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Yellowfin tuna—Georgia Langdon, AFMA
Southern bluefin tuna—Jarrad James, AFMA
Fishing bins—Dylan Maskey, AFMA
Longline hooks—Heesh Garroun, 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, Water and the Environment 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 Agriculture, Water and the Environment—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

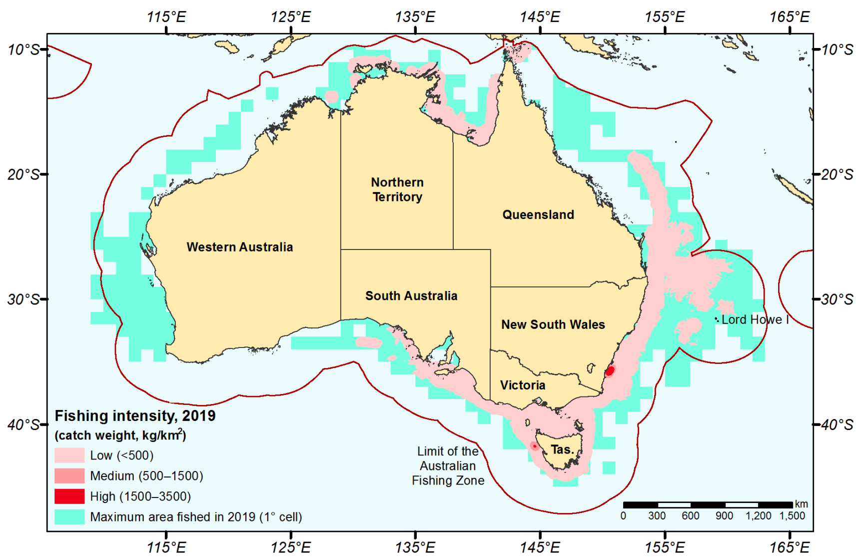
H Patterson, J Woodhams, J Larcombe and R Curtotti

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 2020 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 2019 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 such as the Commission for the Conservation of Southern Bluefin Tuna, the Indian Ocean Tuna Commission, and the Western and Central Pacific Fisheries Commission, among others. The reports use information on catch and fishing effort, along with 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 2019. Economic status is presented for the 2018–19 financial year.

FIGURE 1.1 Fishing intensity of all Australian Government–managed fisheries, 2019



1.1 Assessing biological status

Stock status addresses 2 questions—whether the current size of the fish stock is above the level at which the stock is considered to be overfished (biomass status) and whether current levels of fishing mortality (landed catch, discards and other sources of mortality) will cause the stock to become overfished (fishing mortality status). Stock status is expressed in relation to the reference points prescribed by the Commonwealth Fisheries Harvest Strategy Policy (HSP; Department of Agriculture and Water Resources 2018b).

Biomass (B) status typically 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 currently, or have been, an important part of a fishery.

Specifically, stocks may be included if they meet 1 or more of the criteria below:

- a species that represents a significant component of the fishery in terms of volume or value
- 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
- 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 1 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 (ERA) process for the fishery or sector.

Conversely, stocks may be removed from the reports if they cease to be an important part of a fishery (that is, the fishery changes practices or markets change). The following stocks will not be removed:

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

1.2 Biological status in 2019

Fishery status reports 2020 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 by the Australian Government and 1 or more other Australian jurisdictions or other countries.

The status of the 96 fish stocks managed solely or jointly by the Australian Government in 2019 is summarised as follows:

- The number of stocks classified as not subject to overfishing (Figure 1.3) decreased to 78 (79 in 2018), and the number of stocks classified as not overfished (Figure 1.4) remained at 70 (70 in 2018). Of these, 66 stocks were both not subject to overfishing and not overfished (67 in 2018).
- The number of stocks classified as subject to overfishing (Figure 1.3) increased to 4 (2 in 2018), and the number of stocks classified as overfished (Figure 1.4) increased to 12 (11 in 2018). One stock remained classified as both overfished and subject to overfishing (1 in 2018).
- The number of stocks classified as uncertain with regard to fishing mortality decreased to 14 (15 in 2018), and the number of stocks classified as uncertain with regard to biomass decreased to 14 (15 in 2018). Of these, 6 stocks were uncertain with respect to both fishing mortality and biomass.

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.

FIGURE 1.2 Biological status of fish stocks in 2019, by fishery or sector

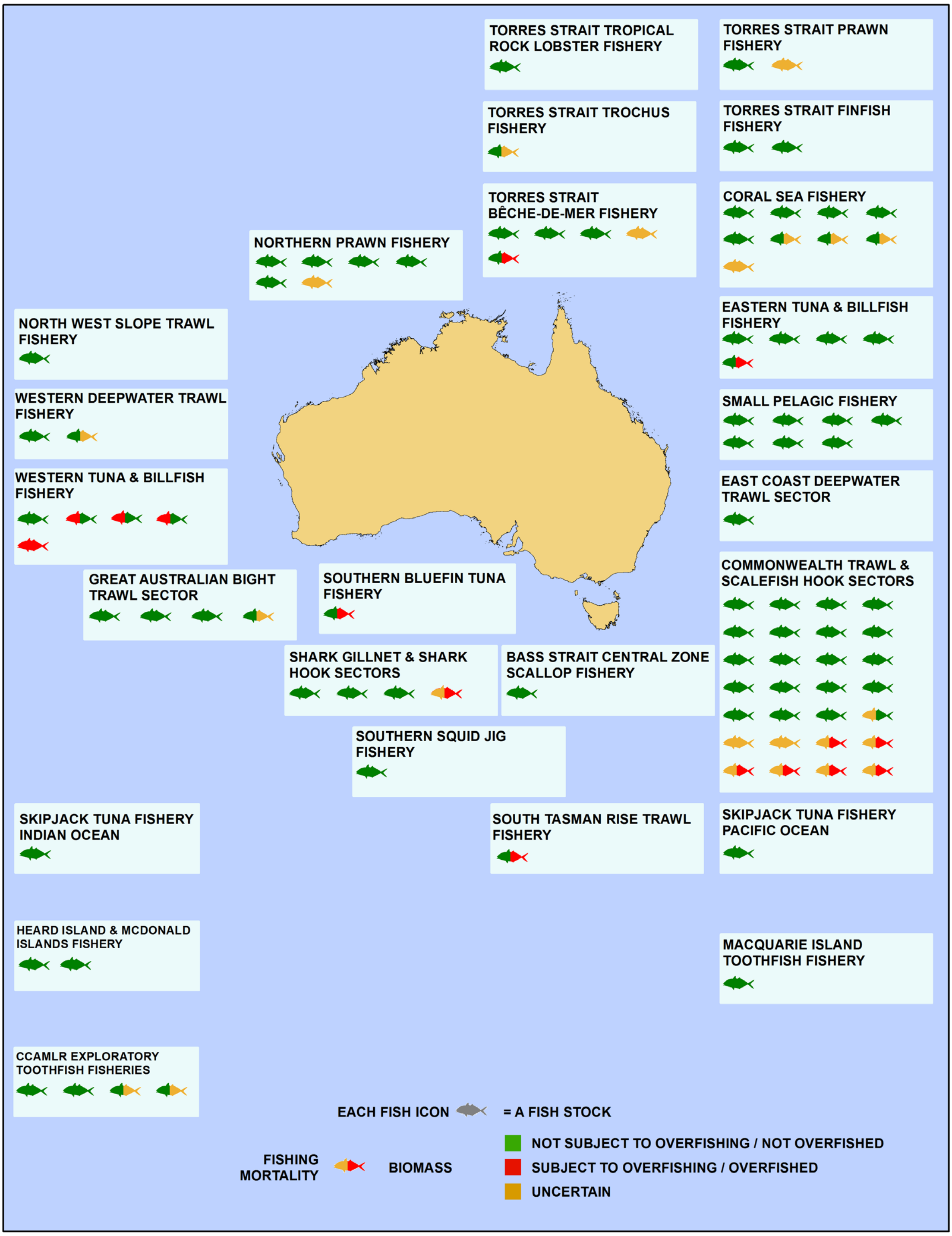


FIGURE 1.3 Fishing mortality status (number of stocks), 2004 to 2019

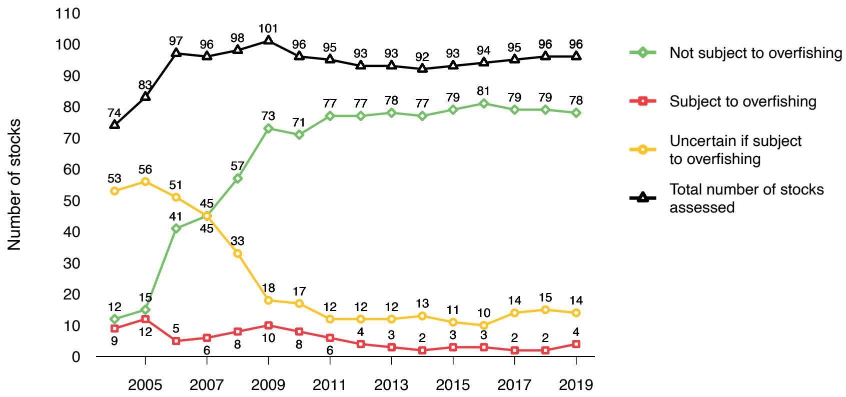
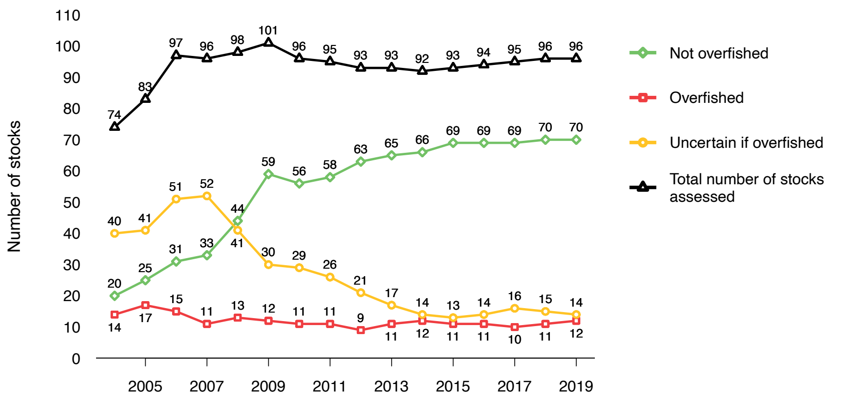


FIGURE 1.4 Biomass status (number of stocks), 2004 to 2019



Stocks that have changed status

Four stocks managed solely by the Australian Government changed status in 2019 (Table 1.1). In the Coral Sea Fishery, white teatfish (*Holothuria fuscogilva*) is considered not subject to overfishing as there was no commercial catch in 2018–19. In the Northern Prawn Fishery (NPF), redleg banana prawn (*Fenneropenaeus indicus*) are now considered not subject to overfishing as the low level of fishing mortality is unlikely to reduce the relatively high biomass to below the limit reference point. In the Southern and Eastern Scalefish and Shark Fishery (SESSF), the southern and western zone orange roughy (*Hoplostethus atlanticus*) stocks are considered uncertain for fishing mortality status in 2019. While in previous years both stocks were classified as not subject to overfishing, this was considered inappropriate when (similar to other rebuilding species) 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. To ensure consistency in approach across like stocks, both the southern zone and western zone orange roughy stocks have been classified as uncertain with regard to fishing mortality status in 2019.

Four stocks in jointly managed fisheries changed status in 2019. The status of brown tiger prawn (*Penaeus esculentus*) in the Torres Strait Prawn Fishery is now considered to be not subject to overfishing and not overfished, based on the results of a 2019 assessment. The biomass status of striped marlin (*Kajikia audax*) stock in the Eastern Tuna and Billfish Fishery (ETBF) changed to overfished in 2019 because the stock assessment indicated the biomass was below the default limit reference point. In the Western Tuna and Billfish Fishery (WTBF), both the albacore (*Thunnus alalunga*) and bigeye tuna (*T. obesus*) stocks are now classified as subject to overfishing because updated stock assessments indicate that the fishing mortality rates are above that required to produce maximum sustainable yield (MSY).

TABLE 1.1 Stocks with a changed status in 2019 and their status in 2018

Fishery	Common name (scientific name)	2018		2019	
		Fishing mortality	Biomass	Fishing mortality	Biomass
Stocks in fisheries managed solely by the Australian Government					
Coral Sea Fishery	White teatfish *(Holothuria fuscogilva)*	Uncertain	Uncertain	Not subject to overfishing	Uncertain
Northern Prawn Fishery	Redleg banana prawn *(Fenneropenaeus indicus)*	Uncertain	Not overfished	Not subject to overfishing	Not overfished
Southern and Eastern Scalefish and Shark Fishery: Commonwealth Trawl Sector	Orange roughy, southern zone *(Hoplostethus atlanticus)*	Not subject to overfishing	Overfished	Uncertain	Overfished
Southern and Eastern Scalefish and Shark Fishery: Commonwealth Trawl Sector	Orange roughy, western zone *(Hoplostethus atlanticus)*	Not subject to overfishing	Overfished	Uncertain	Overfished
Stocks in fisheries managed jointly by the Australian Government					
Torres Strait Prawn Fishery	Brown tiger prawn *(Penaeus esculentus)*	Uncertain	Uncertain	Not subject to overfishing	Not overfished
Eastern Tuna and Billfish Fishery	Striped marlin *(Kajikia audax)*	Not subject to overfishing	Not overfished	Not subject to overfishing	Overfished
Western Tuna and Billfish Fishery	Albacore *(Thunnus alalunga)*	Not subject to overfishing	Not overfished	Subject to overfishing	Not overfished
Western Tuna and Billfish Fishery	Bigeye tuna *(Thunnus obesus)*	Not subject to overfishing	Not overfished	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)

Stocks classified as overfished and/or subject to overfishing

Stocks classified as overfished and/or subject to overfishing in 2019 are largely the same as in 2018 for fisheries solely managed by the Australian Government, but there were 3 new stocks classified as overfished or subject to overfishing for jointly managed stocks (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, 7 stocks in fisheries managed solely by the Australian Government were classified as overfished in 2019 (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, gulper sharks (*Centrophorus harrissoni*, *C. moluccensis* and C. *zeehaani*) and school shark (*Galeorhinus galeus*) are also listed as conservation-dependent under the EPBC Act, which carries management requirements.

Eight stocks in jointly managed fisheries were classified as overfished or subject to overfishing in 2019 based on the results of updated stock assessments. This is 3 more stocks than in 2018 (Table 1.2). One stock, striped marlin in the WTBF, remains classified as both overfished and subject to overfishing.

Assessing status for overfished stocks

It is becoming increasingly difficult to assess status for a number of overfished stocks. This is a result of a range of factors, including uncertainty in the level of total fishing mortality (commercial catch, discards, recreational catch and post-release survival), uncertainty associated with the current biomass stemming from outdated and/or increasingly uncertain stock assessments, and uncertainty in the level of catch that would provide for rebuilding in the specified time frame (for example, the time frame articulated by rebuilding strategies).

A robust evaluation of the state of overfished stocks (biomass) and the fishing mortality required to rebuild those stocks is often outdated or increasingly uncertain. Examples include blue warehou (last published assessment in 2013) and eastern gemfish (last published assessment in 2010) (see Chapter 9 for further detail). Similarly, the last full assessment for school shark was published in 2009; this was the last time an estimate of relative biomass was provided. A close-kin mark recapture (CKMR) study, a relatively new technique being applied to fish stocks, led to an assessment of the school shark stock in 2019 (Thomson et al. 2019). This assessment estimated the future stock response to various fishing mortality rates, but was not able to provide an estimate of current biomass relative to unfished biomass (see Chapter 12 for further detail).

Quantitative assessments for long-term overfished stocks are typically not being updated because the time series of necessary data (for example, catch, effort, catch-per-unit-effort and/or biological data) required to update them has been disrupted, often by management efforts and interventions aimed at recovering the stocks (for example, zero commercial TACs), affecting the potential reliability of an updated assessment. While efforts to improve our understanding of the state of these stocks and their response to management intervention have begun (such as in the case of school shark and the CKMR work), this is not the case for all species. Further, assessment efforts to date have demonstrated limitations in what can be achieved (see Chapter 12 for a full description). These realities continue to make it difficult to evaluate the management performance (status) for 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 edition in the series. The reports intend to provide a national assessment of the status of key wild-capture fish stocks managed around Australia. 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 the states and territories.

The 2018 reports provide assessments for 406 stocks across 120 key species (or species complexes). The reports consider similar biological information to that considered by the *Fishery status reports*, but interpret that information within a nationally agreed classification system, which is different from that reported on in the *Fishery status reports* (see Appendix). *Status of Australian fish stocks reports 2020* is due to be released in late 2020.

TABLE 1.2 Stocks classified as overfished and/or subject to overfishing in 2019, and their status in 2018

Fishery	Common name (scientific name)	2018		2019		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. Biomass is below the limit reference point.
SESSF: CTS and SHS Chapter 9	Gemfish, eastern zone (*Rexea solandri*)					Uncertainty remains around total fishing mortality and rebuilding to the limit reference point within the specified time frame. Biomass is below the limit reference point.
SESSF: CTS and SHS Chapter 9	Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)					Fishing mortality is uncertain despite low landed catch and protection through closures. Populations are likely to be highly depleted.
SESSF: CTS Chapter 9	Orange roughy, southern zone (*Hoplostethus atlanticus*)					No reliable indicators to determine whether current fishing mortality will allow stock to rebuild within the specified time frame. No updated stock assessment to estimate the biomass is available.

TABLE 1.2 Stocks classified as overfished and/or subject to overfishing in 2019, and their status in 2018 continued

Fishery	Common name (scientific name)	2018		2019		Comments
		Fishing mortality	Biomass	Fishing mortality	Biomass	
SESSF: CTS Chapter 9	Orange roughy, western zone (*Hoplostethus atlanticus*)					No reliable indicators to determine whether current fishing mortality will allow stock to rebuild within the specified time frame. No updated stock assessment to estimate the biomass is available.
SESSF: CTS Chapter 9	Redfish (*Centroberyx affinis*)					Catch is above the RBC, and it is unclear whether total removals are above the level that will allow rebuilding. Biomass is below the limit reference point.
SESSF: SGSHS Chapter 12	School shark (*Galeorhinus galeus*)					Uncertain if the current fishing mortality rate in will allow recovery within the specified time frame. Biomass is likely below 20% of unexploited levels.
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. No updated stock assessment to estimate the biomass is available.
Torres Strait Bêche-de-mer Fishery Chapter 19	Sandfish (*Holothuria scabra*)					No catch in 2019. The most recent full survey (2009) indicated that the stock was overfished.
Southern Bluefin Tuna Fishery Chapter 23	Southern bluefin tuna (*Thunnus maccoyii*)					The global TAC, set in line with the management procedure, should allow rebuilding within the prescribed time frame. The estimate of spawning biomass is below 20% of unfished biomass.
Eastern Tuna and Billfish Fishery Chapter 21	Striped marlin (*Kajikia audax*)					The current fishing mortality rate is below that required to produce MSY. The current estimate of biomass is below the default Commonwealth limit reference point.

continued ...

TABLE 1.2 Stocks classified as overfished and/or subject to overfishing in 2019, and their status in 2018 continued

Fishery	Common name (scientific name)	2018		2019		Comments
		Fishing mortality	Biomass	Fishing mortality	Biomass	
WTBF Chapter 24	Striped marlin (*Kajikia audax*)					The current fishing mortality rate exceeds that required to produce MSY. The current estimate of biomass is below the default Commonwealth limit reference point.
WTBF Chapter 24	Albacore *(Thunnus alalunga)*					The current fishing mortality rate is above that required to produce MSY. The most recent estimate of spawning biomass is above the default Commonwealth limit reference point.
WTBF Chapter 24	Bigeye tuna *(Thunnus obesus)*					The current fishing mortality rate is above that required to produce MSY. The most recent estimate of spawning biomass is above the default Commonwealth limit reference point.
WTBF Chapter 24	Yellowfin tuna (*Thunnus albacares*)					The current fishing mortality rate is above that required to produce MSY. The most recent estimate of spawning biomass is above the default Commonwealth limit reference point.

Notes: **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 2019, 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		2019	
		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	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																																

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2019, 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		2019	
		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	Fishing mortality	Biomass
Northern Prawn Fishery	Redleg banana prawn (*Fenneropenaeus indicus*)	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	Yellow	Yellow	Green	Yellow	Green	Green	Green
Northern Prawn Fishery	White banana prawn (*Fenneropenaeus merguiensis*)	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	Green	Green
Northern Prawn Fishery	Brown tiger prawn (*Penaeus esculentus*)	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	Green	Green
Northern Prawn Fishery	Grooved tiger prawn (*Penaeus semisulcatus*)	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	Green	Green
Northern 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	Green	Green	Green	Green	Green	Green
Northern Prawn Fishery	Red endeavour prawn (*Metapenaeus ensis*)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
North West Slope Trawl Fishery	Scampi (*Metanephrops australiensis*, *M. boschmai*, *M. velutinus*)	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	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Australian sardine (*Sardinops sagax*)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Blue mackerel, east (*Scomber australasicus*)	Grey	Grey	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
Small Pelagic Fishery	Blue mackerel, west (*Scomber australasicus*)	Grey	Grey	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
Small Pelagic Fishery	Jack mackerel, east (*Trachurus declivis*)	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	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Jack mackerel, west (*Trachurus declivis*)	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	Green	Green	Green	Green	Green	Green

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2019, 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		2019	
		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	Fishing mortality	Biomass
Small Pelagic Fishery	Redbait, east (*Emmelichthys nitidus*)	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	Green	Green	Green	Green
Small Pelagic Fishery	Redbait, west (*Emmelichthys nitidus*)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue-eye trevalla (*Hyperoglyphe antarctica*)	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue grenadier (*Macruronus novaezelandiae*)	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	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue warehou (*Seriolella brama*)	Red	Red	Yellow	Red	Yellow	Red	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red
SESSF: Commonwealth Trawl Sector	Deepwater sharks, eastern zone (18 species)	Grey	Grey	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow
SESSF: Commonwealth Trawl Sector	Deepwater sharks, western zone (18 species)	Grey	Grey	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow
SESSF: Commonwealth Trawl Sector	Eastern school whiting (*Sillago flindersi*)	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	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Flathead (*Neoplatycephalus richardsoni* and 4 other species)	Yellow	Green	Red	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: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, eastern zone (*Rexea solandri*)	Red	Red	Red	Red	Yellow	Red	Green	Red	Green	Red	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, western zone (*Rexea solandri*)	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	Green	Green	Green	Green

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2019, and their status since 2004 continued

Fishery	Common name (scientific name)	Status: 2004 Fishing mortality	2004 Biomass	2005 Fishing mortality	2005 Biomass	2006 Fishing mortality	2006 Biomass	2007 Fishing mortality	2007 Biomass	2008 Fishing mortality	2008 Biomass	2009 Fishing mortality	2009 Biomass	2010 Fishing mortality	2010 Biomass	2011 Fishing mortality	2011 Biomass	2012 Fishing mortality	2012 Biomass	2013 Fishing mortality	2013 Biomass	2014 Fishing mortality	2014 Biomass	2015 Fishing mortality	2015 Biomass	2016 Fishing mortality	2016 Biomass	2017 Fishing mortality	2017 Biomass	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)	Grey	Grey	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	Yellow	Red	Yellow	Red
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Jackass morwong (*Nemadactylus macropterus*)	Yellow	Yellow	Green	Green	Green	Yellow	Yellow	Yellow	Red	Red	Red	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	John dory (*Zeus faber*)	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	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
SESSF: Commonwealth Trawl Sector	Mirror dory (*Zenopsis nebulosa*)	Yellow	Yellow	Yellow	Yellow	Green	Green	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	Green
SESSF: Commonwealth Trawl Sector	Ocean jacket (*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	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ocean perch (*Helicolenus barathri*, *H. percoides*)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)	Grey	Grey	Red	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: Commonwealth Trawl Sector	Orange roughy, eastern zone (*Hoplostethus atlanticus*)	Red	Red	Red	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Orange roughy, southern zone (*Hoplostethus atlanticus*)	Red	Red	Red	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	Green	Red	Yellow	Red
SESSF: Commonwealth Trawl Sector	Orange roughy, western zone (*Hoplostethus atlanticus*)	Red	Red	Red	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	Green	Red	Yellow	Red

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2019, and their status since 2004 continued

