Corner Inlet-Nooramunga Fishery Assessment 2016

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Executive summary

Fisheries Victoria conducts periodic assessments of the status of key fish species and the fisheries they support. These assessments compile relevant data from commercial fishery catch and effort reporting, recreational fishery monitoring programs, scientific surveys and other data, such as age and length composition, to support a 'weight of evidence' approach to assessing stock or fishery status. Formal assessment meetings are held to present and discuss the data with stakeholders. The information delivered through the stock and fishery assessment process is used by fisheries managers to consider the need for review of current management arrangements.

A formal assessment workshop on the Corner Inlet-Nooramunga fishery was conducted at Welshpool, Victoria on 22 April 2016. The assessment workshop was attended by recreational and commercial fishers; representatives of the commercial and recreational fishing sectors; Fisheries Victoria managers, scientists and compliance officers; external scientists, and natural resource and catchment management representatives. This assessment of the Corner Inlet-Nooramunga fishery relied largely on data collected from the commercial fishery, as there has been no assessment of recreational fishing there since 1995.

The Corner Inlet-Nooramunga fishery is a multi-species fishery. During 2014/15, the total commercial catch of all species was 263 tonnes, which was harvested primarily by haul seines (197 tonnes) and mesh nets (65 tonnes). The catch has decreased by 85 tonnes since 2011/12. Although the commercial catch has remained relatively stable since 1996/97, fishing effort (days) has decreased over the same period. The main target species of the fishery continue to be rock flathead and King George whiting, followed by calamari and southern sea garfish. While a variety of other species are also caught, and collectively make an important contribution to the fishery, these four species account for approximately 60% of the catch by weight.

The review of catch rate and length composition data indicated that the King George whiting fishery, while highly variable over time, is healthy. The recent summer period has seen a sharp rise in catch rates of King George whiting and local fishers have commented that the abundance of whiting is the best they have seen in many years. The spike in catch rates is consistent with what is being observed in Port Phillip Bay and appears related to high recruitment of small juveniles into Corner Inlet-Nooramunga in 2013 that have now grown into the fishery. Catch rates are expected to decline over the coming 1–2 years as these fish are caught and or leave the system to mature in coastal waters.

Rock flathead catch rates indicate the population within Corner Inlet-Nooramunga has declined since their most recent peak in 2009/10. The annual catch rate is at its lowest since the late 1990s. Seasonal catch rate variation is evident for mesh nets, with highest catch rates typically in spring/summer. Increased mesh net catch rates in spring/summer are thought to relate to targeting of spawning adults that become more vulnerable to mesh nets at that time. The most recent spring/summer spike in mesh net catch rates was not observed for haul seine methods, or the prior winter period, and is consistent with higher catchability of spawning fish rather than increased abundance.

In summary for the key target species in Corner Inlet-Nooramunga, the status is mixed. The King George whiting population is abundant and will support good catches over the coming year, however, the rock flathead population has seen a continual decline since 2010/11 and the ongoing trajectory of the rock flathead fishery is uncertain. Some workshop attendees believe that the targeting of rock flathead during the October–December spawning season is a risk to sustainability and recovery of the rock flathead fishery.

The status of other species is less certain because they are individually caught in lower volumes or not specifically targeted by commercial fishers. Calamari catch rates are typically highly variable in the system because of its short life-cycle. Recent year catch rates have been well above the long-term average. Gummy shark catch rates have declined markedly since the most recent peak in 2010/11 but appear to have stabilised in recent years at slightly below the long-term average. Garfish catch rates are highly variable, but have dropped to well below the long-term average in the recent year, and there is a declining trend in the five-year average catch rates since 2004/05. Catch rates for most of the other fin-fish species reported (i.e. Australian salmon, flounder, silver trevally, sand flathead and blue spotted flathead) are similar to or above their long-term averages in the recent year, with the exception of yellow-eye mullet where catch rates have decreased over the long-term, and despite a recent increase are still below the long-term average.

Issues raised by workshop attendees and through local knowledge surveys included: changes to fishery operators, gear configurations, effort levels and levels of adherence to local codes of practice; ongoing loss of seagrass, in particular the recent impacts of sea urchin grazing and uncertainty over the impacts of fire retardant chemicals used to fight fires.

Background

Overview of Corner Inlet-Nooramunga fishery

Corner Inlet-Nooramunga is a large, shallow embayment in eastern Victoria (Figure 1). The system is highly tidal with deep channels and large shallow banks that allow for the growth of seagrass (Fine leaf - *Zostera* and Broad leaf - *Posidonia*) which provides important habitat for various fish species including King George whiting, rock flathead and garfish. The Corner Inlet-Nooramunga Fishery area is defined by the Fisheries Regulations as:

> *The total area of all bays, inlets, entrances bounded by a line running south-westerly from the mean high water mark on the south-western end of the Ninety Mile Beach (McLoughlins Entrance) which follows the mean high water mark along the outer or seaward shoreline of the Nooramunga Islands that enclose Shoal or Shallow Inlet, crossing the entrances at McLoughlins Beach, Manns Beach, Kate Kearney Entrance and Port Albert with a straight line between the mean high water marks on the seaward extremities on each side of each entrance, continuing along the mean high water mark on the outer seaward shoreline of Snake Island to the navigation light on Bentley Point then in a straight line to the mean high water mark on the most northern point of Entrance Point on Wilson's Promontory* (Figure 2).

The 1,550-hectare Corner Inlet Marine National Park, within which all methods of fishing are prohibited, is located to the north and east of Wilsons Promontory National Park (within fishing area 1, Figure 2) adjacent to the southern shores of Corner Inlet-Nooramunga.

Corner Inlet-Nooramunga is an internationally recognised Ramsar wetland supporting a rich diversity of plants and animals as well as the important commercial and recreational fisheries. In 1995/96, there were 33 commercial access licences for the Corner Inlet-Nooramunga fishery. Voluntary licence buy-backs in 1999/00 and 2005/06 reduced the number of licences to 18 and it has been capped at this number since.

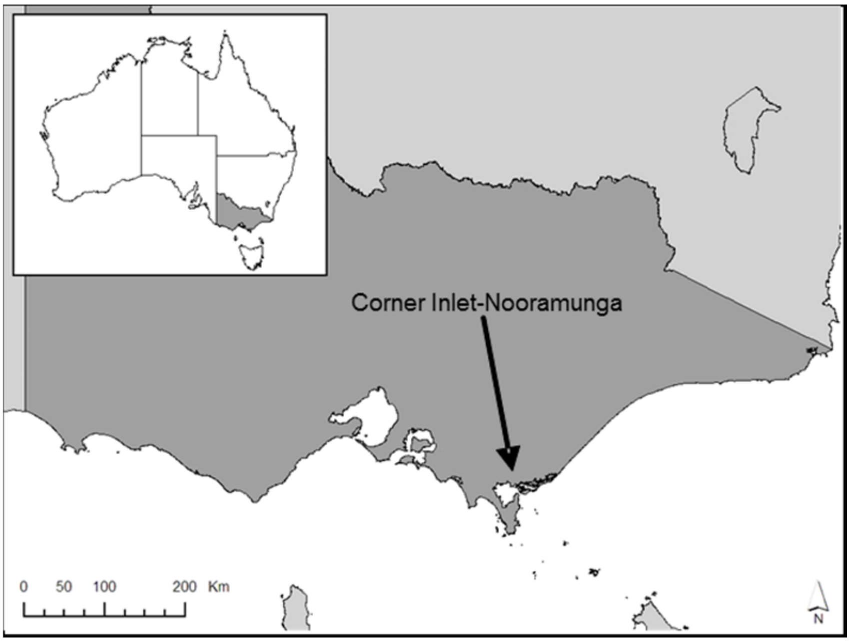

Figure 1. Map of Victoria showing the location of Corner Inlet-Nooramunga.

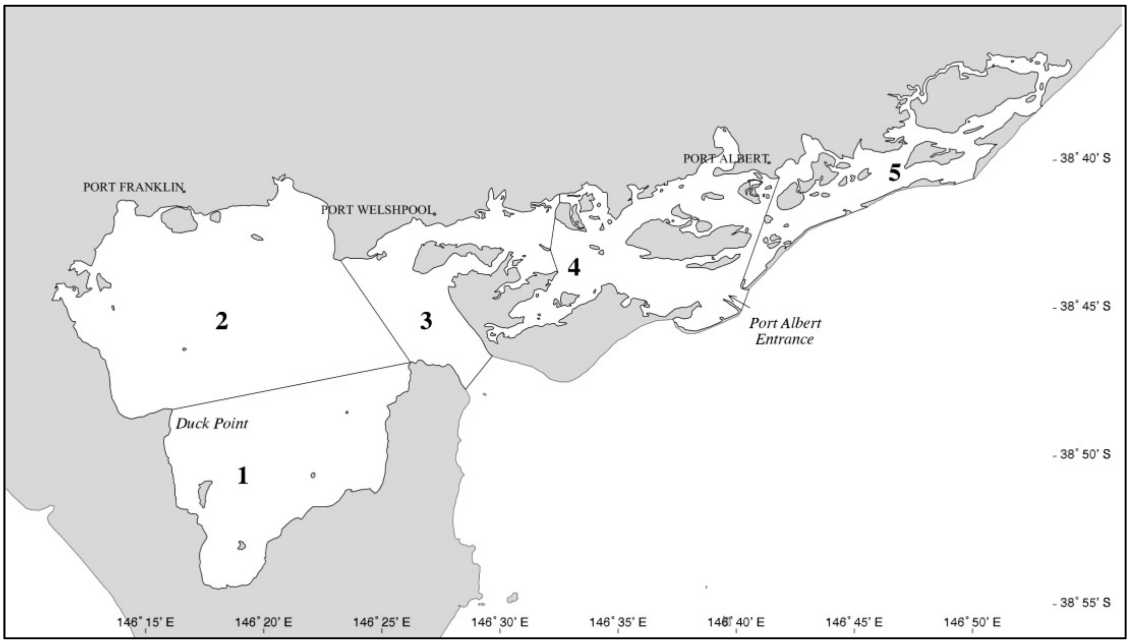

Figure 2. Map of Corner Inlet-Nooramunga showing the five commercial fishing reporting areas.

Commercial fishery

The Corner Inlet-Nooramunga fishery is managed using the a range of input controls: limits on the number of licences, limits on gear type (listed under fishing methods above), spatial and temporal closures (including a weekend closure to minimise conflict with recreational fishers) and legal size limits for individual species.

Corner Inlet Fishery Access Licence holders are limited to using the following gear:

- a seine net of no greater than 650 m in length;
- a mesh net of no greater than 1,300 m if fishing alone or 1,650 m if fishing with assistance;
- up to 20 hoop nets;
- a longline or combination of longlines with no more than 400 hooks attached;
- up to six fishing lines that are not longlines with no more than three hooks or one bait jig each; and
- up to two hand operated bait pumps.

Licences are renewable annually subject to the licence holder being fit and proper and are fully transferable. Conditions of the Corner Inlet Fishery Access Licence are outlined in the *Fisheries Regulations 2009* (available online at: http://www.legislation.vic.gov.au/). Corner Inlet Fishery Access Licence holders must not use commercial fishing equipment between midnight on Friday and 5PM the following Sunday and are governed by gear and size limit restrictions (refer to Fisheries Regulations, Table 1).

Some Corner Inlet-Nooramunga commercial fishers are signatories to the *Victorian Bays and Inlets Fisheries Association Environmental Management System* (2013 (available online at: http://siv.com.au/) and operate in accordance with agreed environmental management and fishing. Further, most of the Corner Inlet-Nooramunga commercial fishers follow the Corner Inlet Fisheries Habitat Association (CIFA) local code of practise that stipulates:

- seine net shots are limited to no more than two per day (from midnight to midnight);
- shots must be shot and closed up within ninety minutes; and
- operators cannot work both sides of the line known as the Middle Ground in any one day.

Commercial fishers predominantly use haul seines or mesh (gill) nets to catch a variety of species in Corner Inlet-Nooramunga. Haul seines harvest the majority of the commercial catch (71%), followed by mesh nets (29%). Over the past decade, there has been a decline in haul seine effort while mesh net effort has increased.

Species caught by commercial haul seines and mesh nets include:

- King George whiting (*Sillaginodes punctatus*)
- Rock flathead (*Platycephalus laevigatus*)
- Australian salmon (*Arripis trutta*)
- Flounder (*Rhombosolea spp*)
- Gummy shark (*Mustelus antarcticus*)
- Silver trevally (*Pseudocaranx spp*)
- Southern calamari (*Sepioteuthis australis*)
- Southern sea garfish (*Hyporhamphus melanochir*)
- Sand flathead (*Platycephalus bassensis*)
- Yellow-eye mullet (*Aldrichetta forsteri*)
- Blue spotted flathead (*Platycephalus speculator)*
- Snapper (*Chrysophrys auratus*)

Information of the life-history and stock structure of key species is included in Appendices1 and 2.

Recreational fishery

The most common species retained by recreational fishers in Corner Inlet-Nooramunga are sand and blue spotted (yank) flathead, King George whiting, Australian salmon, silver trevally, calamari and snapper (Conron and Coutin 1995). Recent data on recreational fishing trends and targeting preferences is lacking, but recreational effort in the system is thought to be increasing (Kemp *et al.* 2013a). There is no ongoing monitoring of recreational fishing activities or catches in Corner Inlet-Nooramunga.

Recreational fishers must hold a recreational fishing licence in order to fish in Corner Inlet-Nooramunga, or anywhere else in the State, unless they are exempt from the requirement and are regulated by legal minimum lengths, gear restrictions and bag/possession limits (Table 1).

Table 1. Legal minimum size limits for key species and associated recreational bag limits.

Species	**Minimum legal length for both commercial and recreational (centimetres)** ***Total length unless specified***	**Recreational bag/possession limit**
King George whiting	27	20
Rock flathead, sand flathead, blue spotted (yank) flathead	27	20
Garfish	No minimum length	40
Snapper	28	10, of which no more than 3 can be equal to or exceed 40 cm
Silver trevally	20	20
Australian salmon	21	20
Flounder	23	20
Yellow eye mullet	No minimum length	40
Gummy shark	45 (partial length)	2
Southern Calamari	No minimum length	10

Corner Inlet-Nooramunga fisheries assessment 2016

A formal assessment workshop for the Corner Inlet-Nooramunga fishery was conducted at Welshpool, Victoria on 22 April 2016. The assessment workshop was attended by:

- recreational and commercial fishers;
- representatives of the commercial and recreational fishing sectors including Seafood Industry Victoria and the Victorian Recreational Peak Fishing Body — VRFish;
- Fisheries Victoria managers, scientists and compliance officers;
- an external scientist; and
- natural resource and catchment management representatives including Parks Victoria and West Gippsland Catchment Management Authority.

The most recent Corner Inlet-Nooramunga Fishery Assessment prior to this was in 2012 (Kemp *et al*. 2013a) which coincided with the most recent rock flathead assessment (Kemp *et al*. 2013b).

Fishery assessment process

Stock and fisheries assessments are designed primarily to provide information on the status of fish stocks and their associated fisheries in Victoria's bays and inlets. They contribute towards assessing biological sustainability objectives and the performance of management arrangements in achieving these.

Fisheries Victoria has developed a process to conduct periodic formal assessments of the status of key marine and estuarine finfish stocks and the fisheries they support.

The assessment activities include:

- The synthesis of all relevant fisheries dependent data;
- Evaluation of fisheries-independent monitoring and research data;
- Convening a workshop for scientists, resource users and resource managers to assess and discuss the status of the stock/fishery in question; and
- Production of an assessment report that provides scientific information to support fishery management decision making.

The assessment process provides:

- Scientific evidence on the status of the fish stocks and harvest pressures on those stocks;
- Opportunity to draw on the knowledge of stakeholder groups;
- Information to underpin evidence-based decisions in an ecologically sustainable development management context;
- Information that complements Victorian fisheries management planning processes; and
- An accountable and transparent fishery assessment process.

The assessment process for the Corner Inlet-Nooramunga fishery used a 'weight-of-evidence' approach that assessed available fishery-dependent commercial data, and other data including size and age composition; and fishery-independent data that included local fishing knowledge surveys. This report is structured to provide an overview of the main outcomes of the assessment in the "Status of Corner Inlet-Nooramunga fishery indicators 2016" section including. The assessment data is summarised in tables of key performance indicators. Time series of the data are then included as figures. Other supporting information is included in appendices.

Fishery status classifications

A qualitative classification framework has been developed as an indicative summary of status for individual indicators (Table 2). This classification approach provides an assessment of the recent status of individual indicators (primarily catch rate time series, or other abundance proxies) relative to the long-term averages. The classifications readily identify the condition of fishery and stock performance indicators, and in particular highlight areas of concern from a management and fishery performance perspective.

Table 2. Qualitative classification ratings and descriptions applied to individual fishery status indicators.

Indicator status classification	Description
Above average	The indicator is ≥ 20% higher than the long-term average.
Average	The indicator is within 20% of the long-term average.
Below average	The indicator is ≤ 20% lower than the long-term average.
Limited Data	A limited amount of information has been collected, or, the available data is inappropriate/insufficient to confidently assess stock/fishery status, or, there are inconsistent or contradictory signals in the data that preclude determination of stock/fishery status.
	Red flags identify specific concerns/issues or uncertainties regarding an indicator's status.
* Long-term refers to the duration of the time-series.	

The primary indicators used to determine fishery status are catch rates from either the haul seine or mesh net method but other indicators also contributed to the weight of evidence approach. Although mesh nets and haul seines are used to catch most species in the Corner Inlet-Nooramunga fishery, the gear type used to take the highest proportion of the catch for each species was the primary gear type used for calculating the catch rate indicators. The dominant gear type for each species was determined by calculating the proportion of catch for the previous ten years for each gear (haul seine and mesh net) by species (Table 3).

