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Contact
Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)

Postal address	GPO Box 858 Canberra ACT 2601
Switchboard	+61 2 6272 3933
Email	info.abares@agriculture.gov.au
Web	agriculture.gov.au/abares

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Port Lincoln—Matt Daniel, AFMA
Live prawns—Lee Georgeson, ABARES
Blue mackerel—Josh Cahill, AFMA
Fishing net—AFMA

Contents

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The assistance of AFMA officers with the preparation of these reports, including the provision of information on management arrangements, fishery data and photographs, is appreciated. The input of scientists, industry representatives, fishery managers and other members of resource assessment groups is also appreciated, as are the contributions from CSIRO Marine and Atmospheric Research, the Australian Antarctic Division, and the fishery research agencies of state and territory governments. The contribution of previous ABARES employees to earlier versions of the *Fishery status reports* is also appreciated. The contribution of the in-house production team at the Department of Agriculture was invaluable in producing the report, as was the contribution of the scientific editors at Biotext.

Status determination of stocks in jointly managed fisheries requires the use of data and assessments compiled by regional fisheries organisations, including the Commission for the Conservation of Southern Bluefin Tuna, the Indian Ocean Tuna Commission, the Secretariat of the Pacific Community, the Secretariat of the South Pacific Regional Fisheries Management Organisation, and the Western and Central Pacific Fisheries Commission. The contribution of these data is greatly appreciated.

The following data sources are acknowledged:

- Geoscience Australia—coastline, state boundaries, place names, bathymetric features, Australian Fishing Zone and Exclusive Economic Zone boundaries
- AFMA—Australian Government fisheries logbook, catch disposal and observer data; fisheries management boundaries
- Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)—CCAMLR statistical division boundaries
- Australian Government Department of the Environment and Energy—boundaries of marine protected areas
- Commission for the Conservation of Southern Bluefin Tuna, Indian Ocean Tuna Commission, Western and Central Pacific Fisheries Commission—catch-and-effort data.

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Chapter 1
Overview

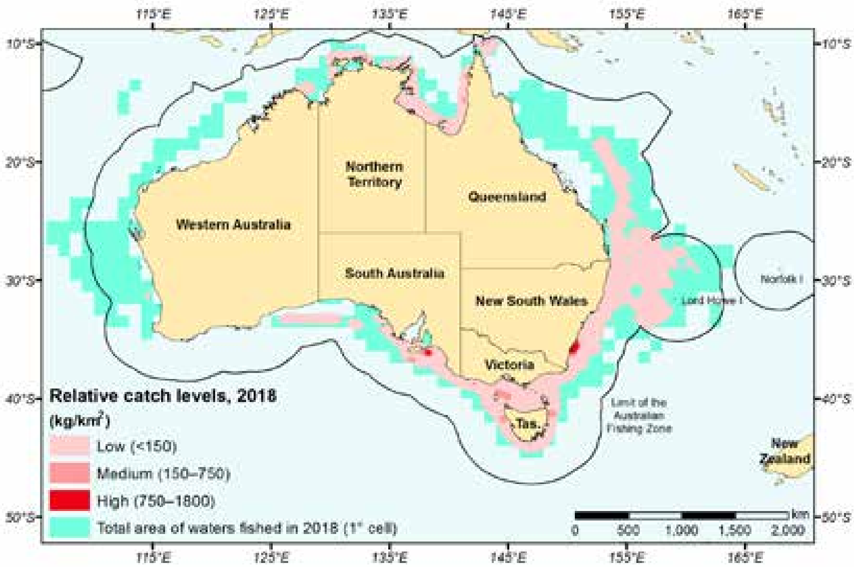
H Patterson, J Woodhams, A Williams and R Curtotti

The Australian Government's approach to fisheries management includes maintaining fish stocks at ecologically sustainable levels and, within this context, maximising the net economic returns (NER) to the Australian community (Department of Agriculture and Water Resources 2018b). It also considers the impact of fishing activities on non-target species and the long-term sustainability of the marine environment, as required by the *Fisheries Management Act 1991* and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This requires an understanding of the biological status of stocks, the economic status of fisheries and the state of marine environments that support fisheries.

Fishery status reports 2019 provides an independent assessment of the biological status of fish stocks and the economic status of fisheries managed, or jointly managed, by the Australian Government (Commonwealth fisheries) (Figure 1.1). It summarises the performance of these fisheries in 2018 and over time, against the requirements of fisheries legislation and policy. The reports assess all key commercial species from Australian Government–managed fisheries and examine the broader impact of fisheries on the environment, including on non-target species.

To complete these reports, ABARES uses data and information from agencies such as the Australian Fisheries Management Authority (AFMA) and regional fisheries management organisations. The reports use information on catch and fishing effort, and other information for the most recent complete fishing season that is available, and the most recent stock assessments. Commonwealth fisheries operate with different fishing season dates, so the currency of catch data in the reports varies. To compare status from year to year, biological status and environmental status are presented for 2018. Economic status is presented for the 2017–18 financial year.

FIGURE 1.1 Relative catch levels of all Australian Government–managed fisheries, 2018



1.1 Assessing biological status

Assessments of stock status provide an indication of whether the current size of a fish stock is above the level at which the stock is considered to be overfished (biomass status) and whether current levels of catch will allow the stock to remain in that state (fishing mortality status). Stock status is expressed in relation to the reference points prescribed by the recently revised Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018b).

Biomass (B) status relates to how many fish there are—specifically, whether the biomass in the year being assessed is above the level at which the risk to the stock is considered to be unacceptable. The HSP defines this level as the limit reference point, below which the stock is considered to be overfished.

Fishing mortality (F) status relates to the level of fishing pressure on a stock—specifically, whether fishing mortality in the year(s) being assessed is likely to result in the stock becoming overfished, or prevent the stock from rebuilding from an overfished state. If fishing mortality exceeds either of these thresholds, a stock is considered to be subject to overfishing.

Stocks are included in the *Fishery status reports* if they are a target or key commercial species in a fishery managed solely or jointly by the Australian Government and meet one or more of the criteria below. Conversely, stocks may be removed from the reports if they do not meet at least one of these criteria:

- a species or stock managed under a total allowable catch (TAC)
- a species or stock previously classified as 'overfished' that has not yet recovered to above the limit reference point.

In addition, stocks may be included if they meet one or more of the criteria below. Such stocks are assessed on a case-by-case basis:

- a species previously included in the *Fishery status reports* as a single stock that has been reclassified as multiple stocks to align with species biology or management
- a byproduct species of ecological and/or economic importance, if it meets one or more of the following criteria
  - for several consecutive years or fishing seasons, the total catch (landings and discards) of the byproduct species is approximately equal to, or greater than, that of any other stock currently targeted and/or assessed in that fishery or sector
  - the value of the total catch landed of the byproduct species is considered to be an important economic component of the fishery or sector
  - the byproduct species or stock is listed as being at high risk from fishing activity in the ecological risk assessment process for the fishery or sector.

1.2 Biological status in 2018

Fishery status reports 2019 assesses 96 fish stocks across 22 fisheries (Figure 1.2); 65 stocks were assessed across 9 fisheries that are managed solely by AFMA on behalf of the Australian Government, and 31 stocks were assessed across 13 fisheries that are managed jointly with other Australian jurisdictions or other countries. One new stock is included in *Fishery status reports 2019*: the Antarctic toothfish (*Dissostichus mawsoni*) stock in the Commission for the Conservation of Antarctic Marine Living Resources exploratory toothfish fishery in division 58.4.2, which was formally fished by an Australian vessel for the first time in 2018. This is a jointly managed stock because it occurs in the area covered by the Convention on the Conservation of Antarctic Marine Living Resources.

The status of the 96 fish stocks managed solely or jointly by the Australian Government in 2018 is summarised as follows:

- The number of stocks classified as not subject to overfishing (Figure 1.3) remained at 79 (79 in 2017), and the number of stocks classified as not overfished (Figure 1.4) increased to 70 (69 in 2017). Of these, 67 stocks were both not subject to overfishing and not overfished (65 in 2017).
- The number of stocks classified as subject to overfishing (Figure 1.3) remained at 2, and the number of stocks classified as overfished (Figure 1.4) increased to 11 (10 in 2017). One stock was classified as both overfished and subject to overfishing (0 in 2017).
- The number of stocks classified as uncertain with regard to fishing mortality increased to 15 (14 in 2017), and the number of stocks classified as uncertain with regard to biomass decreased to 15 (16 in 2017). Of these, 8 stocks were uncertain with respect to both fishing mortality and biomass.

Fishery status reports 2019 shows a continuation of the patterns seen in stock status in recent years, with four stocks changing status for 2018 (Figures 1.3 and 1.4). This is the sixth consecutive year that no stock in a fishery solely managed by the Australian Government has been classified as subject to overfishing.

Status outcomes are summarised separately for stocks in fisheries solely managed by the Australian Government and stocks in fisheries that are jointly managed. This allows an evaluation of the performance of fisheries management against the relevant legislation and policies, which may differ between these groups of fisheries.

FIGURE 1.2 Biological status of fish stocks in 2018, by fishery or sector

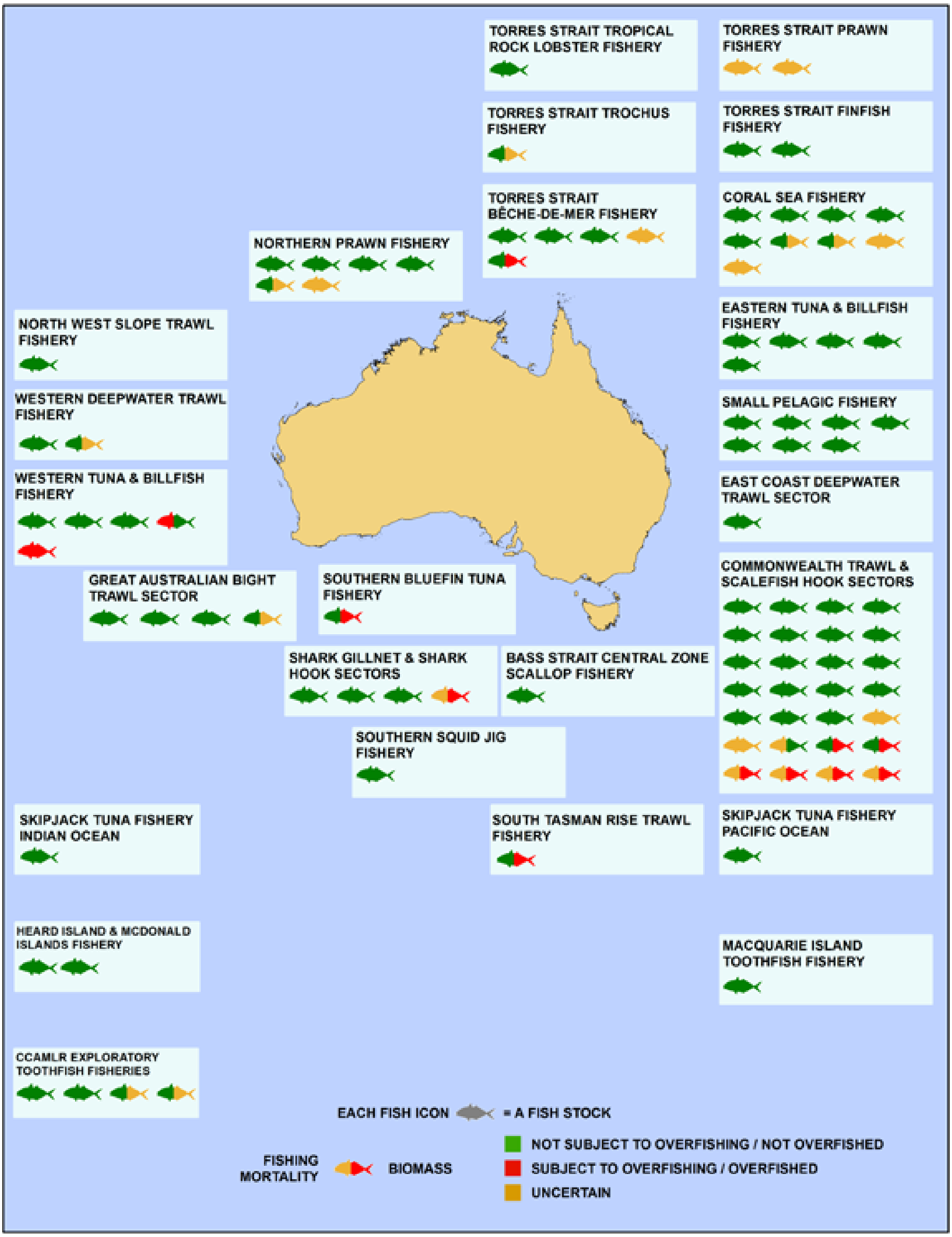


FIGURE 1.3 Fishing mortality status (number of stocks), 2004–2018

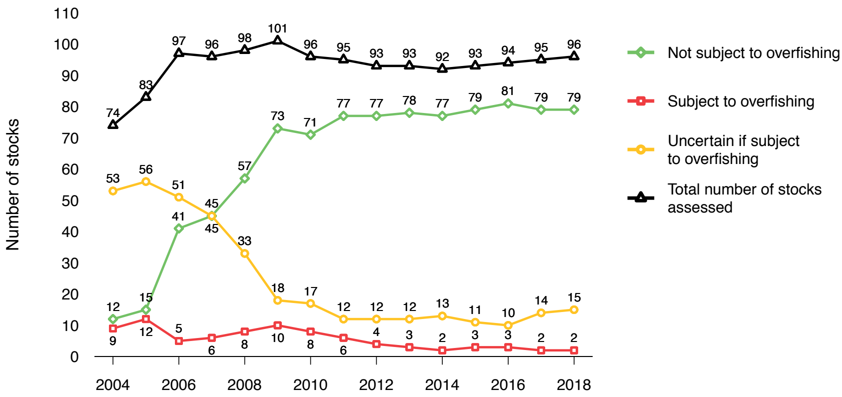
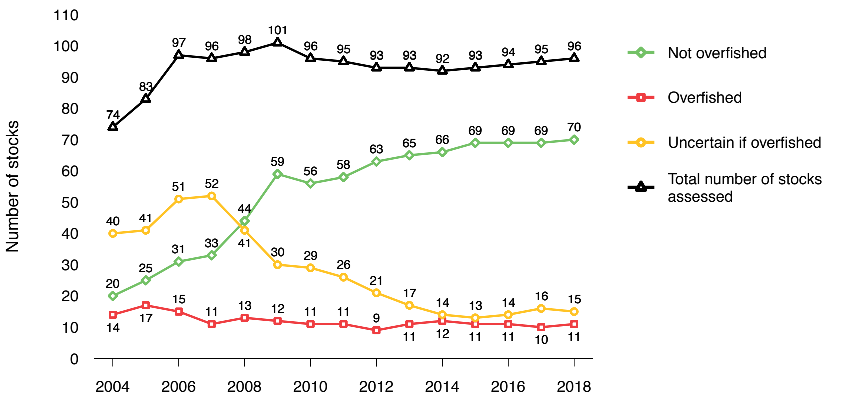


FIGURE 1.4 Biomass status (number of stocks), 2004–2018



Stocks that have changed status

Four stocks changed status in 2018. Status changes were largely due to improved and updated stock assessments, or uncertainty in setting the recommended biological catch (RBC). The status of four stocks in fisheries solely managed by the Australian Government changed in 2018 (Table 1.1). In the Southern and Eastern Scalefish and Shark Fishery (SESSF), the two deepwater shark stocks are now classified as uncertain for fishing mortality because catches in 2018 exceeded the RBC, and it is unknown whether this will deplete the population below its biomass limit reference point, given that the biomass for these stocks is also uncertain. Also in the SESSF, ocean perch (*Helicolenus barathri* and *H. percoides*) is now considered not subject to overfishing because the total fishing mortality in 2018 was below the RBC. The level of uncertainty around biomass for ruby snapper (*Etelis carbunculus*, *Etelis* spp.) has improved in the Western Deepwater Trawl Fishery. A stock assessment from the Western Australian–managed fisheries indicates that the stock is well above the limit reference point. This, together with the level of recent catches, has resulted in the stock now considered not overfished.

One stock in jointly managed fisheries changed status in 2018. The biomass status of striped marlin (*Kajikia audax*) stock in the Western Tuna and Billfish Fishery (WTBF) changed to uncertain in 2017 because biomass estimates from multiple assessment models used in 2017 ranged both above and below the limit reference point. An updated stock assessment in 2018 indicated that the stock was below the biomass limit reference point, while fishing mortality remained well above the level that would achieve maximum sustainable yield. The stock is now classified as both overfished and subject to overfishing.

TABLE 1.1 Stocks with a changed status in 2018 and their status in 2017

Fishery	Common name (scientific name)	2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass
Stocks in fisheries managed solely by the Australian Government					
Southern and Eastern Scalefish and Shark Fishery: Commonwealth Trawl Sector	Deepwater sharks, eastern zone (multiple species)	Not subject to overfishing	Uncertain	Uncertain	Uncertain
Southern and Eastern Scalefish and Shark Fishery: Commonwealth Trawl Sector	Deepwater sharks, western zone (multiple species)	Not subject to overfishing	Uncertain	Uncertain	Uncertain
Southern and Eastern Scalefish and Shark Fishery: Commonwealth Trawl Sector	Ocean perch (*Helicolenus barathri* and *H. percoides*)	Uncertain	Not overfished	Not subject to overfishing	Not overfished
Western Deepwater Trawl Fishery	Ruby snapper (*Etelis carbunculus*, *Etelis* spp.)	Not subject to overfishing	Uncertain	Not subject to overfishing	Not overfished
Stocks in fisheries managed jointly by the Australian Government					
Western Tuna and Billfish Fishery	Striped marlin (*Kajikia audax*)	Subject to overfishing	Uncertain	Subject to overfishing	Overfished

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

Stocks classified as overfished and/or subject to overfishing

Stocks classified as overfished and/or subject to overfishing in 2018 are largely the same as in 2017 (Tables 1.2 and 1.3). Table 1.2 summarises the status determinations and why the stocks were classified as overfished or subject to overfishing; the full details and evidence are provided in the relevant chapters. Briefly, seven stocks in fisheries managed solely by the Australian Government were classified as overfished in 2018 (Tables 1.2 and 1.3). These stocks occur in the SESSF and are subject to stock rebuilding strategies. Blue warehou (*Seriolella brama*), eastern gemfish (*Rexea solandri*), orange roughy (*Hoplostethus atlanticus*), gulper sharks (*Centrophorus* spp.) and school shark (*Galeorhinus galeus*) are listed as conservation-dependent under the EPBC Act, which carries management requirements.

Five stocks in jointly managed fisheries were classified as overfished or subject to overfishing in 2017. This remains the same in 2018, but striped marlin in the WTBF is now classified as both overfished and subject to overfishing (Table 1.2).

Assessing fishing mortality status for overfished stocks

It is becoming increasingly difficult to assess fishing mortality status for a number of overfished stocks: blue warehou, eastern gemfish and redfish (*Centroberyx affinis*). This is a result of a range of factors, including a lack of data, and uncertainty in the catch data and in the assessments. These species are subject to rebuilding strategies, which specify a biologically reasonable time frame for recovery to a biomass above the limit reference point. Although all overfished stocks have an RBC of zero, their rebuilding strategies include an incidental catch allowance to account for catches that are regarded as unavoidable when fishing for other species.

Catches that breach these allowances have been reported for each species since rebuilding strategies were implemented for them. Such breaches constitute overfishing for the purposes of status determination. There is also some level of discarding of these species, which can vary between years and can be difficult to estimate. The level of discard mortality is also uncertain. Information on the level of discarding is often not available for the most recent season at the time of drafting of these reports. When the known retained catch of the species approaches the incidental catch allowance, it is often difficult to be certain that the total catch has not exceeded the allowance because of the uncertainties in discard estimates. This increases the uncertainty about the level of influence the incidental catch of the species (and potential overfishing) may have on its rebuilding time frame. Furthermore, the assessment models that are used to develop the catch allowances generally assume average conditions (for example, recruitment) for their projections. The purpose of these projections is not to track recovery annually but to predict an ‘on average’ expected rebuilding time frame. A failure to detect a trend in fishery data that resembles the trajectory of the projection is not necessarily evidence that the species is not responding but may reflect ‘non-average’ conditions. Moreover, some assessments are more than six years old, and the evidence for fishing mortality effects is inferred from indicators rather than estimation using an assessment model. These models also rarely include ecosystem effects, such as changes in trophic interactions, which may influence the effect that fishing mortality has on rebuilding time frames.

These realities can make it unclear whether incidental catch is hindering recovery of a stock and what time frame of recovery is biologically reasonable, and therefore whether a stock under a rebuilding plan is subject to overfishing. This is the case for blue warehou, eastern gemfish and redfish. It is becoming increasingly apparent that standard data collection and assessment protocols are unable to deliver a concise picture of fishing mortality status for these overfished stocks.

Status of Australian fish stocks reports

In January 2019, the Fisheries Research and Development Corporation (FRDC) released *Status of Australian fish stocks reports 2018*, the fourth in the series. The reports provide a national assessment of the status of key wild-capture fish stocks that are managed by the Australian Government, the states and the Northern Territory. The reports were initiated in 2012 by the FRDC and ABARES. They are developed collaboratively by the FRDC, ABARES, CSIRO, and government fishery research agencies in all states and the Northern Territory. The 2018 reports provide assessments for 406 stocks across 120 key species (or species complexes). The reports consider the same biological information as the *Fishery status reports*, but interpret that information within a nationally agreed classification system (see Appendix). This national reporting framework is designed to improve the ability to compare the status of fish stocks across Australia.

Tuna pens off the coast of Port Lincoln
Matt Daniel, AFMA

TABLE 1.2 Stocks classified as overfished and/or subject to overfishing in 2018, and their status in 2017

Fishery	Common name (scientific name)	2017		2018		Comments
		Fishing mortality	Biomass	Fishing mortality	Biomass	
Stocks in fisheries managed solely by the Australian Government						
SESSF: CTS and SHS Chapter 9	Blue warehou (*Seriolella brama*)					Total removals are below the incidental catch allowance, but the level of fishing mortality that will allow the stock to rebuild is unknown. There is no evidence that the stock is rebuilding.
SESSF: CTS and SHS Chapter 9	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.
SESSF: CTS and SHS Chapter 9	Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)					Populations are likely to be highly depleted, and fishing mortality is uncertain despite low landed catch and protection through closures.
SESSF: CTS Chapter 9	Orange roughy, southern zone (*Hoplostethus atlanticus*)					Closure of most areas deeper than 700 m and negligible catches. No updated stock assessment.
SESSF: CTS Chapter 9	Orange roughy, western zone (*Hoplostethus atlanticus*)					Closure of most areas deeper than 700 m and negligible catches. No updated stock assessment.
SESSF: CTS Chapter 9	Redfish (*Centroberyx affinis*)					Biomass is below the limit reference point. Catch is above the RBC, and it is unclear whether total removals are above the level that will allow rebuilding.
SESSF: SGSHS Chapter 12	School shark (*Galeorhinus galeus*)					Uncertain if the fishing mortality rate in 2017–18 will allow recovery within the specified time frame. Biomass is likely to remain below 20% of unexploited levels.

continued ...

TABLE 1.2 Stocks classified as overfished and/or subject to overfishing in 2018, and their status in 2017 continued

Fishery	Common name (scientific name)	2017		2018		Comments
		Fishing mortality	Biomass	Fishing mortality	Biomass	
Stocks in fisheries managed jointly by the Australian Government						
South Tasman Rise Trawl Fishery Chapter 28	Orange roughy (*Hoplostethus atlanticus*)					Fishery has been closed under domestic arrangements since 2007 because of stock depletion.
Torres Strait Bêche-de-mer Fishery Chapter 19	Sandfish (*Holothuria scabra*)					No catch in 2017. The most recent full survey (2009) indicated that the stock was overfished.
Southern Bluefin Tuna Fishery Chapter 23	Southern bluefin tuna (*Thunnus maccoyii*)					The estimate of spawning biomass is below 20% of unfished biomass. The global TAC, set in line with the management procedure, should allow rebuilding within the prescribed time frame.
WTBF Chapter 24	Striped marlin (*Kajikia audax*)					The most recent estimates of biomass from multiple models range above and below the default Commonwealth limit reference point. The current fishing mortality rate exceeds that required to produce MSY.
WTBF Chapter 24	Yellowfin tuna (*Thunnus albacares*)					The most recent estimate of spawning biomass is above the default Commonwealth limit reference point. The current fishing mortality rate is above that required to produce MSY.

Note: **CTS** Commonwealth Trawl Sector. **MSY** Maximum sustainable yield. **RBC** Recommended biological catch. **SESSF** Southern and Eastern Scalefish and Shark Fishery. **SGSHS** Shark Gillnet and Shark Hook sectors. **SHS** Scalefish Hook Sector. **TAC** Total allowable catch. **WTBF** Western Tuna and Billfish Fishery.

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004

Fishery	Common name (scientific name)	Status																													
		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
Stocks in fisheries managed solely by the Australian Government																															
Bass Strait Central Zone Scallop Fishery	Commercial scallop (*Pecten fumatus*)																														
Coral Sea Fishery: Sea Cucumber Sector	Black teatfish (*Holothuria whitmaei*)																														
Coral Sea Fishery: Sea Cucumber Sector	Prickly redfish (*Thelenota ananas*)																														
Coral Sea Fishery: Sea Cucumber Sector	Surf redfish (*Actinopyga mauritiana*)																														
Coral Sea Fishery: Sea Cucumber Sector	White teatfish (*Holothuria fuscogilva*)																														
Coral Sea Fishery: Sea Cucumber Sector	Other sea cucumber species (~11 species)																														
Coral Sea Fishery: Aquarium Sector	Multiple species																														
Coral Sea Fishery: Lobster and Trochus Sector	Tropical rock lobster (*Panulirus ornatus*, possibly other species)																														
Coral Sea Fishery: Line and Trap Sector	Mixed reef fish and sharks																														
Coral Sea Fishery: Trawl and Trap Sector	Numerous fish, shark and crustacean species																														
Northern Prawn Fishery	Redleg banana prawn (*Fenneropenaeus indicus*)																														
Northern Prawn Fishery	White banana prawn (*Fenneropenaeus merguiensis*)																														

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status																													
		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
Northern Prawn Fishery	Brown tiger prawn (*Penaeus esculentus*)																														
Northern Prawn Fishery	Grooved tiger prawn (*Penaeus semisulcatus*)																														
Northern Prawn Fishery	Blue endeavour prawn (*Metapenaeus endeavouri*)																														
Northern Prawn Fishery	Red endeavour prawn (*Metapenaeus ensis*)																														
North West Slope Trawl Fishery	Scampi (*Metanephrops australiensis*, *M. boschmai*, *M. velutinus*)																														
Small Pelagic Fishery	Australian sardine (*Sardinops sagax*)																														
Small Pelagic Fishery	Blue mackerel, east (*Scomber australasicus*)																														
Small Pelagic Fishery	Blue mackerel, west (*Scomber australasicus*)																														
Small Pelagic Fishery	Jack mackerel, east (*Trachurus declivis*)																														
Small Pelagic Fishery	Jack mackerel, west (*Trachurus declivis*)																														
Small Pelagic Fishery	Redbait, east (*Emmelichthys nitidus*)																														
Small Pelagic Fishery	Redbait, west (*Emmelichthys nitidus*)																														

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status																													
		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue-eye trevalla (*Hyperoglyphe antarctica*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue grenadier (*Macruronus novaezelandiae*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue warehou (*Seriolella brama*)																														
SESSF: Commonwealth Trawl Sector	Deepwater sharks, eastern zone (18 species)																														
SESSF: Commonwealth Trawl Sector	Deepwater sharks, western zone (18 species)																														
SESSF: Commonwealth Trawl Sector	Eastern school whiting (*Sillago flindersi*)																														
SESSF: Commonwealth Trawl Sector	Flathead (*Neoplatycephalus richardsoni* and 4 other species)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, eastern zone (*Rexea solandri*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, western zone (*Rexea solandri*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)																														

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status																													
		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Jackass morwong (*Nemadactylus macropterus*)																														
SESSF: Commonwealth Trawl Sector	John dory (*Zeus faber*)																														
SESSF: Commonwealth Trawl Sector	Mirror dory (*Zenopsis nebulosa*)																														
SESSF: Commonwealth Trawl Sector	Ocean jacket (*Nelusetta ayraud*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ocean perch (*Helicolenus barathri*, *H. percoides*)																														
SESSF: Commonwealth Trawl Sector	Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)																														
SESSF: Commonwealth Trawl Sector	Orange roughy, eastern zone (*Hoplostethus atlanticus*)																														
SESSF: Commonwealth Trawl Sector	Orange roughy, southern zone (*Hoplostethus atlanticus*)																														
SESSF: Commonwealth Trawl Sector	Orange roughy, western zone (*Hoplostethus atlanticus*)																														
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, Cascade Plateau (*Pseudocyttus maculatus*)																														

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status																													
		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, non–Cascade Plateau (*Pseudocyttus maculatus*)																														
SESSF: Commonwealth Trawl Sector	Oreodory: other (*Neocyttus rhomboidalis, Allocyttus niger, A. verrucosus*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Pink ling (*Genypterus blacodes*)																														
SESSF: Commonwealth Trawl Sector	Redfish (*Centroberyx affinis*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ribaldo (*Mora moro*)																														
SESSF: Commonwealth Trawl Sector	Royal red prawn (*Haliporoides sibogae*)																														
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Silver trevally (*Pseudocaranx georgianus*)																														
SESSF: Commonwealth Trawl Sector	Silver warehou (*Seriolella punctata*)																														
SESSF: East Coast Deepwater Trawl Sector	Alfonsino (*Beryx splendens*)																														
SESSF: Great Australian Bight Trawl Sector	Bight redfish (*Centroberyx gerrardi*)																														

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status 2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
SESSF: Great Australian Bight Trawl Sector	Deepwater flathead (*Neoplatycephalus conatus*)	yellow	yellow	yellow	yellow	yellow	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green
SESSF: Great Australian Bight Trawl Sector	Ocean jacket, west (*Nelusetta ayraud*)	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	yellow	yellow	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green
SESSF: Great Australian Bight Trawl Sector	Orange roughy (*Hoplostethus atlanticus*)	yellow	yellow	yellow	yellow	yellow	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow
SESSF: Shark Gillnet and Shark Hook sectors	Elephantfish (*Callorhinchus milii*)	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	green	green	green	green	green	green	yellow	yellow	green	green	green	green	green	green	green	green	green	green	green	green
SESSF: Shark Gillnet and Shark Hook sectors	Gummy shark (*Mustelus antarcticus*)	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green
SESSF: Shark Gillnet and Shark Hook sectors	Sawshark (*Pristiophorus cirratus*, *P. nudipinnis*)	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	green	green	green	green	green	green	green	green	green	green	green	green
SESSF: Shark Gillnet and Shark Hook sectors	School shark (*Galeorhinus galeus*)	yellow	red	yellow	red	yellow	red	yellow	red	yellow	red	red	red	red	red	red	red	red	red	yellow	red	yellow	red	yellow	red	yellow	red	yellow	red	yellow	red
Southern Squid Jig Fishery	Gould's squid (*Nototodarus gouldi*)	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green
Western Deepwater Trawl Fishery	Deepwater bugs (*Ibacus* spp.)	yellow	yellow	yellow	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow
Western Deepwater Trawl Fishery	Ruby snapper (*Etelis carbunculus*)	yellow	yellow	yellow	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	yellow	green	green
Macquarie Island Toothfish Fishery	Patagonian toothfish (*Dissostichus eleginoides*)	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status 2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
Stocks in fisheries managed jointly by the Australian Government																															
South Tasman Rise Trawl Fishery	Orange roughy (*Hoplostethus atlanticus*)	Yellow	Red	Yellow	Red	Yellow	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red
Torres Strait Finfish Fishery	Coral trout (*Plectropomus* spp., *Variola* spp.)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Torres Strait Finfish Fishery	Spanish mackerel (*Scomberomorus commerson*)	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Torres Strait Tropical Rock Lobster Fishery	Tropical rock lobster (*Panulirus ornatus*)	Yellow	Red	Yellow	Red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Torres Strait Prawn Fishery	Brown tiger prawn (*Penaeus esculentus*)	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow
Torres Strait Prawn Fishery	Blue endeavour prawn (*Metapenaeus endeavouri*)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow
Torres Strait Bêche-de-mer Fishery	Black teatfish (*Holothuria whitmaei*)	Green	Red	Green	Red	Green	Red	Yellow	Red	Yellow	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Torres Strait Bêche-de-mer Fishery	Prickly redfish (*Thelenota ananas*)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Torres Strait Bêche-de-mer Fishery	Sandfish (*Holothuria scabra*)	Green	Red	Green	Red	Green	Red	Yellow	Red	Yellow	Red	Red	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Yellow	Red	Yellow	Red	Green	Red	Green	Red
Torres Strait Bêche-de-mer Fishery	White teatfish (*Holothuria fuscogilva*)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Torres Strait Bêche-de-mer Fishery	Other sea cucumbers (up to 18 species)	Grey	Grey	Grey	Grey	Yellow	Yellow	Grey	Grey	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow
Torres Strait Trochus Fishery	Trochus (*Trochus niloticus*)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow
Eastern Tuna and Billfish Fishery	Striped marlin (*Kajikia audax*)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status																													
		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
Eastern Tuna and Billfish Fishery	Swordfish (*Xiphias gladius*)																														
Eastern Tuna and Billfish Fishery	Albacore (*Thunnus alalunga*)																														
Eastern Tuna and Billfish Fishery	Bigeye tuna (*Thunnus obesus*)																														
Eastern Tuna and Billfish Fishery	Yellowfin tuna (*Thunnus albacares*)																														
Skipjack Tuna Fishery: Pacific Ocean	Skipjack tuna (*Katsuwonus pelamis*)																														
Skipjack Tuna Fishery: Indian Ocean	Skipjack tuna (*Katsuwonus pelamis*)																														
Southern Bluefin Tuna Fishery	Southern bluefin tuna (*Thunnus maccoyii*)																														
Western Tuna and Billfish Fishery	Striped marlin (*Kajikia audax*)																														
Western Tuna and Billfish Fishery	Swordfish (*Xiphias gladius*)																														
Western Tuna and Billfish Fishery	Albacore (*Thunnus alalunga*)																														
Western Tuna and Billfish Fishery	Bigeye tuna (*Thunnus obesus*)																														
Western Tuna and Billfish Fishery	Yellowfin tuna (*Thunnus albacares*)																														
Heard Island and McDonald Islands Fishery	Mackerel icefish (*Champsocephalus gunnari*)																														
Heard Island and McDonald Islands Fishery	Patagonian toothfish (*Dissostichus eleginoides*)																														

continued ...

Table 1.3 Biological stock status of all stocks assessed in 2018, and their status since 2004 continued

Fishery	Common name (scientific name)	Status																													
		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
CCAMLR exploratory toothfish fisheries 58.4.1	Toothfish (*Dissostichus mawsoni*)																									Not subject to overfishing	Uncertain	Not subject to overfishing	Uncertain	Not subject to overfishing	Uncertain
CCAMLR exploratory toothfish fisheries 58.4.2	Toothfish (*Dissostichus mawsoni*)																													Not subject to overfishing	Uncertain
CCAMLR exploratory toothfish fisheries 88.1	Toothfish (*Dissostichus mawsoni*)																											Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished
CCAMLR exploratory toothfish fisheries 88.2	Toothfish (*Dissostichus mawsoni*)																							Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished

Fishing mortality — Not subject to overfishing (green); Subject to overfishing (red); Uncertain (yellow)

Biomass — Not overfished (green); Overfished (red); Uncertain (yellow)

Notes: **CCAMLR** Commission for the Conservation of Antarctic Marine Living Resources. **SESSF** Southern and Eastern Scalefish and Shark Fishery. Individual stocks may have been classified as multispecies stocks in earlier years. The status determination process changed in 2004—refer to Chapter 30 for more information. Grey shading indicates that the stock was not assessed.

Sushi and sashimi
Lee Georgeson, ABARES

1.3 Economic status

Assessing economic status

The evaluation of economic status in the *Fishery status reports* assesses each fishery's performance against the economic objective of the *Fisheries Management Act 1991* to maximise NER to the Australian community, within the constraints of ecologically sustainable development. Economic status is expressed in relation to the target reference points prescribed by the HSP, which are set at more conservative levels than the limit reference points used to assess biological status. At the stock level, economic status indicates whether the biomass is at a level that is consistent with achieving the HSP target reference point—a biomass target consistent with achieving maximum economic yield (MEY) from the fishery. When biomass is below the target reference point and moving further away from it, rebuilding of the stock would be required to bring the biomass closer to the reference point. When biomass is above the target reference point, fishing down the stock to the reference point is required to maximise NER. At the fishery level, moving stocks towards their respective target reference points leads to an improvement in the economic status of the fishery and helps ensure that the economic objective of the *Fisheries Management Act 1991* is met.

Determining whether economic status of a fishery is improving or deteriorating is constrained by data limitations and relies on interpretation of a number of economic indicators. For example, an increasing trend in fishery-level NER driven predominantly by an increasing trend in the economic productivity of a fishery provides a strong indicator that the economic status of the fishery is improving. However, an increasing trend in fishery-level NER caused predominantly by favourable movements in market prices for inputs and outputs is not conclusive evidence that the fishery is moving closer to its target, because changes in market prices change the position of the economic target reference point.

The ABARES financial and economic surveys are important for estimating NER and thereby assessing the economic performance of fisheries managed by the Australian Government. NER estimates provide a full account of the return to the community from managing fisheries because they include all revenues earned and costs incurred. These costs include economic costs (for example, wages, use of family labour in the business, economic depreciation), fishery management costs (including those components not cost recovered from industry) and the full cost of fuel—that is, inclusive of fuel tax credits gained by the fishery. As a result, NER are typically lower than aggregate fishery profitability derived through an accounting framework, which only considers explicit costs and revenues in deriving estimates of profits. To assess economic status, movements in NER are assessed alongside other economic indicators, including the extent to which stocks managed in the fishery have moved closer to their respective economic target reference points.

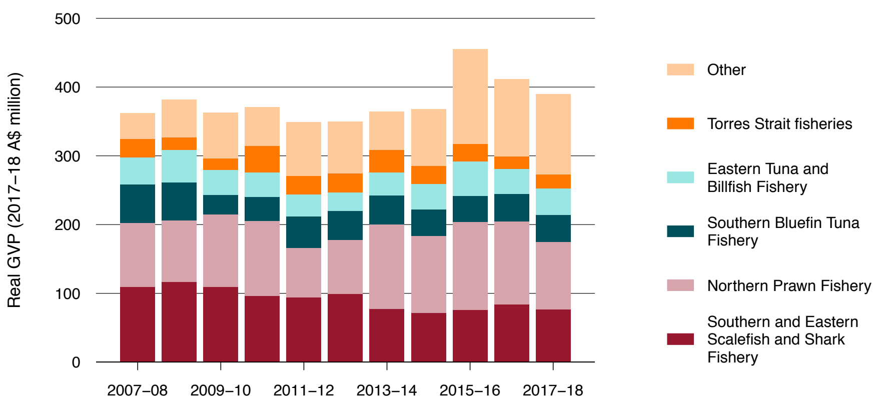
Direct estimates of NER are only available for key Commonwealth fisheries for which ABARES routinely assesses financial and economic performance by surveying industry. Where direct estimates of NER are not available, a range of indicators are used to assess the economic performance of fisheries, and to make inferences about trends in NER. Effects of management arrangements and performance of the fishery against the HSP's MEY objective are also assessed. For jointly managed fisheries (to which the HSP does not apply), economic performance is evaluated against relevant management objectives. Table 1.4 summarises indicators of economic performance.

Economic status in 2017–18

Fishery status reports 2019 assesses the economic status of all fisheries managed solely and jointly by the Australian Government. These fisheries generated an estimated gross value of production (GVP) of $390 million in 2017–18, accounting for 22% of wild-catch fisheries GVP in Australia ($1.79 billion).[1] These fisheries also accounted for about 12% of Australia's total fisheries and aquaculture GVP in 2017–18.

The Commonwealth fisheries GVP was dominated by production from four major fisheries in 2017–18 that together accounted for 65% of total Commonwealth fisheries GVP. In 2017–18, the Northern Prawn Fishery (NPF) made a large contribution to overall Commonwealth fishery GVP, with a GVP of $98.2 million (25% contribution). The multisector SESSF was also a valuable Commonwealth fishery, with a GVP of $76.4 million (20% contribution). The wild-catch sector of the Southern Bluefin Tuna Fishery (SBTF) and the Eastern Tuna and Billfish Fishery (ETBF) also made substantial contributions to fisheries GVP in 2017–18, with values of $39.7 million and $38.4 million, respectively (Figure 1.5).

FIGURE 1.5 Gross value of production of fisheries managed solely or jointly by the Australian Government, 2007–08 to 2017–18



1 GVP figures are subject to revision, and consequently may differ in past and future publications.

TABLE 1.4 Indicators and summary of economic status of Commonwealth fisheries for 2017–18

Fishery	**Performance relative to MEY target**	**NER trend**	**Fishing right latency in fishing season**	**2016–17 fishery GVP (% change from 2015–16)**
Bass Strait Central Zone Scallop Fishery	MEY target not specified	Negative in 2009–10 and 2010–11 (–$1.1 million). Likely to be increasing since 2010–11	Low uncaught TAC	$6.72 million (+12%)
Coral Sea Fishery	MEY target not specified	Not available	High uncaught TAC in the non-aquarium part of the fishery	Confidential
Norfolk Island Fishery	MEY target not specified	Not available	Offshore fishery closed to commercial fishing. Unknown in the inshore fishery	Not available
Northern Prawn Fishery	Tiger prawn stocks above B_{MEY} target. MEY catch trigger in place for banana prawns but too early to determine its effect on NER	Positive	Low unused effort	$98.15 million (–17%)
North West Slope Trawl Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential
Small Pelagic Fishery	MEY target not specified	Not available	High uncaught TAC	Confidential
SESSF: Commonwealth Trawl and Scalefish Hook sectors **a**	Of the four key species, three are above or close to B_{MEY} targets. Some overfished stocks require rebuilding for improvement in economic status	Positive	High uncaught TAC for some species	$43.96 million (–7%)
SESSF: East Coast Deepwater Trawl Sector	No fishing effort	Not available	High uncaught TAC	Confidential
SESSF: Great Australian Bight Trawl Sector	Bight redfish and deepwater flathead above or close to B_{MEY} target	Not available but likely to be positive, and have decreased	High uncaught TAC	$9.16 million (–9%)
SESSF: Shark Hook and Shark Gillnet sectors **b**	Gummy shark stock close to, or above, target. Biomass of school shark requires rebuilding	Positive in 2016–17; estimated to become negative in 2017–18	Low uncaught TAC for key target species	$23.30 million (–8%)
Southern Squid Jig Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential

2016–17 management costs (% share of GVP)	Primary management instrument	Comments about economic status
$0.39 million (6%)	ITQs and spatial management	NER are likely to have improved since 2010–11 (the last available survey year), when real NER were –$1.2 million (in 2017–18 dollars). It is uncertain whether NER are now positive. Compared with 2010–11, GVP in 2017–18 was higher, fewer vessels were used in the fishery, and unit fuel prices and total management costs of the fishery declined.
$0.16 million (confidential)	Catch triggers and TACs	Estimates of NER are not available, and the trend in economic performance for these sectors in 2017–18 is uncertain. Catch in the Aquarium Sector increased in 2017–18. Catch and effort in the Sea Cucumber Sector decreased in 2017–18, whereas catch and effort in the Line and Trap Sector increased relative to the previous year.
Not available	Input controls	Economic status is unknown.
$1.75 million (2%)	Individual transferable gear units (headrope length)	NER reached a high of $30.9 million in 2015–16, supported by a strong increase in tiger prawn catch, marking a fourth consecutive annual increase in NER. The performance in 2016–17 remained stable at $30.3 million. In 2017–18, lower GVP and higher unit fuel prices are expected to reduce NER.
$0.05 million (confidential)	Limited entry and catch triggers	Estimates of NER are not available. Increased catch in the 2016–17 and 2017–18 fishing seasons suggests increased GVP, but the effect of this on NER is uncertain because fishing costs in the 2016–17 and 2017–18 fishing seasons are likely to have increased. A high degree of latent fishing effort indicates that NER are likely to be low.
$1.42 million (confidential)	ITQs	NER in the CTS rose to $4.0 million in 2016–17, a result largely driven by lower operating costs. Preliminary estimates from the survey suggest that NER were –$0.17 million in 2017–18. This negative result is driven by lower forecast income and higher operating costs.
$2.69 million for CTS (6% of CTS GVP)	ITQs	NER in the CTS rose to $4.0 million in 2016–17, a result largely driven by lower operating costs. Preliminary estimates from the survey suggest that NER were –$0.17 million in 2017–18. This negative result is driven by lower forecast income and higher operating costs.
$0.00 million (confidential)	ITQs	Latency is high in the fishery. No fishing effort between 2013–14 and 2017–18, and low catches in 2018–19 indicate low NER.
$0.50 million (5%)	ITQs	A strong increase in fuel price, despite a moderate reduction in fishing hours, together with lower GVP and catch volumes, indicate that NER were likely to be lower in 2017–18 and 2018–19 than in 2016–17.
$2.44 million for GHTS (10% of GHTS GVP)	ITQs	NER for the GHTS were $4.0 million in 2016–17. Preliminary estimates indicate that NER were likely to be negative for 2017–18. Although gummy shark biomass is not constraining NER, the management of non-target species and marine mammal interactions has likely contributed to low NER in recent years.
$0.14 million (confidential)	Individual transferable gear units (jig machines)	Catch and effort in the fishery increased from 2016–17 to 2017–18. In the same period, catch-per-unit-effort increased, suggesting lower unit fishing costs, and prices for landed catch increased. This suggests that NER are likely to have improved.

continued ...

TABLE 1.4 Indicators and summary of economic status of Commonwealth fisheries for 2017–18 continued

Fishery	Performance relative to MEY target	NER trend	Fishing right latency in fishing season	2017–18 fishery GVP (% change from 2016–17)
Western Deepwater Trawl Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential
Torres Strait Finfish Fishery	Not applicable **c**	Not available	Not applicable	$0.99 million (–18%)
Torres Strait Tropical Rock Lobster Fishery	Not applicable **c**	Not available	Low uncaught TAC	$15.01 million (+19%)
Torres Strait Prawn Fishery	Not applicable **c**	Not available	High unused effort	$4.60 million (+16%)
Torres Strait Bêche-de-mer Fishery	Not applicable **c**	Not available	High uncaught TAC	Not available
Torres Strait Trochus Fishery	Not applicable **c**	Not available	High uncaught TAC	Not available
Eastern Tuna and Billfish Fishery	MEY target not adequately specified or applied	Increasing trend; turned positive in 2010–11	Low uncaught quota for target species	$38.40 million (+8%)
Skipjack Tuna Fishery	MEY target not specified	No fishing	High non-participation by licence holders	No fishing
Southern Bluefin Tuna Fishery	MEY target not specified	Not available	Low uncaught TAC	$39.74 million (+3%)
Western Tuna and Billfish Fishery	MEY target not specified	Not available	High uncaught TAC (more than 95% in 2015 and 2016 fishing seasons)	Confidential
Heard Island and McDonald Islands Fishery	Not applicable **c**	Not available but likely to be positive	Low uncaught TAC	Confidential
Macquarie Island Toothfish Fishery	Not applicable **c**	Not available but likely to be positive	Low uncaught TAC	Confidential
CCAMLR exploratory toothfish fisheries	Not applicable **c**	Not available	Low uncaught TAC	Confidential

2017–18 management costs (% share of GVP)	Primary management instrument	Comments about economic status
$0.05 million (confidential)	Limited entry	Estimates of NER are unavailable and GVP is confidential because of the low number of active vessels in the fishery. An increase in catch and active vessels in the 2017–18 fishing season may indicate economic improvement in the fishery; however, this may have been offset by an increase in fishing costs. Whether NER increased or decreased in the 2017–18 fishing season is uncertain.
Not available	Non-tradeable quota	Estimates of NER are not available.
Not available	Limited entry for non–Traditional Inhabitant sector and TAC	NER in the fishery are uncertain, although economic conditions may have improved in the 2017–18 fishing season as a result of GVP increasing faster than effort.
$0.21 million (5%, AFMA costs only)	Tradeable effort units (nights)	Estimates of NER are unavailable. An increase in GVP and a decrease in hours trawled per vessel in 2017–18 indicate that NER may have improved.
Not available	TACs	Estimates of NER and GVP are unavailable. A low level of catch indicates low NER. Increased catch in 2018 resulted in some improvement in economic performance.
Not available	TACs	Little to no catch has been recorded in the fishery since 2010, suggesting fishers have a low incentive to fish.
$1.59 million (4%)	ITQs	Preliminary estimates suggest NER for the fishery remained positive between 2015–16 and 2017–18. NER improved significantly in 2015–16. Non–survey based estimates indicate that NER increased in 2017–18.
$0.06 million (no fishing)	Limited entry	No Australian vessels fished in 2017 or 2018.
$1.19 million (3%)	ITQs	NER are expected to have remained positive in 2017–18, reflecting low levels of quota latency. However, the overfished status of the stock poses a risk to future NER. Economic status will improve as the stock is rebuilt under the management procedure.
$0.24 million (confidential)	ITQs	Participation rate was low and latency remained high in 2018, suggesting little economic incentives to fish and relatively small NER.
$1.42 million (confidential)	ITQs	Estimates of NER are not available but are likely to be positive. Likely positive NER for the 2016–17 and 2017–18 fishing seasons are indicated by low levels of latency for targeted species.
$0.43 million (confidential)	ITQs	Estimates of NER are not available but are likely to be positive for the 2017–18 and 2018–19 fishing seasons due to low TAC latency for Patagonian toothfish in both seasons.
Confidential	Limited entry and TACs	Estimates of NER are not available, and NER remain uncertain. Australian fishers have been active across the exploratory areas from 2014–15 to 2017–18.

a NER estimates and management costs are only available for the CTS and exclude the Scalefish Hook Sector. **b** NER estimates and management costs are only available for the GHTS, which includes Scalefish Hook Sector catches and gillnet scalefish catches. **c** These fisheries are jointly managed fisheries that are not managed under MEY objectives. Statistics are provided by financial year.

Notes: **AFMA** Australian Fisheries Management Authority. B_{MEY} Biomass at maximum economic yield. **CCAMLR** Commission for the Conservation of Antarctic Marine Living Resources. **CTS** Commonwealth Trawl Sector. **GHTS** Gillnet, Hook and Trap Sector. **GVP** Gross value of production. **ITQ** Individual transferable quota. **MEY** Maximum economic yield. NER Net economic returns. **SESSF** Southern and Eastern Scalefish and Shark Fishery. **TAC** Total allowable catch. The South Tasman Rise Trawl Fishery is not shown because it has been closed since 2007.

Fisheries managed solely by the Australian Government

ABARES undertakes regular economic surveys of the most valuable fisheries managed solely by the Australian Government: the Commonwealth Trawl Sector (CTS), and the Gillnet, Hook and Trap Sector (GHTS) of the SESSF; and the NPF. These fisheries are managed under MEY objectives. Together, they accounted for 84% of the GVP of all solely Australian Government–managed fisheries in 2017–18.

The tiger prawn component of the NPF is explicitly managed to a MEY target, using a bio-economic model to set effort levels that are estimated to produce MEY. The banana prawn component of the NPF is separately managed through an MEY-based catch rate trigger for season closure. NER in the NPF increased to $30.9 million in 2015–16, and preliminary estimates indicate that NER remained stable in 2016–17 as a result of a strong catching season for banana prawns. In 2017–18, lower GVP and higher unit fuel prices are expected to have a dampening effect on NER (Bath, Curtotti & Mobsby 2018). The bio-economic modelling of the tiger prawn component of the fishery has facilitated an improvement in the economic performance of this component of the fishery.

In the CTS and the GHTS, MEY is pursued through the application of proxies for biomass targets (B_{MEY}) for individual stocks. For the most valuable species targeted in these two sectors, current biomass levels are generally estimated to be close to, or above, their respective B_{MEY} targets, meaning that stock levels are not constraining profits. NER in the CTS rose to $4.0 million in 2016–17, a result largely driven by lower operating costs. Preliminary estimates from the survey suggest that NER were –$0.17 million in 2017–18. This negative result is driven by lower forecast income and higher operating costs. In the GHTS, positive NER were maintained in the decade leading up to, and including, 2008–09. However, NER were negative in 2009–10, declining to –$0.4 million, as spatial closures aimed at reducing marine mammal interactions and efforts to avoid (overfished) school shark affected the sector's economic performance (Skirtun & Green 2015). Since then, NER have followed an increasing trend, with an estimated NER of $4.0 million in 2016–17. Preliminary estimates indicate that NER were likely to be negative for 2017–18. This negative result is potentially a result of lower catch volume of gummy shark and higher unit fuel prices. This reverses a trend of recovery in NER that started in 2013–14.

In the Great Australian Bight Trawl Sector, the development of a bio-economic model for the two key target species (deepwater flathead—*Platycephalus conatus*, and bight redfish—*Centroberyx gerrardi*) has improved the ability to target B_{MEY} (Kompas et al. 2012). The most recent stock assessments for bight redfish and deepwater flathead suggest that fishery profitability is unlikely to be constrained by stock status.

Some fisheries that had been small in previous years were significantly larger by 2017–18, including the Small Pelagic Fishery (SPF), the Bass Strait Central Zone Scallop Fishery (BSCZSF) and the Southern Squid Jig Fishery (SSJF). The BSCZSF and the SPF underwent management changes that allowed growth in GVP. For the BSCZSF, surveys in recent years have shown substantially larger biomass levels that have allowed higher TACs and more areas to be opened to fishing under the rules of the harvest strategy. In the SPF, the use of a large factory freezer midwater trawl vessel allowed a larger catch in 2015–16, but catches were sharply down in 2016–17 as a result of the trawler no longer operating in the fishery. An increase in the level of catch in 2017–18 suggests that GVP is likely to have increased in 2017–18. Changes in NER are uncertain, however, because of a lack of information about changes in the cost structures of the fishery. For the SSJF, catch and effort increased from 2016–17 to 2017–18. In the same period, catch-per-unit-effort increased, suggesting lower unit fishing costs, and prices for landed catch increased. This suggests that the economic incentive to fish increased in 2017–18 and that NER in the fishery are likely to have improved.

Low catch-and-effort levels in the other fisheries (Coral Sea Fishery, East Coast Deepwater Trawl Sector, North West Slope Trawl Fishery and Western Deepwater Trawl Fishery) indicate low NER in 2017–18. For these fisheries, it is often difficult to assess economic status because of a lack of economic data.

Jointly managed fisheries

Of the fisheries jointly managed by the Australian Government, the major fisheries include the SBTF, the ETBF, and the Torres Strait Tropical Rock Lobster Fishery (TSTRLF). Combined, these three fisheries generated a GVP of $93.1 million and accounted for 48% of the GVP of all jointly managed fisheries in 2017–18. Individually, these fisheries generated GVPs of $39.7 million, $38.4 million and $15.0 million, respectively, in 2017–18.

Estimates of NER are not available for the SBTF. However, the fishery provides fish to South Australia's southern bluefin tuna aquaculture industry (generating $126 million GVP at the farm gate in 2017–18). Although the stock's current low biomass level poses a risk to the future flow of NER from the fishery, the current international management arrangements, which are designed to allow the stock to rebuild, would be expected to improve NER in the future.

Economic status in the ETBF has improved. Preliminary estimates suggest that NER for the fishery remained positive between 2015–16 and 2017–18, driven by increased catch, higher prices of key species and a significant fall in the fuel price.

Torres Strait fisheries are managed in accordance with the *Torres Strait Fisheries Act 1984*. This Act details a range of management priorities, including acknowledging and protecting the traditional way of life and livelihood of Traditional Inhabitants. As a result, these fisheries are not evaluated against the MEY objective of the HSP in these reports, and achieving the fishery's economic potential needs to be considered alongside the social and cultural objectives of Torres Strait Islander and Aboriginal people. The TSTRLF was the most valuable commercial fishery in Torres Strait in 2017–18, followed by the Torres Strait Prawn Fishery.

Latency in fisheries

In many fisheries, the degree of latency—that is, the proportion of TAC left uncaught, or the level of non-participation by licence holders—is high (Table 1.4). High levels of latency indicate that the economic incentive to participate actively in the fishery is lacking and that the overall economic performance of the fishery is likely to be low. In general, input controls, such as allowable effort, and output controls, such as TACs, should be set in line with the aim of achieving MEY. When targets are not set at MEY levels, profits tend to be dissipated as a result of unconstrained fishing effort or catch. This may be the case when fishers collectively fish below the TAC or effort control target.

For some fisheries, the degree of latency can be explained in terms of the type of fishery and the industry structure. For example, for some jointly managed fisheries where Australia maintains an economic interest, latency may be high because the negotiated TAC for Australian fishers is not set according to MEY criteria. For some fisheries managed solely by the Australian Government, the fleet structure of the fishery may not be well aligned with the MEY target, and hence the TAC remains uncaught at the end of the fishing season.

However, for some fisheries, the reasons for persistently high latency remain unclear and warrant further investigation. For example, the TACs for a number of species in the SESSF have increasingly been undercaught in recent seasons.

The MEY target can be set higher than the optimum level for a number of reasons, including that:

- estimating MEY targets requires investments in data collection and modelling that are constrained by available resources; managers therefore frequently use proxy targets that may not be optimal for a given species or multispecies stock
- market conditions, such as fish prices or input prices for fuel and labour, may have changed, making a model-derived MEY target and/or proxy inaccurate
- a stock may be less abundant than anticipated, or located further afield, and thus more costly to catch
- regulatory changes in gear or spatial restrictions may mean that it is no longer economically profitable to catch to the previous MEY target.

Practical considerations sometimes make it difficult to catch to the MEY target. For example, an undercaught species may be co-caught with a targeted high-value species that has been fished to quota. Targeting the undercaught species may be too costly or impractical within a season. Similarly, a reduction in quota for a target species will likely reduce the catch of co-caught species. MEY targets designed for multispecies fisheries would help to address this cause of undercatch. In addition, fishers may not be able to obtain quota for the undercaught species because of the costs involved in obtaining quota in a market with few transactions.

1.4 Environmental status in 2018

The *Fishery status reports* examines the broader impact of fisheries on the environment, in response to the requirements of the *Fisheries Management Act 1991*, the EPBC Act and the Commonwealth Fisheries Bycatch Policy (Department of Agriculture and Water Resources 2018a). The Australian Government aims to implement an ecosystem-based approach to fisheries management as part of meeting the principles of ecologically sustainable development. This requires a holistic approach to management that considers fisheries' interactions with, and impacts on, bycatch species (including protected species), marine habitats, communities and ecosystems.

Ecological risk assessment

A key component of AFMA's ecosystem-based approach to fisheries management has been the application of an ecological risk management (ERM) framework that is designed to respond to the outcomes of the ecological risk assessment (ERA) process (Hobday et al. 2007). Fishery-specific ERM reports integrate the information from the ERAs and other management requirements, such as recovery plans and threat abatement plans, and detail AFMA's management response. Fishery-specific actions for bycatch and discarding are identified in fishery-specific bycatch and discarding workplans. The ERA framework has been revised, and reviews for the ETBF, the SESSF and the SPF have commenced.

Protected species interactions

During the normal course of fishing operations, fishers can interact with protected species listed under the EPBC Act. Legislation requires them to take all reasonable steps to minimise interactions and report any interactions that occur. AFMA reports interactions with protected species reported by fishers in logbooks to the Australian Government Department of the Environment and Energy quarterly. The species involved and the level of interactions vary between fisheries and sectors, as well as with gear, area and season. Although interactions with protected species are rare, they can still be a significant source of mortality for the affected populations.

Considerable progress has been made in some fisheries to implement measures to reduce interactions with protected species. Examples are:

- compulsory use of turtle excluder devices in the NPF
- implementation of a threat abatement plan for the incidental catch (or bycatch) of seabirds during pelagic longline fishing operations in the ETBF, the WTBF and the Macquarie Island Toothfish Fishery
- use of seal excluder devices in the SPF and in the winter blue grenadier trawl fishery of the SESSF
- gillnet fishing closures in the Shark Gillnet and Shark Hook sectors of the SESSF to avoid interactions with Australian sea lions.

Recently, there has been a focus on seabird interactions with trawl fisheries. Following sea trials in 2015 to assess the impact of two new devices designed to reduce seabird interactions, since 1 May 2017, all vessels in the CTS and the Great Australian Bight Trawl Sector must use one of the following mitigation devices: sprayers, bird bafflers or pinkies (large floats attached in front of trawl warps to scare birds away), with zero discharge of fish waste.

AFMA also introduced new dolphin mitigation strategies in the SPF and the GHTS of the SESSF that came into force on 10 May 2017. These strategies apply to all trawling operations in the SPF and the whole gillnet sector of the GHTS. They were developed in consultation with stakeholders and marine mammal experts.

Data collection

Limited availability of reliable data on interactions with protected species remains problematic in some fisheries. The rare nature of interactions with protected species creates a challenge for obtaining reliable estimates of interaction rates, particularly at lower levels of observer coverage. Reliable data are critical for determining the extent of interactions, evaluating the potential impact on populations (particularly for high-risk species) and demonstrating the effectiveness of management measures.

AFMA has continued to strengthen independent monitoring capabilities by introducing electronic monitoring (e-monitoring) programs in several fisheries and subfisheries to improve logbook reporting and to verify logbook reports of interactions with protected species. A preliminary comparison of catch-and-discard data for target, byproduct and bycatch species, as well as wildlife interactions, identified a significant increase in reported nominal discard and interactions per unit effort in the first two years after e-monitoring was introduced (Emery et al. 2019). While not discounting possible environmentally driven shifts in availability and abundance, or individual vessel effects, evidence suggests that e-monitoring has led to significant changes in logbook reporting, particularly in the ETBF (Emery et al. 2019).

E-monitoring became mandatory on 1 September 2014 for boats using automatic demersal longline gear, and on 1 July 2015 for gillnet boats that fish more than 50 days per year and manual demersal longline boats that fish more than 100 days per year. E-monitoring became mandatory in the ETBF and the WTBF on 1 July 2015 for pelagic longline boats that fish more than 30 days per year.

The aim is for e-monitoring analysts to randomly review 10% of the video footage, and a risk-based approach is used to audit more footage from boats that are suspected of misreporting. In the GHTS, all gillnet hauls are audited in the Australian sea lion management zones, to verify any bycatch of protected species. More information on e-monitoring can be found on the AFMA website.[2]

2 afma.gov.au/monitoring-enforcement/electronic-monitoring-program

1.5 References

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Blue grenadier
Heesham Garroun, AFMA

Chapter 2
Bass Strait Central Zone Scallop Fishery

N Marton and R Curtotti

FIGURE 2.1 Area and relative fishing intensity in the Bass Strait Central Zone Scallop Fishery, 2018

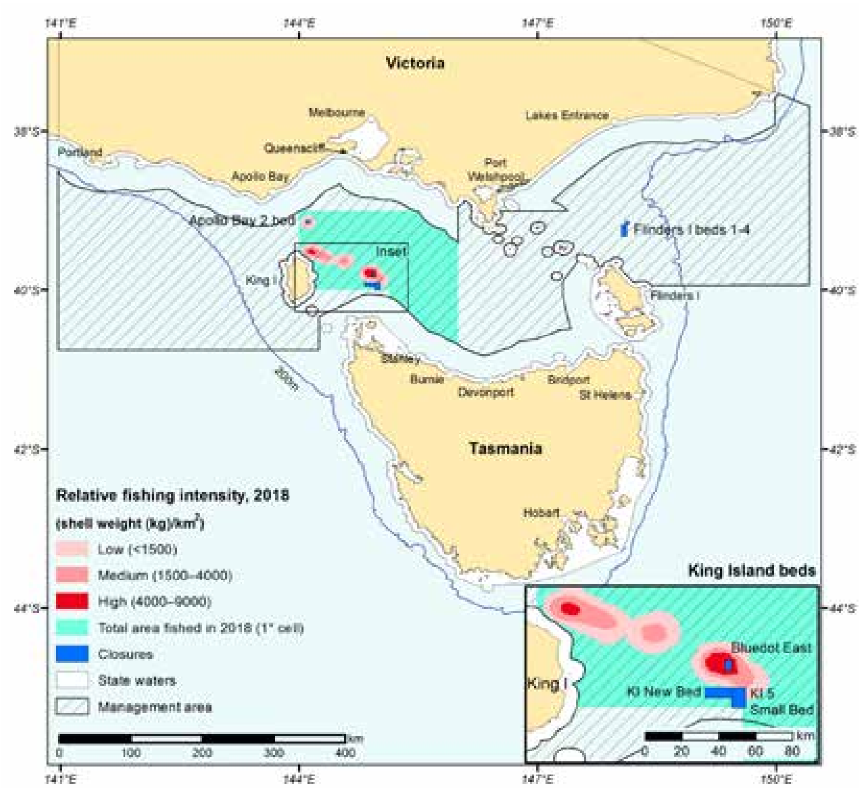


TABLE 2.1 Status of the Bass Strait Central Zone Scallop Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Commercial scallop (*Pecten fumatus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Large, stable biomass identified in western Bass Strait. Total allowable catch and catch in 2018 small relative to known biomass.
Economic status	NER are likely to have improved since 2010–11 (the last available survey year) when real NER were –$1.2 million (in 2017–18 dollars), although it is uncertain whether NER are now positive. Compared with 2010–11, GVP in 2017–18 was higher, fewer vessels were used in the fishery, and unit fuel prices and total management costs of the fishery declined.				

Notes: **GVP** Gross value of production. **NER** Net economic returns.

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

2.1 Description of the fishery

Area fished

The Bass Strait Central Zone Scallop Fishery (BSCZSF) operates in the central area of Bass Strait between the Victorian and Tasmanian scallop fisheries (Figure 2.1). In 2018, fishing was permitted throughout the management area, except in five scallop beds (Figure 2.1) that were closed to fishing under the harvest strategy. Fishing in 2018 was concentrated on beds east of King Island. This was a similar area to that fished in 2014, 2015, 2016 and 2017.

Fishing methods and key species

The fishery is a single-species fishery targeting dense aggregations ('beds') of commercial scallop (*Pecten fumatus*) using scallop dredges.

Management methods

The fishery is managed through a range of input controls (seasonal and area closures) and output controls (total allowable catch [TAC]), together with quota statutory fishing rights and individual transferable quota controls. A TAC of 100 t also exists for doughboy scallops (*Chlamys asperrima*); however, because there is no market for the species, it is usually not retained.

Following a three-year closure under the 2005 Ministerial Direction to cease overfishing and recover fish stocks, the fishery reopened in 2009 under a formal harvest strategy (AFMA 2007), which was updated for the 2012 season (AFMA 2012b). The harvest strategy was substantially revised for the 2014 season (AFMA 2014) and updated in 2015 for clarity (AFMA 2015).

Management methods have changed considerably since 2009. The changes include a reduction in the scallop size limit used in the harvest strategy to define a bed as 'commercially viable'; a shift from 'most area closed, little area open' to 'most area open, little area closed' (2014); and consideration of scallop density in determining which areas to open and close (2014).

The current harvest strategy uses a tiered management approach, whereby a 150 t TAC can initially be set as a 'default opening', covering the whole BSCZSF management area, to allow operators to search widely for scallop beds (AFMA 2015). The revisions to the harvest strategy in 2014 aimed, in part, to increase knowledge of the biomass by encouraging exploratory fishing outside known beds. The exploratory period was omitted in 2015, 2016, 2017 and 2018 in favour of a return to surveying the known King Island beds. However, in recent years, the survey vessels have conducted some exploratory fishing as part of the survey.

Tier 1 of the harvest strategy states that, if the scientific survey identifies one or more scallop beds with a combined biomass of 1,500 t or more, with scallops greater than 85 mm in length and in 'high' density, and these beds are closed to commercial fishing, the TAC can be increased to 1,000 t. If 800 t of this TAC is taken, the TAC can be increased to 1,500 t; it can be increased again to 2,000 t if 1,300 t is taken.

Tier 2 of the harvest strategy states that, if the scientific survey identifies one or more scallop beds with a combined biomass of 3,000 t or more, with scallops greater than 85 mm in length and in 'high' density, and these beds are closed to commercial fishing, the TAC can be initially set to at least 2,000 t.

The harvest strategy is due to be reviewed in 2019–20. Considerations for the revised harvest strategy include the incorporation of economics into the TAC setting process, ensuring that the harvest strategy is robust to the inherent variability of the stock (through appropriate scaling of the TAC and protected biomass across a range of surveyed biomasses), and ensuring consistency with the updated Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018a) and guidelines (Department of Agriculture and Water Resources 2018b).

The 2018 fishery operated under tier 2 of the harvest strategy, with a TAC of 3,876 t. TACs in previous seasons have included provision for a stepped TAC, where the TAC could be increased (to a predetermined maximum) during the season based on catches. The Scallop Resource Assessment Group recommended removing the step function in the TAC because there was no biological basis for it, and it may distort the market or increase transaction costs when trading quota (AFMA 2018).

Fishing effort

The fishery has a history of boom and bust, with the catch peaks (1982–1983, 1994–1996, 2003 and 2017) generally becoming progressively smaller. These peaks have been interspersed with fishery-wide closures, the most recent being from 2006 to 2008 (Figure 2.2). The number of active vessels during the 1982–1983 peak is unknown, but 103 vessels operated in the fishery during the 1994–1996 peak.

The fishery reopened in 2009 with 26 active vessels. The number of active vessels decreased before stabilising at 11 or 12 vessels (12 in 2018). Dredge-hours have fluctuated widely since the fishery reopened: from 4,000 in 2009 to 656 in 2013 (the lowest level since 2002), then up to 6,900 in 2016 (the highest since 1998 when 39 vessels were active in the fishery). Dredge-hours were relatively stable in 2017 and 2018 (Table 2.2), despite catch increasing in both years.

TABLE 2.2 Main features and statistics for the BSCZSF

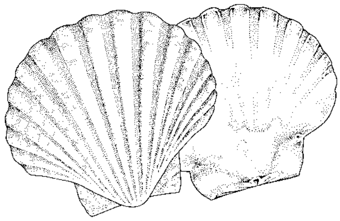
Fishery statistics a	2017 fishing season b			2018 fishing season c		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19) d**
Commercial scallop	3,000 (+120) **e**	2,964	$6.7 million	3,876 (+124) **e**	3,253	na
Doughboy scallop	100	0.4	$0.0 million	100	0	na
Total fishery	**3,220**	**2,964**	**$6.7 million**	**4,100**	**3,253**	**na**
Fishery-level statistics						
Effort	5,274 dredge-hours			5,414 dredge-hours		
Fishing permits **f**	63			55		
Active vessels	12			12		
Observer coverage	3 days			0 days		
Fishing methods	Scallop dredge					
Primary landing ports	Devonport and Stanley (Tasmania); Apollo Bay, Melbourne, Queenscliff and San Remo (Victoria)					
Management methods	Input controls: seasonal and area closures Output controls: TAC, quota SFRs with ITQs					
Primary markets	Domestic: fresh					
Management plan	*Bass Strait Central Zone Scallop Fishery Management Plan 2002* (amended 2014)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Value statistics are by financial year. **b** Fishing season was 11 July – 31 December 2017. **c** Fishing season was 19 July – 31 December 2018. **d** Economic data for 2018–19 were not available at the time of report drafting. **e** A research quota also exists for commercial scallop (120 t in 2017 and 124 t in 2018). **f** Number of entities that hold a commercial scallop SFR.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing right. **TAC** Total allowable catch.

Scallops
Mike Gerner, AFMA

2.2 Biological status

Commercial scallop (*Pecten fumatus*)



Line drawing: FAO

Stock structure

Scallops in the Commonwealth, Tasmanian and Victorian scallop fisheries form one genetically homogeneous population (Ovenden et al. 2016) but are managed separately. Additionally, distinct genetic links have been identified between some beds, but not others, most likely due to non-random dispersal and subsequent settlement of larvae, meaning that recruitment does not occur in a simple, predictable manner (Ovenden et al. 2016).

Catch history

A fishery for commercial scallops has operated in central Bass Strait since 1973 (Young & Martin 1989). The fishery is spatially structured, with the fleet tending to congregate on one or two known beds for the season. These may be revisited for several seasons until the bed is depleted or the fleet moves to more favourable beds, either within the same area or in an entirely different area. In this way, the fishery has moved back and forth between beds in eastern and western Bass Strait several times during its history. Catch in the fishery peaked in 1982 (21,000 t) and 1983 (24,000 t), landed by an unknown number of vessels. The next peaks were in 1994 (8,100 t landed by 73 vessels) and 1995 (7,700 t landed by 103 vessels).

The fishery reopened in 2009, with operators focusing on beds north-east of Flinders Island in eastern Bass Strait.

In the early years after reopening, scallop condition deteriorated, with die-off events in 2010 (AFMA 2011) and 2011 (AFMA 2012a). In 2012, scallops were reported to be in poor condition in part of the fishery (and, conversely, in good condition in another area later in the season) (DPIPWE 2012). An outbreak of paralytic shellfish toxin was detected in 2013. Management responded by increasing open areas, reducing size limits and changing season start dates. However, total landed catch declined between 2009 and 2013.

In 2014, operators began fishing beds around King Island. Three main beds were fished around King Island in 2014; this expanded to five in 2015 and eight in 2016. Five main beds were fished in 2018, two of which were also fished in 2017. Catch, catch rates and scallop quality all improved after the fishery moved to the King Island region.

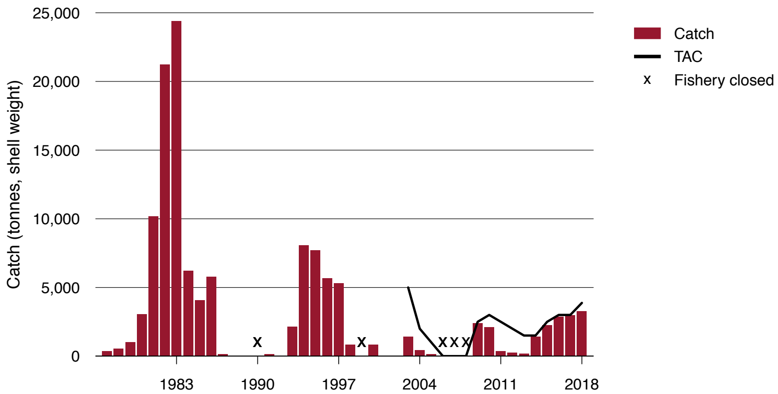
The harvest strategy encourages exploratory fishing. Although the exploratory fishing period was only used in 2014, logbook records in each year since then all provide evidence of some exploratory fishing around King Island during the main season (that is, outside the formal exploratory fishing period). Survey vessels have also conducted some exploratory fishing of additional sites of interest in recent years, adding to the general knowledge base. If these beds show sufficient promise, they may be formally surveyed and biomass estimates generated.

The King Island region was not fished between 1998 and 2014, and biomass surveys for the region were not completed before fishing recommenced there in 2014. However, a survey in 2015 identified three beds near King Island with a total combined biomass of 'adult' scallops (shell length greater than 85 mm) of 9,300 t (Knuckey, Koopman & Davis 2015), and a 2016 survey identified eight beds with a combined biomass of 22,090 t of adults (Knuckey, Koopman & Davis 2016). In 2017, four beds near King Island were surveyed, with an estimated combined biomass of 16,230 t (Knuckey et al. 2017). Beds were also surveyed north of King Island, with an estimated combined biomass of 5,460 t ('Apollo Bay' beds), and in eastern Bass Strait, with an estimated combined biomass of 1,090 t ('Flinders Island' beds) (Knuckey et al. 2017). In comparison, combined biomass estimates for beds in the Flinders Island region were 3,800 t in 2016 (Knuckey, Koopman & Davis 2016) and as high as 10,100 t in 2012 (Semmens 2012).

In 2018, beds were surveyed and adult scallop biomass estimated as follows: six beds near King Island with a combined biomass of 24,700 t, two Apollo Bay beds with a combined biomass of 3,700 t and one Flinders Island bed with a biomass of 1,700 t (Knuckey, Koopman & Hudson 2018). These beds were a mixture of previously surveyed beds, new beds and an amalgamation of previous, separate beds. A high proportion of dead scallops were found at two beds (Knuckey, Koopman & Hudson 2018), and there was no sign of substantial recruitment in the beds surveyed (AFMA 2018). However, biomass estimates overall are large relative to previous surveys, with one bed estimated to contain more than 14,000 t of adult scallops.

The 2018 fishery opened on 19 July 2018 with a TAC of 3,876 t. Fishing generally focused on the same areas as the 2014, 2015, 2016 and 2017 seasons (that is, east of King Island), and operators reported scallops in good condition. The fishery closed on 31 December 2018 with 3,253 t of the 3,876 t TAC landed.

FIGURE 2.2 Catch and TAC of commercial scallop in the BSCZSF, 1977–2018



Notes: **TAC** Total allowable catch. Catches before the establishment of the BSCZSF in 1986 are likely to include some catch from outside the central zone.
Source: AFMA catch disposal records; Sahlqvist 2005

Stock assessment

No quantitative, model-based stock assessment is available for the BSCZSF; the current harvest strategy is dependent on biomass surveys in a combination of new and previously surveyed sites (discussed below).

Recruitment of commercial scallops in Bass Strait (Young, McLoughlin & Martin 1992) and elsewhere (for example, Port Phillip Bay; Coleman 1998) has been historically variable, and this variability appears to continue. Surveys of eastern Bass Strait in 2009 identified large numbers of small scallops north-east of Flinders Island (Harrington & Semmens 2010). Surveys in 2015, 2016, 2017 and 2018 likewise identified small scallops near Flinders Island (Knuckey, Koopman & Davis 2015, 2016; Knuckey et al. 2017; Knuckey, Koopman & Hudson 2018). Beds in western Bass Strait have typically comprised large scallops and only limited amounts of small scallops. Although the presence of small scallops in eastern Bass Strait is an encouraging sign for the fishery, they were found in far larger amounts during the 2009 survey of the eastern area.

Surveys between 2009 and 2018 have covered a large area, encompassing approximately 60% of the 6 nautical mile by 8 nautical mile fishing grids that comprised the total historical baseline of grids fished since 1991.[1] However, because of die-off events, such as those observed in 2010 and 2011, the reliability of earlier surveyed biomass estimates decreases rapidly with time, even for unfished beds. Recently, repeated surveys of some beds have shown consistent biomass estimates between years, suggesting that, at least in these surveyed areas, biomass has been stable.

1 Because different spatial reporting grids were used in the 1970s, the total historical fishing area was taken for the period 1991–2017. This is not the same as the total management area, which is far larger; the percentage covered is therefore far smaller. The 99th percentile was taken to exclude very small catches.

Surveys in 2018 covered about 10% of the grids from the historical baseline area. Adult biomass from these surveyed beds was estimated at almost 30,100 t, the largest estimated biomass since the fishery reopened in 2009 (surveyed beds had an estimated biomass of almost 26,000 t in 2016 and an estimated 22,800 t in 2017). By their nature, surveys target areas where scallop beds are expected to be found at a particular time, so these biomass estimates cannot be extrapolated to the entire historical fishing area.

Since the re-emergence of scallop beds in western Bass Strait, surveys have covered a broader area (both eastern and western Bass Strait) and more beds: 2 beds in 2014, 4 in 2015, 10 in 2016 and 12 in 2017. Only nine beds were surveyed in 2018 because of the cost involved and to ensure that both new and previously surveyed beds are surveyed in any one year. The harvest strategy appears at present to be effective in providing information on the biomass across a range of locations in both eastern and western Bass Strait. However, the extent of survey effort has in the past been influenced by the nature of the fishing season—for example, poor fishing seasons generally result in limited surveying and poorer information.

The harvest strategy is due to be reviewed in 2019–20 and should give greater guidance on incorporating economics into the TAC setting process; ensuring that the decision-making process is robust to the inherent variability of the stock (including through scaling the TAC and protected biomass for large surveyed biomasses); updating the level of the 'floor' (tier 1) scallop bed closures particularly in light of the recent high biomasses giving evidence that the contemporary fishery can support far larger biomasses, and ensuring consistency with the updated HSP.

Stock status determination

Scallop in the BSCZSF are a 'highly variable stock' (as defined by the HSP) that naturally undergoes large spatial and temporal changes in biomass or productivity through time. The total biomass observed in surveys over the past decade shows high variability within which die-offs have occurred in individual beds, as well as the re-emergence of beds in western Bass Strait, and declining biomass in some individual beds in both eastern and western Bass Strait. Overall, however, recent observed biomass appears relatively large.

Managing scallops in the BSCZSF based on an assumption of biomass equilibrium is challenging and probably inappropriate. In such cases, the HSP allows for the use of dynamic reference points with due consideration given to their consequences during extended periods of low productivity/recruitment. The current harvest strategy for scallops in the BSCZSF uses a form of fixed exploitation rate via a tier system, whereby a specified amount of the known spawning biomass is preserved through a combination of bed closures and TAC limits that constrain the catch in the open beds.

The current BSCZSF harvest strategy implies a dynamic limit referee point (LRP) of 1500 t of high-density, adult scallops at tier 1 with a maximum TAC of 2,000 t. Tier 2 implies a dynamic LRP of 3000 t with a TAC greater than 2000 t and the remaining area of the fishery open to fishing. As noted above, this requires review. In 2018, the fishery operated at tier 2; however, a larger biomass (15,700 t) was closed to fishing. Additionally, the TAC of 4000 t relative to the total known biomass of 30,100 t means that 26,100 t (86%) of known biomass was unfished if the TAC was fully caught. Further, the TAC was not fully caught, so escapement was larger again (89%). This is similar to recent years, with a relatively large biomass (26,000 t) surveyed in 2016 (escapement 89%) and 22,800 t in 2017 (escapement 87%). These biomass estimates are comparable to the very large historical annual catches taken from the fishery at its peak (24,000 t in 1983), when the fleet was much larger and the extent of exploitation (and as a result catch) was unconstrained. This suggests current biomass may be approaching levels that led to these historical high catches. Even with the current harvest strategy and independent of fishing, it is possible that biomass will decline in future years as a result of other influences, such as environmental factors. However, at this stage, total biomass of known beds appears substantial and stable. As a result of these large, relatively persistent biomasses, protected biomass far exceeding the dynamic LRP and high escapement, the stock is classified as **not overfished** and **not subject to overfishing**.

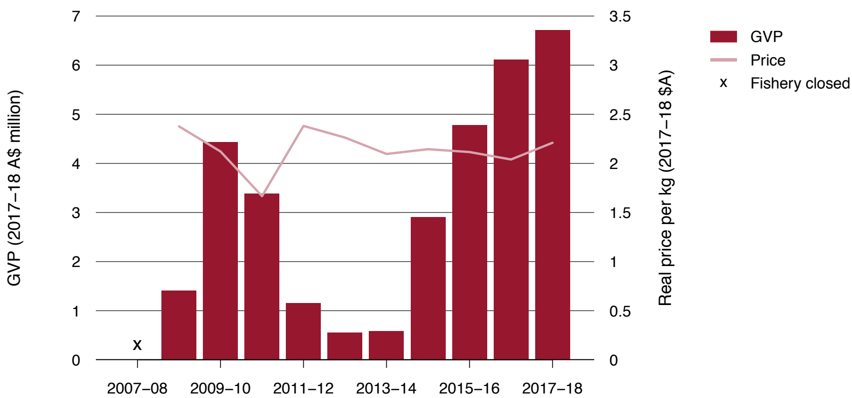
2.3 Economic status

Key economic trends

The most recent economic survey of the BSCZSF estimated that real net economic returns (NER), including management costs, were negative: –$1.2 million in 2009–10 and –$1.2 million in 2010–11 (2016–17 dollars; George, Vieira & New 2012). These results are comparable to those from the survey of the fishery for 1997–98 and 1998–99, when real NER were –$1.8 million and –$1.1 million, respectively (2016–17 dollars; Galeano et al. 2001).

Comparison of the fishery's gross value of production (GVP) before and after the most recent closure (2006–2008) reveals a considerable increase immediately following reopening of the fishery (Figure 2.3). Before the closure, GVP was $0.5 million in 2004–05 and $0.2 million in 2005–06 (2015–16 dollars). Since the fishery's reopening, higher GVPs of $1.4 million and $4.3 million were achieved in 2008–09 and 2009–10, respectively (noting that 2008–09 only captures the first month of the 2009 season). However, real GVP fell to $1.1 million in 2011–12 and $0.5 million in 2012–13. GVP has increased annually since 2013–14. In 2017–18, GVP is estimated to be $6.7 million, the highest in real terms since 1997–98.

FIGURE 2.3 Real GVP and real prices received for catch in the BSCZSF, by financial year, 2007–08 to 2017–18



Notes: **GVP** Gross value of production. Overlap between seasons and financial years should be taken into account in interpreting this figure. The fishery was closed between the 2006 and 2008 calendar years, inclusive.

Management arrangements

The BSCZSF harvest strategy was first developed following the Australian Government's Securing our Fishing Future structural adjustment program in 2006, which removed 22 licences from the fishery. The harvest strategy was implemented in 2009, following three years (2006–2008) with a zero TAC. It was revised in 2012, but not directly applied for the 2012 and 2013 fishing seasons. Instead, a somewhat less precautionary approach to protecting juvenile scallops was taken in both seasons, with a commercially viable area being determined based on a reduced minimum size limit of 85 mm rather than the 90 mm limit previously used.[2] The harvest strategy was reviewed again in 2014 in response to concerns about the cost-effectiveness of management and the flexibility of fishing operations in the fishery. The harvest strategy is described in detail under 'Management methods'.

Performance against economic objective

The HSP (Department of Agriculture and Water Resources 2018a) requires that harvest strategies pursue the economic objective of maximising NER. To meet this objective, the HSP recommends that harvest strategies should be designed to manage stock levels consistent with maximum economic yield (MEY), or, if MEY is not estimated, a biomass that is 1.2 times greater than the biomass at maximum sustainable yield (MSY), or a justified alternative biomass level. Negative NER in the BSCZSF in 2009–10 and 2010–11 suggest that the economic objective was not being met.

2 Subsequent research presented to ScallopRAG and the Scallop Management Advisory Committee (AFMA 2017) showed there to be only a 13% difference in fecundity between an 85 mm scallop and a 90 mm scallop and that both sized scallops still had the opportunity for two major spawning events (Semmens et al. 2019), which is the underlying intent of the size restriction in the harvest strategy (AFMA 2015).

The naturally sporadic and fluctuating availability of scallops in the BSCZSF makes it difficult to develop appropriate target reference points for MSY and MEY (AFMA 2015). The 2015 BSCZSF harvest strategy (AFMA 2015) recognises the difficulties associated with managing the fishery using a biomass target that is relative to virgin biomass. Within the context of ecological sustainability, maximising economic returns to the Australian community and economic, efficient management are objectives of the 2015 BSCZSF harvest strategy. A decline in management costs as a proportion of GVP suggests a movement towards more efficient management of the BSCZSF.

Since 2014, the harvest strategy has used a tiered approach to determining levels of access to the scallop resource, as described under 'Management methods'. It takes a co-management approach and allows fishers some flexibility in where they apply their effort in the fishery. The fishery operated under the tiered harvest strategy for the first time in the 2014 fishing season. This approach allows a high proportion of prospective beds to be not fished, thereby enhancing the long-term economic viability of the fishery. Since adopting the latest harvest strategy, real GVP has followed an increasing trend.

Several factors suggest that NER in the BSCZSF may have improved from the –$1.2 million (in 2017–18 dollars) recorded in 2010–11, although it is uncertain whether NER are now positive. In real terms, GVP was around $3.8 million higher in 2017–18 than in 2010–11, reflecting an increase in catch and higher average prices. Moreover, fuel prices were significantly lower in 2017–18 than in 2010–11, and there were more known beds, closer to landing ports, allowing less steaming time to fishing grounds, indicating lower costs of fishing in the latter period. Fishery management costs were also lower in 2017–18 than in 2010–11. In addition, the total catch in 2017–18 was achieved with six fewer vessels (a reduction of one-third) than in 2010–11, which is expected to have reduced the economic costs for the fishery.

2.4 Environmental status

The BSCZSF has export approval under the *Environment Protection and Biodiversity Conservation Act 1999* until October 2026.

Haddon, Harrington & Semmens (2006) suggested that the habitat impacts from scallop dredges are low at the scale of the fishery, since fishers target areas of soft sediment and high scallop abundance to optimise economic returns. The authors were unable to detect impacts on physical habitat from a scallop dredge using single-beam acoustic surveys between 2003 and 2004. They suggested that this may be due to the naturally dynamic habitat in the region, driven by large tidal currents and heavy seas, or that the level of fishing was below that required to adversely affect the habitat. Similarly, Semmens et al. (2015) were unable to detect a significant difference between species assemblages in fished and unfished areas over a reasonably short time, indicating that scallop dredging appears to have a relatively short- to medium-term impact on species assemblages. However, Semmens et al. (2015) cautioned that this finding may be influenced by historical fishing of the area they treated as unfished, meaning that species most affected by dredging may now be too rare to be effectively sampled with scallop dredges. They also cautioned that certain species are less likely to be retained in scallop dredges, and that their absence from dredge samples in both the fished and unfished areas could mean that they were disturbed but not retained.

A level 2 (Productivity Susceptibility Analysis) ecological risk assessment considered 142 species (Hobday et al. 2007). Of these, the targeted scallops and 25 bycatch species were categorised as high risk. The Residual Risk Assessment on the high-risk species, which takes into account the mitigating effect of management measures, suggested that four invertebrate species may be at high risk: King Island crassatella (*Eucrassatella kingicola*), southern blue-ringed octopus (*Hapalochlaena maculosa*), pebble crab (*Bellidilia undecimspinosa*) and black-and-white seastar (*Luidia australiae*) (AFMA 2009). Twenty-eight habitats were also assessed, none of which were categorised as being at high risk (Hobday et al. 2007). The current management arrangements, along with only a restricted area of the fishery being fished each year since 2009, limit potential impacts on habitat and bycatch species.

Australian Fisheries Management Authority publishes quarterly logbook reports of interactions with protected species on its website. No interactions were reported in the BSCZSF in 2018.

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Chapter 3
Coral Sea Fishery

T Emery, F Helidoniotis and AH Steven

FIGURE 3.1 Area fished within the Coral Sea Fishery, 2017–18

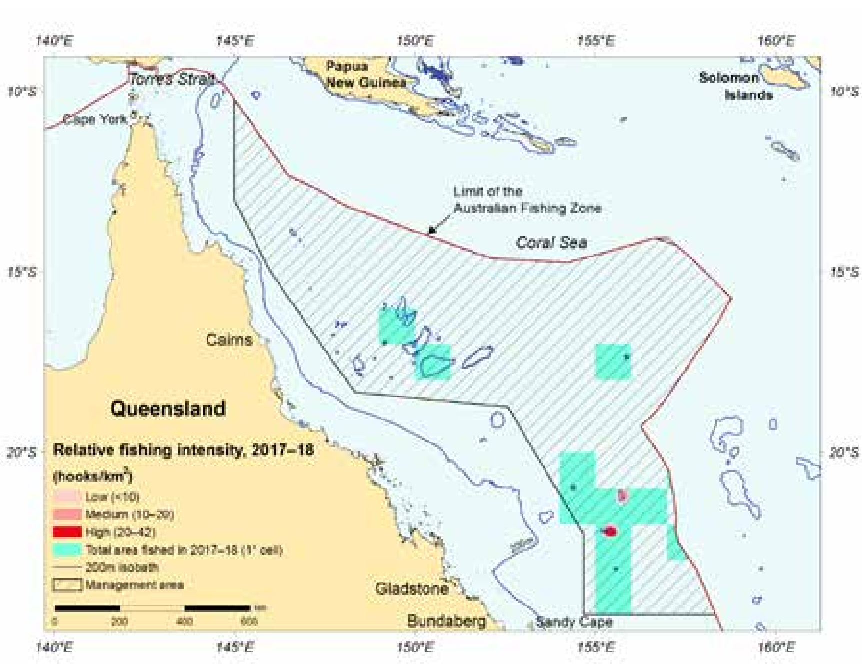


TABLE 3.1 Status of the Coral Sea Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Black teatfish (*Holothuria whitmaei*)					Catch in 2017–18 is less than the plausible sustainable yield and therefore unlikely to affect stock status.
Prickly redfish (*Thelenota ananas*)					Catch in 2017–18 is less than the plausible sustainable yield and therefore unlikely to affect stock status.
Surf redfish (*Actinopyga mauritiana*)					Catch in 2017–18 is less than the plausible sustainable yield and therefore unlikely to affect stock status.
White teatfish (*Holothuria fuscogilva*)					Minimal catch in 2017–18 but no current assessment to determine fishing mortality or biomass status.
Other sea cucumber species (~11 species)					Minimal catch in 2017–18 but no current assessment to determine biomass status.
Aquarium Sector (>500 species)					Catch in 2017–18 and for previous years likely to represent a small proportion of the estimated overall population size and therefore unlikely to affect stock status.
Tropical rock lobster (*Panulirus ornatus*)					No catch in 2017–18; historical catch is less than the plausible sustainable yield.
Line and Trap Sector (numerous finfish and shark species)					Species-specific estimates of maximum sustainable yield are uncertain due to changes in species composition; no current assessment to determine biomass status.
Trawl and Trap Sector (numerous finfish, shark and crustacean species)					No catch in 2017–18; no current assessment to determine biomass status.
Economic status	Estimates of net economic returns are not available. Catch in the Aquarium Sector increased in 2017–18; however, the economic performance of this sector is uncertain because of a lack of economic information. Catch and effort in the Sea Cucumber Sector decreased in 2017–18, whereas catch and effort in the Line and Trap Sector increased relative to the previous year. The trend in economic performance for these sectors in 2017–18 is uncertain.				

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

3.1 Description of the fishery

Area fished

The Coral Sea Fishery (CSF) extends from Cape York to Sandy Cape, Queensland (Figure 3.1). It is bounded on the east by the Australian Fishing Zone and on the west by a line 10–100 nautical miles east of the eastern boundary of the Great Barrier Reef Marine Park.

Fishing methods and key species

The CSF is a multispecies, multigear fishery targeting a variety of fish, sea cucumbers and crustaceans. Fishing methods include hand collection, demersal line, dropline, trotline, traps and trawl. Several separate fisheries existed in the Coral Sea before their integration into the CSF, including the East Coast Deepwater Finfish Fishery, the East Coast Deepwater Crustacean Trawl Fishery and the North Eastern Demersal Line Fishery.

Management methods

Management of the CSF involves both input (fishing effort) and output (catch) controls, including limited entry, total allowable catches (TACs), spatial closures, move-on provisions, size limits and catch-and-effort triggers, which are used to initiate further analysis and assessment. The harvest strategies for the sectors recognise the low effort and diverse nature of the fishery, and this is taken into account in assessing their performance. ABARES analysed harvest levels in the Sea Cucumber, Lobster and Trochus, Aquarium, and Line and Trap sectors of the CSF (Chambers 2015; Larcombe & Roach 2015; Leatherbarrow & Woodhams 2015; Woodhams, Chambers & Penrose 2015). This work, part of the Reducing Uncertainty in Stock Status (RUSS) project, investigated current and historical catches, and indicators of population size to evaluate stock status.

The Australian Fisheries Management Authority (AFMA) is reviewing the harvest strategies of the Aquarium, Line and Trap, and Trawl and Trap sectors. The Aquarium Sector Harvest Strategy is expected to be finalised for implementation in mid to late 2019. The Line, Trap and Trawl Harvest Strategy is expected to be finalised in 2019 and implemented in time for the 2020 season. It is expected that the updated harvest strategies will more closely identify the key commercial species for each sector and revise associated catch triggers to monitor catches. Given the lack of fishing for lobster and trochus, and minimal activity in the Sea Cucumber Sector, these harvest strategies are not currently being reviewed.

Fishing effort

In 2017–18, eight vessels were active in the fishery: five in the Line and Trap Sector, two in the Aquarium Sector and one in the Sea Cucumber Sector.

Catch

Approximately 64.7 t of fish products (excluding the Aquarium Sector, where catch is recorded as the number of individuals) was taken in the CSF during 2017–18, representing an increase from the 52.8 t taken in the 2016–17 season (Table 3.2). Most of this catch (63.6 t) was finfish.

TABLE 3.2 Main features and statistics for the CSF

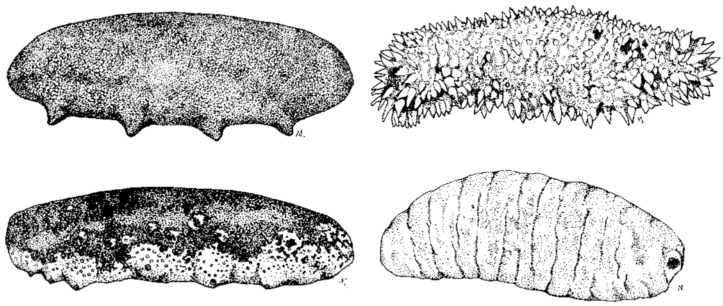
Fishery statistics a	**2016–17 fishing season**			**2017–18 fishing season**		
Stock	**TAC (t) or catch trigger**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Aquarium Sector	40,000 individuals **b**	26,811 individuals	Confidential	40,000 individuals **b**	36,678 individuals	Confidential
Black teatfish	1	0.08	Confidential	1	0.06	Confidential
Greenfish and lollyfish	10	0	0	10	0	0
Other sea cucumbers	10	0	0	5	0.01	Confidential
Prickly redfish	20	0.32	Confidential	20	0.33	Confidential
Sandfish	1	0	0	1	0	0
Surf redfish	10	0	0	10	0.04	Confidential
White teatfish	4	2.4	0	4	0.58	Confidential
Total sea cucumbers	**150**	**2.8**	**Confidential**	**150**	**1.02**	**Confidential**
Tropical rock lobster	30 **b**	0	0	30 **b**	0	0
Trochus	30 **b**	0	0	30 **b**	0	Confidential
Line, trap and trawl operations (numerous finfish and shark species)	–	49.9	Confidential	–	63.6	Confidential
Total fishery	**–**	**52.8 c**	**Confidential**	**–**	**64.7 c**	**Confidential**

Fishery-level statistics		
Effort	Sea Cucumber: 96 dive-hours Lobster: 0 dive-hours Aquarium: 1,581 dive-hours Line and Trap, and Trawl and Trap: 147,204 hooks, 160 lines set, 0 trap lifts, 0 trawl-hours	Sea Cucumber: 38 dive-hours Lobster: 0 dive-hours Aquarium: 2,204 dive-hours Line and Trap, and Trawl and Trap: 385,616 hooks, 187 lines set, 0 trap lifts, 0 trawl-hours
Fishing permits	16 fishing permits across the Line and Trap (8), Trawl and Trap (2), Sea Cucumber (2), Aquarium (2), and Lobster and Trochus (2) sectors	16 fishing permits across the Line and Trap (8), Trawl and Trap (2), Sea Cucumber (2), Aquarium (2), and Lobster and Trochus (2) sectors
Active vessels	9	8
Observer coverage	Sea Cucumber: 100% Lobster: 0 Trochus: 0 Aquarium: 0% Line and Trap, and Trawl and Trap: 5.6%	Sea Cucumber: 0% Lobster: 0% Trochus: 0% Aquarium: 0% Line and Trap, and Trawl and Trap: 10.6%
Fishing methods	Hand collection (includes barbless hooks and line, scoop, cast and seine nets), with or without the use of breathing apparatus; line (demersal longline, dropline and trotline); traps and trawl (finfish and crustacean)	
Primary landing ports	Bowen, Innisfail, Mooloolaba (Queensland)	
Management methods	Input controls: limited entry, spatial closures Output controls: catch triggers, size restrictions, TACs for sea cucumbers Other: move-on provisions	
Primary markets	Domestic: fish products—fresh, frozen; aquarium species—live International: South-East Asia—dried sea cucumber (bêche-de-mer); worldwide—live aquarium species	
Management plan	*Management arrangements booklet 2018–19—Coral Sea Fishery* (AFMA 2018)	

a Unless otherwise indicated, fishery statistics are provided by fishing season, which matches the financial year (1 July – 30 June). Value statistics are provided by financial year. **b** Trigger limits. **c** Total catch weight excludes Aquarium Sector catch.
Notes: **GVP** Gross value of production. **TAC** Total allowable catch. – Not applicable.

3.2 Biological status

Sea Cucumber Sector



Line drawing: FAO

Stock structure

Primary target species in the Sea Cucumber Sector include black teatfish (*Holothuria whitmaei*), white teatfish (*H. fuscogilva*), surf redfish (*Actinopyga mauritiana*) and prickly redfish (*Thelenota ananas*). Limited information is available on the stock structure of these four species. For management purposes, each species is assumed to be a single biological stock. Another dozen sea cucumber species have either been taken or could potentially be taken in the fishery, should a market arise (Woodhams, Chambers & Penrose 2015). The stock structure of these other sea cucumber species is unknown. Given the lack of information on stock structure, status is determined for each stock at the fishery level.

Catch history

Permit holders also operate in the Queensland state-managed sea cucumber fishery. Consequently, catch and effort applied in the CSF has been sporadic through time because the state fishery is more accessible. Catch of sea cucumbers peaked at 49 t in 2000–01. Following a marked decline in catch and catch rate of black teatfish on some reefs, annual catch limits were reduced. Since 2003–04, the annual sea cucumber catch has fluctuated between 0 t and 9.2 t. Annual catches since 2007–08 have generally been less than 3 t, with 1 t recorded in 2017–18.

Stock assessment

Thirteen species or species groups have been reported in historical catches from the Sea Cucumber Sector, but no formal quantitative stock assessment of any species has been done.

Research by ABARES estimated biomass using a habitat-based approach to determine stock status for black teatfish, white teatfish, surf redfish and prickly redfish in 2012 (Woodhams, Chambers & Penrose 2015). Estimates of habitat area were made from a geomorphological classification undertaken as part of the Millennium Coral Reef Mapping Project (Andréfouët et al. 2005), and population densities were derived from survey data collected from the Lihou Reef and Coringa–Herald national nature reserves (Ceccarelli et al. 2008; Oxley et al. 2003, 2004). Average animal weights from commercial catch data were used to estimate biomass, and surplus production models were used to estimate maximum sustainable yield (MSY).

Stock status determination

Stock status is evaluated using outputs of the surplus production models and catch, which provide an estimate of biomass in 2010 as a proportion of biomass at the start of the assessment period (1997). Using an estimate of median biomass for black teatfish and prickly redfish, total biomass in 2010 exceeded 99% of biomass at the start of the assessment period. Since this estimate, catches have remained low, not exceeding the estimate of MSY. As a result, black teatfish and prickly redfish are classified as **not overfished** and **not subject to overfishing**.

Catches of surf redfish have remained low—only 0.04 t was recorded in 2017–18—and well below historical peaks that exceeded 4 t per season. Given that catches of surf redfish have been less than the median estimate of MSY (879 kg) for 16 of the 20 seasons since 1997–98 (including the 2017–18 season), surf redfish is classified as **not overfished** and **not subject to overfishing**.

Catch of white teatfish decreased from 2.4 t in 2016–17 to 0.6 t in 2017–18 and continues to remain well below the 1999–2000 historical peak of 19.7 t. As a result of data limitations, a plausible initial biomass estimate could not be established for white teatfish, and the status of the stock is **uncertain** with respect to both biomass and fishing mortality. Since stock status classification is at the fishery level, caution is required when considering status at the level of an individual reef. Historical catch at some reefs has been high, and effects of this reef-level catch should be considered further.

Given the lack of stock assessments of the group of other sea cucumber species, the biomass status for this multispecies stock is classified as **uncertain**. Since there was minimal catch of other sea cucumber species in 2017–18, the stock is classified as **not subject to overfishing**.

Aquarium Sector

Stock structure

While a large number of species are taken by the Aquarium Sector of the CSF, there is currently no defined or easily discernible target species. As such, a single fishery-level stock is assumed for the purposes of status determination.

Stock assessment

The ABARES assessment of the Aquarium Sector (Leatherbarrow & Woodhams 2015), based on data up to the 2008–09 fishing season, indicated that fishing in the sector was unlikely to be having an adverse impact on the stock. Under current permit conditions, operators can only fish about 7% of suitable habitat within the CSF in any given year. Around 35% of the suitable habitat in the fishery is fully protected within the Coringa–Herald and Lihou Reef national nature reserves (Figure 3.1). Investigation of annual extraction rates for key commercial fish families suggests that historical extraction rates have been very low (Leatherbarrow & Woodhams 2015). Furthermore, a species-specific risk assessment suggests low or very low risk to the species harvested in the fishery (Leatherbarrow & Woodhams 2015).

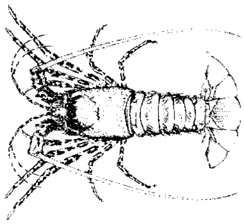
Since this assessment, there have been no substantial changes to catch levels. In 2017–18, the catch increased from 26,811 to 36,678 individuals. Although this catch was the highest of the last five years, it remains around the historical average and represents a small proportion of the estimated population sizes for species groups in the CSF (Leatherbarrow & Woodhams 2015). Consequently, it is unlikely to have a detrimental impact on the stock.

The harvest strategy for the Aquarium Sector is being revised in 2019 after consultation with industry, scientists and relevant government agencies, and informed by the work undertaken by ABARES as part of the RUSS project in 2015 (Leatherbarrow & Woodhams 2015). AFMA plans to implement the revised harvest strategy early in the 2019–20 fishing season.

Stock status determination

Based on the most recent assessment (Leatherbarrow & Woodhams 2015) and recent fishing activity levels, the Aquarium Sector stock is classified as **not overfished** and **not subject to overfishing**.

Tropical rock lobster



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Stock structure

Tropical rock lobster (*Panulirus ornatus*) populations in the Coral Sea, northern Queensland (Crayfish and Rocklobster Fishery) and Torres Strait are thought to comprise a single biological stock, as a result of the mixing of larvae in the Coral Sea (Pitcher et al. 2005). Stock assessments have only been made on subcomponents of this biological stock (Keag, Flood & Saunders 2012). Status is determined for the single stock at the fishery level.

Catch history

Historical catch records from the hand collection sector in the Coral Sea suggest that at least two species have been landed. Tropical rock lobster has been the main species caught, with smaller quantities of painted spiny lobster (*P. versicolor*) also recorded (Chambers 2015). Catches of tropical rock lobster ranged from less than 200 kg to more than 2 t per year between 2000 and 2004. Annual catches have been less than 2 t since 2005, and no lobster has been caught in the dive sector since 2006–07.

Stock assessment

No quantitative stock assessment has been undertaken on Coral Sea tropical rock lobster. As a result of limited targeting of lobster in the Coral Sea, insufficient information is available from logbook data to estimate stock size or sustainable yields. However, when the number of reefs, the potential reef area in the CSF, and the pattern of catch and effort recorded in fisher logbooks are considered, it is likely that none of the major reefs in the CSF have ever been extensively fished. Extrapolated estimates of lobster density on Coral Sea reefs, inferred from catch rates, suggest that lobster abundance is likely to be many times higher than would be required to support the total historical catch of less than 10 t (Chambers 2015). Consequently, current fishing activity in the sector is unlikely to be having an adverse impact on the stock (Chambers 2015).

Stock status determination

Based on the number of reefs, the potential reef area and low levels of fishing effort, the tropical rock lobster stock is classified as **not overfished**. Lobster was not harvested in the 2017–18 season, and the stock is classified as **not subject to overfishing**.

Line and Trap, and Trawl and Trap sectors

Stock structure

While a large number of species are taken in these sectors (noting that there has been not, trap or trawl catch for a number of years), there is currently no defined or discernible target species. As such, a single fishery-level stock is assumed for each sector for the purposes of status determination.

Catch history

The total landed catch across four different fishing gears was 63.6 t in 2017–18, which was an increase from 49.9 t in 2016–17. A total of 68% of the catch was taken using demersal longline (43.6 t), 5% using rod and reel (3 t), 20% using mechanised handline (12.5 t) and 7% using dropline (4.5 t).

No trap effort has been recorded since 2010–11, and no trawl effort has been recorded since 2006–07. The number of hooks deployed in auto-longline and dropline methods substantially increased in 2017–18 to 385,616, up from 147,204 in 2016–17, which represented the highest effort since 2012–13.

Stock assessment

The Line and Trap, and Trawl and Trap sectors take a wide variety of finfish, shark and, historically, crustacean species (using trawl gear). There are no formal single-species stock assessments for any of the species taken in these sectors. In 2012, ABARES used a multispecies approach that considered historical catch levels and conservative yield estimates to evaluate stock status (Larcombe & Roach 2015). The work summarised catch and effort across sectors, and species taken by line-and-trap operations. Three separate species assemblages were considered: a deep assemblage, a reef assemblage and a shark assemblage.

In 2017, the yield scenarios for some species in the deep assemblage were revised based on new natural mortality (M) estimates (Wakefield et al. 2015; Williams et al. 2015) and changes in species composition, leading to a reduction in both species-specific and deep assemblage MSY estimates. It was also noted that 0.3 was an appropriate overarching exploitation constant to use for the CSF deepwater scalefish assemblage (Fry, Brewer & Venables 2006; Kirkwood, Beddington & Rossouw 1994). The harvest strategy for the line, trawl and trap sectors of the CSF is currently being updated.

At the fishery level, the total line catch in 2017–18 (63.6 t) was higher than the most conservative (low biomass and lowest exploitation constant) revised estimate of all-species sustainable yield (31.5 t), but lower than the estimate for medium biomass and lowest exploitation constant (90.2 t) (Larcombe & Roach 2015). In 2017–18, flame snapper (*Etelis coruscans*) constituted approximately 74%, 56% and 52% of the auto-longline, dropline and mechanised handline catch, respectively, with a total of 41.2 t caught—an increase of 16.1 t from 2016–17. In 2017–18, rosy snapper (*Pristipomoides filamentosus*) constituted approximately 5%, 1%, 14% and 78% of the auto-longline, dropline, mechanised handline, and rod-and-reel catch, respectively, with a total of 6.4 t caught—a decrease of 5.8 t from 2016–17. In 2017–18, ruby snappers (*Etelis* spp.) constituted approximately 5%, 6% and 7% of the auto-longline, dropline and mechanised handline catch, respectively, with a total of 3.2 t caught—an increase of 0.7 t from 2016–17.

In some fishing seasons, sharks have been a large component of the total catch for these sectors—for example, blacktip sharks (*Carcharhinus* spp.) were more than 50% of the total line catch in 2005–06. However, no data are available to evaluate the effect of this harvest on shark populations in the CSF or the effect on these species throughout their distributions. Therefore, it is difficult to draw conclusions about the biomass status of sharks in these sectors. However, the line catch of sharks has been low (less than 400 kg) for the past decade, and, despite a small increase in the previous two years (689 kg in 2016–17 and 852 kg in 2017–18), due to increased use of mechanised handlines, current catches are unlikely to constitute overfishing.

Although trawling has contributed a large proportion of the total catch from the fishery in some years, no trawl operations have been reported in the CSF since the 2006–07 season. Trawlers in the CSF have historically targeted finfish and crustaceans. ABARES did not consider any finfish or crustaceans taken by trawling (Larcombe & Roach 2015), and limited information is available on the sustainability of harvest of these species groups within the fishery.

Stock status determination

The line catch in 2017–18 was within the MSY estimate for medium biomass and lowest exploitation constant (90.2 t) for the combined deepwater assemblage. However, uncertainty in species-specific estimates of MSY remain, given significant shifts in the species composition of catches during the past 10 years. Fishing effort has spatially contracted and substantially increased in recent years to target flame snapper, and the reliability of the yield estimates for individual species or at the scale of single reefs is questionable. Therefore, fishing mortality in the Line and Trap Sector is classified as **uncertain**. Because there was no effort in the Trawl and Trap Sector, it remains classified as **not subject to overfishing**.

Although it is unlikely that the primary commercial finfish that make up the catch of line-and-trap operations are overfished, uncertainty remains about the effect of historical fishing on several low-productivity finfish species, and on sharks and other species that were historically caught in trawl operations. Therefore, the biomass of both the Line and Trap, and Trawl and Trap sectors is classified as **uncertain**.

3.3 Economic status

Key economic trends

The Aquarium Sector is likely to have contributed most of the value of the CSF in recent years. The sector's gross value of production is difficult to estimate because catch is reported as the number of fish rather than the weight of fish. As well, prices are different for different species, and prices of individual fish vary with sex, colour, size and age. A large proportion of this sector's catch is exported and traded in the United States; as a result, the value of production is influenced by movements in the exchange rate.

The Australian Bureau of Statistics records the exports of live Australian ornamental fish species (with no distinction made between marine and non-marine species). In 2016–17, these exports were valued at $2.4 million and increased to $3 million in 2017–18. Exports from Queensland accounted for 77% in 2016–17 and 63% in 2017–18 of total live Australian ornamental fish exports. It is not possible to determine the CSF's contribution to this total. The Queensland Marine Aquarium Fish Fishery is larger than the CSF in terms of vessel numbers (DEEDI 2010) and is likely to make a larger contribution to total exports than the CSF. Total catch in the CSF increased by 37%, from 26,811 individuals in the 2016–17 season to 36,678 individuals in 2017–18. In the same period, effort increased by 39%, from 1,581 dive-hours in 2016–17 to 2,204 dive-hours in 2017–18. The lack of economic data available for this sector makes it difficult to determine the trend in economic performance.

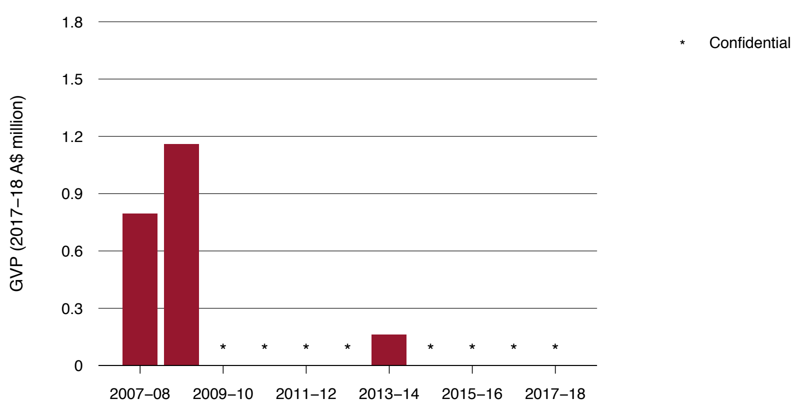
The sea cucumber market is mostly driven by China's demand for bêche-de-mer. Most sea cucumber is exported to Hong Kong and then redistributed to mainland China (Purcell, Williamson & Ngaluafe 2018). In 2016–17, 91% of sea cucumber from Australia was exported to Hong Kong, increasing to 93% in 2017–18, although Hong Kong imports of sea cucumber are declining (UN Comtrade 2019).

The CSF has a high degree of latency in sea cucumber catch (all species); in 2016–17, latency was 96% and in 2017–18 it increased to 99%. The high degree of latency and decreasing catch in the CSF is likely explained by two factors. First, the CSF is further from shore than the East Coast Sea Cucumber Fishery, where sea cucumbers may be more readily accessible and fishing costs probably less. Second, uncertainty around the Chinese luxury seafood market has likely caused catch to vary.

No tropical rock lobster or trochus was caught in the 2016–17 and 2017–18 fishing seasons, and therefore these sectors did not generate net economic returns (NER).

Line operations made up 95% of total catch in the CSF in the 2016–17 fishing season, excluding the Aquarium Sector. Total catch in the fishery increased by 12 t in 2017–18, of which 98% was contributed by line operations, indicating that the Line and Trap Sector is the most profitable in the CSF (excluding the Aquarium Sector). The improvement in catch coincides with a large increase in effort, potentially indicating higher costs. The trend in NER for the Line and Trap, and Trawl and Trap sectors is uncertain.

FIGURE 3.2 Real GVP for the CSF (excluding the Aquarium Sector), 2007–08 to 2017–18



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

Management arrangements

The CSF is managed through a range of input controls and output controls. A low-cost approach to management is likely to be appropriate in view of the fishery's relatively low fishing effort.

Performance against economic objective

The CSF is a relatively data-poor fishery, and its performance against the objectives of the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) is difficult to assess. Given the lack of data, it is difficult to set management controls (for example, TACs and trigger levels) that demonstrably meet the economic objective of maximising NER.

A lack of information about the mix of fish caught in the Aquarium Sector means that assessing economic performance of the fishery is difficult. The increase in catch (from 26,811 individuals in 2016–17 to 36,678 individuals in 2017–18) is associated with an increase in dive effort (from 1,581 hours in 2016–17 to 2,204 hours in 2017–18). As a result, the trend in economic performance is uncertain.

The existence of undercaught TACs and latent effort in the sea cucumber, tropical rock lobster and trochus sectors of the fishery suggests that fishers have little incentive to participate in these sectors, reflecting expectations of low profits. While there is a high degree of uncertainty, the Line and Trap Sector is likely to have low NER. There is latency in the number of active vessels in the sector, suggesting that fishers have relatively low incentive to participate in the fishery (five vessels in 2016–17 and 2017–18 out of eight registered permits in both years).

3.4 Environmental status

The CSF was reaccredited under parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* until 18 December 2020. Conditions placed on the approval include AFMA limiting the take of species listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This includes a requirement that no more than 50 humphead Maori wrasse (*Cheilinus undulatus*) or 40 t of mixed species belonging to the family Acroporidae are harvested per year from the CSF. AFMA is also required to review the species composition and spatial extent of all coral harvested when 20 t has been harvested, and ensure that a disproportionate amount of each coral genus is not taken from a single reef. Furthermore, AFMA is required to report to CITES on the harvested weight and harvest locations for each coral genus; and the sex, length and harvest location of each humphead Maori wrasse. Other recommendations include reviewing and revising ecological risk assessments, and bycatch and discarding workplans, and developing and implementing fisheries management strategies for the CSF.

In 2007, a qualitative level 1 (Scale, Intensity, Consequence Analysis) ecological risk assessment of eight sectors in the CSF covered a broad suite of species and associated habitats. A semi-qualitative level 2 ecological risk assessment was then undertaken in 2009 for protected species and chondrichthyans (AFMA 2009). Harvest strategy trigger limits will be updated in 2019 for both the Aquarium and Line, Trap and Trawl sectors.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. A single interaction with a shortfin mako (*Isurus oxyrinchus*) was reported in the CSF in 2018; the animal was hooked and reported dead.

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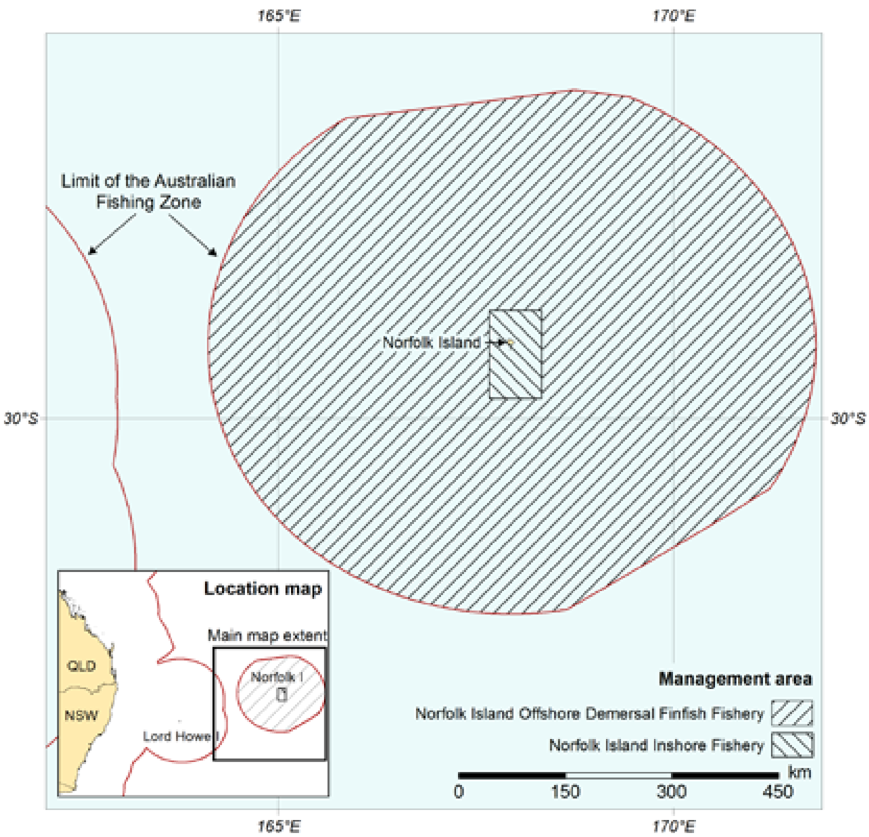
Chapter 4
Norfolk Island Fishery

H Patterson

FIGURE 4.1 Management area of the Norfolk Island Fishery



4.1 Description of the fishery

The Norfolk Island Fishery is currently an inshore recreational and charter-based line fishery (Figure 4.1).

An offshore exploratory commercial trawl-and-line fishery operated between 2000 and 2003. Limited effort in the fishery during this period meant that the permit holders failed to meet the required 50 days of fishing over three years. Low catches of orange roughy (*Hoplostethus atlanticus*) and alfonsino (*Beryx splendens*) indicated that small stocks of these species could occur in the Australian Exclusive Economic Zone around Norfolk Island. Bass groper (*Polyprion americanus*), hapuku (*P. oxygeneios*) and blue-eye trevalla (*Hyperoglyphe antarctica*) dominated hook catches.

No harvest strategy has been developed for the fishery because of the absence of commercial fishing. A harvest strategy and management plan will need to be developed before establishment of a commercial fishery.

Norfolk Island Inshore Recreational and Charter Fishery

The Norfolk Island Inshore Recreational and Charter Fishery covers an area of 67 nautical miles (nm) × 40 nm on the shelf and upper slope adjacent to Norfolk Island. Demersal species are primarily targeted on reefs and pinnacles 5–10 nm (but up to 30 nm) offshore, at depths of 20–50 m. The catch is dominated by redthroat emperor (*Lethrinus miniatus*), known locally as 'trumpeter', but around 40 commercial species have been identified from the inshore fishery. Other important demersal species (or species groups) are cods and groupers (Serranidae), Queensland grouper (*Epinephelus lanceolatus*), yellowtail kingfish (*Seriola lalandi*) and snapper (*Chrysophrys auratus*). Important pelagic species include yellowfin tuna (*Thunnus albacares*), trevally (*Pseudocaranx* spp.) and skipjack tuna (*Katsuwonus pelamis*).

Limited research has been conducted on the Norfolk Island Fishery. The Australian Fisheries Management Authority's data summary for the Norfolk Island Inshore Recreational and Charter Fishery provides catch data from 2006 to 2009 (AFMA 2010).

4.2 Biological status

Data on catch and effort for the target species in the inshore fishery are limited, although anecdotal reports suggest that catch rates in recent years may have declined from historical levels reported by Grant (1981). No stock assessments or biomass estimates for species taken within the inshore fisheries have been made. No stock status classifications have been given to this fishery, since there are no defined stocks for management purposes.

4.3 Economic status

The offshore fishery is currently closed to commercial fishing. All permits for the fishery have expired, and no valid fishing concessions exist. Low catch levels and the operator failure to meet the required number of fishing days during the exploratory fishery period suggest that there is limited potential for positive net economic returns to be generated from this fishery. For the inshore fishery, no commercial fishing permits currently exist, and no indicators are available to allow conclusions on the fishery's economic performance.

4.4 Environmental status

No ecological risk assessments have been undertaken or are planned for this fishery, because of the absence of commercial fishing. Since no fishing occurred in the offshore demersal fishery in 2018, no interactions with protected species were reported.