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

Fishery	Common name (scientific name)	2012 Fishing mortality	2012 Biomass	2013 Fishing mortality	2013 Biomass	2014 Fishing mortality	2014 Biomass	2015 Fishing mortality	2015 Biomass	2016 Fishing mortality	2016 Biomass	2017 Fishing mortality	2017 Biomass	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, Cascade Plateau (*Pseudocyttus maculatus*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, non–Cascade Plateau (*Pseudocyttus maculatus*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Oreodory: other (*Neocyttus rhomboidalis*, *Allocyttus niger*, *A. verrucosus*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Yellow	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Pink ling (*Genypterus blacodes*)	Yellow	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Redfish (*Centroberyx affinis*)	Green	Yellow	Green	Yellow	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ribaldo (*Mora moro*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Royal red prawn (*Haliporoides sibogae*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Silver trevally (*Pseudocaranx georgianus*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Silver warehou (*Seriolella punctata*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: East Coast Deepwater Trawl Sector	Alfonsino (*Beryx splendens*)	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 2019, 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		2019	
		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	Fishing mortality	Biomass
SESSF: Great Australian Bight Trawl Sector	Bight redfish (*Centroberyx gerrardi*)	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	Green	Green
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	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	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	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	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	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	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	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	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	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	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	Green	Green

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2019, 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		2019	
		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	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	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	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	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	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	Green	Green
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	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	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	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	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	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	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	Green	Yellow

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2019, 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		2019	
		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	Fishing mortality	Biomass
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	Green	Red
Eastern Tuna and Billfish Fishery	Swordfish (*Xiphias gladius*)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green
Eastern Tuna and Billfish Fishery	Albacore (*Thunnus alalunga*)	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	Green	Green
Eastern Tuna and Billfish Fishery	Bigeye tuna (*Thunnus obesus*)	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Red	Red	Green	Red	Green	Red	Green	Red	Red	Red	Red	Red	Red	Red	Red	Green	Green	Green	Green	Green	Green
Eastern Tuna and Billfish Fishery	Yellowfin tuna (*Thunnus albacares*)	Green	Green	Red	Green	Red	Green	Red	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Skipjack Tuna Fishery: Pacific Ocean	Skipjack tuna (*Katsuwonus pelamis*)	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	Green	Green
Skipjack Tuna Fishery: Indian Ocean	Skipjack tuna (*Katsuwonus pelamis*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Southern Bluefin Tuna Fishery	Southern bluefin tuna (*Thunnus maccoyii*)	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Yellow	Red	Green	Red	Green	Red	Green	Red
Western Tuna and Billfish Fishery	Striped marlin (*Kajikia audax*)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Green	Red	Green	Red	Yellow	Red	Red	Red	Red
Western Tuna and Billfish Fishery	Swordfish (*Xiphias gladius*)	Yellow	Yellow	Yellow	Yellow	Red	Green	Red	Green	Red	Yellow	Red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Western Tuna and Billfish Fishery	Albacore (*Thunnus alalunga*)	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Yellow	Yellow	Red	Green	Red	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green
Western Tuna and Billfish Fishery	Bigeye tuna (*Thunnus obesus*)	Red	Green	Red	Green	Yellow	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green
Western Tuna and Billfish Fishery	Yellowfin tuna (*Thunnus albacares*)	Yellow	Yellow	Red	Yellow	Red	Green	Red	Green	Red	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2019, 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		2019	
		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	Fishing mortality	Biomass
Heard Island and McDonald Islands Fishery	Mackerel icefish (*Champsocephalus gunnari*)	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	Green	Green	Green	Green	Green	Green
Heard Island and McDonald Islands Fishery	Patagonian toothfish (*Dissostichus eleginoides*)	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	Green	Green	Green	Green	Green	Green
CCAMLR exploratory toothfish fisheries 58.4.1	Toothfish (*Dissostichus mawsoni*)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Yellow	Green	Yellow	Green	Yellow	Green	Yellow
CCAMLR exploratory toothfish fisheries 58.4.2	Toothfish (*Dissostichus mawsoni*)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Yellow	Green	Yellow
CCAMLR exploratory toothfish fisheries 88.1	Toothfish (*Dissostichus mawsoni*)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green
CCAMLR exploratory toothfish fisheries 88.2	Toothfish (*Dissostichus mawsoni*)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

	Green	Red	Yellow
Fishing mortality	Not subject to overfishing	Subject to overfishing	Uncertain
Biomass	Not overfished	Overfished	Uncertain

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.

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. 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/or declining away from this point, rebuilding of the stock is required to increase biomass and maximise NER. When biomass is above the target reference point, a higher level of fishing mortality (catch) is required to bring the stock down to the target reference point and 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.

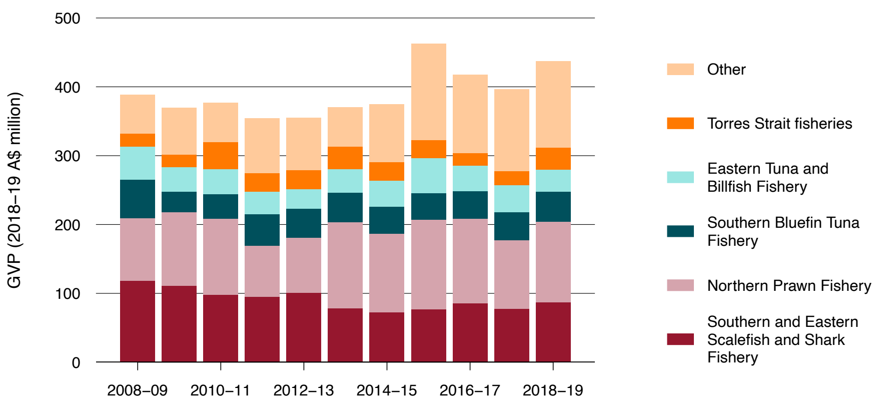
Direct estimates of NER are only available for key Commonwealth fisheries for which ABARES routinely assesses financial and economic performance by surveying industry. Where direct estimates of NER are not available, a range of indicators are used to assess the economic performance of fisheries, and 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 the relevant objectives for those fisheries. Table 1.4 summarises indicators of economic performance.

Economic status in 2018–19

Fishery status reports 2020 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 $437 million in 2018–19, accounting for 24% of wild-catch fisheries GVP in Australia ($1.79 billion).[1] These fisheries also accounted for about 14% of Australia's total fisheries and aquaculture GVP in 2018–19.

The 2018–19 Commonwealth fisheries GVP was dominated by production from 4 major fisheries that together accounted for 65% of total Commonwealth fisheries GVP. The NPF made a large contribution to overall Commonwealth fishery GVP, with a GVP of $117.6 million (27% contribution). The multisector SESSF was also a valuable Commonwealth fishery, with a GVP of $86.9 million (20% contribution). The wild-catch sector of the Southern Bluefin Tuna Fishery (SBTF) and the ETBF also made substantial contributions to fisheries GVP, with values of $43.4 million and $32.1 million, respectively (Figure 1.5).

FIGURE 1.5 Gross value of production of fisheries managed solely or jointly by the Australian Government, 2008–09 to 2018–19



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 2018–19

Fishery	Performance relative to MEY target	NER trend	Fishing right latency in fishing season	2018–19 fishery GVP (% change from 2017–18)
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	$6.33 million (–6%)
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	$117.63 million (+20%)
North West Slope Trawl Fishery	MEY target not specified	Increasing	High non-participation by licence holders	Confidential
Small Pelagic Fishery	MEY target not specified	Not available but likely increasing	High uncaught TAC	Confidential
SESSF: Commonwealth Trawl and Scalefish Hook sectors **a**	Of the 4 key species, 3 are above or close to B_{MEY} targets. Some overfished stocks require rebuilding for improvement in economic status	Declining	High uncaught TAC for some species	$49.47 million (16%)
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	$8.48 million (–7%)
SESSF: Shark Hook and Shark Gillnet sectors **b**	Gummy shark stock close to, or above, target. Biomass of school shark requires rebuilding	Volatile: Positive in 2016–17; estimated to become negative in 2017–18 and then positive in 2018–19	Low uncaught TAC for key target species	$23.66 million (19%)
Southern Squid Jig Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential

2018–19 management costs (% share of GVP)	Primary management instrument	Economic status
$0.28 million (4%)	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). Compared with 2010–11, GVP in 2018–19 was higher and fewer vessels were used in the fishery.
$0.16 million (confidential)	Catch triggers and TACs	Estimates of NER are not available. Catch in the Aquarium Sector decreased in 2018–19 and the economic performance of this sector is uncertain. No catch was taken in the Sea Cucumber, or Lobster and Trochus sectors in 2018–19, and catch in the Line Sector decreased relative to the previous year. The trend in economic performance for these sectors is also uncertain.
Not available	Input controls	Economic status is unknown.
$1.97 million (2%)	Individual transferable gear units (headrope length)	NER reached a high of $32.1 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 $30.9 million. In 2017–18, lower GVP and higher unit fuel prices are expected to have a dampening effect on NER.
$0.14 million (confidential)	Limited entry and catch triggers	Estimates of NER are not available for the fishery. It is likely that operating costs in the fishery decreased in 2018–19 following a decrease in average effort per vessel. This, combined with higher catch per hour trawled, indicates that NER improved in 2018–19.
$1.11 million (confidential)	ITQs	Estimates of NER are not available for the fishery. A substantial increase in catch in the 2018–19 and 2019–20 fishing seasons suggests that the GVP is likely to have increased, and also indicate a potential increase in NER.
$2.96 million for CTS (6% of CTS GVP)	ITQs	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 and –$1.07 million in 2018–19. These negative results are driven by lower forecast income and higher forecast operating costs.
$0.00 million (confidential)	ITQs	A high level of latency exists for this fishery. No fishing effort between 2013–14 and 2017–18, and low catches in 2018–19 and 2019–20 indicate low NER.
$0.37 million (4%)	ITQs	An increase in fuel price, together with lower GVP indicate that NER are likely to have been lower in 2018–19 than in 2017–18.
$2.50 million for GHTS (8% of GHTS GVP)	ITQs	NER for the GHTS were $3.4 million in 2016–17. Preliminary estimates indicate that NER were likely negative for 2017–18 but recovering to $5.6 million in 2018–19.
$0.09 million (confidential)	Individual transferable gear units (jig machines)	Catch in the fishery decreased significantly in 2019 while effort remained similar to 2018 levels. NER in the fishery are likely to have declined in 2018–19.

continued ...

TABLE 1.4 Indicators and summary of economic status of Commonwealth fisheries for 2018–19 continued

Fishery	Performance relative to MEY target	NER trend	Fishing right latency in fishing season	2018–19 fishery GVP (% change from 2017–18)
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	$0.86 million (–16%)
Torres Strait Tropical Rock Lobster Fishery	Not applicable **c**	Not available	Low uncaught TAC	$19.72 million (+31%)
Torres Strait Prawn Fishery	Not applicable **c**	Not available	High unused effort	$11.23 million (+144%)
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	$32.08 million (–16%)
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	$43.43 million (+9%)
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

2018–19 management costs (% share of GVP)	Primary management instrument	Economic status
$0.14 million (confidential)	Limited entry	Estimates of NER are unavailable and GVP is confidential because of the low number of active vessels in the fishery. In 2018–19, an increase in catch per active vessel was balanced with an increase in effort per active vessel and higher fuel costs, indicating an uncertain trend in NER.
Not available	Non-tradeable quota	Estimated NER are not available for the fishery. GVP declined in the 2018–19 fishing season, likely due to lower catch. However, participation from the Traditional Inhabitant Boat Sector increased in 2018–19, indicating a potential increase in the socio-economic benefits for Torres Strait Islander communities.
Not available	Limited entry for non–Traditional Inhabitant Sector and TAC	NER in the fishery are uncertain, although positive economic improvements are likely to have occurred in the 2018–19 fishing season as a result of significant increases in TAC and gross value of product.
$0.27 million (1%, AFMA costs only)	Tradeable effort units (nights)	An increase in average GVP per vessel was matched by a similar increase in hours trawled per vessel, indicating that NER remained steady in 2018–19. The strong increase in GVP and increased vessel participation indicate positive NER.
Not available	TACs	Estimates of NER and GVP are unavailable. Despite a decline in catch in 2019, NER are likely positive for this fishery. Increasing opportunities and participation for traditional inhabitants in the fishery are important objectives for this fishery.
Not available	TACs	Little to no catch has been recorded in the fishery since 2010, suggesting fishers have a low incentive to fish.
$1.41 million (4%)	ITQs	NER followed an increasing trend over the decade to 2016–17 and became positive in 2010–11. Non–survey based estimates of NER for 2017–18 and 2018–19 indicate positive NER.
$0.07 million (no fishing)	Limited entry	No Australian vessels fished in 2018 or 2019.
$1.47 million (3%)	ITQs	NER are expected to have remained positive in 2018–19, 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.
$0.27 million (confidential)	ITQs	Participation rate was low and latency remained high in 2019, suggesting little economic incentive to fish and relatively small NER.
$0.84 million (confidential)	ITQs	Estimates of NER are not available but are likely to be positive. Likely positive NER for the 2018–19 and 2019–20 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 88% of the GVP of all solely Australian Government–managed fisheries in 2018–19.

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 catch season for banana prawn. 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 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 2 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 and –$1.07 million in 2018–19. These negative results are 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 from 2009–10 to 2014–15, 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 been volatile, with an estimated NER of –$3.5 million in 2017–18 and $5.60 million in 2018–19.

In the Great Australian Bight Trawl Sector, the development of a bio-economic model for the 2 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 low GVP in previous years were significantly larger by 2018–19, including the Small Pelagic Fishery (SPF) and the Bass Strait Central Zone Scallop Fishery (BSCZSF). 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 and 2018–19 taken by other vessels suggests that GVP is likely to have recovered. Changes in NER are uncertain, however, because of a lack of information about changes in the cost structures of the fishery. For the Southern Squid Jig Fishery, catch and effort increased from 2016–17 to 2017–18 but declined in 2018–19. NER in the fishery are indicated to have declined in 2018–19, driven mainly by lower catch in the fishery, despite similar effort levels to 2017–18.

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 2018–19. 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 3 fisheries generated a GVP of $95.2 million and accounted for 44% of the GVP of all jointly managed fisheries in 2018–19. Individually, these fisheries generated GVPs of $43.4 million (wild-caught southern bluefin tuna as input to tuna farms), $32.1 million and $19.7 million, respectively, in 2018–19.

Estimates of NER are not available for the SBTF. However, the fishery provides fish to South Australia's southern bluefin tuna aquaculture industry (generating $129 million GVP at the farm gate in 2018–19). Although the stock's current low biomass level has dampened the 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 peoples. The TSTRLF was the most valuable commercial fishery in Torres Strait in 2018–19, 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. Sometimes this is not possible when the economic fundamentals of the fishery are poorly understood. 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 (Knuckey et al. 2018).

The target can be set higher than the MEY 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 2019

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 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.

In 2018–19, AFMA's focus on ERA was updated when the revised Commonwealth Fisheries Harvest Strategy and Commonwealth Bycatch policies and their respective supporting guidelines were implemented in November 2018. The framework requires that each fishery set out how it will address any impacts identified through the risk assessment process, particularly those impacts that fishing has on commercial; bycatch; and threatened, endangered and protected species.

The updated ERA methodology has been applied to 11 fisheries. A number of these reassessments resulted in a significant reduction in the number of 'potential high-risk species' identified—for example, from 7 to 1 species in the ETBF, and from 8 to 0 species in the Small Pelagic Fishery (midwater trawl).

Protected species interactions

During the normal course of fishing operations, fishers can interact with protected species listed under the EPBC Act. All Commonwealth-managed fisheries have been accredited under the EPBC Act. To be accredited, the fishery's management regime must require fishers to take all reasonable steps to ensure that members of listed threatened species (other than conservation-dependent species), listed migratory species, cetaceans and listed marine species are not killed or injured as a result of fishing. The ERA must find that the regime does not, or is not likely to adversely affect the survival or recovery of a protected species, or the conservation status of a listed migratory species, cetacean or listed marine species or a population of that species. After the management plan is accredited, operators are exempt from requiring permits under part 13 of the EPBC Act for interactions with the species detailed above, but interactions must be reported.

AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment, and these are summarised in each chapter.

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 and continued running of a threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations in the ETBF, the WTBF, the longline sectors in the SESSF, the Heard Island and McDonald Islands Fishery, and the Macquarie Island Toothfish Fishery
- refinement of seabird mitigation monitoring and measures in the ETBF
- introduction of biological material retention requirements in the CTS of the SESSF to minimise seabird interactions in high-risk areas
- 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.

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 2 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 in the GHTS 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 in the Australian sea lion management zones are audited, to verify any bycatch of protected species. It should be noted that e-monitoring, while very good at certain data collection activities (for example, counts of target species) cannot replace all the activities performed by physical observers, such as the collection of biological samples. Furthermore, efforts should be made to calibrate reporting through e-monitoring with physical observation to understand inherent differences in reporting rates (Bartholomew et al. 2018). More information on e-monitoring can be found on the AFMA website.[2]

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

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Chapter 2

Bass Strait Central Zone Scallop Fishery

N Marton and R Curtotti

FIGURE 2.1 Area and fishing intensity in the Bass Strait Central Zone Scallop Fishery, 2019

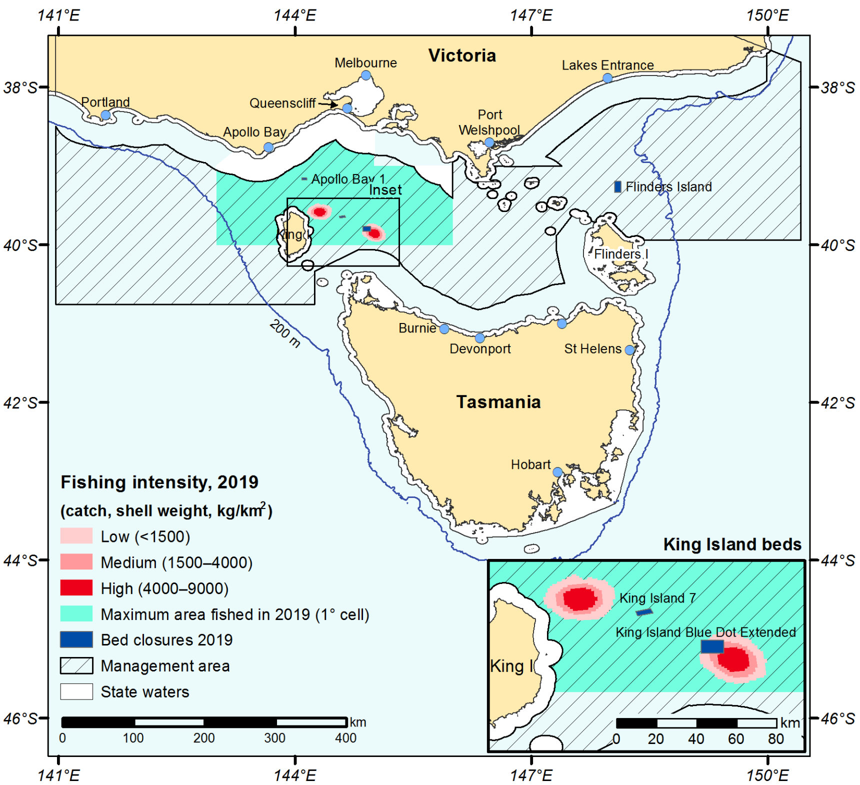


TABLE 2.1 Status of the Bass Strait Central Zone Scallop Fishery

Biological status					
Stock	2018		2019		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Commercial scallop (*Pecten fumatus*)					Large, stable biomass identified in western Bass Strait. Total allowable catch and catch in 2019 was 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). Compared with 2010–11, gross value of production in 2018–19 was higher and fewer vessels were used in the fishery.

Note: **NER** Net economic returns.

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

Scallops in bins
AFMA

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 2019, fishing was permitted throughout the management area, except in 4 scallop beds that were closed to fishing under the harvest strategy. Fishing in 2019 was concentrated on beds east of King Island. This was a similar area to that fished since 2014.

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 3-year closure under the 2005 Ministerial Direction to cease overfishing and recover overfished 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 again 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 2014 revisions to the harvest strategy were aimed, in part, at increasing knowledge of the biomass by encouraging exploratory fishing outside known beds. The exploratory period was used in 2014 but was then omitted for several years in favour of a return to surveying the known King Island beds. However, in recent years, some exploratory fishing has been done by survey vessels as part of the survey.

Tier 1 of the harvest strategy states that, if the scientific survey identifies 1 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, to be taken in the remainder of the fishery open to fishing. 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 1 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, to be taken in the remainder of the fishery open to fishing.

The harvest strategy is currently being reviewed. Considerations for the revised harvest strategy include the incorporation of economics into the TAC-setting process; ensuring that the decision-making process is robust to the inherent variability of the stock (including through appropriate scaling of the TAC and protected biomass across a range of surveyed biomasses); levels; and ensuring consistency with the updated Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018a) and guidelines (Department of Agriculture and Water Resources 2018b).

In 2019, the fishery operated under tier 2 of the harvest strategy, with the TAC set at 3,897 t.

Fishing effort

The fishery has a history of boom and bust, with the catch peaks (1982 to 1983, 1994 to 1996, 2003 and 2018) generally becoming progressively smaller with time. 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 to 1983 peak is unknown, but 103 vessels operated in the fishery during the 1994 to 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 2019). Dredge-hours have fluctuated widely since the fishery reopened, varying 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 at over 5,000, dropping to 3,890 in 2019—the lowest level since 2014 (Table 2.2).

TABLE 2.2 Main features and statistics for the BSCZSF

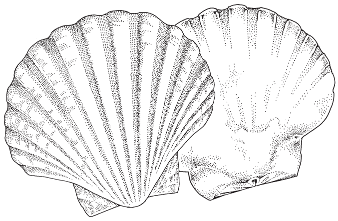
Fishery statistics a	**2018 fishing season** b			**2019 fishing season** c		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)** d
Commercial scallop	3,876 (+124) **d**	3,253	$6.7 million	3,897 (+103) **d**	2,931	$6.3 million
Doughboy scallop	100	0	0	100	0	0
Total fishery	**4,100**	**3,253**	**$6.7 million**	**4,100**	**2,931**	**$6.3 million**
Fishery-level statistics						
Effort	5,414 dredge-hours			3,890 dredge-hours		
Fishing permits **e**	63			48		
Active vessels	12			12		
Observer coverage	0 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 19 July to 31 December 2018. **c** Fishing season was 12 July to 31 December 2019. **d** A research quota also exists for commercial scallop (124 t in 2018 and 103 t in 2019). **e** Number of entities that own a commercial scallop SFR.
Notes: **GVP** Gross value of production. **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch.

Scallops
AFMA

2.2 Biological status

Commercial scallop (*Pecten fumatus*)



Line drawing: FAO

Stock structure

Commercial scallops in the Commonwealth, Tasmanian and Victorian scallop fisheries form 1 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 1 or 2 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, with 3 main beds fished. The number of beds fished expanded to 5 in 2015 and 8 in 2016. Two of the beds fished in 2018 were also fished in 2017. Fishing was concentrated on 3 surveyed beds in 2019, with some additional activity outside these beds. Catch, catch rates and scallop quality all improved after the fishery moved to the King Island region. Catch in 2019 remained stable relative to recent (2016 to 2018) catches at around 3,000 t. Some operators reported catch was limited by decreasing demand for seafood and subsequently lower prices (AFMA 2020).

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. Both east and western Bass Strait have been surveyed each year since 2014, and beds have consistently been identified in both regions.

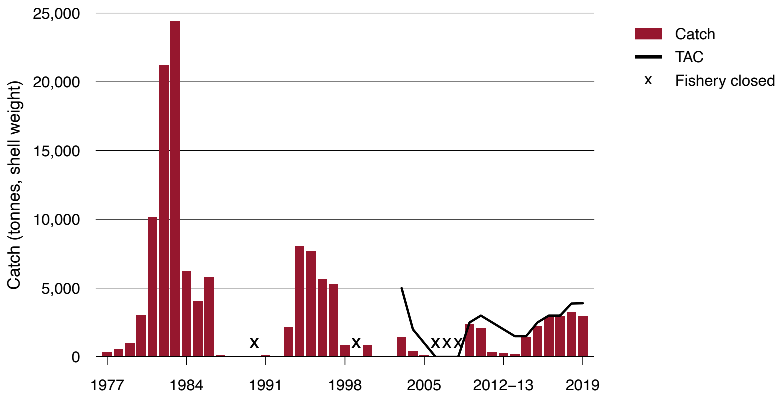
The 2019 biomass survey comprised 9 King Island beds with an estimated combined biomass of 41,925 t, 2 Apollo Bay beds with an estimated combined biomass of 1,517 t and 1 Flinders Island bed with an estimated biomass of 1,607 t (Koopman et al. 2019).