Table 3. Proportion (percentage) of fish caught for each species by weight by gear types from 2005 to 2015. Bold numbers indicate the fishing method that caught the greatest proportion of each species' catch.

Species	Mesh net	Haul seine	Species	Mesh net	Haul seine
Australian salmon	8	**92**	Southern sea garfish	2	**98**
Flounder	10	**90**	Blue spotted flathead	**55**	45
Gummy shark	**84**	15	Rock flathead	**77**	23
King George whiting	11	**89**	Southern sand flathead	30	**70**
Silver trevally	3	**97**	Snapper	13	**78**
Southern calamari	2	**98**	Yellow-eye mullet	49	**51**

Fisheries assessment data sources

Fisheries Victoria uses the monthly returns provided by commercial licence holders to obtain information on catch, species composition, effort, fishing date, fishing area and gear including type, net length, soak time and number of shots. This assessment relied on commercial fishery data, as there were no diary anglers or creel surveys that focussed on Corner Inlet-Nooramunga.

Sources of data used to inform the assessments varied among species (Table 4). Raw data was subject to quality checks to identify anomalous records and records with missing effort data (for commercial methods). Catch rate data for the key species; King George whiting and rock flathead was assessed using raw and standardised data. The method used for catch rate standardisation is summarised below and in detail in Appendix 3.

Table 4. Summary of data used for the 2016 Corner Inlet-Nooramunga fisheries assessment.

Data Category	Fishery	Data type	Fishing methods	Species	Time series	Data treatment
Fishery dependent	Commercial	Catch	All methods	King George whiting Rock flathead Australian salmon Flounder Gummy shark Silver trevally Southern calamari Southern sea garfish Southern sand flathead Yellow-eye mullet Blue spotted flathead Snapper	1978/79–2014/15	Raw
		Effort	All methods (days/year)	All effort	1978/79–2014/15	Raw
		Effort	Haul seine (shots/year) Mesh net (Km hrs/year)	All effort	1998/99–2014/15	Raw by fishing area
		Catch rate (catch per unit effort, CPUE)	Haul seine (Kg/shot)	King George whiting Rock flathead Australian salmon Flounder Southern sea garfish Southern sand flathead Yellow-eye mullet Snapper	1979/80–2014/15	Raw (all) Standardised (rock flathead and King George whiting only) Annual (all) Long-term average (all) Five-year moving average (all)
		(Catch per unit effort)	Mesh net (Kg/Km hrs)	King George whiting Rock flathead Gummy shark Blue spotted flathead		
		Length frequency	Haul seine	King George whiting	2010/11–2015/16	Weighted frequency
				Rock flathead	2011/12, 2015/16	
			Mesh net	Rock flathead	2010/11, 2015/16	Weighted frequency
		Age at length		Rock flathead	2015	By sex
		Age distribution (Haul seine and mesh net)		Rock flathead	2015/16	Combined sex
	Recreational	None available				Most recent recreational data is reported by Conron and Coutin (1995)

Selection of catch rate data for rock flathead and King George whiting

Representative assessment of the commercial catch per unit effort (CPUE) also referred to as ‘catch rate’, for individual species in a multi-species fishery like Corner Inlet-Nooramunga is a challenge. Fishers do not provide targeted effort data (e.g. effort applied to targeting particular species), and therefore effort can erroneously be attributed to catches of a particular species when the fishers are operating in areas or in ways in which they have lower likelihood of encountering or catching that species. Ultimately, this can lead to misleading interpretation of catch rate data.

Two approaches were used to select data for inclusion for estimating catch rates of rock flathead and King George whiting prior to applying standardisation of the catch rate data (discussed below).

<u>Rock flathead:</u>

- Selecting only trip records (i.e. daily records of catches for each gear type and fishing area) of mesh net types M1, M2, M3 and MM, as these mesh net types caught 95.4% of rock flathead in Corner Inlet-Nooramunga (M4 and M5 mesh nets types were excluded as these larger mesh sizes are more likely to catch larger species such as gummy shark).
- Using logistic sub-setting of trip records based on the probability of rock flathead being caught in particular records.

In logistic sub-setting, a statistical approach is used to identify trip records where the species composition of the catch indicates that rock flathead has a high probability of being present in the catch, irrespective of whether it was actually present or not. This has the effect of removing records where rock flathead were unlikely to have been captured. See Appendix 3 for a more detailed description of the logistic sub-setting method.

For rock flathead logistic sub-setting retained 13,875 or 58% of all mesh net records. Selection of gear types M1, M2, M3 and MM retained 15,943 or 67% of all mesh net records.

<u>King George whiting</u>

- All haul seine records were retained as King George whiting catch was spread more uniformly across haul seine types.
- Using logistic sub-setting of trip records based on the probability of King George whiting being caught in particular records.

Logistic sub-setting retained 55,700 or 99.9% of haul seine records as almost all haul seine records had a high probability of King George whiting catch.

These analyses supported the use of logistical sub-setting for rock flathead mesh net records and found that it was not required for King George whiting haul seine records.

Standardisation of CPUE data

CPUE (catch per unit effort, or ‘catch rate’) based on commercial catch and effort data is an integral part of stock assessments. Raw (nominal) CPUE may lead, however, to misleading indicators of relative abundance because it can be influenced by factors that are not related to abundance such as: fishing area, season, fisher experience skill, gear used and gear efficiency. Standardisation uses statistical procedures to remove the influence of these factors on catch rate data so that they are more proportional to stock abundance and less influenced by these external factors (Gavaris 1980; Maunder and Punt 2004; Shono 2008). For the assessment of rock flathead and King George whiting catch rates were standardised for financial year, fishing area, month of fishing, operator number (as a surrogate for fishers’ fishing skills), gear type and interactions between gear type and operator as random effects. The statistical procedures used for standardisation are explained in more detail in Appendix 3.

Integrated local knowledge

The local knowledge survey for the 2016 assessment is focussed on the commercial fishery as there was only one respondent to the survey questionnaire for the recreational sector. Six active Corner Inlet-Nooramunga commercial fishers responded to a standard set of questions and provided further commentary on their perceptions of the status of individual fishery species in Corner Inlet-Nooramunga and factors influencing catches and abundance.

Status of Corner Inlet-Nooramunga fishery indicators 2016

Commercial catch and effort

During 2014/15, the total commercial catch of all species for the Corner Inlet-Nooramunga fishery was 263 tonnes, harvested primarily by haul seines (197 tonnes) and mesh nets (65 tonnes) (Figure 3). The catch has decreased by 85 tonnes since 2011/12, and catches in 2013/14 and 2014/15 were the lowest since 2002/03. Since 1979/80, the fishery has been dominated by haul seine and mesh net methods (Figure 4). Although the commercial catch has remained relatively stable since 1996/97, fishing effort (days) has decreased over the same period to approximately 2,000 fisher days/year in 2014/15 (Figures 3 and 4).

Haul seines harvest the majority of King George whiting (89%), southern sea garfish (98%), calamari (98%), silver trevally (97%), Australian salmon (92%) and flounder (all species) (90%); whereas mesh nets harvest the majority of rock flathead (77%) and gummy shark (84%) (Table 3).

During 2014/15, commercial fishing effort was largely dominated by haul seines (1,461 days, approximately 75% of all fisher days) (Figure 4). The greatest amount of haul seine effort (shots) was applied to areas 2, 1, 4, 3 and 5 in decreasing order of effort (Figure 5). Since 2009/10 haul seine effort (shots) has increased most in area 2, has decreased in area 5 and been relatively stable in the other areas. Similarly, for mesh netting, area 2 received most effort in 2014/15 (Figure 6). From 2011/12, mesh net effort has increased in areas 2, 3, 4 and 5, but has decreased dramatically in area 1 (Figure 6). Over the last two years the mesh net effort in area 2 has decreased but remains higher than it was in 2011/12 (Figure 6).

Rock flathead constituted 18% (by weight), King George whiting (17%), calamari (11%), southern sea garfish (9%), silver trevally (6%), yellow-eye mullet (5%), skates and rays (5%), Australian salmon (4%) and snapper (0.1%) of the total commercial catch (Figure 7). The proportion of species caught varied between fishing zones with area 1 and area 2 contributing to the majority of fish caught for most species, with the exception of silver trevally (which had higher catches in area 4 than area 2), southern calamari (which had similar proportions of catch from areas 1, 2 and 3) and Australian salmon (which had similar proportions of catch from all areas) (Figure 8).

King George whiting

The fluctuation in haul seine catch rates for King George whiting (Figure 9) is consistent with the biology of this species. King George whiting recruit into Corner Inlet-Nooramunga as small juveniles derived from coastal spawning areas, reach the legal size (27 cm, total length, TL) at about 2 years of age and then most leave the system by 3–4 years of age to complete their life in coastal waters (Appendix 1). This life-cycle means that strong pulses of new recruitment into the system provide high catch rates for 1–2 years and the fishery can vary significantly over short-time scales (i.e. 2–3 years) depending on the overlap and frequency of these strong juvenile recruitment events.

While this fishery is naturally variable, catch rates have remained stationary around the long-term average since 1978/79 (Figure 9). In 2014/15, the average haul seine catch rate across all areas was just below the long-term average and the five-year average has tracked close to the long-term average since 2006/07 (Figure 9**,** Table 5). Standardised and nominal catch rates are very similar indicating that variation among fishers and other external influence on catch rates are minimal and similar over time (Figure 9). Historical peak catch rates have been in; 1986/87–89/90, 1991/92, 1996/97, and more recently in 2003/04, 2006/07–07/08 and 2011/12, the early peak catch rates were higher than the more recent peaks (Figure 9).

The annual time series of catch rates for each season tend to be consistent and match closely with annual aggregated data, with the exception of 2003/04 when the spring and winter seasons did not peak similar to the summer and autumn (Figure 10). Summer has consistently been the best season for maximising haul seine catch rates of King George whiting (Figure 10). Catch rates (kg/shot) by season have generally remained below 40 kg/shot since 1998/99, with the exception of the most recent summer (2015/16) when catch rates increased dramatically to around 60 kg/shot (Figure 10). This recent summer peak in King George whiting catch rates is confirmed by the fisher survey responses that indicated King George whiting catches over the past summer/autumn are the best they have been in many years (see *Integrated Knowledge*).

From 2010/11 to 2014/15, the length frequency distribution of King George whiting caught using haul seine nets exhibited a bimodal distribution with modes at about 27–28 cm and 34–35 cm fork length (Figure 11). This is consistent with the presence of two adjacent age classes of fish in the fishery at any one year (as discussed above). However, in

2015/16 the distribution is quite different with a broader spread of sizes from 27–30 cm and low proportions of fish in the 34–35 cm range. It should be noted that the length frequency data for the 2015/16 season represent an incomplete year, with the last length data included being from January 2016. As King George whiting grow rapidly over the summer/autumn months, the full year of length data may show a slightly different distribution but this will need to be confirmed when the full data set is obtained.

Overall, the catch rate data for King George whiting are satisfactory and consistent with historical variation. The high catch rates in the most recent summer (2015/16), and supporting information from fisher surveys suggest that King George whiting are currently very abundant in Corner Inlet-Nooramunga and that the fishery will be strong over the coming year until these fish move out to ocean waters.

Rock flathead

Catch rates of rock flathead for both the haul seine and mesh net methods increased from 1978/79 through to the late-1980s (Figures 12–15). Since the early-1990s, the long-term catch rate trend stabilised, but variation at the 1–3 year time scale has been high (Figures 12–15). For mesh nets, the peak periods for rock flathead catch rates occurred from 1989/90–1993/94 and then for three shorter periods: 2000/01–2002/03, 2004/05–2006/07 and, most recently, between 2008/09–2011/12 (Figures 12 and 13). The annual catch rates (both nominal and standardised) by mesh net have declined continually since 2009/10 (Figures 12 and 13).

Peaks in haul seine catch rates occurred in 1993/94, 2001/02–2002/03 and recently from 2009/10–2011/12 (Figure 15). The most recent peak in 2009/10 was consistent for both haul seine and mesh nets, as is the recent decline in catch rate since 2009/10. The most recent year of the haul seine catch rate is close to the long-term average, but the five-year average remains above the long-term average due to the influence of the high catch rates from 2009/10–2011/12 (Figure 15).

Standardisation of mesh net catch rate data retained by either the logistic sub-setting or selected gear (M1, M2, M3) approach produced very similar results (Figure 14). Since 1999/2000, the effect of standardisation has been to reduce the estimated catch rates from the nominal, but the patterns of variation remain similar between the standardised and nominal data (Figures 12 and 13). Importantly, the recent decline is consistent between the standardised and nominal catch rate data, which is consistent with the catch rate decline being related to changes in abundance or availability of rock flathead. The recent five-year average standardised mesh net catch rates are close to the long-term average, however, the 2014/15 catch rates have dropped to more than 20% lower than the long-term average (Figures 12 and 13).

Mesh net catch rates are generally greatest during spring and summer (Figure 16), but for haul seines, apart from autumn in 2010/11 and 2011/12, there is no clear seasonal variation in catch rates (Figure 17). In the most recent spring/summer (2015/16) a major increase in mesh net catch rates occurred (Figure 16). If the recent spring/summer increase in mesh net catch rate was due to an increased abundance of rock flathead in Corner Inlet-Nooramunga an increase in the haul seine catch rate would also be expected; but this did not occur (Figure 17). Further, the mesh net catch rates in the prior winter remained low and consistent with the declining trend (Figure 16). The most likely explanation for the increase in spring/summer catch rate for 2015/16 is therefore increased catchability rather than a rapid increase in abundance. Increased catchability during the spawning season may relate to aggregative behaviour or increased movement during spawning making rock flathead more vulnerable to mesh nets.

Length frequency distributions of haul seine catches showed a stable spread of the lengths across time from 27–55 cm total length and modes at about 30 cm (Figure 18). The proportion of fish ≥40 cm total length was variable above 20% until 2015/16 when it dropped to 15% (Table 7). The drop in 2015/16 may be related to either an increase in the proportion of smaller fish in the population, or a decrease in the proportion of larger fish — the decline in catch rates suggests the latter is more likely.

For the mesh net method, only two years of length frequency data were available: 2011/12 and 2015/16 (Figure 19). The 2011/12 length distribution had a higher mode at 39 cm than for the 2015/16 distribution at 35 cm. Further, while the spread of the distributions is similar (maximum sizes around 56–58 cm, Table 7), there were notably more fish above 40 cm in the 2011/12 year (Figure 19, Table 7).

Differences in growth rates are evident between male and female rock flathead with males growing slower and reaching smaller maximum lengths than females (Figure 20). The age frequency distributions for fish captured by both methods extended to 11–12 years of age (Figures 21 and 22). Fish caught by haul seine were dominated by 2 and 3-year-old fish (Figure 22) whereas those caught by mesh net were dominated by fish of 3 years of age (Figure 21).

Overall the catch rate and length frequency data for rock flathead indicate a declining population in Corner Inlet-Nooramunga since 2009/10. Annual catch rates are at their lowest since the late 1990s. While the five-year average catch rates are satisfactory in comparison to the long-term average, the recent 6-year period of decline is notable.

Seasonal catch rate spikes in spring/summer are thought to relate to targeting of spawning adults that become more vulnerable to mesh nets at that time.

Australian salmon

Haul seine catch rates of Australian salmon have shown a long-term increasing trend since the late 1980s (Figure 23).The recent five-year moving average is now more than 20% above the long-term average, although catch rates have been highly variable over the last 5 years.

Flounder

Haul seine catch rates of flounder have shown an increasing trend since the early 1990s, but have been highly variable over time with peaks in 1978/79, 1984/85, 1997/98, 2004/05 and 2011/12 (Figure 24). The most recent peak was in 2011/12, and catch rates have declined since to be just above the long-term average. The recent five-year average catch rate is well above the long-term average, despite the decline over the last 3 years.

Gummy shark

Gummy sharks are primarily caught by mesh nets. Mesh net catch rates for both the 'all' (combined sizes) mesh net data and the larger mesh net data (M5) show a long-term increasing trend up until 2009/10, but show a subsequent decrease to 2013/14 (Figure 25 and 26). In 2014/15, the catch rate seems to have stabilised at, or just below, the long-term average (Figures 25 and 26).

Silver trevally

Catch rates of silver trevally by haul seine have shown a long-term increasing trend since 1979/80, but with high variability (Figure 27). Peaks in catch rates occurred in 1989/90, 2001/02 and 2008/09 (Figure 27). The catch rate in 2014/15 was similar to the long-term average.

Southern calamari

Haul seine catch rates of southern calamari have shown a long-term increasing trend since 1978/79, with a notable jump from 1997/98 (Figure 28). The annual catch rates have been highly variable since then, reflecting the short-lived nature of calamari (Appendix 1). The catch rate increased in 2014/15, and after a lower period from 2010/11–2013/14, was well above the long-term average.

Southern sea garfish

Haul seine catch rates of southern sea garfish declined from 1979/90 to an historical low in 1996/97, however, over the past 10 years the catch rates appear to have stabilised, with variation around the long-term average (Figure 29). The most recent year of data indicates a significant drop in catch rate from the previous two years. The low abundance of garfish in the recent year was commented on by commercial fishers in the surveys and workshop, and the future trajectory is uncertain. While the five-year average catch rate is still within 20% of the long-term average, it is trending downwards (Figure 29).

Southern sand flathead

Southern sand flathead catch rates by haul seine have varied at levels below the long-term average since 1998/99, but have displayed an increasing trend since 2006/07 (Figure 30). The recent five-year average catch rate is now just within 20% of the long-term average, although the annual data have shown a declining trend since 2011/12 (Figure 30).

