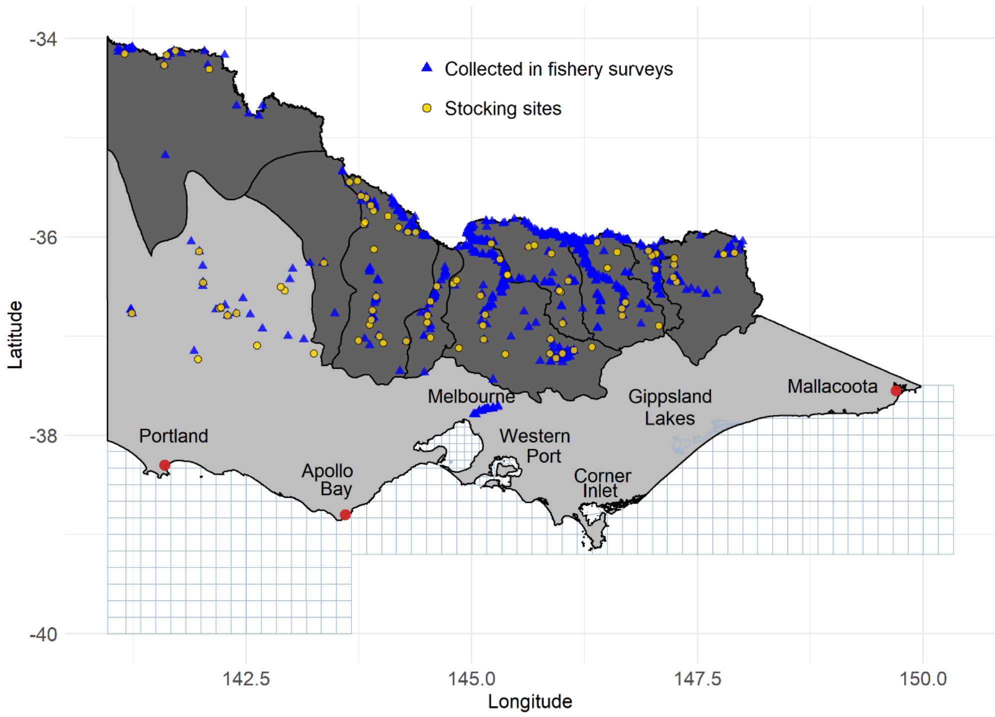


Figure 135 Victorian Murray cod distribution and stocking sites.

Assessment Summary

In the absence of consistent, long-term estimates or population abundances and harvest by anglers, the status of the Victorian Murray cod stock and associated fisheries were evaluated using:

- Nominal catch estimates (fish per machine minute) and length composition from fishery-independent (electrofishing) surveys of six indictor riverine populations (Broken Creek and River, Campaspe River, Goulburn River, Gunbower Creek, Loddon River and Ovens River) (Ingram et al. 2019) (reference period first record since 1990 - 2015) (Ingram et al 2019).

This assessment found:

- *Fishing pressure* – commercial harvest of Murray cod in Victoria ceased in 2001. There is no recent information on recreational harvest or effort at state level.
- *Biomass* – Electro-fishing survey CPUE (as fish per machine minute) has generally increased in all indicator rivers except the Loddon River (Figure 136). CPUE in the Broken Creek and River, Campaspe River, Goulburn River, Gunbower Creek and Ovens River has above the mean nominal CPUE for the reference period since the early 2010s, whereas CPUE in the Loddon River has remained below the mean nominal CPUE for the reference period for most of the last decade.
  Although the Broken Creek and River and Goulburn River are stocked annually with hatchery-bred juveniles, the majority of Murray Cod sampled from the river are naturally spawned (Tonkin *et al*. 2019), suggesting that changes in CPUE are due to natural recruitment rather than stocking.
  Similar proportions of stocked and naturally spawned Murray Cod have been sampled from the Gunbower Creek (Tonkin *et al*. 2019), indicating that both stocking and natural recruitment have contributed to changes in CPUE.
  Although the Campaspe River and Loddon River are stocked annually, insufficient information is available to determine if stocked fish are contributing to the fishery (Ingram *et al*. 2015, Tonkin *et al*. 2019).
  Increase in the Ovens River CPUE is due solely to natural recruitment as no stocking occurs.
  Note that the minimum CPUE for the reference period is zero for all three rivers due to the presence of zero catch in some years.
- *Length composition* – Long-term length composition data for electrofishing surveys is limited for much of the assessment (Figure 137). A wide range of fish size were observed in each river but in recent years most Murray cod measured were below the minimum legal size limit while Murray cod over the maximum legal size limit were uncommon but observed in all rivers (Figure 137 and Figure 138). Small fish (recruits presumed to be less than one year old and <10 cm) were present in all rivers indicating either recent natural recruitment (Ovens River) or recent stockings of hatchery-bred fish to a lesser or greater extent along with natural recruitment (other rivers) (Figure 138). Mature fish (> 60 cm) were present but uncommon in all six rivers in recent years.

Stock status summary: As there is no consistent, long-term estimates of population abundances and recreational harvest for Murray cod, state-wide stock status was based on assessment of six indicator riverine populations (Broken Creek and River, Campaspe River, Goulburn River, Gunbower Creek, Loddon River and Ovens River). Although information from these rivers is limited to infrequent and irregular annual electro-fishing surveys, CPUE appears to be increasing in most rivers (except the Loddon River). There is no information on fishing pressure, biomass and size composition for Murray cod in impoundments but these populations are largely sustained by stocking hatchery-bred fish rather than natural recruitment. On the basis that CPUE appears to be increasing in five of six indicator rivers the Murray Cod stock status has been assessed as **recovering**.

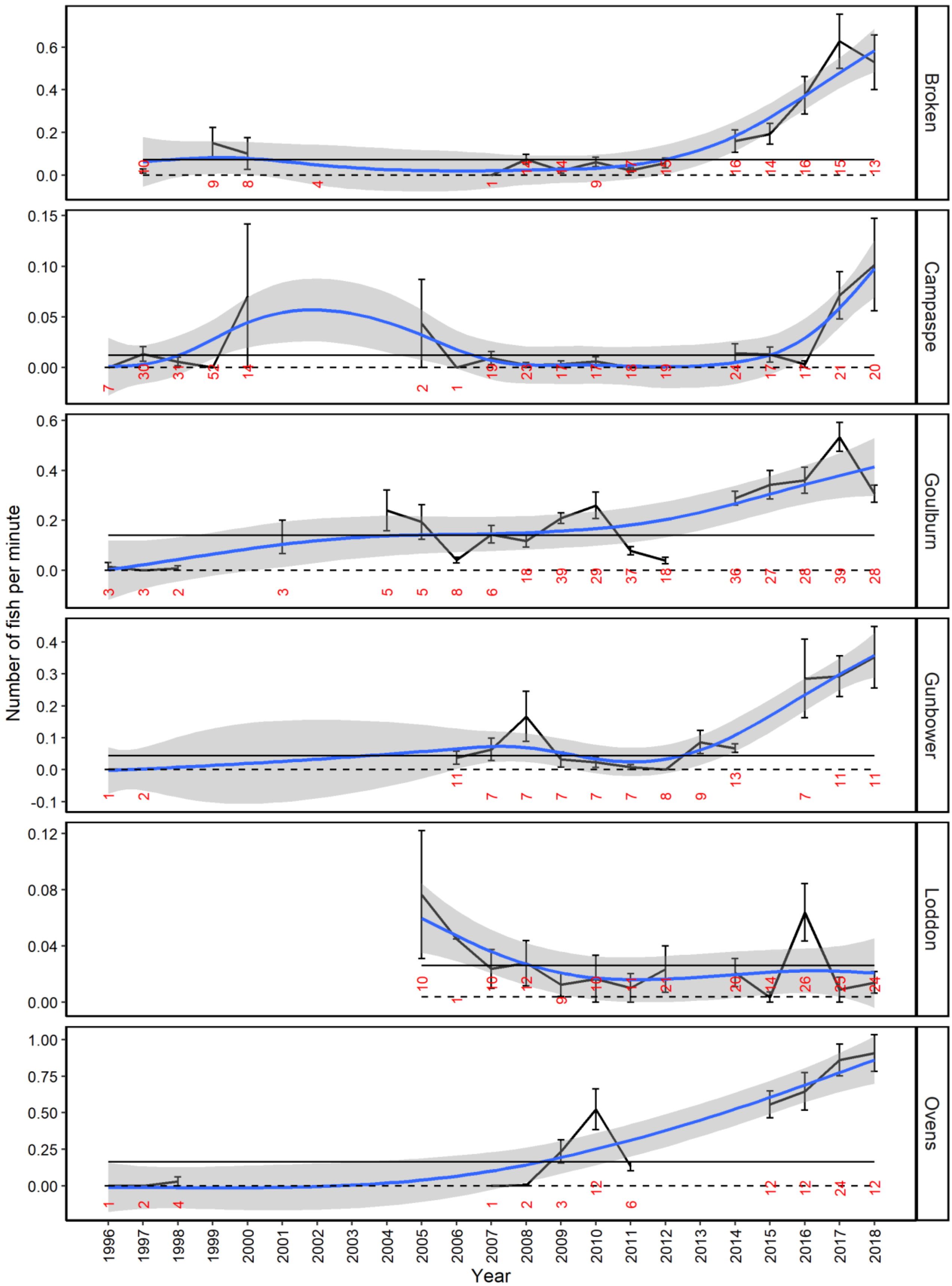


Figure 136 Electrofishing fishery survey catch-per-unit-effort (CPUE) (nominal) for Murray cod in six indicator rivers. Horizontal black line is the mean nominal CPUE during the reference period (first record since 1990 to 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of sites surveyed each year.