These beds were a mixture of previously surveyed beds and new beds. In addition to the 12 beds fully surveyed, 1 additional bed (called the JH bed) to the south-west of the King Island beds was identified before the survey and was thought to contain a large proportion of juvenile scallops. It was therefore surveyed using a slightly different methodology with a focus on monitoring how the scallops in this bed grow over time. A high proportion of dead scallops was found at 2 beds in 2018 (Knuckey, Koopman & Hudson 2018), and there was no sign of substantial recruitment in the surveyed beds (AFMA 2018).

The 2019 survey identified recruitment at the JH bed, which is almost exclusively juveniles, and 3 other King Island beds, which contained a mixture of juvenile and adult scallops (AFMA 2019; Koopman et al. 2019). It is not clear where these recruits have come from (AFMA 2019). Scallops in most beds surveyed are ageing (AFMA 2019), with 3 of the 12 beds comprising more dead than live scallops (Koopman et al. 2019).

The 2019 fishery opened on 12 July 2019 with a TAC of 3,897 t. Fishing generally focused on the same areas as the 2014, 2015, 2016, 2017 and 2018 seasons (that is, east of King Island), and operators reported scallops in good condition. The fishery closed on 31 December 2019 with 2,931 t of the 3,897 t TAC landed.

FIGURE 2.2 Catch and TAC of commercial scallop in the BSCZSF, 1977 to 2019



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) is variable. Surveys of eastern Bass Strait in 2009 identified large numbers of small (that is, presumably young) scallops north-east of Flinders Island (Harrington & Semmens 2010). Surveys since 2015 likewise identified small scallops near Flinders Island (Knuckey, Koopman & Davis 2015, 2016; Knuckey et al. 2017; Knuckey, Koopman & Hudson 2018; Koopman et al. 2019). Beds in western Bass Strait have typically comprised large scallops and only limited amounts of small scallops; however, 1 juvenile bed was found in 2019 (Koopman et al. 2019). Although the presence of small scallops is an encouraging sign for the fishery, they were found in far larger numbers during the 2009 survey of eastern Bass Strait.

Surveys between 2009 and 2018 have covered a large area, encompassing approximately 63% 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 to 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 2019 covered about 14% of the grids from the historical baseline area. Adult biomass from these surveyed beds was estimated at just over 45,000 t, the largest estimated biomass since the fishery reopened in 2009 (surveyed beds had an estimated biomass of almost 26,000 t in 2016, 22,800 t in 2017 and 30,100 t in 2018). 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, 12 in 2017 and 9 in 2018. Twelve beds were surveyed in 2019, comprising a mixture of both new and previously surveyed beds. 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.

Stock status determination

Scallop in the BSCZSF is managed as a highly variable stock that can undergo large spatial and temporal changes in biomass or recruitment through time in the absence of fishing. Surveys over the past decade have shown that biomass can decline gradually or rapidly (for example, through mass die-offs). Similarly, scallop beds can re-emerge or re-establish from relatively small sizes. Overall, however, recent observed biomass appears relatively large.

Managing scallops in the BSCZSF using an assumption of biomass equilibrium is challenging and probably inappropriate. In such cases, the Commonwealth Fisheries Harvest Strategy Policy allows for the use of dynamic reference points with due consideration given to their consequences during extended periods of low productivity or recruitment. The current harvest strategy for scallops in the BSCZSF uses a form of fixed exploitation rate through 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 reference point (LRP) of 1,500 t of high-density, adult scallops at tier 1 with a maximum TAC of 2,000 t. Tier 2 implies a dynamic LRP of 3,000 t with a TAC greater than 2,000 t and the remaining area of the fishery open to fishing. In 2019, the fishery operated at tier 2; however, a larger biomass (10,200 t) was closed to fishing. Additionally, the TAC of 3,897 t relative to the total known biomass of just over 45,000 t means that 41,000 t (91%) of known biomass was unfished if the TAC was fully caught. Furthermore, the TAC was not fully caught, so escapement was larger (94%). This is similar to recent years, with a relatively large biomass (26,000 t) surveyed in 2016 (escapement 89%), 22,800 t in 2017 (escapement 87%) and 30,100 t in 2018 (escapement 89%). 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. 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**.

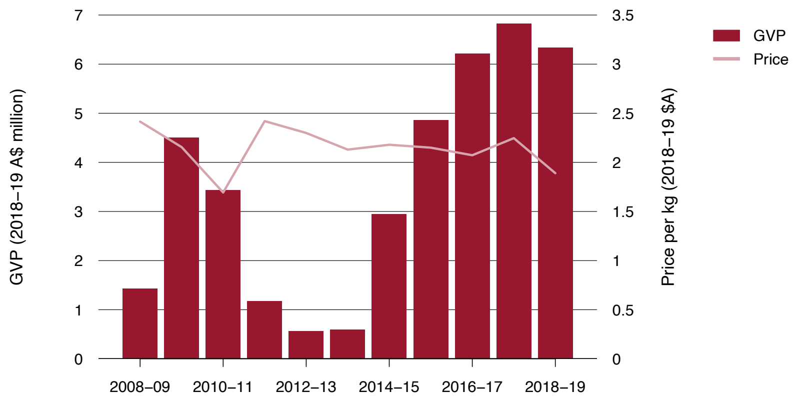
2.3 Economic status

Key economic trends

Estimates of net economic returns (NER) for recent years are not available.

Comparison of the fishery's gross value of production (GVP) before and after the most recent closure (2006 to 2008) reveals a considerable increase immediately following reopening of the fishery (Figure 2.3). GVP has increased annually from 2013–14 to 2017–18. In 2018–19, GVP is estimated to have declined by 6% to $6.3 million.

FIGURE 2.3 Real GVP and real prices received for catch in the BSCZSF, by financial year, 2008–09 to 2018–19



Notes: **GVP** Gross value of production. 'Real' indicates that value has been adjusted for inflation. 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.

Performance against economic objective

The Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018a) requires that harvest strategies pursue the economic objective of maximising NER. In practice this means that fisheries are managed in a way that helps them generate the highest possible economic return from the use of resources applied to the fishery. To meet this objective, the policy 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. However, the variability in biomass and availability of scallops in the BSCZSF makes it difficult to develop appropriate target reference points for MSY and MEY (AFMA 2015).

Several factors suggest that NER in the BSCZSF may have improved from the –$1.2 million (in 2017–18 dollars) recorded in 2010–11 (George, Vieira & New 2012), although it is uncertain whether NER are now positive. In real terms, GVP was around $2.9 million higher in 2018–19 than in 2010–11, reflecting an increase in catch and higher average prices. Moreover, 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 2018–19 than in 2010–11. In addition, the total catch in 2018–19 was achieved with 6 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 4 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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions were reported in the BSCZSF in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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Chapter 3
Coral Sea Fishery

T Emery, I Butler and AH Steven

FIGURE 3.1 Area fished within the Coral Sea Fishery, 2018–19 fishing season

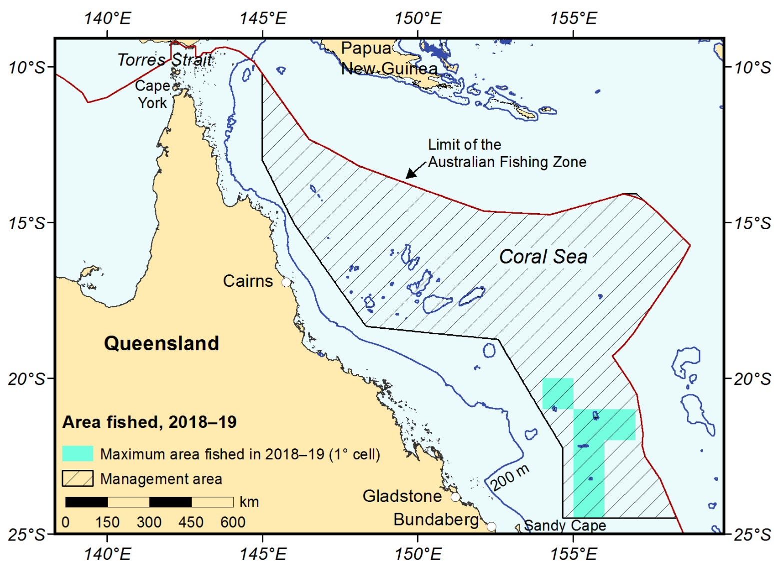


TABLE 3.1 Status of the Coral Sea Fishery

Stock	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
	Biological status				
Black teatfish (*Holothuria whitmaei*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No commercial catch in 2018–19. Historical catch less than median estimate of MSY.
Prickly redfish (*Thelenota ananas*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No commercial catch in 2018–19. Historical catch less than median estimate of MSY.
Surf redfish (*Actinopyga mauritiana*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No commercial catch in 2018–19. Historical catch less than median estimate of MSY.
White teatfish (*Holothuria fuscogilva*)	Uncertain	Uncertain	Not subject to overfishing	Uncertain	No commercial catch in 2018–19. No reliable assessment to determine biomass.
Other sea cucumber species (~11 species)	Not subject to overfishing	Uncertain	Not subject to overfishing	Uncertain	No commercial catch in 2018–19. No reliable assessment to determine biomass.
Aquarium Sector (>500 species)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch in 2018–19 likely to represent a small proportion of the estimated overall population size and therefore unlikely to affect stock status.
Lobster and Trochus Sector	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No catch in 2018–19. Historical catch is less than the plausible sustainable yield.
Line Sector (numerous finfish and shark species)	Uncertain	Uncertain	Uncertain	Uncertain	Species-specific estimates of MSY are uncertain due to changes in species composition. No current assessment to determine biomass status.

Economic status

Estimates of net economic returns are not available. Catch in the Aquarium Sector decreased in 2018–19 and the economic performance of this sector is uncertain. No catch was taken in the Sea Cucumber, or Lobster and Trochus sectors in 2018–19, and catch in the Line Sector decreased relative to the previous year. The trend in economic performance for these sectors is also uncertain.

Note: **MSY** maximum sustainable yield.

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

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. The modern-day CSF is a multispecies, multigear fishery targeting a variety of fish, sea cucumbers and crustaceans. Fishing methods include hand collection, demersal line, dropline and trotline. Historically, catch was also taken by trawl, but this fishing method is no longer permitted in the fishery. Further, since the Coral Sea Marine Park[1] was established, use of traps is no longer permitted. The Trawl and Trap Sector in the CSF has consequently been removed from this chapter. As a result of the marine park there are also several specific gear restrictions in different zones. Table 3.2 shows the fishing gear allowed in each zone of the Coral Sea Marine Park.

TABLE 3.2 Gear restrictions in each zone of the Coral Sea Marine Park in the CSF

Fishing method	Special Purpose Zone (Trawl)	Habitat Protection Zone	Habitat Protection Zone (Reefs)	National Park Zone
Dropline	Yes	Yes	Yes	No
Hand collection (hookah, scuba, snorkel)	Yes	Yes	Yes	No
Hand net (hand, barrier, skimmer, cast, scoop, drag, lift)	Yes	Yes	Yes	No
Longline (demersal, auto-longline)	Yes	No	No	No
Minor line (handline, rod and reel, trolling, squid jig, poling)	Yes	Yes	No	No
Trotline	Yes	No	No	No

1 See parksaustralia.gov.au/marine/pub/maps/fnl-mp-2018-cs-map-zones.pdf.

Management methods

Management of the CSF involves both input (fishing effort) and output (catch) controls, including limited entry, total allowable catches (TACs), spatial closures, effort restrictions, move-on provisions, size limits and catch-and-effort triggers, which are used to initiate further analysis and assessment (AFMA 2019b). The harvest strategies for the sectors recognise the low effort and diverse nature of the fishery, and this is considered in assessing their performance. ABARES analysed harvest levels in the Sea Cucumber, Lobster and Trochus, Aquarium, and Line 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 project, investigated current and historical catches, and indicators of population size to evaluate stock status.

In 2019, a revised harvest strategy was implemented by the Australian Fisheries Management Authority (AFMA) for the Aquarium Sector (AFMA 2019a). In the absence of species-specific reference points, this strategy sets annual catch triggers for key family groups based on conservative estimates of stock size to meet the sustainability objectives of the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018).

AFMA is scheduled to review the harvest strategy for the Line Sector. The updated harvest strategy is expected to provide a more accurate list of key commercial species and revise associated catch triggers to monitor catches.

Given the absence of fishing in the Lobster and Trochus Sector, and minimal fishing in the Sea Cucumber Sector, harvest strategies for these sectors (AFMA 2008a, b) are not currently being reviewed by AFMA. The Lobster and Trochus Sector is currently managed using a range of catch triggers and move-on provisions that provide precautionary limits and mitigate against localised depletion (AFMA 2008a). The Sea Cucumber Sector is currently managed using TACs, move-on provisions and a rotational zone plan where the fishery is divided into 21 zones, with 164 days allocated across zones to all permit holders and fished on a competitive basis (AFMA 2008b). However, several of these reefs (Kenn Reefs, Bougainville Reef, Mellish Reef, Osprey Reef and Lihou Reefs) are designated as National Park Zone under Coral Sea Marine Park habitat restrictions where commercial fishing is now prohibited.

Fishing effort

In the 2018–19 fishing season, 6 vessels were active in the fishery: 4 in the Line Sector and 2 in the Aquarium Sector. No effort was recorded for the Sea Cucumber or Lobster and Trochus sectors. In the Aquarium Sector, there were 10,798 dive-hours in 2018–19, which was an increase from 2,204 dive-hours in 2017–18, with the same number of vessels fishing. In the Line Sector, 204,046 hooks and 111 lines were set in 2018–19, which was a decrease from 385,616 hooks and 187 lines set in 2017–18. Although no trawl effort was recorded between 2006–07 and 2017–18, 6 hours of trawl activity were recorded in 2018–19 from a single vessel before permits were removed from the fishery.

Catch

Approximately 25.7 t of fish products (excluding the Aquarium Sector, where catch is recorded as the number of individuals) was taken in the CSF during the 2018–19 season, representing a sizeable decrease from the 64.7 t taken in the 2017–18 season (Table 3.3). All this catch was finfish.

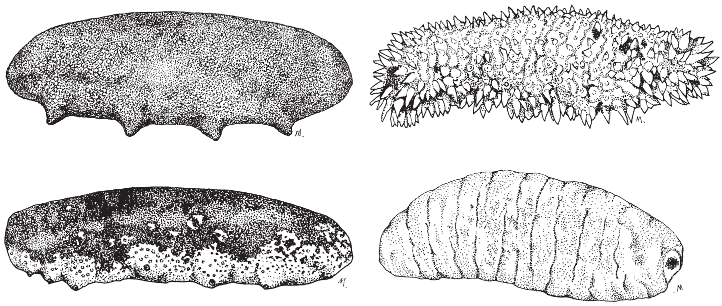
TABLE 3.3 Main features and statistics for the CSF

Fishery statistics a	2017–18 fishing season			2018–19 fishing season		
Stock	**TAC (t) or catch trigger**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**
Aquarium Sector	40,000 individuals **b**	36,678 individuals	Confidential	40,000 individuals **b**	24,318 individuals	Confidential
Sea Cucumber Sector						
Black teatfish	1	0.06	Confidential	1	0	0
Other sea cucumbers	105	0.01	Confidential	105	0	0
Prickly redfish	20	0.33	Confidential	20	0	0
Sandfish	1	0	0	1	0	0
Surf redfish	10	0.04	Confidential	10	0	0
White teatfish	4	0.58	Confidential	4	0	0
Total sea cucumbers	**150**	**1.02 c**	**Confidential**	**150**	**0**	**0**
Lobster and Trochus Sector						
Tropical rock lobster	30 **b**	0	0	30 **b**	0	0
Trochus	30 **b**	0	0	30 **b**	0	0
Line Sector						
Line, trap and trawl operations (numerous finfish and shark species)	–	63.6	Confidential	–	25.7	Confidential
Total fishery	**–**	**64.7 d**	**Confidential**	**–**	**25.7 d**	**Confidential**
Fishery-level statistics						
Effort	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			Sea Cucumber: 0 dive-hours Lobster: 0 dive-hours Aquarium: 10,798 dive-hours Line: 204,046 hooks, 111 lines set, 0 trap lifts, 6 trawl hours **e**		
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			14 fishing permits across the Line (8), Sea Cucumber (2), Aquarium (2), and Lobster and Trochus (2) sectors		
Active vessels	8			6		
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 and line (demersal longline, dropline and trotline).					
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: China, Hong Kong—dried sea cucumber (bêche-de-mer); worldwide—live aquarium species					
Management plan	*Management arrangements booklet 2019*—Coral Sea Fishery (AFMA 2019b)					

a Unless otherwise indicated, fishery statistics are provided by fishing season, which matches the financial year (1 July to 30 June). Value statistics are provided by financial year. **b** Trigger limits. **c** Catches are wet weight. **d** Total catch weight excludes Aquarium Sector catch. **e** Trawl effort recorded before both permits were removed from the fishery through the marine bioregional planning process.
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 4 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. Commercial 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 commercial sea cucumber catch has fluctuated between 0 t and 9.2 t. Annual commercial catches since 2007–08 have generally been less than 3 t, with no commercial catch recorded in the 2018–19 fishing season.

While commercial catch by operators in the CSF has remained low, Skewes and Persson (2017) reported significant illegal catch by unlicensed foreign-owned and foreign-crewed fishing vessels (FFV)—primarily from Vietnam. Of the 15 vessels apprehended in 2016–17, 13 contained sea cucumber product—predominately white and black teatfish, assumed caught among select reefs in the CSF. Skewes and Persson (2017) reported that 1 vessel was apprehended with 133% and 61% of the white and black teatfish CSF TACs, respectively. There have been no confirmed sightings of FFV's in the Coral Sea since November 2017 (AFMA, 2020, pers. comm.).

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 undertaken.

ABARES estimated biomass in 2012 using a habitat-based approach to determine stock status for black teatfish, white teatfish, surf redfish and prickly redfish (Woodhams, Chambers & Penrose 2015). Estimates of habitat area were made from a geomorphological classification 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). Surplus production models and catch provided an estimate of biomass in 2010 as a proportion of biomass at the start of the assessment period (1997) for prickly redfish and black teatfish stocks; however, this was not possible for white teatfish and questionable for surf redfish due to data availability (Woodhams, Chambers & Penrose 2015).

In 2017, Skewes and Persson (2017) surveyed 8 reefs in the Coral Sea Commonwealth Marine Reserve (CSCMR), which made up approximately 51% of available shallow reef habitat area within the CSCMR, to quantify and assess the status of sea cucumber populations. Species density was highest for lollyfish (>100 individuals per ha), particularly on Coringa Bank, which contributed the bulk of the density estimate. Greenfish was the next abundant (~15 per ha) and found in high densities on both Coringa Bank and Kenn Reefs. The third-highest density species was prickly redfish at 6.3 per ha, which was found in most reefs apart from Wreck Reefs. Black teatfish and white teatfish had very low overall densities of 1.6 and 0.8 per ha, respectively, and were found on only 5 of the 8 reefs. All other species of sea cucumbers averaged below 2 per ha.

Population biomass estimates were formulated by Skewes and Persson (2017) using data from all sampled reef habitats and size of surveyed sea cucumbers. Of the 4 target species, prickly redfish had the greatest biomass at 1,903 t (±624 t 90% confidence interval [CI]) liveweight, making up around 30% of all species sampled. The biomass estimate for black teatfish was 340 t (±155 t 90% CI) and the biomass estimate for white teatfish was 187 t (±158 t 90% CI). However, the biomass estimates for white teatfish is likely to be underestimated due to the lack of survey data for deeper habitats (Skewes & Persson 2017). The biomass estimate for surf redfish was low at 10 t.

Stock status determination

Using an estimate of median biomass for black teatfish, total biomass in 2010 exceeded 99% of biomass at the start of the assessment period (1997) (Woodhams, Chambers & Penrose 2015). In the 2017 survey, the population biomass estimate of 340 t liveweight (±155 t 90% CI) was similar to the one for the same reefs by Woodhams, Chambers & Penrose (2015). The biomass status for black teatfish is therefore classified as **not overfished**. Because no catch of black teatfish was reported in 2018–19, black teatfish is classified as **not subject to overfishing**.

Using an estimate of median biomass for prickly redfish, total biomass in 2010 exceeded 99% of biomass at the start of the assessment period (1997) (Woodhams, Chambers & Penrose 2015). In the 2017 survey, the population biomass estimate of prickly redfish was 1,903 t liveweight (±624 t 90% CI) and made up more than 30% of all sea cucumber biomass from the 8 reefs surveyed (Skewes & Persson 2017). It was noted that this would have been an underestimation due to depth restrictions on survey sites. The biomass estimate from the 2017 survey was also significantly higher than the estimate for the same reefs by Woodhams, Chambers & Penrose (2015). The biomass status for prickly redfish is therefore classified as **not overfished**. Because no catch of prickly redfish was reported in 2018–19, prickly redfish is classified as **not subject to overfishing**.

In the 2017 survey, the population biomass estimate of surf redfish was 10 t liveweight and made up less than 1% of all sea cucumber biomass from the 8 reefs surveyed (Skewes & Persson 2017). It was noted that this would have been an underestimation due to no sampling in areas with adverse weather and sea conditions. There was no reported catch of surf redfish in 2018–19. Given that commercial catches of surf redfish for much of the past 2 decades have been less than the median estimate of MSY (879 kg) estimated by Woodhams, Chambers & Penrose (2015), the biomass of surf redfish is unlikely to have been reduced to below the limit reference point. On this basis, the stock is classified as **not overfished**. Because no catch of surf redfish was reported in 2018–19, the stock is classified as **not subject to overfishing**.

As a result of data limitations, a plausible initial biomass estimate could not be established for white teatfish by Woodhams, Chambers & Penrose (2015). In the 2017 survey, the population biomass estimate of white teatfish was 187 t liveweight (±158 t 90% CI) (Skewes & Persson 2017), but this was likely underestimated due to the lack of survey data from deeper habitats. Furthermore, the density of white teatfish estimated by Skewes and Persson (2017) was very low throughout the reefs sampled, suggesting a strong causal link with historical commercial fishing pressure and illegal fishing. The reconciliation of biomass status is therefore not possible with the available information. As such, the biomass status for white teatfish is classified as **uncertain**. Because no catch of white teatfish was reported in 2018–19, white teatfish is classified as **not subject to overfishing**.

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 no catch reported in 2018–19, 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 determining stock status.

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 but in 2018–19 catch declined to 24,318 individuals. The 2018–19 catch 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, catch is unlikely to have had a detrimental impact on the stock.

A revised harvest strategy for the Aquarium Sector was implemented in July 2019 (AFMA 2019a) after consultation with industry, scientists and relevant government agencies; it was informed by the ABARES assessment of Leatherbarrow and Woodhams 2015. The strategy sets catch triggers for 6 key commercial family groups that constitute around 80% of the total catch: Serranidae, Labridae, Pomacentridae, Acanthuridae, Blenniidae and Gobiidae, and Pomacanthidae (Table 3.4). These catch triggers are based on assessments of standing stock size (number of individuals), using the estimate of known reef area and fish density provided by Leatherbarrow and Woodhams (2015). The strategy also sets catch triggers for 'other species' of finfish that make up 20% of the total finfish catch, as well coral from the family Acroporidae, live rock (dead coral with organisms living in it) and humphead Maori wrasse (*Cheilinus undulatus*) (Table 3.4). The decision rules associated with the catch trigger limits require more detailed catch-and-effort data analyses and management responses if sustainability concerns are identified.

TABLE 3.4 Catch triggers for the Aquarium Sector of the CSF

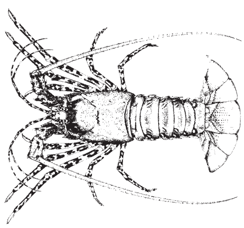
Taxon	Level 1 trigger	Level 2 trigger
Serranidae	11,000 individuals	22,000 individuals
Labridae	18,000 individuals	36,000 individuals
Pomacentridae	20,000 individuals	40,000 individuals
Acanthuridae	20,000 individuals	40,000 individuals
Blenniidae & Gobiidae	12,000 individuals	24,000 individuals
Pomacanthidae	12,000 individuals	24,000 individuals
All other finfish species	Equal to highest historical catch of all 'other species'	Equal to twice the highest historical catch of all 'other species'
Acroporidae (coral)	20 t	40 t
Live rock	20 t	40 t
Humphead Maori wrasse	10 individuals	50 individuals

Source: Modified from AFMA (2019a)

Stock status determination

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

Lobster and Trochus Sector



Line drawing: FAO

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 been undertaken on subcomponents of this biological stock (Keag, Flood & Saunders 2012), but none are available for the CSF. A fishery-level stock is assumed for determining stock status.