4.5 References

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Chapter 5
Northern Prawn Fishery

M Parsa, J Larcombe and R Curtotti

FIGURE 5.1 Relative fishing intensity in the Northern Prawn Fishery, 2018

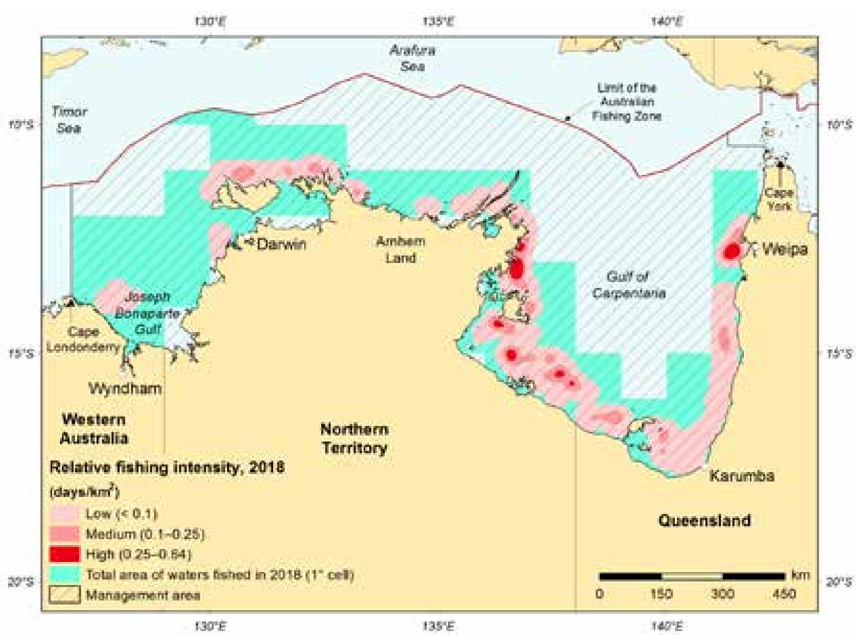


TABLE 5.1 Status of the Northern Prawn Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Redleg banana prawn (*Fenneropenaeus indicus*)					Low recruitment and declining catch rate. A management strategy evaluation is underway to determine suitable effort controls. Spawning biomass is above the LRP of $0.5B_{MSY}$.
White banana prawn (*Fenneropenaeus merguiensis*)					High natural recruitment variability is primarily linked to environmental factors. Harvest strategy aims to provide for adequate escapement and for fishing effort to approximate E_{MEY}.
Brown tiger prawn (*Penaeus esculentus*)					Effort is below E_{MSY}, and catch is below MSY. Spawner stock size is above the LRP of $0.5S_{MSY}$.
Grooved tiger prawn (*Penaeus semisulcatus*)					Effort is near E_{MSY}, and catch is below MSY. Spawner stock size is above the LRP of $0.5S_{MSY}$.
Blue endeavour prawn (*Metapenaeus endeavouri*)					Catch is below the estimate of MSY. Spawner stock biomass is above the LRP of $0.5S_{MSY}$.
Red endeavour prawn (*Metapenaeus ensis*)					No current reliable stock assessment
Economic status	NER reached a high of $30.9 million in 2015–16, supported by a strong increase in tiger prawn catch, marking a fourth consecutive annual increase in NER. The performance in 2016–17 remained stable at $30.3 million. In 2017–18, lower gross value of production and higher unit fuel prices are expected to have a dampening effect on NER.				

Notes: **B_{MSY}** Biomass at MSY. **E_{MEY}** Effort that achieves maximum economic yield. **E_{MSY}** Effort that achieves MSY. **LRP** Limit reference point. **MSY** Maximum sustainable yield. **NER** Net economic returns. **S_{MSY}** Spawner stock size at MSY.

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

5.1 Description of the fishery

Area fished

The Northern Prawn Fishery (NPF) extends from Joseph Bonaparte Gulf across the top end to the Gulf of Carpentaria (Figure 5.1). White banana prawn (*Penaeus merguiensis*) is mainly caught during the day on the eastern side of the Gulf of Carpentaria, whereas redleg banana prawn (*Fenneropenaeus indicus*) is caught during both day and night, mainly in Joseph Bonaparte Gulf. White banana prawns form dense aggregations ('boils') that can be located using spotter planes, which direct the trawlers to the aggregations. The highest catches are taken offshore from mangrove forests, which are the juvenile nursery areas. Tiger prawns (*P. esculentus* and *P. semisulcatus*) are primarily taken at night (daytime trawling has been prohibited in some areas during the tiger prawn season). Most catches come from the southern and western Gulf of Carpentaria, and along the Arnhem Land coast. Tiger prawn fishing grounds may be close to those of banana prawns, but the highest catches come from areas near coastal seagrass beds, the nursery habitat for tiger prawns. Endeavour prawns (*Metapenaeus endeavouri* and *M. ensis*) are mainly a byproduct, caught when fishing for tiger prawns.

Fishing methods and key species

The NPF uses otter trawl gear to target a range of tropical prawn species. White banana prawn and two species of tiger prawn (brown and grooved) account for around 80% of the landed catch. Byproduct species include endeavour prawns, scampi (*Metanephrops* spp.), bugs (*Thenus* spp.) and saucer scallops (*Amusium* spp.). In recent years, many vessels have transitioned from using twin gear to using a quad rig comprising four trawl nets—a configuration that is more efficient.

Management methods

The NPF is managed through a series of input controls, including limited entry to the fishery, individual transferable effort units, gear restrictions, bycatch restrictions, and a system of seasonal and spatial closures. The fishery has two seasons: a predominantly banana prawn season that runs from 1 April to 15 June, and a longer tiger prawn season, running from the start of August to the end of November. Catch rates are monitored throughout the fishing seasons, and the season length can be shortened in accordance with harvest strategy decision rules (Dichmont et al. 2012).

The merits of input (effort) and output (total allowable catch) controls have been extensively evaluated in the NPF. In late 2013, mainly because of the difficulty in setting catch quotas for the highly variable white banana prawn fishery, the Australian Fisheries Management Authority (AFMA) determined that the fishery would continue to be managed through input restrictions and units of individual transferable effort. The NPF harvest strategy is being reviewed in 2019–2020, including management strategy evaluation for the redleg banana prawn subfishery.

Fishing effort

The NPF developed rapidly in the 1970s, with effort peaking in 1981 at more than 40,000 fishing days and more than 250 vessels. During the next three decades, fishing effort and participation were reduced to the current levels of around 8,000 days of effort and 52 vessels. This restructuring of the fishery was achieved through a series of structural adjustment and buyback programs, and the implementation of management measures to unitise and control fishing effort. Total catches also fell during this period, but by a much smaller percentage, illustrating the clear transformation of the fleet to more efficient vessels.

Catch

Total NPF catch in 2018 was 6,778 t, comprising 6,675 t of prawns and 103 t of byproduct species (predominantly squid, bugs and scampi). Annual catches tend to be quite variable from year to year because of natural variability in the banana prawn component of the fishery.

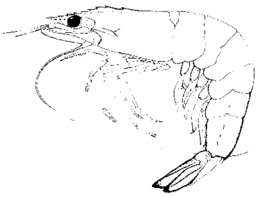
TABLE 5.2 Main features and statistics for the NPF

Fishery statistics a	2017 fishing season		2018 fishing season b	
Stock	**Catch (t)**	**GVP (2016–17)**	**Catch (t)**	**GVP (2017–18)**
Banana prawns	5,045	$62.8 million	4,708	$65.3 million
Tiger prawns	1,080	$46.1 million	1,463	$26.0 million
Endeavour prawns	380	$4.3 million	492	$5.3 million
Other catch (prawns)	7	$0.5 million	12	$0.4 million
Other catch (not prawns)	90	$5.1 million	103	$1.2 million
Total fishery	**6,602**	**$118.8 million**	**6,778**	**$98.2 million**
Fishery-level statistics				
Effort	Banana season: 2,304 shots Tiger season: 5,219 shots		Banana season: 2,506 shots Tiger season: 5,573 shots	
Fishing permits	52		53	
Active vessels	52		53	
Observer coverage	Crew member observers: 1,169 days (15.8%) Scientific observers: 152 days (2.1%)		Crew member observers: 1,255 days (15.7%) Scientific observers: 148 days (1.9%)	
Fishing methods	Otter trawl			
Primary landing ports	Darwin (Northern Territory); Cairns and Karumba (Queensland). Much of the catch is offloaded onto motherships at sea.			
Management methods	Input controls: individual tradeable gear units, limited entry, gear restrictions			
Primary markets	Domestic: fresh and frozen International: Japan—frozen			
Management plan	*Northern Prawn Fishery Management Plan 1995* (amended 2012)			

a Fishery statistics are provided by fishing season, unless otherwise indicated. Value statistics are by financial year. Therefore, changes in catch may appear to be inconsistent with changes in value. **b** Fishing season predominantly for banana prawns: 1 April – 15 June; predominantly for tiger prawns: 1 August – 30 November.
Notes: **GVP** Gross value of production.

5.2 Biological status

Redleg banana prawn (*Fenneropenaeus indicus*)



Line drawing: FAO

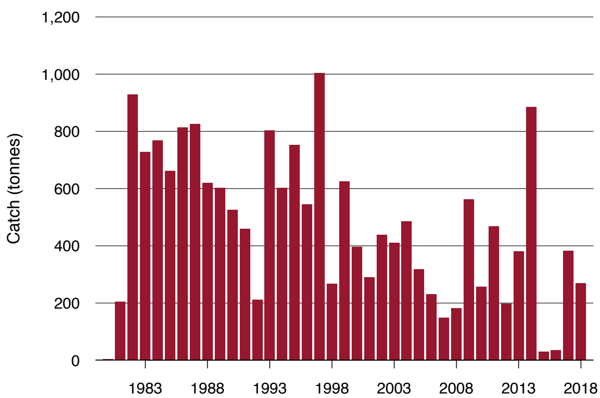
Stock structure

Redleg banana prawn is widely distributed across the Indo-West Pacific Ocean. In Joseph Bonaparte Gulf, a single stock is assumed for assessment purposes.

Catch history

Most of the NPF redleg banana prawn catch is taken in Joseph Bonaparte Gulf, with a smaller proportion taken in the wider NPF to the east. A small amount of catch is also taken in regions adjacent to the NPF. The catch of redleg banana prawn usually contributes a relatively small component of the total banana prawn catch in the fishery. The highest catch reported was 1,005 t in 1997 (Figure 5.2). Since then, most reported catches have been below the average of 482 t, except in 2014 (886 t). The lowest reported catches were in 2015 and 2016, both below 50 t. In 2018, the catch was 269 t.

FIGURE 5.2 Redleg banana prawn catch, 1980–2018



Source: CSIRO

Stock assessment

Estimates of maximum sustainable yield (MSY) and its corresponding spawning biomass level (B_{MSY}) are difficult to derive for short-lived, variable stocks such as redleg banana prawn. Typically, yield is determined largely by the strength of annual recruitment, and therefore annual sustainable yields can be expected to fluctuate widely around deterministic estimates (Plagányi et al. 2009).

The most recent accepted assessment for the stock was in 2018 (Plagányi et al. 2018). Catch rates (the index of abundance) for 2015 and 2016 were excluded from the base-case model because they poorly represent fishing effort in these years. Data from 2017 (when effort increased again) were included. The assessment model uses quarterly time steps of catch and effort. As a result, outputs from the model depend on the distribution of effort across fishing seasons, and sensitivity to this has been explored in the past. The updated assessment showed that spawning biomass declined substantially between 2014 and 2017 to below B_{MEY} (biomass at maximum economic yield) (Figure 5.3), before increasing slightly at the end of 2017 to a level below the B_{MEY} target but above the biomass limit ($0.5B_{MSY}$). The assessment concluded that the biomass declines were likely due to the combined impact of fishing and major environmental anomalies (discussed further below).

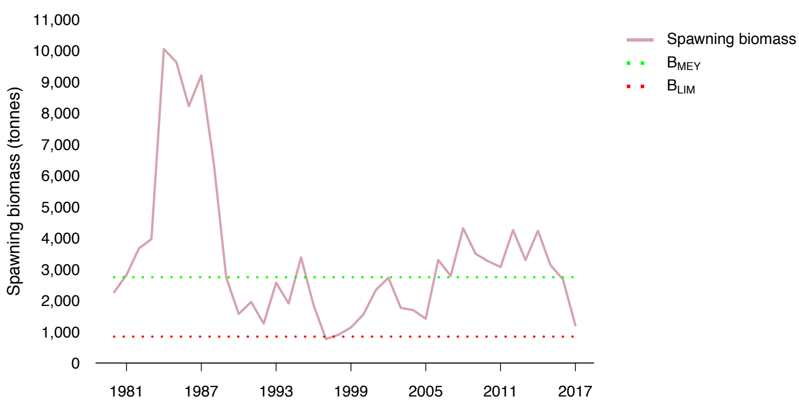
The Northern Prawn Resource Assessment Group (NPRAG) analysed the anomalously low Joseph Bonaparte Gulf catches of redleg banana prawn in 2015 and 2016 (Plagányi et al. 2017). One hypothesis is that recruitment or availability was lower in 2015 and 2016 as a result of anomalous environmental factors. Preliminary work by Plagányi et al. (2017) found an association between catch rates and different combinations of El Niño conditions (Southern Oscillation Index) and seasonal rainfall. The model predicted low catch rates in both 2015 and 2016 as a result of El Niño conditions and below-median rainfall.

Another hypothesis for the low Joseph Bonaparte Gulf catch and effort is the potential existence of more favourable fishing opportunities in other parts of the multispecies NPF, particularly for tiger prawn in the Gulf of Carpentaria, thereby leading to low fishing effort in Joseph Bonaparte Gulf. Predictably, preliminary analysis found that, when revenue-per-unit-effort is lower in Joseph Bonaparte Gulf than in the Gulf of Carpentaria, operators will preferentially fish the Gulf of Carpentaria (AFMA 2017a). This would contribute to low effort in Joseph Bonaparte Gulf during years of unfavourable environmental conditions, as explained above. Thus, low Joseph Bonaparte Gulf effort and catches may, in part, result from a combination of poor environmental conditions in Joseph Bonaparte Gulf and better fishing opportunities elsewhere.

The redleg banana prawn harvest strategy uses a proxy limit reference point (LRP) based on $0.5B_{MSY}$, which correlates with a catch of 390 kg per vessel per day. The LRP is deemed to have been breached if catch rates fall below 390 kg per vessel per day in August, September and October, and there have been at least 100 days fishing over the full fishing year. In this scenario, the fishery will be closed for the first three-month 'season' the following year. The fishery will also be closed if catch rates fall below 390 kg per vessel per day in each of two consecutive years and there have been at least 100 days fishing activity in the fishery in each year. In this scenario, the fishery would be closed for all of the following year. Under the harvest strategy, when effort is below 100 days, the fishery remains open in both seasons of the following year, regardless of whether catch rates fall below 390 kg per vessel per day in August, September and October. There is no precedent for two consecutive years with such low fishing effort. Consequently, in late 2016, NPRAG recommended reviewing the decision rules for redleg banana prawn under the NPF harvest strategy (AFMA 2016), including potentially modifying the season opening for years with fewer than 100 fishing days and considering environmental conditions (AFMA 2017b). The current harvest strategy requires two full years of very low catch rates (effectively two overfished years) together with sustained fishing effort before there is a management response of closing the fishery for a whole year. The harvest strategy has no mechanism to adjust catch or effort levels to achieve the B_{MEY} target, or to progressively reduce catch or effort as biomass approaches the limit.

In November 2018, NPRAG determined that a management strategy evaluation would assess the effectiveness of a range of alternative decision rules in achieving management objectives before revising and incorporating the rates into the new harvest strategy.

FIGURE 5.3 Estimated spawning biomass for redleg banana prawn, 1980–2017



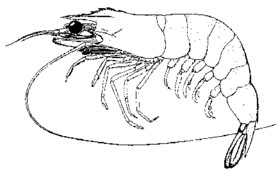
Notes: B_{LIM} Biomass limit reference. B_{MEY} Biomass at maximum economic yield.
Source: Plagányi et al. 2017

Stock status determination

The most recent assessment (2018) estimated that biomass had declined substantially between 2014 and 2017. Although this decline is a cause of concern, the estimated biomass remained above the LRP in 2017. The biomass status of the redleg banana prawn stock is therefore **not overfished**.

The current harvest strategy for redleg banana prawn is poorly suited to the current low biomass level of the stock, providing no direction for a progressive reduction in effort as the stock approaches the LRP. Although management has previously advocated to the fishing industry that effort be constrained in the redleg banana prawn fishery, any such response would be voluntary. A lack of control over fishing effort, together with the recent variability in annual recruitment and declines in catch rates, makes it difficult to determine whether current fishing mortality will result in the biomass falling below the LRP. As a result, the level of fishing mortality of redleg banana prawn is classified as **uncertain**.

White banana prawn (*Penaeus merguiensis*)



Line drawing: FAO

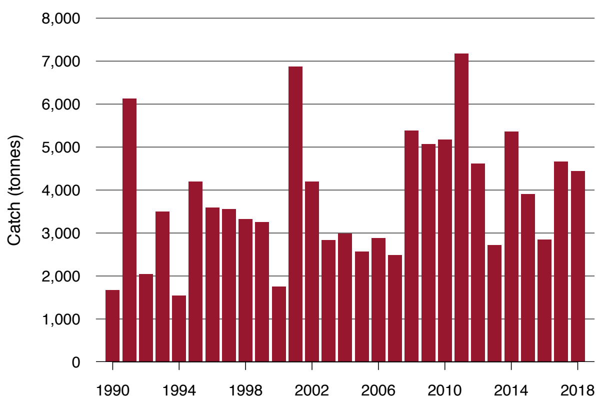
Stock structure

The stock structure of white banana prawn is uncertain. In the NPF, there is some evidence of substock structuring associated with significant river catchments and their annual flow regime, but, in the absence of clear information on biological stock structure, status is reported at the fishery level.

Catch history

Catch in 2018 was 4,439 t (Figure 5.4). Seasonal catch is highly variable and is associated with rainfall in some areas (Venables et al. 2011).

FIGURE 5.4 White banana prawn catch, 1990–2018



Source: CSIRO

Stock assessment

The environmentally driven variability of this resource means that a robust stock–recruitment relationship cannot be determined. Because annual yields are largely dependent on annual recruitment and recruitment is closely associated with seasonal rainfall, it has not been possible to develop a stock assessment for white banana prawn. To see whether total allowable catches could be implemented for the fishery, CSIRO modelled the relationship between historical catch and rainfall, to investigate whether the next year's catch could be predicted based on the most recent wet-season rainfall. Unfortunately, large uncertainties remain because the model cannot accurately predict catch levels in some years, particularly in recent years (Buckworth et al. 2013).

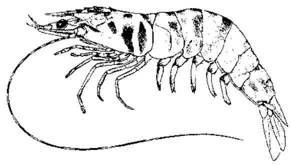
Harvest rates for white banana prawn in the fishery are understood to have been high (>90% of available biomass) in some years (Buckworth et al. 2013), but banana prawns are believed to be resilient to fishing pressure, and recruitment appears to be more closely associated with seasonal rainfall than with fishing mortality. The harvest strategy for the stock includes an objective to allow enough escapement to ensure an adequate spawning biomass and subsequent recruitment (Dichmont et al. 2012). This is achieved by closing the season when catch rates fall below a trigger level. The trigger is also designed to achieve an economic outcome by closing fishing when catch rates fall to an uneconomical level (based on an annual trigger that is computed using estimates of fuel costs and prawn prices for that year).

Stock status determination

With the adoption of the harvest strategy, a relatively small fleet and a lack of evidence of recruitment overfishing, this stock is classified as **not subject to overfishing** and **not overfished**.

Leaving port
Alan Speckter, AFMA

Brown tiger prawn (*Penaeus esculentus*)



Line drawing: FAO

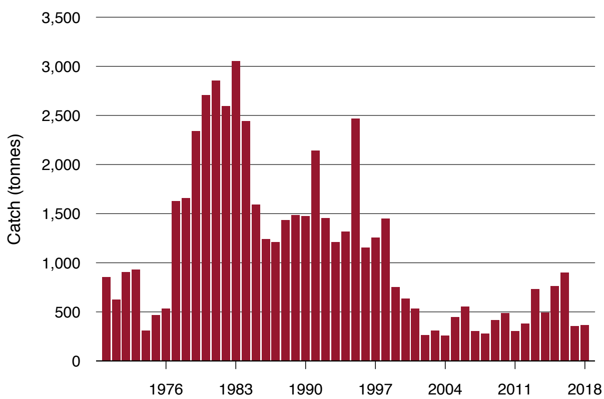
Stock structure

Brown tiger prawn appears to be endemic to tropical and subtropical Australian waters. Some genetic evidence indicates that there are separate stocks on the east and west coasts (Ward et al. 2006). However, the biological stock structure in the NPF is uncertain, and the population in the Gulf of Carpentaria is assumed to be a single stock for management purposes.

Catch history

Brown tiger prawns are caught primarily in the first season in the southern and western Gulf of Carpentaria, but also in waters westward towards Joseph Bonaparte Gulf. Catch of brown tiger prawn in 2018 was 366 t (Figure 5.5).

FIGURE 5.5 Brown tiger prawn catch, 1970–2018



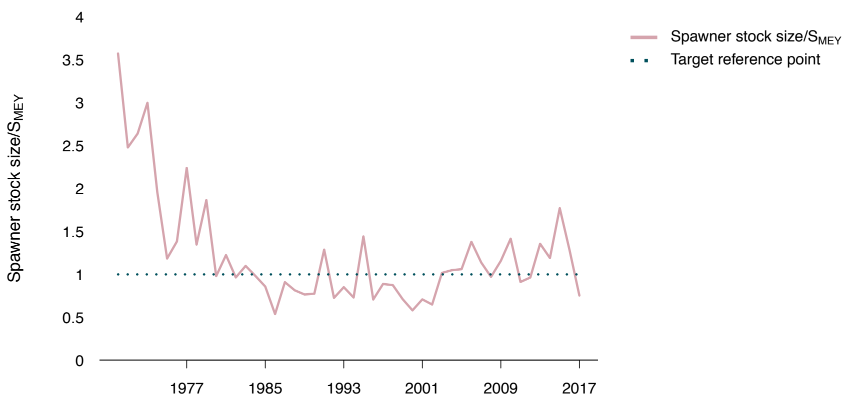
Source: CSIRO

Stock assessment

The stock assessment for the tiger prawn fishery uses a multispecies approach, with a weekly, sex- and size-structured population model for brown and grooved tiger prawns, and a Bayesian hierarchical production model for blue endeavour prawn (*Metapenaeus endeavouri*). It is integrated with an economic model that calculates maximum economic yield (MEY). Full assessments are undertaken every two years, with data collected continuously in intervening years. The most recent tiger prawn fishery assessment (Deng et al. 2018) also included a Bayesian hierarchical biomass production model as a scenario testing model for red endeavour prawn (*M. ensis*).

The base-case estimate of the size of the brown tiger prawn spawner stock at the end of 2017 as a percentage of spawner stock size at MSY (S_{2017}/S_{MSY}) was 78% (range across sensitivities 69–79%; Deng et al. 2018). The base-case estimate of the size of the spawner stock as a percentage of stock size at MEY (S_{2017}/S_{MEY}) was 75% (Figure 5.6) (range across sensitivities 67–76%). These results indicate a substantial decline in biomass compared with the 2015 assessment (Figure 5.6). This decline appears to be largely due to poor recruitment in recent years (Deng et al. 2018), which is of some concern, particularly if this trend continues. However, the abundance indices are within the range of historical variability (Deng et al. 2018), and the 2019 recruitment survey showed that recruitment increased in 2019 (Roy Deng [CSIRO], 2019, pers. comm). For the most recent assessment, the estimate of effort in 2017 as a percentage of effort at MSY (E_{2017}/E_{MSY}) was 52%. The estimate of effort in 2017 as a percentage of effort at MEY (E_{2017}/E_{MEY}) was 42%. Catch of brown tiger prawn has remained substantially below the base-case estimate of MSY (1,083 t) since the assessment (see Figure 5.5).

FIGURE 5.6 Spawner stock size as a proportion of S_{MEY} for brown tiger prawn, 1970–2017

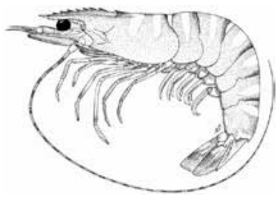


Note: S_{MEY} Spawner stock size at maximum economic yield.
Source: Deng et al. 2018

Stock status determination

Effort in recent years has been less than the level associated with MSY and MEY, but shows an increasing trend since 2005. Catches in recent years have been less than MSY. The latest assessment shows a significant recent decline in biomass; however, the five-year moving average estimate of spawner stock biomass for the base-case model (and all other sensitivities) remains above the LRP ($0.5S_{MSY}$) in the most recent assessment. Therefore, brown tiger prawn in the NPF is classified as **not subject to overfishing** and **not overfished**.

Grooved tiger prawn (*Penaeus semisulcatus*)



Line drawing: Karina Hansen

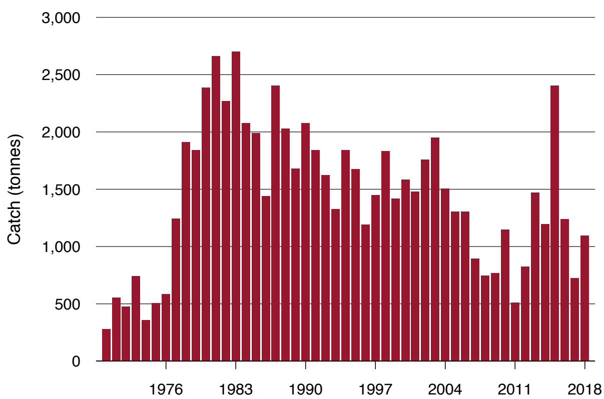
Stock structure

Grooved tiger prawn ranges across northern Australian waters, the Indo-West Pacific Ocean and the Mediterranean Sea. The biological stock structure is uncertain, but the population in the Gulf of Carpentaria is assumed to be a single stock for assessment purposes.

Catch history

The annual catch of grooved tiger prawn, which is primarily taken in the second season, peaked in the early 1980s at more than 2,500 t and has shown a declining trend since then (Figure 5.7), except for the 2015 catch of 2,405 t. Catch in 2018 was 1,097 t.

FIGURE 5.7 Grooved tiger prawn catch, 1970–2018



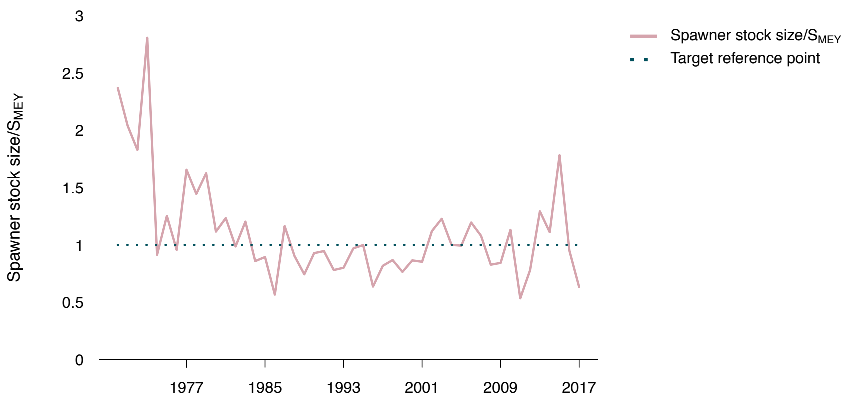
Source: CSIRO

Stock assessment

For the most recent assessment (Deng et al. 2018), the base-case estimate of the size of the grooved tiger prawn spawner stock at the end of 2017 as a percentage of spawner stock size at MSY (S_{2017}/S_{MSY}) was 74% (range across sensitivities 69–84%). The base-case estimate of the size of the spawner stock as a percentage of spawner stock size at MEY (S_{2017}/S_{MEY}) was 63% (range across sensitivities 58–64%), indicating a substantial decline in biomass compared with the 2015 grooved tiger prawn assessment (Figure 5.8). This decline appears to be largely due to poor recruitment in recent years (Deng et al. 2018).

For the most recent assessment, the estimate of effort in 2017 as a percentage of effort at MSY (E_{2017}/E_{MSY}) was 49%. The estimate of effort in 2017 as a percentage of effort at MEY (E_{2017}/E_{MEY}) was 71%. The 2018 catch of grooved tiger prawn (1,097 t; Figure 5.7) was below the base-case estimate of long-term average MSY (1,654 t).

FIGURE 5.8 Spawner stock size as a proportion of S_{MEY} for grooved tiger prawn, 1970–2017

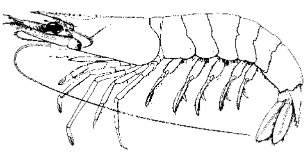


Note: S_{MEY} Spawner stock size at maximum economic yield.
Source: Deng et al. 2018

Stock status determination

Catches of grooved tiger prawns in the past six years were below MSY except in 2015 when recruitment was higher than average. The estimated spawning stock biomass for the base-case model is below the biomass levels associated with MSY and MEY; however, the five-year moving average estimate of spawn stock biomass for the base case (and all other sensitivities) remains above the LRP ($0.5S_{MSY}$) in the most recent assessment. Grooved tiger prawn in the NPF is therefore classified as **not subject to overfishing** and **not overfished**.

Blue endeavour prawn (*Metapenaeus endeavouri*)



Line drawing: FAO

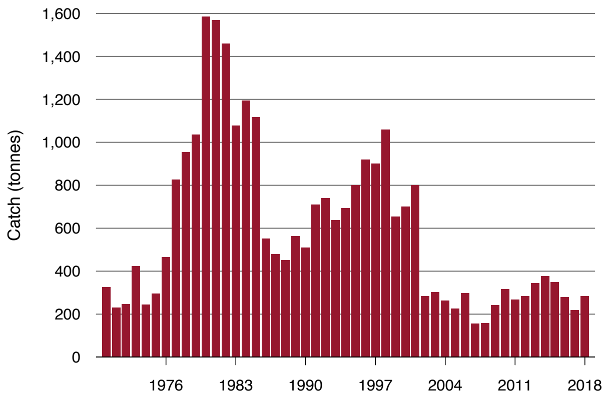
Stock structure

Blue endeavour prawn ranges across northern Australia waters and parts of the Indo-West Pacific Ocean. The biological stock structure is uncertain, but the population in the NPF is assumed to be a single stock for management purposes.

Catch history

Annual catches of blue endeavour prawn peaked in the early 1980s at more than 1,500 t, and again in the late 1990s at 1,000 t (Figure 5.9). Since 2002, annual catches have averaged around 300 t, with 283 t caught in 2018. Blue endeavour prawn is a byproduct of the tiger prawn fishery, and so catches are linked to changes in effort targeting tiger prawns.

FIGURE 5.9 Blue endeavour prawn catch, 1970–2018



Source: CSIRO

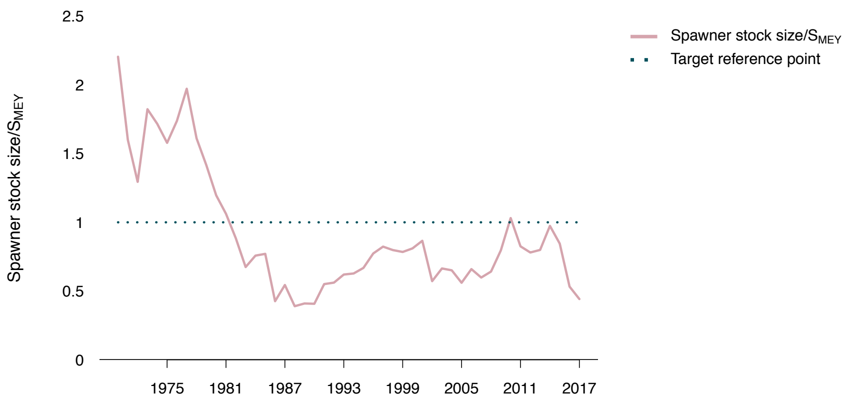
Stock assessment

The stock is assessed using a Bayesian hierarchical biomass dynamic model, within the same overall bio-economic model system used for the two tiger prawn species (Deng et al. 2018).

The base-case estimate of the size of the blue endeavour prawn spawner stock at the end of 2017 as a percentage of stock size at MSY (S_{2017}/S_{MSY}) was 41% (range across sensitivities 41–62%). The base-case estimate of the size of the spawner stock as a percentage of stock size at MEY (S_{2017}/S_{MEY}) was 44% (range across sensitivities 39–61%), indicating a substantial decline in biomass compared with the 2015 blue endeavour prawn assessment (Figure 5.10). Similar to the two tiger prawn stocks, the recent decline in biomass is thought to be associated with poor recruitment, which in turn may be related to environmental factors (Roy Deng [CSIRO], 2019, pers. comm).

The 2018 catch of blue endeavour prawn (283 t; Figure 5.9) was substantially less than the base-case estimate of MSY (752 t).

FIGURE 5.10 Spawner stock size as a proportion of S_{MEY} for blue endeavour prawn, 1970–2017

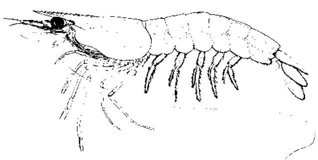


Note: S_{MEY} Spawner stock size at maximum economic yield.
Source: Deng et al. 2018

Stock status determination

The catch in 2018 was well below the estimated MSY, and the estimate of spawner stock size (five-year moving average) for the base case was above the LRP ($0.5S_{MSY}$). Blue endeavour prawn in the NPF is therefore classified as **not subject to overfishing** and **not overfished**.

Red endeavour prawn (*Metapenaeus ensis*)



Line drawing: FAO

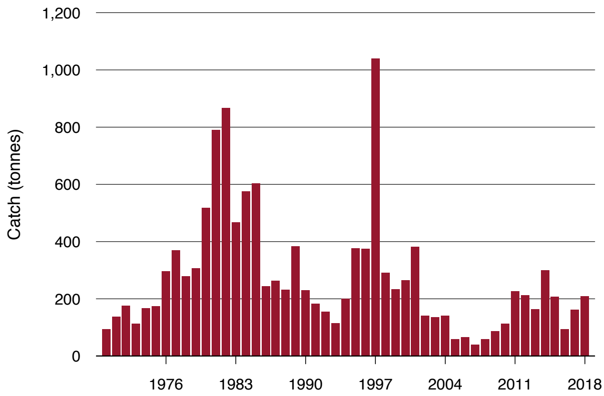
Stock structure

Red endeavour prawn ranges across northern Australian waters and parts of the Indo-West Pacific Ocean. The biological stock structure is uncertain, but the population within the NPF is assumed to be a single stock for management purposes.

Catch history

Annual catches of red endeavour prawn have been variable over the history of the fishery, with peak annual catches exceeding 800 t in 1982 and 1997 (Figure 5.11). Since 1998, catches have been below 400 t, with 209 t caught in 2018. Red endeavour prawn is a byproduct of the tiger prawn fishery.

FIGURE 5.11 Red endeavour prawn catch, 1970–2018



Source: CSIRO

Stock assessment

A preliminary assessment of red endeavour prawn, using a Bayesian hierarchical biomass dynamic model as a scenario test model, was undertaken in 2018 (Deng et al. 2018) to explore whether the model could provide a preliminary indication of the stock status of this species. Since the sensitivity of the outputs of the model has not been significantly tested against different model input scenarios, the assessment results were not considered reliable for determining the stock status of red endeavour prawn.

Catches in recent years have been quite low compared with historical highs. This is most likely related to the overall decline in fishing effort directed at tiger prawns, and the closure of some areas and time periods where red endeavor prawn was historically targeted, rather than being an indication of a fall in red endeavour prawn biomass (which is also the case for blue endeavor prawn).

Stock status determination

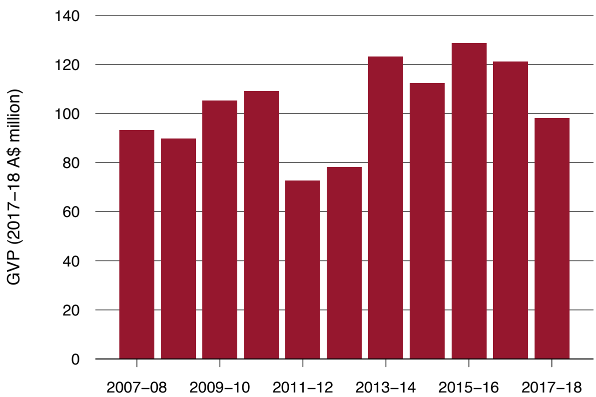
Given the preliminary nature of the 2018 stock assessment, red endeavour prawn is classified as **uncertain** with regard to fishing mortality and biomass status.

5.3 Economic status

Key economic trends

The gross value of production (GVP) for the NPF fluctuated during the decade to 2017–18, peaking at $129 million in 2015–16 and reaching a low of $73 million (in 2017–18 dollars) in 2011–12 (Figure 5.12). During the same period, the average GVP per active vessel increased by 5% to $1.78 million (in 2017–18 dollars).

FIGURE 5.12 GVP and GVP per active vessel for the NPF, 2007–08 to 2017–18



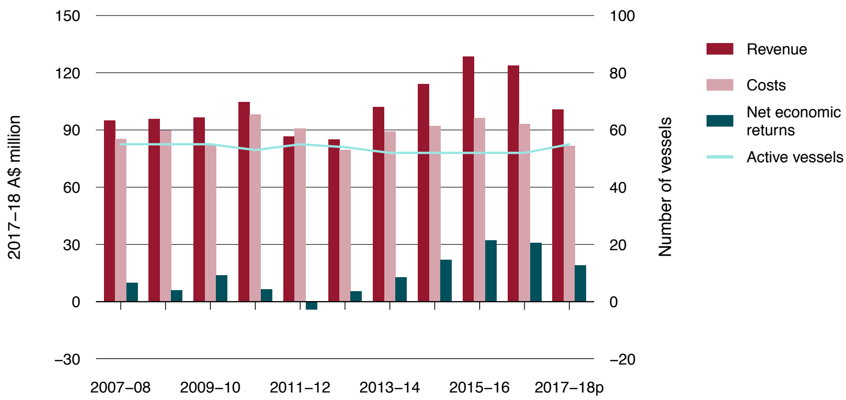
Notes: **GVP** Gross value of production. 2017–18 data are preliminary.

Since the early 1990s, ABARES has used data from economic surveys of the NPF to estimate the net economic returns (NER) earned in the fishery. The most recent survey in 2017 provided survey-based estimates of NER for the 2014–15 and 2015–16 financial years, and forecasts for 2016–17 (Mobsby, Curtotti & Bath 2019).

Real NER in the NPF have varied considerably during the period 2006–07 to 2016–17 (Figure 5.13). In 2006–07 and 2011–12, real NER were negative, estimated at –$3.7 million and –$4.0 million (in 2017–18 dollars), respectively. NER have followed an increasing trend since 2011–12, reaching a peak of $32.1 million in 2015–16, supported by a strong increase in tiger prawn catch and good prices. The NER improvement in 2015–16 was the fourth consecutive annual increase in NER. The strong performance in 2015–16 was forecast to be repeated in 2016–17, following a strong increase in banana prawn catch in 2016–17, albeit slightly lower, at ($30.30 million). In 2017–18, which comprises the 2017 tiger prawn season and 2018 banana prawn season, lower GVP and higher unit fuel prices are expected to have a dampening effect on NER.

Increasing profitability during this period is likely to stem from a combination of factors, including favourable market conditions and management changes that have occurred in the fishery in recent years. Favourable market conditions include a lowering of the Australian dollar exchange rate and fuel prices after 2012–13. Management changes include targeting of MEY in the tiger prawn component of the fishery from 2004–05; implementation of the Securing our Fishing Future structural adjustment program (which concluded in 2006–07), resulting in a 50% reduction in the fleet; and the adoption of quad trawl gear. The structural adjustment program removed 43 class B statutory fishing rights from the fishery, reducing the already declining active vessel numbers from 86 in 2005–06 to 55 in 2007–08. Since then, active vessel numbers have declined slightly, to 52 in 2017. Together, these changes are likely to have improved the economic performance of the fishery.

FIGURE 5.13 Real revenue, costs, NER and active vessel numbers for the NPF, 2007–08 to 2017–18



Notes: **NER** Net economic returns. **p** Preliminary non-survey-based estimates. NER include management costs.
Source: Mobsby, Curtotti & Bath 2019

Total factor productivity (a measure of fishers' ability to convert inputs into outputs over time) in the fishery increased from 2005–06 to 2010–11, at a rate robust enough to offset declining terms of trade from declining prices and high fuel costs (Mobsby, Curtotti & Bath 2019; Figures 5.14 and 5.15). This trend was largely driven by growth in outputs and a slightly declining inputs index. Most of the increase in the outputs index coincides with increases in banana prawn catch per vessel; however, targeting MEY in the tiger prawn component of the fishery would also have supported this improved productivity at a time of declining terms of trade. Because the productivity index was not adjusted for stock effects, productivity growth also reflects favourable environmental conditions at the time, which allowed increases in catch, particularly for banana prawns, rather than just changes in efficiency measures and technology adopted by fishers. From 2010–11 to 2015–16, total factor productivity generally declined, but the negative impact of this on NER has been more than offset by a strongly positive trend in terms of trade, largely as a result of improved prices for banana and tiger prawns, and lower fuel costs since 2013–14. The positive trend in terms of trade has largely driven the steady rise in NER during the period.

FIGURE 5.14 Total factor productivity index, 2005–06 to 2015–16

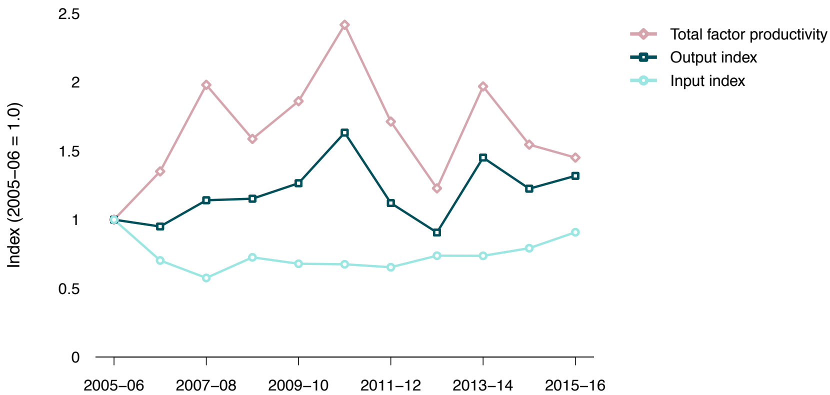
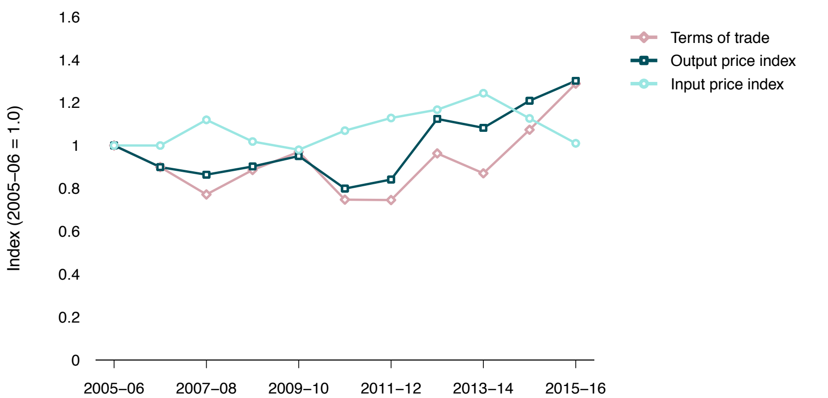


FIGURE 5.15 Terms of trade index, 2005–06 to 2015–16



Management arrangements

The NPF is managed using input controls. The main control is individual tradeable gear units, which limit the length of headrope on trawl nets. Controls on season length, spatial closures and other gear restrictions are also applied.

An assessment of the impact of the structural adjustment program by Vieira et al. (2010) suggested that, for the benefits of the program to be preserved, management arrangements in fisheries targeted by the program need to be set in ways that prevent a repeated build-up of fishing capacity. In recent years, AFMA has sought to better align banana prawn catch levels with the MEY objective. In 2014, an MEY catch-rate trigger for banana prawn was introduced to the fishery (AFMA 2015).

Performance against economic objective

The tiger prawn component of the fishery has explicit MEY targets (across two tiger prawn stocks and one endeavour prawn stock), and a bio-economic model is used to estimate annual fishing effort required to move towards S_{MEY}. Stocks are assessed every two years. Spawning stock sizes of both stocks of tiger prawn were below S_{MEY} at the end of the 2017 season (Deng et al. 2018). Spawner stock size of blue endeavour prawn for the same period was also estimated to be below S_{MEY}. Effort levels as a proportion of effort at MEY for brown tiger prawn and grooved tiger prawn were estimated to be below effort at MEY. Current effort limits in the fishery are based on outputs from the fishery's bio-economic model, and are designed to achieve an MEY (optimal profit at the fleet level) target over a seven-year projection period (noting that the target changes with every assessment because of changes in biological and economic parameters).

Recruitment for all stocks is variable, particularly for white banana prawn, for which recruitment is closely associated with rainfall. Therefore, no B_{MEY} target is defined for white banana prawn. Instead, an MEY-based catch-rate trigger was implemented for the 2014 banana prawn season, with mechanisms in place to adjust total annual effort levels to ensure that the fishery remains sustainable and profitable (AFMA 2015).

An updated assessment of redleg banana prawn, primarily caught in Joseph Bonaparte Gulf, indicates that spawning stock biomass fell to below the B_{MEY} target but remained above the LRP ($0.5B_{MSY}$) between 2014 and 2017.

Targeting MEY in the fishery is consistent with the economic objective of maximising economic returns, and could be expected to increase NER in the fishery. Targeting MEY of the tiger prawn component of the fishery began in 2004–05. Despite declining terms of trade from 2004–05 to 2010–11, productivity and NER improved. Although the targeting of MEY over this period is likely to have supported these improvements, other factors, such as the structural adjustment program and improved banana prawn catch, also contributed. The banana prawn catch trigger targeting MEY has only been in place since 2014, so it is too early to determine its effect on NER.

5.4 Environmental status

The NPF was reaccredited under part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* in December 2018. The current approval of a wildlife trade operation (part 13A) expires on 6 January 2024. Three recommendations accompanied the strategic assessment, relating to the management and monitoring of sawfish and sea snake species.

The NPF was certified as a sustainable fishery by the Marine Stewardship Council in November 2012 and recertified in January 2018.

Ecological risk assessment (ERA) of the NPF has assessed 9 target species, 135 byproduct species, 516 discard species (chondrichthyans and teleosts only), 128 protected species, 157 habitats and 3 communities (AFMA 2008). Following review of the level 2 Productivity Susceptibility Analysis (PSA) risk rankings, using residual risk guidelines (AFMA 2008), 26 species remained at high risk. During and following the level 2 PSA work, selected taxonomic groups were the subject of level 2.5 studies (Brewer et al. 2007). Milton et al. (2008) estimated temporal trends in abundance of sea snakes in the NPF to provide a quantitative assessment of trawling on populations. Although most populations had been relatively stable, two species (spectacled seasnake [*Hydrophis kingii*] and large-headed seasnake [*H. pacificus*]) showed evidence of decline on the trawl grounds. Results from a level 3 Sustainability Assessment for Fishing Effects analysis of elasmobranchs in the NPF (Zhou & Griffiths 2011) indicate that, of the 51 species considered, fishing impacts may have exceeded the maximum sustainable fishing mortality harvest rate for 19 species, although these estimates were highly uncertain. Based on these risk assessments, three species are currently considered to be at high risk in the NPF: porcupine ray (*Urogymnus asperrimus*) and two species of mantis shrimp (*Dictyosquilla tuberculata* and *Harpiosquilla stephensoni*). The ERA is currently being updated.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. In the NPF in the 2018 calendar year, 621 sawfish interactions were reported, of which 425 were released alive, 193 were dead and the remainder were injured; 11,048 sea snakes were caught, of which 8,593 were released alive, 2,107 were dead and 348 had an unknown life status; 169 seahorse and pipefish species were caught, of which 118 were released alive and the remainder were dead; and 78 turtle interactions were reported, with all but 4 being released alive. Reports also indicate that one dolphin was caught and released alive.

The fishery has had a bycatch management plan for many years, and NPF Industry has been leading projects on bycatch reduction devices with the aim of reducing bycatch in the fishery by 30%.

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Chapter 6
North West Slope Trawl Fishery

N Mazloumi, J Woodhams and AH Steven

FIGURE 6.1 Area fished in the North West Slope Trawl Fishery, 2017–18

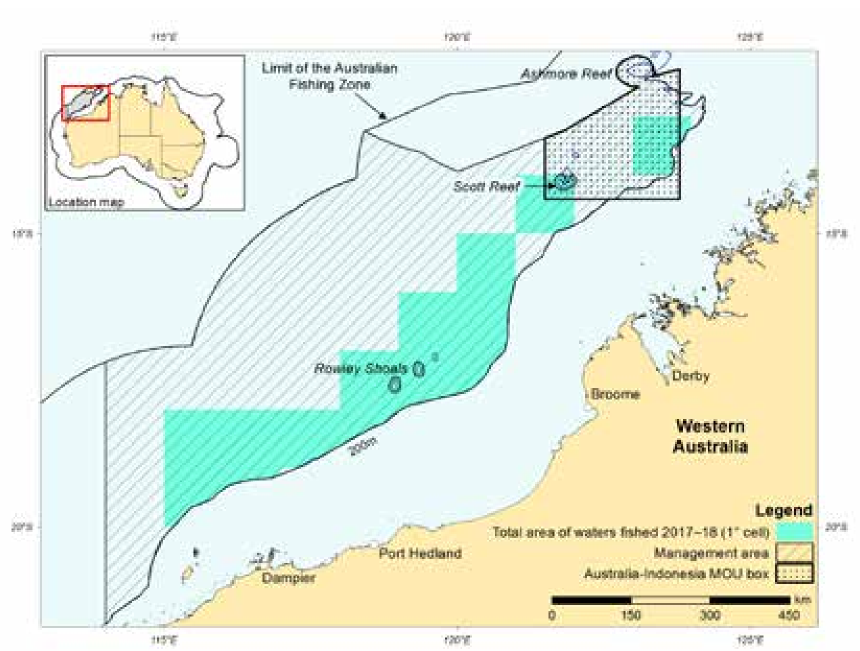


TABLE 6.1 Status of the North West Slope Trawl Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Scampi (*Metanephrops australiensis, M. boschmai, M. velutinus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Trawl effort is relatively low compared with historical levels, and nominal catch-per-unit-effort is relatively high.
Economic status	Estimates of NER are not available for the fishery. Increased catch in the 2016–17 and 2017–18 fishing seasons suggests increased gross value of production, but the effect of this on NER is uncertain because fishing costs in the 2016–17 and 2017–18 fishing seasons are likely to have increased. A high degree of latent fishing effort indicates that NER are likely to be low.				

Note: **NER** Net economic returns.

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

Scampi
Mike Gerner, AFMA

6.1 Description of the fishery

Area fished

The North West Slope Trawl Fishery (NWSTF) operates off north-western Australia from 114°E to 125°E, roughly between the 200 m isobath and the outer boundary of the Australian Fishing Zone. A large area of the Australia–Indonesia MOU box (an area off north-western Western Australia where Indonesian fishers may operate using only traditional methods) falls within the NWSTF (Figure 6.1). There have been recent changes to the boundary of this fishery to more closely align with the 200 m isobath.

Fishing methods and key species

The NWSTF has predominantly been a scampi fishery using demersal trawl gear. The key species is Australian scampi (*Metanephrops australiensis*). Smaller quantities of velvet scampi (*M. velutinus*) and Boschma's scampi (*M. boschmai*) are also harvested. Mixed snappers (Lutjanidae) have historically been an important component of the catch. At the height of the fishery, in the late 1980s and early 1990s, deepwater prawns, particularly red prawn (*Aristaeomorpha foliacea*), were targeted and dominated the total catch. However, difficulties in maintaining markets for deepwater prawns led to a decline in the number of vessels operating in the fishery and a return to primarily targeting scampi.

Management methods

In 2011, the Australian Fisheries Management Authority (AFMA) updated the harvest strategy for the western trawl fisheries (NWSTF and Western Deepwater Trawl Fishery—WDTF; AFMA 2011). Given the relatively low levels of catch, the purpose of the harvest strategy is to allow fishing at current levels without additional management costs. The revised strategy uses historical catches and catch rates from 2000 to 2010 as the basis for triggers for further management actions, if fishing activity increases. An annual review determines whether these catch triggers have been reached. It is not clear whether the maximum catch over the chosen reference period (2000–2010) is a valid indicator of sustainable harvest levels, given the nearly 30 years of exploitation in this fishery, or whether catch rates over the reference period are representative of unfished biomass levels. Given the recent boundary amendments to the Western Australian Offshore Constitutional Settlement arrangement, AFMA has commenced a review of the current harvest strategy, with a focus on the triggers for mixed snapper species.

The 2010 stock assessment of scampi in the NWSTF (Chambers & Larcombe 2015) may provide information for refining catch and catch-rate triggers for these species.

Fishing effort

Fishing commenced in the NWSTF in 1985. The number of active vessels peaked at 21 in 1986–87 and declined through the 1990s before increasing to 10 in 2000–01 and 2001–02. Vessel numbers have since decreased to stabilise at one or two vessels each year since 2008–09 (Table 6.2). Historical effort, in trawl-hours, increased in the 2017–18 fishing season and largely follows the same trend as the number of active vessels (Figure 6.2). Fishing effort often increases when boats cease to operate in the Northern Prawn Fishery in a given season and move to the NWSTF.

TABLE 6.2 Main features and statistics for the NWSTF

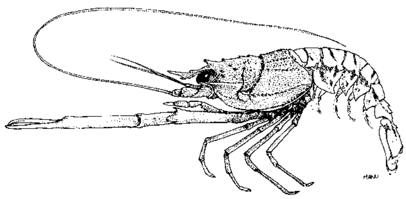
Fishery statistics [a]	**2016–17 fishing season**			**2017–18 fishing season**		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Scampi (*Metanephrops australiensis, M. boschmai, M. velutinus*)	–	37.5	Confidential	–	55.2	Confidential
Total fishery	**–**	**57.7**	**Confidential**	**–**	**79.7**	**Confidential**
Fishery-level statistics						
Effort	141 days; 2,868 trawl-hours			219 days; 3,731 trawl-hours		
Fishing permits	4			6		
Active vessels	2			4		
Observer coverage	12 days (9%)			14 days (6.4%)		
Fishing methods	Demersal trawl					
Primary landing ports	Darwin (Northern Territory), Point Samson (Western Australia)					
Management methods	Input controls: limited entry, gear restrictions Output controls: harvest strategy contains catch trigger for scampi, deepwater prawns and some finfish (redspot emperor and saddletail snapper)					
Primary markets	Domestic: Brisbane, Perth, Sydney—fresh and frozen product International: China, Hong Kong, Japan, Singapore, Spain, United States—frozen product					
Management plan	*North West Slope Trawl Fishery and Western Deepwater Trawl Fishery: statement of management arrangements* (AFMA 2012)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 July – 30 June. Value statistics are by financial year.

Notes: **GVP** Gross value of production. **TAC** Total allowable catch. – Not applicable.

6.2 Biological status

Scampi (*Metanephrops australiensis, M. boschmai* and *M. velutinus*)



Line drawing: FAO

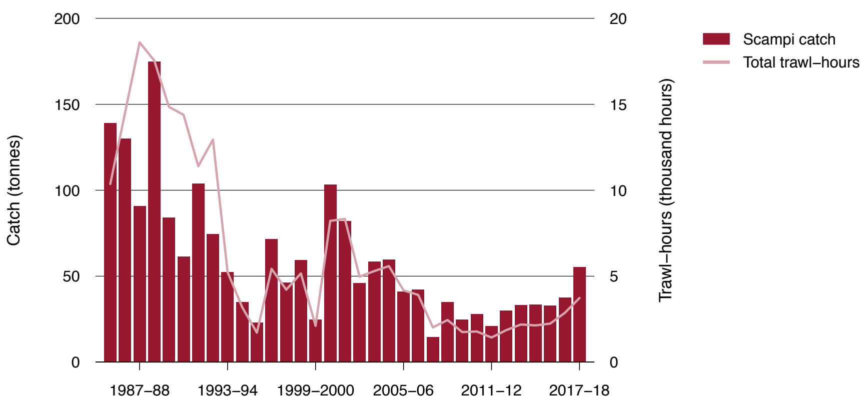
Stock structure

The NWSTF targets several species of scampi. The stock structure of these species (predominantly *M. australiensis*, *M. boschmai* and *M. velutinus*) is not known, and they are grouped into a multispecies stock for management and assessment purposes. Scampi in the NWSTF are therefore assessed as a single stock.

Catch history

Trends in total catch have largely followed trends in active vessels and fishing effort (Figure 6.2). Scampi catch in recent years has increased from a relatively stable 30 t in 2012–13 to 55.2 t for the 2017–18 fishing season. Total catch has primarily consisted of scampi, except in 2011–12, when mixed snapper accounted for a large proportion of the catch (32 t of snapper and 21 t of scampi).

FIGURE 6.2 Catch and effort for scampi in the NWSTF, 1985–86 to 2017–18



Source: AFMA

Stock assessment

In 2010, the scampi stock (predominantly *M. australiensis*, *M. boschmai* and *M. velutinus*) was assessed using surplus production models (Chambers & Larcombe 2015). This assessment indicated that scampi biomass at the end of 2008 was most likely between 65% and 85% of unfished biomass. The fishing mortality rate was estimated to have been well below the rate that would achieve maximum sustainable yield.

Wallner and Phillips (1995) noted that scampi catch rates in the NWSTF tended to decline quickly in response to fishing but recovered after grounds were rested for relatively short periods. They suggested that scampi might spend a greater proportion of time in burrows after the grounds have been trawled, temporarily reducing their catchability. If scampi respond to fishing in this way, catch-per-unit-effort (CPUE) should decline more quickly than abundance. Stock assessments based on CPUE would tend to be precautionary (that is, the stock would be less depleted than indicated by CPUE).

Nominal CPUE has been close to historical highs since the 2010 stock assessment, suggesting that biomass remains high. Trawl effort has been low over the same period (Figure 6.2), which suggests low levels of fishing mortality during this time.

The possible conservative nature of CPUE indices used in the stock assessments suggests that, provided scampi remain a primary target for the fishery, use of nominal (unstandardised) CPUE and annual catch is probably adequate for assessment purposes. Standardised CPUE series should be produced every 3–5 years, and assessment models fitted to periodically update relative biomass estimates. Analysis of the mean carapace length of Australian scampi measured by observers could provide a comparative indicator of total mortality.

Stock status determination

Chambers and Larcombe (2015) assessed the scampi stock as not overfished and not subject to overfishing in 2008–09. Since then, catch and effort have remained relatively low (Figure 6.2), and nominal catch rates are relatively high compared with historical levels. Based on these indicators and information from the previous stock assessment, scampi in the NWSTF are classified as **not overfished** and **not subject to overfishing**.

6.3 Economic status

Key economic trends

The gross value of production of the fishery has been confidential since 2006–07 because of the small number of active vessels in the fishery. Total catch has been on an upward trend; the total volume landed in the NWSTF increased by 5% in 2016–17 and by 38% in 2017–18. Scampi has a relatively high unit value compared with other species caught in the fishery and so is the main target species. In the 2016–17 fishing season, scampi made up 65% of total catch, increasing to 69% in the 2017–18 season. Total catch of scampi has increased over the past two seasons. In the 2016–17 season, the volume of scampi landed was 14% higher than in 2015–16. The volume of scampi landed in the 2017–18 fishing season increased by a further 47%.

The past three seasons have seen a significant increase in fishing effort. In 2015–16, fishing effort increased by 5%, in 2016–17 by 28% and in 2017–18 by 30%. The increase in effort, combined with 5% and 15% fuel price increases in 2016–17 and 2017–18, respectively, likely indicate an increase in total fishing costs.

With likely rising revenue and costs in the fishery in the past three seasons, the overall effect on the fishing fleet's profitability is unclear. Moreover, economic surveys of the NWSTF have not been undertaken. However, it is likely that net economic returns of the NWSTF remain relatively low. As at March 2019, there were seven fishing permits in the NWSTF. In the 2016–17 fishing season, four permits had a nominated vessel, but only two of the four boats were active. In 2017–18, the number of nominated vessels increased to six, but only four boats were active in the fishery, indicating a decline in latent effort. High levels of latent effort can indicate low net economic returns.

Management arrangements

Under the harvest strategy, the fishery is managed through input controls and catch triggers. As higher catch triggers are reached, the harvest strategy may require more sophisticated stock assessment techniques to be applied (AFMA 2011). Such stock assessments would inform potential changes to management arrangements for the fishery, including a change to output controls, if catch increased sufficiently to justify such measures.

Performance against economic objective

The fishery's performance against the economic objective is uncertain because there is no explicit economic target or supporting analyses. Given the likelihood that the fishery is of relatively low value, with low levels of fishing effort, a low-cost management approach such as that currently being applied is appropriate.

6.4 Environmental status

The NWSTF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 18 December 2020.

Chondrichthyans and teleosts caught in the NWSTF and the WDTF have been assessed to level 3 of the AFMA ecological risk assessment framework (Zhou, Smith & Fuller 2009). None of the species assessed were found to be at high risk at the current level of fishing effort.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in the NWSTF in 2018.

6.5 References

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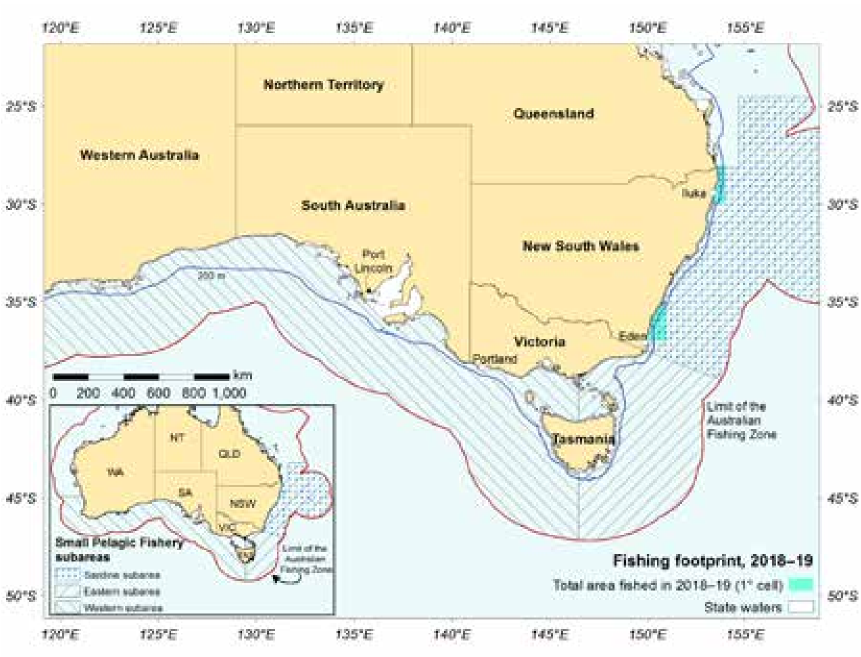
Chapter 7

Small Pelagic Fishery

N Marton and AH Steven

FIGURE 7.1 Area fished in the Small Pelagic Fishery, 2018–19



Note: Some effort data are not shown on this map for confidentiality reasons.

TABLE 7.1 Status of the Small Pelagic Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Australian sardine (*Sardinops sagax*)					Recent catches have been below the RBC. Historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Blue mackerel, east (*Scomber australasicus*)					Recent catches have been below the RBC. Historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Blue mackerel, west (*Scomber australasicus*)					Recent catches have been below the RBC. Historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Jack mackerel, east (*Trachurus declivis*)					Recent catches have been below the RBC. Recent historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Jack mackerel, west (*Trachurus declivis*)					Recent catches have been below the RBC. Historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Redbait, east (*Emmelichthys nitidus*)					Recent catches have been below the RBC. Historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Redbait, west (*Emmelichthys nitidus*)					Recent catches have been below the RBC. Historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Economic status	Estimates of NER are not available for the SPF, although the high degree of latency in the fishery suggests that NER are likely low. An increase in the level of catch in 2017–18 suggests that gross value of production is likely to have increased in 2017–18. Trends in NER are uncertain because of a lack of information about changes in cost structures of the industry.				

Notes: **NER** Net economic returns. **RBC** Recommended biological catch.

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

7.1 Description of the fishery

Area fished

The Small Pelagic Fishery (SPF) extends from southern Queensland to southern Western Australia (Figure 7.1). The fishery has three subareas, each with its own stock-level total allowable catch (TAC).

Fishing methods and key species

The fishery includes purse-seine and midwater trawl fishing vessels. The key target species for the purse-seine vessels are Australian sardine (*Sardinops sagax*), blue mackerel (*Scomber australasicus*) and jack mackerel (*Trachurus declivis*). The key target species for the midwater trawl fishery are blue mackerel, jack mackerel and redbait (*Emmelichthys nitidus*).

Management methods

Almost all small pelagic stocks are multijurisdictional (that is, managed by both the Australian and state governments) under Offshore Constitutional Settlement arrangements. The exceptions are the western stocks of Australian sardine, which are managed by Western Australia, South Australia and Victoria.

Stocks in the SPF are managed under a harvest strategy that has been revised several times in recent years. The review of the 2014 harvest strategy (AFMA 2014) included ecosystem and population modelling (Smith et al. 2015). Recommendations from the review were incorporated into the current harvest strategy (AFMA 2017b), which adopts a target reference point of $0.5B_0$ (50% of the unfished biomass) and a limit reference point of $0.2B_0$.

The harvest strategy has three tiers, with static exploitation rates for each tier and stock. Operating at tier 1 requires a recent egg survey and a biomass estimate based on the daily egg production method (DEPM). Tier 1 allows for the highest exploitation rates (Table 7.2). A tier 1 recommended biological catch (RBC) can be set for a maximum of five seasons after the egg survey and DEPM-based biomass estimate. If an updated survey is not conducted, the harvest strategy steps down to tier 2. Tier 2 has reduced exploitation rates in acknowledgement of the increasing uncertainty over time as to how well the DEPM-based biomass estimate reflects current biomass. Similarly, the harvest strategy steps down from tier 2 to tier 3 after a further 5 or 10 years (depending on the species), with a subsequent reduction in exploitation rate. Stocks without a DEPM-based biomass estimate have biomass estimated using the Atlantis ecosystem model developed for the SPF. These have a further reduced exploitation rate but are still classified as tier 3. When setting the RBCs for the 2018–19 season, redbait (west) was the only SPF stock without a DEPM-based biomass estimate. A DEPM-based biomass estimate was finalised for redbait west in 2019 (based on surveys in late 2017) to support management in 2019–20. Consequently, the Atlantis-derived biomass estimate and associated exploitation rate are no longer used.

TABLE 7.2 SPF harvest strategy tier levels when stocks have a DEPM-based biomass estimate

Stock	Tier 1		Tier 2		Tier 3 a	Year of most recent egg survey
	Max. exploitation rate (%)	Max. time at rate (seasons)	Max. exploitation rate (%)	Max. time at rate (seasons)	Max. exploitation rate (%)	
Australian sardine	20	5	10	5	5	2014
Blue mackerel, east	15	5	7.5	5	3.75	2015
Blue mackerel, west	15	5	7.5	5	3.75	2005
Jack mackerel, east	12	5	6	10	3	2014
Jack mackerel, west	12	5	6	10	3	2017
Redbait, east	10	5	5	10	2.5	2006
Redbait, west **b**	10	5	5	10	2.5	2017

a No time limit applies for a stock at tier 3. **b** Maximum exploitation rate was 1.25% of the Atlantis-SPF ecosystem-based biomass estimate up to the 2018–19 season because there was no DEPM biomass estimate. A DEPM biomass estimate has since been generated.
Note: **DEPM** Daily egg production method.

Biomass is difficult to estimate for small pelagic species that exhibit high interannual variability. Where DEPM-based biomass estimates are available, a key assumption for assessing small pelagic stocks is that these estimates are a reliable indicator of population size. However, outputs from DEPM surveys can have large confidence intervals (CIs). In this chapter, spawning biomass estimates are generally presented with the 95% CI of the range of possible estimates.

Fishing effort

Most historical fishing effort occurred off the east and west coasts of Tasmania. Effort in the SPF increased in 2014–15, 2015–16 and 2016–17 with the operation of a factory freezer trawler. This vessel has since left Australian waters (AFMA 2016), but a different midwater trawler entered the fishery in 2017.

Catch

Small pelagic fish are generally caught during targeted fishing for a single species. They are also caught in small quantities in other Commonwealth- and state-managed fisheries, including the Southern and Eastern Scalefish and Shark Fishery, the Eastern Tuna and Billfish Fishery, the Western Tuna and Billfish Fishery, and the New South Wales Ocean Hauling Fishery.

Catch in the SPF increased from around 6,000 t in 1984–85 to a peak of almost 42,000 t in 1986–87. Average catches of around 12,000 t per year were also taken in the early 1990s, comprising mostly redbait. Until recently, minimal catch and effort in the SPF have reflected a lack of markets and processing facilities. The operation of a factory freezer trawler in the 2014–15, 2015–16 and 2016–17 fishing seasons led to increased catches, reaching a peak of around 12,000 t in 2015–16. After the factory freezer trawler left the fishery during the 2016–17 season (AFMA 2016), total catch decreased. Since then, catch has increased to over 9,000 t in 2018–19, due to increasing catches of eastern blue mackerel and eastern jack mackerel by a smaller vessel that entered the fishery in late 2017.

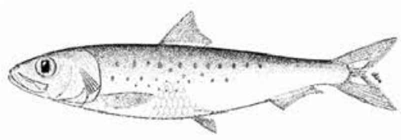
TABLE 7.3 Main features and statistics for the SPF

Fishery statistics a	2017–18 fishing season			2018–19 fishing season	
Stock name	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**
Australian sardine	9,550	97	Confidential	9,510	132
Blue mackerel, east	12,090	2,858	Confidential	12,090	3,811
Blue mackerel, west	3,230	–	Confidential	3,230	–
Jack mackerel, east	18,880	2,748	Confidential	18,890	4,942
Jack mackerel, west	920	–	Confidential	4,190	–
Redbait, east	3,410	10	Confidential	3,420	539
Redbait, west	820	–	Confidential	820	–
Total fishery	**48,900**	**5,713**	**Confidential**	**52,150**	**9,424**
Fishery-level statistics					
Effort	Purse seine: 152 search-hours Midwater trawl: 223 shots			Purse seine: 208 search-hours Midwater trawl: 216 shots	
Fishing permits	29 entities held quota SFRs in 2017–18			31 entities held quota SFRs in 2018–19	
Active vessels	Purse seine: 2 Midwater trawl: 1			Purse seine: 3 Midwater trawl: 1	
Observer coverage	Purse seine: 0% Midwater trawl: 36%			Purse seine: 21% Midwater trawl: 18%	
Fishing methods	Purse seine, midwater trawl				
Primary landing ports	Iluka, Ulladulla (New South Wales)				
Management methods	Input controls: limited entry, gear restrictions Output controls: TACs, with ITQs implemented from 1 May 2012				
Primary markets	Domestic: fishmeal, bait and human consumption International: human consumption				
Management plan	*Small Pelagic Fishery Management Plan 2009*				

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 May – 30 April. Value statistics are by financial year and are not available for 2018–19.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch. – Not applicable.

7.2 Biological status

Australian sardine (*Sardinops sagax*)



Line drawing: FAO

Stock structure

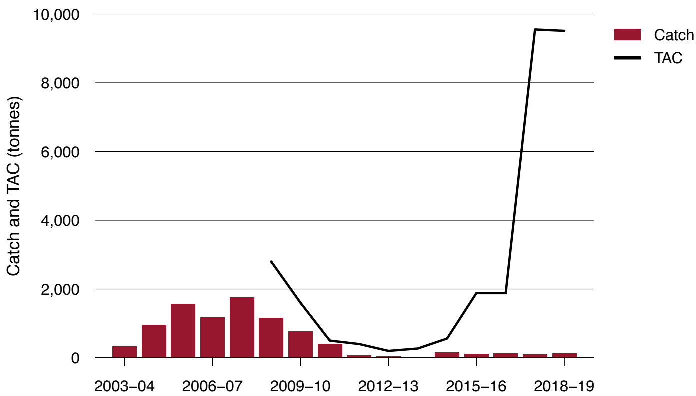
Several studies have found evidence of stock structuring of Australian sardine across southern Australia (Dixon, Worland & Chan 1993; Izzo, Gillanders & Ward 2012; Yardin et al. 1998); however, the boundaries were not conclusively defined. Izzo et al. (2017), using an integrated assessment that included genetic, morphological, otolith, growth, reproductive and fishery data, found evidence for at least four isolated stocks (south-west coast of Western Australia, Great Australian Bight and Spencer Gulf, Bass Strait and Port Phillip Bay, and eastern Australia). Since the sardine subarea (off eastern Australia; Figure 7.1) is the only area of the SPF that is fished, Australian sardine in the SPF is assessed and managed as a single east coast stock.

Catch history

State catches of Australian sardine comprise most of the total catch. Unlike in the Commonwealth fishery, state catches are not constrained by catch limits. State catches increased substantially from 2001–02 to 2009–10, contributing to reductions in the Commonwealth TAC.

Total sardine catch from Commonwealth and state fisheries (other than that taken in South Australia) peaked in 2007–08 at 4,619 t, before decreasing to 894 t in 2014–15—its lowest level since 2001–02. Total catch increased to 2,887 t in 2016–17, primarily driven by increased catches by the Victorian fleet. The total combined catch (state and Commonwealth, excluding Victorian catches because they were confidential) for 2017–18 was 427 t, comprising 97 t of Commonwealth catch and 330 t of state catch. Commonwealth catch for 2018–19 was 132 t (Figure 7.2); state catches are not yet available.

FIGURE 7.2 Commonwealth Australian sardine catch and TAC in the SPF, 2003–04 to 2018–19



Note: **TAC** Total allowable catch.

Stock assessment

Egg surveys for the east coast stock of Australian sardine (undertaken in association with eastern blue mackerel egg surveys) were last conducted in August–September 2014. Spawning biomass was estimated using the DEPM at 49,600 t (95% CI 24,200–213,300 t) (Ward et al. 2015a).

Although the 2014 DEPM result was available for use for both the 2015–16 and 2016–17 seasons, results from the previous DEPM estimate (Ward et al. 2007) were used. This was to allow for additional testing (including a management strategy evaluation [MSE]) on the SPF harvest strategy in use at that time. The SPF Scientific Panel used the 2014 DEPM estimate for the first time in 2017 to recommend an RBC for 2017–18.

The 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For Australian sardine, Smith et al. (2015) suggested that tier 1 harvest rates could be increased from 15% to 33%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than five years. A tier 1 harvest rate of 20% was formally adopted in the 2017 SPF harvest strategy. This lower harvest rate reflects uncertainty in some of the life-history characteristics of the eastern Australian sardine stock and differences from the rate applied for the South Australian Sardine Fishery (25%) (AFMA 2015a). Also, adopting a 33% harvest rate would have been a considerable increase on the rate at the time (AFMA 2015a). Smith et al. (2015) noted that there was some concern around the level of risk for breaching the B_{20} limit reference point if regular egg surveys were not conducted.

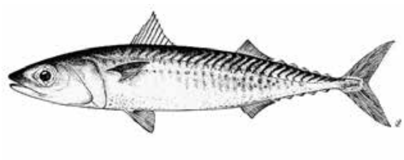
Because of the age of the DEPM estimate, the 2018–19 season was treated as season three of five at tier 1, despite it only being the second season that tier 1 had been used. The tier 1 exploitation rate of 20% equates to an RBC of 9,915 t. After factoring in state catches, the Australian Fisheries Management Authority (AFMA) Commission agreed to a TAC of 9,510 t.

The most recent year that catch data for all states (including Victoria) and the Commonwealth are available is 2016–17, when the total catch was 2,887 t. This is below the RBC calculated using an MSE-tested harvest strategy. Commonwealth catch for 2017–18 and 2018–19 was also below the RBC.

Stock status determination

Recent catches have been below the RBC calculated using an MSE-tested harvest strategy and are a small proportion of the most recent estimate of biomass. This level of fishing mortality is unlikely to have substantially reduced spawning biomass. On this basis, the Australian sardine stock is classified as **not overfished** and **not subject to overfishing**.

Blue mackerel, east (*Scomber australasicus*)



Line drawing: FAO

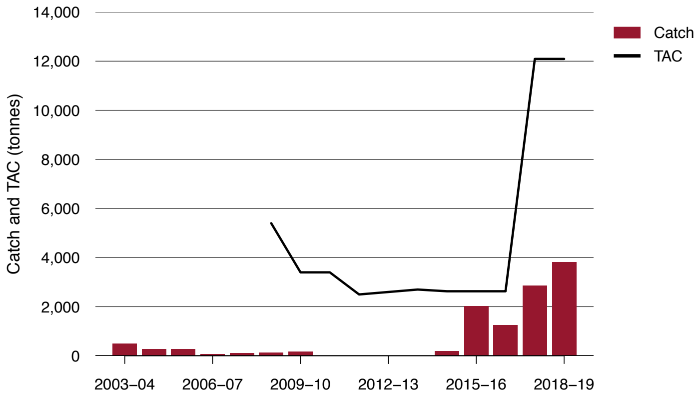
Stock structure

The stock structure of blue mackerel is uncertain. Genetic analysis of samples from southern Queensland, Western Australia and New Zealand indicates population subdivisions. Genetic differences were detected between Western Australia and Queensland, and between Western Australia and New Zealand, but not between Queensland and New Zealand (Schmarr et al. 2007; Whittington, Ovenden & Ward 2012). No finer-scale analyses of blue mackerel have been undertaken to further define stock structure. Blue mackerel within the SPF is assessed and managed as separate stocks in the eastern and western subareas (Figure 7.1).

Catch history

Most of the eastern blue mackerel catch has historically been taken in state fisheries. However, Commonwealth catch began exceeding state catch in 2015–16 and continues to be higher. Total combined catch in 2017–18 was 3,119 t, comprising 2,858 t from the Commonwealth and 261 t from state fisheries. The highest reported catches were in 2018–19 when Commonwealth catch was 3,811 t (Figure 7.3). State catches for the season are not yet available.

FIGURE 7.3 Commonwealth eastern blue mackerel catch and TAC, 2003–04 to 2018–19



Note: **TAC** Total allowable catch.

Stock assessment

Egg surveys for the eastern stock of blue mackerel (and Australian sardine) were conducted in August–September 2014. For eastern blue mackerel, the DEPM-based estimate of spawning biomass was 83,300 t (95% CI 35,100–165,000 t) (Ward et al. 2015a). However, because samples of adult blue mackerel were not collected during the egg survey, reproductive parameters of adult blue mackerel taken from previous egg surveys off southern Australia between 2001 and 2006 were used. Ward et al. (2015a) therefore suggest that their estimate of spawning biomass be treated with caution.

As for Australian sardine, although the 2014 DEPM-based biomass estimate was available for use for both the 2015–16 and 2016–17 seasons, results from the previous DEPM-based biomass estimate (Ward et al. 2007) were used. This was to allow for additional testing (including MSE) of the SPF harvest strategy in use at that time (Pascoe & Hillary 2016; Punt, Little & Hillary 2016). The SPF Scientific Panel used the 2014 DEPM estimate for the first time in 2017 to recommend an RBC.

The 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For blue mackerel, it was suggested that tier 1 harvest rates could be increased from 15% to 23%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than five years. Smith et al. (2015) noted that there was some concern around the level of risk for breaching the B_{20} limit reference point if regular egg surveys were not conducted. There was also some concern about the age structure and reproductive biology parameters available for use in the MSE (AFMA 2015b). As a result, a tier 1 harvest rate of 15% was formally retained in the 2017 SPF harvest strategy.

Because of the age of the DEPM-based biomass estimate, the 2018–19 season was treated as season three of five at tier 1, despite it only being the second season that tier 1 had been used. The tier 1 exploitation rate of 15% equates to an RBC of 12,495 t. After factoring in state catches, the AFMA Commission agreed to a TAC of 12,090 t.

The most recent year that both state and Commonwealth catch data are available is 2017–18, when the total catch was 3,119 t. This is below the RBC calculated using the MSE-tested harvest strategy. Commonwealth catch for 2018–19 was also below the RBC.

Stock status determination

Recent catches have been below the RBC calculated using an MSE-tested harvest strategy and are a small proportion of the most recent estimate of biomass (3.7% in 2017–18, including state catches, and 4.6% in 2018–19, which does not include state catches). This level of fishing mortality is unlikely to have substantially reduced spawning biomass. On this basis, the eastern blue mackerel stock is classified as **not overfished** and **not subject to overfishing**.

Blue mackerel, west (*Scomber australasicus*)

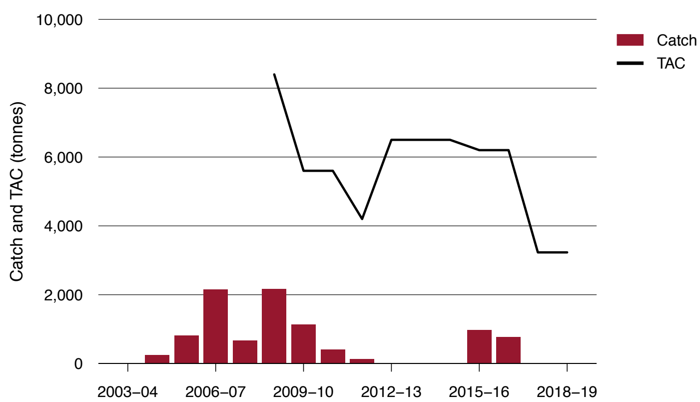
Stock structure

See blue mackerel, east.

Catch history

Very little western blue mackerel was caught before 2004–05. Total Commonwealth-landed catch increased in 2005–06, peaked in 2008–09 at 2,164 t and decreased steadily thereafter. Catch was negligible between 2011–12 and 2014–15 in both the state and Commonwealth fisheries. No Commonwealth catch was reported in 2017–18 or 2018–19 (Figure 7.4), and state catches have been either negligible or confidential in recent years. State catches are not available for 2018–19.

FIGURE 7.4 Commonwealth western blue mackerel catch and TAC, 2003–04 to 2018–19



Note: **TAC** Total allowable catch.

Stock assessment

An egg survey for western blue mackerel was conducted in 2005, and a spawning biomass of 56,228 t (95% CI 10,993–293,456 t) was estimated using the DEPM (Ward & Rogers 2007). However, the SPF Resource Assessment Group considered this to be too low and adjusted the estimate to 86,500 t.

The 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For western blue mackerel, it was suggested that tier 1 harvest rates should be set at 23%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than five years. Smith et al. (2015) noted that there was some concern around the level of risk for breaching the B_{20} limit reference point if regular egg surveys were not conducted, and so lower harvest rates were adopted (starting at 15% for tier 1) in the 2017 SPF harvest strategy.

Tier 3 of the 2017 harvest strategy (a harvest rate of 50% of tier 2) was used to recommend a 2018–19 RBC of 3,243 t. This was the second season that tier 3 was used to set an RBC for western blue mackerel. After factoring in state catches, the AFMA Commission agreed to a TAC of 3,230 t.

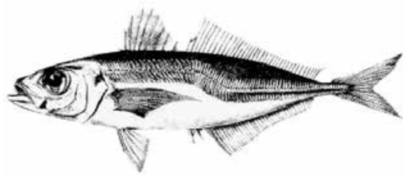
The most recent year that both state and Commonwealth catch data are available is 2017–18, when the total catch was less than 1 t. This is below the RBC calculated using an MSE-tested harvest strategy. There was no Commonwealth catch in 2018–19.

Stock status determination

Recent catches have been below the RBC calculated using an MSE-tested harvest strategy and are a small proportion of the most recent estimate of biomass (peaking at approximately 4% in 2008–09). Although the 2005 biomass estimate is dated, the level of fishing mortality in any year is unlikely to have substantially reduced spawning biomass. On this basis, the western blue mackerel stock is classified as **not overfished** and **not subject to overfishing**.

Small pelagic purse-seine net
AFMA

Jack mackerel, east (*Trachurus declivis*)



Line drawing: FAO

Stock structure

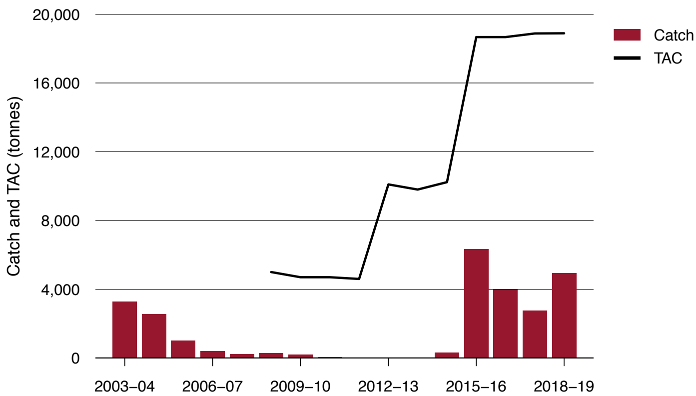
The stock structure of jack mackerel is unclear. Richardson (1982) found evidence of population subdivision between Western Australia, including the Great Australia Bight, and eastern Australia. Similarly, a DEPM estimate for western jack mackerel appears to show some stock structuring around the Bonney Coast west of Bass Strait (AFMA 2017d). Richardson (1982) also found evidence of a Wahlund effect (where multiple populations are detected in a single sample) in east coast samples, suggesting some additional structuring. Smolenski, Ovenden & White (1994) found evidence of structuring between New South Wales and south-eastern Tasmania, although the differences appeared not to be temporally consistent. These studies suggest that further investigation of stock structure in jack mackerel on the east coast is warranted. Currently, jack mackerel in the SPF is assessed and managed as separate stocks in the eastern and western subareas (Figure 7.1).

Catch history

The jack mackerel purse-seine fishery was established off Tasmania in the mid 1980s, with initial catches exceeding 40,000 t (Kailola et al. 1993). Catches then declined as a result of an absence of surface schools of jack mackerel, and the purse-seine fishery ceased in 2000 (Ward et al. 2011).

Commonwealth catch increased to 9,873 t in 1997–98, fluctuated markedly to 2003–04 and then declined as a result of decreasing effort in the fishery. State catches have been negligible in recent years; however, Commonwealth catch has increased, reaching 6,316 t in 2015–16 before decreasing to 4,942 in 2018–19 (Figure 7.5). The total combined catch (state and Commonwealth) for 2017–18 was 2,751 t, comprising 2,748 t of Commonwealth catch and 3 t of state catch. Commonwealth catch for 2018–19 was 4,942 t (Figure 7.5). State catches are not yet available for 2018–19.

FIGURE 7.5 Commonwealth eastern jack mackerel catch and TAC, 2003–04 to 2018–19



Note: **TAC** Total allowable catch.

Stock assessment

The most recent egg survey for eastern jack mackerel was conducted off eastern Australia in January 2014 (Ward et al. 2015b), and a spawning biomass of 157,805 t (95% CI 59,570–358,731 t) was estimated using the DEPM.

An MSE in 2015 suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For eastern jack mackerel, it was suggested that tier 1 harvest rates should be set at 12%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than five years. Additional testing in 2016 was also used to assess harvest rates and target reference points (Pascoe & Hillary 2016; Punt, Little & Hillary 2016). A tier 1 harvest rate of 12% was formally adopted in the 2017 SPF harvest strategy. The SPF Scientific Panel used the 2014 DEPM-based biomass estimate to recommend a 2018–19 RBC of 18,937 t, using tier 1 of the 2017 harvest strategy (AFMA 2017c). After factoring in state catches, the AFMA Commission agreed to a TAC of 18,890 t.

The most recent year that both state and Commonwealth catch data are available is 2017–18, when the total catch was 2,751 t. This is below the RBC calculated using an MSE-tested harvest strategy. Commonwealth catch in 2018–19 was also below the RBC.

Stock status determination

Recent catches have been below the RBC calculated using an MSE-tested harvest strategy and are a small proportion of the most recent estimate of biomass (peaking at 4% in 2015–16). This level of fishing mortality is unlikely to have substantially reduced spawning biomass. On this basis, the eastern jack mackerel stock is classified as **not overfished** and **not subject to overfishing**.

Jack mackerel, west (*Trachurus declivis*)

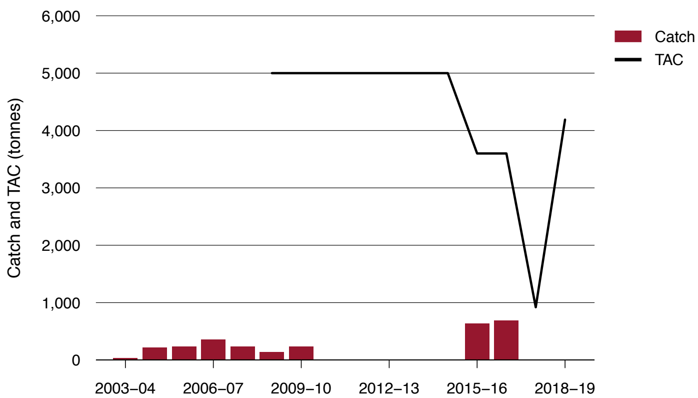
Stock structure

See jack mackerel, east.

Catch history

Total catch (state and Commonwealth) for western jack mackerel did not exceed 250 t before 2005–06. Commonwealth catch was zero or negligible from 2011–12 to 2014–15, and increased to 634 t in 2015–16 and 686 t in 2016–17. No Commonwealth catch was reported for 2017–18 or 2018–19 (Figure 7.6). State catches are not available for 2018–19 and have been confidential for the preceding three years.

FIGURE 7.6 Commonwealth western jack mackerel catch and TAC, 2003–04 to 2018–19



Note: **TAC** Total allowable catch.

Stock assessment

Between December 2016 and February 2017, western jack mackerel was surveyed to estimate biomass using the DEPM (Ward et al. 2018). Biomass was estimated in a core area and an extended area (into Bass Strait) after opportunistic sampling. Because the extended area showed extensive spawning in Bass Strait, it was included in the biomass estimate, but with a caveat that it is underestimated because the area was not extensively sampled. Biomass was initially estimated at 34,978 t (AFMA 2017d) but was revised down to 31,069 t (Ward et al. 2018).

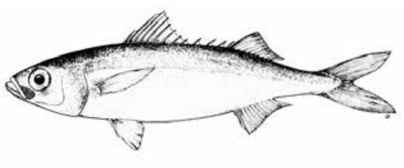
The 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For western jack mackerel, it was suggested that tier 1 harvest rates should be set at 12%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than five years. Because information on life history and productivity for western jack mackerel is limited, data from eastern jack mackerel were used in the MSE instead, which may compromise the model outputs for the stock. A tier 1 harvest rate of 12% was formally adopted in the 2017 SPF harvest strategy.

The SPF Scientific Panel recommended a 2018–19 RBC of 4,197 t, using the initial biomass estimate and tier 1 of the 2017 harvest strategy (AFMA 2017c). After factoring in state catches, the AFMA Commission agreed to a TAC of 4,190 t.

Stock status determination

In years when catches have been taken, they have been below the RBC calculated using an MSE-tested harvest strategy and are a small proportion of the most recent estimate of biomass (peaking at approximately 2.2% in 2016–17). This level of fishing mortality is unlikely to have substantially reduced spawning biomass. On this basis, the western jack mackerel stock is classified as **not overfished** and **not subject to overfishing**.

Redbait, east (*Emmelichthys nitidus*)



Line drawing: FAO

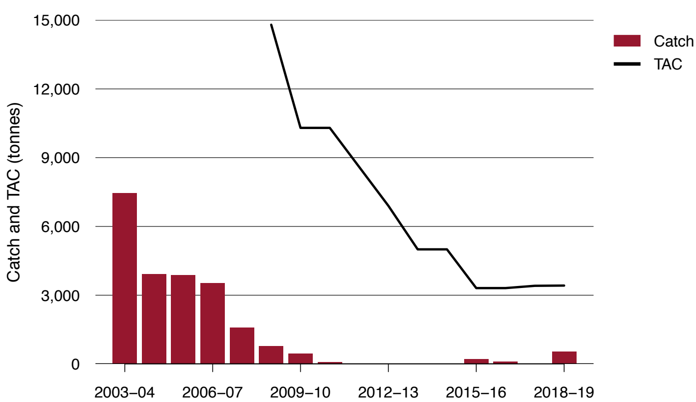
Stock structure

The stock structure of redbait in Australia has not been studied. Redbait within the SPF is assessed and managed as separate stocks in the eastern and western subareas (Figure 7.1).

Catch history

The redbait fishery started in the early 1980s. Total landings (Commonwealth and state) were less than 2,000 t per year between 1984–85 and 2000–01, but increased in 2001–02 and subsequent years, peaking at 7,450 t in 2003–04. Annual catches decreased steadily thereafter. Commonwealth catch for 2018–19 was 539 t (Figure 7.7). State catches have been negligible or confidential in recent years and are not available for 2018–19.

FIGURE 7.7 Commonwealth eastern redbait catch and TAC, 2003–04 to 2018–19



Note: **TAC** Total allowable catch.

Stock assessment

The most recent DEPM surveys for eastern redbait—in 2005 and 2006 (Neira et al. 2008)—provided spawning biomass estimates of 86,990 t (coefficient of variation [CV] 0.37) and 50,782 t (CV 0.19), respectively. The average of these two estimates (68,886 t) was used to generate an RBC of 3,444 t for 2018–19, using the tier 2 decision rule (AFMA 2017c). After factoring in state catches, the AFMA Commission agreed to a TAC of 3,420 t.

An MSE in 2015 suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For eastern redbait, it was suggested that tier 1 harvest rates should be set at 9%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than five years. A tier 1 harvest rate of 10% for a maximum of 5 years and a tier 2 harvest rate of 5% for a maximum of 10 years were adopted by the AFMA Commission for eastern redbait. Given the age of the DEPM estimate, the tier 2 harvest control rule was used as the basis for the 2018–19 RBC.

Peak total (Commonwealth and state) catch in 2003–04 was 10% of the estimated spawning biomass average. Catch has consistently declined each year since then. Commonwealth catch in 2018–19 was less than 1% of the spawning biomass estimate, and 16% of the RBC.

Stock status determination

Recent catches have been below the RBC calculated using an MSE-tested harvest strategy and are a small proportion of the most recent estimate of biomass (8% in 2018–19). This level of fishing mortality is unlikely to have substantially reduced spawning biomass. On this basis, the redbait east stock is classified as **not overfished** and **not subject to overfishing**.

Redbait, west (*Emmelichthys nitidus*)

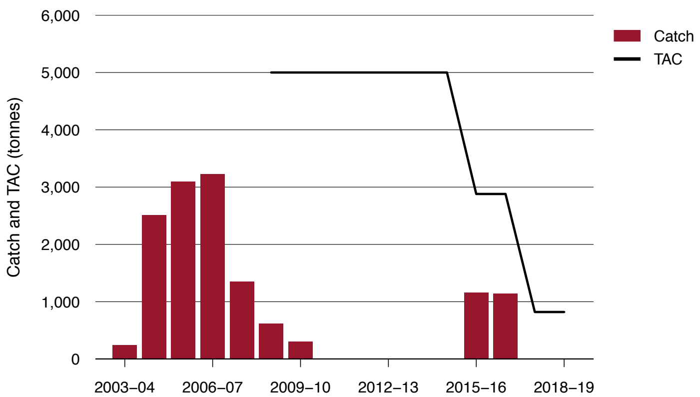
Stock structure

See redbait, east.

Catch history

No catches of western redbait were reported before 2001–02. Commonwealth catches increased from 1,100 t in 2001–02 to a peak of 3,228 t in 2006–07, and decreased steadily thereafter, with no reported catch between 2010–11 and 2014–15. Commonwealth catches were taken again in 2015–16 (1,157 t) and 2016–17 (1,140 t), but no catch was reported in 2017–18 or 2018–19 (Figure 7.8). No state catches have been reported in recent years.

FIGURE 7.8 Commonwealth western redbait catch and TAC, 2003–04 to 2018–19



Note: **TAC** Total allowable catch.

Stock assessment

An MSE in 2015 suggested linking harvest strategy settings to the productivity of each species (Smith et al. 2015). For western redbait, it was suggested that tier 1 harvest rates should be set at 10%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than five years. A harvest rate of 10% of the egg survey biomass estimate was formally adopted for tier 1 stocks in the 2017 SPF harvest strategy (AFMA 2017b), with tier 2 being half the tier 1 level and tier 3 being 1.25% of the Atlantis-SPF ecosystem modelling.

An RBC of 825 t was calculated based on the mean biomass estimate (66,000 t) from the Atlantis-SPF model in 2015 (Fulton 2015). State catches were deducted from the RBC to obtain the 2018–19 TAC of 820 t. This RBC is a substantial decrease from the value generated by the previous harvest strategy (2,900 t), which applied up to and including the 2016–17 season. The spawning biomass of western redbait estimated by the Atlantis-SPF model is consistent with spawning biomass estimates for other similar stocks; however, at the time there was little empirical evidence to corroborate the outputs of the modelling.

Biomass has since been estimated using the DEPM (Ward et al. 2019). The DEPM-based biomass was estimated at 66,787 t (95% CI 28,797–190,392 t). The RBC generated from these analyses was 6,678 t (AFMA 2018).

Stock status determination

Recent catches have been below the RBC calculated using an MSE-tested harvest strategy and are not expected to have reduced the stock to below the limit reference point. The stock is therefore classified as **not overfished**. No catch of western redbait was recorded in 2018–19. The stock is therefore classified as **not subject to overfishing**.

7.3 Economic status

Key economic trends

The gross value of production (GVP) in the SPF was estimated to be $1.3 million in 2007–08 (2016–17 dollars). This was 65% lower than the estimate for 2005–06 ($3.8 million in 2016–17 dollars), primarily as a result of a rapid decline in prices and production. In 2007–08, attributed management costs were about 57% of GVP. This indicates that net economic returns (NER) were likely to have been low in that year, even before fishing costs are considered. The GVP has been confidential since 2007–08 because fewer than five vessels have operated in the fishery. The number of vessels remained steady at three in 2017–18. A decrease in the level of catch, from 13,210 t in the 2015–16 financial year, when a factory freezer trawler operated in the fishery, to 8,150 t in the 2017–18 financial year, suggests that GVP probably decreased, but this catch level is well above the five-year average to 2014–15.

Management arrangements

The fishery is managed largely with output controls, with TACs set for each stock. For the 2018–19 fishing season, 31 entities held statutory fishing rights. Of the combined TACs for small pelagic stocks that were available in 2017–18, 82% were uncaught.

Performance against economic objective

A meaningful biomass target to provide maximum economic yield (MEY) is difficult to determine for the SPF because of the high interannual variability in biomass levels (AFMA 2017b). However, economic targets have been estimated for the key species caught in the fishery in Pascoe and Hillary (2016) and Smith et al. (2015). These studies suggest that MEY for the key species caught can approximate maximum sustainable yield (MSY) under certain assumptions and range from around B_{30} to B_{36} for the target species (Smith et al. 2015). Given the uncertainty in these estimates, the Harvest Strategy Policy (HSP) proxy of $1.2B_{MSY}$ is applied, with an additional level of precaution, recognising that small pelagic fish have some level of ecological function in the ecosystem. This results in targets of B_{50} for target species, slightly above the default B_{48} target given in the HSP.

The exit from the fishery of a factory freezer trawler part-way through the 2016–17 season resulted in higher quota latency than in the previous season, indicating that economic performance of the fishery may have declined. Some of this latency has dissipated with the subsequent entry of a new vessel to the fishery following the departure of the factory trawler. Trends in NER are uncertain because of the lack of information about changes in cost structures of the industry as a result of structural change in the fishing fleet in recent years. The high level of latency in the fishery suggests that NER are low.

7.4 Environmental status

The management plan for the SPF was most recently accredited under part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* on 21 October 2018; this accreditation expires on 21 October 2023. Two conditions were placed on the accreditation: that, before fishing, midwater trawl vessels have mitigation devices in place for dolphins, seals and seabirds; and that new midwater trawl vessels carry one observer for the first 10 trips, with additional observers or monitoring to be implemented after scientific assessment. Minimum levels for observer coverage in the SPF are 10% of days fished for purse-seine vessels and 20% of days fished for midwater trawl vessels.

Recent research by CSIRO (Smith et al. 2015) found that depletion of the four main target species in the SPF (jack mackerel, redbait, blue mackerel and Australian sardine) has only minor impacts on other parts of the ecosystem. The research suggested that, unlike other areas that show higher levels of dependence on similar species, such as in Peru (Smith et al. 2011), the food web in southern and eastern Australia does not appear to be highly dependent on SPF target species, and none of the higher trophic–level predators, including tunas, seals and penguins, has a high dietary dependence on the species.

Separate ecological risk assessments have been done for the midwater trawl and purse-seine fishing methods used in the fishery. For purse seine, 235 species were assessed at level 2; of these, 108 were assessed as being at high risk (Daley et al. 2007), with 29 remaining at high risk after applying AFMA's residual risk guidelines (AFMA 2010). The ecological risk management plan identifies 3 seal species and 26 whale and dolphin species as being at high risk in the SPF. For midwater trawl, 185 species were assessed at level 1; none were deemed high risk, so none progressed to level 2, mainly because of limited historical and current fishing activity (Bulman et al. 2017). The report by CSIRO applied a revised methodology for conducting ecological risk assessments for Commonwealth fisheries. The results of this assessment will be used to inform the management of bycatch in this fishery.

Interactions with marine mammals are a key environmental concern for the midwater trawl fishery. A study commissioned by AFMA (January 2005 to February 2006) to quantify the nature and extent of interactions, and to evaluate potential mitigation strategies, found that fur seals entered the net in more than 50% of midwater trawl operations during the study. The observed mortality rate was 0.12 seals per shot, using bottom-opening seal excluder devices (Lyle & Willcox 2008). The study concluded that effective, upward-opening seal excluder devices are needed when this type of gear is used. No dolphin interactions were recorded during the study.

In response to these results, AFMA requires all midwater trawlers to have an AFMA-approved, upward-opening seal excluder device before starting to fish. The purse-seine code of practice for the SPF (SPF Industry 2008) requires fishers to avoid interactions with species, where possible; implement mitigation measures, where necessary; release all captured protected species alive and in good condition; and report all interactions with protected species.

In May 2017, AFMA implemented the Small Pelagic Fishery Dolphin Strategy (AFMA 2017a). The strategy aims to minimise dolphin interactions in the trawl sector of the fishery by creating incentives for fishers to innovate and adopt best practice to minimise interactions. The strategy was reviewed in 2018–19, with an updated strategy due to be released in the third quarter of 2019.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. Thirty-three interactions with protected species were reported in the SPF during 2018. These comprised 18 New Zealand fur seals (*Arctocephalus forsteri*; 3 alive and 15 dead); 5 Australian fur seals (*A. pusillus*; dead); 3 unidentified seals (dead); 3 common dolphins (*Delphinus* sp.); 2 shy albatross (*Thalassarche cauta*; alive); 1 unidentified albatross (alive); and 1 prion, petrel or shearwater (alive).

7.5 References

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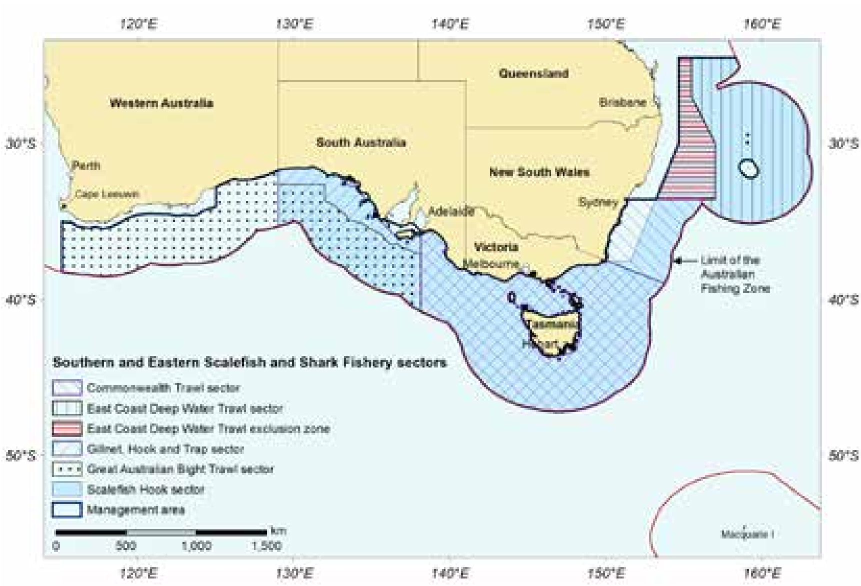
Chapter 8

Southern and Eastern Scalefish and Shark Fishery

F Helidoniotis, T Emery, J Woodhams and R Curtotti

FIGURE 8.1 Area and sectors of the Southern and Eastern Scalefish and Shark Fishery



8.1 Description of the fishery

The Southern and Eastern Scalefish and Shark Fishery (SESSF) is a multisector, multigear and multispecies fishery, targeting a variety of fish and shark stocks. The management area covers almost half the area of the Australian Fishing Zone (Figure 8.1), and spans both Commonwealth waters and the waters of several Australian states under Offshore Constitutional Settlement arrangements. A number of marine parks established by the Australian Government fall within the SESSF management area (for more information, see https://parksaustralia.gov.au/marine/).

The SESSF remained the largest Commonwealth fishery in terms of volume caught in the 2017–18 fishing season. In 2017–18, the gross value of production (GVP) of the SESSF was $76 million, accounting for 20% of the GVP of Commonwealth fisheries.

The primary mechanism for controlling the harvest of stocks in the SESSF is through the allocation of annual total allowable catches (TACs). TACs are determined for all key commercial stocks, along with some secondary or byproduct stocks. The TAC for each stock is distributed among fishers as individual transferable quotas for the fishing season. In addition to TACs, management arrangements in the SESSF include limited entry, gear restrictions (for example, restrictions on mesh size, setting depth, number of hooks and trap dimensions), spatial closures, prohibited species (for example, black cod—*Epinephelus daemelii*), trip limits for certain species (for example, snapper—*Chrysophrys auratus*), codes of conduct, move-on rules, and requirements for observers, electronic monitoring and vessel monitoring systems.

The SESSF was established in 2003 by amalgamating four fisheries—the South East Trawl, Great Australian Bight Trawl, Southern Shark Non-trawl and South East Non-trawl fisheries—under common management objectives. The 2003 management plan for the SESSF came into operation on 1 January 2005 (amended in 2016). Originally, each of the four fisheries had its own management advisory committee. In 2009, the Australian Fisheries Management Authority (AFMA) created the South East Management Advisory Committee (SEMAC) to provide advice to the AFMA Commission on management measures for the entire SESSF. The Small Pelagic Fishery Management Advisory Committee and the Squid Management Advisory Committee became part of SEMAC in 2010, whereas the Great Australian Bight Trawl Sector (GABTS) Management Advisory Committee remains separate.

Landings in the SESSF have generally decreased over time as a result of reductions in fishing effort, although catches for some key target species (for example, pink ling—*Genypterus blacodes*, and blue-eye trevalla—*Hyperoglyphe antarctica*) have remained relatively stable. In 2017–18 and 2018–19, landings in the Commonwealth Trawl Sector (CTS) and the Gillnet Hook and Trap Sector (GHTS) were 10,847 t and 10 580 t, respectively, representing around 49% of available quota. Landed catches for other sectors of the SESSF are reported in the respective chapters of *Fishery status reports*.

The SESSF was one of the fisheries targeted by the Securing our Fishing Future structural adjustment package (2006–07), which was intended to halt overfishing, improve economic conditions and efficiency of fishers, and recover overfished stocks. The package reduced the number of fishing vessels by purchasing fishing endorsements. Although this contributed to lower landings and GVP, net economic returns (NER) improved in the years immediately after implementation of the SESSF harvest strategy framework (HSF) and the Securing our Fishing Future structural adjustment package (George & New 2013; Ward et al. 2013). After implementation, other factors came into play, and NER for some sectors of the SESSF declined. Since 2013–14, NER have improved for the CTS and the GHTS. Trends in NER are reported in the relevant chapters.

8.2 Sectors of the fishery

Current management arrangements are structured around the four primary sectors of the fishery: the CTS, the East Coast Deepwater Trawl Sector (ECDTS), the GABTS and the GHTS.

The status of the stocks taken in these sectors is presented in Chapters 9, 10, 11 and 12, respectively. The GHTS includes the Scalefish Hook Sector (SHS), the Shark Gillnet and Shark Hook sectors (SGSHS), and the Trap Sector. In this report, the SHS is reported with the CTS (Chapter 9) because most stocks are shared. The SGSHS is reported separately (Chapter 12). The Trap Sector is not reported in detail because of its low historical fishing effort and landings; however, in 2016–17, both increased, with 8,178 shots undertaken and 15.8 t of hagfish (class Myxini) caught. In 2017–18, effort again increased, to 20,452 shots, but only 610 kg of hagfish was caught. This suggests that future landings of hagfish should be closely monitored.

8.3 Harvest strategy performance

A tiered HSF has been applied in the SESSF since 2005. The framework has evolved since its introduction, particularly after the inaugural Commonwealth Fisheries Harvest Strategy Policy (HSP) was released in 2007 and again after the HSP was updated in 2018 (Department of Agriculture and Water Resources 2018b). The current SESSF HSF applies to all sectors, and each stock under quota is assigned to one of three 'tiers' for assessment and calculation of a recommended biological catch (RBC) (AFMA 2019a). The assessment tiers have been developed to accommodate different levels of data quantity, data quality and knowledge about stocks.

The harvest control rules, target and limit reference points, and tier for each stock are described in the HSF (AFMA 2019a). Each tier in the HSF generates an RBC through the assessment and subsequent application of associated harvest control rules (HCRs), with HCRs intended to move a stock away from a limit reference point and towards the target reference point (AFMA 2019a). A number of post-assessment rules (referred to as meta rules) are applied to RBCs to account for discarding, recreational catches, state catches and discount factors for the assessment tier (AFMA 2019a). The SESSF HSF has undergone a management strategy evaluation test to ensure that the HCRs are robust to model structure and parameter uncertainties (Fay, Punt & Smith 2009; Little et al. 2011; Wayte 2009). Rules are also in place to prevent large changes in TACs between years (a large change–limiting rule) and to implement multiyear TACs.

For overfished stocks, the HCRs in the SESSF HSF recommend a zero RBC. AFMA allocates incidental catch allowances to permit small catches of these stocks when fishers are targeting other stocks and some level of catch is unavoidable. The HSF provides guidance on the various considerations under such circumstances.

Key commercial stocks under quota in the SESSF are currently managed towards a B_{MEY} (biomass at maximum economic yield) target, although only a few of these targets are estimated using a bio-economic model because of the data requirements and complexity of such models. For stocks that have had a maximum sustainable yield (MSY) estimated, a $1.2B_{MSY}$ proxy for B_{MEY} may be used as the target. For other stocks, a target that is equivalent to the proxy $0.48B_0$ (48% of the unfished biomass) is applied. It may be possible to improve the economic performance of the fishery by optimising targets across a combination of the more economically important stocks, acknowledging the complexities associated with targeting in this fishery.

Some relatively less economically important stocks in this fishery, often referred to as secondary commercial stocks, also have designated targets. These are often associated with MSY or $0.40B_0$.

8.4 Biological status

The number of stocks in the SESSF assessed for fishing mortality and biomass status increased from 24 in 2004 to 37 since 2009.

For fishing mortality status, of the 37 stocks (34 under quota; AFMA 2018) assessed across the SESSF in 2018 (Figure 8.2):

- 29 stocks (78%) were classified as not subject to overfishing
- 0 stocks (0%) were classified as subject to overfishing
- 8 stocks (22%) were classified as uncertain.

For biomass status (Figure 8.3):

- 27 stocks (73%) were classified as not overfished
- 7 stocks (19%) were classified as overfished
- 3 stocks (8%) were classified as uncertain if overfished.

Controlling fishing mortality is the primary management method used by AFMA. The year 2013 was the first year since 2006 that no stocks had been classified as subject to overfishing. This has continued for subsequent years.

A stock is overfished if it is estimated to be below the limit reference point of 20% of unfished levels ($0.2B_0$). The SESSF includes several stocks that are classified as overfished (that is, the current biomass is estimated to be below the limit reference point). These overfished stocks are blue warehou (*Seriolella brama*), eastern gemfish (*Rexea solandri*), gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*), school shark (*Galeorhinus galeus*), redfish (*Centroberyx affinis*), and orange roughy (*Hoplostethus atlanticus*) in two zones (southern and western). AFMA continues to work with stakeholders to control the level of fishing mortality applied to these stocks. Overfished stocks with an uncertain fishing mortality status in 2018 are blue warehou, eastern gemfish, gulper sharks, school shark and redfish.

FIGURE 8.2 Fishing mortality status for all stocks assessed in the SESSF, 2004–2018

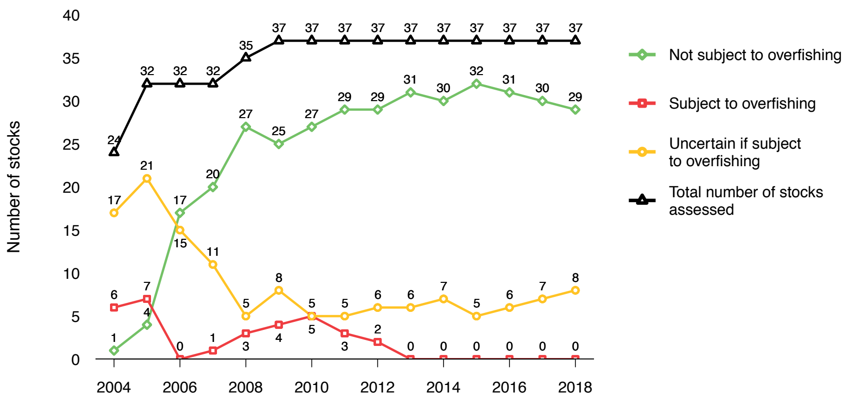
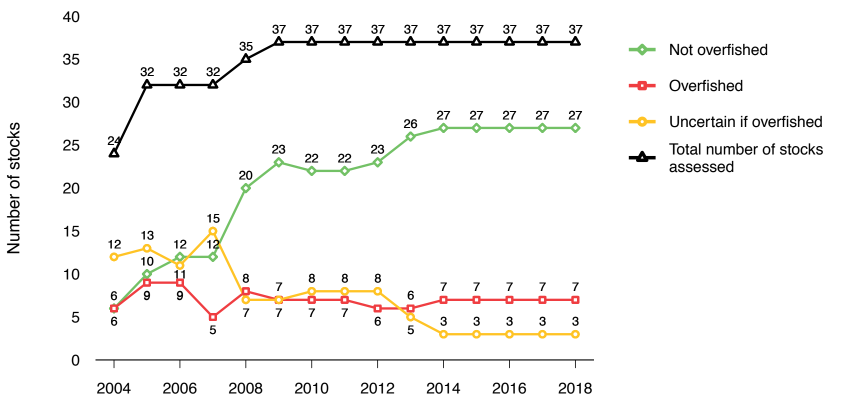


FIGURE 8.3 Biomass status for all stocks assessed in the SESSF, 2004–2018



8.5 Economic status

The SESSF HSF provides a framework to assess the economic status of the fishery. Indicators of stock biomass are used to assess the current biomass of stocks relative to their B_{MEY} target (or its proxy, $1.2B_{MSY}$ or $0.48B_0$). When this information is combined with indicators of profitability and efficiency, the economic status of SESSF sectors can be assessed in terms of whether they are moving towards or away from MEY.

Scalefish catches in the CTS and the SHS accounted for 55% of SESSF GVP in 2017–18 (Figure 8.4). These sectors are therefore key drivers of economic performance in the SESSF. Of these two sectors, only the CTS is surveyed as an individual sector by ABARES as part of its fishery economic surveys program; the SHS is surveyed as part of the GHTS. NER for the CTS followed a positive trend from 2005–06 to a peak of $7.7 million in 2010–11. NER declined from 2010–11 to 2013–14, and then followed an increasing trend from 2013–14 to 2016–17. Based on preliminary estimates, NER for the sector are estimated to have declined in 2017–18, as a result of lower catch volume affecting revenue and higher unit fuel prices increasing fishing costs.

The estimated biomass for two of the most valuable species within the sector (blue grenadier—*Macruronus novaezelandiae*, and tiger flathead—*Neoplatycephalus richardsoni*), together contributing 37% of catch volume and 42% of gross value of fisheries production in 2017–18, remained above or close to their respective B_{MEY} targets (Chapter 9). However, TACs are significantly undercaught for some quota species in the fishery, possibly indicating that some stock-specific targets do not reflect the actual economic conditions in the fishery (for example, costs and prices).

Fish bins
Dylan Maskey, AFMA

Historically, orange roughy has contributed substantially to GVP of the CTS. The rebuilding of orange roughy stocks over the longer term should improve the economic status of the sector, although sustainable catch levels are likely to be much lower than peak historical levels. The recommencement of fishing for orange roughy in the eastern zone boosted GVP from 2015–16 to 2017–18. Likewise, the blue grenadier catch remained substantially lower than the TAC between 2014–15 and 2017–18, suggesting that increased catch of this species could increase the GVP and overall economic performance of the sector in future seasons.

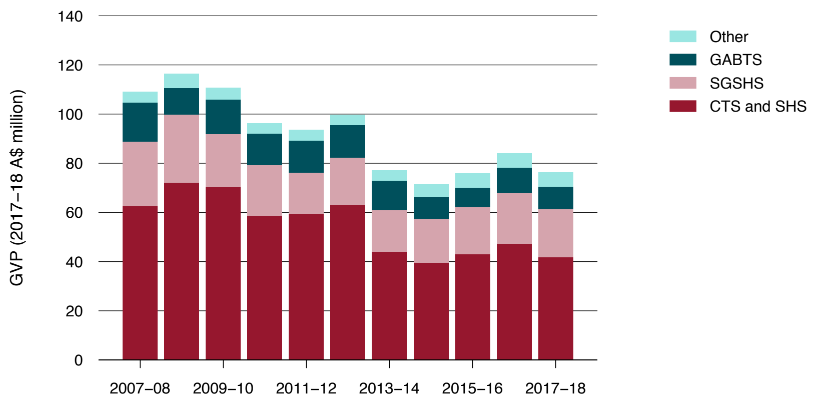
Economic indicators for the GHTS were used to assess the economic status of the SGSHS, which accounted for 84% of GVP in the GHTS in 2017–18. For the decade preceding 2009–10, estimates of NER in the GHTS had been positive. Estimates were negative from 2009–10 to 2014–15 before recovering to above zero in 2015–16 and 2016–17. Based on preliminary estimates, NER for the sector are estimated to have again become negative in 2017–18, with lower catch volumes of gummy shark (*Mustelus antarcticus*) and blue eye-trevalla (*Hyperoglyphe antarctica*), a species attributed to the CTS and the SHS, contributing to lower estimated NER. This is despite biomass levels of gummy shark, the main target species of the sector, being close to or above the target reference (Chapter 12). Recent spatial closures aimed at reducing marine mammal interactions and controls on the take of school shark are likely to have contributed to low NER in recent years. A key challenge for the sector is rebuilding the school shark stock, potentially resulting in NER increasing over time. However, the rebuilding of the stock is likely to be associated with adjustment costs that stem from avoiding the species during the rebuilding process.

The development of a bio-economic model for the two key commercial stocks in the GABTS (deepwater flathead—*Neoplatycephalus conatus*, and bight redfish—*Centroberyx gerrardi*) has improved the ability of the sector to target B_{MEY} (Kompas et al. 2012). The most recent stock assessments for bight redfish projected biomass levels at the start of 2014–15 to be above the B_{MEY} target (Haddon 2015), potentially allowing increased profits to be made if the stock is fished down to its MEY target reference point. The most recent stock assessment for deepwater flathead suggests that biomass has rebuilt towards the B_{MEY} target (Chapter 11). Hence, fishery profitability is unlikely to be constrained by stock status.

In the ECDTS, levels of fishing effort have been low in recent years. Low expected profit in the sector appears to have discouraged activity in the fishery. As a result, the sector has generated minimal NER.

Overall, the economic status of the SESSF has shown some improvement in recent years. The negative change in economic performance in the GHTS that occurred in the period 2010–11 to 2013–14 has reversed. Surveys by ABARES show positive NER for this sector between 2015–16 and 2016–17. This change reinforces the positive NER in the CTS in this period; meanwhile, the GABTS continues to pursue estimated B_{MEY} targets for its key species. For 2017–18, it is estimated, based on non-survey methods, that the economic performance of both the GHTS and CTS sectors of the SESSF has deteriorated, with negative returns estimated for both sectors. Given this, the future trend of NER for these sectors is uncertain.

FIGURE 8.4 Real GVP in the SESSF by sector, 2007–08 to 2017–18



Notes: **CTS** Commonwealth Trawl Sector. **GABTS** Great Australian Bight Trawl Sector. **GVP** Gross value of production. **SGSHS** Shark Gillnet and Shark Hook sectors. **SHS** Scalefish Hook Sector. GVP for the SGSHS includes only gummy shark, school shark and sawshark, and elephantfish caught in the gillnet and hook sectors. GVP for other sectors includes non-scalefish product caught in the CTS and the SHS, non-shark product caught in the SGSHS, and product caught in the Victorian Inshore Trawl and East Coast Deepwater Trawl sectors of the SESSF.

The SESSF HSF will continue to make an important contribution to the economic performance of the fishery by guiding management decisions that explicitly aim to maximise NER. The HSF also offers the opportunity to adjust management settings (for example, to re-examine proxy settings where TACs are continually not met or to move the fishery closer to its economic potential).

8.6 Environmental status

General bycatch and discards

Bycatch is defined in the updated Commonwealth Fisheries Bycatch Policy (Department of Agriculture and Water Resources 2018a) as a species that is either taken in a fishery and returned to the sea or a species that is killed or injured as a result of interacting with fishing equipment in a fishery, but not taken. Under the policy, there are two bycatch categories: 'general bycatch' (non-target species taken in a fishery and returned to the sea) and 'EPBC listed' bycatch (species listed under the *Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act] and afforded a higher level of protection).

Tuck, Knuckey & Klaer (2013) evaluated bycatch and discards in six Commonwealth fisheries, including the SESSF, and concluded that trawling in the South East Trawl (SET) Sector and the GABTS, and Danish-seining account for the greatest volume of bycatch in the Commonwealth fisheries examined. This largely reflects the high level of fishing activity in these sectors and fisheries. Bycatch and discards largely comprise small fish species with little or no commercial value, but also include crustaceans, sharks, molluscs and, more rarely, marine mammals, reptiles and seabirds.

Data collected by the Integrated Scientific Monitoring Program (ISMP) over 20 years have shown a reduction in the volume of trawl discards since the mid 2000s. This reduction is probably a result of a one-third decrease in trawling effort in the SESSF during this time, combined with changes in mesh types and increased mesh sizes used in trawl net codends. Tuck, Knuckey & Klaer (2013) found that discard rates for quota species have been variable, and dependent on market prices, availability of quota and sporadic influxes of small fish. However, data for bycatch and discards of rarer commercial species are often lacking, because observer coverage is often focused on key commercial species.