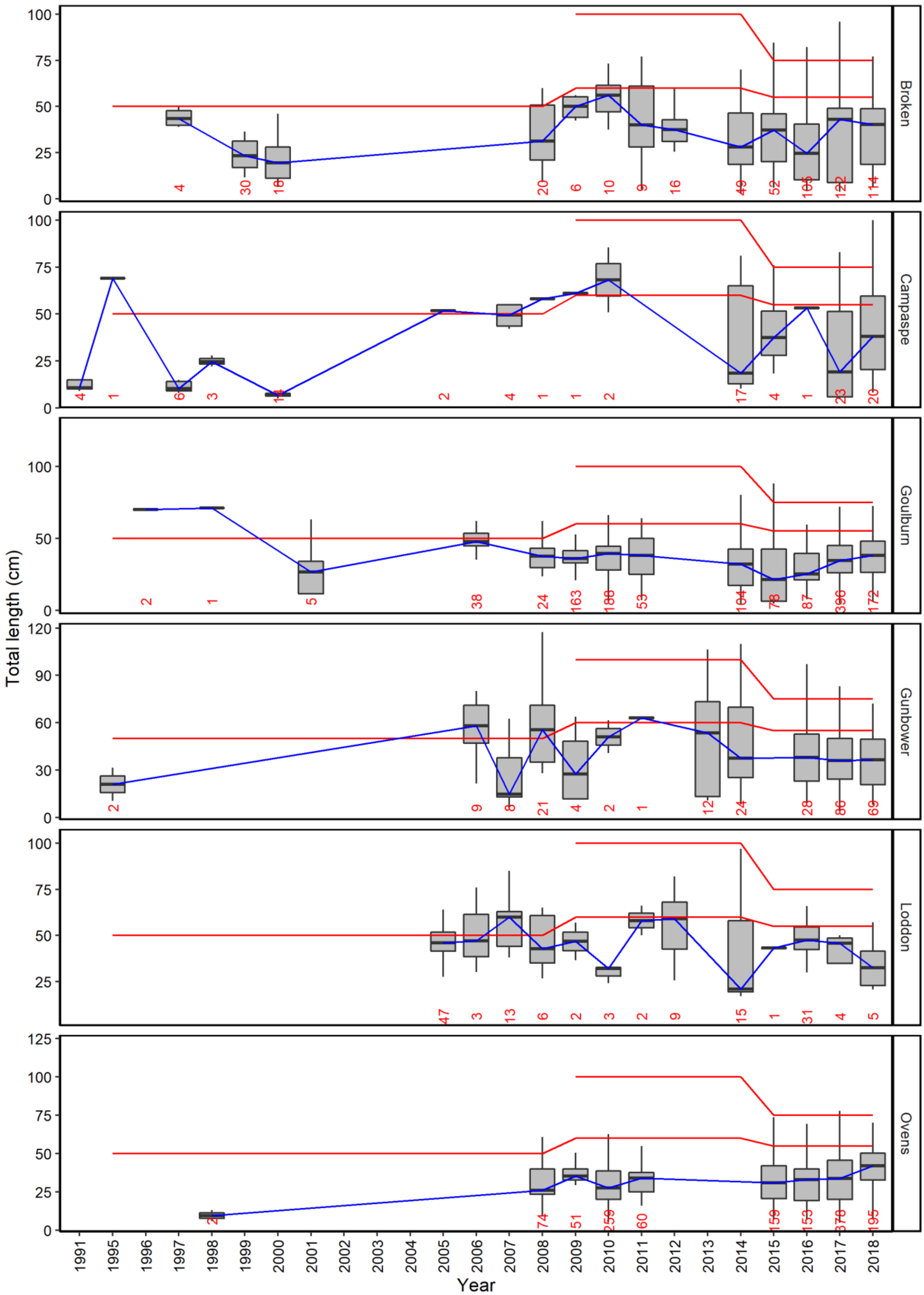
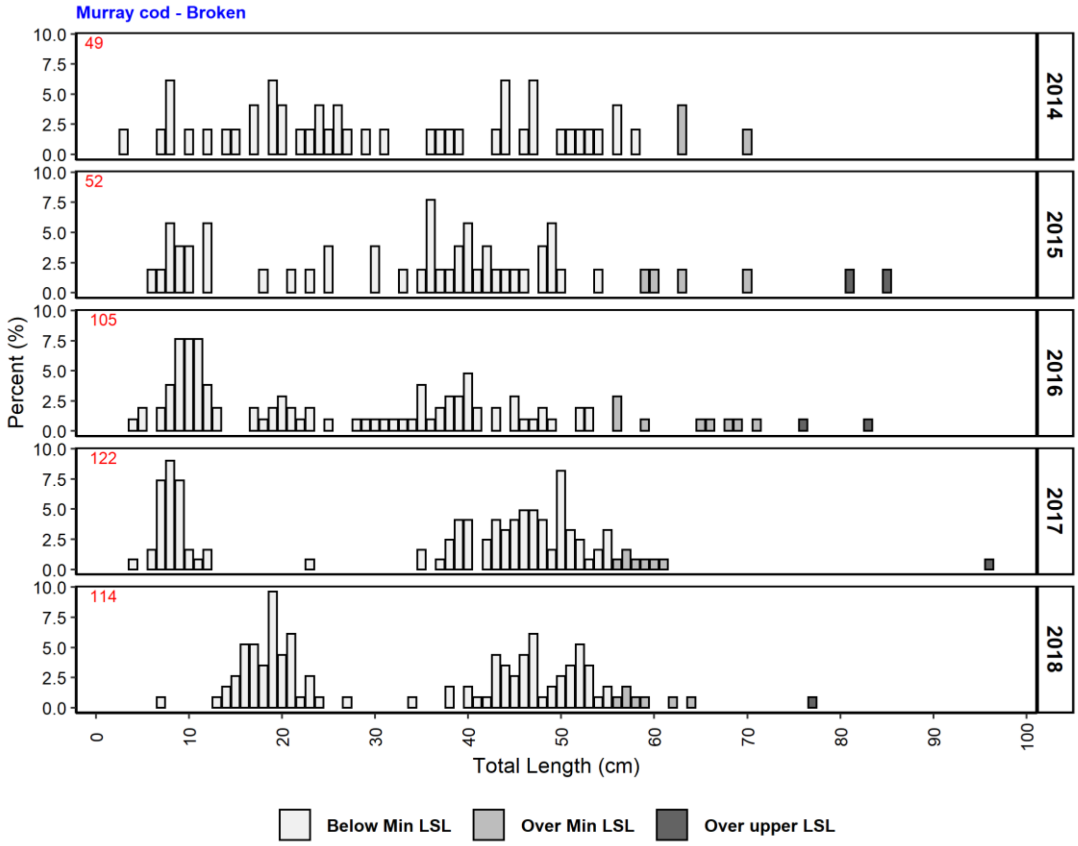
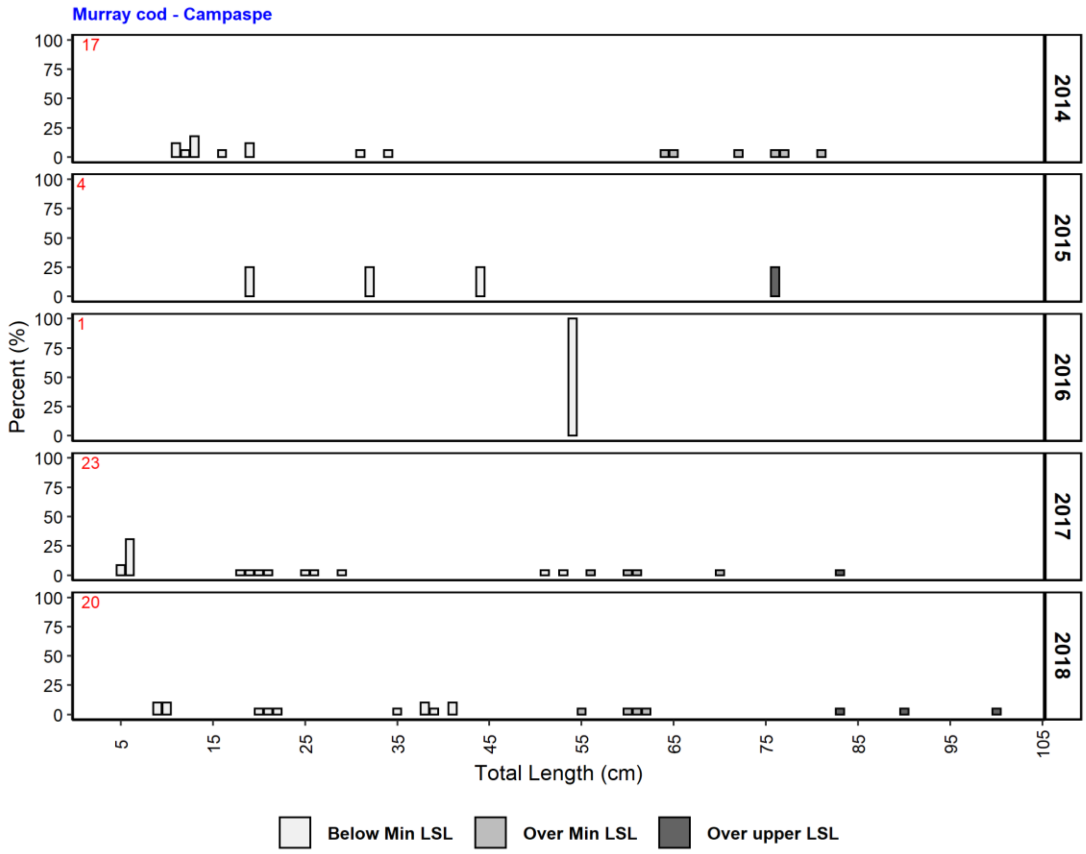
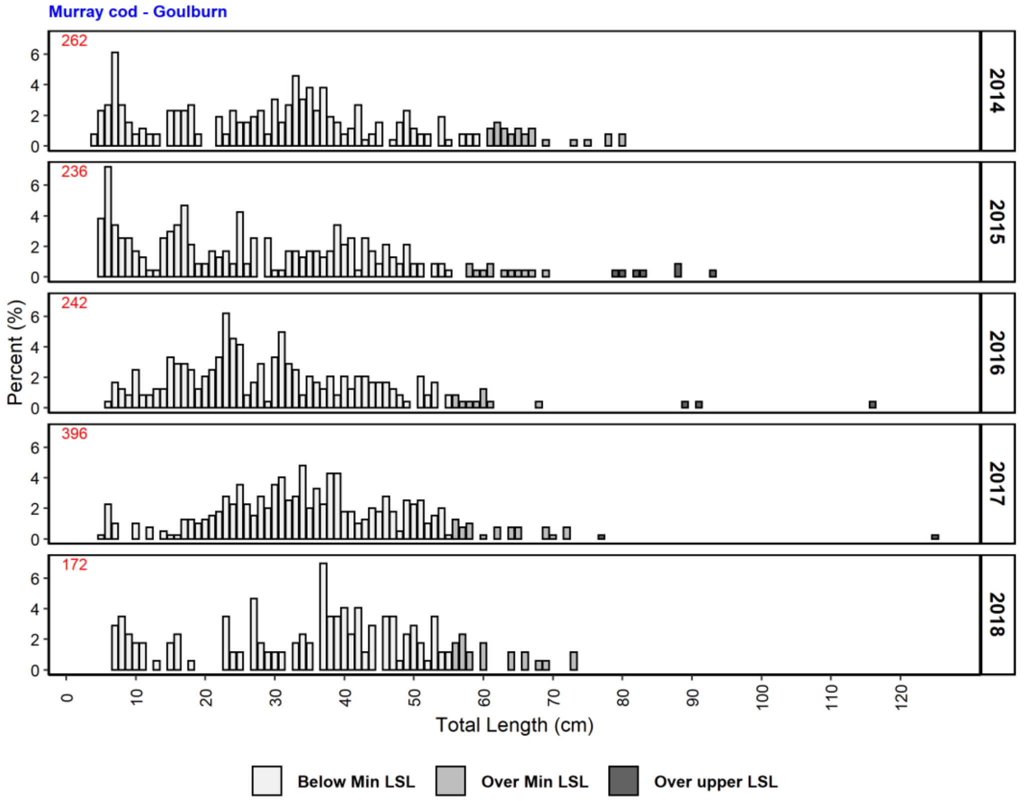
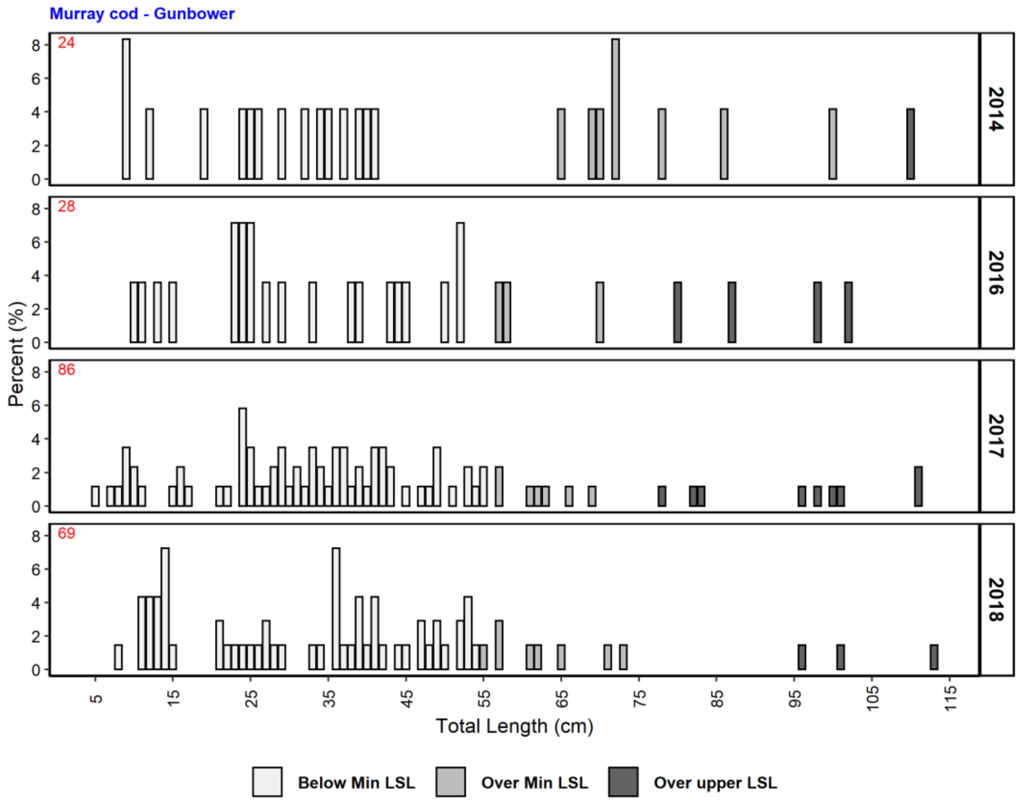