Catch history

Historical catch records from the hand collection sector in the Coral Sea suggest that at least 2 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 recorded caught by the 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**. No lobster has been recorded caught since 2006–07, and the stock is classified as **not subject to overfishing**.

Line Sector

Stock structure

While a large number of species are taken in this sector, there is currently no defined or discernible target species. As such, a single fishery-level stock is assumed for determining stock status.

Catch history

The total landed catch across 4 different fishing gears was 25.7 t in 2018–19, which was a substantial decrease from the 63.6 t taken in 2017–18. A total of 64% of the catch was taken using demersal longline (16.5 t), 26% using mechanised handline (6.6 t), 6% using dropline (1.6 t) and 4% using bottom otter trawl (1 t).

In 2018–19, flame snapper (*Etelis coruscans*) constituted approximately 58%, 41% and 4% of the auto-longline, dropline and mechanised handline catch, respectively, with a total of 10.5 t caught. This represented a substantial decline in both the proportion of flame snapper and total catch by gear since 2017–18. In 2017–18, flame snapper made up approximately 74%, 56% and 52% of the auto-longline, dropline and mechanised handline catch, respectively, with a total of 41.2 t caught.

In 2018–19, rosy snapper (*Pristipomoides filamentosus*) constituted approximately <1%, 6% and 43% of the auto-longline, dropline and mechanised handline catch, respectively, with a total of 2.9 t caught. This is a decrease from the 6.4 t taken in 2017–18. In 2018–19, ruby snappers (*Etelis* spp.) constituted approximately 10%, 0% and 1% of the auto-longline, dropline and mechanised handline catch, respectively, with a total of 1.8 t caught. This is a decrease from the 3.2 t taken in 2017–18.

No trap effort has been recorded since 2010–11 and is no longer permitted. While no trawl effort was recorded between 2006–07 and 2017–18, there was a small amount of effort (6 hours) in 2018–19 from a single vessel before the 2 permits were removed from the fishery and the fishing method no longer permitted. All the catch (970 kg) was finfish.

After a large increase in the number of hooks deployed among auto-longline and dropline methods in 2017–18 (385,616 hooks), representing the highest effort since 2012–13, there was a decrease in 2018–19 (204,046 hooks). However, it is important to note the number of hooks deployed in 2018–19 was still the second-highest effort recorded since 2012–13.

Stock assessment

The Line Sector takes a wide variety of finfish and shark species, but there is no formal, single-species stock assessment for any species. 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 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 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 (ABARES unpublished). 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).

At the fishery level, the total line catch in 2018–19 (25.7 t) was lower than the most conservative (low biomass and lowest exploitation constant) estimate of all-species sustainable yield (31.5 t) (Larcombe & Roach 2015).

In some fishing seasons, sharks have been a large component of the total catch for the CSF. For example, blacktip sharks (*Carcharhinus* spp.) were more than 50% of the total line catch in 2005–06. Although most sharks, including blacktip sharks, are considered to be harvested sustainably across Australia (Simpfendorfer et al. 2019), no data are available to evaluate the effect of the catch 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 3 years (689 kg in 2016–17, 852 kg in 2017–18 and 1 t in 2018–19), due to increased use of mechanised handlines, current catches are unlikely to constitute overfishing.

Stock status determination

The line catch in 2018–19 was less than the MSY estimate for low biomass and lowest exploitation constant (31.5 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. Despite a decline in 2018–19, fishing effort has spatially contracted and substantially increased in recent years. Further, the reliability of the yield estimates for individual species or at the scale of single reefs is questionable. Therefore, fishing mortality in the Line Sector is classified as **uncertain**.

Although it is unlikely that the primary commercial finfish that make up the catch of line operations are overfished, uncertainty remains about the effect of historical fishing on several low-productivity finfish and shark species. Therefore, the biomass of the Line Sector 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. Additionally, 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 2017–18, these exports were valued at $3 million and decreased to $2.8 million in 2018–19. Exports from Queensland accounted for 63% of the Australian total in 2017–18 and increased to 67% in 2018–19. 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 2018 it had 27 active licences and 103,000 individual fish were caught (QDAF 2019). This fishery is likely to make a larger contribution to total exports than the CSF.

Total catch of aquarium species in the CSF decreased by 34%, from 36,670 individuals in the 2017–18 season to 24,318 in the 2018–19 season. In the same period, effort increased by 390%, from 2,204 dive-hours to 10,798, indicating a higher cost per individual fish caught. The lack of economic data available for this sector makes it difficult to determine the trend in economic performance.

A high degree of latency exists for non-aquarium species caught in the CSF. 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). Latency in sea cucumber catch (all species) in 2017–18 was 99% and no sea cucumbers were caught in the 2018–19 fishing season. Also, no tropical rock lobster or trochus were caught in the 2017–18 and 2018–19 fishing seasons.

The decrease in catch coincides with decreases in effort (number of hooks and line sets used). The trend in net economic returns (NER) for this sector remains unclear.

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 and uncertain. 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.

Undercaught TACs and latent effort in the sea cucumber, tropical rock lobster and trochus sectors of the fishery suggest that fishers have little incentive to participate in these sectors, reflecting expectations of low profits, under prevailing unit prices for landed species and the cost of inputs. While there is a high degree of uncertainty, the Line 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 (8 vessels in 2017–18 and 6 in 2018–19). Given this, the low cost approach currently taken for the management of this fishery, where management costs are set to a minimum within the context of a set of appropriate triggers for management review as the need arises, is appropriate.

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 8 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).

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions were reported for 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

3.5 References

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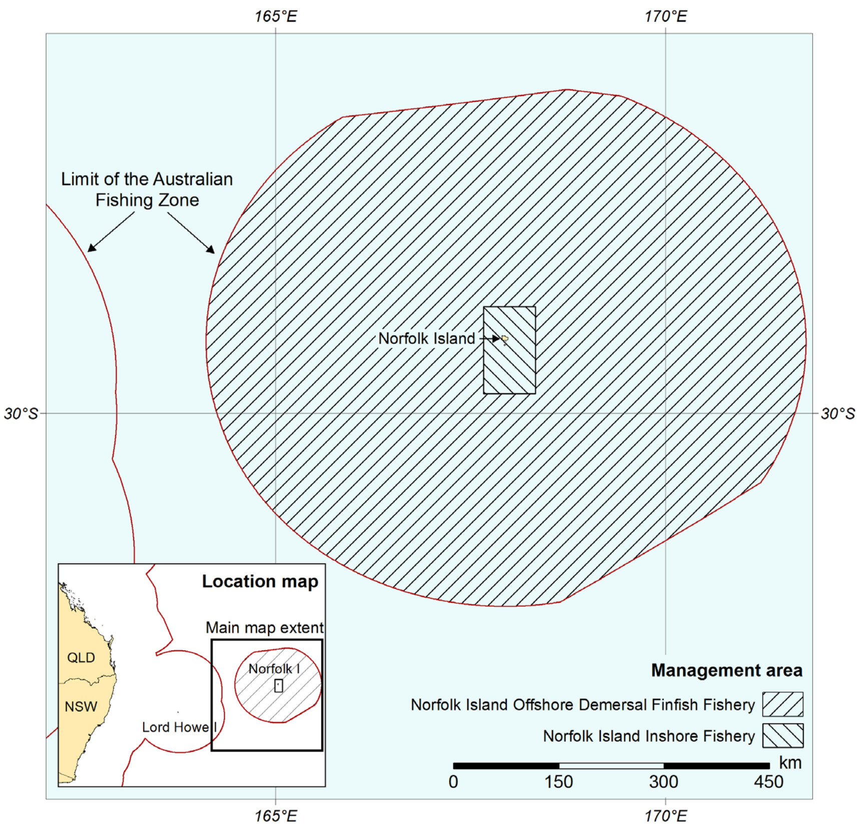
Prickly redfish
Tim Skewes

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 currently consists of 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 50 days of fishing over 3 years required by the permit. 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 since 2003. 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.

4.5 References

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Chapter 5

Northern Prawn Fishery

M Parsa, J Larcombe, I Butler and R Curtotti

FIGURE 5.1 Fishing intensity in the Northern Prawn Fishery, 2019

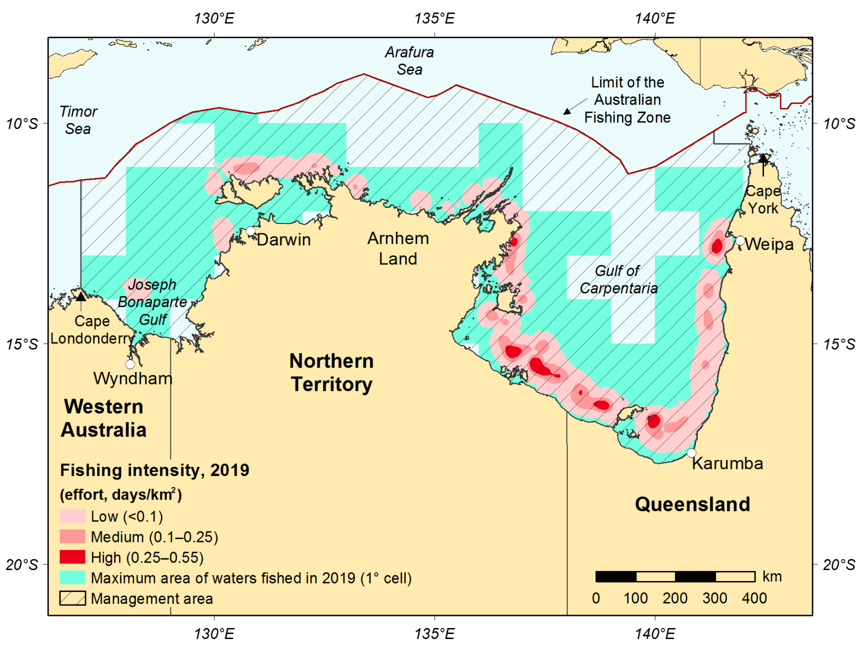


TABLE 5.1 Status of the Northern Prawn Fishery

Biological status

Stock	2018		2019		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Redleg banana prawn (*Fenneropenaeus indicus*)					Fishing mortality in 2019 unlikely to drive the stock into an overfished state. Spawning biomass estimated to be 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 $32.05 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 $30.9 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 (*P. 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 all 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 2 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.). Most vessels have transitioned from using twin gear to using a quad rig comprising 4 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 2 seasons: a predominantly banana prawn season that runs from 1 April to 15 June, and a longer tiger prawn season, running from 1 August to 30 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. A review of the NPF redleg banana prawn subfishery harvest strategy is due for completion in 2020, including management strategy evaluation of additional harvest control rules.

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 3 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 2019 was 8,581 t, comprising 8,449 t of prawns and 132 t of byproduct species (predominantly squid, bugs and scampi) (Table 5.2). Annual catches tend to be quite variable from year to year because of natural variability in the banana prawn component of the fishery.

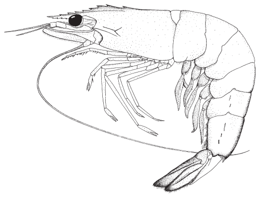
TABLE 5.2 Main features and statistics for the NPF

Fishery statistics a	2018 fishing season		2019 fishing season b	
Stock	**Catch (t)**	**GVP (2017–18)**	**Catch (t)**	**GVP (2018–19)**
Banana prawns	4,708	$65.3 million	5,640	$70.0 million
Tiger prawns	1,463	$26.0 million	2,086	$38.4 million
Endeavour prawns	492	$5.3 million	656	$6.4 million
Other catch (prawns)	12	$0.4 million	67	$0.2 million
Other catch (not prawns)	103	$1.2 million	132	$2.7 million
Total fishery	**6,778**	**$98.2 million**	**8,581**	**$117.7 million**
Fishery-level statistics				
Effort	Banana season: 2,506 shots Tiger season: 5,573 shots		Banana season: 2,392 Tiger season: 5,827	
Fishing permits	53		52	
Active vessels	53		52	
Observer coverage	Crew member observers: 1,255 days (15.7%) Scientific observers: 148 days (1.9%)		Crew member observers: 1,028 days (12.7%) Scientific observers: 198 days (2.4%)	
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 and China—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 to 15 June; predominantly for tiger prawns: 1 August to 30 November.
Notes: **GVP** Gross value of production.

5.2 Biological status

Redleg banana prawn (*Penaeus indicus*)



Line drawing: FAO

Stock structure

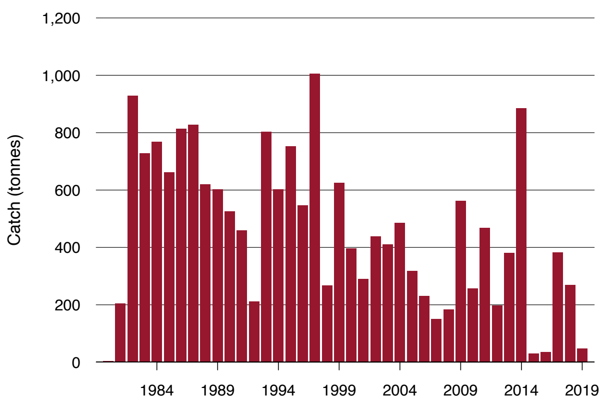
Redleg banana prawn is widely distributed across the Indo-West Pacific Ocean. In Joseph Bonaparte Gulf, a single separate stock is assumed for assessment purposes.

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. Over the past decade, annual catches have averaged 296 t but with high variability. Particularly low catches occurred in 2015 (30 t) and 2016 (35 t), increasing in 2017 (283 t) and 2018 (269 t). Catch in 2019 dropped to 48 t (Figure 5.2).

Effort in 2019 was similar to 2015 and 2016, with fewer than 100 fishing days. In 2019 there was no fishing activity in the third quarter, when the highest effort has historically occurred (AFMA 2020). Anecdotal reports indicate that high tiger prawn prices resulted in a shift in effort from the redleg banana prawn fishery to the tiger prawn fishery in the Gulf of Carpentaria in the third quarter.

FIGURE 5.2 Redleg banana prawn catch, 1980 to 2019



Source: CSIRO

Stock assessment

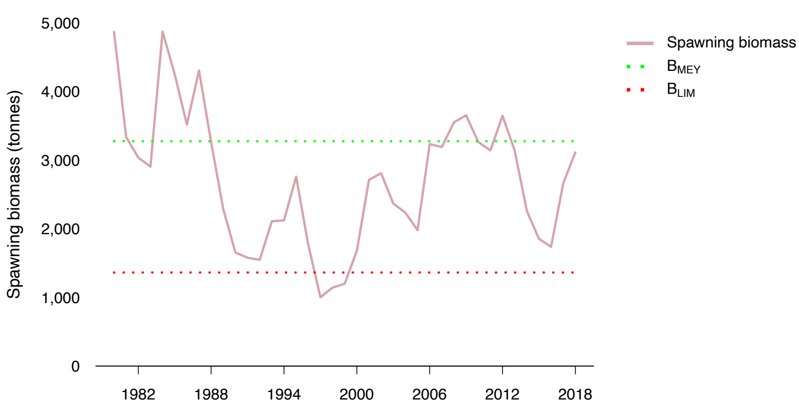
Estimates of maximum sustainable yield (MSY) and its corresponding spawning biomass level (B_{MSY}) are difficult to derive for short-lived, variable stocks such as redleg banana prawn. Typically, yield is determined largely by the strength of annual recruitment, and therefore annual sustainable yields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

The most recent accepted assessment for the stock was in 2019 (Plagányi et al. 2019). 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 median spawning biomass was substantially below the B_{MEY} (biomass at maximum economic yield) target for 2014 to 2016 and approached (but remained above) the biomass limit ($0.5B_{MSY}$) in 2015 and 2016 (Figure 5.3). However, the biomass has since trended up and in 2018 was estimated to be close to the target level (Figure 5.3).

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). They found a connection between reduced catch rates, in part stemming from impacted recruitment, and the El Niño conditions and relatively low seasonal rainfall (Plagányi et al. 2020). In addition, another recent study found that, when revenue-per-unit-effort is higher in the Gulf of Carpentaria than in the Joseph Bonaparte Gulf, operators will preferentially fish in the Gulf of Carpentaria (Pascoe et al. 2020). This study suggested that economic conditions may have been the dominant driver of low fishing effort in Joseph Bonaparte Gulf during those years.

Effort is a key element of the harvest strategy for the redleg banana prawn fishery, and large fluctuations in effort have been problematic for the implementation of the harvest strategy in recent years. Given the uncertainties around the existing harvest strategy and the recent incidence of low effort and low catch years, NPRAG recommended reviewing the decision rules for redleg banana prawn under the NPF harvest strategy (AFMA 2016, 2017). New decision rules have been developed and preliminary results were presented in March 2020 to NPRAG, with a set of decision rules selected for further sensitivity testing.

FIGURE 5.3 Estimated spawning biomass for redleg banana prawn, 1980 to 2018



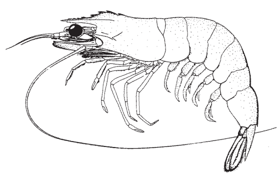
Notes: B_{LIM} Biomass limit reference. B_{MEY} Biomass at maximum economic yield.
Source: Plagányi et al. 2019

Stock status determination

As with other short-lived, highly variable stocks in Australia, biomass of the redleg banana prawn stock in the Joseph Bonaparte Gulf is understood to fluctuate widely from year to year. The most recent estimate of biomass was above the limit reference point (LRP), and close to the target, and was followed by a year of relatively low catch and effort in 2019. On this basis, the redleg banana prawn stock is unlikely to have been reduced to below the LRP and is therefore classified as **not overfished**.

Catch in 2019 is unlikely to drive the biomass below the LRP and on this basis, the stock is classified as **not subject to overfishing**.

White banana prawn (*Penaeus merguiensis*)



Line drawing: FAO

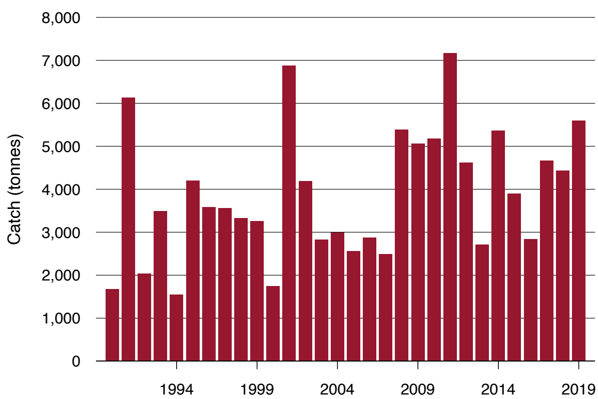
Stock structure

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 2019 was 5,592 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 to 2019



Source: CSIRO

Stock assessment

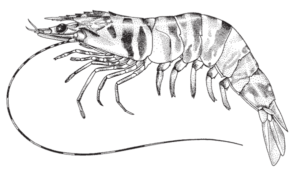
The environmentally driven variability of this resource means that a robust stock–recruitment relationship cannot be determined. Because annual yields are largely dependent on annual recruitment and recruitment is closely associated with seasonal rainfall, it has not been possible to develop a stock 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. 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**.

Brown tiger prawn (*Penaeus esculentus*)



Line drawing: FAO

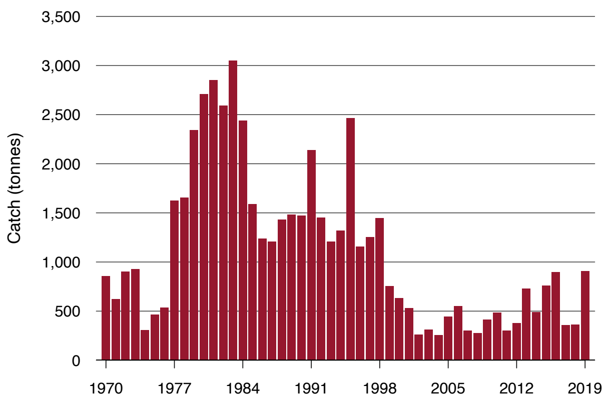
Stock structure

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 southern and western Gulf of Carpentaria, but also in waters westward towards Joseph Bonaparte Gulf. Catch of brown tiger prawn in 2019 was 908 t, which was the highest catch reported since 1999 (Figure 5.5).

FIGURE 5.5 Brown tiger prawn catch, 1970 to 2019



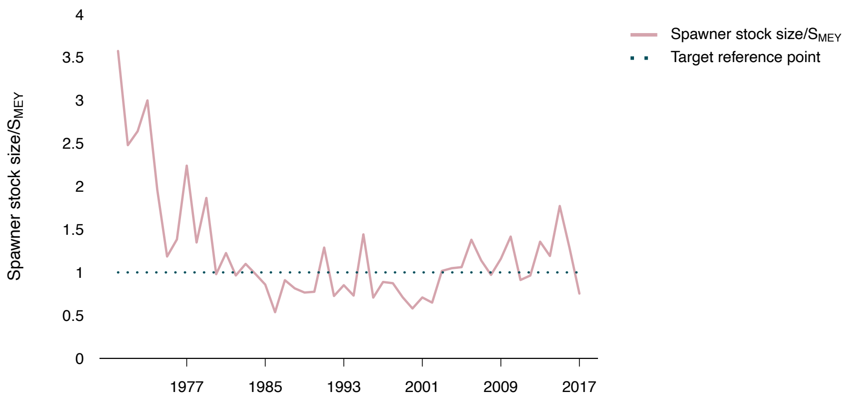
Source: CSIRO

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*) (Punt et al. 2011). It is integrated with an economic model that calculates MEY (Punt et al. 2010). Full assessments are undertaken every 2 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 for red endeavour prawn (*M. ensis*) as an additional sensitivity to the base-case model.

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 decline in biomass compared with the 2015 assessment. 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 (Hutton 2019). 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 was substantially below the base-case estimate of MSY (1,083 t) in 2017 and 2018, but was close to estimated MSY in 2019 (see Figure 5.5).

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



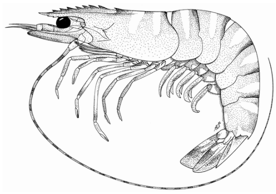
Note: S_{MEY} Spawner stock size at maximum economic yield.
Source: Deng et al. 2018

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 recent decline in biomass; however, the 5-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**.

Prawns
Austral Fisheries

Grooved tiger prawn (*Penaeus semisulcatus*)



Line drawing: Karina Hansen

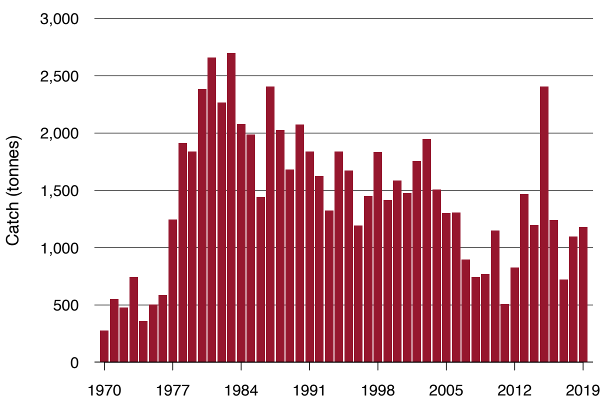
Stock structure

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 2019 was 1,178 t.

