Chapter 9

Commonwealth Trawl and Scalefish Hook sectors

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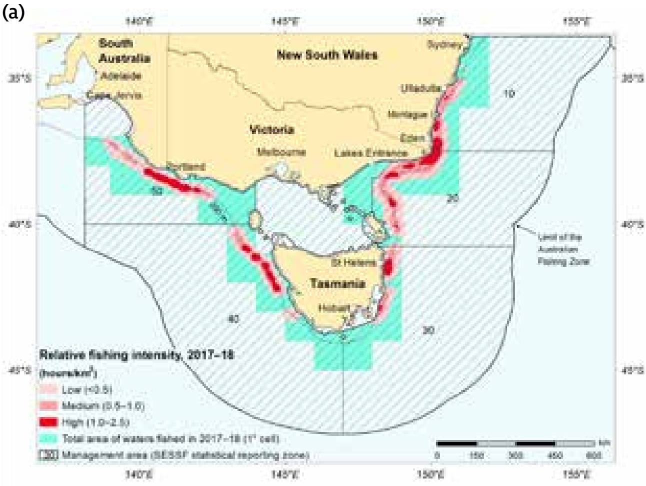
FIGURE 9.1 Relative fishing intensity (a) in the Commonwealth Trawl Sector and (b) by Danish-seine operations, 2017–18 fishing season

(a)



(b)

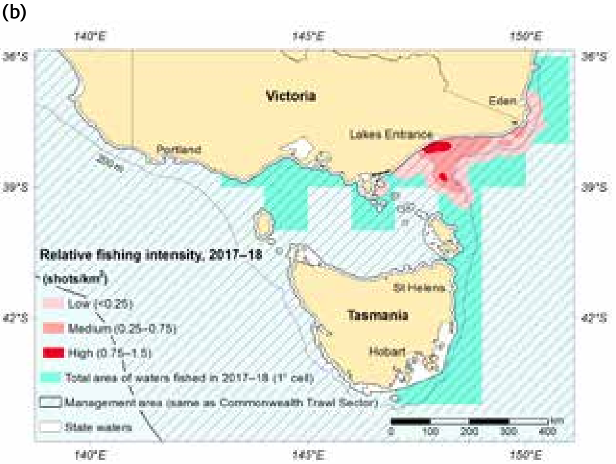
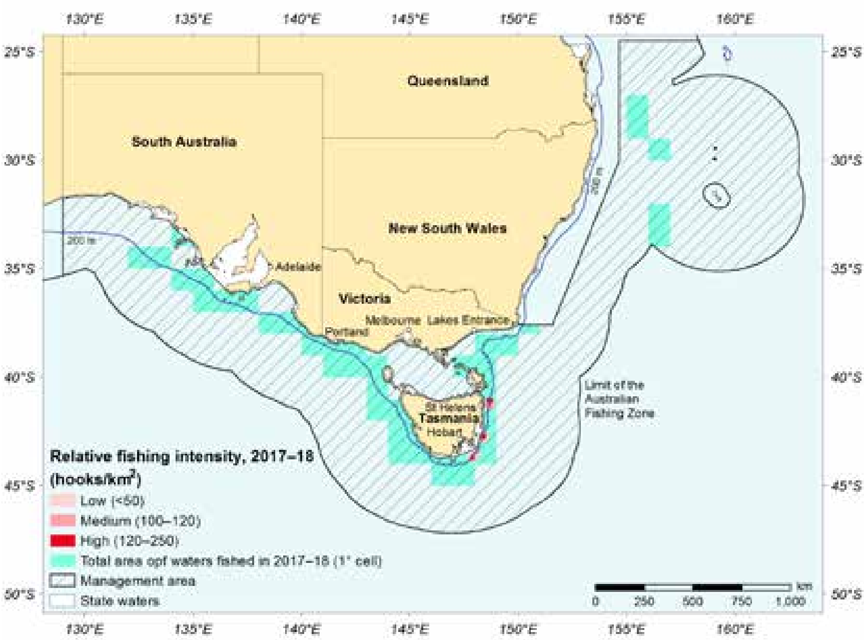


FIGURE 9.2 Relative fishing intensity in the Scalefish Hook Sector, 2017–18 fishing season



Sampling otoliths
Dylan Maskey, AFMA

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors

Status	2016		2017		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Blue-eye trevalla (*Hyperoglyphe antarctica*)					CPUE is between the limit and target reference points. Fishing mortality is below the most recent RBC.
Blue grenadier (*Macruronus novaezelandiae*)					Estimated spawning biomass was above target in 2012. Total removals have remained below the long-term RBC.
Blue warehou (*Seriolella brama*)					Total removals are below the incidental catch allowance. No evidence that the stock is rebuilding.
Deepwater sharks, eastern zone (multiple species)					Substantial areas where historical catch was taken are closed, and less than 50% of the TAC was caught. Multispecies nature of stock makes CPUE potentially unreliable as the index of abundance.
Deepwater sharks, western zone (multiple species)					Substantial areas where historical catch was taken are closed, and less than 50% of the TAC was caught. Multispecies nature of stock makes CPUE potentially unreliable as the index of abundance.
Eastern school whiting (*Sillago flindersi*)					2017 estimate of biomass is above the target reference point. Total removals since 2009 have been below the RBC.
Flathead (*Neoplatycephalus richardsoni* and four other species)					Recent estimates of biomass are above the target reference point, and current catches are below the RBC.
Gemfish, eastern zone (*Rexea solandri*)					Biomass is below the limit reference point. Uncertainty remains around total fishing mortality and rebuilding to the limit reference point within the specified time frame.

continued ...

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors continued

Status	2016		2017		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Gemfish, western zone (*Rexea solandri*)					Estimated spawning biomass is above the target reference point. Catches have been stable in recent years and below the RBC.
Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)					Populations are below the limit reference point, and fishing mortality is uncertain, despite low landed catch and protection from closures.
Jackass morwong (*Nemadactylus macropterus*)					Accepting the 'regime shift' scenario for the eastern stock, estimates of spawning biomass depletion are above the limit reference point. Total removals remain below the RBC calculated for the regime shift scenario.
John dory (*Zeus faber*)					Catches and fishing mortality rates are low. Assessment indicates that biomass is above the limit reference point.
Mirror dory (*Zenopsis nebulosa*)					Recent CPUE is above the limit reference point. Total mortality is below RBCs for eastern and western stocks.
Ocean jacket (*Nelusetta ayraud*)					History of stable CPUE, increasing in recent years.
Ocean perch (*Helicolenus barathri*, *H. percoides*)					Recent CPUE (including discards) is above the limit reference point for both species. Total fishing mortality is above the RBC.
Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)					Most recent estimate of spawning biomass (2008) is above the target reference point. Catches since the last estimate have been below the RBC.
Orange roughy, eastern zone (*Hoplostethus atlanticus*)					Most recent stock assessment estimated biomass to be between the limit and target reference points. Fishing mortality has not exceeded the TAC.

continued ...

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors continued

Status	2016		2017		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Orange roughy, southern zone (*Hoplostethus atlanticus*)					Negligible catches. Closure of most areas deeper than 700 m. No updated stock assessment.
Orange roughy, western zone (*Hoplostethus atlanticus*)					Negligible catches. Closure of most areas deeper than 700 m. No updated stock assessment.
Smooth oreodory, Cascade Plateau (*Pseudocyttus maculatus*)					Low recent catches. CPUE is above the target reference point.
Smooth oreodory, non–Cascade Plateau (*Pseudocyttus maculatus*)					Closure of most areas deeper than 700 m. Recent CPUE is above the target reference point. New tier 5 assessment indicates catch is below levels that would result in depletion.
Other oreodories (*Allocyttus niger*, *Neocyttus rhomboidalis*, *A. verrucosus*, *Neocyttus* spp.)					Recent CPUE is stable, near the target reference point. Total fishing mortality exceeds the RBC. Closure of most areas deeper than 700 m.
Pink ling (*Genypterus blacodes*)					Fishing mortality for both stocks is below the RBC. Western stock is above target. Biomass of eastern stock is between the limit and target reference points.
Redfish (*Centroberyx affinis*)					Biomass is below the limit reference point. Catch is above the tier 1 and tier 4 RBCs. It is unclear if total removals are above the level that will allow rebuilding.
Ribaldo (*Mora moro*)					Standardised CPUE has remained stable and above the target reference point. Catches have remained below RBCs.
Royal red prawn (*Haliporoides sibogae*)					Recent average CPUE is above the limit reference point, and catches have been below the RBC in recent years.

continued ...

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors continued

Status	2016		2017		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Silver trevally (*Pseudocaranx georgianus*)					Recent average CPUE is above the target, and recent catches have been below the RBC.
Silver warehou (*Seriolella punctata*)					Spawning biomass is between the limit and target reference points. Total removals are below the RBC.
Economic status	NER were negative in 2013–14 (–$1.34 million) for the first time since 2004–05, but positive in 2014–15 ($0.17 million). NER in the CTS are projected to rise over 2015–16 ($3.48 million) and 2016–17 ($4.24 million) because of higher GVP and lower operating costs. Despite the TACs for key species being set to an economic target, many species were undercaught during the 2016–17 season. This suggests that economic performance could improve further if approaches to setting MEY-based target reference points and TACs were improved. In particular, it may be beneficial to develop ways of setting target reference points for a multispecies fishery and deriving cost-effective estimates of species-specific B_{MEY} for some of the more valuable species.				

Notes: **B_{MEY}** Biomass at maximum economic yield. **CPUE** Catch-per-unit-effort. **CTS** Commonwealth Trawl Sector. **GVP** Gross value of production. **MEY** Maximum economic yield. **NER** Net economic returns. **RBC** Recommended biological catch. **TAC** Total allowable catch.

Fishing mortality	Not subject to overfishing	Subject to overfishing	Uncertain
Biomass	Not overfished	Overfished	Uncertain

Fish bins
Dylan Maskey, AFMA

9.1 Description of the fishery

Area fished

The Commonwealth Trawl Sector (CTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF) extends from east of Sydney southwards through Bass Strait and around Tasmania to Cape Jervis in South Australia, where it abuts the Great Australian Bight Trawl Sector (GABTS; Chapter 11; Figure 9.1). To the north, the CTS adjoins the East Coast Deepwater Trawl Sector (Chapter 10) at 24°30'S off Queensland. From the same boundary, the Scalefish Hook Sector (SHS) extends around south-eastern Australia to the border of South Australia and Western Australia (Figure 9.2). The SHS is managed as part of the Gillnet, Hook and Trap Sector (GHTS) of the SESSF, but is reported in this chapter because it shares many target species with the CTS. The CTS and the SHS are major domestic sources of fresh fish for the Sydney and Melbourne markets. In contrast to several Commonwealth fisheries, CTS and SHS landings are rarely exported to overseas markets.

The distribution of many CTS and SHS stocks do not lie wholly within the jurisdiction of Commonwealth waters, as stocks also straddle inshore state waters. Under Offshore Constitutional Settlement arrangements, some states have ceded control of SESSF quota-managed species to the Australian Government. In these cases, the catches in state waters by Australian Government–endorsed vessels are debited against their SESSF total allowable catch (TAC) limits. However, New South Wales retains jurisdiction over non-trawl fishers along the New South Wales coastline out to 80 nautical miles (nm) offshore, and over trawl fishers out to 80 nm offshore north of Sydney and out to 3 nm offshore south of Sydney.

Fishing methods and key species

The CTS and the SHS are multigear and multispecies fisheries, targeting a variety of fish and shark stocks using different gear types in different areas or depth ranges. Effort in these fisheries is widely distributed, but, since 2005—after the closure to trawling of most SESSF waters deeper than 700 m—effort has become increasingly concentrated on the shelf rather than on the slope or in deeper waters.

The CTS predominantly involves demersal otter trawl and Danish-seine fishing methods. Pair trawling and midwater trawling methods are also permitted under the SESSF management plan, but are rarely used. The SHS employs a variety of longline and dropline hook fishing methods, some of which are automated.

Management arrangements

Management of the CTS and the SHS follows the SESSF harvest strategy framework (HSF; AFMA 2009b; see Chapter 8). Both the CTS and the SHS are managed under individual transferable quotas (ITQs) for key commercial species. TACs are set for quota species for each fishing season and allocated to quota holders. All TACs are determined by the Australian Fisheries Management Authority (AFMA) Commission each year. To help reduce assessment and management costs, and create greater certainty for industry, use of multiyear TACs (MYTAC) has been increasing since 2009–10. The AFMA Commission determines TACs each year, irrespective of whether stocks are under a MYTAC. Breakout rules specify the circumstances for reviewing the stock during the MYTAC period, and allow for management intervention in the event of unexpected deviation from predicted stock status trends. Twenty-two stocks were under MYTACs across the SESSF in 2017–18 (AFMA 2017b); 15 of these are reported in this chapter.

A total of 19,382 t of quota was available across the species and species groups assessed in this chapter for the 2017–18 fishing season (1 May 2017 – 30 April 2018). This was a decrease of 713 t from 2016–17 (Table 9.2). Most of the 2017–18 quota was for target species. A further 444 t was allocated as 'incidental catch allowances' to permit unintentional catches of eastern gemfish (*Rexea solandri*), blue warehou (*Seriolella brama*), orange roughy (*Hoplostethus atlanticus*—southern and western zones[1]) and redfish (*Centroberyx affinis*). Most of the overall quota decrease resulted from decreased TACs for silver warehou (*Seriolella punctata*; –604 t), flathead (*Neoplatycephalus richardsoni* and four other species; –347 t) and mirror dory (*Zenopsis nebulosa*; –90 t), and smaller decreases for some other stocks. These decreases were partially offset by TAC increases for eastern school whiting (*Sillago flindersi*; +118) and jackass morwong (*Nemadactylus macropterus*; +39 t) and smaller increases for some other stocks.

Fishing effort

In 2017–18, trawlers reported 57,747 hours of fishing effort—a slight increase from the 52,303 hours in 2016–17 (Figure 9.3; Table 9.2). The number of active trawlers decreased from 34 in 2016–17 to 32 in 2017–18 (Table 9.2). Danish-seine effort decreased from 10,038 shots in 2016–17 to 9,965 shots in 2017–18, and the number of vessels increased from 16 in 2016–17 to 18 in 2017–18. Fishing effort in the SHS increased slightly from 3.205 million hooks in 2016–17 to 3.547 million hooks in 2017–18 (Figure 9.4; Table 9.2).

1 The orange roughy southern zone TAC contains both 'incidental' catch allowance and 'target' quota because quota is apportioned in accordance with the orange roughy eastern zone stock assessment. Orange roughy from Pedra Branca in the southern zone is included as part of the assessed eastern stock. The incidental catch component was 31 t in 2017–18 (AFMA 2017b).

Catch

The total landings of all species managed under TACs from the CTS in 2017–18 were 7,763 t. Flathead (tiger flathead), blue grenadier (*Macruronus novaezelandiae*), pink ling (*Genypterus blacodes*), eastern school whiting and silver warehou accounted for approximately 77 per cent of the landed catch. Flathead catches have decreased since 2015–16, from 2,907 t to 2,873 t in 2016–17 and 2,434 t in 2017–18. Catches of blue grenadier decreased from 1,744 t in 2015–16 to 1,306 t in 2016–17 and 1,619 t (representing around 20 per cent of the quota) in 2017–18. The total scalefish landings from the GHTS (of which the SHS comprises the primary component reported in this chapter) in the 2017–18 fishing season were estimated to be 650 t, slightly lower than the 774 t landed in the 2016–17 fishing season. Total catch for both sectors reported in this chapter (quota stocks and ocean jackets—non-quota stock) was 8,631 t in 2017–18; 7,763 t was from CTS quota stocks, 650 t was from GHTS quota stocks, and 216 t was from ocean jacket non-quota stocks (ocean jacket includes both ocean jacket and leather jacket). This was similar to the total landed catch in 2016–17 of 8,691 t.

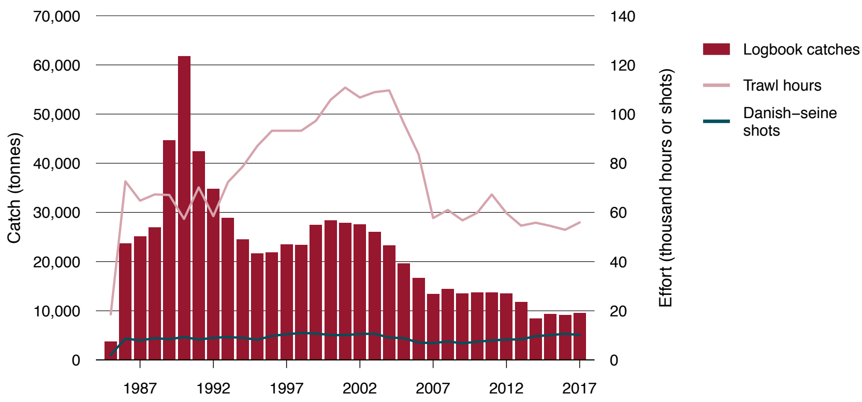
The term 'landed catch' refers to the catch that is reported at the port; it excludes discards. Data on discards are collected for the SESSF as part of the Integrated Scientific Monitoring Program. The discard data, collected over the previous four years, were converted into a weighted average to estimate discards for the current fishing season (see Table 36 in Thomson & Upston [2016]). These estimates are included when reporting on stock status.

The terms 'agreed TAC' and 'actual TAC' both refer to the TAC permitted by management. In general, the agreed TAC is estimated by subtracting the discount factor, state catches and discards from the recommended biological catch (RBC) (AFMA 2016b). The actual TAC is the agreed TAC adjusted for any overcaught or undercaught TAC from the previous season.

Information on gross value of production (GVP) for the 2017–18 season was not available at the time of publication. During 2016–17, scalefish catches in the CTS accounted for 56 per cent of the GVP in the SESSF. Scalefish GVP in the CTS increased by 9 per cent, from $36.80 million in 2015–16 to $40.01 million in 2016–17. The GVP in the SHS increased by 36 per cent, from $4.71 million in 2015–16 to $6.41 million in 2015–16, driven by an increase in the value of blue-eye trevalla catch. Overall, the total scalefish GVP in 2016–17 for both sectors was $46.42 million (Table 9.2).

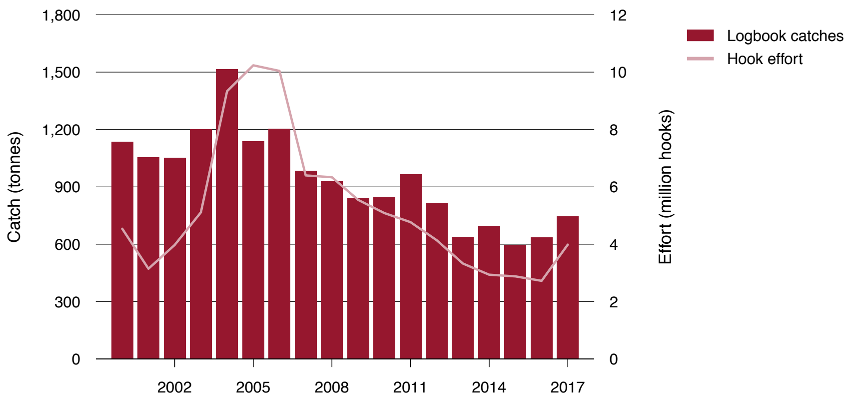
Flathead (tiger flathead and other flathead species) contributed $18.60 million to GVP in 2016–17, the most of any scalefish (Table 9.2); this was an increase of 1 per cent from $18.40 million in 2015–16. The value of pink ling catch increased by 11 per cent in 2016–17 to $5.2 million, reflecting an increase in catch that more than offset a decline in average price. The value of blue-eye trevalla (*Hyperoglyphe antarctica*) catch (largely caught in the SHS) increased by 57 per cent in 2016–17 to $4.05 million because of a significant increase in catch volume. This was the highest value catch of blue-eye travella in real terms since 2009–10. Blue grenadier accounted for $2.54 million, which was 14 per cent higher than in 2015–16 ($2.24 million) but 85 per cent lower than in 2012–13 in real terms.

FIGURE 9.3 Total catch and fishing effort for the CTS, 1985–2017



Source: Australian Fisheries Management Authority

FIGURE 9.4 Total catch and fishing effort for the SHS, 2000–2017



Source: Australian Fisheries Management Authority

TABLE 9.2 Main features and statistics for the CTS and the GHTS a

Fishery statistics b	2016–17 fishing season			2017–18 fishing season	
Stock	**TAC (t) c**	**Catch (t) (trawl, GHTS)**	**Real value (2016–17)**	**TAC (t) c**	**Catch (t) (trawl, GHTS)**
Blue-eye trevalla	410	432 (45, 388)	$4.05 million	458	327 (51, 276)
Blue grenadier	8,810	1,311 (1,306, 5)	$2.54 million	8,765	1,624 (1,619, 5)
Blue warehou	118 **d**	16 (16, 0.2)	$0.04 million	118 **d**	25 (24, 0.6)
Deepwater sharks, eastern zone	47	25 (24, 0.6)	na	46	23 (22, 0.7)
Deepwater sharks, western zone	215	75 (75, 0.5)	na	215	80 (79, 0.6)
Eastern school whiting	868	718 (717, 0)	$1.49 million	986	736 (736, 0)
Flathead (tiger flathead and several other species)	2,882	2,874 (2,873, 1)	$18.6 million	2,712	2,436 (2434, 1)
Gemfish, eastern zone	100 **d**	30 (24, 6)	$0.06 million	100 **d**	30 (27, 3)
Gemfish, western zone **e**	247	73 (70, 4)	$0.19 million	199	77 (76.7, <1)
Jackass morwong	475	213 (212, 1)	$0.47 million	513	185 (182, 3)
John dory	167	82 (82, <1)	$0.72 million	175	83 (83, <1)
Mirror dory	325	275 (275, <1)	$0.99 million	235	220 (220, <1)
Ocean perch	190	163 (144, 19)	$0.52 million	190	169 (150, 19)
Orange roughy, Cascade Plateau	500	0	0	500	0
Orange roughy, eastern zone	465	363	$1.64 million	465	297
Orange roughy, southern zone	66 **f**	43	$0.43 million	66 **f**	53
Orange roughy, western zone	60 **d**	22	$0.11 million	60 **d**	23
Smooth oreodory, Cascade Plateau	150	0	0	150	0
Smooth oreodory, non–Cascade Plateau	90	48 (47, 0.5)	$0.19 million	90	55
Other oreodories	128	108 (108, <1)	$0.37 million	128	106 (105, 1)
Pink ling	1,144	913 (607, 306)	$5.22 million	1,154	1,036 (740, 297)
Redfish	100 **d**	39 (39, <1)	$0.08 million	100 **d**	26 (26, <1)
Ribaldo	355	88 (49, 39)	$0.31 million	355	95 (55, 40)
Royal red prawn	387	127 (127, 0)	$0.89 million	384	222 (222, 0)
Silver trevally	588	53 (52, <1)	$0.24 million	613	55 (55, <1)
Silver warehou	1,209	312 (311, <1)	$0.45 million	605	432 (432, <1)

continued ...

TABLE 9.2 Main features and statistics for the CTS and the GHTS a continued

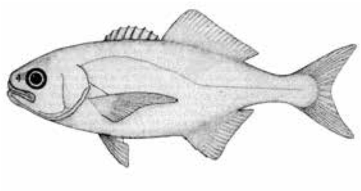
Fishery statistics b	2016–17 fishing season			2017–18 fishing season	
Non-quota species	**TAC (t) c**	**Catch (t) (trawl, GHTS)**	**Real value (2016–17)**	**TAC (t) c**	**Catch (t) (trawl, GHTS)**
Gulper sharks	na	0.5 (0.5, 0)	na	na	0.35 (0.2, 0.1)
Ocean jacket **g**	na	289	$0.61 million	na	216
Total	**20,095**	**8,691**	**$46.42 million**	**19,382**	**8,631**
Fishery-level statistics					
Effort Otter trawl Danish-seine Scalefish hook	 52,303 trawl-hours 10,038 shots 3.205 million hooks			 57,747 trawl-hours 9,965 shots 3.547 million hooks	
Boat statutory fishing rights	57 trawl; 37 scalefish hook			57 trawl; 37 scalefish hook	
Active vessels	34 trawl; 16 Danish-seine; 17 scalefish hook			32 trawl; 18 Danish-seine; 29 scalefish hook	
Observer coverage CTS Auto-longline (scalefish)	 Trawl: 129 fishing-days Danish-seine: 25 fishing-days 0 sea-days			 Trawl: 212 fishing-days Danish-seine: 20 fishing-days 26 sea-days	
Fishing methods	Trawl, Danish-seine, hook (dropline, demersal longline), trap (minor)				
Primary landing ports	Eden, Sydney and Ulladulla (New South Wales); Hobart (Tasmania); Lakes Entrance and Portland (Victoria)				
Management methods	Input controls: limited entry, gear restrictions, area closures Output controls: TACs, ITQs, trip limits				
Primary markets	Domestic: Sydney, Melbourne—fresh, frozen International: minimal				
Management plan	Southern and Eastern Scalefish and Shark Fishery Management Plan 2003				

a The SHS is managed as part of the GHTS. **b** Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 May – 30 April. Real-value statistics are provided by financial year and were not available for the 2017–18 financial year at the time of publication. **c** TACs shown are the 'agreed' TACs. These may differ from 'actual' TACs, which may include undercatch and overcatch from the previous fishing season. Consequently, catch for some stocks may slightly exceed agreed TACs. **d** Incidental catch allowance. **e** Not including the Great Australian Bight Trawl Sector. **f** Total catch includes a 31 t incidental catch allowance and 35 t of target quota, resulting from apportioning quota from the orange roughy eastern zone stock to the Pedra Branca area, which is part of the southern zone but included in the eastern zone assessment. **g** Catch figures are combined for the trawl and non-trawl sectors.

Notes: **CTS** Commonwealth Trawl Sector. **GHTS** Gillnet, Hook and Trap Sector. **ITQ** Individual transferable quota. **na** Not available. **SHS** Scalefish Hook Sector. **TAC** Total allowable catch.