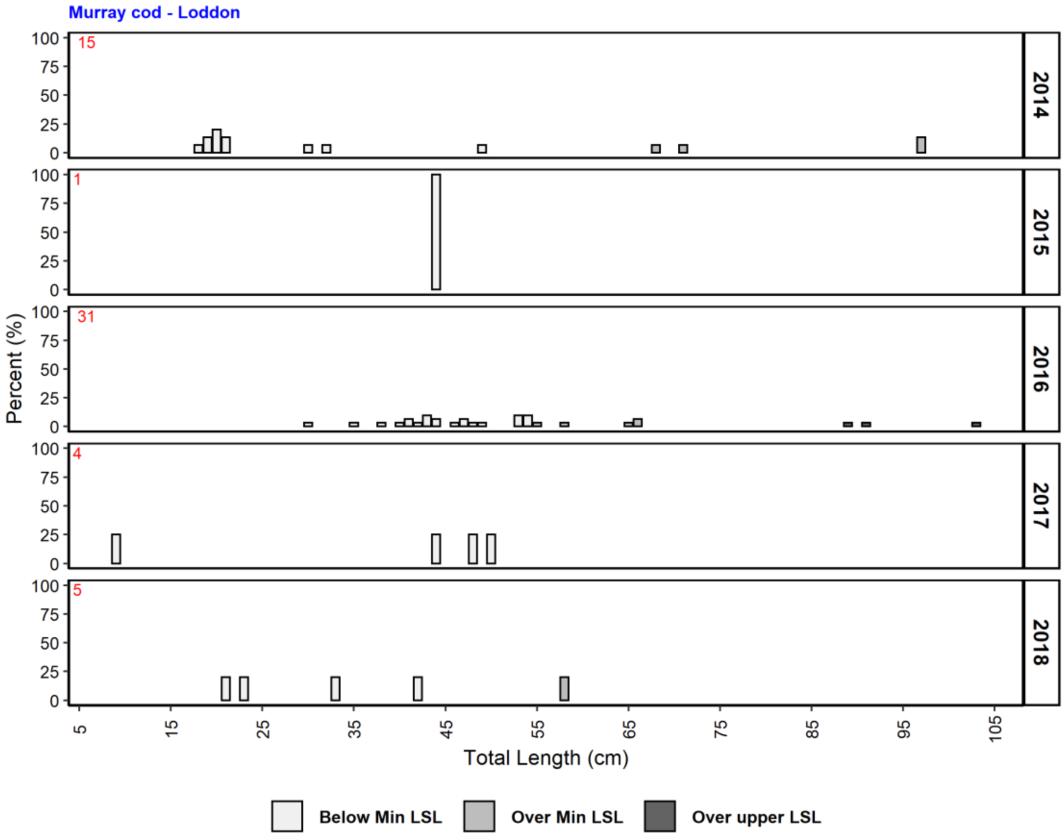
Figure 137 Box-plots of Murray cod electro-fishing survey length composition 1991-2018 for three indicator rivers. Red numbers on x-axis indicate number of fish sampled. Blue line = median length, red line = LML LMLs.


Murray cod - Broken
49
2014
52
2015
105
2016
122
2017
114
2018
Percent (%)
Total Length (cm)
Below Min LSL
Over Min LSL
Over upper LSL


Murray cod - Campaspe
17
2014
4
2015
1
2016
23
2017
20
2018
Percent (%)
Total Length (cm)
Below Min LSL
Over Min LSL
Over upper LSL


Murray cod - Goulburn
262
236
242
396
172
2014
2015
2016
2017
2018
Percent (%)
Total Length (cm)
Below Min LSL
Over Min LSL
Over upper LSL


Murray cod - Gunbower
24
28
86
69
2014
2016
2017
2018
Percent (%)
Total Length (cm)
Below Min LSL
Over Min LSL
Over upper LSL



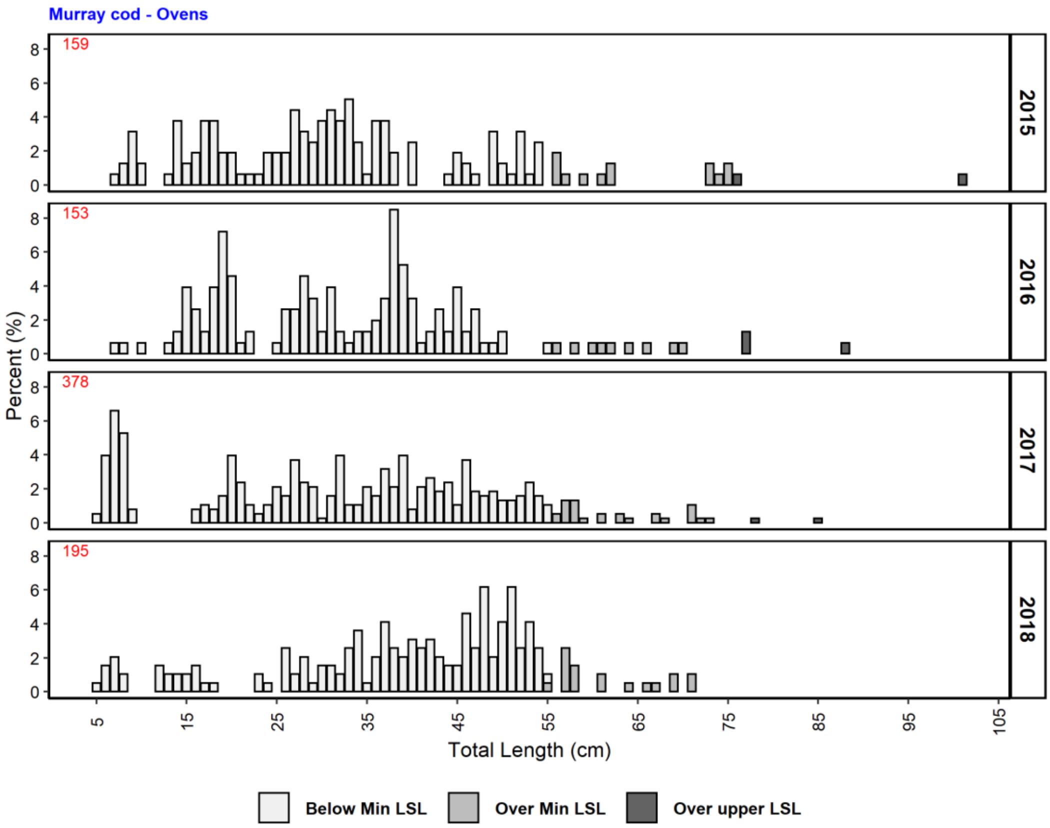


Figure 138 Length frequency histograms of Murray cod electro-fishing survey catches from 2014–2018 for six indicator rivers. Red numbers indicate number of fish measured.

Snook (*Sphyraena novaehollandiae*)

Stock Structure and Biology

Snook (*Sphyraena novaehollandiae*), a relative of the Barracudas, are distributed throughout southern Australia and New Zealand (Gomon et al. 2008). Relatively little is known about snook, including the stock structure, as they are landed in relatively low quantities in Victoria, South Australia and Tasmania (Moore, 2018; Steer, 2018) being a by-product taken while targeting other more valuable species. Snook reach maturity at 40–42 cm and spawn from late November to February (Bertoli, 1994). Snook grow quickly and have a maximum age of at least 10 years (Bertoli, 1994).

Management/Assessment Unit

Historically, snook were landed commercially in the largest quantities in Port Phillip Bay, however, since effort in Port Phillip Bay has declined following the buyout, the largest quantities are now landed in Corner Inlet (Figure 139). As nothing is known about the stock structure of snook, and the only fishery that lands significant quantities in Victoria is in Corner Inlet, the status of snook in Victoria is assessed using data from Corner Inlet alone.

In Corner Inlet, <2 tonnes of snook have been landed by mesh nets in all years other than 2018/19, which is considered insufficient to provide a reliable CPUE indicator of biomass. Landings from seine in Corner Inlet have generally been >5 tonnes; as such, seine CPUE is used as the primary indicator of stock performance.

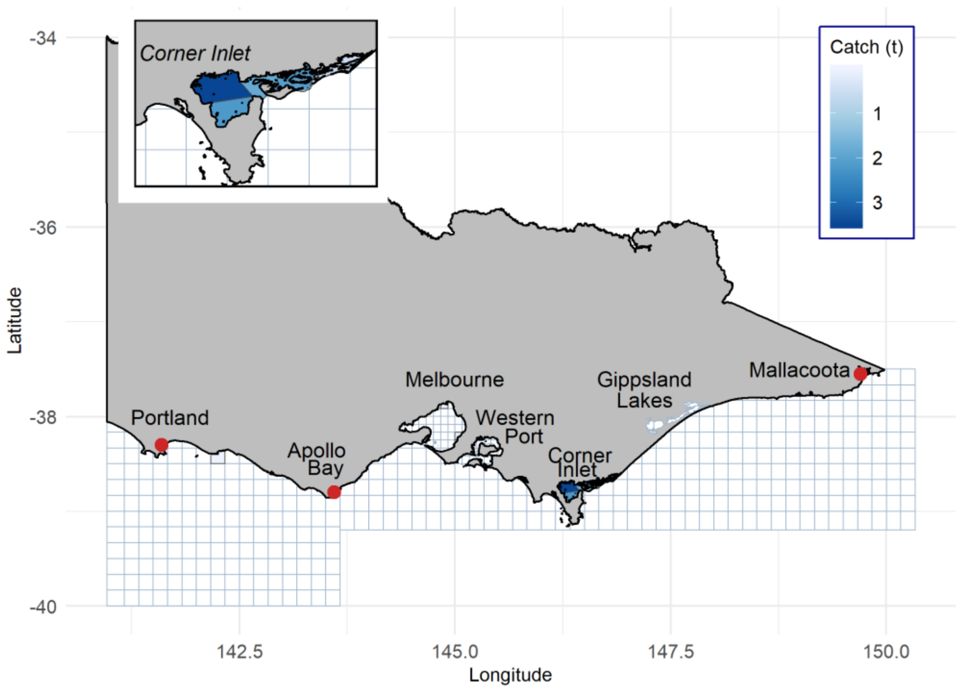


Figure 139 Spatial distribution of state-wide landings of snook from Victorian fisheries during the 2018/19 financial year.

Assessment Summary

This assessment found:

- *Fishing pressure* – The very large decrease in total snook landings (Figure 140) has largely resulted from decreased fishing effort in Port Phillip Bay (see Appendix 2) due to the buyout. Conversely, fishing effort of both seine and mesh net in Corner Inlet has increased in recent years, which has seen the highest landings of snook ever reported from Corner Inlet.
- *Biomass* – CPUE for snook in Corner Inlet using seine nets has remained relatively consistent from 1978–2018 (Figure 141), albeit with some interannual variability around the reference period average. This variability may be a result of natural variation in the population or because snook represent a relatively minor by-product of this fishery (i.e. not targeted and hence caught in relatively low quantities). This variability means the GAM has defaulted to a linear model that shows a slightly increasing trend throughout the time series. Snook catches receive a moderate price at market so there is no reason to suspect that they are discarded which would render the CPUE trend to be unreliable.

Stock status summary: Stable, or slightly increasing CPUE, with no evidence that snook abundance has declined in Corner Inlet from 1978–2018. Fishing effort is at historic highs within this fishery and there is a possibility that this could result in some localised depletion. Despite this possibility and being typically associated with reef and seagrass habitats, snook are highly active and relatively pelagic, which in combination with the very low levels of fishing pressure observed implies that they may potentially replenish from the stocks that live outside of Corner Inlet. Nevertheless, it is important that the performance of the stock(s) is carefully monitored, especially if fishing effort remains high or increases. At present there is no indication that the level of fishing has, or will, result in recruitment impairment of snook in Victoria. The stock status of Snook in Corner Inlet, and more generally throughout the State appears to be sustainable.