Yellow-eye mullet

Haul seine catch rates of yellow-eye mullet continually declined from 1979/80 until 2002/03 after which they stabilised at low levels until 2010/11 (Figure 31). They then increased from 2010/11 until 2013/14, but in 2014/15 they decreased again to be below the long-term average (Figure 31). The five-year average catch rate is still well below 20% of the long-term average.

Blue spotted (yank) flathead

Since 1998/99 mesh net catch rates of blue spotted flathead have increased, with the five-year average in 2014/15 being well above the long-term average. Peak catch rates occurred in 2009/10, however, since then, catch rates have declined and the current annual catch rate is similar to the long-term average (Figure 32).

Snapper

Haul seine catch rates of snapper are typically very low in Corner Inlet-Nooramunga and occasional peaks reflect sporadic juvenile recruitment catch events (Figure 33). The method catches smaller fish of 3–4 years of age and the peaks in 1992/93, 2008/09 and 2012/13 would indicate peaks in local spawning success 3–4 years prior (snapper spawn in coastal waters adjacent to Corner Inlet-Nooramunga, Appendix 1).

Integrated local knowledge

The follow section summarises the perceptions of the commercial fishers for their main target species and the fishery in general.

King George whiting

Four of the six commercial fishers who responded to the survey questions indicated that the abundance of legal size King George whiting had increased over the last year, with two suggesting that the abundance was similar. The fishers who indicated that abundance had increased commented that abundance/catches of King George whiting were the best in many years, some saying the best in 20 or 25 years. One fisher commented that large numbers of small King George whiting were observed in autumn 2015 that had now recruited to fishery and were over 30 cm length. *(Note: these fish would most likely have been derived from spawning in winter 2013; a similarly strong cohort is currently being caught in the Port Phillip Bay fishery, also derived from the 2013 spawning season)*. The same fishers were, however, inconsistent in their perceptions on the abundance of undersize King George whiting; one said they had decreased, two said they had increased and two said they were similar; the sixth fisher used mesh nets that did not catch undersize King George whiting. Half of the fishers suggested the size of the King George whiting they were catching had increased over the last five years and the other half said that sizes were similar. The two fishers that targeted whiting in the Port Albert and Manns Beach areas (Areas 4 and 5) were consistent in their view that the size of King George whiting in these areas was the largest in many years. The status of King George whiting was rated as ‘good’ at the present time.

Rock flathead

Fishers who fished the western part of Corner Inlet-Nooramunga (areas 1, 2 and 3) indicated rock flathead abundance had declined in that region over the last five-years, but fishers fishing the eastern area near Port Albert/Manns Beach (Areas 4 and 5) suggested that the legal size rock flathead abundance had been similar over the last five years and that the numbers of juveniles (undersize) had increased. Apart from one fisher, who primarily targeted rock flathead in the most eastern region (Area 5), the status of rock flathead was considered to be deteriorating. There were concerns over the longer-term status of rock flathead in the face of seagrass losses in the western fishing areas, including unprecedented and unchecked urchin grazing of seagrass. Changes to fishing behaviour including longer mesh net soak times due to fewer issues with crabs (crabs depend on the seagrass also), and increased targeted mesh netting effort during the spawning period (when rock flathead move more and become more vulnerable to meshing) were perceived as risks to sustainability.

Fishers conveyed various theories about rock flathead movement behaviour within the Corner Inlet-Nooramunga system and between it and the adjacent ocean waters. Rock flathead movement behaviour and how movement behaviour may influence catch rates (and associated perceptions of population status) is poorly understood. Also, the source of juvenile recruitment into Corner Inlet-Nooramunga is uncertain, and it is unknown if significant juvenile recruitment is occurring. Further research on rock flathead movement and the development of a survey approach to monitor juvenile recruitment would be valued by the local industry.

Other species

The surveys focussed on the main target species, which for all the surveyed fishers were either King George whiting or rock flathead. Comments on other species included that garfish abundance had declined, silver trevally abundance was improving and that catches of gummy shark were increased last year.

Overall fishery condition

Five of six commercial fishers indicated that overall, they were satisfied with the status of the Corner Inlet-Nooramunga fishery and one was unsatisfied (largely due to concerns regarding seagrass loss and the potential for increased effort in Corner Inlet-Nooramunga after the Port Phillip Bay commercial netting buy-out).

Other issues

All fishers were concerned about ongoing loss of seagrass, particularly in the Corner Inlet basin (areas 1 and 2). The growing impact of urchin grazing on seagrass was raised and fishers were concerned that Government agencies were not undertaking any research to investigate this issue. The impact of fire retardant chemicals on seagrass was also raised as an issue requiring investigation. Changes to seine net gear, particularly the use of heavier foot-line weights, was mentioned as having a potential impact on seagrass. Targeting of rock flathead during the October–December spawning season was considered by some to be a risk to the sustainability of the rock flathead fishery and its recovery and needs to be considered by industry and management. Concerns about changes to fishery operators, effort levels and levels of adherence to 'local codes of practice' as new fishers enter the fishery were also raised.

Fishery indicator summary tables and classifications

Table 5. Fishery status determinations using catch rate indicators for key species of the Corner Inlet–Nooramunga fishery: *Haul seine method.*

Species	King George whiting	Rock flathead	Australian salmon	Flounder (unspecified)	Silver trevally
Indicator	Commercial haul seine catch rate (kg/shot) (Figure 9)	Commercial haul seine catch rate (kg/shot) (Figure 15)	Commercial haul seine catch rate (kg/shot) (Figure 23)	Commercial haul seine catch rate (kg/shot) (Figure 24)	Commercial haul seine catch rate (kg/shot) (Figure 27)
Minimum	8.9	0.52	0.9	0.96	1.3
Maximum	44.7	18.20	13.1	6.83	23.0
Long-term average ± 20%	20.2 ± 4.0 (standardised)	7.68 ± 1.5	4.33 ± 0.9	3.13 ± 0.63	7.99 ± 1.6
Recent year five-year average	18.33 (standardised)	9.71	9.1	4.99	7.59
Most recent year	16.46	6.94	6.3	3.65	6.77
Trend in five-year moving average over last five years	Variable	Decreasing	Stable	Increasing	Decreasing
Number of years below long-term average over last five years	5	0	0	0	1
Status (5-year average)	**Average**	**Above average**	**Above average**	**Above average**	**Average**
Notes	Standardised catch rates remain within 20% of long-term average. Catch rates are expected to increase based on recent seasonal catch rate data for summer 2015/16 (Figure 10)	Annual catch rates are declining although the five-year average is still within 20% of the long-term average. Red flag is for the sustained decline since 2009/10 and uncertain future trajectory.	Catches have increased over the long-term and the five-year average is well above the long-term average.	The five-year average shows an increasing trend however, the annual catch rate has decreased in last three years, but is still above the long-term average.	Catch rates are within 20% of the long-term average however have decreased over the last five years.

Table 5 Continued. Fishery status determination using catch rate indicators for key species of the Corner Inlet-Nooramunga fishery: *Haul seine method.*

Species	Southern calamari	Southern sea garfish	Sand flathead	Yellow-eye mullet	Snapper
Indicator	Commercial haul seine catch rate (kg/shot) (Figure 28)	Commercial haul seine catch rate (kg/shot) (Figure 29)	Commercial haul seine catch rate (kg/shot) (Figure 30	Commercial haul seine catch rate (kg/shot) (Figure 31)	Commercial haul seine catch rate (kg/shot) (Figure 33)
Minimum	0.12	6.13	0.69	1.66	0
Maximum	14.3	33.8	4.04	17.91	2.36
Long-term average ± 20%	5.35 ± 1.1	19.15 ± 3.8	1.89 ± 0.37	6.49 ± 1.29	0.23 ± 0.04
Recent year five-year average	1.56	15.73	1.56	3.8	0.31
Most recent year	1.45	11.26	1.45	4.11	0.06
Trend in five-year moving average over last five years	Decreasing	Stable/Decreasing	Increasing	Increasing	Decreasing
Number of years below long-term average over last five years	0	5	5	5	0
Status (5-year average)	**Above average**	**Average**	**Average**	**Below average**	**NA**
Notes	Catch rates have increased since 1979/80 and are above the long-term average.	Catch rates have varied around the long-term average since the late 1990s. Red flag reflects concerns about the recent major drop in catch rate. The annual catch rate for 2014/15 is well below the long-term average.	Annual catch rates have decreased in recent years. The five-year average is only just within the 20% range below the long-term average.	Catch rates have been relatively stable over the past 12 years with increasing catch rates in the past 5 years, but still below the long-term average. In addition, although the annual catch rate in 2013/14 was at the long-term average, it has dropped again in 2014/15.	Catch rates are generally very low and highly variable. Catch rates are thus largely uninformative of population status. Snapper is not an important species within this fishery.

Table 6. Fishery status determinations using catch rate indicators for key species of the Corner Inlet-Nooramunga fishery: *Mesh net method*.

Species	Rock flathead	Rock flathead	Gummy shark	Gummy shark	Blue spotted flathead
Indicator	**Standardised** Commercial mesh net catch rate (kg/shot) Gear M1, M2, M3. (Figure 12)	**Standardised** Commercial mesh net catch rate (kg/shot) logistic sub-setting (Figure 13)	Commercial mesh net catch rate (kg/km hr) M5 (125–130 mm). (Figure 25)	Commercial mesh net catch rate (kg/km hr) for all nets. (Figure 26)	Commercial mesh net catch rate (kg/km hr) (Figure 32)
Minimum	0.93	1.76	5.2	0.16	0.17
Maximum	21.55	23.57	21.95	4.34	2.00
Long-term average ± 20%	7.84 ± 1.57	8.73 ± 1.74	13.26 ± 2.6	1.72 ± 0.34	0.90 ± 0.18
Recent year five-year average	7.84	9.03	13.8	2.32	1.29
Most recent year	8.01	8.01	10.4	1.68	0.87
Trend in five-year moving average over last five years	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing
Number of years below long-term average over last five years	1	0	0	0	0
Status (5-year average)	**Average**	**Average**	**Average**	**Above average**	**Above average**
Notes	Catch rates remain above the long-term trend; however have been decreasing continually since 2009/10. The future trajectory is uncertain for this key species.	Catch rates remain above the long-term trend; however have been decreasing continually since 2009/10. The future trajectory is uncertain for this key species.	Catch rates have shown a major decline since 2010/11, but have stabilised in recent years.	Catch rates have shown a major decline since 2010/11, but have stabilised in recent years.	Catch rates have declined since 2009/10, and have stabilised at the long-term average in recent years.

Table 7. Summary of length-frequency and age distributions of King George whiting and rock flathead commercial catches in Corner Inlet-Nooramunga.

Descriptor	King George whiting	Rock flathead	
Indicator	Haul seine, fork length frequency distribution from 2010/11–2015/16 (Figure 11).	Haul seine net, total length frequency distribution from 2010/11–2015/16 (Figure 18). Ageing	Mesh net, total length frequency. 2011/12, 2015/16 (Figure 19)
Minimum	26	27	30
Maximum	42	58	56
Mode (most recent year)	27 cm	28	35
Proportion of retained catch	≥35 cm	≥40 cm	≥40 cm
2010/11	19%	27%	46%
2011/12	23%	23%	N/A
2012/13	31%	21%	N/A
2013/14	9%	29%	N/A
2014/15	14%	26%	N/A
2015/16	4%	15%	5%
Notes	A bimodal frequency distribution was observed from 2010/11 to 2014/15 however, the number of larger fish (≥35 cm FL) was low in 2015/16.	Since 2010/11 the majority of fish caught were around 30 cm TL. The number ≥40 cm was variable until 2015/16, when the lowest proportion of larger fish was recorded.	Few fish ≥40 cm were observed in the 2015/16 distribution.
Von Bertalanffy growth parameters (Haul seine only)		**Male**	**Female**
L_∞ (cm)	N/A	38	44
k	N/A	0.48	0.41

Fishery indicator figures

Commercial catch and effort summary

Combined species

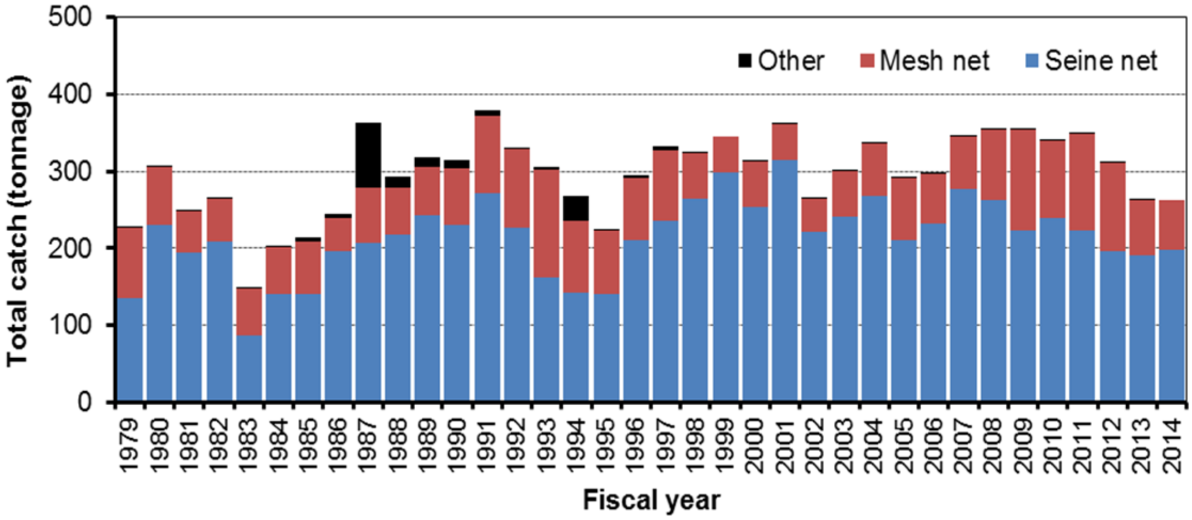

Figure 3. Commercial catch (tonnes) by combined fishing methods used to harvest finfish species in Corner Inlet-Nooramunga from 1979 to 2014 (fiscal year).

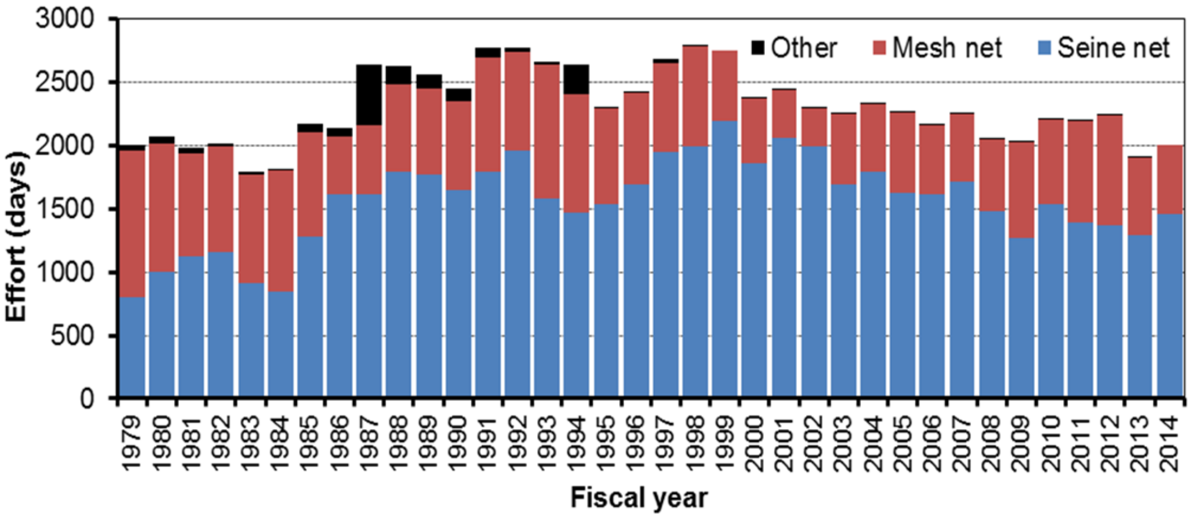

Figure 4. Commercial fishing effort (days) by main fishing methods used to harvest finfish species in Corner Inlet-Nooramunga from 1979 to 2014 (fiscal year).

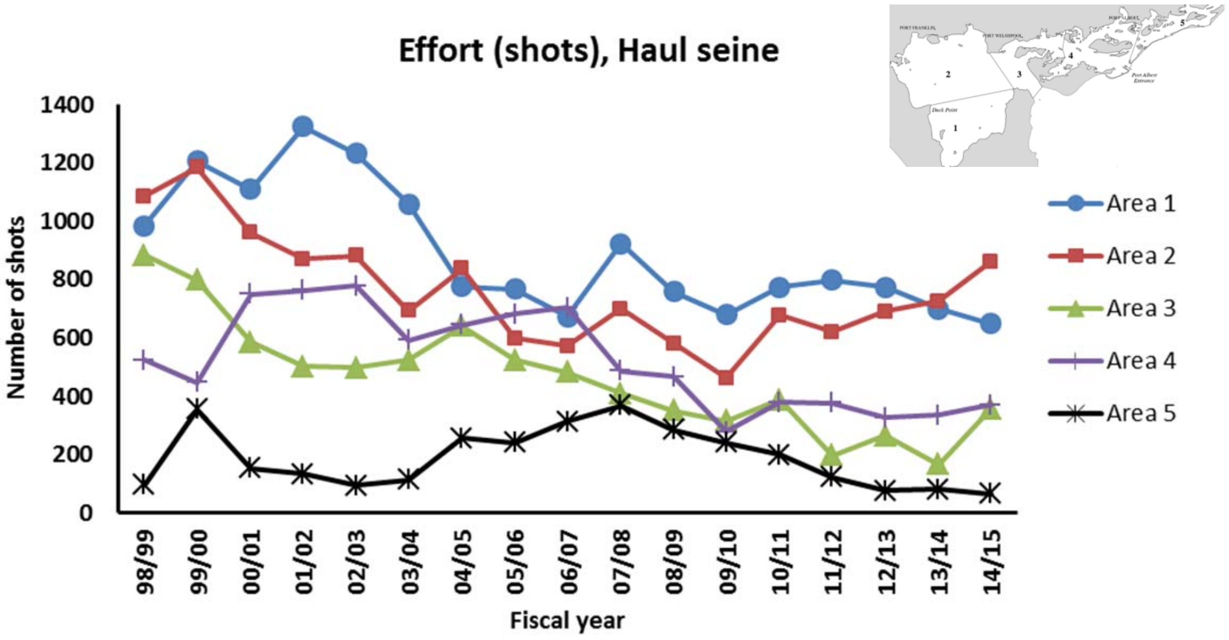

Figure 5. Commercial fishing effort (number of shots/year) for haul seines by fishing area in Corner Inlet-Nooramunga from 1998/99 to 2014/15.