A distinction can be made between highly targeted shots on single-species aggregations (such as orange roughy or blue grenadier) and general shots for multiple species in the SET and GABT sectors of the SESSF. General shots may be referred to as 'market fishing', and are associated with higher levels of byproduct, and discarding of target and non-target species (Tuck, Knuckey & Klaer 2013). ISMP data show that up to 50% of catch weight is caught and discarded in the 'market fishery' of the CTS, and 40–60% in the GABTS (Tuck, Knuckey & Klaer 2013). Commercial species are discarded for various reasons, but most discards are small fish species with little or no commercial value. In comparison, bycatch in more targeted fishing can be extremely low. For example, bycatch levels were less than 1% when orange roughy was targeted in the GABTS.

A key change in the SET Sector was setting the minimum codend mesh size at 90 mm; this was introduced in 1965 to reduce the catch of small tiger flathead (Tuck, Knuckey & Klaer 2013). Studies have shown an escapement rate of around 70% of all species swept into the codend that are able to fit through the mesh, equating to around 30% of the catch weight (Tuck, Knuckey & Klaer 2013). Animals passing through this mesh size were mainly small finfish. Other changes that have helped reduce bycatch in both the SET Sector and the GABTS include the use of 'T-90 panels' or 'T-90 lengtheners', bycatch reduction devices and 110 mm diamond mesh. Trials of mesh size and type led to mandatory requirements for bycatch reduction in the CTS in 2006 and the GABTS in 2007. Tuck, Knuckey & Klaer (2013) reported that the level of bycatch reduction achieved through these measures has not been formally tested.

Introduction of new bycatch mitigation measures in the Danish-seine component of the fishery has been limited, despite trials showing that a change from 75 mm mesh to T-90 in codends did not affect the catch weight of targeted species but reduced the catch weight of non-commercial species by around 27% (across the study). Reasons for the lack of uptake include limited spatial and temporal coverage of the trials, and concern from industry about the use of the T-90 codend at certain times of the year (Tuck, Knuckey & Klaer 2013).

In the GHTS, which includes the SGSHS, discarding of target species is minimal, with 2% of teleosts and 3% of chondrichthyans discarded (Walker et al. 2005), noting that management measures are now in place that require fishers to release live school shark. Trials to estimate discards for non-target species have reported that discards can account for more than 30% of catch weight in commercial nets (6 inch mesh—that is, 15 cm or 150 mm). The most commonly discarded species were draughtboard shark (*Cephaloscyllium laticeps*), Port Jackson shark (*Heterodontus portusjacksoni*) and spikey dogfish (*Squalus megalops*). Discards in the trials increased to 40%, on average, for 5 inch mesh (127 mm) and almost 80% for 4 inch mesh (101.6 mm) (Braccini, Walker & Gason 2009).

Trawling impacts

Pitcher et al. (2015) used modelling to quantify and assess cumulative threats, risks to benthic biodiversity and the effects of management actions in the south-east marine region, which covers a large part of the SESSF management zone. The research indicated that, from around 1985, when consistent logbook records were available, all 10 benthic taxa types declined in abundance in trawled areas until the mid 2000s. Around this time, fishing effort decreased as a result of economic conditions and the Securing our Fishing Future structural adjustment package, and large areas were closed to trawling.

The lowest total regional abundance of benthic taxa types across the south-east marine region was around 80–93% of pre-trawl abundance after the peak in fishing effort between 2000 and 2005. After this time, all taxa were predicted to recover by between 1% and 3% in the following decade.

The research indicated that the reduction in fishing effort was the main factor influencing the magnitude of recovery. In some cases, spatial management that excluded trawling led to improved abundance of some benthic taxa types. Most fishery closures and Australian marine parks had little detectable influence on abundance. In other cases, closures reduced the abundance of some taxa in some areas because trawling was displaced to areas where such taxa were more abundant (Pitcher et al. 2015).

Protected species

The SESSF interacts with various species listed as protected or conservation-dependent under the EPBC Act. Six former target species in the SESSF are listed as conservation-dependent: orange roughy, eastern gemfish, Harrisson's dogfish (*Centrophorus harrissoni*), southern dogfish (*C. zeehaani*), school shark and, most recently, blue warehou. These species, discussed in Chapters 9 and 12, are under rebuilding or recovery strategies. They are currently managed under incidental catch allowances, closed areas and trip limits, to allow for incidental catch when fishers are targeting other species.

Recent reductions in interactions with protected species have been observed, to varying degrees. However, the reductions are difficult to attribute to recent measures to mitigate catch of protected species because of a lack of data. These measures have included fishery closures to protect Australian sea lions (*Neophoca cinerea*) and gulper sharks; seabird mitigation measures for longline and trawl fisheries; seal, turtle and other bycatch excluder devices; and gear modifications (Tuck, Knuckey & Klaer 2013). Trends in protected species interactions are also difficult to interpret with confidence because the ISMP was originally designed only to provide estimates of the retained and discarded proportions of fish catch in the SESSF. A review of the ISMP in 2009 sought to facilitate better estimates of interactions with protected species and bycatch of major non-quota species.

Fishers are required to take all reasonable steps to avoid interactions with EPBC-listed species (other than those listed as 'conservation-dependent') and are required to report all interactions in their logbooks. An interaction is defined as any physical contact that a person, boat or gear has with a protected species, including catching and colliding with any of these species. Every three months, AFMA reports all interactions with protected species recorded in logbooks to the Australian Government Department of the Environment and Energy. These reports (which are published on the AFMA website) provide the basis for reports of the number of interactions with protected species within the SESSF in 2018. Interactions are known to occur with species groups protected under the EPBC Act, including marine mammals (cetaceans and pinnipeds), seabirds, sharks (white shark—*Carcharodon carcharias*, grey nurse shark—*Carcharias taurus*, shortfin mako shark—*Isurus oxyrinchus*, porbeagle shark—*Lamna nasus*) and syngnathids (seahorses and pipefish). Although these interactions are rare, they can have a significant impact on some species that have small populations (Komoroske & Lewison 2015). However, it is difficult to obtain robust estimates of total interactions or interaction rates at low levels of observer coverage or monitoring, especially when such interactions are rare (Komoroske & Lewison 2015; Martin, Stohs & Moore 2015). The introduction of electronic monitoring of all fishing activity in the GHTS has improved estimates of interactions with protected species, with some evidence suggesting increases in nominal interactions per unit effort in the first two years of the program (Emery et al. 2019). Trails of electronic monitoring are currently underway in the CTS (AFMA 2019b).

Pinnipeds (seals and sea lions)

The areas fished by the SESSF overlap with the distributions of the Australian fur seal (*Arctocephalus pusillus doriferus*), New Zealand fur seal (*A. forsteri*), Antarctic fur seal (*A. gazella*) and Australian sea lion. Fur seal populations have recovered substantially following heavy harvesting in the 18th and 19th centuries. The CTS and gillnet operations in the SGSHS, in particular, are known to interact with these species, whereas interactions with the hook sectors are much rarer. Between 1993 and 2000, data collected by the ISMP and its precursor (the Scientific Monitoring Program) indicated that an average of 720 fur seals might be caught incidentally by small trawlers operating in the CTS each year (Knuckey, Earys & Bosschietter 2002). Because of their smaller vessel size and net sizes, wet-boat trawlers have reduced ability to apply mitigation methods such as seal excluder devices (SEDs), which are designed for larger nets. Trials of a flexible SED design suitable for use in smaller nets have been reasonably successful (Knuckey 2009), but reliably estimating and reducing the level of interactions between seals and wet-boats remain difficult. A trial using a shortened codend to reduce seal bycatch was completed in late 2014. The trial found no definitive proof that short trawl nets had lower interaction rates with seals, caught fewer seals or resulted in lower mortality rates of caught seals (Koopman, Boag & Knuckey 2014).

Minimising seal interactions has been a focus for the winter trawl fishery for blue grenadier off western Tasmania. SEDs have been compulsory for freezer boats in this component of the SESSF since 2005, and modifications to fishing practices seem to have substantially reduced the incidence of seal bycatch in the midwater nets of factory vessels. Observers have been deployed on factory trawlers to verify interaction rates. In 2007, the South East Trawl Fishing Industry Association (SETFIA) released an updated trawl industry code of conduct for responsible fishing. It also released an industry code of practice that aims to minimise interactions with fur seals, as well as addressing the environmental impacts of the fishery more generally.

The Australian sea lion is endemic and listed as vulnerable under the EPBC Act. Sea lion populations were reduced substantially by sealing between the 18th and early 20th centuries, and recovery has been slow (DEWHA 2010). Australian sea lions show high genetic differentiation because of the high fidelity of female sea lions to their natal sites, indicating that animals lost from a colony are unlikely to be replaced by immigrants from other colonies (DEWHA 2010). The small size of some colonies suggests that the loss of a few breeding females from a population can significantly reduce the long-term recovery prospects of that population (Goldsworthy et al. 2010).

In 2003, closures were introduced around the Pages Islands (the largest sea lion colony) and around Kangaroo Island in South Australia. In December 2009, interim voluntary closures of 4 nautical miles were introduced around all colonies. The current declaration of the SESSF as an approved Wildlife Trade Operation under the EPBC Act includes a requirement to maintain management measures clearly directed towards limiting the impact of fishing activity on Australian sea lions to levels that will help the recovery of the species, including all subpopulations.

The mortality of Australian sea lions caught as bycatch in shark gillnets has been a concern. However, implementation of the Australian sea lion management strategy (AFMA 2010) reduced sea lion interactions in gillnets to close to zero. Measures taken by AFMA included spatial closures around colonies, increased observer coverage and trigger limits, with observed levels of bycatch above the trigger limits resulting in the closure of larger areas (AFMA 2010).

Warp deflector
Will Hansen, AFMA

AFMA lowered the trigger limit for sea lion mortalities in December 2011, following advice from marine mammal experts about risks to some sea lion subcolonies. The trigger limit was reduced from 52 animals to 15 animals across seven management zones in the Australian sea lion management area (AFMA 2011a). Two sea lion mortalities in the gillnet sector in the 2017–18 fishing season resulted in Australian Sea Lion Management Zone D being closed to gillnet fishing from 11 September 2017 to 9 March 2019.

Increased onboard observer coverage or electronic monitoring has obtained reliable data on interaction rates, and it is important that this monitoring continues. In the first six months of the sea lion management strategy, the prescribed level of observer coverage was not achieved. Consequently, the Australian Government funded a trial of onboard cameras to monitor Australian sea lion bycatch in 2010–11. In 2011, an expert review of the management strategy resulted in AFMA introducing a Temporary Order (six months, effective 1 May) that increased the size of closed areas around 31 colonies and required 100% observer coverage on gillnet vessels off South Australia in the Australian sea lion management area. This area consists of several zones, each with an interaction limit that triggers closure of the zone if the limit is reached. Electronic monitoring has been deployed in the fishery and is used instead of a scientific observer. The Temporary Order was replaced by a Closure Direction, which extended protection to 50 known Australian sea lion colonies. The existing closures around Australian sea lion colonies will be retained, and were incorporated into the permanent Closure Direction for the SESSF from the beginning of the 2015–16 fishing season. Observer requirements in the Australian sea lion management area off South Australia, including 100% onboard observers or electronic monitoring, have been continued under conditions attached to permits and statutory fishing rights.

The introduction of electronic monitoring in the GHTS from 1 July 2015 led to an increase in nominal reported interactions per unit effort for pinnipeds in the first two years of the program (Emery et al. 2019). In 2018, 284 pinniped interactions were reported in CTS and GHTS logbooks: 2 with an Australian sea lion, 26 with New Zealand fur seals, 177 with Australian fur seals and 79 with seals of unknown species. This is an increase from the 179 interactions reported in 2017. In the CTS, 82% of all pinniped interactions in 2018 were reported from bottom-trawling operations; the remainder (18%) were reported from Danish-seine operations. Of the pinniped interactions reported in logbooks in the GHTS in 2018, 91% were reported from gillnet operations.

Dolphins

All cetacean species are protected under the EPBC Act. Increased observer coverage in the SGSHS in 2011 highlighted interactions with dolphins and potential under-reporting in logbooks (AFMA 2011a). Two dolphin mortalities were reported in logbooks between January and September 2010 (AFMA 2011b), and 52 interactions with dolphins were reported from September 2010 to September 2011 (AFMA 2011b). In response, AFMA closed about 27,239 km^2 south-west of Kangaroo Island to gillnet fishing, where most of the interactions had been reported (dolphin gillnet closure). Observer coverage was increased to 100% (onboard observer or camera) in the area adjacent to the dolphin gillnet closure, and 10% onboard observer coverage was required across the eastern part of the fishery in Bass Strait and around Tasmania.

In 2014, AFMA worked with experts in the marine mammal working group and the fishing industry to implement the first stage of a dolphin management strategy. The objectives of the strategy are to reduce dolphin interactions in gillnets to near zero, and strengthen responsible fishing practices through electronic monitoring and individual accountability. On 8 September 2015, AFMA reopened the dolphin gillnet closure to limited gillnet fishing, with 100% electronic monitoring and individual boat-level performance standards. In May 2017, the dolphin strategy was extended to gillnet fishing across the entire SESSF. Under the strategy, fishers who do not have interactions with dolphins may continue fishing responsibly. However, there are now management responses for any dolphin bycatch in the gillnet fishery, and individual operators incur escalating management responses if they catch dolphins.

The introduction of electronic monitoring in the GHTS from 1 July 2015 led to an increase in nominal reported interactions per unit effort for dolphins in the first two years of the program (Emery et al. 2019). In 2018, interactions were reported with 56 dolphins in the GHTS, all of which were dead; 4 interactions were reported in the CTS—all dolphins were dead. This is a decrease from the 67 interactions reported in 2017.

Seabirds

In 1998, in accordance with EPBC Act requirements, the Australian Government developed a threat abatement plan for the incidental bycatch of seabirds during oceanic longline fishing operations. The plan, which was revised in 2006, 2014 and 2018 (Commonwealth of Australia 2018), applies to longline operations in all Commonwealth fisheries, including the SESSF, and is the main guide to mitigating seabird bycatch in this sector. In accordance with the threat abatement plan, SESSF longline operators are required to keep interaction rates below 0.01 interactions per 1,000 hooks set. The levels of seabird bycatch recorded by auto-longline, demersal longline, dropline and trotline operators in the SESSF are low compared with those in other pelagic longline fisheries that target tuna and billfish (Brothers 1991; Brothers et al. 2010; CCAMLR 2002).

Seabirds also interact with otter-board trawling activities—they are vulnerable to injury as a result of striking the trawl warps (the trawling cables) during fishing operations, predominantly when catches are being processed and offal is discarded into the water. Analysis of observer data suggests that the number of interactions may be high, but further work is needed to understand their scale and significance (Phillips et al. 2010). Given the difficulty in documenting these interactions (birds suffering warp strike are not landed and are not easily observed), obtaining reliable estimates of seabird mortalities is difficult, even with onboard observers. The issue was investigated by a research project between AFMA and the Tasmanian Department of Primary Industries, Parks, Water and Environment. Mitigation measures, such as offal management and bird-scaring devices, have been effective in reducing seabird bycatch elsewhere. During 2011, AFMA worked with SETFIA to develop tailored seabird management plans for individual vessels, to address this issue.

As part of their boat-specific seabird management plans, vessels are required to use effective seabird mitigation devices. In late 2014, AFMA completed a trial using observers to test the effect of seabird mitigation devices on seabird interactions with otter trawlers. The trial showed that the use of warp deflectors (large floats attached in front of trawl warps to scare birds away—often called 'pinkies') reduced heavy contact between actively feeding seabirds and warp wires by around 75% (Pierre, Gerner & Penrose 2014). Based on the outcomes of the trial, AFMA mandated a minimum requirement in seabird management plans of 600 mm pinkies. SETFIA has also introduced a code of conduct and training program to improve seabird avoidance measures, and undertook a trial of alternative seabird mitigation devices, including water sprayers and bird bafflers. SETFIA reported that water sprayers and bird bafflers used in the trial reduced interactions between seabirds and the warp by 58.9% and 86.7%, respectively, when compared with the warp deflector or pinkie (Koopman et al. 2018). As a result, on 1 May 2017, AFMA required trawl boats in the SESSF to use one of the following mitigation devices: sprayers, bird bafflers, and pinkies with zero discharge of fish waste. To further reduce seabird interactions in the CTS, from 1 November 2019, AFMA will phase in a requirement for all otter-board trawl vessels to not discharge offal while fishing gear is deployed off the west coast of Tasmania, and then from 1 July when fishing south of 38°S.

Seabird interactions are under-reported for numerous reasons, including that it is difficult to observe seabirds interacting with fishing gear and vessels, particularly trawl gear, and that seabirds may not have visible injury after interactions such as warp strikes. During 2018, 161 seabird interactions were reported: 112 in the GHTS and 49 in the CTS. This is an increase from 98 seabird interactions reported in 2017. Of the 161 interactions, most were with the following groups: 5 were reported as unclassified petrels, prions and shearwaters, all of which were dead; 7 were with white-chinned petrels (*Procellaria aequinoctialis*), 4 of which were dead; 6 were with shy albatross (*Thalassarche cauta*), 4 of which were dead; 2 were with grey-headed albatross (*T. chrysostoma*), both of which were dead; 47 were with unclassified albatrosses, 39 of which were dead; 10 were with cormorants, all of which were dead; 74 were with unclassified shearwaters, 52 of which were dead; and 4 were with unclassified birds, all of which were dead.

Sharks

In 2018, 189 interactions with protected sharks were reported in logbooks: 183 in the GHTS (119 of which were dead) and 6 in the CTS (1 dead). The most prevalent shark was shortfin mako, with 119 interactions reported, 93 of which were dead. Twenty-five white sharks were reported, 20 in the GHTS and 5 in the CTS; 20 were released alive and 5 were dead. Twenty-seven porbeagle sharks were reported, of which 20 were dead and 7 were alive; 5 longfin makos (*Isurus paucus*) were reported, of which 2 were dead and 3 were alive; and 2 grey nurse sharks were reported, all of which were released in an unknown condition. The EPBC Act requires all white sharks and grey nurse sharks to be released alive, if possible.

During 2012, in view of their overfished status, a proposal was made to list Harrisson's dogfish and southern dogfish as threatened species under the EPBC Act. On 30 May 2013, the then Minister for Sustainability, Environment, Water, Population and Communities decided to list Harrisson's dogfish and southern dogfish in the conservation-dependent category, noting that both species have experienced severe historical declines after being overfished. These species are subject to recovery plans that specify management actions to stop their decline and support their recovery.

Syngnathids (seahorses and pipefish)

Syngnathids are taken as bycatch in the CTS in otter-trawl and Danish-seine nets, but they are often small and difficult to observe among large catches of fish. No interactions with syngnathids were reported in 2018 in the CTS.

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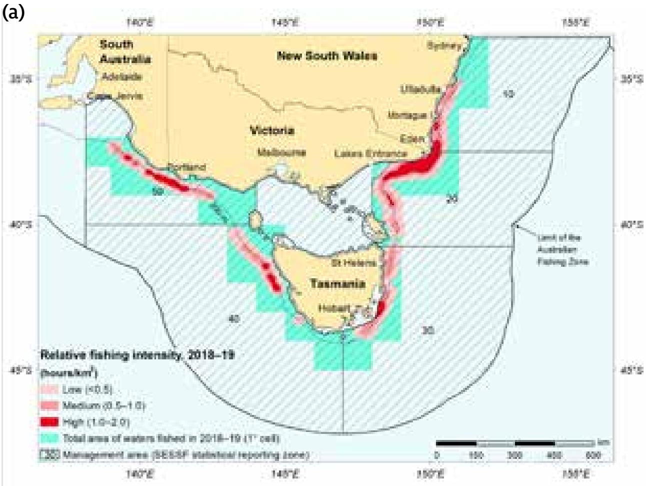
Hauling the catch
AFMA

Chapter 9
Commonwealth Trawl and Scalefish Hook sectors

F Helidoniotis, T Emery, J Woodhams and R Curtotti

FIGURE 9.1 Relative fishing intensity (a) in the Commonwealth Trawl Sector and (b) by Danish-seine operations, 2018–19 fishing season

(a)



(b)

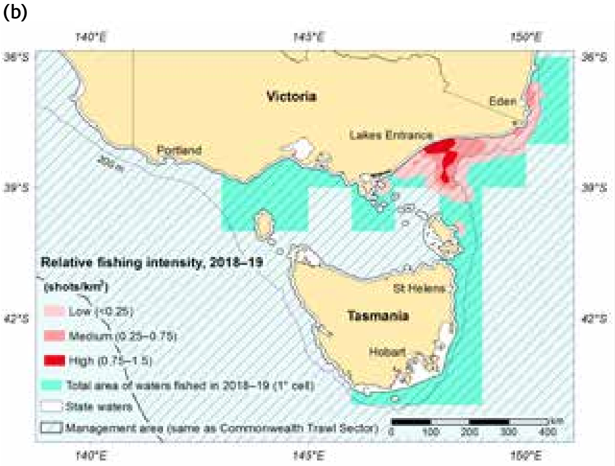
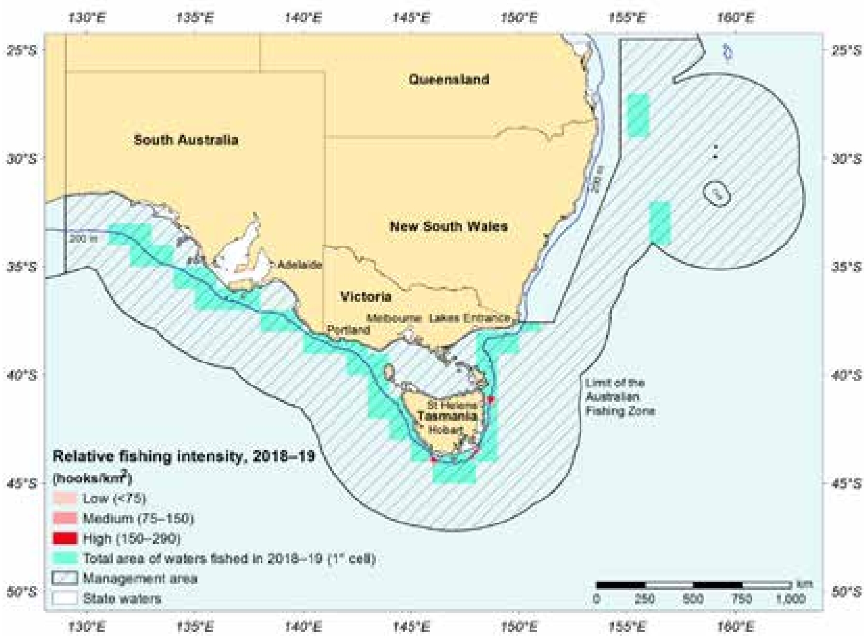


FIGURE 9.2 Relative fishing intensity in the Scalefish Hook Sector, 2018–19 fishing season



Trawler
Lee Georgeson, ABARES

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Blue-eye trevalla (*Hyperoglyphe antarctica*)					CPUE for the slope population 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 the target reference point. Total removals have remained below the long-term RBC.
Blue warehou (*Seriolella brama*)					Total removals are above the incidental catch allowance. No evidence that the stock is rebuilding.
Deepwater sharks, eastern zone (multiple species)					Multispecies nature of stock makes CPUE unreliable as the index of abundance. Uncertain how catch may impact biomass.
Deepwater sharks, western zone (multiple species)					Multispecies nature of stock makes CPUE unreliable as the index of abundance. Uncertain how catch may impact biomass.
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.
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.

continued ...

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

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
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. Estimates of spawning biomass for the western stock are above the target reference point. Total removals in both east and west remain below the RBC.
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 below the RBC.
Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)					Most recent estimate of spawning biomass (2011) 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 RBC.

continued ...

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

Status	2017		2018		Comments
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
Orange roughy, southern zone (*Hoplostethus atlanticus*)					Most recent assessment estimated that stock is depleted; stock is classified as overfished. Negligible catches. Closure of most areas deeper than 700 m. No updated stock assessment.
Orange roughy, western zone (*Hoplostethus atlanticus*)					Most recent assessment estimated that stock is depleted; stock is classified as overfished. 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. 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.

continued ...

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

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Royal red prawn (*Haliporoides sibogae*)					Recent average CPUE is above the limit reference point, and total fishing mortality has been below the RBC in recent years.
Silver trevally (*Pseudocaranx georgianus*)					Recent average CPUE is above the limit reference point, and recent total fishing mortality has 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 in the CTS rose to reach $4.0 million in 2016–17, largely driven by lower operating costs. Preliminary estimates from the survey suggest that NER were –$0.17 million in 2017–18. This negative result is driven by lower forecast income and higher forecast operating costs.				

Notes: **CPUE** Catch-per-unit-effort. **CTS** Commonwealth Trawl Sector. **NER** Net economic returns. **RBC** Recommended biological catch.

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

Flathead
Heather Patterson, ABARES

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 distributions of many CTS and SHS stocks do not lie wholly within the jurisdiction of Commonwealth waters, because 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, 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 uses 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 in the 2018–19 season followed the SESSF harvest strategy framework (HSF; AFMA 2017a) (see Chapter 8). The HSF was updated in 2019 (AFMA 2019). Stocks in 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 (MYTACs) has been increasing since 2009–10. The AFMA Commission determines TACs each year, irrespective of whether stocks are under a MYTAC. A decision-tree approach (replacing the use of 'breakout rules') specifies the circumstances for reviewing the stock during the MYTAC period, and allows for management intervention in the event of unexpected deviation from predicted trends in stock size or response to fishing (AFMA 2018b). Twenty stocks were under MYTACs across the SESSF in 2018–19 (AFMA 2018b); 15 of these are reported in this chapter.

A total of 19,268 t of quota was available across the stocks assessed in this chapter for the 2018–19 fishing season (1 May 2018 – 30 April 2019). This was a decrease of 114 t from 2017–18 (Table 9.2). A small proportion of this quota (409 t) was allocated as 'incidental catch allowances' to allow 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 between 2017–18 and 2018–19 resulted from decreased TACs for silver trevally (*Pseudocaranx georgianus*; –306 t), flathead (*Neoplatycephalus richardsoni* and four other species; –205 t) and eastern school whiting (*Sillago flindersi*; –166 t). These decreases were partially offset by TAC increases for orange roughy eastern zone (+233 t) and john dory (*Zeus faber*; +88 t).

Fishing effort

In 2018–19, trawlers reported 54,298 hours of fishing effort—a slight decrease from the 57,747 hours in 2017–18 (Figure 9.3; Table 9.2). The number of active trawlers remained stable, with 32 active in both 2017–18 and 2018–19 (Table 9.2). Danish-seine effort increased from 9,965 shots in 2017–18 to 10,430 shots in 2018–19, and the number of vessels increased from 18 in 2017–18 to 19 in 2018–19. Fishing effort in the SHS increased slightly from 3.547 million hooks in 2017–18 to 3.733 million hooks in 2018–19 (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.

Catch

Total catch (catch disposal records) for quota stocks and non-quota stocks (gulper shark—*Centrophorus* spp., and ocean jacket—*Nelusetta* spp.) for both sectors was 8,454 t in 2018–19; 7,574 t was from CTS quota stocks, 740 t was from GHTS quota stocks, and 140 t was ocean jacket (including leather jacket—*N. ayraud*). The total landed catch (including catch of all other species) of 8,454 t was a decrease on the total landed catch of 8,631 t in 2017–18.

The total catch reported in logbooks, of all species managed under TACs from the CTS in 2018–19, was 7,574 t. Flathead (tiger flathead), blue grenadier (*Macruronus novaezelandiae*), pink ling (*Genypterus blacodes*), eastern school whiting and orange roughy accounted for approximately 72% of the catch (Table 9.2). Flathead catches have decreased in recent years, from 2,873 t in 2016–17 to 2,434 t in 2017–18 and then 2,035 t in 2018–19. Catches of blue grenadier increased from 1,619 t in 2017–18 to 1,804 t (representing around 24% of the available quota) in 2018–19. The total scalefish landings from the GHTS (of which the SHS comprises the primary component reported in this chapter) in the 2018–19 fishing season were estimated to be 740 t, higher than the 651 t landed in the 2017–18 fishing season.

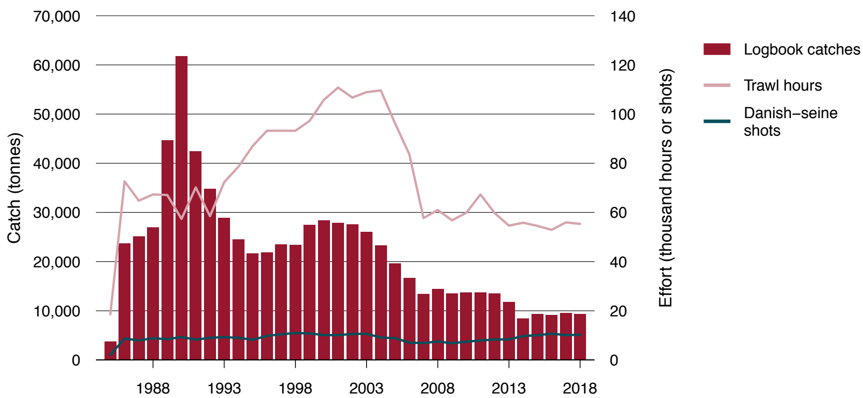
The term 'landed catch' refers to catch that is reported at the port; it excludes discards. Data on discards are collected for the SESSF as part of the Integrated Scientific Monitoring Program. The discard data, collected over the previous four years, were converted into a weighted average to estimate discards for the current fishing season (see Table 41 in Castillo-Jordán et al. 2018). AFMA use a four-year weighted average of discards when determining a TAC from the recommended biological catch (RBC) (AFMA 2017c) and, for consistency, the same estimates are included when reporting on stock status.

The terms 'agreed TAC' and 'actual TAC' are both referred to in this chapter. In general, the agreed TAC is estimated by subtracting the discount factor, state catches and discards from the 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 2018–19 season was not available at the time of publication. During 2017–18, scalefish catches in the CTS accounted for 55% of the GVP of the SESSF. Scalefish GVP in the CTS decreased by 7%, from $40.01 million in 2016–17 to $37.09 million in 2017–18. The GVP in the SHS decreased by 25%, from $6.41 million in 2016–17 to $4.78 million in 2017–18. Overall, the total scalefish GVP in 2017–18 for both sectors was $41.86 million (Table 9.2).

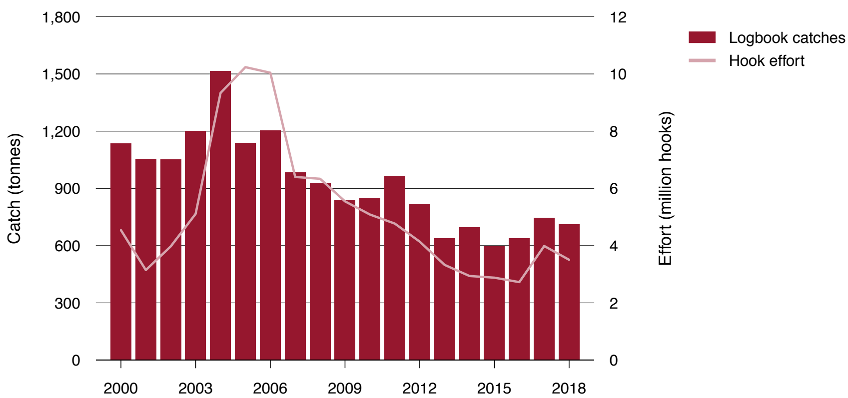
Flathead (tiger flathead and other flathead species) contributed $15.78 million to GVP in 2017–18, the most of any scalefish (Table 9.2); this was a decrease of 14% from $18.40 million in 2016–17. The value of pink ling catch decreased by 3% in 2017–18 to $5.05 million. The value of blue-eye trevalla (*Hyperoglyphe antarctica*) catch (largely caught in the SHS) decreased by 27% in 2017–18 to $2.94 million. Blue grenadier accounted for $2.80 million in 2017–18, which was 10% higher than in 2016–17 ($2.54 million) but 84% lower than in 2012–13 in real terms.

FIGURE 9.3 Total catch and fishing effort for the CTS, 1985 to 2018



Source: AFMA

FIGURE 9.4 Total catch and fishing effort for the SHS, 2000 to 2018



Source: AFMA

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

Fishery statistics b	2017–18 fishing season			2018–19 fishing season	
Stock	**TAC (t) c**	**Catch (t) (CTS, GHTS)**	**GVP (2017–18)**	**TAC (t) c**	**Catch (t) (CTS, GHTS)**
Blue-eye trevalla	458	327 (51,276)	$2.94 million	462	373.6 (31.3, 342.3)
Blue grenadier	8,765	1,624 (1,619, 5)	$2.80 million	8,810	1,808 (1,804, 4)
Blue warehou	118 **d**	25 (24, 0.6)	$0.11 million	118 **d**	54.2 (54.2, <1)
Deepwater sharks, eastern zone	46	23 (22, 0.7)	na	23	19.8 (19, 0.8)
Deepwater sharks, western zone	215	80 (79, 0.6)	na	264	78.7 (78, 0.7)
Eastern school whiting	986	736 (736, 0)	$2.27 million	820	537 (537.1, 0)
Flathead (tiger flathead and several other species)	2,712	2,436 (2,434, 1.4)	$15.78 million	2,507	2,036 (2,034.9, 0.9)
Gemfish, eastern zone	100 **d**	30 (27, 3)	$0.07 million	100 **d**	39.1 (33.8, 5.3)
Gemfish, western zone **e**	199	77 (76.7, <1)	$0.17 million	200	78.5 (78.5, <1)
Jackass morwong	513	185 (182, 3)	$0.45 million	505	186 (183.9, 2.3)
John dory	175	83 (83, <1)	$0.82 million	263	61.8 (61.8, <1)
Mirror dory	235	220 (220, <1)	$0.58 million	253	117.5 (117.5, <1)
Ocean perch	190	169 (150, 19)	$0.04 million	241	195 (168.7, 26.3)
Orange roughy, Cascade Plateau	500	0	0	500	0
Orange roughy, eastern zone	465	297	$2.30 million	698	855.8
Orange roughy, southern zone	66 **f**	53	$0.18 million	84 **f**	78.5
Orange roughy, western zone	60 **d**	23	$0.84 million	60 **d**	19
Smooth oreodory, Cascade Plateau	150	0	0	150	0
Smooth oreodory, non–Cascade Plateau	90	55	$0.14 million	90	74.1
Other oreodories	128	106 (105, 1)	$0.10 million	185	104 (102, 1.5)
Pink ling	1,154	1,036 (740, 297)	$5.05 million	1,117	952 (645.5, 306.9)
Redfish	100 **d**	26 (26, <1)	$0.11 million	100 **d**	30.8 (30.8, <1)
Ribaldo	355	95 (55, 40)	$0.22 million	430	107.3 (60, 47.3)
Royal red prawn	384	222 (222, 0)	$0.88 million	381	147 (147, 0)
Silver trevally	613	55 (55, <1)	$0.23 million	307	8.3 (8.3, <1)
Silver warehou	605	432 (432, <1)	$0.57 million	600	352 (352, <1)

continued ...

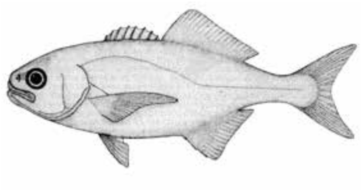
TABLE 9.2 Main features and statistics for the CTS and the GHTS a continued

Fishery statistics b	2017–18 fishing season			2018–19 fishing season	
Non-quota species	**TAC (t) c**	**Catch (t) (CTS, GHTS)**	**GVP (2017–18)**	**TAC (t) c**	**Catch (t) (CTS, GHTS)**
Gulper sharks	na	0.35 (0.27, 0.9)	na	na	0.38 (0.38, 0)
Ocean jacket **g**	na	216	$0.26 million	na	140
Total	**19,382**	**8,631**	**$41.86 million**	**19,268**	**8,454**
Fishery-level statistics					
Effort Otter trawl Danish-seine Scalefish hook	 57,747 trawl-hours 9,965 shots 3.547 million hooks			 54,298 trawl-hours 10,430 shots 3.733 million hooks	
Boat statutory fishing rights	57 trawl; 37 scalefish hook			57 trawl; 37 scalefish hook	
Active vessels	32 trawl; 18 Danish-seine; 29 scalefish hook			32 trawl; 19 Danish-seine; 21 scalefish hook	
Observer coverage CTS Auto-longline (scalefish)	 Trawl: 212 fishing days Danish-seine: 20 fishing days 26 sea-days			 Trawl: 193 fishing days Danish-seine: 27 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. Value statistics are provided by financial year and were not available for the 2018–19 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 53 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

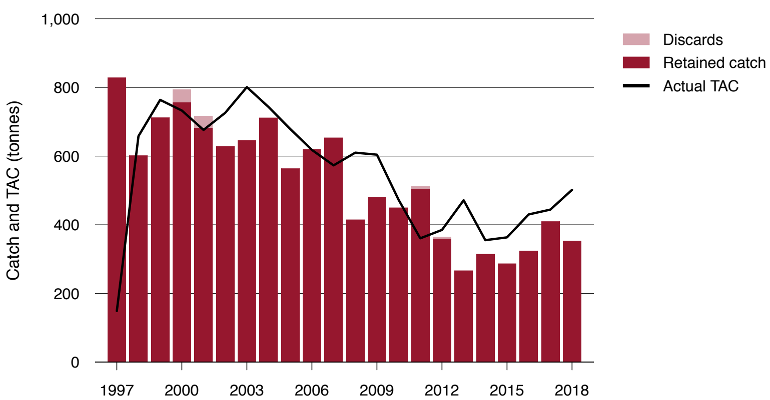
Stock structure

In the 2018–19 fishing season, blue-eye trevalla was managed as a single biological stock in the SESSF. However, spatial heterogeneity in stock structure has been reported based on phenotypic variation in age and growth, otolith chemistry, and potential larval dispersal between regions around the south-east of Australia (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) led to the decision by the South East Resource Assessment Group (SERAG) in November 2018 to assess the seamount and slope subpopulations as separate stocks for the 2019–20 fishing season (AFMA 2018c).

Catch history

Blue-eye trevalla catch peaked at more than 800 t in 1997 (Figure 9.5). Commonwealth-landed catch in the 2018–19 fishing season was 373.6 t. State catch was 17.5 t, and weighted average discards between 2014 and 2017 were 0.1 t (Castillo-Jordán et al. 2018). For the 2018–19 fishing season, catch and discards combined were 373.7 t.

FIGURE 9.5 Blue-eye trevalla annual catches (CTS, SHS and states) and fishing season TACs, 1997–2018



Notes: **TAC** Total allowable catch. Data for 2018 do not include discards and state catch.
Sources: Sporcic 2018; AFMA catch disposal records (2018 data)

Stock assessment

The management of the blue-eye trevalla stock for the 2018–19 fishing season was based on the standardised catch-per-unit-effort (CPUE) and associated tier 4 analyses undertaken by Haddon (2017b)(Figure 9.6). A CPUE series was standardised using a combination of auto-longline (2002–2016) and dropline (1997–2006) data from zones 20–50 and the eastern seamounts (Haddon 2017b), and then the tier 4 harvest control rules from the SESSF HSF (AFMA 2017a) were applied. This generated a single-year RBC of 481.6 t (Haddon 2017b), with the AFMA Commission subsequently determining a TAC of 462 t for the 2018–19 season.

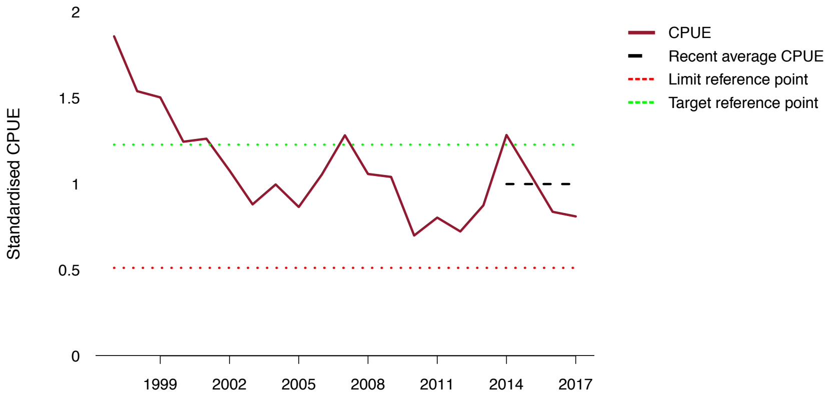
In 2018, a new assessment split the stock into two regions (slope and seamount populations), with each assessed separately to inform the determination of an RBC for the 2019–20 fishing season. A tier 4 assessment was completed for the slope stock and a tier 5 assessment for the seamount stock (due to poor CPUE data) (AFMA 2018c).

The slope assessment suggested that the previous steep decline in CPUE (2013–2016) had levelled out and that CPUE remained between the target and limit reference points as defined by the SESSF HSF (AFMA 2017a). As previously noted by Haddon (2016), this assessment has various sources of uncertainty. Two factors that could influence catch rates and fishing behaviour, resulting in a low bias for CPUE, include the presence of killer whales (orcas—*Orcinus orca*) near fishing operations and resulting depredation, and exclusions from historical fishing grounds following closures implemented to rebuild gulper shark stocks (AFMA 2014b). The previous analysis (Haddon 2016) did not detect large effects on CPUE due to the closures, but uncertainty remains about the effect of whale depredation on CPUE.

The age-structured stock reduction analysis undertaken for the seamount population predicted that constant catches of around 25 t for lower productivity scenarios and 48 t for higher productivity scenarios would lead to relative stability in depletion. Although highly uncertain, a maximum sustainable yield (MSY) analysis of the seamount catch generated an MSY of about 45–50 t, with a depletion estimate of about 33% of the unfished biomass ($0.33B_0$). It was predicted, based on the catch MSY, that constant catches of 40 t or less would lead to the mean and median depletion levels remaining stable at the proxy of $0.48B_0$ (AFMA 2018a, e).

The application of the SESSF tier 4 harvest control rule to the outputs of the standardised CPUE series for the slope stock generated a single-year RBC of 439 t. SERAG agreed to an RBC of 36 t for the seamount stock, based on the output of the age-structured stock reduction analysis and catch MSY analysis for the 2019–20 fishing season (AFMA 2018a, e).

FIGURE 9.6 Standardised auto-longline and dropline CPUE index for blue-eye trevalla to the east and west of Tasmania, 1997–2017



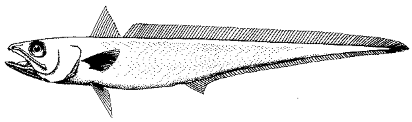
Note: **CPUE** Catch-per-unit-effort.
Source: Sporcic 2018

Stock status determination

The four-year average CPUE (2013–2016) from the analysis undertaken by Haddon (2017b) is between the limit and the target reference points defined by the SESSF HSF. The blue-eye trevalla stock is therefore classified as **not overfished**.

In the 2018–19 fishing season, catch and discards combined were 373.6 t, which is below the RBC (481.6 t). This indicates that, if the fishing mortality in 2018–19 is maintained, the stock is unlikely to be depleted to a level below the biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Blue grenadier (*Macruronus novaezelandiae*)



Line drawing: Rosalind Poole

Stock structure

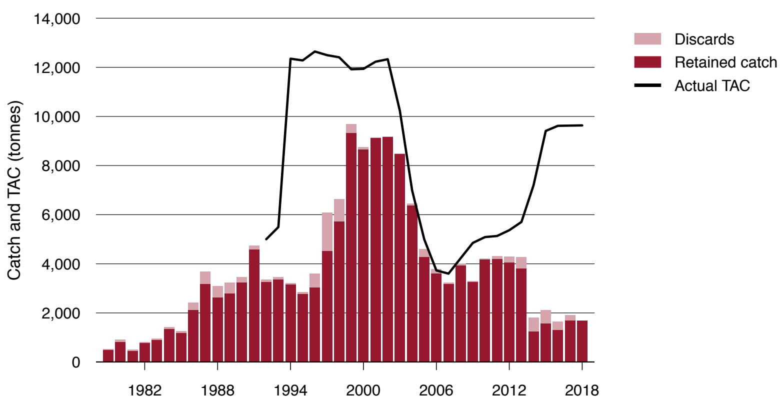
Blue grenadier is assessed as a single stock. There are two discernible subfisheries: the winter spawning fishery off western Tasmania and the widely spread catches of the non-spawning fishery.

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. The average state catch was 0.1 t, and the weighted average discards between 2014 and 2017 were 689.08 t (Castillo-Jordán et al. 2018). Commonwealth-landed catch in the 2018–19 fishing season was 1,804.6 t.

FIGURE 9.7 Blue grenadier annual catches (CTS and SHS) and fishing season TACs, 1979–2018



Notes: **TAC** Total allowable catch. Data for 2018 do not include discards.
Sources: Castillo-Jordán & Tuck 2018; AFMA catch disposal records (2018 data)

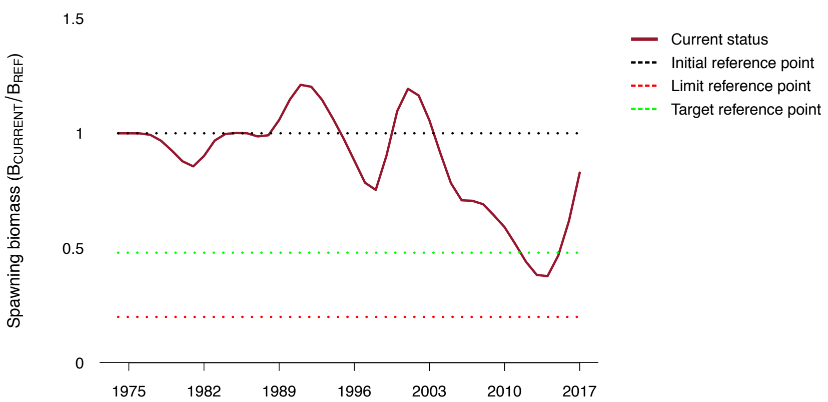
Stock assessment

Blue grenadier in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2017a). The stock is considered to be a key commercial stock, and has a target reference point of 48% of the unfished spawning stock biomass ($0.48SB_0$; Figure 9.8) (Castillo-Jordán & Tuck 2018).

The assessment underpinning the management of blue grenadier for the 2018–19 season is the tier 1 assessment of Tuck (Tuck 2013). The assessment estimated that the spawning biomass depletion for 2012 was approximately 77% ($0.77SB_0$), and predicted the depletion level for 2014 to be approximately 94% ($0.94SB_0$). The 2013 assessment produced an RBC of 8,138 t and an average three-year (2014–2016) RBC of 8,810 t (Tuck 2013). In 2015, AFMA recommended an RBC of 8,810 t, which continued into the 2018–19 season (AFMA 2018b). AFMA also extended the three-year MYTAC that started in 2014–15 for a fifth year, into the 2018–19 season (AFMA 2018b).

An updated tier 1 assessment (Castillo-Jordán & Tuck 2018) indicated that the predicted spawning biomass depletion for 2019 would be $1.22SB_0$. This is above the target $0.48SB_0$, and higher than the level predicted for 2019 by the 2013 assessment ($0.9–1.0SB_0$).

FIGURE 9.8 Estimated female spawning biomass for blue grenadier, 1973–2017



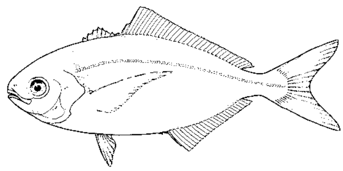
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Castillo-Jordán & Tuck 2018

Stock status determination

The assessment underpinning the management of blue grenadier for the 2018–19 season (Tuck 2013) indicated that spawning biomass would be above the target reference point if recommended catches were taken. An updated assessment in 2018 confirmed that biomass was indeed above the target reference point. As such, the stock remains classified as **not overfished**.

For the 2018–19 fishing season, the landed catch and discards combined were 2,497 t, which is below the RBC of 8,810 t calculated in 2013 (Tuck 2013). This level of catch is unlikely to deplete the stock to a level below the biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Blue warehou (*Seriolella brama*)



Line drawing: Rosalind Poole

Stock structure

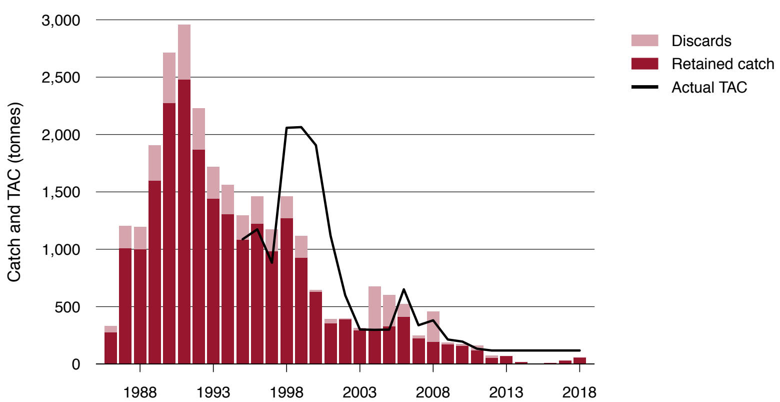
Blue warehou is assumed to have separate eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks (Morison et al. 2013). Although these stocks are assessed separately, status is reported for a combined stock, reflecting the unit of management.

Catch history

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. While landed catches decreased to just 2 t in 2015–16, they have since increased to 54.2 t in 2018–19. Meanwhile, discards have significantly increased from 6.1 t in 2016 to 146.2 t in 2017. State catch was 7.6 t, and weighted average discards between 2014 and 2017 totalled 80.7 t (Castillo-Jordán et al. 2018). In 2018–19, catch and discards combined (using the weighted average discards) were 142.5 t.

The increase in the discard estimate was largely driven by very small fish being caught by Danish-seiners in eastern Bass Strait (AFMA 2018a). Note, however, that the discard estimate for 2017 is very uncertain because of under reporting and extrapolation of the data (Paul Burch [CSIRO], 2019, pers. comm.). In 2018–19, catch and discards combined were 134.9 t, which was above the 2018–19 incidental catch allowance of 118 t.

FIGURE 9.9 Blue warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2013–2018 do not include discards and state catch.
Sources: Haddon 2013; AFMA catch disposal records (2013–2018 data)

Stock assessment

Blue warehou was managed as a tier 4 stock under the SESSF HSF (AFMA 2017a), but it has been classified as overfished since 1999 and is currently managed under a rebuilding strategy (AFMA 2014a) with an incidental catch allowance of 118 t.

The standardised CPUE series of both the eastern and western blue warehou stocks declined after the reference period of 1986–1995 (Haddon 2013). 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 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 may not be an accurate indicator of biomass.

In 2008, a rebuilding strategy was implemented for blue warehou (subsequently revised in 2014) with the goal of rebuilding 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).

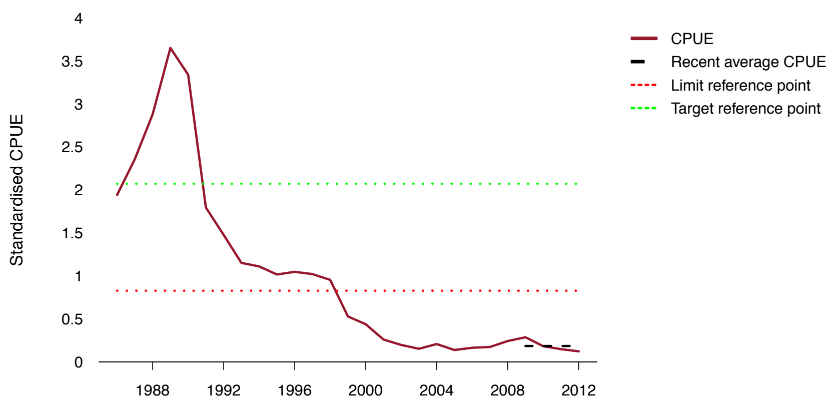
Under the rebuilding strategy, targeted fishing for blue warehou is not permitted. AFMA set an annual incidental catch allowance of 133 t for blue warehou for 2011–12, which was reduced to 118 t in 2012–13 and applied to subsequent fishing seasons. The incidental catch allowance includes triggers of 27 t in the east and 91 t in the west. These triggers are intended to alert AFMA and SERAG 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). In September 2015, the Shelf Resource Assessment Group (ShelfRAG) discussed whether the rebuilding strategy for blue warehou was meeting its objectives (AFMA 2015c), 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.

AFMA has also introduced a move-on provision to reduce the risk of large catches of blue warehou in the 2019–20 fishing season. Fishers that catch more than 200 kg of blue warehou in a single shot (retained or discarded) must not fish within 3 nm of the previous shot for 24 hours (AFMA 2019).

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 2013

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



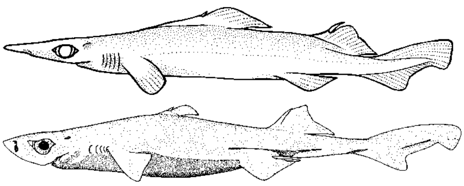
Notes: **CPUE** Catch-per-unit-effort. CPUE outside the reference period (1986–1995) is unlikely to accurately reflect biomass.
Source: Haddon 2013

Stock status determination

The most recent indicators 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 (AFMA 2014a), with an incidental catch allowance of 118 t. In 2018–19, catch and discards combined were 142.5 t, which was above the incidental catch allowance of 118 t. This incidental catch allowance is based on a statistical analysis undertaken by CSIRO that determined that 118 t of the 154 t of blue warehou caught in 2010 was unavoidable (AFMA 2014a). This level of unavoidable catch has provided the basis for subsequent incidental catch allowances set by AFMA. Therefore, while the incidental catch allowance was exceeded in 2018–19, there are no reliable indicators to determine whether the current level of fishing mortality will allow the stock to rebuild to above the limit reference point within a biologically reasonable time frame. An alternative index of abundance with which to assess status is a priority for this species, with new genetic approaches (for example, close kin) not reliant on CPUE being considered (AFMA 2018a). The fishing mortality of the stock is therefore classified as **uncertain**.

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* spp.) (Klaer et al. 2014). Identification of some sharks is difficult. Black shark and Plunket's dogfish are both possibly confounded with the roughskin shark group. The pearl shark group is a combination of the brier and platypus sharks (Haddon 2013).

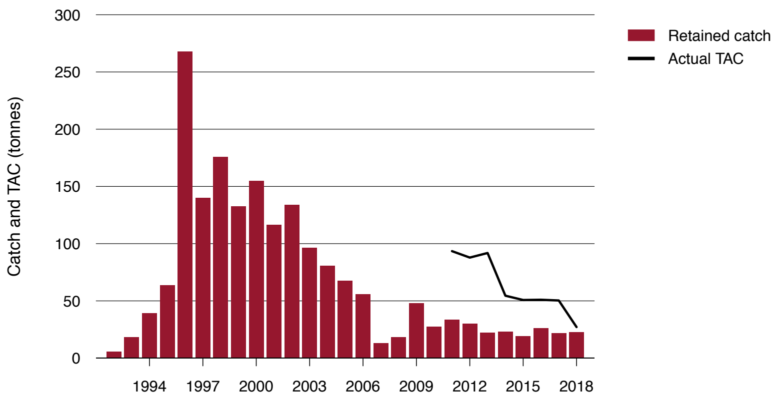
Little is known about the stock structure of these deepwater sharks. They are benthopelagic species that have been sampled in oceanic environments over the abyssal plains, and are distributed widely across ocean basins, and along the middle and lower continental shelves. The eastern zone extends from 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

TACs for the deepwater shark multispecies stock are set separately for the eastern and western zones, and cover all deepwater shark species taken in those zones. 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 2018–19 season was 19.8 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 2018–19 fishing season was 78.7 t (Figure 9.13). Weighted average discards were 38.8 t (eastern) and 76.08 t (western) (Castillo-Jordán et al. 2018). State catch is not known.

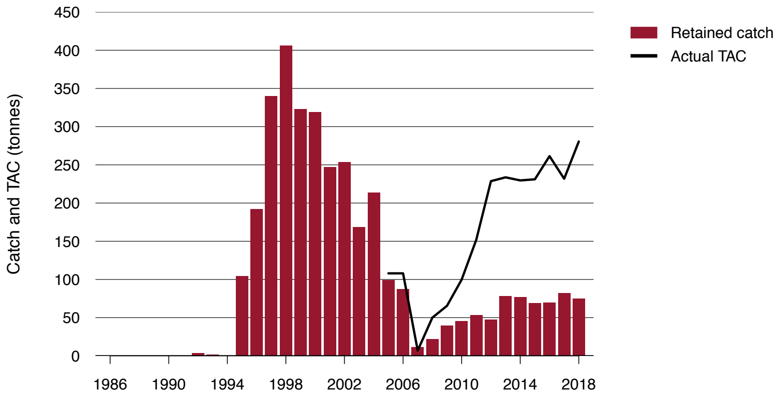
In 2018–19, platypus sharks (mixed), roughskin dogfishes (mixed), longsnout dogfish and sleeper sharks (mixed) accounted for most of the catch in the east; and platypus sharks (mixed), longsnout dogfish and sleeper sharks (mixed) accounted for most of the catch in the west.

FIGURE 9.12 Deepwater shark annual catches (CTS) and fishing season TACs, eastern zone, 1992–2018



Notes: **TAC** Total allowable catch. Data for 2018 include catch disposal records from the CTS and the SHS.
Source: Sporcic 2018; AFMA catch disposal records (2018 data)

FIGURE 9.13 Deepwater shark annual catches (CTS) and fishing season TACs, western zone, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2018 include catch disposal records from the CTS and the SHS.
Source: Sporcic 2018; Sporcic & Haddon 2018a; AFMA catch disposal records (2018 data)

Stock assessment

Both eastern and western deepwater shark stocks are managed as tier 4 stocks under the SESSF HSF (AFMA 2017a). Analyses by Haddon and Sporcic (2017b) underpinned the management of eastern and western deepwater shark for the 2018–19 season.

The RBC for the eastern deepwater shark stock was 9 t (Haddon & Sporcic 2017b). AFMA implemented a TAC of 23 t (AFMA 2018e) as a result of the large change–limiting rule within the harvest strategy that aims to avoid large changes in TACs between years. The TAC for the previous year was 46 t. CPUE was very near the limit reference point identified by Haddon and Sporcic (2017b) and remains at similar levels in the latest analyses (Sporcic & Haddon 2018a).

The RBC for the western deepwater shark stock was 313 t (Haddon & Sporcic 2017b). The recent average CPUE was above the target reference point in Haddon and Sporcic (2017b) and remains at similar levels in the latest analyses (Sporcic & Haddon 2018a).

Deepwater closures may differentially affect the CPUE of deepwater sharks in the eastern and western zones because of the different fishing conditions between the two areas. In the western zone, the CPUE remains high; however, in the eastern zone, CPUE has declined (Haddon & Sporcic 2017b).

There have been ongoing issues with producing reliable standardised CPUE series for these stocks to support the tier 4 harvest control rule of the harvest strategy, and currently there is limited scope to improve these data. The lack of historical data, together with the multispecies nature of the stock and difficulties in species identification by fishers, mean that the standardised CPUE series may not be a reliable index of abundance for the stock or its component species.

Deepwater sharks are mobile animals that cover a broad range of depths (Morison et al. 2013). A significant area of the fishery—around 54% 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. Recently, part of the closure was reopened to allow deepwater trawling for western stocks. However, if 25 t of orange roughy is taken, then the closure is reinforced (AFMA 2017d). These closures may offer a level of protection to the deepwater shark stocks, if they are similarly distributed across the open and closed areas.

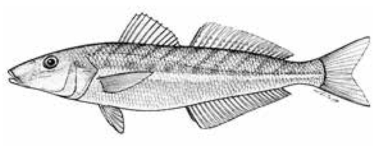
Stock status determination

The deepwater shark stocks are both multispecies stocks, and robust data on historical catch composition and discards are lacking. Further, CPUE is unlikely to provide a reliable index of abundance for these stocks or their component species. As a result, the biomass levels of these stocks are classified as **uncertain**.

For the eastern stock, the landed catch and discards combined were 58.2 t, which is substantially above both the RBC (9 t) and the TAC (23 t). For the western stock, the landed catch and discards combined were 154.8 t, which is below the RBC of 313 t.

Although large areas are closed to fishing, which could provide some protection to the deepwater shark stocks, there is no reliable indication of biomass and therefore little confidence in a comparison of catch or fishing mortality with the RBC. On this basis, fishing mortality of the eastern and western deepwater shark stocks is classified as **uncertain**.

Eastern school whiting (*Sillago flindersi*)



Line drawing: FAO

Stock structure

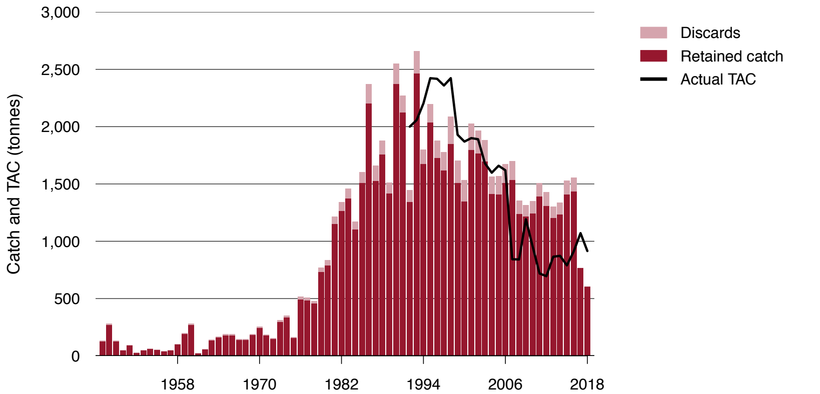
Eastern school whiting occurs from southern Queensland to western Victoria. Genetic studies have suggested two stocks in this range, with the division between a 'northern' stock and a 'southern' stock in the Sydney – Jervis Bay area. However, the current SESSF management and stock assessment assume a 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 approximately 50% of the total catch (Day 2017a), with Commonwealth-landed catch in the 2018–19 fishing season being 537 t (Figure 9.14). State catch was 707 t, and weighted average discards between 2014 and 2017 were 103.9 t (Castillo-Jordán et al. 2018).

FIGURE 9.14 Eastern school whiting annual catches (CTS, SHS and state combined) and fishing season TACs, 1947–2018



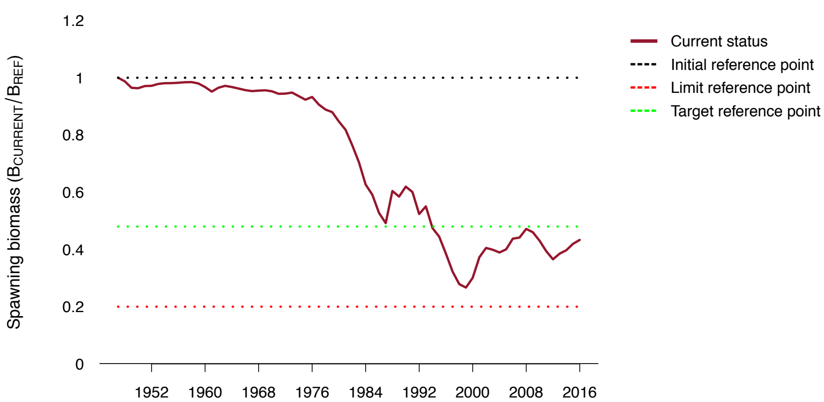
Notes: **TAC** Total allowable catch. Data for 2017 and 2018 do not include state catches and discards.
Sources: Day 2017a; AFMA catch disposal records (2017–2018)

Stock assessment

Eastern school whiting is managed as a tier 1 stock under the SESSF HSF (AFMA 2017a). The tier 1 assessment by Day (2017a) underpinned the management of the stock for the 2018–19 season.

The assessment estimated spawning biomass depletion in 2018 to be 47% of unfished levels ($0.47SB_0$), which was marginally below the target reference point of 48% ($0.48SB_0$) (Figure 9.15). An average RBC, over a three-year period (2018–2020), of 1,615 t was also calculated (Day 2017a). AFMA used this information to generate a three-year MYTAC (starting in the 2018–19 season) for Commonwealth fishers of 820 t (AFMA 2018b).

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



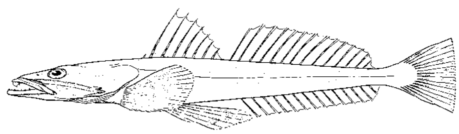
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Day 2017a

Stock status determination

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

For the 2018–19 fishing season, the total landed catch was 537 t, the state catch was 706.97 t and the weighted average discards were 103.92 t (Castillo-Jordán et al. 2018). The landed catch and discards combined were 1,348 t, which is below the 2017 estimated RBC of 1,615 t. This indicates that the fishing mortality in 2018–19, 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

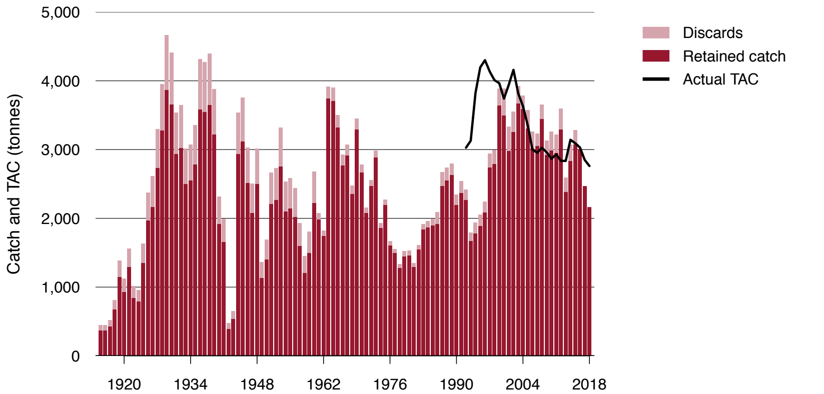
For SESSF management purposes, 'flathead' refers to a group of species. However, the catch is almost entirely tiger flathead (*Neoplatycephalus richardsoni*). The 'flathead' group includes sand flathead (*Platycephalus bassensis*) and, from 1996 onwards, southern or 'yank' flathead (*P. speculator*), 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 (Figure 19.6). The Commonwealth-landed catch of flathead in the 2018–19 fishing season was 2,036 t, taken almost entirely from the CTS (Table 9.2). State catches were 196.2 t, and weighted average discards between 2014 and 2017 were 124.7 t (Castillo-Jordán et al. 2018).

FIGURE 9.16 Flathead annual catches (CTS and state combined) and fishing season TACs, 1915–2018



Notes: **TAC** Total allowable catch. Data for 2016–2018 do not include discards and state catch.
Sources: Day 2016, 2017b; AFMA catch disposal records (2016–2018 data)

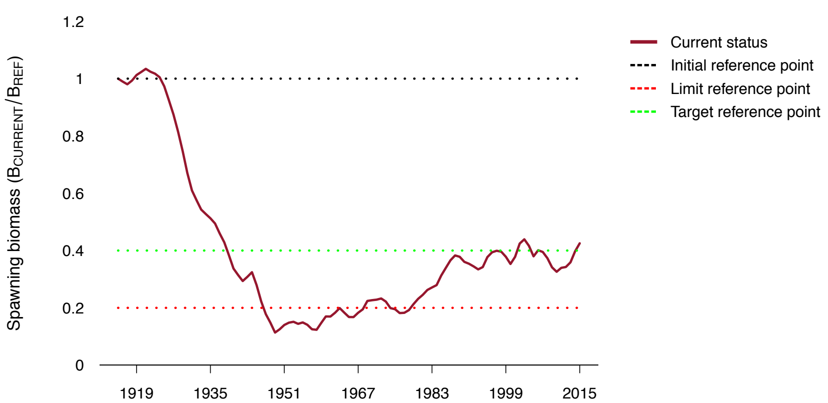
Stock assessment

Flathead is managed as a tier 1 stock under the SESSF HSF (AFMA 2017a). The tier 1 assessments by Day (2016, 2017b) underpinned the management of flathead for the 2018–19 season. The flathead assessment is based on biological parameters for tiger flathead, which accounts for about 95% of the flathead catch (Morison et al. 2013).

The updated 2017 assessment predicted spawning biomass depletion for 2018 of 41.6% (0.42SB_0), which is above the target reference point of 40% (0.40B_0) (AFMA 2017b), and produced an RBC of 2,865 t (Day 2017b) (Figure 9.17).

The 2,507 t TAC for the 2018–19 season is the second year of a three-year MYTAC (AFMA 2018b).

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



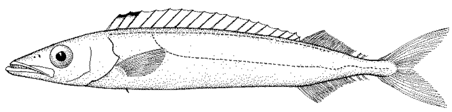
Notes: **$B_{CURRENT}$** Current biomass. **B_{REF}** Unfished biomass.
Sources: Day 2016, 2017b

Stock status determination

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

For the 2018–19 fishing season, the landed catch and discards combined were 2,357 t, which is below the RBC of 2,837 t. This indicates that the fishing mortality in 2018–19, 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).

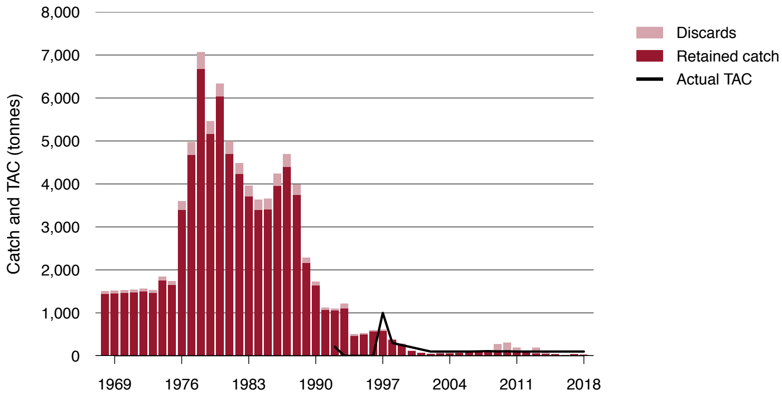
Catch history

Catch of gemfish (eastern zone) peaked in 1978 at more than 6,000 t. Catch decreased rapidly after 1987, to between 50 and 100 t between 2000 and 2012. Since 2013, catch has been below 50 t (Figure 9.18).

Total fishing mortality (including Commonwealth and state catches and discards over the past five years) has been variable since 2013. In 2013, discards alone were around 141 t—around double the landed catch at the time (Castillo-Jordán et al. 2018). Since 2014, total mortalities have been below the incidental catch allowance of 100 t—that is, 72.7 t in 2014 (discards 35.3 t; catches 37.4 t), 67.6 t in 2015 (discards 38.1 t; catches 29.5 t), 40.7 t in 2016 (discards 10.4 t; catches 30.3 t) and 68.6 t in 2017 (discards 36.5 t; catches 32.1 t) (Castillo-Jordán et al. 2018). Total state catches from 2014 to 2017 did not exceed 11 t (Castillo-Jordán et al. 2018).

For the 2018–19 fishing season, trawl (33.9 t) and non-trawl (5.1 t) landings (39.1 t in total) were slightly higher than the landings in the previous two seasons (30.4 t in 2016–17 and 32.2 t in 2017–18). State catch was 4.4 t, and weighted average discards between 2014 and 2017 were 29.7 t (Castillo-Jordán et al. 2018). Total catch, including discards for the 2018–19 fishing season, was 73.2 t.

FIGURE 9.18 Gemfish annual catches (CTS, SHS and state combined) and fishing season TACs, eastern zone, 1968–2018



Notes: **TAC** Total allowable catch. Data for 2015–2018 do not include discards and state catch.
Sources: Little & Rowling 2011; AFMA catch disposal records (2009–2018 data)

Stock assessment

Eastern gemfish is currently managed under a rebuilding strategy (AFMA 2015a) that states that the stock 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.

The most recent assessment was completed in 2010 using 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% of the 1968 level ($0.156SB_0$) (Figure 9.19). A preliminary update of the 2010 assessment in 2016 (Little 2016) indicated that the spawning stock biomass in 2015 had decreased to 8.3% ($0.083SB_0$), likely as a result of a lack of recruitment to the fishery (AFMA 2016c).

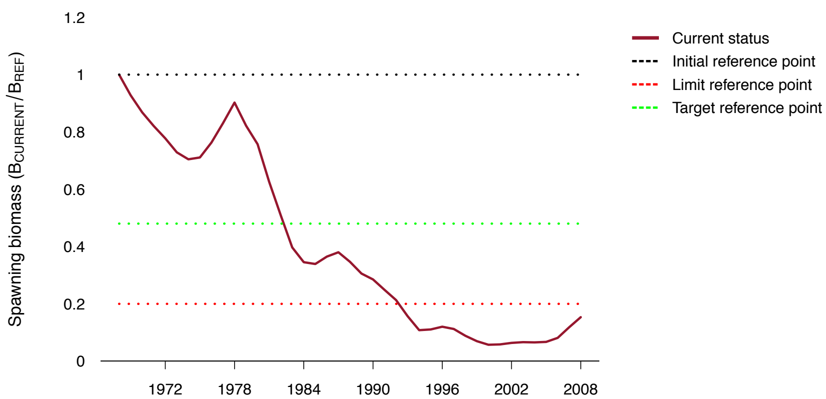
The 2010 assessment (Little & Rowling 2011) included projections of eastern gemfish biomass that were based on two scenarios: total catches of 100 t each year and zero catches each year. The projection for zero catch indicated that biomass may reach the limit reference point of $0.2SB_0$ by 2017. Projections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

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% of the 1968 level in 2008, which is below the limit reference point ($0.2SB_0$). Subsequent, but preliminary, analyses indicate that biomass may have decreased further to 8.3% in 2015. As a result, eastern gemfish remains classified as **overfished**.

Total catch, including discards, for the 2018–19 fishing season was around 74 t, which is below the incidental catch allowance of 100 t. However, there is little evidence that the stock is recovering, and indications that it may have actually declined further since the last accepted assessment. Additionally, the level of fishing mortality that will allow the stock to rebuild if recruitment conditions are below average is unknown. On this basis, the fishing mortality of the stock is classified as **uncertain**.

Gemfish, western zone (*Rexea solandri*)

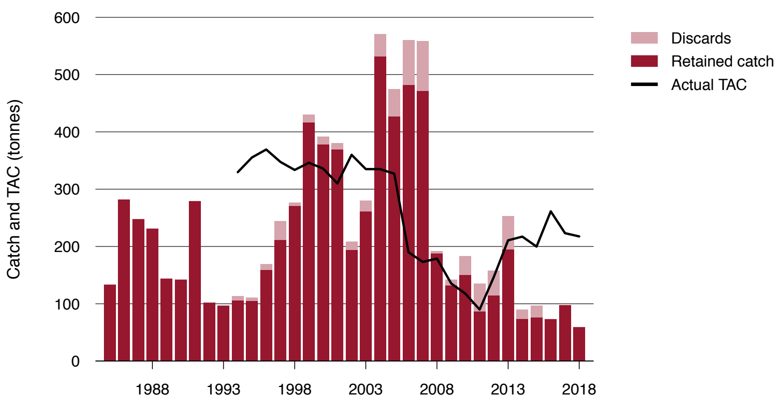
Stock structure

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 (AFMA 2018b). 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 2018–19 fishing season was 78.5 t. Weighted average discards between 2014 and 2017 were 77.4 t, and there were no state catches (Castillo-Jordán et al. 2018).

FIGURE 9.20 Gemfish annual catches (CTS and SHS) and fishing season TACs, western zone, 1985–2018



Notes: **TAC** Total allowable catch. Data for 2016–2018 exclude discards and state catches.
Sources: Helidoniotis & Moore 2016; AFMA catch disposal records (2016–2018 catch data)

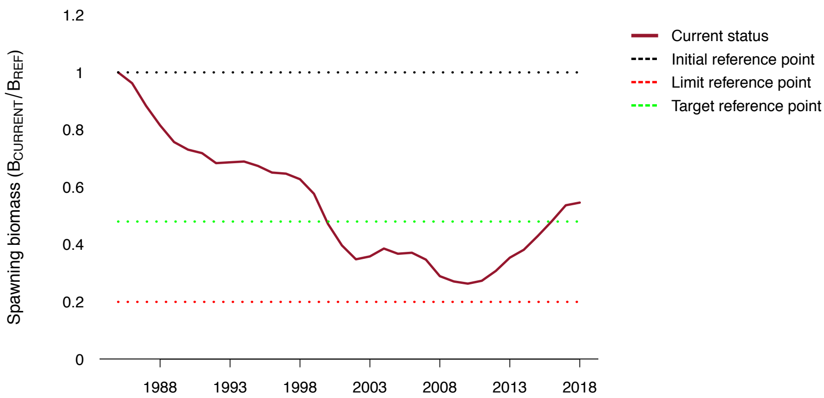
Stock assessment

Management arrangements for western gemfish currently differ between the CTS and the GABTS. Western gemfish catch in the CTS is currently managed under 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 (AFMA 2017a) if catch exceeds 1,000 t over three years (AFMA 2018b). Western gemfish is managed as a tier 4 stock under the SESSF HSF (AFMA 2017a) when catches are less than 1,000 t over three years.

Historically, the management of the stock alternated between a tier 4 analysis and a tier 1 assessment. The tier 1 assessment by Helidoniotis and Moore (2016) underpinned the management of western gemfish in zones 40 and 50 of the CTS for the 2018–19 season. The assessment predicted that spawning biomass depletion in 2019 would be 54% ($0.54SB_0$), which is above target reference point ($0.48SB_0$) (Figure 9.21). An RBC of 200.4 t was generated for the CTS. Catches in the GABTS are not considered.

AFMA implemented a TAC of 200 t for the 2018–19 fishing year, the second year of a three-year MYTAC (AFMA 2018b). A tier 4 analysis was recently conducted (Haddon & Sporcic 2017b), and the recent four-year average CPUE (2013–2016) was above the target, which was consistent with the tier 1 assessment.

FIGURE 9.21 Estimated spawning stock biomass of gemfish, western zone, 1985–2018, for the CTS and the GABTS



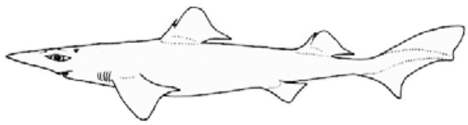
Notes: **B**$_{CURRENT}$ Current biomass. **B**$_{REF}$ Unfished biomass.
Source: Helidoniotis & Moore 2016. Data for 2015–2018 are predicted values.

Stock status determination

Estimated spawning biomass in 2019 is above the target reference point. The stock is therefore classified as **not overfished**.

Total catch for the stock in the 2018–19 season was 156 t, which is below the 200 t RBC and TAC. This indicates that, if catches in 2018–19 were maintained, they would be unlikely to deplete the stock below the 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

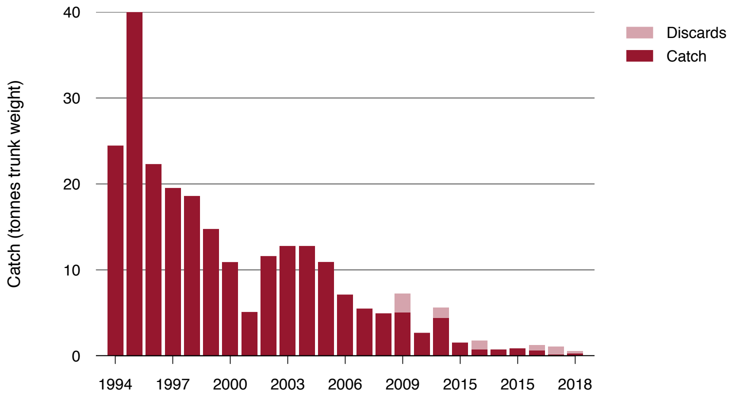
Gulper sharks are assessed as a multispecies stock comprising Harrisson's dogfish (*Centrophorus harrissoni*), southern dogfish (*C. zeehaani*) and endeavour dogfish (*C. moluccensis*). Harrisson's dogfish is endemic to south-eastern Australia, from southern Queensland to south-eastern Tasmania, and 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. 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. The reported catch in the 2017–18 and 2018–19 fishing seasons was 0.35 t and 0.38 t, respectively.

FIGURE 9.22 Gulper shark annual catch and discards for the SESSF (all sectors), 1994–2018



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 relatively higher risk of depletion from low levels of fishing effort, and also 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% 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% 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% of carrying capacity (range 4–20%) and the seamount population at 75% (range 50–100%). For southern dogfish, the eastern population was estimated to be at 11% of carrying capacity (range 6–19%) and the central population at 16% (range 8–33%). 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 2009). 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% 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% of the core habitat of Harrisson's dogfish on the continental shelf and slope, 16.2% of the core habitat of the eastern population of southern dogfish and 24.3% 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 (Britannia, Derwent Hunter and Queensland) overlaying the Murray and Freycinet Commonwealth marine reserves (areas that allow access to line fishing) (AFMA 2014c).

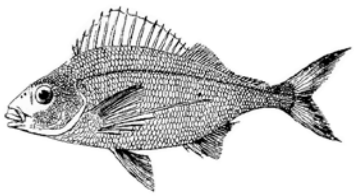
On 30 May 2013, the then Minister for Sustainability, Environment, Water, Population and Communities listed Harrisson's dogfish and southern dogfish under the EPBC Act as threatened species in the conservation-dependent category. The minister noted that both species have experienced severe historical 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% 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, the level of fishing mortality of gulper sharks is classified as **uncertain**. 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

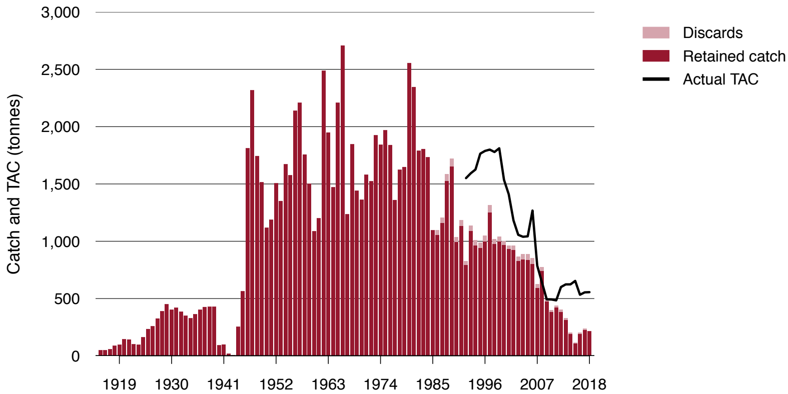
Stock structure

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 (western Tasmania and western Victoria) zones (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, catches have continued to decline and have been less than 500 t per year (Figure 9.23). For the eastern stock, the catch (logbook data) was 124 t in the 2018–2019 season, the average state catch was 6.4 t, and weighted average discards between 2014 and 2017 were 14 t, giving a total of 144.4 t (Castillo-Jordán et al. 2018). For the western stock, the catch (logbook data) was 35.9 t in the 2018–2019 season, the average state catch was 1.3 t, and weighted average discards between 2014 and 2017 were 3.9 t, giving a total of 41.1 t (Castillo-Jordán et al. 2018). Commonwealth-landed catch in the 2018–19 fishing season was 186 t. State catch was 7.8 t, and weighted average discards between 2014 and 2017 were 17.9 t (Castillo-Jordán et al. 2018), giving a total of 211.7 t.

FIGURE 9.23 Jackass morwong annual catches (CTS, SHS and state combined) and fishing season TACs, eastern and western stocks combined, 1915–2018



Notes: **TAC** Total allowable catch. Data for 2018 do not include discards and state catches.
Sources: Tuck, Day & Castillo-Jordán 2018a,b; AFMA catch disposal records (2018 catch data)

Stock assessment

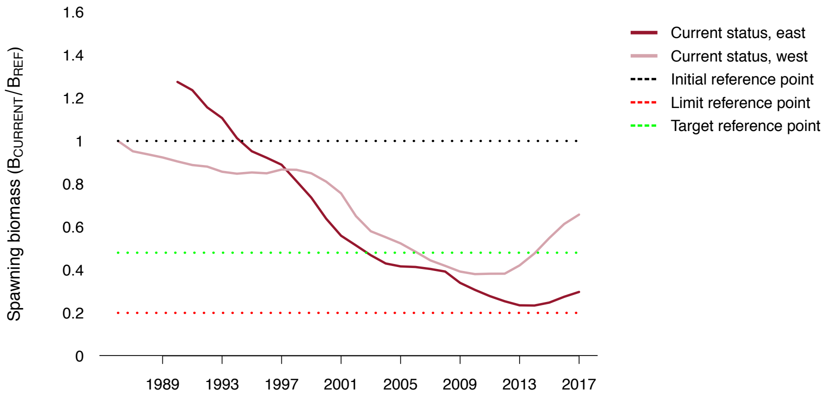
Jackass morwong is managed as a tier 1 stock under the SESSF harvest strategy (AFMA 2017a). Separate integrated stock assessment models have been developed for the eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks. Assessments for the eastern and western stocks were published in 2011 (Wayte 2012), 2013 (Wayte 2014), 2015 (Tuck et al. 2015a, b; Tuck, Day & Wayte 2015) and 2018 (Tuck, Day & Castillo-Jordán 2018a, b).

The major changes between the 2015 and 2018 assessments for both stocks were the addition of estimated discard rates, new tuning methods (Francis weighting) and recruitment estimated for an additional year (AFMA 2018c).

For the eastern stock, a new base-case assessment in 2011 involved a change in productivity (a 'regime shift'), attributed to long-term oceanographic changes (Wayte 2013). The new base case provided a better fit to the data, but the assessment remained sensitive to natural mortality, the last year of recruitment estimation and the stock–recruitment relationship (Tuck, Day & Wayte 2015). The adoption of a 'regime shift scenario' in the stock assessment resulted in a more optimistic spawning biomass depletion from $0.26B_0$ in 2011 to $0.35B_0$ (that is, 35% of the 1988 equilibrium biomass) in 2019, which is between the limit reference point ($0.2B_0$) and the target reference point ($0.48B_0$) (Figure 9.24). The analyses of Wayte (2013), which provided evidence for a regime shift, have now been accepted as influencing jackass morwong productivity (AFMA 2018c). However, SERAG has acknowledged that the regime shift contributes to considerable uncertainty in the jackass morwong assessment and that in the future there is a need to consider how best to fit regime/productivity shifts into models for non-recovering species (AFMA 2018c, d).

For the western stock, assessments are uncertain because only sporadic age data are available, length compositions are based on a very low number of sampled fish and the quality of the CPUE data is questionable (AFMA 2015c, 2018c). The 2018 assessment predicted the spawning stock biomass to be $0.68B_0$ in 2019 (compared with $0.69B_0$ in 2015), which is above the target reference point of $0.48B_0$ (Figure 9.24).

FIGURE 9.24 Estimated spawning stock biomass for eastern (1988–2017) and western (1984–2017) 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 biomass in 1988.
Source: Tuck, Day & Castillo-Jordán 2018a,b

Stock status determination

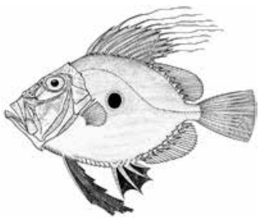
The western jackass morwong assessment (Tuck et al. 2015a, b) estimates that spawning biomass depletion in 2016 was 68% ($0.68SB_0$), which is above the target reference point of $0.48SB_0$. Based on logbook data, catch of the western stock (61.4 t in 2018–19) is below the RBC estimated by the 2015 assessment. This indicates that the fishing mortality rate in 2018–19, 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.

The acceptance of a recruitment shift in the assessment for eastern jackass morwong resulted in a decrease in the estimate of recent depletion from close to the limit reference point to closer to the target reference point. The eastern jackass morwong assessment (Tuck, Day & Wayte 2015) estimates that spawning biomass depletion in 2016 was 37% ($0.37SB_0$), which is between the target and limit reference points. Based on logbook data, catch of the eastern stock (124.6 t in 2018–19) is below the RBC estimated by the 2015 assessment. This indicates that the fishing mortality rate in 2018–19, if maintained, would be unlikely to deplete the stock to a level below its biomass limit reference point. The eastern stock is classified as not overfished and not subject to overfishing.

For the 2018–19 fishing season, the total landed catch was 186.2 t, the average state catch was 7.8 t, and the weighted average discards were 17.9 t. The landed catch and discards combined were 211.8 t, which is below the RBC of 543 t estimated from the 2015 assessment for the 2018–19 fishing season. 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 eastern jackass morwong. Although the regime shift scenario fitted the data better than a no-change scenario in productivity, other hypotheses to explain conflicts within the input data have not yet been fully explored. Establishing a mechanism for accepting regime shift scenarios is a SERAG priority for non-recovering species more broadly (AFMA 2018c). However, there is a knowledge gap about status determination in the presence of climate change.

John dory (*Zeus faber*)



Line drawing: Rosalind Poole

Stock structure

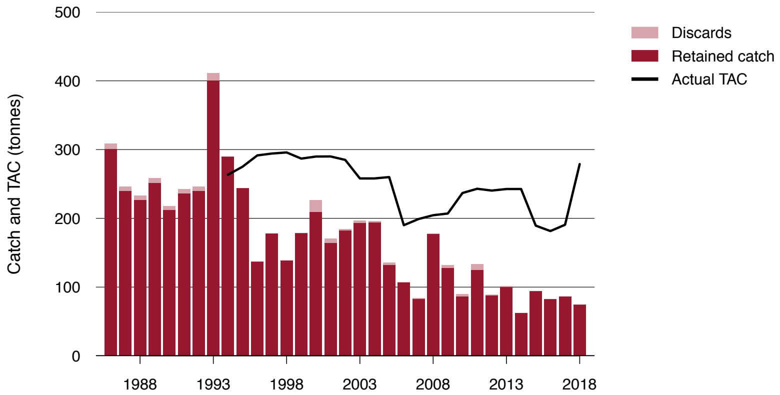
John dory inhabits coastal and continental-shelf waters of Australia, the western Indian Ocean, the eastern Atlantic Ocean, the Mediterranean Sea, Japan and New Zealand. In southern Australia, its distribution stretches from Moreton Bay in southern Queensland to Cape Cuvier in Western Australia, with 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 2001 (Figure 9.25). Commonwealth-landed catch in the 2018–19 fishing season was 61.8 t. State catches were 7.27 t, and weighted average discards were 2.47 t (Castillo-Jordán et al. 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 biomass at maximum sustainable yield (B_{MSY}) proxy target of $0.4B_0$.

FIGURE 9.25 John dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2014–2018 do not include discards and state catch.
Sources: Haddon 2014; AFMA catch disposal records (2014–2018 catch data)

Stock assessment

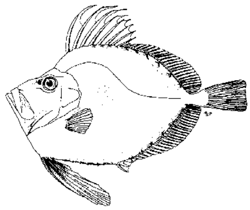
John dory was managed as a tier 3 stock under the SESSF HSF (AFMA 2017a). The tier 3 assessment by CSIRO in 2017 (Castillo-Jordán 2017) underpinned the management of john dory for the 2018–19 season. The assessment accounted for catches in zones 10–80 of the SESSF (Castillo-Jordán 2017), which comprise the GABTS, the CTS and the East Coast Deepwater Trawl Sector. The analysis consisted of a yield-per-recruit model and catch-curve analysis, and was an update to the yield analyses presented in Thomson (2014).

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 (AFMA 2018b; Castillo-Jordán 2017). This is higher than the RBC estimated by the 2014 assessment, largely as a result of the new ageing data. The lower RBC in the previous assessment 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 indicated that the john dory stock in zones 10–20 has stabilised (Sporcic & Haddon 2018a). The 2018–19 TAC was 263 t, the first year of a three-year MYTAC (AFMA 2018b).

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 to below the biomass limit reference point. In addition, recent catches are low relative to historical levels. For the 2018–19 fishing season, the total landed catch was 61.8 t, weighted average discards were 2.5 t and state catches were 7.3 t, giving a total of 71.5 t. This is below the RBC of 485 t. As a result, the stock is classified as **not subject to overfishing** and **not overfished**.

Mirror dory (*Zenopsis nebulosa*)



Line drawing: FAO

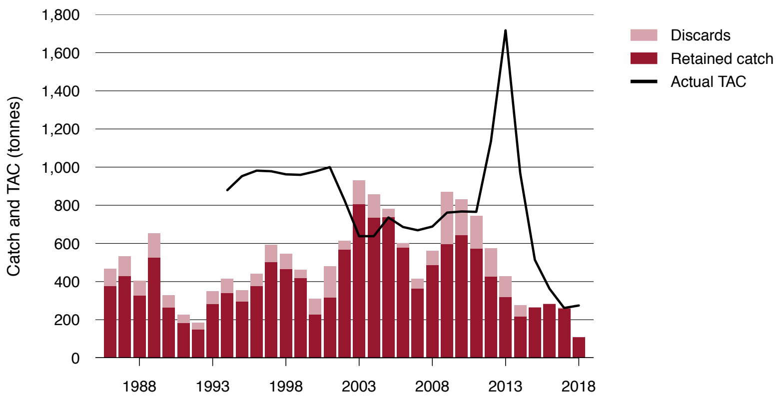
Stock structure

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 has been split into eastern and western management units.

Catch history

Most of the mirror dory catch is byproduct in the CTS, mainly caught east of Bass Strait. The catch has ranged between 200 and 700 t per year (Figure 9.26). Commonwealth-landed catch in the 2018–19 fishing season was 118 t. Weighted average discards between 2014 and 2017 were 7.01 t in the east and 0.32 t in the west, and state catch was 4.93 t in the east (no reports for the west) (Castillo-Jordán et al. 2018).

FIGURE 9.26 Mirror dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2018 do not include discards and state catch.
Sources: Sporcic 2018; AFMA catch disposal records (2018 catch data)

Stock assessment

Mirror dory was managed as a tier 4 stock under the SESSF HSF (AFMA 2017a).

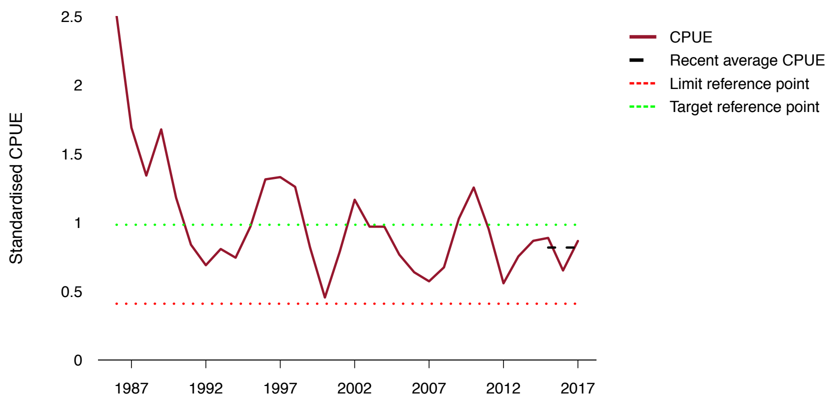
The analyses that underpinned the management of mirror dory for the 2018–19 season were the standardisation of catch rates and application of the tier 4 harvest control rules, as reported by Haddon and Sporcic (2017b). The assessments included discards for the eastern stock but not for the western stock, given the lower level of discards (AFMA 2018a).

The stock was subdivided into an eastern unit (zones 10–30) and a western unit (zones 40–50) for analysis. For the eastern unit, applying the tier 4 harvest control rule to the standardised CPUE series with discards resulted in an RBC of 198 t (Haddon & Sporcic 2017b). For the western unit, applying the tier 4 harvest control rule to the standardised CPUE series resulted in an RBC of 122 t (Haddon & Sporcic 2017b).

The total RBC for the eastern and western units combined for the 2018–19 season was 322 t (AFMA 2018e). Recent average CPUE was above the limit reference point but below the target reference point for both the western (Figure 9.27) and eastern (Figure 9.28) units.

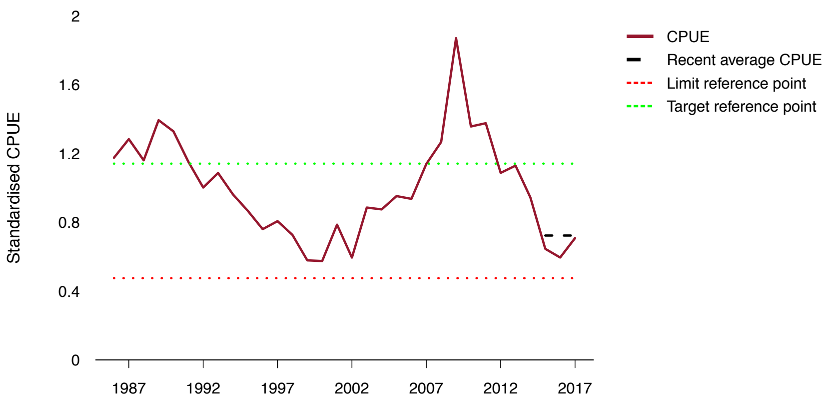
Consistent with SERAG advice, the AFMA Commission set the TAC for mirror dory at 253 t for the 2018–19 fishing year (AFMA 2018e).

FIGURE 9.27 Standardised CPUE for western mirror dory, 1986–2017



Note: **CPUE** Catch-per-unit-effort.
Source: Sporcic 2018

FIGURE 9.28 Standardised CPUE for eastern mirror dory, 1986–2017



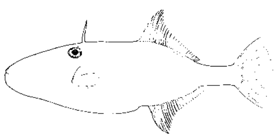
Note: **CPUE** Catch-per-unit-effort.
Source: Sporcic 2018

Stock status determination

Recent average CPUE for the eastern and western units are above their respective limit reference points. As a result, the stock is classified as **not overfished**.

For the 2018–19 fishing season, the RBC for the eastern and western units combined was 322 t (AFMA 2018b). Total landed catch was 118 t, the total weighted average discards between 2014 and 2017 for the east and west combined were 7.3 t, and the total average state catch was 4.93 t (Castillo-Jordán et al. 2018). The landed catch and discards combined were 130 t, which is below the RBC of 322 t. This indicates that the fishing mortality in 2018–19, 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

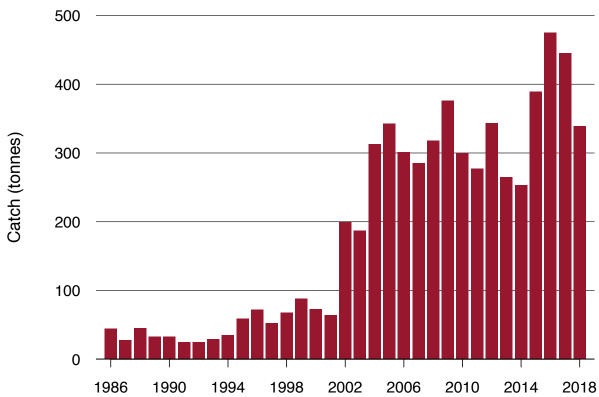
Stock structure

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). 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).

Catch history

Ocean jacket is caught in the CTS (zones 10–50), and in zones 82 and 83 in the Great Australian Bight. Only trawl-caught 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). 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 2018–19 fishing season was 129 t. Weighted average discards between 2014 and 2017 were 395.5 t, and average state catch was 367.4 t (Castillo-Jordán et al. 2018). The landed catch and discards combined in 2018–19 were 891 t.

FIGURE 9.29 Ocean jacket catch in the CTS and the SHS, 1986–2018

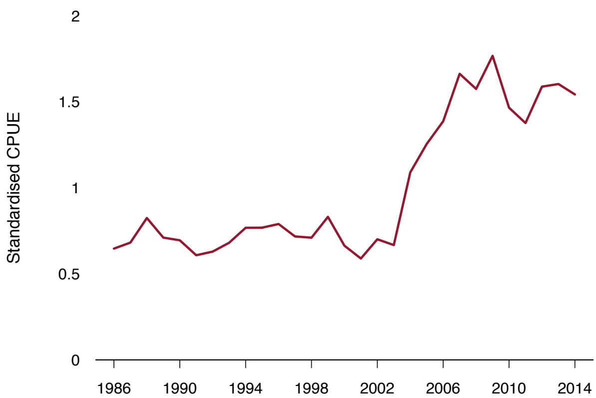


Note: Catch includes chinaman leatherjacket and unspecified leatherjackets. Data from 2017 and 2018 do not include discards or state catches.
Sources: Haddon & Sporcic 2017a; AFMA catch disposal records (2017–2018 catch data)

Stock assessment

There is no formal stock assessment for ocean jacket. A standardised CPUE series shows a similar trend to landings, suggesting that abundance of ocean jacket increased after 2003. Following a gradual decline since 2013 the CPUE increased in 2017 (Sporcic & Haddon 2018a). There continues to be uncertainty over discarding of this species in the CTS and the GHTS.

FIGURE 9.30 Standardised CPUE for ocean jacket, 1986–2014

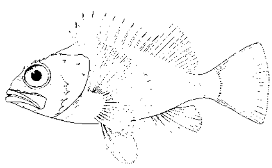


Note: **CPUE** Catch-per-unit-effort. There is no tier 4 assessment for ocean jacket, and so there are no target and limit reference points.
Source: Haddon & Sporcic 2017a

Stock status determination

The standardised CPUE series increased substantially between 2003 and 2007, and remains relatively high (Sporcic & Haddon 2018a). Ocean jacket is therefore classified as **not overfished**. The landed catch and discards combined in 2018–19 were 891 t, which is an increase on previous years; however, CPUE remains relatively high compared with historical levels. As a result, ocean jacket is classified as **not subject to overfishing**.

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



Line drawing: FAO

Stock structure

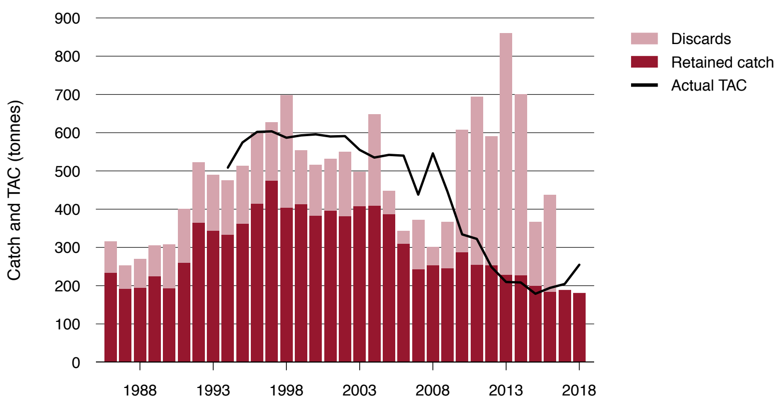
Ocean perch is managed as a single stock that includes two species: the inshore reef ocean perch (*Helicolenus percoides*) and the offshore bigeye ocean perch (*H. barathri*). Ocean perch stock structure is uncertain, but there is probably an east–west structuring of stocks (Morison et al. 2013). Reef ocean perch and 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 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 2018–19 fishing season was 194 t (Figure 9.31).

Most (inshore) reef ocean perch are discarded because of their smaller size. About 85% of total mortalities (catch plus discards) were discards (Castillo-Jordán et al. 2018). Weighted average discards of (inshore) reef ocean perch between 2014 and 2017 were 54 t, and average state catches were 4.1 t (Castillo-Jordán et al. 2018). Discards for (offshore) bigeye ocean perch are lower; about 30% of total mortalities (catch plus discards) were discards (Castillo-Jordán et al. 2018). Weighted average discards of (offshore) bigeye ocean perch between 2014 and 2017 were 58.3 t, and average state catches were 15.12 t (Castillo-Jordán et al. 2018).

FIGURE 9.31 Total ocean perch (reef and bigeye) annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2017 and 2018 exclude discards and state catch.
Sources: Haddon & Sporcic 2017b; AFMA catch disposal records (2017–2018 catch data)

Stock assessment

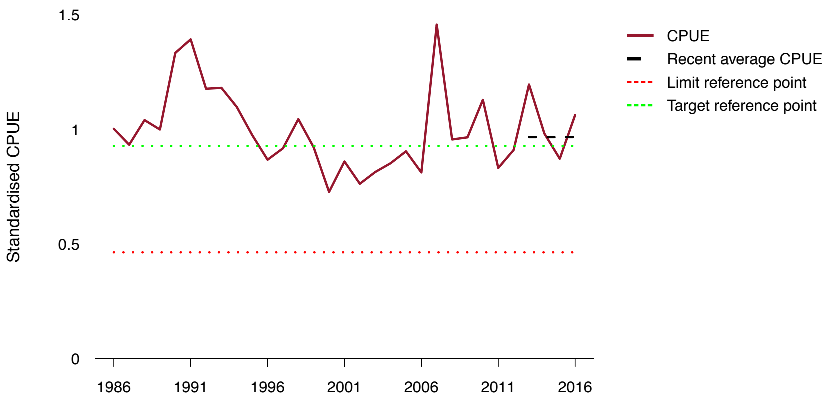
Both stocks are managed as tier 4 stocks under the SESSF HSF (AFMA 2017a). A B_{40} (B_{MSY} proxy) target reference point is applied to both species (Morison et al. 2013).

The standardised CPUE and associated tier 4 assessment by Haddon and Sporcic (2017b) underpinned the management of reef and bigeye ocean perch for the 2018–19 season.

The 2017 tier 4 analyses produced an RBC of 247 t for reef ocean perch and 345 t for bigeye ocean perch (Haddon & Sporcic 2017b). The RAG noted that the high discard rate for reef ocean perch had made the standardisation and associated tier 4 analyses uncertain, and, given the amount of discards required to be deducted, would have resulted in a TAC of zero (AFMA 2018e). The RAG recommended that reef ocean perch be removed from the ocean perch quota basket and that a catch trigger be set for the species instead (AFMA 2018b). Accordingly, the TAC was determined based on the RBC for offshore ocean perch only and was set at 241 t for 2018–19, the first year of a three-year MYTAC (AFMA 2018b).

The four-year average CPUE (2013–2016) for (offshore) bigeye ocean perch was between the target and limit reference points (Figure 9.32). The standardised CPUE for reef ocean perch is no longer accepted by the RAG and is no longer being used to recommend an RBC.

FIGURE 9.32 Standardised CPUE for bigeye (offshore) ocean perch, 1986–2016



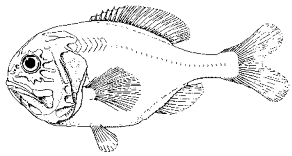
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017b

Stock status determination

Since the standardised CPUE for reef ocean perch is no longer accepted by the RAG and is no longer being used to recommend an RBC, future status for the ocean perch stock will likely be based only on information for the offshore species. Noting uncertainties in the CPUE series for reef ocean perch, the recent average CPUE was above the limit for both species (Haddon & Sporcic 2017b). As a result, the stock is considered to be **not overfished**.

Noting uncertainties in the CPUE series for reef ocean perch and the resulting uncertainties in the RBC that was derived from the tier 4 harvest control rules, the total catch mortality for (inshore) reef ocean perch was 81.6 t, which is below the RBC of 247 t. The total catch (landed catch plus discards) for bigeye ocean perch was 182.8 t, which is below the RBC of 345 t. As a result, the fishing mortality status for the ocean perch stock is classified as **not subject to overfishing**.

Orange roughy (*Hoplostethus atlanticus*)

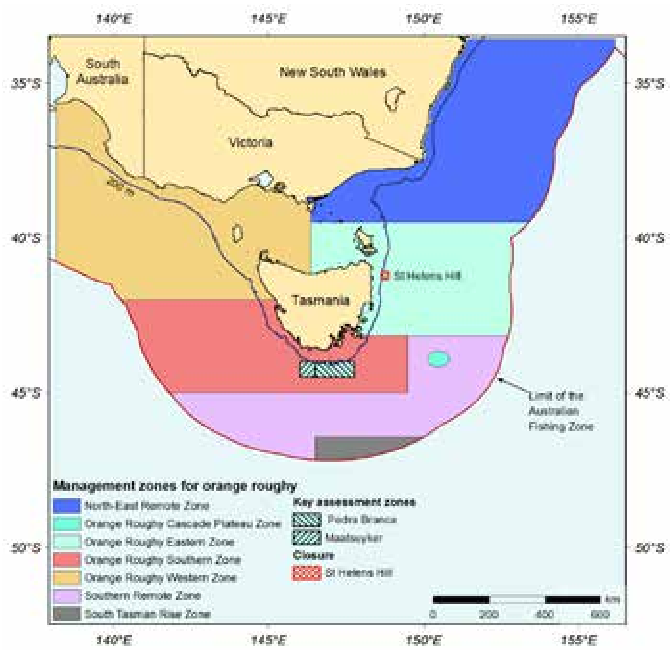


Line drawing: Rosalind Poole

Stock structure

Orange roughy in the CTS is currently broken up into seven management zones: Cascade Plateau, eastern zone, southern zone, western zone, South Tasman Rise, north-east remote zone and southern remote zone (Figure 9.33). An orange roughy stock occurs in the Great Australian Bight, outside the CTS, but 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 in 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 2014d).

FIGURE 9.33 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 9.34, 9.35, 9.37 and 9.38.

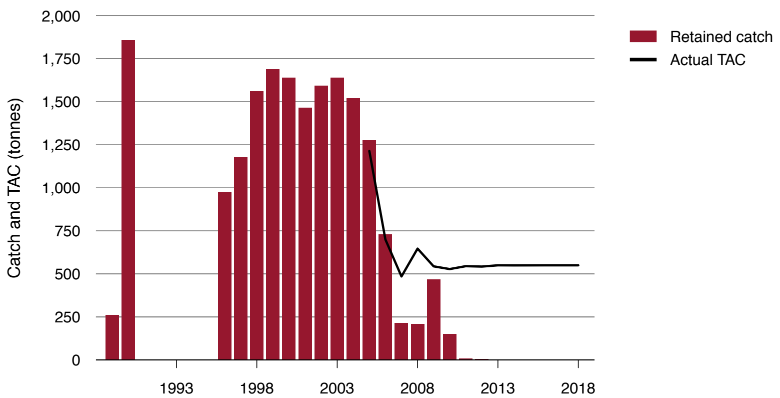
In October 2006, orange roughy was listed as conservation-dependent under the EPBC Act and placed under the Orange Roughy Conservation Programme (ORCP). The ORCP was replaced by the Orange Roughy Rebuilding Strategy (ORRS) in 2015 (AFMA 2015b), the primary objective of which is to return all orange roughy 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% 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 2 t in 2015–16; no catch was taken in 2016–17, 2017–18 or 2018–19 (Figure 9.34). Discard estimates and state catches were not reported in Castillo-Jordán et al. (2018) and are unknown.

FIGURE 9.34 Orange roughy catch (CTS), Cascade Plateau, 1989–2018



Notes: **TAC** Total allowable catch.
Sources: Various, including AFMA 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 60% of the unfished biomass ($0.6B_0$). After the ORRS was introduced, it 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 2017a). 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 $0.73B_0$ (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 target 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 undertaken in 2009 using the 2006 stock assessment 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 no new catch or acoustic data were available.

Stock status determination

The projections undertaken in 2009 predicted that the 2011 spawning stock biomass of Cascade Plateau orange roughy would be at 63–64% of unfished levels ($0.63–0.64SB_0$) 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, 2017–18 and 2018–19). 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 2018–19, the stock remains classified as **not subject to overfishing**.

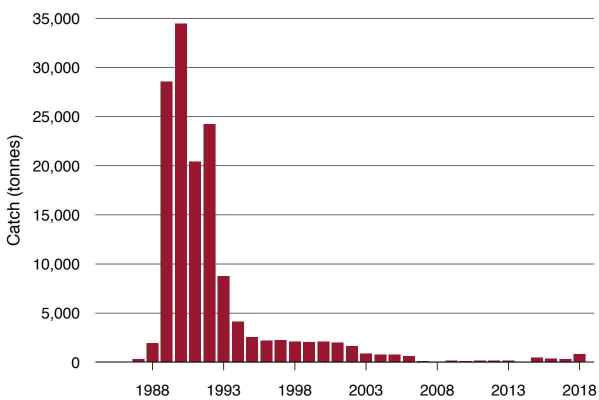
Orange roughy, eastern zone

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 9.35).

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, 2015b). 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 2018–19 fishing season was 855.8 t (Figure 9.35). Weighted average discards between 2014 and 2017 were 2.74 t; there were no state catches (Castillo-Jordán et al. 2018).

FIGURE 9.35 Orange roughy catch (CTS), eastern zone, 1985–2018



Sources: Haddon 2017a; AFMA catch disposal records (2017–2018 catch data)

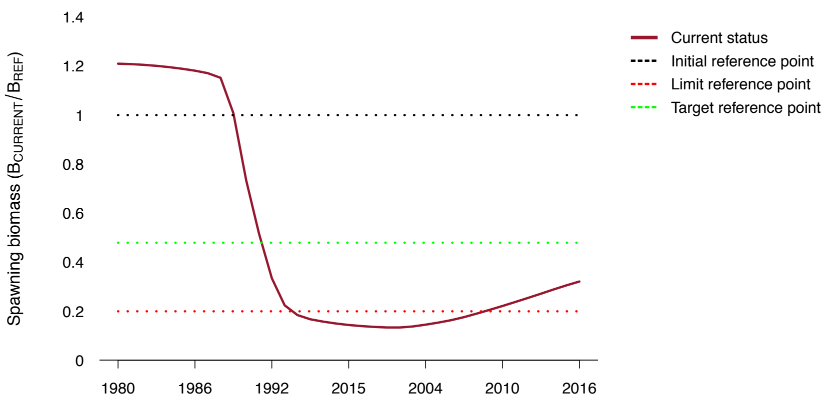
Stock assessment

Orange roughy (east) was managed as a tier 1 stock under the SESSF HSF (AFMA 2017a). The tier 1 assessment by Haddon (2017a), using data up to 2016, underpinned the management of orange roughy (east) for the 2018–19 season. 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.

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%. 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%. The consequences of selecting an incorrect base-case model were tested by a risk evaluation. The risk evaluation involved taking the projected catches generated from one model and substituting them into the other model—that is, 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 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).

The 2017 assessment produced an RBC of 1,314 t for the 2018–19 fishing season, including Pedra Branca (AFMA 2018b; Haddon 2017a). The spawning stock depletion was at approximately 34% of unfished levels ($0.34SB_0$) (Figure 9.36). AFMA recommended a TAC of 698 t, which was the first year of a three-year MYTAC (AFMA 2018b).

FIGURE 9.36 Estimated female spawning stock biomass for orange roughy, eastern zone, 1980–2016



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

Stock status determination

The 2017 assessment estimates that eastern zone orange roughy has rebuilt to above the limit reference point ($0.34B_0$). On this basis, the eastern zone orange roughy stock is classified as **not overfished**.

For the 2018–19 fishing season, the RBC was 1,314 t (AFMA 2018b). The landed catch and discards combined were 859 t, which was below the RBC of 1,314 t. This indicates that the fishing mortality in 2018–19 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

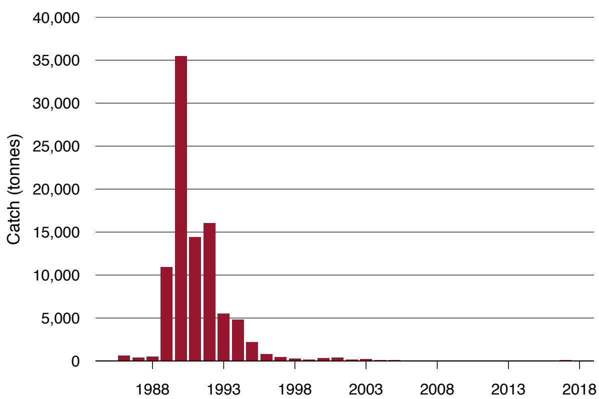
Catch history

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 9.37 and 9.38). 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 9.37). The western zone produced a peak historical catch of 5,128 t in 1987 (Figure 9.38).

The southern and western zone stocks were declared overfished and placed under the ORCP in 2006, subsequently replaced by the ORRS (AFMA 2015b). Targeted commercial fishing ceased at this time, and catch was limited by incidental catch allowances.

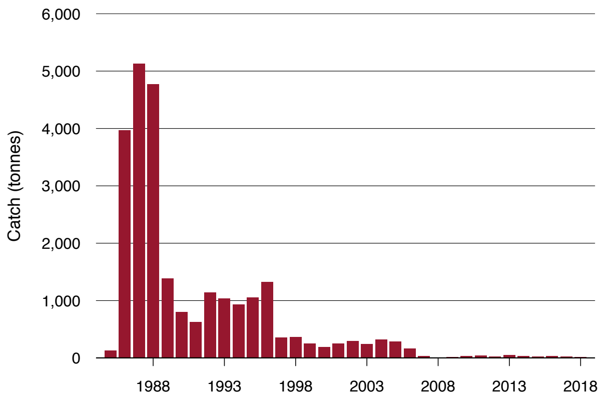
In the 2018–19 fishing season, 78.5 t of orange roughy was landed from the southern zone and 19 t from the western zone. Weighted average discards (2014–2017) were 38.7 t in the western zone and zero in the southern zone. There are no state catches (Castillo-Jordán et al. 2018).

FIGURE 9.37 Orange roughy catch (CTS), southern zone, 1985–2018



Sources: Various, including AFMA catch disposal records

FIGURE 9.38 Orange roughy catch (CTS), western zone, 1985–2018



Sources: Various, including AFMA 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% 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.

The last accepted assessment of the western zone was in 2002. The 2002 assessment projected that there was a greater than 90% probability that the 2004 biomass would be less than 30% 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% ($0.32SB_0$) estimated for 2015. 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 1994–1996 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 2015d). However, the RAG continues to advise an RBC of zero.

For the 2018–19 season, AFMA set incidental catch allowances of 84 t for the southern zone and 60 t for the western zone (AFMA 2018b).

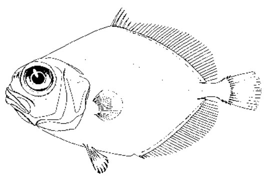
Stock status determination

The previous assessments of orange roughy in the southern and western zones (Wayte 2002) estimated that the stocks were substantially depleted. Based on this information, the southern and western zone 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 biomass status may be classified as uncertain.

Given that catches in the southern and western zones are below the incidental catch, 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**.

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



Line drawing: FAO

Stock structure

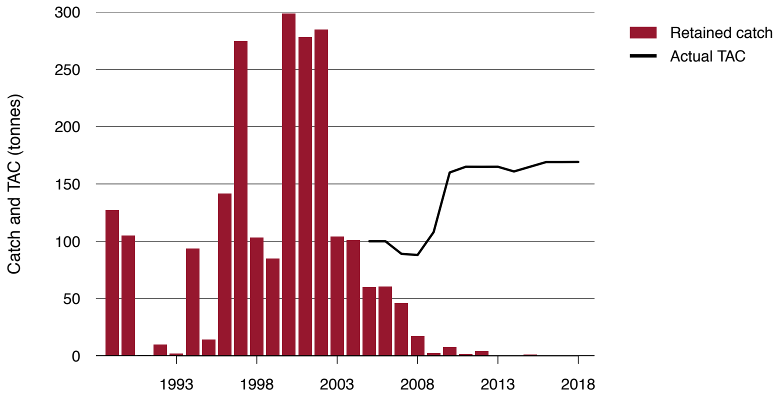
Little is known about the stock structure of smooth oreodory. For assessment and management purposes, smooth oreodory is treated as a single stock throughout the SESSF, excluding the Cascade Plateau and South Tasman Rise, which are managed as separate stocks.

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.

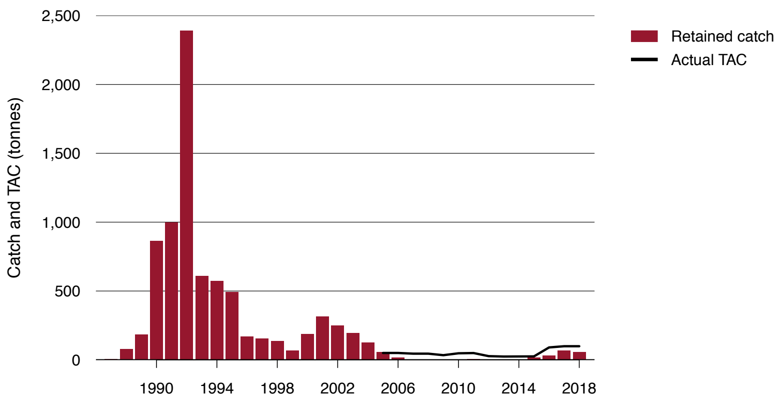
Catches of smooth oreodory on the Cascade Plateau reached maximum levels of 275–300 t in 1997, 2000, 2001 and 2002, but have otherwise generally remained below 100 t (Figure 9.39). There was zero catch in the 2016–17, 2017–18 and 2018–19 seasons. In contrast, annual smooth oreodory catches in other areas exceeded 500 t from 1990 to 1995, reaching almost 1,000 t in 1991 and peaking at 2,390 t in 1992 (Figure 9.40). Catches have been low in the intervening period; however, the recent opening of the Pedra Branca area to orange roughy fishing meant that catches of smooth oreodory increased (AFMA 2018b). Catch increased to 57.7 t in the 2017–18 season and 74.2 t in the 2017–18 season. Weighted average discards between 2014 and 2017 were zero for the Cascade stock and 3.07 t for non-Cascade stocks; there are no state catches (Castillo-Jordán et al. 2018).

FIGURE 9.39 Smooth oreodory annual catches (CTS) and fishing season TACs, Cascade Plateau, 1989–2018



Notes: **TAC** Total allowable catch.
Sources: Haddon 2012; AFMA logbook records

FIGURE 9.40 Smooth oreodory annual catches (CTS) and fishing season TACs, non–Cascade Plateau, 1987–2018



Notes: **TAC** Total allowable catch.
Sources: Haddon 2012; AFMA logbook records

Stock assessment

Smooth oreodory on the Cascade Plateau and non–Cascade Plateau smooth oreodory were previously managed as tier 4 stocks under the SESSF HSF (AFMA 2017a). However, because of low catches, the CPUE standardisations were considered unreliable (AFMA 2018b).

For the 2018–19 fishing season, there was no RBC for Cascade Plateau smooth oreodory. The current low effort and catches (less than 10 t per year since 2009) meant that a tier 4 would be unreliable and would recommence when catches increased to above this level (AFMA 2018b). Instead, a TAC of 150 t was implemented until catches reach the 10 t trigger (AFMA 2018b).

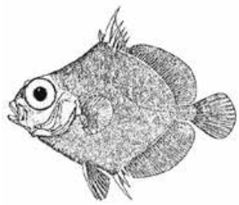
A 2015 tier 5 assessment by CSIRO (Haddon et al. 2015) underpinned the management of non–Cascade Plateau smooth oreodory for the 2018–19 fishing season. The assessment produced an RBC of 90 t. The tier 5 approach uses a depletion-based stock reduction analysis (DBSRA) and a weight-of-evidence approach to develop an RBC. 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 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% ($0.2B_0$) and would keep the stock above $0.35B_0$ at least 90% 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).

Stock status determination

For the Cascade Plateau stock, the low catches since 2002 and, more recently, since 2009 mean that CPUE is unlikely to be a reliable indicator of abundance. However, it is unlikely that recent low catches have resulted in any substantial change in abundance. For the non–Cascade Plateau stock, the DBSRA assumed that the current depletion level is $0.48B_0$, which was considered plausible, given the recent low levels of catch and 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**.

There was no catch of Cascade Plateau smooth oreodory in 2018–19. The total catch of non–Cascade Plateau smooth oreodory was below the RBC. On this basis, 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

Other oreodories are a multispecies stock comprising a number of species, including warty oreodory, spikey oreodory, rough oreodory and black oreodory. They are benthopelagic species, caught mainly below 600 m. Little is known about the stock structure of these species; they are treated as a single stock for assessment and management purposes (Morison et al. 2013).