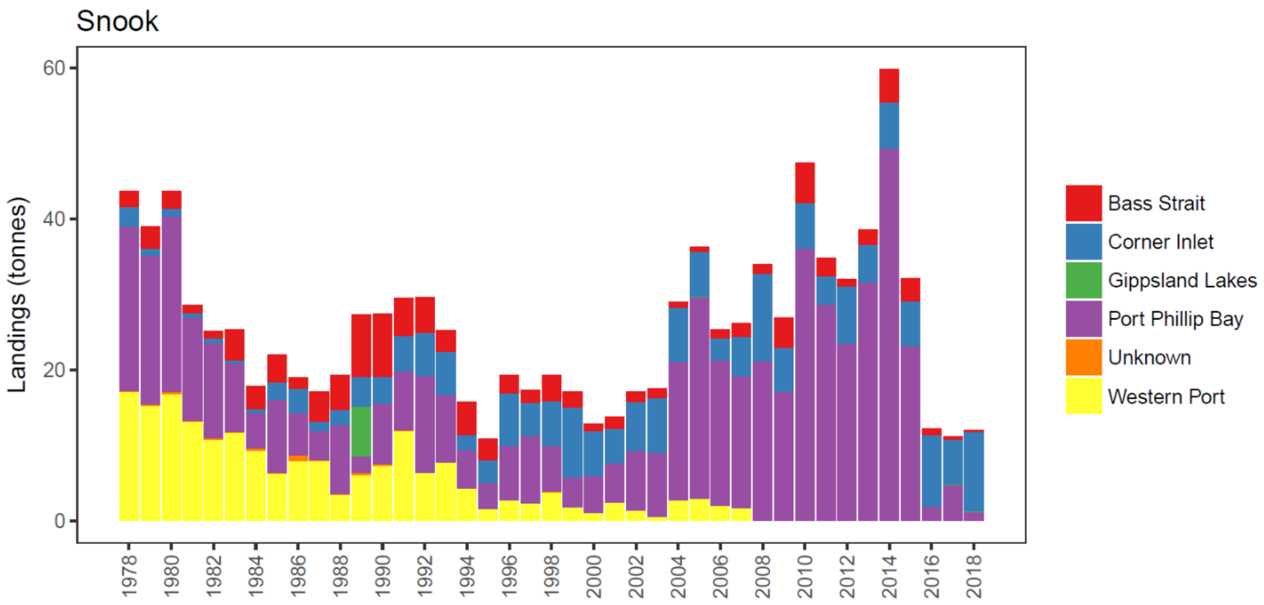


Figure 140 Total Victorian commercial catches of snook by area (1978–2018 financial years).

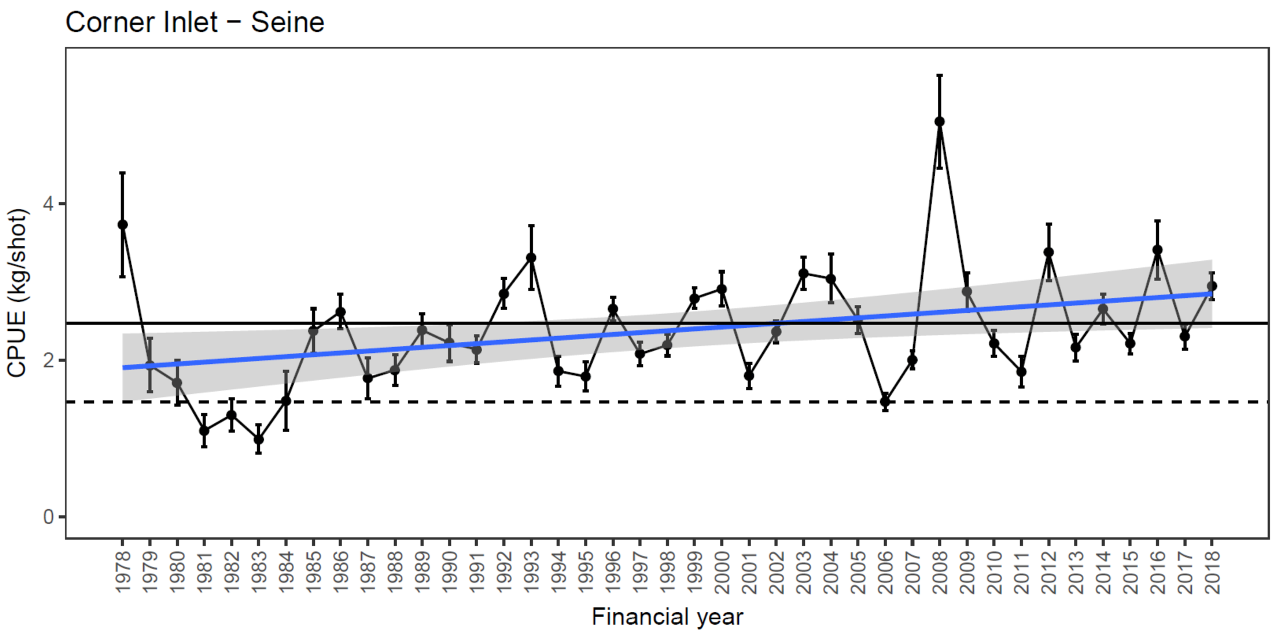


Figure 141 Catch-per-unit-effort (CPUE) of snook from the Corner Inlet seine fishery (1978–2018 financial years).

Golden perch (*Macquaria ambigua*): State-wide

Stock Structure and Biology

Golden perch occurs throughout most of the Murray–Darling system of south-eastern Australia, with the exception of the upper reaches of some tributaries. In Victoria the golden perch population is considered to comprise a state-wide stock that occurs in the lower sections of river catchments north of the Great Dividing Range (Figure 142). Phylogenetic analyses based on mitochondrial DNA suggests golden perch in the Murray-Darling basin (including Victorian waters) represents one monophyletic clade (Faulks *et al.* 2010). Golden perch have been translocated into waters outside their natural range, including the Wimmera River and lakes in western Victoria (Figure 142). Hatchery-bred juvenile golden perch are also stocked into selected waters, mainly within its natural range and mainly within impoundments, to maintain and enhance the recreational fishery (Figure 142). Golden perch completes its lifecycle solely within freshwater. Spawning in Victoria occurs mainly in spring and early summer (October to February), usually in association with elevated temperatures and increasing water flow and flooding. Populations in rivers are sustained by both natural recruitment and stocking whereas populations in impoundments are sustained by stocking only. Maturity occurs at about 4 years (>1.5 kg) for females and 3 years for males. Golden perch supports a highly valuable and popular recreational fishery. There is no commercial harvest of golden perch in the state. The recreational fishery is managed through strict recreational bag and size (slot) limits, restrictions on fishing methods such as set lines and supplementation by stocking hatchery-bred fish.

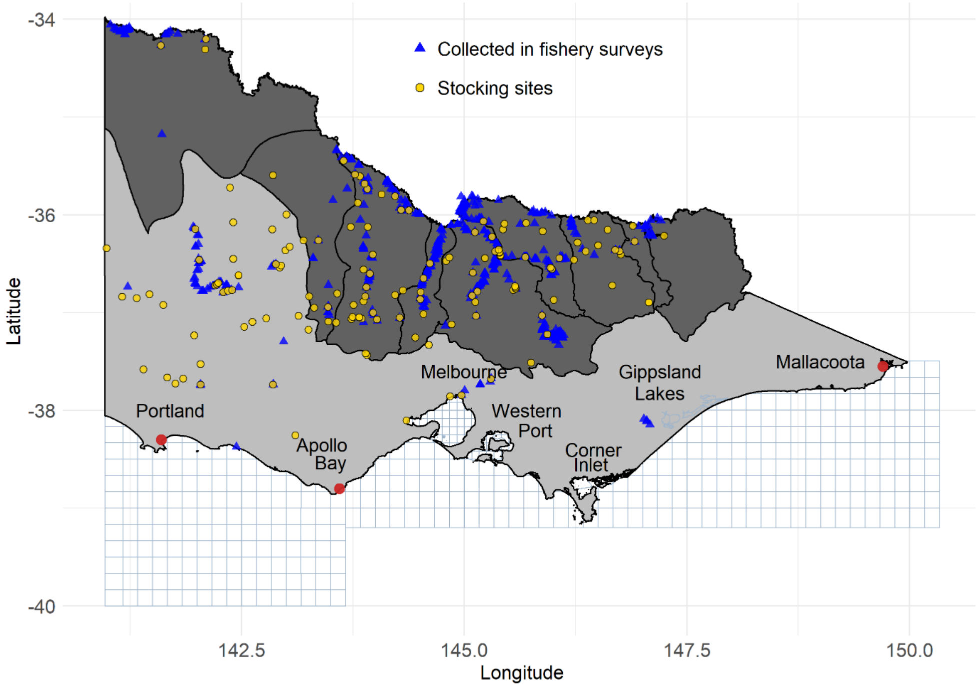


Figure 142 Victorian golden perch distribution and stocking sites.

Assessment Summary

In the absence of consistent, long-term estimates or population abundances and harvest by anglers, the status of the Victorian golden perch stock and associated fisheries were evaluated using:

- Nominal catch estimates (fish per machine minute) and length composition from fishery-independent (electrofishing) surveys of six indictor riverine populations (Broken Creek and River, Campaspe River, Goulburn River, Gunbower Creek, Loddon River and Wimmera River) (Ingram *et al.* 2019) (reference period first record since 1990–2015).

This assessment found:

- *Fishing pressure* – commercial harvest of golden perch in Victoria ceased in 2001. There is no recent information on recreational harvest or effort at state level.
- *Biomass* – In recent years electro-fishing survey CPUE (as fish per machine minute) has generally increased in four indicator rivers (Campaspe River, Goulburn River, Gunbower Creek and Wimmera River), remained stable in one river (Broken Creek and River) and declined in one river (Loddon River) (Figure 143). CPUE values for the Broken Creek and River and Loddon River were below the mean nominal CPUE for the reference period in the last two years of assessment. CPUE values for the Campaspe River, Goulburn River, Gunbower Creek and Wimmera River have been above the mean nominal CPUE for the reference period since the early 2010s. All six rivers are stocked annually with hatchery-bred juveniles. Regular stockings into the Campaspe, Goulburn and Loddon rivers is making a substantial contribution to populations (Ingram *et al*. 2015, Tonkin *et al*. 1919). All golden perch sampled from the Campaspe River above Rochester were stocked and the majority of fish sampled from the Goulburn and Loddon rivers were stocked (Tonkin *et al*. 1919). Despite regular stocking The CPUE in the Loddon River has been declining since 2014. There is no information available to determine if stocked fish are contributing to fisheries in the Broken Creek and River, Gunbower Creek and Wimmera River. Note that the minimum CPUE for the reference period is zero for all three rivers due to the presence of zero catch in some years.
- *Length compositions* – Long-term length composition data for electrofishing surveys is limited for much of the assessment (Figure 144). Most fish measured were above the LML whereas small fish (recruits presumed to be less than one year old and <10 cm) were uncommon (and absent in some years) in all rivers (Figure 144 and Figure 145). Small fish that were present may indicate recent stockings of hatchery-bred fish (all rivers are stocked annually), but some fish may also be from natural recruitment (Figure 145). Mature fish (> 30 cm) were common and present in all rivers in recent years (Figure 145).

Stock status summary: As there is no consistent, long-term estimates of population abundances and recreational harvest for golden perch, state-wide stock status was based on assessment of six indicator riverine populations (Broken Creek and River, Campaspe River, Goulburn River, Gunbower Creek, Loddon River and Wimmera River). Although information from these rivers is limited to infrequent and irregular annual electro-fishing surveys, CPUE appears to be increasing in four rivers, stable in one river and declining in one river. All rivers are stocked annually. There is no information on fishing pressure, biomass and size composition for golden perch in impoundments but these populations are largely sustained by stocking hatchery-bred fish rather than natural recruitment. On the basis that CPUE appears to be increasing in four of six indicator rivers it is anticipated that the golden perch stock will progressively improve under favourable environmental conditions.