9.2 Biological status

Blue-eye trevalla (*Hyperoglyphe antarctica*)



Line drawing: FAO

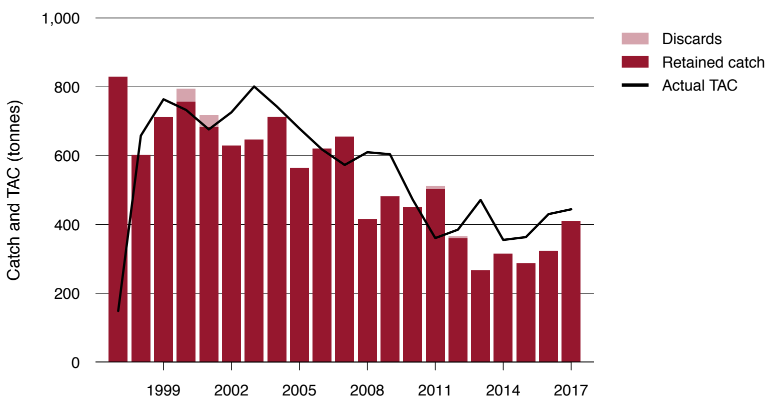
Stock structure

Blue-eye trevalla is managed as a single biological stock in the SESSF (Robinson et al. 2008). Recently, three lines of evidence, based on phenotypic variation in age and growth, otolith chemistry and potential larval dispersal, suggest spatial patterns that may delineate natural subpopulations (Williams et al. 2017). Four geographically distinct subpopulations were proposed in the SESSF, with three in the CTS. These three subpopulations are interconnected through regional exchange of larvae (Williams et al. 2017). The results of the study by Williams et al. (2017) have not been implemented into management, and the stock is treated as a single biological stock for management purposes.

Catch history

Blue-eye trevalla catch peaked at more than 800 t in 1997 (Figure 9.5). Commonwealth-landed catch in the 2017–18 fishing season was 328.5 t. The weighted average discards between 2013 and 2016 were 0.38 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.5 Blue-eye trevalla annual catches (CTS, SHS and states) and fishing season TACs, 1997–2017



Notes: **TAC** Total allowable catch. Data for 2016 and 2017 do not include discards and state catch.
Source: Haddon 2017b; Australian Fisheries Management Authority catch disposal records (2017 data)

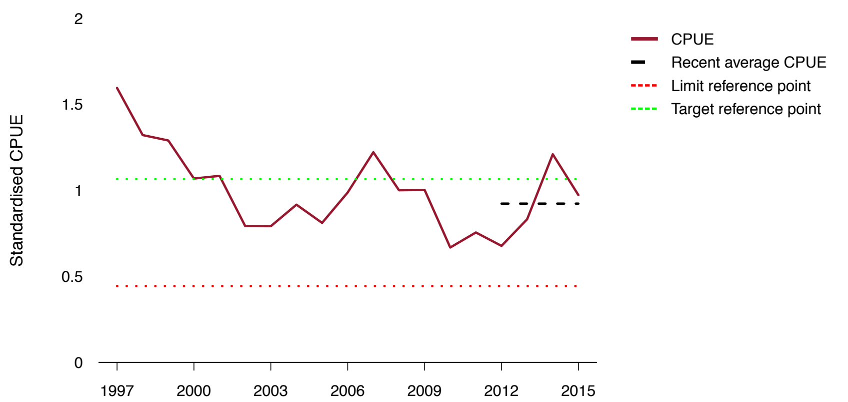
Stock assessment

The RBC for this stock is derived using a standardised catch-per-unit effort (CPUE) series (using non-trawl data from 1997 to 2016) with the application of the tier 4 harvest control rules from the SESSF HSF. As noted in Haddon (2016b) there are various sources of uncertainty in the CPUE standardisation. Two factors may potentially influence catch rates and fishing behaviour, which may result in CPUE being biased low: the presence of killer whales (orcas—*Orcinus orca*) near fishing operations and removing caught blue-eye trevalla off the fishing lines, and exclusions from historical fishing grounds following closures implemented to rebuild gulper shark (*Centrophorus* spp.) stocks (AFMA 2014e). The previous analysis (Haddon 2016b) did not detect large effects on CPUE due to the closures; however, uncertainty remains about the effect of whale depredations on CPUE.

The CPUE indicates a decrease between 2014 and 2015 (Figure 9.6); however, a three-year decrease in CPUE (albeit less steep) also occurred between 2001 and 2003 after which CPUE increased (Haddon 2017a). It is not clear whether the recent three-year decrease should be a concern. Most of the catch is now caught by only a few vessels; consequently, the CPUE is currently more sensitive to changes in the fishing behaviour of these vessels. This is expected to increase the variance of the CPUE (Haddon 2016b).

The application of the SESSF tier 4 harvest control rule to the outputs of the standardised CPUE series generated an RBC of 481.6 t (Haddon 2017b) for 2017–18.

FIGURE 9.6 Standardised auto-longline and dropline CPUE index for blue-eye trevalla to the east and west of Tasmania, 1997–2015



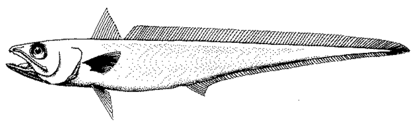
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon 2016a

Stock status determination

The four-year average CPUE (2013–2016) is between the limit and the target as defined by the SESSF HSF. The blue-eye trevalla stock is therefore classified as **not overfished**.

For the 2017–18 fishing season, the catch was 328.5 t, and the weighted average discards were 0.38 t (Castillo-Jordán, Althaus & Thomson 2018). The catch and discards combined were 328.9 t, which is below the RBC (481.6 t). This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Blue grenadier (*Macruronus novaezelandiae*)



Line drawing: Rosalind Poole

Stock structure

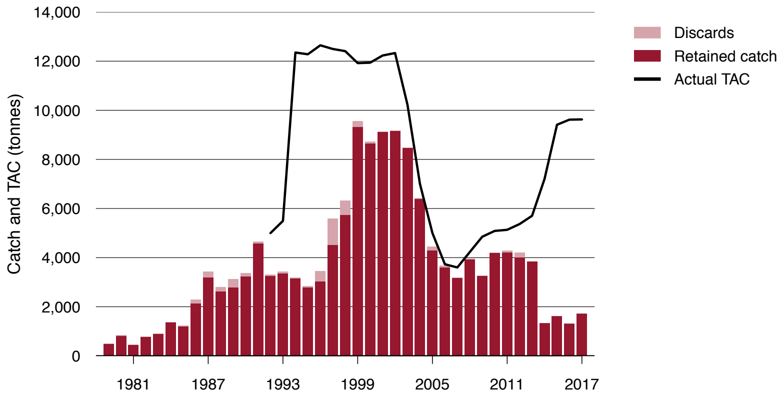
Blue grenadier is assessed as a single stock. There are two defined subfisheries: the winter spawning fishery off western Tasmania and the widely spread catches of the non-spawning fishery.

A stock structure study using otolith chemistry and otolith shape (Hamer et al. 2009) has proposed that more than one stock of blue grenadier is fished in the SESSF. Specifically, the otolith indicators provided support for separate stocks of blue grenadier being fished by the GABTS and the CTS of the SESSF. The study also indicated that blue grenadier from the western Tasmanian and eastern Bass Strait regions of the CTS were unlikely to be part of one highly mixed south-eastern Australian stock. However, this stock structure hypothesis has not been implemented into management and is not currently considered in the application of the SESSF HSF for the species.

Catch history

The blue grenadier fishery started in the early 1980s, and between 1985 and 1995 mainly targeted non-spawning fish. From 1995 onwards, a fishery developed on spawning aggregations, and total catches increased to average around 8,000 t from 1999 to 2003 (Figure 9.7). Catches since then have varied in response to changes in the TAC and the influence of market conditions. Commonwealth-landed catch in the 2017–18 fishing season was 1,623 t. The weighted average discards between 2013 and 2016 were 712.07 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.7 Blue grenadier annual catches (CTS and SHS) and fishing season TACs, 1979–2017



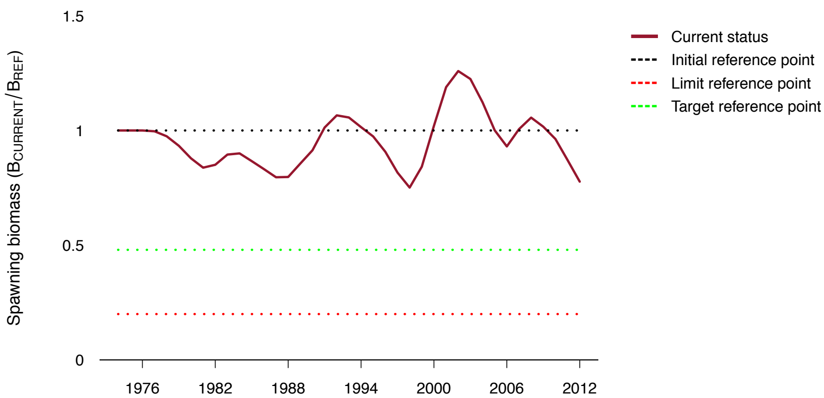
Notes: **TAC** Total allowable catch. Data for 2013–2017 do not include discards.
Source: Tuck 2013; Australian Fisheries Management Authority catch disposal records (2013–2017 data)

Stock assessment

The most recent stock assessment for blue grenadier was conducted in 2013 (Tuck 2013) using catch-and-effort data to the end of 2012, as well as estimates of spawning biomass from industry-based acoustic surveys (2003–2010) and egg survey estimates of female spawning biomass (1994–95). Results for the base-case model concluded that the spawning biomass in 2012 was around 77 per cent of the unexploited spawning stock biomass (SB_0), and was forecast to be approximately 94 per cent of SB_0 in 2014 (Tuck 2013; Figure 9.8).

To determine the RBC, the tier 1 harvest control rule from the SESSF HSF was applied to the assessment results. The harvest control rule generated a three-year RBC of 8,810 t, starting in 2014–15. AFMA recommended a conservative TAC of 6,800 t for 2014–15 (approximately 2,000 t below the RBC), after considering industry's preference for a cautious approach to support economic stability (AFMA 2014b). The MYTAC increased to 8,796 t in the following season (2015–16) and was 8,810 t in the 2016–17 season. In 2017, AFMA extended the three-year MYTAC for a fourth year, recommending a TAC of 8,765 t for the 2017–18 fishing season (AFMA 2017a).

FIGURE 9.8 Estimated female spawning biomass for blue grenadier, 1973–2012



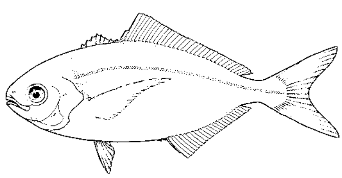
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Tuck 2013

Stock status determination

The most recent assessment of blue grenadier (Tuck 2013) indicated that the spawning biomass was above the target reference point and catches since this assessment was undertaken have been below the RBC. As such, the stock remains classified as **not overfished**.

For the 2017–18 fishing season, the landed catch was 1,623 t, and the weighted average discards were 712 t. The landed catch and discards combined were 2,335 t, which is below the RBC of 8,810 t calculated in 2013 (Tuck 2013). This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Blue warehou (*Seriolella brama*)



Line drawing: Rosalind Poole

Stock structure

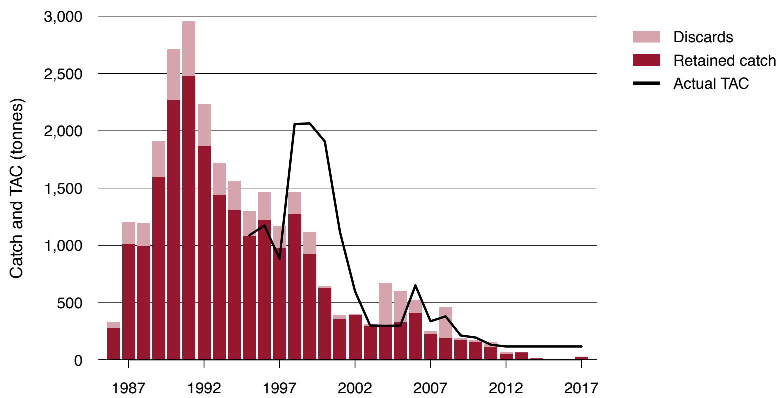
Blue warehou is assumed to have separate eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks (Morison et al. 2013). While these stocks are assessed separately, status is reported for a combined stock, reflecting the unit of management.

Catch history

In 2016–17 the catch and discards combined were 24.68 t, which was below the 2016–17 incidental catch allowance of 118 t. Landings of blue warehou peaked in 1991 at 2,478 t (Figure 9.9). Catch has since declined, with less than 500 t landed per year since 2000. A rebuilding strategy that established blue warehou as an incidental catch-only species was first implemented in 2008, with the objective of rebuilding stocks by 2024. Landed catches since then have shown a continued decline, from 65 t in 2013–14 to 16 t in 2014–15, and 2 t in 2015–16. Recently, landed catches have increased slightly, to 16 t in 2016–17 and 24.7 t in the 2017–18 fishing season.

The previous decline in landed catches may reflect one or more factors, including the ability of fishers to avoid catches, the low incidental bycatch TAC, low abundance and low availability. Occasionally a discrepancy in catch estimates may occur between logbook and the official AFMA estimates. For example 6.5 t was reported in logbooks for 2015–16, whereas 2 t was reported by AFMA (AFMA Catchwatch reports for 2015). The reason for the discrepancy is unclear, but may reflect misidentification by fishers. The weighted average discards between 2013 and 2016 were 6.83 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.9 Blue warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2017



Notes: **TAC** Total allowable catch. Data for 2013–2017 do not include discards and state catch.
Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2013–2017 data)

Stock assessment

Blue warehou has been classified as overfished since 1999 and is currently managed under a rebuilding strategy (AFMA 2014a, 2017a), with an incidental catch allowance of 118 t. Under the rebuilding strategy, targeted fishing for blue warehou is not permitted.

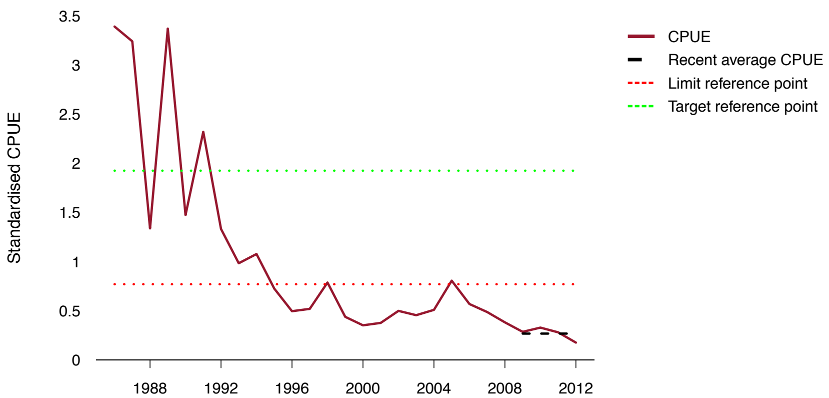
The 2008 rebuilding strategy for blue warehou was revised in 2014 with the goal of rebuilding blue warehou stocks to the limit reference point by or before 2024 (one mean generation time plus 10 years). Initially, the 2008 strategy implemented a rebuilding time frame of one mean generation time only (which is approximately six years to 2014; AFMA 2014a). However, when assessed in 2013, the standardised CPUE remained below the CPUE expected if the biomass was above its limit reference point suggesting, that the stock was not likely to rebuild by 2014. In February 2015, the species was listed as conservation-dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Department of the Environment 2015).

In September 2015, the SESSF Resource Assessment Group (RAG) discussed whether the rebuilding strategy for blue warehou was meeting its objectives (AFMA 2015d), and noted a lack of signs of recovery and potential range contraction. It also noted that current SESSF catches, even with low recruitment, should not be impeding recovery.

The standardised CPUE series of both the eastern and western blue warehou stocks declined after the reference period of 1986–1995 (Haddon 2013b). For the eastern stock, CPUE has been below the limit reference point since 1998. For the western stock, CPUE has been below the limit reference point for most years since 1995, except for 1998 and 2005 (Figures 9.10 and 9.11). Although each CPUE series is presented as a continuous line, they should be interpreted in two separate periods for each stock (Figures 9.10 and 9.11). The CPUE for the reference period (1986–1995) is the relative abundance when there was no quota management or rebuilding strategy in place. The period after 1995 includes the period of quota-based management measures and, from around 2000 onwards, efforts to limit targeting. Consequently, CPUE outside the reference period (1986–1995) may not be an accurate index of biomass.

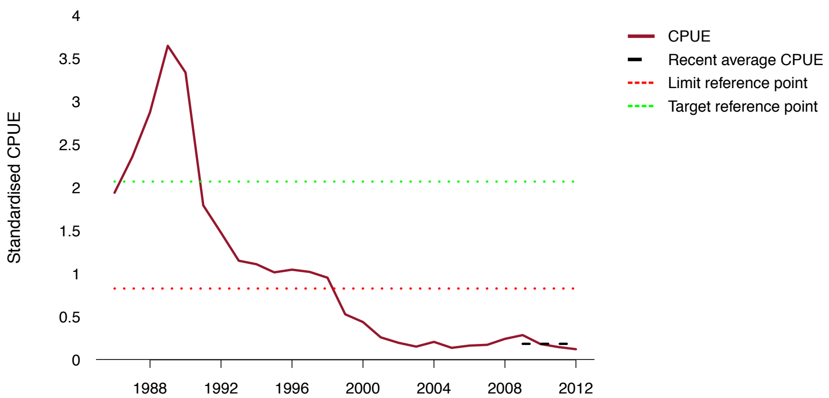
AFMA set an annual incidental catch allowance of 133 t for blue warehou for 2011–12, which was reduced to 118 t in 2012–13 and applied to subsequent fishing seasons. The incidental catch allowance includes triggers of 27 t in the east and 91 t in the west. These triggers are intended to alert AFMA and the RAG if the ratio of catches in the east and the west change substantially, and result in increased reporting requirements for commercial fishers encountering blue warehou (AFMA 2014a).

FIGURE 9.10 Standardised CPUE for blue warehou, western stock, 1986–2012



Notes: **CPUE** Catch-per-unit-effort. CPUE outside the reference period (1986–1995) is unlikely to accurately reflect biomass.
Source: Haddon 2013b

FIGURE 9.11 Standardised CPUE for blue warehou, eastern stock, 1986–2012



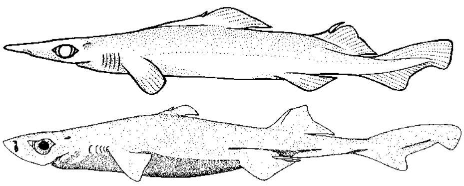
Notes: **CPUE** Catch-per-unit-effort. CPUE outside the reference period (1986–1995) is unlikely to accurately reflect biomass.
Source: Haddon 2013b

Stock status determination

The most recent indicator of biomass (albeit uncertain and dated) indicated that blue warehou had been reduced to below the limit reference point. Given that there is no evidence to suggest that the stock is likely to have rebuilt to above this level, blue warehou remains classified as **overfished**.

Blue warehou is under a rebuilding strategy. The incidental catch allowance is 118 t. The landed catch for 2017–18 was 24.7 t, and the weighted average discards were 6.83 t (Castillo-Jordán, Althaus & Thomson 2018). The catch and discards combined were 31.53 t. Although this catch is below the incidental catch allowance of 118 t, there are no reliable indicators to determine whether the current level of fishing mortality will allow the stock to rebuild. The stock is therefore classified as **uncertain** with regard to fishing mortality.

Deepwater sharks, eastern and western zones (multiple species)



Line drawing: FAO and Anne Wakefield

Stock structure

The deepwater shark stock comprises multiple species of deepwater sharks, including dogfish (Squalidae), brier shark (*Deania calcea*), platypus shark (*D. quadrispinosa*), Plunket's shark (*Centroscymnus plunketi*), roughskin shark (species of *Centroscymnus* and *Deania*), 'pearl shark' (*D. calcea* and *D. quadrispinosa*), black shark (*Centroscymnus* species) and lantern shark (*Etmopterus* species) (Klaer et al. 2014). The black shark is possibly confounded with roughskin and black (roughskin) shark, and Plunket's dogfish is possibly also confounded with the roughskin shark group. The pearl shark group is a combination of the brier and platypus sharks (Haddon 2013a).

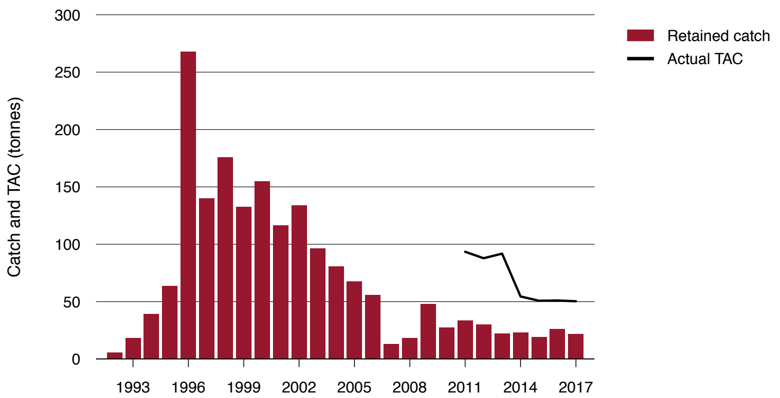
Little is known about the stock structure of these deepwater sharks. They are benthopelagic species that have been sampled in oceanic environments over the abyssal plains, and are distributed widely across ocean basins, and along the middle and lower continental shelves. The eastern zone extends from New South Wales, around the Tasmanian east coast and up the Tasmanian west coast to 42°S, including Bass Strait to 146°22'E. The western zone includes the remainder of the SESSF, around to Western Australia. This boundary cuts across deepwater shark trawl grounds. The most likely biological boundary for these species is the biogeographical boundary between the two systems dominated by the Eastern Australian Current and the Leeuwin Current off the south coast of Tasmania (Morison et al. 2013). For the purposes of these status reports, the eastern zone is treated as one stock and the western zone is treated as another stock.

Catch history

The eastern deepwater shark fishery started in about 1990. Landed catches increased steadily to around 200 t in 1998, with a single higher peak of about 330 t in 1996, before decreasing steadily to around 25 t in recent years (Figure 9.12). The eastern catch in the 2017–18 season was 22.9 t, below the agreed TAC of 46 t. The western catch followed a similar trend, starting in 1993; it increased to a peak of about 400 t in 1998, before decreasing steadily to less than 10 t in 2007. Catch in the 2017–18 fishing season was 79.7 t, below the agreed TAC of 215 t for the western stock (Figure 9.13).

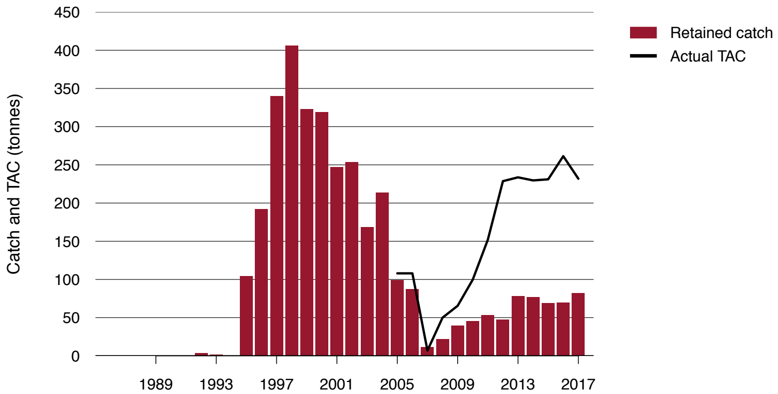
TACs for the deepwater shark multispecies stock are set separately for the eastern and western areas, and cover all deepwater shark species taken in those areas. In 2017–18, platypus sharks (mixed), roughskin dogfishes (mixed) and sleeper sharks (mixed) accounted for most of the catch in the east; and platypus sharks (mixed), longsnout dogfish and sleeper sharks (mixed) accounted for most of the catch in the west. Discards estimates for deepwater shark were not determined (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.12 Deepwater shark annual catches (CTS) and fishing season TACs, eastern zone, 1992–2017



Notes: **TAC** Total allowable catch. Data for 2011–2017 include catch disposal records from the CTS and the SHS.
Source: Australian Fisheries Management Authority catch disposal records (2011–2017 data)

FIGURE 9.13 Deepwater shark annual catches (CTS) and fishing season TACs, western zone, 1986–2017



Notes: **TAC** Total allowable catch. Data for 2011–2017 include catch disposal records from the CTS and the SHS.
Source: Australian Fisheries Management Authority catch disposal records (2011–2017 data)

Stock assessment

Both eastern and western deepwater shark stocks were managed as tier 4 stocks under the SESSF HSF in the 2017–18 fishing season. There have been ongoing issues with producing reliable standardised CPUE series for these stocks that are required to apply the tier 4 harvest control rule, and currently there is limited scope to improve these data. The paucity of historical data, together with the multispecies nature of the stock and difficulties in species identification by fishers, means that the standardised CPUE series may not be a reliable index of abundance for the individual species or the multispecies stock (Haddon & Sporcic 2017b).

Deepwater sharks are mobile animals that cover a broad range of depths (Morison et al. 2013). A significant area of the fishery—around 54 per cent of the area where catch of this stock was previously taken—has been closed as part of the 700 m depth closures to manage orange roughy stocks. These closures offer a significant level of protection to the stock of deepwater sharks, assuming that they are similarly distributed across the open and closed areas. In 2013, a portion of the orange roughy 700 m closed area was reopened under SESSF Closure Direction No. 6 2013 so that deepwater sharks could be fished. The remaining closures still offer protection, justifying the waiving of discount factors in setting MYTACs.