Catch history

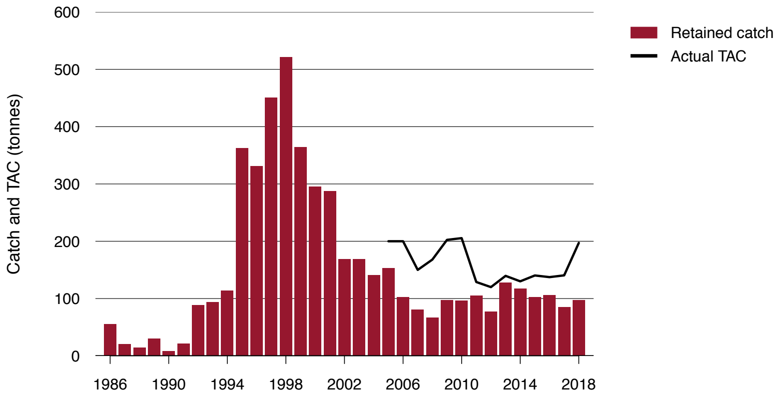
Catch peaked in the mid to late 1990s, but has since declined to around 100 t in recent years and was 81 t in 2018–19 (Figure 9.41).

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 and then the ORRS reduced the opportunity to target oreodories.

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.

Weighted average discards over the period 2014–2017 were 256.8 t, and there were no reported state catches (Castillo-Jordán et al. 2018).

FIGURE 9.41 Other oreodories annual catches (CTS) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch.
Sources: Haddon & Sporcic 2017b; AFMA logbook records

Stock assessment

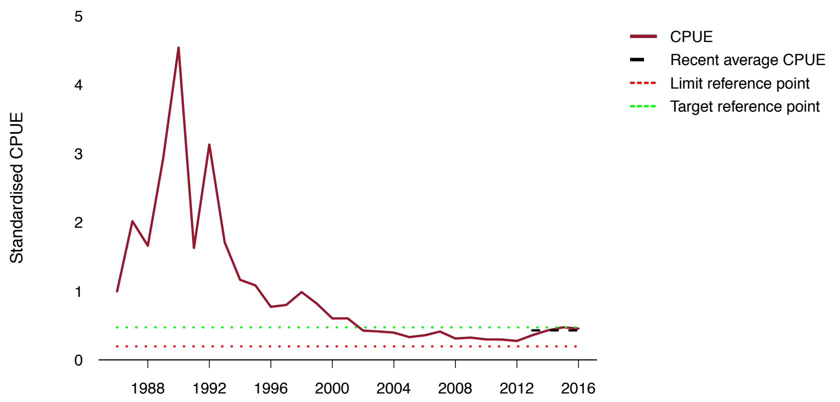
The other oreodories stock was managed as a tier 4 stock under the SESSF HSF (AFMA 2017a).

The standardised CPUE and associated tier 4 assessment by Haddon and Sporcic (2017b) underpinned the management of other oreodories for the 2018–19 season. In previous analyses, the majority (89%) of the catch is reported as spikey oreodory (Sporcic 2015), so the CPUE series 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.

Standardised CPUE declined steadily from 1998 to 2006 in the 2017 analyses, but has since stabilised, remaining near the target CPUE (Figure 9.42). The recent average CPUE (2013–2016) was above the target CPUE, and the 2017 tier 4 assessment produced an RBC of 256 t (Haddon & Sporcic 2017b). Discards were included in the standardisations.

The TAC for the 2018–19 season was set at 185 t, which was the first year of a three-year MYTAC (AFMA 2018b).

FIGURE 9.42 Standardised CPUE for other oreodories, 1986–2016



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

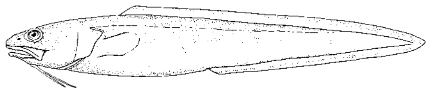
Stock status determination

Since the CPUE has remained stable near the target level, other oreodories are classified as **not overfished**.

Total landings were 81 t, weighted average discards were 256.8 t, and no state catches were reported. The total fishing mortality in 2018–19 was 337 t, which is above the RBC of 256 t and the TAC of 185 t. This indicates that the fishing mortality rate in 2018–19, if maintained, may deplete the stock to a level below the limit reference point. However, given that current indications of stock size (standardised CPUE) indicate that the stock is near the target reference point, the management agency has some time to control total mortality. On this basis, the fishing mortality status of the stock is classified as **uncertain**.

Brickle curtain
Lee Georgeson, ABARES

Pink ling (*Genypterus blacodes*)



Line drawing: Rosalind Poole

Stock structure

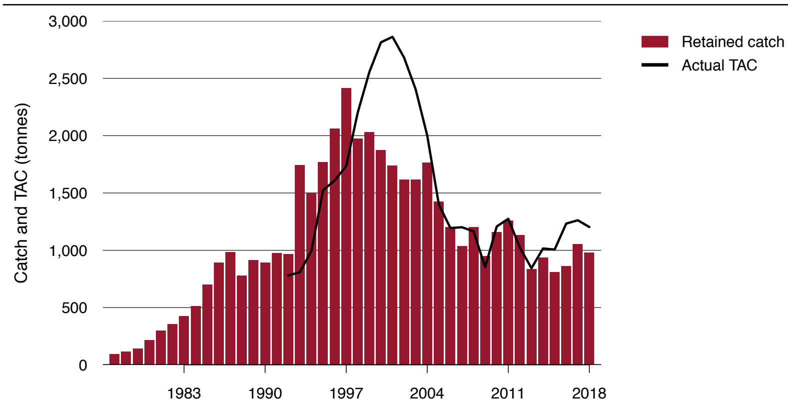
Clear and persistent differences are seen between the eastern and western areas for pink ling in catch-rate trends, size and age (Morison et al. 2013). This indicates that there are either two separate stocks, or that exchange between eastern and western components of the stock is low and they should 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 9.43). 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 2018–19 fishing season was 952 t, comprising approximately 372.2 t for the eastern stock and 479.9 t for the western stock (according to logbook data and excluding the GABTS). The weighted average discards between 2014 and 2017 were 35.2 t for eastern pink ling and 24.1 t for western pink ling (Castillo-Jordán et al. 2018). State catches were 63.0 t for eastern pink ling and 0.05 t for western pink ling (Castillo-Jordán et al. 2018).

FIGURE 9.43 Pink ling annual catches (CTS, SHS and state combined) and fishing season TACs, 1977–2018



Notes: **TAC** Total allowable catch. Data for 2013–2018 do not include state data.
Sources: Cordue 2013; AFMA catch disposal records (2013–2018 catch data)

Stock assessment

Pink ling was managed as a tier 1 stock under the SESSF HSF (AFMA 2017a). The tier 1 assessment by Cordue (2015) underpinned the management of pink ling for the 2018–19 season.

Because of complexities in controlling catch of the stock, pink ling is managed under a harvest strategy that uses projections of stock response to various levels of catch and the risk that those catches may pose to breaching the limit reference point. This approach is taken while trying to pursue targets for the western stock and rebuild the eastern stock.

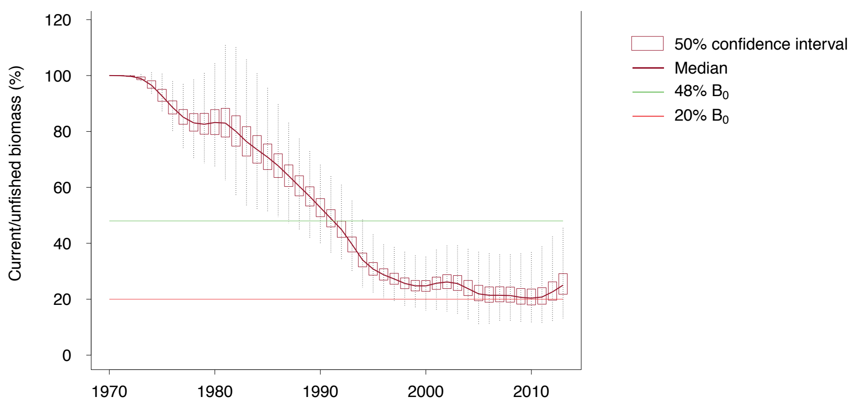
The 2015 assessment produced an RBC of 250 t for the eastern stock and 990 t for the western stock (AFMA 2018e). For the eastern stock, projections of stock response to various constant-catch scenarios indicated that catches below 550 t posed a relatively low (<10%) risk (Table 9.3; Cordue 2015). Subsequently, AFMA set a TAC for the eastern stock of 500 t (AFMA 2018e).

The assessment estimated the median biomass depletions for the two stocks in 2015 to be $0.30B_0$ for the eastern stock (Figure 9.44) and $0.72B_0$ for the western stock (Figure 9.45).

An updated assessment (Cordue 2018) estimated the median biomass depletions in 2018 to be $0.35B_0$ for the eastern stock and $0.84B_0$ for the western stock.

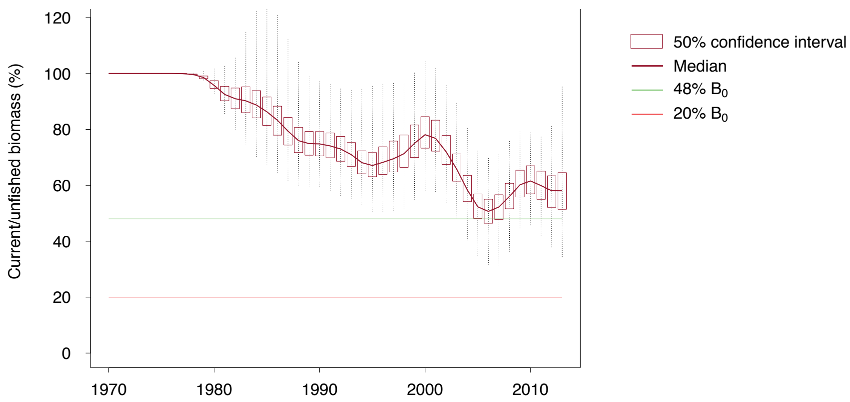
The total RBC for the 2018–19 fishing season was 1,240 t (AFMA 2018b). The TAC for the 2018–19 season applied for the eastern and western stocks combined was 1,117 t, which was the third year of a three-year MYTAC (AFMA 2018b).

FIGURE 9.44 Estimated spawning stock biomass for eastern pink ling, 1970–2015



Source: Cordue 2015

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



Source: Cordue 2015

TABLE 9.3 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: **B_{2017}/B_0** Predicted biomass ratio in 2017. **B_{2022}/B_0** Predicted biomass ratio in 2022. **$B_{2017}<0.2B_0$** Biomass below 20% B_0 in 2017. **$B_{2022}<0.2B_0$** 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% of the unfished biomass, and the median biomass depletion for the eastern pink ling stock at 30% of the unfished biomass. On this basis, both stocks are considered as not overfished, and so the combined stock of pink ling is classified as **not overfished**.

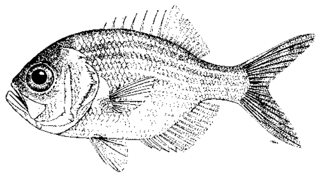
Western pink ling catch in the 2018–19 fishing season was 480 t (logbook data). Average discards were 24.1 t, and state catch was 0.05 t. The total mortality combined was 504 t, which was below the western RBC of 990 t. The western stock would be classified as not subject to overfishing.

Eastern pink ling catch in 2018–19 was 372 t. Average discards were 35.1 t, and state catch was 63.0 t, bringing the total to 470 t. This exceeds the RBC of 250 t but is below the TAC of 500 t.

Although the total mortality of eastern pink ling in 2018–19 was above the RBC, at that mortality level the probability of the biomass being depleted to below $0.2B_0$ in 2017 is less than 0.04% (Table 9.3).

In addition, the updated assessment (Cordue 2018) reported that the biomass depletion was $0.35B_0$ in 2018. Therefore, the eastern stock appears to be recovering since the 2015 assessment under the current approach to TAC setting. On this basis, the pink ling stock 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). The evidence for separate stocks was reviewed and considered to be insufficient; hence, the most recent stock assessment (Tuck & Day 2014) assumes a single stock. Status is determined for a single stock in the east coast of the SESSF (zones 10, 20 and 30).

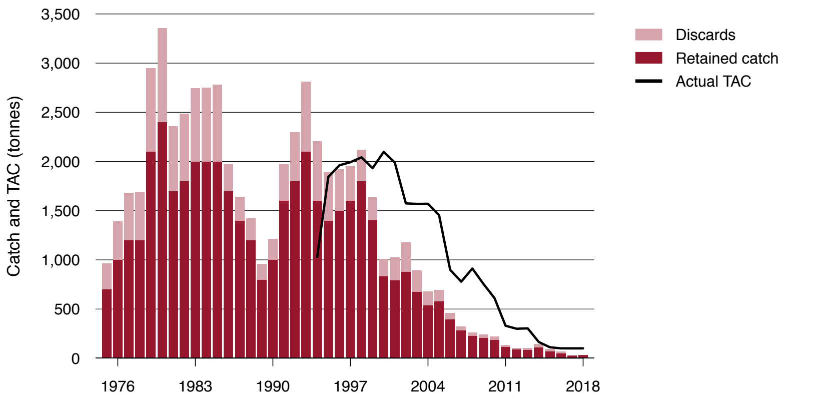
Catch history

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. Commonwealth-landed catch was 27.4 t in 2017–18 and 30.8 t in 2018–19 (Figure 9.46).

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 et al. 2018). Weighted average discards between 2014 and 2017 were 33.75 t, and state catches were 10.03 t (Castillo-Jordán et al. 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 2018–19 seasons (AFMA 2018b). Annual catches have remained below the TAC since 2000 (Figure 9.46).

FIGURE 9.46 Redfish annual catches (CTS, SHS and state combined) and fishing season TACs, 1975–2018



Notes: **TAC** Total allowable catch. Data for 2017 and 2018 do not include discards and state catch.
Sources: Tuck et al. 2017; AFMA catch disposal records 2017–(2018 catch data)

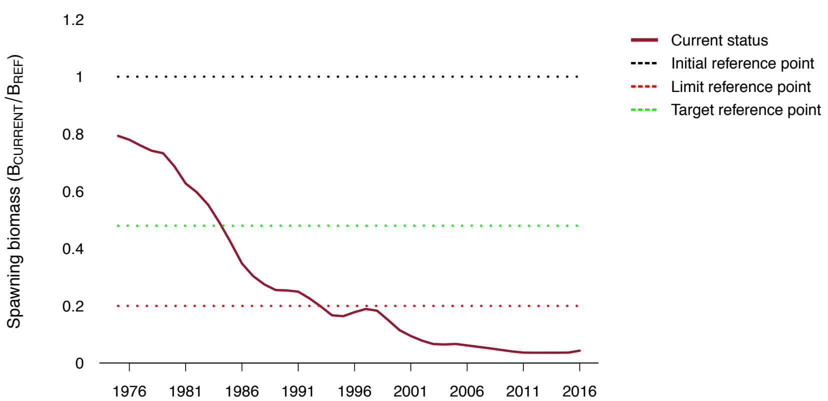
Stock assessment

Redfish is currently managed under the Redfish Stock Rebuilding Strategy 2016–2021 (AFMA 2016a). The management objective is to rebuild the stock to the limit reference point ($0.2SB_0$) within 27 years (2042), being one mean generation time plus 10 years (that is, 16.7 years plus 10 years; Tuck & Day 2014).

The most recent assessment of redfish was in 2017 (Tuck et al. 2017). The base-case model used by the RAG to provide advice predicted spawning biomass in 2018 to be 8% of unexploited levels ($0.8SB_0$), a decrease from the previous assessment that predicted 11% ($0.11SB_0$) in 2015 (Tuck & Day 2014) (Figure 9.47).

The RBC from the 2017 assessment was zero, and incidental catch TAC was set at 100 t for the 2018–19 season (AFMA 2018b) to cover redfish taken incidentally while targeting other species.

FIGURE 9.47 Estimated female spawning stock biomass for redfish, 1975–2016



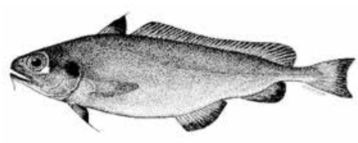
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Tuck et al. 2017

Stock status determination

The 2017 assessment estimated spawning stock biomass for redfish at 8% of unfished levels in 2018. On this basis, redfish is classified as **overfished**.

The spawning biomass appears to have decreased between the 2014 and 2017 assessments, despite mortality being constrained below the incidental catch allowance. 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

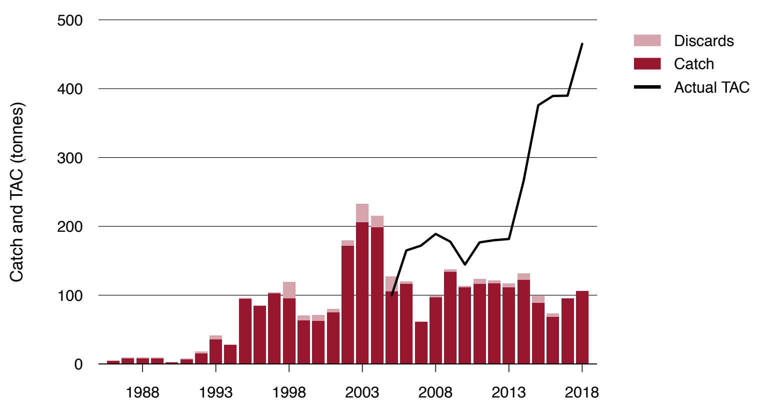
Stock structure

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% 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. Commonwealth-landed catch dropped in 2005 to about 100 t, following implementation of a TAC, and remained below 100 t until 2018–19, when 107.3 t was taken (Figure 9.48). Weighted average discards between 2014 and 2017 were 5.4 t, and state catches were 2.7 t (Castillo-Jordán et al. 2018).

FIGURE 9.48 Ribaldo annual catches (CTS and SHS) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2017 and 2018 do not include discards.
Sources: Haddon & Sporcic 2017b; AFMA catch disposal records (2017–2018 catch data)

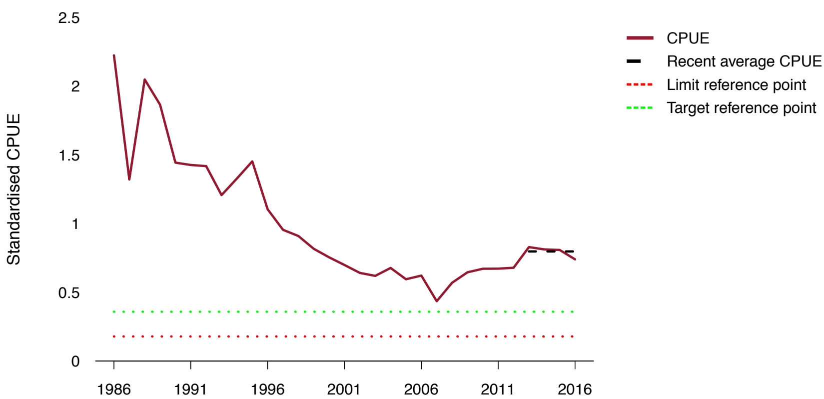
Stock assessment

Ribaldo was managed as a tier 4 stock under the SESSF HSF (AFMA 2017a).

The standardised CPUE and associated tier 4 assessment by Haddon and Sporcic (2017b) underpinned the management of ribaldo for the 2018–19 season (Figure 9.49). The 2017 analyses used 1995–2004 as the reference period (when catches first approached 100 t), and produced an RBC of 430 t using the B_{40} target (AFMA 2018b; Haddon & Sporcic 2017b). An updated CPUE standardisation in 2018 (with data to 2017) showed that CPUE had remained stable (Sporcic & Haddon 2018a).

The TAC for the 2018–19 season was set at 430 t, which was the first year of a three-year MYTAC (AFMA 2018b).

FIGURE 9.49 Standardised CPUE for ribaldo, 1986–2016



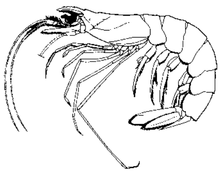
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017b

Stock status determination

Standardised CPUE has remained stable and has been above the target level for the past decade. On this basis, ribaldo is classified as **not overfished**.

For the 2018–19 fishing season, the total landed catch and discards combined were 115 t, which is below the RBC of 430 t. This indicates that the fishing mortality in 2018–19, 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**.

Royal red prawn (*Haliporoides sibogae*)



Line drawing: FAO

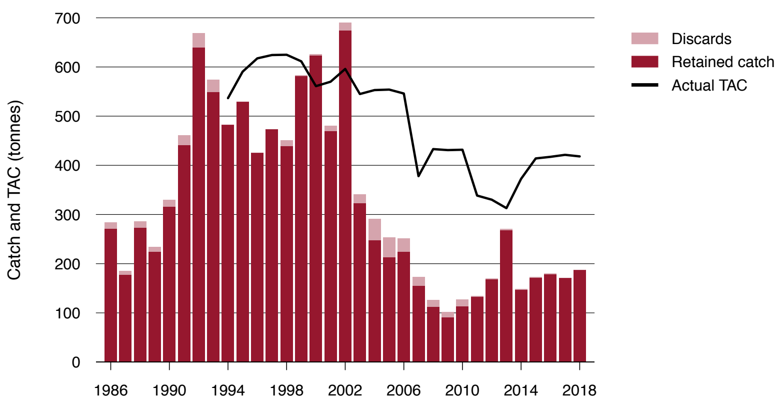
Stock structure

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, these populations are assumed to comprise a single stock for assessment and management purposes (Morison et al. 2013). The sustainability of stocks outside the SESSF (such as those in Western Australia) is 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 9.50). 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 2018–19 fishing season was 147 t. Weighted average discards between 2014 and 2017 were 12.8 t, and state catch was 9.3 t (Castillo-Jordán et al. 2018).

FIGURE 9.50 Royal red prawn annual catches (CTS and state combined) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2017 and 2018 do not include discards and state catch.
Sources: Haddon & Sporcic 2017b; AFMA catch disposal records 2017–(2018 catch data)

Stock assessment

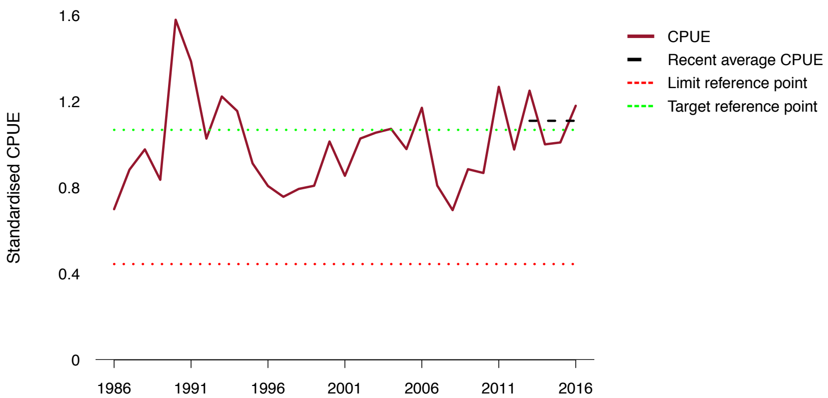
Royal red prawn was managed as a tier 4 stock under the SESSF HSF (AFMA 2017d). SERAG has provided advice on the RBC using the B_{40} target reference point (AFMA 2017d).

The standardised CPUE and associated tier 4 assessment by Haddon and Sporcic (2017b) underpinned the management of royal red prawn for the 2018–19 season. The recent four-year average CPUE is marginally below the target reference point (Figure 9.51).

The 2017 analyses produced an RBC of 431 t (AFMA 2018b; Haddon & Sporcic 2017b). Some concerns about using a standardised CPUE for this stock have been expressed by SERAG 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.

The TAC set for the 2018–19 season was 381 t, which was the first year of a three-year MYTAC (AFMA 2018b).

FIGURE 9.51 Standardised CPUE for royal red prawn, 1986–2016



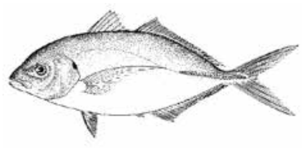
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

The recent average CPUE is marginally above the target reference point. As a result, this stock is classified as **not overfished**.

Total catch and discards combined were 169 t. This is below the RBC for the stock of 431 t. This indicates that the fishing mortality in 2018–19, 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

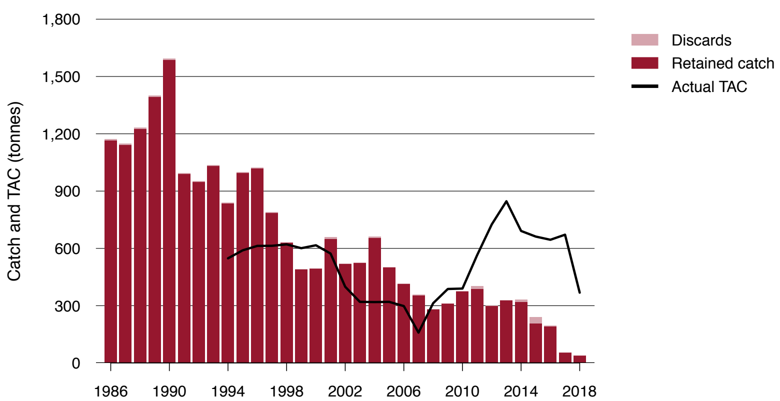
Silver trevally is found in Australian and New Zealand waters. In Australia, it ranges from northern New South Wales, around southern Australia to Western Australia. Little is known of the stock structure, but angler tag–recapture studies on Australia's south-east coast indicate restricted post-settlement movement, potentially leading to ecological stock structuring over moderate (hundreds of kilometres) distances (Fowler, Chick & Stewart 2018). This research supports the contention that silver trevally off south-eastern Australia represents a single stock that is distinct from the fishery off the North Island of New Zealand (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, corresponding with a peak catch in 1990 of 1,588 t, was the result of efficient vessels entering the fishery in 1989 (Haddon 2013). Catch has since declined (Figure 9.52). The Commonwealth-landed catch in the 2018–19 fishing season was 8.3 t. State catch was 123.2 t, and weighted average discards between 2014 and 2017 were 29.9 t (Castillo-Jordán et al. 2018).

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).

FIGURE 9.52 Silver trevally annual catches (CTS, SHS and state combined) and fishing season TACs, 1986–2018



Notes: **TAC** Total allowable catch. Data for 2017 and 2018 exclude discards and state data.
Sources: Haddon & Sporcic 2017b; AFMA catch disposal records (2017–2018 catch data)

Stock assessment

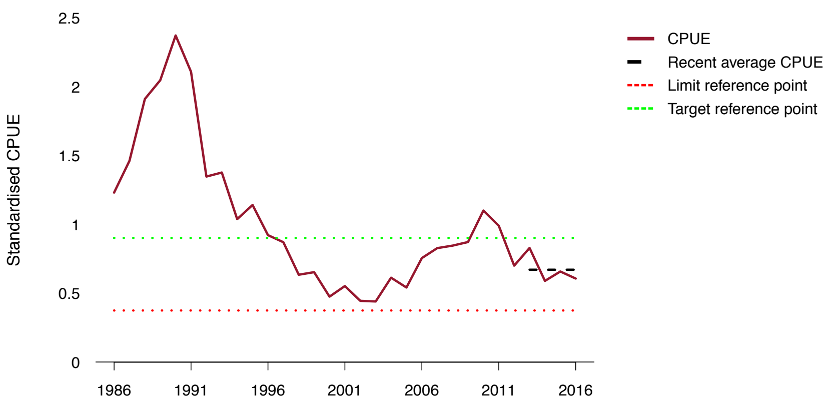
Silver trevally is managed as a tier 4 stock under the SESSF HSF (AFMA 2017a).

The current TAC was set based on application of the SESSF tier 4 harvest control rule to the CPUE analysis completed in 2017 (Haddon & Sporcic 2017b). This found the recent average CPUE to be halfway between the target and limit reference points, and produced an RBC of 445 t (Haddon & Sporcic 2017a; Figure 9.53). This was converted to a MYTAC of 307 t and applied to the 2018–19 fishing season.

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 2013) 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. ShelfRAG recommended waiving the default tier 4 discount factor of 15% of the RBC, on the basis that the marine park provides enough precaution as a refuge for spawning adults and juveniles across a significant portion of the species' distribution (AFMA 2013, 2018a). 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 9.53 Standardised CPUE for silver trevally, 1986–2016



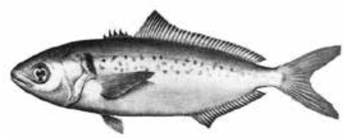
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017a

Stock status determination

The recent average CPUE was above the limit reference point. As a result, silver trevally is classified as **not overfished.**

The landed catch and discards combined were 161.4 t, which is below the RBC of 445 t. This indicates that the fishing mortality in 2018–19, 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 on the stock structure of silver warehou using genetics (mitochondrial DNA), morphology, otolith shape and otolith microchemistry did not indicate the presence of separate stocks east and west of Bass Strait, although there were indications of some structuring around Tasmania (Robinson et al. 2008). 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).

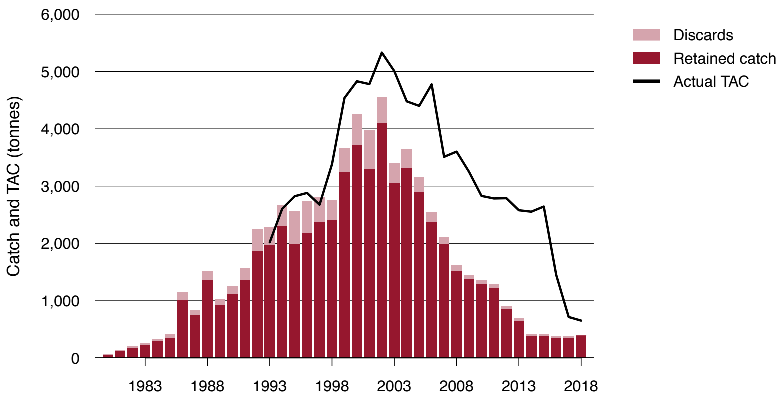
Catch history

Silver warehou has been a targeted species throughout most of the history of the fishery. Silver warehou catches steadily increased from the start of the fishery to peaks of 4,450 t in 2002 and 4,435 t in 2004 (Figure 9.54). Catches subsequently declined to 276 t in 2015–16 and 311 t in 2016–17.

The TAC in 2018–19 (600 t) was the final year of a three-year MYTAC, which saw the TAC steadily reduce from 2,417 t in 2015–16 (AFMA 2018b).

The Commonwealth-landed catch in the SESSF for the 2018–19 fishing season was 351.6 t. State catch was 1 t, and weighted average discards between 2014 and 2017 were 73.2 t (Castillo-Jordán et al. 2018).

FIGURE 9.54 Silver warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1980–2018



Notes: **TAC** Total allowable catch. Data for 2018 do not include discards and state catch.
Sources: Burch et al. 2019; AFMA catch disposal records (2018 catch data)

Stock assessment

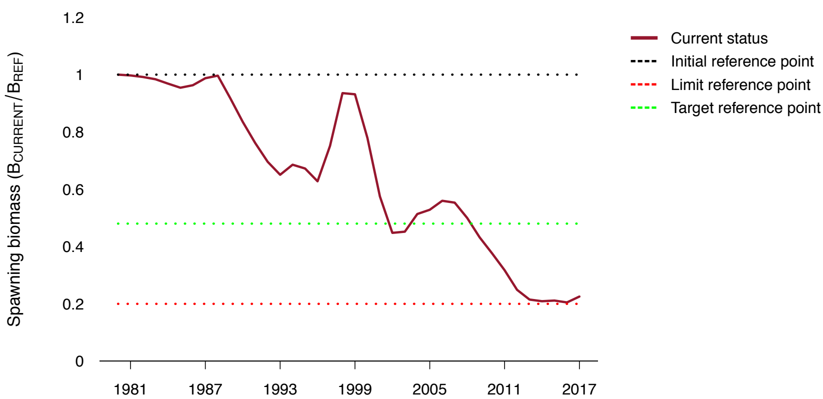
Silver warehou is managed as a tier 1 stock under the SESSF HSF, with a target reference point of $0.48B_0$. The most recent assessment in 2018 (Burch et al. 2019) projected the 2019 spawning biomass to be $0.31B_0$ under the base-case scenario (assuming average recruitment) (Figure 9.55). This was a reduction from the 2015 assessment (Thomson, Day & Tuck 2015), which predicted the spawning biomass to be $0.4B_0$ in 2016. The major changes from the 2015 assessment to the 2018 assessment were new tuning methods (Francis weighting), inclusion of catch data from the Gillnet Hook and Trap Sector and the Small Pelagic Fishery, incorporation of discarded catch estimates from factory trawlers when these vessels had observers under the Integrated Scientific Monitoring Program, removal of the fishery-independent survey abundance index from the base case, and not estimating recruitment in 2015 (AFMA 2018c). The application of the SESSF tier 1 harvest control rule to the base-case scenario (assuming average recruitment) generated an RBC of 942 t for 2019–20 (Burch et al. 2019).

Previous silver warehou assessments (Tuck & Fay 2010) estimated that historical recruitment has been fluctuating around average, with a number of years of high recruitment, resulting in the use of an 'average' recruitment scenario in projections. Subsequent assessments have estimated that recruitment has been mostly below average since 2003, repeatedly revising recent recruitment estimates downwards (AFMA 2018e). The most recent assessment in 2018 (Burch et al. 2019), using data to 2017, confirmed that biomass has been below the target since 2009, and estimated that it declined to near the $0.20B_0$ limit from 2014 to 2017.

The 2018 stock assessment (Burch et al. 2019) undertook projections based on two scenarios of below-average recruitment—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 based on current levels (348 t) was used in projections under these scenarios. Under the assumption of average recruitment (base-case scenario), the return to target is estimated at about 2030, while projections under the poor recruitment scenario indicate that spawning biomass continues to increase, but more slowly than the base case. Under the very poor recruitment scenario, projections show that spawning biomass plateaus at 27% of virgin stock biomass between 2019 and 2023 (AFMA 2018c, e). While the 2018 assessment predicted above-average recruitment, given 'overly optimistic' previous assessments, SERAG agreed to use the 'poor' recruitment scenario to provide RBC advice, which suggested that catches below 600 t would allow the biomass to rebuild (AFMA 2018c, e).

The TAC for 2019–20 was set at 450 t, a reduction of 150 t from the previous fishing season.

FIGURE 9.55 Estimated spawning stock biomass for silver warehou, 1980–2017



Notes: $\mathbf{B}_{CURRENT}$ Current biomass. $\mathbf{B}_{REF}$ Unfished biomass.
Source: Burch et al. 2019

Stock status determination

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

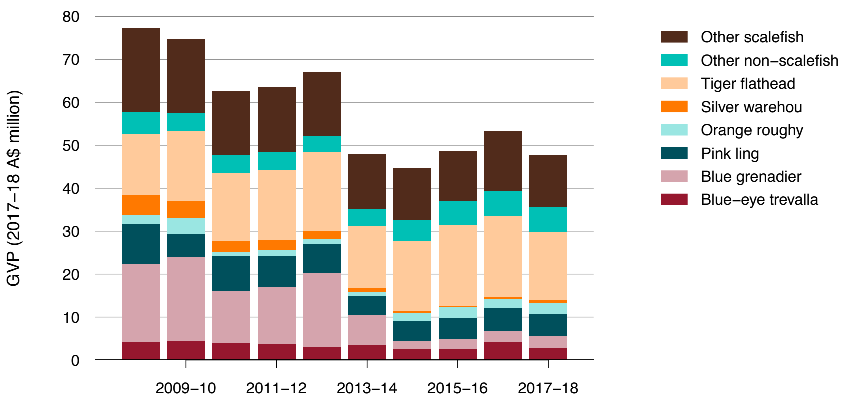
Total landed catch and discards combined were 425.8 t in 2018–19, which was below the RBC of 604 t. Catches below 600 t mean that the biomass is expected to gradually improve, and that the risk of falling below the limit reference point is low. This indicates that, if future biomass is stable and the fishing mortality in 2018–19 is maintained, the stock is unlikely to be depleted to a level below the 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 55% of total SESSF GVP ($76.42 million) in 2017–18. From 2007–08 to 2012–13, real GVP for the two sectors averaged $68.53 million (in 2017–18 dollars; Figure 9.56). By 2013–14, it had fallen, and has since remained below $55 million. Since 2007–08, declines in the value of blue grenadier and silver warehou catches have been the key drivers of the reduction in scalefish GVP. In 2007–08, silver warehou catches were valued at $3.77 million, and blue grenadier catches were valued at $13.44 million. By 2017–18, the GVP of silver warehou catches had declined to $566,000, and blue grenadier catches had declined to $2.80 million. In terms of value during 2017–18, the mix of stocks caught was dominated by tiger flathead ($15.78 million; 33% of total GVP) and pink ling ($5.05 million; 11%).

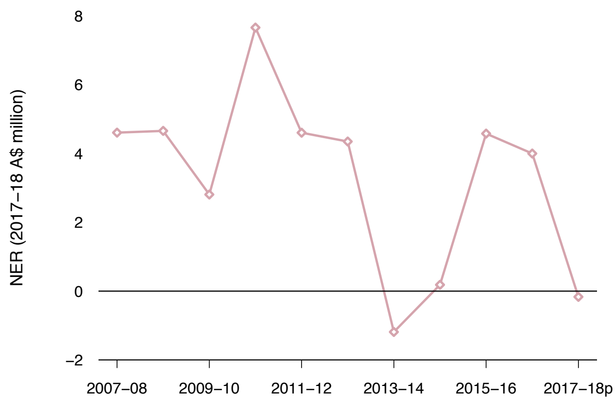
FIGURE 9.56 Real GVP, by key stocks, for the CTS and the SHS, 2008–09 to 2017–18



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

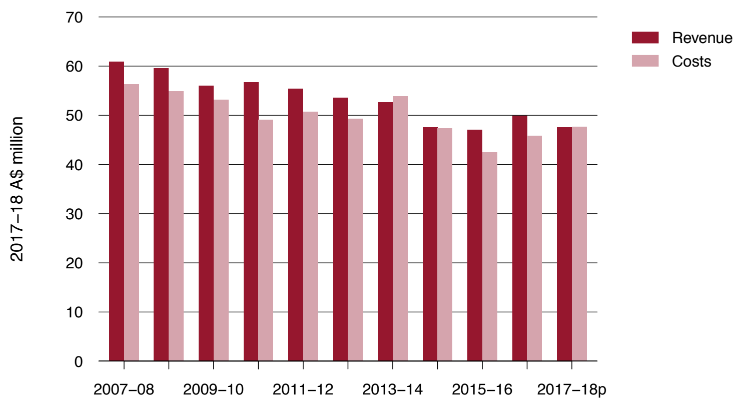
Estimates of net economic returns (NER) associated with scalefish catches for the CTS and the SHS combined are not available, because ABARES undertakes economic surveys of the CTS separately from the SHS (which is surveyed as part of the GHTS). However, with respect to value, the CTS accounts for most of the scalefish catch. ABARES economic surveys of the CTS estimate that NER in the CTS in 2013–14 were –$1.19 million (Bath, Mobsby & Koduah 2018). 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% decline in catch from 2012–13, as well as lower unit prices. NER rose to reach $4.0 million by 2016–17 as a result of a fall in operating costs that exceeded a slight fall in fishing income (Mobsby forthcoming). The increase in NER in this period was supported by improvements in fishers' terms of trade. Preliminary estimates from the survey suggest that NER were –$0.17 million in 2017–18 (Figures 9.57 and 9.58). NER are estimated to have decreased in 2017–18 because lower levels of income to 2016–17 are expected and operating costs are estimated to be higher as a result of higher levels of effort (trawl-hours and shots) in the fishery combined with higher unit fuel prices.

FIGURE 9.57 NER for the CTS, by financial year, 2007–08 to 2017–18



Notes: **NER** Net economic returns. Results for 2017–18 are preliminary, non-survey based estimates.

FIGURE 9.58 Revenue and costs for the CTS, by financial year, 2007–08 to 2017–18



Note: Results for 2017–18 are preliminary, non-survey based estimates.
Source: Mobsby forthcoming

Management arrangements

Stocks in both the CTS and the SHS are managed under ITQs. TACs are set for key target stocks 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 stock level and have not taken account of interactions between stocks caught in the sector. If management settings are based on the maximum economic yield (MEY) of individual stocks, achieving the objective for one stock may be constrained by the management settings targeting the MEY of another stock. Under the revised Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018), all key commercial stocks are required to be managed to a biomass level that achieves overall MEY for the fishery, while byproduct stocks are not required to be managed to MEY. This recognises that it is not feasible to set MEY targets for all species caught in a multispecies fisheries and allows management to focus its efforts on optimising the returns gained from key commercial stocks.

Performance against economic objective

The Commonwealth Fisheries Harvest Strategy Policy allows biomass at MEY (B_{MEY}) targets to be set for key commercial stocks (most often $0.48B_0$). Tiger flathead, blue grenadier, pink ling and blue-eye trevalla were key commercial stocks caught in 2017–18, and accounted for 63% of total scalefish GVP in both sectors in 2017–18. The biomass of these stocks, relative to the respective B_{MEY} targets, therefore provides an indication of performance against the objective of maximising NER.

Of the four key stocks, only tiger flathead has a quantitatively estimated stock-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% 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 2018, an updated stock assessment estimated that the western pink ling stock was $0.84B_0$, which is significantly above the target reference point; however, in the east, the stock was $0.35B_0$, which is below the target reference point. The stock of blue-eye trevalla is between the limit and target reference points. Except for eastern pink ling and blue-eye trevalla, it can be concluded that these four key stocks 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% in the 2013–14 fishing season to 83% in the 2017–18 fishing season and remained high at 81% in the 2018–19 season. This partly reflects a higher TAC for the stock, 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.

The TAC of some key commercial stocks and many byproduct stocks remained undercaught in the 2018–19 season. Exploring the reasons for undercaught TAC in the fishery has been the focus of recent research for the SESSF fishery. Knuckey et al. (2018) provide a range of potential contributing factors to undercaught TAC for the fishery. The study provides an important reference for management to better understand undercaught TACs in the management context for the fishery.

Vessels could use existing technology more efficiently—the median vessel operated at only 64% 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.

Pink ling
Gavin Kewan, AFMA

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Silver trevally
Grant Robinson, AFMA

Chapter 10

East Coast Deepwater Trawl Sector

L Georgeson and R Curtotti

FIGURE 10.1 Area fished in the East Coast Deepwater Trawl Sector 2018–19

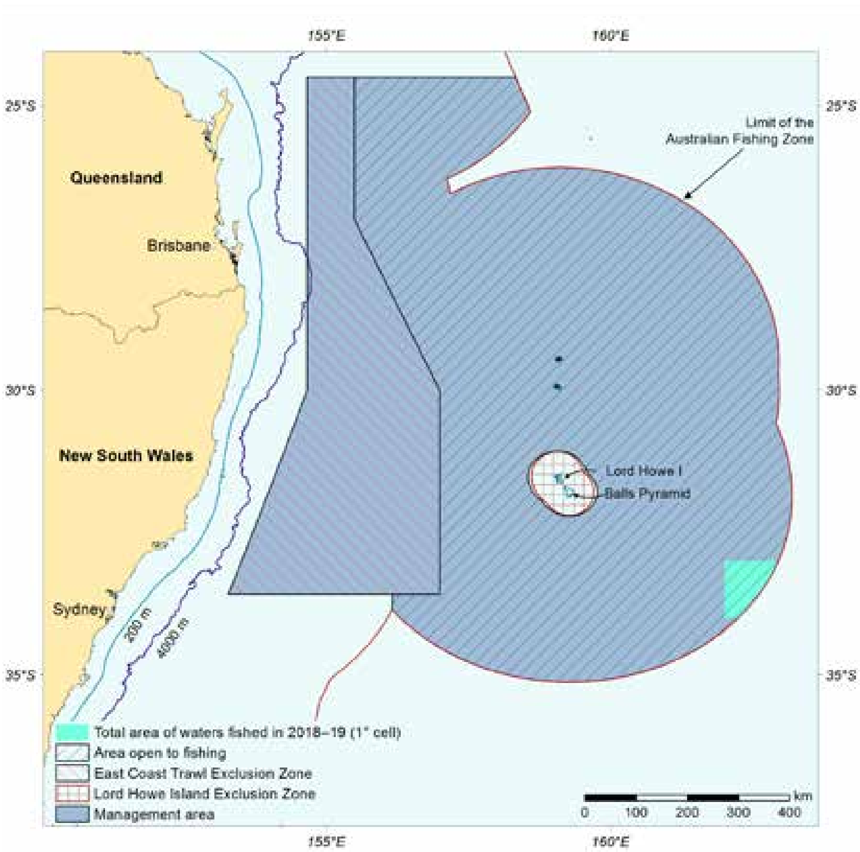


TABLE 10.1 Status of the East Coast Deepwater Trawl Sector

Status	2018		2019		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Alfonsino (*Beryx splendens*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No fishing effort between 2013–14 and 2017–18. Low catch and effort in 2018–19.
Economic status	A high level of latency exists for this fishery. No fishing effort between 2013–14 and 2017–18, and low catches in 2018–19 indicate low net economic returns.				

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

10.1 Description of the fishery

Area fished

The East Coast Deepwater Trawl Sector (ECDTS) is located beyond the 4,000 m isobath of the continental margin off eastern Australia. The ECDTS began as an exploratory fishery in the early 1990s, primarily taking small quantities of orange roughy (*Hoplostethus atlanticus*) and other deepwater species near Lord Howe Rise (Figure 10.1). The northern part of the fishery became part of the Coral Sea Fishery in 1994, and the southern part was amalgamated with the Southern and Eastern Scalefish and Shark Fishery (SESSF) in 2000.

Fishing methods

Operators in the ECDTS are authorised by the Australian Fisheries Management Authority (AFMA) to fish using midwater trawl, demersal otter trawl, Danish seine trawl and pair trawling gears. Fishing in the 1990s mostly targeted orange roughy around Lord Howe Rise. Since 2000, the fishery has targeted mostly alfonsino (*Beryx splendens*). Important byproduct species include blue-eye trevalla (*Hyperoglyphe antarctica*) and boarfish (Pentacerotidae). Boarfish has a catch limit of 200 t to regulate catch, and orange roughy has a 50 t incidental catch limit. If catches exceed these limits, the fishery would be closed for the remainder of the season.

Management methods

The fishery operates in accordance with the SESSF harvest strategy framework (AFMA 2017; see Chapter 8). Fishers must have statutory fishing rights for the Commonwealth Trawl Sector (CTS) to be granted access to the ECDTS. When the SESSF was established, AFMA established permanent trawl exclusion areas to protect the eastern Australian seamounts, and areas around Lord Howe Island and Ball's Pyramid (Figure 10.1).

The ECDTS area is adjacent to Australia's extended continental-shelf jurisdiction (recognised in 2008 under the United Nations Convention on the Law of the Sea). New Zealand and Australian vessels fish in adjacent high-seas waters of the South Pacific Regional Fisheries Management Organisation Convention area. The distributions of most deepwater species taken by this sector extend well beyond the Australian Exclusive Economic Zone (EEZ), extending into the high seas, and across Lord Howe Rise and Challenger Plateau to the New Zealand EEZ.

Fishing effort

Effort during the 1990s was low and variable, with small quantities of orange roughy and other species taken around Lord Howe Rise. Since 2000, when reliable records began, effort has also been variable, with the number of active vessels peaking at six in 2001 (108 trawl-hours) and the level of effort in trawl-hours peaking in 2011 (160 trawl-hours), when only one vessel was active. There was no effort in the fishery between 2013–14 and 2017–18. In the 2018–19 fishing season, one vessel was active in the fishery, with 9 trawl-hours reported. Most of the effort in the fishery since 2000 has been directed at fishing for alfonsino, with smaller quantities of blue-eye trevalla and other species also taken.

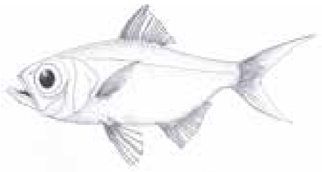
TABLE 10.2 Main features and statistics for the ECDTS

Fishery statistics a	**2017–18 fishing season**			**2018–19 fishing season**	
Stock	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**
Alfonsino	1,017	0	0	1,017	Confidential
Total fishery	**1,267** b	**0**	**0**	**1,267** b	**Confidential**
Fishery-level statistics					
Effort	0			9 trawl-hours	
Fishing permits	10			10	
Active vessels	0			1	
Observer coverage	0			0	
Fishing methods	Demersal and midwater trawl				
Primary landing ports	Sydney (NSW), Brisbane (Qld)				
Management methods	Input controls: limited entry, boat SFRs, permits Output controls: TAC and ITQ (alfonsino); catch or trigger limits (orange roughy, blue-eye trevalla and boarfish)				
Primary markets	Domestic: frozen or chilled				
Management plan	*Southern and Eastern Scalefish and Shark Fishery Management Plan 2003*				

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 May – 30 April. **b** Includes a 200 t non-tradeable catch limit for boarfish and a 50 t incidental catch limit for orange roughy.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch.

10.2 Biological status

Alfonsino (*Beryx splendens*)



Line drawing: William Murray

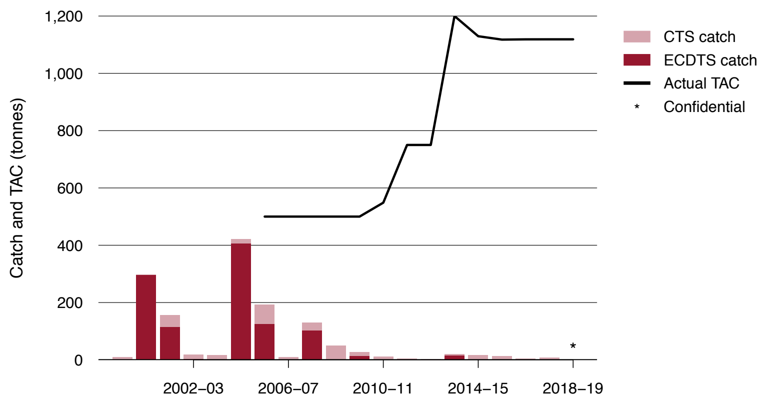
Stock structure

Alfonsino is a widely occurring benthopelagic species that aggregates around seamounts and features on the upper continental slope. Alfonsino in Australia's EEZ is currently managed as a single management unit across the CTS and the ECDTS, with a single total allowable catch (TAC) that applies only within the EEZ. Alfonsino is caught along the continental shelf break in the SESSF and the East Coast Deep Water Zone (ECDWZ). The alfonsino catch in the ECDWZ has largely been taken in an area south-east of Lord Howe Island—approximately half of this area is outside the Australian Fishing Zone (AFZ), effectively straddling both the ECDWZ and the high seas (Morison et al. 2013). The biological stock structure of alfonsino fished in the ECDTS is unknown. It is likely that alfonsino on the northern Lord Howe Rise constitutes a straddling stock, extending from within the Australian EEZ out into the high seas.

Catch history

Fishing in the ECDTS has been intermittent. Catch and catch-per-unit-effort data are sporadic, fluctuating without any clear trend. Catches of alfonsino, the main target species, have been low in most years, usually below 100 t. Catches peaked at 407 t in 2004–05 (Figure 10.2). Zero catch was taken in the ECDTS between 2013–14 and 2017–18, reflecting zero effort. The 2018–19 alfonsino TAC was 1,017 t. Low levels of catch of alfonsino and other species were taken in the 2018–19 fishing season, although these data are withheld, consistent with AFMA's data disclosure policy.

FIGURE 10.2 Catch and TAC for alfonsino in the ECDTS and the CTS, 1999–2000 to 2018–19



Notes: **CTS** Commonwealth Trawl Sector. **TAC** Total allowable catch.

Stock assessment

The limited, patchy and highly variable nature of catch-and-effort data for alfonsino in the ECDTS resulted in the Slope Resource Assessment Group rejecting early attempts at a tier 4 assessment in 2007 and recommending that alfonsino be assessed under tier 3. A 2011 assessment (Klaer 2012) used age-frequency data from length frequencies and otoliths collected in 2007 and 2009. Catch-curve analyses estimated a lower total mortality than previous assessments and indicated that fishing mortality was less than F_{48} (the fishing mortality that would be expected to result in a spawning stock biomass of 48% of the unfished level, on average, in the long term).

The Klaer (2012) assessment was updated in 2013, using catch-at-age data up to 2010 and New Zealand data from the high-seas fishery on northern Lord Howe Rise (Klaer 2013). This assessment produced a total alfonsino recommended biological catch (RBC), including the high seas, of 1,228 t. The AFZ RBC, which was calculated as the total RBC minus the expected future high-seas catch based on average catch for the past four years, was 1,070 t. After applying the 5% tier 3 discount factor, AFMA implemented a three-year TAC of 1,017 t for 2014–15 through to 2016–17, with 10% overcatch and undercatch provisions. This TAC was rolled over for 2017–18 and 2018–19.

The 2013 assessment update estimated current fishing mortality as F_{CURR} = 0.022, well below the estimated F_{RBC} = 0.149 (Klaer 2013).

Stock status determination

The 2013 assessment for alfonsino indicates that, since 2000, fishing mortality has remained below the level that would constitute overfishing and that fishing mortality is well below the target. While there was some catch taken in 2018–19, this was well below the TAC. As a result, this stock is classified as **not subject to overfishing**. Alfonsino catches have remained well below RBC levels since at least 2000. As a result, biomass is unlikely to have been reduced to below the limit reference point. In the absence of any evidence to suggest otherwise, the stock is classified as **not overfished**.

10.3 Economic status

Key economic trends

Estimates of net economic returns (NER) are not available for the ECDTS, and estimates of the sector's gross value of production are confidential. Fishing effort in the ECDTS declined by 85% between 2012–13 and 2013–14, down to eight hours. There was no fishing activity between 2013–14 and 2017–18. Fishing effort was 9 trawl-hours in 2018–19. The long distance to fishing grounds for the CTS fleet and use of trawl gear for targeting this species means that fuel costs are likely to make up a higher proportion of total fishing costs in the ECDTS than for the key CTS fishing grounds. Higher expected profit in the CTS and other fisheries that permit holders operate in may be a key driver of inactivity in the ECDTS.

Management arrangements

Current management arrangements do not appear to be influencing a low participation in the fishery.

Performance against economic objective

The high level of latency, in terms of the proportion of the TAC uncaught, suggests that expected profit in the sector is insufficient to justify fishing effort. No fishing activity between 2013–14 and 2017–18, and low catch in 2018–19 indicate that NER have been low.

The sector's key target species, alfonsino, is currently managed under the SESSF harvest strategy, with a target set to meet the economic objective of the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018).

10.4 Environmental status

The ECDTS has not been assessed separately under AFMA's ecological risk assessment process, but was included in the assessment of the CTS (Chapter 9). Orange roughy was declared conservation-dependent in 2006. The Orange Roughy Conservation Programme (AFMA 2006) was replaced by the Orange Roughy Rebuilding Strategy in 2015 (AFMA 2015). There is no targeted fishing for this species in the ECDTS, and there has been no reported catch in the fishery since 2003.

AFMA publishes quarterly reports of logbook interactions with species protected under the *Environment Protection and Biodiversity Conservation Act 1999* on its website. No interactions with species protected under the Act were reported in the ECDTS for 2018. Interactions with protected species and impacts on benthic habitats are unlikely to be of concern because of zero or low effort in the fishery in recent years.

10.5 References

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—— 2013, 'Yield, total mortality values and tier 3 estimates for selected shelf and slope species in the SESSF 2012', in GN Tuck (ed.), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2012*, part 2, AFMA & CSIRO Marine and Atmospheric Research, Hobart.

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Alfonsino
Lee Georgeson, ABARES

Chapter 11

Great Australian Bight Trawl Sector

A Moore, N Mazloumi and D Mobsby

FIGURE 11.1 Relative fishing intensity in the Great Australian Bight Trawl Sector, 2018–19 fishing season

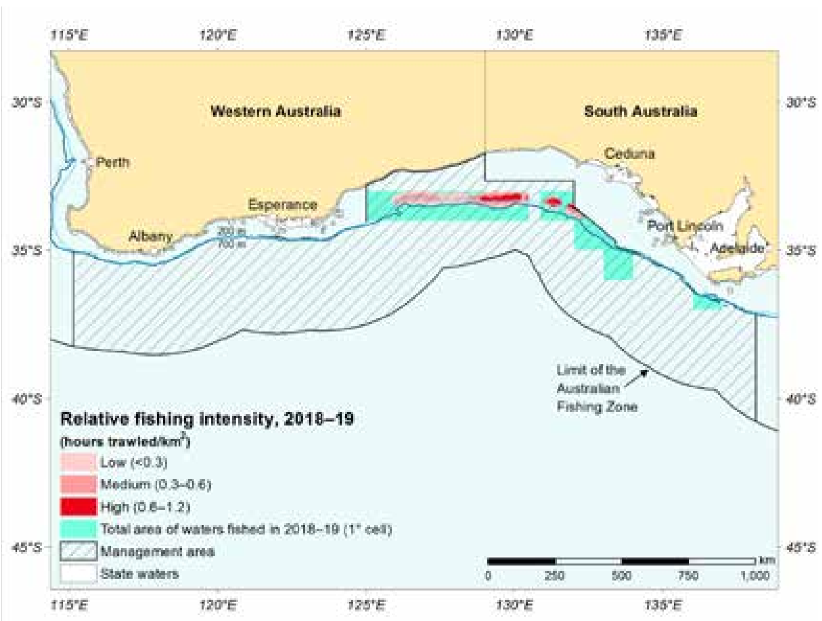


TABLE 11.1 Status of the Great Australian Bight Trawl Sector

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Bight redfish (*Centroberyx gerrardi*)					Catch is below RBC. Estimate of current biomass is above the target.
Deepwater flathead (*Platycephalus conatus*)					Catch is below RBC. Estimate of current biomass is near the target.
Ocean jacket (*Nelusetta ayraud*)					Catch has been stable in recent years. No formal assessment. Fishery-independent survey data indicate stock is not overfished.
Orange roughy (*Hoplostethus atlanticus*)					No commercial catch. No formal assessment of biomass, and impact of historical catches is uncertain.
Economic status	A significant increase in fuel price, together with lower gross value of production and catch volumes, indicate that net economic returns are likely to have been lower in 2017–18 and 2018–19 than in 2016–17.				

Note: **RBC** Recommended biological catch.

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

Birds on a baffler boom
AFMA

11.1 Description of the fishery

Area fished

The former Great Australian Bight Trawl Fishery was amalgamated with the Southern and Eastern Scalefish and Shark Fishery (SESSF) in 2003 to become the Great Australian Bight Trawl Sector (GABTS; Figure 11.1) of the SESSF.

The GABTS can be divided into a continental-shelf fishery (at depths of less than 200 m), an upper continental-slope fishery (at depths of about 200–700 m) and a deepwater fishery (on the mid-slope to lower slope, depth 700–1,000 m).

Fishing methods and key species

The fishing methods used in the GABTS are otter trawl and Danish-seine; pair trawling has been trialled in the past. In shelf waters, trawling is usually at depths of 120–200 m, targeting mainly deepwater flathead (*Platycephalus conatus*) and bight redfish (*Centroberyx gerrardi*). The shelf fishery operates all year. For upper continental–slope trawling, target species include blue grenadier (*Macruronus novaezelandiae*), western gemfish (*Rexea solandri*) and pink ling (*Genypterus blacodes*). Ocean jacket (*Nelusetta ayraud*) is an important byproduct species, with 170 t landed in 2018–19. Other byproduct species include angel shark (*Squatina* spp.), yellow-spotted boarfish (*Paristiopterus gallipavo*), latchet (*Pterygotrigla polyommata*) and jackass morwong (*Nemadactylus macropterus*). Danish-seine targets deepwater flathead on the continental shelf.

Management methods

The Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) and the SESSF Harvest Strategy Framework (AFMA 2019) both apply to the key species in the GABTS (see Chapter 8). Under the framework, recommended biological catches (RBCs) are usually based on achieving a default target reference point of 48% of the unfished biomass ($0.48B_0$), as a proxy for the biomass producing maximum economic yield (B_{MEY}). However, a bio-economic model (Kompas et al. 2012) estimated B_{MEY} target reference points of $0.43B_0$ for deepwater flathead and $0.41B_0$ for bight redfish in the GABTS. These estimated B_{MEY} targets were used by the Australian Fisheries Management Authority (AFMA) Commission to set the total allowable catch (TAC) for bight redfish and deepwater flathead for the 2018–19 fishing season.

Fishing effort

In 2018–19, total trawl fishing effort across all depths was 12,086 hours, down from the 2004–05 peak of 30,866 hours. The continental shelf continues to be the focus of fishing effort, with 10,954 trawl-hours in 2018–19 (Figure 11.2) compared with 1,132 trawl-hours on the continental slope (Figure 11.3).

The deepwater fishery historically targeted orange roughy (*Hoplostethus atlanticus*). However, since 2007, when most of the historical orange roughy fishing grounds were closed under the Orange Roughy Conservation Programme (AFMA 2006), little effort has occurred at these depths.

There are 10 boat statutory fishing rights in the sector that allow a boat to fish in the fishery, and separate quota statutory fishing rights that allow quota species to be landed. Four trawl vessels and one Danish-seine vessel operated in the fishery in 2018–19.

Catch

Reduced effort in the fishery has led to reduced catches of key target species over time. Deepwater flathead continues to dominate catches, with 529 t landed in the 2018–19 fishing season, which was 47% of the TAC (1,128 t in 2018–19). Bight redfish landings in 2018–19 were 220 t, which was 36% of the TAC (600 t in 2018–19).

FIGURE 11.2 Catch and effort on the GABTS shelf, 1988–89 to 2018–19

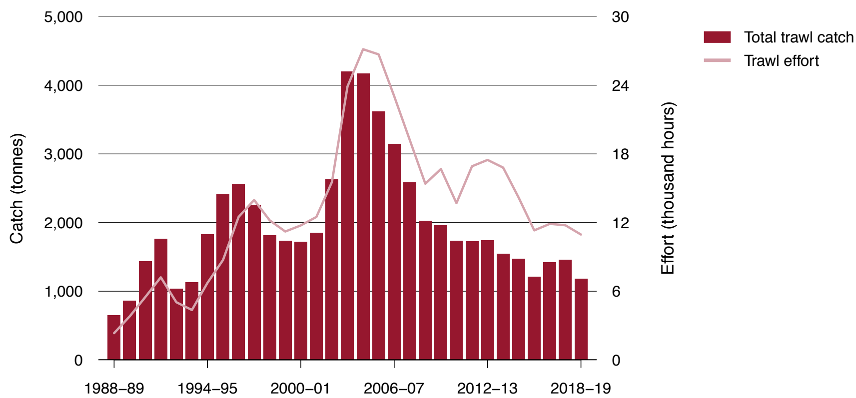


FIGURE 11.3 Catch and effort on the GABTS slope, 1988–89 to 2018–19

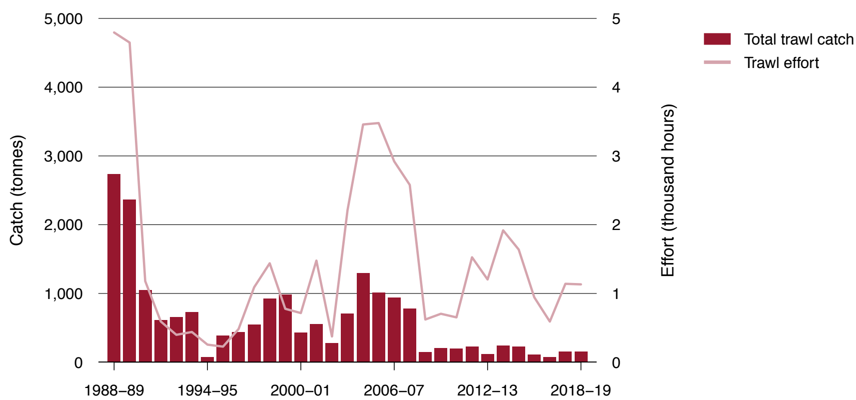


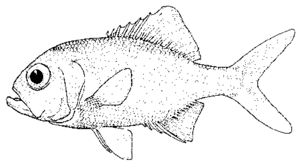
TABLE 11.2 Main features and statistics for the GABTS

Fishery statistics a	2017–18 fishing season			2018–19 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**
Bight redfish	800	308	$1.30 million	600	220	na
Deepwater flathead	1,128	548	$4.57 million	1,128	529	na
Ocean jacket	–	193	$0.27 million	–	170	na
Orange roughy **b**	0 (200, 50)	0 (0, 0)	$0.10 million	0 (200, 50)	0 (0, 0)	na
Total	**1,928**	1,049	**$9.16 million**	**1,928**	**919**	**na**
Fishery-level statistics						
Effort	12,905 trawl-hours; 442 shots			12,421 trawl-hours; 451 shots		
Fishing permits	10			10		
Active vessels	4 trawl; 1 seine			4 trawl; 1 seine		
Observer coverage	250 trawl-hours (1.80%)			358 trawl-hours (2.88%)		
Fishing methods	Danish-seine, trawl					
Primary landing ports	Adelaide, Port Lincoln, Thevenard (South Australia)					
Management methods	Input controls: limited entry, area closures, gear restrictions Output controls: ITQs, TACs, trigger limits					
Primary markets	Domestic: Melbourne, Perth, Sydney					
Management plan	*Southern and Eastern Scalefish and Shark Fishery Management Plan 2003*					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 May – 30 April. Value statistics are by financial year and were not available for the 2018–19 financial year at time of publication. **b** A 200 t research quota and a 50 t bycatch TAC in the Albany and Esperance zones are not included in the total catch.
Notes: **GVP** gross value of production. **ITQ** Individual transferable quota. **na** Not available. **TAC** Total allowable catch. – Not applicable.

11.2 Biological status

Bight redfish (*Centroberyx gerrardi*)



Line drawing: FAO

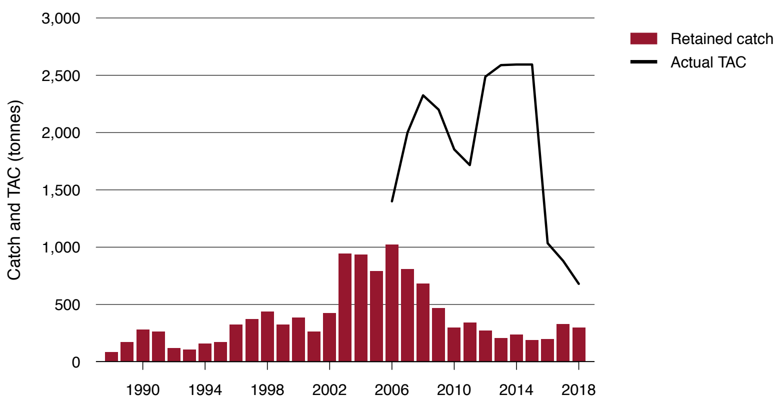
Stock structure

The biological stock structure of bight redfish in the GABTS is unknown. A single biological stock is assumed for assessment and management purposes.

Catch history

Catch of bight redfish in the GABTS increased to 572 t in 2003–04, before almost doubling after the temporary introduction of additional vessels in the fishery, which included a freezer trawler. Catch reached a peak of 1,407 t in 2007–08. Most of the additional vessels left the fishery by 2008, and effort decreased to around half of peak levels. Landed catch in the 2018–19 fishing season was 220 t (Figure 11.4).

FIGURE 11.4 Bight redfish annual catches and fishing season TACs in the GABTS, 1988–2018



Note: **TAC** Total allowable catch.

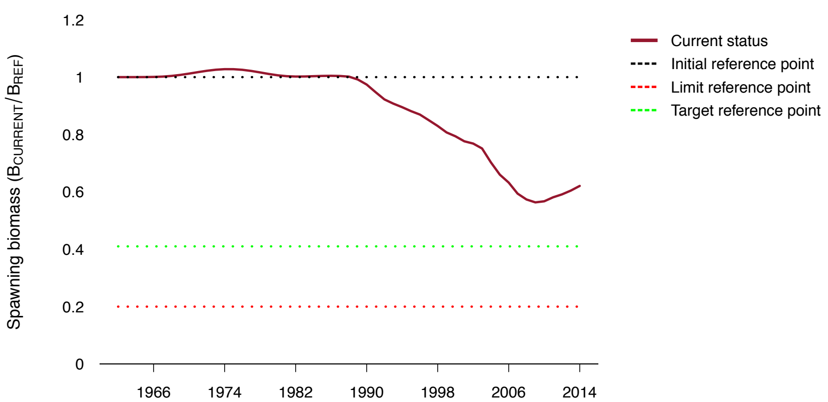
Stock assessment

The target reference point for bight redfish of 41% of the unfished spawning stock biomass ($0.41SB_0$; Kompas et al. 2012) was accepted by the Great Australian Bight Resource Assessment Group (GABRAG) in 2011 (AFMA 2011). The 2011 tier 1 stock assessment for bight redfish (Klaer 2011) was updated in 2015 (Haddon 2015). The base-case assessment predicted the female spawning biomass at the start of 2015–16 to be 63% of unexploited female spawning stock biomass and above the target reference point of $0.41SB_0$. The unexploited female spawning biomass was estimated to be 5,451 t. The large reduction in the estimate of female spawning biomass from the 2011 assessment (26,210 t) reflects that the data now available for the updated assessment are more informative about the unfished biomass and the effects of fishing (Figure 11.5).

Fishery-independent trawl surveys undertaken each year between 2006 and 2011 (except for 2010) estimated relative abundance of the main target and byproduct species on the shelf (Knuckey & Hudson 2007; Knuckey, Hudson & Koopman 2008; Knuckey, Koopman & Hudson 2009, 2011). A fishery-independent trawl survey in 2015 estimated that the relative biomass of bight redfish (2,573 t; coefficient of variation [CV] 0.28) had decreased 80% from the previous 2011 estimate (13,189 t; CV 0.13). The GABTS industry has noted a decrease in the availability of bight redfish in recent seasons. Length-frequency data suggest a truncation of larger bight redfish between 2011 and 2013. Ageing data also indicate a reduction in the abundance of older redfish in recent years.

The updated stock assessment (Haddon 2015) produced an RBC under the 20:35:41 harvest control rule of 862 t for the 2016–17 fishing season and a long-term average RBC of 797 t. The 2018–19 season was the third year of a five-year bight redfish TAC that was set at 600 t in 2018–19.

FIGURE 11.5 Estimated spawning biomass of bight redfish in the GABTS, 1962–2014

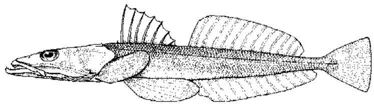


Source: Haddon 2015

Stock status determination

The 2015 stock assessment predicted female spawning biomass to be 63% of unfished levels and above the target reference point of $0.41B_0$. Catch in recent seasons continues to be well below RBCs. On this basis, bight redfish is classified as **not overfished** and **not subject to overfishing**.

Deepwater flathead (*Platycephalus conatus*)



Line drawing: Karina Hansen

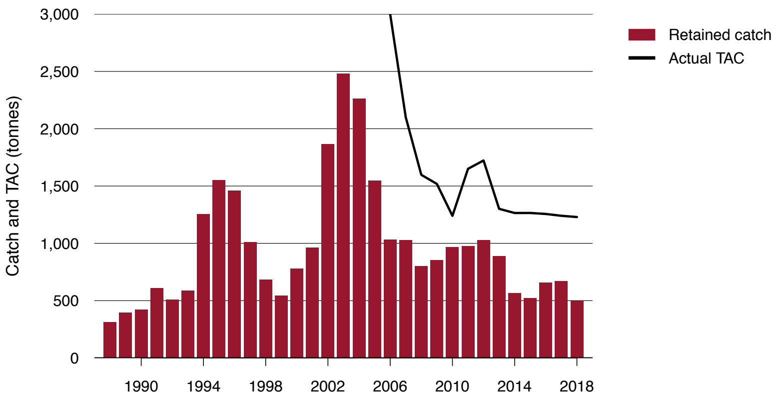
Stock structure

The biological stock structure of deepwater flathead in the GABTS is unknown. A single biological stock is assumed for assessment and management purposes.

Catch history

Catch of deepwater flathead peaked at 2,629 t in 2004, and has been relatively stable at, or at less than, 1,000 t since 2008–09. Landed catch in the 2017–18 fishing season was 548 t (Figure 11.6).

FIGURE 11.6 Deepwater flathead annual catches and fishing season TACs in the GABTS, 1988–2018



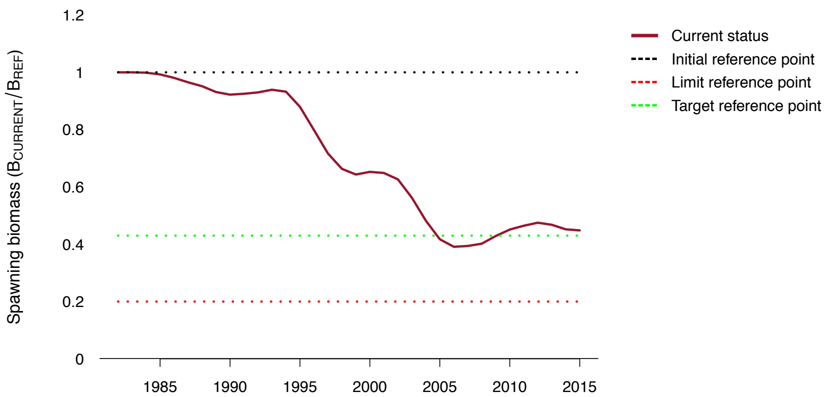
Note: **TAC** Total allowable catch.

Stock assessment

The target reference point for deepwater flathead of $0.43SB_0$ (Kompas et al. 2012) was accepted by GABRAG in 2011 (AFMA 2011). The 2013 tier 1 stock assessment for deepwater flathead (Klaer 2013) was updated in 2016 (Haddon 2016). The 2016 base-case assessment predicted the female spawning biomass at the start of 2016–17 to be 45% of unexploited female spawning stock biomass, above the target reference point of $0.43SB_0$ (Figure 11.7). The unexploited female spawning biomass in 2016–17 was estimated to be 4,993 t. Application of the 20:35:43 harvest control rule produced an RBC for 2017–18 of 1,155 t and a long-term RBC of 1,093 t. A TAC of 1,128 t was retained for the 2018–19 fishing season.

The results of the 2015 fishery-independent trawl survey (Knuckey, Koopman & Hudson 2015) suggested that, in 2014–15, estimated relative biomass of deepwater flathead decreased to 5,065 t (CV 0.09) from 9,227 t (CV 0.05) in the 2010–11 survey—a 45% reduction (Knuckey, Koopman & Hudson 2009, 2011, 2015). However, the updated stock assessment suggested no change in depletion level between 2013 and 2016 (Haddon 2016), although the estimate of unexploited female spawning stock biomass had decreased from 9,320 t to 4,993 t. The GABTS industry has noted a decrease in availability of deepwater flathead in recent seasons, which correlates with decreasing catch. There is no evidence of a truncation in size or age structure of deepwater flathead (Haddon 2016).

FIGURE 11.7 Estimated spawning biomass of deepwater flathead in the GABTS, 1982–2015

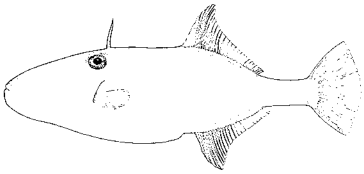


Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Haddon 2016

Stock status determination

The 2016 stock assessment predicted spawning biomass to be at 45% of the unfished levels in 2016–17 and above the target reference point of $0.43SB_0$. Catch continues to be below the RBC. On this basis, deepwater flathead is classified as **not overfished** and **not subject to overfishing**.

Ocean jacket (*Nelusetta ayraud*)



Line drawing: FAO

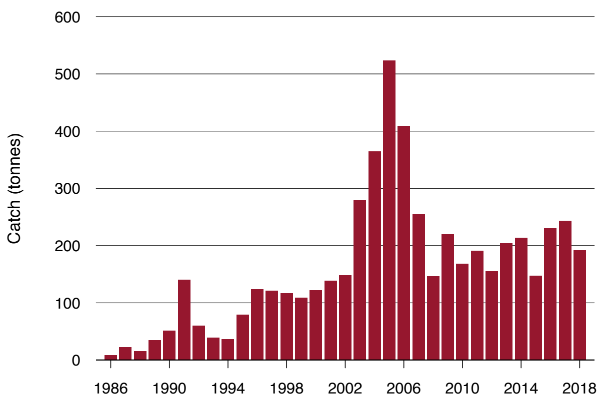
Stock structure

The biological stock structure of ocean jacket is unknown. In the GABTS, it is assessed as a separate stock from the stock in the Commonwealth Trawl and Scalefish Hook sectors.

Catch history

Landed catch of ocean jacket peaked in 2005 at 527 t. It has decreased since then, and has been less than 250 t since 2008–09 (Figure 11.8). Landed catch in the 2018–19 fishing season was 170 t.

FIGURE 11.8 Ocean jacket catch in the GABTS, 1986–2018



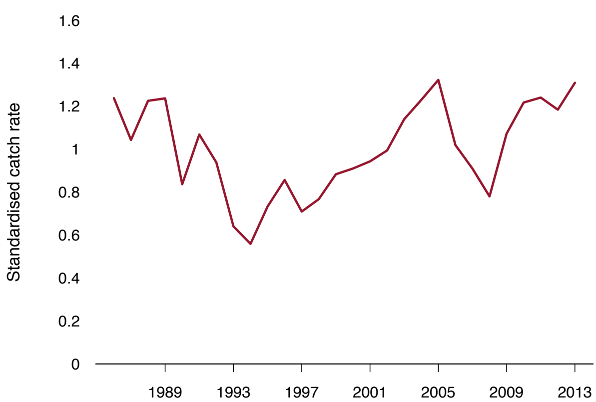
Stock assessment

Formal stock assessments are not conducted for ocean jacket in the GABTS. Standardised catch rates have been variable; the most recent catch rates were similar to those at the start of the series (1986) (Sporcic & Haddon 2015; Figure 11.9).

Ocean jacket represented 16–35% of survey catch by weight in the 2006, 2008, 2009 and 2011 fishery-independent trawl surveys, with an increase in relative abundance between 2009 and 2011 (Knuckey & Hudson 2007; Knuckey, Hudson & Koopman 2008; Knuckey, Koopman & Hudson 2009, 2011). Ocean jacket represented 7% of the catch in the 2015 fishery-independent trawl survey, with an estimated relative biomass of 3,702 t (CV 0.19) (Knuckey, Koopman & Hudson 2015) compared with 27,712 t (CV 0.20) in 2011. A bycatch survey of the GABTS in 2002 indicated that ocean jacket is often discarded (Knuckey & Brown 2002), potentially limiting the use of commercial catch-per-unit-effort as an index of abundance for this species.

Ocean jacket is a relatively short-lived species (approximately six years), reaching maturity within 2–3 years. Large cyclical changes in abundance appear to have occurred off eastern Australia (Miller & Stewart 2009). Historical catch data suggest that ocean jacket was fished down off the east coast of Australia in the 1920s and 1950s (Klaer 2001). There are no age data for ocean jacket from the GABTS, and the available historical length-frequency data are too old to be used as an index of abundance.

FIGURE 11.9 Standardised catch rate for ocean jacket in the GABTS, 1986–2013

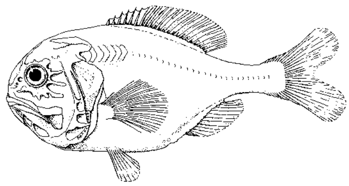


Source: Sporcic & Haddon 2015

Stock status determination

No formal stock assessment for ocean jacket in the GABTS has been done. However, a history of relatively low catches and life-history characteristics that lead to large changes in abundance irrespective of fishing suggest that it is unlikely that the stock is overfished. The level of catch in 2018–19 is unlikely to constitute overfishing. On this basis, ocean jacket in the GABTS is classified as **not overfished** and **not subject to overfishing**.

Orange roughy (*Hoplostethus altanticus*)



Line drawing: Rosalind Murray

Stock structure

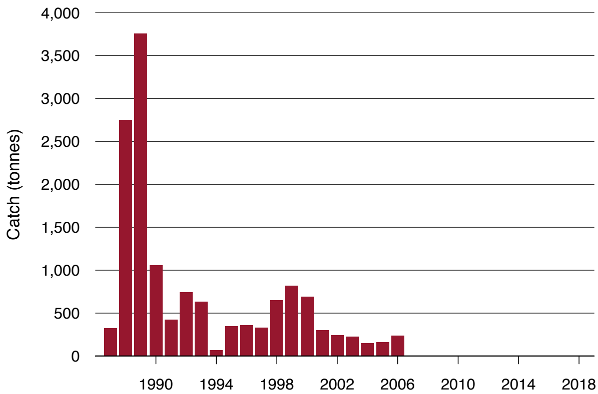
The stock structure of orange roughy in the Australian Fishing Zone (AFZ) is unresolved. Based on the existing data and fishery dynamics, multiple regional stocks of orange roughy are assumed, and the fishery is managed and assessed as a number of discrete regional management units, shown in Figure 9.33 (Chapter 9).

Gonçalves da Silva, Appleyard & Upston (2012) examined variation in a large number of loci using genetic techniques that can detect low levels of genetic differentiation. The study concluded that orange roughy in the AFZ 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).

Catch history

Catch of orange roughy in the GABTS peaked at 3,757 t in 1988–89 and then declined (Figure 11.10). Since 1990, most of the GABTS catch has come from grounds off Albany and Esperance in the western part of the fishery. Early fishery-independent trawl surveys on the continental slope in the Great Australian Bight reported that orange roughy had the highest maximum catch rate (1,820 kg/hr) of any slope species at that time (Newton & Klaer 1991). The highest catch rates came from the locations of the original aggregations off Kangaroo Island and Port Lincoln, although the surveys found no large aggregations comparable with the historical aggregations. It seems likely that orange roughy across the Great Australian Bight has been depleted, with no large aggregation being seen since 1990. However, the actual level of depletion is unknown. Catch was zero between 2008–09 and 2011–12, and negligible thereafter. No catch was reported in the 2018–19 fishing season.

FIGURE 11.10 Orange roughy catch in the GABTS, 1987–2018



Stock assessment

No quantitative stock assessment has been conducted for orange roughy in the GABTS because the available data are sporadic and spatially scattered (Knuckey, Hudson & Nemec 2010).

Early catches were reported as coming from temporary feeding aggregations associated with cold-water upwelling off Kangaroo Island and Port Lincoln. Catches from these aggregations ranged from 2,500 to 3,784 t (Newton 1989). Aggregations have not been found in the same locations since then (Wayte 2004). A spawning aggregation was discovered in 1990 on a ridge 30 nautical miles from the Port Lincoln grounds (Newton & Tuner 1990). This aggregation, which has not been seen since, initially supported trawl catches of around 40 t/shot, typical of lightly exploited orange roughy fisheries, but only yielded a total catch of 800 t before being depleted.

Orange roughy was listed as conservation-dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2006. A deep-water management strategy was implemented to address the requirements of the Orange Roughy Conservation Programme (AFMA 2006), under which commercial fishing was closed in several orange roughy zones across the Great Australian Bight, particularly the areas deeper than 700 m. More than 96% of the historical catch (1988–2005) and more than 99% of the more recent catch (2001–2005) was taken in these closed zones. Until sustainable harvest levels can be determined, fishing will be allowed in these zones only under a research program that has been approved by AFMA. The orange roughy incidental catch allowance remained at 50 t for the 2018–19 fishing season, with zero reported catch. The 2006 Orange Roughy Conservation Programme was replaced by the Orange Roughy Rebuilding Strategy in 2014 (AFMA 2014). Existing arrangements in the GABTS fishery have been maintained under the updated rebuilding strategy.

Stock status determination

No recent survey or representative catch-trend data are available to determine the abundance of orange roughy in the Great Australian Bight. As a result, the level of biomass of this stock is classified as **uncertain**. Given that zero or negligible orange roughy catch has been reported in recent years, and that areas where more than 96% of historical catches were taken are now closed, orange roughy is classified as **not subject to overfishing**.

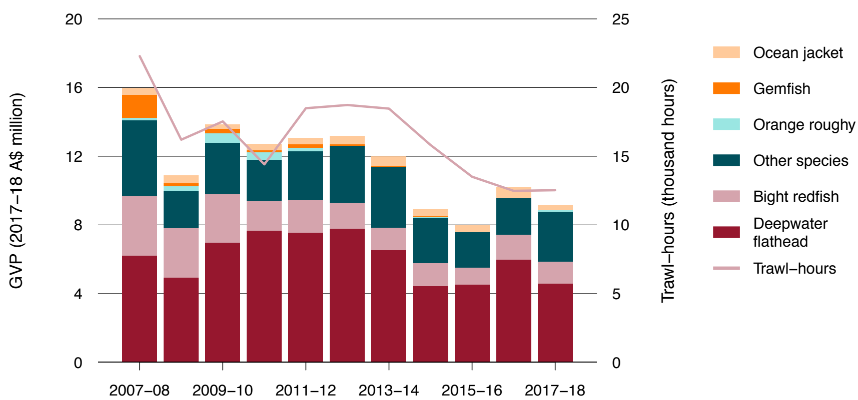
11.3 Economic status

Key economic trends

The gross value of production (GVP) in real terms (measured in 2017–18 dollars) for the GABTS decreased from $16.0 million in 2007–08 to $9.2 million in 2017–18 (Figure 11.11). Reductions in the catch resulted in real GVP declining substantially in 2008–09, falling to $10.9 million. Since 2009–10, there has been a trend of declining GVP, which has been the result of a similar declining trend in landed catch. Changes in hours trawled have generally been closely related to changes in GVP over the period 2007–08 to 2017–18 (Figure 11.11). Hours trawled in the sector decreased by 54% from 2007–08 to 2017–18, while GVP declined by 66% in real terms.

GVP declined by 9% in 2017–18, which was largely the result of reduced catch volume, particularly of deepwater flathead—a key commercial stock in the sector. In 2017–18, the value of deepwater flathead catch declined by 22% to $4.57 million (50% of total GVP), and bight redfish (the second most valuable stock caught in the sector) contributed $1.3 million (14% of total GVP).

FIGURE 11.11 Real GVP for the GABTS by key stock and trawl-hours, 2007–08 to 2017–18



Notes: **GVP** Gross value of production. Trawl-hours do not include Danish-seine effort. One Danish-seine vessel was active from 2012–13 to 2017–18.

Management arrangements

Like other SESSF sectors, the GABTS is a limited-entry fishery managed under TACs for key commercial stocks, allocated as individual transferable quotas. During the 2017–18 and the 2018–19 fishing seasons, there was a high level of quota latency for the two primary stocks caught in the sector. For the 2017–18 fishing season, 548 t of deepwater flathead was caught (49% of the 1,128 t TAC), and 308 t of bight redfish was caught (39% of the 800 t TAC). For the 2018–19 fishing season, 529 t of deepwater flathead was caught (47% of the 1,128 t TAC), and 220 t of bight redfish was caught (37% of the 600 t TAC). Market prices for bight redfish are sensitive to supply (Kompas et al. 2012), so the high level of latency may be partly explained by fishers not wanting to land large volumes of bight redfish that could drive down the market price. For this reason, the industry has voluntary trip limits in place for bight redfish.

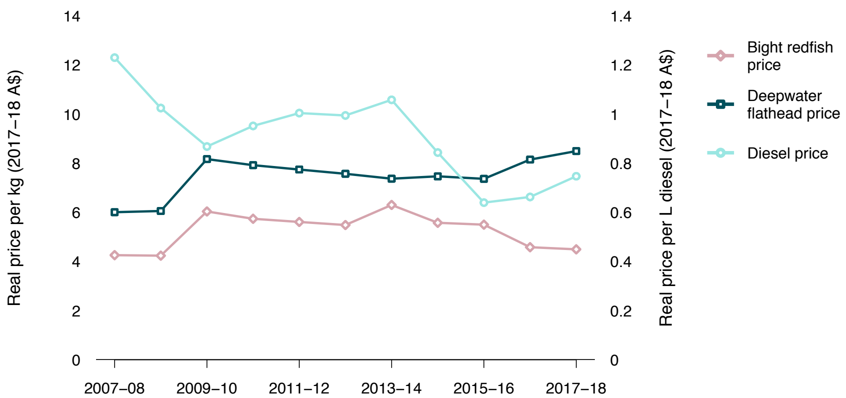
The GABTS began a trial of fishery co-management in July 2009 (AFMA 2012a). This has seen the Great Australian Bight Fishing Industry Association take a greater role in management decisions, including making direct operational recommendations to AFMA, improving fisheries data collection, developing a chain-of-custody process to improve product traceability and developing a boat-operating procedures manual. Such an approach should be associated with improvements in the cost, efficiency and adaptability of management (FRDC 2008). The trial of co-management arrangements received positive feedback from those operating in the GABTS (GABMAC 2010), and these arrangements have been maintained in the sector.

Performance against economic objective

Trawling—the main method used in the sector—is typically fuel-intensive. Fluctuations in the price of fuel are therefore likely to be a key driver of sector profitability. The Australian average off-road diesel price fell sharply between 2014–15 and 2015–16, but has since trended upwards (Figure 11.12). In 2017–18, the average off-road diesel price increased by 15%, while total trawl-hours declined by only 3%. In 2018–19, the average off-road diesel price continued its upward trend, increasing by a further 15%, and total trawl-hours declined by a further 6%.

Estimates of net economic returns (NER) for the GABTS are not available. However, a significant increase in fuel price, despite a moderate reduction in fishing hours, together with lower GVP in 2017–18 and lower catch of bight redfish and deepwater flathead in 2018–19, indicate that NER are likely to have been lower in 2017–18 and 2018–19 than in 2016–17.

FIGURE 11.12 Annual average prices for deepwater flathead and bight redfish, and annual average off-road diesel price, 2007–08 to 2017–18



Note: The off-road diesel price is the price per litre paid by farmers (excludes goods and services tax).

The most recent stock assessments for bight redfish projected biomass levels at the start of 2014–15 to be above the target (Haddon 2015), potentially allowing increased profits from the stock as it is fished down to its MEY target reference point. Similarly, the latest assessment for deepwater flathead indicates that the stock is also slightly above the MEY target (Haddon 2016). Hence, it is unlikely that fishery profitability is constrained by stock size.

Estimates of specific bio-economic target reference points for the two key stocks have improved the ability to manage stocks at levels that maximise NER. However, as noted by Kompas et al. (2012), the accuracy of the target for each stock could be improved with information on how prices for each stock are influenced by catch levels. Taking these factors into account in the setting of target reference points for each stock would allow an improved assessment of economic performance.

11.4 Environmental status

The GABTS ecological risk management report (AFMA 2008, 2012b, 2015) indicated that two byproduct invertebrate species groups—cuttlefish (various species) and octopods (various species)—were at high risk in this fishery (level 2 Residual Risk Assessment). However, this risk determination primarily reflected uncertainty resulting from a lack of data. The level 3 Sustainability Assessment for Fishing Effects excluded invertebrates and indicated that fishing mortality did not exceed the reference point for any of the 204 vertebrate species assessed (Zhou, Smith & Fuller 2007). Impacts on bycatch species have been further reduced by a decrease in effort and closures in the fishery.

As part of their boat-specific seabird management plans, vessels are required to use effective seabird mitigation devices. In late 2014, AFMA completed a trial, using observers, to test the effect of seabird mitigation devices on seabird interactions with otter trawlers. The trial showed that the use of warp deflectors (large floats attached in front of trawl warps to scare birds away—often called 'pinkies') reduced heavy contact between actively feeding seabirds and warp wires by around 75% (Pierre, Gerner & Penrose 2014). Based on the outcomes of the trial, AFMA mandated a minimum requirement in seabird management plans of 600 mm pinkies.

The South East Trawl Fishing Industry Association has also introduced a code of conduct and a training program to improve seabird avoidance measures. In June 2016, a trial of alternative seabird mitigation devices, including water sprayers and bird bafflers, was completed. Water sprayers and bird bafflers used in the trial reduced interactions between seabirds and the warp by 58.9% and 83.7%, respectively, when compared with the warp deflector or 'pinkie' (Koopman et al. 2018). This potentially represents an overall decrease in heavy interactions of 90% (water sprayer) and 96% (bafflers) compared with using no mitigation device at all. Following the success of this trial, AFMA announced that from 1 May 2017 all vessels in the Commonwealth Trawl Sector and GABTS fisheries must use one of the following mitigation devices: sprayers, bird bafflers or pinkies with zero discharge of fish waste.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in the GABTS in 2018.

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Chapter 12

Shark Gillnet and Shark Hook sectors

T Emery, J Woodhams and R Curtotti

FIGURE 12.1 Relative fishing intensity in (a) the Shark Gillnet Sector and (b) the Shark Hook Sector of the Southern and Eastern Scalefish and Shark Fishery, 2018–19 fishing season

(a)

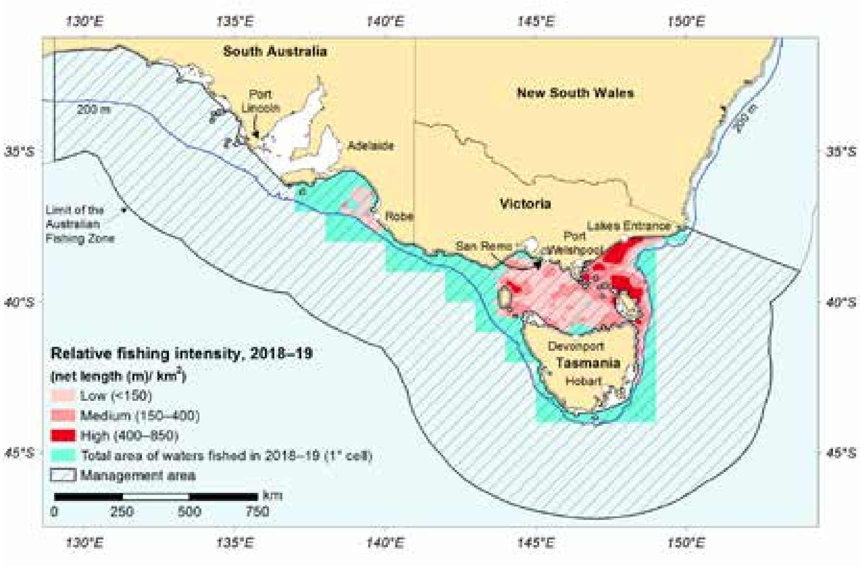
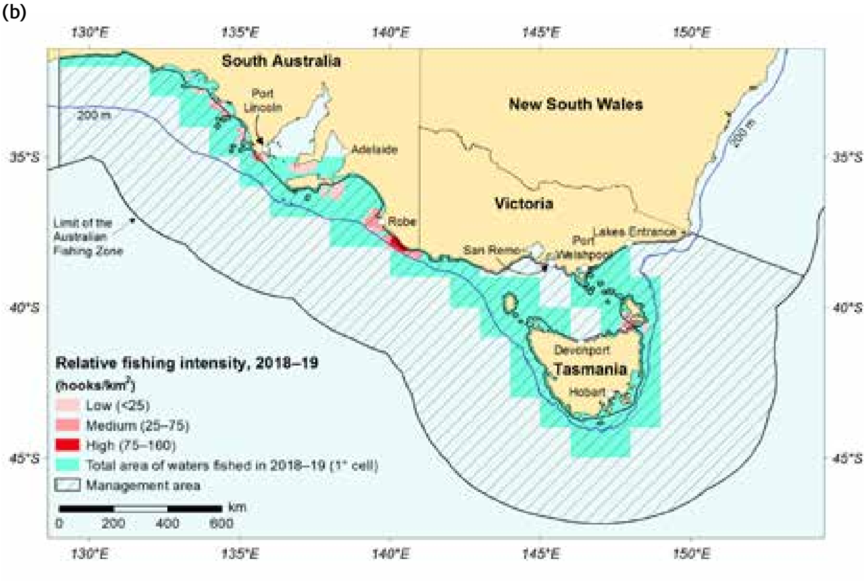


FIGURE 12.1 Relative fishing intensity in (a) the Shark Gillnet Sector and (b) the Shark Hook Sector of the Southern and Eastern Scalefish and Shark Fishery, 2018–19 fishing season continued

(b)



Measuring gillnet
Dylan Maskey, AFMA

TABLE 12.1 Status of the Shark Gillnet and Shark Hook sectors

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Elephantfish (*Callorhinchus milii*)					Standardised CPUE remains relatively stable and above the limit reference point, indicating stability in biomass and fishing mortality.
Gummy shark (*Mustelus antarcticus*)					Catch is below RBC. Estimates of pup production are close to, or above, the target reference point.
Sawsharks (*Pristiophorus cirratus*, *P. nudipinnis*)					CPUE is above the target reference point; catch is below RBC.
School shark (*Galeorhinus galeus*)					Uncertain if fishing mortality in 2018–19 will allow recovery within the specified time frame. Biomass is likely to remain below 20% of unexploited levels.
Economic status a	NER were –$3.9 million in 2014–15. Preliminary estimates for 2015–16 and 2016–17 indicate that NER are likely to become positive. Although gummy shark biomass is not constraining NER, the management of non-target species and marine mammal interactions has likely contributed to low NER in recent years.				

a NER refer to the entire Gillnet, Hook and Trap Sector; therefore, this figure includes scalefish. Shark species account for around 70% of total Gillnet, Hook and Trap Sector gross value of production.
Notes: CPUE Catch-per-unit-effort. NER Net economic returns. RBC Recommended biological catch.

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

12.1 Description of the fishery

Area fished

The Shark Gillnet and Shark Hook sectors (SGSHS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF) extend south from the New South Wales – Victoria border, around Tasmania, and west to the South Australia – Western Australia border. Most fishing occurs in waters adjacent to the coastline and throughout Bass Strait (Figure 12.1).

Fishing methods and key species

The SGSHS uses demersal gillnet and longline to target gummy shark (*Mustelus antarcticus*). School shark (*Galeorhinus galeus*), elephantfish (*Callorhinchus milii*) and sawsharks (*Pristiophorus cirratus* and *P. nudipinnis*) are byproducts from the gummy shark fishery. School shark was historically the primary target species in the fishery, but biomass was reduced below the limit reference point around 1990. Although overfished, school shark is the second most economically important species in the fishery.

Other important byproduct species (by weight) are snapper (*Chrysophrys auratus*), whiskery shark (*Furgaleus macki*), broadnose sevengill shark (*Notorynchus cepedianus*), bronze whaler (*Carcharhinus brachyurus*), draughtboard shark (*Cephaloscyllium laticeps*) and blue morwong (*Nemadactylus valenciennesi*).

Management methods

The fishery is managed using a combination of input controls (gear restrictions and closed areas) and output controls (individual transferable quotas and limits on the proportion of school shark to gummy shark catch). The four principle commercial stocks taken in the SGSHS are managed under the SESSF harvest strategy framework (AFMA 2014a). The harvest strategy is summarised in Chapter 8. School shark is subject to an incidental catch limit, and other measures to reduce targeting and catch. Spatial closures across the fishery protect pupping areas and school shark.

Gear and area closures have been implemented (primarily off South Australia) to reduce the risk of interactions with Australian sea lions and dolphins. These have changed the fishing areas and targeting behaviour of fishers, influenced the take of target species and consequently affected catch-per-unit-effort (CPUE). These and other key wildlife bycatch issues are discussed further in Chapter 8.

From 1 July 2015, electronic monitoring (e-monitoring) has been mandatory for all full-time vessels in the SGSHS. The management aim is to review at least 10% of all recorded hauls to verify the accuracy of logbooks. In addition, gillnet boats operating off South Australia's Australian Sea Lion Management Zones are subject to 100% review of video footage to monitor interactions with protected species. The deployment of physical observers ceased with the commencement of e-monitoring, but this meant that some important data from the fishery were not collected, and physical observers were deployed again from September 2017 to July 2018. In late 2018, trials of the Shark Industry Data Collection project (SIDaC) were undertaken to collect size composition data and samples for close-kin work.

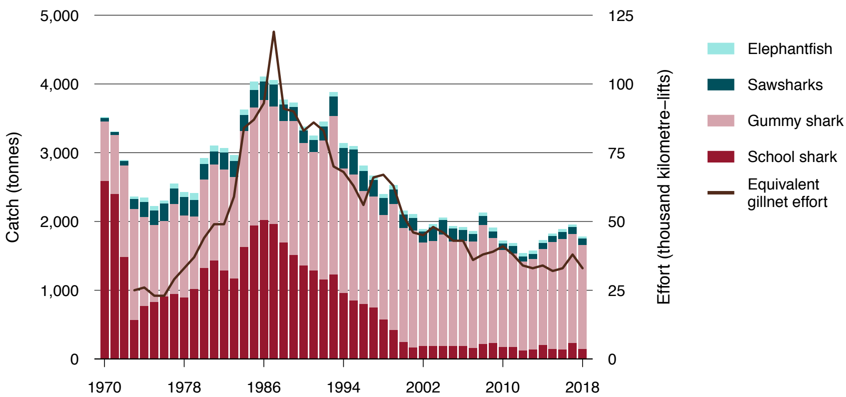
Fishing effort

Before spatial closures, which have been progressively implemented since 2003, effort in the SGSHS was spread across the waters of South Australia and eastern Victoria. However, the spatial closures outlined above have resulted in gillnet effort being concentrated off Victoria (Figure 12.1). Effort in the gillnet sector peaked in 1987 at 99,000 km of gillnet hauled, but has decreased to around one-third of this level in recent years. Hook effort has been variable in recent years, ranging between 1.1 million and 2.3 million hooks per season.

Catch history

Fishing for sharks in the waters off southern Australia began in the 1920s, using longlines. During the 1970s and 1980s, the sector mainly targeted school shark (Figure 12.2). Adoption of monofilament gillnets and concern about mercury content in large school sharks, coupled with declining school shark catches, resulted in gummy shark becoming the principal target species from around 1986 (Figures 12.2 and 12.3). This transition occurred in the early 1970s in Bass Strait, and later in the waters off South Australia and Tasmania. Recent catch records indicate that trawl operations in the SESSF are now landing more sawshark and elephantfish than gillnet operations.

FIGURE 12.2 Annual landings and effort in the SGSHS, by species, 1970–2018



Note: 'Equivalent gillnet effort' is an estimate of total effort after converting hook effort to the equivalent gillnet effort using the methods in Walker et al. (1994).

FIGURE 12.3 Annual landings in the Commonwealth Trawl Sector, by species, 2001–2018

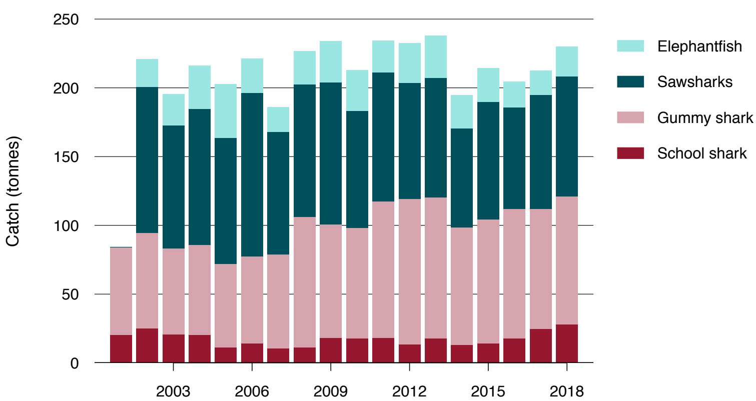


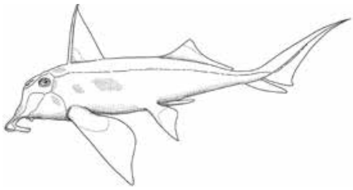
TABLE 12.2 Main features and statistics for the SGSHS

Fishery statistics a	2017–18 fishing season			2018–19 fishing season	
Stock	**TAC (t)**	**Catch (t) (GHTS, CTS)**	**GVP (2017–18) (GHTS, CTS)**	**TAC (t)**	**Catch (t) (GHTS, CTS)**
Elephantfish	122	62 (27, 34)	<$0.10 million (<$0.10 million, <$0.10 million)	114	50 (28,22)
Gummy shark	1,916	1,744 (1,604, 140)	$17.13 million ($16.21 million, $0.92 million)	1,763	1,682 (1,512, 170)
Sawsharks	481	205 (98, 107)	$0.41 million ($0.20 million, $0.21 million)	430	179 (82, 97)
School shark	215 **b**	206 (181, 25)	$1.87 million ($1.66 million, $0.21 million)	215 **b**	196 (166, 30)
Total	**2,734**	**2,216 (1,910, 306)**	**$19.51 million ($18.10 million, $1.41 million)**	**2,522**	**2,126 (1,789, 337)**
Fishery-level statistics					
Effort	Gillnet: 36,538 km of net hauled Hook: 2,094,906 hooks set			Gillnet: 32,008 km of net hauled Hook: 2,165,571 hooks set	
Fishing permits **c**	Gillnet: 61 Hook: 13			Gillnet: 61 Hook: 13	
Active vessels	Gillnet: 37 Hook: 38			Gillnet: 41 Hook: 37	
Observer coverage **d**	Gillnet: 10% Hook: 10%			Gillnet: 10% Hook: 10%	
Fishing methods	Demersal gillnet, demersal longline, dropline, mechanised handline, auto-longline				
Primary landing ports	Adelaide, Port Lincoln, Robe (South Australia); Devonport, Hobart (Tasmania); Lakes Entrance, San Remo, Port Welshpool (Victoria)				
Management methods	Input controls: gear restrictions, closed areas Output controls: ITQs, school shark/gummy shark catch ratio restriction, size limits, trip limits				
Primary markets	Domestic: Melbourne, Adelaide and Sydney—fresh and frozen				
Management plan	*Southern and Eastern Scalefish and Shark Fishery Management Plan 2003*				

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is between 1 May and 30 April. Value statistics are by financial year and were not available for the 2018–19 financial year at the time of publication. Components of catch may not sum to total due to rounding. **b** Incidental catch allowance. **c** In the GHTS, additional permit types limit gear use and access to state waters. **d** Numbers of hooks observed relate only to the Shark Hook Sector. Since 1 July 2015, e-monitoring has been mandatory for all full-time vessels in the SGSHS. Video footage of at least 10% of all recorded hauls is reviewed to verify the accuracy of logbooks. In addition, gillnet boats operating off South Australia's Australian Sea Lion Management Zones are subject to 100% review of video footage for interactions with protected species.
Notes: **CTS** Commonwealth Trawl Sector. **GHTS** Gillnet, Hook and Trap Sector. **GVP** Gross value of production. **ITQ** Individual transferable quota. **TAC** Total allowable catch (for the entire Southern and Eastern Scalefish and Shark Fishery).

12.2 Biological status

Elephantfish (*Callorhinchus milii*)



Line drawing: Karina Hansen

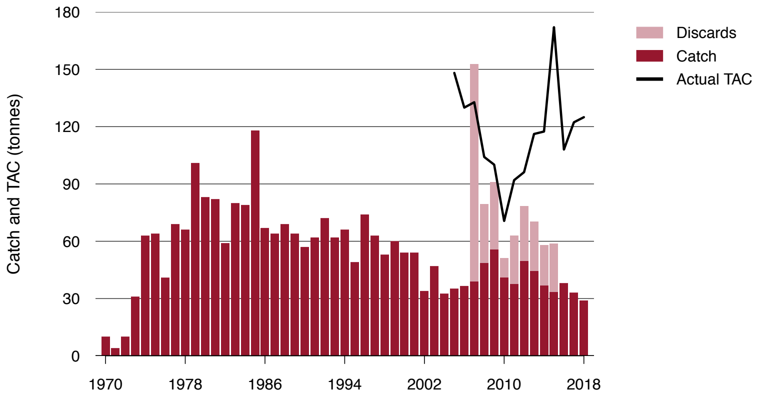
Stock structure

Stock structure of elephantfish is not known, and populations are considered to constitute a single stock for management purposes.

Catch history

Elephantfish is a small component (~3%) of landed catch of the four stocks assessed in this chapter. Catch of elephantfish in the SGSHS increased during the 1970s and peaked at almost 120 t in 1985 (Figure 12.4). Catch has since declined, and has been relatively stable at around 50–60 t in recent years. Reported catch in 2018–19 in the Gillnet, Hook and Trap Sector (GHTS) and the Commonwealth Trawl Sector (CTS) combined was 50 t (Table 12.2). The level of discarding in the SGSHS is uncertain and variable. Burch et al. (2018) used data from the Independent Scientific Monitoring Program (ISMP) to estimate a discard rate of 57.4% for elephantfish in 2014. Data are not available to update this rate. Castillo-Jordán et al. (2018) report state catch for elephantfish from New South Wales, South Australia, Tasmania, Victoria and Western Australia. Estimated total catch of elephantfish from all states (excluding Western Australia) during 2013–2017 averaged around 3.7 t. Recreational catch of elephantfish is unknown for all states but has been considered insignificant in New South Wales and Tasmania (Woodhams et al. 2018a). In Victoria, historical recreational catches have been significant, with up to 45 t caught in Western Port in March–May 2008. Catch rates and popularity of this fishery have declined more recently (Conron 2016), which presents an uncertainty in assessing this stock.

FIGURE 12.4 Annual elephantfish catch and fishing season TAC in the SGSHS, 1970–2018



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season. Discard data are only available by calendar year and for 2007–2015.
Source: Sporcic & Thomson 2015; AFMA catch disposal records (2016–2018 catch data)

Stock assessment

Elephantfish has been managed as a tier 4 stock under the SESSF harvest strategy framework since 2009. The tier 4 harvest strategy framework uses standardised CPUE as an index of abundance.

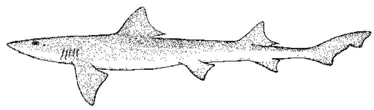
The Shark Resource Assessment Group (SharkRAG) did not agree to apply the harvest control rule for elephantfish in 2018 (to apply for the 2019–20 season) and recommended rolling over the total allowable catch (TAC) from the 2018–19 season. The main reasons were the high and sometimes variable levels of discarding of the stock (which undermines the use of CPUE based on landed catches), uncertain estimates of recreational catch (which are thought to be a significant portion of the catch) and the challenges these present for applying the harvest control rule.

The CPUE standardisations performed for the stock (both including and excluding discards) show relative stability in recent years (albeit with a decreasing trend) when compared with CPUE in the late 1990s and early 2000s. The recent average CPUE was above the target for the series including discards and slightly below the target (but above the limit) for the series excluding discards. In making its TAC recommendation for 2019–20, SharkRAG recorded that 'it felt that it did not have any new concerns about stock status' (AFMA 2018a). Improved estimation of discarding across the fishery should help to reduce uncertainty in the CPUE series in the future. It was noted that these analyses will be updated after receiving advice from South East Resource Assessment Group in 2019 on species that are currently difficult to assess (AFMA 2019).

Stock status determination

Although it was not possible to output a reliable recommended biological catch (RBC) through a harvest control rule for this stock in 2018, the standardised CPUE series, albeit variable, indicated relative stability and was above the limit reference point based on the last accepted analysis in 2015. Catches since 2015 have been relatively stable, and below the RBC and TAC because elephantfish are not actively targeted. This indicates that the fishery is unlikely to be applying an unsustainable level of fishing mortality to the stock. On this basis, the stock is classified as **not overfished** and **not subject to overfishing**.

Gummy shark (*Mustelus antarcticus*)



Line drawing: Karina Hansen

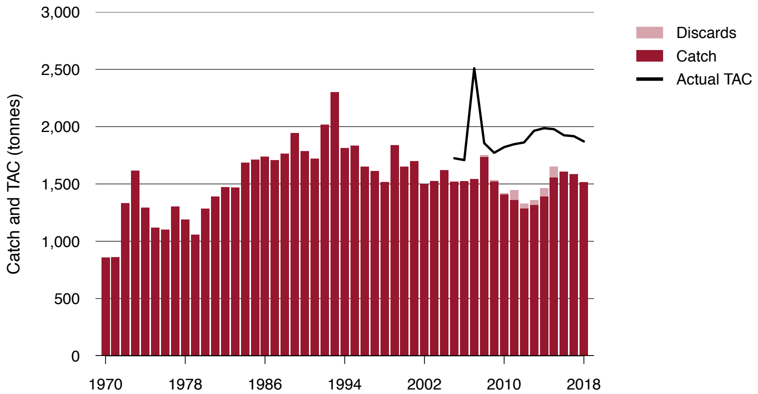
Stock structure

The most recent research on stock structure for gummy shark indicates that there are most likely two stocks in Australian waters: one in southern Australia, extending from Bunbury in Western Australia to Jervis Bay in New South Wales, and another in eastern Australia, extending from Newcastle to the Clarence River in New South Wales (White & Last 2008). The southern Australian biological stock is split into four populations for modelling purposes: the continental shelf of Bass Strait, Tasmania, South Australia and Western Australia. The first three are assessed together by the Commonwealth (Punt, Thomson & Sporcic 2016) and are reported here. The fourth is assessed and reported separately by Western Australia (Braccini & Blay 2019).

Catch history

Catch of gummy shark in the SGSHS increased after 1970, initially as byproduct in the school shark fishery, and then increasingly as a target as school shark catches decreased from 1986 (Figure 12.5). Catch in the SGSHS reached a peak of around 2,300 t in 1993. It dropped to a low of 1,288 t in 2012, before increasing to around 1,700 t in recent years (Figure 12.5). Total Commonwealth catch (including from the CTS) in 2018–19 was 1,682 t, which is approximately 79% of the total catch across the four stocks assessed in this chapter. The level of discarding in the SGSHS is uncertain. Burch et al. (2018) used ISMP data to estimate a discard rate of 5.1% for gummy shark in 2014. Data are not available to update this rate. Castillo-Jordán et al. (2018) report state catch for gummy shark for New South Wales, South Australia, Tasmania, Victoria and Western Australia. Reported state catch of gummy shark during 2013–2017 averaged around 564 t (around 133 t if Western Australia is excluded). State recreational catches are poorly known, with limited data reported—for example, 37 t was reported in South Australia in 2013–14 and 934 fish were reported caught in Western Australia in 2015–16 (Woodhams et al. 2018b). In 2018, SharkRAG recommended deducting the weighted average state catch from the RBC, which is standard practice for other SESSF species (AFMA 2019).

FIGURE 12.5 Annual gummy shark catch and fishing season TAC in the SGSHS, 1970–2018



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season. Discard data are only available by calendar year and for 2007–2015.
Source: Punt, Thomson & Sporcic 2016; AFMA catch disposal records (2016–2018 catch data)

Stock assessment

The most recent update of the integrated stock assessment model for gummy shark was in 2016, using data to the end of 2015 (Punt, Thomson & Sporcic 2016). Updated inputs to the assessment included landing data from 2013 to 2015, revisions to earlier catch and length-frequency data, new age-frequency data and updated CPUE indices. Some changes to the model structure were also made: catches by the different gear types are now assumed to occur simultaneously rather than sequentially; the 'hook fleet' has been separated into trawl, deep and shallow fleets; and allowances have been made for age-reading errors. As before, the assessment uses estimated pup production as a proxy for biomass because of the expected close relationship between pup production and female spawning biomass. This is because most of the data come from the gillnet sector, which catches a narrow size range of fish and does not catch adults.

Bass Strait, South Australian and Tasmanian regions were treated as separate populations in the model, with no movement of animals between these populations and no density-dependent effects of one population on another. The models share some model-estimated parameter values, especially Tasmania, where the data are unable to support full parameter estimation. The model also assumes commonality in biological parameters, including age–length and length–weight relationships, fecundity, gear selectivity, and overall availability as a function of age.

The gillnet closures off South Australia have influenced catch and CPUE of gummy shark in this area. When the 2014 assessment was run, there was concern that the South Australian CPUE data were less reliable as an index of abundance in recent years (Thomson & Sporcic 2014). Consequently, South Australian CPUE data after 2009 were not included in the 2014 or 2016 assessments.

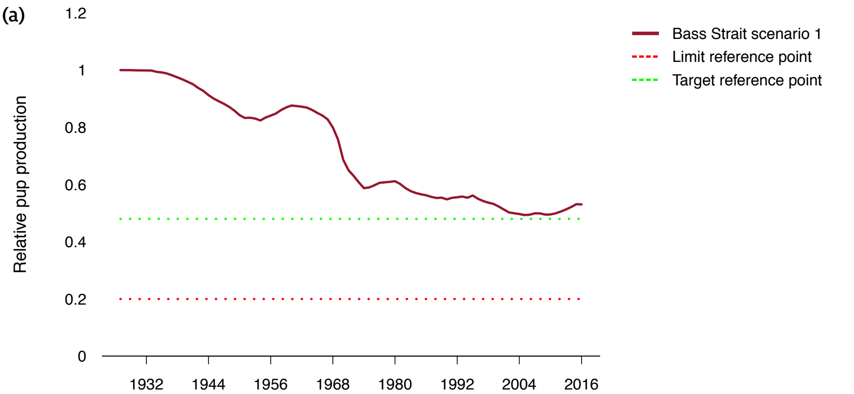
The model estimated RBCs and relative pup production for each population. The RBCs were then summed to give a stock-level RBC for the fishery. In addition, different gear types are known to have different selectivities, which result in differences in the average size of sharks caught. Consequently, a range of RBCs were calculated, based on different catch proportions taken by line and gillnet, which were assessed against their impact on pup production at a regional level (Punt, Thomson & Sporcic 2016).

The base-case assessment estimated 2016 pup production as a proportion of the unfished level of pup production (P_0; 1927) to be above $0.48P_0$ (48% of virgin pup production) for all three populations modelled: $0.53P_0$ for Bass Strait (Figure 12.6a), $0.63P_0$ for South Australia (Figure 12.6b) and $0.75P_0$ for Tasmania (Figure 12.6c). These are all slightly lower than those estimated by the 2014 assessment (Thomson & Sporcic 2014).

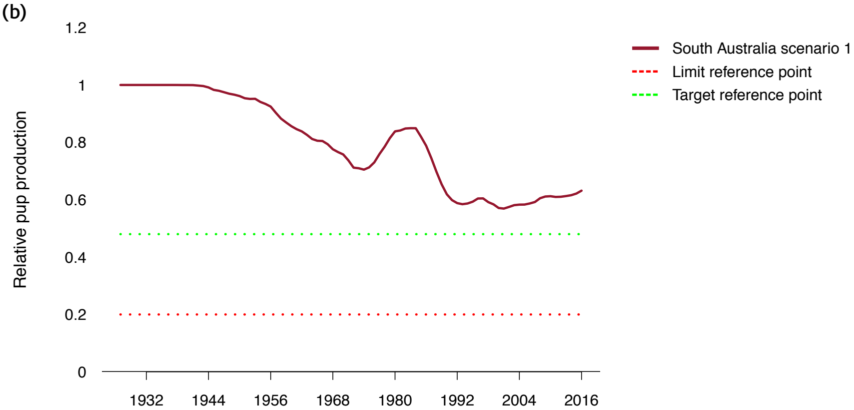
Gillnet vessel
Mike Gerner, AFMA

FIGURE 12.6 Estimated pup production as a proportion of unfished level of pup production for gummy shark in (a) Bass Strait, (b) South Australia and (c) Tasmania, 1927–2016

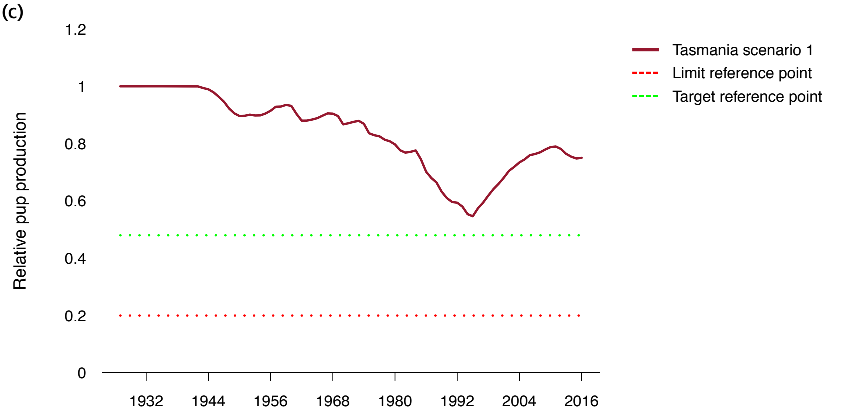
(a)



(b)



(c)

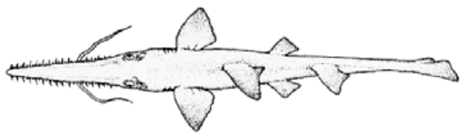


Source: Punt, Thomson & Sporcic 2016

Stock status determination

The 2016 stock assessment estimated pup production in the most recent year (2015) to be above the target for each of the three populations modelled. As a result, gummy shark in the SGSHS is classified as **not overfished**. Given that recent catches in 2018–19 totalling 1,901 t (Commonwealth 1,682 t, discards 86 t and state weighted average 133 t) were less than the RBC of 1,961 t, the current fishing mortality is unlikely to deplete the population below the limit biomass reference point. Therefore, the stock is classified as **not subject to overfishing**.

Sawshark (*Pristiophorus cirratus, P. nudipinnis*)



Line drawing: FAO

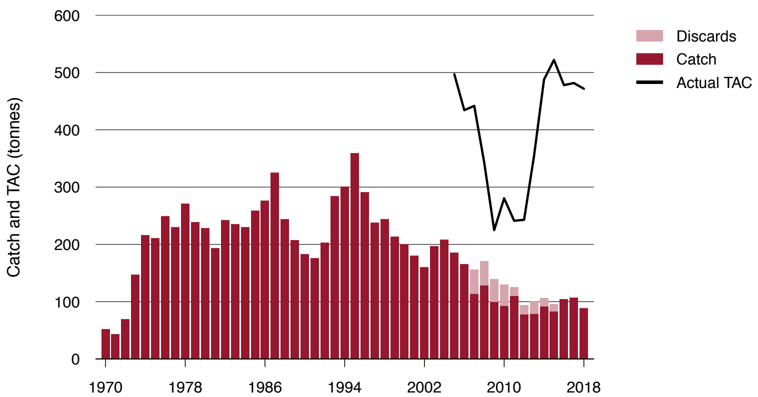
Stock structure

Three species of sawshark (common sawshark—*Pristiophorus cirratus*, southern sawshark—*P. nudipinnis* and eastern sawshark—*P. peroniensis*) are caught in southern Australian waters. Little is known about the stock structure or movements of sawshark. Two species dominate reported sawshark catches in this sector: common sawshark and southern sawshark. For assessment purposes, all sawsharks found south of the Victoria – New South Wales border are assumed to be common or southern sawshark, and those found north of that border are assumed to be eastern sawshark (AFMA 2014e). Around 90% of the total sawshark catch from southern Australia is taken from Bass Strait (AFMA 2011a). All sawshark catch in the SESSF is managed under a single TAC, and status is reported for a single multispecies stock.

Catch history

Catch of sawshark in the SGSHS increased in the early 1970s to around 200 t by 1974, and then fluctuated between about 170 and 350 t per year until the early 2000s. Combined catch in the SGSHS and the CTS in 2018–19 was 179 t (Figure 12.7; Table 12.2), which is approximately 8% of the total catch across the four stocks assessed in this chapter. The level of discarding in the SGSHS is uncertain. Burch et al. (2018) used ISMP data to estimate a discard rate of 15.5% for sawshark in 2014. Data are not available to update this rate. Castillo-Jordán et al. (2018) report state catch for sawshark from New South Wales, South Australia, Tasmania, Victoria and Western Australia. Estimated total catch of sawshark from all states during 2013–2017 averaged around 17.1 t (around 11.7 t if Western Australia is excluded). State recreational catches are unknown but considered low (Woodhams et al. 2018c).