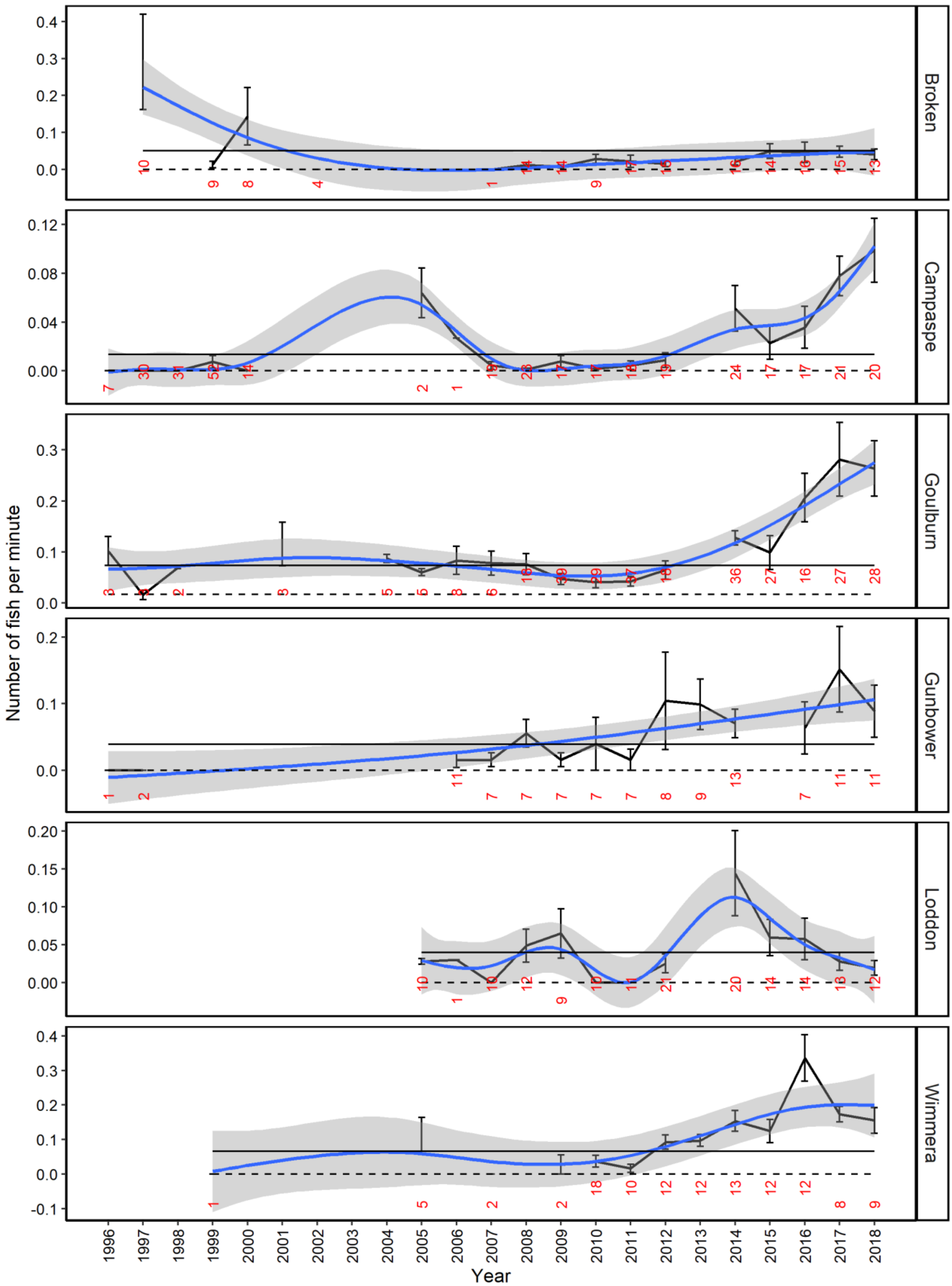


Figure 143 Electrofishing fishery survey catch-per-unit-effort (CPUE) (nominal) for golden perch in six indicator rivers. Horizontal black line is the mean nominal CPUE during the reference period (first record since 1996 to 2015) and the dashed black line is the minimum CPUE within the reference period. Blue line is a generalised additive model (GAM) of the nominal CPUE trend with the shaded grey area representing the 95% confidence interval of the GAM. Red numbers along x-axis are numbers of sites surveyed each year.

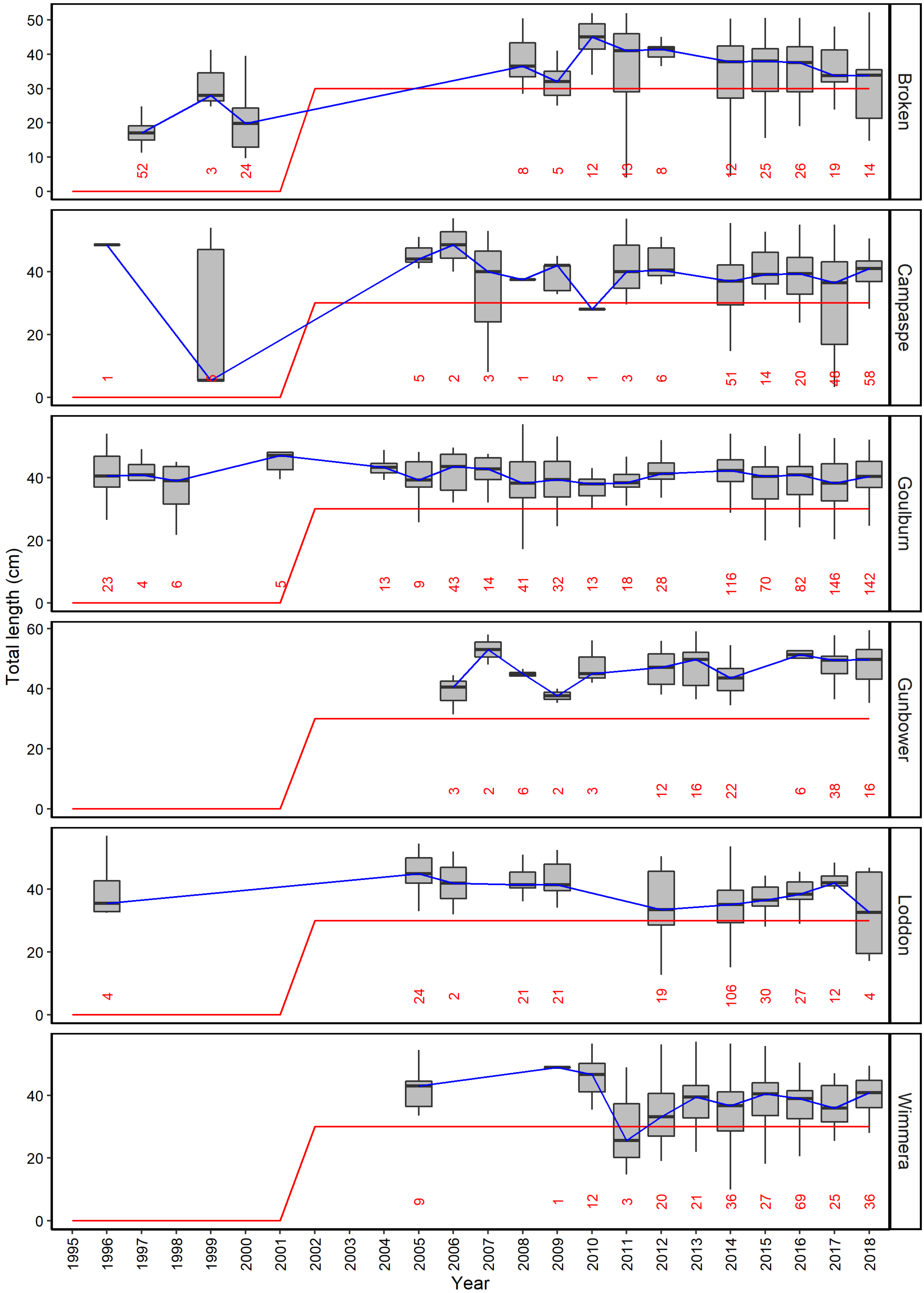
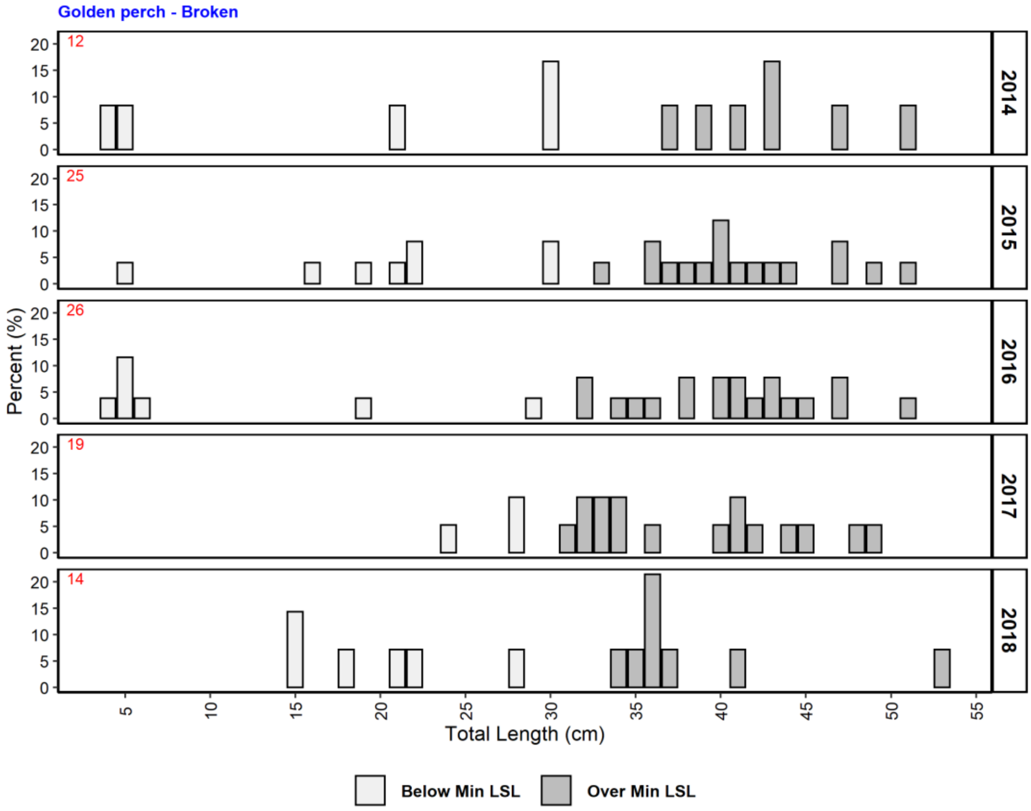
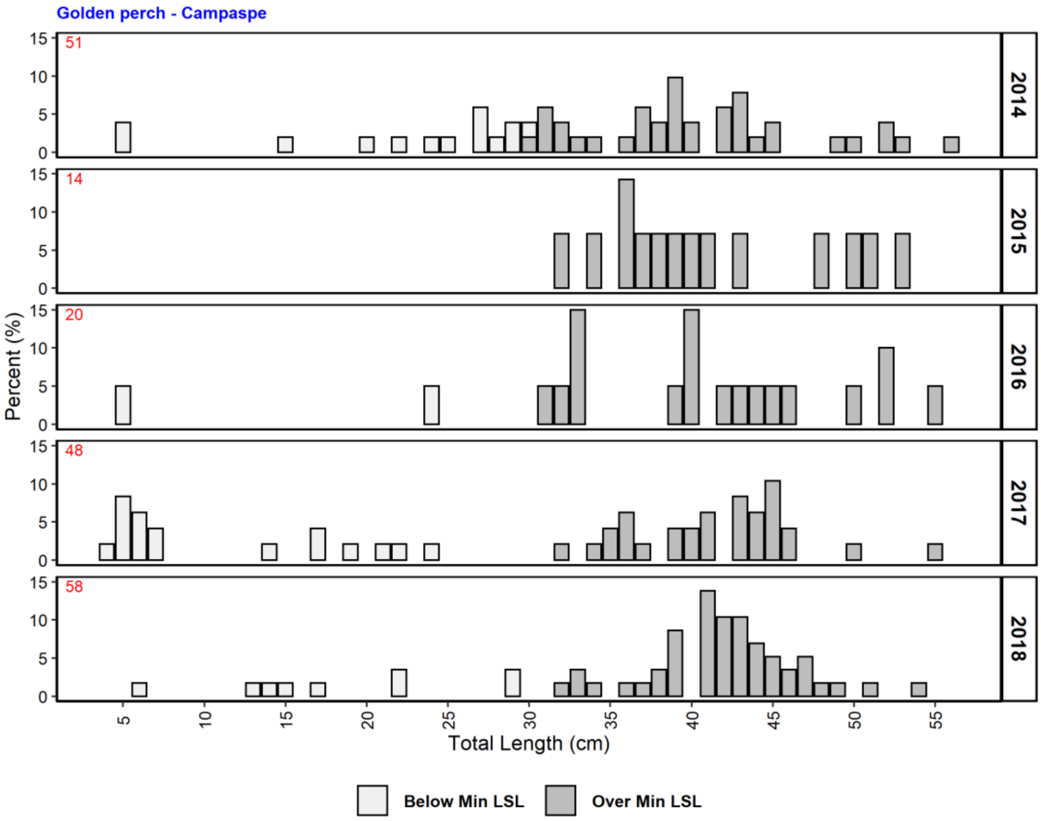
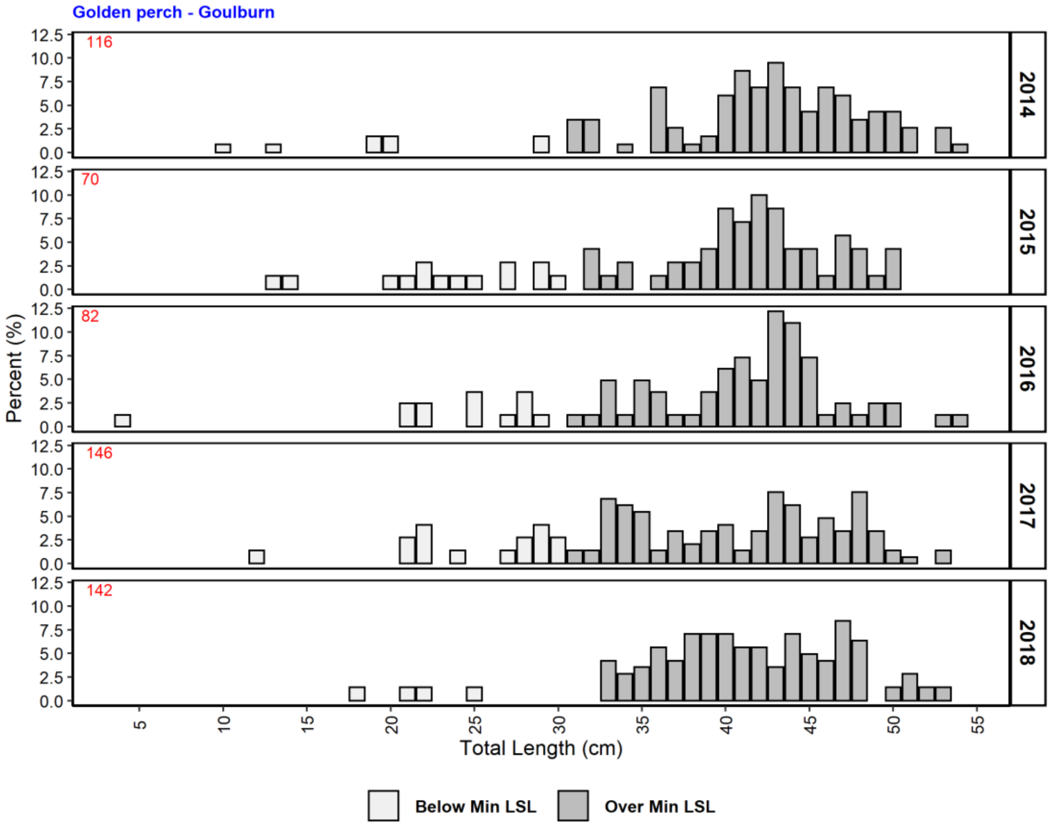
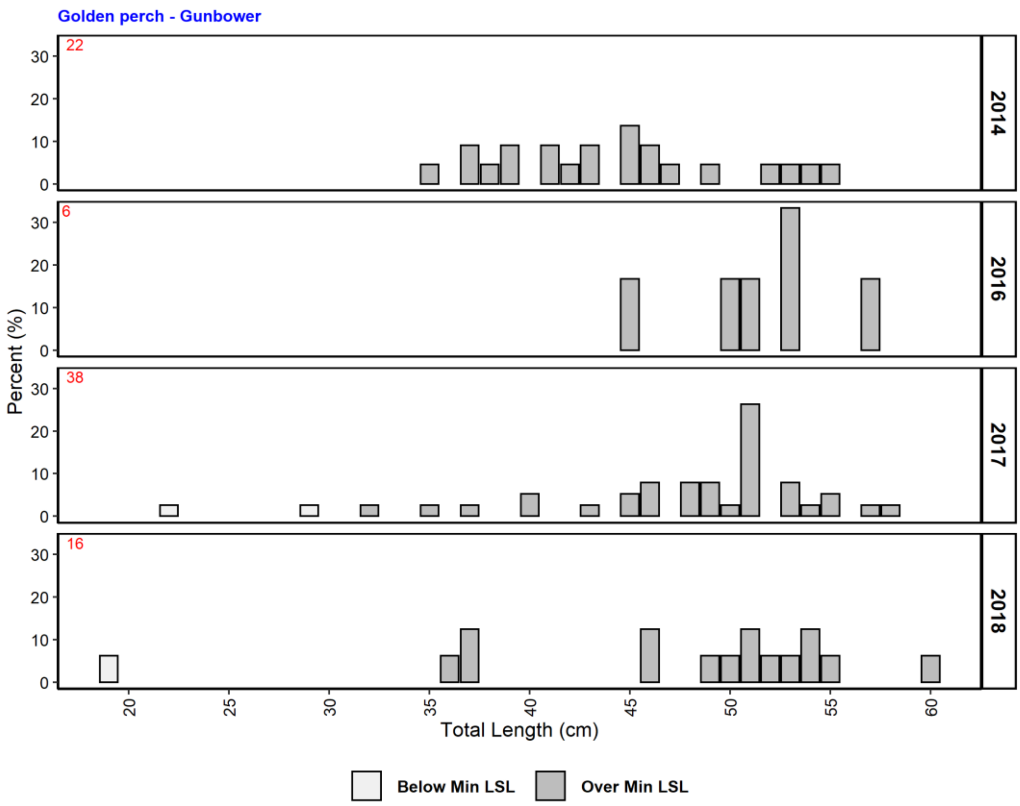