FIGURE 5.7 Grooved tiger prawn catch, 1970 to 2019



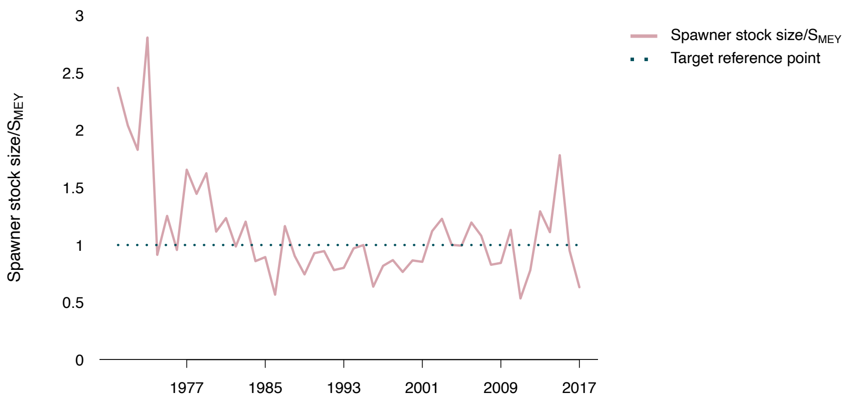
Source: CSIRO

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 2019 catch of grooved tiger prawn (1,178 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 to 2017

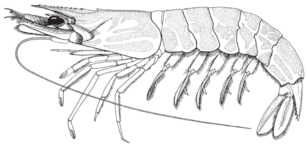


Note: S_{MEY} Spawner stock size at maximum economic yield.
Source: Deng et al. 2018

Stock status determination

Catches of grooved tiger prawns in the past 6 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 5-year moving average estimate of spawning 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

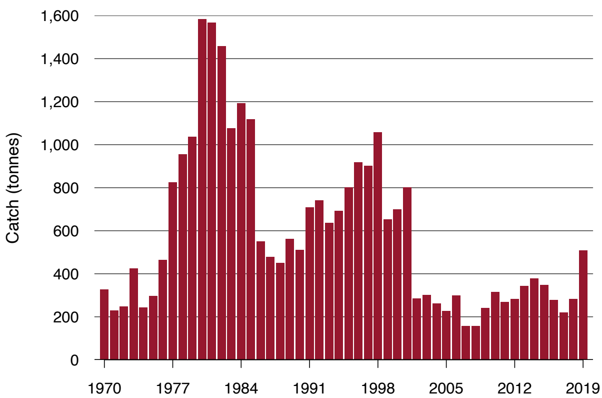
Stock structure

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). During 2002 to 2018, annual catches have averaged around 300 t; however, in 2019, the catch of blue endeavour prawn increased to 509 t. 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 to 2019



Source: CSIRO

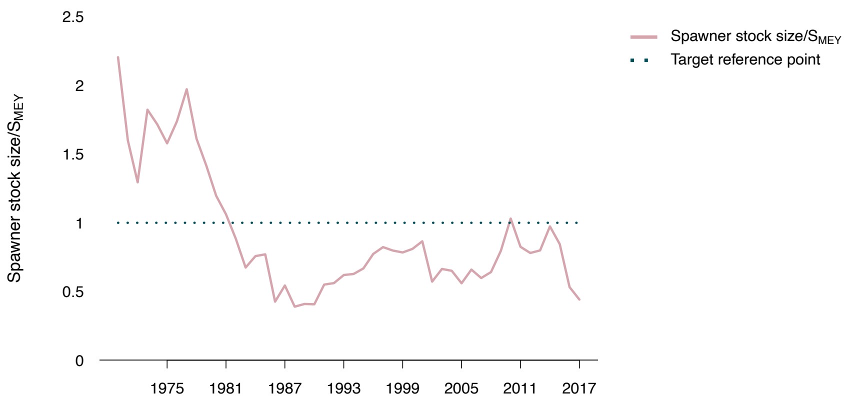
Stock assessment

The stock is assessed using a Bayesian hierarchical biomass dynamic model, within the same overall bio-economic model system used for the 2 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 2 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 (R Deng [CSIRO], 2019, pers. comm.).

The 2019 catch of blue endeavour prawn (509 t; Figure 5.9) was 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 to 2017

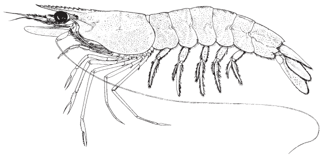


Note: **S_{MEY}** Spawner stock size at maximum economic yield.
Source: Deng et al. 2018

Stock status determination

The catch in 2019 was below the estimated MSY, and the estimate of spawner stock size (5-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

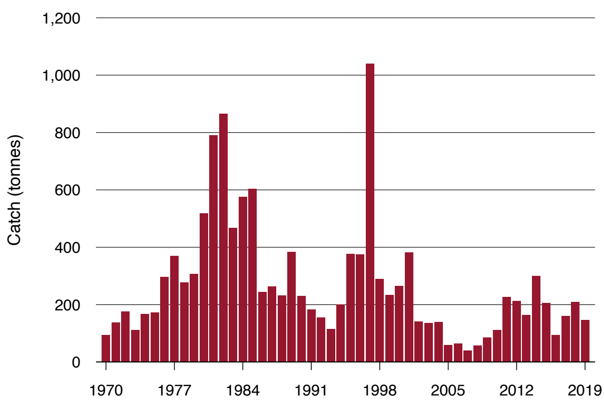
Stock structure

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 147 t caught in 2019. Red endeavour prawn is a byproduct of the tiger prawn fishery.

FIGURE 5.11 Red endeavour prawn catch, 1970 to 2019



Source: CSIRO

Stock assessment

A preliminary assessment of red endeavour prawn, using a Bayesian hierarchical biomass dynamic model as an additional sensitivity test to the base case, 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

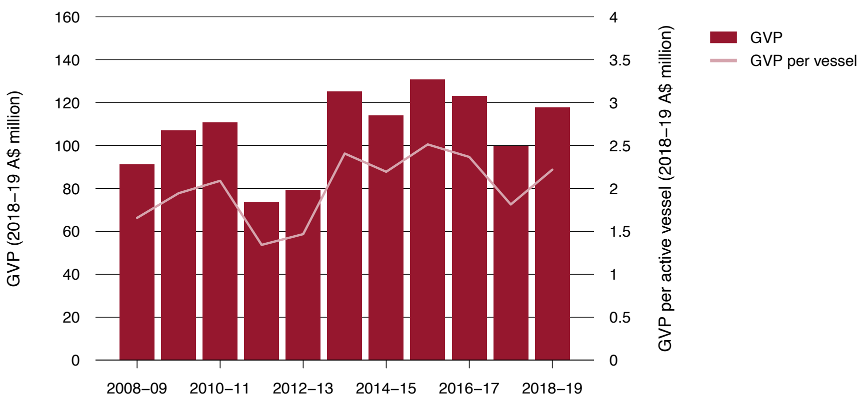
Given the preliminary nature of the 2018 stock assessment, red endeavour prawn is classified as **uncertain** with regard to fishing mortality and biomass status.

5.3 Economic status

Key economic trends

The gross value of production (GVP) for the NPF fluctuated during the decade to 2018–19, peaking at $129 million in 2015–16 and reaching a low of $73 million (in 2018–19 dollars) in 2011–12 (Figure 5.12). During the same period, the average GVP per active vessel increased by 34% to $2.22 million (in 2018–19 dollars).

FIGURE 5.12 GVP and GVP per active vessel for the NPF, 2008–09 to 2018–19



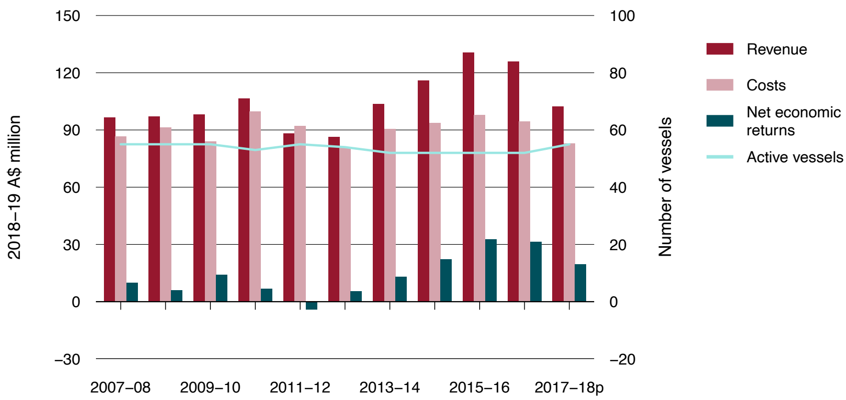
Notes: **GVP** Gross value of production. 2018–19 data are preliminary.

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 2008–09 to 2017–18 (Figure 5.13). In 2011–12, real NER were negative, estimated at –$4.0 million (in 2018–19 dollars). NER have followed an increasing trend since 2011–12, reaching a peak of $32.05 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 $30.9 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 a 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, 2003–04 to 2015–16

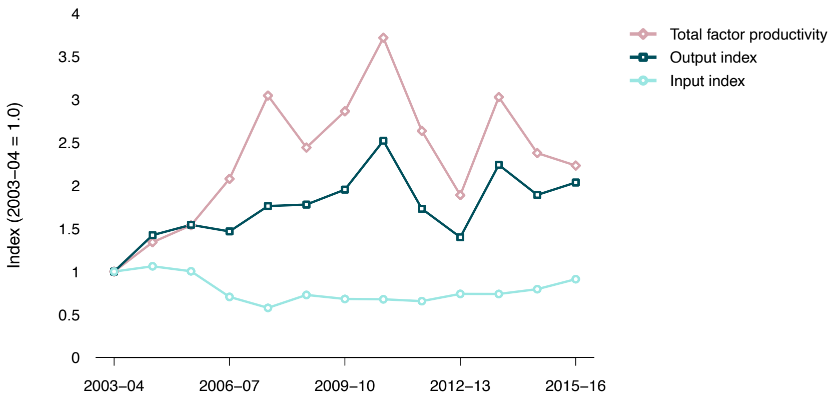
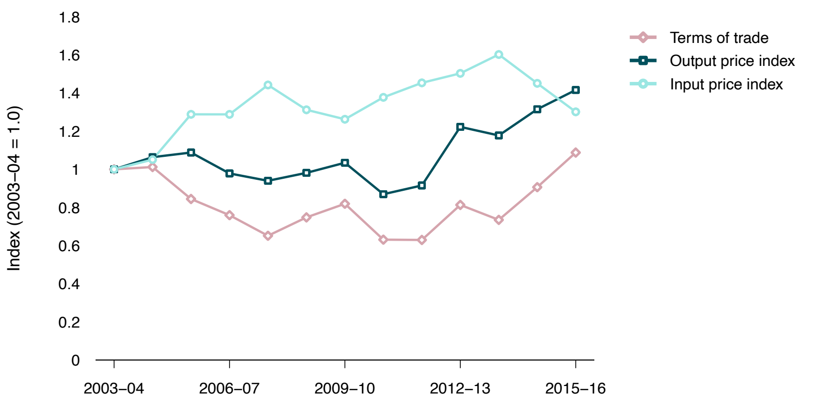


FIGURE 5.15 Terms of trade index, 2003–04 to 2015–16



Performance against economic objective

The tiger prawn component of the fishery has explicit MEY targets (across 2 tiger prawn stocks and 1 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 2 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}. 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 7-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 is implemented annually (since 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).

Targeting MEY in the fishery is consistent with the economic objective of maximising economic returns, and could be expected to maintain positive 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, 2 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, 3 species are currently considered to be at high risk in the NPF: porcupine ray (*Urogymnus asperrimus*) and 2 species of mantis shrimp (*Dictyosquilla tuberculata* and *Harpiosquilla stephensoni*). The ERA is currently being updated.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE) and these are summarised below.

In the NPF in 2019, 433 sawfish interactions were reported, of which 349 sawfish were released alive, 79 were dead 4 were injured and 1 was released in unknown condition; 8,094 sea snakes were caught, of which 6,259 were released alive, 1,762 were dead, 3 were injured and 70 had an unknown life status; 85 seahorse and pipefish species were caught, of which 15 were released alive, 68 were dead and 2 had an unknown life status; and 73 turtle interactions were reported, with all but 2 turtles being released alive. Reports also indicate that 1 whale shark (*Rhincodon typus*) was caught and released alive.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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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AFMA

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Chapter 6

North West Slope Trawl Fishery

I Butler and AH Steven

FIGURE 6.1 Area fished in the North West Slope Trawl Fishery, 2018–19 fishing season

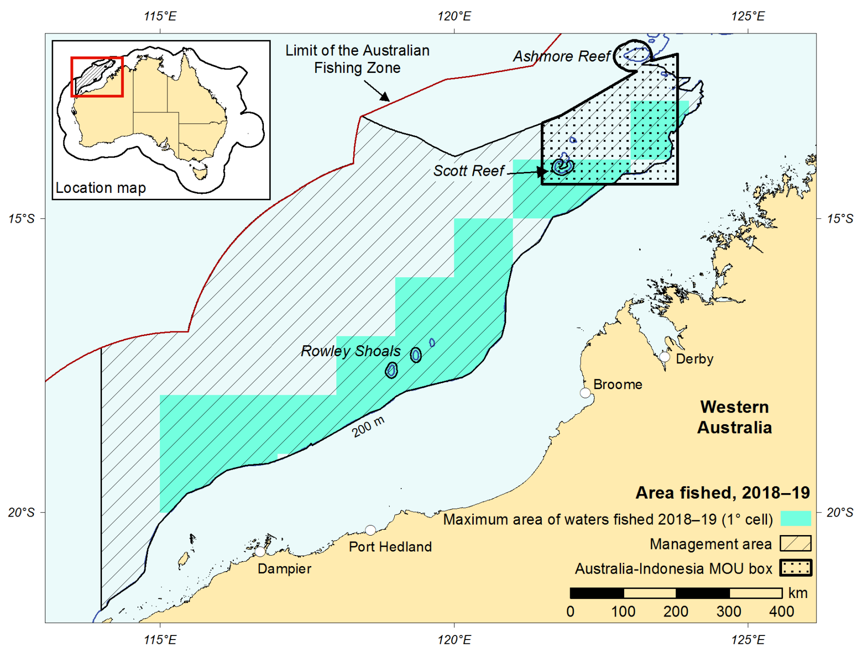


TABLE 6.1 Status of the North West Slope Trawl Fishery

Stock	Biological status 2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
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. It is likely that operating costs in the fishery decreased in 2018–19 following a decrease in average effort per vessel. This, combined with higher catch per hour trawled, indicates that NER improved in 2018–19.

Note: **NER** Net economic returns.

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

Scampi
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). The boundary of the fishery has recently been changed to align more closely 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 to 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 the 1986–87 season and declined through the 1990s before increasing to 10 in the 2000–01 and 2001–02 seasons. Vessel numbers have since decreased to between 1 and 4 each year since 2006–07 (Table 6.2). Four vessels operated in the 2017–18 and 2018–19 seasons. Trawl-hours decreased from 3,731 in the 2017–18 fishing season to 2,869 in 2018–19 (Figure 6.2). Fishing effort in the NWSTF often increases each year when boats cease to operate in the Northern Prawn Fishery and move to the NWSTF.

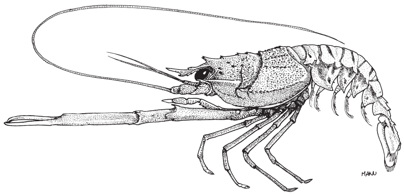
TABLE 6.2 Main features and statistics for the NWSTF

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)**
Scampi (*Metanephrops australiensis, M. boschmai, M. velutinus*)	–	55.2	Confidential	–	41.1	Confidential
Total fishery	**–**	**79.8**	**Confidential**	**–**	67.4	**Confidential**
Fishery-level statistics						
Effort	219 days; 3,731 trawl-hours			151 days; 2,869 trawl-hours		
Fishing permits	6			7		
Active vessels	4			4		
Observer coverage	14 days (6.4%)			22 (14.6%)		
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 to 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

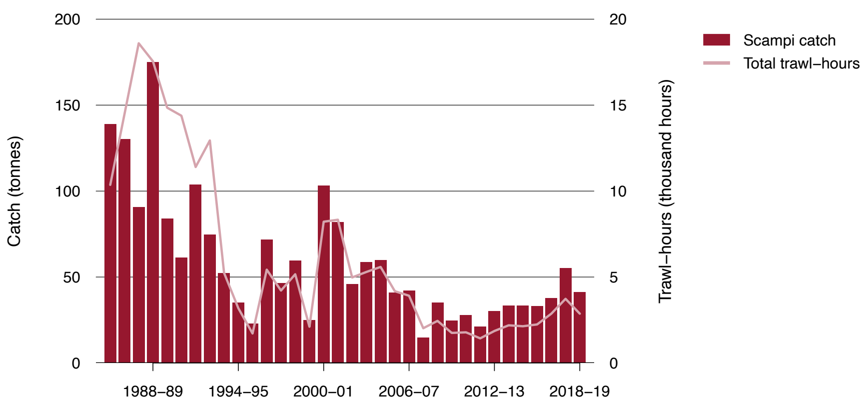
Stock structure

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 makes up a large proportion of the total catch in the fishery and has been relatively stable at between 35 t and 55 t since 2002. Catch in 2019 was 41.1 t, down from 55 t in 2018. Scampi made up approximately 61% of the total catch (67.4 t) in 2019, with the rest made up of various finfish and other crustaceans.

FIGURE 6.2 Catch and effort for scampi in the NWSTF, 1985–86 season to 2018–19 season



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 (MSY).

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 and 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 relatively consistent since the 2010 stock assessment, suggesting that biomass is likely to remain high. Catch since 2000 has been well below the MSYs (74–102 t) calculated by Chambers and Larcombe (2015).

To monitor stock levels, standardised CPUE series should be produced every 3–5 years, and assessment models fitted to periodically update relative biomass estimates. Such modelling should be a priority for this fishery. Analysis of the mean carapace length of Australian scampi measured by observers could also 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. Although the stock assessment has not been updated since then, nominal catch rates are relatively high and catches have been below estimated MSYs. As a result, 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 NWSTF has been confidential since 2006–07 because of the small number of active vessels in the fishery. Total catch in the fishery has generally been variable; in 2017–18, the total volume landed increased by 38% from 2016–17 but decreased by 12.4% in 2018–19.

Scampi generally has a relatively high unit value compared with other species caught in the fishery and so is the main target species. In the 2017–18 fishing season, scampi contributed 69% of total catch, decreasing to 61% in 2018–19. The decrease in scampi catch in 2018–19 may indicate lower levels of profitability in the fishery in 2018–19.

Across the fishery, average catch per day of fishing and catch per hour trawled increased in the 2018–19 fishing season, indicating higher revenue per unit of effort. The positive effect of this on vessel-level profitability is reinforced by lower unit fishing costs flowing from lower average effort expended per vessel across the fishery in the 2018–19 fishing season. As a result, net economic returns are likely to have improved in the 2018–19 fishing season, but remain at low levels as indicated by the low levels of activity in the fishery and the high costs of operating in remote fisheries.

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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with species protected under the EPBC Act were reported in the NWSTF in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

6.5 References

AFMA 2011, *Harvest strategy for the Western Deepwater Trawl Fishery and North West Slope Trawl Fishery 2011*, Australian Fisheries Management Authority, Canberra.

——2012, *North West Slope Trawl Fishery and Western Deepwater Trawl Fishery statement of management arrangements*, Australian Fisheries Management Authority, Canberra.

Chambers, M & Larcombe, J 2015, 'North West Slope Trawl Fishery scampi assessment', in J Larcombe, R Noriega & I Stobutzki (eds), *Reducing uncertainty in fisheries stock status*, ABARES research report, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Wallner, BG & Phillips, BF 1995, 'Development of a trawl fishery for deepwater metanephropid lobsters off the northwest continental slope of Australia: designing a management strategy compatible with species life history', *ICES Marine Science Symposium*, vol. 199, pp. 379–90.

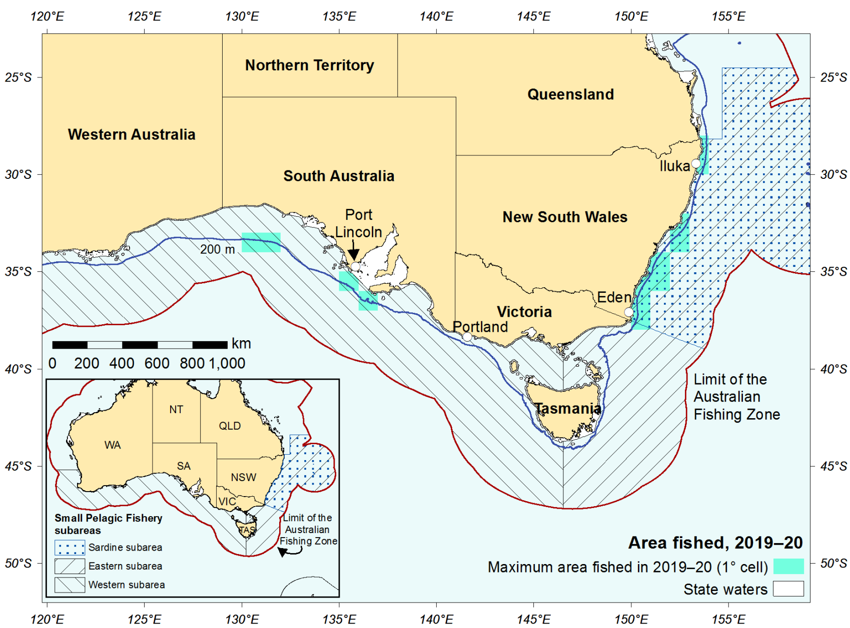
Zhou, S, Smith, T & Fuller, M 2009, *Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries*, report to the Australian Fisheries Management Authority, Canberra.

Scampi
AFMA

Chapter 7
Small Pelagic Fishery

R Noriega and AH Steven

FIGURE 7.1 Area fished in the Small Pelagic Fishery, 2019–20 fishing season



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

TABLE 7.1 Status of the Small Pelagic Fishery

Stock	Biological status				Comments
	2018		2019		
	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 fishery. A substantial increase in catch in the 2018–19 and 2019–20 fishing seasons suggests that the gross value of production is likely to have increased and also indicate a potential increase in NER.

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 3 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 2014b) included ecosystem and population modelling (Smith et al. 2015). Recommendations from the review were incorporated into the current harvest strategy (AFMA 2017c), 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 3 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 5 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 about 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), which further reduces the 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. When setting the RBCs for the 2019–20 season, all SPF stocks had a DEPM-based biomass estimate.

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.

TABLE 7.2 SPF harvest strategy tier levels and DEPM-based biomass estimate

Stock	Tier 1		Tier 2		Tier 3 a	Year of 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 b
Blue mackerel, east	15	5	7.5	5	3.75	2015 b
Blue mackerel, west	15	5	7.5	5	3.75	2005
Jack mackerel, east	12	5	6	10	3	2019
Jack mackerel, west	12	5	6	10	3	2018
Redbait, east	10	5	5	10	2.5	2006
Redbait, west	10	5	5	10	2.5	2019

a No time limit applies for a stock at tier 3. **b** Results from an egg survey in 2019 are expected to be used to set the TAC for 2021–22.
Note: **DEPM** Daily egg production method.

Fishing effort

Most historical fishing effort has occurred off the east and west coasts of Tasmania. Purse-seine effort peaked at 1,093 search-hours in 2005–06. Search effort declined to 45 hours in 2013–14, increasing to 208 search-hours in 2018–19. There were 197 search-hours in 2019–20 (Table 7.3). Trawl effort in the SPF increased in 2015–16 with the operation of a factory freezer trawler. This vessel left the fishery in late 2016 (AFMA 2016), resulting in a decrease in effort (number of shots) of approximately 40%. A different midwater trawler entered the fishery in 2017 (AFMA 2017a), slightly increasing effort levels between 2016–17 and 2018–19. Midwater trawl effort more than doubled to 448 shots in the 2019–20 fishing season (Figure 7.2).

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 16,094 t in 2019–20, due to increasing catches of eastern blue mackerel, eastern jack mackerel and eastern redbait.