For eastern deepwater shark, the RBC was 47 t. AFMA extended the three-year MYTAC for a fourth year, recommending a TAC of 46 t for the 2017–18 fishing season (AFMA 2017a). Since 2009, the CPUE trend in the eastern zone has been declining, with the recent four-year average being marginally above the limit reference point.

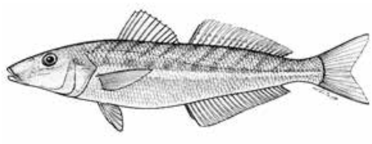
For western deepwater shark the recent four-year average CPUE was above the target, and an RBC of 312.5 t was generated. AFMA extended the three-year MYTAC for a fourth year, and following support for a cautious approach from industry and the RAG, a TAC of 215 t for the 2017–18 fishing season (AFMA 2017a) was recommended.

Stock status determination

Deepwater sharks are multispecies stocks, and robust data on historical catch composition and discards are lacking, CPUE is unlikely to provide a reliable index of abundance for these stocks or their component species. As a result, these stocks are classified as **uncertain** with regard to the level of biomass.

Given the large area closed to fishing (from which historical catch was taken) and the low catches in recent years, it is unlikely that fishing mortalities have been at a level that would deplete either stock below its biomass limit reference points. Consequently, the eastern and western deepwater shark stocks are classified as **not subject to overfishing**.

Eastern school whiting (*Sillago flindersi*)



Line drawing: FAO

Stock structure

Eastern school whiting occurs from southern Queensland to western Victoria. Genetic studies have suggested two stocks in this range, with the division between a 'northern' stock and a 'southern' stock in the Sydney – Jervis Bay area. However, the current SESSF management and stock assessment assume a single stock because the evidence for the two-stock hypothesis was not conclusive (Morison et al. 2013).

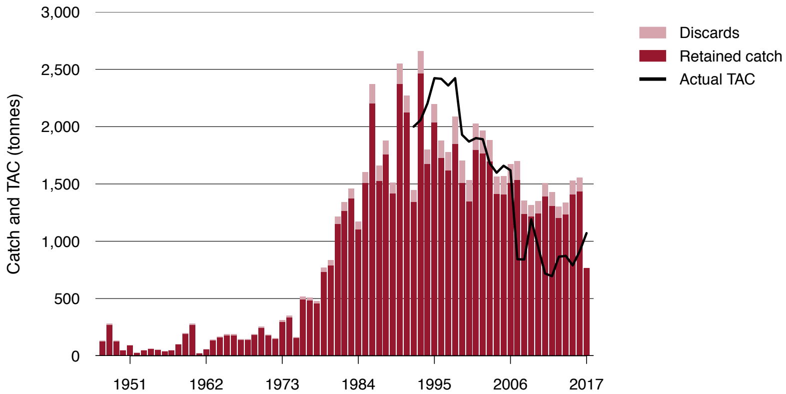
Catch history

Catch of eastern school whiting increased markedly from around 500 t in the mid 1970s to a peak of around 2,500 t in the early 1990s.

Historically, most of the total catch of eastern school whiting has come from New South Wales state waters. In recent years, the catch in these waters has decreased from historical levels of approximately 1,000 t per year to around 400 t. Since 2014, the Commonwealth catch has made up 50 per cent of the total catch (Day 2017a).

Recent catch has dropped off to levels less than half the historical peak, with Commonwealth-landed catch in the 2017–18 fishing season being 736 t (Figure 9.14). The weighted average discards between 2013 and 2016 were 85.49 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.14 Eastern school whiting annual catches (CTS, SHS and state combined) and fishing season TACs, 1947–2017



Notes: **TAC** Total allowable catch. Data up to 2016 include Commonwealth and state catches and discards; 2017 data do not include state catches and discards.
Source: Australian Fisheries Management Authority catch disposal records (2016–2017 catch data); CSIRO Integrated Scientific Monitoring Program (2009–2016 discard data)

Stock assessment

Eastern school whiting was managed as a tier 1 stock under the SESSF HSF in the 2017–18 fishing season. The 2009 assessment (Day 2010) was updated in 2017, and includes data up to the end of 2016 for catch, discards, CPUE, length, age and ageing error (Day 2017a). The spawning stock biomass predicted by the base-case was 49 per cent of the unfished spawning biomass ($0.49SB_0$). However, an alternative scenario estimated the spawning stock biomass to be 47 per cent of the unfished biomass ($0.47SB_0$), slightly below the target biomass ($0.48SB_0$). Considerable uncertainty was observed in the estimate of spawning biomass depletion (with asymptotic intervals between $0.3SB_0$–$0.7SB_0$; Day 2017a), (Figure 9.15). Similar uncertainty was also observed in the base-case scenario.

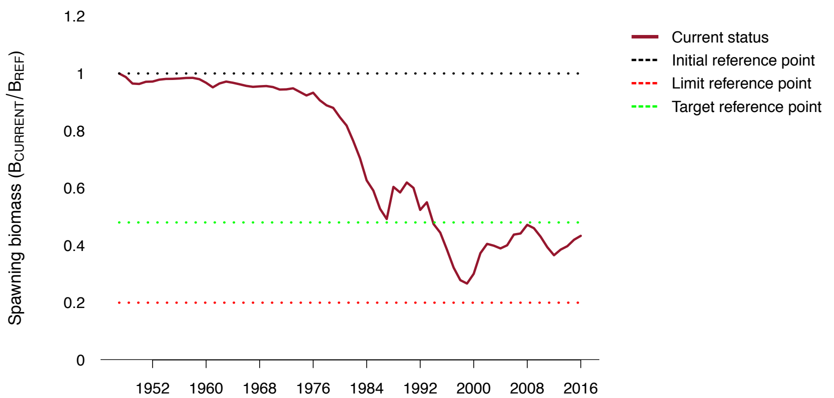
Day (2017a) reported on stock status projections under a range of 18 alternative scenarios. With the exception of one scenario, all estimated spawning biomass to be above the limit, with some estimating spawning biomass to be above the target ($0.39B_0$–$0.53SB_0$). The exception was the scenario that excluded catch north of Barrenjoey. This scenario estimated depletion to be $0.17SB_0$. However, this scenario was considered unrealistic given the low estimate of total mortality (0.43; Day 2017a).

The RBC predicted by the 2017 assessment was 1,606 t (Day 2017a), and this pertains to the 2018–19 season. However, the official RBC for the 2017–18 season was 1,660 t (AFMA 2017a). For clarity, this is referred to as a 'long-term RBC' because it was generated out of the previous 2009 assessment of Day (2010) and not the more recent assessment. Although the assessment is almost eight years old, it remains as the official assessment for the 2017–18 season. Using this long-term RBC of 1,660 t, a MYTAC of 986 t was set for the 2017–18 season (AFMA 2017a).

Estimates of eastern school whiting biomass have varied considerably between successive assessments, largely as a result of the variable and relatively late age of recruitment to the fishery (2–3 years) for this short-lived species. Previously, the life-span was estimated to be seven years (Day 2012). This was recently updated to nine years following a revised treatment in the way historical otoliths were prepared (Day 2017a). Previous RAG advice has also included concerns that biological and fishery information for eastern school whiting has been collected from a relatively small area of the fishery (primarily from the Lakes Entrance Danish-seine fleet) and may not be representative of the species distribution that extends from Queensland to western Victoria.

Eastern school whiting is caught in both New South Wales state waters (NSW) and Commonwealth waters. Historically, most of the total catch of eastern school whiting has come from NSW. Since 2014, the Commonwealth catch has made up 50 per cent of the total catch (Day 2017a).

FIGURE 9.15 Spawning stock biomass for eastern school whiting, 1945–2016



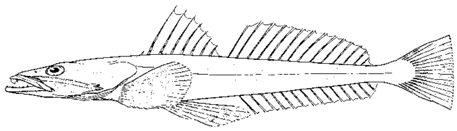
Notes: **B**$_{CURRENT}$ Current biomass. **B**$_{REF}$ Unfished biomass.
Source: Day 2017a

Stock status determination

The most recent integrated assessment (Day 2017a) forecasted spawning stock biomass to be 47 per cent of the unfished level at the beginning of 2018. While slightly below the target reference point (0.48SB_0), spawning stock biomass is estimated to be above the limit. As a result, school whiting is classified as **not overfished**.

For the 2017–18 fishing season, the total landed catch was 736.25 t, and the weighted average discards were 85.49 t. The landed catch and discards combined were 821.7 t, which is below the RBC estimated by the 2009 assessment and the RBC estimated by the more recent 2017 assessment. This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Flathead (*Neoplatycephalus richardsoni* and four other species)



Line drawing: Rosalind Poole

Stock structure

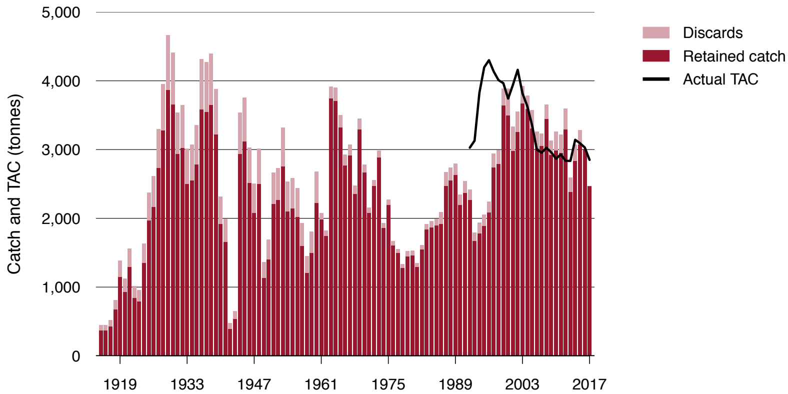
For SESSF management purposes, 'flathead' refers to a group of species. However, the catch is almost entirely tiger flathead (*Neoplatycephalus richardsoni*). The 'flathead' group includes sand flathead (*Platycephalus bassensis*) and, from 1996 onwards, southern or 'yank' flathead (*P. speculator*), bluespot flathead (*P. caeruleopunctatus*), and gold-spot or toothy flathead (*N. aurimaculatus*).

Tiger flathead is endemic to Australia. It is found on sandy or muddy substrates in continental-shelf and upper-slope waters from Coffs Harbour in northern New South Wales through Bass Strait and around Tasmania to south-east South Australia (Kailola, FRDC & BRS 1993). Most of the Australian commercial catch comes from depths between 50 and 200 m. The stock structure of tiger flathead is poorly understood. There is some evidence of morphological variation across the distribution range, with observed regional differences in growth, appearance and the timing of reproduction, especially off eastern Tasmania. No stock identification studies using genetic or other techniques have been undertaken. For assessment and management purposes, a single stock has been assumed throughout all zones of the SESSF.

Catch history

Flathead catch has been historically variable, generally fluctuating between 1,500 and 4,000 t per year. Catch in recent decades has been relatively stable at approximately 3,000 t (Figure 9.16). The Commonwealth-landed catch of flathead in the 2017–18 fishing season was 2,438 t, taken almost entirely by the CTS (Table 9.2). The weighted average discards between 2013 and 2016 were 134.3 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.16 Flathead annual catches (CTS and state combined) and fishing season TACs, 1915–2017



Notes: **TAC** Total allowable catch. Data for 2016 and 2017 do not include discards and state catch.
Source: Day 2016, 2017b; Australian Fisheries Management Authority catch disposal records (2016–2017 data)

Stock assessment

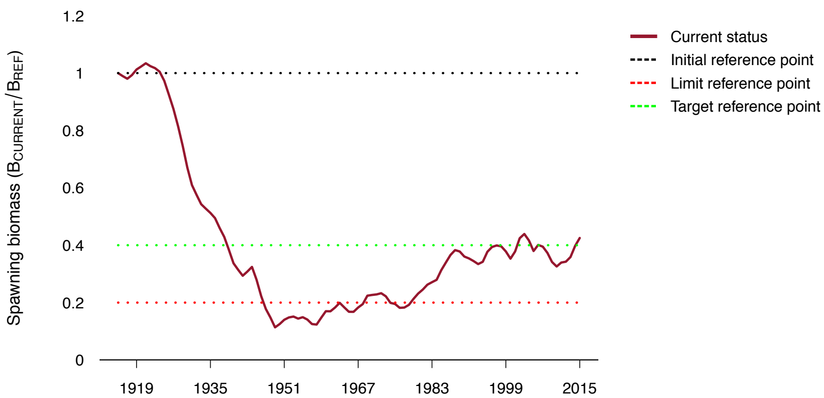
Flathead is managed as a tier 1 stock under the SESSF HSF. The flathead assessment is based on biological parameters relating to tiger flathead, which accounts for about 95 per cent of the flathead catch (Morison et al. 2013). However, the assessment and TAC include catches of all flathead species because the different species cannot be distinguished in historical data.

The most recent assessment was generated in December 2016 (Day 2016) and updated in January 2017 (Day 2017b). This assessment included updated data on catch, discards, CPUE, length and age data, and ageing error data for an additional three years (to 2015) (Day 2016). The assessment reports spawning biomass depletion as a percentage of its unfished level. Originally, in the December 2016 assessment, the spawning stock biomass was forecasted to be 43 per cent ($0.43SB_0$) for 2017. In the updated January 2017 assessment, the final base-case model forecast the 2017 spawning stock biomass to be 42 per cent of unfished spawning biomass ($0.42SB_0$; Figure 9.17), slightly above the target of 40 per cent ($0.4SB_0$). This was a reduction from the spawning stock biomass in 2014, which was 50 per cent of unfished spawning biomass (Day & Klaer 2013).

The biomass at maximum economic yield (B_{MEY}) target reference point for flathead has been set at $0.4SB_0$ (Morison et al. 2013), reflecting a more conservative estimate of biomass at maximum sustainable yield (B_{MSY}) from the 2013 assessment model ($0.32SB_0$), multiplied by a proxy of 1.2 B_{MSY}.

The RBC recommended for the 2017–18 season was 2,901 t (AFMA 2017a).

FIGURE 9.17 Estimated spawning stock biomass for flathead, 1913–2015



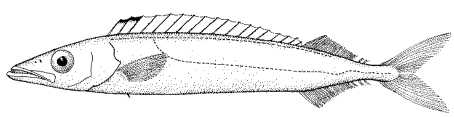
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Day 2016, 2017b

Stock status determination

The most recent assessment forecasts the spawning biomass of tiger flathead to be above the target reference point. As a result, the stock is classified as **not overfished**.

For the 2017–18 fishing season, the total landed catch was 2,438 t, and the weighted average discards were 134.3 t. The landed catch and discards combined were 2,572.3 t, which is below the RBC of 2,901 t. This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Gemfish, eastern zone (*Rexea solandri*)



Line drawing: Sharne Weidland

Stock structure

There are two biologically distinct stocks of gemfish in Australia: an eastern stock and a western stock, separated by a boundary on the western side of Bass Strait (Colgan & Paxton 1997; Moore, Ovenden & Bustamante 2017).

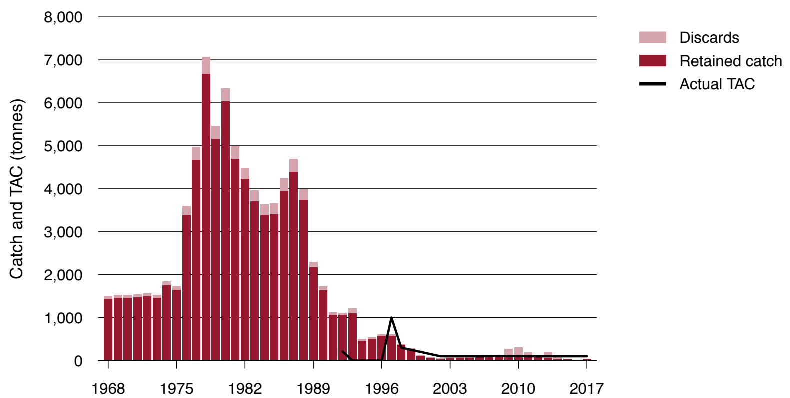
Catch history

Catch of gemfish (eastern zone) peaked in 1978 at more than 6,000 t. Catch decreased rapidly after 1987 (Figure 9.18).

The revised eastern gemfish stock rebuilding strategy (AFMA 2015a) states that eastern gemfish should be rebuilt to, or above, the limit reference point by 2027 (19 years from 2008). Projections to support this time frame rely on at least average levels of recruitment and assume that total removals are limited to the 100 t incidental catch allowance.

Commonwealth-landed catch in the 2017–18 fishing season was 32.2 t. The weighted average discards between 2013 and 2016 were 26.43 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.18 Gemfish annual catches (CTS, SHS and state combined) and fishing season TACs, eastern zone, 1968–2017



Notes: **TAC** Total allowable catch. Data for 2015–2017 do not include discards and state catch.
Source: Little & Rowling 2011; Australian Fisheries Management Authority catch disposal records (2015–2017 data); CSIRO Integrated Scientific Monitoring Program (2009–2014 discard data)

Stock assessment

Eastern gemfish is managed as a tier 1 stock under the SESSF HSF. The most recent assessment was completed in 2010 with data on catch and length frequency up to 2009 (Little & Rowling 2011). The base-case model estimated that the spawning stock biomass in 2009 was 15.6 per cent of the 1968 level ($0.156SB_0$; Figure 9.19). A preliminary update of the 2010 assessment in 2015 indicated that the spawning stock biomass in 2015 had decreased to 8.3 per cent ($0.083SB_0$), likely as a result of a lack of recruitment to the fishery (AFMA 2016c). Eastern gemfish is subject to a stock rebuilding strategy (AFMA 2015a) and an incidental catch allowance of 100 t.

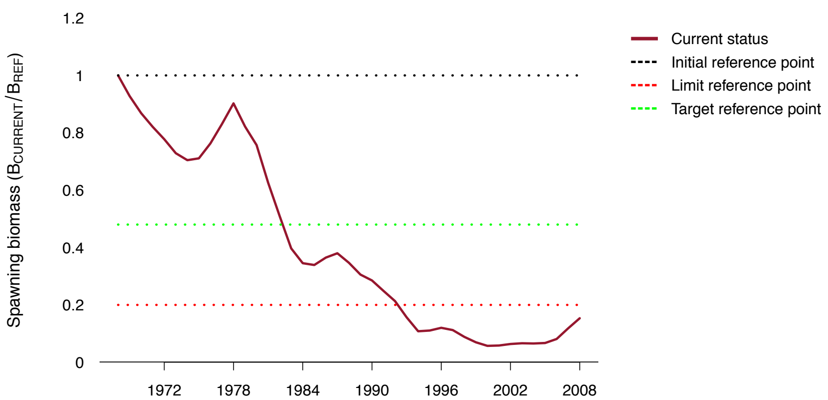
The 2010 assessment (Little & Rowling 2011) included projections of eastern gemfish biomass that were based on two scenarios: total catches of 100 t each year and zero catches each year. The projection for zero catch indicated that biomass may reach the limit reference point of $0.2SB_0$ by 2017. Projections for annual catches of 100 t saw biomass reach the limit reference point in 2025 (Little & Rowling 2011).

In 2011, an analysis of spawning potential ratio (SPR) based on the 2010 assessment (Little 2012) provided a measure of annual fishing mortality, expressed as the ratio of the spawning ability of the current stock to that of the unfished ('equilibrium') stock. The SPR analyses suggest high fishing mortality rates for eastern gemfish until the late 1990s, but much lower rates since 2002. The direct proxy for fishing intensity is determined by subtracting the SPR value from 1 (that is, 1 – SPR). The fishing intensity was above 0.5 in the late 1970s to 2000 but has declined to below 0.3 since 2002 (Little 2012).

For the 2016–17 fishing season, trawl (24 t) and non-trawl (6 t) landings (30 t in total) were comparable to the landings in the previous two seasons (37 t in 2014–15 and 30 t in 2015–16). Discards gradually decreased over the three years (since 2013). In 2015 and 2016, discards were 35 t and 7.5 t, respectively (Castillo-Jordán, Althaus & Thomson 2018). In 2013, discards were around 131 t—around double the landed catch at the time (Castillo-Jordán 2017). For the 2017–18 season, total removal was 58.63 t (32.2 t was landed, and weighted average discards were 26.43 t), which is below the 100 t incidental catch allowance. Stronger year-classes moving through the fishery and high discard rates may be a sign of increased recruitment and stock rebuilding; however, age-frequency data for 2014 show a strong truncation, with few mature fish (Thomson et al. 2015). The reasons for this are unclear; contributing factors may include industry efforts to avoid the species, unfavourable environmental conditions, or distribution of the fish in the population.

Moore, Ovenden & Bustamante (2017) estimated the effective population sizes for both the eastern and western stocks of gemfish using microsatellite markers. The results suggest that genetic drift is occurring in the eastern stock but not in the western stock. This suggests that the spawning biomass in the eastern stock has fewer effective genetically successful contributors between generations than expected. Hybridisation between the eastern and western populations was detected; however, there was no evidence of introgression of genetic material between the populations, suggesting that all hybrids are sterile. It is unclear at this stage what is contributing to the decreased effective population size in eastern gemfish.

FIGURE 9.19 Estimated spawning stock biomass of gemfish, eastern zone, 1965–2008



Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Little & Rowling 2011

Stock status determination

The most recent (2010) estimate of spawning stock biomass was 15.6 per cent of the 1968 level in 2008, which is below the limit reference point ($0.2SB_0$). Subsequent analyses indicate that this may have decreased to 8.3 per cent in 2015. As a result, eastern gemfish remains classified as **overfished**.

Total landed catch for the 2017–18 fishing season was 32.2 t, and the weighted average discards were 26.43 t. The landed catch and discards combined were 58.63 t, which is below the incidental catch allowance of 100 t. The recent catch history includes years when the incidental catch allowance was exceeded, indicating that management arrangements may not be sufficient to limit fishing mortality. Additionally, the level of fishing mortality that will allow the stock to rebuild if recruitment conditions are below average is unknown. The stock is therefore classified as **uncertain** if subject to overfishing.

Gemfish, western zone (*Rexea solandri*)

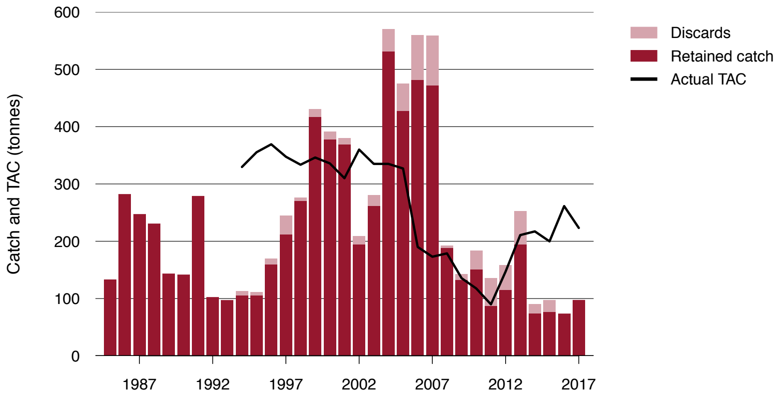
Stock structure

The eastern and western gemfish stocks in Australia are separated by a boundary on the western side of Bass Strait (Colgan & Paxton 1997; Moore, Ovenden & Bustamante 2017). Genetic studies indicate that gemfish throughout the western zone, including in the CTS and in the GABTS, is one biological stock (Moore, Ovenden & Bustamante 2017).

Catch history

Western gemfish is fished in both the GABTS and the CTS; however, the TAC applies only to the CTS. Western gemfish is targeted in the CTS, whereas incidental catches are more common in the GABTS. Western gemfish was targeted in the GABTS over four years from 2004 to 2007, and catches were as high as 532 t (Figure 9.20). In 2008, targeted fishing for western gemfish in the GABTS ceased and catches became largely incidental, partly due to low prices for gemfish and a key vessel leaving the fishery (AFMA 2010). Commonwealth-landed catch in the 2016–17 fishing season was 73.3 t. The weighted average discards between 2012 and 2015 were 63.07 t (Thomson & Upston 2016).

FIGURE 9.20 Gemfish annual catches (CTS and SHS) and fishing season TACs, western zone, 1985–2017



Notes: **TAC** Total allowable catch. Data for 2016 and 2017 exclude discards.
Source: Helidoniotis & Moore 2016; Australian Fisheries Management Authority catch disposal records (2016–2017 catch data)

Stock assessment

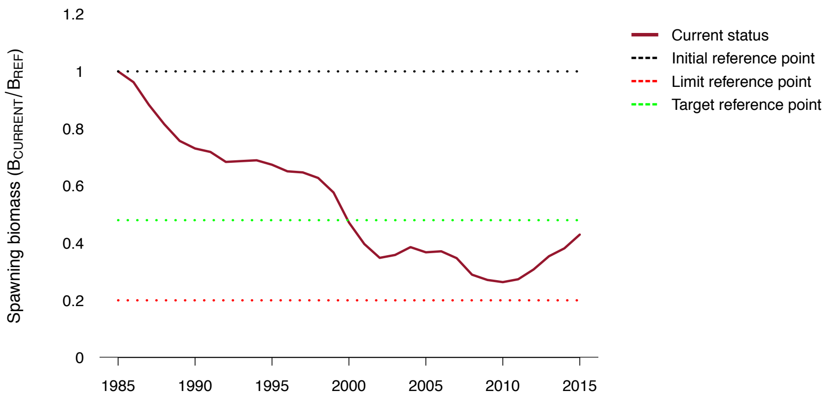
Management arrangements for western gemfish currently differ between the CTS and the GABTS. Western gemfish catch in the CTS is currently restricted by a three-year MYTAC. The GABTS has not moved to implement quota for western gemfish, instead relying on a catch trigger, which would manage the stock as a tier 1 stock under the SESSF HSF (2009) if catch exceeds 1,000 t over three years (AFMA 2014c). Western gemfish is managed as a tier 4 stock under the SESSF HSF (2009) when catches are less than 1,000 t over three years.