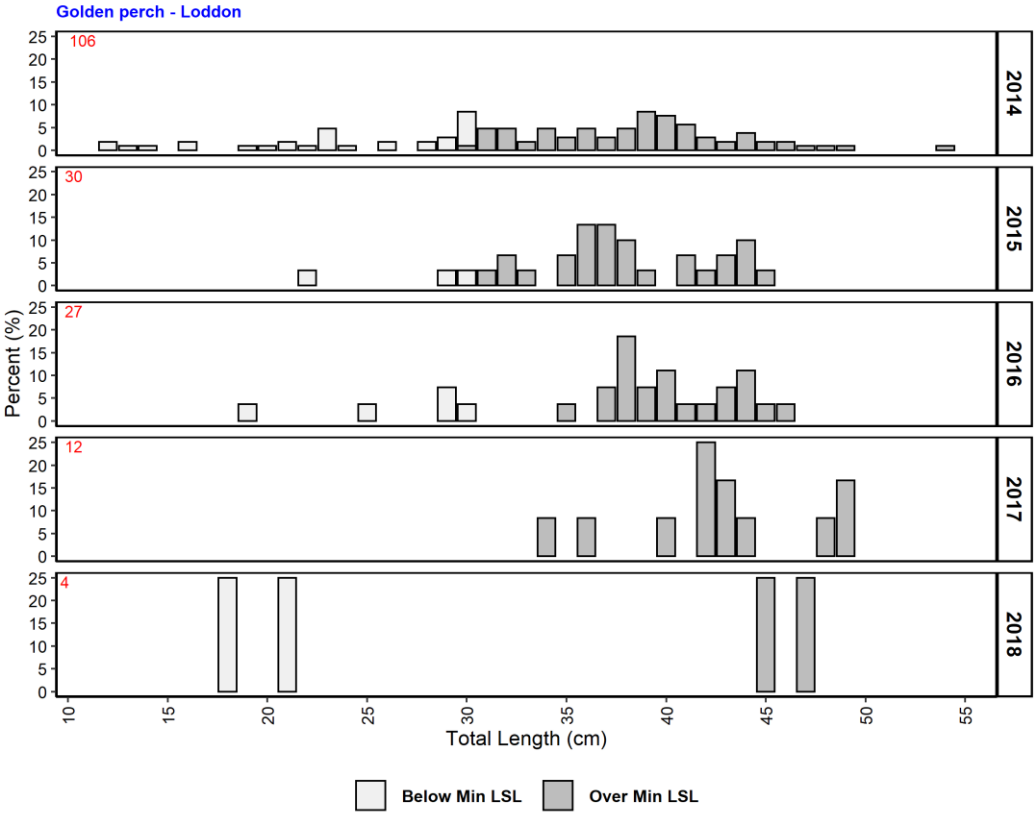
Figure 144 Box-plots of golden perch electro-fishing survey length composition 1995-2018 for six indicator rivers. Red numbers on X-axis indicate number of fish sampled. Blue line = median length, red line = LML.


Golden perch - Broken
Percent (%)
12
25
26
19
14
2014
2015
2016
2017
2018
Total Length (cm)
Below Min LSL
Over Min LSL


Golden perch - Campaspe
Percent (%)
51
14
20
48
58
2014
2015
2016
2017
2018
Total Length (cm)
Below Min LSL
Over Min LSL


Golden perch - Goulburn
116
70
82
146
142
2014
2015
2016
2017
2018
Percent (%)
Total Length (cm)
Below Min LSL
Over Min LSL


Golden perch - Gunbower
22
6
38
16
2014
2016
2017
2018
Percent (%)
Total Length (cm)
Below Min LSL
Over Min LSL



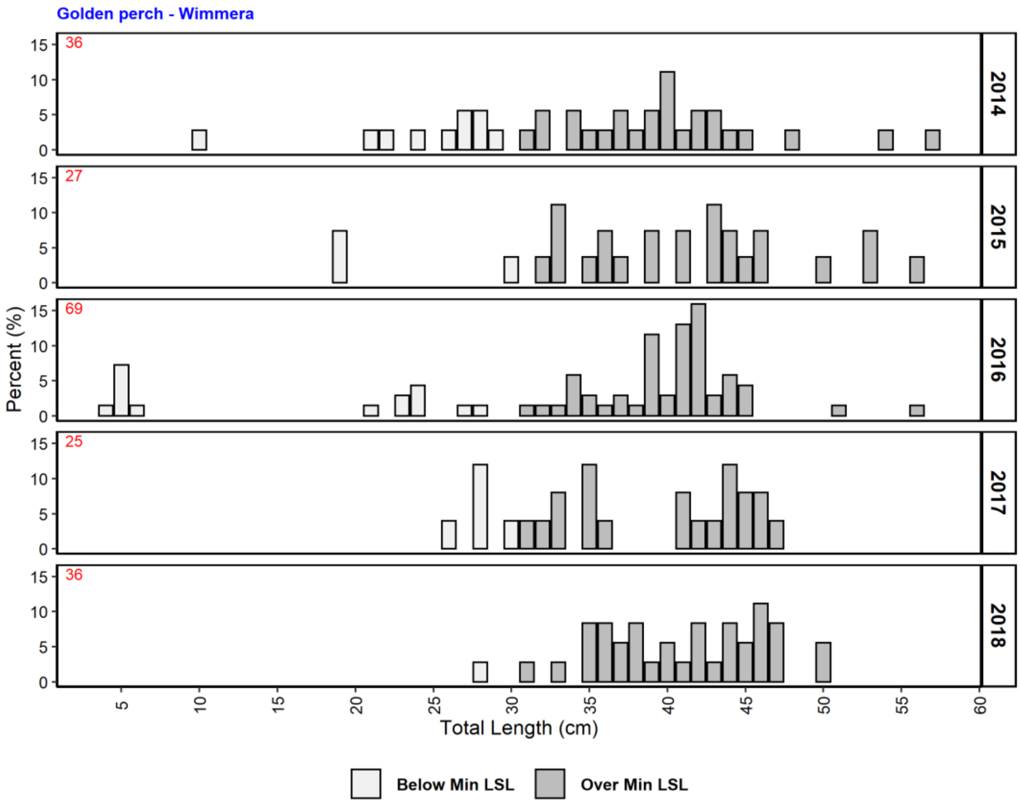


Figure 145 Length frequency histograms of golden perch electro-fishing survey catches from 2014–2018 for six indicator rivers. Red numbers indicate number of fish measured.