FIGURE 7.2 Total catch and fishing effort for the SPF, 2001–02 to 2019–20 fishing season

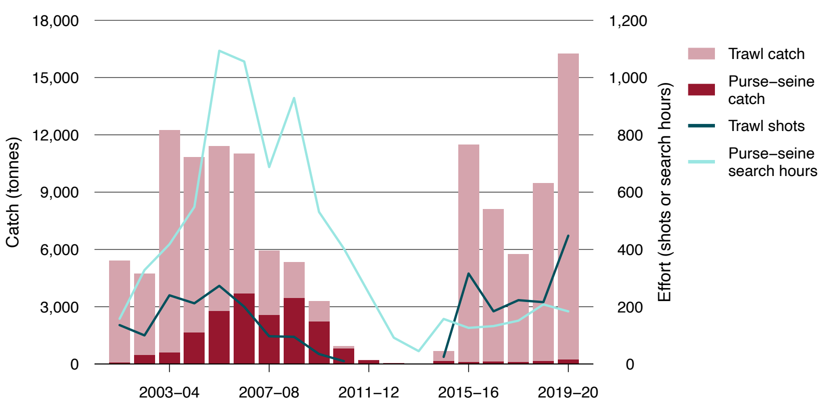


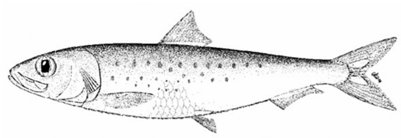
TABLE 7.3 Main features and statistics for the SPF

Fishery statistics a	2018–19 fishing season			2019–20 fishing season		
Stock name	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**	**TAC (t)**	**Catch (t)**	**GVP (2019–20)**
Australian sardine	9,510	132	Confidential	9,050	226	Confidential
Blue mackerel, east	12,090	3,811	Confidential	11,970	5,617	Confidential
Blue mackerel, west	3,230	–	Confidential	3,240	9	Confidential
Jack mackerel, east	18,890	4,942	Confidential	18,730	7,808	Confidential
Jack mackerel, west	4,190	–	Confidential	4,200	12	Confidential
Redbait, east	3,420	539	Confidential	3,150	2,412	Confidential
Redbait, west	820	–	Confidential	6,680	9	Confidential
Total fishery	**52,150**	**9,424**	**Confidential**	**57,020**	**16,093**	**Confidential**
Fishery-level statistics						
Effort	Purse seine: 208 search-hours Midwater trawl: 216 shots			Purse seine: 197 search-hours Midwater trawl: 448 shots		
Fishing permits	31 entities held quota SFRs in 2018–19			31 entities held quota in 2019–20		
Active vessels	Purse seine: 3 Midwater trawl: 1			Purse seine: 3 Midwater trawl: 1		
Observer coverage	Purse seine: 21% Midwater trawl: 18%			Purse seine: 0% Midwater trawl: e-monitoring 10%; onboard observers 7%		
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 to 30 April. Value statistics are by financial year and are not available for 2019–20.
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*)



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Stock structure

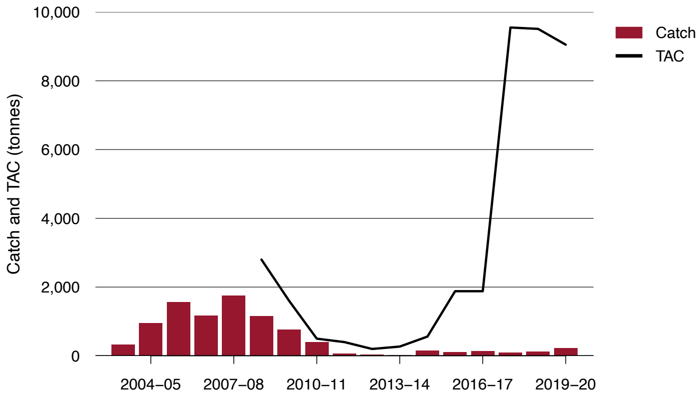
Several studies have found evidence of stock structuring of Australian sardine across southern Australia (Dixon, Worland & Chan 1993; Izzo, Gillanders & Ward 2012; Yardin et al. 1998); however, the boundaries were not conclusively defined. Izzo et al. (2017), using an integrated assessment that included genetic, morphological, otolith, growth, reproductive and fishery data, found evidence for at least 4 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 2018–19 was 596 t, comprising 132 t of Commonwealth catch and 464 t of state catch. Commonwealth catch for 2019–20 was 226 t (Figure 7.3). State catches are not yet available.

FIGURE 7.3 Commonwealth Australian sardine catch and TAC in the SPF, 2003–04 season to 2019–20 season



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 completed in August–September 2014, and a spawning biomass of 49,600 t (95% CI 24,200–213,300 t) was estimated using the DEPM (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]) of the SPF harvest strategy in use at that time. The SPF Scientific Panel used the 2014 DEPM estimate to recommend an RBC for 2019–20. Results from an egg survey in 2019 are expected to be used when the TAC is set for 2021–22.

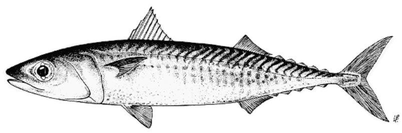
The 2015 MSE of the SPF harvest strategy suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For Australian sardine, Smith et al. (2015) suggested that tier 1 harvest rates could be increased from 15% to 33%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than 5 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 differs 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 in 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 (that is, 20% of the pre-exploitation spawning biomass) if regular egg surveys were not conducted.

Because of the age of the DEPM estimate, the 2019–20 season was treated as season 4 of 5 at tier 1, despite it only being the third 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 9,050 t.

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

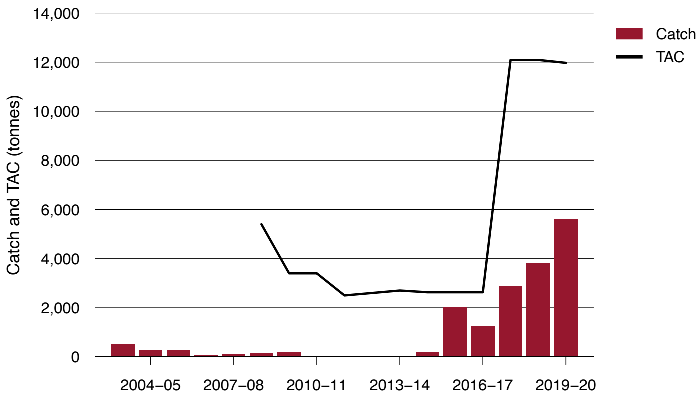
The stock structure of blue mackerel is uncertain. Genetic analysis of samples from southern Queensland, Western Australia and New Zealand indicates population subdivisions. Genetic differences were detected between Western Australia and Queensland, and between Western Australia and New Zealand, but 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).

Blue mackerel
Lee Georgeson, ABARES

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 2018–19 was 4,265 t, comprising 3,811 t from the Commonwealth and 454 t from state fisheries. Commonwealth catch increased to 5,617 t in 2019–20 (Figure 7.4). State catches for the season are not yet available.

FIGURE 7.4 Commonwealth eastern blue mackerel catch and TAC, 2003–04 season to 2019–20 season



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.

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. Results from an egg survey in 2019 are expected to be used when the TAC is set for 2021–22.

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 5 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 2019–20 season was treated as season 4 of 5 at tier 1, despite it only being the third 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 11,970 t.

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 (5.1% in 2018–19, including state catches, and 6.7% in 2019–20, not including 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*)

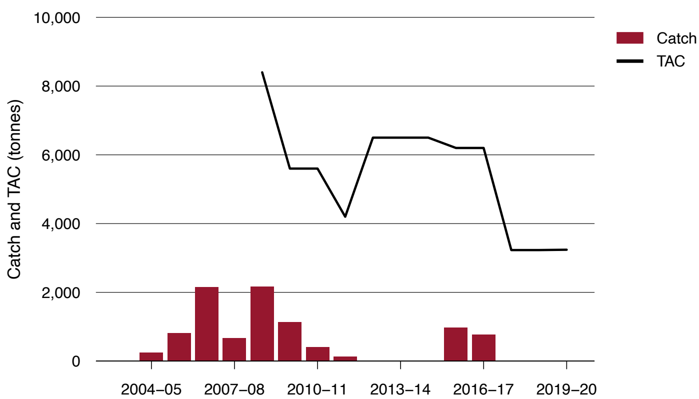
Stock structure

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 Commonwealth and state fisheries. No Commonwealth catch was reported in 2017–18 or 2018–19. Commonwealth catch for 2019–20 was 9 t (Figure 7.5), state catches have been either negligible or confidential in recent years.

FIGURE 7.5 Commonwealth western blue mackerel catch and TAC, 2003–04 season to 2019–20 season



Note: **TAC** Total allowable catch.

Stock assessment

An egg survey for western blue mackerel was completed 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.

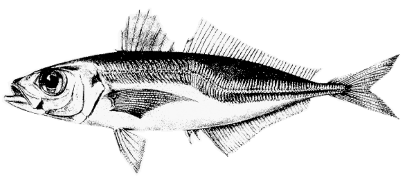
The 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For western blue mackerel, it was suggested that tier 1 harvest rates should be set at 23%, that tier 2 harvest rates should be set at 50% of tier 1, and that neither should be applied for longer than 5 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 2019–20 RBC of 3,243 t. This was the third 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 3,240 t.

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. 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**.

Jack mackerel, east (*Trachurus declivis*)



Line drawing: FAO

Stock structure

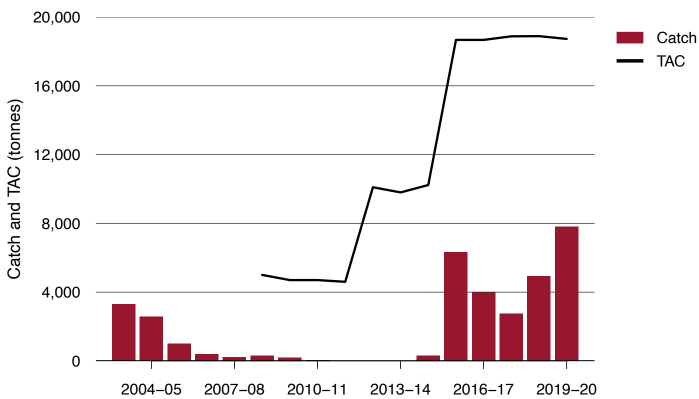
The stock structure of jack mackerel is unclear. Richardson (1982) found evidence of population subdivision between Western Australia, including the Great Australia Bight, and eastern Australia. Similarly, a DEPM estimate for western jack mackerel appears to show some stock structuring around the Bonney 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. Commonwealth catch has increased, reaching 6,316 t in 2015–16, decreasing to 4,942 in 2018–19 and increasing again to 7,808 t in 2019– 20 (Figure 7.6). State catches have been negligible in recent years. The total combined catch (Commonwealth and state) for 2018–19 was 4,947 t, comprising 4,942 t of Commonwealth catch and 5 t of state catch. Commonwealth catch for 2019–20 was 7,808 t (Figure 7.6). State catches are not yet available for 2019–20.

FIGURE 7.6 Commonwealth eastern jack mackerel catch and TAC, 2003–04 season to 2019–20 season



Note: **TAC** Total allowable catch.

Stock assessment

The most recent egg survey for eastern jack mackerel available for the (then) SPF Scientific Panel to use when setting an RBC 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 egg survey for eastern jack mackerel in January and February 2019 produced a biomass estimate of 156,292 t (AFMA 2019c). However, these results were not available when developing an RBC or for AFMA to set a TAC in 2019–20; they were used to inform the 2020–21 TAC.

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 5 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 2019–20 RBC of 18,937 t, using tier 1 of the 2017 harvest strategy (AFMA 2019d). The AFMA Commission agreed to a TAC of 18,730 t.

Stock status determination

Recent catches have been low and below the RBC calculated using an MSE-tested harvest strategy. 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*)

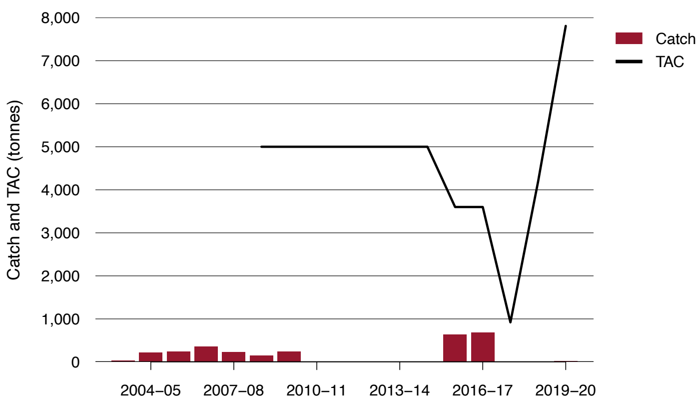
Stock structure

See jack mackerel, east.

Catch history

Total catch (Commonwealth and state) for western jack mackerel did not exceed 250 t before 2005–06. Commonwealth catch was zero or negligible from 2011–12 to 2014–15, increasing to 634 t in 2015–16 and 686 t in 2016–17. No Commonwealth catch was reported for 2017–18 or 2018–19 (Figure 7.7). Commonwealth catch was 12 t for 2019–20. State catches are not available for 2019–20 and have been confidential for the preceding 4 years.

FIGURE 7.7 Commonwealth western jack mackerel catch and TAC, 2003–04 season to 2019–20 season



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 5 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.

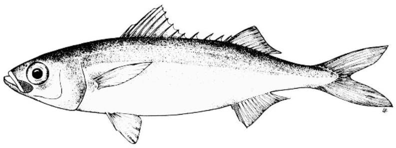
The SPF Scientific Panel recommended a 2019–20 RBC of 4,197 t, using the initial biomass estimate and tier 1 of the 2017 harvest strategy (AFMA 2019d). After factoring in state catches, the AFMA Commission agreed to a TAC of 4,200 t.

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. 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**.

Australian sardine
Heesh Garroun, AFMA

Redbait, east (*Emmelichthys nitidus*)



Line drawing: FAO

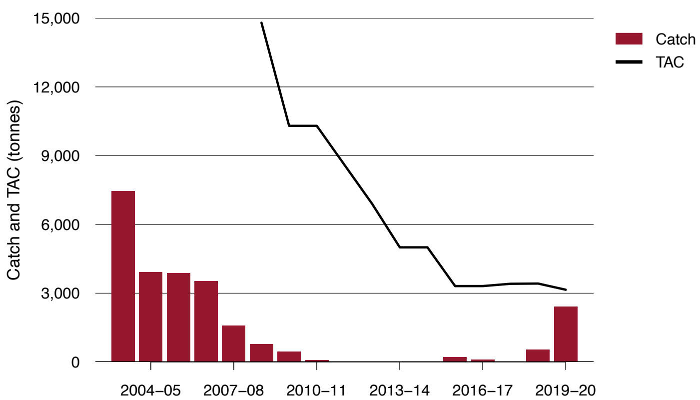
Stock structure

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 2019–20 was 2,412 t, up from 539 t in 2018–19 (Figure 7.8). State catches have been negligible or confidential in recent years and are not available for 2019–20.

FIGURE 7.8 Commonwealth eastern redbait catch and TAC, 2003–04 season to 2019–20 season



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 2 estimates (68,886 t) was used to generate an RBC of 3,444 t for 2019–20, using the tier 2 decision rule (AFMA 2019d). After factoring in state catches, the AFMA Commission agreed to a TAC of 3,444 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 5 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 2019–20 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 2019–20 was 3.5% of the spawning biomass estimate, and 70% 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. 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*)

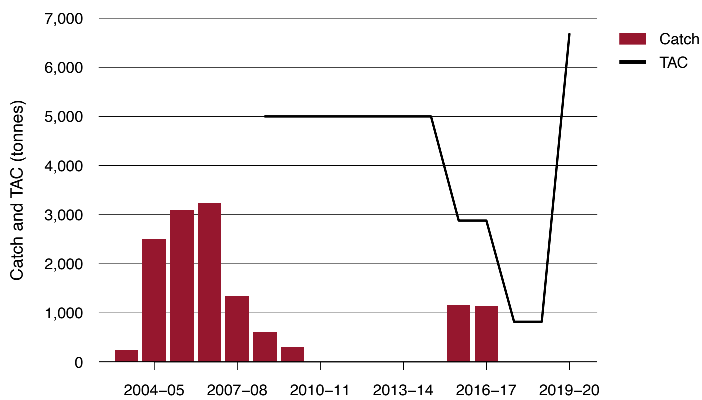
Stock structure

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 7.9). Commonwealth catch was 9 t in 2019–20. No state catches have been reported in recent years.

FIGURE 7.9 Commonwealth western redbait catch and TAC, 2003–04 season to 2019–20 season



Note: **TAC** Total allowable catch.

Stock assessment

An egg survey for western red bait was completed in 2017, and a spawning biomass of 66,787 t (95% CI 28,797–190,392 t) was estimated using the DEPM (Ward et al. 2019). The new biomass estimate moved the stock from a tier 3 Atlantis-SPF ecosystem-based (model-derived) biomass estimate of 66,000 t with an exploitation rate of 2.5% (Fulton 2015) to a tier 1, egg-survey-based biomass estimate of 66,787 t with an exploitation rate of 10%. The SPF Scientific Panel recommended a 2019–20 RBC of 6,678 t, based on the DEPM for this stock. This was the first season that tier 1 was used to set an RBC for western red bait. Subsequently, the AFMA Commission agreed to a TAC of 6,680 t.

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 5 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 2017c), with tier 2 being half the tier 1 level and tier 3 being 1.25% of the Atlantis-SPF ecosystem modelling.

Stock status determination

Recent catches have been low and below the RBC calculated using an MSE-tested harvest strategy. This level of fishing mortality is unlikely to have substantially reduced spawning biomass. On this basis, the western red bait stock is classified as **not overfished** and **not subject to overfishing**.

7.3 Economic status

Key economic trends

The 2019–20 fishing season saw the largest catch since the 2015–16 fishing season. While 72% of TAC was not caught in 2019–20 (82% in 2018–19), total catch increased significantly—by 71%—in 2019–20. The number of shots undertaken also increased in 2019–20. These increases indicate that incentives to fish in the SPF have improved, and that gross value of production (GVP) and net economic returns (NER) have likely improved from previous years. This is supported by catch per unit of search-hour and catch per vessel operating almost doubling, indicating lower fishing costs. The increase in catch coincides with a new 40 m midwater trawler that has recently commenced fishing in the SPF (AFMA 2017a).

Estimates of NER are not available for the SPF because there have been no recent surveys. The most recent available estimate of GVP is $1.4 million (2019–20 dollars) for 2007–08. This was 65% lower than the 2005–06 estimate ($3.9 million in 2019–20 dollars). Since then, the GVP of the SPF has been confidential because of a limited number of operators in the fishery.

Performance against economic objective

Economic targets have been estimated for the key species caught in the fishery by Pascoe and Hillary (2016) and Smith et al. (2015). These studies suggest that maximum economic yield for the key species caught can approximate maximum sustainable yield 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 applies 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.

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.

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* (EPBC Act) 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 1 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 4 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.

The SPF Bycatch and Discard Workplan 2014–2016 includes specific measures to address the risks highlighted by the ecological risk assessment and to minimise the risk of further interactions with non-target species (AFMA 2014a). Management actions under the workplan include implementing upward-opening seal excluder devices and developing vessel management plans for each midwater trawl vessel operating in the fishery to minimise the risk of interactions with seabirds, seals and dolphins (AFMA 2019b). A fisheries management strategy is being developed that will replace the workplan and outline bycatch arrangements.

In May 2017, AFMA implemented the Small Pelagic Fishery Dolphin Strategy (AFMA 2017b). 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 2018–2019, and amendments to conditions came into effect on 1 November 2019. To fish in the SPF, all trawl vessels must have an AFMA-approved dolphin mitigation plan that outlines the actions being taken by the fisher to minimise dolphin interactions on that particular vessel (AFMA 2019a).

In accordance with accreditation under the EPBC Act (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). Thirty-two interactions with protected species were reported in the SPF during 2019. These comprised 12 New Zealand fur seals (*Arctocephalus forsteri*; 1 alive and 11 dead), 15 common dolphins (*Delphinus* sp.; 2 alive and 13 dead), 1 bottlenose dolphin (*Tursiops truncatus*; dead), 3 shortfin makos (*Isurus oxyrinchus*; 1 alive and 2 dead) and 1 unidentified bird (alive).

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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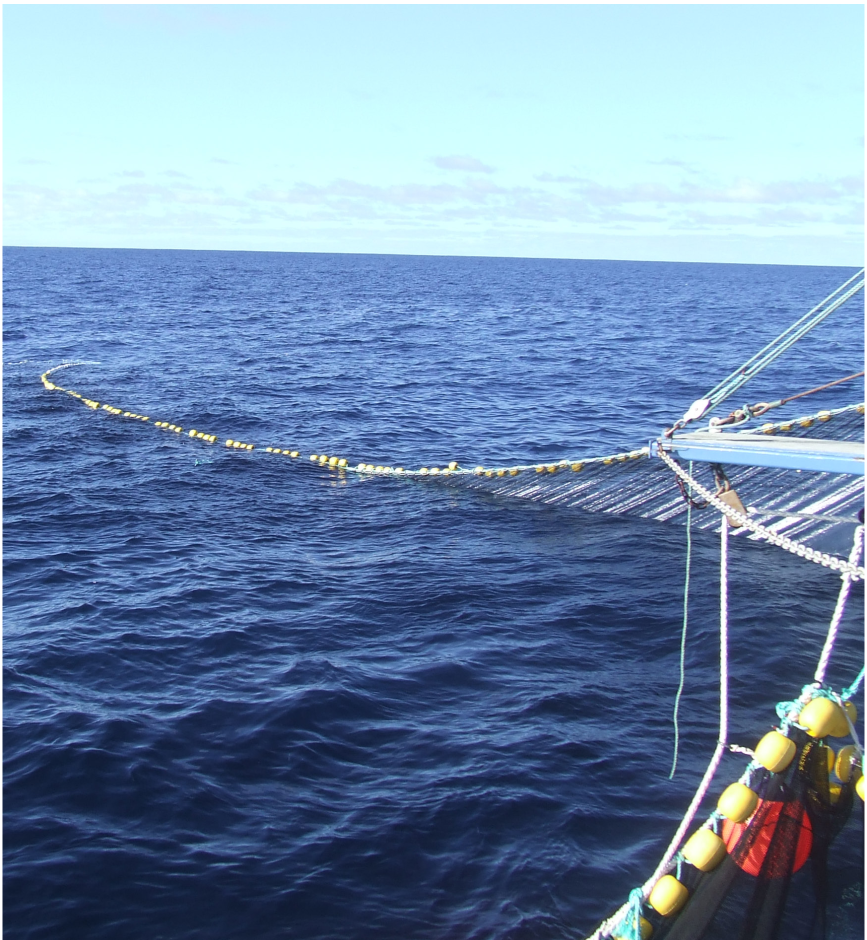


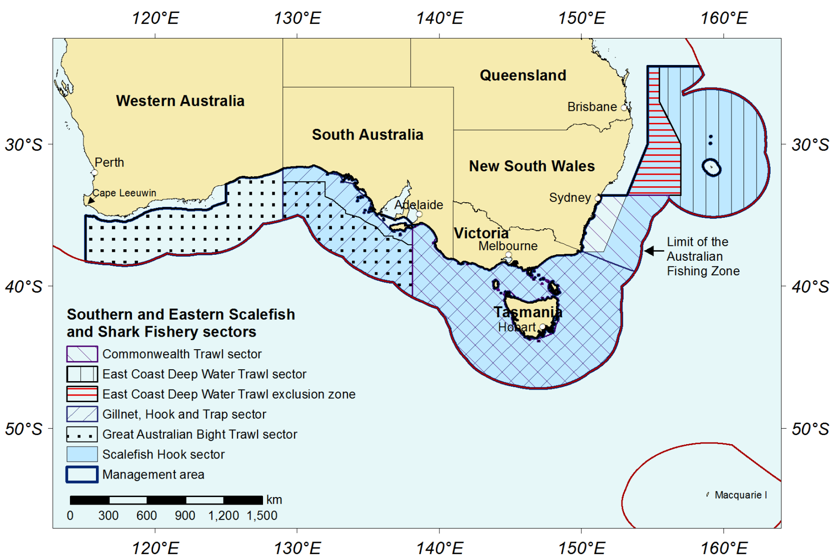
Purse seine
Mike Gerner, AFMA

Chapter 8

Southern and Eastern Scalefish and Shark Fishery

T Emery, N Marton, I Butler, 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.[1]

The SESSF remained the largest Commonwealth fishery in terms of volume caught in the 2018–19 fishing season. In 2018–19, the gross value of production (GVP) of the SESSF was $87 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 (e-monitoring) and vessel monitoring systems.

Consultation in the SESSF is undertaken through a series of Management Advisory Committees (MACs) and Resource Assessment Groups (RAGs). In the SESSF, RAGs include the South East RAG (SERAG), SharkRAG, the Great Australian Bight RAG (GABRAG) and the SESSFRAG. Members of the RAGs include Australian Fisheries Management Authority (AFMA) managers, fisheries scientists, industry members, economists and other interest groups. This group provides advice and recommendations to the MACs, AFMA managers and the AFMA Commission on stock assessments; scientific analyses; the status of fish stocks; and the impact of fishing on target, non-target and threatened, endangered and protected (TEP) species and habitats.

In the SESSF, MACs include the South East MAC (SEMAC) and the Great Australian Bight MAC (GABMAC). Members of the MACs include AFMA managers, industry members, policy analysts, conservationists, state and territory managers, economists, and recreational fishing interest groups. These committees provide advice to AFMA managers and the AFMA Commission on the formulation of management arrangements that are consistent with overarching policy and legislation using, among other things, information obtained from the RAGs on the status of fish stocks, non-target and TEP species, and the impacts of fishing on the marine environment.

1 See https://parksaustralia.gov.au/marine

The SESSF was established in 2003 by amalgamating 4 fisheries—the South East Trawl, the Great Australian Bight Trawl, the Southern Shark non-trawl and the South East non-trawl fisheries—under common management objectives. The Southern and Eastern Scalefish and Shark Fishery (SESSF) Management Plan 2003 was gazetted on 1 October 2003. Originally, each of the 4 fisheries had its own MAC. In 2009, AFMA created SEMAC to provide advice to the AFMA Commission on management measures for the entire SESSF. The Small Pelagic Fishery MAC and the Squid MAC also became part of SEMAC in 2010, whereas GABMAC remains separate.