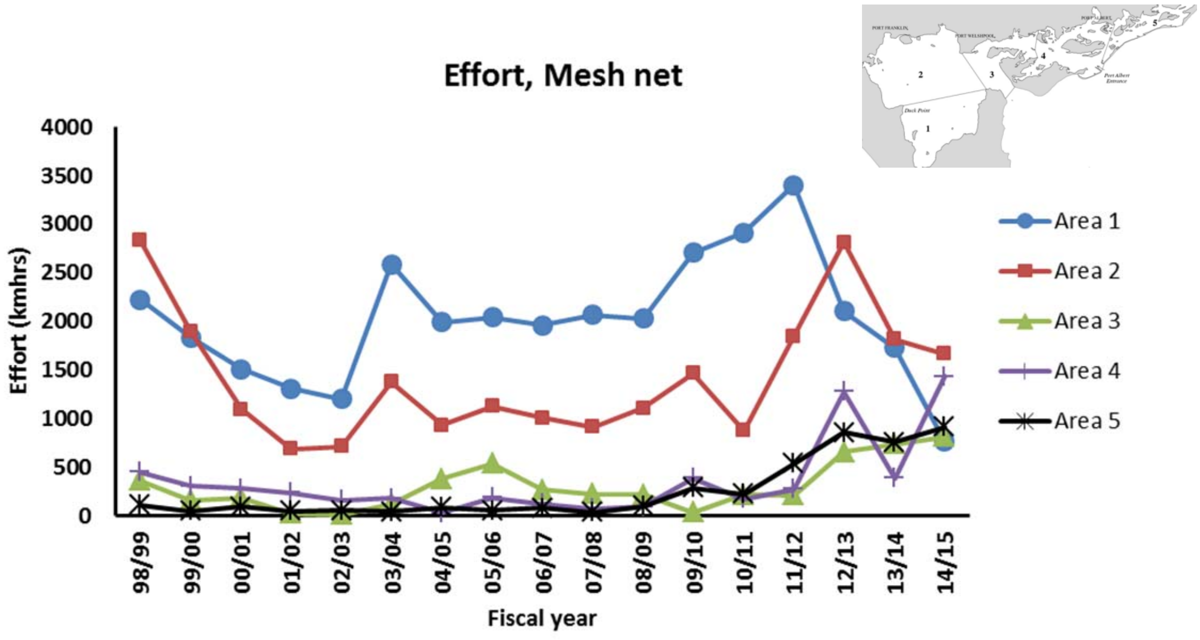

Figure 6. Commercial fishing effort (km hr/year) for mesh nets in Corner Inlet-Nooramunga from 1998/99 to 2014/15.

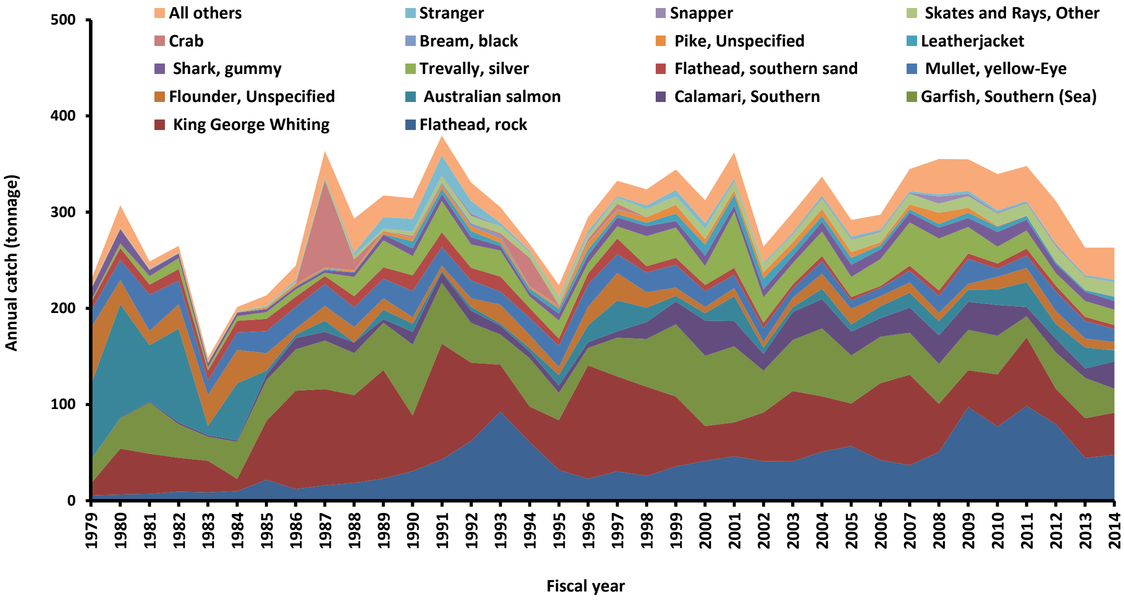

Figure 7. Trends in annual commercial harvest (tonnes) of finfish species of the Corner Inlet-Nooramunga fishery from 1979 to 2014 (fiscal year).

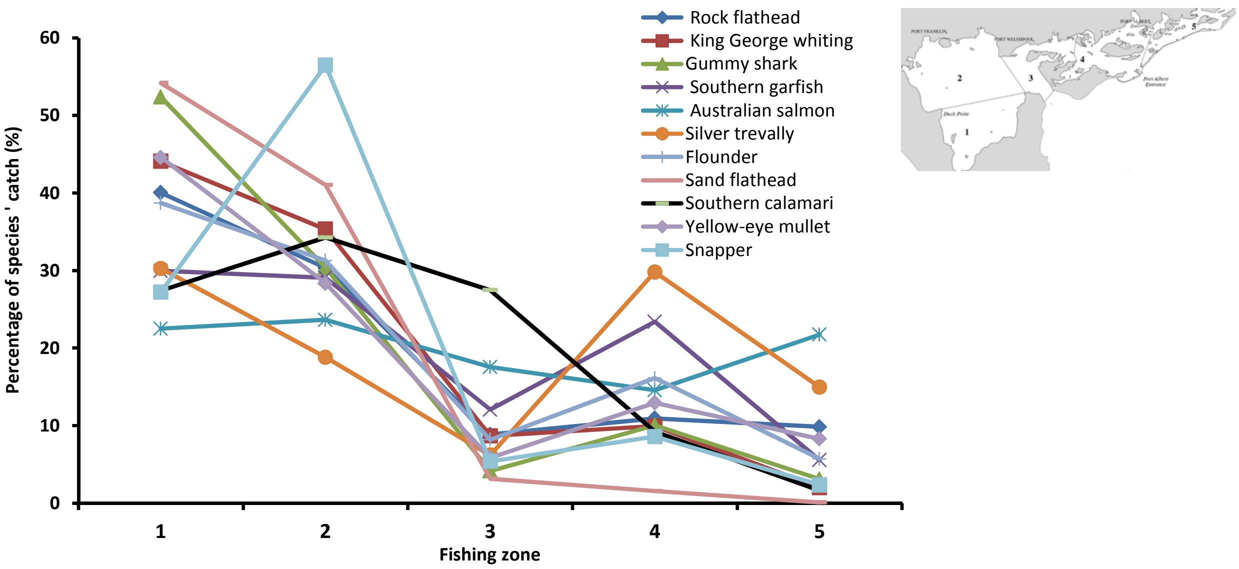

Figure 8. The proportion of key species' harvested from each fishing area in Corner Inlet-Nooramunga. Combined catch data from 2010/11 to 2015/16.

Catch rate, length and age information by species

King George whiting

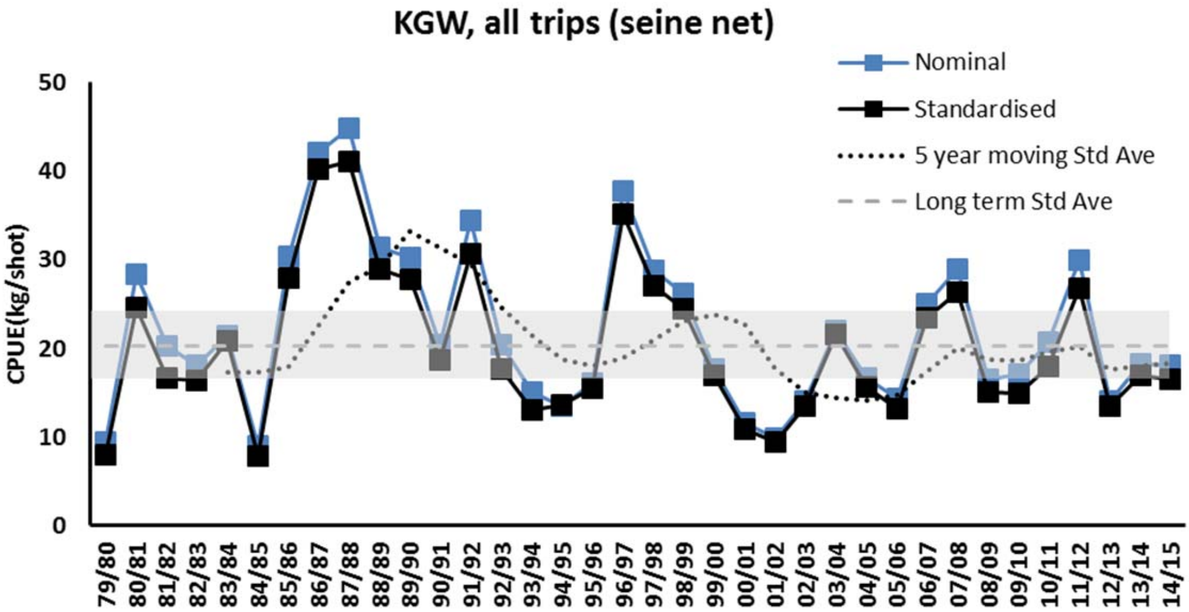

Figure 9. Annual catch rate (CPUE) (kg/shot) of King George whiting caught in Corner Inlet-Nooramunga by haul seine from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term standardised CPUE. The five-year moving average is for standardised CPUE data.

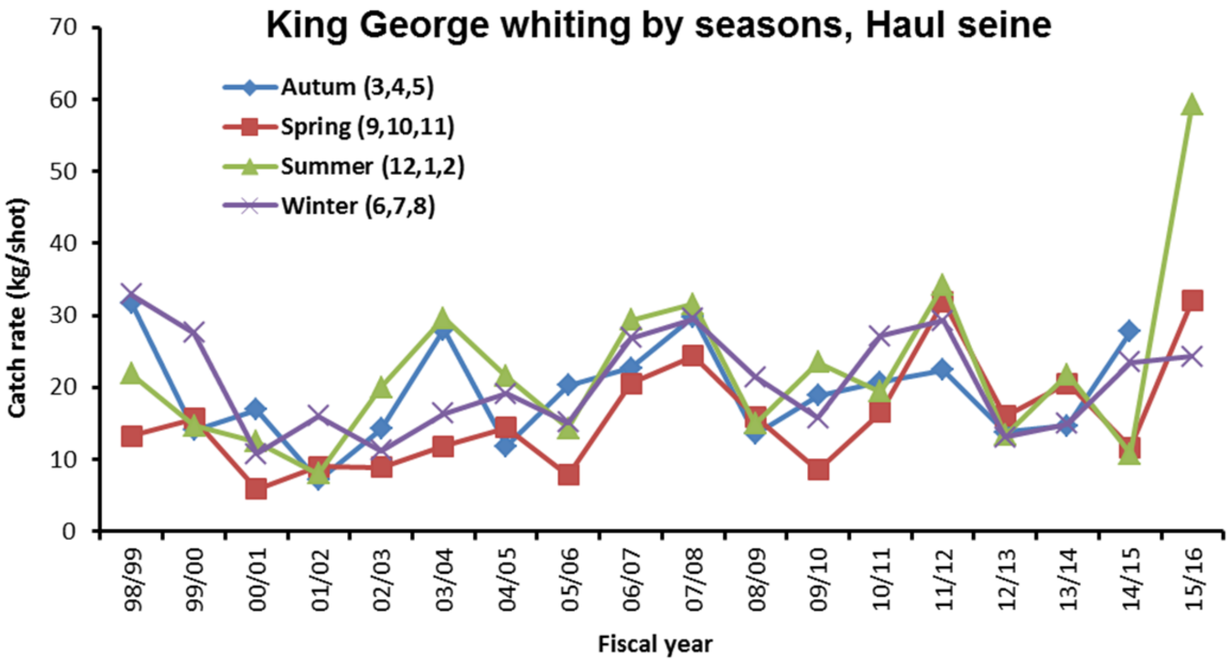

Figure 10 Seasonal catch rate (kg/shot) of King George whiting caught in Corner Inlet-Nooramunga by haul seine from 1998/99 to 2015/16.

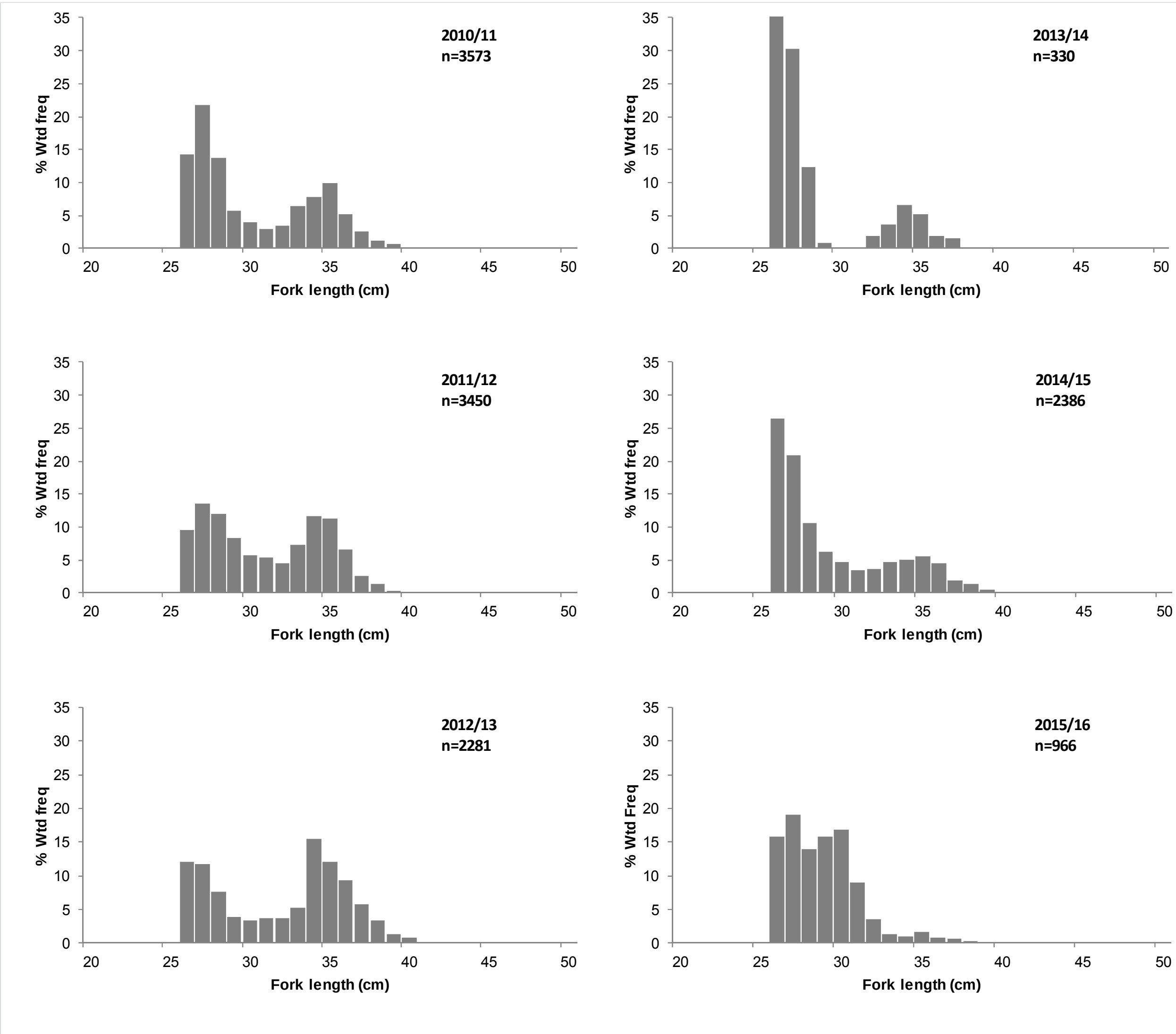

Figure 11. Weighted length frequency distributions of King George whiting caught in Corner Inlet-Nooramunga by haul seines from 2010/11 to 2015/16. Note: 2015/16 is an incomplete year, see summary discussion on pages 9–10.