Greenback flounder (*Rhombosolea tapirina*): Corner Inlet

Stock Structure and Biology

Greenback Flounder has a wide distribution in Australia, from Jervis Bay on the central coast of New South Wales, around the south of the continent including Tasmania, and up to Mandurah on the south-eastern coast of Western Australia [Kailola et al. 1993]. They also occur in New Zealand [Sutton et al. 2010].

The broad distribution of Greenback Flounder in Australia is thought to be divisible into a number of separate biological stocks. Genetic studies have demonstrated that the most significant division occurs between Australian and New Zealand populations [van den Enden et al. 2000]. Within Australia, there is strong evidence that populations in western Tasmania are genetically isolated from populations in Victoria, and northern and south-eastern Tasmania. These results are consistent with those of Kurth [1957], who identified distinct western and eastern Tasmania populations on the basis of morphometrics. Biological stock structure along the southern mainland coasts of Australia is not known.

Assessment Summary

In the absence of consistent, long-term estimates or population abundances and harvest by anglers, the status of the Victorian Greenback Flounder stock and its associated fisheries were evaluated using standardised CPUE from haul seine and mesh net catches of flounder and sole from commercial landings in Corner Inlet. This enabled use of the entire time period for which catch and effort were available, noting that there have been shifts in species reporting from 'Flounder, unspecified' to species-specific reporting. Given this, and the fact that Greenback Flounder are the most common all flounder Greenback and Long-nosed) and sole species were combined (Figure 146). There could be disagreement with this, but it is reasonable to assume that many fishers may have misidentified these species in the past, and this was the only way to analyse the data back to 1978. Gear type was also limited to the two types based on catch history (Figure 147).

This assessment found:

- *Fishing pressure* – Victorian catches of this species have averaged 11 t annually over the past two decades and accounted for 73% of the national cumulative commercial catch over the past five years.

- *Biomass* – Haul seine catch rates have shown an increasing trend in the standardised curve since a trough in the early 1990s (Figure 148), but have been highly variable over time with peaks in the raw data in 1978/79, 1984/85, 1997/98, 2004/05 and 2011/12 (Conron et al. 2016). In contrast the trend for mesh net catch-per-unit-effort (CPUE) follows a consistently negative trajectory which levelled out close to zero after the mid-2000s (Figure 148). This produces a conflicting impression about stock status, but the mesh net results have much higher uncertainty and hence are less reliable. This is because of a past history of commercial operators targeting flounder, likely with specifically designed mesh nets (loosely slung with small drop), whereas in recent years fishers in Corner Inlet have predominantly targeted rock flathead and mesh net flounder landings are low. The two species would rarely be encountered together given that flounder live entirely on sand and rock flathead live entirely on seagrass in Corner Inlet so this would have a major bearing on CPUE unrelated to changes in biomass.

  The increasing trend in haul seine CPUE slowed asymptotically from the mid-2000s reaching its zenith in

2018/19 (Figure 148). It is unclear if it has now stabilised or is at the top of a cycle that will show a decreasing pattern over the next two decades like it did from the late1970s to early 1990s. Although the CPUE trends from the two different types of nets would indicate an undefined classification if the assumption that CPUE was reflecting biomass in each instance, the uncertainty in this assumption for mesh net CPUE supports relying exclusively on haul seine CPUE.

Stock status summary: Biomass proxy (CPUE) from haul seining is currently 1.5 times its long-term average (1986–2015). This is evidence that there is no recruitment impairment or biomass depletion, thereby implying that the stock of Greenback Flounder in Corner Inlet is sustainable..

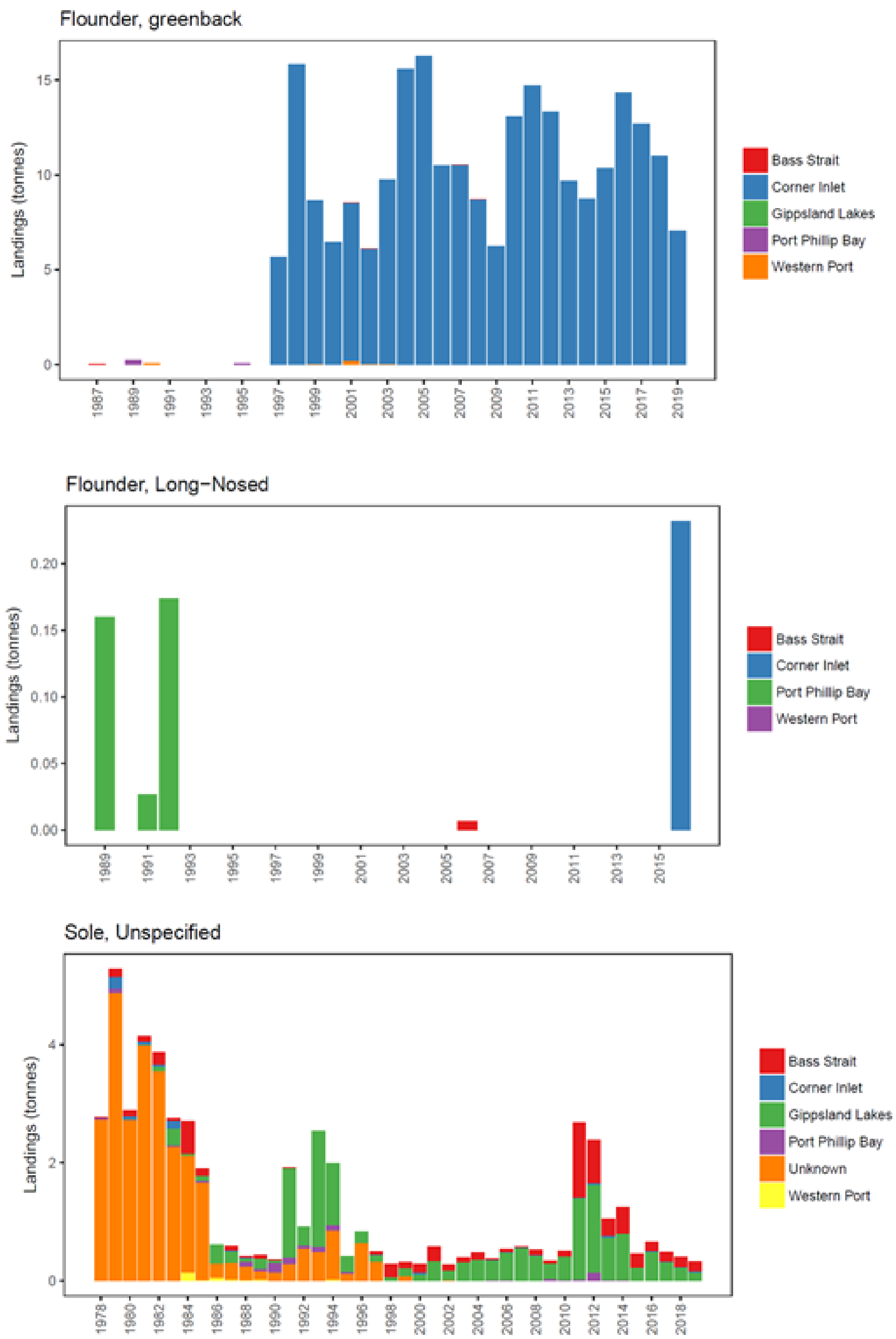


Figure 146. Catches of flounder and sole from reported commercial landings among Victorian bays and inlets.

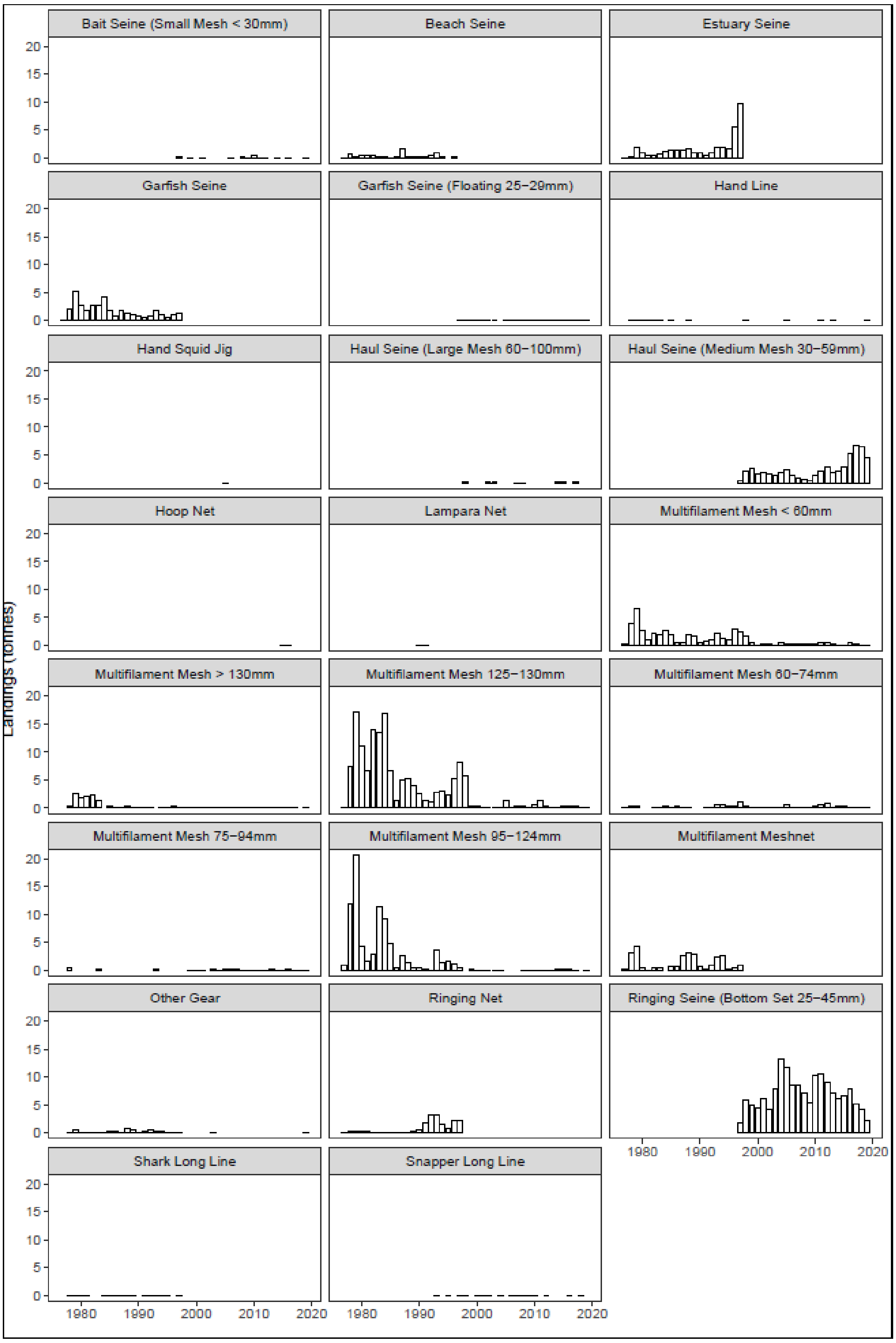


Figure 147. Catches of Greenback Flounder among gear types reported from Victoria during the past four decades.