Landings in the SESSF have generally decreased over time because of reductions in fishing effort, although in the 2019–20 fishing season, total landings increased to their highest level since the 2011–12 fishing season, mainly due to a large increase in the catch of blue grenadier (*Macruronus novaezelandiae*) in the Commonwealth Trawl Sector (CTS). This increase in catches of blue grenadier was partially offset by a decline in the catches of both pink ling (*Genypterus blacodes*) and blue-eye trevalla (*Hyperoglyphe antarctica*), which have historically had relatively stable catches. In the 2019–20 fishing season, total landings in the CTS, the Gillnet, Hook and Trap Sector (GHTS), the Great Australian Bight Trawl Sector (GABTS) and the East Coast Deepwater Trawl Sector (ECDTS) were 14,920.1 t, 2,707.0 t, 1,600.0 t and 7.8 t, respectively, for a total 19,234.8 t.

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 (principally Chapter 9 and Chapter 12).

Gillnet vessel
AFMA

8.2 Sectors of the fishery

Current management arrangements are structured around the 4 primary sectors of the fishery: the CTS, the ECDTS, the GABTS and the GHTS.

The status of the stocks taken in these sectors are 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 the 2017–18 fishing season, both increased, with 8,759 shots undertaken and 36 t of hagfish (class Myxini) landed (that is, based on catch disposal record data). In 2018–19, catch and effort again increased, to 19,402 shots and 85 t landed. A similar amount of catch and effort was witnessed in the 2019–20 fishing season, with 23,030 shots recorded and 84 t landed.

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 release of the inaugural Commonwealth Fisheries Harvest Strategy Policy (HSP) in 2007, and since the release of an updated HSP in 2019 (Department of Agriculture and Water Resources 2019b). The current SESSF HSF applies to all sectors, and each stock under quota is assigned to 1 of 3 '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. Under the SESSF HSF, an RBC recommendation can also be made using alternative assessment methods if: (i) it is considered more appropriate for a quota species than the traditional 3 'tiers' for assessment and; (ii) it meets the intent of the HSP. A variety of 'tier 5' approaches, such as catch at maximum sustainable yield (MSY) and age-structured stock reduction analysis approaches have been used recently to inform RBC recommendations (for example, blue-eye trevalla).

Harvest control rules (HCRs), target and limit reference points, and the tiers 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 HCRs, with the HCRs intended to move a stock away from a limit reference point and towards the target reference point (AFMA 2019a). Several 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 unavoidable catches of these stocks when fishers are targeting other stocks. The HSF provides guidance on the various considerations under such circumstances. These stocks are also typically subject to rebuilding strategies that articulate rebuilding targets and time frames, and place controls on catch.

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 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 of 48% of the unfished biomass ($0.48B_0$) 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 2018b) assessed across the SESSF in 2019 (Figure 8.2):

- 27 stocks (73%) were classified as not subject to overfishing
- 0 stocks (0%) were classified as subject to overfishing
- 10 stocks (27%) 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. No SESSF stock was subject to overfishing in 2019. However, 10 stocks were classified as uncertain for fishing mortality status in 2019, 7 of which were classified as overfished.

A stock is considered to be overfished where biomass (or its proxy) is estimated to be below the limit reference point. Typically, the limit reference point is set at the HSP proxy level of 20% of unfished levels ($0.2B_0$). The SESSF includes 7 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 2 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 2019 are blue warehou, eastern gemfish, gulper sharks, orange roughy southern and western, school shark and redfish. It is important to note that the change to an uncertain fishing mortality status for orange roughy in the southern and western zones in 2019 was not brought about through additional information or new data. It stemmed from the need to ensure consistency in the status applied to stocks that have no recent validation of biomass and therefore 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.

FIGURE 8.2 Fishing mortality status for all stocks assessed in the SESSF, 2004 to 2019

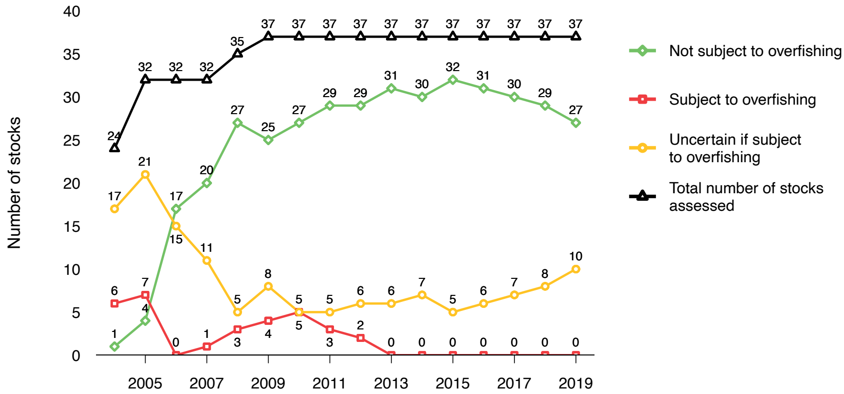
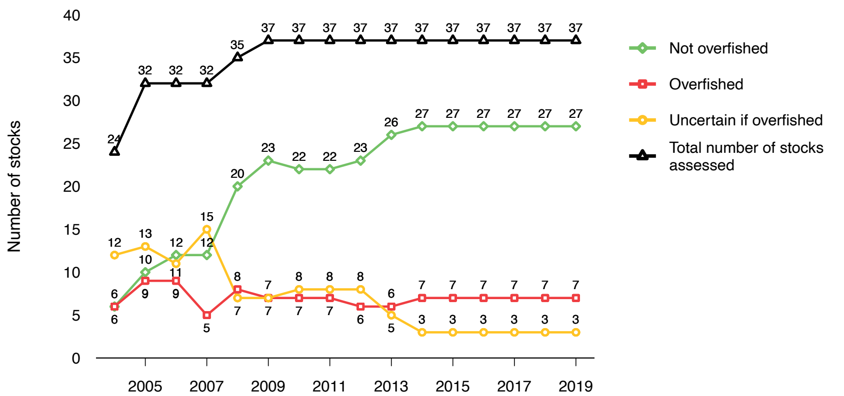


FIGURE 8.3 Biomass status for all stocks assessed in the SESSF, 2004 to 2019



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 57% of SESSF GVP in 2018–19 (Figure 8.4). These sectors are therefore key drivers of economic performance in the SESSF. Of these 2 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 peak at $7.8 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 declined in 2017–18 and 2018–19, by $5.0 million over the 2 years, to –$1.1 million. A negative NER indicates that the fishery is not covering the full economic cost of inputs, including an adequate economic return to capital and labour resources employed, and the full cost of management resources expended. The decline in NER in these years was driven by lower catch volume (affecting revenue), higher unit fuel prices and higher fishing effort, combining to increase costs.

The estimated biomass for 2 of the most valuable species within the CTS (blue grenadier and tiger flathead—*Neoplatycephalus richardsoni*), together contributing 38% of catch volume and 35% of GVP in 2018–19, 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).

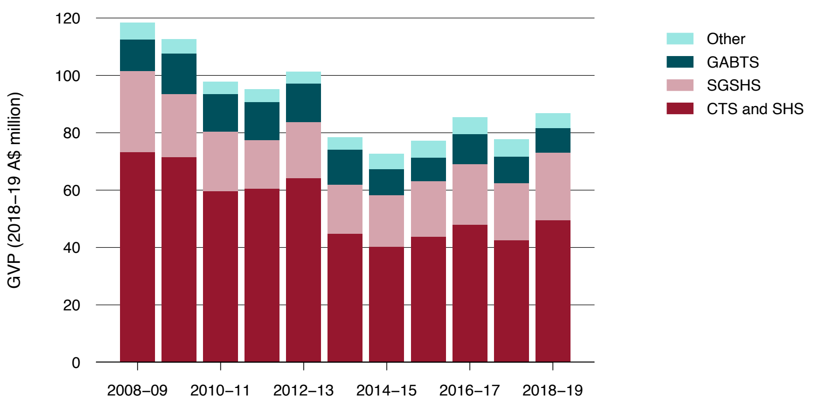
Historically, orange roughy has contributed substantially to GVP of the CTS. The rebuilding of orange roughy stocks over the longer term should improve the economic status of the sector, although sustainable catch levels are likely to be much lower than peak historical levels. The recommencement of fishing for orange roughy in the eastern zone boosted GVP from 2015–16 to 2018–19. Orange roughy has become a significant proportion of the catch volume and value of the CTS sector, accounting for 9% of volume caught and 17% of value in 2018–19. The blue grenadier catch remained substantially lower than the TAC between 2014–15 and 2018–19, 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 80% of GVP in the GHTS in 2018–19. 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, a species attributed to the CTS and the SHS. Preliminary estimates for 2018–19 indicate a recovery in NER to an estimated $5.6 million, which is the highest level since 2008–09, largely driven by a significant increase in fishing revenue from higher catch volumes and lower overall fishing costs. 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 most recent stock assessments for bight redfish (*Centroberyx gerrardi*) and deepwater flathead (*Platycephalus conatus*) (Chapter 11) indicate spawning biomass in 2020–21 for these species to be above the target reference point, with catch in recent seasons well below the RBC. This indicates potential for increased profits to be made if the stock is fished down to its MEY target reference point. 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.

FIGURE 8.4 Real GVP in the SESSF by sector, 2008–09 to 2018–19



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. 'Real' indicates that value has been adjusted for inflation. 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.

Overall, the economic status of the SESSF has been mixed in recent years. The deterioration 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, and non–survey based estimates indicate a significant improvement in NER for 2018–19. This change offsets an emerging negative trend in NER in the CTS in this period; meanwhile, the GABTS continues to pursue estimated B_{MEY} targets for its key species.

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

The Commonwealth Fisheries Bycatch Policy defines bycatch as species that are either taken in a fishery and returned to the sea, or killed or injured through interaction with fishing equipment in a fishery, but not taken (Department of Agriculture and Water Resources 2018a). The policy identifies 2 types of bycatch: general bycatch, and species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that are afforded a higher level of protection.

Tuck, Knuckey & Klaer (2013) evaluated bycatch and discards in 6 Commonwealth fisheries, including the SESSF, and concluded that trawling in the south-east CTS and the GABTS, and Danish-seining in the CTS 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 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. A study examining bycatch from different gear configurations in the Danish-seine sector confirmed that bycatch of smaller fish, notably small flathead and eastern school whiting (*Sillago flindersi)*, while targeting tiger flathead could be reduced by moving to a larger mesh size (Koopman et al. 2010). Industry, through the South East Trawl Fishing Industry Association (SETFIA), requested an increase in minimum mesh size in Danish-seine codends when fishing for flathead from 70 mm to 75 mm. This was implemented through changes to concession conditions for the start of the 2019–20 fishing season. 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.

Fishing in the SESSF can be broken into 2 categories: targeted fishing and general 'market fishing'. Bycatch (and therefore discarding) is minimal when target fishing (such as for orange roughy or blue grenadier); however, discards can be up to 50% of catch (by weight) in the market fishery of the CTS, 40–50% in the GABTS (Koopman et al. 2017; Tuck, Knuckey & Klaer 2013) and more than 30% of catch in the GHTS (Braccini, Walker & Gason 2009). Management measures were introduced in the 2014–15 season that require the release of live school shark. The post-release survival of live school shark (and other sharks in the sector) remains a key uncertainty and is expected to be a priority for research funding in coming years. The GHTS is subject to e-monitoring, with trials recently completed for the CTS (AFMA 2019b). The effect of increased levels of e-monitoring, particularly on protected species, is discussed further below.

Trawling impacts

Demersal trawling can cause significant physical disturbance to benthic habitats. The extent of disturbance typically depends on a range of factors, including gear design, the frequency of trawling and habitat type, and the biological characteristics of the organisms exposed to the gear (Hiddink et al. 2019; Kaiser 2019).

Pitcher et al. (2016, 2018) looked at trawl operations in the SESSF and estimated the swept area by habitat type for the CTS and the GABTS. They used various biophysical datasets to characterise 20 habitat assemblages for the CTS and 13 for the GABTS. They found that actual swept area is low relative to the full extent of areas where trawling is permissible, but that trawling activity is concentrated in certain locations and habitat assemblages.

Pitcher et al. (2016) estimated that 7.7% of the CTS is trawled annually (9.5% combined area over all years considered) and that 3.8% of the GABTS is trawled annually (4.9% over all years considered). Certain areas of the fishery (and therefore habitat assemblages) are targeted by repeated trawling (up to ~1.75 times per year in both that CTS and GABTS areas). Habitat characterisation for benthic assemblages is limited in south-east Australia, but the habitat assemblages in these fishing areas associated with the shelf edge are typically composed of habitat-forming benthos such as sponges, ascidians, stalked crinoids, bryozoans, black corals and octocorals (Pitcher et al. 2016; Ward et al. 2006; Williams et al. 2018).

Protected and conservation-dependent species

The SESSF interacts with various species listed as protected or conservation-dependent under the EPBC Act. Six species previously targeted 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 managed under stock rebuilding or recovery strategies. With the exception of Harrison's dogfish and southern dogfish (which are no-take species), these species are subject to incidental catch allowances to provide for incidental catch when fishers are targeting other species. Additional management arrangements include closed areas, gear restrictions and/or trip limits.

Interactions are known to occur with other 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 typically rare, they can have a significant impact on some species that have small populations (Komoroske & Lewison 2015).

Historically, it has been difficult to obtain robust estimates of interactions and/or interaction rates with listed species. (Komoroske & Lewison 2015; Martin, Stohs & Moore 2015). The introduction of e-monitoring 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 2 years of the program (Emery et al. 2019). Trials of e-monitoring have recently been completed in the CTS, with the final report pending at the time of drafting (AFMA 2019b).

In accordance with accreditation under the EPBC Act (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

Gillnet
Mike Gerner, AFMA

Pinnipeds (seals and sea lions)

The areas fished by sectors in the SESSF overlap with the distributions of the Australian fur seal (*Arctocephalus pusillus doriferus*), long-nosed fur seal (formerly New Zealand fur seal) (*A. forsteri*), Antarctic fur seal (*A. gazella*) and Australian sea lion (ASL) (*Neophoca cinerea*), all of which are protected under the EPBC Act. These seals were hunted extensively in the 18th and 19th centuries, resulting in substantial decreases in numbers.

The recovery of species, since hunting was discontinued in the 1920s and protections were put into place, has been mixed. Fur seal populations have largely recovered (Evans, Rogers & Goldsworthy 2017) to the point where key colonies of Australian fur seal, for example, are believed to have reached carrying capacity, although there was a ~4% reduction in pups from 2007 to 2013 (McIntosh et al. 2018). On the other hand, ASL numbers have not returned to pre-exploitation levels (DSEWPC 2013). Abundance in the Great Australian Bight (the broader area of the Great Australian Bight as distinct from the area of operation of the GABTS), where 93% of ASL are currently found, is understood to be decreasing (Evans, Rogers & Goldsworthy 2017). In the Great Australian Bight, numbers are understood to have declined by 76% over the past 38 years, resulting in the listing of this species as 'endangered' under International Union for Conservation of Nature criteria (Evans, Rogers & Goldsworthy 2017).

SETFIA promotes a code of conduct for responsible fishing, which follows an industry code of practice (2007) that aims to minimise interactions with pinnipeds and addresses the environmental impacts of the fishery more generally.

The SESSF operates under the Australian Sea Lion Management Strategy, implemented in 2010 (AFMA 2010). The strategy aims to monitor and minimise the impacts of interactions between Australian sea lions and gillnets used by Commonwealth shark fishers so as to enable breeding colonies of sea lions to recover. This strategy defines objectives and actions to be carried out within sea lion management areas (AFMA 2015a). A variety of education and fishing measures have been adopted, including closed areas around breeding colonies, 100% fishing monitoring through observers or e-monitoring, transitionary arrangements from gillnets to hooks, and trigger limits on interactions. As a result of these measures, interactions with sea lions have reduced from an estimated 300+ interactions per year, before 2010 (Goldsworthy et al. 2010), to 2 reported interactions (1 alive; 1 dead) in 2019. The reasons behind the continued decline in sea lion abundance are not clear.

In 2019, 234 pinniped interactions were reported in logbooks for the CTS (168) and GHTS (66): 2 with Australian sea lions (1 alive; 1 dead), 28 with New Zealand fur seals (5 alive; 23 dead), 133 with Australian fur seals (22 alive, 111 dead) and 71 with seals of unknown species (14 alive; 57 dead). This is a decrease from the 284 interactions reported in 2018. In the CTS, 80% of all pinniped interactions in 2019 were reported from bottom-trawling operations; 10% were reported from Danish-seine operations and 6% from midwater seine.

Dolphins and whales

All cetacean species are protected under the EPBC Act. Increased observer coverage in the SGSHS in 2011 highlighted interactions with dolphins and potential underreporting in logbooks. 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). This closure resulted in a reduction of approximately 80% of the total South Australian catch compared with the years preceding the closure (AFMA 2017). 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 e-monitoring and individual accountability. On 8 September 2015, AFMA reopened the dolphin gillnet closure to limited gillnet fishing, with 100% e-monitoring and individual vessel-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 e-monitoring in the GHTS from 1 July 2015 led to an increase in nominal reported interactions per unit effort for dolphins in the first 2 years of the program (Emery et al. 2019).

In September 2019, additional spatial management was introduced, which will require operators to cease fishing in a higher-risk area off South Australia (the South Australian Dolphin Zone) after only 1 review period if they cannot stay under the threshold interaction rate. The role of e-monitoring as a key monitoring tool was also increased at this time.

In 2019, 35 interactions (all dead) with dolphins were reported in the GHTS and 9 interactions (all dead) were reported in the CTS. Total dolphin interactions in 2019 (44) were down from the 60 interactions reported in 2018. Two interactions with killer whales (both alive) also occurred in the GHTS in 2019.

Seabirds

Seabirds are globally one of the most threatened of the bird groups, with many species showing declines in population (Gorta et al. 2019; Phillips et al. 2016). Many species exhibit long lives, delayed sexual maturity and low reproductive rates, which can result in low resilience and slow population recovery from predation and mortality (Dias et al. 2019; Phillips et al. 2016). Seabird populations are particularly affected by invasive alien species and predators, fishing, disease, and climate change, which have resulted in substantial decreases in abundance of seabirds globally (Dias et al. 2019; DSEWPC 2011); this is also the case for those found in south-eastern Australia (Gorta et al. 2019).

The SESSF interacts with a variety of seabird species, all of which are protected under the EPBC Act. In particular, seabirds are vulnerable to injury from being hooked when setting longline gear, or struck or trapped by otter trawl gear. To mitigate the risk of interactions, fishers in the SESSF are required to use seabird mitigation devices such as tori lines, sprayers, bafflers and warp deflectors ('pinkies'). The combination of these mitigation devices has reduced interactions by ~90% (Koopman et al. 2018). Seabird management plans are compulsory for all otter trawl boats in the CTS and the GABTS, and automatic longline boats in the GHTS. These plans detail boat-specific approaches to implementing seabird mitigation, including physical mitigation and handling of biological material.

To further reduce seabird interaction with otter trawl boats, AFMA has introduced additional conditions such that otter trawl boats in the CTS must not discharge biological material when fishing gear is deployed south of 38°S unless an exemption has been provided based on proven and effective mitigation. Industry is developing new and improved approaches to mitigating the risk of seabirds interacting with trawl gear, with a number of exemptions already approved (AFMA, pers. comm., 2020).

SESSF fishers follow the *Seabird bycatch operational guidelines for Commonwealth fisheries* (AFMA 2018a), which assists fishers with following government policies and legislation relating to seabirds, and provides a consistent approach to minimising or avoiding seabird interactions. In addition, SESSF longline fishers follow the Threat Abatement Plan for the Incidental Catch (or Bycatch) of Seabirds During Oceanic Longline Fishing Operations (2018), which binds the Commonwealth and its agencies in responding to the impact of longline fishing activities on seabirds, and identifies the research, management and other actions needed to reduce the impacts of this key threatening process on affected seabird populations. In accordance with the threat abatement plan, SESSF longline operators are required, for example, to maintain minimum levels of observer or e-monitoring coverage and keep interaction rates below 0.01 interactions per 1,000 hooks set.

Seabird interactions are typically underreported 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 a visible injury after interactions such as warp strikes.

During 2019, 98 seabird interactions were reported: 39 in the GHTS and 59 in the CTS. This is a decrease from 161 seabird interactions reported in 2018. Of the 98 interactions, 3 were reported as unclassified petrels, prions and shearwaters, all of which were alive; 3 were with white-chinned petrels (*Procellaria aequinoctialis*), 2 of which were dead; 6 were with shy albatross (*Thalassarche cauta*), 3 of which were dead; 59 were with unclassified albatrosses, 46 of which were dead and 1 injured; 2 were with unclassified cormorants, both of which were dead; 8 were with unclassified shearwaters, 4 of which were dead; 10 were with unclassified birds, 4 of which were dead; and 2 were with little penguins (*Eudyptula minor*), both of which were dead. The type of seabird for 5 interactions was not reported.

Sharks

Three shark species relevant to the SESSF are listed under the EPBC Act as conservation-dependent: school shark (effective January 2009), Harrisson's dogfish (effective June 2013) and southern dogfish (effective June 2013). All 3 species have been assessed as overfished since their first inclusion in the *Fishery status reports*. School shark is subject to a rebuilding strategy (AFMA 2015b) that articulates a 66-year rebuilding time frame for the stock to the limit reference point ($0.20B_0$). The 2 gulper shark species are subject to a management strategy that notes that the time to rebuild to the limit reference point ($0.25B_0$) is expected to be around 62 years for southern dogfish and around 86 years for Harrisson's dogfish (AFMA 2012). Measures in the 2 strategies to facilitate rebuilding are discussed in the respective chapters (Chapter 12 for school shark, and Chapter 9 for gulper sharks).

Other non-commercial shark species, listed under the EPBC Act, are caught or interacted with in SESSF fisheries. These are the mako sharks (short and long-finned), grey nurse shark, scalloped hammerhead shark (*Sphyrna lewini*) and white shark. Interactions with these species must be reported annually. The EPBC Act also requires all white sharks and grey nurse sharks to be released alive, if possible.

In 2019, 136 interactions with protected sharks were reported in logbooks: 134 in the GHTS (102 of which were dead) and 2 in the CTS (1 dead). Most interactions (92) were with shortfin mako sharks and 16 were with white sharks (12 alive). No interactions with grey nurse sharks were recorded.

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 2019 in the SESSF.