In 2017, the stock was managed as a tier 4 stock under the SESSF HSF (2009) for zones 40 and 50 in the CTS. The Great Australian Bight was not included. The current tier 4 analysis includes updated data for total catches, total discards and the standardised CPUE from the CTS only (zones 40 and 50). The recent four-year average CPUE (2013–2016) was above the target, and an RBC of 436.3 t was generated from the application of the tier 4 harvest control rule (Haddon & Sporcic 2017b). However, AFMA recommended an RBC of 200 t (AFMA 2017a).

There are uncertainties about the discard data—the amount of discarding varies between years, and the reporting of discards is uncertain (Helidoniotis & Moore 2016). High levels of discards have been estimated, and the inclusion of discards in the tier 4 analysis increases the CPUE. This in turn increases the RBC, although the increase is somewhat offset by removing the discards before setting a TAC.

The standardisation of the CPUE series for western gemfish accounts for vessel participation and gear variability. However, the varying discard rates in fishing grounds and the potential for hyperstability in this aggregating species (that is, the CPUE remains stable while stock biomass is changing) are not explicitly accounted for in the standardisation. If CPUE estimates are not indexing stock biomass, CPUE estimates may mislead the assessment (Haddon 2016b).

FIGURE 9.21 Estimated spawning stock biomass of gemfish, western zone, 1985–2015, for the CTS and the GABTS



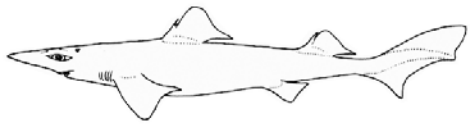
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Helidoniotis & Moore 2016

Stock status determination

The four-year CPUE average (2013–2016) was above the target reference point. The stock is therefore classified as **not overfished**.

For the 2017–18 fishing season, the agreed and actual TACs were 199 t and 223 t, respectively. The landed catch for the 2017–18 season was 77.4 t, and the weighted average discards were 52.03 t, giving a total of 129 t, which is below the estimated RBC of 200 t. This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)



Line drawing: FAO

Stock structure

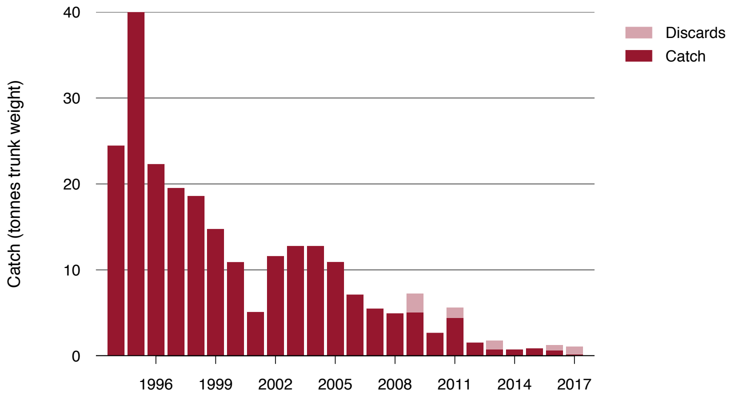
Gulper sharks are assessed as a multispecies stock comprising Harrisson's dogfish (*Centrophorus harrissoni*), Southern dogfish (*C. zeehaani*) and endeavour dogfish (*C. moluccensis*). Harrisson's dogfish is endemic to south-eastern Australia, from southern Queensland to south-eastern Tasmania, and adjacent seamounts. Southern dogfish is endemic to southern Australia, from Shark Bay in Western Australia to Forster in New South Wales (Williams et al. 2013). Endeavour dogfish has a broader range than Harrisson's and southern dogfish, extending beyond the boundaries of the SESSF and Australia. Within Australia, endeavour dogfish occurs along the west and east coasts, but is uncommon off the south coast (Last & Stevens 2009). Greeneye spurdog (*Squalus chloroculus*) is widely distributed in temperate and subtropical waters of most oceans, and may constitute a species complex (Last & Stevens 2009).

To support the revision of the AFMA *Upper-slope dogfish management strategy* (AFMA 2012) in 2013, Williams et al. (2013) investigated the relative carrying capacity and depletion of subpopulations of Harrisson's and southern dogfish. Results indicated different depletion levels in different areas, suggesting the separation of gulper sharks into several populations: a continental margin and a seamount population for Harrisson's dogfish; and eastern, central and western populations for southern dogfish.

Catch history

Estimated landings of gulper sharks (derived from liver oil production from 1994 to 2001) averaged about 20 t (trunk weight) from 1994 to 1998, with a peak of 40 t in 1995. Catches averaged about 10 t from 2002 to 2005 and have since declined. Despite gulper sharks being a no-take multispecies stock, landings for the trawl fishery have been recorded in recent years (Figure 9.22). This may reflect reporting errors. The level of reported catch has declined over the past decade, and was very low in the 2016–17 and 2017–18 fishing seasons (0.5 and 0.35 t, respectively). There is also the potential for unreported or underestimated discards, based on the large degree of overlap of current fishing effort with the core range of the species. Low levels of mortality can pose a risk for such depleted populations.

FIGURE 9.22 Gulper shark annual catch and discards for the SESSF (all sectors), 1994–2017



Notes: Estimated catch of upper-slope gulper sharks from 1994 to 2001 is based on liver oil quantity. Catch history is compiled using data from various sources.

Stock assessment

Gulper sharks have very low productivity due to a slow growth rate, late age at maturity and low fecundity. These life-history characteristics place them at higher risk of rapid depletion at low levels of fishing effort, and make their recovery slow once stocks are depleted (Daley, Stevens & Graham 2002; Simpfendorfer & Kyne 2009; Williams et al. 2013). Williams et al. (2013) have shown that gulper sharks undertake day–night migrations across their depth range, from relatively deep daytime residence depths (to 1,000 m) to shallower night-time feeding depths (up to 200 m), rendering them susceptible to capture over a wide depth range. Williams et al. (2013) also found that the geographic distribution of fishing during periods of high fishing effort in the CTS (1984–2011), demersal and auto-longline fisheries (1992–2010), Commonwealth gillnet fisheries (1997–2010) and New South Wales state fisheries coincides with the most depleted areas of Harrisson's and southern dogfish. Post-capture survival of gulper sharks in the trawl sector is low; most gulper sharks are dead when the net is hauled. In the auto-longline sector, post-capture survival is potentially higher (subject to fishing gear soak time and handling practices); a preliminary study by CSIRO estimated post-capture survival at 60–93 per cent for the 70 southern dogfish tagged and released in the study (Williams et al. 2013).

Gulper sharks were historically targeted because they have high squalene (liver oil) content. The resulting historical depletion of gulper sharks off the east coast is well documented (Graham, Andrew & Hodgson 2001; Wilson et al. 2009). Graham, Andrew & Hodgson (2001) reported declines in CPUE of 95.8–99.9 per cent between research trawl surveys conducted in 1976–77 and 1996–97 for greeneye spurdog, and endeavour, Harrisson's and southern dogfish on the New South Wales upper slope. Williams et al. (2013) derived depletion estimates for the identified subpopulations of Harrisson's and southern dogfish, expressed as a percentage of the initial relative carrying capacity. For Harrisson's dogfish, the continental margin population was estimated to be at 11 per cent of carrying capacity (range 4–20 per cent) and the seamount population at 75 per cent (range 50–100 per cent). For southern dogfish, the eastern population was estimated to be at 11 per cent of carrying capacity (range 6–19 per cent) and the central population at 16 per cent (range 8–33 per cent).

No estimate could be derived for the western population of southern dogfish because of limited data availability. Williams et al. (2013) confirmed that, in some areas, large reductions in abundance had resulted from quite low levels of fishing effort.

AFMA released the *Draft upper slope dogfish management strategy* in 2009, which protected several areas of known occurrence of dogfish, and implemented daily catch and trip limits (AFMA 2009a). The strategy was reviewed by Musick (2011) and found to be inadequate to ensure recovery of Harrisson's, southern and endeavour dogfish, and greeneye spurdog, with fishing mortality still exceeding estimated sustainable levels. The strategy was subsequently revised in 2012, following research on depletion rates of upper-slope dogfish subpopulations (Williams et al. 2013), with a recovery objective of rebuilding Harrisson's and southern dogfish stocks to 25 per cent of their original carrying capacity. Williams et al. (2013) examined the amount of core habitat area for Harrisson's and southern dogfish that would be protected under a proposed closure network designed to meet this objective. Under the closure network, it is estimated that, in AFMA-managed waters, 25 per cent of the core habitat of Harrisson's dogfish on the continental shelf and slope, 16.2 per cent of the core habitat of the eastern population of southern dogfish and 24.3 per cent of the core habitat of the central population of southern dogfish would be protected (from trawling and/or demersal longline fishing). These closures were implemented in February 2013. Additional closures were subsequently implemented on the Tasmanian seamounts (Queensland, Britannia and Derwent Hunter) overlaying the Murray and Freycinet Commonwealth marine reserves (areas that allow access to line fishing) (AFMA 2014c).

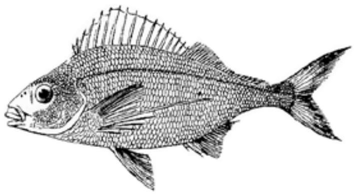
On 30 May 2013, the then Minister for Sustainability, Environment, Water, Population and Communities listed Harrisson's dogfish and southern dogfish under the EPBC Act as threatened species in the conservation-dependent category. The minister noted that both species have experienced severe historical declines following overfishing, and are subject to recovery plans that provide for management actions to stop their decline and support their recovery. Measures to further reduce fishing mortality include a combined trigger limit of three Harrisson's dogfish and/or southern dogfish; a zero retention limit for greeneye spurdog, and Harrisson's, southern and endeavour dogfish; and guidelines for handling practices. In 2014, a research and monitoring workplan was developed to establish methods for monitoring the rebuilding of dogfish abundance.

Stock status determination

In the absence of any evidence of recovery to above the limit reference level, gulper sharks remain classified as **overfished** because of the substantial depletion of Harrisson's and southern dogfish in areas of southern and eastern Australia.

Although it has been estimated that the closures implemented in 2013 will protect 16.2–25 per cent of the core distribution areas of these species, no evidence has yet been obtained showing rebuilding, and the effect of the closures remains to be seen. As a result, gulper sharks are classified as **uncertain** with respect to the level of fishing mortality. Resolution of stock structure may result in one or more of the subpopulations being classified as not subject to overfishing.

Jackass morwong (*Nemadactylus macropterus*)



Line drawing: FAO

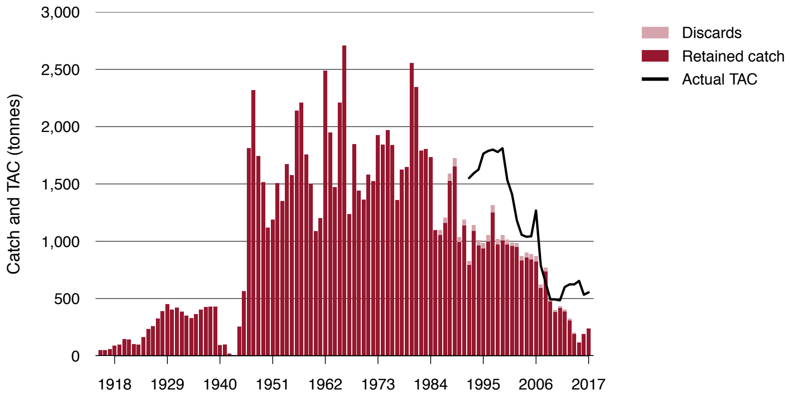
Stock structure

Jackass morwong is distributed around the southern half of Australia (including Tasmania), New Zealand, and St Paul and Amsterdam islands (Indian Ocean); and off south-eastern South America and southern Africa. It occurs to depths of 450 m and, in Australian waters, is most abundant between 100 and 200 m. Genetic studies have shown no evidence of separate stocks in Australian waters, but found that New Zealand and Australian stocks are distinct (Elliott & Ward 1994). Although analysis of otolith microstructure found differences between jackass morwong from southern Tasmania and those off New South Wales and Victoria, it is unclear whether such differences indicate separate stocks (Morison et al. 2013). Nonetheless, it is assumed for the purposes of the stock assessment that there are separate stocks of jackass morwong in the eastern (New South Wales and eastern Victoria) and western zones (western Tasmania and western Victoria) (Morison et al. 2013). Catches of jackass morwong are also reported from the GABTS (Chapter 11), but this stock is currently managed separately from the western stock.

Catch history

Catches of jackass morwong peaked at more than 2,500 t in the mid 1960s and have declined since the 1980s. During the past five years, they have continued to decline and have been less than 500 t per year (Figure 9.23). Eastern catches have declined in response to reduced TACs. Commonwealth-landed catch in the 2017–18 fishing season was 184.7 t. The weighted average discards between 2013 and 2016 were 29.51 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.23 Jackass morwong annual catches (CTS, SHS and state combined) and fishing season TACs, eastern and western stocks combined, 1915–2017



Notes: **TAC** Total allowable catch. Data for 2015–2017 do not include discards and state catches.
Source: Tuck et al. 2015; Australian Fisheries Management Authority catch disposal records (2017 catch data)

Stock assessment

Separate integrated stock assessment models are undertaken for the eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks. The eastern and western stocks were assessed in 2011 (Wayte 2012), 2013 (Wayte 2014) and 2015 (Tuck et al. 2015).

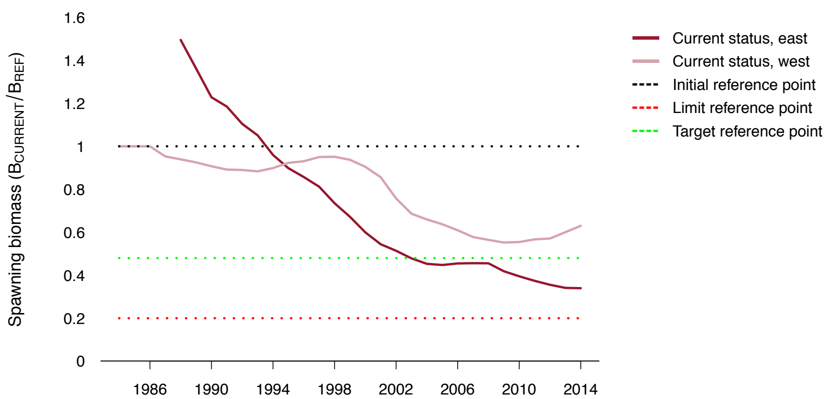
Assessments of western jackass morwong are uncertain because only sporadic age data are available, length compositions are based on a very low number of sampled fish, and catches in the west are low (only 23 t was reported in logbooks in 2015–16) (AFMA 2015d). The 2015 assessment predicted the spawning stock biomass to be $0.69B_0$ in 2016 (compared with $0.68B_0$ in 2012), which is above the target reference point of $0.48B_0$ (Figure 9.24).

Previous stock assessments for eastern jackass morwong indicated a gradual recovery from below the limit reference point ($0.2SB_0$) in the early 2000s. The most recent assessment (Tuck et al. 2015) predicted spawning biomass to be $0.365B_0$ in 2016 (compared with $0.4B_0$ in 2012), which is between the limit reference point ($0.2B_0$) and the target reference point ($0.48B_0$).

Model estimates of recruitment for the eastern stock since the late 1980s have been consistently below the average predicted by the stock–recruitment relationship (AFMA 2011). In 2011, a new base-case assessment was undertaken for the eastern stock that involved a change in productivity (a 'regime shift'), attributed to long-term oceanographic changes (Wayte 2013). The assessment for the eastern stock uses separate stock–recruitment relationships before and after 1988, with lower recruitment after 1988. Compared with older assessments, the 2012 and 2015 assessments provided a better fit to the data, although they remained sensitive to the value of natural mortality and the choice of the last year for which recruitment was estimated. Management strategy evaluation predicted a lower risk of the biomass falling below the limit reference point if total removals were consistent with the RBCs derived from the assessments that assumed this recruitment shift (Morison et al. 2013). The adoption of a 'regime shift scenario' in the stock assessment resulted in a more optimistic spawning biomass depletion ($0.2B_0$) in 2011 to $0.37B_0$ (37 per cent of the 1988 equilibrium biomass) in 2016.

The implication for management of adopting the regime shift has been examined (Wayte 2013). It was noted that the RBC generated by the application of the tier 1 harvest control rule resulted in a higher RBC under the regime shift scenario than under the 'no shift' scenario (358 t under the regime shift scenario and 92 t under the no shift scenario; Wayte 2013). Conversely, the long-term RBC for the regime shift scenario was almost half that of the no shift scenario (488 t for regime shift and 1053 t for no shift). Although the regime shift scenario is more precautionary in the long term, it is less so in the short term if in reality there has been no regime shift. The analyses of Wayte (2013) provide evidence for a regime shift that satisfied criteria presented in Klaer et al. (2015) that the regional fisheries oceanography for jackass morwong has changed, and it was plausible that this may have impacted its productivity. The RBC for the 2017–18 season was 551 t (AFMA 2017a).

FIGURE 9.24 Estimated spawning stock biomass for eastern (1988–2014) and western (1984–2014) stocks of jackass morwong



Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass. Biomass estimates are available for the eastern stock from 1915 to 1987. However, pre-1988 estimates are not presented for the eastern stock because the new regime shift base case resets the reference biomass to the unfished equilibrium biomass in 1988.
Source: Tuck et al. 2015

Stock status determination

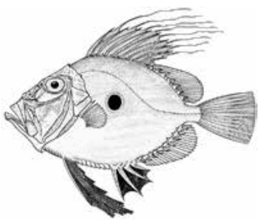
For western jackass morwong the most recent assessment (Tuck et al. 2015) estimates that spawning biomass depletion in 2016 was 66 per cent ($0.66SB_0$), which is above the target reference point of $0.48SB_0$. Based on logbook data, catch of the western stock (54.5 t in 2017–18) is below the RBC of 249 t estimated by the 2015 assessment. This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The western stock is classified as not overfished and not subject to overfishing.

For eastern jackass morwong, acceptance of a recruitment shift in the assessment resulted in a decrease in the estimate of recent depletion from close to the limit reference point closer to the target reference point. Based on logbook data, catches of the eastern stock were 107 t in 2017–18. The catches are below the RBC of 314 t estimated in the 2015 assessment. This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is classified as not overfished and not subject to overfishing.

For the 2017–18 fishing season, the total landed catch was 184 t, and the weighted average discards were 28.96 t. The landed catch and discards combined were 213 t, which is below the RBC of 551 t. Based on the best available information, jackass morwong is classified as **not overfished** and **not subject to overfishing**.

Climate changes are considered to have resulted in a decrease in stock biomass for the eastern jackass morwong. Although, the regime shift scenario fitted the data better than a scenario of no change in productivity, a full exploration of other hypotheses to explain conflicts within the input data have not yet been fully explored. This presents a knowledge gap regarding status determination in the presence of climate change.

John dory (*Zeus faber*)



Line drawing: Rosalind Poole

Stock structure

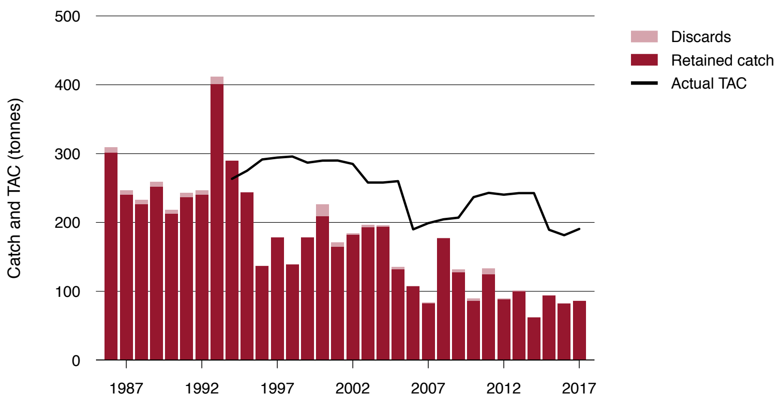
John dory inhabits coastal and continental-shelf waters of Australia, the western Indian Ocean, the eastern Atlantic Ocean, the Mediterranean Sea, Japan and New Zealand. In southern Australia, its distribution stretches from Moreton Bay in southern Queensland to Cape Cuvier in Western Australia, with a limited distribution in eastern Bass Strait. In recent years, most of the SESSF john dory catch has been taken off New South Wales and eastern Victoria (Morison et al. 2013). John dory in the SESSF is considered to constitute a single stock for assessment and management purposes.

Catch history

The catch of john dory averaged between 200 and 300 t from 1986 to 1995, peaking at about 400 t in 1993. Catches have since decreased and have been below 200 t per year since 2012 (Figure 9.25). Commonwealth-landed catch in the 2017–18 fishing season was 82.6 t. The weighted average discards were 1.83 t (Castillo-Jordán, Althaus & Thomson 2018).

John dory is infrequently targeted in the SESSF. Most of the catch was historically taken as byproduct by trawlers targeting other shelf species, such as redfish and flathead. Because most john dory catches are not targeted, it is considered a 'secondary species' rather than a target species, and is managed to the default B_{MSY} proxy target of $0.4B_0$.

FIGURE 9.25 John dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2017



Notes: **TAC** Total allowable catch. Data for 2014–2017 do not include discards and state catch.
Source: Haddon & Sporcic 2017b; Australian Fisheries Management Authority catch disposal records (2014–2017 catch data)

Stock assessment

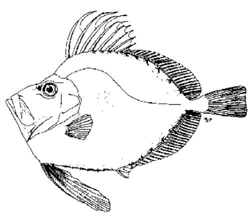
John dory was managed as a tier 3 stock under the SESSF HSF in 2017. The assessment accounted for catches in zones 10–80 of the SESSF (Castillo-Jordán 2017), which comprise the GABTS, the CTS and the East Coast Deepwater Trawl Sector. The analyses consisted of a yield-per-recruit model and catch-curve analysis, and was an update to the yield analyses presented in Thomson (2014). Yield and total mortality estimates are provided using data from selectivity-at-age, length-at-age, weight-at-age, age at maturity and natural mortality. The 2017 assessment included new ageing data from 2010 to 2016. These data are considered to be more representative than those used in previous assessments. For example, the 2011 assessment consisted of inadequate sampling over the winter period, which may have influenced the results.

Total mortality was estimated from catch curves constructed from length-frequency information. The assessment estimated an equilibrium fishing mortality rate (F_{CURR}) of 0.036, which was below the target fishing mortality reference point (F_{spr40} = 0.126) that would achieve a biomass of $0.4B_0$. This indicates that the current biomass is likely to be above this target. There is no historical evidence to suggest that the stock has previously fallen below the target. Application of the tier 3 harvest control rule to the outputs of the 2017 assessment, and using the $0.4B_0$ target, generated an RBC of 485 t for the 2018–19 season. This is higher than the RBC estimated by the 2014 assessment, largely as a result of the new ageing data (the RBC for 2017–18 is officially 203 t according to AFMA [2017a]). The lower RBC was due to the stock being estimated to be more depleted (Castillo-Jordán 2017; Tuck 2014). This variability in biomass depletion demonstrates that the tier 3 produced variable results. In another report on standardised CPUE, the results for john dory in zone 10–20 indicated that that portion of the stock is in decline (Haddon & Sporcic 2017a). The 2017–18 TAC was 175 t (AFMA 2017a).

Stock status determination

The latest estimate of fishing mortality was below the target, indicating that fishing mortality is at a level that is unlikely to reduce the stock below the biomass limit reference point. In addition, recent catches are low relative to historical levels.
For the 2017–18 fishing season, the total landed catch was 82.6 t, and the weighted average discards were 1.83 t, giving a total of 84.43 t, which is below the RBC of 203 t. As a result, the stock is classified as **not subject to overfishing** and **not overfished**.

Mirror dory (*Zenopsis nebulosa*)



Line drawing: FAO

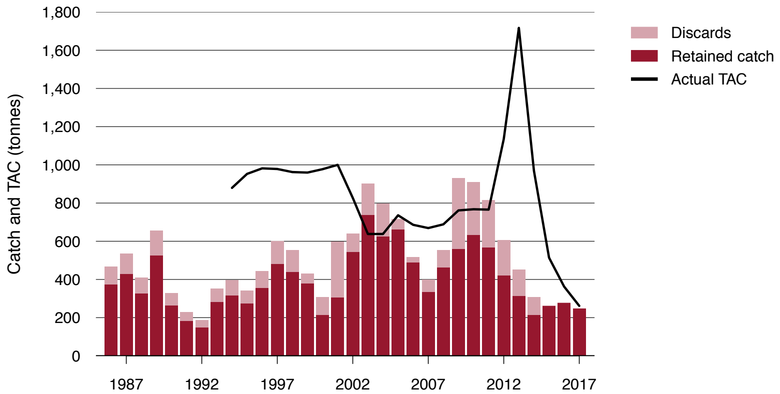
Stock structure

Mirror dory is found throughout the southern Pacific Ocean at depths of 30–800 m. A single stock of mirror dory in the SESSF area is assumed for management purposes (Morison et al. 2013). To make it easier to assess the stock, the stock has been split into eastern and western management units.

Catch history

Most of the mirror dory catch is byproduct in the CTS and is mainly caught east of Bass Strait. The catch of mirror dory has ranged between 200 and 700 t per year (Figure 9.26). Commonwealth-landed catch in the 2017–18 fishing season was 220 t. The weighted average discards between 2013 and 2016 were 16.64 t in the east and 6.71 in the west (Castillo-Jordán 2017).