FIGURE 12.7 Sawshark catch and TAC in the SGSHS, 1970–2018



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season. Discard data are only available by calendar year and for 2007–2015.
Source: Haddon & Sporcic 2018; AFMA catch disposal records (2016–2018 catch data)

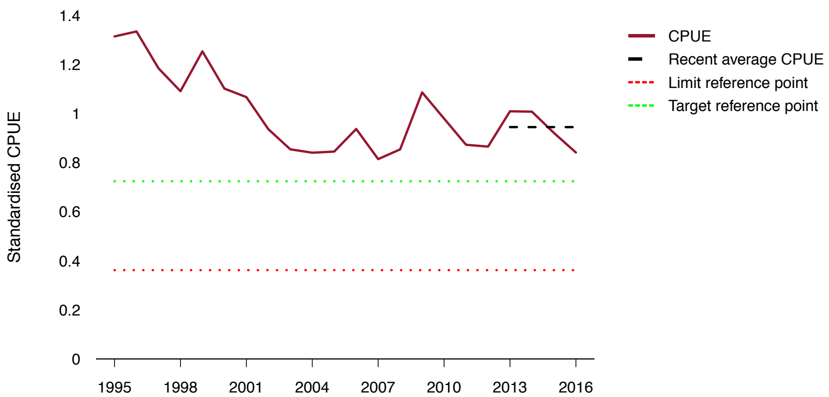
Stock assessment

Sawshark has been managed as a tier 4 stock under the SESSF harvest strategy framework since 2009. Potential avoidance of this species by operators using gillnets suggests that the corresponding standardised CPUE may not adequately reflect stock abundance. As a result, SharkRAG recommended using standardised trawl CPUE as an index of abundance (AFMA 2015c) for applying the tier 4 harvest control rule.

The most recent CPUE analyses of sawshark (three alternative CPUE series were constructed), using SESSF trawl data to 2017, indicated that current CPUE was above the target reference point (Sporcic & Haddon 2018) (see Figure 12.8). The adopted tier 4 analyses in 2017 produced an RBC of 519 t, which was converted to the first year of a three-year TAC of 430 t for the 2018–19 fishing season.

In 2014, SharkRAG recommended a decrease in the biomass target (B_{TARG}) from 48% to 40% of unfished biomass. Since sawshark is currently a byproduct species in the gillnet sector, SharkRAG noted that commercial catch largely depends on effort targeted at gummy shark (AFMA 2014c).

FIGURE 12.8 Standardised CPUE index for sawshark in the CTS, 1995–2016 (trawl)



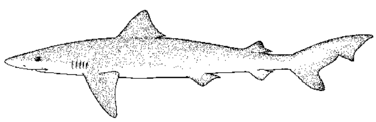
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2018

Stock status determination

The average recent CPUE for sawshark was estimated to be above the target reference point (Figure 12.8). On this basis, the stock is assessed as **not overfished**.

Given that recent catches in 2018–19 totalled 191 t (Commonwealth 179 t, and state weighted average 12 t), which is less than the RBC of 519 t, the current fishing mortality is unlikely to deplete the population below the limit reference point. On this basis, the stock is assessed as **not subject to overfishing**.

School shark (*Galeorhinus galeus*)



Line drawing: Karina Hansen

Stock structure

School shark has a broad distribution throughout temperate waters of the eastern North Atlantic, western South Atlantic, and north-eastern and south-eastern Pacific oceans; and temperate waters off South Africa, New Zealand and southern Australia. There is some uncertainty about the stock structure for school shark; however, a recent genetic study found there is likely to be one genetic stock spread between Australia and New Zealand (Hernández et al. 2015). School shark is managed as a single stock in the SESSF.

Catch history

Catch of school shark in the SGSHS peaked at more than 2,500 t in 1970 and then declined rapidly to around 500 t in 1973. Catch in the sector again increased to around 2,000 t in 1986, before declining steadily through the late 1980s and 1990s, stabilising at around 200 t per year from 2000 onwards (Figure 12.9). In 2009, the species was listed as conservation-dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and has been subject to other measures to reduce catch. These include the implementation of a catch ratio of 20% school shark to gummy shark—whereby a quota holder must hold five times more gummy shark quota than their school shark catch (2011–12 season)—and the requirement that all live-caught school shark be released (2014–15 season).

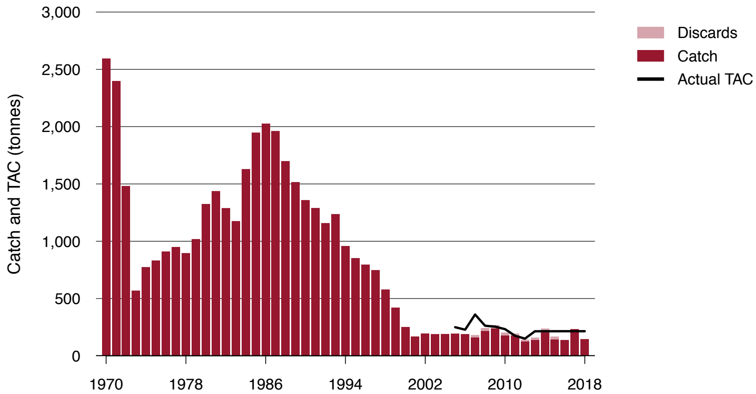
The reported landed catch in the SGSHS in 2018–19 was 196 t, which is approximately 9% of the total catch across the four stocks assessed in this chapter. The level of discarding in the SGSHS is uncertain. Burch et al. (2018) used ISMP data to estimate a discard rate of 15.1% for school shark in 2014. New ISMP data are not available to update this number.

Applying the 2014 discard rate to the Commonwealth commercial catch of 196 t results in an estimated 29.6 t of additional school shark catch by the commercial fishery in 2018–19, assuming 100% mortality. We do not know what the level of post-release survival for these discarded sharks is, but it is unlikely to be zero, making the assumption of 100% mortality conservative.

Walker et al. (2008) used tag–recapture data to estimate a mortality rate of 44% for school shark taken using gillnets. Braccini, Walker and Gason (2009) report a similar rate (41%) in their study of gillnet-caught school shark. We do not have a comparable number for line-caught school shark. Rogers et al. (2017) examined survival of relatively large discarded female school shark from line fishing using satellite popup tags. The authors indicate that their results are skewed towards healthy/lively individuals and that survival of injured individuals remains a gap in knowledge. Further, the study did not use fishing methods (or gear) completely consistent with that used by the commercial fleet, which will further distance the results from what we can expect to occur in the commercial fishery. That said, all sharks tagged in the study (10 animals) survived for at least five days post-release (longest time frame recorded is 44 days). We do not have a survival rate for discarded sharks from the trawl fleet, but it is reasonable to assume that survivability of discarded trawl-caught school shark would be low because of the restricted movement of catch within the nets (particularly the codend) and the crushing that can occur in trawl nets.

An estimate of state catch for the 2018–19 fishing season is not available. However, Castillo-Jordán et al. (2018) report state catches up to and including 2017. The state catches they report (excluding Western Australia) show relative stability over the past five years. Pending evidence of any significant changes in activity in state fisheries, catch in 2018–19 is likely to be at similar levels to that reported for the previous five years for each state. The average during 2013–2017 was approximately 23 t across South Australia, Victoria, Tasmania and New South Wales. The discard rate (or post-release survival) for state catches is unknown. State recreational catches are also not available, except for estimates of 9 t in 2008 and 53 t in 2014 from South Australia (Castillo-Jordán et al. 2018). Total mortality in state fisheries is uncertain as a result.

FIGURE 12.9 Annual school shark catch and fishing season TAC in the SGSHS, 1970–2018



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season. Discard data are only available by calendar year and for 2007–2015.
Source: Thomson 2012; AFMA catch disposal records

Stock assessment

Assessments for school shark indicate that the stock has been overfished since approximately 1990, and the stock has been classified as such since ABARES began status reporting in 1992. In 2018, a close kin mark–recapture study and a new population dynamics model (termed a 'close-kin model' [CKM]) provided an estimate of current absolute abundance and recent population trend (2000–2017) from a single region and population (that is, assuming one mixed stock) (AFMA 2018b). In contrast to previous assessments, the CKM does not provide an estimate of population depletion for unfished biomass levels.

The abundance of school shark (in numbers) estimated by the CKM (c. 80,000 adults) was lower than the previous assessment model projections undertaken in 2012 (c. 200,000 adults; Thomson 2012). However, the 2012 estimate was not as robust as the new estimate derived from the CKM model (because absolute biomass was confounded with productivity in the 2012 model). Although there were indications in the CKM that some stock recovery occurred during 2000–2017, there was large uncertainty associated with this trend (AFMA 2018a). It was noted that continued close-kin sampling and analysis will increase confidence in the trend in abundance in the future.

Catch and abundance projections were based on four constant exploitation rate scenarios (zero, the 2017 and 2016 rates, and the 2013–2017 mean exploitation rate). These calculations used the deterministic projection (that is, the median), rather than a more conservative approach such as choosing a lower confidence limit from a set of stochastic projections.

SharkRAG recommended using the 2013–2017 mean exploitation rate to set an incidental catch TAC for the next three years based on the projections. This rate provided total fishing mortality estimates of 256 t in 2019–20, 263 t in 2020–21 and 270 t in 2021–22. The 2013–2017 fishing mortality rate provided for a consistent recovery, as opposed to the 2017 fishing mortality rate, which would lead to an initial reduction in stock size (for the first two years) before recovery (AFMA 2018c).

It is important to note that the CKM model only considers 2000–2017, since this was the period over which the animals sampled would have been born. It was unable to account for historical high catches before 2000. Similar difficulty hampered the previous assessment model, which used complex stock structure assumptions to reconcile observed CPUE time series with large historical catches (Punt & Pribac 2001). From a management perspective, this creates considerable uncertainty because (a) the adult abundance estimate from the CKM cannot be directly compared with the previous 2012 stock assessment estimate (AFMA 2018b), and (b) we may be unable to determine an estimate of unfished biomass or initial abundance for school shark, making it impossible to estimate biomass or population size relative to an unfished state, as required under the School Shark Rebuilding Strategy (AFMA 2015b). From a stock perspective, this could mean that (a) the population sampled from the CKM may not be the same stock that supported catches before 2000 and could be a smaller subset (or stock) of a multistock population that was fished historically (AFMA 2018c), or (b) the school shark population could have been subject to a productivity shift (similar to jackass morwong) (AFMA 2018c). If true, either would have ramifications for the appropriateness of current reference points under the current harvest strategy framework (AFMA 2014a). This remains a significant area of uncertainty for assessing the school shark stock, and there may be other untested explanations for the inability of the CKM model to account for catches before 2000.

In December 2018, SharkRAG supported continued close-kin sampling (for three years) and use of the CKM for estimating abundance of school shark, while also discussing the utility and complexity of updating the old school shark assessment with addition of the recent CKM work. At this time, SharkRAG also discussed the need for updating the School Shark Rebuilding Strategy (AFMA 2015b) in light of the latest information provided by the CKM work.

Stock status determination

Since the CKM does not provide an estimate of population depletion compared with historical unfished levels, biomass status in 2018–19 is determined based on the most recent estimate of population depletion. The last full stock assessment in 2009 (Thomson & Punt 2009), which used data up to 2008, estimated the biomass at $0.12B_0$. Projections of this model in 2012 indicated that recovery to $0.2B_0$ would take 23 years under a zero-catch scenario (Thomson 2012). Landings have not been zero in the intervening period, averaging 192 t in the SGSHS over the last five years. On this basis, the stock remains classified as **overfished**.

Combining commercial catch, discards (assuming 100% mortality) and state catches provides an estimated total mortality for the stock in 2018–19 of around 248 t. If we assume some level of survivability in discarded sharks in the SGSHS (40% for line and gillnet, and 100% for trawl), the estimated total mortality for the stock is around 233 t. Under both scenarios, total mortality is above the incidental catch allowance (215 t) and above the maximum level (225 t) reported to allow recovery in the time frame specified in the rebuilding strategy, noting that discards from state fisheries are unknown. However, this level of catch is below the highest level (250 t) forecast to allow for recovery in the 2012 modelling (assuming gear selectivity, and spatial and temporal distribution of catches remain similar to those in 2011). This level of catch is also less than the total fishing mortality estimate of 256 t generated from the CKM for 2019–20, which allowed for a consistent recovery in stock size.

It is important to note that the discard rate and the mortality of those discards have been key uncertainties in the calculation of total mortality for this stock, and should be addressed as a priority.

Other indications that the school shark stock may have stabilised and may even be recovering include an increasing preliminary index of school shark abundance based on trawl CPUE (Sporcic 2016), surveys by the Institute for Marine and Antarctic Studies showing higher numbers of pups from school shark pupping areas off Tasmania (McAllister et al. 2015) and anecdotal reports from industry. Furthermore, the CKM suggested that some stock recovery occurred between 2000 and 2017, although there was large uncertainty associated with this trend. Given the above information, the level of school shark fishing mortality in 2018–19 is classified as **uncertain**.

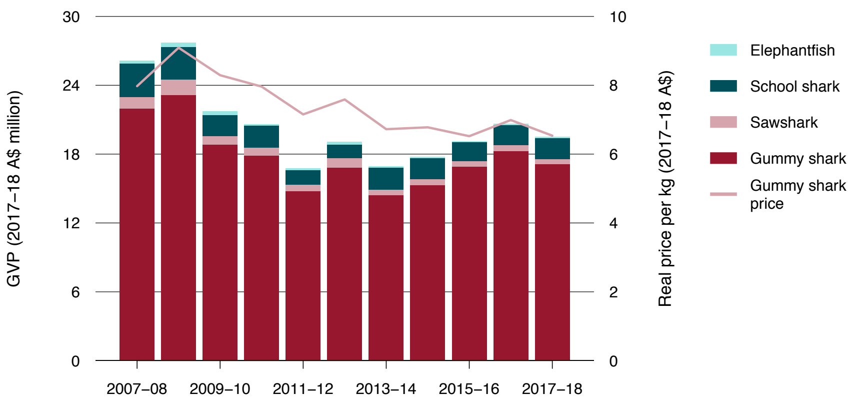
Hauling the gear
Gavin Kewana, AFMA

12.3 Economic status

Key economic trends

The real gross value of production (GVP) in the SGSHS for the four shark species taken in the GHTS declined from a peak of $27.2 million in 2008–09 to $16.61 million in 2013–14 and then recovered to $19.5 million by 2017–18 (Figure 12.10). This recent recovery is primarily the result of higher volumes of gummy shark landings. Gummy shark accounts for the majority of GVP in the SGSHS (88% in 2017–18).

FIGURE 12.10 Real GVP for the SGSHS, by key species, and real price for gummy shark, 2007–08 to 2017–18

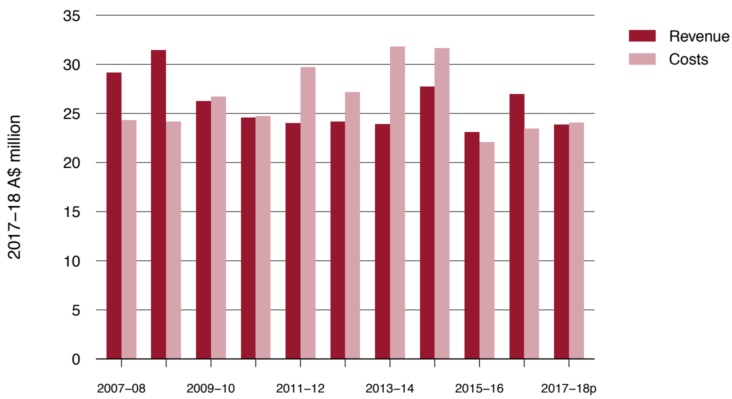


Note: **GVP** Gross value of production.

The four shark species that make up the SGSHS—gummy shark, school shark, sawshark and elephantfish—accounted for around 71% of the GHTS GVP in the decade to 2017–18, with scalefish species making up the remainder. Therefore, overall economic performance in the GHTS may contribute to an understanding of the economic status of the SGSHS.

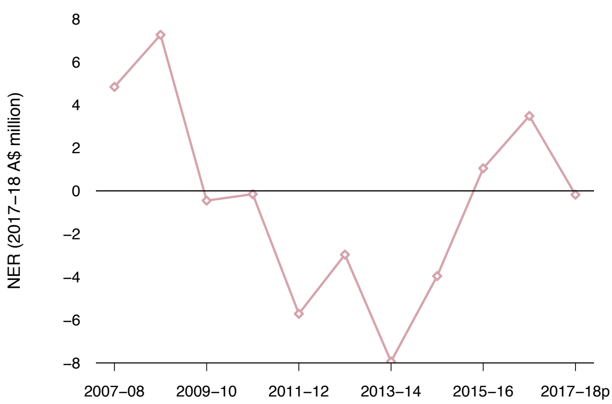
Survey-based estimates of revenue, costs and net economic returns (NER) in the GHTS are available for 2016–17, and preliminary estimates are available for 2017–18 (Figures 12.11 and 12.12). In 2017–18, non-survey based estimates indicate that NER became negative, –$0.18 million, potentially a result of lower catch volume of gummy shark and higher unit fuel prices. This reverses a trend of recovery in NER that started in 2013–14. Estimates for 2015–16 and 2016–17 indicate that NER were positive in those years due to higher unit prices (increasing fishing income) and lower fuel prices (causing operating costs to decline). NER increased further in 2016–17, driven by the highest catch and GVP levels in the fishery since 2010–11 (Mobsby forthcoming). NER reached a low of –$7.93 million in 2013–14 and remained negative in 2014–15. NER were positive between 2003–04 and 2008–09, peaking at $7.25 million in 2008–09.

FIGURE 12.11 Real revenue and costs for the GHTS, 2007–08 to 2017–18



Note: Data for 2017–18 are preliminary.
Source: Mobsby forthcoming

FIGURE 12.12 Real NER for the GHTS, 2007–08 to 2017–18



Notes: **NER** Net economic returns. NER estimates for 2017–18 are preliminary non-survey based estimates.
Source: Mobsby forthcoming

A profit decomposition of the gillnet sector of the GHTS (Skirtun & Vieira 2012) showed that the key driver of profitability in the sector from 2006–07 to 2008–09 was productivity growth. This was linked to the Securing our Fishing Future structural adjustment package (completed in 2006–07), which is considered to have removed the least efficient vessels from the sector (Vieira et al. 2010). The decline in NER in recent years can be partly linked to falls in the price of fish in the fishery, making the role of productivity in driving NER improvement less clear. Productivity followed an increasing trend between 2009–10 and 2013–14, and may have provided some support to a declining trend in NER (Mobsby forthcoming). Productivity was more variable from 2014–15 to 2016–17, and coincided with a period of improvement in NER for the fishery, indicating that fisher terms of trade may have been a more important factor driving NER improvement in this period (Mobsby forthcoming).

Management arrangements

Significant spatial closures have been implemented in recent years to reduce the catch of protected species, primarily off the South Australian coast (see Chapter 8). This started with voluntary closures in 2009–10, followed by mandatory closures in 2010–11. As a result, fishing intensity relocated to other areas. Particularly affected were operators who had the full extent of their usual fishing grounds closed, and those who had to switch to use of hooks rather than gillnets in areas where gillnet closures are in place. Some South Australian gillnet fishers also operate in the South Australian Rock Lobster Fishery, which is considered to be profitable (Econsearch 2014) and could have supported some SGSHS operators affected by the closures. These changes would have reduced the profitability of gillnet operations in South Australia, contributing to the negative NER in the GHTS following the closures.

South Australian gillnet operators (subject to specific qualification criteria) can use hook methods in areas where gillnetting is prohibited (or restricted), so that they can continue to operate. However, anecdotal reports from industry suggest that their vessel-level economic efficiency is lower using these methods (AFMA 2011b). Anecdotal information also indicates that allowing gillnet permit holders to use hooks has had a negative impact on the value of hook permits in the sector, because rights provided by hook permits have become less exclusive.

School shark biomass remains below the limit reference point, and stock rebuilding measures are likely to be affecting sector profitability. These measures include low incidental catch allowances and the prohibition of targeted fishing. School shark is often caught incidentally with gummy shark—the main target species of the sector—and actively avoiding school shark can involve an increase in trip length, increasing the cost of catching gummy shark. Additionally, given the relatively high beach prices of school shark, changes in its catch allowance can have a relatively large influence on the revenue of the sector. Operators who do not hold quota for school shark, or actively avoid it when targeting gummy shark, are forfeiting a potential means of profit. The substantial time projected for rebuilding of the school shark stock means that it may be some time before these issues are resolved.

Preliminary results from trials to test the efficiency of longer gillnets (4,200–6,000 m) were considered inconclusive by SharkRAG in January 2016 (AFMA 2016). However, giving fishers the option to use longer nets provides them with greater flexibility to operate under individual transferable quotas, potentially improving efficiency and NER. In 2017, AFMA removed net length restrictions in Commonwealth waters for vessels with e-monitoring.

Performance against economic objective

A comparison of the biomass levels of key species with harvest strategy targets gives additional information on the economic status of the SGSHS. Gummy shark is the primary driver of economic performance in the SGSHS, accounting for 88% of SGSHS GVP in 2017–18. The target reference point for gummy shark is the B_{MEY} (biomass that corresponds to maximum economic yield) proxy of $0.48P_0$ (48% of virgin pup production). The results of the 2016 stock assessment indicate that the biomass of gummy shark stocks is likely to be above the target reference point. If the proxy accurately reflects B_{MEY} for this species, the results indicate that biomass is not currently constraining NER and that there may be potential for expansion in the sector.

School shark is the second most valuable species in the sector, accounting for 10% of SGSHS GVP in 2017–18, despite being caught under an incidental catch allowance. The school shark to gummy shark quota restriction implemented in 2011–12 may have reduced gummy shark catch and therefore current GVP (AFMA 2014d). Efforts to rebuild the school shark stock towards target levels should lead to increases in NER.

The challenge of reducing marine mammal interactions may affect the degree to which economic performance can be improved in the short term. Recent closures to mitigate interactions are likely to have contributed to the observed negative NER for the GHTS from 2009–10 to 2014–15, and may be related to increased gummy shark quota latency during this period. In 2015–16 to 2016–17, NER were positive and linked to productivity growth, indicating that the industry is actively adjusting to new operating conditions.

12.4 Environmental status

The SESSF was accredited against parts 13 and 13A of the EPBC Act in February 2016. Conditions associated with the accreditation relate to the impact of fishing on bycatch species, particularly Australian sea lions (*Neophoca cinerea*), dolphins, seals and seabirds. Further recommendations associated with the accreditation relate to requirements for ecological risk assessment, and monitoring of bycatch and discarding.

A level 2 ecological risk assessment of 329 species resulted in 21 assessed as being at high risk (16 chondrichthyans and 5 marine mammals; Walker et al. 2007). A level 3 Sustainability Assessment of Fishing Effects assessment was completed for all 195 chondrichthyan and teleost species identified in the shark gillnet fishery, regardless of their level 2 Productivity Susceptibility Analysis (PSA) risk score. The assessment found seven species (all chondrichthyan) to be at high risk (Zhou, Fuller & Daley 2012). One species (common sawshark) was removed during the residual risk analysis (AFMA 2014b). The remaining six species considered to be at high risk are all sharks: bronze whaler, white shark (*Carcharodon carcharias*), whiskery shark, smooth hammerhead shark (*Sphyrna zygaena*), school shark and broadnose sevengill shark. A 2010 residual risk assessment of PSA results for non-teleost and non-chondrichthyan species identified five marine mammal species as high risk (AFMA 2010). A subsequent residual risk analysis removed two species (as a result of no interactions being recorded in the fishery) and included one further species (as a result of higher than expected interactions), resulting in four marine mammal species considered to be at high risk in the fishery: Australian fur seal (*Arctocephalus pusillus doriferus*), Australian sea lion, New Zealand fur seal (*A. forsteri*) and common dolphin (*Delphinus delphis*) (AFMA 2012). The results of the ecological risk assessments have been consolidated to form a priority list in an ecological risk assessment strategy for the SESSF (AFMA 2015a). Results from a revised ecological risk assessment of 233 species across three ecological components in 2018 for the SGSHS are still to be finalised.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. Reports for the GHTS in the 2018 calendar year indicate 418 interactions: 113 with mammals, 111 with seabirds, 183 with sharks, 10 with little penguins—*Eudyptula minor* (1 alive; 9 dead) and 1 with a leatherback turtle—*Dermochelys coriacea* (alive). The mammal interactions comprised 56 interactions with dolphins (all dead), 19 with Australian fur seals (1 alive; 18 dead), 2 with sea lions (1 alive; 1 dead), 6 with New Zealand fur seals (all dead) and 30 with seals (unclassified; 3 alive; 26 dead; 1 unknown). In 2018, 120 seabirds (29 alive; 91 dead) were caught, including albatrosses, cormorants, petrels, prions and shearwaters.

Logbooks reported that 129 shortfin mako sharks—*Isurus oxyrinchus* (9 alive; 92 dead; 28 in unknown condition), 5 longfin mako sharks—*I. paucus* (3 alive; 2 dead), 27 porbeagle sharks—*Lamna nasus* (7 alive, 20 dead), 2 grey nurse sharks—*Carcharias taurus* (2 in unknown condition) and 20 white sharks (15 alive; 5 dead) were caught during 2018. Measures to reduce interactions with Australian sea lions and dolphins are discussed in Chapter 8.

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Chapter 13

Southern Squid Jig Fishery

N Mazloumi, T Emery and R Curtotti

FIGURE 13.1 (a) Relative fishing intensity in the Southern Squid Jig Fishery and (b) Commonwealth Trawl Sector squid catch, 2018

(a)

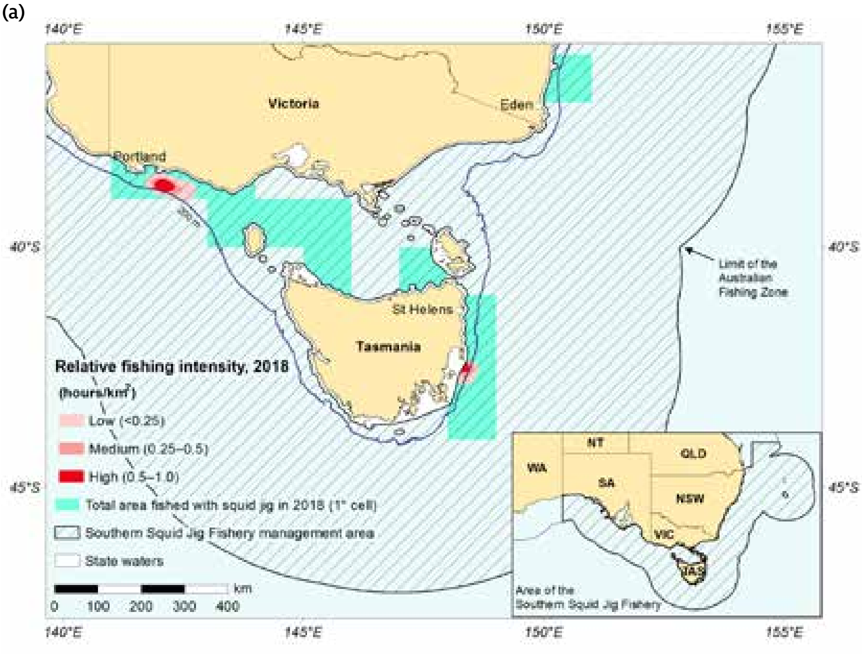
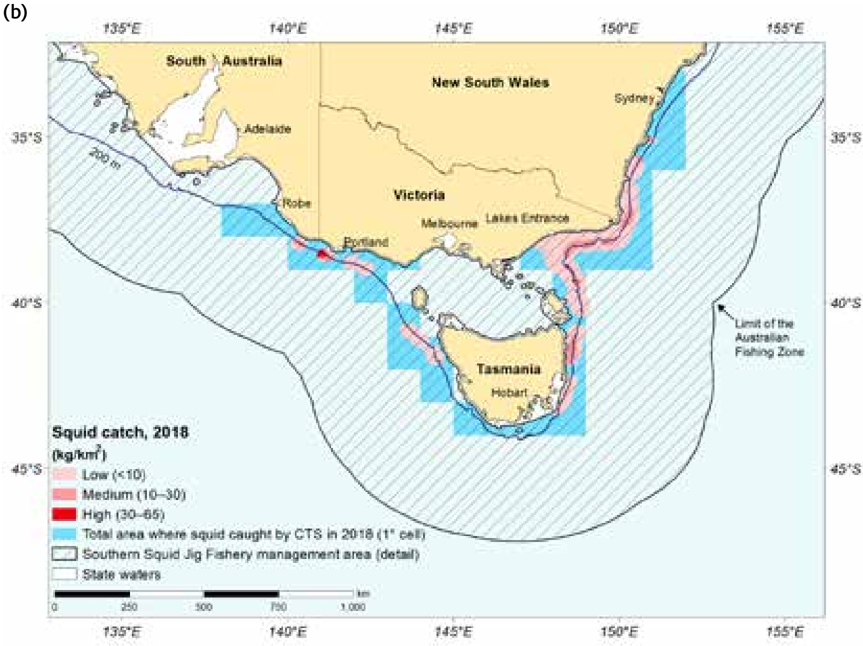


FIGURE 13.1 (a) Relative fishing intensity in the Southern Squid Jig Fishery and (b) Commonwealth Trawl Sector squid catch, 2018 continued

(b)



Note: **CTS** Commonwealth Trawl Sector.

TABLE 13.1 Status of the Southern Squid Jig Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Gould's squid (*Nototodarus gouldi*)					In 2018, catch and effort in the SSJF increased relative to 2017 but remained lower than the historical average (1996–2005). Intermediate or limit catch triggers were not exceeded in 2018. In 2018, catch rates in the SSJF and CTS were the highest and second highest on record, respectively.
Economic status	Catch and effort in the fishery increased from 2016–17 to 2017–18. In the same period, catch-per-unit-effort increased, suggesting lower unit fishing costs, and prices for landed catch increased. This suggests that the economic incentive to fish increased in 2017–18 and that NER in the fishery are likely to have improved.				

Notes: **CTS** Commonwealth Trawl Sector. **NER** Net economic returns. **SSJF** Southern Squid Jig Fishery.

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

13.1 Description of the fishery

Area fished

The Southern Squid Jig Fishery (SSJF) is located off New South Wales, Victoria, Tasmania and South Australia, and in a small area off southern Queensland. Most fishing takes place off Portland, Victoria (Figure 13.1). Australian jig vessels typically operate at night in continental-shelf waters between depths of 60 and 120 m. Squid are also caught in the Commonwealth Trawl Sector (CTS) and the Great Australian Bight Trawl Sector (GABTS).

Fishing methods and key species

The SSJF is a single-method (jigging), single-species fishery, targeting Gould's squid (*Nototodarus gouldi*). Up to 10 automatic jig machines are used on each vessel; each machine has two spools of heavy line, with 20–25 jigs attached to each line. High-powered lamps are used to attract squid. Squid are also caught as an incidental catch in the CTS and the GABTS by demersal trawling.

Management methods

The Commonwealth SSJF is managed by the Australian Government, whereas jigging operations within coastal waters (inside the 3 nautical mile limit) are generally managed by the relevant state government. Squid are listed as a 'permitted species' in the state-managed commercial fisheries of New South Wales, Tasmania and South Australia, whereas no regulations apply to squid in Victorian commercial fisheries (AFMA 2014).

The species' short life span, fast growth and sensitivity to environmental conditions result in highly variable recruitment and strongly fluctuating stock sizes (Jackson & McGrath-Steer 2003), making it difficult to estimate biomass before a fishing season. Therefore, the SSJF harvest strategy (AFMA 2007) relies on within-season monitoring against catch triggers for the jig and trawl sectors. Current harvest strategies based on catch-and-effort triggers have been implemented because of difficulties in collecting real-time catch, effort and size data, and growth estimates needed for within-season depletion analyses. Because of the low fishing effort relative to historical levels and conservative trigger limits, a move towards a more responsive management approach is not currently considered a high priority.

Fishing effort

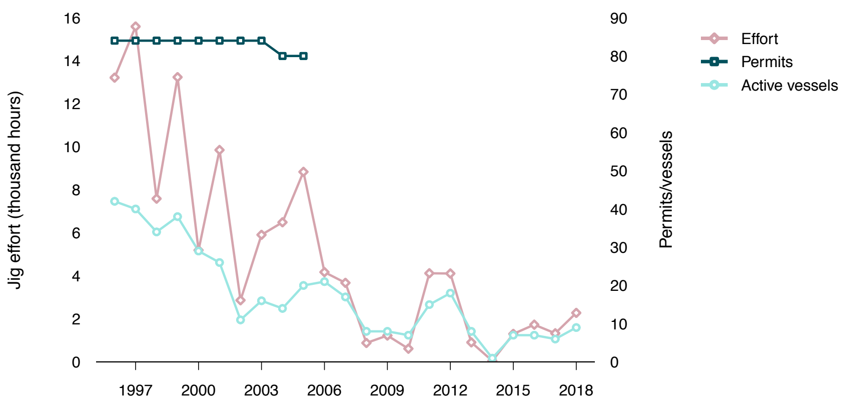
In 2018, there were 4,900 gear statutory fishing rights (SFRs), nine active vessels and a total fishing effort of 2,281 jig-hours in the SSJF (Table 13.2). From 1996 to 2005, annual average jig fishing effort was 8,878 jig-hours before declining to just 617 jig-hours by 2010. Since 2010, annual jig fishing effort has fluctuated between 50 and 4,122 jig-hours (Figure 13.2). High costs relative to revenue and higher variability in catch-per-unit-effort are the main reasons for the reduced effort in recent years. However, in 2018, jig fishing effort increased due to improved catch rates, and higher demand and prices for the product in the domestic market (AFMA 2018b). Trawling effort in the CTS and the GABTS is discussed in Chapters 9 and 11, respectively.

TABLE 13.2 Main features and statistics for the SSJF

Fishery statistics a	2017			2018		
Fishery	**TAE**	**Catch (t)**	**GVP (2016–17)**	**TAE**	**Catch (t)**	**GVP (2017–18)**
SSJF	550 standard jigging machines **b**	213	$0.57 million	550 standard jigging machines **b**	811	$2.7 million
CTS	–	569	$1.54 million	–	784	$2.4 million
GABTS	–	46	$0.13 million	–	53	$0.16 million
Total	**–**	**828**	**$2.24 million**	**–**	**1,649**	**$5.26 million**
Fishery-level statistics						
Effort	1,332 jig-hours			2,281 jig-hours		
Gear SFRs **c**	4,900			4,900		
Active vessels	6			9		
Observer coverage	0			0		
Fishing methods	Squid jig					
Primary landing ports	Hobart (Tasmania); Portland and Queenscliff (Victoria)					
Management methods	Input controls: gear SFRs, number of jig machines					
Primary markets	Domestic: Melbourne—fresh International: Canada, China, Hong Kong					
Management plan	*Southern Squid Jig Fishery Management Plan 2005*					

a The SSJF fishing season is 1 January – 31 December. Value statistics are by financial year. **b** Defined in the Southern Squid Jig Fishery Management Plan 2005 as a squid jigging machine that has two elliptical spools with one jig line on each spool. **c** Fishing rights that allow fishers to use a defined type and quantity of fishing gear. Operators in 2018 require 8.91 SFRs to be nominated to their boat for each standard squid jigging machine they use (AFMA 2018a).
Notes: **CTS** Commonwealth Trawl Sector. **GABTS** Great Australian Bight Trawl Sector. **GVP** Gross value of production. **SFR** Statutory fishing right. **TAE** Total allowable effort. – Not applicable.

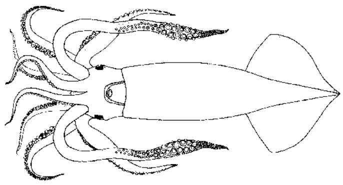
FIGURE 13.2 Effort, number of permits and number of active vessels in the SSJF, 1996–2018



Note: Permits were replaced by gear statutory rights in 2005.

13.2 Biological status

Gould's squid (*Nototodarus gouldi*)



Line drawing: FAO

Stock structure

Gould's squid is assumed to be a single biological stock throughout southern Australian waters. Genetic studies support this hypothesis (Jackson & McGrath-Steer 2003). Analysis of statoliths has shown that some Gould's squid caught in Victorian waters and the Great Australian Bight were hatched in a number of different regions off southern Australia (Virtue et al. 2011). The genetic homogeneity is more a function of egg mass and juvenile drift as a result of seasonal longitudinal ocean currents than large-scale migrations between the two areas (Green et al. 2015).

Catch history

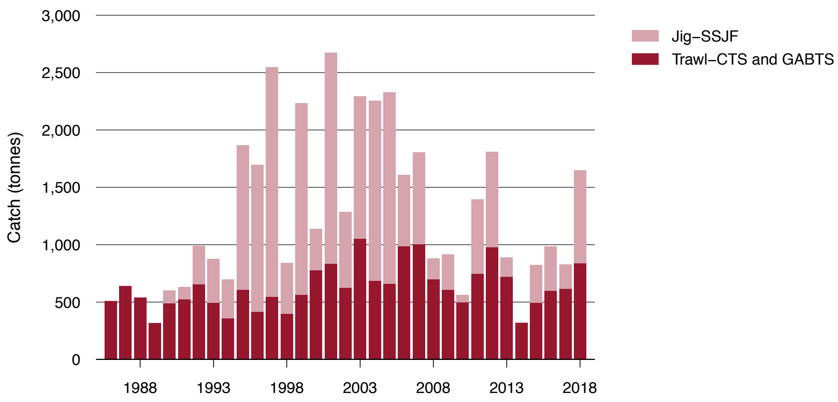
Before the SSJF began, Japanese commercial jig vessels fished waters off southern Australia in the 1970s and in the southern Australian Fishing Zone in the 1980s under joint-venture partnerships with Australian companies. The highest catch of Gould's squid from south-eastern Australian waters (7,914 t) was taken by Japanese jig vessels in 1979–80. Commercially viable jig catch rates were also achieved in south-eastern waters, particularly in western Bass Strait, proving the feasibility of a fishery for Gould's squid. Taiwanese and Korean vessels were also licensed to fish in Bass Strait until 1988, with annual catches ranging from 13 to 2,309 t.

In 2018, 1,649 t of squid was reported across three sectors—SSJF (811 t), CTS (784 t) and GABTS (53 t)—up from 828 t in 2017 (Table 13.2). Catch rates improved in 2018, and the catch in 2018 was the highest in the SSJF since 2012 (Figure 13.3).

During the past 10 years, SSJF annual catches have fluctuated between 832 t in 2012 and 2 t in 2014, increasing to 213 t in 2017 and 811 t in 2018. In the CTS, the annual catch over the same period was between 944 t in 2012 and 260 t in 2014, increasing to 784 t in 2018, up from 569 t in 2017. In the GABTS, annual catch has remained fairly stable, averaging around 52 t since 2013. In 2018, the nominal average catch rate in the SSJF increased substantially to 355 kg/hr, the highest catch rate recorded in the fishery in recent history (Figure 13.4).

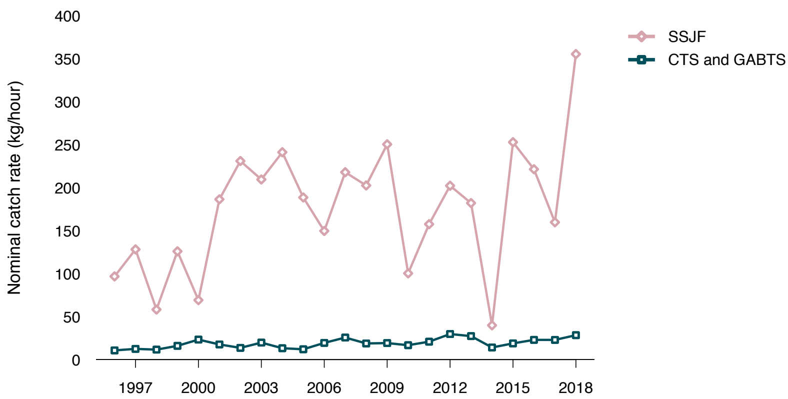
The Gould's squid stock is also fished in waters managed by New South Wales and Tasmania. The total catch of Gould's squid in Tasmanian-managed waters in 2017–18 was 528 t, which was an increase from 176 t in 2016–17 and represented a moderately high catch for the state (Moore et al. 2019). In New South Wales–managed waters, the total catch of Gould's squid in 2017 was 7.88 t (Noriega et al. 2018).

FIGURE 13.3 Squid catch in the SSJF, the CTS and the GABTS, 1986–2018



Notes: **CTS** Commonwealth Trawl Sector. **GABTS** Great Australian Bight Trawl Sector. **SSJF** Southern Squid Jig Fishery.

FIGURE 13.4 Nominal catch rate of Gould's squid in the SSJF, the CTS and the GABTS, 1996–2018



Notes: **CTS** Commonwealth Trawl Sector. **GABTS** Great Australian Bight Trawl Sector. **SSJF** Southern Squid Jig Fishery.

Stock assessment

Gould's squid is short lived (with a maximum life span of 12 months), spawns multiple times during its life, and displays highly variable growth rates, and size and age at maturity (Jackson & McGrath-Steer 2003). These characteristics mean that the population may be less susceptible to fishing mortality than longer-lived species. However, its short life expectancy implies a reliance on a single cohort, meaning recruitment to the stock is susceptible to environmental and fishery impacts (Jackson & McGrath-Steer 2003; Noriega et al. 2018).

Given the highly variable nature of squid availability (in terms of abundance and location) and the lack of biomass estimates with which to set meaningful biological reference points, the *Southern Squid Jig Fishery harvest strategy* uses a system of within-season monitoring against precautionary catch-and-effort triggers for the jig and trawl sectors. It includes a 3,000 t intermediate catch trigger or a 30 standard vessel effort trigger, and a 5,000 t limit catch trigger in the jig sector. The intermediate trigger requires a depletion analysis to be undertaken and increased investment in monitoring and data collection, while the limit trigger requires a suspension of fishing activities pending another depletion analysis. There is also a 2,000 t limit catch trigger for the trawl sector, with a control rule equivalent to the jig sector. Lastly, both sectors have a 4,000 t combined intermediate trigger and a 6,000 t combined limit trigger, with depletion analyses requirements equivalent to those listed above for the jig sector using data from all sectors.

ABARES conducted a depletion analysis for the central region of the SSJF from Cape Otway in Victoria to Robe in South Australia for 1995–2006 (Barnes, Ward & Boero 2015). The results suggested declines in stock biomass for most seasons, with escapement in five seasons estimated to be between 30% and 40%. However, these results are for only one region of the fishery and do not indicate exploitation rates for the whole stock. Furthermore, the limited data on squid growth for the domestic fishery and lack of an agreed estimate of natural mortality affect the magnitude of depletion estimates. Given these limitations, it was noted that further depletion analysis to guide within-season management decisions under the harvest strategy will require improved real-time fishery monitoring throughout the fishing season (Barnes, Ward & Boero 2015). Given the release of the revised Commonwealth Fisheries Harvest Strategy Policy in 2018, the Southern Squid Jig Fishery Resource Assessment Group recommended that the *Southern Squid Jig Fishery harvest strategy* should be reviewed, supported by an updated depletion analysis to inform the setting of revised trigger limits (AFMA 2018b).

Stock status determination

The high historical catches of Gould's squid taken by foreign vessels in the late 1970s and the 1980s indicate that a large annual harvest can be taken from the stock in years of high abundance without greatly reducing recruitment and biomass for subsequent seasons. These historical catches were used as a basis to set the catch triggers in the *Southern Squid Jig Fishery harvest strategy*, which have not been exceeded over the past decade. The relatively stable CTS catch rates in recent years suggest long-term stability in the availability, and perhaps biomass, of Gould's squid in the areas trawled. The stock is therefore classified as **not overfished**. In 2018, effort in the fishery increased as a result of record high catch rates, as well as higher prices and demand on the domestic market (AFMA 2018b). However, total effort in 2018 was lower than the historical average (1996–2005), which believe has not led to an overfished stock in both the jig and trawl sectors, and therefore the stock is classified as **not subject to overfishing**.

13.3 Economic status

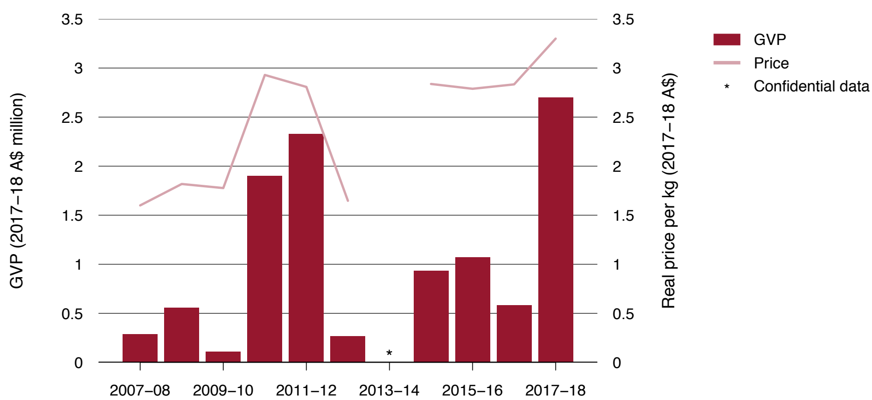
Key economic trends

Low fishing effort resulted in the lowest SSJF catch on record in 2014 (2 t). Catch in the SSJF has since increased to 384 t in 2016, 213 t in 2017 and 811 t in 2018, with a value of $2.7 million in 2017–18 (Figure 13.5). Squid also contributed $2.4 million in the CTS and $0.16 million in the GABTS during 2017–18.

Effort levels in the fishery increased from 1,332 jig-hours in 2017 to 2,281 jig-hours in 2018. In the same period, catch-per-unit-effort increased, suggesting lower unit fishing costs, and prices for landed catch increased. Increased effort and catch from the low levels of 2014 suggest that the incentive to fish and potentially net economic returns improved between 2015 and 2018.

The lack of a reliable supply for the domestic market has restricted the development of processing facilities. Most vessels operating in the SSJF do not have onboard refrigeration or processing facilities. The catch is chilled on board but must be returned to port each morning for processing or freezing, limiting the total amount of squid that can be taken on each trip. Catch volume and value in the SSJF are still low relative to other Commonwealth fisheries. It could expected that NER are also likely to be low.

FIGURE 13.5 Real GVP and average unit prices in the SSJF, 2007–08 to 2017–18



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

Management arrangements

The short life span of squid, a weak relationship between recruitment and stock abundance, and high interannual variability in squid abundance or availability mean that establishing an economic biomass target is challenging to achieve for the SSJF. Instead of a biomass target, the fishery's harvest strategy has a 3,000 t catch trigger to initiate an assessment of the state of the stock. This aims to prevent the risk of depletion in the SSJF, by allowing catches above the trigger level only if they are justified by assessment results (AFMA 2007). The trigger has not been reached since the harvest strategy was implemented in 2007.

The SSJF is managed using input (effort limit) controls. In the absence of formal stock assessments, total allowable effort (TAE) in the fishery has been set by the Southern Squid Jig Fishery Resource Assessment Group and the South East Management Advisory Committee at levels that maintain the capacity of the fleet to respond to changes in markets or the availability of squid.

The high degree of latent effort in the fishery allows the fishery to respond quickly to profitable opportunities provided by an increase in squid abundance or price (AFMA 2017). The number of squid jigging machines allocated to gear SFRs is determined by dividing the TAE for the fishing year by the total number of gear SFRs for the fishing season. In 2018, the TAE was 550 standard jigging machines, with 4,900 gear SFRs present in the fishery, meaning that each jigging machine required 8.91 gear SFRs. Although the level of gear SFR latency (unused gear) has been variable in the SSJF, it has persisted at high levels since 1996. There were 35 owners of SFRs in the 2018 season, with only 9 vessels active. This suggests that market factors rather than management arrangements have constrained effort.

Performance against economic objective

The catch trigger approach implemented in the SSJF has no clear link to economic performance, so it is difficult to determine how well the fishery is meeting the economic objective of the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018).

Despite effort increasing in the recent fishing season, high levels of latent fishing effort have persisted in the SSJF. Reducing this latent effort may be beneficial for the fishery by preventing the entry of excessive capacity in profitable years when prices are high. However, a lower TAE would need to be supported by a well-functioning market for unused gear SFRs, to ensure that the fishery can still optimise the exploitation of a variable stock in years of increased abundance and high prices. Establishing a catch trigger that is closely aligned with economic performance would provide greater certainty around the level of latent effort that is desired for this fishery, but would be challenging to achieve given the life characteristics of squid and high seasonal variability in squid availability.

13.4 Environmental status

The SSJF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and therefore has export approval until 9 October 2026. There were no additional recommendations under this exemption.

The ecological risk assessment of the fishery, completed in 2006, did not identify any threats to the environment from jig fishing (AFMA 2009; Furlani et al. 2007). The SSJF is a highly selective fishery with little bycatch. Occasionally, schools of pelagic sharks, especially blue shark (*Prionace glauca*), are attracted by the schooling squid, and barracouta (*Thyrsites atun*) frequently attack squid jigs. The main effect of these interactions is damage to, or loss of, fishing gear; consequently, these species are avoided, with operators usually moving to another area when such interactions occur. Some gear is lost at times; it sinks to the seabed because of line weights.

The Australian Fisheries Management Authority publishes quarterly logbook reports of interactions with species that are protected under the EPBC Act. No interactions were reported for the SSJF in 2018. The occurrence of fur seals (*Arctocephalus* spp.) near working jig vessels has been raised as a possible concern in the past.

13.5 References

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Squid packed in crates
Dylan Maskey, AFMA

Chapter 14

Western Deepwater Trawl Fishery

N Mazloumi, J Woodhams and AH Steven

FIGURE 14.1 Area fished in the Western Deepwater Trawl Fishery, 2017–18

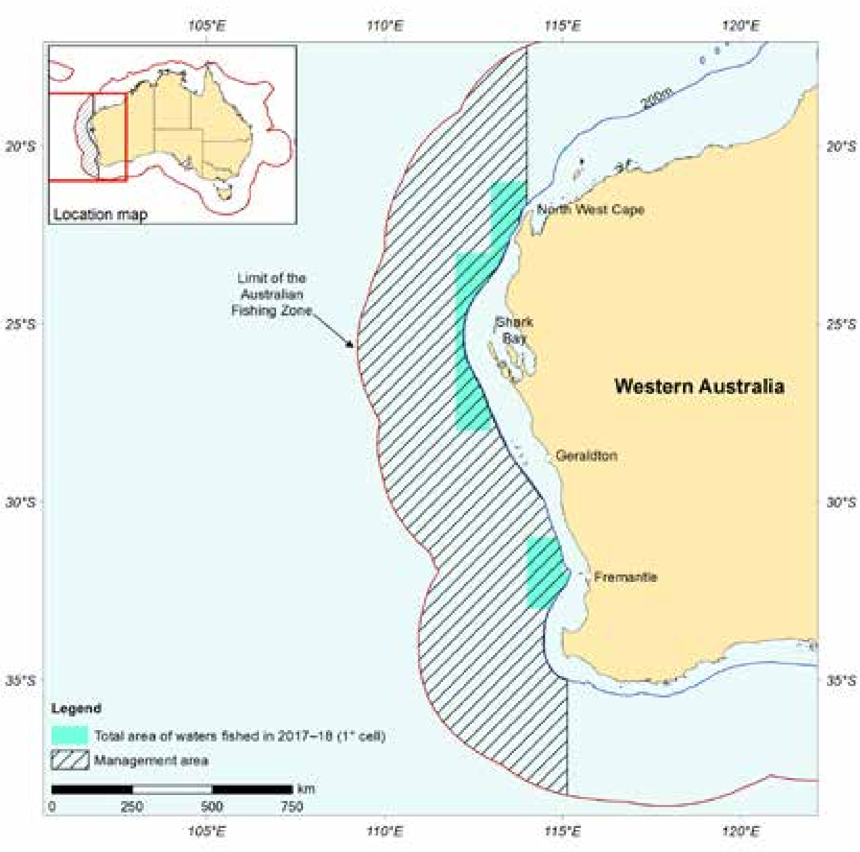


TABLE 14.1 Status of the Western Deepwater Trawl Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Deepwater bugs (*Ibacus* spp.)					Fishing mortality levels are unlikely to constitute overfishing. No reliable estimate of biomass.
Ruby snapper (*Etelis carbunculus*, *Etelis* sp.)					Fishing mortality levels are unlikely to constitute overfishing. Biomass above the limit reference point.
Economic status	Estimates of NER are unavailable, and gross value of production is confidential because of the low number of active vessels in the fishery. Fishing catch and the number of active vessels have been historically low. An increase in catch and active vessels in the 2017–18 fishing season may indicate economic improvement in the fishery; however, this may have been offset by the increase in fishing effort and fuel prices, which increase costs in the fishery. Therefore, whether NER increased or decreased in the 2017–18 fishing season is uncertain.				

Note: **NER** Net economic returns.

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

Fshing net
AFMA

14.1 Description of the fishery

Area fished

The Western Deepwater Trawl Fishery (WDTF) operates in Commonwealth waters off the coast of Western Australia between the western boundary of the Southern and Eastern Scalefish and Shark Fishery in the south (115°08'E) and the western boundary of the North West Slope Trawl Fishery (NWSTF) in the north (114°E) (Figure 14.1). There have been recent changes to the boundary of this fishery to more closely align with the 200 m isobath. Effort in recent years has been localised in the area offshore and slightly south of Shark Bay in Western Australia.

Fishing methods and key species

Operators in the fishery use demersal trawl, and catch more than 50 species in waters seaward of a line approximating the 200 m isobath, in habitats ranging from temperate–subtropical in the south to tropical in the north. Catches in the WDTF were historically dominated by six commercial finfish species or species groups: orange roughy (*Hoplostethus atlanticus*), oreos (Oreosomatidae), boarfish (Pentacerotidae), eteline snapper (Lutjanidae: Etelinae), apsiline snapper (Lutjanidae: Apsilinae) and sea bream (Lethrinidae). Between 2000 and 2005, deepwater bugs (*Ibacus* spp.) emerged as the most important target species. A wide variety of finfish species made up the catch in 2017–18, with deepwater bugs and ruby snapper (*Etelis* sp.) making up around 50% of the whole catch.

Management methods

The fishery is managed under the same harvest strategy as the NWSTF (AFMA 2011; see Chapter 6).

Fishing effort

The number of vessels active in the fishery and total hours trawled have fluctuated from year to year. Notably, total hours trawled were relatively high for a brief period during the early 2000s when fishers targeted ruby snapper and deepwater bugs. Total fishing effort was comparatively low between 2005–06 and 2016–17. While only three vessels were active again in 2017–18, trawl-hours increased markedly to just over 1,100 hours (Table 14.2).

Catch

Catch in the WDTF has been variable, peaking at around 378 t in 1994–95 and then again at 347 t in 2001–02. The peak in catch in the early to mid 1990s consisted mostly of orange roughy, whereas the peak in catch at the turn of the century consisted mostly of orange roughy, deepwater bugs and, to a lesser extent, ruby snapper.

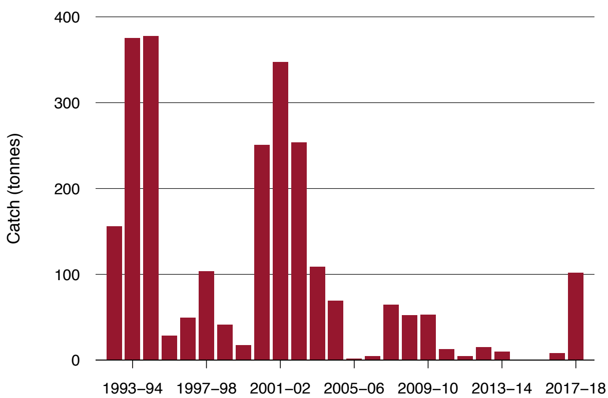
Total catch had been relatively low in recent years, consisting mostly of deepwater bugs, with minimal catch of finfish. However, catches increased substantially in 2017–18, consisting mostly of ruby snapper, deepwater bugs and mixed fish (Table 14.2; Figure 14.2).

TABLE 14.2 Main features and statistics for the WDTF

Fishery statistics a	**2016–17 fishing season**			**2017–18 fishing season**		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Deepwater bugs	–	7.6	Confidential	–	22.1	Confidential
Ruby snapper	–	0	0	–	28	Confidential
Total fishery	**–**	**8.3**	**Confidential**	**–**	**101.9**	**Confidential**
Fishery-level statistics						
Effort	11 days, 180.5 trawl-hours			100 days, 1,108.3 trawl-hours		
Fishing permits	4			7		
Active vessels	1			3		
Observer coverage	0 days (0%)			6 days (6%)		
Fishing methods	Demersal trawl					
Primary landing ports	Carnarvon, Fremantle (Western Australia)					
Management methods	Input controls: limited entry (11 permits), gear restrictions Catch controls: trigger limits for key commercial species					
Primary markets	Domestic: Brisbane, Perth, Sydney—frozen, chilled International: Japan, Spain, United States—frozen					
Management plan	*North West Slope Trawl Fishery and Western Deepwater Trawl Fishery: statement of management arrangements* (AFMA 2012)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 July – 30 June. Value statistics are provided by financial year, which is also 1 July – 30 June.
Notes: **GVP** Gross value of production. **TAC** Total allowable catch. – Not applicable.

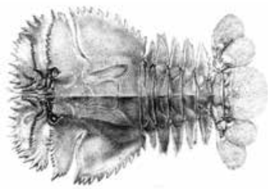
FIGURE 14.2 Total catch in the WDTF, 1992–93 to 2017–18



Source: AFMA

14.2 Biological status

Deepwater bugs (*Ibacus* spp.)



Line drawing: FAO

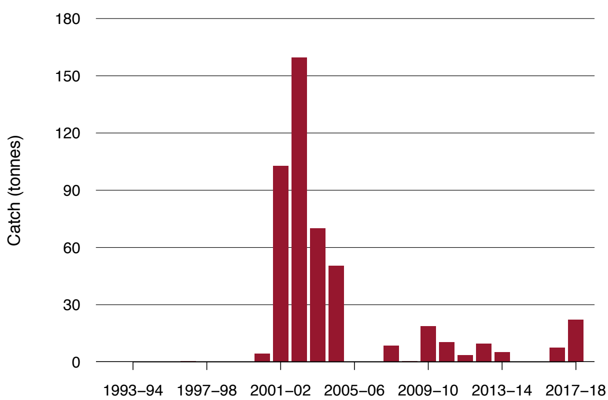
Stock structure

The WDTF targets several species of deepwater bugs. Stock structure of these species is not known, and they are grouped into a multispecies stock for status assessment.

Catch history

The catch history of deepwater bugs in the WDTF is characterised by relatively low levels of catch in most years, with four years of relatively high catches between 2001–02 and 2004–05, peaking at 160 t in 2002–03 (Figure 14.3). In 2017–18, catch was 22.1 t, up from around 7.6 t in 2016–17 and zero for the two seasons before this period (Figure 14.3).

FIGURE 14.3 Deepwater bug catch in the WDTF, 1992–93 to 2017–18



Source: AFMA

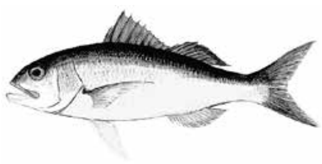
Stock assessment

A formal stock assessment for deepwater bugs has not been done, and little information is available with which to assess stock status. Relatively low levels of fishing effort, low levels of catch and sporadic targeting of key commercial species make it difficult to quantitatively assess stock status.

Stock status determination

Catch of bugs in the WDTF in 2017–18 was the highest since the historical peak in 2001–02 to 2004–05. There is no current or reliable indication of what sustainable catch might be for this stock. However, catch of bugs in the WDTF over the preceeding decade was relatively low, averaging less than 10 t. This level of catch is substantially below the levels of bug catch taken on the east coast of Australia, where stocks are considered to be sustainable (Stewardson et al. 2018) (Figure 14.3). Given that recent catches have been relatively low and localised, and catches of the same complex of species in another fishery are substantially higher and considered to be sustainable, the level of catch in the WDTF is be unlikely to drive the stock into an overfished state. As a result, deepwater bugs are classified as **not subject to overfishing**. While catches remain relatively low, it is unlikely that the stock would be considered as being subject to overfishing. However, given the absence of reliable information on sustainable catch levels, if catches continue to increase, additional information may be required that confirms these levels of catch are sustainable in the long term to avoid an uncertain fishing mortality status classification. Few empirical data inform the biomass status for this stock. As a result, the level of biomass of the stock is **uncertain**.

Ruby snapper (*Etelis* sp.)



Line drawing: FAO

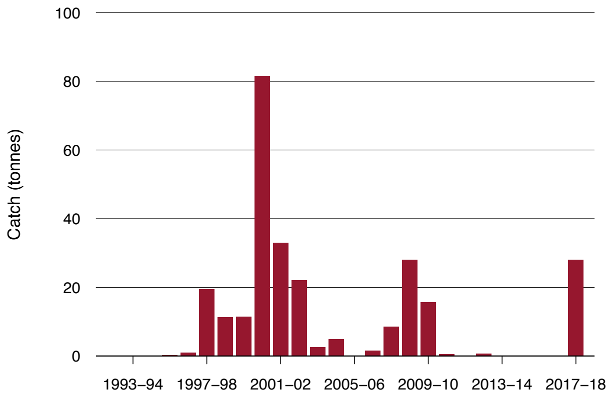
Stock structure

Four species of *Etelis* are captured in the WDTF, although ruby snapper (*Etelis* sp.) is the most commonly captured. A recent taxonomic revision of ruby snapper revealed two morphologically similar species that are now recognised as *Etelis* sp. (ruby snapper) and *Etelis carbunculus* (pygmy ruby snapper) (Andrews et al. 2016; Wakefield et al. 2014; Williams et al. 2017). However, catches for these two species are currently reported as a single species. The stock structure of ruby snapper caught in the WDTF is uncertain. In the absence of clear information on biological stock structure, this stock is assessed at the fishery level.

Catch history

Catches of ruby snapper in the WDTF peaked in 2000–01 (around 70 t), with a smaller peak in 2008–09 (around 24 t). Catches were relatively small between 2010–11 and 2016–17, but increased in 2017–18 to 28 t (Figure 14.4).

FIGURE 14.4 Ruby snapper catch in the WDTF, 1992–93 to 2017–18



Source: AFMA

Stock assessment

The only stock assessment for ruby snapper in the WDTF was published in 2002 (Hunter, Dichmont & Venables 2002). However, the reliability and accuracy of outputs from this assessment were weakened by the poor quality and limited quantity of data. The assessment identified biological characteristics that potentially increase the species' vulnerability to overfishing: the species is relatively long lived, has a slow growth rate and aggregates in restricted continental-shelf habitats. Hunter, Dichmont & Venables (2002) showed that fishing for ruby snapper in the WDTF was historically restricted to the area of the continental-shelf region from Shark Bay to North West Cape. Commercial catch-per-unit-effort has been highly variable—it was initially around 400 kg/hr in January 1997, peaked at 900 kg/hr in September 1997 and declined to less than 200 kg/hr towards the end of the study period in mid 2001. Although Hunter, Dichmont and Venables (2002) could not conclusively identify the cause of the decline in catch rates, they concluded that it probably resulted from a combination of changes in stock abundance and fleet movements.

The WDTF overlaps with Western Australian state-managed demersal fisheries that also target ruby snapper. Therefore, it is highly likely that these fisheries are exploiting the same stock of ruby snapper. Catch-curve and spawner-per-recruit analyses using direct age data from 1997 and 2011 were used to assess the status of ruby snapper in Western Australian fisheries (Wakefield et al. forthcoming). Results indicated that the stock was at approximately 60% of the unfished biomass level in 1997 and 2011. Fishing mortality rates were relatively low for 1997 (0.04) and 2011 (0.05) compared with the estimated natural mortality rate of 0.11 per year, which suggests that the stock was not subject to overfishing during those periods.

Stock status determination

A weight-of-evidence approach based on catch and landing data since the 1992–93 fishing season (Figure 14.4), together with information published with the 2002 stock assessment and the assessments undertaken for Western Australian state-managed fisheries (summarised above), were used to determine stock status.

Although catch in 2017–18 was the third largest on record for the fishery, and substantially above that of previous years, catches of ruby snapper in the WDTF over the past decade have been relatively low (average around 11 t). There is no current or reliable indication of what the sustainable catch might be for this stock. However, the assessment of the ruby snapper stock from the Western Australian state-managed fisheries indicates that the biomass of the stock was well above the Commonwealth's limit reference point of $0.2B_0$ in 1997 and 2011. Catches from 2011 to 2016–17 were substantially lower than in previous years, and likely well below levels that would drive the stock into an overfished state. It is also unlikely that the catch increase to 28 t for a single year (2017–18) would be sufficient to drive the stock into an overfished state. As a result, ruby snapper is classified as **not overfished** and **not subject to overfishing**.

14.3 Economic status

Key economic trends

Net economic returns (NER) are unavailable for the WDTF. The gross value of production (GVP) of the fishery is confidential because of the low number of active vessels. Historically, fishing has been opportunistic in the fishery, and catch levels have been variable.

The number of permits, the number of active vessels and fishing effort all increased in the 2017–18 fishing season, suggesting increased incentive to participate in the fishery. Total catch increased more than 10-fold to around 102 t (the 2017–18 fishing season was the first year since 2003–04 when catch exceeded 100 t), indicating increased fishing income. However, the increases in the number of active boats, fishing effort (hours trawled) and higher fuel prices are likely to have increased the total operating cost for the fishery. Therefore, whether NER increased or decreased in the 2017–18 fishing season is uncertain.

Changes in species catch composition in the fishery can indicate changes in the economic incentives to target different species. Of the target species, bugs represented 91% of the total catch in 2016–17, decreasing to 22% in 2017–18. Ruby snapper value may have increased in the 2017–18 season; it represented 0% of the catch in 2016–17, increasing to 27% in 2017–18. Catch of other species represented 9% in 2016–17 and increased to 51% in 2017–18, also indicating increased economic value of non-target species.

Management arrangements

The fishery has the same harvest strategy as the NWSTF (Chapter 6). The WDTF is managed through input controls (11 permits with a five-year duration).

Performance against economic objective

The fishery's performance against the economic objective is uncertain. Historically, fishing has been opportunistic, with a range of species caught in low volumes, typically generating low overall value. Given these characteristics, low-cost management arrangements are appropriate. However, management structures may require review if catch continues to trend upwards.

14.4 Environmental status

The WDTF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 18 December 2020.

The Western Trawl fisheries (NWSTF and WDTF) have been assessed to level 3 of the Australian Fisheries Management Authority (AFMA) ecological risk assessment (Zhou, Fuller & Smith 2009). No species were found to be at high risk at the current level of fishing effort.

AFMA publishes quarterly summaries of logbook reports of interactions with protected species on its website. No interactions with protected species listed under the EPBC Act were reported in the WDTF in 2018.

14.5 References

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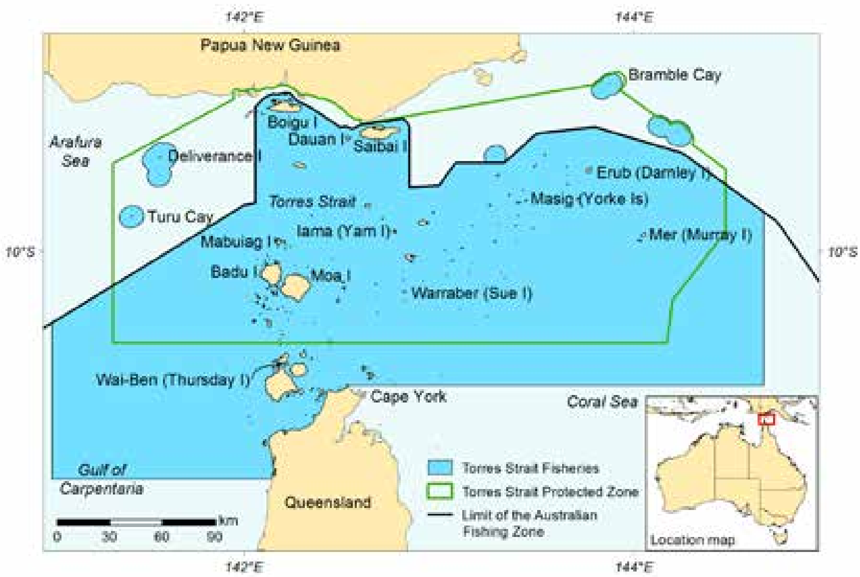
Chapter 15

Torres Strait fisheries

R Noriega, A Williams and AH Steven

FIGURE 15.1 Area of the Torres Strait fisheries



Torres Strait is located between Cape York Peninsula (north Queensland) and Papua New Guinea (PNG; Figure 15.1). It connects the Arafura and Coral seas, and is an important shipping route. There are hundreds of islands and reefs in Torres Strait, with 17 island communities plus several communities in the Northern Peninsula Area on Cape York. The area produces seafood for local consumption, and for sale in Australia and overseas. Local seafood is a primary food source for Torres Strait Islanders, as well as being central to traditional island culture and an important source of income.

The 1985 Torres Strait Treaty between Australia and PNG established the boundaries between the two nations and provides for joint management of the shared marine resources. The treaty is concerned with sovereignty and maritime boundaries, protection of the marine environment, and optimum use of commercial resources in the region. It also establishes the Torres Strait Protected Zone (TSPZ; Figure 15.1), in which each nation exercises sovereign jurisdiction over migratory fish and sedentary species in its own waters. The principal purpose of establishing the TSPZ is to acknowledge and protect the way of life and livelihood of the Traditional Inhabitants of the area. This includes protecting traditional fishing methods and rights of free movement.

The management area for each Australian fishery in Torres Strait extends south of the TSPZ (Figure 15.1). In each fishery, this area of the management zone is referred to as the 'outside but near area'. The boundary of the outside but near area for each fishery varies; these boundaries are shown in the fishery maps in subsequent chapters.

Under the treaty, Australia and PNG are required to cooperate on the conservation and management of the commercial fisheries in the TSPZ; they also engage in regular bilateral discussions. This cooperation includes negotiating and setting catch-sharing provisions for several Torres Strait fisheries under article 23 of the treaty. Catch sharing includes the development of subsidiary conservation and management arrangements under article 22 of the treaty.

In Australia's area of the TSPZ, traditional fishing and commercial fisheries are managed by the Torres Strait Protected Zone Joint Authority (PZJA), which was established under the *Torres Strait Fisheries Act 1984*. The PZJA comprises the ministers from the Australian and Queensland governments responsible for fisheries, and the Chair of the Torres Strait Regional Authority (TSRA). The TSRA (an Australian Government statutory authority) was established in 1994 under the *Aboriginal and Torres Strait Islander Commission Act 1989* (now the *Aboriginal and Torres Strait Islander Act 2005*), and has responsibility for managing programs that aim to improve the way of life and livelihood of Torres Strait Islanders and Aboriginal people living in Torres Strait.

On 7 August 2013, the High Court of Australia held that Commonwealth and Queensland legislation that prohibited fishing for commercial purposes without a licence did not extinguish the native title rights of certain Torres Strait communities to take resources from defined areas. In practice, this means that native title holders are still required to comply with Commonwealth and Queensland licensing requirements to undertake commercial fishing, but may do so without extinguishing their non-exclusive native title rights.

Two Australian commercial fishing sectors operate in Torres Strait: the Traditional Inhabitant Boat Sector, operating under Traditional Inhabitant Boat (TIB) licences; and the non–Traditional Inhabitant Sector, operating under Transferable Vessel Holder (TVH) licences. TIB licences are available only to fishers who satisfy the Traditional Inhabitant requirements. TVH licences are issued to other commercial fishers.

It is mandatory for all TVH licence holders to report catch-and-effort data in logbooks. There is no equivalent catch-and-effort logbook for TIB licence holders. However, the PZJA implemented a mandatory fish receiver system (FRS) for all Torres Strait fisheries (excluding the Torres Strait Prawn Fishery) on 1 December 2017. The FRS replaced the voluntary docket-book system used by fish buyers and processors, and records catch-and-effort information from all fishers, including TIB fishers. Under the FRS, all licensed commercial fishers are required to unload their catch to a licensed fish receiver, and licensed receivers are only permitted to receive product from a licensed fisher.

The commercial fisheries currently managed by the PZJA are prawn, tropical rock lobster, Spanish mackerel, reef line, bêche-de-mer (sea cucumber), trochus (top shell), pearl shell, crab, barramundi and traditional fishing (including turtle and dugong). Five of these fisheries—prawn, tropical rock lobster, pearl shell, Spanish mackerel, and turtle and dugong—are article 22 fisheries that are jointly managed by PNG and Australia. For Australian fishers, the Torres Strait Tropical Rock Lobster Fishery is the most commercially valuable of the Torres Strait fisheries, with a gross value of production of $15.0 million (278 t, whole-weight equivalent) in the 2017–18 financial year. This is followed by the Torres Strait Prawn Fishery (278 t, worth $4.6 million in 2017–18).

The Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018) does not prescribe management arrangements for fisheries jointly managed by the Australian Government and other (domestic or international) management agencies, such as the fisheries in Torres Strait. The PZJA has asked its management forums to provide advice on the application of the HSP to the Torres Strait fisheries. A harvest strategy for the Torres Strait Prawn Fishery was implemented in 2011 (AFMA 2011). No harvest strategies are currently in place for any other Torres Strait fisheries.

15.1 References

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Chapter 16

Torres Strait Finfish Fishery

A Williams, N Marton and AH Steven

FIGURE 16.1 Area of the Torres Strait Finfish Fishery

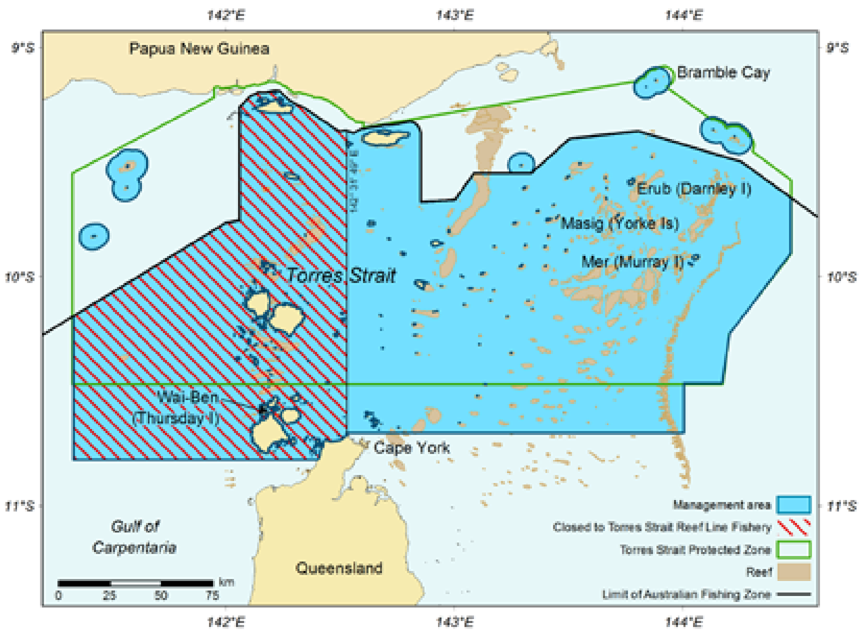


TABLE 16.1 Status of the Torres Strait Finfish Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Coral trout (*Plectropomus* spp., *Variola* spp.)					Management strategy evaluation testing suggests that current catches are well below the level likely to lead to biomass declines. Most recent biomass estimate indicated a biomass above $0.6B_0$.
Spanish mackerel (*Scomberomorus commerson*)					Current fishing mortality rate is below that required to produce MSY. Most recent average estimate of biomass is above $0.2B_0$.
Economic status	Estimated net economic returns are not available for the fishery. The economic performance of the fishery in the 2017–18 fishing season is uncertain.				

Notes: **B_0** Unfished biomass. **B_{20}** 20% of unfished biomass. **MSY** Maximum sustainable yield.

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

16.1 Description of the fishery

Area fished

Most commercial fishing in the Torres Strait Finfish Fishery (TSFF) takes place in the north-eastern region of Torres Strait (Figure 16.1). A large area of the fishery west of 142°32'E is closed to commercial fishing for the Torres Strait Finfish (Reef Line) Fishery (TSFRLF). The western closure is currently under review (AFMA 2018b).

The TSFF has two components: the Torres Strait Spanish Mackerel Fishery (TSSMF) and the TSFRLF. Two commercial sectors—the Traditional Inhabitant Boat (TIB) and non-TIB sectors—participate in the TSSMF and the TSFRLF.

Fishing methods and key species

Traditional fishing targets a range of species, including those targeted by the commercial sectors, the catch of which is taken into account in the management of the commercial sectors.

The TSSMF targets Spanish mackerel (*Scomberomorus commerson*), primarily by trolling from small dories or dinghies tendered to a larger primary vessel or operating independently. Byproduct is a relatively minor component of catch. Most of the byproduct is other mackerel species (grey, school, spotted and shark mackerel), but small quantities of reef fish, including coral trout, are also retained (AFMA 2005; Begg et al. 2006).

The TSFRLF is a multispecies demersal hook-and-line fishery targeting mainly coral trout (*Plectropomus* spp., *Variola* spp.), with smaller catches of other groupers/cods (Serranidae), mackerels (Scombridae), snappers (Lutjanidae), emperors (Lethrinidae) and trevally (Carangidae). The most recent data indicate that coral trout make up more than 90% of the retained commercial catch (by weight) for both the TIB and non-TIB sectors, while barramundi cod and rock cods represent 5%, and red emperor represents 2%.

Both sectors have historically discarded more than half their total catch, in numbers, as bycatch (Williams et al. 2008). The TIB Sector retains a wider range of species than the non-TIB Sector, mainly for subsistence (Busilacchi et al. 2012, 2013).

A variety of fishing gears, including hook and line, nets, spears and traps, are used by subsistence fishers in the TSSMF and the TSFRLF. Estimated yields of reef fish for the subsistence fishing sector are similar to those for the TIB and non-TIB commercial sectors combined (Busilacchi 2008; Busilacchi et al. 2013). However, the species composition of the subsistence and commercial catches differs: traditional subsistence fishing takes predominantly trevallies (Carangidae), mullet (Mugilidae), sardines (Clupeidae) and rabbitfish (Siganidae).

Management methods

The fishery is managed through both input controls (limited entry, vessel restrictions and prohibited species) and output controls (size limits and amount of leased quota).

A management plan for the TSFF was finalised in 2013. The plan provides for the setting of a total allowable commercial catch (TACC). In 2008, the Australian Government funded a 100% buyback of non-TIB fishing licences, such that the Torres Strait Regional Authority now holds a 100% share of the fishery in trust for Traditional Inhabitants. Non-TIB fishers are required to operate by leasing catch allowances under a temporary annual licence (called a 'sunset licence'). These operators lease quota for Spanish mackerel, coral trout and other finfish species each year through the Torres Strait Regional Authority.

Although the Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018) does not apply to fisheries jointly managed by the Australian Government and other (domestic or international) management agencies, the HSP does represent the government's preferred approach to management. A formal harvest strategy for the TSFF is being developed (AFMA 2018a). In the interim, the proxy limit reference point specified in the HSP ($0.2B_0$) is used for status determination.

Fishing effort

Effort in the fishery has decreased from peaks in the early 2000s. Several factors have contributed to the decline, including the voluntary surrender of Transferable Vessel Holder (TVH) fishing licences, government-funded structural adjustment and logistical difficulties relating to freezer capacity. The fishery for coral trout on the Queensland east coast focuses primarily on live export (QDAFF 2013). The removal of the ban on live exports in Torres Strait has previously done little to increase activity in the TSFRLF, primarily because of difficulties and costs associated with transporting live fish from remote areas. In 2017, live coral trout were exported for the first time.

Catch

Catch in the TIB and TVH sectors has followed the trends in effort, discussed above.

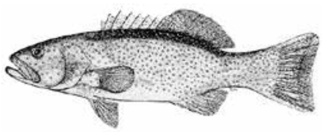
TABLE 16.2 Main features and statistics for the TSFF

Fishery statistics a	**2016–17 fishing season**			**2017–18 fishing season**		
Stock	**TACC (t)**	**Catch (t)** b	**GVP (2016–17)**	**TACC (t)**	**Catch (t)** b	**GVP (2017–18)**
Coral trout	134.9	25.7	Confidential	134.9	25.3	Confidential
Spanish mackerel	187.0	93.2	Confidential	132.0	71.9	Confidential
Other	–	2.2	Confidential	–	1.7	Confidential
Total fishery		**121.1**	**$1.2 million**		**98.9**	**$1 million**
Fishery-level statistics						
Effort (days) TSSMF	Spanish mackerel: TIB—not available Sunset permits **c**—396 operation-days, 849 tender-days			Spanish mackerel: TIB—not available Sunset permits—395 operation-days, 748 tender-days		
TSFRLF	Coral trout: TIB—not available Sunset permits—205 coral trout operation-days, 205 tender-days (same for all TSFRLF species)			Coral trout: TIB—not available Sunset permits—182 coral trout operation-days, 182 tender-days (same for all TSFRLF species)		
Fishing permits	TIB: 266 mackerel endorsements, 248 line endorsements Sunset permits: 7 mackerel and/or line licences			TIB: 163 mackerel endorsements, 143 line endorsements Sunset permits: 7 mackerel and/or line licences		
Active vessels TSSMF	Spanish mackerel: TIB—7 Sunset permits—5			Spanish mackerel: TIB—11 Sunset permits—7		
TSFRLF	Coral trout: TIB—11 Sunset permits—4			Coral trout: TIB—13 Sunset permits—3		
Observer coverage	0 days			0 days		
Fishing methods	Coral trout and mixed reef species: handline, rod and line Spanish mackerel: trolled baits, lures and handlines					
Primary landing ports	Cairns (Queensland); Torres Strait island fish receivers on Erub (Darnley), Masig (Yorke) and Mer (Murray) islands					
Management methods	Input controls: limited entry, vessel restrictions, prohibited species Output controls: size limits, amount of leased quota					
Primary markets	Domestic: frozen International: frozen					
Management plan	*Torres Strait Finfish Fishery Management Plan 2013*					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 July – 30 June. Value statistics are provided by financial year and are in 2017–18 dollars. **b** Catch figures include both TIB and non-TIB catch; however, reporting by the TIB Sector is not mandatory, so additional unreported catch and fishing effort are likely. **c** All finfish and Spanish mackerel quotas in Torres Strait are held in trust and managed by the Torres Strait Regional Authority on behalf of the TIB Sector. 'Sunset' permits allow non–Traditional Inhabitant fishers to fish in Torres Strait, and take finfish and Spanish mackerel leased from the TIB Sector. Sunset permits are issued each year and expire on 30 June each year. Six sunset permits are available for primary boats that carry a small number of tenders.
Notes: **GVP** Gross value of production. **TACC** Total allowable commercial catch. **TIB** Traditional Inhabitant Boat. **TSFRLF** Torres Strait Finfish (Reef Line) Fishery. **TSSMF** Torres Strait Spanish Mackerel Fishery. – not applicable.

16.2 Biological status

Coral trout (*Plectropomus* spp., *Variola* spp.)



Line drawing: FAO

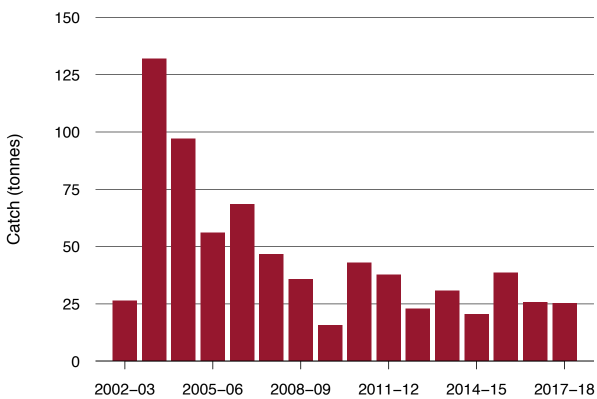
Stock structure

Coral trout in Torres Strait comprise four species: common coral trout (*Plectropomus leopardus*), barcheek coral trout (*P. maculatus*), passionfruit coral trout (*P. areolatus*) and bluespot coral trout (*P. laevis*). Each species is likely to be a single genetic stock in Torres Strait (Evans et al. 2010). The species are usually not distinguished in fishery logbooks. Therefore, the status is reported for the TSFF rather than for individual species or stocks.

Catch history

Commercial catch of coral trout in the TSFRLF peaked in 2003–04 at 132 t before falling below 50 t in 2007–08 (Figure 16.2). Catch has remained below this level since then.

FIGURE 16.2 Catch history for coral trout in the TSFRLF, 2002–03 to 2017–18



Source: AFMA

Stock assessment

The coral trout stock in the TSFRLF has not been formally assessed. However, a management strategy evaluation (MSE) was undertaken for the stock using catch data up to 2004 (Williams et al. 2007; Williams, Little & Begg 2011). Four constant-catch scenarios, ranging from 80 to 170 t, were tested. All achieved a biomass of at least 70% of the assumed unfished levels by 2025. The MSE also evaluated the effects of spatial and seasonal closures, and minimum size limits on achieving management objectives. Changes in the management and operation of the fishery since the MSE was completed may have diminished the relevance of the results for informing current management. A formal stock assessment is currently being developed, with draft results presented at the March 2019 Torres Strait Finfish Resource Assessment Group meeting. The draft assessment estimated the mean spawning biomass to be around 80% of unfished levels, with all model scenarios estimating spawning biomass to be above 65% of unfished levels (AFMA 2019). The assessment results are considered preliminary and therefore are not used for status determination.

Stock status determination

In the absence of an accepted stock assessment, the status of the coral trout stock is evaluated against the results of the MSE, combined with a comparison of the 2017–18 catch with the historical catch record (Figure 16.2). The biomass in 2004 was estimated to be more than 60% of unfished levels (Williams et al. 2007; Williams, Little & Begg 2011). Reported commercial catch in recent years has been below the historical catch levels and well below the lowest catch level simulated in the MSE (80 t per year). The results of the 80 t catch simulation indicated that the stock would increase to more than 80% of the unfished biomass within 20 years at that catch level (Williams et al. 2007; Williams, Little & Begg 2011).

Catch from the TIB Sector is likely to have been under-reported in the past because it was not mandatory for this sector to report catch-and-effort data. Reporting for the TIB Sector only became mandatory on 1 December 2017 (through the fish receiver system; see Chapter 15), and then only for catch that is sold commercially; reporting is still not required for subsistence fishing. Furthermore, representatives of the TIB Sector have advised that catches in the sector have increased in recent years (AFMA 2017). The unknown catch from the TIB Sector, together with the age of the MSE, give some cause for caution. However, effort for the TIB Sector has historically been around four to five times lower than that for the TVH Sector, with the difference in catch volumes even larger (Williams et al. 2008). As such, while the likely under-reporting and increasing TIB catches are of interest, and should be monitored closely through the new fish receiver system, the likely magnitude of total catches is unlikely to have reached the 80 t level simulated in the MSE in any year since 2004. As a result, the stock is classified as **not overfished** and **not subject to overfishing**.

Spanish mackerel (*Scomberomorus commerson*)

Line drawing: FAO

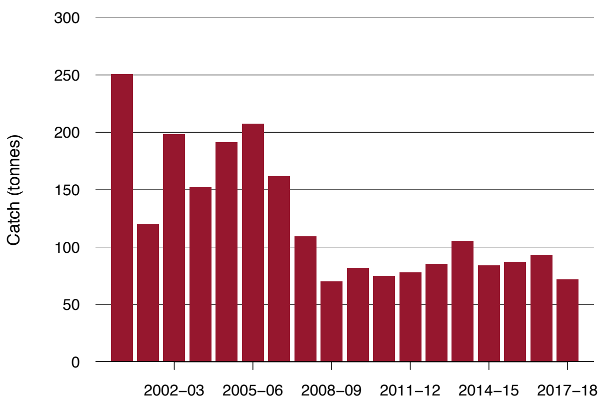
Stock structure

Spanish mackerel in Torres Strait comprise a separate biological stock from Spanish mackerel on the Queensland east coast and further west across northern Australia (Begg et al. 2006; Buckworth et al. 2007).

Catch history

Annual catches of Spanish mackerel declined from a peak of 251 t in 2000–01 to around 70 t in 2008–09 and have since remained at approximately 80–100 t (Figure 16.3).

FIGURE 16.3 Catch history for Spanish mackerel in the TSSMF, 2000–01 to 2017–18



Source: AFMA

Stock assessment

The stock assessment of Spanish mackerel in 2006 (Begg et al. 2006) was updated in 2016 using data to 2014 (O'Neill & Tobin 2016) and again in 2018 using data to 2017–18 as part of the harvest strategy development (AFMA 2019). The updated assessments use an integrated age-structured model, and input data on catch, effort and length-at-age of Spanish mackerel. The updated assessments do not use the model region structure or spatial catch data used by Begg et al. (2006) because of a large amount of missing or imprecise location data.

The most recent assessment update in 2019 included additional catch data from 2015 to the end of 2018, including a time series of TIB Sector catches. Recruitment was modelled stochastically, unlike previous assessments when recruitment was deterministic. Four standardised catch-per-unit-effort (CPUE) time series were developed that captured the potential effects of effort creep (either 0% or 1% annual increase in fishing power), and the effect of accounting for the number of dories used (either zero dories, or number of dories reported). All four standardised CPUE time series indicated a continued decline in abundance since 2009. A total grid of 48 models were run that included combinations of the four CPUE series, five natural mortality rates (0.25, 0.3, 0.35, 0.4 and 0.44) and two historical catch time series, one of which incorporated an annual harvest of 100 t between 1979 and 1986 to account for the presumed unreported catches by Taiwanese gillnet vessels. Some model runs, particularly where natural mortality was high and a historical Taiwanese gillnet catch was assumed, failed to converge, and were not included in the final grid of 39 models.

The median estimated spawning biomass in 2017–18 across the grid of 39 models was $0.26SB_0$ (ranging from 0.15 to $0.45SB_0$), with four of the 39 models estimating spawning biomass at below SB_{20}. The median estimated harvest rate (H) in 2017–18 across the models was 0.24, which was below the estimated harvest rate at maximum sustainable yield (MSY) (H_{MSY}) of 0.29.

Projections of the 2019 assessment grid of models included four constant catch scenarios (80 t, 94 t, 110 t and 120 t). The 80 t and 94 t constant catches resulted in increasing spawning biomass across all 39 models. The 110 t and 120 t constant catches were less optimistic, with spawning biomass predicted to decrease to below $0.2SB_0$ for some models with constant catches of 110 t and 120 t. Because of increasing concern around the biomass levels of the stock, the Torres Strait Finfish Resource Assessment Group recommended decreasing the recommended biological catch (RBC) from 125 t in 2018–19 to 94 t for the 2019–20 season. The 94 t RBC was agreed to by the Protected Zone Joint Authority, resulting in a TACC of 82 t after a 10 t subsistence catch and a 2 t recreational catch were deducted.

The potential for hyperstability in the catch rates of Spanish mackerel in Torres Strait remains a concern. Hyperstability occurs when catch rates are maintained while the underlying abundance declines. It is frequently observed in fisheries that target schooling species such as the Spanish mackerel fishery, where most fishing activity is concentrated on large spawning aggregations around Bramble Cay. Although Begg et al. (2006) recommended the collection of finer-scale spatial and temporal data to be reported by fishers to improve the standardisation of catch rates and provide a more robust index of abundance, the reporting of more precise catch-and-effort data has not improved.

Stock status determination

Declining CPUE across the four standardised CPUE series and the potential for hyperstability in catch rates are cause for some concern and will need to be monitored closely in coming years to ensure that the decreased RBC maintains the stock at a desired level. However, the median estimate of Spanish mackerel spawning biomass in 2017–18 was above $0.2SB_0$. As a result, the stock is classified as **not overfished**. Reported catches since 2014–15 have been below the estimated catch at F_{MSY} of 94 t, and the harvest rate in 2017–18 was estimated to be below H_{MSY}. On this basis, the stock is classified as **not subject to overfishing**.

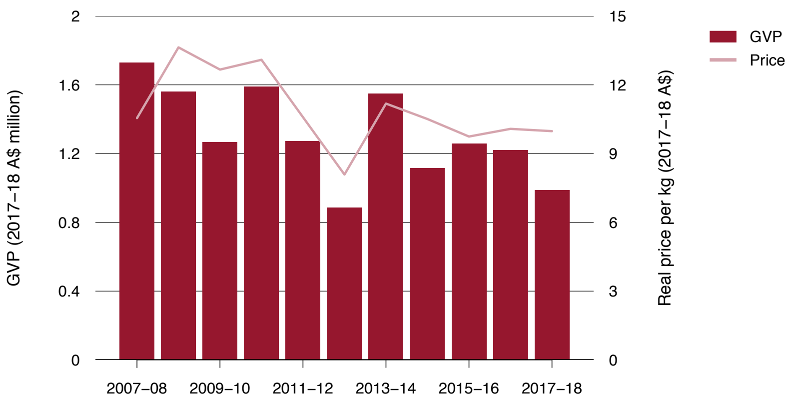
16.3 Economic status

Key economic trends

In the 2017–18 fishing season, coral trout and Spanish mackerel catch declined, in comparison with 2016–17. The decline in catch and unit price for both coral trout and Spanish mackerel has resulted in the lowest gross value of production (GVP) since the 2012–13 fishing season. The decline in 2017–18 GVP is consistent with the overall fall in fishing effort, fishing permits, catch and unit landing prices in the TSSMF and the TSFRLF.

Quota leasing arrangements were introduced in 2008 following a structural adjustment in the fishery. The amount of quota leased for each fishing season is determined by the Torres Strait Regional Authority, based on the level of interest from non-TIB fishers and the amount of quota that Torres Strait community representatives are willing to make available (TSFFWG 2010). Leasing arrangements are likely to generate some positive economic returns to the Torres Strait community as revenue from leasing activity is invested in capacity building for TIB fishers (TSRA 2015). Revenue generated from leased quota was $291,500 in 2017–18 (TSRA 2018).

FIGURE 16.4 Real GVP and average price per kilogram for the TSFF, 2007–08 to 2017–18



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

Management arrangements

The switch from TVH endorsements to the new leasing arrangements aims to increase community revenue to Traditional Inhabitants of Torres Strait. Leasing arrangements allow quota to be leased to non-TIB fishers, with the leasing revenue used for capacity building of the TIB fishing industry (TSRA 2013).

The Torres Strait Finfish Fishery Management Plan 2013 requires harvest levels to be set at or below levels that maintain biologically viable stocks of target and non-target species, following consultation with the Torres Strait Fisheries Management Advisory Committee and other stakeholders.

Performance against economic objective

The key objectives of the TSFF management plan are to acknowledge and protect the traditional way of life of Traditional Inhabitants, including their rights in relation to traditional fishing for finfish, and to conserve resources in a way that minimises the impact on the marine environment. Optimising economic viability of the fishery is one objective, but, unlike fisheries solely managed by the Australian Government, targeting maximum economic yield is not a key focus. The quota leasing arrangements in the fishery provide a means to meet the objectives under the Torres Strait Treaty to promote economic development and employment for Traditional Inhabitants (TSFMAC 2012).

Leasing revenue is intended to provide investment funding to build the capacity of Traditional Inhabitant fishing industries. In 2015–16, $1,000 in grant payments were disbursed, leaving the Finfish Quota Trust account with a closing balance of $1.3 million at the end of the financial year. No grant payments were made in 2016–17, leaving a closing balance of $1.5 million at the end of the 2016–17 financial year (TSRA 2016, 2017). In 2017–18, no grant payments were made again, closing the Finfish Quota Trust account with $1.7 million (TSRA 2018).

Estimates of net economic returns are not available for the fishery. The 2017–18 fishing season's decline in catch and landing prices has coincided with lower effort in the fishery. Total effort by the TIB Sector is broadly unknown. Consequently, there is uncertainty around the economic performance of the fishery in the 2017–18 fishing season. An increase in the number of active vessels in the 2017–18 season, especially across the TIB Sector, may indicate renewed interest in the fishery by customary fishers.

16.4 Environmental status

The TSFF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and has export approval until 18 December 2020.

No ecological risk assessments have been conducted for the TSFF. The strategic assessment report (AFMA 2012) assumes that the impacts of fishing on the ecosystem are restricted to anchoring, mooring and other anthropogenic activities; vessel accidents, leading to pollution such as oil spills; and potential translocation of species by hull and anchor fouling. The report concludes that direct impacts on the environment are likely to be minimal because of the low-impact nature of the hook-and-line fishing methods used in the fishery.

The Australian Fisheries Management Authority publishes quarterly logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in the TSFF in 2018.

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Coral trout
Ashley Williams, ABARES

Chapter 17

Torres Strait Tropical Rock Lobster Fishery

R Noriega, T Emery and AH Steven

FIGURE 17.1 Regional map showing the management area of the Torres Strait Tropical Rock Lobster Fishery

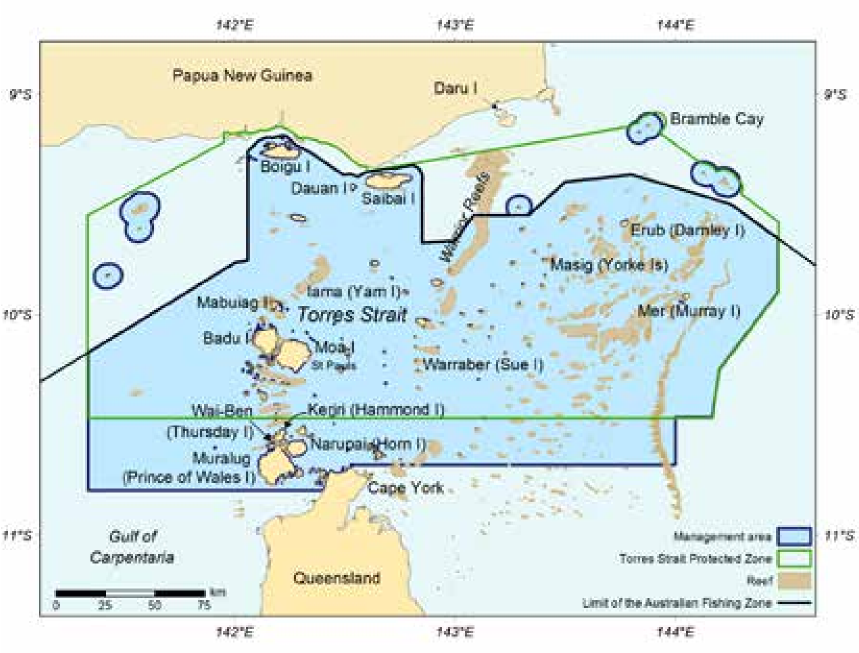


TABLE 17.1 Status of the Torres Strait Tropical Rock Lobster Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Tropical rock lobster (*Panulirus ornatus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Closure of the fishery in 2018 restricted fishing mortality levels to F_{TARG}. Spawning stock biomass in 2018 was above the limit reference point but below the target reference point. Spawning stock biomass is expected to increase in 2019 and fluctuate widely around the target.
Economic status	Net economic returns in the fishery are uncertain, although positive economic improvements may have occurred in the 2017–18 fishing season as a result of gross value of production increasing faster than effort.				

Note: F_{TARG} Target reference point for fishing mortality rate.

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

Tropical rock lobster
AFMA

17.1 Description of the fishery

The Torres Strait Tropical Rock Lobster Fishery (TSTRLF) is commercially fished in the Torres Strait Protected Zone (TSPZ) by Australian and Papua New Guinean nationals. Australians hold Transferable Vessel Holder (TVH) licences or Traditional Inhabitant Boat (TIB) licences (see Chapter 15).

Area fished

The TSTRLF extends from Cape York to the northern border of the TSPZ (Figure 17.1). Most catch comes from the western and south-eastern parts of the fishery, where the densities of tropical rock lobster are highest (AFMA 2013). Access to this fishery is shared by Australia and Papua New Guinea (PNG) under formal arrangements in the Torres Strait Treaty (see Chapter 15).

Fishing methods and key species

The TSTRLF is based on a single species: tropical rock lobster (*Panulirus ornatus*). It is predominantly a dive-based, hand-collection fishery. Divers use surface-supplied air (hookah) or free-dive, and predominantly work from 6-metre vessels (one diver per vessel). Some lobsters are also collected at night on shallow reef flats by fishers using a light and handheld spear or scoop net.

Operators can use motherships (primary vessels; large catch-storage vessels) in conjunction with smaller fishing vessels (tenders), or operate fishing vessels individually. The TVH Sector predominantly uses hookah gear and operates using primary vessels with tenders. This allows these vessels to travel to more distant fishing grounds and fish for a few days to several weeks. In contrast, TIB Sector operators predominantly work from small dinghies (<6 metres long) and undertake trips of one or two days, with divers working from smaller boats that depart from their local island communities. The TIB Sector has significantly increased its supply to market of live lobsters as opposed to tailed lobster over the past five to six years. This has been facilitated by changes in fishing behaviour and improved logistics chains rather than a change in the types of boats used in operations.

Management methods

During the 2017–18 season, the TSTRLF was managed primarily through effort restrictions (input controls). Since 2006, and in preparation for the Tropical Rock Lobster Fishery Management Plan, a recommended biological catch (RBC) was advised for each fishing season and apportioned between Australia and PNG. Because of a low RBC and the likelihood that catches would exceed the Australian catch share of the RBC in the 2017–18 season, the Torres Strait Fisheries (Tropical Rock Lobster) Management Instrument 2018 was made on 19 July 2018, providing for a binding total allowable catch (TAC) for the TSTRLF. The Australian TAC is Australia's catch share of the final TAC, as agreed with PNG.

On 26 November 2018, the Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018 was determined to coincide with the commencement of the Torres Strait Fisheries Amendment (Tropical Rock Lobster) Management Instrument 2018. This legislation came into force for the start of the 2018–19 season on 1 December 2018. The management plan provides for the introduction and establishment of a fishing quota system for the TSTRLF, following resolution of a formal quota allocation process as prescribed by the management plan. As the TSTRLF transitions to a fully operational management plan, separate interim TAC shares have been implemented for the TIB and TVH sectors through the management instrument. In May 2019, the Australian Fisheries Management Authority and the PNG National Fisheries Authority reached final agreement, as required under the Torres Strait Treaty, on catch-sharing arrangements for the 2018–19 season, resulting in a final TAC of 494.85 t for the TSTRLF.

While the management plan is being implemented, a range of input controls are in place, including a limited commercial fishing season (from 1 December to 30 September); a ban on the use of hookah gear between 1 October and 31 January, and around specified new and full moon periods; and gear restrictions that limit the collection of lobsters to hand collection, or collection by handheld implements such as snares, scoop nets or spears. In addition to the TAC, other output controls include minimum size limits for commercially caught lobsters of 90 mm carapace length or 115 mm tail length, and a prohibition on the possession of tropical rock lobster meat that has been removed from any part of a tropical rock lobster, on any boat, unless that lobster was taken in the course of traditional fishing.

A revised harvest strategy for the TSTRLF is being developed, with defined fishery-specific target and limit reference points, which is expected to be introduced from December 2019 (DEE 2018). The revised harvest strategy uses a limit reference point for biomass (32% of spawning biomass in 1973 [SB_{1973}]—$0.32SB_{1973}$), a target reference point for biomass ($0.65SB_{1973}$) and a target reference point for fishing mortality rate ($F_{TARG} = 0.15$). It has decision rules designed to maintain the stock at (or return the stock to) the target biomass reference point (B_{TARG}), maintain the stock above a limit biomass reference point (B_{LIM}) and implement rebuilding strategies if the stock falls below the B_{LIM} in two successive years. An interim harvest strategy is currently used to determine a binding TAC and to control harvest levels.

Fishing effort

Fishing effort in the TSTRLF is reported as tender-days, which is the common unit of effort across all sectors. Reported fishing effort (available since 1994) for the TVH Sector reached a peak of 5,200 tender-days in 2003–04 before decreasing to approximately 1,200 in 2008–09. Effort then increased to 3,008 tender-days in 2012–13 before decreasing to 1,506 in 2017–18 (Table 17.2). Fishing effort in the TIB Sector has been more difficult to estimate because the docket book system used to collect catch-and-effort data up until 2017 has been voluntary. Mandatory catch reporting, known as the Fish Receiver System, became mandatory for all Torres Strait fisheries, except the Torres Strait Prawn Fishery, on 1 December 2017. This system requires all catch from the TSTRLF to be landed to a licensed fish receiver and recorded. Analyses of the TIB effort data (available since 2004) that adjust for under-reporting and remove duplicate records under the docket book system (Campbell 2017) indicate that effort has decreased from more than 9,000 tender-days in 2004–05 to the lowest level of 2,619 in 2012–13. Since then, effort increased to 5,852 tender-days in 2014–15 before declining to 4,874 in 2017–18. Fishing effort for the PNG sector in Australian waters has decreased from a peak of more than 2,200 tender-days in 2009–10, and has been zero since 2013–14.

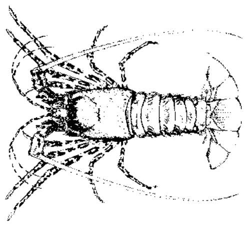
TABLE 17.2 Main features and statistics for the TSTRLF

Fishery statistics a	**2016–17 fishing season**			**2017–18 fishing season**		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)** b	**GVP (2017–18)**
Australia (TVH, TIB)	334	267	$12.9 million	254.15	261	$15.0 million
PNG	161	113	na	44.85	85 **c**	na
Total fishery	**495**	**380**	**na**	**299**	**346**	**na**
Fishery-level statistics						
Effort **d**	TVH: 2,352 tender-days, 942 operation-days TIB: 3,842 tender-days PNG: 0 tender-days (in Australian waters)			TVH: 1,506 tender-days, 558 operation-days TIB: 4,874 tender-days PNG: 0 tender-days (in Australian waters)		
Fishing permits	TVH: 12 licences, 34 tenders TIB: 248 PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters			TVH: 12 licences, 34 tenders TIB: 398 **e** PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters		
Active vessels	TVH: 10 TIB: 248 PNG: 0 (cross-endorsed)			TVH: 9 TIB: 214 PNG: 0 (cross-endorsed)		
Observer coverage	0			0		
Fishing methods	Hand collection using handheld implements (snare, net or spear) on shallow reef flats at night; free-diving or use of hookah gear during the day					
Primary landing ports	Cairns, Thursday Island (Queensland); Daru (PNG)					
Management methods	Input controls: gear controls, seasonal closures, vessel length restriction Output controls: TAC, minimum size limit (>115 mm tail length or >90 mm carapace length), bag limit of 3 lobsters per person (or 6 lobsters per dinghy if more than one person aboard the boat) for recreational fishing					
Primary markets	Domestic: live lobsters and frozen tails International: Hong Kong/China (live lobsters); United States (frozen tails)					
Management plan	*Torres Strait Fisheries* (Quotas for Tropical Rock Lobster (Kaiar)) *Management Plan 2018* (came into effect on 1 December 2018)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 December – 30 September unless the TAC is reached before that time. Value statistics are by financial year. **b** Estimate at time of publishing; this figure is preliminary and likely to be updated in future editions of this publication. **c** Catch taken inside the Torres Strait Protected Zone in the PNG part of the fishery for the period 1 January – 30 December 2018. In contrast, the fishing season for the Australian part of the fishery ran from 1 December 2017 to 31 July 2018, ending early under the Torres Strait Fisheries (Tropical Rock Lobster) Management Instrument 2018. **d** Tender-day is a day of fishing effort using a fishing tender or dory. **e** As at snapshot date 1 July 2018.
Notes: **GVP** Gross value of production. **na** Not available. **PNG** Papua New Guinea. **TAC** Total allowable catch. **TIB** Traditional Inhabitant Boat. **TVH** Transferable Vessel Holder.

17.2 Biological status

Tropical rock lobster (*Panulirus ornatus*)



Line drawing: Karina Hansen

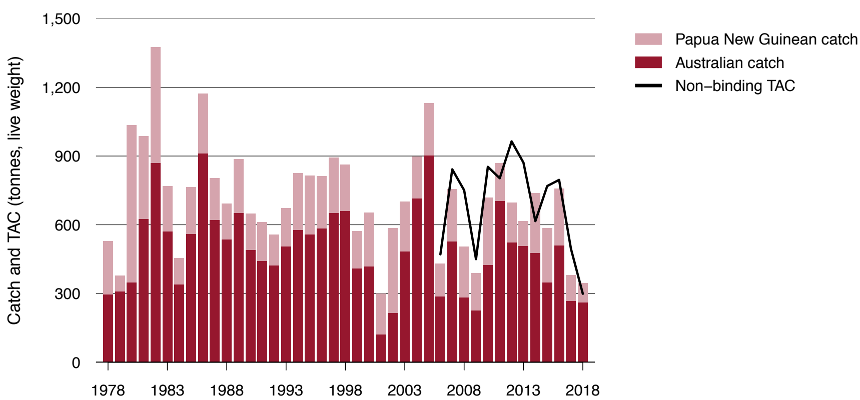
Stock structure

Although postlarval-stage lobsters are locally resident, tropical rock lobster populations in Torres Strait (managed under the Protected Zone Joint Authority), the Coral Sea (managed by the Commonwealth) and Queensland (managed by Queensland) are considered to comprise a single biological stock as a result of the mixing of larvae in the Coral Sea (Pitcher et al. 2005; Plagányi et al. 2018). Assessments presented here relate specifically to the stock resident in Torres Strait.

Catch history

Total catch of tropical rock lobster since 1978 has fluctuated between 122 and 932 t per year for the Australian sectors (TVH and TIB) and 70 and 225 t for PNG (Figure 17.2). Average catches over the past five years were 352 t for the Australian sectors and 187 t for PNG.

FIGURE 17.2 Catch and TAC of tropical rock lobster in the TSTRLF, 1978–2018



Note: **TAC** Total allowable catch.
Sources: AFMA, PZJA

Stock assessment

The statistical catch-at-age model developed by Plagányi et al. (2009) was used for the 2018 assessment (Plagányi et al. 2019). The assessment used a time series of catch data from 1973 to 2017, and incorporates annual fishery-independent preseason (2005–2008 and 2014–2018) and mid-season (1989–2014) survey data, and catch-per-unit-effort data from the TVH (1994–2018) and TIB (2004–2018) sectors (Plagányi et al. 2019).

The stock assessment for the 2018–19 season estimated the 2018 spawning biomass to be 1,969 t (90% confidence interval 1,260–2,678 t), or 46% of the estimated unfished (1973) level ($0.46SB_{1973}$) (Plagányi et al. 2019). Estimates of parameters related to maximum sustainable yield (MSY) are considered to be uncertain because of highly variable annual recruitment and a limited number of age classes in the fishery. For such recruitment-driven fisheries, annual yields can be expected to fluctuate widely about deterministic quantities such as MSY. The TAC is calculated each year based on the target fishing mortality rate of 0.15 (F_{TARG}), which is estimated to keep the biomass at a recent average level agreed by stakeholders.

For the 2017–18 season, the Tropical Rock Lobster Resource Assessment Group recommended a TAC of 299 t, but 346 t was caught (Table 17.2). The Australian portion of this TAC was 254.15 t, with 261 t caught, so the fishery was closed early from 31 July 2018 (PZJA 2018b). The RBC for the 2018–19 season was 641 t, based on the outputs from the reference case assessment model (Plagányi et al. 2019). This is higher than 2017–18 due to the higher densities of lobsters observed in the 2018 preseason survey (Plagányi et al. 2019); however, the spawning biomass remains lower than average, estimated to be at 46% of unfished levels ($0.46SB_{1973}$). Nevertheless, the spawning biomass is expected to fluctuate widely around the average target spawning biomass level and to increase in 2019 (Plagányi et al. 2019).

Stock status determination

The model-estimated biomass in 2018 ($0.46SB_{1973}$) was below the interim target reference point ($0.65SB_{1973}$) but above the interim limit reference point ($0.40SB_{1973}$). In 2018, the TAC of 299 t (based on a target fishing mortality rate of 0.15 [F_{TARG}]) was exceeded, resulting in a management decision to close the fishery early to ensure that there was enough spawning stock for subsequent fishing seasons. Spawning stock biomass is expected to increase in 2019 and fluctuate widely around the target (Plagányi et al. 2019). As a result, this stock is classified as **not overfished**. The total catch of 346 t in 2018 was above the TAC of 299 t, which was assessed to have been at the target fishing mortality of 0.15 (Plagányi et al. 2019). However, the recommended TAC of 641 t in 2019, based on a target fishing mortality rate of 0.15, is much higher than the catch in 2018, indicating that the catch in 2018 is unlikely to drive the stock below the limit reference point. Therefore, the stock is classified as **not subject to overfishing**.

17.3 Economic status

Key economic trends

Catch in the fishery is landed as either whole lobster or lobster tails, with whole lobsters generally being landed live. All catch and value figures discussed here have been converted to whole weight to allow comparisons of catch composition.

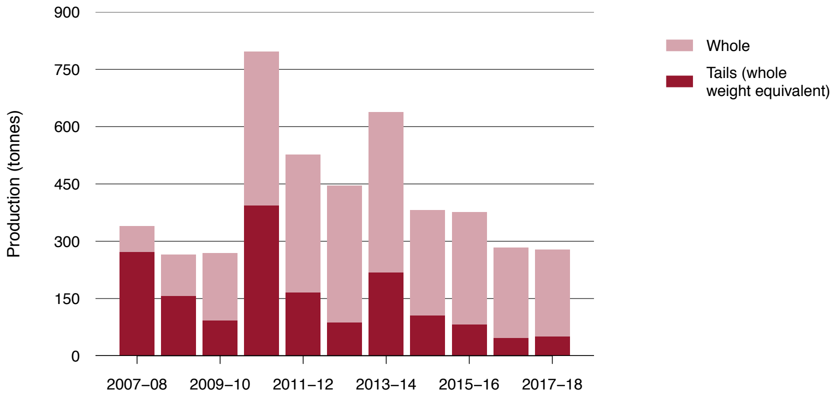
In the 2017–18 fishing season, landed catch across the fishery exceeded the TAC by 47 t; Australia (TVH and TIB) exceeded the TAC by 7 t. Landed catch declined by 9% in the 2017–18 fishing season, from 380 t in 2016–17 to 346 t in 2017–18, with Australia's share declining by 2% (from 267 t in 2016–17 to 261 t in 2017–18) (Figure 17.3).[1] The 2017–18 TAC for the fishery was reduced by 40%; Australia's share of the TAC declined by 24%.

The catch quantity of whole lobster decreased from 236 t in 2016–17 to 227 t in 2017–18. However, the quantity of tails landed in 2017–18 increased by 10% (to 51 t [whole-weight equivalent]) compared with the previous year (47 t). Effort in the TIB Sector of the fishery increased by 27% in the 2017–18 fishing season compared with the 2016–17 season. The number of fishing permits in 2017–18 increased by 60%, but the number of active vessels decreased by 14%. In comparison, effort in the TVH Sector decreased by 36%, and concurrently the number of active vessels decreased by 10% in the 2017–18 fishing season. Across the two sectors, effort (tender-days) increased by 3%. The Australian commercial fishing season runs from 1 December to 30 September and so spans financial years (Table 17.2).

The gross value of production (GVP) of the Australian fishery increased by 19%, from $12.9 million in 2016–17 to $15 million in 2017–18 (Figure 17.4). The increase in GVP can be attributed to an increase in the landing price of whole lobster and lobster tail. Although net economic returns in the fishery are uncertain, it is likely that the TSTRLF experienced some positive economic improvements in the 2017–18 fishing season, since GVP grew faster than effort.

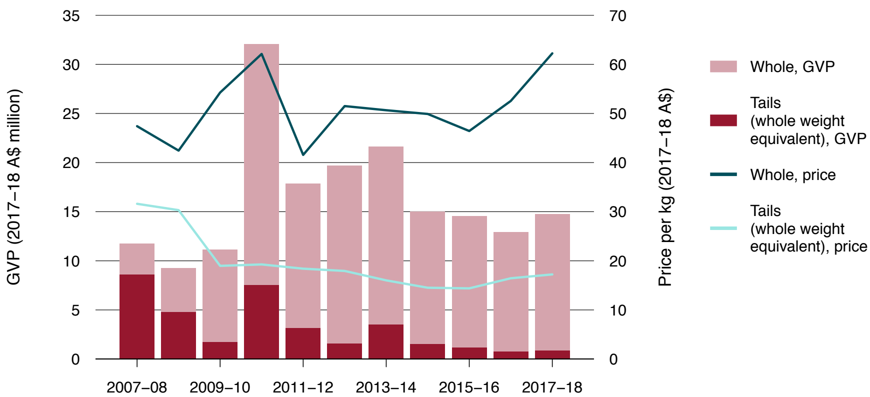
1 Catch weights and gross value of production in this section are given by financial year.

FIGURE 17.3 Production volumes of whole lobster and lobster tails in the Australian sectors of the TSTRLF, 2007–08 to 2017–18



Note: Lobster tail production has been converted to whole weight.

FIGURE 17.4 Real GVP and price for whole lobster and lobster tails (whole-weight equivalent) in the TSTRLF, 2007–08 to 2017–18



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

Management arrangements

The fishery was previously managed under input controls that included seasonal closures, temporal restrictions on the use of hookah equipment and minimum size limits (Table 17.2; AFMA, 2013, pers. comm.; PZJA 2015). In previous years, nominal non-binding TACs were also in place.

Under new legislation that came into effect on 1 December 2018, a number of output controls will be established for the fishery, such as a fishing quota system and a binding TAC. The fishing quota system will allocate a quota to the TIB Sector as a whole and separate quotas to individuals in the TVH Sector. Until the quota allocation process is finalised, separate interim TAC shares have been implemented: the TIB Sector will be able to take a 66.17% share of the TAC and the remaining 33.83% of the TAC will be apportioned to individuals in the TVH Sector. The introduction of a binding TAC will help stabilise the fishery's ecological condition, and individual quotas will potentially reduce competition between sectors for the resource (PZJA 2018a).

A voluntary buyout of TVH Sector fishing licences began in 2011, aimed at increasing the ownership and participation of Traditional Inhabitants in the fishery (PZJA 2013). The buyback, through an open tender process, resulted in a 2% increase in the Traditional Inhabitants' share of fishery catch, to 56.2% of the Australian share (PZJA 2013). The buyback was completed in 2012, with the Protected Zone Joint Authority committed to developing a management plan for the fishery that ensures the sustainability of the resource. Since then, the Torres Strait Regional Authority has independently purchased a further three TVH licence packages that were operating in the TSTRLF.

Performance against economic objective

Like other Torres Strait fisheries, the TSTRLF is managed against objectives that differ from those of solely Australian Government–managed fisheries. The TSTRLF management objectives are relevant to economic performance, but have a broader focus on social and cultural factors. They include the objectives of (PZJA 2015):

- maintaining the fishing mortality at a level below the level that produces MSY (F_{MSY}), accounting for all sources of fishing mortality
- in accordance with the Torres Strait Treaty, protecting the traditional way of life and livelihood of Traditional Inhabitants, particularly in relation to their traditional fishing for tropical rock lobster
- providing for optimal utilisation, cooperative management with Queensland and PNG, and catch sharing with PNG
- monitoring interactions between the prawn and lobster fisheries
- maintaining appropriate controls on fishing gear allowed in the fishery, to minimise impacts on the environment
- promoting economic development in the Torres Strait area, with an emphasis on providing the framework for commercial opportunities for Traditional Inhabitants, and ensuring that the opportunities available to all stakeholders are socially and culturally appropriate for Torres Strait, and the wider Queensland and Australian communities
- optimising the value of the fishery.

In conjunction with increases in landing price and GVP in the 2017–18 fishing season, the number of tender-days and fishing permits increased in the TIB Sector. These indicators suggest that the fishery is playing a role in promoting economic development and commercial opportunities for Traditional Inhabitants in Torres Strait.

17.4 Environmental status

The TSTRLF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 18 December 2020.

The fishery has little direct impact on the marine environment or other fish species, since hand-collection fishing methods allow careful selection of catch. The level 1 ecological risk assessment did not identify any species at medium or high risk, and found that interactions with protected species were negligible or low because of the nature of the fishery (Furlani et al. 2007). Therefore, no further risk assessments were undertaken (AFMA 2009).

The Australian Fisheries Management Authority publishes quarterly summaries of logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in the TSTRLF in 2018.

17.5 References

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Chapter 18
Torres Strait Prawn Fishery

M Parsa, T Emery and AH Steven

FIGURE 18.1 Relative fishing intensity in the Torres Strait Prawn Fishery, 2018

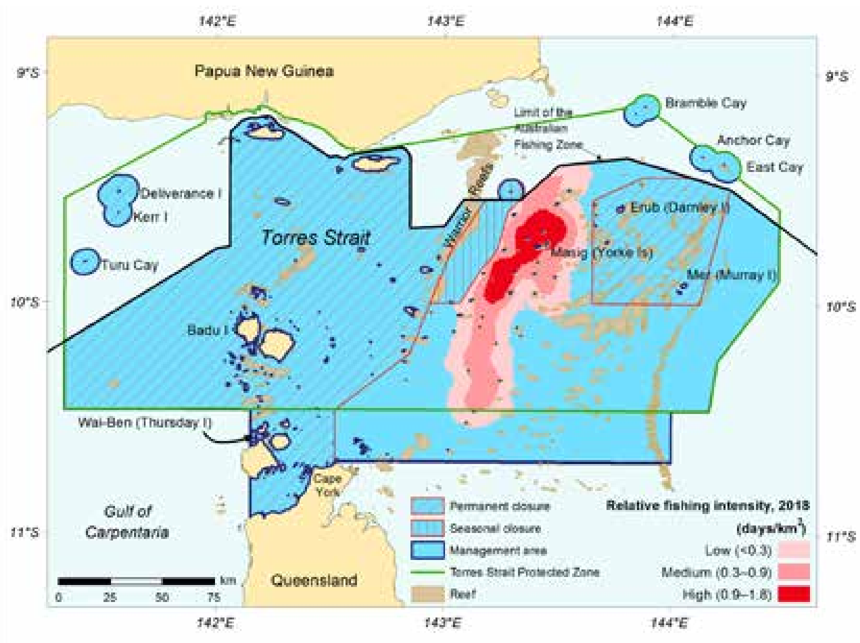


TABLE 18.1 Status of the Torres Strait Prawn Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Brown tiger prawn (*Penaeus esculentus*)	Uncertain	Uncertain	Uncertain	Uncertain	Uncertainty in estimates of biomass and fishing mortality because of the significant time since last stock assessment.
Blue endeavour prawn (*Metapenaeus endeavouri*)	Uncertain	Uncertain	Uncertain	Uncertain	Uncertainty in estimates of biomass and fishing mortality because of the significant time since last stock assessment.
Economic status	An increase in the gross value of production with a decrease in hours trawled per vessel in 2017–18 indicate that economic returns from the fishery may have improved.				

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

18.1 Description of the fishery

Area fished

The Torres Strait Prawn Fishery (TSPF) operates in the eastern part of the Torres Strait Protected Zone (TSPZ) and south of the TSPZ in nearby Queensland waters (called the 'outside but near area') (Figure 18.1). This fishery is shared by Australia and Papua New Guinea (PNG) under formal arrangements in the Torres Strait Treaty (see Chapter 15).

Fishing methods and key species

Prawns are harvested at night using demersal otter trawl (prawn trawl). Fishers usually deploy four nets divided into two pairs, with a pair of nets towed from a boom on each side of the fishing vessel. Trawl tows last between two and a half and four hours at an average speed of around 3 knots. Fishers normally complete three or four tows per night (DSEWPaC 2013; Turnbull et al. 2007).

The target species of the fishery are brown tiger prawn (*Penaeus esculentus*) and blue endeavour prawn (*Metapenaeus endeavouri*). Byproduct species include redspot king prawn (*Melicertus longistylus*),[1] slipper lobster (*Scyllarides* spp.), Moreton Bay bugs (*Thenus* spp.), octopus (Octopodidae), cuttlefish (*Sepia* spp.) and squid (Teuthoidea).

1 Although small volumes of other king prawn species (*M. latisulcatus*, *M. plebejus*) are recorded in logbook records, research surveys in Torres Strait suggest that the commercial catch largely consists of a single species for each prawn group—that is, brown tiger prawn (*P. esculentus*), blue endeavour prawn (*M. endeavouri*) and redspot king prawn (*M. longistylus*) (C Turnbull, AFMA consultant, 2015, pers. comm., 23 July).

Management methods

The Australian component of the fishery is managed by the Torres Strait Protected Zone Joint Authority (PZJA), established under the *Torres Strait Fisheries Act 1984* (Cth). Currently, all licences in the fishery are held by the non-Indigenous Transferable Vessel Holder Sector.