Rock flathead

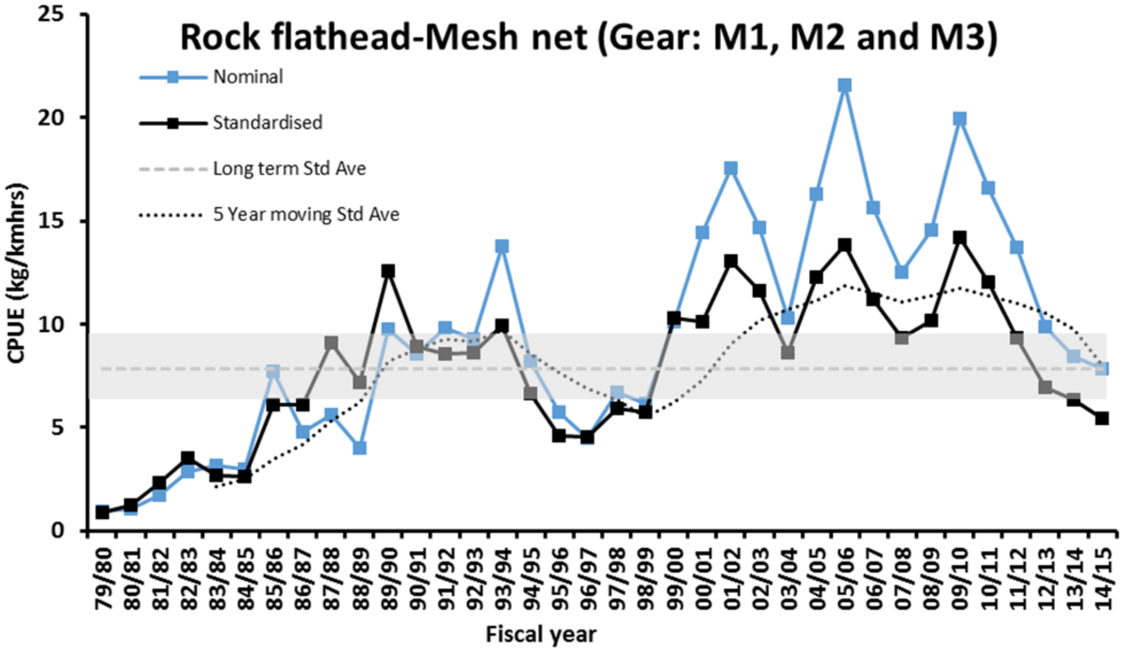

Figure 12. Annual and standardised catch rate (CPUE) (kg/km hr) of rock flathead caught in Corner Inlet-Nooramunga by mesh net (M1, M2, M3) from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term standardised CPUE. The five-year moving average is for standardised CPUE data.

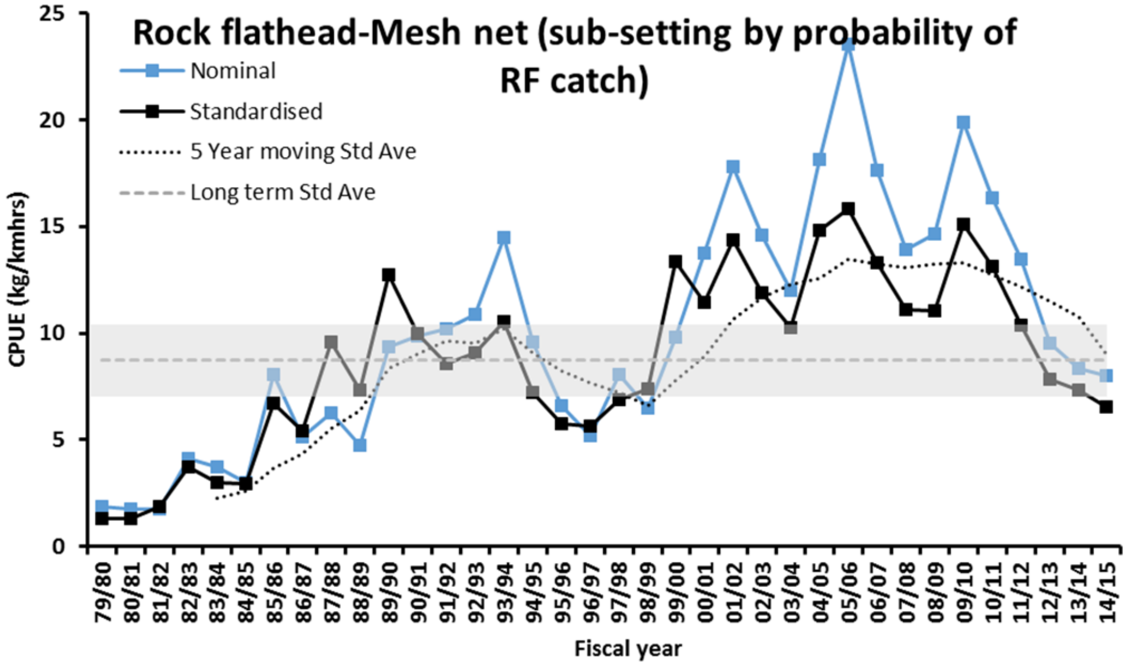

Figure 13. Annual and standardised catch rate (CPUE) (kg/km hr) of rock flathead caught in Corner Inlet-Nooramunga using logistic sub-setting of species caught using mesh nets from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term standardised CPUE. The five-year moving average is for standardised CPUE data.

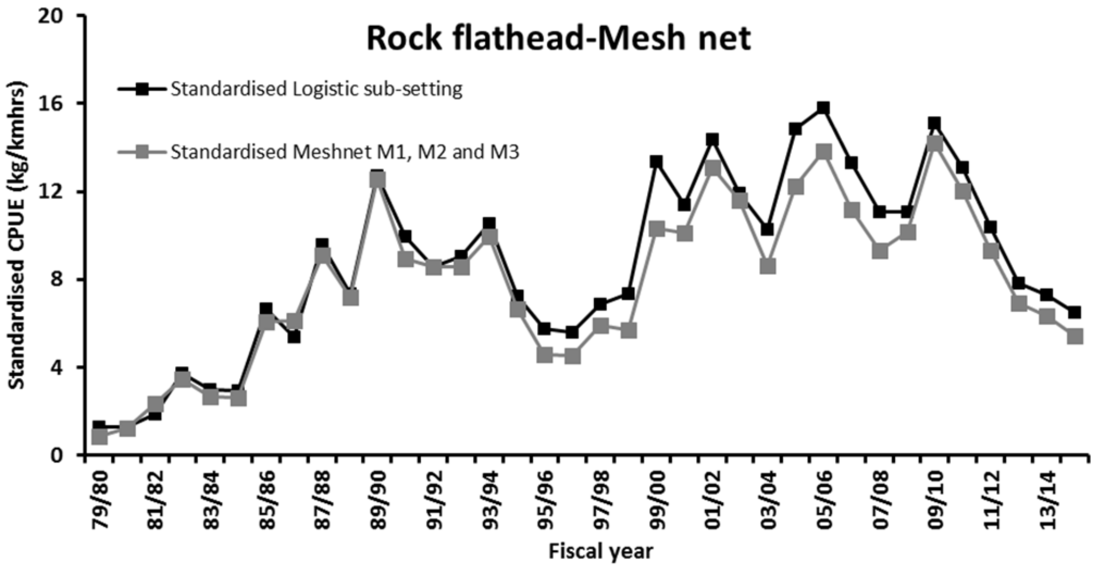

Figure 14. Standardised CPUE for the M1, M2, M3 mesh net gear sizes and logistic sub-setting data selection approaches for rock flathead caught in Corner Inlet-Nooramunga by mesh net from 1979/80 to 2014/15.

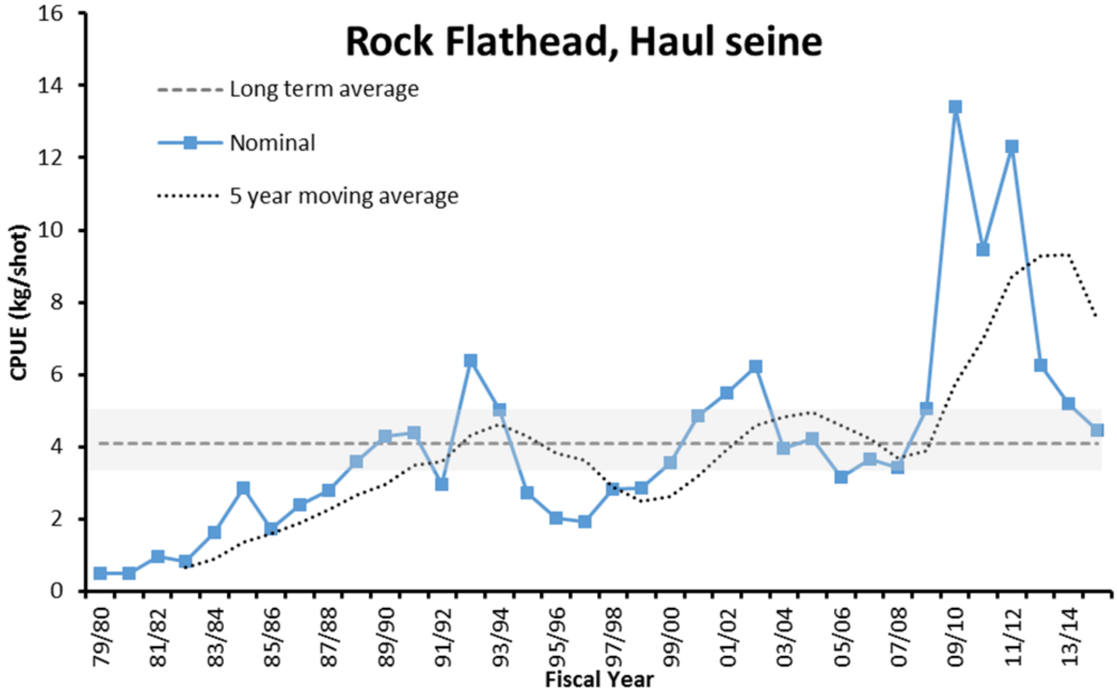

Figure 15. Annual catch rate (CPUE) (kg/shot) of rock flathead caught in Corner Inlet-Nooramunga by haul seine from 1978/79 to 2014/15. Greyed region indicates +/- 20% of the long-term CPUE.

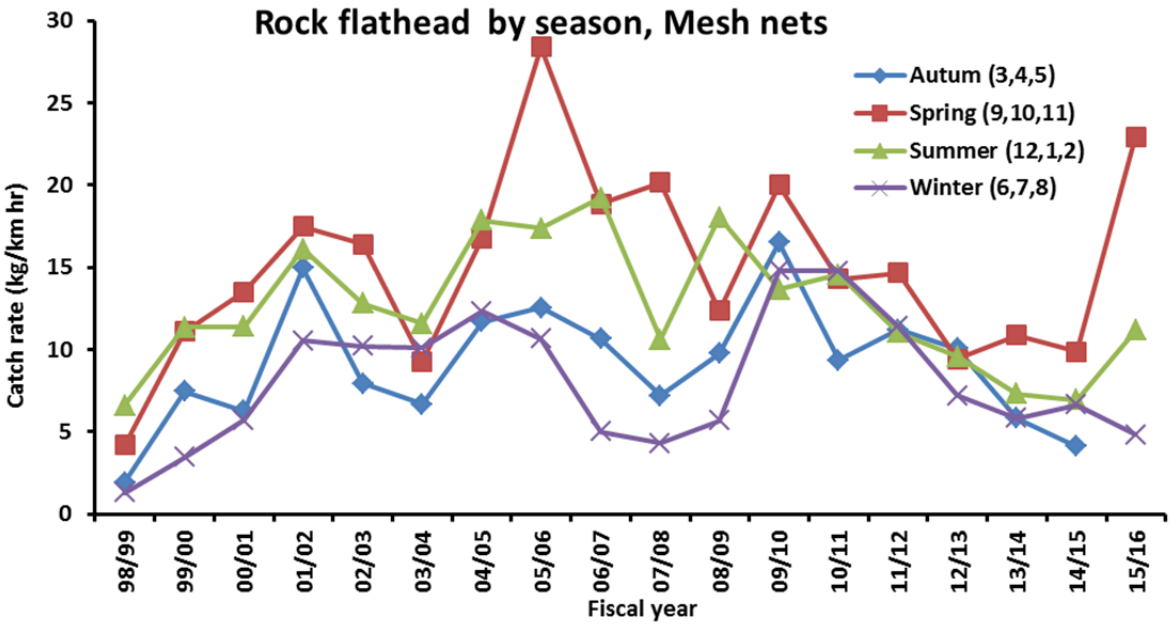

Figure 16. Seasonal catch rates (kg/km hr) of rock flathead caught in Corner Inlet-Nooramunga by mesh nets from 1998/99 to 2015/16.

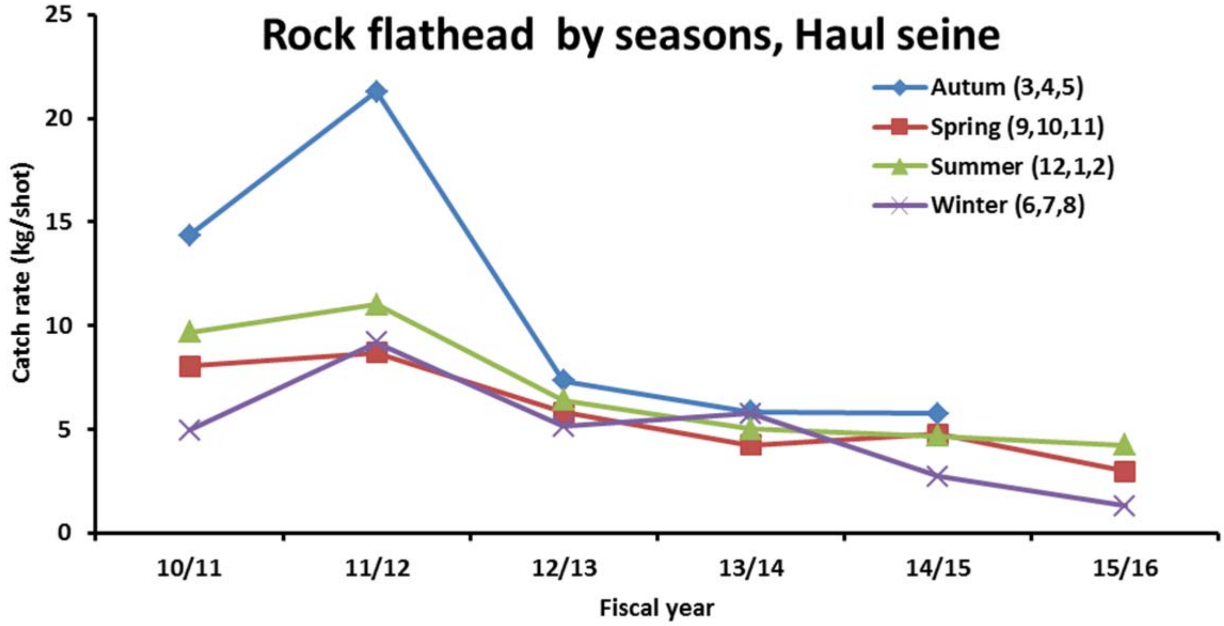

Figure 17. Seasonal catch rates (kg/shot) of rock flathead caught in Corner Inlet-Nooramunga by haul seine from 2010/11 to 2015/16.

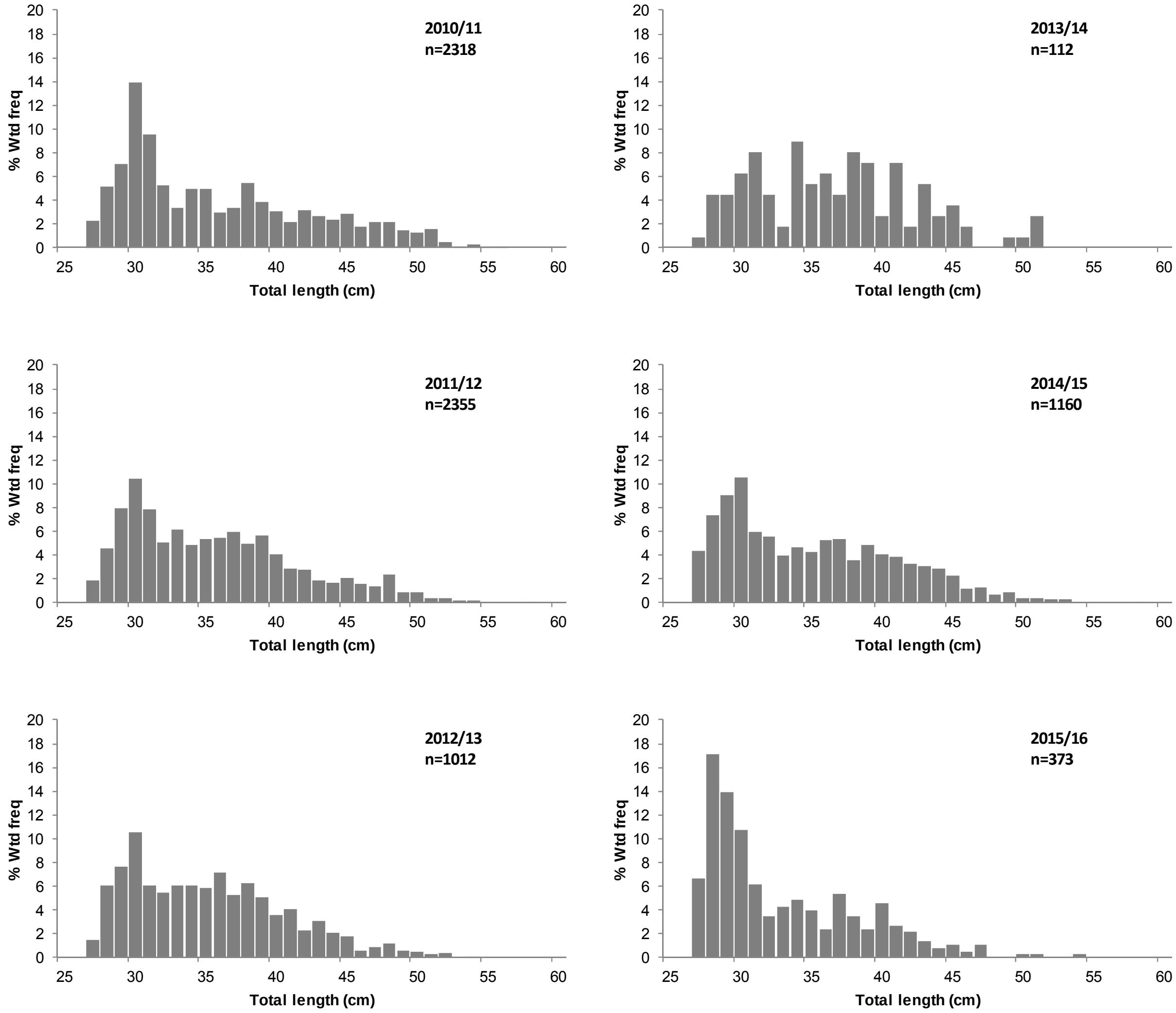

Figure 18. Weighted length frequency distributions of rock flathead caught in Corner Inlet-Nooramunga by haul seine from 2010/11 to 2015/16.