FIGURE 9.26 Mirror dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2017



Notes: **TAC** Total allowable catch. Data for 2017 do not include discards and state catch.
Source: Haddon & Sporcic 2017b; Australian Fisheries Management Authority catch disposal records (2017 catch data)

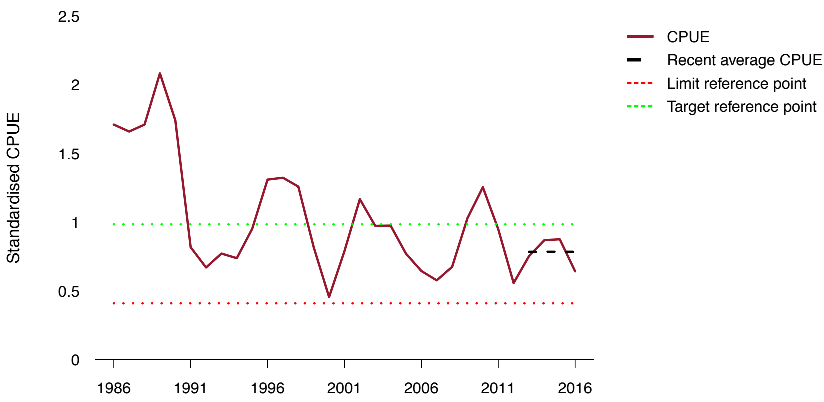
Stock assessment

Mirror dory is currently managed as a tier 4 stock under the SESSF HSF, with the most recent analyses completed in 2017 (Haddon & Sporcic 2017b). The stock was subdivided into an eastern unit (zones 10–30) and a western unit (zones 40–50) for analyses. Application of the tier 4 harvest control rule to the standardised CPUE series without discards for the eastern unit resulted in an RBC of 200 t. Application of the tier 4 harvest control rule to the standardised CPUE series with discards resulted in an RBC of 111 t. Note that these RBCs pertain to the 2018–19 season.

Application of the tier 4 harvest control rule to the standardised CPUE series without discards for the western unit resulted in an RBC of 122 t (for the 2018–19 season). Application of the tier 4 harvest control rule to the standardised CPUE series with discards for the western unit resulted in an RBC of 67.82 t (Haddon & Sporcic 2017b) for the 2018–19 season.

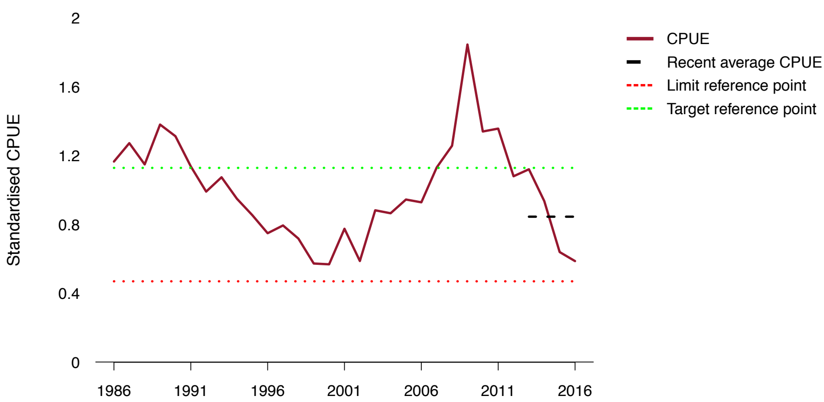
The total RBC for the eastern and western units combined for the 2017–18 season was 198 t for the east and 104 t for the west (AFMA 2017d), giving a total of 302 t (AFMA 2017a,d). For both the western (Figure 9.27) and eastern (Figure 9.28) units, recent average CPUE has been above the limit but below the target reference point. In the eastern stock, the RAG has noted that the CPUE and catch levels have been declining (AFMA 2017a).

FIGURE 9.27 Standardised CPUE for western mirror dory, 1986–2016



Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

FIGURE 9.28 Standardised CPUE for eastern mirror dory, 1986–2016



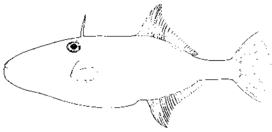
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

The 2017 tier 4 analyses indicate that the recent average CPUE for the eastern and western units are above their respective limit reference points, and the stock is classified as **not overfished**.

For the 2017–18 fishing season, the RBC was 198 t in the east and 104 t in the west (AFMA 2017d); the combined RBC was 302 t (AFMA 2017a). Total landed catch was 220.3 t, and the total weighted discards for east and west combined were 23.35 t (Castillo-Jordán, Althaus & Thomson 2018). The landed catch and discards combined were 243.65 t, which is below the RBC of 302 t. This indicates that the fishing mortality rate in 2017–18, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Ocean jacket (predominantly *Nelusetta ayraud*)



Line drawing: FAO

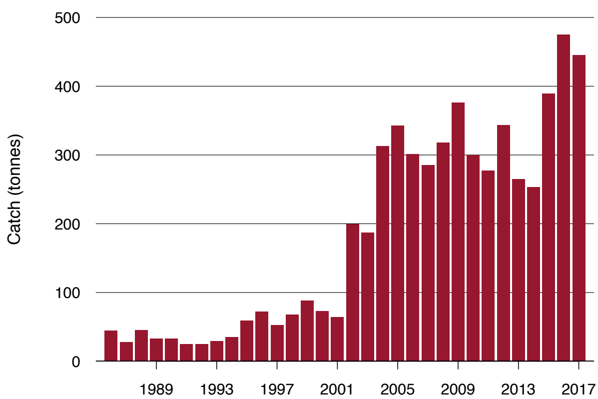
Stock structure

The ocean jacket stock comprises chinaman leatherjacket, which makes up most of the catch, and unspecified leatherjackets. Little is known about the biological structure of this multispecies stock. Ocean jacket taken in the GABTS is assessed separately (Chapter 11).

Catch history

Total catch of ocean jacket remained stable, at around 50 t, between 1986 and 2001 (Figure 9.29). Since then, ocean jacket has been an important non-quota byproduct species in the SESSF, with current catch levels exceeding those of many quota species. Catch peaked in 2016 at 475 t. Commonwealth-landed catch in the 2017–18 fishing season was 216.4 t.

FIGURE 9.29 Ocean jacket catch in the CTS and the SHS, 1986–2017

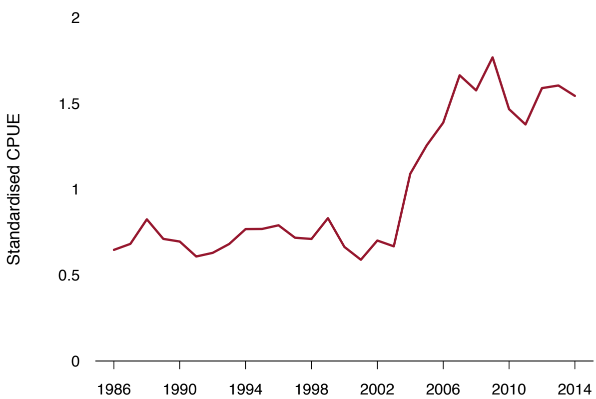


Note: Catch includes chinaman leatherjacket and unspecified leatherjackets.
Source: Sporcic 2015; Australian Fisheries Management Authority catch disposal records (2016–2017 catch data)

Stock assessment

Ocean jacket is caught in the CTS (zones 10–50) and in zones 82 and 83 in the Great Australian Bight. Only catches from the CTS are considered here. Historical catch data indicate substantial variations in ocean jacket abundance off south-eastern Australia in the 1920s and 1950s (Miller & Stewart 2009). Ocean jacket is a relatively short-lived species (six years), reaching maturity within 2–3 years and exhibiting large cyclical changes in abundance (Miller & Stewart 2009). A standardised CPUE series shows a similar trend to landings, suggesting that abundance of ocean jacket increased after 2003 and has gradually declined since 2013 (Figure 9.30; Haddon & Sporcic 2017a). There continues to be uncertainty over discarding of this species in the CTS and the GHTS, and discards have not been recently reported for this species.

FIGURE 9.30 Standardised CPUE for ocean jacket, 1986–2014

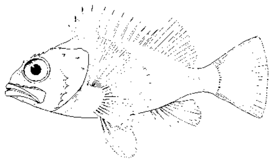


Notes: **CPUE** Catch-per-unit-effort. There is no tier 4 assessment for ocean jacket, and so there are no target and limit reference points.
Source: Sporcic & Haddon 2016

Stock status determination

There is no formal stock assessment for ocean jacket. The standardised CPUE index increased substantially between 2003 and 2007, and remains high (Haddon & Sporcic 2017a). Ocean jacket is therefore classified as **not overfished**. Despite recent high catches, CPUE has remained high compared with historical levels, and therefore ocean jacket is classified as **not subject to overfishing**.

Ocean perch (*Helicolenus barathri, H. percoides*)



Line drawing: FAO

Stock structure

Ocean perch is managed as a single stock that includes two species: the inshore reef ocean perch (*Helicolenus percoides*) and the offshore bigeye ocean perch (*H. barathri*). Ocean perch stock structure is uncertain, but there is probably an east–west structuring of stocks (Morison et al. 2013). Reef ocean perch and the bigeye ocean perch have been assessed separately since 2009, but a single TAC is set for the two species. Based on the depth of capture and logbook records, most of the landed ocean perch is considered to be bigeye (offshore) ocean perch.

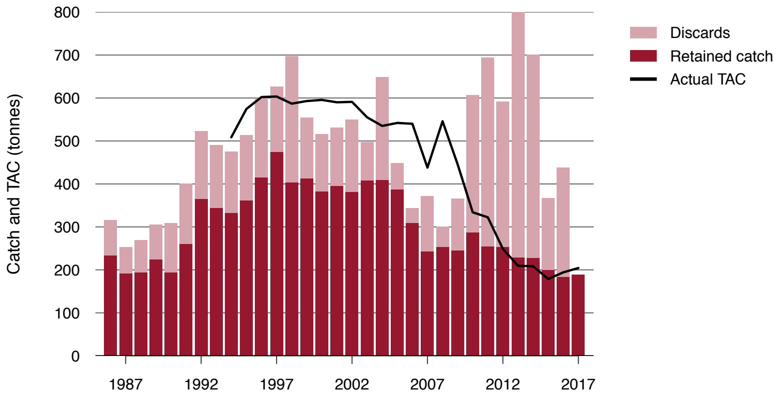
Catch history

Bigeye ocean perch has been a significant part of trawl catches since the continental-slope trawl fishery developed in the late 1960s (Morison et al. 2013). Total landed catch (both species) of ocean perch since the 1970s has generally been between 200 and 400 t, peaking at 475 t in 1997. The Commonwealth-landed catch in the 2017–18 fishing season was 169 t (Figure 9.31).

Most reef ocean perch (more than 85 per cent in recent years) are discarded because of their smaller size (Upston & Thomson 2015). The weighted average discards of reef ocean perch between 2013 and 2016 were 247.91 t (Castillo-Jordán, Althaus & Thomson 2018). Discard rates for bigeye ocean perch are much lower, with 37.19 t estimated to have been discarded in 2016 (Castillo-Jordán, Althaus & Thomson 2018).

Since 2000, annual landings of bigeye ocean perch by New South Wales fishers have been around 15–36 t, and for reef ocean perch the landings have been around 5–23 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.31 Total ocean perch (reef and bigeye) annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2017



Notes: **TAC** Total allowable catch. Data for 2017 exclude discards and state catch.
Source: Haddon & Sporcic 2017b; Australian Fisheries Management Authority catch disposal records (2017 catch data)

Stock assessment

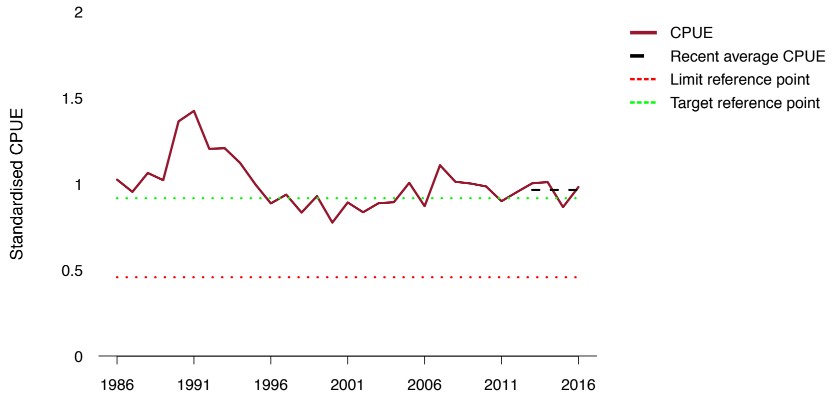
Bigeye and reef ocean perch were managed as a tier 4 stock under the SESSF HSF. A B_{40} (B_{MSY} proxy) target reference point is applied to both species (Morison et al. 2013).

The RBC for this combined stock in the 2017–18 fishing season was an extension of the three-year RBC generated in 2014–15 (AFMA 2013e). This was 385 t, comprising 283 t for bigeye ocean perch and 102 t for reef ocean perch. Because of the high discards, the RBC is not used when calculating the TAC for the basket stock; total RBC for the basket stock is based on the offshore ocean perch only (Dan Corrie, AFMA, pers. comm.). The TAC set by the AFMA Commission for the 2017–18 fishing season was 190 t, covering both species.

Although discards of inshore ocean perch are high and variable, and have substantial influence on CPUE values, recent discards are well estimated by the Integrated Scientific Monitoring Program, and the RAG advised that the inclusion of discards provided a more reliable index of abundance (AFMA 2013b). As such the standardised CPUEs for ocean perch include discards.

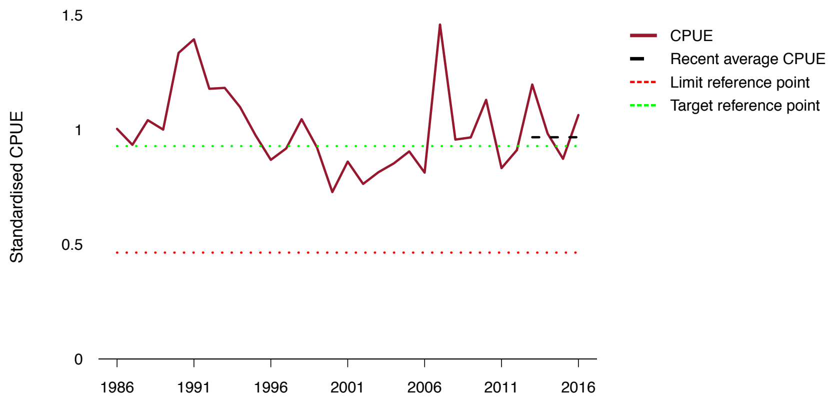
The CPUE standardisation and tier 4 HCR were re-run in 2017 with updated data (Haddon & Sporcic 2017b). The four-year average CPUE (2013–2016) for bigeye ocean perch was above the target reference point, resulting in an RBC of 344.74 t. The four-year average CPUE (2013–2016) for reef ocean perch was between the limit and the target, and resulted in an RBC of 247.9 t.

FIGURE 9.32 Standardised CPUE, including discards, for reef (inshore) ocean perch, 1986–2016



Notes: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

FIGURE 9.33 Standardised CPUE for bigeye (offshore) ocean perch, 1986–2016



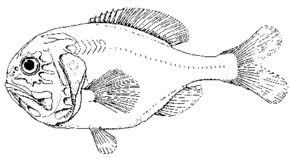
Notes: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

The recent average CPUE was above the limit for both species (Haddon & Sporcic 2017b). As such, both species and the combined stock are considered to be **not overfished**.

We know that discard rates are not the same for both species, but because we do not have species-level landings data it is not possible to compare total fishing mortality at the species level with the species-level RBC. Given that we cannot determine whether the fishing mortality rate applied to each species is likely to deplete that species to a level below its biomass limit reference point, the fishing mortality status for the stock is classified as **uncertain**.

Orange roughy (*Hoplostethus atlanticus*)

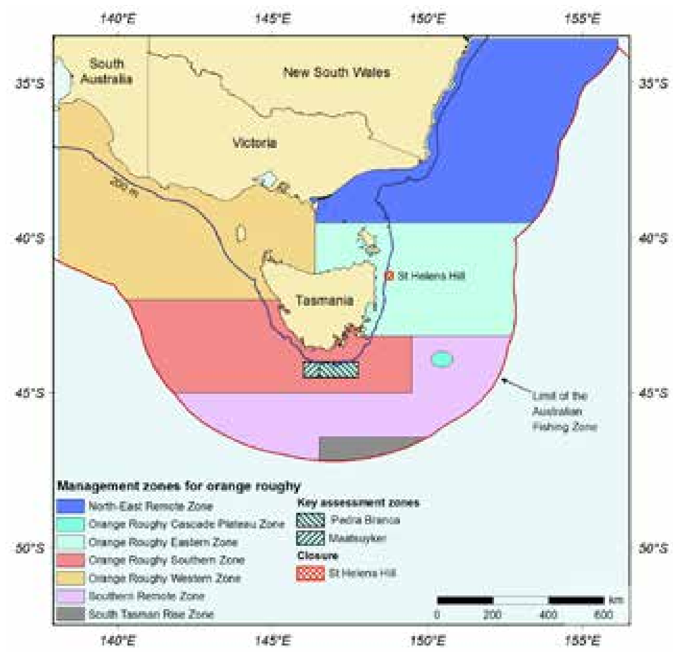


Line drawing: Rosalind Poole

Stock structure

Currently orange roughy in the CTS is broken up into the following management zones: Cascade Plateau, eastern zone, southern zone, western zone, South Tasman Rise, north-east remote zone, and southern remote zone. Outside the CTS a stock of orange roughy occurs in the Great Australian Bight (and therefore that stock is not included in this chapter). A study on genetic variation in orange roughy (Gonçalves da Silva, Appleyard & Upston 2012) examined the variation of a large number of loci using genetic techniques that have the power to detect low levels of genetic differentiation. The study concluded that orange roughy within the Australian Fishing Zone form a single genetic stock, but identified some differentiation between Albany/Esperance, Hamburger Hill (in the Great Australian Bight) and south-eastern Australia. It was noted that the amount of genetic exchange needed to maintain genetic homogeneity is much less than the amount needed for demographic homogeneity, and that residency or slow migration may result in separate demographic units despite genetic similarity (Morison et al. 2013). Orange roughy on the Cascade Plateau has distinct morphometrics, parasite populations, size and age composition, and spawning time, and is considered to be a separate management unit within the southern remote zone (AFMA 2014f). The fishery is managed and assessed as a number of discrete regional management units (Figure 9.34).

FIGURE 9.34 Management zones for orange roughy in the SESSF



Overall catch history

Orange roughy was historically targeted in aggregations around seamounts, mainly at depths from 600 m to about 1,300 m. The first aggregation was discovered off Sandy Cape, western Tasmania, in 1986 (Smith & Wayte 2004). Several other non-spawning aggregations were discovered in 1986 and 1988, producing annual landings ranging from 4,600 to 6,000 t. The discovery of a large spawning aggregation on St Helens Hill and elsewhere off eastern Tasmania in 1989 resulted in significant growth of the fishery, with declared catches exceeding 26,000 t in 1989 and 40,000 t in 1990, making this the largest and most valuable finfish fishery in Australia at the time (Morison et al. 2013). Catches declined steadily after 1990, reaching low levels between 2000 and 2005. Following indications of decreasing CPUE and availability, the introduction of management zones and TACs prevented further increases in catches of orange roughy (Smith & Wayte 2004). Individual catch histories for the Cascade Plateau, eastern, southern and western orange roughy zones are shown in Figures 9.35, 9.36, 9.38 and 9.39.

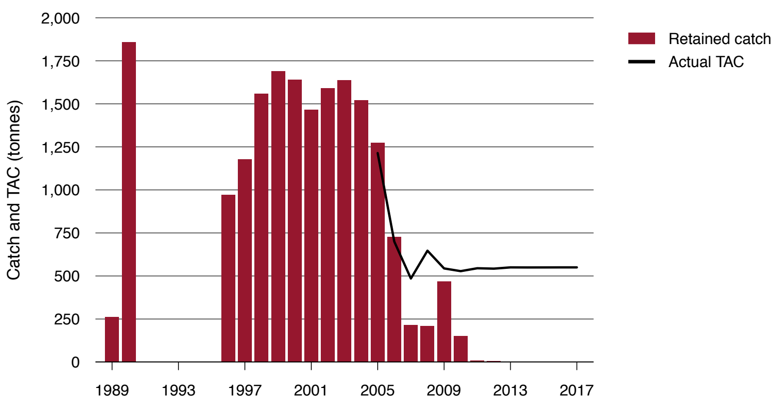
In October 2006, orange roughy was listed as conservation-dependent under the EPBC Act and placed under the Orange Roughy Conservation Programme (ORCP). The ORCP was replaced by the Orange Roughy Rebuilding Strategy (ORRS) in 2015 (AFMA 2015b), the primary objective of which is to return all orange roughy stocks to levels at which the species can be harvested in an ecologically sustainable manner. Management actions to minimise fishing mortality and support rebuilding include deepwater closures, targeted fishing for orange roughy stocks that are above the limit reference point of 20 per cent of the unfished spawning biomass, restricting effort by limiting entry to existing fisheries, and ongoing research and monitoring to support stock assessments.

Orange roughy, Cascade Plateau

Catch history

Orange roughy on the Cascade Plateau is the only orange roughy fishery assessed in the CTS that is not estimated to have been depleted to below the limit reference point; this fishery shows a somewhat different catch trend from the depleted fisheries. Catch of orange roughy on the Cascade Plateau peaked at 1,858 t in 1990. No catch was taken between 1991 and 1995. Catches have been below 10 t in recent years, despite the TAC remaining at 500 t, reflecting negligible effort in the fishery. The landed catch was 0.3 t in 2014–15, 2 t in 2015–16 and 0 t in 2016–17. Reported landed catch from the Cascade Plateau in the 2017–18 season was zero (Figure 9.35); discard estimates were not reported (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.35 Orange roughy catch (CTS), Cascade Plateau, 1989–2017



Note: **TAC** Total allowable catch.
Source: Various, including Australian Fisheries Management Authority catch disposal records

Stock assessment

A requirement of the ORCP was to maintain the spawning biomass of orange roughy on the Cascade Plateau at or above $0.6B_0$. In 2015, the ORCP was replaced by the ORRS (AFMA 2015b). The ORRS adopted the standard target reference point of $0.48B_0$ and the limit reference point of $0.2B_0$, in line with the default settings of the SESSF HSF (AFMA 2014d). This revised target also applies to the Cascade Plateau stock.

Spawning aggregations of Cascade Plateau orange roughy have been assessed using acoustic survey abundance indices since 2003. These assessments rely on the single largest acoustic estimate of biomass each year, rather than trends in time series, because spawning aggregations on the Cascade Plateau are highly variable and have shown no discernible trends in volume or estimated biomass over time (Morison et al. 2013). Because fishing effort has been low, and therefore new data are lacking, the stock has not been formally assessed since 2009.

The 2006 assessment estimated female spawning biomass to be 73 per cent of the unfished biomass (Wayte & Bax 2007). Because the stock was assessed to be above the $0.6B_0$ reference point that was in place at the time, application of the SESSF HSF tier 1 harvest control rules allowed the setting of TACs to enable fish-down towards the reference point. Spawning aggregations did not form in 2007 and 2008, and the TAC was undercaught for the first time in the fishery's history in 2007 (151 t caught out of a TAC of 500 t) and 2008 (121 t caught out of a TAC of 700 t).

Projections from the most recent formal stock assessment for orange roughy on the Cascade Plateau, in 2009, predicted that, if the 315 t long-term RBC was fully caught by 2011, the spawning biomass of the stock would be at $0.64SB_0$ in 2011 (Morison et al. 2012). Taking into account the lower catch levels of 2007 and 2008, the assessment suggested that a TAC of 500 t would maintain the stock at $0.63SB_0$ in 2011. Noting low fishing effort and a lack of new data, AFMA has continued to set an annual TAC of 500 t. This stock was scheduled for an assessment in 2014, but the assessment was postponed because there were no new catch or acoustic data.

Stock status determination

The most recent assessment (2009) predicted that the 2011 spawning stock biomass of Cascade Plateau orange roughy would be at 63–64 per cent of unfished levels ($0.63SB_0$–$0.64SB_0$) if the long-term RBC of 315 t was fully caught by 2011. Recent catches have been less than 10 t (zero in 2016–17 and 2017–18). On the available evidence, the biomass is still likely to be significantly above the limit reference point. As such, the stock is classified as **not overfished**. Given the zero catch in 2017–18, the stock remains classified as **not subject to overfishing**.

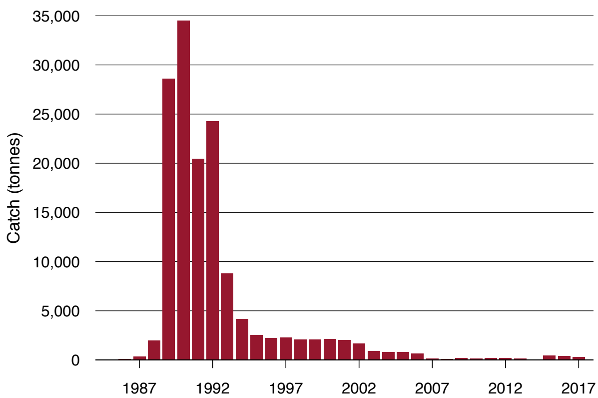
Orange roughy, eastern zone

Catch history

The eastern, southern and western orange roughy fisheries show similar catch trends. The eastern zone has supported higher cumulative catches than the southern and western zones, producing a reported catch of 76,714 t from 1989 to 1992 (Figure 9.36).

Along with the southern and western zones, the eastern zone was declared overfished and placed under the ORCP in 2006. Orange roughy catch in the eastern zone was limited to incidental catch allowances, to allow for unavoidable catches made while targeting other species. Most of the historical fishing grounds for orange roughy deeper than 700 m were also closed to trawling in January 2007 (AFMA 2006). Targeted fishing for orange roughy in the eastern zone recommenced in the 2015–16 fishing season following acoustic surveys and an updated stock assessment. The Commonwealth-landed catch in the 2017–18 fishing season was 296.7 t, lower than in the 2016–17 fishing season catch of 363 t (Figure 9.36). The weighted average discards between 2013 and 2016 were 6.62 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.36 Orange roughy catch (CTS), eastern zone, 1985–2017



Source: Haddon 2017a; Australian Fisheries Management Authority catch disposal records (2017 catch data)

Stock assessment

The 2006 assessment for the eastern zone (Wayte 2006) estimated that spawning stock biomass had declined to 10 per cent of unfished levels ($0.1SB_0$), following the large catches taken in the late 1980s and early 1990s (Figure 9.37). The base-case estimate of spawning biomass from this assessment was less than 15,000 t. The 2006 model estimates of biomass were primarily driven by the substantial decline in abundance of larger and older orange roughy in the fishery.