Under the Torres Strait Treaty, PNG is entitled to 25% of the TSPF resource in the Australian jurisdiction (excluding the effort in nearby Queensland waters), and Australia is entitled to 25% of the TSPF resource in the PNG jurisdiction (Cocking 2016). Historically, some Australian boats fished in PNG waters, but this ceased soon after ratification of the Torres Strait Treaty. There is no official record of PNG boats fishing in Australian waters, and PNG operators have only sporadically activated their entitlements to fish in their own waters of the TSPF.

The fishery is subject to several spatial and temporal closures (Figure 18.1) that were initiated for various reasons, including protection of undersized tiger prawns (those that are below commercially marketable sizes; Watson & Mellors 1990), protection of pearl shell beds and protection of breeding populations of marine turtles.

The PZJA released a harvest strategy for the TSPF in 2011 (AFMA 2011), which defines a set of trigger, target and limit reference points, and decision rules for the whole fishery, based on the most sensitive target species—tiger prawn. A catch trigger is also in place for endeavour prawn. Triggers are set at levels that acknowledge the reduced effort in the fishery in recent years, and the harvest strategy provides for revision and update to the trigger levels if activity in the fishery increases. The strategy incorporates a long-term economic target that will be pursued once catch-and-effort triggers in the fishery are reached. A short-term economic target is not in place because the fishery does not currently have the resources to estimate biomass at maximum economic yield (B_{MEY}). Also, since a B_{MEY} target would limit the available fishing days, there is concern that this limitation would put additional economic pressure on operators who are fishing, when effort is already well below target levels.

The harvest strategy limit reference point is 20% of unfished biomass ($0.2B_0$), consistent with the default provided for in the Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018). The current target reference point (B_{TARG}) is the biomass that would support maximum sustainable yield (B_{MSY}) for tiger prawn. In contrast, the triggers in this fishery are aligned with MEY, consistent with the fishery's goal to move to MEY-based targets when fishing activity increases. The triggers are based on fishers catching 75% of Australia's portion of total allowable catch (or expending 75% of Australia's portion of the total allowable effort [TAE]). The proxy used for B_{MEY} is $1.2B_{MSY}$, equating to $0.34B_0$ where $B_{MSY} = 0.28B_0$.

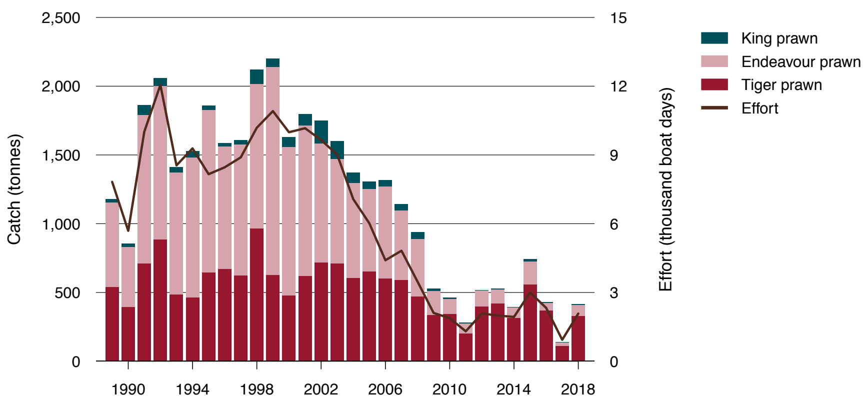
Fishing effort

From 1999 to 2011, fishing effort in the TSPF decreased steadily from more than 10,000 days to less than 1,500 days, largely as a result of economic conditions in the fishery (Figure 18.2). Effort increased to approximately 3,000 days in 2015, but has since declined, reaching 935 days in 2017—the lowest recorded for the fishery. The 2017 effort represented 13.6% of the TAE for the Australian fishery.[2] In 2018, effort increased to 2,073 days.

Catch

In addition to brown tiger prawn and blue endeavour prawn, king prawn (*M. longistylus*, *M. latisulcatus* and *M. plebejus*) has also been a historically important component of the catch in the fishery. The total combined catch of brown tiger prawn, blue endeavour prawn and king prawn decreased from a historical high of more than 2,000 t in 1999 to less than 300 t in 2011 (Figure 18.2). Since the 1990s, the total combined catch has declined steadily, but increased slightly in 2011–2015 (Figure 18.2; Table 18.2). The total combined catch in 2017 (137 t) was the lowest since 1978, when catch records for the fishery began, but, in 2018, catch in the TSPF increased to 419 t. The proportion of brown tiger prawn in the total catch has increased from below 30% in 1999 to more than 70% in each year since 2010.

FIGURE 18.2 Prawn catch by species, and fishing effort, in the TSPF, 1989–2018



2 The 9,200 days of TAE in the fishery are shared between Australia and PNG, with Australian operators able to access 6,867 fishing days before an option to access unused PNG days is considered by the PZJA (Cocking 2016); 2,070 fishing days are available to PNG operators and 263 days are held in trust by the Australian Government.

TABLE 18.2 Main features and statistics for the TSPF

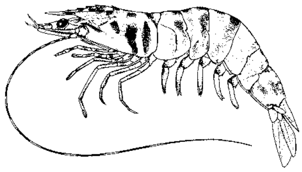
Fishery statistics a	2017			2018		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Brown tiger prawn	–	111	$3.1 million	–	329	$3.9 million
Blue endeavour prawn	–	25	$0.3 million	–	84	$0.4 million
Total fishery	**–**	**137 b**	**$4.0 million c**	**–**	**419**	**$4.6 million c**
Fishery-level statistics						
Effort (days)	935			2,073		
Fishing permits	60 (47 inactive licences)			60 (37 inactive licences)		
Active vessels	13			23		
Observer coverage	19 days (2.2% of active effort)			39 days (1.9% of active effort)		
Fishing methods	Demersal otter trawl					
Primary landing ports	Cairns, Innisfail (Queensland)					
Management methods	Input controls: total allowable effort on fishing nights, individual transferable effort units, limited entry (although licences are transferable), gear restrictions, time and area closures, vessel length restrictions					
Primary markets	Domestic: frozen International: minor to Japan—frozen					
Management plan	*Torres Strait Prawn Fishery Management Plan 2009*					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 February – 1 December. Value statistics are provided by financial year. **b** Total fishery catch includes the catch of brown tiger, endeavour and king prawns only. **c** Includes non-prawn byproduct species.
Notes: **GVP** Gross value of production. **TAC** Total allowable catch. – Not applicable.

Tiger prawn
Mike Gerner, AFMA

18.2 Biological status

Brown tiger prawn (*Penaeus esculentus*)



Line drawing: FAO

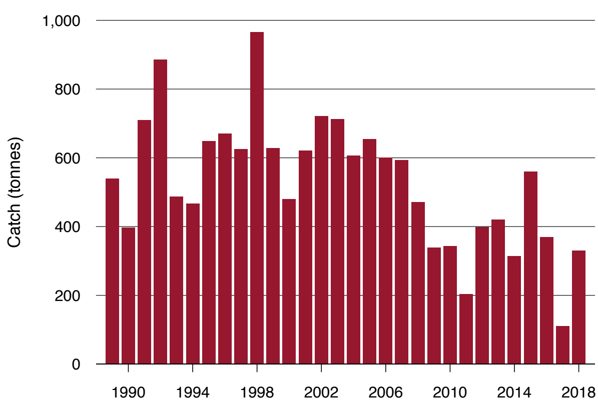
Stock structure

Brown tiger prawn is endemic to tropical and subtropical waters of Australia. There is evidence of genetic separation of brown tiger prawns from the east and west coasts of Australia (Ward et al. 2006); however, the stock structure across northern Australia is uncertain. Brown tiger prawns are considered to constitute a single stock in Torres Strait for assessment and management purposes.

Catch history

Catch of brown tiger prawn has fluctuated over time, peaking in 1998 at 965 t. Catch decreased to 204 t in 2011 but increased to 560 t in 2015. In 2017, catch of brown tiger prawn was 111 t, the lowest catch reported in this fishery, but increased to 329 t in 2018 (Figure 18.3).

FIGURE 18.3 Brown tiger prawn catch in the TSPF, 1989–2018



Source: AFMA

Stock assessment

The most recent stock assessment of brown tiger prawn in Torres Strait was completed in 2006 using data to the end of 2003 (O'Neill & Turnbull 2006). Since the 2006 assessment, further assessment model runs have been conducted with updated data (Turnbull & Rose 2007), but no full assessments have been undertaken. The most recent model runs (Turnbull & Rose 2007) indicate that tiger prawn biomass steadily increased from 2000 to 2006, and was between 60% and 80% of the unfished (1980) biomass ($0.6B_0$ and $0.8B_0$). This was considerably higher than estimates of B_{MSY}, which were $0.28B_0$ to $0.38B_0$, depending on the spawner–recruitment relationship used (O'Neill & Turnbull 2006). A delay-difference model (O'Neill & Turnbull 2006) estimated MSY for tiger prawns to be 606 t (90% confidence interval [CI] 436–722 t), and effort at MSY (E_{MSY}) to be 8,245 fishing nights[3] (90% CI 5,932–9,823 nights) using the Ricker spawner–recruitment relationship. Using the Beverton–Holt spawner–recruitment relationship, MSY was estimated to be 676 t (90% CI 523–899 t) and E_{MSY} to be 9,197 nights (90% CI 7,116–12,231 nights).

The 2006 assessment is still used to inform management decisions in the fishery. However, brown tiger prawn is a relatively short-lived species, with variable recruitment that can be influenced by environmental factors. Changes in fleet dynamics and vessel efficiency are also likely to influence the long-term relevance of the 2006 assessment, as are fluctuations in catch and effort. As a result, the outputs from the 2006 stock assessment will become less relevant over time. Mediating this risk is the substantial underuse of fishing effort, with less than 50% of available fishing nights being used each year since 2008, and annual catches remaining below the 2006 mean estimate of MSY since 2005 (Figure 18.3). Nominal catch rates for tiger prawn have declined since 2013, but remain above levels reported in the 1990s and early 2000s (Turnbull & Cocking 2018). In addition, the harvest strategy for the fishery (AFMA 2011) imposes conservative trigger points—set at 4,000 days and 680 t of tiger prawn, which corresponds to approximately 75% of the Australian portion of the estimated effort and catch at B_{34} (B_{MEY}), respectively. When these trigger points are reached, additional research, a revised harvest strategy to develop decision rules for setting the TAE based on B_{MEY}, and an updated stock assessment are required. Catch and effort in the fishery remain below the trigger points. A new stock assessment will be completed in 2019.

Stock status determination

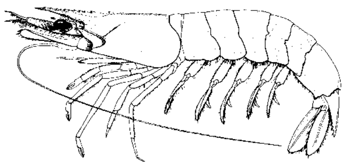
Assessment of brown tiger prawn status in 2018 is based on a comparison of recent catches (Figure 18.3) with estimates of MSY from the 2006 assessment (O'Neill & Turnbull 2006), a comparison of recent effort with estimates of E_{MSY} from the 2006 assessment (O'Neill & Turnbull 2006) and the 2006 estimates of biomass (Turnbull & Rose 2007).

The tiger prawn catch has been below the 2006 estimates of MSY for both Ricker (606 t) and Beverton–Holt (676 t) spawner–recruitment relationships since 2005. The effort in the fishery has been below the 2006 estimates of E_{MSY} for the Beverton–Holt (9,197 nights) and Ricker (8,245 nights) spawner–recruitment relationships since 2003 and 2004, respectively. However, uncertainty around the current level of MSY, and therefore E_{MSY}, is increasing with time since the most recent stock assessment in 2006. As a result, the stock is classified as **uncertain** with regard to the level of fishing mortality.

3 The terms 'day' and 'night' are both used in this chapter when discussing fishing effort because effort units are allocated in notional 'days' (referring to a 24-hour period), but fishing actually occurs at night.

Although the HSP does not apply to the jointly managed TSPF, the default HSP proxy limit of $0.2B_0$ is used to inform status evaluations. The 2006 estimate of tiger prawn biomass (between $0.6B_0$ and $0.8B_0$) was considerably higher than the estimate of B_{MSY} and well above the HSP proxy limit reference point of $0.2B_0$. However, uncertainty around the current level of biomass is increasing with time since the most recent stock assessment in 2006, and the cause of recent declines in catch rates is unclear. Therefore, the biomass status of the stock is classified as **uncertain**.

Blue endeavour prawn (*Metapenaeus endeavouri*)



Line drawing: FAO

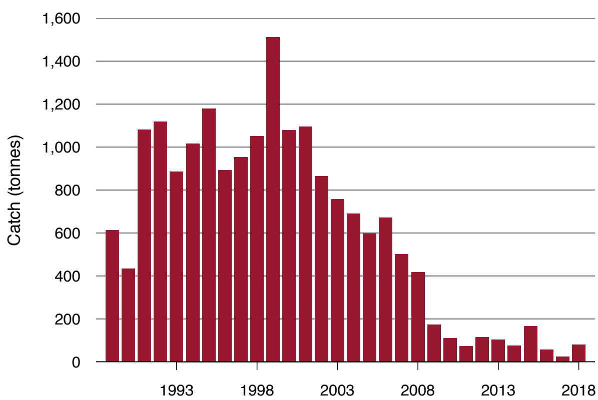
Stock structure

Endeavour prawn occurs across northern Australia from Shark Bay in Western Australia to Moreton Bay in Queensland. Little is known about the stock structure of blue endeavour prawns across this region. In Torres Strait, they are considered to constitute a single stock for management and assessment purposes.

Catch history

Annual catches of blue endeavour prawn were relatively high during the 1990s, averaging more than 1,000 t and peaking at more than 1,500 t in 1999 (Figure 18.4). Annual catches have decreased since then, reaching the lowest reported catch of 25 t in 2017, but increasing slightly to 84 t in 2018. This decline reflects decreasing fishing effort through the 2000s and increased targeting of tiger prawns because of their higher market value (Turnbull & Cocking 2018).

FIGURE 18.4 Endeavour prawn catch in the TSPF, 1989–2018



Source: AFMA

Stock assessment

The most recent stock assessment for blue endeavour prawn was completed in 2009, using data to the end of 2007 (Turnbull et al. 2009). This assessment evaluated abundance of cohorts (annual year-classes) of the stock through time, allowing tracking of size-related variability in productivity.

A deterministic size- and age-structured model with a fixed stock–recruitment steepness value of 0.5 provided an MSY estimate of 1,105 t (90% CI 1,060–1,184 t) and an E_{MSY} estimate of 10,079 nights (90% CI 9,667–10,800 nights). A stochastic size- and age-structured assessment was also run, but this model did not achieve convergence of parameter estimates and was not accepted. Similarly, a deterministic model with a fixed steepness of 0.7 did not achieve convergence. The biomass estimate from the deterministic model, with steepness fixed at 0.5, was approximately $0.8B_0$, which is considerably higher than the estimate of $0.43B_0$ for B_{MSY}.

The 2009 stock assessment is still used to inform management decisions in the fishery. However, similar to brown tiger prawn, the outputs from the 2009 stock assessment for blue endeavour prawn have become less relevant over time, with increased uncertainty in current status due to highly variable recruitment, short life span, changes in fleet dynamics and vessel efficiency, and changes in catch and effort. Furthermore, nominal catch rates for blue endeavour prawn have declined by more than 50% since 2008 (Turnbull & Cocking 2018).

Stock status determination

The stock status classification of blue endeavour prawn in 2018 is based on a comparison of recent catches with estimates of MSY from the 2009 assessment, a comparison of recent fishing effort with estimates of E_{MSY}, and the 2009 estimates of biomass. Since 2002, catch has been below the lower 90% CI of estimated MSY (1,060 t), and effort has been below the lower 90% CI of E_{MSY} (9,667 nights). However, uncertainty around the current level of MSY, and therefore E_{MSY}, is increasing with time since the most recent stock assessment in 2009. As a result, the stock is classified as **uncertain** with regard to the level of fishing mortality.

Although the HSP does not apply to the TSPF, in the absence of a prescribed limit reference point for this stock, the default HSP proxy limit reference point of $0.2B_0$ is used to determine stock status. The 2007 biomass estimate of $0.8B_0$ is above the estimated B_{MSY} of $0.43B_0$ and well above the HSP proxy limit reference point of $0.2B_0$. However, uncertainty around the current level of biomass is increasing with time since the most recent stock assessment in 2009, and the cause of the significant decline in catch rates since 2008 is unclear. Therefore, biomass status of the stock is classified as **uncertain**.

18.3 Economic status

Key economic trends

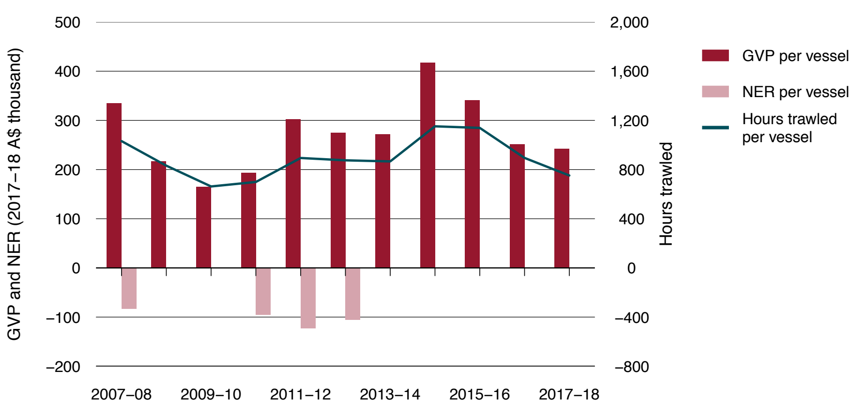
Economic surveys by ABARES of key Commonwealth fisheries since the early 1990s provide information that allows calculation of net economic returns (NER) and financial performance measures for the TSPF. Historical data per vessel for gross value of production (GVP), NER and hours trawled between 2007–08 and 2017–18 are shown in Figure 18.5.

Estimates of NER are not available for 2008–09, 2009–10 or from 2012–13 to 2017–18 because economic surveys of the fishery were not undertaken for these years. NER for the TSPF have been negative since 2004–05 (Skirtun et al. 2015). Based on the latest survey in 2013, it was estimated that NER remained negative at –$2.3 million in the 2012–13 financial year, an improvement from –$2.7 million in 2011–12. High input costs and low prices in 2011–12 and 2012–13 made it difficult to operate profitably in the fishery (Skirtun et al. 2015).

In the 2017–18 fishing season, the TSPF experienced a 17% increase in GVP, and hours trawled per vessel decreased by 16%, suggesting a potential improvement in NER. In the 2017–18 fishing season, tiger prawn accounted for the largest share of fishery GVP (85%; $3.9 million), followed by endeavour prawn (9%; $0.4 million). Other prawn species, and other non-prawn byproduct species caught, accounted for the remainder (6%; $0.3 million) of the GVP of the fishery.

Between 2007–08 and 2009–10, the number of hours trawled per vessel almost halved in response to declines in profitability. This is reflected by the GVP per vessel (an indicator of vessel revenue), which followed a declining trend from 2007–08, reaching its lowest level in 2009–10 before increasing significantly in 2014–15 and 2015–16 and declining again in 2016–17 and 2017–18 (Figure 18.5). In 2017–18, GVP per vessel declined by 3% to $242,000, largely as a result of more vessels fishing, and the effort input for the year averaged 752 trawl-hours per vessel.

FIGURE 18.5 GVP, NER and hours trawled per vessel in the TSPF, 2007–08 to 2017–18



Notes: **GVP** Gross value of production. **NER** Net economic returns. NER are not available for all years.

Although estimates of NER for 2017–18 are not available, improvement in fishery-level GVP and catch and lower trawl-hours per active vessel relative to 2016–17 may indicate an improvement in economic performance of the fishery. However, some of these benefits could be offset by a higher diesel fuel price in the 2017–18 season and a decline in GVP per active vessel. High levels of latency remain a concern for the fishery.

Management arrangements

The fishery is managed using input controls. Limits on the number of boat licences and tradeable fishing nights are the main input controls, and these are combined with other restrictions on gear and vessel characteristics (Cocking 2016). In their analysis of profit trends in the TSPF, Skirtun and Vieira (2012) suggested that management arrangements in the fishery may have been a constraint on greater productivity gains and, therefore, higher profitability. The recent divergence in trends in economic performance of the Northern Prawn Fishery (NPF) and the TSPF may also be linked to differences in management arrangements. Although both the NPF and the TSPF are managed with input controls, the TSPF is also managed through limits on maximum vessel size (AFMA 2011). This restriction may have constrained autonomous adjustment in the TSPF and, as a result, fishery-level efficiency. High levels of latent effort have remained in the TSPF and are likely to have reduced the incentive to trade in effort entitlements, limiting the movement of effort entitlements to the most efficient fishers.

In February 2017, the Prawn Fishery Management Plan Amendment was released, where there was a decision to cancel units of fishing capacity that are surrendered or for which a levy is not paid. The removal of surrendered units of fishing capacity from the TAE will benefit licence holders who pay levies, by increasing the distribution of entitlements (PZJA 2017).

The TSPF has limits on maximum vessel size (AFMA 2011). Because larger vessels tend to have larger fuel and catch-holding capacities, they can stay at sea longer and are better able to operate in geographically isolated fisheries such as the TSPF. However, this management arrangement may be constraining economic performance in the fishery. In recognition of this, in early 2011, the Torres Strait Prawn Management Advisory Committee recommended trials of alternative fishing gear and vessel size configurations (PZJA 2011).

Performance against economic objective

The TSPF is managed according to the economic objective of promoting economic efficiency and ensuring the optimal use of the fishery resource, consistent with the principles of ecologically sustainable development and a precautionary approach. Although these objectives are implicitly consistent with maximising economic yields, the harvest strategy for the fishery does not currently have a target biomass level associated with an estimate of MEY (B_{MEY}). This has been attributed to the low economic value of the fishery and the high cost of estimating a B_{MEY} target (AFMA 2011). The B_{MSY} target will remain until decision rules relating to increased fishing activity are activated that will require a B_{MEY} target to be determined and implemented (AFMA 2011). According to the most recent assessment (2007), the biomass levels of brown tiger and blue endeavour prawns are likely to be well above B_{MSY} at current effort levels, and so economic performance is currently not constrained by biomass.

18.4 Environmental status

Prawn trawling is a relatively non-selective fishing method. As a result, a variety of byproduct and bycatch species are caught with the target species. Bycatch typically includes finfish, cephalopods, crabs, lobsters, scallops, sharks and rays. Trawling also has potential impacts on benthic communities and protected species, including turtles, sea snakes and syngnathids (seahorses and pipefish). Research surveys between 2004 and 2006 collected independent data on the weight, composition and distribution of bycatch in the TSPF (Turnbull & Rose 2007). The surveys were in two areas: the main prawn trawling grounds, and adjacent areas that are seasonally or permanently closed to trawling. No major differences were found in the overall composition and abundance of bycatch species between areas that are open, partially closed and entirely closed to trawling. However, there were some differences in the relative proportions of different bycatch species between open and closed areas.

The TSPF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 9 October 2026.

A level 1 (Scale, Intensity, Consequence Analysis) ecological risk assessment has been conducted for the TSPF (Turnbull et al. 2007). The fishery also has a bycatch and discard workplan that was updated in early 2015 (AFMA 2015). Pitcher et al. (2007) provided comprehensive data on the biodiversity of seabed habitats in Torres Strait, cataloguing more than 3,600 species, comprising fishes, crustaceans and other species that make up the benthos. Examination of the likely extent of past effects of trawling on the benthos and bycatch in the TSPZ indicated that trawling has had an effect on the biomass of 21 of the 256 species analysed. Of the 21 species, 9 have shown a negative response, while 12 have shown an increase in biomass in association with trawling. This research was updated using data to 2011, and showed that, because of a substantial reduction in effort and the trawl footprint since 2005, there is little to no sustainability risk to any species at the current levels of fishing effort (Pitcher 2013).

Since the beginning of the 2002 fishing season, the PZJA has required operators in the TSPF to use turtle excluder devices in trawl gear. In 2004, the use of bycatch reduction devices became mandatory. In May 2008, the PZJA also agreed to implement trawl exclusion zones around Deliverance Island, Kerr Islet and Turu Cay (Figure 18.1) to protect important nesting areas for green turtle (*Chelonia mydas*) and flatback turtle (*Natator depressus*).

Australian Fisheries Management Authority publishes quarterly summaries of logbook-reported interactions with protected species on its website. In 2018, 725 sea snakes of unknown species were caught in the TSPF, of which 377 were released alive, 11 were dead and 1 was injured. The remaining snakes were released in an unknown conditions. One Pacific ridley turtle was released alive, and one unidentified turtle was released in an unknown condition.

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Chapter 19

Torres Strait Bêche-de-mer and Trochus fisheries

F Helidoniotis, J Woodhams and AH Steven

FIGURE 19.1 Area of the Torres Strait Bêche-de-mer and Trochus fisheries

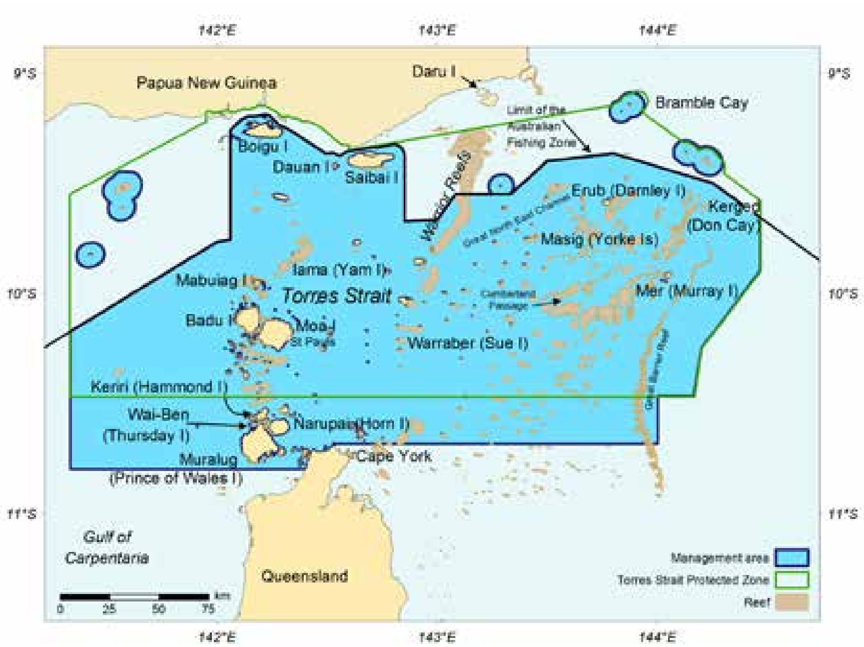


TABLE 19.1 Status of the Torres Strait Bêche-de-mer and Trochus fisheries

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Black teatfish (*Holothuria whitmaei*)					No catch in 2018. Recent survey indicates a recovering stock.
Prickly redfish (*Thelenota ananas*)					Catch is below TAC. Survey indicates relatively stable densities.
Sandfish (*Holothuria scabra*)					No catch in 2018. Most recent full survey (2009) indicated that stock was overfished.
White teatfish (*Holothuria fuscogilva*)					Catch is below TAC. Survey indicates relatively stable densities.
Other sea cucumbers (up to 18 species)					Uncertain biomass and fishing mortality status for at least two species taken in 2018.
Trochus (*Trochus niloticus*)					Minimal catch in 2018. Uncertain biomass status.
Economic status	Estimates of NER and gross value of production are unavailable. A low level of catch in the TSBDMF indicates low NER. Increased catch in 2018 likely caused some improvement in economic performance in the fishery, noting that social objectives aimed at increasing opportunities for Traditional Inhabitants and encouraging participation in the fishery are also important for this fishery. Little to no catch has been recorded in the TSTF since 2010, suggesting fishers have a low incentive to fish in this fishery.				

Notes: **NER** Net economic returns. **TAC** Total allowable catch. **TSBDMF** Torres Strait Bêche-de-mer and Trochus fishery.

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

19.1 Description of the fishery

Area fished

Both the Torres Strait Bêche-de-mer Fishery (TSBDMF) and the Torres Strait Trochus Fishery (TSTF) operate in tidal waters within the Torres Strait Protected Zone (TSPZ) and south of the TSPZ, in the waters defined as the 'outside but near area' (Figure 19.1; AFMA 2011, 2013, 2015).

Bêche-de-mer (sea cucumber) has historically been harvested in the eastern parts of Torres Strait, with most of the catch typically taken from the Great North East Channel, Don Cay, Darnley Island, Cumberland Channel and Great Barrier Reef regions. Western Torres Strait is included in the fishery, but is documented as having naturally low abundance of sea cucumbers (AFMA 2013).

Catch of trochus has been low in recent years. In 2005 (a year for which we have a reasonable idea of catch location), most trochus was taken from central-eastern Torres Strait regions, including the Great North East Channel, Darnley Island and Warraber Island (AFMA 2011).

Fishing methods and key species

Historically, the main species of sea cucumber harvested in Torres Strait have been black teatfish (*Holothuria whitmaei*), prickly redfish (*Thelenota ananas*), sandfish (*H. scabra*), white teatfish (*H. fuscogilva*), surf redfish (*Actinopyga mauritiana*), deepwater redfish (*A. echinites*) and other blackfish species (*Actinopyga* spp.). In recent years, market demand and fishing effort for curryfish species (*Stichopus* spp.) have increased significantly. Sea cucumbers are collected by hand, usually while free-diving or reef-top walking. Reef walking occurs at low tide along the reef edges. Diving occurs from dinghies, crewed by two or three fishers. Although the depth range of most targeted species is between 0 and 20 m, a combined ban on hookah (surface-supplied underwater breathing apparatus) and scuba diving limits most fishing effort to a depth of approximately 10 m. Following collection, sea cucumbers are processed for market; typically, this involves gutting, grading, cleaning, boiling and salting. A few operators are also drying the product before sending it to market (AFMA, 2019, pers. comm.).

Trochus (*Trochus niloticus*) typically occurs on high-energy areas of reefs, on substrates dominated by stony or coral pavements and associated with turf algae (Murphy et al. 2010). Trochus is collected by hand while reef-top walking at low tide, or from reef tops and reef edges while free-diving (without scuba or hookah gear) (AFMA 2011).

No byproduct or bycatch occurs in these fisheries because fishing by hand allows preferred species to be selected. Interactions with protected species are minimal. The only concerns relate to potential physical damage to coral reef structures from walking during collection at low tide (Department of the Environment 2014).

Management methods

The TSBDMF is managed using a range of input and output controls. Input controls include limiting participation in the fishery to Traditional Inhabitant Boat (TIB) licence holders. Traditional Inhabitants who wish to fish commercially for sea cucumbers are required to hold a TIB licence and use a boat no longer than 7 m. Collection is limited to hand fishing, including use of non-mechanical handheld devices; use of hookah and scuba gear is prohibited.

Output controls include minimum size limits on 10 species; zero total allowable catch (TAC) for sandfish, black teatfish and surf redfish; and TACs for white teatfish (15 t), prickly redfish (15 t) and other sea cucumber species combined (80 t).

The TSTF is managed using various input and output controls. Input controls include limiting participation in the fishery to TIB licence holders, limiting fishers to using vessels no longer than 20 m, restricting trochus harvest to hand fishing using non-mechanical devices, and prohibiting the use of hookah and scuba gear. Output controls include minimum (80 mm) and maximum (125 mm) basal diameter size limits, and a TAC of 150 t.

Although the Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018) does not apply to fisheries jointly managed by the Australian Government and other (domestic or international) management agencies, the HSP does represent the government's preferred approach to management. The Torres Strait Protected Zone Joint Authority (PZJA) has asked its management forums to provide advice on the application of the HSP to Torres Strait fisheries. No formal harvest strategies are in effect in the TSBDMF or the TSTF; however, a formal harvest strategy for the TSBDMF is being developed.

Fishing effort

Effort in the TSBDMF had been increasing in recent years, and a small amount of catch was recorded in the TSTF in 2017 and 2018. The number of fishing permits in both the TSBDMF and the TSTF was higher in 2017 than in 2018; however, these values may change daily and therefore annual estimates might not be directly comparable (Table 19.2).

Catch

Historically, sandfish was a primary target species in the TSBDMF, mostly fished on the Warrior Reefs complex (Figure 19.1). Following a considerable decline in sandfish abundance and the subsequent introduction of a zero TAC in 1998, targeting shifted to black teatfish, and what was thought to be surf redfish but is now understood to be primarily deepwater redfish and a number of blackfish species (Skewes et al. 2010).

ABARES received substantial updates to catch data for the TSBDMF in 2017 as a result of a concerted effort by the Australian Fisheries Management Authority (AFMA) in early 2017 to follow up on unreported catch. This process resulted in substantially higher catches being reported for some sea cucumber species in some years. Total catch for the TSBDMF in 2018 was 60.48 t, up from just under 19 t in 2017.

A small catch of trochus was reported in 2017 (0.1 t) and 2018 (0.04 t; Table 19.2). Small amounts of trochus were likely taken in previous years that were unreported (AFMA, 2018, pers. comm.).

From 1 December 2017, all operators in Torres Strait fisheries (excluding the Torres Strait Prawn Fishery) have been required to land their catch to a licensed fish receiver (see Chapter 15). The introduction of this system has improved our understanding of commercial harvests and is expected to improve the accuracy of future catch data.

TABLE 19.2 Main features and statistics for the TSBDMF and the TSTF

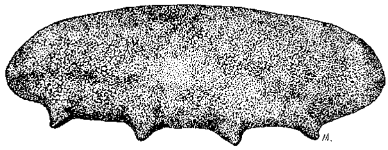
Fishery statistics a	2017			2018		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Black teatfish	0	0	0	0	0	0
Prickly redfish	20	4.1	na	15	12.4	na
Sandfish	0	0	0	0	0	0
White teatfish	15	0.1	na	15	1.4	na
Other sea cucumber species (18 species)	80	14.7 **b**	na	80	46.6	na
Total fishery (TSBDMF)	**115**	**18.9**	**na**	**115**	**60.5**	**na**
Trochus	150	0.1	na	150	0.04	na
Total fishery (TSTF)	**150**	**0.1**	**na**	**150**	**0.04**	**na**

Fishery-level statistics		
Effort (no. of sellers)	Bêche-de-mer: 10 Trochus: 1	Bêche-de-mer: 13 Trochus: 1
Fishing permits	Bêche-de-mer: 150 **c** Trochus: 80 **c**	Bêche-de-mer: 123 **d** Trochus: 59 **d**
Active vessels	na	na
Observer coverage	0	0
Fishing methods	Hand collection—free-dive or reef walking	
Primary landing ports	Torres Strait Island fish receivers	
Management methods Bêche-de-mer Trochus	 Input controls: limited entry, gear restrictions, vessel length restrictions Output controls: TACs, size limits Input controls: limited entry, gear restrictions, vessel length restrictions Output controls: TACs, size limits	
Primary markets Bêche-de-mer Trochus	 Domestic: minimal International: Asia—predominantly China, Hong Kong and Singapore Domestic: minimal International: historically, markets have included China, France, Germany, Italy, Japan, the Philippines, Spain, Thailand, the United Kingdom and the United States	
Management plan	No formal management plans	

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 January – 31 December. Value statistics are by financial year. Reported catch is understood to be gutted wet weight. **b** Some part of the 'other sea cucumber' catch may be prickly redfish. **c** As at 30 June 2017. **d** As at 1 July 2018.
Notes: **GVP** Gross value of production. **na** Not available. **TAC** Total allowable catch.

19.2 Biological status

Black teatfish (*Holothuria whitmaei*)



Line drawing: FAO

Stock structure

Black teatfish in Torres Strait is assumed to represent a single biological stock (Tim Skewes [CSIRO], 2013, pers. comm.).

Stock assessment

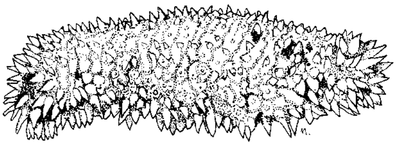
The Torres Strait black teatfish stock was last surveyed in 2009 (Skewes et al. 2010). This survey showed increases in the mean density (from fewer than 1 individual per hectare to just over 10 individuals per hectare), mean length (an increase of almost 6%) and mean weight (an increase of more than 11%) of black teatfish compared with the 2005 survey. However, there is considerable uncertainty around these estimates. Because of the increased densities and animal size, Skewes et al. (2010) recommended reopening the fishery for black teatfish with a TAC of 25 t, which would be an extraction rate of about 4% of the lower 90th percentile of the standing stock estimate (estimated at 625 t). A separate study of black teatfish on the Great Barrier Reef had estimated that harvest rates of less than 5% of the virgin biomass were likely to be sustainable (Uthicke, Welch & Benzie 2003).

In November 2011, the PZJA Hand Collectables Working Group considered options for increasing the zero TAC, taking into account results from the work by Skewes et al. (2010). The working group noted that increasing the TAC would result in increased targeting of this species, which would probably stimulate interest in the fishery. It also acknowledged that a level of precaution was required in developing the fishery to minimise the risks of exceeding the TAC, localised depletion and unsustainable harvest of other species. As a result, the PZJA endorsed a one-month trial of fishing for black teatfish in 2014 and 2015, operating under a conservative 15 t TAC. Some overcatch was recorded in both years. A zero TAC was set for 2016 and 2017.

Stock status determination

No catch was reported in 2017 or 2018. On this basis, the stock is classified as **not subject to overfishing**. Given the indications of recovery from the most recent survey, black teatfish is classified as **not overfished**.

Prickly redfish (*Thelenota ananas*)



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Stock structure

Prickly redfish in Torres Strait is assumed to represent a single biological stock (Tim Skewes [CSIRO], 2013, pers. comm.).

Stock assessment

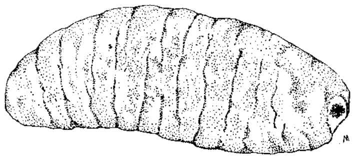
The Torres Strait prickly redfish stock was last surveyed in 2009 (Skewes et al. 2010). This survey indicated that densities had remained relatively stable across surveys in 1995, 2002, 2005 and 2009, ranging from 1.42 to 2.15 prickly redfish per hectare. Between 2005 and 2009, the density increased from 1.44 to 1.99 prickly redfish per hectare. The mean size of prickly redfish increased from 2,147 to 2,812 g between 2005 and 2009. Well-established and consistent methodologies were used in the surveys, but considerable uncertainty remains around these estimates.

The TAC for prickly redfish in 2018 (15 t) is based on an estimate of maximum sustainable yield (MSY), using a biomass estimate from the 2002 survey (Skewes et al. 2004). The TAC was reduced from 20 to 15 t during 2017 due to sustainability concerns coming from previous overfishing and inadequate catch reporting (PZJA 2018). MSY was estimated using a simplified surplus production model that relies on estimates of biomass and natural mortality (M). The surplus production model assumed an MSY of $0.2MB_0$ and used the lower bound of the 90% confidence interval of the 2002 estimate of standing stock (approximately 343 t) as B_0. Following the 2002 survey of eastern Torres Strait, Skewes et al. (2004) classified prickly redfish as 'exploited' where the population was currently being fished, or had previously been fished, but showed no evidence of severe depletion. The application of meta-rules for calculating the TAC, based on the level of exploitation, led to the MSY estimate being halved, generating a TAC of 20 t. The combination of using the lower bound of the 90% confidence interval for biomass, using a 0.2 scaling factor for natural mortality (instead of the more typical 0.5) and halving the final MSY estimate (to account for previous exploitation) resulted in a TAC that is considered to be conservative.

Stock status determination

Since calculation of the TAC in 2004, catches of prickly redfish have been sporadic, but increasing. Reported catch has been below the 15 t TAC in every year except 2015, when it exceeded 28 t. Although the data that support the current TAC are close to 15 years old, the average catch since the TAC was calculated has been around 12.4 t. Densities, lengths and weights of prickly redfish remained relatively stable between 1995 and 2009. On this basis, the stock is classified as **not overfished** and **not subject to overfishing**.

Sandfish (*Holothuria scabra*)



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Stock structure

Sandfish in Torres Strait is assumed to represent a single biological stock (Tim Skewes [CSIRO], 2013, pers. comm.).

Stock assessment

The Torres Strait sandfish stock was last surveyed in 2010 (Murphy et al. 2011). At that time, survey densities were around 80% lower than in 1995, when the stock was already considered to be depleted. Results from the survey indicated a mean density of 94 ± 50 sandfish per hectare (± standard error [SE]), which was similar to that in 2004 (94 ± 25 sandfish per hectare), suggesting that there had been no recovery up to the time of the 2010 survey. The reason for the lack of observable recovery of sandfish between 1998 and 2010 is not clear, given that the fishery has been closed since 1998. Murphy et al. (2011) suggested several possible causes, including illegal fishing and poor recruitment.

With respect to recruitment, Murphy et al. (2011) hypothesised that the relatively low density of sandfish remaining on Warrior Reefs may have reduced fertilisation success, because remaining sandfish are widely dispersed. They also noted that sandfish can burrow into the sand, making them difficult for survey observers to see (Murphy et al. 2011). However, Murphy et al. (2011) considered it unlikely that the proportion of buried sandfish would have differed from one survey to the next because all surveys sampled the same sites during the same season, lunar phase, tide and time of day, providing confidence in comparability of density estimates between years. Low density estimates in recent surveys are therefore likely to indicate actual low density, rather than underestimates resulting from increased proportions of buried sandfish.

In 2012, CSIRO and AFMA conducted a small-scale experimental fishing trial of the Warrior Reefs sandfish stock (Murphy et al. 2012). Methodology differed significantly from that used in previous surveys. Differences included sampling at different 'locations'[1] from the previous surveys (only three previous 'sites' were included), walking random search tracks rather than straight-line transects and choosing fishing areas of known high density (see Murphy et al. 2012).

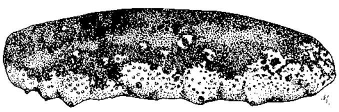
1 The term 'location' was used in the 2012 experimental fishing trial rather than 'site'. These locations were data logger tracks that indicated where experimental fishing occurred. They were labelled locations rather than sites because they were not generally separated by 500 m, a characteristic of the sites used in previous full-scale stock surveys. Locations were chosen by individual fishers rather than being specified by experimental design. Of the 37 locations fished, 14 were next to three sites surveyed for sandfish in previous years (Nicole Murphy [CSIRO], 2013, pers. comm.).

Previous survey reports emphasised the importance of sampling at the same sites (at the same lunar phase, tide and time of day) for each survey, to allow repeated measures for statistical analysis of data (for example, Murphy et al. 2010). Given the methodological differences, caution should be used when comparing the 2012 work with previous surveys. Although the findings of the 2012 study indicate that the density, biomass and size frequency of the stock had improved, it is unclear whether these data reflect real improvements in the stock or are artefacts of the different experimental design. The stock status determination provided here therefore continues to rely on the findings of the most recent full-scale sandfish survey (Murphy et al. 2010).

Stock status determination

Sandfish has been subject to a zero TAC since 1998. Illegal catch taken by Papua New Guinea nationals has been reported in recent years, but no such reports were received for 2018 (AFMA, 2019, pers. comm.). On this basis, the stock is classified as **not subject to overfishing**. Since no recovery in overall density was observed between the full-scale surveys in 2004 and 2010, and there is no other robust information to inform stock status, the stock remains classified as **overfished**.

White teatfish (*Holothuria fuscogilva*)



Line drawing: FAO

Stock structure

White teatfish in Torres Strait is assumed to represent a single biological stock (Tim Skewes [CSIRO], 2013, pers. comm.).

Stock assessment

The Torres Strait white teatfish stock was last surveyed in 2009 (Skewes et al. 2010). The results of this survey indicated that white teatfish density was relatively stable (or possibly increased) since surveys in 1995, 2002 and 2005. Mean density (±SE) increased from 0.47 (±0.20) to 0.85 (±0.43) per hectare between 2005 and 2009 (Skewes et al. 2010). Differences in the density estimates between years were not statistically significant. Between 2005 and 2009, mean weight increased from 2,341 to 2,736 g, and mean length increased from 276 to 296 mm.

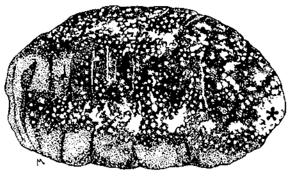
The 2009 survey estimated the biomass of white teatfish to be 110 t. The resulting TAC for white teatfish (using the same methods described for prickly redfish) was 15 t. However, it is likely that this survey underestimated the biomass, as a result of the 20 m safety limit imposed on diving depth for survey operations. White teatfish can occur at depths of more than 40 m, and previous research indicates that most inhabit waters deeper than 20 m (SPC 1994). Furthermore, the northern Don Cay region (Figure 19.1) was not included in the survey, potentially contributing to an underestimate of stock size. Past surveys may also have underestimated abundance and biomass for similar reasons. Given the historical restrictions on the use of breathing apparatus in this fishery, the depth preference of white teatfish is also likely to have protected the species from some level of fishing effort.

Stock status determination

Recent catches of white teatfish have been sporadic, with all but two years (2013 and 2014) being below the TAC. Although the data that support the current TAC are close to 15 years old, the average catch for the period since the TAC was calculated (2004) has been around 5 t—substantially below the 15 t TAC.

The reported catch in 2018 was around 1.4 t—well below the 15 t TAC. This stock is therefore classified as **not subject to overfishing**. The relatively stable densities, mean weights and lengths from surveys up to 2009 indicate that the portion of the stock available to the fishery has also remained relatively stable. Because there are no more recent data to indicate that this situation has changed, the stock is classified as **not overfished**.

Other sea cucumbers (18 species)



Line drawing: FAO

Stock structure

The 'other sea cucumber' stock is a basket stock of up to 18 species of sea cucumber. Together, these species are considered to constitute a single stock for management purposes.

Stock assessment

Many of the individual species within this multispecies stock have been included in previous surveys (1995, 2002, 2005 and 2009) of sea cucumbers in Torres Strait. The results of the 2002 survey (Skewes et al. 2004) were used to estimate MSY, and subsequently TACs, for 15 of the species (see section on prickly redfish for methodology for MSY and TAC calculation). For species considered to be 'unexploited' (that is, little or no fishing currently or in the recent past), the recommended TAC was equal to the estimate of MSY (this includes *Holothuria atra*—lollyfish, and curryfish species). For species currently or previously fished, but showing no evidence of severe depletion, the recommended TAC was half of MSY (this includes *H. fuscopunctata*—trunkfish, *H. lessoni*—golden sandfish, *Stichopus chloronotus*—greenfish, and *Bohadschia argus*—leopardfish). Finally, for species considered 'overexploited' (where the population is severely depleted and densities are several times lower than unfished biomass levels) or with MSY estimates less than 10 t, the recommended TAC was zero (this includes *Actinopyga miliaris*—hairy blackfish, and deepwater redfish). Because of the multispecies nature of this stock, the PZJA has established an 80 t TAC for all species combined (Table 19.2). This TAC is not biologically meaningful at the individual species level.

Stock status determination

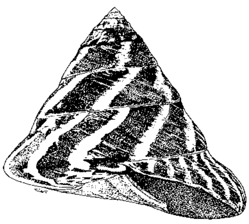
Catch of this stock in 2018 comprised a number of species, at least two of which (deepwater redfish and blackfish) were considered to have been reduced to low levels and therefore to have a recommended TAC of zero (Skewes et al. 2004).

The 2018 catch was around 46.6 t, which is below the 80 t TAC set by the PZJA. Curryfish made up most of the catch—41.5 t.

Although the total catch was below the basket TAC and the species-specific catch for most species was below the species-specific TAC recommended by Skewes et al. (2004), the catches of redfish and blackfish were above the zero TACs recommended by Skewes et al. (2004). It is unclear if the catches in 2018 (and for other years since TACs were calculated) would impede effective recruitment and recovery of redfish or blackfish species. As such, the stock as a whole is considered to be **uncertain** with regard to the level of fishing mortality.

At the time of the last full-scale survey, some species that make up this multispecies stock were considered to have been reduced to low levels by historical fishing. It has also been a number of years since the last survey. As a result, the biomass status of some species, and therefore the stock as a whole, remains **uncertain**.

Trochus (*Trochus niloticus*)



Line drawing: FAO

Stock structure

Trochus in Torres Strait is assumed to represent a single biological stock (Tim Skewes [CSIRO], 2013, pers. comm.).

Stock assessment

Trochus was surveyed in Torres Strait in 1995, 2002, 2005 and 2009, mostly in combination with surveys of sea cucumbers and other reef-dwelling marine resources. The 2009 survey sampled 113 sites (11 specifically for trochus) over 10 days, during which 73 specimens were found at 12 sites. The survey transects sampled to a depth of 20 m, but trochus was not found deeper than 3 m. Murphy et al. (2010) suggested that the low numbers, and often complete absence, of trochus may be because it has quite different habitat requirements from bêche-de-mer. When suitable trochus habitat was identified and specifically targeted, animals were commonly found. In the 2009 survey, the average density of trochus was estimated at 25 individuals per hectare (lower 90th percentile: 5 individuals per hectare), with a standing stock estimate of 634 t (lower 90th percentile: 138 t). The density of trochus in 2009 was similar to that observed in 1995, and the authors suggested that it was comparable to that of unfished stocks in other south Pacific locations.

Despite the well-established and repeated methodology used in the surveys, the reliability of the estimates of density and standing stock is uncertain because of the small number of sites at which trochus was found (only 12 of 113 sites), the low total number of trochus observed (73) and the resulting high variability around mean estimates of density. Murphy et al. (2010) concluded that the density estimates had very low precision and that the probability of detecting even large changes in trochus density was low.

Murphy et al. (2010) recommended setting a trigger catch level of 75 t (live shell weight), based on historical information, anecdotal harvest patterns and a 20% exploitation rate of the estimated standing stock. It was recommended that the TAC should be reassessed and the stock assessed if catch exceeded this level. The current TAC for trochus in Torres Strait is 150 t, but there is no robust assessment or survey basis for that level of catch (Murphy et al. 2010).

Stock status determination

A small catch of trochus was reported in 2018 (around 0.04 t). It is also likely that there were small amounts of unreported catch in previous years (AFMA, 2018, pers. comm.). Given the uncertain biomass status, it is unclear what level of catch is sustainable. However, it is unlikely that 0.04 t would have a measurable impact on biomass. As a result, the stock is classified as **not subject to overfishing**. Given the long history of fishing for trochus in Torres Strait (pre-European settlement; DPIE 1994), the unfished biomass is unknown. Furthermore, although the results of the 2009 survey suggested that trochus densities were similar to unfished stocks in other south Pacific locations, the very low precision of the results means that the biomass status of trochus remains **uncertain**.

19.3 Economic status

Key economic trends

Estimates of net economic returns (NER) and gross value of production are unavailable for the TSBDMF or the TSTF.

The TSBDMF catch was higher in the 2018 season than in 2017, particularly for prickly redfish (high-value species) and other sea cucumber species. The increase in sea cucumber catch is likely driven by demand from China, particularly from the Hong Kong region (Purcell, Williamson & Ngaluafe 2018). In 2016–17, 91% of sea cucumber exports from Australia were destined for Hong Kong, increasing to 93% in 2017–18. For Torres Strait Islanders, the TSBDMF is an important commercial fishery (PZJA 2014a).

NER in the TSTF are likely to have remained low due to little to no fishing activity over the past four fishing seasons. Low levels of participation in the TSTF are likely due to limited overseas market demand for shells.

Management arrangements

Both fisheries are managed under TACs and a range of input and output controls. Participation in the TSBDMF is limited to Traditional Inhabitants. Both fisheries have restrictions on collection methods.

Performance against economic objective

The HSP is not prescribed for Torres Strait fisheries, and there are no explicit economic targets for the TSBDMF or the TSTF.

For the TSBDMF, the PZJA aims to provide for the sustainable use of resources, develop stocks for the benefit of Australian Traditional Inhabitants and develop a long-term strategy for sandfish (PZJA 2014a). The trial opening of a black teatfish fishery in 2014 and 2015, and hookah gear trials in 2011–12 appear to have generated increased activity in the TSBDMF. Rebuilding the sandfish stock should increase the potential benefits to local communities from the fishery.

For the TSTF, the PZJA aims to optimise resource use, maximise opportunities for Traditional Inhabitants and encourage participation in the fishery (PZJA 2014b). Expectations of low economic returns are likely to have contributed to low participation in the fishery.

19.4 Environmental status

Both the bêche-de-mer and trochus fisheries are included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The TSBDMF is exempt from export controls until 18 December 2020, and the TSTF is exempt until 9 October 2026.

No ecological risk assessments have been conducted for the bêche-de-mer fishery or the trochus fishery. The most recent EPBC Act assessments of the fisheries (Department of the Environment 2014) assume that impacts on the ecosystem of each fishery would be restricted to exploitation of target species; translocation of species through anchor and hull fouling; and impacts on reef ecosystems related to anchoring, mooring and other anthropogenic activities, such as reef-top walking.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in either fishery in 2018.

19.5 References

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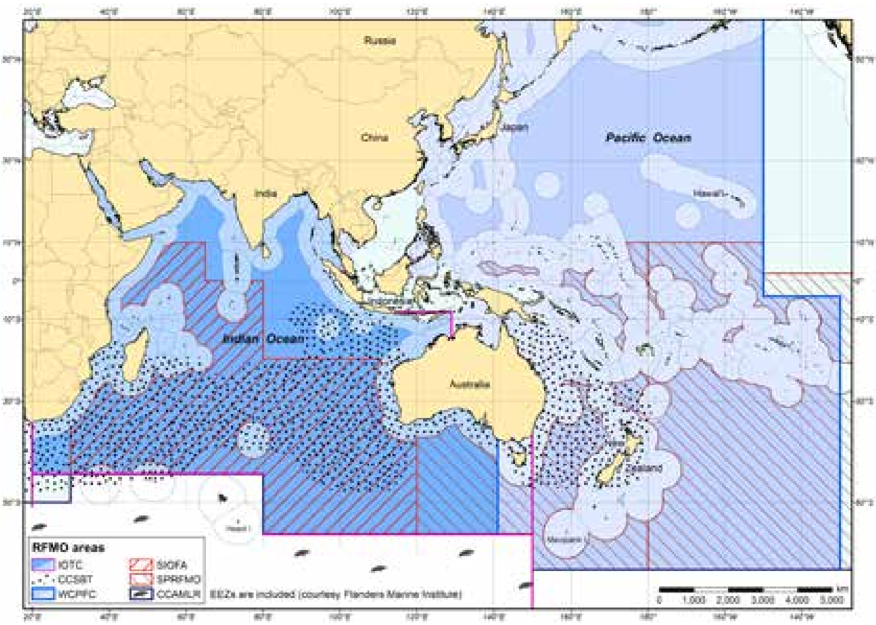
Chapter 20
International fishery management arrangements

H Patterson

FIGURE 20.1 Areas of competence for regional fisheries management organisations



Notes: **CCAMLR** Commission for the Conservation of Antarctic Marine Living Resources. **CCSBT** Commission for the Conservation of Southern Bluefin Tuna. **EEZ** Exclusive Economic Zone. **IOTC** Indian Ocean Tuna Commission. **SIOFA** Southern Indian Ocean Fisheries Agreement. **SPRFMO** South Pacific Regional Fisheries Management Organisation (see Chapter 28 for full extent). **WCPFC** Western and Central Pacific Fisheries Commission. IOTC and WCPFC areas of competence include EEZs.

Several fish stocks of commercial importance to Australia have ranges extending outside the Australian Fishing Zone (AFZ) into the high seas and the Exclusive Economic Zones (EEZs) of other countries. These stocks are important for Australia in providing economic benefits for the Australian fishing industry. They require regional cooperative action for effective management. Management responsibility is shared by multiple governments through international instruments (conventions and agreements), which are often implemented through a regional fisheries management organisation (RFMO) or other international body (Figure 20.1). As a party to these international instruments, Australia implements measures agreed by the relevant body in managing its domestic fishery; in a number of cases, Australia's domestic standards exceed those agreed internationally. Australia's continued engagement in international fisheries processes is critical to supporting access for the Australian fishing industry, and promoting responsible management to ensure sustainability of the fisheries and the ecosystems that support them.

This chapter provides an introduction to international fisheries arrangements to which Australia is a party. Status reports for the domestic fisheries that target stocks that are managed under international instruments are provided in Chapters 21–28. Although the fisheries of Torres Strait are also managed under an international agreement, they differ substantially from the fisheries described here and are therefore addressed separately in Chapters 15–19.

Through participation in RFMOs and other international fisheries bodies, Australia aims to implement its commitments and obligations under overarching international instruments, including the:

- 1982 United Nations Convention on the Law of the Sea (UNCLOS)
- 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement)
- 1995 United Nations Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries
- 1995 Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas
- 2006 and 2009 United Nations General Assembly (UNGA) resolutions on sustainable fisheries (UNGA 61/105, UNGA 64/72)
- 2009 Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.

Globally, the species targeted on the high seas vary by area and fishing fleet. Some of the most extensive high-seas fisheries are pelagic fisheries catching highly migratory tunas, billfishes and sharks (defined under UNCLOS Annex 1). Currently, five conventions or agreements have been established to manage such species and species groups; Australia is party to three of these:

- Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
- Convention for the Conservation of Southern Bluefin Tuna
- Agreement for the Establishment of the Indian Ocean Tuna Commission (IOTC).

Australia has also participated in the development of newer agreements to fill gaps in the international management of other non–highly migratory stocks in the high seas:

- Southern Indian Ocean Fisheries Agreement (SIOFA)
- Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean (SPRFMO).

Arrangements for demersal species in Antarctic waters, and for the AFZ of Heard Island and McDonald Islands, are implemented through the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The AFZ of Macquarie Island is adjacent to the CCAMLR Convention area, rather than within it. However, for consistency, the Macquarie Island Toothfish Fishery is generally managed in line with CCAMLR arrangements.

The Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018) requires that harvest strategies be developed for all Commonwealth fisheries, apart from those that are managed under the joint authority of the Australian Government and another Australian jurisdiction, or an international management body or arrangement. However, the HSP notes that the Australian Government will advocate the principles of the policy when negotiating with these bodies. In addition, where no harvest strategy has been developed in the RFMO, and Australia is a major harvester of the stock, the Australian Fisheries Management Authority must implement a strategy consistent with the objectives of the HSP. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) adopted a management procedure in 2011 that is analogous to a harvest strategy (Chapter 23). Considerable progress has also been made towards adopting harvest strategy principles and revised reference points in the IOTC, and the Western and Central Pacific Fisheries Commission (WCPFC) in recent years. The scientific committees of some RFMOs report against reference points for biomass and fishing mortality when providing advice on stock status. These may be defined differently from those in the HSP, although the limit reference points, or alternative limit reference points, adopted by the WCPFC and the IOTC are the same as prescribed in the HSP. For jointly managed stocks, ABARES determines stock status in light of the limit reference points described in the HSP and considers the impacts of fishing mortality from all fleets on the stocks.

20.1 Regional fisheries management organisations

Western and Central Pacific Fisheries Commission

The WCPFC is responsible for the world's largest and most valuable tuna fishery. In 2017, the total tuna catch from the fishery was worth more than US$5.84 billion and constituted about 54% of the global tuna catch. The WCPFC area of competence includes the EEZs of many developing Pacific island states (Figure 20.1), for which tuna fishing is a significant source of income. The WCPFC has a specific mandate to manage fishing impacts on all highly migratory fish species listed in UNCLOS Annex 1, except sauries (Scomberesocidae). See Chapter 21 for more information.

Commission for the Conservation of Southern Bluefin Tuna

The Convention for the Conservation of Southern Bluefin Tuna, which established the CCSBT, originated from discussions between Australia, Japan and New Zealand in the mid 1980s, following an observed decline in stock biomass. The convention applies to southern bluefin tuna (*Thunnus maccoyii*) throughout its range, rather than within a specified geographic area. Therefore, it covers areas of the Indian, Atlantic and Pacific oceans (Figure 20.1), overlapping with the areas of competence of the CCAMLR, the WCPFC and the IOTC. The CCSBT's primary management measure is a global total allowable catch (TAC), which is allocated to members and cooperating non-members. Currently, Australia, Japan, New Zealand, the Republic of Korea, Indonesia and the Fishing Entity of Taiwan hold most of the global TAC. See Chapter 23 for more information.

Indian Ocean Tuna Commission

The IOTC is an intergovernmental organisation established under the Agreement for the Establishment of the Indian Ocean Tuna Commission, and is an article XIV body of the FAO. It is mandated to manage tuna and tuna-like species in the Indian Ocean and adjacent seas (Figure 20.1). The IOTC's area of competence covers a large number of countries, and both artisanal and industrial fishing vessels. Membership of the IOTC is open to Indian Ocean coastal countries, and countries or regional economic integration organisations that actively fish for tunas in the Indian Ocean and are members of the United Nations or one of its specialised agencies. The IOTC is responsible for the world's second largest tuna fishery in terms of both volume and value. The Indian Ocean differs from other oceans in that small-scale or artisanal fisheries take around the same quantity of tuna as industrial fisheries; much of this catch is neritic (inshore) tuna-like species, which are under IOTC management. See Chapter 24 for more information.

Commission for the Conservation of Antarctic Marine Living Resources

The CCAMLR was established to conserve and manage the Southern Ocean Antarctic ecosystem, mainly in high-seas areas. It originated from concern over the effects of fishing for krill (*Euphausia superba*) on the broader Antarctic ecosystem. The objective of the CCAMLR is the conservation and rational use of Antarctic marine living resources. In managing fisheries within its area of competence, the CCAMLR uses harvest strategies that specifically incorporate ecological links in setting TACs. Such an approach views the entire Southern Ocean as a suite of interlinked ecological systems—this distinguishes the CCAMLR Convention from the other multilateral fisheries conventions. The strategies result in conservative TACs that aim to reduce the effects of fishing on other species, such as predators of the target species. There is also a focus on mitigating impacts on the benthic environment and bycatch, particularly seabirds. Fisheries in the CCAMLR Convention area are required to have high levels of observer coverage, data collection and reporting, and there are specific requirements for new or exploratory fisheries. See Chapters 25 and 27 for more information.

Southern Indian Ocean Fisheries Agreement

The SIOFA entered into force on 21 June 2012. The objectives of the agreement are to ensure the long-term conservation and sustainable use of the non–highly migratory fisheries resources in the SIOFA area of competence through cooperation among the parties. The agreement promotes the sustainable development of fisheries in the area, taking into account the needs of developing states bordering the area that are parties to the agreement—in particular, the small-island developing states. See Chapter 28 for more information.

South Pacific Regional Fisheries Management Organisation

The Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean entered into force on 24 August 2012. The convention, which is implemented by the SPRFMO, covers non–highly migratory fisheries resources in the southern Pacific Ocean. The area has been fished by vessels from numerous countries, using both pelagic and demersal gear. The largest fisheries focus on pelagic species in upwelling areas of higher productivity off the west coast of South America. Other fisheries target demersal species found on seamounts and ridges in the central and western areas of the southern Pacific Ocean. See Chapter 28 for more information.

20.2 References

Department of Agriculture and Water Resources 2018, *Commonwealth Fisheries Harvest Strategy Policy*, Department of Agriculture and Water Resources, Canberra.

Chapter 21
Eastern Tuna and Billfish Fishery

J Larcombe, H Patterson and D Mobsby

FIGURE 21.1 Relative fishing intensity in the Eastern Tuna and Billfish Fishery, 2018

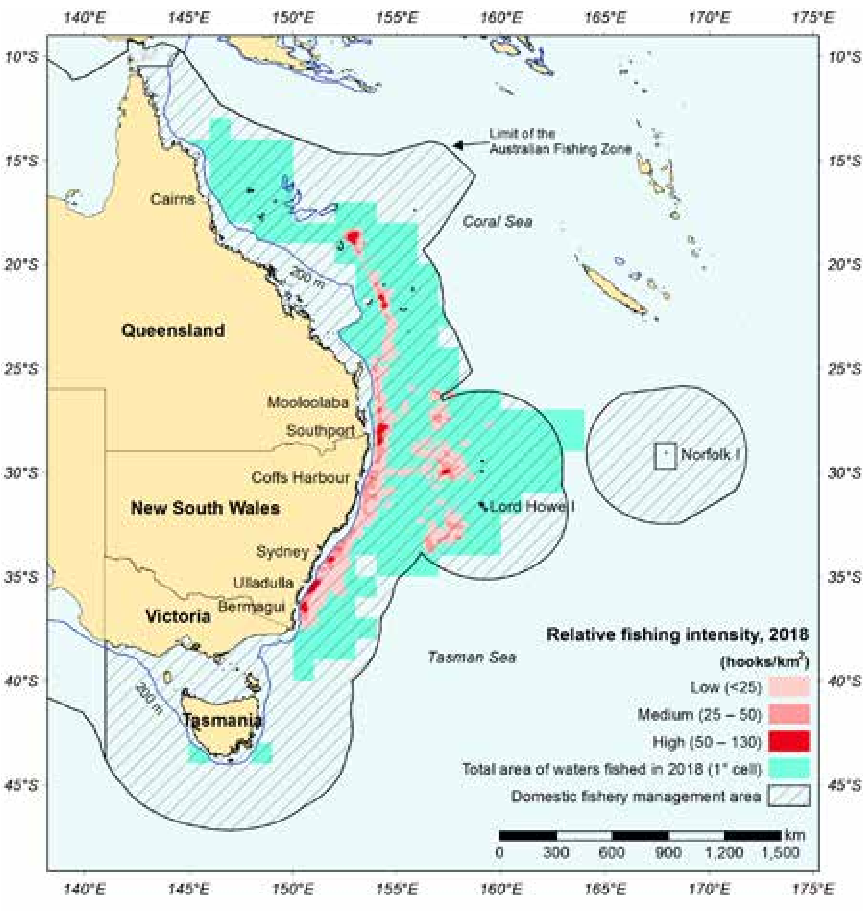


TABLE 21.1 Status of the Eastern Tuna and Billfish Fishery

Status	2017		2018		Comments a
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Striped marlin (*Kajikia audax*), south-west Pacific					Most recent estimate of spawning biomass (2012) is above the default limit reference point of B_{20} but below B_{MSY}. Current fishing mortality rate is below MSY levels.
Swordfish (*Xiphias gladius*), south-west Pacific					Most recent estimate of biomass (2017) is likely above the default limit reference point. Recent fishing mortality is likely below F_{MSY}.
Albacore (*Thunnus alalunga*), south Pacific					Most recent estimate of spawning biomass (2018) is well above the default limit reference point. Recent estimate of fishing mortality is below F_{MSY}.
Bigeye tuna (*Thunnus obesus*), western and central Pacific					Most recent estimate of spawning biomass (2017) is likely above the limit reference point. Recent fishing mortality is likely below F_{MSY}.
Yellowfin tuna (*Thunnus albacares*), western and central Pacific					Most recent estimate of biomass (2017) is highly likely above the limit reference point. Ocean-wide estimates of fishing mortality are highly likely below F_{MSY}.
Economic status	Preliminary estimates suggest NER for the fishery remained positive between 2015–16 and 2017–18. NER improved significantly in 2015–16, rising 40% to $9.1 million, before falling to $4.2 million in 2016–17. The increased NER in 2015–16 were supported by a significant increase in fishing revenue (reflective of the very high yellowfin tuna catch that year). Non-survey-based estimates indicate that NER increased in 2017–18 to $5.1 million because of an increase in estimated fishing revenue more than offsetting estimated higher fishing costs.				

a Regional assessments of species and the default limit reference points from the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) are used as the basis for status determination.

Notes: **B_{20}** 20% of unfished biomass. **B_{MSY}** Biomass at MSY. **F_{MSY}** Fishing mortality at MSY. **MSY** Maximum sustainable yield. **NER** Net economic returns.

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

21.1 Description of the fishery

Area fished

The Eastern Tuna and Billfish Fishery (ETBF) operates in the Exclusive Economic Zone, from Cape York to the Victoria – South Australia border, including waters around Tasmania and the high seas of the Pacific Ocean (Figure 21.1). Domestic management arrangements for the ETBF are consistent with Australia's commitments to the Western and Central Pacific Fisheries Commission (WCPFC; see Chapter 20).

Fishing methods and key species

Key species in the ETBF are shown in Table 21.1. Most of the catch in the fishery is taken with pelagic longlines, although a small quantity is taken using minor-line methods (Table 21.2). Some ETBF longliners catch southern bluefin tuna (*Thunnus maccoyii*) off New South Wales during winter, after fishing for tropical tunas and billfish earlier in the year, while others take them incidentally when targeting other tunas. All southern bluefin tuna taken must be covered by quota and landed in accordance with the Southern Bluefin Tuna Fishery Management Plan 1995. Recreational anglers and game fishers also target tuna and marlin in the ETBF. Many game fishers tag and release their catch, especially marlins. The retention of blue marlin (*Makaira mazara*) and black marlin (*M. indica*) has been banned in commercial fisheries since 1998, and catch limits have been introduced on longtail tuna (*T. tonggol*), in recognition of the importance of these species to recreational anglers.

Management methods

The primary ETBF tuna and billfish species are managed through total allowable catches allocated as individual transferable quotas (ITQs). The Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018) is not prescribed for fisheries managed under international agreements. However, a harvest strategy framework was developed for the ETBF (Campbell 2012) to set the total allowable commercial catch (TACC) for the five main species. For reasons set out below, this harvest strategy framework has been discontinued for the three tuna species, and is being redeveloped for swordfish (*Xiphias gladius*) and striped marlin (*Kajikia audax*).

Australia's catch in the ETBF as a percentage of the total catch from all nations in the Coral and Tasman seas has been declining across the major target species. This is due primarily to an increase in the catch by other nations for some species. In 2013, the Tropical Tuna and Billfish Fisheries Resource Assessment Group (TTRAG) found that the ETBF harvest strategy was not likely to achieve its objectives according to the requirements of the HSP for bigeye tuna (*T. obesus*), yellowfin tuna (*T. albacares*) and albacore (*T. alalunga*). Changes to Australia's catch of these tuna species could not be expected to result in a change in the stock status (because of a lack of feedback to the stock as a whole).

The Australian Fisheries Management Authority (AFMA) Commission subsequently directed TTRAG to cease using the harvest strategy to calculate recommended biological commercial catch levels for bigeye tuna, yellowfin tuna and albacore, and to prepare information on stock status of tunas. In the absence of an accepted domestic harvest strategy, and noting that WCPFC harvest strategies for these species are still under development and there has been no allocation of tuna catches by the WCPFC as yet, AFMA considered a range of other factors in applying TACCs. These include stock status, local catch indices, historical catch levels in the fishery, and limits determined by the WCPFC (through conservation and management measures) or agreed through regional arrangements.

The harvest strategies for swordfish and striped marlin were reviewed in 2017–18, including management strategy evaluation. The review determined that the harvest strategies were not likely to be effective at achieving HSP objectives and so required redevelopment. The AFMA Commission agreed and requested that TTRAG provide the best available scientific indicators to provide catch limit advice while a new harvest strategy is developed.

The status of ETBF tuna and billfish is derived from regional assessments undertaken for the WCPFC. Assessment results over the relevant geographic area modelled are used to determine stock status, but supplementary management advice may also be derived from the region most relevant to Australia. The WCPFC has agreed limit reference points for some stocks, but, where agreed limit reference points are absent, status determination was informed by the proxies specified in the HSP.

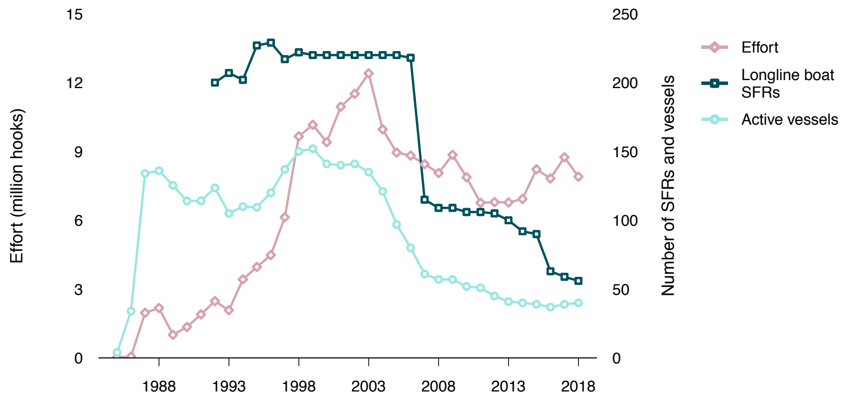
In 2017, the WCPFC Scientific Committee adopted key changes to the way it treats uncertainty in the stock assessments and communicates that uncertainty. Management statistics and stock status are based on a structural uncertainty grid that incorporates all plausible models across all combinations of key uncertainty axes (for example, steepness, natural mortality, growth, tagging parameters). The structural uncertainty grid may comprise a large number of separate models (generally up to 72) that may be weighted when some axis settings are less plausible than others. The various management quantities are then expressed as the median of the grid, with a range of uncertainty around that median. There will also be a probability (or a proxy of the probability) associated with breaching each of the key reference points (for example, percentage of the grid models where recent spawning biomass was below the limit reference point). The status information in this chapter reflects this change.

Since 1 July 2015, electronic monitoring has been mandatory for all full-time pelagic longline vessels in the ETBF and the Western Tuna and Billfish Fishery. At least 10% of video footage of all hauls is reviewed to verify the accuracy of logbooks, which must be completed for 100% of shots.

Fishing effort

The number of active vessels in the fishery (Figure 21.2) has decreased substantially in the past decade (from around 150 in 2002 to 37 in 2016), probably as a result of a decline in economic conditions in the fishery and the removal of vessels through the Securing our Fishing Future structural adjustment package in 2006–07 (Vieira et al. 2010).

FIGURE 21.2 Longline fishing effort, number of boat SFRs and active vessels in the ETBF, 1985–2018

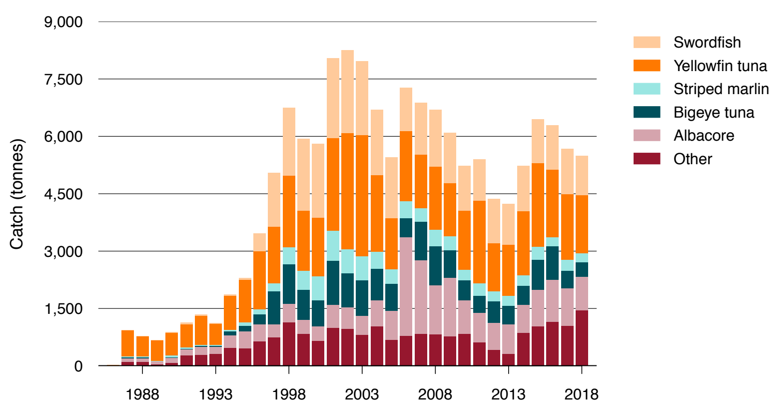


Note: **SFR** Statutory fishing right.
Source: AFMA

Catch

Following a decrease in effort, the total retained catch of all species in the ETBF declined from a high of more than 8,000 t in 2002 to around 4,200 t in 2013. Catch declined from 4,624 t in 2017 to 4,046 t in 2018 (Figure 21.3). Swordfish and yellowfin tuna continue to be the main target species.

FIGURE 21.3 Total catch (from logbook data) for all methods, by species, in the ETBF, 1987–2018



Source: AFMA

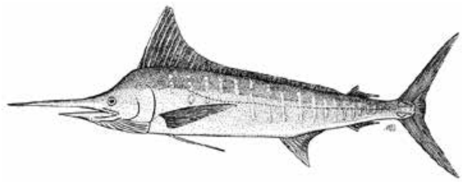
TABLE 21.2 Main features and statistics for the ETBF

Fishery statistics a	**2017**			**2018**		
Stock	**TACC (t)**	**Catch (t)**	**GVP (2016–17)**	**TACC (t)**	**Catch (t)**	**GVP (2017–18)**
Striped marlin	351	288	$1.0 million	311	246	$1.6 million
Swordfish	1,285	1,180	$9.3 million	960	1,027	$9.2 million
Albacore	2,500	992	$4.1 million	2,351	889	$2.7 million
Bigeye tuna	1,056	450	$7.3 million	957	367	$4.3 million
Yellowfin tuna	2,400	1,714	$12.6 million	2,054	1,517	$18.8 million
Total fishery	**7,592**	**4,624**	**$35.7 million**	**6,633**	**4,046**	**$38.4 million**
Fishery-level statistics						
Effort	Longline: 8.75 million hooks Minor line: na			Longline: 7.90 million hooks Minor line: 0		
Fishing permits	Longline boat SFRs: 85 Minor-line boat SFRs: 93			Longline boat SFRs: 82 Minor-line boat SFRs: 84		
Active vessels	Longline: 39 Minor line: 2			Longline: 40 Minor line: 0		
Observer coverage	Longline: 10.2% **b** Minor line: zero			Longline: 10.8% **b** Minor line: zero		
Fishing methods	Pelagic longline, minor line (trolling, rod and reel, handline)					
Primary landing ports	Bermagui, Coffs Harbour and Ulladulla (New South Wales); Cairns, Mooloolaba and Southport (Queensland)					
Management methods	Output controls: TACCs and ITQs Input controls: limited entry, gear restrictions					
Primary markets	Domestic: fresh International: Japan, United States—mainly fresh; Europe—frozen; American Samoa, Indonesia, Thailand—albacore mainly for canning					
Management plan	*Eastern Tuna and Billfish Fishery Management Plan 2010*					

a Fishery statistics are provided by calendar year to align with international reporting requirements. The 2018 season ran for 10 months as the fishing season transitioned to a calendar year; in 2019, season and calendar year will be the same. Value statistics are by financial year. Total value includes value from non-quota species caught in the ETBF. **b** From 1 July 2015, electronic monitoring became mandatory for all full-time pelagic longline vessels in the ETBF. At least 10% of video footage of all hauls is reviewed to verify the accuracy of logbooks, which must be completed for 100% of shots. The percentage of hooks observed is provided.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing right. **TACC** Total allowable commercial catch.

21.2 Biological status

Striped marlin (*Kajikia audax*)



Line drawing: FAO

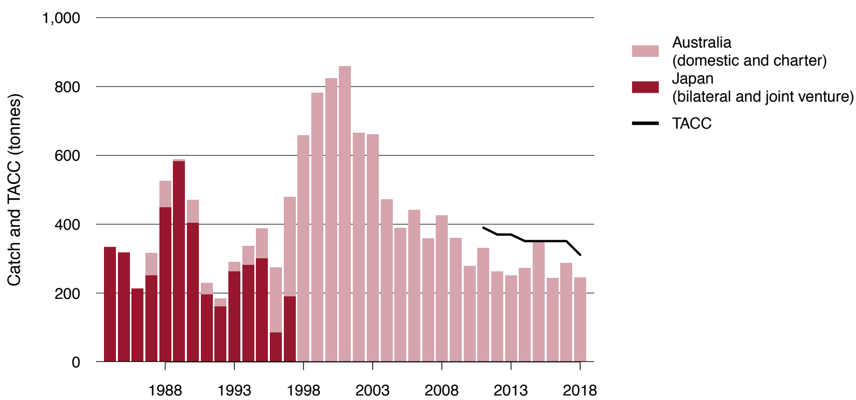
Stock structure

Genetic studies have identified multiple stocks of striped marlin in the Pacific Ocean (for example, McDowell & Graves 2008; Purcell & Edmands 2011). As a result, the north Pacific Ocean and south-west Pacific Ocean (SWPO) stocks are assessed separately (WCPFC 2013). Information for the SWPO stock is reported here.

Catch history

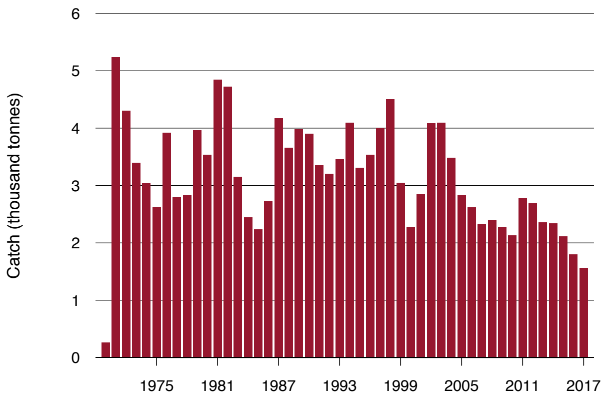
Catch for the ETBF decreased slightly in 2018 to 246 t (Figure 21.4), while catch in the south Pacific decreased from 1,801 t in 2016 to 1,560 in 2017 (Figure 21.5). An increase in the south Pacific catch in 2011–12 was driven in part by increases in catch in the north that are not subject to the current conservation and management measure (CMM) for striped marlin—WCPFC CMM 2006-04—which only applies south of 15°S.

FIGURE 21.4 Striped marlin catch and TACC in the ETBF, 1984–2018



Note: **TACC** Total allowable commercial catch.
Source: AFMA

FIGURE 21.5 Striped marlin catch in the south Pacific, 1970–2017



Source: WCPFC

Stock assessment

The last stock assessment for striped marlin in the SWPO was conducted in 2012 (Davies, Hoyle & Hampton 2012). Significant changes in the base case from the previous (2006) assessment included a 50% reduction in Japanese longline catches over the entire model time period (because catches in the previous assessment were erroneously counted twice), faster growth rates, and the steepness of the stock–recruitment relationship being fixed at a higher level (0.8 rather than 0.55). A decreasing trend in recruitment through time was found, particularly from 1950 to 1970. There were conflicts among the standardised catch-per-unit-effort time series, and a series from the Japanese longline fishery was considered to be the most representative. Estimates of equilibrium maximum sustainable yield (MSY) and the associated reference points were highly sensitive to the assumed values of natural mortality and steepness in the stock–recruitment relationship. Estimates of stock status relative to MSY-based reference points, as used by the WCPFC, are therefore uncertain.

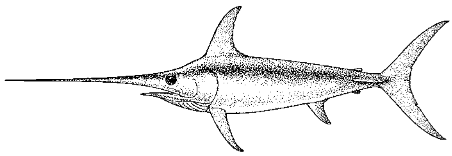
The base case in the assessment estimated that the latest (2010) spawning biomass had been reduced to 34% of the levels predicted to occur in the absence of fishing ($SB_{CURRENT}/SB_{F=0}$ = 0.34 for the base case; range 0.32–0.44 across the base case and sensitivities). It was estimated that the spawning biomass was below the level associated with MSY ($SB_{CURRENT}/SB_{MSY}$ = 0.87; range 0.67–1.14). Fishing mortality (2007–2010) was below F_{MSY} ($F_{CURRENT}/F_{MSY}$ = 0.81; range 0.51–1.21), and catches during this period were close to the estimated MSY (2,081 t; range 1,914–2,276 t). Annual catches during the most recent five years (2013–2017) have averaged around 2,000 t, around the estimated MSY.

Stock status determination

The most recent estimate of the SWPO spawning biomass of striped marlin is above the limit reference point adopted for tunas (20% of the levels predicted to occur in the absence of fishing; 0.2%$SB_{F=0}$), noting that the WCPFC has yet to adopt a limit reference point for this stock. The most recent base-case estimates of fishing mortality and most of the sensitivity analyses are below the level associated with MSY, and recent catches are close to the estimated MSY level. SWPO striped marlin is classified as **not subject to overfishing** and **not overfished**. The recent catch levels and the age of the stock assessment both contribute to increased uncertainty around the stock status of striped marlin in 2018. The Scientific Committee of the WCPFC recommended measures to control overall catch, through expansion of the geographical scope of CMM 2006-04 to cover the distribution of the stock; the WCPFC has not yet adopted this recommendation. An updated assessment is due in 2019.

Yellowfin tuna
Kevin McLoughlin, ABARES

Swordfish (*Xiphias gladius*)



Line drawing: Gavin Ryan

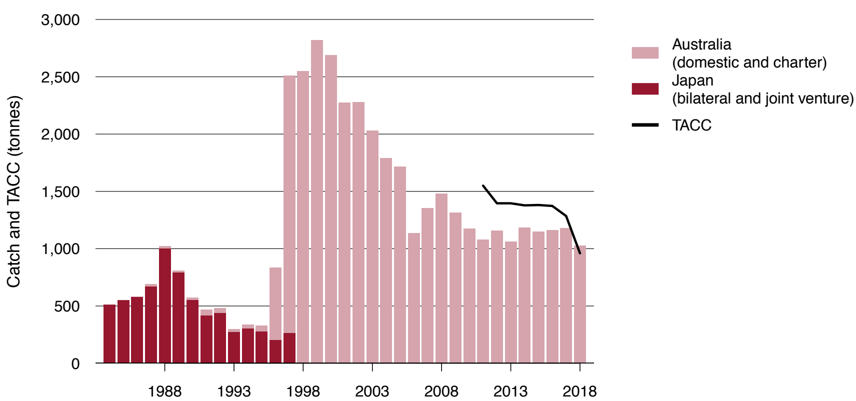
Stock structure

Although studies of swordfish have generally indicated a low level of genetic variation in the Pacific Ocean (Kasapidis et al. 2008), the WCPFC assesses two stocks separately: a north Pacific stock and an SWPO stock. The information reported here is for the SWPO stock.

Catch history

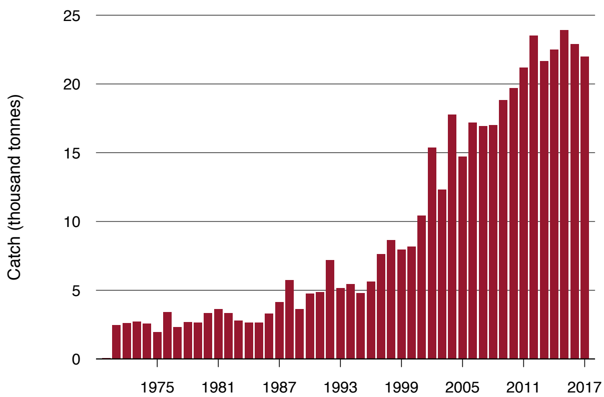
Swordfish catch in the ETBF decreased slightly in 2018 (Figure 21.6). Catch in the south Pacific has generally been increasing since 2001, but decreased slightly in 2017 to 21,992 t (Figure 21.7).

FIGURE 21.6 Swordfish catch and TACC in the ETBF, 1984–2018



Note: **TACC** Total allowable commercial catch.
Source: AFMA

FIGURE 21.7 Swordfish catch in the south Pacific, 1970–2017



Source: WCPFC

Stock assessment

The SWPO stock of swordfish was most recently assessed in 2017 using the assessment package MULTIFAN-CL (Takeuchi, Pilling & Hampton 2017). The stock assessment is based on a structural uncertainty grid that includes steepness, size data weighting, diffusion rate and natural mortality as the main uncertainties. The uncertainty grid using this approach contained 72 related models. The WCPFC Scientific Committee agreed to use the full grid, with equal weighting for all axes of uncertainty. Note that the primary uncertainty in the 2013 assessment (Davies et al. 2013), relating to growth and maturity schedules, has been resolved based on new research (Farley et al. 2016).

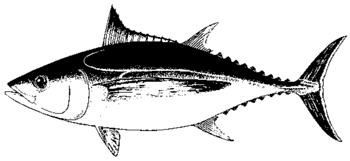
Across all models in the uncertainty grid, the spawning biomass declines steeply between the late 1990s and 2010, but the rate of decline has been less since then. These declines are greater in the eastern region 2 (equator to 50°S, 165°E to 130°W), where fishing mortality is also greater than in the western region 1 where the Australian fishery operates.

The median recent spawning stock biomass was 35% of the levels predicted to occur in the absence of fishing ($SB_{recent}/SB_{F=0}$ = 0.35; 80% probability interval = 0.29–0.43). There was a very low probability that the recent spawning stock biomass has breached the limit reference point. The median recent fishing mortality was 86% of the fishing mortality associated with MSY (F_{recent}/F_{MSY} = 0.86; 80% probability interval = 0.51–1.23). The probability that the recent fishing mortality was above F_{MSY} was about 32%.

Stock status determination

Based on the uncertainty grid, the spawning biomass is highly likely above the limit reference point of 20%$SB_{F=0}$ adopted for tunas (noting that the WCPFC Commission has yet to adopt a limit reference point for this stock). As a result, the swordfish stock in the SWPO is classified as **not overfished**. Recent fishing mortality is also likely below F_{MSY}. The stock is therefore classified as **not subject to overfishing**.

Albacore (*Thunnus alalunga*)



Line drawing: FAO

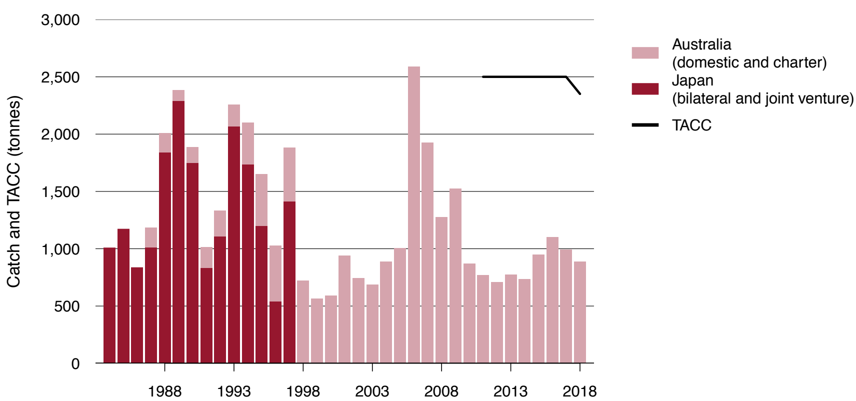
Stock structure

Two distinct stocks of albacore (north Pacific and south Pacific) are found in the Pacific Ocean, generally associated with the two oceanic gyres. These two stocks are assessed separately (WCPFC 2015). Information for the south Pacific albacore stock is reported here.

Catch history

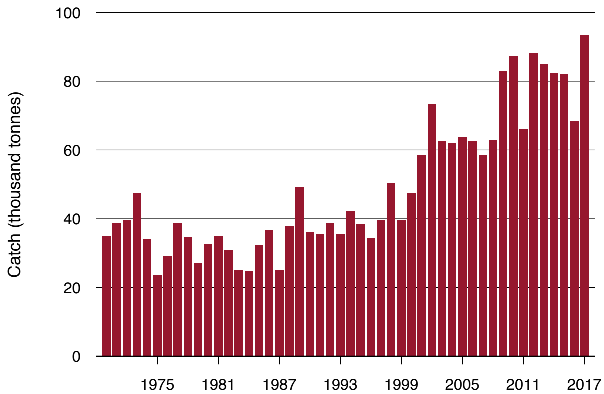
Catches in the ETBF decreased slightly to 889 t in 2018 (Figure 21.8). Catches in the south Pacific have been stable in recent years, but increased to 93,327 t in 2017 from 68,390 t in 2016 (Figure 21.9). The WCPFC Scientific Committee recommended that longline fishing mortality be reduced if the WCPFC's goal is to maintain economically viable catch rates.

FIGURE 21.8 Albacore catch and TACC in the ETBF, 1984–2018



Note: **TACC** Total allowable commercial catch.
Source: AFMA

FIGURE 21.9 Albacore catch in the south Pacific, 1970–2017



Source: WCPFC

Stock assessment

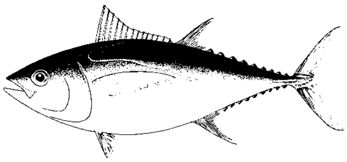
The assessment for albacore in the south Pacific was updated in 2018 using MULTIFAN-CL (Tremblay-Boyer et al. 2018). Significant improvements in the 2018 stock assessment included modifications to the catch rate index of abundance, inclusion of a higher natural mortality (0.4) in the grid, inclusion of alternative growth models and a simplified regional structure. These changes resulted in more optimistic outcomes than the 2015 assessment. The WCPFC Scientific Committee provided advice based on the full set of 72 models in the uncertainty grid, with equal weighting for all axes of uncertainty.

The median recent spawning stock biomass was 52% of the levels predicted to occur in the absence of fishing ($SB_{recent}/SB_{F=0}$ = 0.52; 80% probability interval = 0.37–0.63). The probability that the recent spawning stock biomass had breached the limit reference point was zero. The median recent fishing mortality was 20% of the level associated with MSY (F_{recent}/F_{MSY} = 0.20; 80% probability interval = 0.08–0.41). The probability that the recent fishing mortality was above F_{MSY} was zero.

Stock status determination

The most recent estimate of spawning biomass is very likely above the default limit reference point of 20% of initial unfished levels. The most recent estimates of fishing mortality are very likely below the levels associated with MSY, and recent catches are around MSY. As a result, albacore in the south Pacific Ocean is classified as **not subject to overfishing** and **not overfished**.

Bigeye tuna (*Thunnus obesus*)



Line drawing: FAO

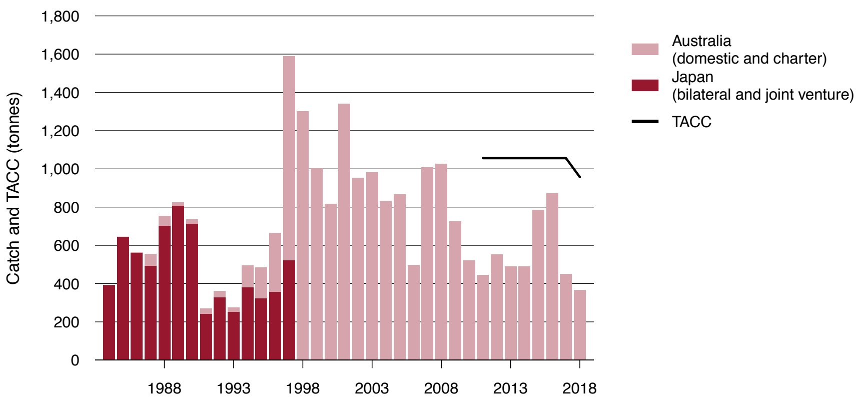
Stock structure

Genetic data have indicated that bigeye tuna in the Pacific Ocean is a single biological stock (Grewe & Hampton 1998).

Catch history

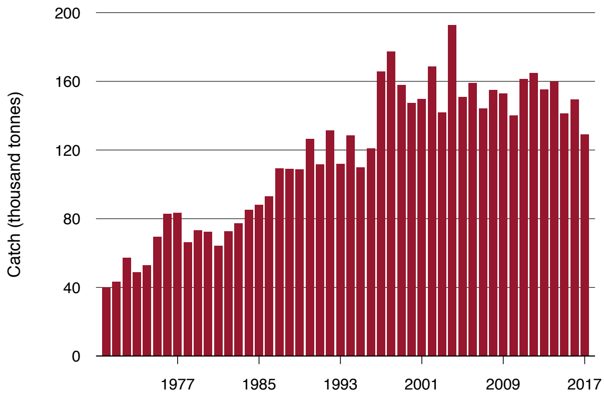
Catches of bigeye tuna decreased in the ETBF in 2018, from 450 t in 2017 to 367 t (Figure 21.10), the lowest catch since 1996. Catches increased in the south Pacific in 2017 (Figure 21.11). Recent bigeye tuna catch in the WCPFC area (129,066 t in 2017) is below the estimated MSY (median 158,551 t). Catches have been close to, and occasionally substantially above, this MSY level since around 1997 (Figure 21.11).

FIGURE 21.10 Bigeye tuna catch and TACC in the ETBF, 1984–2018



Note: **TACC** Total allowable commercial catch.
Source: AFMA

FIGURE 21.11 Bigeye tuna catch in the WCPFC area, 1970–2017



Source: WCPFC

Stock assessment

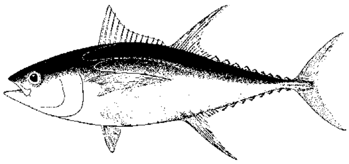
The bigeye tuna stock in the western and central Pacific Ocean (WCPO) was most recently assessed in 2017 (McKechnie, Pilling & Hampton 2017) using MULTIFAN-CL. The assessment was re-evaluated in 2018, incorporating an updated new growth curve resulting from analysis of an enhanced set of otolith data, but maintaining the other inputs of the 2017 assessment (Vincent, Pilling & Hampton 2018). The stock assessment is based on a structural uncertainty grid that includes steepness, growth, maturity, tagging dispersion, size data weighting and regional structure as the main uncertainties. The uncertainty grid using this approach contained 36 related models after models that used an older and inaccurate bigeye growth curve were removed. The updated assessment of biomass and fishing mortality status is more optimistic (as a result of the inclusion of the new growth curve, new regional structures and increased recruitment), and uncertainty is lower than in the 2017 assessment, primarily due to removal of old growth models within the grid.

The median recent spawning biomass was 36% of the levels predicted to occur in the absence of fishing ($SB_{recent}/SB_{F=0}$ = 0.36; 80% probability interval = 0.30–0.41). There was a zero probability that the recent spawning stock biomass had breached the limit reference point. The median recent fishing mortality was 77% of the level associated with MSY (F_{recent}/F_{MSY} = 0.77; 80% probability interval = 0.67–0.93). There was a roughly 6% probability that the recent fishing mortality was above F_{MSY}.

Stock status determination

Based on the uncertainty grid, the spawning biomass is very likely to be above the limit reference point of 0.2%$SB_{F=0}$ adopted for tunas. As a result, the stock is classified as **not overfished**. Similarly, recent fishing mortality is very likely to be below F_{MSY}. As a result, the stock is classified as **not subject to overfishing**.

Yellowfin tuna (*Thunnus albacares*)



Line drawing: FAO

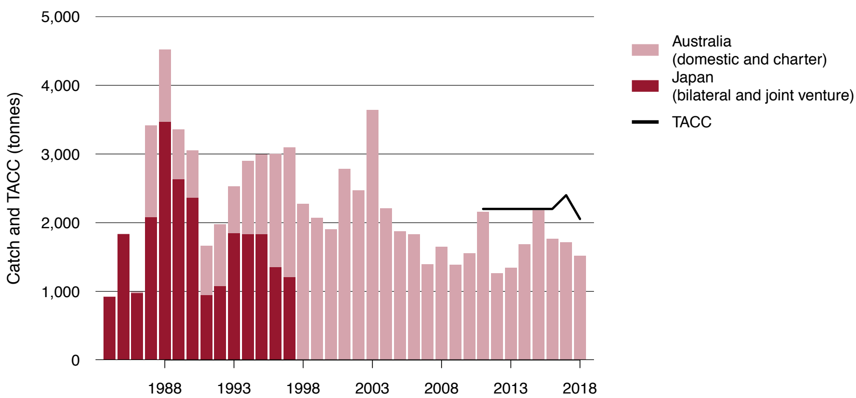
Stock structure

Yellowfin tuna in the WCPO is currently considered to be a single biological stock (Langley, Herrera & Million 2012). However, a recent study using newer genomic techniques provided strong evidence of genetically distinct populations of yellowfin tuna at three sites (Coral Sea, Tokelau and California) across the Pacific Ocean (Grewe et al. 2015). Further work is underway to confirm and expand on this initial study.

Catch history

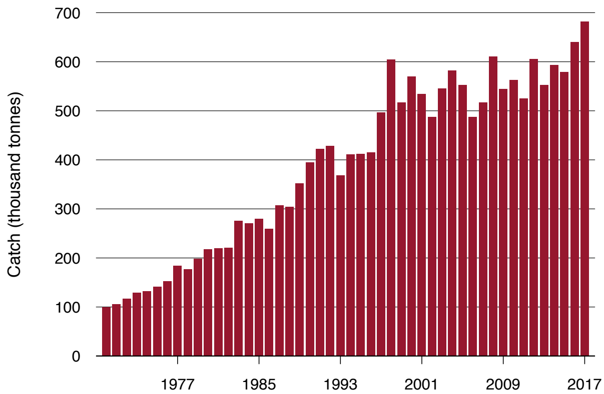
Catch decreased slightly in the ETBF in 2018 to 1,516 t (Figure 21.12). In the south Pacific, the 2017 catch was a record high of 681,391 t (Figure 21.13), which is above the estimated MSY (median 670,800 t).

FIGURE 21.12 Yellowfin tuna catch and TACC in the ETBF, 1984–2018



Note: **TACC** Total allowable commercial catch.
Source: AFMA

FIGURE 21.13 Yellowfin tuna catch in the WCPFC area, 1970–2017



Source: WCPFC

Stock assessment

The yellowfin tuna stock in the WCPO was most recently assessed in 2017 (Tremblay-Boyer et al. 2017) using MULTIFAN-CL. The stock assessment is based on a structural uncertainty grid that includes steepness, tagging dispersion, tag mixing, size frequency and regional structure as the main uncertainties. The uncertainty grid using this approach contained 48 related models. The WCPFC Scientific Committee agreed to use the full grid, with equal weighting for all axes of uncertainty.

The median recent spawning stock biomass was 33% of the levels predicted to occur in the absence of fishing ($SB_{recent}/SB_{F=0}$ = 0.33; 80% probability interval = 0.20–0.41). The probability that the recent spawning stock biomass had breached the limit reference point was about 8%. The median recent fishing mortality was 74% (F_{recent}/F_{MSY} = 0.74; 80% probability interval = 0.62–0.97). The probability that the recent fishing mortality was above F_{MSY} was about 4%.

Stock status determination

Based on the uncertainty grid, the spawning biomass is very likely to be above the limit reference point of 0.2%$S_{BF=0}$ adopted for tunas. As a result, the stock is classified as **not overfished**. Similarly, recent fishing mortality is highly likely to be below F_{MSY}. As a result, the stock is classified as **not subject to overfishing**.

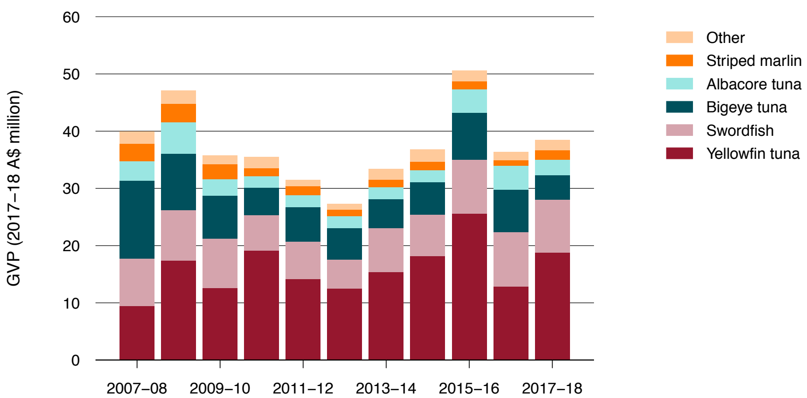
21.3 Economic status

Key economic trends

Gross value of production in the ETBF increased by 8% in 2017–18 to $38.4 million (Figure 21.14). The increase in production value was the result of an increase in the value of yellowfin tuna catch more than offsetting significant declines in the value of albacore and bigeye tuna catch. The value of yellowfin tuna catch increased by 49% in 2017–18 to $18.8 million. This was due to a 60% increase in catch (to 1,858 t) more than offsetting a 7% decline in average price. In 2017–18, yellowfin tuna remained the most valuable species caught in the ETBF, followed by broadbill swordfish ($9.2 million).

In 2017–18, bigeye tuna achieved the highest average price of the five quota species (increasing 6% to around $11.5 per kilogram), so the decline in the value of bigeye tuna catch was the result of a 44% decline in landed catch (on a financial year basis). The increased price for bigeye tuna is largely attributed to strong import demand from the United States (which overtook Japan in 2016–17 to be the key export destination of Australian bigeye tuna).

FIGURE 21.14 Real GVP for the ETBF, 2007–08 to 2017–18



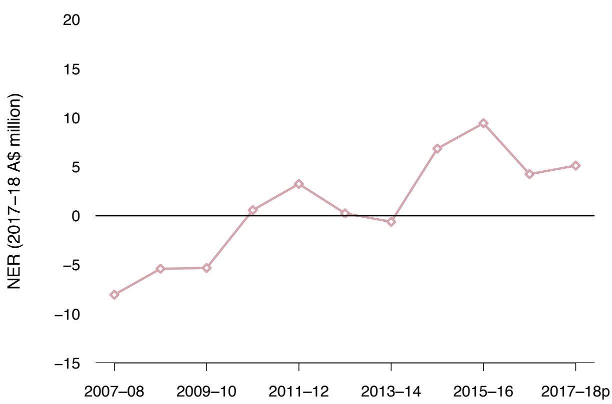
Note: **GVP** Gross value of production.

ABARES has conducted economic surveys of the ETBF since the early 1990s. The survey data are used to estimate the level of net economic returns (NER) earned in the fishery (Figure 21.15). Preliminary survey results for the ETBF are available for the 2015–16 and 2016–17 financial years. Non-survey-based estimates for economic performance are available for the 2017–18 financial year.

In 2015–16, NER for the ETBF are estimated to have increased to $9.4 million—the highest net return to the fishery in real terms since economic surveys of the ETBF began. This was supported by an estimated 32% increase in fishing revenue (largely reflective of the very high yellowfin tuna catch that year), favourable prices (as indicated by an improvement in fishers' terms of trade) and increased productivity (as indicated by an increase in total factor productivity). NER declined in 2016–17, but remained positive at $4.2 million. This was largely the result of a decline in fishing income more than offsetting lower operating costs.

Preliminary non-survey-based estimates of NER for 2017–18 show an increase to $5.1 million, largely as a result of a 10% increase in fishing income.

FIGURE 21.15 NER for the ETBF, 2007–08 to 2017–18



Notes: **NER** Net economic returns. Data for 2015–16 to 2017–18 are preliminary.
Source: Mobsby forthcoming

Management arrangements

In March 2011, output controls were introduced for five key target species in the form of TACCs, allocated as ITQs. The removal of some input controls under ITQs can provide fishers with more flexibility to fish with a more efficient combination of inputs (Elliston & Cao 2004). The transferability of statutory fishing rights among fishers also allows more efficient allocation of these rights. This is likely to result in the catch being taken by the most efficient operators in the fishery.

The fishing season in the ETBF has been March to February, but it was shortened in 2018 and ran from March to December. This was done as a transition to new season dates that will start in January and end in December of each year, with the first calendar year season beginning in 2019.

The setting of TACCs in the ETBF is complicated by uncertainty around what level of TACC is consistent with maximising NER from an internationally shared stock (see 'Performance against economic objective', below). If TACCs are set too high so that they do not constrain a species' catch, the incentive for quota trade and the associated positive impacts for fishery-level efficiency are reduced (Elliston et al. 2004). If TACCs are set too low (based on a stock's biological and economic status), some level of NER will be foregone.

Performance against economic objective

International sharing of stocks complicates both the selection of economic-based targets and the assessment of economic status against the objective of maximum economic yield (MEY) from the fishery (consistent with the HSP), which are intended to maximise NER to the Australian community. For the ETBF, the catch may be a relatively small proportion of the total WCPFC catch, and the degree of connectivity between the Australian population and that in the wider region remains uncertain for most key commercial species. For these internationally shared stocks, a reduction in the Australian catch may not necessarily lead to an appropriate response in stock abundance and, therefore, profitability in the long term. In 2013, it was determined that the potential lack of association between domestic management actions and changes in stock biomass for the tuna species in the ETBF means that stock-wide B_{MEY} may not be relevant. In 2017–18, the harvest strategies for swordfish and striped marlin were reviewed, finding that the harvest strategies were not likely to be effective in achieving the objectives of the HSP (see 'Management methods'). Without an economic-based target for catch (that is, one associated with the fishery-level MEY objective), the level of catch in the fishery cannot be assessed against MEY.

NER are estimated to have been positive for seven of the eight years since the harvest strategy for the fishery was implemented in 2010–11. NER were improving in the fishery before the harvest strategy was implemented, and many factors other than the harvest strategy may have influenced the fishery's economic performance. For example, fishers' terms of trade (the prices paid for inputs relative to prices achieved for outputs) for the ETBF have been generally favourable for the period 2010–11 to 2016–17.

21.4 Environmental status

Product from the ETBF currently has export approval from inclusion on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* until 22 August 2019. Conditions under this approval, in addition to standard conditions of reporting and monitoring, include updating the ecological risk assessment for the ETBF, developing and implementing a framework for the management of non-quota and bycatch species, and continuing to determine the impact of fishing in the ETBF on shark species.

Under the level 3 Sustainability Assessment for Fishing Effects (for fish only), two species of sunfish and three species of shark were identified as being at high risk from the effects of fishing in the ETBF (Zhou, Smith & Fuller 2007). A 2012 review of the ecological risk assessment, using new information on sunfish, has reclassified both sunfish species as medium risk. The priorities of the ecological risk management response are to reduce interactions with marine turtles, seabirds and whales because of their protected status (AFMA 2012), and to reduce the capture and mortality of sharks by implementing the 20-shark trip limit. The ecological risk management report also lists specific actions for the priority groups—for example, all vessels in the ETBF are required to carry line cutters and de-hookers so that sharks, turtles and other protected species can be easily removed from fishing gear, should they become hooked or entangled.

The introduction of electronic monitoring in the ETBF from mid 2015 has improved the accuracy of logbooks, particularly in the reporting of discarded or released catch. This improved reporting may be reflected in apparent higher levels of interaction for 2018, reported below.

In 2018, logbooks indicated that 1,980 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the ETBF. Of these, 1 was alive, 670 were dead and 1,309 were released in unknown condition. Nine longfin mako sharks (*I. paucus*) were also hooked, with three dead and six released in unknown condition. Six porbeagle sharks (*Lamna nasus*) were hooked, with two dead and four in unknown condition. One hundred and thirty silky sharks (*Carcharhinus falciformis*) were also released in unknown condition, while one whale shark (*Rhincodon typus*) was released alive. Thirty-six green turtles (*Chelonia mydas*) were hooked; 27 were released alive and 9 were dead. Sixty-eight leatherback turtles (*Dermochelys coriacea*) were hooked, with 63 released alive, 4 dead and 1 in an unknown condition. Similarly, 18 loggerhead turtles (*Caretta caretta*) were hooked; all were released alive except for one turtle in unknown condition and three dead. Five hawksbill turtles (*Eretmochelys imbricata*) were hooked, with one dead and four released alive. Seven olive ridley turtles (*Lepidochelys olivacea*) were caught, with all released alive. Twenty-two unidentified turtles were hooked, with 16 alive and 6 dead.

Four black-browed albatrosses (*Thalassarche melanophris*) were caught—three dead and one alive—and six wandering albatross (*Diomedea exulans*), with two alive and four dead. Fifty-six unidentified albatrosses were hooked, with 15 released alive and 41 dead. One sooty shearwater (*Ardenna grisea*), 1 short-tailed shearwater (*Puffinus tenuirostris*) and 17 unidentified shearwaters were hooked, with all being dead except 3 unidentified shearwater. Four Australian gannet (*Morus serrator*) were hooked and dead, as were three unidentified birds.

A number of interactions with marine mammals were recorded; these comprised four unidentified dolphins (three released alive), one dead bottlenose dolphin (*Tursiops truncatus*), seven short-finned pilot whales (*Globicephala macrorhynchus*; five alive and two dead), one long-finned pilot whale (*G. melas*; released alive), one humpback whale (*Megaptera novaeangliae*; released alive) and five unidentified seals (released alive).

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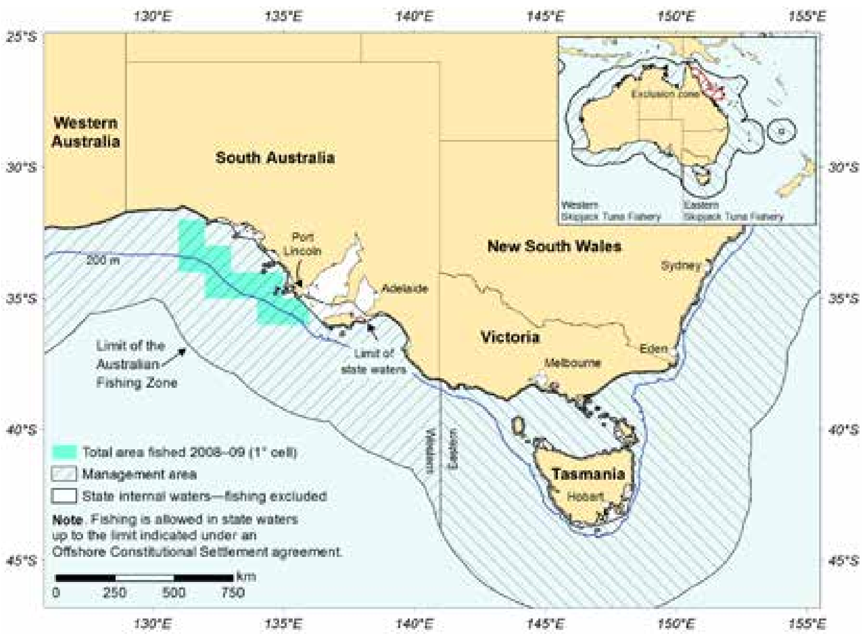
Chapter 22
Skipjack Tuna Fishery

H Patterson and D Mobsby

FIGURE 22.1 Area fished in the Skipjack Tuna Fishery, 2007–08 to 2017–18



Note: The last effort in the fishery occurred in 2008–09.

TABLE 22.1 Status of the Skipjack Tuna Fishery

Status	2017		2018		Comments
Biological status a,b	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Indian Ocean skipjack tuna (*Katsuwonus pelamis*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No Australian vessels fished in 2018. Current estimates of fishing mortality in the Indian Ocean are less than the target reference point. Spawning biomass is above the limit reference point and at the target reference point.
Western and central Pacific Ocean skipjack tuna (*Katsuwonus pelamis*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No Australian vessels fished in 2018. Current estimates of fishing mortality in the WCPO are below F_{MSY}. Spawning biomass is above the limit reference point.
Economic status	No Australian vessels fished in 2017 or 2018. Fishing is opportunistic, and highly dependent on availability and the domestic cannery market. Currently, no domestic cannery has active contracts for skipjack tuna.				

a Ocean-wide assessments and the default limit reference points from the Indian Ocean Tuna Commission are used as the basis for determining the status of Indian Ocean skipjack tuna. **b** Ocean-wide assessments and the limit reference point from the Western and Central Pacific Fisheries Commission are used as the basis for determining the status of Pacific Ocean skipjack tuna.
Notes: **F_{MSY}** Fishing mortality at maximum sustainable yield. **WCPO** Western and central Pacific Ocean.

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

22.1 Description of the fishery

Area fished

Two stocks of skipjack tuna (*Katsuwonus pelamis*) are thought to exist in Australian waters: one on the east coast that is part of a broader stock in the Pacific Ocean and one on the west coast that is part of a larger stock in the Indian Ocean. The two stocks are targeted by separate fisheries: the Eastern Skipjack Tuna Fishery (ESTF) and the Western Skipjack Tuna Fishery (WSTF). These are collectively termed the Skipjack Tuna Fishery (STF), but the two stocks are assessed separately. The ESTF and the WSTF extend through the same area as the Eastern Tuna and Billfish Fishery (ETBF; Chapter 21), and the Western Tuna and Billfish Fishery (WTBF; Chapter 24), respectively, with the exception of an area of the ETBF off northern Queensland (Figure 22.1). Australian waters are at the edge of the species' range, with centres of abundance in the equatorial waters of the Indian and Pacific oceans. Availability of skipjack tuna in both the ESTF and the WSTF is highly variable. The Indian Ocean stock of skipjack tuna is managed under the jurisdiction of the Indian Ocean Tuna Commission (IOTC), whereas the stock found in the western and central Pacific Ocean (WCPO) is managed under the jurisdiction of the Western and Central Pacific Fisheries Commission (WCPFC).

Fishing methods and key species

Historically, most fishing effort has used purse-seine gear (about 98% of the catch). A small amount of pole-and-line effort (when poling is used on its own) is managed as a minor-line component of the ETBF and the WTBF. Skipjack tuna are also caught as bycatch in the ETBF and WTBF longline fisheries.

Management methods

The skipjack tuna harvest strategy consists of a series of catch-level triggers that invoke control rules (AFMA 2008). The control rules initiate closer monitoring of the ESTF and the WSTF, semi-quantitative assessments and revision of trigger levels. The catch triggers are set at different levels for the ESTF and the WSTF, based on historical catch of skipjack tuna in the domestic fisheries and regional assessments of stock status. Management action is only initiated when there is clear evidence of a significant increase in catches. Target and limit reference points are not defined in the Australian skipjack tuna harvest strategy, but have been defined in both the IOTC (on an interim basis) and the WCPFC. These reference points are consistent with those prescribed by the Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018). Catches of skipjack tuna in the ESTF are currently limited to 30,000 t under Conservation and Management Measure 2018-01. If the ESTF or WSTF become active again (see 'Fishing effort'), the Australian Fisheries Management Authority (AFMA) will review the Australian skipjack tuna harvest strategy to take account of both the revised HSP, and progress towards WCPFC or IOTC harvest strategies and allocations. Catches of yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*T. obesus*), which are often caught incidentally in purse-seine fisheries targeting skipjack, are limited by trip and season limits.

Fishing effort

There has been no fishing effort in the STF since the 2008–09 fishing season. Variability in the availability of skipjack tuna in the Australian Fishing Zone and the prices received for product influence participation levels in the fishery.

Catch

Globally, catch of skipjack tuna has increased steadily since the 1970s, and skipjack tuna has become one of the most commercially important tuna species in both the Indian and Pacific oceans. Catch in the STF increased for a short period from 2005 to 2008, peaking at 885 t in 2007–08. The catch was supplied almost exclusively to the cannery in Port Lincoln. However, the cannery closed in 2010, and there has been no catch in the STF since the 2008–09 fishing season.

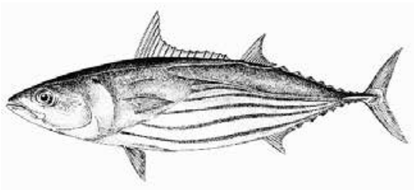
TABLE 22.2 Main features and statistics for the STF

Fishery statistics a	**2016–17 fishing season**			**2017–18 fishing season**		
Fishery	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
ESTF	–	0	$0	–	0	$0
WSTF	–	0	$0	–	0	$0
Total fishery	**–**	**0**	**$0**	**–**	**0**	**$0**
Fishery-level statistics						
Effort	0			0		
Fishing permits	ESTF: 17; WSTF: 14			ESTF: 17; WSTF: 14		
Active vessels	0			0		
Observer coverage	ESTF purse seine: 0 WSTF purse seine: 0			ESTF purse seine: 0 WSTF purse seine: 0		
Fishing methods	Purse seine (predominant), pole-and-line methods (when poling is used on its own, it is managed as a minor-line component of the ETBF and the WTBF)					
Primary landing ports	None; previously Port Lincoln (South Australia) cannery, which closed in May 2010					
Management methods	Input controls: limited entry, gear (net size), area controls, transhipment controls Output controls: bycatch limits					
Primary markets	Domestic and international: currently none					
Management plan	*Skipjack Tuna Fishery management arrangements 2009* (AFMA 2009)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 July – 30 June. Value statistics are provided by financial year.
Notes: **ESTF** Eastern Skipjack Tuna Fishery. **ETBF** Eastern Tuna and Billfish Fishery. **GVP** Gross value of production. **TAC** Total allowable catch. **WSTF** Western Skipjack Tuna Fishery. **WTBF** Western Tuna and Billfish Fishery. – Not applicable.

22.2 Biological status

Indian Ocean skipjack tuna (*Katsuwonus pelamis*)



Line drawing: FAO

Stock structure

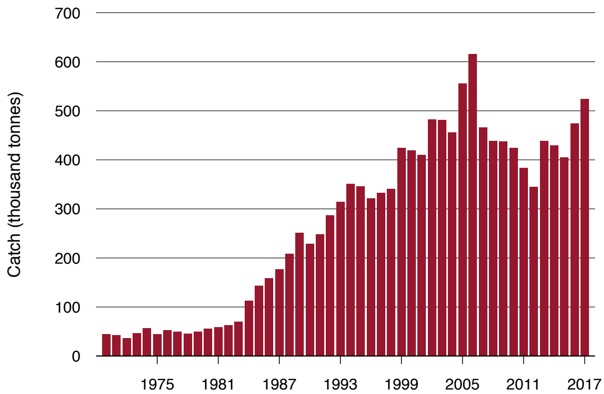
Skipjack tuna in the Indian Ocean is considered to be a single stock for stock assessment purposes. Tagging studies have shown large movements of skipjack tuna in the Indian Ocean and support the assumption of a single biological stock (IOTC 2014).

Catch history

Total catch of skipjack tuna in the Indian Ocean increased slowly from the 1950s, reaching around 50,000 t in the 1970s. With the expansion of the purse-seine fleet in the early 1980s, catch increased rapidly to a peak of 610,000 t in 2006. Since the peak, purse-seine catch has declined, particularly in the areas off Somalia, Kenya and Tanzania, and around the Maldives. A similar decline has occurred in the catch taken by Maldivian pole-and-line vessels. These reduced catches may be partially explained by drops in effort related to the effects of piracy in the western Indian Ocean. Total catch in the IOTC area increased from 474,333 t in 2016 to 524,175 t in 2017 (Figure 22.2).

Historically, effort in the WSTF has been low. In 2005–06, catch was 446 t, before nearly doubling to 847 t in 2006–07 and 885 t in 2007–08. There has been no fishing in the WSTF since 2008–09.

FIGURE 22.2 Skipjack tuna catch in the IOTC area, 1970–2017



Source: IOTC

Stock assessment

A harvest control rule (HCR) was adopted for the Indian Ocean skipjack tuna stock in 2016 (IOTC 2016). The HCR seeks to maintain the skipjack tuna stock biomass (SB) at or above the target reference point ($0.4SB_0$), while avoiding the limit reference point ($0.2SB_0$). The HCR requires a stock assessment to be conducted every three years. Estimates from the stock assessment of current SB, SB_0 and the exploitation rate associated with maintaining the stock at 40% of SB_0 are used to calculate the total annual catch limit. Application of the HCR provides a total annual catch limit for the following three years.

The Indian Ocean skipjack tuna stock assessment was updated in 2017 using Stock Synthesis 3. The updated assessment produced results that differed substantially from the previous assessments in 2011 and 2014 for several reasons, including:

- the correction of an error associated with selectivity for small fish
- the addition of tag–release mortality
- the inclusion of 1% effort creep per year since 1995 for European purse-seine catch-per-unit-effort (IOTC 2017).

The assessment estimated that the stock biomass is at the target reference point and above the limit reference point ($SB_{2016}/SB_0 = 0.40$; range 0.35–0.47). Catch (C) in 2016 (446,723 t) and the average catch over the past five years (2012–2016; 407,450 t) were lower than the estimated catch required to maintain the stock at the target biomass level ($C_{40\%SSB}$ = 510,100 t; range 455,900–618,800 t; Figure 22.2).

The total annual catch limit for the Indian Ocean skipjack tuna stock calculated by applying the HCR was 470,029 t for the period 2018–2020. There is no allocation of this total annual catch limit among Member States of the IOTC unless the stock biomass estimated from the stock assessment falls below $0.40SB_0$.

Stock status determination

The results of the current assessment indicate that the spawning biomass is at the target reference point of 40% of unfished biomass and above the limit reference point of 20% of unfished biomass. As a result, the stock is classified as **not overfished**. The current (2017) level of catch, a proxy for fishing mortality, was above the level estimated to maintain the stock at the target biomass level. However, given that the average catch over the previous five years was well below this level, and the relatively high biomass, the current level of fishing mortality is unlikely to have reduced the stock below the limit reference point, and the stock is therefore classified as **not subject to overfishing**.