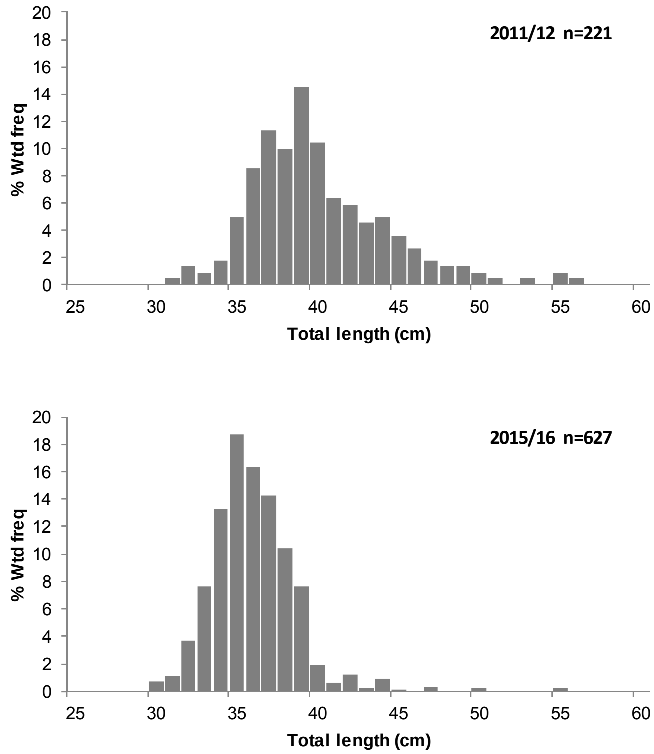

Figure 19. Weighted length frequency distributions of rock flathead caught in Corner Inlet-Nooramunga by mesh net in 2011/12 and 2015/16.

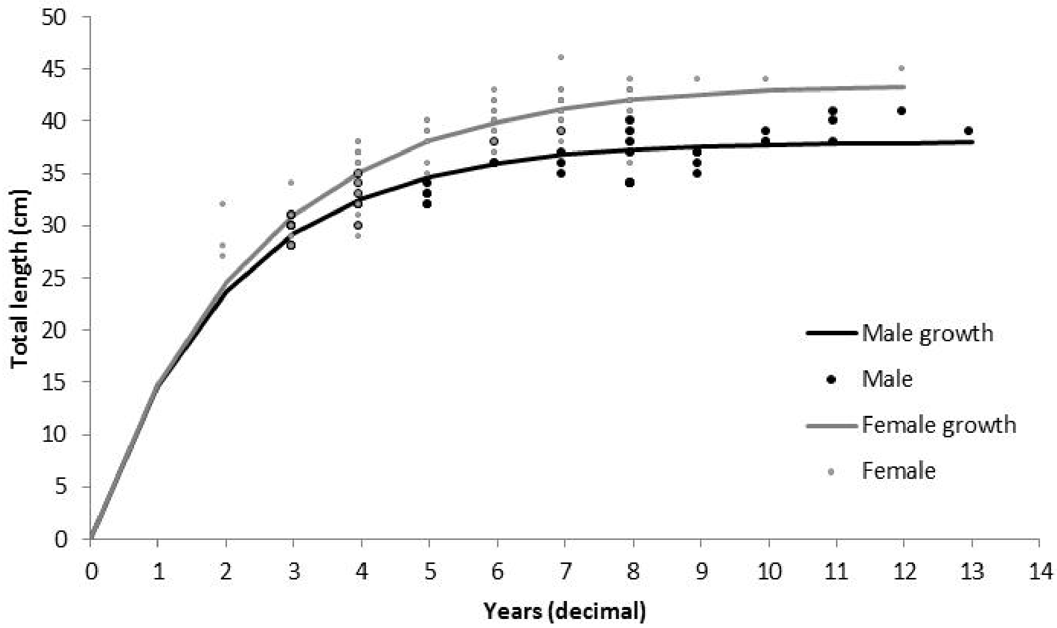

Figure 20. Age-length curves of male and female rock flathead caught in Corner Inlet-Nooramunga during 2015/16.

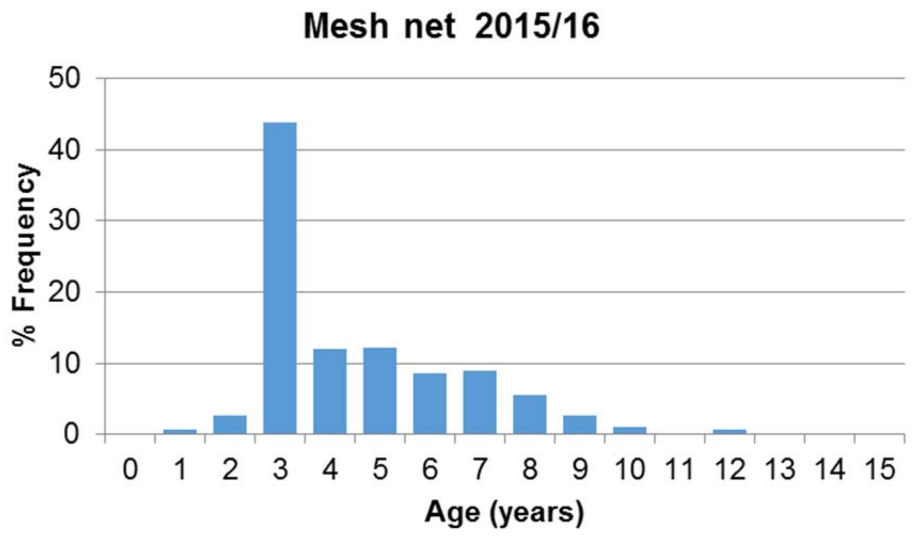

Figure 21. Age frequency distribution of rock flathead caught by mesh net in Corner Inlet-Nooramunga during 2015/16, converted from weighted length frequency data. N=153.

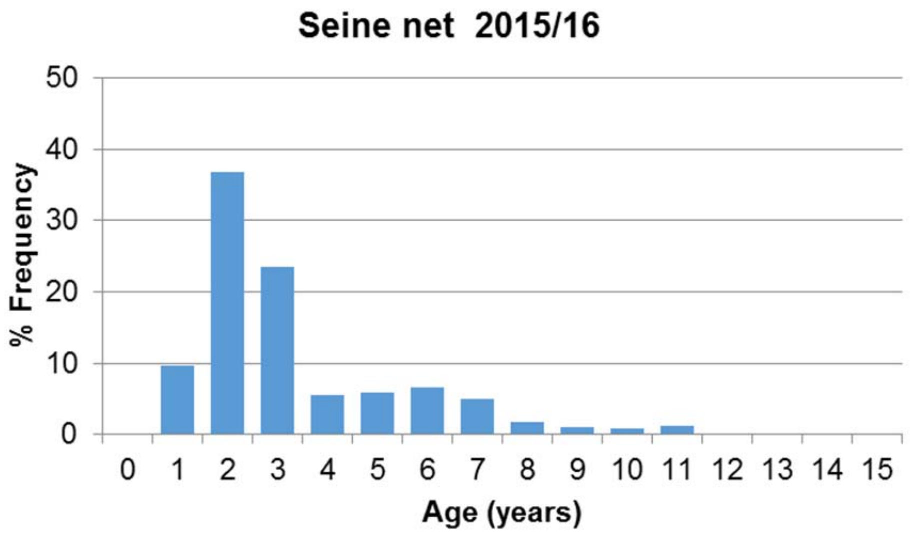

Figure 22. Age frequency distribution of rock flathead caught by seine net in Corner Inlet-Nooramunga during 2015/16, converted from weighted length frequency data. N=153.

Australian salmon

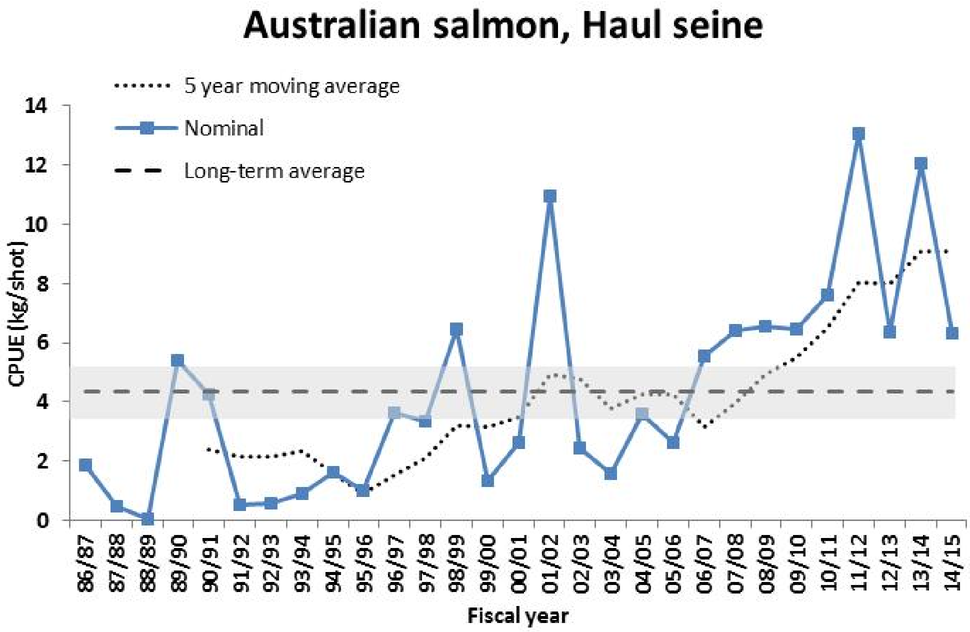

Figure 23. Trend in annual catch rate (CPUE) (kg/shot) of Australian salmon caught in Corner Inlet-Nooramunga by haul seine from 1986/87 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE. Note: years 1978/79–1985/86 are not included due to large catches taken outside the system using different seine net gear.

Flounder

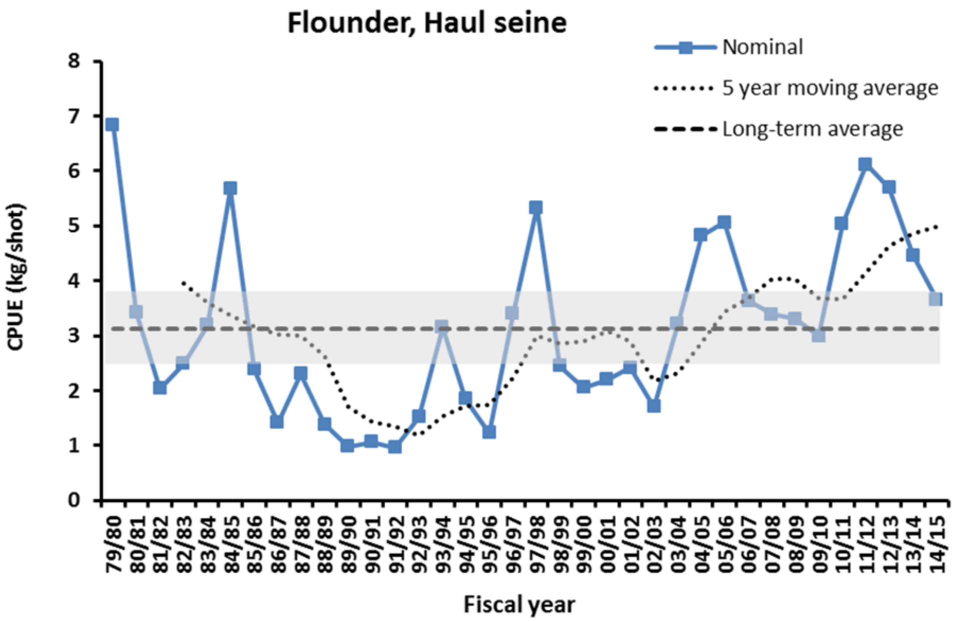

Figure 24. Annual catch rate (CPUE) (kg/shot) of flounder (greenback and unspecified) caught in Corner Inlet-Nooramunga by haul seine from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Gummy shark

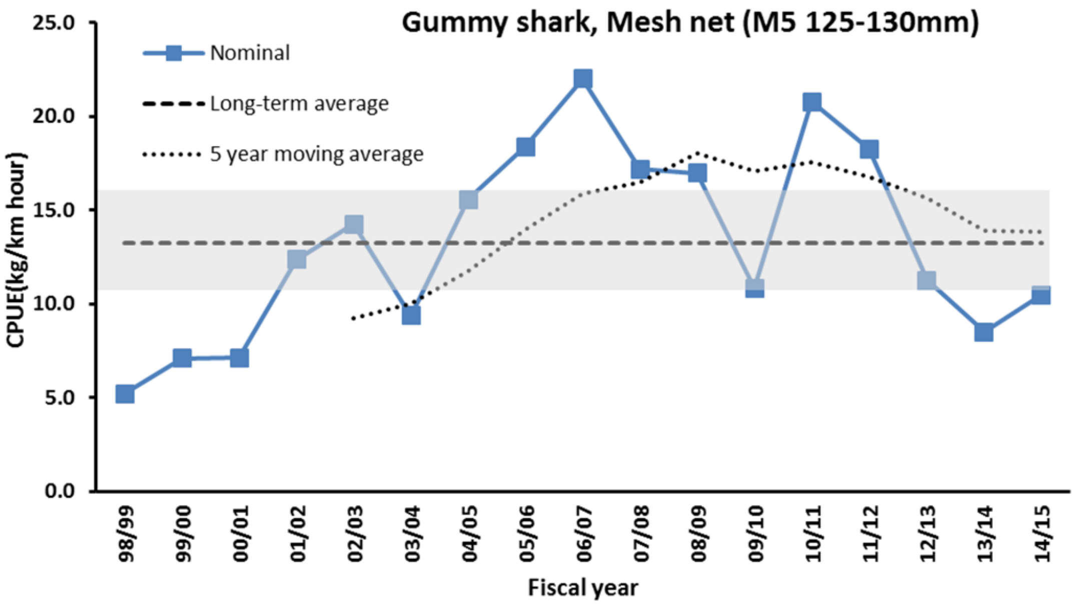

Figure 25. Annual catch rate (CPUE) (kg/km hr) of gummy shark caught in Corner Inlet-Nooramunga by mesh net (M5, 125–130 mm) from 1998/99 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

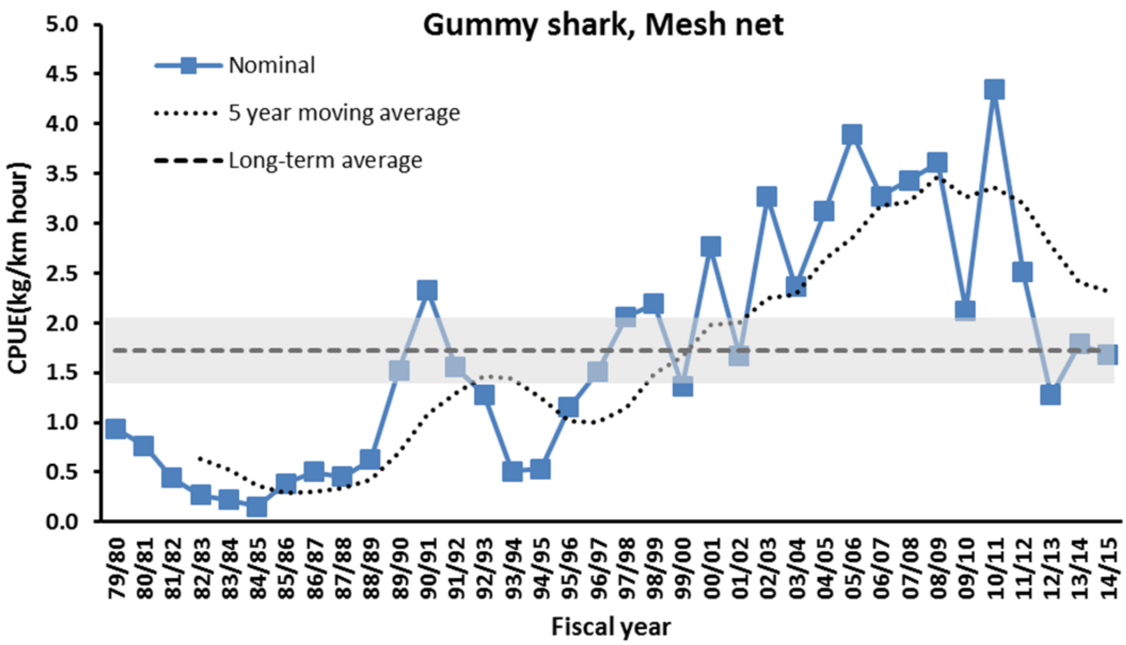

Figure 26. Annual catch rate (CPUE) (kg/km hr) of gummy shark caught in Corner Inlet-Nooramunga by mesh net from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Silver trevally