Compensatory increases in the biological productivity of this stock appear to have occurred as a density-dependent response to the substantial decline in orange roughy abundance during the 1990s. Age at 50 per cent maturity has decreased by up to two years, from 30 to 28 years for males, and length-standardised fecundity is estimated to have increased by 73 per cent between 1987 and 2010 (Pitman, Haddy & Kloser 2013).

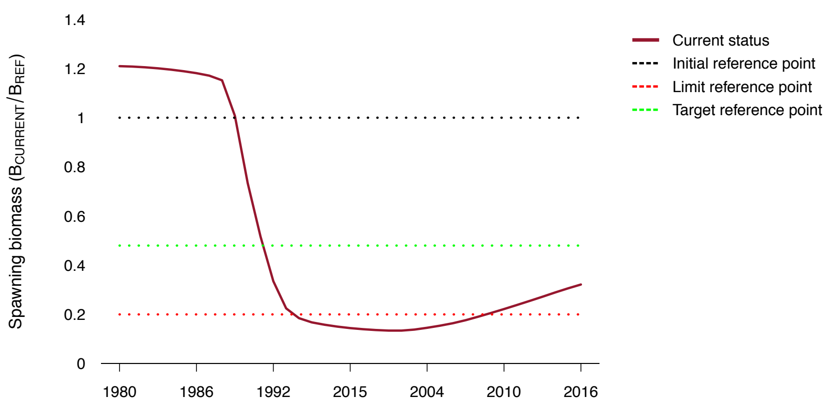
The proportion of the population that spawns each year is uncertain and variable. It was estimated to have increased from 54 per cent in the late 1980s to 71 per cent in the early 1990s (Morison et al. 2013); the most recent estimates were 70 per cent in 2009 and 52 per cent in 2010 (Kloser et al. 2011). As a result, the reproductive potential (a function of spawning biomass, sex ratio, age at maturity and other factors) of the stock in 2010 was estimated to be 32 per cent of that at unfished levels (Kloser et al. 2011).

The biomass of spawning aggregations of eastern orange roughy in 2010 was estimated to be 25,400 t (95 per cent confidence interval [CI] 18,000–32,800 t), based on the combined results of two acoustic surveys at St Helens Hill and St Patricks Head. Assuming that the 2010 proportion of the population spawning (52 per cent) is representative of the entire mature stock, the total biomass in 2010, using the 25,400 t acoustic estimate corrected for spawning fraction, was estimated by Kloser et al. (2011) to be 48,800 t (95 per cent CI 21,100–76,600 t). The difference between the 2006 estimates of biomass (below $0.2B_0$) and the 2010 direct acoustic estimates of B_{CURR} indicated stock rebuilding.

An assessment update was attempted in 2011 using updated commercial catch data for the eastern and southern (Pedra Branca only) zones from 1985 to 2010, the acoustic biomass indices, an egg-production estimate of spawning biomass from 1992 and age-composition data from spawning aggregations since 1992. However, there was a conflict between the catch-at-age declines and increasing acoustic indices that could not be reconciled, and no base case was recommended for applying the tier 1 harvest control rule. However, the RAG did agree that the results of acoustic surveys provided evidence of stock rebuilding (AFMA 2013d).

Using new catch, acoustic and age-composition data, the 2011 assessment was updated in 2014. It predicted the 2015 female spawning biomass (SB_{2015}/SB_0) to be at 26 per cent, with a predicted unfished female spawning biomass of 38,727 t (Upston et al. 2014; Figure 9.37).

FIGURE 9.37 Estimated female spawning stock biomass for orange roughy, eastern zone, 1980–2016



Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Haddon 2017a

The stock structure assumption used in the eastern stock assessment model is based on a single stock covering the entire eastern zone, plus orange roughy from the Pedra Branca seamount in the southern zone, because a proportion of southern zone orange roughy are hypothesised to migrate to the main spawning grounds in the eastern zone (St Helens Hill or St Patricks Head) to spawn in winter (Upston et al. 2014).

As part of the 2014 assessment, an analysis (Markov chain Monte Carlo simulation) was undertaken to explore the probabilities around different model outcomes. This analysis produced biomass and RBC estimates similar to the maximum posterior density estimates from the model. The advice to AFMA was a recommended RBC of 381 t for 2015–16, 512 t for 2016–17 and 647 t for 2017–18. Given the long-lived nature of orange roughy, an expectation that there would be no large year-to-year changes in age structure, and the fact that CPUE is not an adequate indicator of changes in stock status for aggregating stocks, the advice to AFMA did not recommend breakout rules. However, the RAG advice recommended that an acoustic survey be undertaken within the multiyear RBC period to provide additional information for an updated assessment in 2017.

The AFMA Commission subsequently agreed to a MYTAC of 500 t for the 2015–16, 2016–17 and 2017–18 fishing seasons. Because the stock assessment was for the eastern zone stock plus the Pedra Branca seamount (in the southern zone), it was necessary to allocate the TAC between the eastern and southern zone management units. The allocation was based on historical effort data and historical stock assessment allocations, and resulted in a 7 per cent allocation to the southern (Pedra Branca) zone and a 93 per cent allocation to the eastern zone. This resulted in an eastern zone agreed TAC of 465 t for the 2016–17 fishing season, of which 363 t was landed.

An acoustic survey was undertaken in 2016 with the main finding being the detection of a large biomass of orange roughy at St Helens Hill at the start of the survey. This biomass of orange roughy persisted, although it seemed to get deeper and less abundant by the end of the survey (Kloser, Green & Sherlock 2016).

The most recent integrated assessment for orange roughy was completed in 2017 using data up to 2016 (Haddon 2017a). The assumed stock structure is a combination of eastern zone (primarily St Helens Hill and St Patricks Head) and Pedra Branca from the southern zone. The assessment indicates that the stock continues to recover however, the model is highly dependent upon the assumptions made about natural mortality and the steepness of the stock-recruitment relationship.

Two base-case models were developed. The first model used a natural mortality of 0.04 and steepness of 0.75 ($M = 0.04$, $h = 0.75$), with an estimated spawning biomass of 34 per cent. The second, less productive, model used a natural mortality of 0.036 and steepness of 0.6 ($M = 0.036$, $h = 0.6$), and resulted in an estimated spawning biomass of 30 per cent. A form of risk evaluation was conducted to test the consequences of selecting an incorrect model between two base-case models. The risk assessment involved taking the projected catches generated from one model and substituting them into the other model—that is, the catches from the more productive base-case model were substituted into the less productive model to test the consequences of erroneously selecting overestimated catches (overestimated catch scenario), and the catches from the less productive model were substituted into the more productive model to test the consequences of erroneously underestimating catches (underestimated catch scenario). Results from the overestimated catch scenario indicated a cessation of recovery and ongoing depletion from about 2027. In the underestimated catch scenario, the stock recovery would gradually recover and possibly reach the target of $0.48B_0$ by 2050 (Haddon 2017a).

Stock status determination

Based on the 2017 assessment, which estimates that eastern zone orange roughy has rebuilt to above the limit reference point, eastern zone orange roughy is classified as **not overfished**.

For the 2017–18 fishing season, the agreed TAC was 465 t, the actual TAC was 584.4 t and the RBC was 500 t (AFMA 2017a). Total landed catch was 296.7 t, and the weighted average discards were 6.62 t. The landed catch and discards combined were 303.32 t, which is below the RBC of 500 t. This indicates that the fishing mortality rate in 2017–18, if maintained, is unlikely to deplete the stock to a level below its biomass limit reference point. Based on this information, eastern zone orange roughy is classified as **not subject to overfishing**.

Orange roughy, southern and western zones

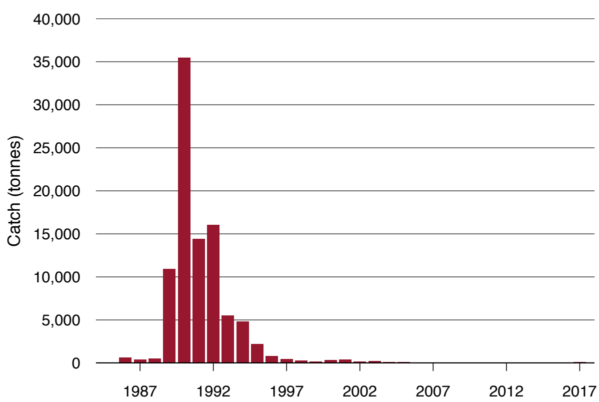
Catch history

The southern and western orange roughy fisheries show similar catch trends to the eastern zone fishery, with a brief period of high catches when fishing first commenced (1989–1992 for the eastern and southern zones; 1986–1988 for the western zone) and low catches thereafter (Figures 9.36, 9.38 and 9.39). The peak catch in the southern zone was 35,430 t in 1990, with subsequent catches of 14,426 t in 1991 and 16,054 t in 1992 (Figure 9.38). The western zone produced a peak historical catch of 5,128 t in 1987 (Figure 9.39).

The southern and western zone stocks were declared overfished and placed under the ORCP in 2006. Targeted commercial fishing ceased at this time and catch was limited by incidental catch allowances.

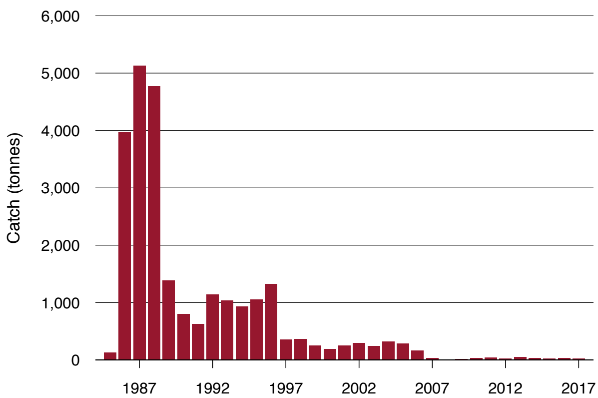
In the 2017–18 fishing season, 53.4 t of orange roughy was landed from the southern zone and 22.5 t from the western zone. For 2017–18, the incidental catch allowances were 66 t for the southern zone and 60 t for the western zone (AFMA 2017b). Weighted average discards (2013–2016) in the western zone were 1.59 t and in the southern zone were 0.91 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.38 Orange roughy catch (CTS), southern zone, 1985–2017



Source: Various, including Australian Fisheries Management Authority catch disposal records

FIGURE 9.39 Orange roughy catch (CTS), western zone, 1985–2017



Source: Various, including Australian Fisheries Management Authority catch disposal records

Stock assessment

The assessment for the southern zone has not been updated since 2000. Standardised catch-per-shot abundance indices, using only data from vessels that had regularly fished this zone, estimated the abundance in 2001 to be 7 per cent of unfished levels ($0.07SB_0$) (Wayte 2002). Because there has been no update to the stock assessment, the RAG continues to advise an RBC of zero.

In response to the updated stock assessment for eastern zone orange roughy in 2017, which included orange roughy from Pedra Branca in the southern zone, the total TAC for the southern zone for the 2017–18 season was 66 t (35 t for Pedra Branca and 31 t for incidental catch).

The western zone was most recently assessed in 2002. The 2002 assessment projected that there was a greater than 90 per cent probability that the 2004 biomass would be less than 30 per cent of the 1985 biomass. In 2017, a preliminary age-based surplus production model was applied to the stock (Haddon 2018), which indicated a potential recovery in the stock, with a spawning biomass depletion of 32 per cent estimated for 2015 ($0.32\ SB_0$). This preliminary model was not recommended for use in management, but the improvement in spawning biomass it indicated suggested the potential for further sampling and exploration of the condition of the stock. No evidence has been found of spawning aggregations in this region. A comparison of the age composition in 1994–96 with that in 2004 showed a marked reduction in the modal age, indicating a heavily fished stock, although it is uncertain whether all the otolith samples were from the same stock.

Noting recovery of the eastern zone orange roughy stock, and a long period of low TACs in the southern and western zones, the RAG considered that the southern and western zones may be showing some level of recovery (AFMA 2015g). However, the RAG continues to advise an RBC of zero.

Stock status determination

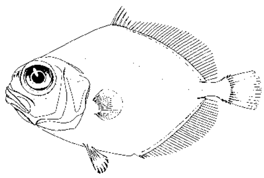
The previous assessments of orange roughy in the southern and western zones (Wayte 2002) estimated that the stocks were substantially depleted, to below $0.2B_0$. Based on this information, the southern and western zones stocks remain classified as **overfished**.

However, given the time that has passed since stocks were fished and the recovery that has been detected in the eastern stock, it is possible that similar rebuilding has occurred in the southern and western zones. This suggests increasing uncertainty around the biomass status of the southern and western zone orange roughy stocks, and the preliminary age-based surplus production model for the western zone stock supports this. In the absence of additional information on stock status, it is possible that future status determination may be classified as uncertain with regard to biomass.

Given the low recent catches in the southern and western zones, and the closure of most areas deeper than 700 m to trawling, orange roughy in the southern and western zones is classified as **not subject to overfishing**.

Unloading the catch
AFMA

Smooth oreodory (Cascade Plateau and non–Cascade Plateau (*Pseudocyttus maculatus*)



Line drawing: FAO

Stock structure

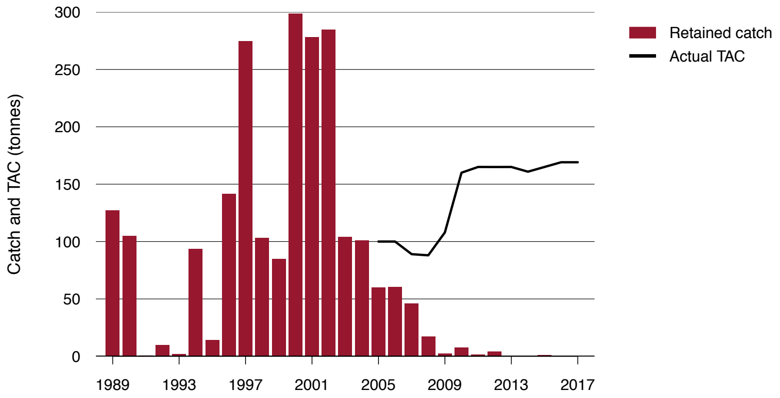
Little is known about the stock structure of smooth oreodory. For assessment and management purposes, smooth oreodory is treated as a single stock throughout the SESSF, excluding the Cascade Plateau and South Tasman Rise, which are managed as separate stocks.

Catch history

Smooth oreodory is targeted in aggregations around seamounts below 600 m, in the same areas as orange roughy. Oreodories have a lower value than orange roughy and historically were not the preferred species. This resulted in some discarding during the 1990s and 2000s, the period of peak orange roughy fishing.

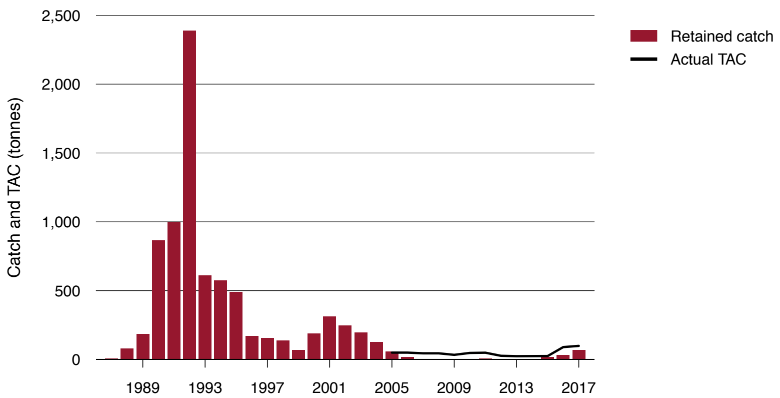
Catches of smooth oreodory on the Cascade Plateau reached maximum levels of 275–300 t in 1997, 2000, 2001 and 2002, but have otherwise generally remained below 100 t (Figure 9.40). There was zero catch in both the 2016–17 and 2017–18 seasons. In contrast, annual smooth oreodory catches in other areas exceeded 500 t from 1990 to 1995, reaching almost 1,000 t in 1991 and peaking at 2,390 t in 1992 (Figure 9.41). In these areas, smooth oreodory catches were negligible from 2007 until the 2015–16 season, when 21 t was landed. The catch increased to 48 t in the 2016–17 season and to 55.2 t in the 2017–18 season. The weighted average discards between 2013 and 2016 were negligible for the Cascade stock (0.07 t) and non-existent for non-Cascade stocks (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.40 Smooth oreodory annual catches (CTS) and fishing season TACs, Cascade Plateau, 1989–2017



Note: **TAC** Total allowable catch.
Source: Haddon 2012; Australian Fisheries Management Authority logbook records

FIGURE 9.41 Smooth oreodory annual catches (CTS) and fishing season TACs, non–Cascade Plateau, 1987–2017



Note: **TAC** Total allowable catch.
Source: Haddon 2012; Australian Fisheries Management Authority logbook records

Stock assessment

Previously, both Cascade Plateau and non–Cascade Plateau stocks were managed as tier 4 stocks under the SESSF HSF. The Cascade Plateau CPUE standardisation has since been discontinued due to low catch levels (less than 10 t per year since 2009). The RAG recommended that the tier 4 analyses be suspended until catches increase above this level (AFMA 2013a).

The most recent CPUE standardisation for smooth oreodory in the Cascade Plateau, indicated that the standardised CPUE has likely been above the target level since 1996 (Haddon 2012). However, this estimate has become increasingly uncertain as a result of the low level of catches (less than 10 t per year) since 2009. The RAG advice has been that recent fluctuations in CPUE for this species are more probably due to uncertainty resulting from low catches, and do not reflect changes in biomass (Morison et al. 2013). Catches of less than 10 t were considered to have little effect on stock biomass (AFMA 2013a).

A tier 5 approach was recently introduced to the SESSF HSF (Haddon et al. 2015). This approach uses a depletion-based stock reduction analysis (DBSRA) and a weight-of-evidence approach to develop an RBC. This approach was applied to the non–Cascade Plateau smooth oreodory stock in 2015 (Haddon et al. 2015). Using this method, the yield level predicted to be sustainable is dependent on the median value selected for the expected state of depletion in the final year of the analysis. Using the DBSRA in this manner for the non–Cascade Plateau smooth oreodory stock, and assuming it is at the target depletion level of $0.48B_0$, it was determined that a catch of 90 t should prevent the stock from falling below the limit reference point of 20 per cent ($0.2B_0$) and would keep the stock above $0.35B_0$ at least 90 per cent of the time.

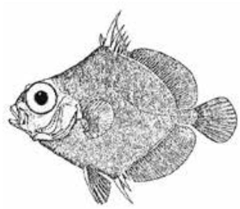
It was considered plausible that the stock was not below a depletion level of $0.48B_0$ because almost all the stock is deeper than 700 m, which has been closed to fishing since 2007 (Haddon & Sporcic 2017b). An RBC of 90 t in the non–Cascade Plateau for the 2016–17 fishing season was recommended by the RAG. The RAG also recommended that the large change–limiting rule not be applied when calculating the TAC because the previous TAC of 23 t was arbitrary and there were no sustainability issues.

Stock status determination

The low catches since 2002 and more recently since 2009 means that CPUE is unlikely to be a reliable indicator of abundance for the Cascade Plateau stock. However, it is unlikely that recent low catches have resulted in any substantial change in abundance. Similarly, although the DBSRA does not estimate biomass, it assumed that the current depletion level of the non-Cascade Plateau stock is $0.48B_0$, which is considered plausible, given that almost all the stock is deeper than 700 m and not currently available to the fishery. Therefore, the smooth oreodory (Cascade Plateau and non–Cascade Plateau) stocks are both classified as **not overfished**.

The analyses for non–Cascade Plateau smooth oreodory generated an RBC of 90 t. Catch of non–Cascade Plateau smooth oreodory was 55.2 t in 2017–18, which was below the RBC of 90 t (AFMA 2017a). Catches have not exceeded this level in the recent past, indicating that annual fishing mortalities rates have not been at a level expected to deplete the population below its limit reference point. As in all years since 2012, catch of Cascade Plateau oreodory was 0 t in 2017–18, and therefore had no impact on the stock biomass. Given the level of catch and negligible discards (<0.5 t), both stocks of smooth oreodory are classified as **not subject to overfishing**.

Other oreodories (warty—*Allocyttus verrucosus*, spikey—*Neocyttus rhomboidalis*, rough—*N. psilorhynchus*, black—*A. niger*, other—*Neocyttus* spp.)



Line drawing: FAO

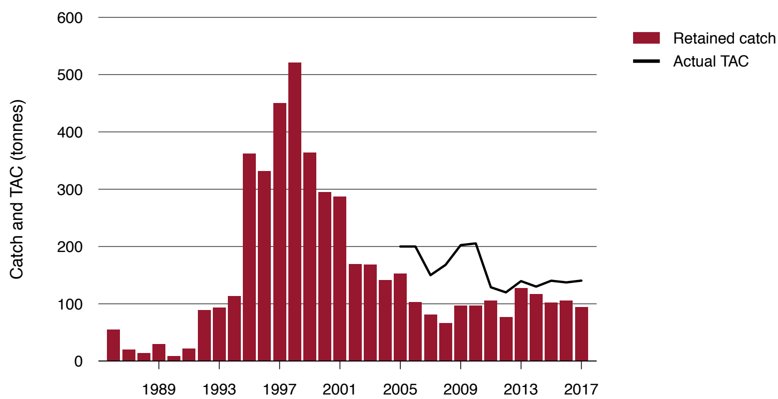
Stock structure

The mixed oreodory multispecies quota includes warty oreodory, spikey oreodory, rough oreodory and black oreodory. Nothing is known about the stock structure of the oreodory species in this multispecies quota. They are benthopelagic species that are caught mainly below 600 m. For assessment and management purposes, they are treated as a single stock in the SESSF (Morison et al. 2013).

Catch history

Catch peaked in 1990 at 980 t, but has since declined to around 100 t in recent years and was 89 t in 2017–18 (Figure 9.42).

FIGURE 9.42 Other oreodories annual catches (CTS) and fishing season TACs, 1986–2017



Notes: **TAC** Total allowable catch.
Source: Haddon & Sporcic 2017b; Australian Fisheries Management Authority logbook records

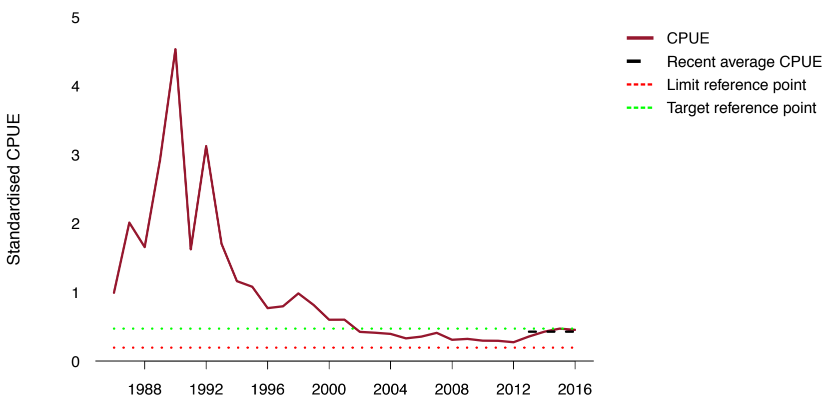
Stock assessment

Other oreodories have historically been caught as a byproduct of fishing for orange roughy. Closure of substantial areas deeper than 700 m (except the Cascade Plateau) to all trawling in 2007 under the ORCP (AFMA 2006) reduced the opportunity to target oreodories.

Other oreodories were managed as a tier 4 stock under the SESSF HSF in 2017 using catch-and-effort data to 2016 (Haddon & Sporcic 2017b). The analyses were based only on data from areas currently open to the fishery and used the revised target reference period of 1993–2001 (Haddon 2013b; Morison et al. 2013). Two CPUE standardisations were considered: with and without discards. The inclusion of discards influences the CPUE trend, particularly over the target period (1993–2001). The inclusion of discards in the standardisation increased the average CPUE in the last four years (2013–2016) to above the target (average = 0.43, target = 0.44). Without discards, the four-year average CPUE for this period was below the target (average = 0.43, target = 0.47). The RBCs generated by applying the tier 4 harvest control rule were 256 t for the CPUE series with discards and 134 t for the CPUE series without the discards. Overall, the standardised CPUE declined steadily from 1998–2006, but has since stabilised, remaining near the target CPUE (which is half the average CPUE over the reference period 1993–2001; Figure 9.43).

The RBC and TAC for the 2017–18 season were based on the CPUE analysis of 2013 (Haddon 2013b) and application of the SESSF tier 4 harvest control rule. AFMA set a three-year TAC based on this analysis, which concluded in 2016–17 season. The RBC was extended for the 2017–18 season based on advice from the RAG, after considering CPUE and current level of catch, that there was low risk in extending the RBC for one year. The RBC applied to other oreodories for the 2017–18 fishing season was 128 t (AFMA 2017a). After consideration of discards, the TAC for the 2017–18 season was 128 t (AFMA 2017a).

FIGURE 9.43 Standardised CPUE for smooth oreodory, non–Cascade Plateau, 1986–2016



Notes: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

Although oreodories are generally considered to be a byproduct of other deepwater fisheries, and much of the deepwater habitat is now closed, catches of these species declined substantially before closures were implemented. It is likely that there was substantial but unquantified discarding during the peak of the orange roughy fishery from 1989 to 1992. However, improving the basis for assessing the status of other oreodories is a low priority, given the protection afforded by current deepwater closures. The latest tier 4 analyses (Haddon & Sporcic 2017b) indicate that recent average CPUE has remained stable near the target reference level since about 2005. In previous assessments, most (89 per cent) of the catch is reported as spikey oreodory (Sporcic 2015), so the CPUE analysis may largely reflect the status of spikey oreodory. There is some uncertainty about the reliability of standardised CPUE as an indicator of biomass for this highly aggregating and multispecies stock.