Western and central Pacific Ocean skipjack tuna (*Katsuwonus pelamis*)

Stock structure

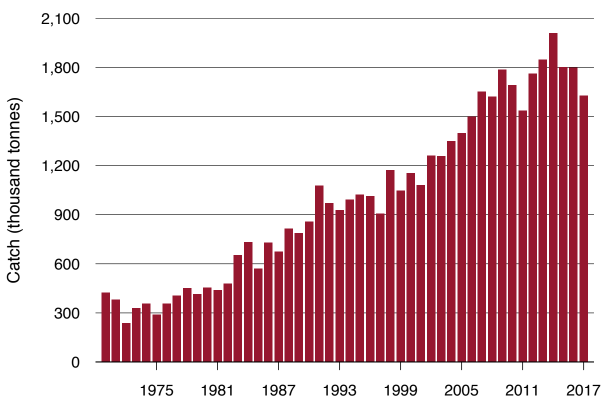
Skipjack tuna in the WCPO is considered to be a single stock for stock assessment purposes (Rice et al. 2014).

Catch history

Catch of skipjack tuna in the WCPO increased steadily throughout the 1980s as a result of growth in the international purse-seine fleet, before stabilising at around 1,000,000 t in the 1990s. Rapid increases in catch in the western equatorial zone have resulted in catches exceeding 1,500,000 t for each of the past 11 years (Figure 22.3).

Historically, effort in the ESTF has been very low. Catch has only been registered once in the past 13 years, with 44 t caught in 2005–06.

FIGURE 22.3 Skipjack tuna catch in the WCPFC area, 1970–2017



Source: WCPFC

Stock assessment

The skipjack tuna stock assessment for the WCPO was updated in 2016 using MULTIFAN-CL software (McKechnie et al. 2016). The update incorporated three additional years of data, including a period of El Niño conditions, and the recommendations of the previous assessment (Rice et al. 2014). The outcome of the updated assessment is largely similar to that of the previous assessment. The base case in the assessment estimated that the latest (2015) spawning biomass was 58% of the level predicted to occur in the absence of fishing ($SB_{latest}/SB_{F=0}$ = 0.58; range 0.39–0.68 across the base case and sensitivities) and well above the adopted limit reference point of $0.2SB_{F=0.}$ Current fishing mortality (2011–2014 average) was estimated to be below the fishing mortality that will support maximum sustainable yield (MSY) ($F_{current}/F_{MSY}$ = 0.45; range 0.38–0.64 across the base case and sensitivities). In 2015, the catch in the WCPFC area was 1,831,440 t (Figure 22.3); this is below the updated estimate of MSY (1,891,000 t). The 2015 catch was above the five-year average of 1,791,788 t.

Stock status determination

The results of the assessment indicate that the spawning biomass is relatively high and above the WCPFC limit reference point of 20% of the spawning biomass predicted to occur in the absence of fishing. As a result, the stock is classified as **not overfished**. The current level of fishing mortality is also below the level required to achieve MSY, so the stock is classified as **not subject to overfishing**.

22.3 Economic status

Key economic trends

Vessels have not been active in the STF since the 2008–09 fishing season; therefore, net economic returns (NER) are estimated to be slightly negative, reflecting the small cost of managing the fishery. Few vessels have fished in either the ESTF or the WSTF since 2003–04, suggesting that there is little economic incentive to fish. Opportunistic fishing was previously prominent in the STF, since the stock availability in Australian waters is highly variable from year to year. Historically, effort has largely depended on both fish availability and the existence of a domestic tuna canning market. Currently, there is no domestic cannery with active contracts for skipjack tuna.

Management arrangements

The harvest strategy in place for the fishery is based on catch-level triggers that initiate management action and close monitoring of the fishery once catches exceed a certain level. Currently, 17 permits are issued in the ESTF and 14 in the WSTF. These are held by 15 companies, 6 of which hold one or more permits for both fisheries (AFMA 2019a, b). This implies that, if operational and market conditions were to change dramatically, fishing effort could be activated. It is unlikely that an increase in effort in the Australian skipjack tuna fisheries in the short term would negatively affect stocks and future NER flows, because the Australian catch is likely to be a relatively small proportion of the global skipjack tuna catch.

Performance against economic objective

The harvest of stocks that are internationally shared complicates both the selection of economic-based targets and the assessment of economic status against maximum economic yield (MEY). Assessment is particularly complicated when the Australian catch is a relatively small proportion of the total international catch. For the STF, reductions in any Australian catch in the fishery may not necessarily lead to an increase in stock and, therefore, profitability in the long term. Consequently, a B_{MEY} target for the STF alone is not appropriate. Given these characteristics and no catch in the fishery since the 2008–09 fishing season, continuation of the low-cost management approach currently applied in the fishery is appropriate.

22.4 Environmental status

In 2016, the STF received a 10-year exemption from export provisions (until 9 October 2026) and was accredited under the *Environment Protection and Biodiversity Conservation Act 1999*. Approval is on the condition that AFMA reviews the fishery's management regime within 12 months of a level 2a trigger being reached.

The STF had previously undergone the ecological risk assessment (ERA) process up to level 3. Based on this assessment, which considered finfish and chondrichthyans, no species was considered to be at high risk because of the low fishing effort in the fishery (Zhou, Fuller & Smith 2009). However, 25 species of marine mammals were identified as high risk in the level 2 ERA process (Daley et al. 2007). Mammals were not considered in the level 3 assessment. The ecological risk management report for the fishery is therefore designed to achieve adequate monitoring to establish the level of interaction that may occur if effort increases, and to quantify the effect of the fishery on the marine mammal species identified as being at high risk (AFMA 2010).

To date, no protected species interactions have been reported in the STF.

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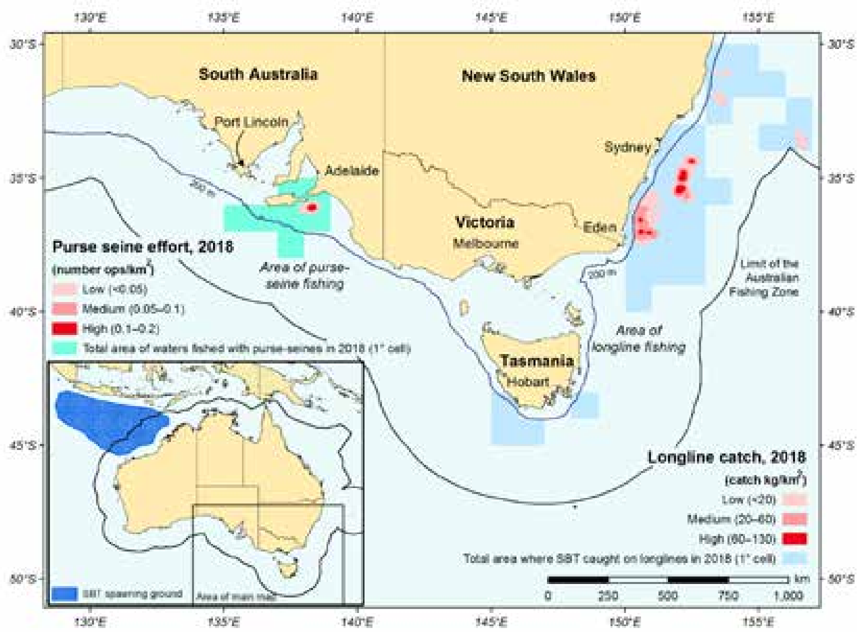
Chapter 23

Southern Bluefin Tuna Fishery

H Patterson, A Williams, B Hennecke and D Mobsby

FIGURE 23.1 Purse-seine effort and longline catch in the Southern Bluefin Tuna Fishery, 2018



Note: **SBT** Southern bluefin tuna.

TABLE 23.1 Status of the Southern Bluefin Tuna Fishery

Status	2017		2018		Comments a
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Southern bluefin tuna (*Thunnus maccoyii*)	Not subject to overfishing	Overfished	Not subject to overfishing	Overfished	The estimate of spawning biomass is below 20% of unfished biomass. The global TAC, set in line with the management procedure, should allow rebuilding within the prescribed time frame.
Economic status	NER are expected to have remained positive in 2017–18, reflecting low levels of quota latency. However, the overfished status of the stock poses a risk to future NER. Economic status will improve as the stock is rebuilt under the management procedure.				

a The global assessment of southern bluefin tuna and the default limit reference point from the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) are used as the basis for status determination.

Notes: **NER** Net economic returns. **TAC** Total allowable catch.

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

23.1 Description of the fishery

Area fished

The Southern Bluefin Tuna Fishery (SBTF) spans the Australian Fishing Zone. Southern bluefin tuna (*Thunnus maccoyii*) is targeted by fishing fleets from a number of nations, both on the high seas and within the Exclusive Economic Zones (EEZs) of Australia, New Zealand, Indonesia and South Africa. Young fish (1–4 years of age) move from the spawning ground in the north-east Indian Ocean into the Australian EEZ and southwards along the Western Australian coast (Figure 23.1). Surface-schooling juveniles are found seasonally in the continental-shelf region of southern Australia. Current evidence suggests that juveniles return to the Great Australian Bight in the austral summer, but there is some uncertainty about the proportion that returns (Basson et al. 2012). Most of the Australian catch is taken in the Great Australian Bight. Smaller amounts are taken from the longline fisheries, mainly off south-eastern Australia.

Fishing methods

Since 1992, most of the Australian catch has been taken by purse seine, targeting juvenile southern bluefin tuna (2–5 years of age) in the Great Australian Bight. This catch is transferred to aquaculture farming operations off the coast of Port Lincoln in South Australia, where the fish are grown to a larger size to achieve higher market prices. Australian domestic longliners operating along the east coast catch some southern bluefin tuna, and recreational fishing for the species has increased in recent years. Throughout the rest of its range, southern bluefin tuna is targeted by pelagic longliners from other fishing nations.

Management methods

The Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) is not prescribed for fisheries managed jointly under international management arrangements, such as the SBTF, which is managed under the 1994 Convention for the Conservation of Southern Bluefin Tuna. In 2011, the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) adopted a management procedure (the Bali Procedure) that is analogous to a harvest strategy, and this has been used to set the global total allowable catch (TAC) since 2012. The management procedure aims to achieve rebuilding of the southern bluefin tuna stock to 20% of its initial unfished biomass (the interim rebuilding target) by 2035, with 70% probability. The global TAC is allocated to members and cooperating non-members as agreed by the CCSBT under the 2011 CCSBT Resolution on the Allocation of the Global Total Allowable Catch. The Australian Fisheries Management Authority (AFMA) sets the TAC for the SBTF in accordance with Australia's allocation. A new management procedure is currently being developed.

The CCSBT has noted that levels of unaccounted mortality may be substantial in the global fishery. A high level of unaccounted mortality may constitute exceptional circumstances because it was not taken into consideration when the management procedure was developed. The CCSBT has agreed to a definition of attributable mortality, and members have agreed to manage all sources of mortality within their national allocations. The CCSBT is also working to better account for non-member catch.

Fishing effort

Most of the Australian fishing effort for southern bluefin tuna is by purse-seine vessels in the Great Australian Bight and waters off South Australia. The number of vessels in the purse-seine fishery has been fairly stable, ranging from five to eight since the 1994–95 fishing season. Since 2011, most fishing has occurred in the east of the Bight, closer to Port Lincoln, resulting in shorter towing distances to bring the fish to the aquaculture grow-out cages.

The number of longline vessels fishing for southern bluefin tuna off the east coast of Australia has been more variable, ranging from 11 to 24 vessels during the past 10 years. Effort in the longline sector is largely dependent on available quota.

Catch

The reported global catch of southern bluefin tuna has declined since the peak catches in the early 1960s, and has been fairly stable since the mid 2000s. The Australian catch and TAC were stable from 1990 to 2009 and were then reduced as part of a global reduction in catch. Since adoption of the management procedure in 2011, the global TAC has increased.

TABLE 23.2 Main features and statistics for the SBTF

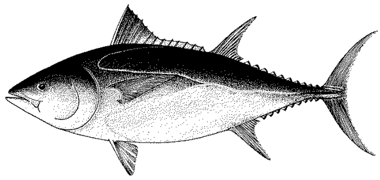
Fishery statistics a	2016–17 fishing season			2017–18 fishing season		
Fishery/sector	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Purse seine	5,694 **b**	4,684	$31.40 million	6,528 **c**	5,124	$32.63 million
Pelagic longline	–	650 **d**	$7.14 million	–	1,035 **d**	$7.11 million
Total fishery	**5,697**	**5,334**	**$38.54 million**	**–**	**6,159**	**$39.73 million**
Fishery-level statistics						
Effort **e**	Purse seine: 1,004 search-hours; 112 shots			Purse seine: 1,137 search-hours; 198 shots		
Fishing permits	85 SFR owners initially allocated			84 SFR owners initially allocated		
Active vessels	Purse seine: 6 Longline: 16			Purse seine: 7 Longline: 31		
Observer coverage **f**	Purse seine: 20 shots (18.3%) Longline: 10.2% (of hooks) in ETBF; 11.7% (of hooks) in WTBF			Purse seine: 40 shots (20.9%) Longline: 10.8% (of hooks) in ETBF; 13.0% (of hooks) in WTBF		
Fishing methods	Purse seine, pelagic longline, minor line (troll and poling)					
Primary landing ports	Port Lincoln (South Australia)					
Management methods	Output controls: TAC, ITQs, area restrictions to control incidental catches in the longline fishery					
Primary markets	International: Japan—fresh, frozen					
Management plan	*Southern Bluefin Tuna Fishery Management Plan 1995*					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Season is 1 December – 30 November. Value statistics are by financial year. **b** Australia carried forward ~32 t of undercatch to the 2016–17 TAC. **c** Australia carried forward ~363 t of undercatch to the 2017–18 TAC. The TAC set by the AFMA Commission was 6,165 t. d Includes some minor-line catch. **e** Effort only for where southern bluefin tuna was caught. **f** Longline observer coverage is provided by calendar year, and includes hooks observed only by the electronic monitoring system.
Notes: **ETBF** Eastern Tuna and Billfish Fishery. **GVP** Gross value of production. **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch. **WTBF** Western Tuna and Billfish Fishery. – Not applicable.

Southern bluefin tuna with catch documentation scheme tag
Matt Daniel, AFMA

23.2 Biological status

Southern bluefin tuna (*Thunnus maccoyii*)



Line drawing: FAO

Stock structure

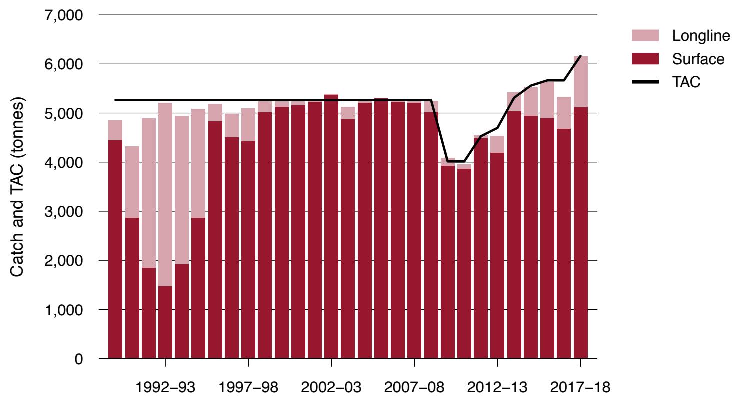
Southern bluefin tuna constitutes a single, highly migratory stock that spawns in the north-east Indian Ocean (off north-western Australia, south of Indonesia; Figure 23.1) and migrates throughout the temperate southern oceans.

Catch history

Troll catches of southern bluefin tuna off the east coast of Australia were reported as early as the 1920s, but significant commercial fishing for southern bluefin tuna commenced in the early 1950s with the establishment of a pole-and-live-bait fishery off New South Wales, South Australia and, later (1970), Western Australia. Purse-seine gear overtook pole as the main fishing method, and catches peaked at 21,500 t in 1982. Australia's catch of southern bluefin tuna was relatively stable from 1989 to 2009, when the global TAC and Australia's TAC were reduced because of the poor state of the biological stock (Figure 23.2). However, the TAC has been slowly increasing with the implementation of the management procedure in 2011. Reported global catch peaked in the early 1960s at more than 80,000 t, before declining steadily until around 2007 (Figure 23.3).

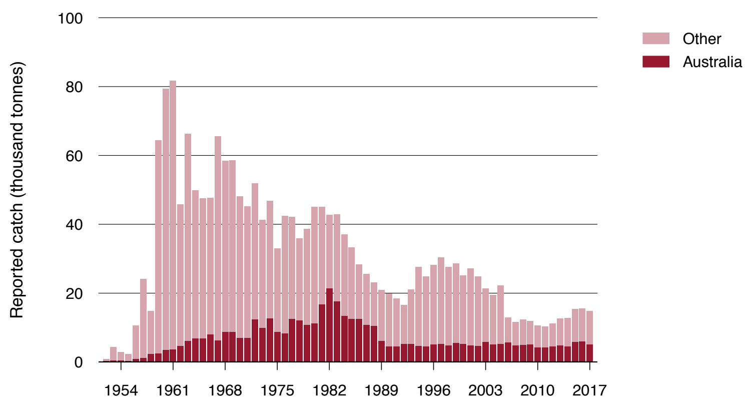
Recreational angling for southern bluefin tuna in Australia has been popular among game fishers for many years, and activity among the general recreational fishing sector has increased in recent years (for example, Rowsell et al. 2008). At present, limited data are available on the recreational catch of southern bluefin tuna, and no total estimate of the national recreational catch is available. Several state surveys have taken place; however, the error associated with these surveys has been estimated to be as high as 47% (Giri & Hall 2015). In 2015, a report on methods to estimate recreational catch of southern bluefin tuna was released (Moore et al. 2015). A national survey, based on this methodology, began in December 2018.

FIGURE 23.2 Southern bluefin tuna catch and TAC (Australia), 1989–90 to 2017–18



Note: **TAC** Total allowable catch.
Source: AFMA

FIGURE 23.3 Southern bluefin tuna catch (global), 1952–2017



Note: Total global catches exceeded reported global catches between 1995 and 2005; some scientists estimate that unreported catches surpassed 178,000 t during this period (Polacheck & Davies 2008).
Source: CCSBT

Stock assessment

The management procedure specifies that a full quantitative stock assessment should be undertaken every three years. In 2017, a revised CCSBT operating model (the quantitative model that is used to assess the spawning biomass of southern bluefin tuna, based on a variety of data sources) was used to run various scenarios to determine the impact of fishing on the stock (CCSBT 2017). The updated assessment incorporated the new half-sibling pair data from a close-kin genetic study, as well as parent–offspring pair data, which add to the data included in the previous assessment (Bravington, Grewe & Davies 2014). The 2011 assessment reported the estimated biomass of southern bluefin tuna 10 years and older (B10+) as a proxy for spawning biomass, whereas the 2014 assessment provided a revised estimate of spawning biomass that includes younger fish. The 2017 assessment used a new estimation of total reproductive output instead of B10+, although B10+ is still provided for comparison because the interim rebuilding target is defined in terms of B10+.

The 2017 assessment examined a range of sensitivities, including scenarios for unaccounted catch mortalities. The CCSBT Extended Scientific Committee noted that the 2017 assessment was constrained by the lack of information on sources of unaccounted mortalities, and so the 'added catch' sensitivity used in 2014 could be a plausible scenario. However, in contrast to the 2014 assessment, the unaccounted mortality scenarios in the 2017 assessment did not reduce the probability of the stock recovering to 20% of the unfished level by 2035 below the prescribed 70% probability.

The reference set of operating models (or base case) for the assessment indicated that the spawning stock biomass remains below the interim target of 20% of the unfished level. Spawning stock biomass (using the total reproductive output method) was estimated at 13% of the initial unfished level (80% confidence interval [CI] 11–17%) and below the level needed to produce the maximum sustainable yield (MSY; CCSBT 2017). The spawning stock biomass of the B10+ group was estimated to be 11% of unfished levels (80% CI 9–13%); the 2014 estimate was 7% of unfished levels (CCSBT 2014). The ratio of current fishing mortality to the level associated with MSY (F_{MSY}) was 0.50 (range 0.38–0.66).

Stock status determination

The current mean estimate for spawning stock biomass of southern bluefin tuna is 13% of unfished levels. As a result, the stock remains classified as **overfished**.

The global TAC for 2017 was set based on the outputs from the management procedure, which should result in a level of fishing mortality that facilitates rebuilding of the stock. The reference case for the updated assessment indicates reduced fishing mortality from that estimated in the 2014 assessment. Substantial uncertainty remains about the level of unaccounted catch mortality. However, unlike in the previous assessment, the unaccounted mortality scenarios in the 2017 assessment did not reduce the probability of the stock recovering by the designated time of 2035. In addition, the outlook for the stock appears more positive, with signs of increased recruitment in recent years and projections under the current management procedure of the stock reaching the interim rebuilding target before 2035. Although caution is warranted and increased recruitment does not indicate increased stock biomass, the outlook for the stock has improved since the 2014 assessment. Given the decrease in fishing mortality noted in the assessment and the fact that the unaccounted mortality scenarios do not impede the probability of recovery, the stock is classified as **not subject to overfishing**. However, future assessments may change the outlook for the stock and will need to be monitored, as will future estimates of unaccounted mortality.

23.3 Economic status

Key economic trends

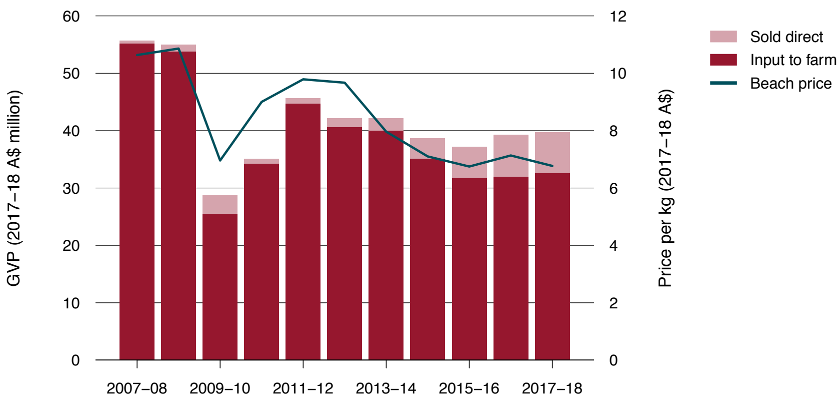
Assessment of economic performance in the wild-catch sector is complicated by the vertical integration of the wild-catch and aquaculture sectors. As noted above, most southern bluefin tuna caught are transferred to aquaculture farms off Port Lincoln. The beach price paid for live fish at the point of transfer to these farms cannot be determined, because operators are generally involved in both wild-catch and aquaculture operations. Therefore, beach prices in the fishery are estimated with reference to export unit values and costs incurred during the aquaculture phase.

In 2017–18, the gross value of production for the SBTF—the combined value of the catch at the point of transfer to farming pens and catch sold direct into global markets—is estimated to have increased by 3% to $39.7 million (Figure 23.4). The increase in production value was driven by higher catch resulting from an increase in the TAC in the 2017–18 fishing season. The increase in catch volume consisted of more southern bluefin tuna being transferred into aquaculture farms. Despite an increase in farm input in 2017–18, a generally declining share of southern bluefin tuna has been ranched in recent years. Conversely, there has been an increase in catch from eastern Australia (predominantly caught by the Commonwealth Eastern Tuna and Billfish Fishery fleet). It is uncertain whether this represents a long-term shift in the pattern of catch in the fishery.

The average price for southern bluefin tuna declined by 3% in 2017–18. There has also been a longer-run decline in southern bluefin tuna prices. Between 2001–02 and 2017–18, the total production value of the SBTF declined by nearly two-thirds in real terms. This was the result of prices falling from an average of $20.3 per kilogram (in 2017–18 dollars) in 2001–02 to $6.77 per kilogram in 2017–18; most of the decline in price occurred from 2001–02 to 2009–10. Since then, prices have been more stable, although lower. For exports, the value of southern bluefin tuna nearly halved in real terms between 2007–08 and 2017–18, which was the result of a decline in unit export prices (Figure 23.5). Australia's southern bluefin tuna industry is highly export oriented, and the decline in price is the result of a number of related factors, including changes in the Australian dollar – Japanese yen exchange rate, falling demand for sashimi tuna in Japan and growth of global bluefin tuna aquaculture production.

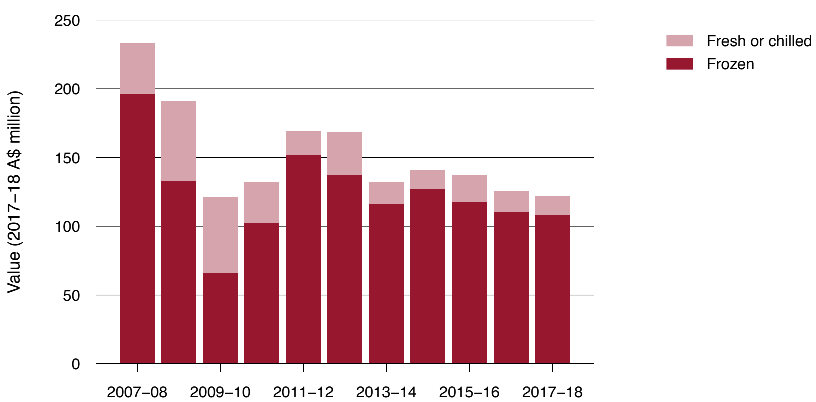
Southern bluefin tuna pens
Matt Daniel, AFMA

FIGURE 23.4 Real GVP and price of southern bluefin tuna, 2007–08 to 2017–18



Note: **GVP** Gross value of production. 'Real' indicates that value has been adjusted for inflation.

FIGURE 23.5 Real value of southern bluefin tuna exports, by processing method, 2007–08 to 2017–18



Note: 'Real' indicates that value has been adjusted for inflation.

Management arrangements

The Australian TAC is allocated primarily to holders of statutory fishing rights in the fishery through individual transferable quotas (ITQs). The ITQs give fishers flexibility to use input combinations that result in the most efficient operation. Theoretically, transferability of ITQs between fishers also allows the catch to be taken by the most efficient operators in the fishery, since quota is expected to gravitate to the most efficient operators. However, other factors are often considered by quota holders when deciding to lease or sell quota, sometimes resulting in quota not being allocated to the most efficient user. This may limit quota transaction activity between the purse-seine operators and longline operators in some years.

Performance against economic objective

The SBTF typically has very little quota latency within a fishing season, indicating that net economic returns (NER) are likely to be positive. The SBTF is a high-value fishery, and analysis of recent economic trends suggests that the fishery remains profitable. However, given the biological status of the southern bluefin tuna stock, it is likely that a proportion of historical profits have been generated by unsustainable global harvest levels. Furthermore, the low biomass level of the stock poses a risk to the future flow of NER from this fishery. Rebuilding of the southern bluefin tuna stock under the current management arrangements would be considered an improvement in the fishery's economic status. The importance of rebuilding the southern bluefin tuna stock is reinforced by the persistence of generally lower southern bluefin tuna prices and the growth in global bluefin tuna aquaculture production in recent years.

23.4 Environmental status

The SBTF has approval for export until 13 December 2019. Conditions placed on the export approval include increasing confidence in the estimates of purse-seine catches, and that the management arrangements start accounting for Australia's attributable catch, including recreational and Indigenous catch, by 2018.

A level 3 ecological risk assessment (Sustainability Assessment for Fishing Effects) of 83 non-target species (6 chondrichthyans and 77 teleosts) to determine the impact of southern bluefin tuna fishing on these species assessed the risk as low (Zhou, Fuller & Smith 2009). The priority of the ecological risk management report is to respond to interactions with protected species (AFMA 2009).

No interactions with protected species were reported for the SBTF in 2018. Interactions with sharks and other protected species using longline gear are discussed in Chapters 21 and 24.

23.5 References

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Southern bluefin tuna
Matt Daniel, AFMA

Chapter 24

Western Tuna and Billfish Fishery

A Williams, H Patterson and D Mobsby

FIGURE 24.1 Area fished in the Western Tuna and Billfish Fishery, 2018

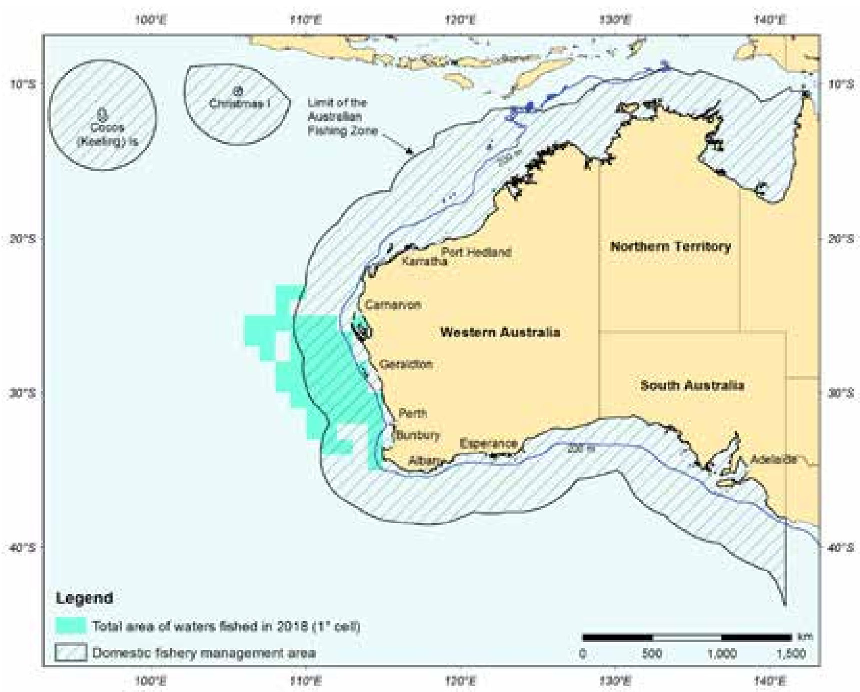


TABLE 24.1 Status of the Western Tuna and Billfish Fishery

Status	2017		2018		Comments
Biological status a	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Striped marlin (*Kajikia audax*)					Most recent estimates of biomass (2018) indicate the stock is below the default Commonwealth limit reference point. Current fishing mortality rate exceeds that required to produce MSY.
Swordfish (*Xiphias gladius*)					Most recent estimate of spawning biomass (2017) is above the default Commonwealth limit reference point. Current fishing mortality rate is below that required to produce MSY.
Albacore (*Thunnus alalunga*)					Most recent estimate of spawning biomass (2016) is above the default Commonwealth limit reference point. Current fishing mortality rate is below that required to produce MSY.
Bigeye tuna (*Thunnus obesus*)					Most recent estimate of spawning biomass (2016) is above the default Commonwealth limit reference point. Current fishing mortality rate is below that required to produce MSY.
Yellowfin tuna (*Thunnus albacares*)					Most recent estimate of spawning biomass (2018) is above the default Commonwealth limit reference point. Current fishing mortality rate is above that required to produce MSY.
Economic status	Participation rate was low and latency remained high in 2018, suggesting little economic incentives to fish and relatively small net economic returns.				

a Ocean-wide assessments and the default limit reference points from the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) are used as the basis for status determination.
Note: **MSY** Maximum sustainable yield.

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

24.1 Description of the fishery

Area fished

The Western Tuna and Billfish Fishery (WTBF) operates in Australia's Exclusive Economic Zone and high seas of the Indian Ocean (Figure 24.1). In recent years, fishing effort has concentrated off south-west Western Australia, with occasional activity off South Australia. Domestic management arrangements for the WTBF reflect Australia's commitment to the Indian Ocean Tuna Commission (IOTC; see Chapter 20).

Fishing methods and key species

Key species in the WTBF are bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), striped marlin (*Kajikia audax*) and swordfish (*Xiphias gladius*). Some albacore (*Thunnus alalunga*) is also taken. The main fishing gear in the WTBF is pelagic longline, with low levels of minor-line fishing (Table 24.2).

TABLE 24.2 Main features and statistics for the WTBF

Fishery statistics a	2017			2018		
Stock	**TACC (t)**	**Catch (t)**	**GVP (2016–17)**	**TACC (t)**	**Catch (t)**	**GVP (2017–18)**
Striped marlin	125	1	Confidential	125	1	Confidential
Swordfish	3,000	166	Confidential	3,000	174	Confidential
Albacore	–	16	Confidential	–	12	Confidential
Bigeye tuna	2,000	67	Confidential	2,000	49	Confidential
Yellowfin tuna	5,000	72	Confidential	5,000	42	Confidential
Total	**10,125**	**322**	**Confidential**	**10,125**	**278**	**Confidential**

Fishery-level statistics		
Effort	Pelagic longline: 417,997 hooks Minor line: na	Pelagic longline: 404,880 hooks Minor line: na
Fishing permits	95 boat SFRs	94 boat SFRs
Active vessels	Pelagic longline: 3 Minor line: 1	Pelagic longline: 2 Minor line: 1
Observer coverage	11.7% b	13.0% b
Fishing methods	Pelagic longline (monofilament mainline), minor line (handline, rod and reel, troll and poling), purse seine	
Primary landing ports	Fremantle and Geraldton (Western Australia)	
Management methods	Input controls: limited entry, gear and area restrictions Output controls: TACCs, ITQs, byproduct restrictions	
Primary markets	International: Japan, United States—fresh, frozen Domestic: fresh, frozen	
Management plan	*Western Tuna and Billfish Management Plan 2005* (amended 2016); SFRs issued 2010	

a Fishery statistics are provided by calendar year to align with international reporting requirements. Value statistics are by financial year.
b From 1 July 2015, e-monitoring became mandatory for all full-time pelagic longline vessels in the WTBF. At least 10% of video footage of all hauls is reviewed to verify the accuracy of logbooks, which are required to be completed for 100% of shots.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing right. **TACC** Total allowable commercial catch. – Not applicable.

Management methods

The management plan for the fishery began in 2005, although the Australian Fisheries Management Authority (AFMA) first granted statutory fishing rights in 2010. Under the management plan, output controls have been implemented in the fishery through individual transferable quotas (ITQs) for the four key commercial species (excluding striped marlin) (Table 24.2). Determinations of total allowable commercial catch (TACC) are made in accordance with Australia's domestic policies, and apply to the Australian Fishing Zone and the high-seas area of the IOTC area of competence. A harvest strategy framework has been developed for the WTBF (Davies et al. 2008), with the intention that it be implemented if fishing effort increases in the fishery and sufficient data are available for use in the strategy. The framework includes a decision tree that defines rules and subsequent adjustments to the recommended biological catch (or level of fishing mortality) in response to standardised size-based catch rates.

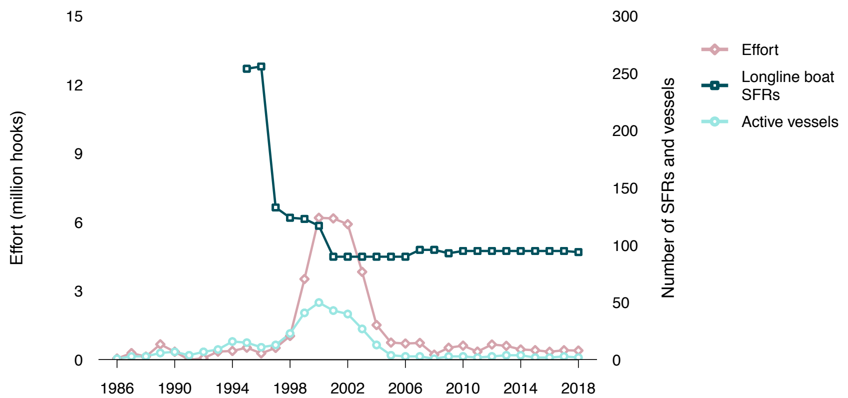
The default limit reference points in the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) are used to determine stock status in the WTBF. The limit reference point for biomass is 20% of the unfished biomass ($0.2B_0$). For fishing mortality, the limit reference point is the fishing mortality that would achieve maximum sustainable yield (F_{MSY}). The IOTC determines stock status relative to target reference points, not limit reference points, resulting in a different stock status reported by the IOTC for some stocks.

Electronic monitoring (e-monitoring) became mandatory for all full-time pelagic longline vessels in the Eastern Tuna and Billfish Fishery and the WTBF from 1 July 2015. At least 10% of video footage of all longline sets is reviewed to verify the accuracy of logbooks, which are required to be completed for 100% of sets.

Fishing effort

Effort in the WTBF was relatively low (<20 vessels) from the mid 1980s to the mid 1990s (Figure 24.2). Effort increased in the late 1990s, peaking at 50 active vessels in 2000, but then declined rapidly. Since 2005, fewer than five vessels have been active in the fishery each year.

FIGURE 24.2 Longline fishing effort, boat statutory fishing rights and active vessels in the WTBF, 1986–2018

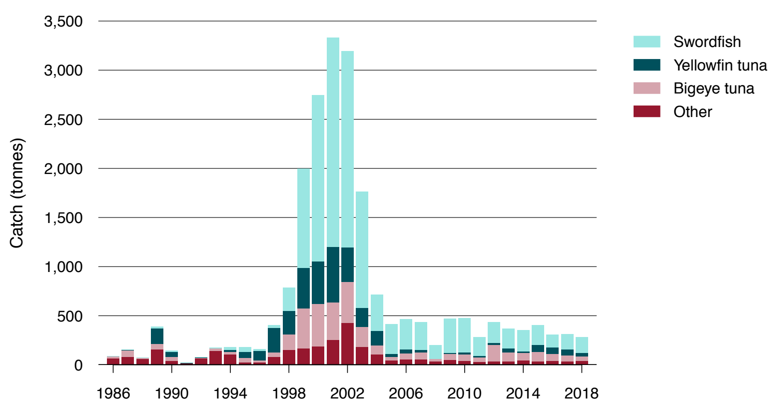


Note: **SFR** Statutory fishing right.
Source: AFMA

Catch

Swordfish is the main target species in the WTBF, with annual catches peaking at more than 2,000 t in 2001 (Figure 24.3) and declining to a few hundred tonnes in recent years. Bigeye and yellowfin tuna are also valuable target species, although catches of these species have never been as high as for swordfish and have been more variable.

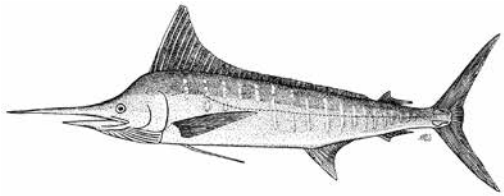
FIGURE 24.3 Total annual catch, by species, in the WTBF, 1986–2018



Source: AFMA

24.2 Biological status

Striped marlin (*Kajikia audax*)



Line drawing: FAO

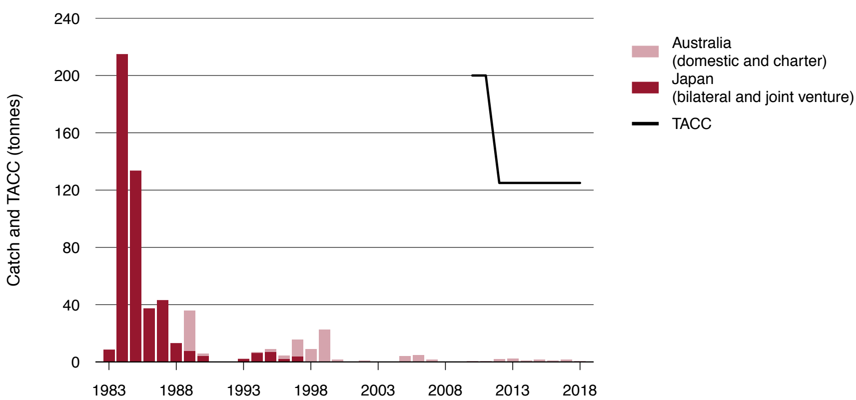
Stock structure

Mamoozadeh, McDowell & Graves (2018) evaluated genetic variation in striped marlin populations sampled from the eastern and western Indian Ocean, and across the Pacific Ocean. Their results suggest that there could be genetically distinct east and west stocks of striped marlin in the Indian Ocean. However, the sample size from the eastern Indian ocean was small (eight fish), and no samples were collected from the central Indian Ocean, making it difficult to delineate a border between potential stocks. Therefore, striped marlin is currently considered to be a single distinct biological stock for assessments in the Indian Ocean.

Catch history

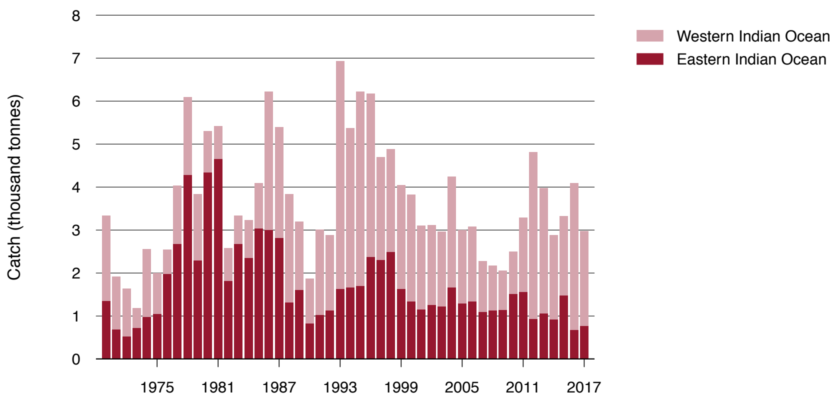
Catches of striped marlin in the WTBF have been relatively low (<50 t) since the mid 1980s and very low (<5 t) since 2000, with less than 1 t taken in 2018 (Figure 24.4). Total international catches in the IOTC area of competence declined from around 6,000 t in 1995 to around 2,000 t in 2009 (Figure 24.5). Annual catches increased from 2009, but declined in 2017 to 3,082 t, which is below the estimated MSY (4,730 t).

FIGURE 24.4 Striped marlin catch and TACC in the WTBF, 1983–2018



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.5 Striped marlin catch in the IOTC area, 1970–2017



Source: IOTC

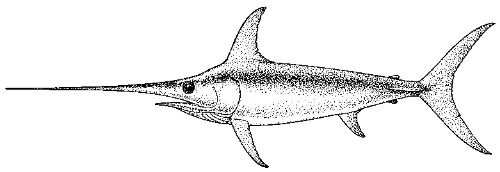
Stock assessment

A new stock assessment in 2018 used two assessment models: JABBA, a Bayesian state-space production model, and Stock Synthesis 3 (SS3) (IOTC 2018). The 2017 spawning biomass for the Indian Ocean–wide stock was estimated to be 13% of unfished (1950) biomass (SS3: SB_{2017}/SB_{1950} = 0.13; range 0.09–0.14) and below the level that supports MSY (JABBA: SB_{2017}/SB_{MSY} = 0.33; no range available) (IOTC 2018). Fishing mortality was estimated to be above F_{MSY} (JABBA: F_{2017}/F_{MSY} = 1.99; 95% confidence interval [CI] 1.21–3.62). Retrospective analysis for both the JABBA and SS3 models produced consistent stock status estimates, thus providing a degree of confidence in the predictive capabilities of the assessments.

Stock status determination

Both models indicate that the stock has been heavily depleted and is below the Commonwealth's biomass limit reference point ($0.2B_0$). The stock is therefore classified as **overfished**. Fishing mortality was estimated to be well above F_{MSY}, so the stock is classified as **subject to overfishing**.

Swordfish (*Xiphias gladius*)



Line drawing: Gavin Ryan

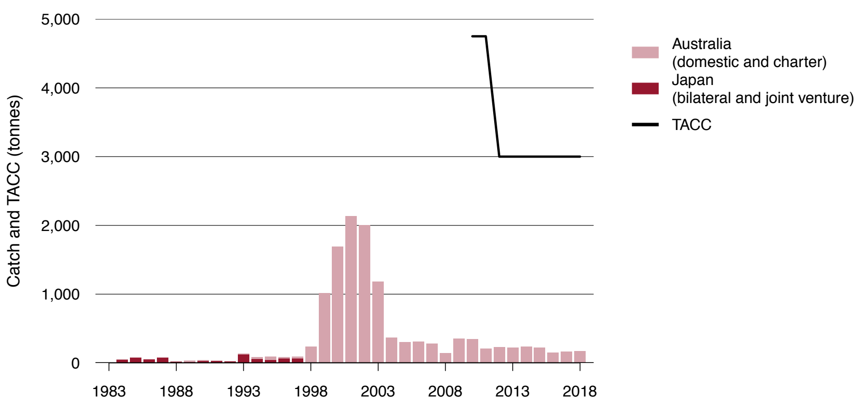
Stock structure

Swordfish in the Indian Ocean is considered to be a single distinct biological stock. The possibility of a separate south-west Indian Ocean stock was examined in the Indian Ocean Swordfish Stock Structure project—a genetic study focused on the links between the south-west and other regions (Muths et al. 2013). The study found that genetic markers were consistent with a single stock in the Indian Ocean.

Catch history

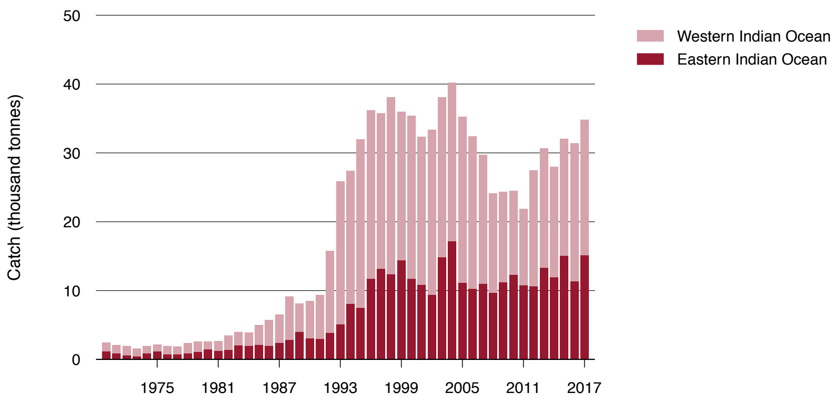
Annual swordfish catch in the WTBF peaked at around 2,000 t in the early 2000s but has declined to below 350 t since 2005. In 2018, the annual catch was 174 t, a slight increase from 2017 (Figure 24.6). Total international catches of swordfish in the IOTC area of competence peaked in 2004 at more than 40,000 t, but declined to around 22,000 t in 2011 (Figure 24.7), likely as a result of the effects of piracy in the western Indian Ocean. Annual catches in the IOTC area of competence have increased since 2011, reaching 34,782 t in 2017, which is above the 2017 estimate of MSY (31,590 t).

FIGURE 24.6 Swordfish catch and TACC in the WTBF, 1983–2018



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.7 Swordfish catch in the IOTC area, 1970–2017



Source: IOTC

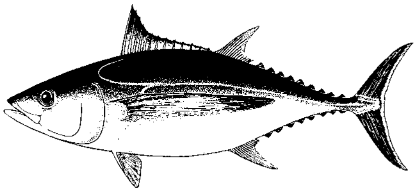
Stock assessment

In 2017, the Indian Ocean swordfish assessment was updated using SS3 with data up to 2015 (IOTC 2017). The SS3 model was spatially disaggregated, sex explicit and age structured. The 2015 spawning biomass for the Indian Ocean–wide stock was estimated to be 31% of unfished (1950) biomass (SB_{2015}/SB_{1950} = 0.31; range 0.26–0.43) and above the level that supports MSY (SB_{2015}/SB_{MSY} = 1.50; 80% CI 1.05–2.45) (IOTC 2017). Fishing mortality was estimated to be below F_{MSY} (F_{2015}/F_{MSY} = 0.76; 80% CI 0.41–1.04).

Stock status determination

Assessments of the ocean-wide stock indicate that swordfish biomass is above the Commonwealth's biomass limit reference point ($0.2B_0$) and that fishing mortality is below F_{MSY}. As a result, the stock is classified as **not overfished** and **not subject to overfishing**.

Albacore (*Thunnus alalunga*)



Line drawing: FAO

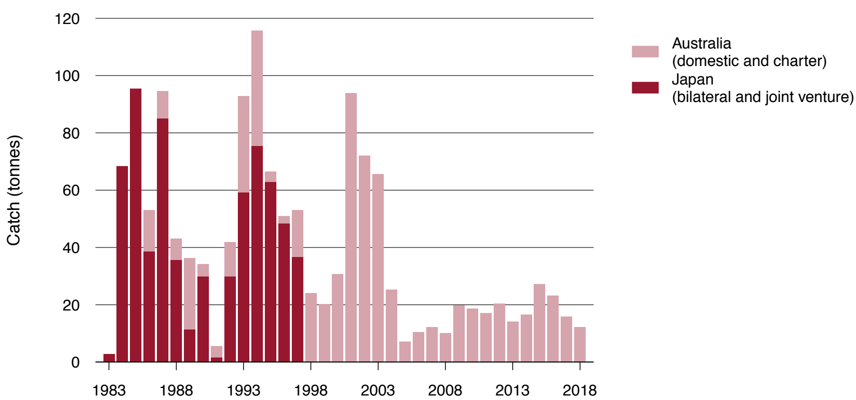
Stock structure

The stock structure of albacore in the Indian Ocean is uncertain, but the species is assumed to be a single biological stock for assessments. A global genetics study of albacore found that the Atlantic Ocean and Indian Ocean populations were not genetically distinguishable, and found no evidence of genetic heterogeneity within the Indian Ocean (Montes et al. 2012). However, the study was based on relatively small sample sizes, and samples were not collected across the entire distribution of albacore in the Indian Ocean. Two distinct stocks of albacore occur in the Atlantic and Pacific oceans, associated with distinct northern and southern ocean gyres. There is no northern gyre in the Indian Ocean, supporting the assumption of a single Indian Ocean albacore stock (IOTC 2014).

Catch history

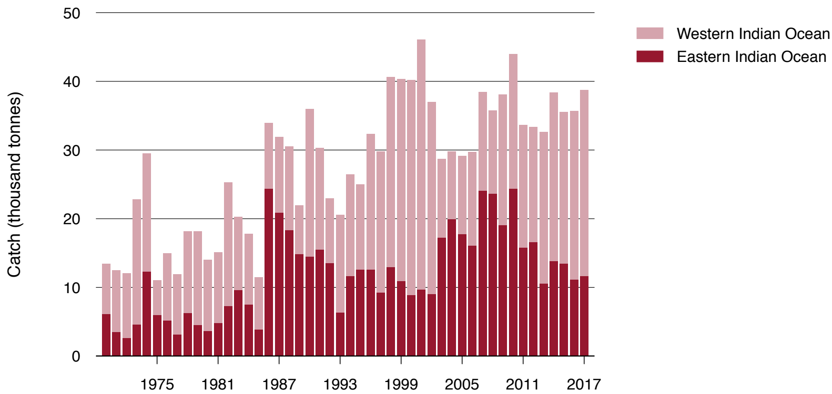
Historically, albacore catches in the WTBF have been low, peaking at 115 t in 1994 and again at 94 t in 2001 (Figure 24.8). Since 2004, annual catches have been below 30 t, and were approximately 12 t in 2018. Total international catches in the IOTC area of competence peaked at more than 43,000 t in 2010, and have fluctuated between 30,000 t and 41,000 t since 2011 (Figure 24.9). The average annual catch during the past five years (2013–2017) was approximately 36,000 t, which is lower than the 2016 estimate of MSY (38,800 t) (IOTC 2018).

FIGURE 24.8 Albacore catch in the WTBF, 1983–2018



Source: AFMA

FIGURE 24.9 Albacore catch in the IOTC area, 1970–2017



Source: IOTC

Stock assessment

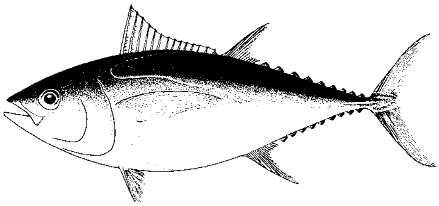
In 2016, five assessment models were used to assess the Indian Ocean albacore stock: SS3, ASPIC, a statistical catch-at-age model (SCAA), a Bayesian state-space production model (BSPM) and a Bayesian biomass dynamic model (BBDM). The results from the SS3 model were used to determine the current status of albacore and provide management advice (IOTC 2018), although the results from all the models were generally consistent. Considerable uncertainty exists in the SS3 model results because of uncertainty in catch-per-unit-effort data and length composition data, and a lack of biological information for albacore stocks in the Indian Ocean (IOTC 2018).

The result of the SS3 model indicated that the current (2014) biomass was above the limit reference point (SB_{2014}/SB_{1950} = 0.37; 80% CI 0.28–0.46) and above the level that supports MSY (SB_{2014}/SB_{MSY} = 1.80; 80% CI 1.38–2.23). Fishing mortality was estimated to be below the level that supports MSY (F_{2014}/F_{MSY} = 0.85; 80% CI 0.57–1.12) (IOTC 2018).

Stock status determination

The assessment indicates that the spawning biomass is above the Commonwealth's biomass limit reference point ($0.2B_0$), and so the stock is classified as **not overfished**. Fishing mortality in the IOTC area is below F_{MSY}, and so the stock is classified as **not subject to overfishing**.

Bigeye tuna (*Thunnus obesus*)



Line drawing: FAO

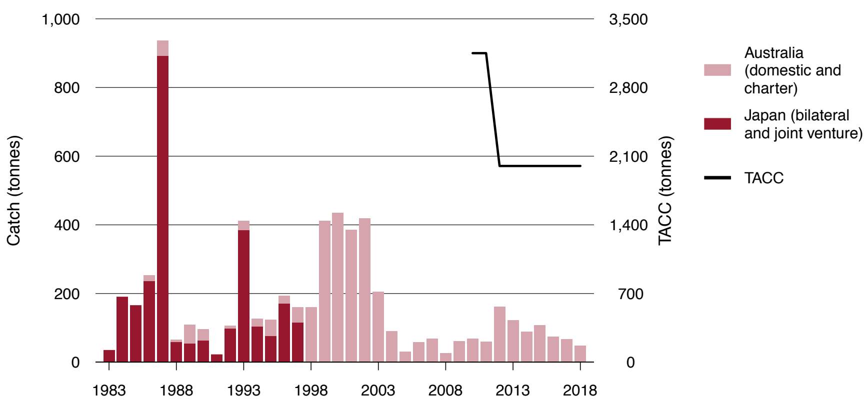
Stock structure

The stock structure of bigeye tuna in the Indian Ocean is uncertain, but the species is considered to be a single distinct biological stock for assessments. The assumption of a single stock is based on a genetic study (Chiang et al. 2008) that indicated no genetic differentiation within the Indian Ocean, and tagging studies that have demonstrated large-scale movements of bigeye tuna within the Indian Ocean (IOTC 2014).

Catch history

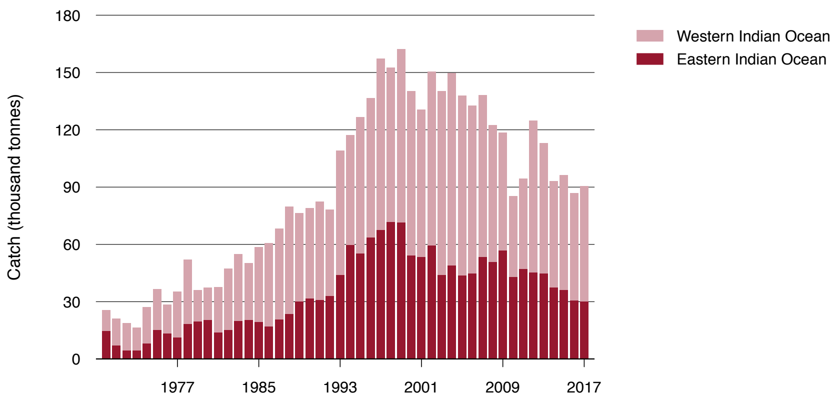
Annual catches of bigeye tuna in the WTBF varied widely between 1983 and 2004, with the highest catch of more than 900 t in 1987 and the lowest catch of less than 22 t in 1991 (Figure 24.10). Catches have been more stable since 2004, and have not exceeded 200 t; catches over the past three years are below 100 t. Total international catches in the IOTC area of competence have declined from a peak of more than 160,000 t in 1999 to less than 100,000 t in recent years (Figure 24.11). Bigeye catch was 90,050 t in 2017 and averaged 95,997 t over the past five years, both of which are below the 2016 MSY estimate of 104,000 t.

FIGURE 24.10 Bigeye tuna catch and TACC in the WTBF, 1983–2018



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.11 Bigeye tuna catch in the IOTC area, 1970–2017



Source: IOTC

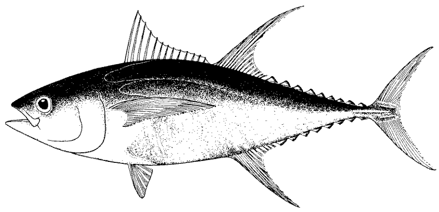
Stock assessment

Six assessment models were used to assess the Indian Ocean bigeye stock in 2016: SS3, ASPIC, SCAA, an Age Structured Assessment Program (ASAP), a BBDM and a BSPM (IOTC 2017). The SS3 assessment was used to provide management advice, and it captured uncertainty in the stock–recruitment relationship, as well as the influence of tagging data on the model outcomes. Current (2015) spawning stock biomass was estimated to be above the level that would produce MSY (SB_{2015}/SB_{MSY} = 1.29; 80% CI 1.07–1.51). Similarly, the assessment indicated that spawning biomass was above 20% of the initial unfished level (SB_{2015}/SB_0 = 0.38; 80% CI not available). Fishing mortality was below the level associated with MSY (F_{2015}/F_{MSY} = 0.76; 80% CI 0.49–1.03).

Stock status determination

The SS3 assessment indicates that bigeye tuna spawning stock biomass is above the Commonwealth's biomass limit reference point ($0.2B_0$). As a result, the Indian Ocean bigeye tuna stock is classified as **not overfished**. Since the current spawning biomass is above the level that would produce MSY, and fishing mortality is below F_{MSY}, the stock is classified as **not subject to overfishing**.

Yellowfin tuna (*Thunnus albacares*)



Line drawing: FAO

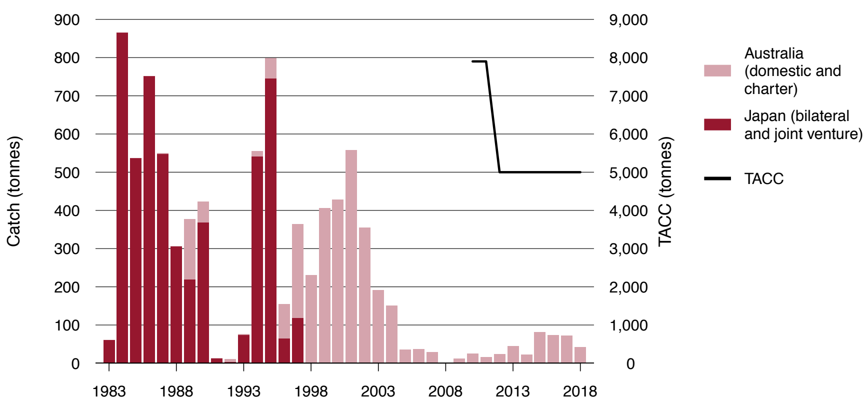
Stock structure

The stock structure of yellowfin tuna in the Indian Ocean is uncertain, but the species is considered to be a single biological stock for assessments. There have been no ocean-wide genetic studies of yellowfin tuna in the Indian Ocean, but tagging studies have demonstrated large-scale movements of yellowfin tuna, which is consistent with the assumption of a single stock (Langley, Herrera & Million 2012).

Catch history

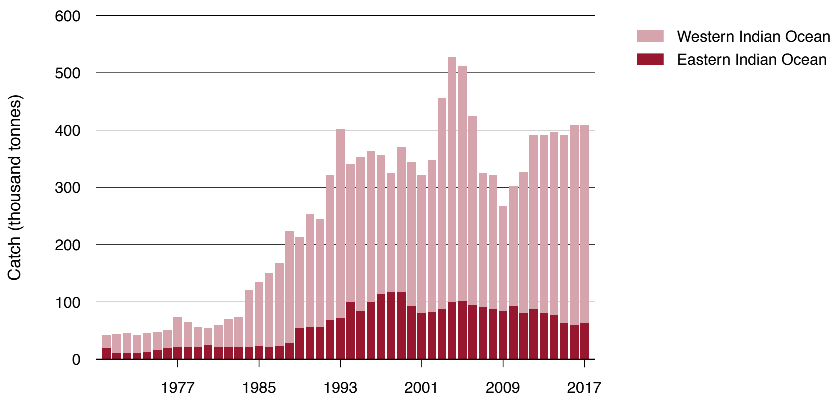
Historical catches of yellowfin tuna in the WTBF have varied widely, from peaks of around 800 t in 1984 and 1995 to less than 15 t in 1991 and 1992 (Figure 24.12). Since the early 2000s, declining effort in the WTBF has resulted in reduced catches of yellowfin tuna. Catches have not exceeded 100 t since 2004 (Figure 24.12). Total international catches in the IOTC area of competence (Figure 24.13) peaked at more than 500,000 t in 2004, then declined for several years (2007–2011) because of the effects of piracy in the north-west Indian Ocean. From 2012 to 2015, catches remained relatively stable at around 400,000 t. Catches increased to 421,910 t in 2016, which is close to the 2016 MSY estimate of 422,000 t, but declined to 409,567 t in 2017.

FIGURE 24.12 Yellowfin tuna catch and TACC in the WTBF, 1983–2018



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.13 Yellowfin tuna catch in the IOTC area, 1970–2017



Source: IOTC

Stock assessment

In 2018, the 2016 yellowfin tuna assessment was updated using SS3 and incorporating catch data, size, frequency data, tagging data and longline catch-per-unit-effort series (IOTC 2018). The results were largely similar to previous assessments, and indicate that 2017 levels of fishing mortality were above the level that would achieve MSY (F_{2017}/F_{MSY} = 1.20; 80% CI 1.00–1.71). Current spawning biomass was estimated to be below the level associated with MSY (SB_{2017}/SB_{MSY} = 0.83; 80% CI 0.74–0.97) but above the Commonwealth's biomass limit reference point (SB_{2017}/SB_0 = 0.30; 80% CI 0.27–0.33).

Stock status determination

The assessments indicate that fishing mortality is above the level associated with MSY. As a result, the yellowfin tuna stock is classified as **subject to overfishing**. The biomass is above the default limit reference point ($0.2B_0$), and, as a result, the stock is classified as **not overfished**.

24.3 Economic status

Key economic trends

Economic surveys have not been conducted in the WTBF since 2001–02 because of the low level of fishing activity. During 2017 and 2018, 95 and 94 fishing permits were issued in the fishery, respectively. A small number of vessels were operational in the fishery in those years (Table 24.2): four vessels (three pelagic longline and one minor line) in the 2017 fishing season and three vessels (two pelagic longline and one minor line) in the 2018 season. Total effort in the fishery decreased from 417,997 hooks in 2017 to 404,880 hooks in 2018, but the average number of hooks per active vessel increased. Total catch for quota species fell 14% in 2018 to 278 t, reflecting that the significant declines in the volumes of bigeye tuna and yellowfin tuna catch more than offset an increase in swordfish catch (Table 24.2).

As in previous years, landed catch in the fishery was a small proportion of the TACC during 2018. This high level of latent quota (the extent to which the TACC is not fully caught) and a relatively low participation rate indicate that permit holders expect low profitability from operating in the fishery.

Management arrangements

Before 2010, the WTBF was managed solely under an input control regime in which entry was limited, and gear and operating areas were restricted. In 2010, output controls were introduced in the form of species-specific TACCs, allocated as ITQs. The effect of the move to ITQs has not been measured because of the low participation in the WTBF in recent years. In general, ITQs allow fishers to use input combinations that are more efficient, particularly after input controls are relaxed. The transferability of fishing rights between fishers can also allow more efficient allocation of fishing rights so that catch is taken by the most efficient operators in the fishery. However, the very low levels of catch relative to the TACC in the WTBF are unlikely to provide any incentive for such trade to occur, minimising any efficiency gains.

Performance against economic objective

Although a harvest strategy has not been implemented because of low levels of effort in the fishery, the current management arrangements are unlikely to be constraining fishers' ability to operate profitably. The high levels of latency experienced in the fishery are more likely to arise from market factors that affect business input costs and international tuna prices. Furthermore, since the WTBF accesses a relatively small component of broader, internationally managed ocean-wide stocks, domestic management actions to control catch are likely to have limited impact on the biomass of these stocks and, therefore, on fishers' ability to access the resource for profitable operations. Hence, the economic objective of maximising net economic returns is likely being met for the fishery, as constraints to further fishing appear to be market related rather than arising from management arrangements.

24.4 Environmental status

The WTBF has been granted continued export approval under the *Environment Protection and Biodiversity Conservation Act 1999*, expiring on 28 November 2019. Conditions of export approval include a requirement to develop and implement a harvest strategy in the WTBF. Because of the very low effort in the fishery, the harvest strategy has not been implemented.

AFMA's ecological risk assessment examined 187 fish species in the WTBF (38 chondrichthyans and 149 teleosts), all of which were classified as being at low risk of potential overfishing, based on the level 3 Sustainability Assessment for Fishing Effects analysis (Zhou, Smith & Fuller 2009). Although no shark species were identified as high risk, an increase in effort could move some species to a higher-risk category. A priority action identified in the WTBF ecological risk management report is to monitor the catch of, and level of interaction with, sharks. Management of shark interactions in this fishery will be reviewed if the landed amount of any one shark species exceeds 50 t within a year (AFMA 2010). Trip limits on sharks apply, depending on species.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. In 2018, 258 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the WTBF; 1 was dead, and 257 were released in an unknown condition. Five porbeagles (*Lamna nasus*) were also released in unknown condition. Twelve leatherback turtles (*Dermochelys coriacea*) were also hooked and released alive, as were 10 loggerhead turtles (*Caretta caretta*). Six olive ridley turtles (*Lepidochelys olivacea*) were hooked, with four alive and two dead. Three flesh-footed shearwaters (*Ardenna carneipes*) and one unidentified albatross were all dead after being hooked. Finally, two long-finned pilot whales (*Globicephala melas*) were hooked, with one released alive and one dead, and one Cuvier's beaked whale (*Ziphius cavirostris*) was released alive.

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AFMA officer
Dylan Maskey, AFMA

Chapter 25

Heard Island and McDonald Islands Fishery

H Patterson and AH Steven

FIGURE 25.1 Area of the Heard Island and McDonald Islands Fishery, 2018

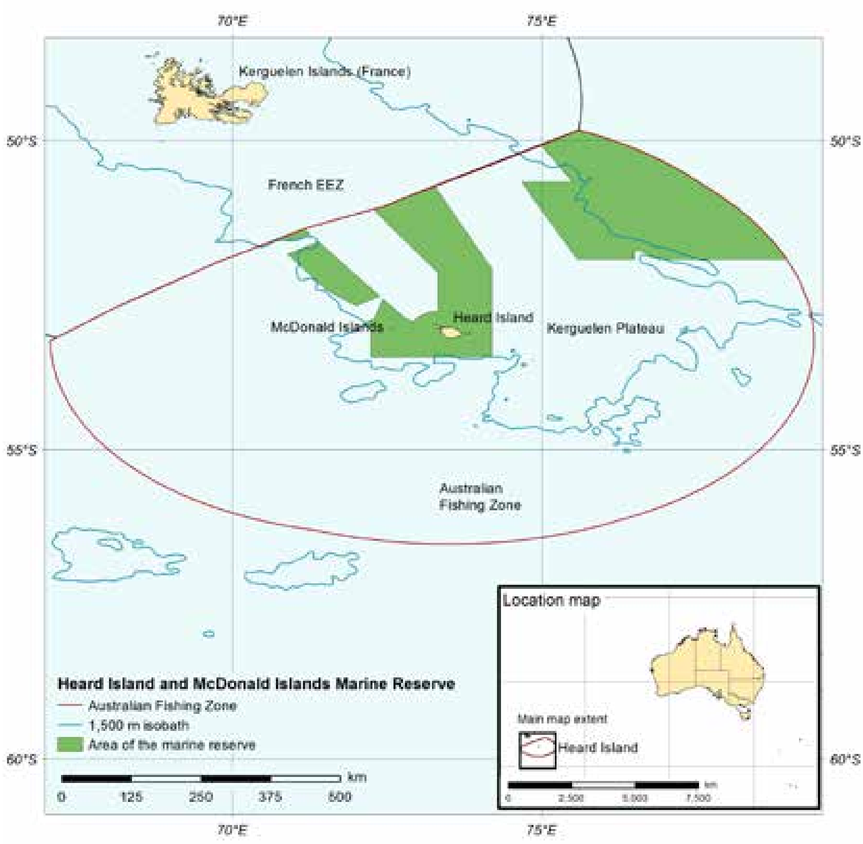


TABLE 25.1 Status of the Heard Island and McDonald Islands Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Mackerel icefish (*Champsocephalus gunnari*)					TACs are set in accordance with a precautionary harvest strategy.
Patagonian toothfish (*Dissostichus eleginoides*)					TACs are set in accordance with a precautionary harvest strategy. Most recent estimates of biomass are above the limit reference point.
Economic status	Estimates of NER are not available but are likely to be positive. Likely positive NER for the 2016–17 and 2017–18 fishing seasons are indicated by low levels of latency for targeted species.				

Notes: **NER** Net economic returns. **TAC** Total allowable catch.

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

Toothfish steaks
Lee Georgeson, ABARES

25.1 Description of the fishery

Area fished

The Australian external territory of Heard Island and McDonald Islands (HIMI) is in the southern Indian Ocean (Figure 25.1), within the area covered by the Convention on the Conservation of Antarctic Marine Living Resources. The islands and their surrounding territorial waters (out to 12 nautical miles [nm]) are closed to fishing and regulated under the *Environment Protection and Management Ordinance 1987*, administered by the Australian Antarctic Division (AAD) of the Australian Government Department of the Environment and Energy. A 1 nm buffer zone around the territorial waters of HIMI extends the area closed to fishing to 13 nm. The HIMI Marine Reserve was declared in October 2002 and then expanded in March 2014 by proclamation after scientific assessment. The reserve now totals 71,200 km². Waters between 12 and 200 nm from HIMI are part of the Australian Fishing Zone (AFZ). The Heard Island and McDonald Islands Marine Reserve Management Plan 2014–2024, made pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), provides the management regime for the reserve.

Fishing methods and key species

The key target species are Patagonian toothfish (*Dissostichus eleginoides*) and mackerel icefish (*Champsocephalus gunnari*). The fishery also has catch limits for bycatch species, such as deep-sea skates (Rajidae) and grey rockcod (*Lepidonotothen squamifrons*), based on assessments of long-term annual yield (Constable, Williams & de la Mare 1998). The catch limits for unicorn icefish (*Channichthys rhinoceratus*) and grenadiers (*Macrourus* spp.), another group of bycatch species, were updated in 2015 based on assessments undertaken by the AAD (Dell et al. 2015; Maschette & Dell 2015). The catch limits are regularly reviewed by the Australian Fisheries Management Authority's (AFMA's) Sub-Antarctic Resource Assessment Group, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Scientific Committee and the CCAMLR Commission, and are considered precautionary. Recent updates of the ecological risk assessments have lowered the risk of fishing to finfish bycatch species (see section 25.4). Demersal longline is the main method used in the fishery, with some catch taken by demersal trawl. Trawl has declined rapidly in favour of longline as the main method used to target toothfish. Mackerel icefish are taken exclusively using demersal and midwater trawl.

Management methods

The AAD, in collaboration with AFMA observers and industry, regularly conducts fisheries-independent, random-stratified trawl surveys for target species (Patagonian toothfish and mackerel icefish) to collect relative abundance data, particularly of juvenile age classes. Harvest strategies for the target species are consistent with the precautionary approach implemented by the CCAMLR and have been used to set catch limits since the mid 1990s. The harvest strategies developed for the Heard Island and McDonald Islands Fishery (HIMIF) are consistent with the guidelines of the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018). For mackerel icefish, the target reference point dictates that the spawning stock biomass be maintained at 75% of the level that would occur in the absence of fishing at the end of a two-year model projection. For Patagonian toothfish, the target reference points dictate that median escapement of the spawning biomass at the end of a 35-year projection period is 50% of the median pre-exploitation level and that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level is less than 10% over the projection.

The importance of the target species (especially mackerel icefish) as prey in the subantarctic ecosystem is taken into account, and catch limits must be sufficiently precautionary to ensure that the abundance of these species meets the ecological needs of dependent species (for example, seabirds and marine mammals). Mackerel icefish in the HIMIF was initially certified as sustainable by the Marine Stewardship Council in March 2006 and was recertified in July 2016. Patagonian toothfish in the HIMIF was recertified as sustainable by the council in July 2017.

Illegal, unreported and unregulated (IUU) longline fishing within the HIMI AFZ, targeting Patagonian toothfish, was a significant problem from the mid 1990s. However, following Australian surveillance and enforcement activities in the area (in cooperation with adjoining nations in the CCAMLR region, notably France), no IUU fishing vessels have been detected since 2004 inside the Australian Exclusive Economic Zone (EEZ) adjacent to HIMI or the French EEZ surrounding the Kerguelen Islands.

Fishing effort

Effort in the HIMIF has been fairly stable, with two to four vessels active at any one time since a total allowable catch (TAC) was first set in the mid 1990s. However, as a result of a higher TAC, seven vessels were active in the 2014–15 fishing season. Four vessels were active in the 2016–17 fishing season.

Catch

Catches of mackerel icefish have been variable over time. It is a short-lived species, exhibiting periodic, large, dominant year-classes. This allows high catches for a year or two. Once that year-class dies out and the next cohort is growing, catches are reduced because less biomass is available to the fishery.

Catches of Patagonian toothfish have been more stable over time, with little variation between the 2000–01 and 2013–14 fishing seasons. Catch in the 2014–15 fishing season increased in response to the increased TAC. Catch in 2015–16 was below the TAC by 606 t. This was due to a decrease in catch rates during the fishing season. Possible reasons for this decrease are currently being investigated and may relate to environmental factors. Catches over the past two seasons have been closer to the TACs, although the 2017–18 catch was 387 t below the TAC.

TABLE 25.2 Main features and statistics for the HIMIF

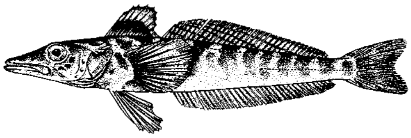
Fishery statistics a	**2016–17 fishing season**			**2017–18 fishing season**		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Mackerel icefish	561	557	Confidential	526	519	Confidential
Patagonian toothfish	3,405	3,357	Confidential	3,525	3,138	Confidential
Fishery-level statistics						
Effort	63 trawl-days 17,089,615 hooks 0 pots hauled			51 trawl-days 16,415,948 hooks 0 pots hauled		
Fishing permits	4 quota SFR holders			4 quota SFR holders		
Active vessels **c**	7			4		
Observer coverage	100% vessel coverage			100% vessel coverage		
Fishing methods	Demersal longline, demersal trawl, midwater trawl, pot (fish traps)					
Primary landing ports	Port Louis (Mauritius)					
Management methods	Input controls: limited entry, gear restrictions, temporal and spatial closures Output controls: TACs, ITQs Other: move-on provisions if bycatch thresholds are reached					
Primary markets	International: China, eastern Europe, Japan, United States—frozen					
Management plan	*Heard Island and McDonald Islands Fishery Management Plan 2002* (amended 2011)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Season is 1 December – 30 November. Value statistics are by financial year. **b** All vessels carry two observers on each trip; 100% of hauls are observed, but generally less than 100% of each haul.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch.

Sunset
Steve Cunliffe, AFMA

25.2 Biological status

Mackerel icefish (*Champsocephalus gunnari*)



Line drawing: FAO

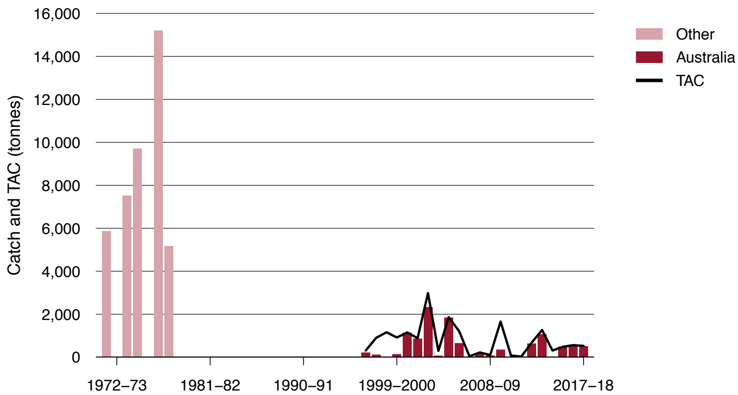
Stock structure

A single stock of mackerel icefish is considered to exist at HIMI; no genetic variation among sites around HIMI has been found (Williams, Smolenski & White 1994). Genetic studies have indicated that the population at HIMI is distinct from other icefish populations in the southern Atlantic Ocean (Kuhn & Gaffney 2006). Mackerel icefish at HIMI and the Kerguelen Plateau in the French EEZ are considered distinct stocks because of their different spawning seasons and growth rates (Williams et al. 2001).

Catch history

The catch history of icefish has been sporadic, with very high and unregulated catches taken by Soviet and Polish fleets across the Kerguelen Plateau in the 1970s, before the declaration of the EEZ around the Kerguelen Islands by France and the AFZ around HIMI. It is uncertain where these earlier catches were taken relative to the current maritime boundaries, although charts from this period indicate that the fishing fleet was aware of some of the banks where icefish currently form aggregations within the Australian EEZ. The initial TAC for icefish was set by the CCAMLR in 1995 following a demersal survey by the AAD. Since then, catches have generally followed the TAC, which takes into account the large natural fluctuations in abundance of the fish (Figure 25.2), except for 2014–15, when catches were well under the TAC because fishers concentrated their efforts on the more valuable Patagonian toothfish (for which the TAC was higher than in previous years). Over the past two seasons, catches have been very close to the TAC, with 519 t taken in 2017–18.

FIGURE 25.2 Catch and TAC of mackerel icefish in the HIMIF, 1971–72 to 2017–18



Note: **TAC** Total allowable catch.
Source: AFMA

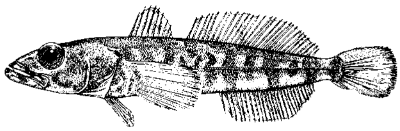
Stock assessment

A random stratified trawl survey in late March to early April 2018 provided information on the abundance and age structure of the mackerel icefish stock (Nowara, Lamb & Ziegler 2018). The 4+ year-class was estimated to account for 51% of the biomass, with a strong 2+ class accounting for 30% (Maschette & Welsford 2018). The stock assessment estimated the current biomass at 6,018 t (Maschette & Welsford 2018). Although the growth parameters used in the assessment were updated, there was only a small effect on the yields. If the 4+ cohort will not be available to the fishery in future years, due to natural mortality, yields of 443 t for the 2018–19 season and 320 t for the 2019–20 season were estimated to satisfy the CCAMLR decision rules. These TACs were endorsed by the CCAMLR (CCAMLR 2018a, b).

Stock status determination

Based on the level of catch, the harvest rate relative to the stock biomass estimate (which, under the harvest strategy, allows for a high rate of escapement) and the robust nature of the assessment (which includes fisheries-independent data), the stock is determined to be **not overfished** and **not subject to overfishing**.

Patagonian toothfish (*Dissostichus eleginoides*)



Line drawing: FAO

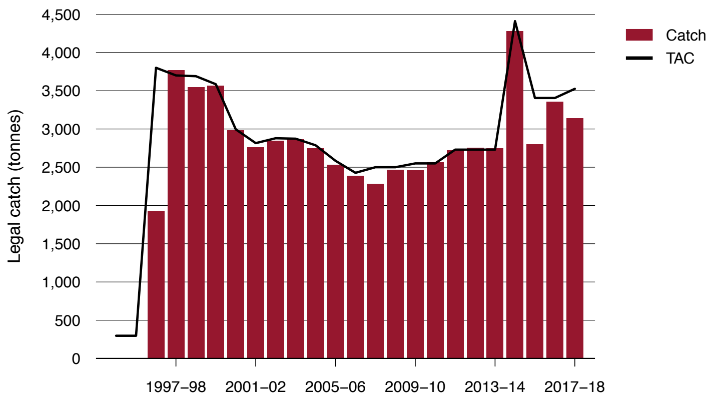
Stock structure

The Patagonian toothfish stock at HIMI is considered to comprise a population distinct from other regional toothfish populations in the south-west Pacific and Atlantic oceans (Appleyard, Ward & Williams 2002). However, limited genetic variation has been found among populations in the western Indian Ocean sector of the Southern Ocean—that is, HIMI, Crozet Islands, Kerguelen Islands, Marion Island and Prince Edward Islands (Appleyard, Williams & Ward 2004; Toomey et al. 2016). Data from tagging studies (for example, Welsford et al. 2011; Williams et al. 2002) indicate that, although adult toothfish at HIMI are relatively sedentary and usually recaptured within 15 nm of their point of release, in some cases they travel significant distances. For example, toothfish tagged at HIMI have been recaptured approximately 800 nm and 1,000 nm away on the Kerguelen and Crozet plateaus, respectively. Thus, toothfish in the Indian Ocean sector of the Southern Ocean may form a metapopulation, with some limited connectivity between the populations. The stock structure of toothfish on the Kerguelen Plateau is being further investigated in collaboration with French scientists so that population models of toothfish in the area can be refined and management can be improved across the Kerguelen Plateau (Péron et al. 2016; Welsford et al. 2011). For the purposes of the assessment, the HIMI toothfish population is considered to be distinct.

Catch history

Catch of Patagonian toothfish in the HIMIF has declined slightly since the late 1990s, but was relatively stable from the early 2000s to 2013–14 and has mirrored the TAC (Figure 25.3). Because of the higher TAC, catches were greater in 2014–15 and the highest since 1994–95. As noted above, catch rates dropped in the 2015–16 fishing season, but catches in the 2016–17 (3,357 t) and 2017–18 (3,138 t) seasons were closer to the TAC.

FIGURE 25.3 Catch and TAC of Patagonian toothfish in the HIMIF, 1994–95 to 2017–18



Note: **TAC** Total allowable catch.
Source: AFMA

Stock assessment

The most recent assessment for Patagonian toothfish (Ziegler 2017) was similar to the 2015 assessment, and included updated survey and ageing data, updated growth parameters, updated maturity parameters, updated tag loss estimates, a bias correction for fish emigration, the use of survey biomass and catch proportions instead of abundance numbers, and iterative data weighting (the 'Francis' method; Francis 2011). The assessment was run using the agreed version of CASAL.

The assessment agreed by the 2017 Working Group on Fish Stock Assessment estimated that the spawning biomass was 61% of unfished levels (SB_{2016}/SB_0 = 0.61; range 0.58–0.64). A catch limit of 3,525 t satisfied the CCAMLR decision rules, and was the recommended TAC for the 2017–18 and 2018–19 fishing seasons (CCAMLR 2017a, b). This TAC is slightly higher than that set for 2015–16 and 2016–17 because the updated maturity parameters indicated higher productivity, which resulted in a higher TAC under the decision rules.

Stock status determination

Given the relatively high spawning biomass, the precautionary TAC that satisfies the CCAMLR decision rules, the robust nature of the stock assessment and the extensive CCAMLR review process, the stock is classified as **not overfished** and **not subject to overfishing**.

25.3 Economic status

Key economic trends

Only a small percentage of the TACs for both Patagonian toothfish and mackerel icefish were left uncaught in the 2016–17 and 2017–18 fishing seasons, supporting overall positive net economic returns (NER) for the fishery.

Patagonian toothfish has constituted, on average, more than 90% of the fishery's annual gross value of production during the past decade. Patagonian toothfish has a higher landing value than mackerel icefish, and experiences strong demand and high prices for export. As such, Patagonian toothfish is the main targeted species in this fishery and consequently drives movement of NER.

Since 2012–13, a commercial TAC has been re-established for mackerel icefish, reflecting increased estimated abundance. Since the TAC of mackerel icefish has been nearly fully caught, at 99%, in the 2016–17 and 2017–18 fishing seasons, it is likely that positive NER were generated for this species.

Management arrangements

A harvest strategy, consistent with the principles of the CCAMLR, is in place for the fishery. The primary management control uses individual transferable quotas (ITQs), in conjunction with input controls. The use of ITQs provides the best chance of achieving maximum efficiency, subject to the fishery's precautionary harvest strategy and strict operational constraints on vessels. Given the low levels of quota latency, positive NER are likely to be generated in the fishery in a manner that is consistent with the conservative ecological objectives.

25.4 Environmental status

The HIMIF is exempt from export controls under the EPBC Act until 9 October 2026. No additional recommendations apply under this exemption, beyond standard recommendations pertaining to reporting.

In 2018, three ecological risk assessments were completed for the HIMIF using the 'ecological risk assessment for effects of fishing' method. The assessments covered the three gear types used in the fishery: demersal trawl, midwater trawl and demersal longline (Bulman et al. 2018; Sporcic et al. 2018a, b). All the assessments were completed to level 1 (Scale Intensity Consequence Analysis). The results for the three assessments were all improved from the previous assessments in 2009. The two trawl gears did not trigger the need for a level 2 analysis because there is limited trawl effort in the fishery. For the longline fishery, although the effort has increased since the previous assessment was undertaken in 2009, improved research and mitigation resulted in only one component (community) requiring further assessment. This was due to a paucity of data on the broader consequences to the ecosystem of removing toothfish. However, ecosystem models of the region are currently being developed and will be used to assess the wider ecosystem effects of fishing.

AFMA publishes quarterly logbook reports of interactions with species protected under the EPBC Act on its website. In the HIMI longline fishery in 2018 (calendar year), nine southern elephant seals (*Mirounga leonina*) became entangled in the longlines and eight died; one was released alive. One white-chinned petrel (*Procellaria aequinoctialis*), one Wilson's storm petrel (*Oceanites oceanicus*) and one grey petrel (*Procellaria cinerea*) also became entangled in the longline and died.

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Chapter 26

Macquarie Island Toothfish Fishery

H Patterson and AH Steven

FIGURE 26.1 Area of the Macquarie Island Toothfish Fishery, 2018

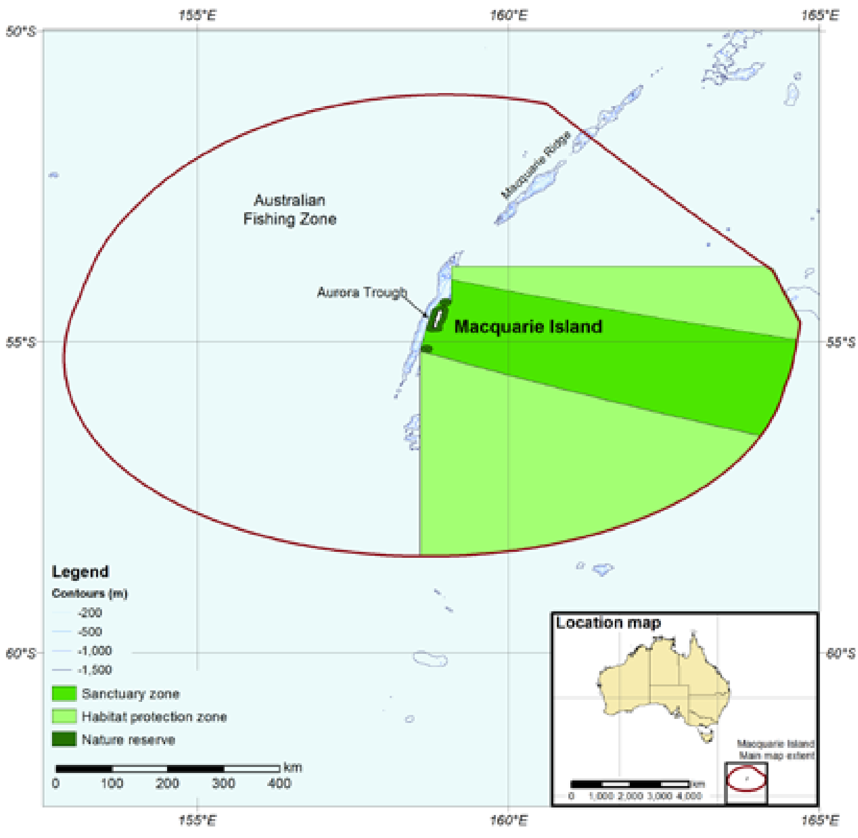


TABLE 26.1 Status of the Macquarie Island Toothfish Fishery

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Patagonian toothfish (*Dissostichus eleginoides*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	TACs are set in accordance with a precautionary harvest strategy. Most recent estimate of biomass is above the limit reference point.
Economic status	Estimates of NER are not available but are likely positive for the 2017–18 and 2018–19 fishing seasons due to low TAC latency for Patagonian toothfish in both seasons. NER in the 2017–18 fishing season are likely to be lower than in the 2018–19 season because of a higher quota latency and a lower catch per longline-day compared with the previous season.				

Notes: **NER** Net economic returns. **TAC** Total allowable catch.

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

26.1 Description of the fishery

Area fished

Macquarie Island is a subantarctic island about 1,500 km south of Tasmania (Figure 26.1). The island is a nature reserve in the Tasmanian reserve system and is included on the World Heritage List (UNESCO 1998). The waters within 3 nautical miles (nm) of the island are under Tasmanian jurisdiction, while waters between 3 nm and the 200 nm outer boundary of the Australian Fishing Zone are managed by the Australian Government. The south-eastern quadrant of the Macquarie Island region out to 200 nm is a marine reserve (Figure 26.1). The Macquarie Island Toothfish Fishery (MITF) is outside the area covered by the Convention on the Conservation of Antarctic Marine Living Resources; however, the ecosystem-based management approach used by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has been adopted for the fishery, including comprehensive observer coverage and precautionary harvest control rules.

Fishing methods and key species

Historically, trawling was the main fishing method used in the MITF. In 2011, longlining was added as an approved fishing method (AFMA 2010). This followed a longlining trial over four seasons (2007–2010) that demonstrated longlining as an effective method for targeting Patagonian toothfish (*Dissostichus eleginoides*) and showed that mitigation methods could be implemented to minimise seabird interactions with longline gear (AFMA 2010). Since the 2010–11 season, toothfish in the MITF have been solely taken using longline, except for a trial of pots in the 2013–14 fishing season. Bycatch is generally low and is regulated by a 50 t limit for any one species. The bycatch, primarily grenadier (*Macrourus* spp.) and violet cod (*Antimora rostrata*), has never exceeded the 50 t limit for any one species in a season.

Management methods

The harvest strategy for Patagonian toothfish is consistent with the guidelines of the Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018). For Patagonian toothfish, the reference points dictate that median escapement of the spawning biomass at the end of a 35-year projection period is 50% of the median pre-exploitation level and that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level is less than 10% over the projection. The total allowable catch (TAC) was previously set separately for the two main areas (Aurora Trough and Macquarie Ridge). However, based on scientific advice that it is highly likely that there is a single stock of Patagonian toothfish around Macquarie Island (see 'Stock structure', below), the management plan was amended in January 2012 to merge the two areas, and a single TAC is now set for the entire fishery. The MITF was recertified as sustainable by the Marine Stewardship Council in July 2017.

Fishing effort

The effort in the fishery has been consistent over time, with one or two vessels active in the fishery every year since the fishery began in 1994.

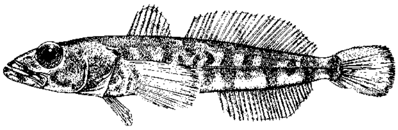
TABLE 26.2 Main features and statistics for the MITF

Fishery statistics a	2017–18 fishing season			2018–19 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2016–17)**	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**
Patagonian toothfish	450	358	Confidential	450	448	Confidential
Fishery-level statistics						
Effort (longline days)	112			95		
Fishing permits	2 quota SFR holders			2 quota SFR holders		
Active vessels	1			1		
Observer coverage b	100% vessel coverage			100% vessel coverage		
Fishing methods	Demersal longline, demersal trawl					
Primary landing ports	Devonport and Hobart (Tasmania); Nelson (New Zealand)					
Management methods	Input controls: limited entry, gear restrictions, closures Output controls: TACs, ITQs					
Primary markets	International: Japan, United States—frozen					
Management plan	*Macquarie Island Toothfish Fishery Management Plan 2006* (amended 2012)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. The 2018–19 fishing season was 15 April 2018 – 14 April 2019. Value statistics are provided by financial year. **b** All vessels carry two observers on each trip; 100% of hauls are observed, but generally less than 100% of each haul.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch.

26.2 Biological status

Patagonian toothfish (*Dissostichus eleginoides*)



Line drawing: FAO

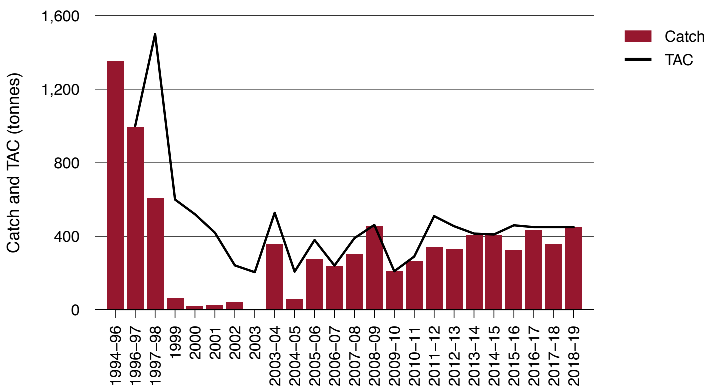
Stock structure

The Patagonian toothfish stock at Macquarie Island is considered to be distinct from other regional toothfish populations in the Southern Ocean (Appleyard, Ward & Williams 2002). Genetic studies (for example, Appleyard, Ward & Williams 2002) and toothfish tagging programs (for example, Williams et al. 2002) indicate that a single stock exists in the MITF.

Catch history

The catch of Patagonian toothfish in the MITF (Figure 26.2) has been variable over time and generally below, but close to, the TAC. Initial catches in the fishery were relatively high but decreased from 1999 to 2003, when the Aurora Trough was effectively closed to commercial fishing, and only a single vessel was permitted to fish to maintain the tagging program and conduct experimental acoustic surveys. Catch in the 2018–19 season was just below the TAC.

FIGURE 26.2 Catch and TAC of Patagonian toothfish in the MITF, 1994–95 to 2018–19



Note: **TAC** Total allowable catch.
Source: AFMA

Stock assessment

The Stock Synthesis 3 software was used in 2017 to assess the Patagonian toothfish stock (Day & Hillary 2017). This integrated two-area assessment fits to tag–recapture, length composition and age-at-length data. The assessment assumes a single stock in the MITF but with spatial structuring of fishing and movement between two areas (northern and southern), with recruitment to both areas. Using this assessment, 2017 female spawning biomass was estimated at 69% of unfished levels ($0.69SB_0$). Following the CCAMLR control rule (which uses a target of $0.50SB_0$ rather than $0.48SB_0$), a two-year TAC was calculated for the MITF for 2018–19 and 2019–20, which was robust to a wide array of catch distributions spread among the different fishing areas.

Stock status determination

The relatively high estimate of current female spawning biomass ($0.69SB_0$) and the robust nature of the assessment result in the stock being classified as **not overfished**. The conservative TAC-setting process, based on applying precautionary CCAMLR control rules, and the maintenance of catch generally below the TAC result in the stock being classified as **not subject to overfishing**.

26.3 Economic status

Key economic trends

Latency can be variable in this fishery. In the 2018–19 fishing season, the TAC was mostly caught. It is expected that the net economic returns (NER) for the 2018–19 fishing season will be positive. The catch per longline was 4.7 t, returning to 2016–17 levels. In comparison, the 2017–18 fishing season had 20% latency and a 3.2 t catch per longline-day due to loss of gear and difficult operating conditions, which likely raised the daily cost of fishing.

The estimated biomass of $0.69SB_0$ in 2018 is well above the targeted level of $0.50SB_0$. This high abundance is likely to result in lower fishing costs and improved profitability. Given that only one operator has fished in the MITF in recent years, it is also likely that individual profit-maximising decisions are aligned with optimum use of the resource, within the constraints of the fishery's precautionary objective.

Management arrangements

The harvest strategy for this fishery is conservative, reflecting the CCAMLR ecosystem-based management approach. Therefore, catch limits aim to maintain stock biomass at levels that are higher than recommended target reference points for other Commonwealth fisheries managed under the HSP.

Average vessel economic performance is likely to have improved since longlining was approved in 2011. The initial demersal longline trial in 2007 found a number of benefits of longline fishing compared with trawl fishing, including increased access to Patagonian toothfish in deeper waters and reduced levels of bycatch (AFMA 2010). These benefits are likely to have improved vessel-level productivity, moderating the negative effects of rough sea conditions experienced in recent years.

26.4 Environmental status

The MITF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and has export approval until 9 October 2026. No additional recommendations apply under this exemption, beyond standard recommendations pertaining to reporting.

The ecological risk assessment process was completed to level 3 (Sustainability Assessment for Fishing Effects) for trawling, because longlining had not yet commenced in the fishery (AFMA 2007). A further assessment determined that no species was at high risk from trawling in the MITF (Zhou, Fuller & Smith 2009).

The level 3 assessment for demersal longlining used data from 2007 to 2010 and is considered preliminary (Zhou & Fuller 2011). Two species—southern lanternshark (*Etmopterus baxteri*) and southern sleeper shark (*Somniosus antarcticus*)—had mean fishing mortality estimated to be slightly higher than the rates corresponding to the maximum number of fish that can be removed in the long term. However, the authors suggested that the level 3 assessment tends to be overly precautionary, and it is likely that the mortality rate was overestimated. This is supported by the low recorded catch for the two species (two southern lantern sharks and nine southern sleeper sharks) over the three years. Further analyses should take place as data become available.

The MITF ecological risk management reports for trawling and demersal longline both outline how the Australian Fisheries Management Authority (AFMA) will continue to monitor bycatch, and interactions with species protected under the EPBC Act, in a manner consistent with CCAMLR principles (AFMA 2010, 2011). AFMA has developed a revised ecological risk assessment framework and is undertaking new assessments under this framework. It is expected that the new assessment framework will be applied to the MITF.

All the catch in the MITF is now taken by longline. AFMA publishes quarterly logbook reports of interactions with species protected under the EPBC Act on its website. In 2018, 12 interactions with porbeagles (*Lamna nasus*) were recorded. Five were released alive, six were dead and one was in an unknown condition.

26.5 References

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UNESCO 1998, *Convention Concerning the Protection of the World Cultural and Natural Heritage*, twenty-first session of the World Heritage Committee, 1–6 December 1997, United Nations Educational, Scientific and Cultural Organization, Naples, Italy.

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——, Fuller, M & Smith, T 2009, *Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries*, report to AFMA, Canberra.

Fishing at Macquarie Island
Australian Longline Pty

Chapter 27

CCAMLR exploratory toothfish fisheries

H Patterson and AH Steven

FIGURE 27.1 CCAMLR Convention area

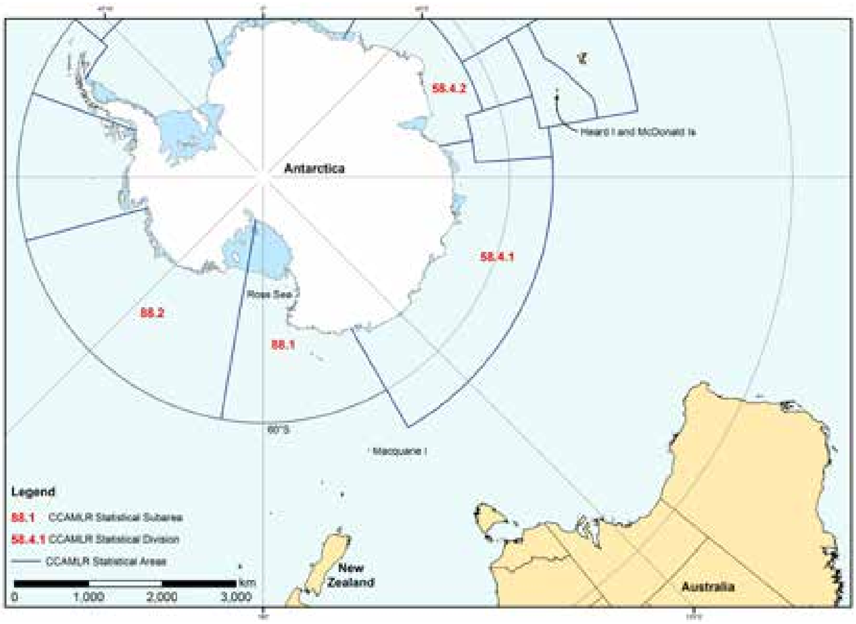


TABLE 27.1 Status of the CCAMLR exploratory toothfish fisheries

Status	2017		2018		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Division 58.4.1, toothfish (*Dissostichus mawsoni*)					No estimate of current biomass available.
Division 58.4.2, toothfish (*Dissostichus mawsoni*) **a**					No estimate of current biomass available.
Subarea 88.1, toothfish *(Dissostichus mawsoni)*					Most recent estimate of biomass is above the limit reference point under the CCAMLR harvest strategy. The TAC is conservative relative to current biomass.
Subarea 88.2, toothfish *(Dissostichus mawsoni, D. eleginoides)*					Most recent estimate of biomass is above the limit reference point under the CCAMLR harvest strategy. The TAC is conservative relative to current biomass.
Economic status	Estimates of NER are not available, and NER remain uncertain. Australian fishers have been active across the CCAMLR exploratory areas from 2014–15 to 2017–18.				

a This stock was not assessed in 2017.
Notes: **CCAMLR** Commission for the Conservation of Antarctic Marine Living Resources. **NER** Net economic returns. **TAC** Total allowable catch.

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

27.1 Description of the fishery

Area fished

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) was established in 1982 to conserve and manage the Southern Ocean Antarctic ecosystem. The objective of the CCAMLR is the conservation of Antarctic marine living resources. The CCAMLR Convention area is defined as the area south of the Antarctic Convergence, as well as the area south of 60°S where the Antarctic Treaty (1959) applies (Figure 27.1).

The CCAMLR defines 'new and exploratory' fisheries for particular areas, and places emphasis on acquiring biological and other information during the development of the fisheries. Participation in such fisheries requires Member States to implement management measures, and a research plan detailing the scientific data that a country plans to collect and contribute to the CCAMLR.

Exploratory fisheries are defined under Conservation Measure 21-02:

i. an exploratory fishery shall be defined as a fishery that was previously classified as a 'new fishery', as defined by Conservation Measure 21-01

ii. an exploratory fishery shall continue to be classified as such until sufficient information is available

   a. to evaluate the distribution, abundance and demography of the target species, leading to an estimate of the fishery's potential yield

   b. to review the fishery's potential impacts on dependent and related species

   c. to allow the Scientific Committee to formulate and provide advice to the Commission on appropriate harvest catch levels, as well as effort levels and fishing gear, where appropriate.

CCAMLR subareas 88.1 and 88.2 (Figure 27.1) lie within the Ross and Amundsen seas. A CCAMLR exploratory fishery operates in each of these subareas. These fisheries are managed separately, with distinct stock assessments. During the 2017–18 season, one Australian vessel participated in these exploratory fisheries.

CCAMLR divisions 58.4.1 and 58.4.2 lie adjacent to East Antarctica (Figure 27.1), and exploratory fisheries operate in both these divisions. During the 2017–18 fishing season, two Australian vessels participated in the fishery in division 58.4.1, and one Australian vessel participated in the fishery in division 58.4.2.

Fishing methods and key species

Demersal longline is the primary method used to target Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian toothfish (*D. eleginoides*) in CCAMLR toothfish fisheries. Before 2017, the exploratory fisheries described here were for *Dissostichus* spp. (that is, both species). To better align the assessments with the target species, the fisheries now have the sole target species *D. mawsoni* (noting that, if any *D. eleginoides* are caught, they are decremented against the catch limit for *D. mawsoni*). New and exploratory fisheries have catch limits for bycatch species, such as skates and rays, whiptails (*Macrourus* spp.) and other species, as well as move-on provisions. The bycatch limits may be based on a percentage of the catch of toothfish (for example, 5% of the catch limit for *Dissostichus* spp.), or may be set as a specific limit (for example, 50 t) for each CCAMLR subarea or division that constitutes a new and exploratory fishery.

Management methods

Harvest strategies for the target species are consistent with the precautionary approach implemented by the CCAMLR that has been used to set catch limits since the mid 1990s. The harvest strategy for toothfish developed by the CCAMLR is consistent with the guidelines of the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018). For toothfish, the reference points in the CCAMLR harvest strategy dictate that median escapement of the spawning biomass at the end of a 35-year projection period is 50% of its median pre-exploitation level, and that the probability of the spawning biomass dropping below 20% of its median pre-exploitation level is less than 10% over the projection period. In exploratory fisheries, total allowable catches (TACs) are fished by approved vessels that have nominated to fish specific subareas or divisions. Shares of the toothfish TAC are not allocated to particular CCAMLR members in exploratory fisheries; however, members may receive allocations to conduct specific research programs. Daily catch-and-effort reporting is required by all vessels, and fishing must cease when the catch limit is reached. Vessels fishing in exploratory fisheries are required to carry scientific observers, and to tag and release toothfish at pre-specified levels as part of the scientific data collection process.

Fishing effort

Australia fished subarea 88.1 for the first time in 2016–17, but began fishing in subarea 88.2 in 2014–15. There was no previous effort by Australian vessels in these subareas, although other CCAMLR members have fished them previously. Division 58.4.1 was fished for the first time by an Australian vessel in 2015–16 (excluding some experimental trawling in the division in 1999–2000). Similarly, in division 58.4.2, Australian fishers undertook some experimental trawling in 1999–2000, but this division was properly fished for the first time by Australia in 2017–18.

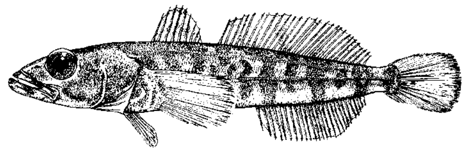
TABLE 27.2 Main features and statistics for the CCAMLR exploratory toothfish fisheries

Fishery statistics a	2016–17 fishing season			2017–18 fishing season		
Fishery	**TAC (t) b**	**Catch (t) c**	**GVP (2016–17)**	**TAC (t) b**	**Catch (t) c**	**GVP (2017–18)**
Division 58.4.1, toothfish	660	10	Confidential	545	91	Confidential
Division 58.4.2	35	–	–	42	28	Confidential
Subarea 88.1, toothfish	2,870	81	Confidential	3,157	100	Confidential
Subarea 88.2, toothfish	619	151	Confidential	619	43	Confidential
Fishery-level statistics						
Effort	Division 58.4.1: 123,250 hooks Division 58.4.2: 0 hooks Subarea 88.1: 33,150 hooks Subarea 88.2: 347,225 hooks			Division 58.4.1: 408,250 hooks Division 58.4.2: 140,250 hooks Subarea 88.1: 293,250 hooks Subarea 88.2: 41,750 hooks		
Fishing permits	Division 58.4.1: 1 Division 58.4.2: 1 Subarea 88.1: 1 Subarea 88.2: 1			Division 58.4.1: 1 Division 58.4.2: 1 Subarea 88.1: 1 Subarea 88.2: 1		
Active vessels	Division 58.4.1: 1 Division 58.4.2: 0 Subarea 88.1: 1 Subarea 88.2: 1			Division 58.4.1: 2 Division 58.4.2: 1 Subarea 88.1: 1 Subarea 88.2: 1		
Observer coverage **d**	100% vessel coverage			100% vessel coverage		
Fishing methods	Demersal longline					
Primary landing ports	Hobart (Tasmania); Nelson (New Zealand)					
Management methods	Input controls: limited entry, gear restrictions, temporal and spatial closures Output controls: TACs Other: move-on provisions if bycatch thresholds are reached					
Primary markets	International: China, Japan, United States—frozen					
Management plan	No formal management plan; operations consistent with CCAMLR conservation measures					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Season is 1 December – 31 August. Value statistics are by financial year. **b** Total available TAC for all participating fleets. **c** Australian catch only. Total catches are provided in Figures 27.2, 27.3, 27.4 and 27.5. **d** All Australian vessels carry two observers on each trip; 100% of hauls are observed, but generally less than 100% of each haul.
Notes: **CCAMLR** Commission for the Conservation of Antarctic Marine Living Resources. **GVP** Gross value of production. **TAC** Total allowable catch. – Not applicable.

27.2 Biological status

Antarctic toothfish (*Dissostichus mawsoni*) in division 58.4.1



Line drawing: FAO

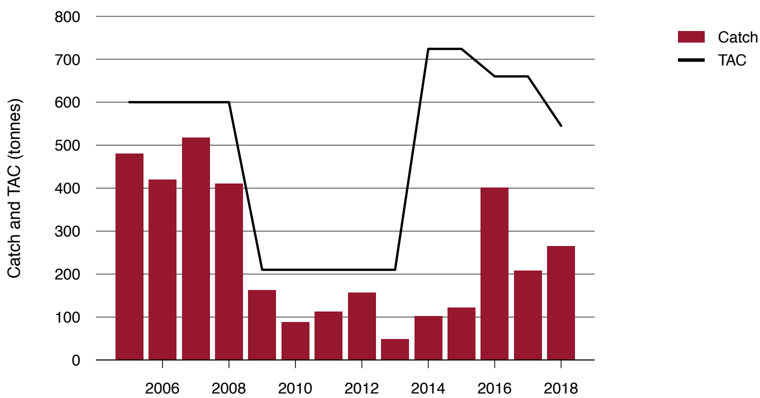
Stock structure

Toothfish in division 58.4.1 is considered a single stock for management purposes.

Catch history

Exploratory fishing is permitted in research blocks within CCAMLR division 58.4.1. Fishing has occurred in the division under licence since 2005, with TACs ranging from 210 to 724 t (Figure 27.2). Australia did not participate in the fishery before 2015–16, although some experimental trawling did occur in 1999–2000.

FIGURE 27.2 Total catch and TAC for CCAMLR division 58.4.1, 2005–2018



Note: **TAC** Total allowable catch.
Source: CCAMLR

Stock assessment

No reliable and accepted integrated stock assessment is available for division 58.4.1. Although some earlier studies applied different tag-based methods to obtain some indication of stock status, these were considered unreliable because of low tag returns (Agnew et al. 2008). The current level of biomass in division 58.4.1 is therefore unknown.

Fishing in the established research blocks, where previous tagging occurred and is ongoing, is intended to provide data for a future stock assessment. The participation of CCAMLR members in the fishery is restricted, and participants must provide a multiyear research plan that will provide data for a future stock assessment. Illegal, unreported and unregulated (IUU) fishing, which has been a significant problem in CCAMLR toothfish fisheries in the past, has been largely eliminated by international enforcement efforts.

To set catch limits for exploratory fishing, biomass in each research block is estimated independently based on tag recoveries, or on mean catch rate compared with an assessed area scaled by the seabed area in the block. The catch limits are then set so that they do not exceed 4% of the estimated stock size. Previous modelling work has demonstrated that this level of harvest will likely allow an overfished stock (<20% of unfished biomass [B_0]) to recover in the long term (Welsford 2011); it is unknown whether the stock in division 58.4.1 is overfished.

Stock status determination

Given that there is no stock assessment for the entire division and no current overall estimate of biomass, the stock is classified as **uncertain** for overfished status. The catch limits set for each research block are based on assessed fisheries, and are set to a level low enough that an overfished stock could recover in the long term. The total catch for the division was below the TAC. In addition, IUU fishing has been largely eliminated, and participation in the fishery has been restrained to a very low level. Given these factors, the stock is considered **not subject to overfishing**.

Antarctic toothfish (*Dissostichus mawsoni*) in division 58.4.2

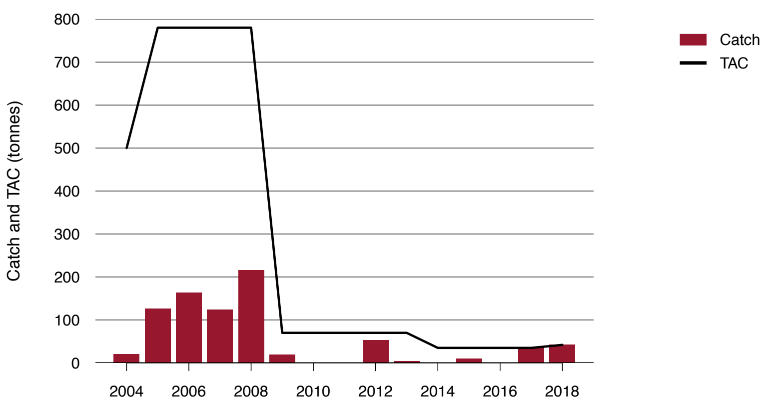
Stock structure

Toothfish in division 58.4.2 is considered a single stock for management purposes.

Catch history

CCAMLR division 58.4.2 contains one research block where exploratory fishing is permitted. Fishing has occurred in the division under licence since 2004, with TACs ranging from 35 to 780 t (Figure 27.3). Australia did not participate in the fishery before 2017–18, although some experimental trawling did occur in 1999–2000.

FIGURE 27.3 Total catch and TAC for CCAMLR division 58.4.2, 2004–2018



Stock assessment

No reliable and accepted integrated stock assessment is available for division 58.4.2. Although some earlier studies applied different tag-based methods to obtain some indication of stock status, these were considered unreliable because of low tag returns (Agnew et al. 2008). The current level of biomass in division 58.4.2 is therefore unknown.

Fishing in the established research block, where previous tagging occurred and is ongoing, is intended to provide data for a future stock assessment. The participation of CCAMLR members in the fishery is restricted, and participants must provide a multiyear research plan that will provide data for a future stock assessment. IUU fishing, which has been a significant problem in CCAMLR toothfish fisheries in the past, has been largely eliminated by international enforcement efforts.

To set catch limits for exploratory fishing, biomass in each research block is estimated independently based on tag recoveries, or on mean catch rate compared with an assessed area scaled by the seabed area in the block. The catch limits are then set so that they do not exceed 4% of the estimated stock size. Previous modelling work has demonstrated that this level of harvest will likely allow an overfished stock (<20% B_0) to recover in the long term (Welsford 2011); it is unknown whether the stock in division 58.4.2 is overfished.

Stock status determination

Given that there is no stock assessment for the entire division and no current overall estimate of biomass, the stock is classified as **uncertain** for overfished status. The catch limits set for each research block are based on assessed fisheries, and are set to a level low enough that an overfished stock could recover in the long term. The total catch for the division was below the TAC. In addition, IUU fishing has been largely eliminated, and participation in the fishery has been restrained to a very low level. Given these factors, the stock is considered **not subject to overfishing**.

Antarctic toothfish (*Dissostichus mawsoni*) in subarea 88.1

Stock structure

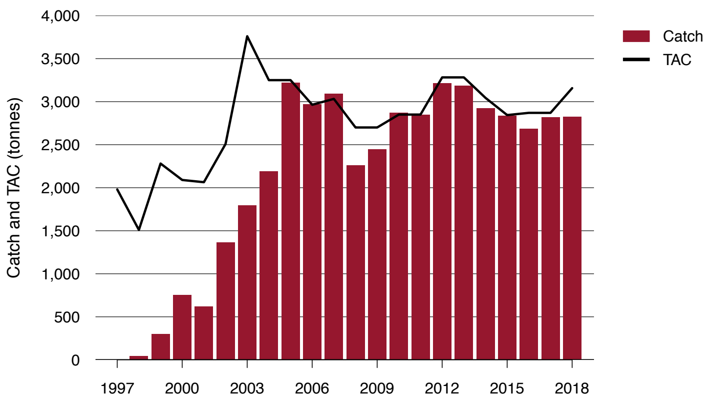
Genetic examination of Antarctic toothfish from widely separated CCAMLR statistical areas (Atlantic Ocean sector, Pacific Ocean sector, Indian Ocean sector) has produced mixed results. Early studies found some weak variation by ocean sector (Kuhn & Gaffney 2008; Smith & Gaffney 2005), whereas a more recent study was unable to detect any genetic variation among fish from the different sectors (Mugue et al. 2014). Tagging studies from numerous locations in the CCAMLR Convention area have indicated that most adult toothfish are sedentary and are recaptured relatively close (<50 km) to where they were tagged (Hanchet et al. 2008; Petrov & Tatarnikov 2010; Welsford et al. 2011). However, a small proportion of tagged fish have been found to travel long distances (CCAMLR Secretariat 2017), and, together with some level of large-scale egg and larvae dispersal, this can result in a lack of differentiation in the genetic stock structure. Newer genomic techniques are being used to better understand stock structure. Preliminary otolith chemistry work has also provided evidence of regional stock structuring (Tana et al. 2014).

The stock assessment boundaries for the Ross Sea (described here) include subarea 88.1, and small-scale research units (SSRUs) A and B from subarea 88.2.

Catch history

Catches were relatively small in the early years of the fishery, but have increased since 2002 as the TAC has increased (Figure 27.4). Most of the catch has been Antarctic toothfish; Patagonian toothfish has accounted for 5% or less of the catch since 2010.

FIGURE 27.4 Total catch and TAC for CCAMLR subarea 88.1, 1997–2018



Note: **TAC** Total allowable catch.
Source: CCAMLR

Stock assessment

The most recent full stock assessment of Antarctic toothfish from CCAMLR subarea 88.1, and subarea 88.2 SSRUs A and B was conducted in 2017 using the CASAL integrated assessment model; it is a Bayesian sex- and age-structured assessment (Mormede 2017). The assessment included catch data and catch-at-age frequencies from 1998 to 2016 for the three areas of the Ross Sea (shelf, slope and north). In addition, tag–recapture data were included, as were survey-based standardised local abundance and catch-at-age frequencies from the survey of the Ross Sea shelf (Large, Robinson & Parker 2017).

The recommended model estimated the current level of biomass at 72% of unfished levels ($B_{2016}/B_0 = 0.72$; range 0.69–0.75). This is higher than the 2015 estimate of unfished biomass; the difference is likely the result of revised estimates of the effective tag survival and detection rates. The yield that satisfied the CCAMLR decision rules was estimated using a number of options to split the catch between the three areas (shelf, slope and north), or between areas north and south of 70°S and the special research zone of the Ross Sea region marine protected area.

All the estimates for yield (3,213–3,378 t) were higher than the pre-specified catch limit in Conservation Measure 91-05, which gives a range of 2,583–3,157 t as the total catch limit. Given this, a catch limit of 3,157 t for the 2017–18 and 2018–19 seasons was recommended (CCAMLR 2017a, b). Previous research has demonstrated that toothfish stocks that are fished at a rate of 3% of the estimated current biomass are likely to rebuild to the target level within two decades, even if currently near the limit reference point of 20% of unfished biomass (Welsford 2011). The catch limit for subarea 88.1 equates to 4.3% of the estimated current biomass. Given the relatively high estimate of current biomass in subarea 88.1, this TAC is therefore regarded as conservative.

Stock status determination

Given the relatively high spawning biomass, which is above the target reference point under the CCAMLR harvest strategy, the stock is classified as **not overfished**. The TAC was set at a conservative level based on previous research. IUU fishing has been largely eliminated by enforcement efforts. Given this precautionary approach, the limited entry to the fishery and the extensive CCAMLR review process, the stock is classified as **not subject to overfishing**.

Antarctic toothfish (*Dissostichus mawsoni*) in subarea 88.2

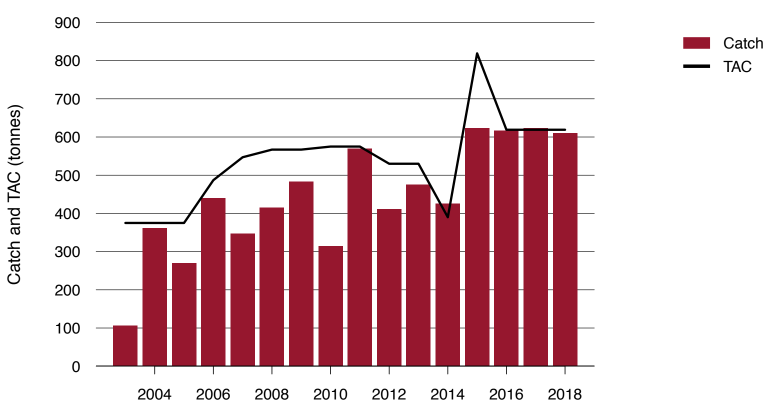
Stock structure

CCAMLR subarea 88.2 is divided into SSRUs that are labelled A to H. The stock assessment boundaries for the Amundsen Sea region (described here) consider SSRUs C–H to be a distinct stock (Hanchet & Parker 2014; Parker, Hanchet & Horn 2014). It is thought that spawning takes place on the northern seamounts in subarea 88.2 (SSRU H), with the larvae being transported by oceanographic processes to the east (SSRUs F–G).

Catch history

No catches were reported before 2001. Catches have generally increased since 2002 as the TAC has increased (Figure 27.5).

FIGURE 27.5 Total catch and TAC for CCAMLR subarea 88.2, 1997–2018



Note: **TAC** Total allowable catch. Catches from subarea 88.2 SSRUs A–B are included in the total catches, despite being assessed as part of subarea 88.1.
Source: CCAMLR

Stock assessment

The most recent full stock assessment of Antarctic toothfish from CCAMLR subarea 88.2 SSRUs C–H was conducted in 2013 using the CASAL integrated assessment model (Mormede, Dunn & Hanchet 2013). The assessment included catch data and catch-at-age frequencies from 2003 to 2013 for each SSRU. In addition, tag–recapture data for SSRU H were included because fishing in the other SSRUs has been inconsistent. Constant recruitment was assumed across the SSRUs.

The model runs produced some conflicting results, with some runs estimating unfished biomass to be lower than that estimated by earlier assessments completed in 2011 and 2013. The conflict was largely driven by the tagging data from SSRU H, which was considered reliable as a result of improved tagging and data collection procedures. In addition, the model runs with a reduced estimate of unfished biomass down-weighted the age data, which were limited and did not include SSRU H, the area from which most of the catch was taken.

The recommended model run down-weighted the age data and used the tagging data (Mormede, Dunn & Hanchet 2013). This model estimated the current level of biomass at 65% of unfished levels (B_{2013}/B_0 = 0.65; range 0.52–0.75). This is lower than the 2011 estimate of 82% of unfished biomass, but remains above the target reference point of 50%. The 2013 Working Group on Fish Stock Assessment could not reach consensus on the assessment, and it was not accepted. The working group noted that the assessment may not be representative of SSRUs C–G because most of the data driving the results came from SSRU H (CCAMLR 2013).

The CCAMLR Scientific Committee provided updated advice on the TAC in 2014 based on two biomass estimates for SSRU H, using the mark–recapture data and Petersen models (Goncharov & Petrov 2014; Parker & Mormede 2014). These were simple models using tagging data for SSRU H only, and excluded all the other data that would be used in an integrated assessment. They did not provide new biomass depletion estimates for subarea 88.2, and consequently the estimate from the 2013 integrated assessment (65%) remains the best biomass depletion estimate available, despite the lack of agreement on the assessment.

Based on the results of the Petersen models, the TAC for subarea 88.2 SSRUs C–H was set at 619 t, with 200 t designated for SSRU H and the remaining 419 t for SSRUs C–G (CCAMLR 2015a, b). A yield of 619 t equates to 3% of the estimated current biomass. Previous research has demonstrated that toothfish stocks that are fished at a rate of 3% are likely to rebuild to the target level within two decades, even if currently near the limit reference point of 20% of unfished biomass (Welsford 2011). Given the relatively high estimate of biomass in subarea 88.2, this TAC is therefore regarded as conservative.

In 2018, additional progress was made on updating the full assessment for SSRUs C–H using age-structured population models developed in CASAL (Mormede & Parker 2018) and data derived from the research plan for the area. While the model runs provide information on the biomass in two areas (north and south) and migration rates, the model should be considered indicative and not used for management advice at this stage. This is due to a lack of year-specific age-frequency data, limited spatial scale of the recaptures in the south and the changing spatial coverage in the northern area. Additional data and further work to rectify these gaps are recommended.

Stock status determination

Given the relatively high spawning biomass estimated in 2013, which is above the target reference point under the CCAMLR harvest strategy, the stock is classified as **not overfished**. The TAC was set at a conservative level based on previous research and was fully taken. IUU fishing has been largely eliminated by enforcement efforts. Given this precautionary approach, the limited entry to the fishery and the extensive CCAMLR review process, the stock is classified as **not subject to overfishing**.