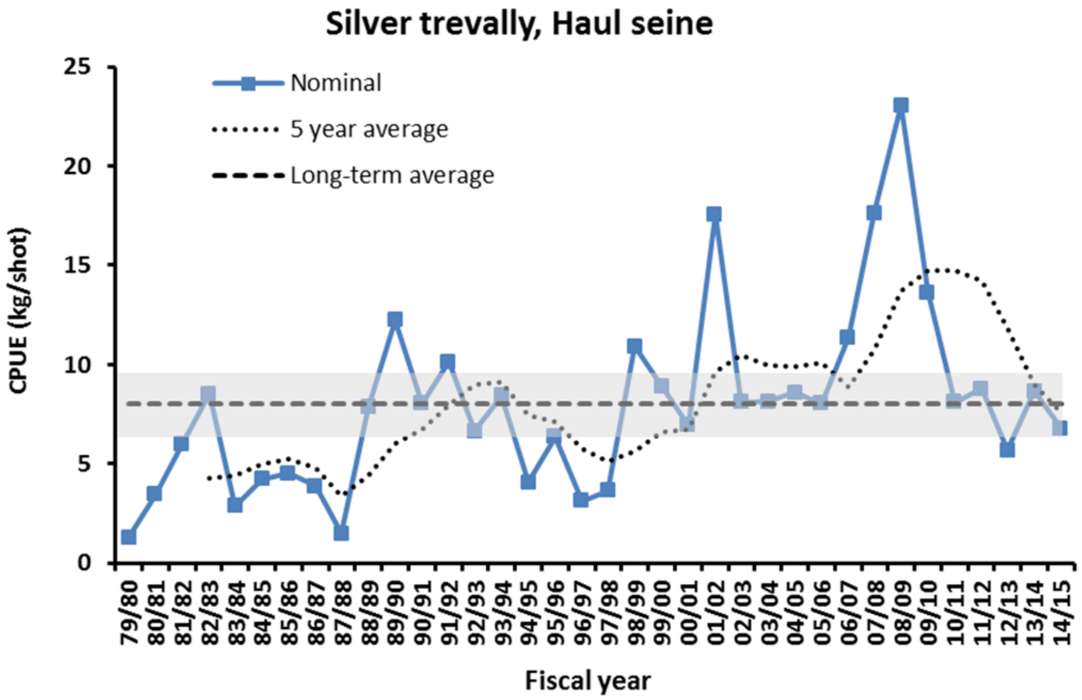

Figure 27. Annual catch rate (CPUE) (kg/shot) of silver trevally caught in Corner Inlet-Nooramunga by haul seine from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Southern calamari

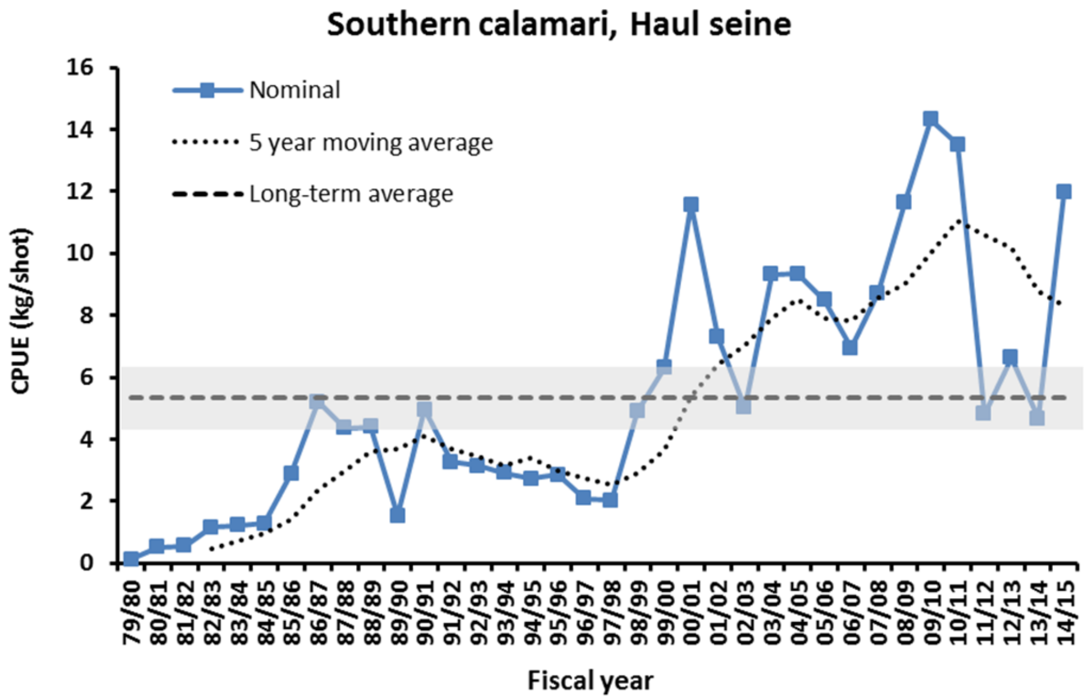

Figure 28. Annual catch rate (CPUE) (kg/shot) of southern calamari caught in Corner Inlet-Nooramunga by haul seine from 1978/79 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Southern garfish

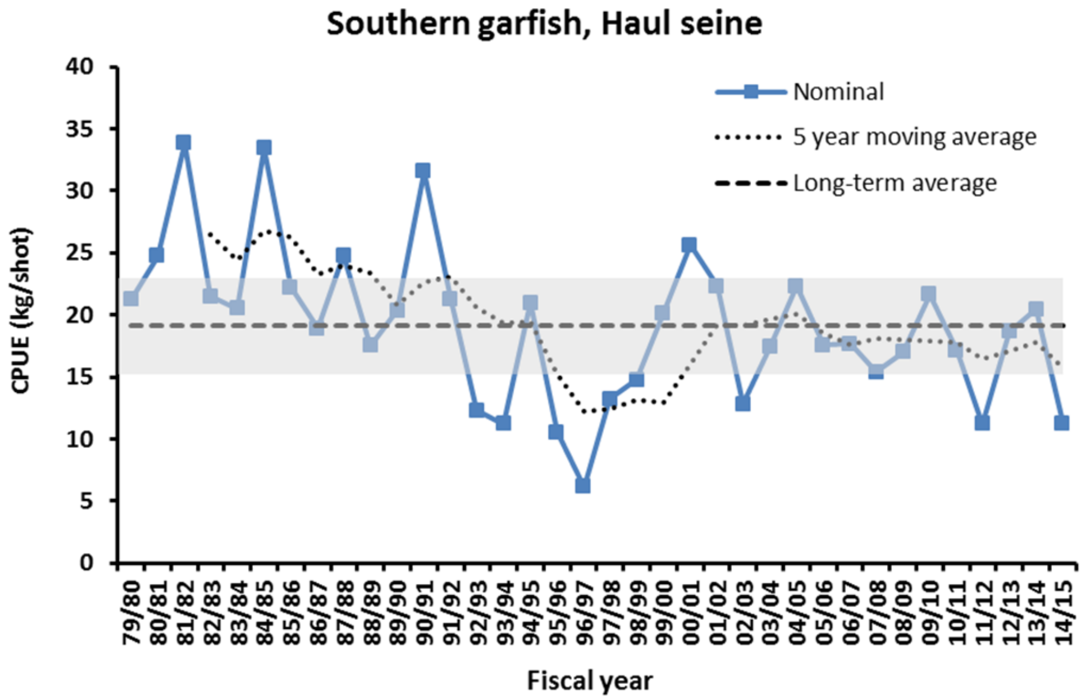

Figure 29 Annual catch rate (CPUE) (kg/shot) of southern garfish caught in Corner Inlet-Nooramunga by haul seine from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Sand flathead

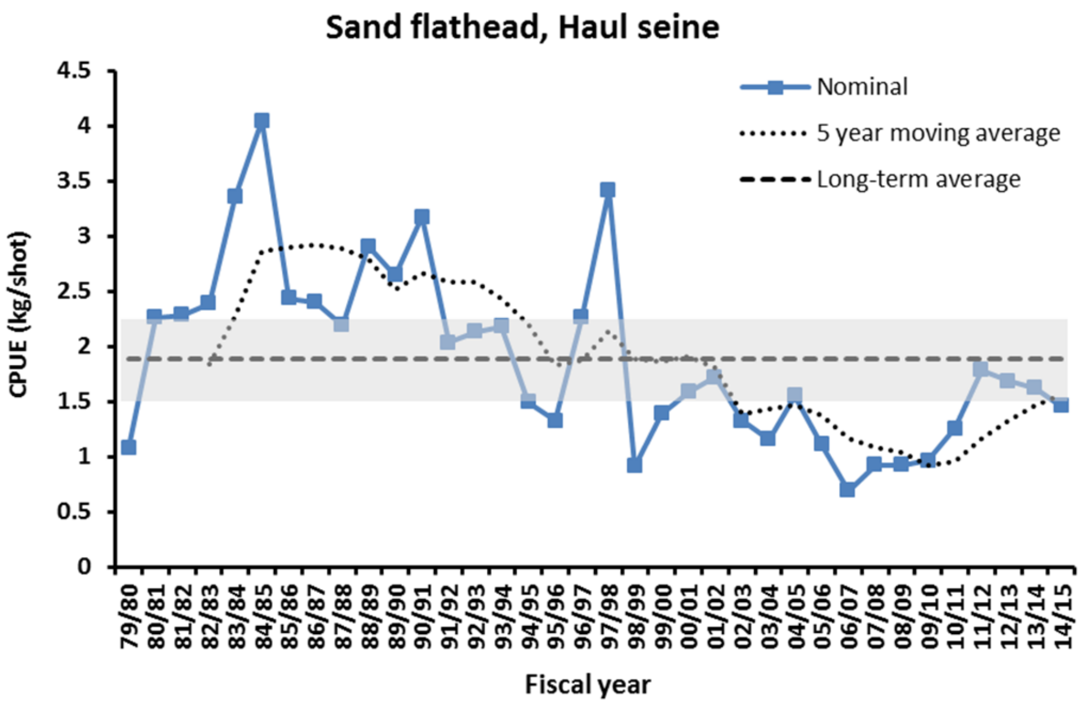

Figure 30. Annual catch rate (CPUE) (kg/shot) of sand flathead caught by haul seine in Corner Inlet-Nooramunga by haul seine from 1978/79 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Yellow-eye mullet

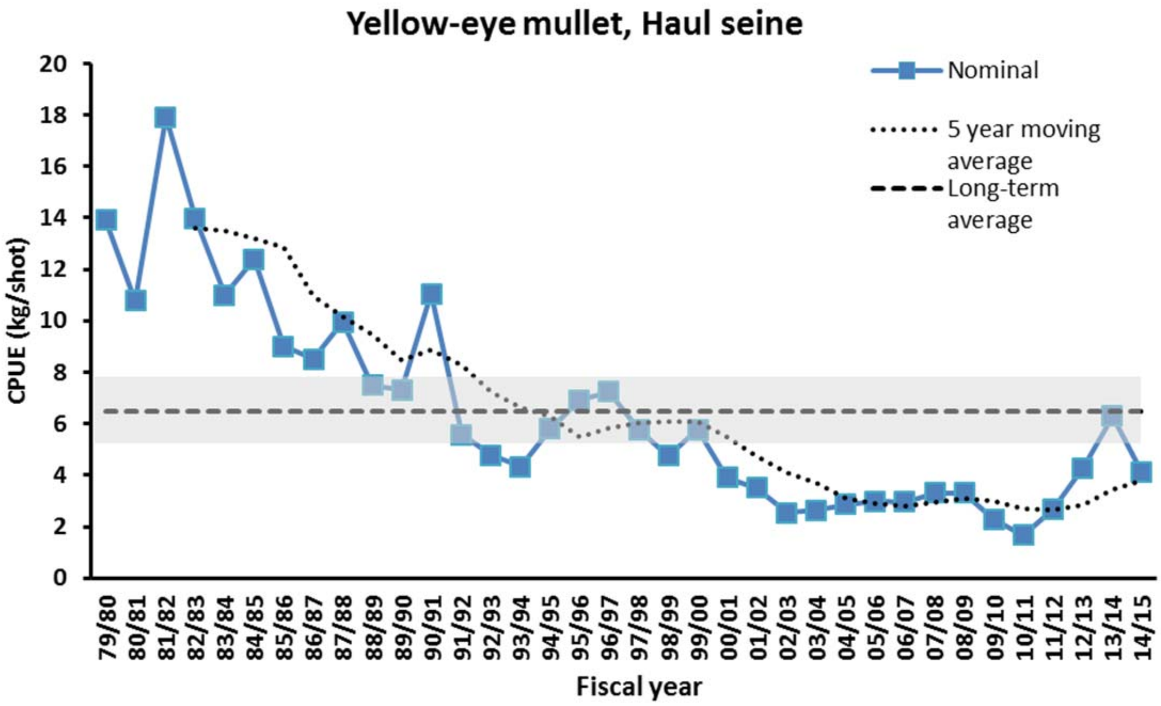

Figure 31. Annual catch rate (CPUE) (kg/shot) of yellow-eye mullet caught in Corner Inlet-Nooramunga by haul seine from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Blue spotted flathead (yank flathead)

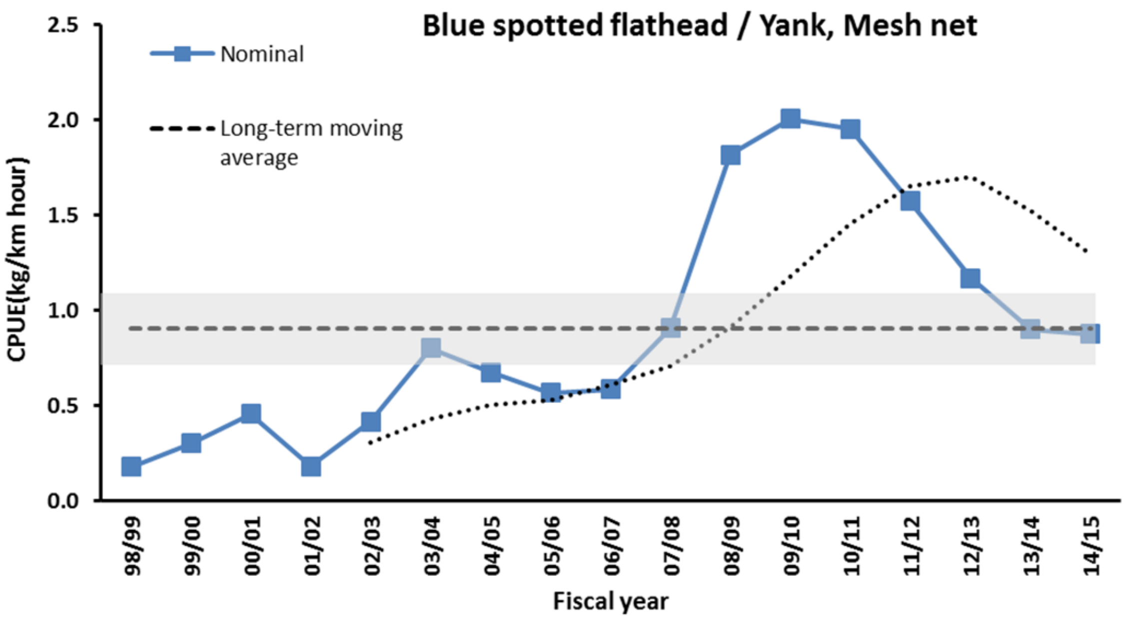

Figure 32. Annual catch rate (CPUE) (kg/km hr) of blue spotted flathead caught in Corner Inlet-Nooramunga by mesh net from 1998/99 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Snapper

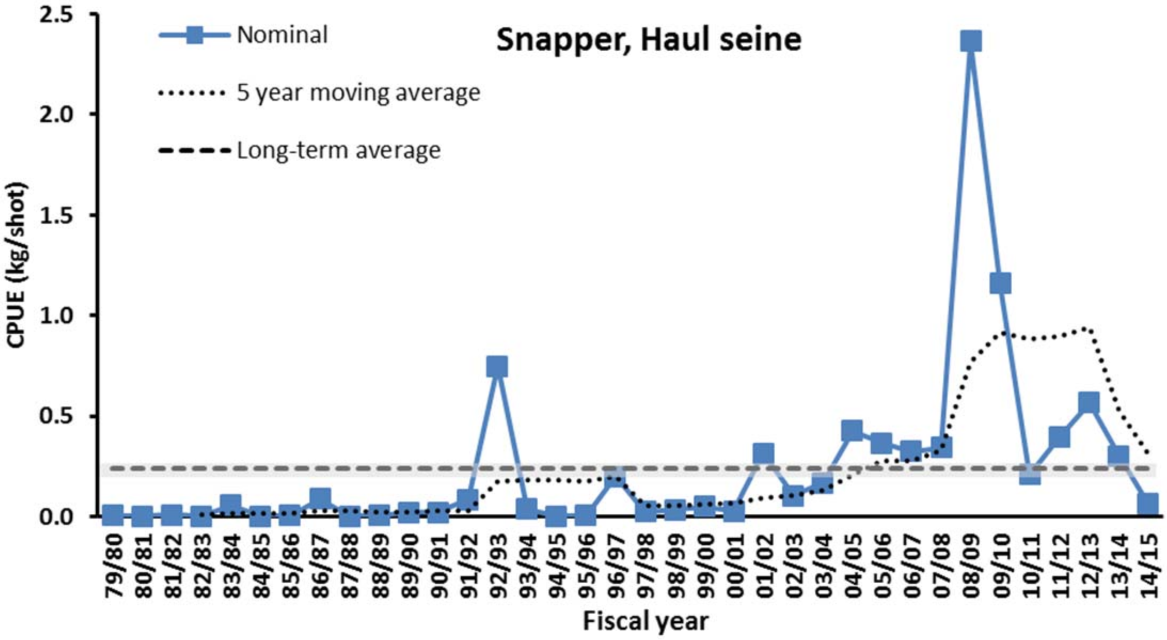

Figure 33. Annual catch rate (CPUE) (kg/shot) of snapper caught in Corner Inlet-Nooramunga by haul seine from 1979/80 to 2014/15. Greyed region indicates +/- 20% of the long term CPUE.