Because CPUE has remained stable near the target level, other oreodories are classified as **not overfished**. The agreed and actual TACs for the 2017–18 fishing season were 128 t and 140 t, respectively (AFMA Catchwatch reports), and the RBC was 128 t (AFMA 2017a). Total landings were 89 t, and the weighted average discards were 70.53 t (Castillo-Jordán, Althaus & Thomson 2018). The total fishing mortality of 159.53 t is above the RBC of 128 t. This indicates that the fishing mortality rate in 2017–18, if maintained, may deplete the stock below the limit reference point. Therefore, the stock is classified as **uncertain if subject to overfishing**.

Pink ling (*Genypterus blacodes*)

Line drawing: Rosalind Poole

Stock structure

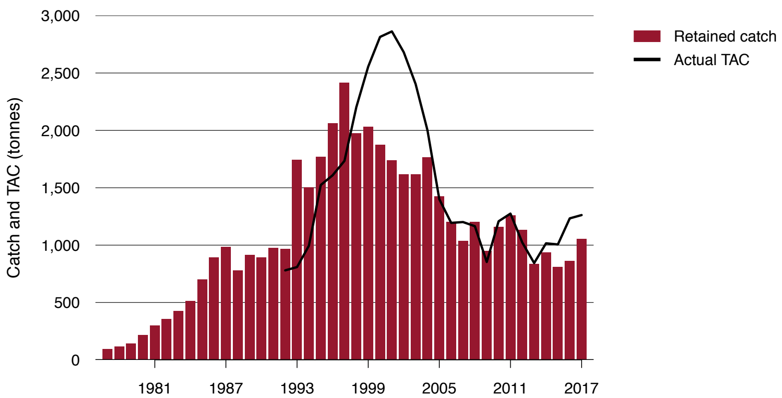
Clear and persistent differences are seen between the eastern and western areas for pink ling in catch-rate trends, and size and age (Morison et al. 2013). This indicates that there are either two separate stocks, or that exchange between eastern and western components of the stock is low and they should be managed as separate stocks. Although genetic variation between eastern and western pink ling has not been found (Ward et al. 2001), the persistent differences in other biological characteristics and catch-rate trends have resulted in pink ling being assessed as separate stocks east and west of longitude 147°E since 2013.

Catches of pink ling are managed under a single TAC. However, AFMA has management arrangements in place to constrain catches of the eastern stock to the eastern catch limit.

Catch history

Combined eastern and western catches of pink ling increased steadily from the start of the fishery in about 1977 to reach a peak of 2,412 t in 1997 (Figure 9.44). Despite TACs continuing to increase from 1997 to 2001, catches declined steadily to about 1,800 t in 2004. From 2004–05 to 2013–14, pink ling catches were limited by the TAC. Commonwealth-landed catch in the 2017–18 fishing season was 1,036.5 t, (comprising approximately 395.5 t for the eastern stock and 508.5 t for the western stock, according to logbook data). The weighted average discards between 2013 and 2016 were 63.9 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.44 Pink ling annual catches (CTS, SHS and state combined) and fishing season TACs, 1977–2017



Notes: **TAC** Total allowable catch. Data for 2013–2017 do not include state data.
Source: Cordue 2013; Australian Fisheries Management Authority catch disposal records (2013–2017 catch data)

Stock assessment

Pink ling has been assessed using a series of complex integrated stock assessment models, with the most recent applying Markov chain Monte Carlo analysis for parameter estimation and projections (Cordue 2013, 2015). The model is age structured and integrates catch-at-age data, length and standardised CPUE abundance indices. Results from this model in 2013 estimated the biomass of the eastern pink ling stock to be around 25 per cent of the unfished biomass, ranging from 17 to 38 per cent, and trending upwards (Cordue 2013). The biomass of the western pink ling stock was stable at around 58 per cent of the unfished biomass, ranging from 41 to 86 per cent. Applying the SESSF tier 1 harvest control rule generated an RBC for eastern pink ling of 122 t (although highly uncertain, ranging from 0 to 500 t) and an RBC for the western stock of 807 t (range 430–1,710 t).

The capacity to constrain eastern pink ling catches to 122 t was not considered practical given that ling are caught as bycatch during targeting of a number of other species in the CTS. Cordue (2013) provided a table of projections of future eastern pink ling biomass under a range of constant-catch scenarios, from 0 to 500 t, together with probability estimates of stock status in relation to target and limit reference levels (Table 9.3).

These projections indicate that, under the Cordue (2013) assessment base case, there is a less than 10 per cent probability of eastern pink ling biomass in 2015 being below 20 per cent of B_0 for catches below about 400 t (Cordue 2013). A three-year global TAC was set at 996 t commencing in 2013–14 (1,022 t after carryover of undercaught TAC from 2013–14), with additional controls to keep eastern catches under the RBC. These controls included a daily catch allowance for the eastern zone and a change in some concession conditions to restrict catch of pink ling from the eastern zone to 25 per cent of quota holdings.

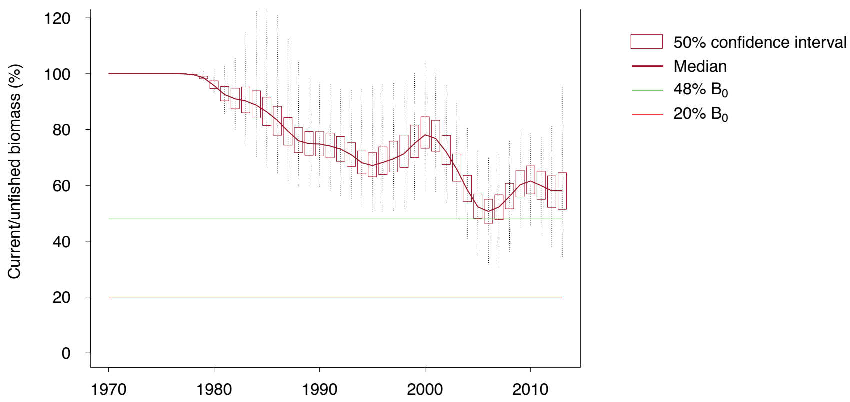
The Cordue (2013) assessment was updated in 2015 (Cordue 2015). The updated assessment estimated the median eastern stock biomass in 2015 to be $0.30B_0$ and the median western stock biomass in 2015 to be $0.72B_0$ (Figures 9.45 and 9.46). The RBCs generated from these results were 250 t for the eastern stock and 990 t for the western stock. Constant-catch scenarios were run for the eastern stock and indicated that catches in excess of 550 t led to a greater than 10 per cent probability of eastern pink ling declining to below the limit reference point by 2022 and that catches greater than 500 t increase the time taken to rebuild the stock to the management target ($0.48B_0$) (AFMA 2015e). On this basis, AFMA was advised that if a TAC greater than the RBC was selected by the AFMA Commission, the updated table showing the range of future constant-catch scenarios should be used as the basis for determining the TAC. Although these constant-catch scenarios (Table 9.4) from the 2015 stock assessment were not used to determine the TAC, they provide a more up-to-date indicator of the sustainable level of fishing mortality than the constant-catch scenarios produced by the 2013 stock assessment. The RBC and TAC for the 2017–18 fishing season was 1,240 t (AFMA 2017a).

TABLE 9.3 Base-case 2013 stock assessment performance indicators for eastern pink ling, showing stochastic projections at a range of future constant catches

Annual catch (t)	B_{2015}/B_0	B_{2020}/B_0	Probability $B_{2015}<0.2B_0$	Probability $B_{2020}<0.2B_0$	Rebuild year
0	0.33	0.56	0.01	0	2019
250	0.30	0.44	0.04	0	2022
300	0.30	0.42	0.05	0.01	2024
350	0.29	0.39	0.07	0.02	2026
400	0.28	0.37	0.09	0.04	2029
450	0.28	0.35	0.11	0.07	2034
500	0.27	0.32	0.14	0.11	2047

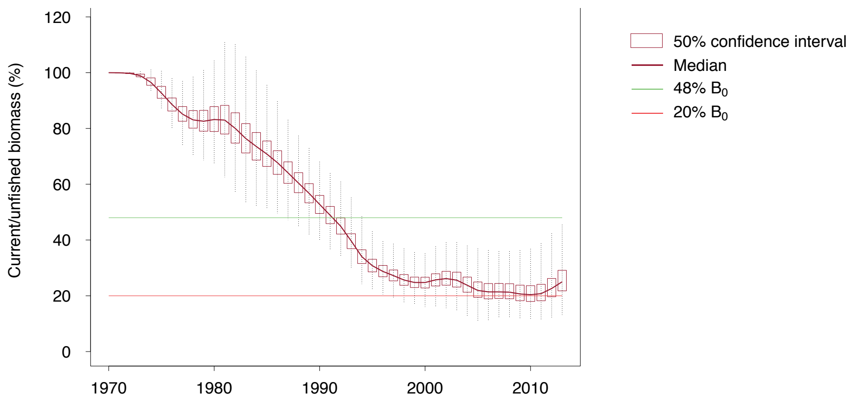
Notes: B_{2015}/B_0 Predicted biomass ratio in 2015. B_{2020}/B_0 Predicted biomass ratio in 2020. $B_{2015}<0.2B_0$ Biomass below 20 per cent B_0 in 2015. $B_{2020}<0.2B_0$ Biomass below 20 per cent B_0 in 2020. Rebuild year is the projected year for rebuilding to 48% B_0.
Source: Cordue 2013

FIGURE 9.45 Estimated spawning stock biomass for western pink ling, 1970–2015



Source: Cordue 2015

FIGURE 9.46 Estimated spawning stock biomass for eastern pink ling, 1970–2015



Source: Cordue 2015

TABLE 9.4 Base-case 2015 stock assessment performance indicators for eastern pink ling, showing stochastic projections at a range of future constant catches

Annual catch (t)	B_{2017}/B_0	B_{2022}/B_0	Probability $B_{2017}<0.2B_0$	Probability $B_{2022}<0.2B_0$	Rebuild year
0	0.38	0.63	0	0	2020
300	0.35	0.48	0.01	0	2023
400	0.33	0.43	0.02	0.01	2026
500	0.31	0.38	0.04	0.04	2036
550	0.30	0.35	0.07	0.08	>2050
600	0.29	0.32	0.09	0.13	>2050
700	0.27	0.17	0.15	0.28	>2050

Notes: $\mathbf{B_{2017}/B_0}$ Predicted biomass ratio in 2017. $\mathbf{B_{2022}/B_0}$ Predicted biomass ratio in 2022. $\mathbf{B_{2017}<B_0}$ Biomass below 20% B_0 in 2017. $\mathbf{B_{2022}<0.2B_0}$ Biomass below 20% B_0 in 2022. **Rebuild year** is the projected year for rebuilding to 48% B_0.
Source: Cordue 2015

Stock status determination

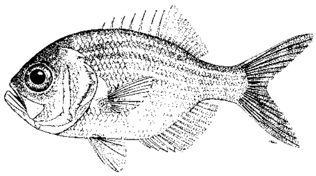
The 2015 assessment estimated the median biomass depletion for the western pink ling stock at 72 per cent of the unfished biomass, and the median biomass depletion for the eastern pink ling stock at 30 per cent of the unfished biomass. The 2015 assessment indicated that the eastern pink ling stock had a very low (1 per cent) probability of being below the limit reference point in 2015. On this basis, both stocks would be considered as not overfished, and so the combined stock of pink ling is classified as **not overfished**.

Western pink ling catch in the 2017–18 fishing season was 508 t and was below the western RBC of 990 t (Cordue 2013). This indicates that the fishing mortality rate in 2017–18, if maintained, is unlikely to deplete the stock to a level below its biomass limit reference point. As a separate stock, the western stock would be classified as not subject to overfishing.

Eastern pink ling catch in 2017–18 was 395 t, exceeding the RBC of 250 produced by the Cordue (2015) stock assessment. However, according to projections from the 2015 stock assessment (Cordue 2015), there is little risk to the stock, with removals up to 550 t per year. The base-case projections suggested that the stock could be rebuilt to the target reference point (B_{48}) within one mean generation time (8.8 years). If two mean generation times are allowed for the rebuild, total removals can be 400–500 t per year. Consideration of recent fishing mortality against the constant-catch scenarios run as part of the 2013 and updated 2015 stock assessments indicates that, as a separate stock, eastern pink ling would be classified as not subject to overfishing.

While the catch of eastern pink ling in 2017–18 was above the RBC, the catch was below a level where, if maintained, is unlikely to deplete the stock to a level below its biomass limit reference point. The catch of western pink ling in 2017–18 was below the RBC and unlikely to deplete the stock to a level below its biomass limit reference points. Therefore, pink ling is classified as **not subject to overfishing**.

Redfish (*Centroberyx affinis*)



Line drawing: FAO

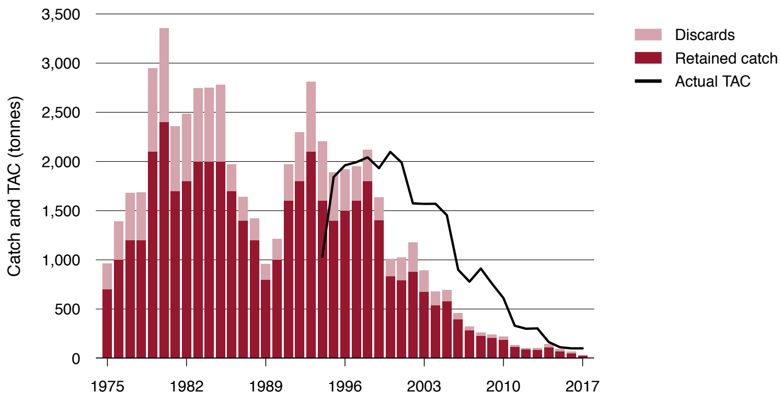
Stock structure

No formal stock delineation studies of redfish have been undertaken in Australia. Tagging studies suggested a single stock of redfish off New South Wales (Morison et al. 2013). However, studies of mean length-at-age suggest differences in growth rates of redfish from the 'northern' and 'southern' sectors of the fishery off eastern Australia (Morison et al. 2013). Previous redfish assessments have therefore assumed that the fishery exploits two separate populations, with the boundary between these 'stocks' being 36°S (immediately north of Montague Island in New South Wales) (Morison et al. 2013). However, following a review of the evidence for separate stocks, the evidence was considered to be insufficient; hence, the most recent stock assessment (Tuck & Day 2014) assumes a single stock combined across regions. Status is determined for a single stock in the east coast of the SESSF (zones 10, 20 and 30).

Catch history

Catches of redfish peaked in the late 1970s and early 1980s, with significant discards recorded on top of landed catch. Landed catch has decreased steadily since the late 1990s. The 2017–18 catch was 27.4 t (Figure 9.47). Estimated discards were 226 t in 2009, but have returned to lower levels in recent years, being usually between 20 t and 70 t since 2010 (Castillo-Jordán, Althaus & Thomson 2018). Discard rates tend to be high when a pulse of recruits first enters the fishery (Klaer et al. 2014). Weighted average discards between 2013 and 2016 were 41.77 t (Castillo-Jordán, Althaus & Thomson 2018). The redfish TAC has been progressively reduced since 2000. The TAC was 276 t in the 2011–12 to 2013–14 seasons, 138 t in 2014–15 and 100 t in the 2015–16 to 2017–18 seasons. Annual catches have remained below the TAC since 2000 (Figure 9.47).

FIGURE 9.47 Redfish annual catches (CTS, SHS and state combined) and fishing season TACs, 1975–2017



Note: **TAC** Total allowable catch. Data for 2017 do not include discards and state catch.
Source: Tuck et al. 2017; Australian Fisheries Management Authority catch disposal records (2017 catch data)

Stock assessment

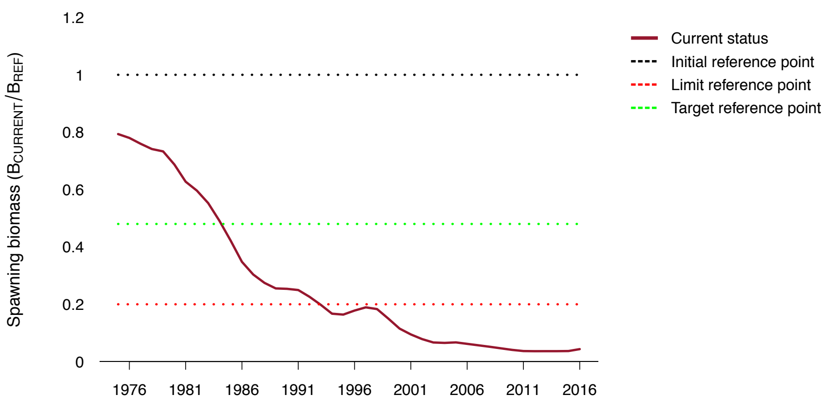
Redfish is managed under an incidental catch allowance and has been assessed using an integrated assessment since 2014. The stock is managed under a redfish stock rebuilding strategy (AFMA 2016a), the main objective of which is to rebuild redfish to the limit reference point ($0.2B_0$) within 27 years (one mean generation time—16.7 years [Tuck & Day 2014]—plus 10 years). The rebuilding strategy prescribes that the TAC will be set at the minimum amount required to cover the catch of redfish taken incidentally while targeting other species. This amount has been set at 100 t (AFMA 2017a). The most recent assessment was conducted in 2017 (Tuck et al. 2017), updating the previous full assessment of 2014 (Tuck & Day 2014).

The 2014 assessment estimated that the stock should rebuild to above the limit reference point by 2018 or 2019 under total fishing mortality of up to 150 t (AFMA 2016a; Tuck & Day 2014). Projections from this assessment assumed average recruitment. Recruitment data used in the stock assessment indicated below-average recruitment between 2001 and 2009. Ageing data suggested three recent years of improved recruitment: 2011 and 2012 (Tuck & Day 2014), and 2013 (Thomson et al. 2015). However, the magnitude of the 2011 recruitment in the 2014 assessment has been greatly reduced in the 2017 assessment (Tuck et al. 2017). Because of this recruitment variability, and the fact that there was only one year of above-average recruitment estimated since 2001, the existence and magnitude of recruitments will need to be closely monitored over the coming years to track progress against the objectives of the rebuilding strategy.

The 2017 assessment includes updated data, including an additional three years of catch, discard, CPUE, length and age data, and ageing error up to the end of 2016. The base-case model used by the RAG for provision of advice predicted spawning biomass in 2018 to be 8 per cent of unexploited levels, a decrease from the previous assessment that predicted 11 per cent ($0.11B_0$) in 2015 (Figure 9.48).

Standardised redfish CPUE (excluding discards) has declined since 2000. Standardised CPUE shows that the CPUE has remained low; it was below 50 kg/hr since 2005 and only 11.7 kg/hr in 2016 (kg/hr were estimated using the geometric mean, which is very similar to the optimum standardised CPUE) (Haddon & Sporcic 2017a).

FIGURE 9.48 Estimated female spawning stock biomass for redfish, 1975–2016



Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Tuck et al. 2017

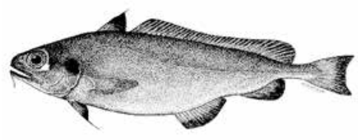
Stock status determination

The 2017 assessment estimated spawning stock biomass for redfish at 8 per cent of unfished levels in 2018. Based on the results of this stock assessment, redfish is classified as **overfished**.

Projections undertaken as part of the stock assessment in 2013 suggested that redfish would recover to the limit reference point by 2018 or 2019 under a total catch of up to 150 t, assuming average recruitment (Tuck & Day 2014). This assumption may not hold.

Landings in 2017–18 were 27.4 t, and the weighted average discards were 41.77 t, giving a total of 69.17 t. Although mortality may have been constrained to less than the incidental catch allowance (100 t) and the projections that allow for recovery, total mortality for the 2017–18 season is unknown, and recruitment is variable and uncertain. Therefore, the stock remains classified as **uncertain if subject to overfishing**.

Ribaldo (*Mora moro*)



Line drawing: FAO

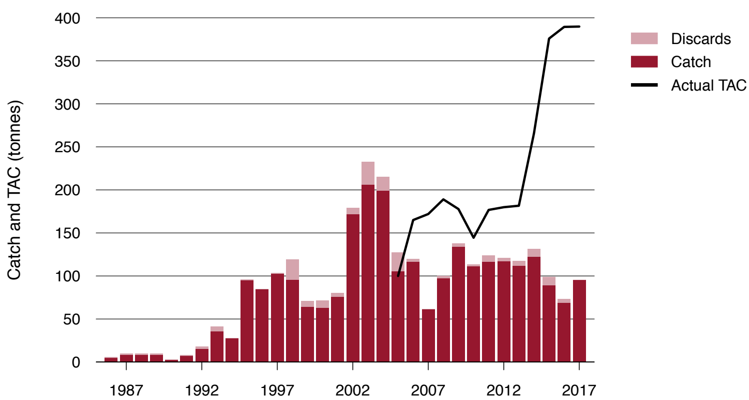
Stock structure

One stock of ribaldo is assumed for assessment and management purposes in the SESSF (Morison et al. 2013).

Catch history

Ribaldo is largely taken as byproduct during fishing for other species; only 5 per cent of the catch is considered to be targeted (Klaer et al. 2013). Similar proportions of the annual catch are taken by trawl and line. Historical catches increased from low levels in 1990 to a peak of more than 200 t in 2003. Catches dropped in 2005 to about 100 t, following implementation of a TAC (Figure 9.49). Landed catches decreased from 90 t in 2015–16 to 87.7 t in 2016–17. The Commonwealth-landed catch in the 2017–18 fishing season was 94.5 t. The weighted average discards between 2013 and 2016 were 6.52 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.49 Ribaldo annual catches (CTS and SHS) and fishing season TACs, 1986–2017



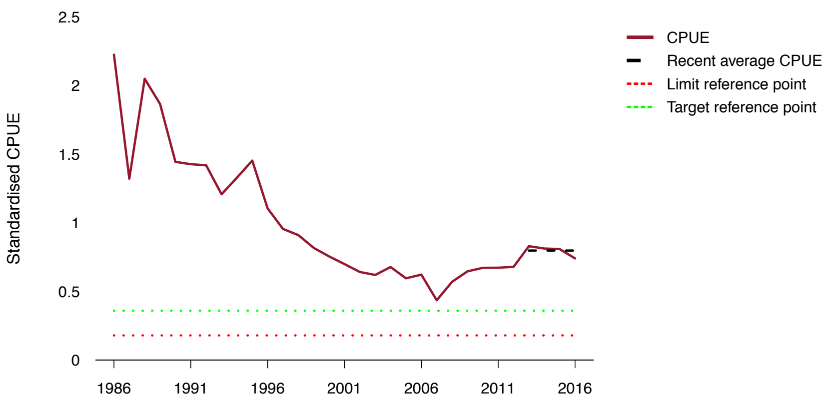
Notes: **TAC** Total allowable catch. Data for 2017 do not include discards.
Source: Haddon & Sporcic 2017b; Australian Fisheries Management Authority catch disposal records (2017 catch data)

Stock assessment

Ribaldo is managed as a tier 4 stock under the SESSF HSF using CPUE from the trawl fleet (Figure 9.50; Morison et al. 2013). The RAG has provided advice on the RBC using the B_{40} target reference point (Morison et al. 2013).

The 2013 analysis used the period 1995–2004 as the reference period (when catches first approached 100 t). Given the lightly exploited nature of the fishery during the reference period, the target CPUE was calculated by dividing the average reference period CPUE by 2, to reflect the likely change in CPUE that would occur as the fishery became fully exploited. Trawl CPUE has been relatively stable since 2000, and auto-longline CPUE has been stable since 2005. Both are above the target level. Throughout this period, catches have remained below the established TACs and below RBCs. The 2013 analysis produced an RBC of 355 t using the B_{40} target (Haddon 2013b). A three-year RBC of 355 t was recommended and adopted, with a review if 70 per cent or more of the TAC is caught, if trawl CPUE changes by 50 per cent or more, or if there is a significant change in the proportion of catch by the line sector (AFMA 2013a). The SESSF tier 4 discount factor was not applied because of the existing closures for both trawl and auto-longline methods. A cursory analysis was conducted in 2017 (with data to 2016). The RBC generated from this analysis was 430 t, indicating that the RBC supports the current TAC.

FIGURE 9.50 Standardised CPUE for ribaldo, 1986–2016



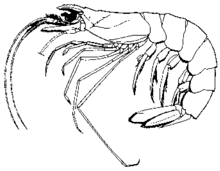
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

Standardised CPUE has remained stable or increased, and has been above the target level for the past decade. Ribaldo is therefore classified as **not overfished**.

For the 2017–18 fishing season, the agreed TAC was 355 t, the actual TAC was 389 t and the RBC was 355 t. Total landed catch was 94.5 t, and the weighted average discards were 6.52 t. The landed catch and discards combined were 101 t, which is below the RBC of 355 t. This indicates that the fishing mortality rate in 2017–18, if maintained, is unlikely to deplete the stock to a level below its biomass limit reference points. The stock is therefore classified as **not subject to overfishing**.

Royal red prawn (*Haliporoides sibogae*)



Line drawing: FAO

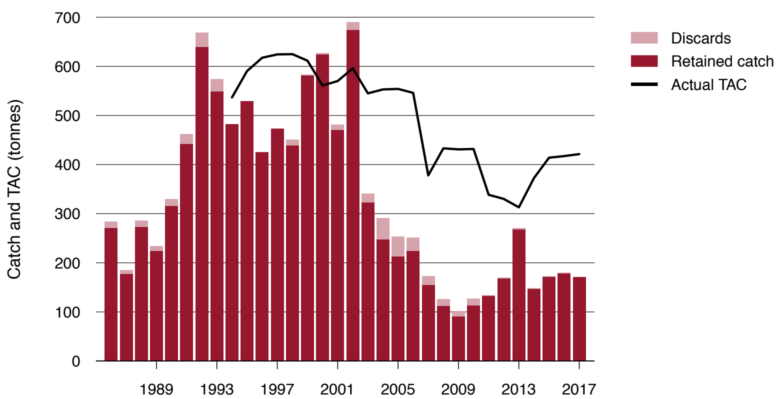
Stock structure

Royal red prawn is widespread, occurring in depths of 350–550 m in the Indian and western Pacific oceans. In Australia, royal red prawn is caught off New South Wales, Queensland and Western Australia between latitudes 10°S and 36°S. Little is known of the stock structure in eastern Australia. Because most of the Australian catch is taken off the New South Wales coast between Port Stephens and Ulladulla, for assessment and management purposes, these populations are assumed to comprise a single stock (Morison et al. 2013). The sustainability of stocks outside of the SESSF (such as those in Western Australia) are not assessed here.