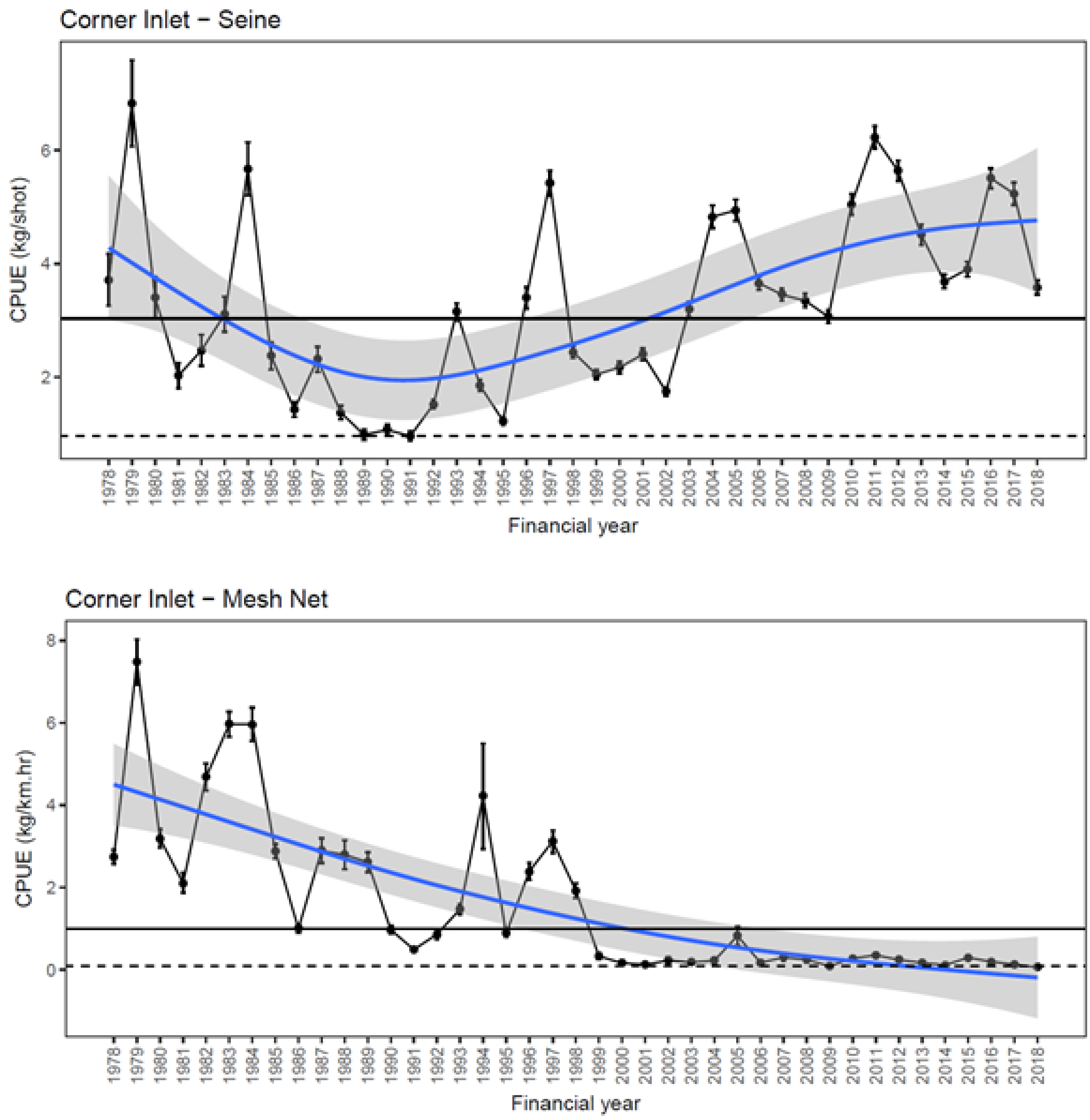


Figure 148. Catch-per-unit-effort (CPUE) for haul seine and mesh net catches from corner inlet during 1978/79 – 2018/19.

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Appendix 1 – Methods

Standardisation and GAMs

CPUE trends are notoriously noisy due to a variety of biological (e.g. migratory behaviour), environmental (e.g. river flows) and fishery related (e.g. changes in targeting or retaining species) factors. Previous assessments have smoothed CPUE trends by using three-year moving averages, that is, the average value of the current and two preceding years. While this technique is generally successful at smoothing trends, it also creates in a lag in the time series, which may result in a failure to respond to changing abundance in a timely fashion. As such, in the current assessment, generalised additive models were fit to the standardised (where available) or nominal CPUE time series using the default setting of the 'stat_smooth' function of the ggplot2 R package, which uses the functions within the mgcv R package. GAMs are particularly appropriate for smoothing noisy time series as the addition of additional parameters to the model (splines) is tested using Akaike's Information Criteria, which penalises each additional parameter meaning the model does not overfit the available data. As such, when the data are a particularly noisy, or when the first additional parameter does not improve the fit of the model, it will default to a simple linear model.

Appendix 2 – Effort in Victorian fisheries

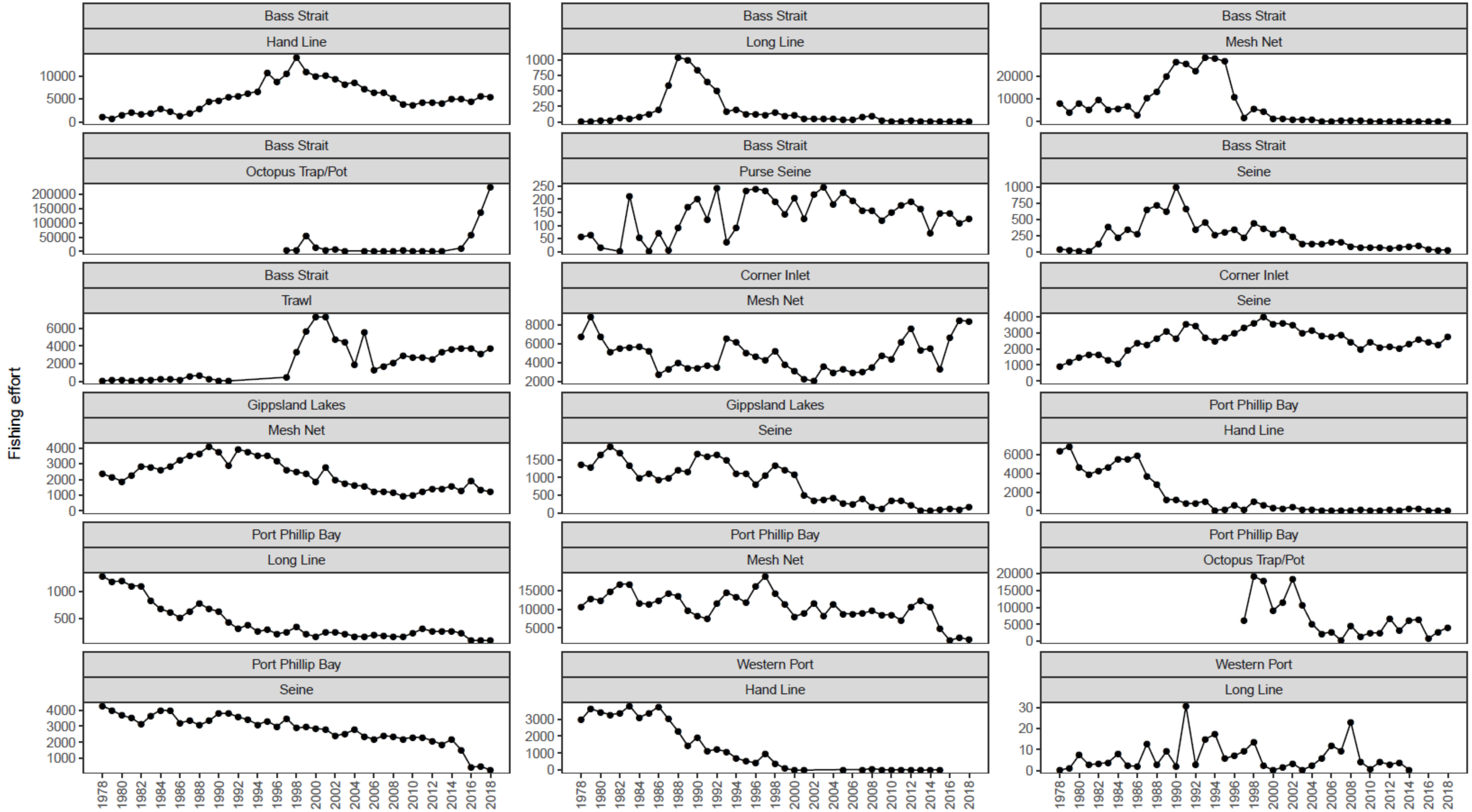

Figure A3.1: Commercial fishing effort by various gears in Victorian waters. Effort units are: hrs for handline and squid jig, ‘000 hooklifts for long line, km.hrs for mesh net and number of shots for seine and trawl.

Appendix 3 – Standardisation and filtering

Table: Details of the models fit to the available data (species X water body X gear). All models were fit using the default settings of the glmmTMB package in R. Model selection and implementation was undertaken following Giri and Gorfine (2018).

Species	Water body	Fishery	Filters	Model details	Response	Fixed effects	Random effects
Snapper (done seasonally)	Port Phillip Bay	Commercial longline	Month from October – March Snapper longline gear only >100 hooks & <600 hooks #shots 1 – 12 only	Model: GLMM. Error distribution: Gamma. Link: Log.	CPUE + 0.01	Financial year	Month + Area:FinancialYear + Fisher:FinancialYear
Snapper (done seasonally)	Port Phillip Bay and Western Port	Recreational creel	Month from October – March Targeting snapper. Fished > 0.5 hours. Number of fishermen >0. Number fishermen <20. Area != Bass Strait.	Model: GLMM Error distribution: Negative binomial. Link: Log. Offset: Log(angler hours).	Retained snapper per hour	Financial year	Avidity + Area + Area:FinancialYear
KGW	Port Phillip Bay and Western Port	Recreational creel	Targeting KGW. Fished > 0.5 hours. Number of fishermen >0. Number fishermen <20. Area != Bass Strait.	Model: GLMM. Error distribution: Negative binomial. Link: Log. Offset: Log(angler hours).	Retained KGW per hour	Financial year	Area + Season + Season:FinancialYear
Sand flathead	Port Phillip Bay and Western Port	Recreational creel	Targeting KGW. Fished > 0.5 hours. Number of fishermen >0. Number fishermen <20. Area != Bass Strait.	Model: GLMM. Error distribution: Negative binomial. Link: Log Offset: Log(angler hours).	Retained flathead per hour	Financial year	Targeting* + Avidity + Area + Area:FinancialYear + Season:FinancialYear
Black bream	Gippsland Lakes	Commercial mesh net	CPUE is catch/net length as soak time not recorded prior to 1998. Mesh size M3 and M4 only. Net length >100 m only	Model: GLMM. Error distribution: Gamma. Link: Log.	CPUE + 0.01	Financial year Inflow**	Fisher + Area + Month + MeshSize + Fisher:MeshSize
Black bream	Gippsland Lakes	Recreational creel	Month from July – November Targeting bream. Fished > 0.5 hours.	Model: GLMM Error distribution: Negative binomial. Link: Log. Offset: Log(angler hours).	Retained black bream	Calendar year Inflow**	Avidity + Year:Season
Wrasse	East/central/west wrasse management zones	Commercial	Fishers with <10 days effort Days of fishing with <5kg catch or <2/>10 hours of effort. 1998 onward only	Model: GLMM. Error distribution: Gamma. Link: Log.	CPUE + 0.01	Financial year	Area + Month + Area:FinancialYear + Month:Year + Fisher:FinancialYear
Commercial scallop	Port Phillip Bay	Commercial	Catch >10 kg, >30 minutes dive time	Model: GLMM. Error distribution: Gamma. Link: Log.	CPUE	Financial year	Fisher + Area + Month + Fisher:Area
Banded morwong	Eastern Victoria	Commercial	Catch > 0, Banded morwong licence only, live banded morwong only.	Model: GLMM. Error distribution: Gamma. Link: Log.	CPUE	Financial year	Fisher + Area + Month + Fisher:Area + Fisher:FinancialYear

[*]Anglers are asked whether they have two target species. In most instances, this indicates two separate fishing methods, however, for flathead, they are readily caught while targeting most other species. However, they are not caught as frequently as when they are the primary target species. Thus, ‘target species’ was included as a factor in the model to prevent filtering to primary target species only.
[**]Combined mean monthly river flow from the Tambo (station #223205), Mitchell (station #224203) and Nicholson (station #223204) Rivers (Source: http://data.water.vic.gov.au/).

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