Appendices

Appendix 1. Life history information for key fishery species in Corner Inlet-Nooramunga

Species	Attribute	Description
Eastern Australian salmon, *Arripis trutta*; western Australian salmon, *A. truttacea*	Distribution and movement	The eastern species occurs along the coast of east Australian states, New Zealand and nearby oceanic islands; the western species occurs from Western Australia, to Victoria and Tasmania (Gomon *et al*. 2008). Forms large migratory schools that move along the coast in near shore waters (Gomon *et al*. 2008).
	Reproduction	Eastern species spawns in the coastal waters of Victoria and New South Wales; western species spawns in Western Australia.
	Growth	Maximum length of the eastern species is 55 cm TL; western species is 75 cm TL (Gomon *et al*. 2008).
	Diet	Juveniles (<15 cm SL) in Port Phillip Bay consume benthic and pelagic crustaceans and fish (Hindell *et al.* 2000). Sub-adults (20–35 cm SL) in Western Port, consume anchovy, pilchard and sandy sprat (Hoedt and Dimmlich 1994).
Greenback flounder, *Rhombosolea tapirina*	Distribution and movement	Occur from southern New South Wales to Western Australia, including Tasmania, and New Zealand (Gomon *et al*. 2008). Found in sheltered bays and inshore waters, to a depth of 100 m (Gomon *et al*. 2008). Juveniles occur over unvegetated habitat (Edgar and Shaw 1995; Jenkins *et al*. 1997). Has an extended larval stage capable of remaining in open ocean plankton (Gomon *et al*. 2008).
	Reproduction	Spawning in Tasmania occurs in estuaries and coastal waters, from June to October (Crawford 1984). In Tasmania, size at first maturity for females and males is 218 and 190 mm TL, respectively (Crawford 1984). Forms sex-specific aggregations (Crawford 1984). Larvae hatch at 1.9 mm, and remain in the plankton for 30 days (Jenkins *et al*. 1993).
	Growth	Maximum length of 45 cm TL (Gomon *et al*. 2008).
	Diet	The diet of larvae consists of the larval stages of bivalves, copepods and invertebrate eggs (Jenkins 1987). Juveniles feed on copepods and small crustaceans (Shaw and Jenkins 1992).
Gummy shark, *Mustelus antarcticus*	Distribution and movement	Occur in southern Australian waters from southern Queensland to similar latitude in Western Australia, including Tasmania (Kuiter 2000). Demersal, found to a depth of 300 m, but are generally found in waters < 80 m deep (Gomon *et al*. 2008).
	Reproduction	Males and females mature at 80 and 85 cm TL (Gomon *et al*. 2008). Gives birth to live young; carrying an average of 15 pups (Gomon *et al*. 2008). Gestation period is ~1 year (Gomon *et al*. 2008). Pups are born in summer at a size of 30–35 cm TL (Rowling *et al*. 2010). Females breed every second year.
	Growth	Maximum length of 175 cm TL (Gomon *et al*. 2008). Longevity is 15 years (Pribac and Punt 2005).
	Diet	Feed on benthic and epibenthic prey, including crabs, lobsters, fishes and octopus (Simpfendorfer *et al*. 2001).

King George whiting, *Sillaginodes punctatus*	Distribution, movement and stock structure	Occur along the southern coastline of mainland Australia and the north coast of Tasmania (Kailola *et al.* 1993). Seagrass is important to newly settled larvae through protection from predators (Hindell *et al.* 2000) and the provision of food (Jenkins and Hamer 2001). From 5–6 months, most fish are found on sand amongst vegetated habitats (Jenkins and Wheatley 1998). In Port Phillip Bay, seagrass in the southern and western areas of the bay have been identified as critical habitat for the species (Morris and Ball 2006). As King George whiting approach maturity (4–5 years of age) they permanently leave Victorian bays and inlets and take up residence in open coastal waters (Jenkins 2005a). King George whiting in spawning condition have rarely been recorded in Victorian waters (Hamer and Jenkins 2004). The only known significant spawning areas for the species are in South Australian waters (Fowler *et al.* 2000). The age and size of King George whiting have been shown to increase in a westerly direction along the Victorian coastline (Hamer and Jenkins 2004). Coupled with the absence of spawning activity in Victorian waters, this suggests that the species gradually migrates to the west towards South Australian waters to spawn (Hamer and Jenkins 2004). Reverse modelling based on larval distributions suggests that most post-larvae that enter Port Phillip Bay, Western Port and Corner Inlet-Nooramunga are derived from a spawning area along the west coast of Victoria, but there is evidence for slight deviations for each bay and inlet (Jenkins *et al.* 2000). It has been suggested that the Corner Inlet-Nooramunga fishery is replenished from a different spawning source than Port Phillip Bay and Western Port (Jenkins *et al.* 2000; Jenkins 2005b). In South Australia, spawning occurs near coastal reefs in autumn/early winter (Fowler *et al.* 2000). Spawning in coastal waters is followed by a protracted larval phase of 3–5 months (Jenkins and May 1994; Fowler and Short 1996; Jenkins *et al.* 2000; Jenkins and King 2006). Post-larvae enter Victorian bays and inlets in spring (Jenkins and May 1994; Jenkins *et al.* 2000).
	Reproduction	Maturity is at 30–35 cm (3–5 years of age) (Scott 1954; Jones *et al.* 1990; Potter *et al.* 1996; Fowler and McGarvey 2000; Jenkins 2005a). Spawns at least 20 times during the spawning season (Fowler *et al.* 1999; Fowler and McGarvey 2000). In South Australia, individuals produce as many as 40,000 to 60,000 eggs per spawning event (Fowler *et al.* 1999), with an annual fecundity ranging from 112,000 to 6,000,000 eggs (Scott 1954; Fowler and McGarvey 2000). Eggs are buoyant and hatch after a few days at a size of 2–3 cm (Bruce 1995). Spawning in South Australia has been observed when seawater temperatures are at 17–19°C (Fowler *et al.* 1999).
	Growth	Maximum length is 72 cm TL (4.8 kg) (Gomon *et al*. 2008). Longevity of 15 years.
	Diet	Juveniles feed on crustaceans; larger benthic organisms (including polychaete worms) dominate the diet of older fish.
Silver trevally, *Pseudocaranx georgianus*	Distribution and movement	The distribution of silver trevally is not fully known due to past confusion with other species (*P. dentex, P. wrighti, P. dinjera* and *Caranx nobilis*), however, is thought to occur from southern New South Wales to southern Western Australia, and New Zealand (Gomon *et al.* 2008). Larvae have been observed entering Lake Macquarie in New South Wales from December to February (Miskiewicz 1987), in coastal waters off Sydney from August to May (Gray *et al.* 1992), off southern New South Wales in May and off northeast Tasmania in March (CMR, Hobart, unpublished data cited in Bruce *et al.* 2002), and off Portland in Victoria in January (F. Neira AMC, Beauty Point, pers. comm. cited in Bruce *et al.* 2002).
	Reproduction	In New South Wales, spawning occurs from spring to autumn (Rowling and Raines 2000). Females in New South Wales mature at a length of 260–280 mm at an age of 5–6 years (Rowling and Raines 2000). Fecundity is estimated at 220,000 eggs for a 370 mm female; fecundity in larger females is presumed to range up to 1,000,000 eggs (Rowling and Raines 2000).
	Growth	Maximum length of 80 cm TL (4.5 kg) (Gomon *et al.* 2008).

		Slow growth rate. Longevity of >20 years.
	Diet	Feeding occurs in both the benthic and pelagic environments, consuming more fish (by weight) than any other non-fish dietary components (Bulman *et al.* 2001; Hindell 2006).
Southern calamari, *Sepioteuthis australis*	Distribution and movement	Inshore squid species endemic to southern Australia, including Tasmania, and New Zealand (Winstanley 1983). Commonly in waters <70 m deep. Individuals are capable of moving large distances (100s of kilometres) (Pecl and Moltschaniwskyj 2006). Two genetically different populations exist in eastern and western Australia that is separated by a hybrid population in the intervening region (Triantafillos and Adams 2001). In South Australia, small calamari (<30 mm DML) and large calamari (>150 mm DML) inhabit shallow, inshore waters; whereas small to medium sized calamari (30 mm to 150 mm) occupy offshore, deeper waters (Smith 1983; Triantafillos 2001).
	Reproduction	Size at first maturity ranges from 132 to 215 mm dorsal mantle length (DML) for females and 117 to 185 mm DML for males (Triantafillos and Adams 2001). Visual surveys of egg masses suggest females spawn throughout the year (Moltschaniwskyj and Pecl 2007), in Tasmania, the majority of spawning occurs when mature calamari aggregate on the east coast during spring/early summer (Moltschaniwskyj and Pecl 2003). In Victoria, anecdotal evidence suggests that spawning starts in late winter. Large calamari and egg masses have been observed in the reef/algal habitats in Point Lonsdale Bight region and in seagrass beds around the Bellarine Peninsula (Green 2015). Males deposit spermatophores in the female (Hanlon 1996). Clusters of eggs have been observed attached to seagrass, macroalgae, sand and rocky substrate (Steer *et al*. 2005; Triantafillos and Adams 2001, Green 2015).
	Growth	Growth is rapid and the entire life cycle is completed in <1 year (Moltschaniwskyj and Pecl 2007, Steer *et al*. 2005, Green *et al*. 2012, Green 2015). Maximum recorded age for females and males is 263 and 291 days, respectively (Bradshaw 2005).
	Diet	Early life-history feed on zooplankton and small crustaceans while adults feed on fish and squid.
Southern sea garfish, *Hyporhamphus melanochir*	Distribution and movement	Occurs from Eden in southern New South Wales to Kalbarri in Western Australia, including Tasmania (Kailola *et al*. 1993; Gomon *et al*. 2008). Morphometric variation suggests there are two distinct stocks in South Australia and Western Australia (Collette 1974). Found in shallow (<20 m deep) inshore waters, in the pelagic environment primarily over seagrass (Kailola *et al*. 1993; McGarvey *et al*. 2006; Gomon *et al.* 2008).
	Reproduction	Spawns inshore during late spring/summer (Ling 1958; Jones 1990) Sex-specific schools form. Matures at ~20 cm SL (Ye *et al*. 2002). Batch fecundity is relatively low (Ye *et al*. 2002). Eggs are large (2.5–3 mm in diameter) relative to body size, and have adhesive filaments that are used to attach to filamentous algae (Mills *et al*. 1997) and seagrass (Ling 1958).
	Growth	Maximum length is 50 cm FL (Collette 1974). Fast growth rate. Mean size at one year is 160–185 mm TL (Victoria, South Australia and Western Australia (Ye *et al*. 2002). Growth slows considerably once individuals attain ~270 mm TL (Ye *et al*. 2002). Protracted spawning season results in a high degree of size variation at age (Ye *et al*. 2002). Longevity is 10 years (Jones 1990).
	Diet	Consumes seagrass, epiphytic algae and invertebrates (Klumpp and Nicholas 1983; Robertson and Klumpp 1983; Earl 2007).

Rock flathead, *Platycephalus laevigatus*	Distribution	Occurs from southern Queensland to southern Western Australia, including Tasmania (Gomon *et al.* 2008). Found in a range of habitats, often seagrass, to a depth of 20 m (Gomon *et al.* 2008; Kuiter 2000). Forms sex-specific aggregations (Koopman 2002).
	Reproduction	Spawn from September to February, with maximum spawning effort observed in October (Koopman 2002).
	Growth	Maximum length of 50 cm SL (Gomon *et al.* 2008). Growth is highly variable. Females and males from Corner Inlet-Nooramunga attain an average size of 39 and 34 cm TL, respectively, at 5 years of age, and 48 and 40 cm TL at 10 years, respectively (Koopman 2002).
	Diet	Smaller rock flathead (25–33 cm TL) consume mainly fish, squid and shrimp, whilst larger fish (>33 cm TL) consume particular crab species and some fish (Klumpp and Nichols 1983). In Port Phillip Bay, 50% of the base nutrition is from food webs supported by seagrass (Hindell 2006).

Appendix 2. Stock structure information for key fishery species of Corner Inlet-Nooramunga

Species	Stock structure
Australian salmon	Eastern Australian salmon (*Arripis trutta*) harvested from Corner Inlet-Nooramunga is part of a single biological stock that is distributed from southern Queensland along the east coast of Australia to western Victoria and Tasmania More than 90% of the total annual Victorian commercial catch of Australian salmon is the eastern species (MacDonald pers. comm.)
Flounder (greenback and unspecified)	Stock structure is unknown Flounder have an extended larval stage, capable of remaining in open ocean plankton for >30 days This assessment assumes flounder in Corner Inlet-Nooramunga are part of a larger stock
Gummy shark	The most recent research on the stock structure of gummy shark suggests that there is likely one stock for southern Australia (extending from Bunbury in Western Australia to Jervis Bay in New South Wales) and a second stock in eastern Australia (extending from Newcastle to the Clarence River in New South Wales) Gummy shark in Corner Inlet-Nooramunga are assumed to be part of the larger southern Australian stock
King George whiting	The stock composition of King George whiting in Victoria is unknown King George whiting spawn and spend a substantial part of the life-cycle in coastal waters Sub-adults are found in Victorian bays and inlets Whiting in Corner Inlet-Nooramunga are part of a larger but unknown stock
Silver trevally	Silver trevally range from northern New South Wales to Western Australia. Little is known of the stock structure. Preliminary research suggests that the silver trevally off south-eastern Australia represent a single stock This assessment assumes the silver trevally in Corner Inlet-Nooramunga are part of a larger south-eastern population
Southern calamari	Stock structure is unknown Individuals are capable of moving large distances (hundreds of kilometres) This assessment assumes calamari in Corner Inlet-Nooramunga are part of a larger stock
Southern sea garfish	Stock structure is unknown
Rock flathead	Stock structure is unknown

Appendix 3. Catch rate data selection and standardisation methods

Logistic sub-setting

A logistic regression of multi-species presence–absence information was used to predict the probability that rock flathead would be present in a trip's catch (i.e. daily records of catches for each gear type and fishing area were analysed, as described in Stephens and MacCall (2004)). For a trip, whenever a species was caught, it was coded as 1 and when the species was not caught it was coded as 0, i.e. presence/absence catch data by species. The species compositions from trip catch records were used to estimate the parameters of the logistic regression. These coefficients were positive or negative based on whether a species is usually caught with rock flathead or not. These parameters were then used to estimate the probability that rock flathead would have been caught on each trip. A critical value of probability that best predicts rock flathead presence and absence in the data set forms an objective basis for sub-setting the trip records. In Corner Inlet-Nooramunga, those trip records for which the estimated probability of catching rock flathead, given the overall catch composition, exceeded 0.45 (this value minimises discrepancy between observed rock flathead catch trips and predicted rock flathead catch trips) were then used in the CPUE (catch rate) standardisation.

For King George whiting haul seine data the value was 0.57.

Standardisation

A Generalised Linear Mixed Model (GLMM, Venables and Dichmont 2004) was used to standardise the rock flathead and King George whiting CPUE data. The catch values were modelled as the response variable with a Negative Binomial error distribution and logarithmic link function. Logarithmically transformed effort was included in the model as an offset variable. A Negative Binomial, rather than a Poisson, distribution was preferred because the Poisson distribution is too restrictive by imposition of the mean being equal to the variance. Factors and variables included in the standardisation models (both for rock flathead and King George whiting) were financial year, included as a fixed effect; fishing area; month of fishing; operator number (as a surrogate for the fishers' fishing skills); gear type and interaction between gear type and operator as random effects.

The standardised CPUE was achieved by generating predicted means for financial years using only fixed effects (year coefficient for financial year). By excluding all the random effects in the prediction, the mean random effect at the population means was zero.

Among the factors included in the random model, the fishers' skill (i.e. operator number) had the strongest effect on the CPUE. Fishers' skill itself, accounted for half of the variability in rock flathead CPUE attributed to the random model and two thirds of the variability in King George whiting CPUE attributed to the random model. The gear type used by fishers was the second most important factor in determining CPUE, while the variability in CPUE due to area and months was about equal.

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