Catch history

Catch of royal red prawn fluctuated around 500 t per year during the 1990s and early 2000s, before declining and stabilising at a level between 100 and 200 t in recent years (Figure 9.51). Catch has been below the TAC in recent years, which can largely be attributed to limited availability of processing facilities for this species and low market demand (Morison et al. 2013). The catch of royal red prawn in the 2017–18 fishing season was 222 t. The weighted average discards between 2013 and 2016 were 1.9 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.51 Royal red prawn annual catches (CTS and state combined) and fishing season TACs, 1986–2017



Note: **TAC** Total allowable catch. Data for 2017 do not include discards and state catch.
Source: Haddon & Sporcic 2017b; Australian Fisheries Management Authority catch disposal records (2017 catch data)

Stock assessment

Royal red prawn is managed as a tier 4 stock under the SESSF HSF (Morison et al. 2013). The RAG has provided advice on the RBC using the B_{40} target reference point (Morison et al. 2013).

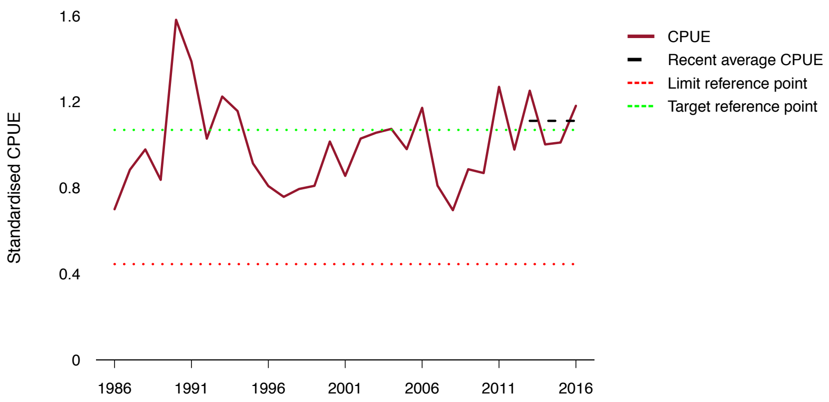
In 2013, the RAG recommended a three-year RBC of 393 t, which was extended for one year for the 2017–18 season. The TAC implemented for these years was 388 t. After deduction of discard estimates and state catch, the agreed TAC was set at 384 t for the 2017–18 fishing season (AFMA 2017a).

The CPUE standardisation and tier 4 harvest control rule were re-run in 2017 (Figure 9.52), with the RBC being slightly higher (430.8 t) than that output in 2013 (AFMA 2017a; Haddon & Sporcic 2017b).

Some concerns about using a standardised CPUE for this stock have been expressed by the RAG because targeting of royal red prawn is market driven (Morison et al. 2013). Such practices may influence CPUE and the application of the SESSF tier 4 harvest control rule.

Royal red prawn
AFMA

FIGURE 9.52 Standardised CPUE for royal red prawn, 1986–2016



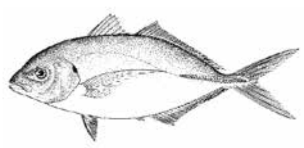
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

The recent average CPUE is marginally above the target reference point, and catches have been below the RBC in recent years. As a result, this stock is classified as **not overfished**.

Total landed catch was 222 t, and the weighted average discards were 1.91 t. The landed catch and discards combined were 223.91 t. This is below the 2017 RBC for the stock of 393 t. This indicates that the fishing mortality rate in 2017–18, if maintained, is unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Silver trevally (*Pseudocaranx georgianus*)



Line drawing: FAO

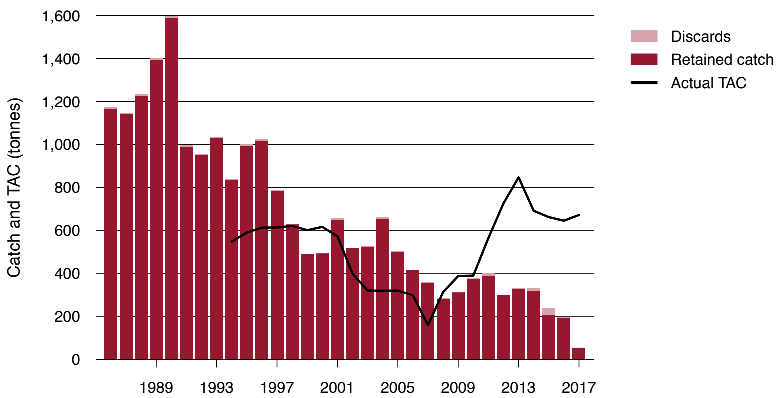
Stock structure

Silver trevally is found in Australian and New Zealand waters. In Australia, they range from northern New South Wales, around southern Australia to Western Australia. Little is known of the stock structure. Preliminary research suggests that silver trevally off south-eastern Australia represents a single stock that is distinct from the North Island of New Zealand fishery (Rowling & Raines 2000). The growth rate of the Australian stock of silver trevally is slower than that reported for the New Zealand stock; however, it matures comparatively early, at about two years of age, with spawning occurring throughout summer (Morison et al. 2013).

Catch history

High CPUE between 1989 and 1991, with a peak catch in 1990 of 1,588 t, was the result of efficient vessels entering the fishery in 1989 (Haddon 2013b). Catch has since declined (Figure 9.53). The Commonwealth-landed catch in the 2017–18 fishing season was 54.8 t. Silver trevally is also a popular target for recreational fishers off south-eastern Australia; the recreational catch in New South Wales was estimated to be around 27 t in 2013–14 (West et al. 2015). The weighted average discards between 2013 and 2016 were 11.94 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.53 Silver trevally annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2017



Notes: **TAC** Total allowable catch. Data for 2017 exclude discards and state data.
Source: Haddon & Sporcic 2017b; Australian Fisheries Management Authority catch disposal records (2017 catch data)

Stock assessment

Silver trevally is managed as a tier 4 stock under the SESSF HSF (Morison et al. 2013).

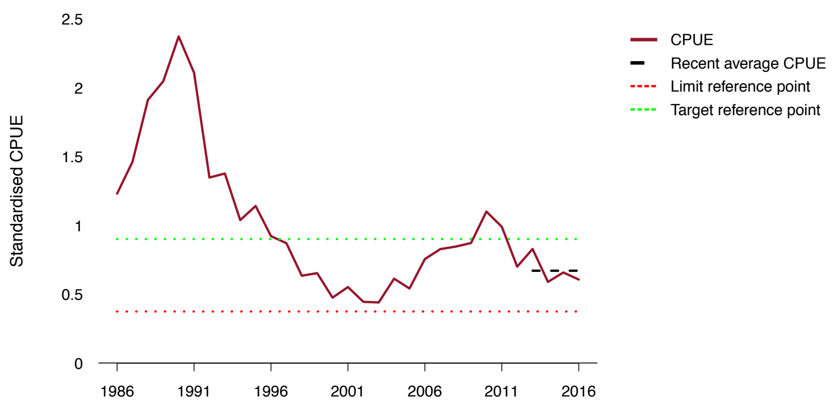
The current TAC was set based on application of the SESSF tier 4 harvest control rule to the CPUE analysis completed in 2013. This found the recent average CPUE to be above the target reference point and generated an RBC of 858 t (Haddon 2013a). This was converted to a MYTAC of 791 t, which was extended for one year and applied to the 2017–18 season.

The CPUE analyses and tier 4 harvest control rule were re-run in 2017 (Haddon & Sporcic 2017b).This found the recent average CPUE to be halfway between the target and limit reference point, and produced an RBC of 445 t (Haddon & Sporcic 2017a; Figure 9.54).

The establishment of Batemans Marine Park in June 2007 has affected the estimation of silver trevally RBCs because historical catch data from within the park boundaries are included in the target catch range component of the RBC calculation, but the CPUE analyses do not include historical activities in this area. The RBC derived from the 2013 analysis (Haddon 2013a) considered CPUE from both within and outside the marine park, and found little difference in the RBC estimate. The RBC derived from the latest 2017 analysis (Haddon & Sporcic 2017b) excluded all data from the marine park. The RAG recommended waiving the default tier 4 discount factor of 15 per cent of the RBC, on the basis that the marine park provides sufficient precaution as a refuge for spawning adults and juveniles across a significant portion of the species' distribution (AFMA 2013a). However, adult silver trevally are highly mobile, and the inclusion of past marine park catches in RBC calculations assumes that silver trevally in these areas are fully available to fisheries outside the park.

Before 2010, most of the silver trevally catch was taken in state waters outside the SESSF (Morison et al. 2013). The closure of silver trevally trawling grounds within Batemans Marine Park, and the New South Wales buyout of state fishing businesses before 2007, have resulted in a sharp decline in New South Wales state catch (Morison et al. 2013).

FIGURE 9.54 Standardised CPUE for silver trevally, 1986–2016



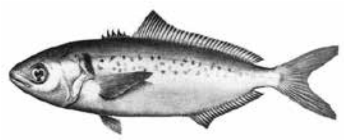
Notes: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

The four-year average standardised CPUE used for the most recent analysis is above the limit reference level. As a result, silver trevally is classified as **not overfished**.

The landed catch in 2017–18 was 54.9 t, and the weighted average discards were 11.94 t. The landed catch and discards combined were 66.84 t, which is below the RBC of 791 t. This indicates that the fishing mortality rate in 2017–18, if maintained, is unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Silver warehou (*Seriolella punctata*)



Line drawing: FAO

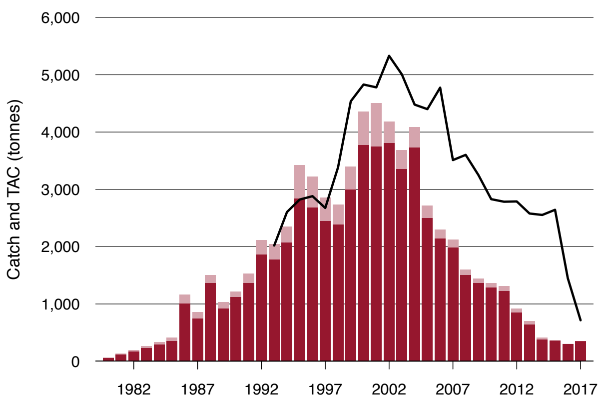
Stock structure

A study has been completed on the stock structure of silver warehou using genetics (mitochondrial DNA), morphology, otolith shape and otolith microchemistry (Robinson et al. 2008). Results did not indicate the presence of separate stocks east and west of Bass Strait, although there were indications of some structuring around Tasmania. This study, together with other information, suggests that silver warehou should be considered as a single biological stock in the SESSF (Morison et al. 2013).

Catch history

Silver warehou is caught entirely by trawl in the CTS and has been a targeted species throughout most of the history of the fishery. Silver warehou catches steadily increased from the start of the fishery in 1980 to peaks of 4,450 t in 2002 and 4,435 t in 2004 (Figure 9.55). Catches subsequently declined to 276 t in 2015–16 and 311 t in 2016–17. The TAC in 2017–18 was 605 t, half that of the previous season. The TAC was the second year of a three year MYTAC, with a large change–limiting rule applied (AFMA 2017a). The Commonwealth-landed catch in the SESSF for the 2017–18 fishing season was 432.5 t. The weighted average discards between 2013 and 2016 were 41.02 t (Castillo-Jordán, Althaus & Thomson 2018).

FIGURE 9.55 Silver warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1980–2017



Notes: **TAC** Total allowable catch. Data for 2015–2017 do not include discards and state catch.
Source: Thomson, Day & Tuck 2015; Australian Fisheries Management Authority catch disposal records (2015–2017 catch data)

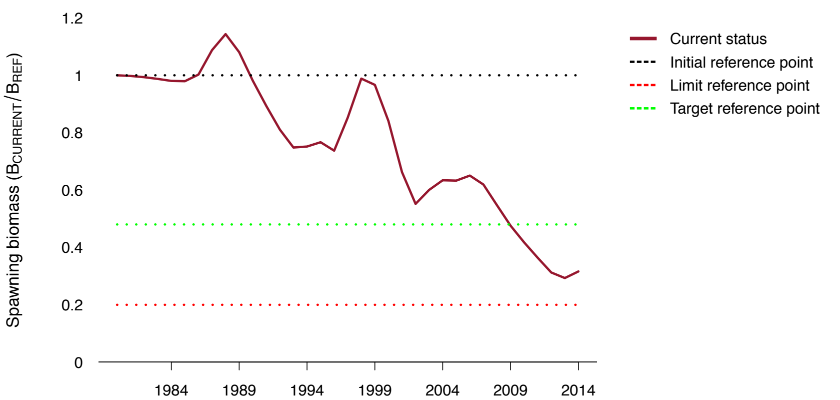
Stock assessment

Silver warehou is managed as a tier 1 stock under the SESSF HSF with a target reference point of $0.48B_0$. The most recent assessment was undertaken in 2015 (Thomson, Day & Tuck 2015) and projected the 2016 spawning biomass to be $0.4B_0$ (Figure 9.56). The 2015 assessment produced a 2016–17 RBC of 1,958 t and a long-term yield of 2,281 t. However, these scenarios assume average recruitment; recruitment has been below average since 2003.

In the initial assessment, sensitivities were run using a 'poor' recruitment scenario (the average of a recent five-year period of poor recruitment) and a 'very poor' recruitment scenario (the average of the worst three of these five years). A constant catch of 381 t was used in projections under these scenarios, based on the volume of recent landed catches of silver warehou. Neither of these low-recruitment scenarios indicated that the stock would approach the target biomass ($0.48B_0$) by 2020 at a catch of 381 t, and the very poor recruitment scenario indicated a decline in spawning biomass to a depletion level below 40 per cent in 2020 (AFMA 2015f). This indicates that, at tested catch levels, future increases in stock are dependent on levels of future recruitment increasing to above the low-recruitment scenarios assumed for these projections.

The RAG (AFMA 2015f) noted that, if one of the objectives of the next silver warehou MYTAC is to increase the biomass from the current estimated level, a catch below 600 t is recommended. Recognising the constraints of the large change–limiting rule, the RAG recommended stepping down to the poor-recruitment scenario RBC of 604 t in two years (AFMA 2015g). For the 2016–17 fishing season, the TAC was constrained by large change–limiting rule and was set at 1,209 t. However, for the 2017–18 fishing season, the TAC was reduced to 605 t (AFMA 2017a).

FIGURE 9.56 Estimated spawning stock biomass for silver warehou, 1980–2014



Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Thomson et al. 2015

Stock status determination

The 2015 stock assessment predicted spawning biomass in 2016 to be $0.4B_0$. Catches since 2015 are unlikely to have reduced the stock to below the limit reference point. Silver warehou therefore remains classified as **not overfished**.

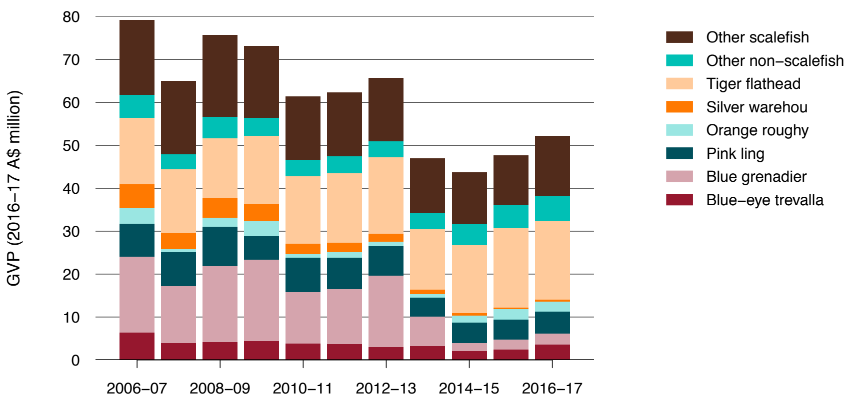
Total landed catch in the SESSF was 432 t, and the weighted average discards were 41.02 t. The landed catch and discards combined were 473 t, which is below the RBC of 605 t. This total fishing mortality was also below the low-recruitment constant-catch scenario that produced an updated 2016–17 RBC of 604 t. This indicates that the fishing mortality rate in 2017–18, if maintained, is unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

9.3 Economic status

Key economic trends

The CTS and the SHS contributed approximately 56 per cent of total SESSF GVP ($82.42 million) in 2016–17. From 2006–07 to 2012–13, real GVP for the two sectors averaged $64.71 million (in 2016–17 dollars; Figure 9.57). By 2013–14, it had fallen, and has since remained below $50 million. Since 2006–07, declines in the value of blue grenadier and silver warehou catches have been the key drivers of the reduction in scalefish GVP. In 2006–07, silver warehou catches were valued at $5.56 million, and blue grenadier catches were valued at $17.66 million. By 2016–17, the GVP of silver warehou catches had declined to $451,000, and blue grenadier catches had declined to $2.54 million. In terms of value during 2016–17, the mix of species caught was dominated by tiger flathead ($18.36 million; 40 per cent of total GVP) and pink ling ($5.22 million; 11 per cent).

FIGURE 9.57 Real GVP, by key species, for the CTS and the SHS, 2006–07 to 2016–17

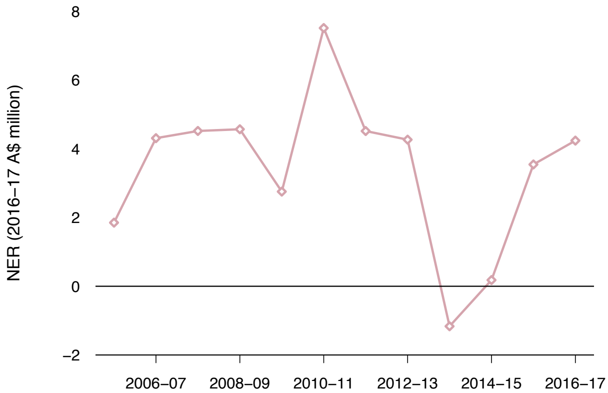


Note: **GVP** Gross value of production.

Estimates of net economic returns (NER) associated with scalefish catches for the CTS and the SHS combined are not available, because ABARES undertakes economic surveys of the CTS separately from the SHS (which is surveyed as part of the GHTS). However, with respect to value, the CTS accounts for most of the scalefish catch. According to an ABARES economic survey of the CTS (Bath, Mobsby & Koduah 2018), NER in the CTS in 2013–14 were –$1.11 million. This was the first time they had been negative since 2004–05. The low NER were driven by low fishing income in the fishery as a result of an 11 per cent decline in catch from 2012–13, as well as lower unit prices. NER rose to $174,793 in 2014–15 as a result of a fall in operating costs that exceeded a smaller fall in fishing income. The increase in NER during 2014–15 was supported by improvements in fishers' terms of trade and fleet productivity. Preliminary estimates from the survey suggest that NER were $3.48 million in 2015–16, primarily as a result of an increase in fishing income exceeding a rise in operating costs (Figures 9.58 and 9.59). NER are estimated to have increased in 2016–17 to $4.24 million because similar levels of income to 2015–16 are expected but operating costs were lower, reflecting lower levels of effort (days fished) in the fishery.

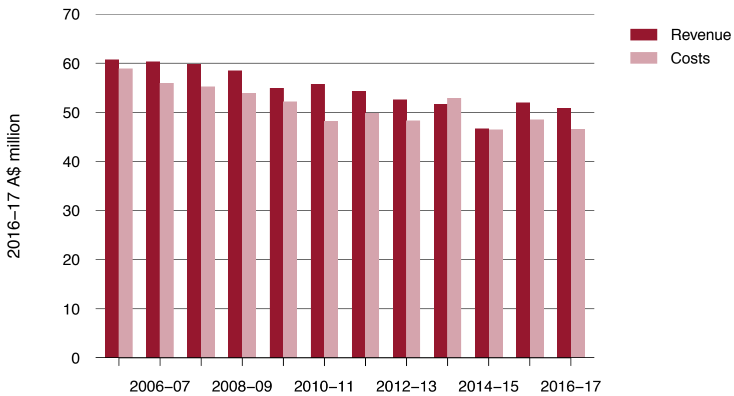
Blue-eye trevalla
AFMA

FIGURE 9.58 NER for the CTS, by financial year, 2005–06 to 2016–17



Notes: **NER** Net economic returns. Results for 2015–16 and 2016–17 are preliminary, non-survey based estimates.

FIGURE 9.59 Revenue and costs for the CTS, by financial year, 2005–06 to 2016–17



Note: Results for 2015–16 and 2016–17 are preliminary, non-survey based estimates.
Source: Bath, Mobsby & Koduah 2018

Management arrangements

Both the CTS and the SHS are managed under ITQs. TACs are set for key target species for each fishing season and allocated to quota holders. This form of management promotes efficiency, because it allows operators to harvest with greater flexibility (with fewer restrictions on inputs), and often results in quota being acquired by the most efficient and profitable operators. ITQ management in the SESSF has used MYTACs for some stocks, which are usually set for three years. Historically, proxy targets have been set at the species level and have not taken account of interactions between species caught in the sector. If management settings are based on the MEY of individual species, achieving the objective for one species may be constrained by the management settings targeting the MEY of another species. Several RAGs have begun to look at target biomass levels below individual B_{MEY} for these secondary species. Vieira et al. (2013) have provided advice on the potential fishery-wide economic benefits that could be derived from setting MSY-based targets for secondary species in the SESSF. Alternative MSY-based $0.48B_0$ targets have been approved by AFMA for ocean perch, ribaldo and john dory.

Performance against economic objective

With the exceptions listed above, all species groups under quota in the SESSF are managed under a harvest strategy that targets B_{MEY}, the biomass level that is likely to be associated with MEY. Management has generally pursued B_{MEY} by using a proxy target reference point (most often $0.48B_0$). Tiger flathead, blue grenadier, pink ling and blue-eye trevalla accounted for 65 per cent of total GVP in both sectors in 2016–17. The biomass of these species, relative to the respective B_{MEY} targets, therefore provides an indication of performance against the objective of maximising NER.

Of the four key species, only tiger flathead has a quantitatively estimated species-specific MEY target, at $0.38B_0$. This was adjusted to $0.40B_0$ to take a more precautionary approach (Morison et al. 2013; Figure 9.17). At 42 per cent of unfished spawning biomass ($0.42SB_0$), the estimated biomass of tiger flathead in 2016 was slightly above the MEY target (Day 2017b). Similarly, at $0.77B_0$, the biomass estimate for blue grenadier in 2013 was above the target reference point ($0.48B_0$) (Tuck 2013; Figure 9.8). In 2015, an updated stock assessment estimated that the western pink ling stock was $0.72B_0$, which is significantly above the target reference point; however, in the east, the stock was $0.30B_0$, which is below the target reference point. The stock of blue-eye trevalla is between the limit and reference points. With the exception of eastern pink ling and blue-eye trevalla, it can be concluded that these four key species are being managed at levels that are not below B_{MEY} targets. This implies that NER are not constrained by these two stocks and improvements are possible if the species were fished down towards B_{MEY}. However, for blue grenadier, lower prices in recent years are likely discouraging participation by the factory vessels best suited to exploiting the stock. Quota latency for blue grenadier increased from 32 per cent in the 2013–14 fishing season to 86 per cent in the 2016–17 fishing season. This partly reflects a higher TAC for the species but may also reflect changed incentives for fishers. Additionally, the availability of the large New Zealand blue grenadier fishery (where the TAC is close to 150,000 t) provides an alternative to those vessels endorsed to fish in New Zealand (Bath, Mobsby & Koduah 2018). The disinclination of fishers to significantly fish-down blue grenadier suggests that the $0.48B_0$ proxy may not be aligned with MEY during recent years

Two other species considered here are silver warehou and orange roughy. Silver warehou accounted for only 1 per cent of scalefish GVP in 2016–17, but had accounted for up to 8 per cent immediately after the adoption of the HSP. An assessment update in 2015 projected silver warehou biomass to be $0.4B_0$ in 2016, which is below the target of $0.48B_0$. Whereas orange roughy accounted for 5 per cent of the value of the scalefish catch in 2016–17, it accounted for more than 50 per cent in the early 1990s. Catches at that time were associated with overfishing, and two of the four orange roughy stocks are currently assessed as overfished. Although all four orange roughy stocks are classified as not subject to overfishing, rebuilding of these stocks is expected to be slow.

NER in the CTS are projected to rise during 2015–16 and 2016–17 because of higher GVP and lower operating costs. NER were negative in 2013–14—the first occurrence of negative NER since 2004–05—but were positive in 2014–15. Despite the TACs for key species being set to an economic target, many species were undercaught during the 2016–17 season. This suggests that economic performance could improve further if approaches to setting MEY-based target reference points and TACs were improved. In particular, it may be beneficial to develop ways of setting target reference points for a multispecies fishery and derive cost-effective estimates of species-specific B_{MEY} for some of the more valuable species.

There is potential for vessels to improve their ability to use existing technology more efficiently—the median vessel operated at only 64 per cent efficiency in 2012–13 (Green 2016). Improvements in efficiency would likely improve NER. The same research indicates that potential productivity of the fishery has also declined since 2008–09; more research is required to determine the reasons for this. If it is the result of management changes, the management objectives served by these changes must be assessed against any associated fall in NER.

9.4 Environmental status

The environmental status of these fisheries is discussed in Chapter 8.

9.5 References

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