27.3 Economic status

Key economic trends

Toothfish is a high-value species with well-established markets and supply chains, but fishing is undertaken in remote areas and under difficult operating conditions. Although there is potential for positive net economic returns (NER) to be generated by fishers in these exploratory areas, fishing has been sporadic and opportunistic, indicating some uncertainty for NER.

Subarea 88.2 was the first of the CCAMLR exploratory fisheries to be fished by Australia, in the 2014–15 fishing season, when Australia's catch was 34% of the global TAC. Since then, Australia's catch has decreased to 24% of the global TAC in 2016–17 and 7% in 2017–18.

Australia first started fishing in division 58.4.1 in the 2015–16 fishing season. Australia caught 2% of the global TAC in 2016–17 and 17% in 2017–18.

Australia first began fishing subarea 88.1 in the 2016–17 fishing season, catching 3% of the global TAC in the 2016–17 and 2017–18 fishing seasons.

Most recently, Australia began fishing in division 58.4.2 in 2017–18, catching 80% of the global TAC.

Management arrangements

The CCAMLR harvest strategy requires that the spawning biomass be 50% of pre-fished levels at the end of a 35-year projection period. For subarea 88.2, however, the TAC was set by calculating current biomass and setting the TAC at 4% of that biomass. This has previously been shown to be a precautionary method of setting the TAC, which is likely to allow stocks near the limit reference point to recover to the target level within two decades. A similar method is used to set the TAC for the research blocks in subarea 88.1 and division 58.4.1. Since the current biomass in subarea 88.2 is estimated to be above the target reference point, the TAC is considered conservative. When the TAC is fully caught, the fishery is closed. It is likely that operators currently incur high management costs given the 'new and exploratory' nature of the fishery. Given the precautionary TAC limits, there is likely potential for improvement in NER derived from these exploratory areas over the longer term for CCAMLR Member States fishing the area.

27.4 Environmental status

The fishery for toothfish in CCAMLR subareas 88.1 and 88.2 has been assessed as exempt from export controls under the *Environment Protection and Biodiversity Conservation Act 1999* until 31 October 2019. The fishery in CCAMLR divisions 58.4.1 and 58.4.2 is exempt until 27 November 2020. No special recommendations were included in the assessments beyond the usual requirements to ensure proper reporting and notification of changes to management arrangements, and to implement relevant CCAMLR conservation measures. No ecological risk assessment has been undertaken for these fisheries; however, catch limits apply for all species, including bycatch.

In the 2017–18 fishing season, no logbook or observer reports noted interactions between an Australian vessel and protected species in the CCAMLR exploratory fisheries.

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Chapter 28

High-seas fisheries for non–highly migratory species

L Georgeson

A small number of Australian fishing vessels target demersal fish species (those associated with the sea floor) in high-seas areas of the south Pacific and southern Indian oceans. The fisheries resources in these areas fall under the jurisdiction of two regional fisheries management treaties: the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean (South Pacific Regional Fisheries Management Organisation [SPRFMO] Convention), and the Southern Indian Ocean Fisheries Agreement (SIOFA). The SPRFMO Convention entered into force on 24 August 2012 and the SIOFA on 21 June 2012. Annual meetings of the SPRFMO Commission and Scientific Committee have been held since 2013. Annual Meetings of the Parties, the SIOFA decision-making body, have been held since 2015; and annual meetings of the SIOFA Scientific Committee have been held since 2016.

Demersal fishing on the high seas by Australian vessels occurs under permits issued by the Australian Fisheries Management Authority (AFMA). High-seas permits allow Australian vessels to fish in high-seas areas outside the Australian Fishing Zone (AFZ), outside the Exclusive Economic Zones (EEZs) of other countries, and within the area of competence of either the SPRFMO or the SIOFA (Figures 28.1 and 28.6).

The Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) does not prescribe management arrangements for fisheries managed under the joint authority of the Australian Government and an international management body or arrangement. However, its principles guide Australia's negotiating positions in international fisheries management forums.

The South Tasman Rise (STR) is an undersea ridge that stretches beyond the AFZ and into the SPRFMO Convention area (Figure 28.4). The South Tasman Rise Trawl Fishery (STRTF) is included in this chapter because it has not operated within the AFZ since 2007. The STR orange roughy (*Hoplostethus atlanticus*) stock is the only high-seas stock that is assigned a status classification in this chapter.

Orange roughy stocks have recently been assessed in the SPRFMO Convention area (Cordue 2017; Edwards & Roux 2017; Roux et al. 2017) and the SIOFA area of competence (Cordue 2018a, b). These assessments are reported briefly in this chapter, but status has not been assigned for any stocks or regional 'management units'. Catch limits for orange roughy for the Louisville Ridge (1,140 t) and the Tasman Sea (346 t) were implemented on 28 April 2019 under SPRFMO Conservation and Management Measure (CMM) 03a-2019. Because of the way catch limits have been determined (that is, one 'global' catch limit for multiple management units in the Louisville Ridge and Tasman Sea areas), and because spatially disaggregated catch data from New Zealand–flagged vessels are not available, fishing mortality status for individual management units cannot be assessed reliably. Biomass status is also challenging to determine because assessments for a number of management units in both the SPRFMO and SIOFA areas provide an estimate of the theoretical maximum potential depletion and not a reliable point estimate of biomass in relation to defined limit and target reference points.

Catch of orange roughy taken by Australian vessels in the SPRFMO and SIOFA areas is currently low and sporadic. Assessment of status may be attempted in future editions of the *Fishery status reports* if the required catch data are available and assessments are deemed sufficiently robust for determining biomass status of individual stocks or management units, and/or catches from these stocks taken by Australian vessels are deemed to constitute a proportion of catches that may influence stock sustainability.

28.1 South Pacific Regional Fisheries Management Organisation Convention area

Description of the fishery

The SPRFMO Convention covers non–highly migratory fisheries resources; it excludes highly migratory species listed in the United Nations Convention on the Law of the Sea (1982). The SPRFMO Convention area has historically been fished by vessels from various nations using pelagic and demersal fishing gear. The main commercial fisheries resources managed by the SPRFMO are Chilean jack mackerel (*Trachurus murphyi*) and jumbo flying squid (*Dosidicus gigas*). The SPRFMO also manages fisheries for lower-volume demersal species such as orange roughy and alfonsino (*Beryx splendens*).

The bottom fisheries target demersal species associated with seamounts, ridges and plateaus in the central, eastern and western areas of the south Pacific Ocean (Figure 28.1). Deep-sea structures tend to attract and support fish resources because their physical and biological properties enhance local productivity and retention. Some deepwater species form dense breeding aggregations over deep-sea structures, potentially allowing high catch rates and large catches (Norse et al. 2012). Some demersal species are slow growing and long lived, and aggregations can represent the accumulation of numerous age classes recruited over many decades. Initial catch rates typically made on these aggregations may not be sustainable, and can lead to rapid declines in abundance and availability (Norse et al. 2012). Long-term sustainable yields are usually only a small percentage of initial high catches.

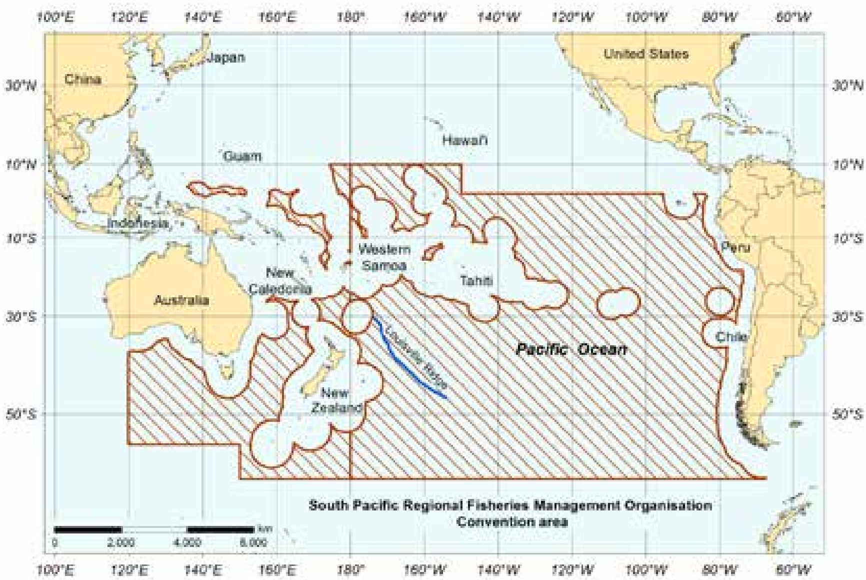
Trawl fleets from the former Union of Soviet Socialist Republics (USSR) began fishing the high seas in the south Pacific for deep-sea species in the early 1970s. These vessels fished several areas, taking pencil (or bigeye) cardinal fish (*Epigonus denticulatus*), orange roughy, blue grenadier (*Macruronus novaezelandiae*) and oreodories (Oreosomatidae) (Clark et al. 2007). Australia's and New Zealand's fisheries expanded into the high seas, and fisheries targeting orange roughy were established on the Louisville Ridge in 1993 and on the STR in 1997. These fisheries were predominantly fished by Australian and New Zealand vessels, but other nations, including Belize, Japan, Norway, Panama, the Republic of Korea and Ukraine, also accessed these deep-sea resources, although taking lower catches (Gianni 2004).

The species composition of catches from Australia's line and trawl fishing has varied over time. Historically, Australian high-seas fishing effort targeted orange roughy using demersal and midwater trawl gear. A low level of non-trawl activity, predominantly dropline and auto-longline methods targeting other species, such as jackass morwong (*Nemadactylus macropterus*), yellowtail kingfish (*Seriola lalandi*) and blue-eye trevalla (*Hyperoglyphe antarctica*), also occurred. Non-trawl catches now exceed those taken by trawl. An increase in catches of emperors (Lethrinidae) and deepwater snappers (*Etelis* spp.) (as well as other more subtropical species) in the non-trawl fishery in recent years reflects a change in the main fishing grounds used by Australian non-trawl vessels. Deep-sea gillnets were prohibited in 2010 under an interim measure applicable to all fishing vessels within the SPRFMO Convention area, and this gillnet prohibition was adopted in a SPRFMO CMM in January 2013 (SPRFMO 2013).

From 2007 until 28 April 2019, and in accordance with SPRFMO CMM 03-2018, Australia restricted fishing to within its 2002–2006 bottom-fishing footprint. In 2019, a revised bottom-fishing CMM (03-2019) was implemented in the SPRFMO Convention area. The revised CMM adopts a spatial management approach that uses predictive models to close areas with a high likelihood of vulnerable marine ecosystem (VME) habitat suitability in conjunction with zoning to allow fishing to continue in key productive areas. Under the revised CMM, catch of species other than orange roughy is limited to the average annual level between 2002 and 2006. Consistent with this and other SPRFMO CMMs, Australian high-seas fishing permits require the implementation of vessel monitoring systems, mandatory 100% observer coverage on all trawl vessels and a minimum of 10% observer coverage per vessel on all non-trawl vessels.

In 2011, Australia completed a bottom fishery impact assessment in the SPRFMO Convention area to examine whether individual bottom-fishing activities by Australian vessels have significant adverse impacts on VMEs (Williams et al. 2011a). The study concluded that the overall risk of significant adverse impacts on VMEs by Australian bottom trawl and bottom longline operations was low, and the impact caused by midwater trawling and droplining was negligible (Williams et al. 2011a). In accordance with CMM 03-2019, Australia and New Zealand intend to complete a cumulative bottom fishery impact assessment in 2020.

FIGURE 28.1 South Pacific Regional Fisheries Management Organisation Convention area



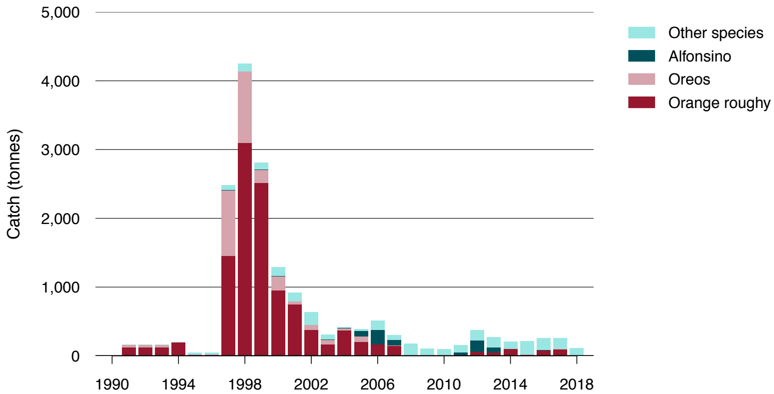
Catch and effort

Two Australian longline vessels were active in the SPRFMO Convention area in 2018. The total reported catch retained by these vessels was 116 t (Figure 28.2). Effort was 753,400 hooks.

Yellowtail kingfish accounted for 21% (24 t) of the 2018 longline catch; the remainder comprised jackass morwong (15%; 18 t), spotcheek emperor (*Lethrinus rubrioperculatus*; 12%; 14 t), yellowback bream (*Dentex spariformis*; 12%; 14 t), flame snapper (*Etelis coruscans*; 11%; 13 t) and other species (28%; 32 t). Logbook-reported discards in the longline fishery were 15 t.

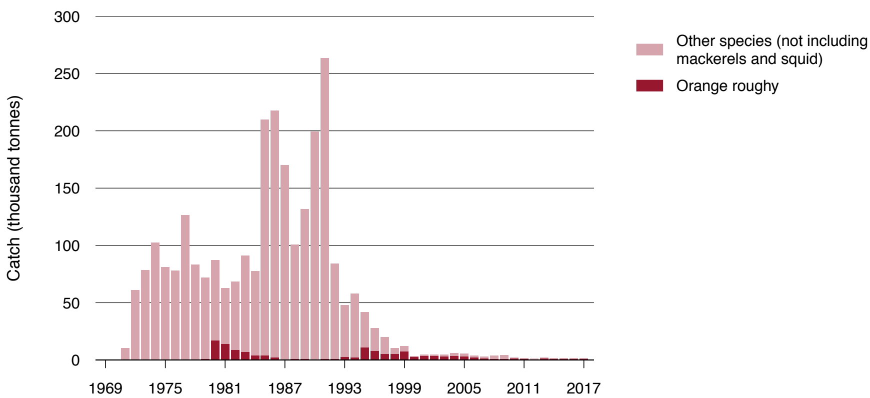
Total reported catch of demersal species by all fleets in the SPRFMO Convention area was 1,516 t in 2016 and 1,680 t in 2017 (Figure 28.3). Most of this catch was reported from the western SPRFMO Convention area, primarily by New Zealand vessels.

FIGURE 28.2 Australian trawl and line catch, by species, in the SPRFMO Convention area, 1990–2018



Source: AFMA

FIGURE 28.3 Total SPRFMO catch of demersal species, 1969–2017



Source: SPRFMO

Stock structure

The biological structure of stocks in the SPRFMO Convention area is uncertain. Research indicates that there is a greater level of genetic structure in global orange roughy populations than has previously been detected (Varela, Ritchie & Smith 2013). Analyses of biological data and various stock assessments have identified separate and geographically distinct fishing areas for orange roughy due to substantial distances or abyssal-depth waters. These fishing areas are STR, northern Lord Howe Rise, southern Lord Howe Rise, Challenger Plateau and West Norfolk Ridge.

In 2013, the first meeting of the SPRFMO Scientific Committee recommended that work be done to identify the existence and distribution boundaries of stocks of orange roughy and alfonsino that straddle EEZ boundaries and extend from EEZs into the SPRFMO Convention area. It is likely that alfonsino on northern Lord Howe Rise and orange roughy on Challenger Plateau, both within the SPRFMO Convention area, constitute such straddling stocks. Under the SPRFMO Convention, such stocks are subject to compatible management arrangements within EEZs and on the high seas.

Several regional management units of orange roughy have been assumed for assessment purposes in the SPRFMO Convention area. In addition to the STR stock (which straddles the AFZ and the SPRFMO Convention area), these units are Louisville North, Louisville Central, Louisville South, Lord Howe Rise, north-west Challenger Plateau and West Norfolk Ridge. Work is currently underway to improve the delineation of biological stocks of orange roughy in the SPRFMO Convention area.

SPRFMO orange roughy stock assessment

Several assessments have been attempted for orange roughy stocks in the SPRFMO Convention area (Clark, Dunn & Anderson 2010; Cordue 2017; Edwards & Roux 2017; Roux et al. 2017; Wayte et al. 2003). The Cordue (2017) assessment is a catch history–based method that uses an age-structured population model with parameters borrowed from five stocks within New Zealand's EEZ. The method focuses on the minimum virgin biomass (B_{min}) that would allow the historical catches to have been taken, assuming a maximum exploitation rate of 67%. The assessment results indicated that in 2015, five of the seven SPRFMO stocks were very likely to have been above a limit reference point of $0.2B_{0}$.[1] There was an indication that the north-west Challenger Plateau and Lord Howe Rise stocks may be below this limit reference point, and that recent exploitation rates would not enable stock biomass to increase.

SPRFMO CMM 03a-2019 was implemented in 2019 and sets catch limits for orange roughy for the management areas to the east and west of New Zealand. These catch limits are a combined 1,140 t for the three Louisville Ridge management units, and a combined 346 t for the three Tasman Sea management units.[2] For the Tasman Sea (which is where most of Australia's fishing has historically taken place), this catch limit has been established such that the limit could be safely taken from any of the three subunits without compromising the sustainability of any one subunit.

It should be noted that the results of the Cordue (2017) assessment are conditional on the stock hypotheses being approximately correct, and are highly uncertain. Nonetheless, catch limits derived from the assessment—particularly for the Tasman Sea—are likely to be highly precautionary. The SPRFMO has recommended that additional work be done to strengthen assessment outputs, including deriving age data from otoliths taken from fish in spawning aggregations and improving acoustic estimates of aggregation biomass.

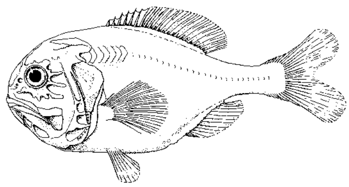
Woodhams et al. (2012) assessed the sustainability of harvest rates of species targeted by Australian vessels in the SPRFMO. The study concluded that only a small proportion of the total assumed habitat area for the target species had been fished by Australian vessels, and that none of the stocks targeted by Australia's high-seas fishing operations have been classified as overfished or subject to overfishing.

1 Reference points for orange roughy have not been adopted by the SPRFMO.

2 The Tasman Sea management units include Lord Howe Rise, north-west Challenger Plateau and West Norfolk Ridge, and exclude Westpac Bank and South Tasman Rise.

28.2 South Tasman Rise Trawl Fishery

Orange roughy (*Hoplostethus altanticus*)



Line drawing: Rosalind Murray

TABLE 28.1 Status of the South Tasman Rise Trawl Fishery

Status	2016		2017		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Orange roughy (*Hoplostethus atlanticus*)	Not subject to overfishing	Overfished	Not subject to overfishing	Overfished	Fishery has been closed since 2007 as a result of stock depletion.
Economic status	Fishery closed.				

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

Description of the fishery

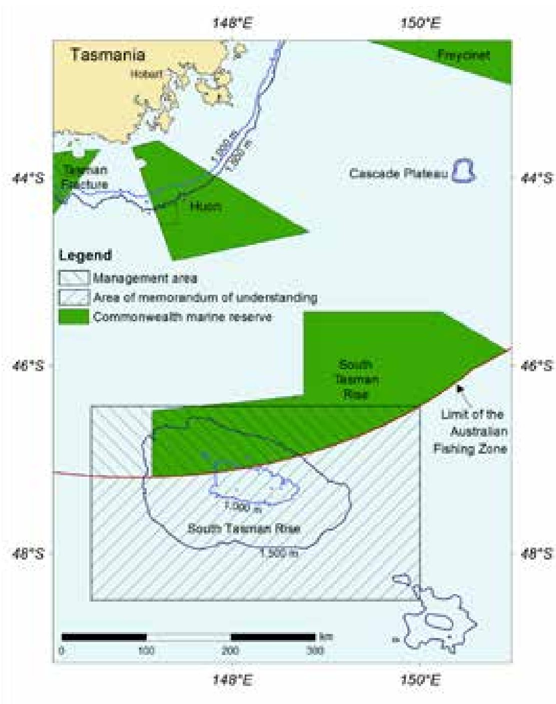
The STRTF includes areas inside both the AFZ and the high seas. The high seas portion falls within the competence of the SPRFMO and is managed in accordance with SPRFMO CMMs.

Fishing began in the STRTF in 1997, using demersal trawl to target a recently discovered orange roughy stock. The fishery has not operated since 2007. Under the United Nations Fish Stocks Agreement,[3] other countries are entitled to access the high-seas portion of the stock, provided that a cooperative management regime with consistent measures for both portions of the stock (inside and outside the EEZ) is established.

Australia and New Zealand established a memorandum of understanding for cooperative management of the orange roughy stock in the STR in 1998. Both governments agreed to set a total allowable catch of zero, which is now reflected in SPRFMO CMM 03a-2019.

3 The full title of the agreement is the United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks; see un.org/depts/los/convention_agreements/convention_overview_fish_stocks.htm.

FIGURE 28.4 Area of the STRTF

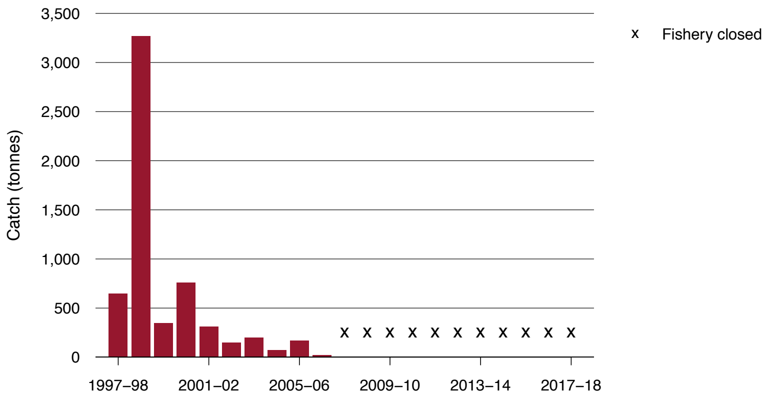


Catch history

Orange roughy catches peaked at 3,270 t in 1998–99 and declined thereafter (Figure 28.5). From 2001 to 2006, when fishing was occurring, less than 10% of the total allowable catch was landed. Following indications of depletion of the orange roughy stock in the 2002 stock assessment and the limited fishing for several subsequent years, the STR was closed to Australian fishing vessels—both inside and outside the AFZ—in 2007.

In the later years of activity in the STRTF, catch was mostly smooth oreodory (*Pseudocyttus maculatus*) and spikey oreodory (*Neocyttus rhomboidalis*). No formal stock assessment of oreodories in the STRTF has been undertaken. However, before the fishery was closed, trends in catch and catch rates for these species indicated that stocks had been fished down. If fishing in the STRTF resumes, management arrangements for oreodories should be considered as part of the development of a revised harvest strategy, to ensure that these species are not overexploited.

FIGURE 28.5 Australian orange roughy catch in the STRTF, 1997–98 to 2017–18



Stock structure

The orange roughy stock in the STR is managed independently, as a discrete population, as are the orange roughy stocks in the other fishing zones in the Southern and Eastern Scalefish and Shark Fishery (see Chapter 9).

Stock assessment

An assessment of the orange roughy stock in the STRTF by Wayte et al. (2003) used catches and catch rates in a standardised catch-per-tow analysis, as well as examining acoustic data collected during the 1998–2002 winter spawning seasons. Annual reported catches in the fishery declined after the first couple of years (Figure 28.5). Standardised catch-per-tow analysis (Wayte et al. 2003) indicated that catch rates declined by 92% between 1997–98 and 2002–03. Anecdotal information suggests that illegal catches in 1999 may have been substantially higher than documented. These reductions in catch and catch rate, when the cumulative total reported catch was 11,341 t, indicate that the initial stock biomass was not large compared with some other orange roughy populations and had been considerably reduced by 2002–03 (Wayte et al. 2003).

No recovery was evident after this, and estimated relative abundance in 2002–03 was only 8% of abundance in 1997–98 (Wayte et al. 2003). No significant acoustic marks, indicative of spawning aggregations, were apparent during industry surveys in 2000, 2001 or 2002. Although orange roughy may not form spawning aggregations in the same location every year, the absence of aggregations for several consecutive years is concerning. The assessment concluded that there was little doubt that the stock size, or the availability of fish to the fishery, had decreased dramatically after the first couple of years of the fishery and shown no signs of recovery. The fishery has not been surveyed since 2002.

Stock status determination

The assessment by Wayte et al. (2003) indicates that the stock biomass had been overfished. The life history characteristics of orange roughy may make the recovery of the stock a slow process—possibly in the order of decades—given the estimated level of depletion. Although the fishery has not been surveyed since 2002, in the absence of any new information, the stock remains classified as **overfished**. Since the fishery is closed, the stock is classified as **not subject to overfishing**.

28.3 Southern Indian Ocean Fisheries Agreement area of competence

Description of the fishery

Fisheries in the SIOFA area predominantly target demersal or benthopelagic species using demersal trawl, midwater trawl and demersal longline gears. Fishing in the SIOFA area occurs on or near seamounts and ridges in the southern Indian Ocean (Figure 28.6). The former USSR began deep-sea trawling in what is now the SIOFA area in the 1960s. USSR vessels conducted periodic deep-sea trawl research cruises on a commercial scale from the mid 1970s until the dissolution of the USSR in 1991. During the 1990s, several Ukrainian-flagged deep-sea trawl vessels operated in the area (Bensch et al. 2009; Clark et al. 2007; Romanov 2003). No catch has been recorded by Ukraine since 2001.

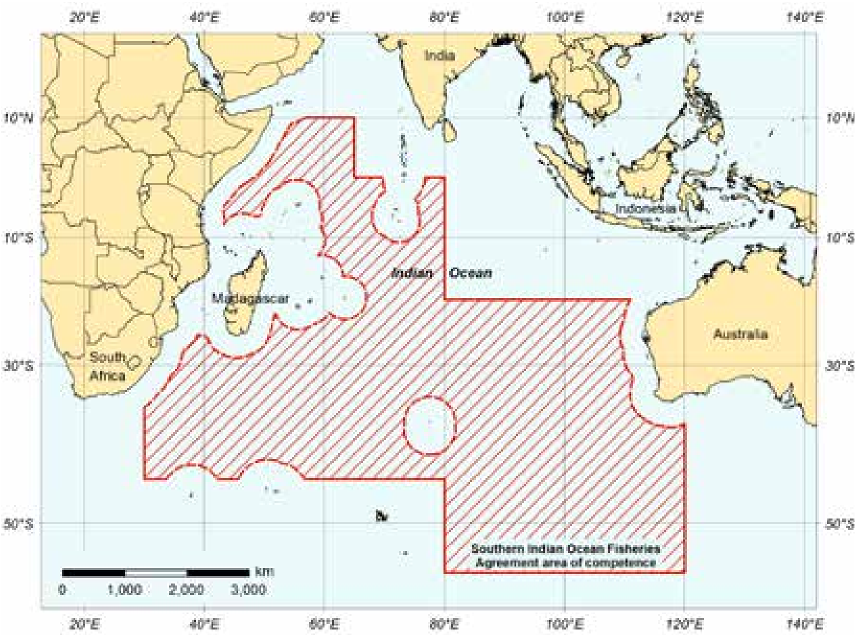
Deep-sea trawlers from Australia and New Zealand were reportedly fishing in the SIOFA area before 1999. In 1999, deep-sea trawling in the area increased substantially after orange roughy stocks were discovered (Japp & James 2005). In 2000, the combined catch of all deepwater species for all international vessels in the area was estimated at 40,000 t (Bensch et al. 2009), which was taken by up to 50 vessels from more than 12 nations. Accurate catch data are not available for many of these vessels because of the unregulated nature of the high-seas fishery at that time (Bensch et al. 2009). Although more vessels were thought to be fishing, only eight reported participating in the fishery to the Food and Agriculture Organization of the United Nations (FAO) in 2001.

Australian vessels have reported catch from the SIOFA area since 1999. Fishing methods have been specified on Australian high-seas permits issued by AFMA since 2008; they include midwater trawl, demersal trawl, auto-longline, dropline and trap. Gillnetting was permitted up to 2008, but there are no records of gillnetting by Australian operators in the area after 1999 (Williams et al. 2011a), and AFMA has since prohibited the use of deepwater gillnets by Australian fishing vessels.

In 2011, Australia completed a bottom fishery impact assessment in the SIOFA area to examine whether individual bottom-fishing activities by Australian vessels have significant adverse impacts on VMEs (Williams et al. 2011a). The study concluded that the current overall risk of significant adverse impacts on VMEs by Australian bottom trawl and bottom longline operations is low, and the impact caused by midwater trawling and droplining is negligible (Williams et al. 2011a).

SIOFA has adopted various CMMs, including CMMs relating to large-scale pelagic driftnets and deepwater gillnets; interim management measures for bottom fisheries; an authorised vessel list; an illegal, unreported and unregulated vessel list; vessels without nationality; data standards and data confidentiality; and measures to regulate at-sea and in-port transshipment and vessel monitoring systems.

FIGURE 28.6 Southern Indian Ocean Fisheries Agreement area of competence



Recent catch and effort

Midwater and demersal trawl have contributed most of Australia's historical catch from the SIOFA area. In 2016, one multipurpose vessel (trawl and demersal longline) was active in the fishery. No Australian vessels fished in the SIOFA area in 2017. One fishing trip was undertaken in late 2018, extending into 2019, using bottom line gears.

Because of confidentiality restrictions, catch data for the SIOFA area cannot be disclosed. The main species caught in 2018 using bottom line gears were hapuku (*Polyprion oxygeneios*) and bass groper (*P. americanus*).

Stock structure

The biological structure of stocks in the SIOFA area is uncertain. For orange roughy, seven regional units have been assumed for assessment purposes: Walters Shoal region, Meeting, North Walters, Seamounts, North Ridge, Middle Ridge and South Ridge.

SIOFA orange roughy stock assessment

Assessments have recently been attempted for seven orange roughy stocks in the SIOFA area (Cordue 2018a, b). The assessment for the Walters Shoal region (Cordue 2018a) incorporates biological data in conjunction with a stock hypothesis, a catch history and acoustic estimates. The results indicate that the absolute scale of the stock is very uncertain because the true scale of the acoustic biomass estimates is poorly known. Virgin biomass is estimated to be in the range of 25,000–90,000 t. Given the stock hypothesis, it is highly likely that stock biomass is above $0.5B_0$.

For six stocks, a catch history–based assessment was undertaken (Cordue 2018b). For three of these stocks, Cordue also did a simple model-based assessment that incorporated acoustic biomass estimates and borrowed results from the Walters Shoal Region. Exploitation rates of 5% and 40% were used to bound stock size and estimates of biomass. Under the assumption of a maximum exploitation rate of 40%, the spawning biomass (SB) in 2017 was estimated to be $0.22SB_0$ for the Seamounts region and $0.43SB_0$ for the South Ridge region. All other stocks were estimated to be above $0.5SB_0$ under this assumption.

Woodhams et al. (2012) assessed the sustainability of harvest rates of species targeted by Australian vessels in the SIOFA area. The study concluded that only a small proportion of the total assumed habitat area for the target species has been fished by Australian vessels, and none of the stocks targeted by Australia's high-seas fishing operations have been classified as overfished or subject to overfishing.

28.4 Economic status

The gross value of production is not available for the SPRFMO and SIOFA areas for confidentiality reasons. In 2018, two vessels were active in the SPRFMO area, and one vessel was active in the SIOFA area. Given limited catches in recent years, the value of the fisheries would be relatively low compared with other Australian fisheries.

The STRTF has been assessed as overfished, and so stocks are below the level associated with maximum economic yield. The fishery has been closed since 2007, so its economic status has not been assessed.

28.5 Environmental status

Deep-sea fisheries generally operate at depths of 200–1,600 m, on continental slopes or isolated oceanic structures such as ridges, seamounts and banks (FAO 2012). The depths and distances from the coast pose challenges to research, assessment and management of the effects of fishing on the environment and on target stocks (FAO 2012).

Impact assessment of bottom fishing

Under the United Nations General Assembly resolutions on sustainable fisheries (specifically, paragraph 83a of resolution 61/105, and paragraph 119(a) of resolution 64/72), states are called on to assess, based on the best available scientific information, whether individual bottom-fishing activities would have a significant adverse impact on VMEs, and to ensure that these activities are managed to prevent such impacts or are not authorised to proceed. This obligation was reflected in the SPRFMO interim measures (SPRFMO 2007), resulting in the development and adoption by the SPRFMO of a standard for impact assessment of bottom fisheries (SPRFMO 2012), compatible with the FAO deepwater guidelines (FAO 2009). SIOFA adopted a similar bottom-fishing impact assessment standard in 2017. The SPRFMO is currently updating its standard in accordance with CMM 03-2019, and Australia and New Zealand are required to undertake a cumulative assessment of bottom-fishing impacts in accordance with this standard by 2020.

The South Tasman Rise Commonwealth Marine Reserve, which came into effect in 2007, overlaps with the STRTF (Figure 28.4). The reserve covers 27,704 km^2, including several seamounts. Commercial fishing is not permitted in the reserve. Several other marine reserves are near the STRTF.

Australia completed bottom-fishing impact assessments for demersal fishing activities in the south Pacific and southern Indian oceans in 2011 (Williams et al. 2011a, b). The impact assessments for both areas concluded that the current overall risk of significant adverse impacts on VMEs by Australian vessels fishing with bottom trawls and bottom-set auto-longlines was low, primarily because of the low fishing effort and the small number of areas of high fishing intensity. The assessments also concluded that the current overall risk of significant adverse impacts on VMEs from midwater trawling and droplining by Australian vessels was negligible (Williams et al. 2011a, b), based on the low level of fishing effort, the small number of areas of high fishing intensity and the effects of current management arrangements.

List of exempt native specimens

Under part 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Australian fisheries are assessed to ensure that they are managed in a manner that does not lead to overfishing, and that fishing operations are managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem. In 2018, Australia's high-seas fisheries were reaccredited for eight years under the EPBC Act.

Since 2010, AFMA observers have recorded few interactions with protected species in the SPRFMO and SIOFA fisheries, and none were reported in 2018.

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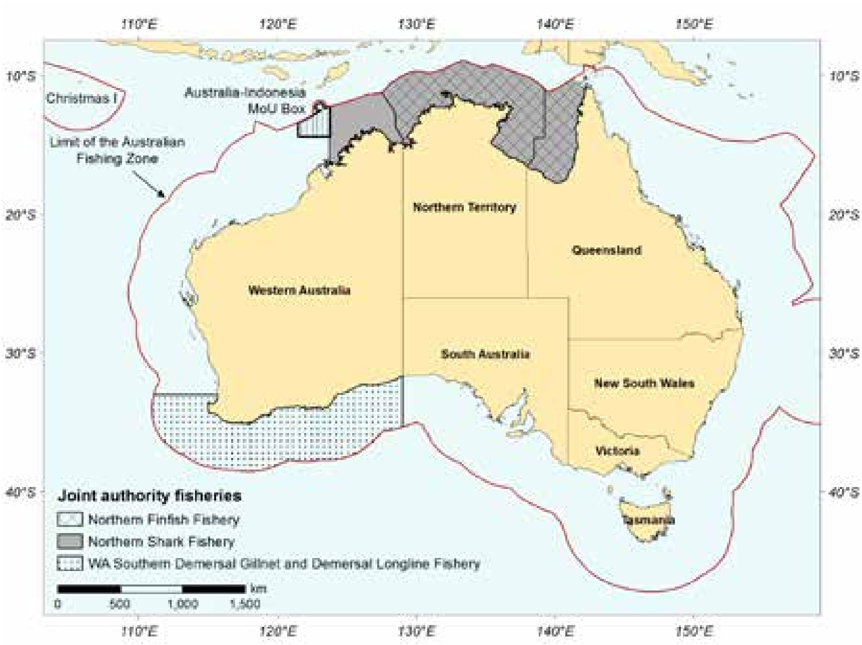
Chapter 29
Joint authority fisheries

R Noriega and T Emery

FIGURE 29.1 Geographic extent of the joint authority fisheries



The Australian Government is a party to several fisheries managed under joint authority arrangements with state governments or the Northern Territory Government. These arrangements are species or area based, and recognise that stocks are likely to be shared with adjacent national or international jurisdictions. In northern Australian waters, several shark and finfish joint authority fisheries (JAFs) are collectively referred to in this report as the Northern Shark Fishery and the Northern Finfish Fishery (Figure 29.1). This chapter reports on these northern fisheries and on the Western Australian Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australian JAF). In each case, strategic directions are provided by members of the joint authority, while the day-to-day management of the fishery is undertaken by the relevant state or territory government, under its legislation. The relevant jurisdictions assess and report on the management and status of the fisheries. The stocks harvested in these fisheries are not formally classified in this report.

Since 1988, the Western Australian Government has managed the Western Australian JAF on behalf of a joint authority comprising the Western Australian and Australian governments. In 1995, under the Offshore Constitutional Settlement (OCS), jurisdiction of the finfish resources (except for tuna and tuna-like species) in the waters off northern Western Australia, west of 123°45'E, was passed to the Western Australian Government. These resources are not further addressed here. On 30 July 2018, the Federal Assistant Minister for Agriculture and Water Resources, and the Western Australian Minister for Water, Fisheries, Forestry, Innovation and ICT, and Science co-signed the amendments to the OCS giving Western Australia sole jurisdiction for the Western Australian JAF. The change in jurisdiction took effect on 1 December 2018.

Also in 1995, under the OCS, the Northern Territory Fisheries Joint Authority (NTFJA) and the Queensland Fisheries Joint Authority (QFJA) were given jurisdiction to manage northern finfish (except for tuna and tuna-like species) and sharks in waters adjacent to each jurisdiction out to the boundary of the Australian Fishing Zone (AFZ) (Figure 29.1).

Torres Strait fisheries are managed under different arrangements by the Protected Zone Joint Authority established under the *Torres Strait Fisheries Act 1984* (Cth) (see Chapter 15).

29.1 Western Australian Temperate Demersal Gillnet and Demersal Longline Fisheries

Currently, two shark fisheries operate off the south and west coasts of Western Australia: the Western Australian JAF and the state-managed West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDF). Collectively, these fisheries are managed as the Temperate Demersal Gillnet and Demersal Longline Fisheries. The Western Australian JAF extends south-east from south of Cape Bouvard (just north of Bunbury on the southern west coast) to the Western Australia – South Australia border (Figure 29.1); it had 17 active vessels in 2016–17 (Woodhams et al. 2018). The WCDF, which is managed under a complementary management plan, extends north from Cape Bouvard and catches many of the same species; it had five active vessels in 2016–17 (Woodhams et al. 2018). The status of species taken in these two fisheries is determined by the Western Australian Department of Primary Industries and Regional Development, using catch-and-effort information from both fisheries. Statistics provided here are from either Woodhams et al. (2018) or Braccini and Blay (2019).

The principal species targeted in the Western Australian JAF are gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark (*Furgaleus macki*) and sandbar shark (*C. plumbeus*). Another 25 species of shark and scalefish are also caught regularly, the most common being hammerhead sharks (Sphyrnidae), spinner shark (*C. brevipinna*) and wobbegong sharks (Orectolobidae) (McAuley et al. 2015). School shark (*Galeorhinus galeus*) was historically targeted in the south-eastern region of the fishery but is currently only taken incidentally as a minor byproduct species. Principal target species in the WCDF are dusky shark, sandbar shark and whiskery shark.

Combined 2016–17 logbook data for the Western Australian JAF and the WCDF indicated a total shark and ray catch of 936 t (a decrease from 994 t in 2015–16), comprising mostly gummy shark (417 t), dusky shark (204 t), sandbar shark (17 t) and whiskery shark (142 t) (Braccini & Blay 2019). Catches of scalefish in both fisheries totalled 133 t in 2016–17 (a decrease from 143 t in 2015–16). The catch included blue groper (*Achoerodus gouldii*), queen snapper (*Nemadactylus valenciennesi*), pink snapper (*Chrysophrys auratus*) and dhufish (*Glaucosoma hebraicum*) (McAuley et al. 2015). Export accreditation was assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the fishery was declared an approved Wildlife Trade Operation until 20 August 2021.

Status of stocks

The fishery is managed primarily by setting maximum fishing effort levels. These are intended to achieve acceptable catches and maintain biomass at greater than 40% of initial unfished levels for the key target species (gummy, whiskery and dusky sharks) (Braccini & Blay 2019). The time frame for achieving the target biomass varies from species to species (McAuley et al. 2015).

The most recent weight-of-evidence assessment of Western Australian gummy shark estimated a low current risk level for the stock, with 87%, 100% and 100% of the simulated current (2015–16) relative total biomass trajectories being above the target, threshold and limit biomass reference points, respectively. Consequently, the gummy shark stock is considered to be sustainable–adequate (Braccini & Blay 2019).

Previous stock assessments of whiskery shark indicate that biomass declined significantly from the 1980s to less than 40% of the unfished level in the early 1990s. The most recent weight-of-evidence assessment estimated a medium current risk level for the whiskery shark stock, with 82%, 92% and 100% of the simulated current (2015–16) relative total biomass trajectories being above the target, threshold and limit biomass reference points, respectively. Consequently, the whiskery shark stock is considered to be sustainable–adequate (Braccini & Blay 2019).

Most dusky sharks taken in the Western Australian JAF are neonates (less than a year old) and 1–2-year-old fish. Demographic analyses, updated in 2005, estimated that the current fishing mortality on these age classes was sustainable, but that a very low level of fishing mortality (1–2% per year) for older dusky sharks (>10 years) would result in negative rates of population growth. Although spatial closures have been implemented to protect adult dusky sharks, they continue to be captured in fisheries within and outside Western Australia's jurisdiction (such as the Commonwealth Western Tuna and Billfish Fishery and the South Australian Marine Scalefish Fishery). Previous estimates indicated that the breeding stock had been depleted by low, but poorly quantified, levels of fishing mortality. The most recent weight-of-evidence assessment estimated a medium current risk level for the dusky shark stock, with 46%, 73% and 100% of the simulated current (2015–16) relative total biomass trajectories being above the target, threshold and limit biomass reference points, respectively. Hence, current management arrangements are considered suitable to allow gradual recovery of the breeding stock, and the dusky shark stock is considered to be sustainable–recovering (Braccini & Blay 2019).

School shark is taken as byproduct in the Western Australian JAF. Management of this species takes into account its overfished status in the Southern and Eastern Scalefish and Shark Fishery (SESSF; Chapter 8). Assessments of school shark in the SESSF incorporate catch information from the Western Australian JAF. Catch of school shark in the Western Australian JAF and the WCDF in 2016–17 was 27 t (Braccini & Blay 2019).

29.2 Northern shark fisheries

Australian gillnetters began fishing in northern Australian waters in about 1980, although there was fishing from foreign vessels before then that continued until 1986. The northern shark fisheries were developed during the 1980s and 1990s, and transferred to the relevant joint authorities in 1995. They include the Northern Territory Offshore Net and Line Fishery, the Queensland Gulf of Carpentaria Inshore Fin Fish Fishery and the Western Australia Joint Authority Northern Shark Fishery (WANSF). The fisheries cover waters off Australia's northern coast, encompassing the Gulf of Carpentaria, the Timor and Arafura seas, Joseph Bonaparte Gulf, and the north-east coast of Western Australia (Figure 29.1).

The primary fishing methods are gillnetting and longlining, and most activity and catch occur in waters off the Northern Territory. Historically, the main commercial species have been blacktip sharks (Australian blacktip—*Carcharhinus tilstoni*, and common blacktip—*C. limbatus*), spot-tail shark (*C. sorrah*) and grey mackerel (*Scomberomorus semifasciatus*). The Australian and common blacktip sharks are difficult to differentiate and so have been treated as a species complex, with the assumption that most are Australian blacktip, although genetic analyses have challenged this assumption (discussed in 'Status of stocks', below). Other shark species, including hammerheads (*Sphyrna* spp.), bull shark (*C. leucas*), pigeye shark (*C. amboinensis*) and tiger shark (*Galeocerdo cuvier*), are also caught. Sharks are also taken as bycatch and byproduct in other fisheries in the area.

Northern Territory Offshore Net and Line Fishery

This fishery is managed by the NTFJA, in accordance with the *Fisheries Act* (NT, 1988). An individual transferable quota management framework and associated harvest strategy were introduced in December 2018 (Northern Territory Government 2018). Most fishing in the waters off the Northern Territory occurs in inshore waters (less than 12 nautical miles [nm] from the coast), targeting blacktip sharks and grey mackerel. Catch-and-effort data for 2018 were provided directly to ABARES from the Northern Territory Department of Primary Industry and Resources. Pelagic gillnets (limited to 2,000 m net length) are the main gear. Although longlines can also be used, they have not been used in the fishery since 2013 (Northern Territory Government 2018). All of the 11 licences issued were active in 2018, recording 595 boat-days fished—well below the peak of 1,801 boat-days in 2003.

The highest domestic catch was reported in 2003 (1,687 t), including 899 t of shark (of which 501 t was blacktip shark) and 766 t of grey mackerel. Total landings have decreased since 2003, to a total catch of 694 t in 2018 (an increase from the 2017 catch of 645 t). The 2018 catch included 32 t of blacktip shark and 502 t of grey mackerel. Export accreditation has been granted under the EPBC Act until 27 March 2022.

Queensland Gulf of Carpentaria Inshore Fin Fish Fishery

The QFJA manages shark fishing in Gulf of Carpentaria waters off Queensland as part of the Gulf of Carpentaria Inshore Fin Fish Fishery. An annual summary of this fishery is provided by the Queensland Department of Agriculture and Fisheries (QDAF 2019). The fishery has two sectors: an offshore sector (7–25 nm) that targets tropical sharks and grey mackerel, and an inshore sector (within 7 nm of the shore) that targets barramundi (*Lates calcarifer*), threadfins (Polynemidae) and sharks. The main gear used is gillnets; operators in the offshore sector are limited to a maximum net length of 1,800 m. Of the 85 licences issued in 2018, 75 were active, 3 in the offshore sector and 72 in the inshore sector (QDAF 2019). In 2018, reported catch of blacktip sharks was 112 t (a decrease from 200 t in 2017) (QDAF 2019).

Queensland considers most barramundi stocks to be sustainable, except for the southern Gulf of Carpentaria stock, which is classified as depleting (Saunders et al. 2018a). The east coast stock of king threadfin (*Polydactylus macrochir*) is considered sustainable; however, the Gulf of Carpentaria stock is considered depleting (QDAF 2017). No concerns for harvest of shark species were identified in reviews by Holmes et al. (2013). Export accreditation has been granted under the EPBC Act until 18 March 2022.

Western Australia Joint Authority Northern Shark Fishery

The Western Australian Government manages the WANSF. For reporting and assessment purposes, this fishery is combined with the adjacent Western Australia North Coast Shark Fishery (WASF) and reported as part of the 'northern shark fishery'. The WANSF extends from longitude 123°45'E to the Northern Territory border, and the WASF extends from longitude 114°06'E to 123°45'E. Western Australia reported on the status of these fisheries in McAuley and Rowland (2012), and Molony, McAuley & Rowland (2013); however, the WANSF and the WASF are no longer included in the Western Australian state of the fisheries report. Since 2005, demersal gillnets and longlines have been permitted in both fisheries, with longlines being the main gear used. Fishing activity has not been reported in the northern shark fishery since 2008–09.

An increase in effort occurred in this fishery between 1999–2000 (less than 100,000 hook-days) and 2004–05 (1.2 million hook-days). The total catch showed a corresponding increase, from approximately 100 t (1999–2000) to 1,294 t (2004–05). Fishing practices also changed, with a shift from primarily gillnetting in the north-eastern region of the fishery to increased demersal longline effort in the south-western region (McAuley & Baudains 2007). The changes reflected increased targeting of sandbar shark and other large species.

The stock assessment for sandbar shark, which considers all take of the species across Western Australian fisheries, suggested that cumulative levels of fishing mortality were increasingly unsustainable between 2001 and 2004, and had probably been unsustainable since at least 1997–98 (McAuley et al. 2015). Three-quarters of the total catch in 2004–05 was from the northern shark fishery alone. A decline in breeding stock abundance has been inferred from fishery-independent survey data from the north-coast region (McAuley et al. 2015).

Management measures to prevent targeting of sandbar shark in the WASF were put in place in 2005; these included closure of about 60% of the fishery to protect breeding stock and limits on the permitted number of fishing days. At the same time, management arrangements to limit effort were established in the WANSF. These measures resulted in a substantial decline in total fishing effort and an associated decrease in total reported catch.

In 2008, the WANSF's Wildlife Trade Operation approval under the EPBC Act was revoked because a formal management plan had not been finalised. The WASF's approval expired in early 2009 and has not been renewed. Therefore, product from these fisheries cannot be exported.

Other catches, including illegal fishing

Across the area of the northern shark fisheries, sharks are caught as bycatch and byproduct in other Commonwealth, state and territory fisheries. In Western Australia, the 2014–15 catch of sharks by other state-managed fisheries was negligible—less than 10 t (it peaked at 31 t in 2005–06)—as a result of a ban on retention in all but three non-shark fisheries (McAuley & Baudains 2007; Molony, McAuley & Rowland 2013). The Northern Territory Government estimates that incidental catch in other Northern Territory fisheries is around 1% of the total combined fisheries shark catch; retention is banned in some fisheries and limited by byproduct limits in others (Martin & McKey 2012). Retention of any shark product has been banned in the Northern Prawn Fishery since 2001.

Under a memorandum of understanding (MOU), Australia allows access by traditional Indonesian fishers to a limited area of the AFZ off north-western Western Australia, known as the 'MOU Box'. Operation Snapshot is an opportunistic activity that aims to estimate catches by traditional Indonesian fisheries operating in these waters (Marshall, Giles & Johnson 2016). In 2015, genetic analysis of 152 shark fins from nine fishing vessels identified 16 species belonging to the families Carcharhinidae (whaler sharks) and Sphyrnidae (hammerhead sharks). The two most abundant species by number were sandbar shark and tiger shark, which made up 43.4% and 29.6% of the catch, respectively, followed by spinner shark (7.2%) and grey reef shark (*Carcharhinus amblyrhynchos*; 5.3%) (Marshall, Giles & Johnson 2016). The observed species composition was similar to that found on other Indonesian vessels fishing in northern Australian waters; however, there was a notable absence of smaller inshore shark species (Marshall, Giles & Johnson 2016).

Historically, illegal foreign fishing in northern waters is generally conducted by small vessels that target a range of species, including shark, reef fish and sedentary species such as sea cucumber and trochus (Vince 2007). In 2017–18, 14 illegal foreign fishing vessels (nine Indonesian and five Papua New Guinean) were apprehended in Australian waters. In 2016–17, 15 illegal foreign fishing vessels were apprehended (six Indonesian, one Papua New Guinean and eight Vietnamese). A high-risk area was the Coral Sea, off far north Queensland, where the eight Vietnamese vessels, fishing for bêche-de-mer, were apprehended. Since these apprehensions and an in-country education program, no Vietnamese boats have been sighted or apprehended inside the AFZ. Overall numbers are well down on the 367 vessels apprehended in 2005–06, reflecting the sustained and coordinated effort by Australian Government agencies to reduce the significant number of vessels being apprehended each year. No Vietnamese fishing vessels were apprehended in the AFZ during 2017–18.

Status of stocks

The Northern Territory Government updated a stock assessment of common blacktip shark and Australian blacktip shark in 2013 (Grubert et al. 2013). The assessment indicated that the species have recovered from depletion associated with the historically high catches of the 1970s and 1980s, when foreign-flagged vessels operated in Australian waters. Fishing mortality for both species was estimated to be below the level that produces maximum sustainable yield (MSY; 19% of MSY for common blacktip shark and 12% of MSY for Australian blacktip shark), and the current level of fishing effort was sustainable. Current biomass is estimated to be at 81% of unfished biomass for common blacktip shark and 90% for Australian blacktip shark.

Genetic studies (Ovenden et al. 2009) of spot-tail and Australian blacktip sharks show little genetic variation in either species across the north, suggesting that it may be appropriate to manage each species as a single stock across the region. In contrast, common blacktip shark may have genetic subdivisions in Australian waters (Ovenden et al. 2009). Genetic studies also detected an apparent change in the relative proportion of common and Australian blacktip sharks in the catch. In the 1980s, Australian blacktip shark was understood to be the major component of the catch, and common blacktip shark was caught in much lower numbers (the ratio of Australian to common blacktip shark was estimated to be 300:1; Stevens & Davenport 1991). More recent studies have indicated a ratio closer to 1:1 (Morgan et al. 2012). In 2011, genetic research demonstrated that hybridisation was occurring between the species (Morgan et al. 2012). The results have increased the uncertainty in the status of the stocks, and the implications have yet to be fully assessed.

29.3 Northern Finfish Fishery

Foreign pair and stern trawlers (Chinese, Japanese, Taiwanese and Thai) have fished waters off northern Australia periodically since the 1930s. After the AFZ was declared, foreign trawlers were licensed to fish in the northern AFZ until 1990. The main regions fished were the Timor and Arafura seas, and the North West Shelf off Western Australia. The foreign fleets' highest catches were 37,100 t on the North West Shelf (1973), 9,100 t in the Timor Sea (1974) and 10,000 t in the Arafura Sea (1983). Australian trawlers started fishing in the area in 1985; a domestic trap-and-line fishery began on the North West Shelf in 1984, and droplining in the Timor Sea began in 1987.

The main species targeted are large red snappers (saddletail snapper—*Lutjanus malabaricus*, and crimson snapper—*L. erythropterus*) and goldband snappers (primarily *Pristipomoides multidens*, but also *P. typus* and *P. filamentosus*). The joint authorities include trawl, dropline and trap fisheries, which have developed differently over time.

Northern Territory

The NTFJA manages two fisheries targeting tropical snappers: the Timor Reef Fishery and the Demersal Fishery. The Timor Reef Fishery operates offshore, north-west of Darwin in a specific area of the Timor Sea. The Demersal Fishery operates in waters from 15 nm out to the AFZ boundary, excluding the area of the Timor Reef Fishery. Until recently, the NTFJA also managed a third snapper fishery, the Finfish Trawl Fishery, but, in February 2012, this was amalgamated into the Demersal Fishery under a new management framework (Saunders, Johnson & McKey 2014). In February 2011, the Northern Territory implemented quota management in the Timor Reef Fishery to better use the offshore snapper stocks and provide increased flexibility to operators (NT DoR 2011; Saunders, Johnson & McKey 2014). Individual transferable quotas were introduced into the new management framework of the Demersal Fishery in 2012.

Vessels in the Demersal and Timor Reef fisheries use vertical droplines and baited traps to target goldband snappers, but also catch red snappers (Lutjanidae), red emperor (*Lutjanus sebae*) and cods (*Epinephelus* spp.). The Demersal Fishery also permits semipelagic finfish trawl gear in two multigear areas. Dropline fishing takes mostly goldband snappers, whereas traps catch nearly equal proportions of goldband snappers and red snappers. Trawl vessels mainly target saddletail snapper and crimson snapper. The status of these fisheries is reviewed in Martin and McKey (2014a, b). Catch-and-effort data for 2018 were provided directly to ABARES from the Northern Territory Department of Primary Industry and Resources.

In 2018, six vessels were active in the Timor Reef Fishery, recording 829 vessel-days, and six vessels were active in the Demersal Fishery, recording 1,341 vessel-days. The Timor Reef Fishery reported a total catch of 837 t in 2018 (836 t in 2017), including 279 t of goldband snappers and 337 t of red snappers. The Demersal Fishery reported a total catch of 3,359 t in 2018, including 250 t of goldband snappers and 2,516 t of red snappers. The Timor Reef Fishery and the Demersal Fishery have been granted an exemption from export restrictions until 13 December 2019.

Queensland

The QFJA manages the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery, which targets red snappers (Keag 2013). The fishery, which commenced in 1998, operates from 25 nm out to the AFZ boundary. A summary of this fishery is provided by the Queensland Department of Agriculture and Fisheries (QDAF 2019). Although three fishing permits are issued to access the fishery, there was no fishing activity in 2016–17 or 2017–18, in contrast to 2015–16, when two vessels were active (QDAF 2019). Catch and effort in this fishery have declined substantially from 2009–10, when total catch was reported to be 781 t from 389 vessel-days. The fishery has been granted export approval until 22 November 2019.

The Queensland Gulf of Carpentaria Line Fishery is primarily a troll fishery for Spanish mackerel (*Scomberomorus commerson*). Red snappers are not considered to be target species for the fishery. There are 46 licences in the fishery; 16 were active in 2018. Total catch in 2018 was 146 t, with an effort level of 679 vessel-days. Spanish mackerel accounted for 99% of the catch in 2018 (QDAF 2019).

Other catches, including illegal fishing

Queensland and the Northern Territory collect catch data for target species taken by recreational fishers and charter vessels. The Northern Prawn Fishery also takes some red snappers as byproduct.

Fishing for red snappers occurs in Indonesia's waters, particularly trawling in the Arafura Sea (Blaber et al. 2005). Saddletail snapper is the dominant species caught in this area. An Australian–Indonesian project in 1999–2000, supported by the Australian Centre for International Agricultural Research (ACIAR), examined the relationship between Australian and Indonesian stocks. The project found that catch levels of red snappers at that time would be unsustainable in the longer term, and that data collection and licensing systems in Indonesia were inadequate. The project provided a catalyst for changes to management arrangements in Australia and Indonesia.

Quantities of red snappers have been documented on Indonesian vessels that have been apprehended fishing illegally in northern Australian waters (Mckey 2008). Illegal fishing has decreased, but the extent of catch and the impact on Australian stocks have not been fully quantified. A more recent ACIAR-supported project used data and modelling outcomes from the northern Australian harvest strategy for tropical snappers (O'Neill et al. 2011) to develop new fisheries policy and management frameworks, fishery-specific stock assessment processes, and improved frameworks for managing red snapper stocks in Indonesia that include the control and management of illegal, unreported and unregulated fishing. The outcomes of this project are reported in West et al. (2013).

Status of stocks

In 2017, the commercial catch of goldband snappers in the Northern Territory was 535 t; 59 t was caught in Queensland (Saunders et al. 2018c). While there is no total allowable commercial catch (TACC) for goldband snappers in Queensland because of relatively low catches, the Northern Territory has a TACC of 1,300 t (900 t in the Timor Reef Fishery and 400 t in the Demersal Fishery).

The northern Australian goldband snapper stock was assessed in 2011 and 2013 using a stochastic stock reduction analysis model. Egg production was estimated to be around 65% of production before the start of the fishery, and the current harvest rate was estimated to be below that required to achieve MSY (Saunders et al. 2018c). The goldband snapper stocks in the Timor Sea may be shared by Indonesia and Australia (Ovenden et al. 2002); however, understanding of the Indonesian catch and its implications for stock assessment is limited.

In 2017, the commercial catch of red snappers was 2,732 t (2,075 t of saddletail snapper and 657 t of crimson snapper) in the Northern Territory and 89 t (77 t of saddletail snapper and 12 t of crimson snapper) in Queensland (Saunders et al. 2018b, d). In Queensland, the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery operates under a TACC of 450 t for quota species (crimson snapper, saddletail snapper and other tropical snappers) (QDAF 2019). This is based on a 1994 assessment that estimated an annual sustainable yield for the total Gulf of Carpentaria of 2,900–9,000 t (Leslie & Roelofs 2011). In the Northern Territory, crimson and saddletail snappers are managed together as 'red snappers' (Saunders et al. 2018d) with a combined TACC of 3,800 t.

The northern Australian saddletail snapper stock was assessed in 2013 using a stochastic stock reduction analysis model. Egg production was estimated to be around 80% of production before the start of the fishery, and the current harvest rate for red snappers was estimated to be below that required to achieve MSY (Saunders et al. 2018d).

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Chapter 30
The status determination process

H Patterson, J Woodhams, A Williams, J Larcombe and R Curtotti

30.1 Legislation and policy

Fisheries Management Act 1991

The *Fishery status reports* assess the performance of Commonwealth fisheries against the objectives of the *Fisheries Management Act 1991* (FM Act, section 3); in particular:

Part 3

a. ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (which include the exercise of the precautionary principle), in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment; and
b. maximising the net economic returns to the Australian community from the management of Australian fisheries; and
c. ensuring accountability to the fishing industry and to the Australian community in AFMA's [Australian Fisheries Management Authority's] management of fisheries resources.

Commonwealth Fisheries Harvest Strategy Policy

The Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018a) supports the implementation of the objectives of the FM Act. The objective of the HSP is the ecologically sustainable and profitable use of Australia's Commonwealth commercial fisheries resources (where ecological sustainability takes priority)—through the implementation of harvest strategies.

To pursue this objective, the Australian Government will implement harvest strategies that:

- ensure exploitation of fisheries resources and related activities are conducted in a manner consistent with the principles of ecologically sustainable development, including the exercise of the precautionary principle
- maximise net economic returns to the Australian community from management of Australian fisheries—always in the context of maintaining commercial fish stocks at sustainable levels
- maintain key commercial fish stocks, on average, at the required target biomass to produce maximum economic yield from the fishery
- maintain all commercial fish stocks, including byproduct, above a biomass limit where the risk to the stock is regarded as unacceptable (B_{LIM}), at least 90% of the time
- ensure fishing is conducted in a manner that does not lead to overfishing—where overfishing of a stock is identified, action will be taken immediately to cease overfishing
- minimise discarding of commercial species as much as possible
- are consistent with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Guidelines for the ecologically sustainable management of fisheries* (Department of the Environment and Water Resources 2007).

Updated guidelines aimed at providing practical assistance in the development of harvest strategies that meet the intent of the HSP were also released in 2018 (Department of Agriculture and Water Resources 2018b).

30.2 Assessing biological status

Fish stock definitions

Where feasible, status is reported for the biological stock, defined as a discrete population of a species that is typically reproductively isolated in space or time from other populations of the same species, resulting in detectable genetic, biological or morphological differences in fish from different populations. Fishing is assumed to affect the entire stock, but not adjacent stocks. This independence between populations of the same species means that separate assessments and management arrangements are often required for each, and is why status is reported separately for each defined stock. The true structure and boundaries of biological stocks are often not well understood, or a stock may straddle the jurisdictional boundaries of several management agencies. In such circumstances, the stock may be treated as a series of convenient geographic components or 'management units' that are managed separately by different jurisdictions or as separate fisheries.

The Commonwealth generally manages fish resources from 3 nautical miles (nm) from the coast out to the 200 nm Exclusive Economic Zone (EEZ) limit, while states or territories manage fish resources within 3 nm. The Australian Government has negotiated Offshore Constitutional Settlement arrangements with states and territories that provide for the shared, cooperative or transferred management of some stocks that straddle this state–Commonwealth boundary. Fish stocks that occur within Torres Strait are managed cooperatively by Australia and Papua New Guinea under the 1985 Torres Strait Treaty, which provides for joint management of the shared resources in the Torres Strait Protected Zone. In the Australian area of this zone, traditional fishing and commercial fisheries are collaboratively managed by the Torres Strait Protected Zone Joint Authority, established under the *Torres Strait Fisheries Act 1984*.

Several fishery resources of commercial importance to Australia have ranges extending outside the Australian Fishing Zone into the high seas and the EEZs of other countries, particularly the highly migratory tunas. Under the United Nations Fish Stocks Agreement (1995), the high-seas components of these straddling stocks are required to be collaboratively managed by regional fisheries management organisations (RFMOs). Australia is an active member of a number of RFMOs, including the Western and Central Pacific Fisheries Commission (WCPFC), the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), the Indian Ocean Tuna Commission (IOTC), the South Pacific Regional Fisheries Management Organisation (SPRFMO) and the Southern Indian Ocean Fisheries Agreement. In managing its domestic fisheries, Australia implements measures agreed by each relevant RFMO. In some cases, Australia's domestic standards exceed those agreed internationally, in which case Australia attempts to obtain international agreement to implement measures consistent with Australian standards.

Reference points and indicators

Two independent aspects of stock status are classified within these reports: the stock's biomass level and its fishing mortality status (Table 30.1). In cases where reference points or estimates of current biomass or fishing mortality have not been determined, other indicators are used to inform stock status. The HSP defines target and limit reference points for Commonwealth fisheries in terms of biomass (B_{TARG} and B_{LIM}, respectively) and fishing mortality (F_{TARG} and F_{LIM}, respectively).

The HSP guidelines allow flexibility for B_{LIM} to be determined relative to spawning biomass, exploitable biomass or total biomass. This flexibility allows for reference points to be consistent with the types of data available for stock assessments. For example, stock assessments that rely mainly on catch-per-unit-effort (CPUE) estimate depletion levels related to the exploitable biomass. Alternatively, stock assessments that use catch age analysis with auxiliary biological information allow estimates of depletion levels related to spawning biomass and overall biomass. As a result, depletion-level estimates of all assessed stocks may not necessarily refer to the same portion of the biomass.

In terms of biomass status, stocks are classified as one of the following:

- not overfished, where the biomass is above B_{LIM} and at a level where recruitment is unlikely to be significantly impaired. This indicates that the biomass is at a level sufficient to ensure that the risk to future levels of recruitment is not excessive (that is, the stock is not recruitment overfished)
- overfished, where the biomass is below B_{LIM} and at a level where recruitment is likely to be significantly impaired. The B_{LIM} threshold reflects the point at which the risk to future levels of recruitment is unacceptable
- uncertain, where there is inadequate information to determine the state of a stock's biomass and the risk to future recruitment.

In terms of fishing mortality, stocks are classified as one of the following:

- not subject to overfishing, where the fishing mortality does not exceed the limit reference point (F_{LIM}). In this case, the stock is not subject to a level of fishing mortality that would move the stock to an overfished state
- subject to overfishing, where the fishing mortality exceeds F_{LIM}. The stock is subject to a level of fishing that would move the stock to an overfished state or prevent it from rebuilding to a not overfished state
- uncertain, where there is inadequate information to determine whether the level of fishing mortality represents overfishing.

Some RFMOs report against reference points for biomass and fishing mortality when providing advice on stock status; however, these reference points may be defined differently from those in the HSP. The limit reference points adopted by the WCPFC are the same as those prescribed in the HSP. However, the IOTC determines stock status relative to target reference points, not limit reference points. For jointly managed stocks, ABARES determines stock status using the limit reference points described in the HSP, and considers the impacts of fishing mortality from all fleets on the stocks. Consequently, the status of some jointly managed stocks reported by RFMOs may differ from that reported by Australia.

In situations where there is no stock assessment–generated estimate of biomass or fishing mortality, other information is used to determine status, such as catch, catch rate (CPUE) time series, size or age. Often, several indicators are used to assess the likely state of biomass or fishing mortality for a stock (weight of evidence). Occasionally, there will be conflicting indicators, leading to no clear picture of likely status. In this situation, an uncertain classification may be determined.

The stock status classification system

The classification system for stock status has been modified several times since the first *Fishery status reports* (1992). In 2004, the 'underfished' and 'fully fished' categories were replaced by a combined category of 'not overfished'. This change was made partly because of potential confusion about the meaning of 'fully fished'. It was also difficult to classify a stock as 'underfished' because data were often lacking for stocks likely to fall into this category.

Another change in 2004 was the inclusion of a distinction between biomass status and fishing mortality status. Before 2004, each stock was given a single status classification, based on the worst-case scenario. For example, if a stock was considered 'subject to overfishing', it was classified as 'overfished', and there was no separate determination of stock biomass status. Also, stocks were only classified as 'not overfished' if overfishing was also not occurring.

In 2007, this classification system was aligned with the reference points defined in the HSP (Table 30.1).

TABLE 30.1 Reference points for fishing mortality and biomass, with associated status implications in line with the HSP

		Fishing mortality rate (F)		
		$F < F_{TARG}$ (fishing mortality is below the target)	$F_{TARG} < F < F_{LIM}$ (fishing mortality is between the limit and the target)	$F > F_{LIM}$ (fishing mortality is above the limit)
Biomass (B)	$B \geq B_{TARG}$ (biomass is greater than or equal to the target)	Not overfished. Overfishing is not occurring.	Not overfished. Overfishing is not occurring.	Not overfished. Overfishing is occurring: note possible planned fish-down where overfishing would not be occurring.
	$B_{TARG} > B > B_{LIM}$ (biomass is between the limit and the target)	Not overfished: rebuild to B_{TARG}. Overfishing is not occurring.	Not overfished: rebuild to B_{TARG}. Overfishing may not be occurring, provided that fishing mortality will allow rebuilding towards target.	Not overfished: rebuild to B_{TARG}. Overfishing is occurring.
	$B < B_{LIM}$ (biomass is below the limit)	Overfished: adopt and follow a rebuilding strategy to rebuild biomass above B_{LIM} within a required time frame. Overfishing may not be occurring.	Overfished: adopt and follow a rebuilding strategy to rebuild biomass above B_{LIM} within a required time frame. Overfishing may not be occurring, provided that fishing mortality will allow rebuilding towards target within a required time frame.	Overfished: adopt a rebuilding strategy to rebuild biomass above B_{LIM} within a required time frame. Overfishing is occurring: reduce fishing mortality.

Note: Colours show how these reference points relate to stock status classifications used for each stock.

Fishing mortality Not subject to overfishing Subject to overfishing

Status determination framework

A weight-of-evidence decision-making framework for biological status determination was a key output of the Reducing Uncertainty in Stock Status (RUSS) project, undertaken from 2009 to 2012 (Larcombe, Noriega & Stobutzki 2015). Application of the framework requires the assembly of an evidence base to support status determination and is analogous to a review of fisheries indicators. The framework provides a structure for the assembly and review of indicators of biomass and fishing mortality status. The framework provides guidance on interpreting these indicators, and aims to provide a transparent and repeatable process for status determination. It requires a description of attributes of the stock and the fishery, documentation of lines of evidence for status, and presentation of the key information used to support the status classification. Expert judgement plays an important role in status determination, with an emphasis on documenting the key evidence and rationale for the decision. Separate decision-making processes are used to determine biomass and fishing mortality. This framework is relatively more important and more often applied in the absence of formal stock assessments.

The framework is more heavily relied upon when status is not immediately obvious (for example, when directly output from a robust and reliable stock assessment), and multiple indicators of status need to be used to support a determination.

30.3 Assessing economic status

The economic status of each Commonwealth fishery (excluding jointly managed Torres Strait fisheries) is determined by assessing management performance against the economic objective of the FM Act, which is to maximise net economic returns (NER) to the Australian community from the management of Australian fisheries. Performance against this objective is evaluated using three criteria: key economic trends, management arrangements and performance against the HSP's economic objective.

The economic status of Torres Strait fisheries is also evaluated. However, because these fisheries are managed under the *Torres Strait Fisheries Act 1984*, the HSP and its economic objective do not apply. Therefore, performance of these fisheries is assessed against fishery-specific objectives, as well as those of section 8 of the *Torres Strait Fisheries Act 1984*. These are:

- to acknowledge and protect the traditional way of life and livelihood of Traditional Inhabitants, including their rights in relation to traditional fishing
- to manage commercial fisheries for optimum utilisation
- to have regard, in developing and implementing licensing policy, to the desirability of promoting economic development in the Torres Strait area and employment opportunities for Traditional Inhabitants.

Key economic trends

NER are a major indicator of a fishery's economic performance. NER measure the difference between the revenue a fishery earns in a given year and the economic costs it incurred earning those revenues. These include costs associated with fuel, crew, repairs, fishery management, depreciation, and the opportunity cost of capital and owner–operator labour.

Survey estimates of NER calculated by ABARES are available for some of the most valuable Commonwealth fisheries. For other fisheries, indicators of fishery revenue and costs are analysed to evaluate likely changes in profitability. Although estimates of a fishery's gross value of production are readily available and provide an indicator of revenue, information on costs is more difficult to obtain. Measures of fishing effort and fuel prices are used for some fisheries to provide an indication of total fishery costs. For data-poor fisheries, the level of unused fishing rights ('latency') can provide an indication of NER. High latency suggests that the fishery is operating at or above a point equivalent to its theoretical open-access equilibrium—at this point, average NER are zero, and all potential resource rents from using the resource are likely to be lost.

Changes in a fishery's NER reflect changes in factors that are both external and internal to the control of fishers and fishery managers. External factors include fish prices and fuel prices, while internal factors include catch and fishing effort. The evaluation of a fishery's economic status primarily focuses on factors that are under the control of fishery managers. However, external factors can be highly variable and complicate the determination of economic status. Therefore, a fishery's NER should be interpreted over time (that is, in terms of its NER trend), and use other fishery information and performance indicators. For example, if a fishery generates positive NER, this does not necessarily mean a positive economic status in the context of maximising NER from the resource. Management arrangements may be impeding the generation of additional NER. Similarly, the catches generating these positive NER may be associated with overfishing. In these cases, economic status could be improved by reducing management constraints or rebuilding stock status.

Economic productivity measures support the interpretation of a fishery's trend in NER and its overall economic status. Productivity measures indicate how effectively a fishery's inputs (such as fuel, labour, capital and the fish stock) are converted into output (catch). At given output prices, an improvement in fishery productivity will be associated with an improvement in NER. Productivity growth in a fishery over time will reflect some combination of improved production decisions by fishers and improvements in fishery management.

Management arrangements

Management arrangements can be a key influence on whether a fishery achieves its full economic potential. The assessment of economic status therefore considers whether a fishery's NER could be improved under alternative arrangements. An informed assessment requires an understanding of a fishery's characteristics, which can vary considerably across fisheries. This allows evaluation of the relative advantages and disadvantages of alternative management arrangements for that fishery.

Management arrangements in Commonwealth fisheries can be categorised as either input controls (for example, effort limits) or output controls (for example, catch limits). Input controls restrict a fishery's effort—for example, by restricting gear use, fishing time or fishing areas. If a fishery manager is trying to control a fishery's catch, input controls alone provide no guarantee that a catch target will be met. Over time, such controls can lead to overcapacity and lower economic returns, especially if the controls are not frequently adjusted to counteract an increased efficiency of the limited number of fishing effort units. However, input controls are often associated with lower implementation and monitoring costs than output controls (Rose 2002). They can also have advantages where attempts to control catch are complicated by a stock's high variability and unpredictability.

Output controls restrict a fishery's harvest through the setting of total allowable catches (TACs). Individual transferable quotas (ITQs) are the dominant form of output control used in Commonwealth fisheries—a stock's TAC is allocated to holders of ITQs. Each quota entitles its owner to a share of the TAC in a given season, which can then be sold or leased. An advantage of ITQs is that, once fishers have been allocated a TAC share, the incentive to race to fish against other operators may be diminished and replaced with an incentive to maximise profit for their given catch allocation (Grafton 1996). By directly controlling catch, the need to restrict inputs (and operator efficiency) to indirectly limit catch is reduced, and operators are afforded greater flexibility to choose the most efficient mix of fishing units. However, input controls may still be required to meet other management objectives (for example, controlling bycatch). The transferability of ITQs also means that quota can gravitate to the most efficient fishers, improving overall economic performance of the fishery. However, ITQs can have drawbacks, including high set-up and monitoring costs, and incentives to discard and high-grade catch (Copes 1986; Rose 2002).

Another key management consideration for determining economic status is latency. High levels of latency over a long period indicate low levels of NER and suboptimal fishery economic performance. Latency creates additional issues for fisheries managed with tradeable fishing rights (such as ITQs or effort). These mechanisms can capture efficiency gains through having fishing rights traded towards their most efficient use, but, if TAC or effort levels are maintained above economically viable levels so that latency prevails, the value of fishing rights will be low. This reduces the incentive to trade fishing rights and limits the potential efficiency improvements through the movement of rights to more efficient users (Elliston et al. 2004). Interpretation of latency must consider the characteristics of the fishery. For example, if a fishery targets a highly variable stock, fluctuations in fishing rights latency would be expected.

Management in pursuit of other FM Act objectives relating to sustainability, bycatch and the environment can affect a fishery's profitability. Whether these objectives have been met with the lowest possible cost should also be a key consideration when determining economic status. Costs include not only the management costs incurred in meeting these objectives, but also costs associated with any reduction in NER that results from such management.

Performance against economic objective

The HSP supports the implementation of the economic objective of the FM Act by recommending that harvest strategies are designed to achieve biomass levels that can be expected to maximise a fishery's overall NER. The assessment of economic status considers how well a fishery's harvest strategy meets the economic objective of the FM Act.

This assessment first involves evaluating a fishery's harvest strategy target reference points in terms of how well they reflect a maximum economic yield (MEY) target for that fishery. For some fisheries, target reference points are biomass based (that is, B_{MEY}), and the evaluation will focus on whether the adopted target is consistent with MEY, given the biological and economic characteristics of the stock. For other fisheries, alternative targets are used because biomass targets are considered inappropriate (for example, if the fishery is data-poor or targets highly variable stocks). Such alternatives include catch-rate targets, catch triggers and effort triggers. In these cases, the evaluation focuses on how well the economic objective of the HSP is being met by these alternative approaches.

If a fishery's harvest strategy targets are consistent with MEY, performance indicators can be compared with targets to assess whether the fishery is achieving MEY. For multispecies fisheries, performance against harvest strategy targets is evaluated across the predominant and most valuable stocks caught in the fishery. Performance indicators that are close to target for these stocks will indicate that management is meeting the HSP's economic objective for the fishery. If the performance indicators are off target but moving towards target, performance against MEY is improving. If neither is occurring, then management settings have resulted in suboptimal outcomes for the stock, and management adjustments may be required. Such evaluation focuses on recent historical performance over a number of years (rather than just one year), given the variability in factors that influence a fishery's MEY. If harvest strategy targets do not exist for a fishery, the evaluation focuses on how well the intent of the HSP is being met under the current harvest strategy.

30.4 Assessing environmental status

The Australian Government's fisheries management objectives recognise the need to consider the broader effects of fishing on bycatch species (including species protected under the EPBC Act), marine habitats, communities and ecosystems. *Fishery status reports 2019* reports on key bycatch issues in each fishery and information from ecological risk assessments (ERAs) by AFMA.

Bycatch species

In 2018, the Department of Agriculture released the *Commonwealth Fisheries Bycatch Policy* (Department of Agriculture and Water Resources 2018c). The bycatch policy aims to minimise fishing-related impacts on general bycatch species in a manner consistent with the principles of ecologically sustainable development, and with regard to the structure, productivity, function and biological diversity of the ecosystem. The bycatch policy advocates the use of bycatch strategies that will meet the objectives of the policy, and was released with an associated set of guidelines—*Guidelines for the implementation of the Commonwealth Fisheries Bycatch Policy* (Department of Agriculture and Water Resources 2018d).

Ecological risk assessment

In the early 2000s, AFMA and CSIRO, with funding from the Australian Government, initiated the development of ERAs to assess the impacts of fishing activities on ecological components of fisheries, such as target, bycatch and byproduct species; protected species; habitats; and communities. Broadly speaking, the ERA methodology is hierarchical, moving from a low-level, qualitative analysis of risks (level 1) to fully quantitative assessments of the level of fishing mortality (level 3) (Hobday et al. 2007). Low-risk activities and species are screened out at each step in this process.

The ERA methodology has evolved since its initial implementation and now focuses on aspects of the fishery that are not assessed in other ways (for example, through stock assessment). The AFMA website details each ERA. AFMA has recently developed an ecological risk management guide (AFMA 2017) that helps fishery managers to better implement ERA and ecological risk management across fisheries.

EPBC Act and its interactions with fisheries management

The EPBC Act is the key piece of national legislation for conserving the biodiversity of Australian ecosystems and protecting the natural environments that support these ecosystems. Commonwealth marine areas are 'matters of national significance' under the EPBC Act. The EPBC Act broadly requires that fishing activities do not have a significant negative impact on the Commonwealth marine environment and its biodiversity, including protected species and ecological communities. This is achieved through the requirement for all Commonwealth fisheries to undergo a strategic environmental assessment to determine the extent to which management arrangements will ensure that the fishery is managed in an ecologically sustainable way.

The strategic assessments determine whether a fishery should be accredited for the purposes of part 13 (protected species provisions) and part 13A (wildlife trade provisions) of the EPBC Act. Fisheries management also needs to consider the requirements of species recovery plans, wildlife conservation plans and threat abatement plans that are implemented under the EPBC Act.

Protected species

If a species is protected under the EPBC Act (with the exception of those listed as conservation-dependent), it is an offence to kill, injure, take, trade, keep or move an individual unless the action is covered by a permit issued by the environment minister or is otherwise exempt. In the case of fisheries, interactions with protected species are not offences if they have occurred in a fishery with a fishery management plan or regime accredited under the EPBC Act. This recognises that some level of interaction may be inevitable, but that all reasonable steps should be taken to minimise interactions. Fishers are obliged to report any interactions with protected species, and it is an offence under the EPBC Act and the FM Act not to do so. Interactions with protected species are reported in the *Fishery status reports* for each fishery.

30.5 Presentation of fisheries data

Graphing

Data presented in *Fishery status reports 2019* were obtained from a number of sources. Most were obtained from AFMA daily fishing logs, AFMA catch disposal records, observer databases and the ABARES commodities database. Other sources include fishery-specific stock assessments, CSIRO, public-domain catch-and-effort data from the WCPFC, the IOTC nominal catch database (public domain data), the CCSBT database, the Commission for the Conservation of Antarctic Marine Living Resources, and the SPRFMO database.

Mapping

Relative fishing intensity has been mapped where five or more vessels have fished within a certain area. This fishing intensity is mapped using the kernel density function in ArcGIS and an appropriate radius from each fishing operation point, depending on the extent and spacing of fishing operations. The density function results in a smoothing and spreading of estimated fishing effort, and can result in the total area over which fishing operations take place appearing larger than it is. Where necessary, fishing intensity maps have been truncated to limit fishing to management areas.

Fishing intensity is usually mapped as effort, but, in some fisheries (for example, the Bass Strait Central Zone Scallop Fishery), it is mapped as catch. Three levels of fishing intensity are shown, arbitrarily classified as low, medium and high. As far as possible, the same range classes have been used as in previous years. However, if there has been a major shift in effort or catch, this may not be possible. Fishing operations have been mapped for the 2018 calendar year or the 2017–18 financial year.

The total area fished has been mapped for most fisheries, except for those fisheries with a restricted range, such as the Torres Strait fisheries. For these fisheries, the total area fished is mapped at 111 km^2 (the equivalent of one degree of latitude squared) and does not show catch or fishing effort. This conforms with AFMA's information disclosure policy (AFMA 2010).

Fishery management area boundaries are shown for reference, but area closures are not shown except for certain major closures. The 200 m isobath (bathymetric contour) is shown on all maps, where relevant. This approximates the edge of the continental shelf. Place names, including ports, capes, islands and seas, have been included for reference and orientation.

In most cases, the maps are in the geographic coordinate system (that is, without being projected). All maps of domestic fisheries use the geocentric datum for Australia (GDA94).

30.6 References

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Appendix

Comparison of stock status classifications between the *Fishery status reports* (for Commonwealth fisheries) and the *Status of Australian fish stocks reports* (for all states and territories with wild-capture fisheries)

Fishery status reports				*Status of Australian fish stocks reports*
Biomass		**Fishing mortality**		**Stock status**
Not overfished	+	Not subject to overfishing	=	Sustainable
Overfished	+	Not subject to overfishing	=	↑ Recovering **a**
Not overfished	+	Subject to overfishing	=	↓ Depleting
Overfished	+	Subject to overfishing	=	Depleted **b**
Uncertain if overfished	OR	Uncertain if subject to overfishing	=	Undefined

a For a stock to be considered 'recovering' in the national reports, there must be evidence that the biomass is recovering (that is, increasing). **b** If the *Fishery status reports* classify a stock as 'overfished' and 'not subject to overfishing' but there is no evidence that biomass is recovering, it would be considered as 'depleted' in the national reports rather than 'recovering'.

Note: The *Status of Australian fish stocks reports 2018* includes an additional classification of 'negligible'. This is described as when catches are so low as to be considered negligible and inadequate information exists to determine stock status. In such case, no assessment is conducted unless catches and information increase. No such equivalent classification is used in the *Fishery status reports*.

Acronyms and units

AAD	Australian Antarctic Division
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
ASPIC	a stock production model incorporating covariates
BBDM	Bayesian biomass dynamic model
BSCZSF	Bass Strait Central Zone Scallop Fishery
BSPM	Bayesian state-space production model
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CI	confidence interval
CMM	conservation and management measure
CPUE	catch-per-unit-effort
CSF	Coral Sea Fishery
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTS	Commonwealth Trawl Sector (of the SESSF)
CV	coefficient of variation
DEPM	daily egg production method
ECDTS	East Coast Deepwater Trawl Sector (of the SESSF)
EEZ	Exclusive Economic Zone
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ERA	ecological risk assessment
ESTF	Eastern Skipjack Tuna Fishery
ETBF	Eastern Tuna and Billfish Fishery
FAO	Food and Agriculture Organization of the United Nations
FM Act	*Fisheries Management Act 1991*

FRDC	Fisheries Research and Development Corporation
GABRAG	Great Australian Bight Resource Assessment Group
GABTS	Great Australian Bight Trawl Sector (of the SESSF)
GHTS	Gillnet, Hook and Trap Sector (of the SESSF)
GVP	gross value of production
HIMI	Heard Island and McDonald Islands
HIMIF	Heard Island and McDonald Islands Fishery
HSF	harvest strategy framework
HSP	Commonwealth Fisheries Harvest Strategy Policy
IOTC	Indian Ocean Tuna Commission
ISMP	Integrated Scientific Monitoring Program
ITQ	individual transferable quota
IUU	illegal, unreported and unregulated (fishing)
JAF	joint authority fisheries
LRP	limit reference point
MEY	maximum economic yield
MITF	Macquarie Island Toothfish Fishery
MOU	memorandum of understanding
MSE	management strategy evaluation
MSY	maximum sustainable yield
MYTAC	multiyear total allowable catch
NER	net economic returns
NPF	Northern Prawn Fishery
NPRAG	Northern Prawn Resource Assessment Group
NTFJA	Northern Territory Fisheries Joint Authority
NWSTF	North West Slope Trawl Fishery
ORCP	Orange Roughy Conservation Programme
ORRS	Orange Roughy Rebuilding Strategy
PNG	Papua New Guinea
PZJA	Torres Strait Protected Zone Joint Authority
QFJA	Queensland Fisheries Joint Authority
RAG	Resource Assessment Group
RBC	recommended biological catch
RFMO	regional fisheries management organisation
SB	spawning biomass
SBTF	Southern Bluefin Tuna Fishery
SCAA	statistical catch-at-age model
SE	standard error

SERAG	South East Resource Assessment Group
SESSF	Southern and Eastern Scalefish and Shark Fishery
SETFIA	South East Trawl Fishing Industry Association
SFR	statutory fishing right
SGSHS	Shark Gillnet and Shark Hook sectors (of the SESSF)
SharkRAG	Shark Resource Assessment Group
ShelfRAG	Shelf Resource Assessment Group
SHS	Scalefish Hook Sector (of the SESSF)
SIOFA	Southern Indian Ocean Fisheries Agreement
SPF	Small Pelagic Fishery
SPR	spawning potential ratio
SPRFMO	South Pacific Regional Fisheries Management Organisation
SS3	Stock Synthesis 3
SSJF	Southern Squid Jig Fishery
SSRU	small-scale research unit
STF	Skipjack Tuna Fishery
STR	South Tasman Rise
STRTF	South Tasman Rise Trawl Fishery
SWPO	south-west Pacific Ocean
TAC	total allowable catch
TACC	total allowable commercial catch
TAE	total allowable effort
TIB	Traditional Inhabitant Boat (sector)
TRLRAG	Tropical Rock Lobster Resource Assessment Group
TSBDMF	Torres Strait Bêche-de-mer Fishery
TSFF	Torres Strait Finfish Fishery
TSFRLF	Torres Strait Finfish (Reef Line) Fishery
TSPF	Torres Strait Prawn Fishery
TSPZ	Torres Strait Protected Zone
TSSMF	Torres Strait Spanish Mackerel Fishery
TSTF	Torres Strait Trochus Fishery
TSTRLF	Torres Strait Tropical Rock Lobster Fishery
TTRAG	Tropical Tuna Resource Assessment Group
TVH	Transferable Vessel Holder
UNCLOS	United Nations Convention on the Law of the Sea
USSR	Union of Soviet Socialist Republics
VME	vulnerable marine ecosystem
WANSF	Western Australia Joint Authority Northern Shark Fishery
WCDF	West Coast Demersal Gillnet and Demersal Longline Managed Fishery

WCPFC	Western and Central Pacific Fisheries Commission
WCPO	western and central Pacific Ocean
WDTF	Western Deepwater Trawl Fishery
WSTF	Western Skipjack Fishery
WTBF	Western Tuna and Billfish Fishery

Units

'	minutes of latitude or longitude (for example, 34˚20'S)
˚C	degrees Celsius
˚E, ˚N, ˚S, ˚W	degrees east, north, south, west
cm	centimetre
g	gram
kg	kilogram
km	kilometre
km^2	square kilometre
m	metre
mm	millimetre
nm	nautical mile
t	tonne (1,000 kg)

Year ranges

2017–18	financial year or season
2017 or 2018; 2015–2017	calendar year

Glossary

A

Acoustic survey. Systematic method of gathering information on the abundance of a species in a water body with the help of echo sounders and sonar, which use ultrasonic sound to detect the fish.

Aerial survey. Method of gathering information on movements and density of fish near the surface by visual observation and photography from low-flying aircraft.

Age–length (age–length key or curve). Relationship between age and length.

Age-structured assessment. Assessment of the status of a fish stock based on the relative abundances of fish of different ages in the stock.

Aggregation. Group of fish that come together, often to feed or spawn.

Aquaculture. Commercial growing of marine or freshwater animals and aquatic plants. Often called 'fish farming'.

Area closure. Closure of a given area or fishing ground, often for a defined period. Used as a tool in the management of a fishery.

Artisanal fishing. Fishing for subsistence using traditional methods.

Australian Fishing Zone (AFZ). The area extending seaward of coastal waters (3 nautical miles from the territorial sea baseline) to the outer limits of the Exclusive Economic Zone (EEZ). In the case of external territories, such as Christmas Island, the AFZ extends from the territorial sea baseline to the outer limit of the EEZ. The AFZ is defined in the *Fisheries Management Act 1991*, which also specifies a number of 'excepted waters', notably in Antarctica and Torres Strait, that are excluded from the AFZ.

Autonomous adjustment. An ongoing structural adjustment process that occurs in all fisheries. As technologies and prices change, the characteristics of the fishing fleet required to maximise the net value from the fishery will also change. As a result, fishery fleet behaviour tends to change in line with market signals. The primary role for government in structural adjustment is to establish a management regime that removes any incentives that lead to overcapacity, and that facilitates autonomous adjustment in response to changing economic and biological conditions.

B

B (biomass). Total weight or volume of a stock or a component of a stock.

B_0 (mean equilibrium unfished biomass). Average biomass level if fishing had not occurred.

B_{LIM} (biomass limit reference point). Point beyond which the risk to the stock is regarded as unacceptably high.

B_{MEY} (biomass at maximum economic yield). Average biomass that corresponds to maximum economic yield.

B_{MSY} (biomass at maximum sustainable yield). Average biomass that corresponds to maximum sustainable yield.

B_{TARG} (target biomass). Desired biomass of the stock.

Beach price. A price that would be received by fishers or aquaculture farmers per unit of whole-weight fish at the point of landing or farm gate. It excludes any margins for freight, marketing and processing.

Benthic. Associated with the bottom of a water body.

Beverton–Holt. Mathematical function that describes the relationship between stock size and recruitment.

Biodiversity. Biological diversity; variety among living organisms, including genetic diversity, diversity within and between species, and diversity within ecosystems.

Buyback. Purchase of fishing entitlements by the government to increase structural adjustment in a fishery.

Bycatch. A species that is incidentally (a) taken in a fishery and returned to the sea, or (b) killed or injured as a result of interacting with fishing equipment in the fishery, but not taken. Bycatch can include species listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

Bycatch reduction device. A device that allows fish and other animals to escape immediately after being taken in or with fishing gear (for example, a trawl net).

Byproduct. A species taken incidentally in a fishery while fishing for another species but retained for sale because it has some commercial value, although less value than key commercial species.

C

Carapace. The exoskeleton covering the upper surface of the body of a crustacean.

Carapace length. In prawns, the distance from the posterior margin of the orbit to the mid-caudodorsal margin of the carapace; in lobster, the distance from the tip of the rostrum to the mid-caudodorsal margin of the carapace.

Catch. In relation to fishing, means capture, take or harvest.

Catch-at-age data. Data on the number of fish of each age group in the catch, usually derived from representative samples of the catch.

Catch curve. Method for estimating average recent fishing mortality, based on the age structure of the catch, biology of the species, total catch weight and selectivity of the fishing gear.

Catch-per-unit-effort (CPUE). The number or weight of fish caught by a unit of fishing effort. Often used as a measure of fish abundance.

Catch rate. *See* Catch-per-unit-effort (CPUE).

Catchability. The extent to which a stock is susceptible to fishing; quantitatively, the proportion of the stock removed by one unit of fishing effort.

Chondrichthyans. Fishes that have skeletons made of cartilage rather than bone. This group includes sharks and rays (elasmobranchs), and chimaeras (holocephalans).

Coastal waters. The waters extending 3 nautical miles from the territorial sea baseline. The states and the Northern Territory have jurisdiction over the coastal waters adjacent to them.

Codend. The closed end of a trawl net.

Cohort. Individuals of a stock born in the same spawning season.

Conservation-dependent species. The *Environment Protection and Biodiversity Conservation Act 1999* dictates that a native species is eligible to be included in the conservation-dependent category at a particular time if, at that time, (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long-term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a state or territory; and (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Continental shelf. Either the area of relatively shallow water that fringes a continent from the shoreline to the top of the continental slope (the top of the continental slope is often defined by the 200 m isobath), or a defined maritime zone that comprises the continental shelf where it extends beyond the limit of the Exclusive Economic Zone to the limit of the continental margin. The defined maritime zone is also sometimes referred to as the 'extended continental shelf', and its limit is determined by the United Nations Commission on the Limits of the Continental Shelf.

Continental slope. Region of the outer edge of a continent between the relatively shallow continental shelf and the abyssal depths; often characterised by a relatively steep slope.

Control rules. *See* Harvest control rules.

D

Daily egg production method (DEPM). A method of estimating the spawning biomass of a fish population from the abundance and distribution of eggs and/or larvae.

Danish-seining. A trawling method used by relatively small vessels in shallow waters (up to about 200 m). Lengths of weighted ropes of up to 2,800 m are laid out on the sea floor in a diamond pattern, with the vessel at one end of the diamond and the net at the other. As the vessel moves forward, bringing in the net, the diamond becomes elongated, allowing the fish to be herded into the path of the net (c.f. Purse seining).

Decision rules. *See* Harvest control rules.

Delay-difference model. Type of population model that incorporates age structure.

Demersal. Found on or near the benthic habitat (c.f. Pelagic).

Demersal trawling. Trawling with gear designed to work on or near the seabed. Such gear is used to take demersal species of fish and prawns.

Depletion (stock depletion). Reduction in the biomass of a fish stock.

Discarding. The practice of returning any part of the catch, whether dead or alive, to the sea. In Commonwealth fisheries, the term 'discard' is predominantly used to refer to commercial species that are not retained.

Domestic fishery. Fishery within the Australian Fishing Zone operated by Australian-flagged vessels.

Driftnet. Gillnet suspended by floats so that it fishes the top few metres of the water column. *See also* Gillnet.

Dropline. Fishing line with one or more hooks, held vertically in the water column with weights.

E

E_{MSY}. Effort that supports maximum sustainable yield.

Ecologically sustainable development. Using, conserving and enhancing the community's resources so that ecological processes are maintained and the total quality of life, now and in the future, can be increased.

Economic efficiency. A fishery is economically efficient when fishery-level efficiency and vessel-level efficiency are achieved, and management costs are as low as they can be while still providing the necessary level of management. Fishery-level and vessel-level efficiency means that effort is restricted to the point where the difference between fishing revenue and cost is greatest, and fishers are applying that level of effort at least cost.

Economic profit (profitability). *See* Profit, economic.

Ecosystem. A complex of plant, animal and microorganism communities that, together with the non-living components, interact to maintain a functional unit.

Effort. A measure of the resources used to harvest a fishery's stocks. The measure of effort appropriate for a fishery depends on the methods used and the management arrangements. Common measures include the number of vessels, the number of hooks set, and the number of fishing days or nights.

Effort restriction. Restriction of the permitted amount of fishing effort (for example, total number of hooks) in a fishery; used as a management tool.

Egg survey. Systematic gathering of information on the occurrence and abundance of fish eggs and larvae by collecting them in nets and traps.

Endangered species. Species in danger of extinction because of its low numbers or degraded habitat, or likely to become so unless the factors affecting its status improve. The *Environment Protection and Biodiversity Conservation Act 1999* dictates that a native species is eligible to be included in the endangered category at a particular time if, at that time, (a) it is not critically endangered, and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Endemic species. Species that occurs naturally and exclusively in a given place.

***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).** The central piece of Commonwealth environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places—defined in the EPBC Act as matters of national environmental significance. Parts 10, 13 and 13A relate specifically to aspects of fisheries.

EPBC Act–listed species. All species protected under part 13 of the EPBC Act, including whales and other cetaceans, and listed threatened, marine and migratory species (except for conservation-dependent species, which are managed through rebuilding strategies under the Harvest Strategy Policy).

Escapement. The number, expressed as a percentage, of fish that survive an event (for example, predation, natural mortality, fishing mortality), often to spawn.

Exclusive Economic Zone (EEZ). The area that extends from the limit of the territorial sea, which is 12 nautical miles offshore from the territorial sea baseline, to a maximum of 200 nautical miles, measured from the territorial sea baseline. The EEZ is less than 200 nautical miles in extent where it coincides with the EEZ of another country. In this case, the boundaries between the two countries are defined by treaty. Within its EEZ, Australia has sovereign rights and responsibilities over the water column and the seabed, including the exploration and exploitation of natural resources.

Exploitation rate. The fraction of total animal deaths caused by fishing, usually expressed as an annual value. Can also be defined as the proportion of a population caught during a year.

F

F (fishing mortality). The instantaneous rate of fish deaths due to fishing a designated component of the fish stock. F reference points may be applied to entire stocks or segments of stocks and should match the scale of management unit. Instantaneous fishing mortality rates of 0.1, 0.2 and 0.5 are equivalent to 10%, 18% and 39% of deaths of a stock due to fishing. *See also* M (natural mortality), Mortality.

F_{Curr}. Current level of fishing mortality.

F_{LIM} (fishing mortality limit reference point). Point above which the removal rate from the stock is too high.

F_{MEY} (fishing mortality at maximum economic yield). Fishing mortality rate that corresponds to maximum economic yield.

F_{MSY} (fishing mortality at maximum sustainable yield). Fishing mortality rate that achieves maximum sustainable yield.

F_{TARG} (fishing mortality target). Target fishing mortality rate.

Farm-gate value. *See* Beach price.

Fecundity. Number of eggs an animal produces each reproductive cycle; the potential reproductive capacity of an organism or population.

Fisheries Management Act 1991. One of two main pieces of legislation (the other is the *Fisheries Administration Act 1991*) that details the responsibilities and powers of the Australian Fisheries Management Authority. The Act sets out, among other things, fisheries management objectives and arrangement for regulating, permitting and taking enforcement action with respect to fishing operations.

Fishery-independent survey. Systematic survey by research vessels or contracted commercial fishing vessels to gather information independently of normal commercial fishing operations.

Fishing capacity. Total fishing effort that can be expended by a fleet operating in a fishery.

Fishing down (fish-down). Fishing mortality above F_{MSY} for a stock that is above a biomass target, with the intention of reducing the biomass to the target.

Fishing effort. Amount of fishing taking place, usually described in terms of gear type and the frequency or period of operations (for example, hooks, trawl-hours, net length).

Fishing power. Effectiveness of a vessel's fishing effort relative to that of other vessels or in other periods of time.

Fishing season. The period during which a fishery can be accessed by fishers. Sometimes referred to as a fishing year.

Fishmeal. Protein-rich animal feed made of fish or fish waste.

Free-diving. Diving without the assistance of breathing apparatus. Gear used may include a snorkel, face mask, flippers, weight belt and wetsuit.

G

Gear restriction. Restriction on the amount and/or type of fishing gear that can be used by fishers in a fishery; used as a management tool.

Generation time. Average time taken for an individual animal to replace itself in a population.

Gillnet. Type of passive fishing gear consisting of panels of net held vertically in the water column, either in contact with the seabed or suspended from the sea surface, such that fish attempting to swim through the net are entangled. The mesh size of the net determines the size range of fish caught, because smaller fish can swim through the meshes and larger fish are not enmeshed. *See also* Driftnet.

Gross value of production (GVP). A value obtained by multiplying the volume of catch (whole-weight equivalent) by the average per-unit beach price. In the case of a multispecies fishery, the fishery's GVP is the sum of the GVPs of each species.

Grow-out cage. Pontoons supporting cages in which wild-caught fish are fattened until they reach marketable size.

Growth overfishing. Occurs when fish are harvested at an average size that is smaller than the size that would produce the maximum yield per recruit. This makes the total yield less than it would be if the fish were allowed to grow to an appropriate size. The annual yield is therefore smaller than the maximum sustainable yield.

H

Handline. Hand-held lines of various types used to catch fish.

Harvest control rules. Predetermined rules that control fishing activity according to the biological and economic conditions of the fishery (as defined by monitoring or assessment). Also called 'decision rules' or 'control rules'. Harvest control rules are a key element of a harvest strategy.

Harvest strategy. Strategy outlining how the catch in a fishery will be adjusted from year to year depending on the size of the stock, the economic or social conditions of the fishery, conditions of other interdependent stocks or species, and uncertainty of biological knowledge. Well-managed fisheries have an unambiguous (explicit and quantitative) harvest strategy that is robust to the unpredictable biological fluctuations to which the stock may be subject.

Headrope (headline). In a trawl, the length of rope or wire to which the top wings and cover netting are attached.

High grading. A type of discarding motivated by an output control system. Depending on the costs of fishing, and price differences between large and small fish of the same species, fishers may have an incentive to discard small, damaged or relatively low-value catch so that it does not count against their quota. They then hope to fill the quota with higher-value fish.

High seas. Waters outside national jurisdictions—that is, outside Exclusive Economic Zones.

Highly migratory stock. Refers to fish species or stocks that carry out extensive movement or migrations and can occur in both Exclusive Economic Zones and high seas. This term is usually used to denote tuna and tuna-like species, marlins and swordfish.

Hookah. Underwater breathing apparatus consisting of an onboard air compressor and an air-supply tube attached to a diver's mouthpiece or helmet.

I

Index of abundance. Relative measure of the abundance of a stock (for example, catch per unit of effort).

Individual transferable effort. Shares of a total allowable effort that are allocated to individuals. They can be traded permanently or temporarily. Analogous to individual transferable quotas in a fishery managed with a total unit allowable catch. Usually issued at the start of a fishing season.

Individual transferable quota (ITQ). Management tool by which portions of the total allowable catch quota are allocated to fishers (individuals or companies). The fishers have long-term rights over the quota but can trade quota with others. *See also* Quota.

Input controls. Management measures that place restraints on who fishes (licence limitations), where they fish (closed areas), when they fish (closed seasons) or how they fish (gear restrictions).

Inshore waters. Waters of the shallower part of the continental shelf, usually less than 3 nautical miles from the coast.

Isobath. Contour line linking points of the same depth.

J

Jig. Vertical line with lures, which is moved up and down, or jigged, by hand or machine.

Joint authority. An Offshore Constitutional Settlement arrangement whereby a fishery is managed jointly by the Australian Government and one or more states or territories under a single (Commonwealth, or state or territory) jurisdiction.

Joint venture. Collaborative fishing operation, usually involving two companies from different countries.

K

Key commercial species. A species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.

Key threatening process. Defined under the *Environment Protection and Biodiversity Conservation Act 1999* as a process that threatens the survival, abundance or evolutionary development of a native species or ecological community, requiring the formal development of a threat abatement plan. A threatening process is eligible to be treated as a key threatening process if (a) it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation-dependent, or (b) it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment, or (c) it adversely affects two or more listed threatened species (other than conservation-dependent species), or two or more listed threatened ecological communities.

L

Latency. Fishing capacity that is authorised for use but is not currently being used. Depending on how a fishery is managed, latency might appear in effort (for example, unused vessel statutory fishing rights [SFRs], gear SFRs, quota SFRs, permits or nights fishing) or in quota (for example, where total allowable catches are not fully caught in a quota-managed fishery). It is a low-cost indicator of fishers' views about the profitability of a fishery. High levels of latency can suggest that low expected profits in the fishery do not justify fishing.

Length-frequency distribution; modal size. The number of individuals in a catch or catch sample in each group of lengths (length intervals). The modal size is the length group into which most individuals fall. Some distributions may show several modes, reflecting fish of different ages.

Limit reference point. The level of an indicator (such as biomass or fishing mortality) beyond which the risk to the stock is regarded as unacceptably high.

Limited-entry fishery. Fishery in which the fishing effort is controlled by restricting the number of operators. Usually requires controlling the number and size of vessels, the transfer of fishing rights and the replacement of vessels (c.f. Open-access fishery).

Line fishing. Fishing methods that use fishing lines, including handlines, hand reels, powered reels, pole and line, droplines, longlines, trotlines and troll lines.

Logbook. Official record of catch-and-effort data completed by fishers. In many fisheries, a licence condition makes the return of logbooks mandatory.

Longline. Fishing gear in which short lines (branch lines, snoods or droppers) carrying hooks are attached to a longer mainline at regular intervals. Pelagic longlines are suspended horizontally at a predetermined depth with the help of surface floats. The mainlines can be 100 km long and have several thousand hooks. Droppers on demersal longlines (set at the seabed with weights) are usually more closely spaced.

M

M (natural mortality). Deaths of fish from all natural causes. Usually expressed as an instantaneous rate or as a percentage of fish dying in a year. *See also* F (fishing mortality), Mortality.

Mainline. Longline fishing gear consisting of a mainline kept near the surface or at a particular depth by means of regularly spaced floats or weights. Branch lines (snoods) with baited hooks are attached to the mainline at regular intervals.

Management strategy evaluation (MSE). A procedure whereby management strategies are tested and compared using simulations of stock and fishery dynamics.

Markov chain Monte Carlo (MCMC). As applied in stock assessment, Markov chain Monte Carlo statistical methods are a class of algorithms for sampling from probability distributions around the inputs, based on constructing a Markov chain that has the desired distribution as its equilibrium distribution. The state of the chain after a large number of steps is then used as a sample of the output distribution of the parameters explored.

Maximum economic yield (MEY). The sustainable catch level for a commercial fishery that allows net economic returns to be maximised. For most practical discount rates and fishing costs, MEY implies that the equilibrium stock of fish is larger than that associated with maximum sustainable yield (MSY). In this sense, MEY is more environmentally conservative than MSY and should, in principle, help to protect the fishery from unfavourable environmental impacts that could diminish the fish population.

Maximum sustainable yield (MSY). The maximum average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions. MSY defined in this way makes no allowance for environmental variability, and studies have demonstrated that fishing at the level of MSY is often not sustainable.

Migration. Non-random movement of individuals of a stock from one place to another, often in groups.

Minimum size. Size below which a captured animal may not legally be retained. Usually specified by species. May be varied as a management tool.

Minor line. Term adopted by the Australian Fisheries Management Authority to refer to several line-fishing methods, including trolling, and fishing using a rod and reel, handline, or pole and line.

Modal size. *See* Length-frequency distribution.

Model (population). Hypothesis of how a population functions; often uses mathematical descriptions of growth, recruitment and mortality.

Mortality. Deaths from all causes (usually expressed as a rate or as the proportion of the stock dying each year).

MULTIFAN–CL. A length-based, age-structured model for assessing fishery stocks.

N

Nautical mile (nm). A unit of distance derived from the angular measurement of 1 minute of arc of latitude, but standardised by international agreement as 1,852 m.

Neritic. Designating, or of, the ecological zone (neritic zone) of the continental shelf, extending from low tide to a depth of around 180 m.

Net economic returns (NER). A fishery's NER over a particular period are equal to fishing revenue less fishing costs. Fishing costs include the usual accounting costs of fuel, labour, and repairs and maintenance, as well as various economic costs such as the opportunity cost of owner labour and capital (c.f. Opportunity cost). The concept of NER is very closely related to economic efficiency, a necessary condition for NER to be maximised.

Non-detriment finding. Relating to a species listed in an appendix of the Convention on International Trade in Endangered Species (CITES), a conclusion by a scientific authority that the export of specimens of the species will not negatively affect the survival of that species in the wild. A non-detriment finding is required before an export or import permit, or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-I species, and before an export permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-II species.

Non-target species. Species that is unintentionally taken by a fishery or not routinely assessed for fisheries management. *See also* Bycatch, Byproduct.

Not overfished. *See* Overfished.

O

Oceanic. Open-ocean waters beyond the edge of the continental shelf.

Offshore Constitutional Settlement (OCS). The 1982 package of uniform national, state and territory laws that forms the basis for Australian governments at those levels to enter into agreements for specified fisheries to be managed by a government or group of governments. A fishery might be managed by the Australian Government, one or more state or territory governments, or any combination of the two acting through a joint authority. Fisheries for which OCS arrangements are not in place may be managed under joint control or continue under current management arrangements.

Open-access fishery. Fishery in which there is no limit on the number of operators or vessels allowed to operate in the fishery (c.f. Limited-entry fishery). Such a fishery is liable to suffer the 'tragedy of the commons', where a 'race to fish' generally leaves a fish stock below its maximum sustainable yield and unable to support an economically sustainable fishery. Under open access, a fishery operates with a harvest and effort that result in total revenue-equalling costs, with no economic profits being generated. The fishing effort employed at this point exceeds the level that would achieve maximum economic yield.

Operating model. Simulation of stock dynamics (and the impact of fishing) used in management strategy evaluation.

Opportunity cost. The compensation a resource forgoes by being employed in its present use and not in the next best alternative. For example, the opportunity cost incurred by the skipper of a fishing vessel is the amount they would have received by applying their skill and knowledge in the next best alternative occupation. The opportunity cost of owning a fishing vessel might be the interest that could be earned if the vessel were sold and the capital invested elsewhere. Although these costs are not usually reflected in a firm's financial accounts, they are very important.

Otoliths. Bone-like structures formed in the inner ear of fish. The rings or layers can be counted to determine age.

Otter trawl. Demersal trawl operated by a single vessel in which the net is held open horizontally by angle-towed otter boards (large rectangular 'boards' of timber or steel), and vertically by a combination of floats on the headrope and weights on the ground line. Attached between the head and ground ropes and the towing warps, the otter boards are spread apart by the hydrodynamic forces acting on them when the net is towed.

Output controls. Management measures that place restraints on what is caught, including total allowable catch, quota, size limits and species limits.

Overfished. A fish stock with a biomass below the biomass limit reference point or below its specified indicator limit reference point. 'Not overfished' implies that the stock is not below the threshold; it is now used in place of the status classifications 'fully fished' or 'underfished' that were used in earlier editions of the *Fishery status reports*.

Overfishing, subject to. A stock that is experiencing too much fishing, and the removal rate from the stock is unsustainable. Also:

- Fishing mortality (F) exceeds the limit reference point (F_{LIM}). When stock levels are at or above B_{MSY}, F_{MSY} will be the default level for F_{LIM}.
- Fishing mortality in excess of F_{LIM} will not be defined as overfishing if a formal 'fish-down' or similar strategy is in place for a stock and the stock remains above the target level (B_{TARG}).
- When the stock is less than B_{MSY} but greater than B_{LIM}, F_{LIM} will decrease in proportion to the level of biomass relative to B_{MSY}.
- At these stock levels, fishing mortality in excess of the target reference point (F_{TARG}) but less than F_{LIM} may also be defined as overfishing, depending on the harvest strategy in place and/or recent trends in biomass levels.
- Any fishing mortality will be defined as overfishing if the stock level is below B_{LIM}, unless fishing mortality is below the level that will allow the stock to recover within a period of 10 years plus one mean generation time, or three times the mean generation time, whichever is less.

P

Pair trawling. Trawling by two vessels steaming in parallel with the net towed between them. Very large nets can be held open and towed in this way. The net may be hauled aboard the two vessels alternately for processing of the catch.

Parameter. Characteristic feature or measure of some aspect of a stock, usually expressed as a numerical value (for example, see M [natural mortality]).

Parental biomass. Weight of the adult (reproductively mature) population of a species. *See also* SB (spawning biomass).

Pelagic. Inhabiting surface waters rather than the sea floor. Usually applied to free-swimming species such as tunas and sharks (c.f. Demersal).

Pole-and-line fishing (poling). Fishing method in which fishers attract schools of fish to the vessel with live or dead bait, get them into a feeding frenzy with more bait and water sprayed onto the sea surface to simulate the behaviour of small baitfish, and then use poles with short, fixed lines and lures to 'pole' the fish aboard. Also called 'pole-and-live-bait fishing'.

Population structure. Composition of a population in terms of size, stock (genetic or regional), age class, sex and so on.

Precautionary approach. Approach to resource management in which, where there are threats of serious irreversible environmental damage, a lack of full scientific certainty is not used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary approach, uncertainties should be evaluated and taken into account in a risk assessment, and decisions should be designed to minimise the risk of serious or irreversible damage to the environment.

Productivity (biological). An indication of the birth, growth and death rates of a stock. A highly productive stock is characterised by high birth, growth and mortality rates, and can sustain high harvesting rates.

Productivity (economic). The ability of firms or an industry to convert inputs (for example, labour, capital, fuel) into output. Economic productivity is often measured using productivity indices, which show whether more or less output is being produced over time with a unit of input. The index is calculated by comparing changes in total output (fish) with changes in total inputs such as fuel, labour and capital.

Profit, economic. The difference between total revenue and explicit costs and opportunity costs (*See* Opportunity cost). Explicit costs include wages, fuel, repairs, maintenance and depreciation of physical capital (for example, vessels). Economic profit differs from accounting profit in that it includes opportunity cost.

Protected species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Purse seining. Harvesting of surface-schooling pelagic fish by surrounding the school with a net. A line that passes through rings on the bottom of the net can be tightened to close the net so that the fish cannot escape (c.f. Danish-seining).

Q

Quad gear. Four fishing nets towed simultaneously by a vessel, with the opening of each net being controlled by otter boards.

Quota. Amount of catch allocated to a fishery (total allowable catch), or to an individual fisher or company (individual transferable quota).

Quota species. Species for which catch quotas have been allocated.

R

Real prices; real terms. Real prices are historical prices that have been adjusted to reflect changes in the purchasing power of money (most commonly measured by the consumer price index). Such prices may also be expressed as being in real terms. Commonly, a year is indicated alongside a real price to show the year's prices to which historical prices have been adjusted. Prices quoted in real terms allow meaningful comparison over time because any fluctuations exclude the effect of inflation.

Rebuilding strategy. Strategy designed to rebuild a stock when a measure of its status (for example, its biomass) is below the biomass limit reference point (that is, the stock is assessed as overfished). Stock rebuilding strategies should include elements that define rebuilding targets, rebuilding time horizons and control rules related to the rate of progress.

Recovery plan. Management process to rebuild a stock when a measure of its status (for example, its biomass) is outside a defined limit (that is, the stock is assessed as overfished). Recovery plans should include elements that define stock-specific management objectives, harvesting strategies specified by control rules, and recovery periods.

Recruit. Usually, a fish that has just become susceptible to the fishery. Sometimes used in relation to population components (for example, a recruit to the spawning stock).

Recruitment. The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. Also used to refer to the number of fish from a year-class reaching a certain age.

Recruitment overfishing. Excessive fishing effort or catch that reduces recruitment to the extent that the stock biomass falls below the predefined limit reference point.

Reference point. Specified level of an indicator (for example, fishing mortality, biomass) used as a benchmark for assessment.

Ricker curve/function. Mathematical function that describes the relationship between stock size and recruitment.

S

SB (spawning biomass). Total weight of all adult (reproductively mature) fish in a population. Also called 'spawning stock biomass'.

SB_{MEY}; S_{MEY}. Spawning or 'adult' equilibrium biomass at maximum economic yield.

SB_{MSY}; S_{MSY}. Spawning or 'adult' equilibrium biomass at maximum sustainable yield.

Seasonal closure. Closure of a fishing ground for a defined period; used as a management tool, often to protect one component of the stock.

Seines. Seine nets are usually long, flat nets like a fence that are used to encircle a school of fish, with the vessel driving around the fish in a circle. Purse-seine and Danish-seine nets are used in a range of fisheries.

Shelf break. Region where the continental shelf and continental slope meet—that is, where the seabed slopes steeply towards the ocean depths.

Shot (shot by shot). Pertaining to each separate deployment of a fishing gear by a fishing vessel.

Size frequency. *See* Length-frequency distribution.

Size at maturity. Length or weight of fish when they reach reproductive maturity.

Slope (mid-slope; upper slope). Part of the continental slope—the more steeply dipping sea floor beyond the edge of the continental shelf.

Snood. Short lengths of line that attach baited hooks to longlines (pelagic or demersal). *See also* Longline.

Spawner per recruit (spawner–recruit). An index that gives the number of spawners of a particular age divided by the initial number of recruits.

Spawning potential ratio (SPR). The average fecundity of a recruit over its lifetime when the stock is fished divided by the average fecundity of a recruit over its lifetime when the stock is unfished.

Species group. Group of similar species that are often difficult to differentiate without detailed examination.

Standard length. The length of a fish measured from the tip of the snout to the posterior end of the last vertebra or to the posterior end of the mid-lateral portion of the hypural plate.

Standardised data. Data that have been adjusted to be directly comparable to a unit that is defined as the 'standard' one. For example, catch-per-unit-effort data are often used as an indicator of fish abundance.

Statutory fishing rights (SFRs). Rights to participate in a limited-entry fishery. An SFR can take many forms, including the right to access a fishery or area of a fishery, the right to take a particular quantity of a particular type of fish, or the right to use a particular type or quantity of fishing equipment.

Steepness (h). Conventionally defined as the proportion of unfished recruitment (R_0) that would be expected to be produced if the spawning biomass were reduced to 20% of unfished spawning biomass (S_0). Stocks with high steepness produce many more births than deaths, on average, when the spawning stock is reduced to low levels by fishing. A greater number of individuals can be sustainably taken by fishing from a stock with high steepness than from a comparable stock with lower steepness. The steepness of a stock is typically both very difficult to estimate and highly influential on stock assessment model outputs such as maximum sustainable yield and spawning stock biomass. It is therefore a major source of uncertainty in most comprehensive stock assessments.

Stock. Functionally discrete population that is largely distinct from other populations of the same species and can be regarded as a separate entity for management or assessment purposes.

Stock recruitment. *See* Recruit.

Stock–recruitment relationship. Relationship between the size of the parental biomass and the number of recruits it generates. Determination of this relationship is difficult, and involves studying the population's size–age composition, and growth and mortality rates.

Straddling stock. Migratory species that spends part of its life cycle in two or more jurisdictions, especially one that migrates between Exclusive Economic Zones and the high seas.

Subtropical waters. Waters adjacent to, but not within, the tropics; in the Australian region, the waters south of the Tropic of Capricorn (about 23°26'S).

Surplus production. Inherent productivity of a fish stock that can be harvested sustainably. Based on the theory that, at large stock size, rates of reproduction and stock increase are slowed by self-regulating mechanisms, and that the stock increases faster after removals as it attempts to rebuild. In theory, fishing can be moderated to take advantage of the more productive rates of stock increase, provided it does not exceed the stock's capacity to recover.

Surplus production model. Mathematical representation of the way a stock of fish responds to the removal of individuals (for example, by fishing).

Sustainable yield. Catch that can be removed over an indefinite period without reducing the biomass of the stock. This could be either a constant yield from year to year, or a yield that fluctuates in response to changes in abundance.

T

Tagging. Marking or attaching a tag to an animal so that it can be identified when recaptured; used to study fish growth, movement, migration, and stock structure and size.

Target fishing (targeting). Fishing selectively for particular species or sizes of fish.

Target reference point. The desired state of the stock or fishery (for example, MEY or B_{TARG}).

Target species. *See* Key commercial species.

Taxonomic group. A group of organisms with similar physical, chemical and/or structural composition.

Territorial sea baseline. The baseline from which all the zones (for example, Exclusive Economic Zone) of Australia's maritime jurisdiction are measured. The baseline is defined as the level of lowest astronomical tide along the coast. Straight baselines may be drawn along deeply indented coastlines or to encompass islands fringing the coast. The baseline may also be drawn straight across the entrances to bays and estuaries, rather than following the coast inshore.

Threat abatement plan. Plan formalised under endangered species legislation to counter the effects of a listed key threatening process.

Threatened species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Tori line. Line with streamers, towed as a scaring device over the area behind a vessel where sinking, baited hooks are within range of diving seabirds; attached to a tori pole (boom) at the vessel's stern.

Total allowable catch (TAC). For a fishery, a catch limit set as an output control on fishing (*see also* Output controls). Where resource-sharing arrangements are in place between commercial and recreational fishers, the term total allowable commercial catch (TACC) will apply. The term 'global' is applied to TACs that cover fishing mortality from all fleets, including Commonwealth, state and territory fleets.

Total allowable catch (TAC), actual. The agreed TAC for a species with amendments applied, such as carryover or debits from the previous year.

Total allowable catch (TAC), agreed. The TAC for individual quota species as determined by the Australian Fisheries Management Authority Commission.

Total allowable commercial catch (TACC). *See* Total allowable catch (TAC).

Total allowable effort. An upper limit on the amount of effort that can be applied in a fishery.

Total length. The length of a fish from the tip of the snout to the tip of the longer lobe of the caudal fin, usually measured with the lobes compressed along the midline. It is a straight-line measure, not measured over the curve of the body.

Trap fishing. Fishing by means of traps, often designed to catch a particular species (for example, rock lobster pots).

Trawl fishing. Fishing method in which a large, bag-like net is drawn along behind a vessel to target either demersal or pelagic fish species. There are many variations.

Trigger catch limit. When catches reach this limit, management actions are triggered.

Trigger points. Pre-specified quantities (for example, total catch, spawning biomass) that indicate the need for a management response.

Trolling. Fishing method in which lines with baits or lures are dragged by a vessel at 2–10 knots. Used widely to catch fish such as Spanish mackerel, yellowtail kingfish and several tuna species.

Trotline. A dropline of hooks suspended from a mainline.

Turtle excluder device. A device fitted to a net or a modification made to a net that allows turtles to escape immediately after being captured in the net.

U

Uncertain. Status of a fish stock for which there is inadequate or inappropriate information to make a reliable assessment of whether the stock is overfished or not overfished, or subject to overfishing or not subject to overfishing.

V

Vessel-level efficiency. Vessel-level efficiency requires that revenues be maximised and catching costs be minimised for a given quantity of catch. The choice of management regime will have a substantial bearing on whether vessel-level efficiency is achieved, because it largely defines the incentive structure within which fishers operate.

Vessel monitoring system. Electronic device that transmits the identity and location of a vessel.

Virgin biomass. Biomass of a stock that has not been fished (also called the 'unfished' or 'unexploited' biomass).

Vulnerable species. Species that will become endangered within 25 years unless mitigating action is taken. The *Environment Protection and Biodiversity Conservation Act 1999* dictates that a native species is eligible to be included in the vulnerable category at a particular time if, at that time, (a) it is not critically endangered or endangered, and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria. *See also* Endangered species.

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Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)

Postal address	GPO Box 858 Canberra ACT 2601
Switchboard	+61 2 6272 3933
Email	info.abares@agriculture.gov.au
Web	agriculture.gov.au/abares

agriculture.gov.au/abares

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