Trawl catch
Gavin Kewan, AFMA

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Chapter 9

Commonwealth Trawl and Scalefish Hook sectors

T Emery, N Marton, J Woodhams and R Curtotti

FIGURE 9.1 Fishing intensity in the Commonwealth Trawl Sector for (a) otter board trawl and (b) Danish-seine, 2019–20 fishing season

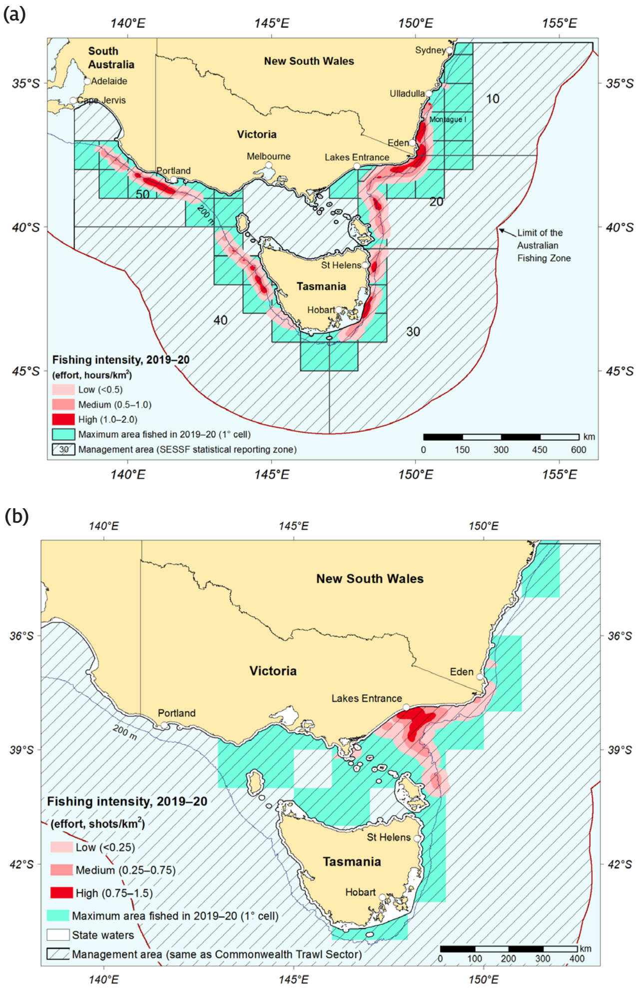
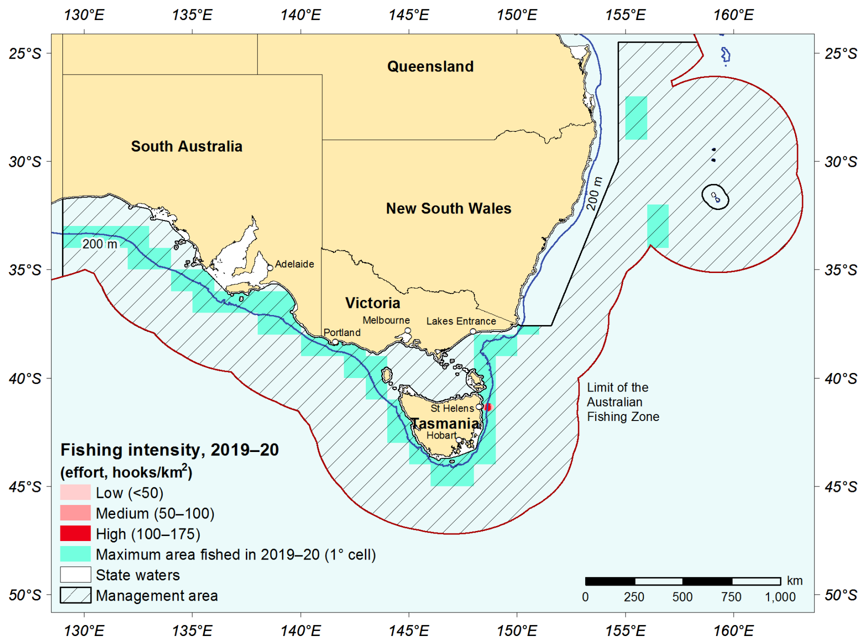


FIGURE 9.2 Fishing intensity in the Scalefish Hook Sector, 2019–20 fishing season



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

Redfish
Tamre Sarhan, AFMA

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors

Stock	Biological status				Comments
	2018		2019		
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Blue-eye trevalla (*Hyperoglyphe antarctica*)					Fishing mortality is below the most recent RBC. CPUE for the slope population is above the limit reference point and catches on seamounts are below the level expected to ensure depletion levels remain stable.
Blue grenadier (*Macruronus novaezelandiae*)					Fishing mortality is below the most recent RBC. Estimated spawning biomass is above the target reference point.
Blue warehou (*Seriolella brama*)					There are no reliable indicators to determine whether current fishing mortality will allow stock to rebuild within the specified time frame. Estimated spawning biomass is below the limit reference point.
Deepwater sharks, eastern zone (multiple species)					There are no reliable indicators to determine whether current fishing mortality is sustainable. Multispecies nature of stock makes CPUE unreliable as the index of abundance.
Deepwater sharks, western zone (multiple species)					There are no reliable indicators to determine whether current fishing mortality is sustainable. Multispecies nature of stock makes CPUE unreliable as the index of abundance.
Eastern school whiting (*Sillago flindersi*)					Fishing mortality is above the most recent RBC, but projections indicate spawning biomass is not at risk of further decline toward the limit reference point. Estimated spawning biomass is above the limit reference point.
Flathead (*Neoplatycephalus richardsoni* and 4 other species)					Fishing mortality is below the most recent RBC. Estimated spawning biomass is above the limit reference point.
Gemfish, eastern zone (*Rexea solandri*)					There are no reliable indicators to determine whether current fishing mortality will allow stock to rebuild within the specified time frame. Estimated spawning biomass is below the limit reference point.

continued ...

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

Stock	Biological status				Comments
	2018		2019		
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Gemfish, western zone (*Rexea solandri*)					Fishing mortality has remained low and the recent indication of biomass suggests that it is unlikely to deplete stock below the limit reference point. CPUE-based proxy for biomass is above the target reference point.
Gulper sharks (*Centrophorus harrissoni, C. moluccensis, C. zeehaani*)					There are no reliable indicators to determine whether current fishing mortality will allow stock to rebuild despite protection from closures. Estimated spawning biomass is below the limit reference point.
Jackass morwong (*Nemadactylus macropterus*)					Fishing mortality is below the most recent RBC in both the east and west. Estimated spawning biomass is above the limit reference point (east) and above the target reference point (west).
John dory (*Zeus faber*)					Fishing mortality is below the most recent RBC. Estimated fishing mortality has been below the target fishing mortality reference point for some time.
Mirror dory (*Zenopsis nebulosa*)					Fishing mortality is below the most recent RBC. CPUE-based proxy for biomass is above the limit reference point for both east and west management units.
Ocean jacket (*Nelusetta ayraud*)					History of stable CPUE, increasing in recent years.
Ocean perch (*Helicolenus barathri, H. percoides*)					Fishing mortality is estimated to be below the most recent RBC for both species. CPUE-based proxy for biomass is above the target reference point for both species.
Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)					Fishing mortality is below the long-term historical RBC. Estimated historical spawning biomass is above the target reference point.

continued ...

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

Stock	Biological status				Comments
	2018		2019		
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Orange roughy, eastern zone (*Hoplostethus atlanticus*)					Fishing mortality is below the most recent RBC. Estimated spawning biomass is above the limit reference point.
Orange roughy, southern zone (*Hoplostethus atlanticus*)					There are no reliable indicators to determine whether current fishing mortality will allow stock to rebuild. Estimated historical spawning biomass is below the limit reference point.
Orange roughy, western zone (*Hoplostethus atlanticus*)					There are no reliable indicators to determine whether current fishing mortality will allow stock to rebuild. Estimated historical spawning biomass is below the limit reference point.
Smooth oreodory, Cascade Plateau (*Pseudocyttus maculatus*)					Fishing mortality on the Cascade Plateau was zero. Fishing mortality outside Cascade Plateau was below the RBC. Estimated historical spawning biomass is above the target reference point.
Smooth oreodory, non–Cascade Plateau (*Pseudocyttus maculatus*)					Fishing mortality is below the most recent RBC. Further protection is provided by closure of most areas deeper than 700 m. Spawning biomass is considered to be at the target reference point.
Other oreodories (*Allocyttus niger, Neocyttus rhomboidalis, A. verrucosus, Neocyttus* spp.)					Fishing mortality is above the most recent RBC but there are uncertainties in the reliability of the discard estimate and CPUE series used to derive the RBC. CPUE-based proxy for biomass is above the limit reference point.
Pink ling (*Genypterus blacodes*)					Fishing mortality is below the most recent RBC in both the east and west. Estimated spawning biomass is above the limit reference point (east) and above the target reference point (west).

continued ...

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

Biological status					
Stock	**2018**		**2019**		**Comments**
	Fishing mortality	**Biomass**	**Fishing mortality**	**Biomass**	
Redfish (*Centroberyx affinis*)					There are no reliable indicators to determine whether current fishing mortality will allow stock to rebuild within the specified time frame. Estimated spawning biomass is below the limit reference point.
Ribaldo (*Mora moro*)					Fishing mortality is below the most recent RBC. CPUE-based proxy for biomass is above the target reference point.
Royal red prawn (*Haliporoides sibogae*)					Fishing mortality is below the most recent RBC. CPUE-based proxy for biomass is above the target reference point.
Silver trevally (*Pseudocaranx georgianus*)					Fishing mortality is below the most recent RBC. CPUE-based proxy for biomass is above the limit reference point.
Silver warehou (*Seriolella punctata*)					Fishing mortality is below the most recent RBC. Estimated spawning biomass is above the limit reference point.

Economic status

NER in the CTS rose to $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 and –$1.07 million in 2018–19. These negative results are 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

9.1 Description of the fishery

Area fished

The Commonwealth Trawl Sector (CTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF) extends south from Fraser Island off Queensland to east of Kangaroo Island off South Australia. The Scalefish Hook Sector (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 SHS extends around south-eastern Australia to the border of South Australia and Western Australia (Figure 9.2). The CTS and the SHS are major domestic sources of fresh fish for the Sydney and Melbourne markets. In contrast to several other Commonwealth fisheries, CTS and SHS landings are rarely exported to overseas markets.

Many CTS and SHS stocks extend across Commonwealth and state waters. Offshore Constitutional Settlement (OCS) arrangements allow the Australian, state and Northern Territory governments to reach agreement on jurisdictional arrangements for fish species. Under OCS arrangements, some states have passed management of SESSF quota-managed species inside 3 nautical miles (nm) from the coastline (coastal waters) to the Commonwealth; outside coastal waters, the Commonwealth has passed management of some SESSF quota-managed species to the states. In general, catches of SESSF quota species by Commonwealth-endorsed vessels across all waters are debited against their SESSF total allowable catch (TAC) limits.

However, New South Wales has retained jurisdiction for all species and methods inside coastal waters. North of Barrenjoey Head, under OCS arrangements, New South Wales has jurisdiction out to about 80 nm for SESSF quota species taken by all methods except purse seining and pelagic longlining (which are not SESSF methods). South of this location, the Commonwealth has retained jurisdiction over SESSF species that are taken by trawl or Danish-seining, whereas New South Wales has jurisdiction for these species out to about 80 nm if taken by other SESSF methods. An additional OCS arrangement that could transfer jurisdiction to the Commonwealth for SESSF species taken by fish trawl methods inside coastal waters south of Barrenjoey Head is under discussion with New South Wales.

Fishing methods and key species

The CTS and the SHS are multigear and multispecies fisheries, targeting a variety of fish and shark species. 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.

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 uses a variety of longline and dropline hook fishing methods, some of which are automated. The primary difference between manual longline and automatic longline is that the hooks are baited by a machine rather than by hand when using automatic longline.

Management arrangements

The CTS and the SHS operated under the SESSF harvest strategy framework (HSF) (AFMA 2019a) and the *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* in the 2019–20 fishing season (see Chapter 8). Stocks in both the CTS and the SHS are managed under TACs and individual transferable quotas (ITQs) for commercial species with TACs 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. A formal 'decision tree' approach (previously 'break-out rules') is in place to review stocks under MYTACs each year to allow for management intervention if indicators of stock size or stock response to fishing deviate from predicted trends (AFMA 2018d). A total of 22,757 t of quota was available across the stocks assessed in this chapter for the 2019–20 fishing season (1 May 2019 to 30 April 2020). This was an increase of 3,711 t from 2018–19 (Table 9.2). A small proportion of this quota (359 t) was allocated as 'incidental catch allowances' to allow unintentional catches of overfished stocks: 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 increase between 2018–19 and 2019–20 resulted from increased TACs for blue grenadier (*Macruronus novaezelandiae*; +3,373 t), john dory (*Zeus faber*; +132 t) and orange roughy—eastern zone (+202 t). These increases were partially offset by TAC decreases for silver warehou (*Seriolella punctata*; –150 t) and mirror dory (*Zenopsis nebulosa*; –65 t).

Fishing effort

In 2019–20, otter board trawlers reported 52,510 hours of fishing effort—a slight decrease from 54,550 hours in 2018–19 (Figure 9.3; Table 9.2). The number of active trawlers declined slightly from 32 in 2018–19 to 30 in 2019–20 (Table 9.2). Danish-seine effort slightly increased from 10,449 shots in 2018–19 to 10,895 shots in 2019–20, while the number of vessels declined from 20 in 2018–19 to 19 in 2019–20. Fishing effort in the SHS increased from 3.7 million hooks in 2018–19 to 3.9 million hooks in 2019–20 (Figure 9.4; Table 9.2).

Catch

Total landed catch (from catch disposal records [CDRs]) for quota stocks and non-quota stocks (gulper shark—*Centrophorus* spp., and ocean jacket—*Nelusetta* spp.) for both sectors (CTS and SHS) was 13,084 t in the 2019–20 fishing season, which was the largest reported catch since 2008. The total landings of stocks under quota in the CTS in the 2019–20 fishing season were 12,346 t, which was a considerable increase from the 7,574 t landed in the 2018–19 fishing season, and was the largest catch reported from this sector since 2006. The total landings of stocks under quota in the SHS in the 2019–20 fishing season were 564 t, which was a decrease from the 740 t landed in the 2018–19 fishing season and the lowest catch reported from this sector since CDRs were introduced.

1 The orange roughy southern zone TAC contains both 'incidental' catch allowance and 'target' quota because quota is apportioned in accordance with the orange roughy eastern zone stock assessment. Orange roughy from Pedra Branca in the southern zone is included as part of the assessed eastern stock.

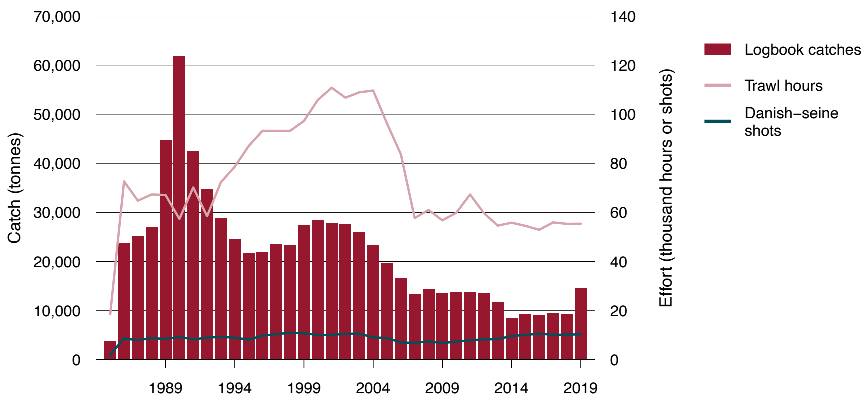
The main species landed in the 2019–20 fishing season in the CTS included blue grenadier (7,037 t), flathead (tiger flathead—*Neoplatycephalus richardsoni*; 1,952 t), orange roughy—eastern zone (619 t), pink ling (*Genypterus blacodes;* 576 t) and eastern school whiting (*Sillago flindersi;* 526 t). In the CTS, the landings of blue grenadier were the highest since the early 2000s. The main species landed in the 2019–20 fishing season in the SHS included pink ling (259 t), blue-eye trevalla (*Hyperoglyphe antarctica;* 200 t) and ribaldo (*Mora moro;* 58 t). In the SHS, the landings of blue-eye trevalla were the lowest since the introduction of CDRs.

The term 'landed catch' refers to catch that is reported at port in CDRs; it excludes discards. Data on discards are collected for the SESSF as part of the Integrated Scientific Monitoring Program, and data on state catches are provided by jurisdictions. Discards and state catch data collected over the previous 4 years are converted into a weighted average to estimate total state catch and discards for the calendar year (see table 41 in Burch, Althaus & Thomson 2019). AFMA use this 4-year weighted average when determining a TAC from the recommended biological catch (RBC) in the SESSF (AFMA 2017b) and, for consistency, the same estimates are included when reporting on stock status. A higher weighting is applied to the most recent year—the ratio used is 8:4:2:1 (Burch, Althaus & Thomson 2019).

Information on gross value of production (GVP) for the 2019–20 season was not available at the time of publication. During 2018–19, scalefish catches in the CTS and the SHS combined accounted for 57% of the GVP of the SESSF. Scalefish GVP in the CTS increased by 13%, from $37.09 million in 2017–18 to $41.96 million in 2018–19. The GVP in the SHS increased by 57%, from $4.78 million in 2017–18 to $7.51 million in 2018–19. Overall, the total scalefish GVP in 2018–19 for both sectors was $42.93 million (Table 9.2).

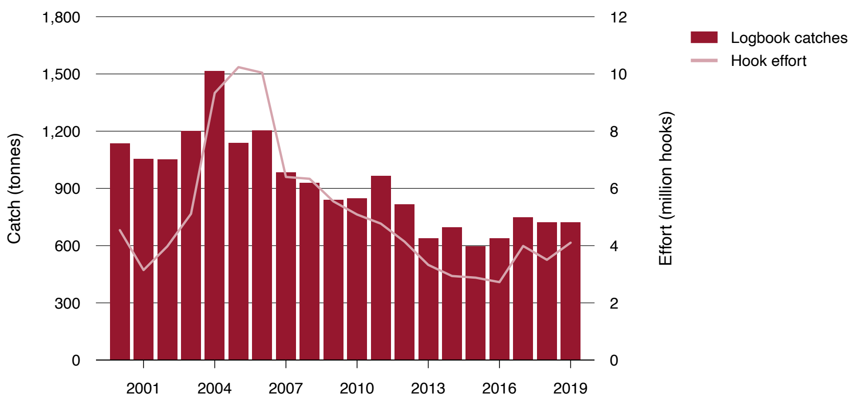
Flathead (tiger flathead and other flathead species) contributed $13.16 million to GVP in 2018–19, the most of any scalefish (Table 9.2); this was a decrease of 17% from $15.78 million in 2017–18. The value of orange roughy (eastern zone) more than tripled, to $7.15 million in 2018–19. The value of pink ling increased by 26% in 2018–19 to $6.38 million. The value of blue-eye trevalla (largely caught in the SHS) increased by 58% in 2018–19 to $4.65 million. Blue grenadier accounted for $4.55 million in 2018–19, which was 63% higher than in 2017–18 ($2.80 million).

FIGURE 9.3 Total catch and fishing effort for the CTS, 1985 to 2019



Source: AFMA logbook records

FIGURE 9.4 Total catch and fishing effort for the SHS, 2000 to 2019



Source: AFMA logbook records

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

Fishery statistics b	2018–19 fishing season			2019–20 fishing season	
Stock	TAC (t) c	Catch (t) (CTS, SHS)	GVP (2018–19)	TAC (t) c	Catch (t) (CTS, SHS)
Blue-eye trevalla	462	373.6 (31.3, 342.3)	$4.65 million	458	215.5 (15.5, 200.0)
Blue grenadier	8,810	1,808 (1,804, 4)	$4.55 million	12,183	7,044.5 (7,037.4, 7.1)
Blue warehou	118	54.2 (54.2, <1)	$0.17 million	118 d	10.1 (9.6, <1.0)
Deepwater sharks, eastern zone	23	19.8 (19, 0.8)	na	24	20.9 (20.2, <1.0)
Deepwater sharks, western zone	264	78.7 (78, 0.7)	na	235	85.2 (84.2, 1.0)
Eastern school whiting	820	537 (537.1, 0)	$1.37 million	788	526.0 (525.9, <1.0)
Flathead (tiger flathead and several other species)	2,507	2,036 (2,034.9, 0.9)	$13.16 million	2,468	1,955.4 (1,951.7, 3.7)
Gemfish, eastern zone	100	39.1 (33.8, 5.3)	$0.09 million	100 d	70.0 (61.9, 8.1)
Gemfish, western zone e	200	78.5 (78.5, <1)	$0.21 million	200	96.2 (95.8, <1.0)
Jackass morwong	505	186 (183.9, 2.3)	$0.64 million	469	109.1 (107.1, 2.0)
John dory	263	61.8 (61.8, <1)	$0.50 million	395	68.3 (68.1, <1.0)
Mirror dory	253	117.5 (117.5, <1)	$0.37 million	188	116.6 (116.6, <1.0)
Ocean perch	241	195 (168.7, 26.3)	$0.43 million	241	169.1 (148.7, 20.4)
Orange roughy, Cascade Plateau	500	0	0	500	23.6 (23.6, 0)
Orange roughy, eastern zone	698	855.8	$7.15 million	900	618.5 (618.5, 0)
Orange roughy, southern zone	84 f	78.5	$0.69 million	94 f	91.1 (91.1, 0)
Orange roughy, western zone	60	19	$0.21 million	60 d	24.0 (24.0, 0)
Smooth oreodory, Cascade Plateau	150	0	0	150	0
Smooth oreodory, non–Cascade Plateau	90	80.8	$0.33 million	90	75.5 (75.5, 0)
Other oreodories	185	163 (161.3, 1.7)	$0.35 million	185	169.7 (168.3, 1.4)
Pink ling	1,117	952 (645.5, 306.9)	$6.38 million	1,288	834.8 (575.9, 258.9)
Redfish	100	30.8 (30.8, <1)	$0.11 million	50 d	29.4 (29.2, <1)
Ribaldo	430	107.3 (60, 47.3)	$0.25 million	422	128.6 (70.4, 58.2)
Royal red prawn	381	147 (147, 0)	$0.56 million	409	163.8 (163.8, 0)
Silver trevally	307	8.3 (8.3, <1)	$0.01 million	292	21.0 (20.9, <1)
Silver warehou	600	352 (352, <1)	$0.37 million	450	306.5 (306.4, <1)

continued ...

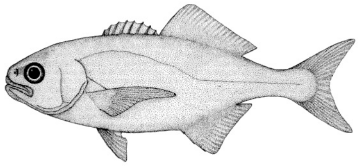
TABLE 9.2 Main features and statistics for the CTS and the SHS [a] continued

Fishery statistics [b]	2018–19 fishing season			2019–20 fishing season	
Non-quota species	**TAC (t) [c]**	**Catch (t) (CTS, SHS)**	**GVP (2018–19)**	**TAC (t) [c]**	**Catch (t) (CTS, SHS)**
Gulper sharks	na	0.38 (0.38, 0)	$0.06 million	na	<1 (<1, 0)
Ocean jacket	na	140 [g]	$0.32 million	na	173.6 (172.9, <1)
Total fishery	**19,268**	**8,454**	**$49.47 million**	**22,757**	**13,148**
Fishery-level statistics					
Effort Otter trawl Danish-seine Scalefish hook	 54,550 trawl-hours 10,449 shots 3.733 million hooks			 52,510 trawl-hours 10,895 shots 3.890 million hooks	
Boat statutory fishing rights	57 trawl; 37 scalefish hook			57 trawl; 37 scalefish hook	
Active vessels	32 trawl; 20 Danish-seine; 21 scalefish hook			30 trawl; 19 Danish-seine; 24 scalefish hook	
At-sea observer coverage CTS Auto-longline (scalefish)	 Trawl: 193 fishing days Danish-seine: 27 fishing days 26 sea-days			 Trawl: 277 fishing days Danish-seine: 24 fishing days 5 sea-days	
Fishing methods	Otter 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 Scalefish Hook Sector is managed as part of the GHTS. **b** Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 May to 30 April. Value statistics are provided by financial year and were not available for the 2019–20 financial year at the time of publication. **c** TACs shown are the 'agreed' TACs. These may differ from 'actual' TACs, which may include undercatch or 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 63 t of target quota, resulting from apportioning quota from the orange roughy eastern zone stock to the Pedra Branca area, which is part of the southern zone but included in the eastern zone assessment. **g** Catch figures are combined for the trawl and non-trawl sectors.
Notes: **CTS** Commonwealth Trawl Sector. **GHTS** Gillnet, Hook and Trap Sector. **ITQ** Individual transferable quota. **na** Not available. **SHS** Scalefish Hook Sector. **TAC** Total allowable catch.

9.2 Biological status

Blue-eye trevalla (*Hyperoglyphe antarctica*)



Line drawing: FAO

Stock structure

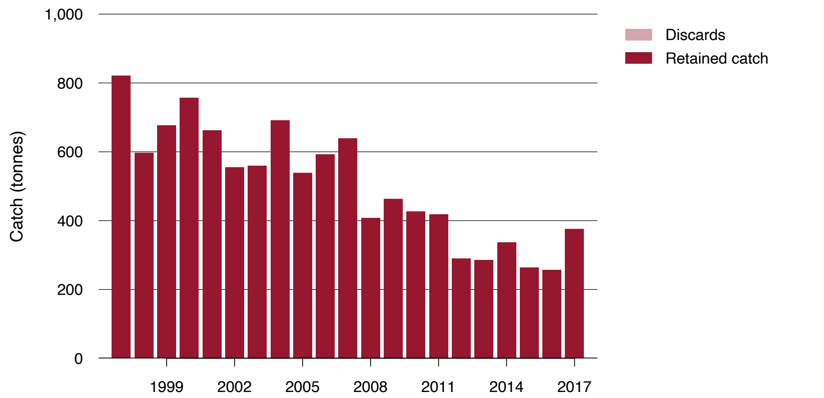
Blue-eye trevalla is managed as a single biological stock in the SESSF; however, stock structuring has been reported based on phenotypic variation in age and growth, otolith chemistry and potential larval dispersal between regions around south-eastern Australia (Williams et al. 2017). Four geographically distinct subpopulations have been proposed in the SESSF, with 3 in the CTS. These 3 subpopulations are interconnected through regional exchange of larvae (Williams et al. 2017). The results of the study by Williams et al. (2017) led to separate RBCs being determined for the slope and seamount stocks, but a global TAC applied (AFMA 2018c) and catch restrictions introduced for the seamount stock for the 2019–20 fishing season.

Catch history

Blue-eye trevalla catch peaked at more than 800 t in 1997 and has generally declined since then (Figure 9.5a). Commonwealth-landed catch in 2019–20 was 215.5 t, based on CDRs (Figure 9.5b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 0.1 t and 27.4 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 243.0 t.

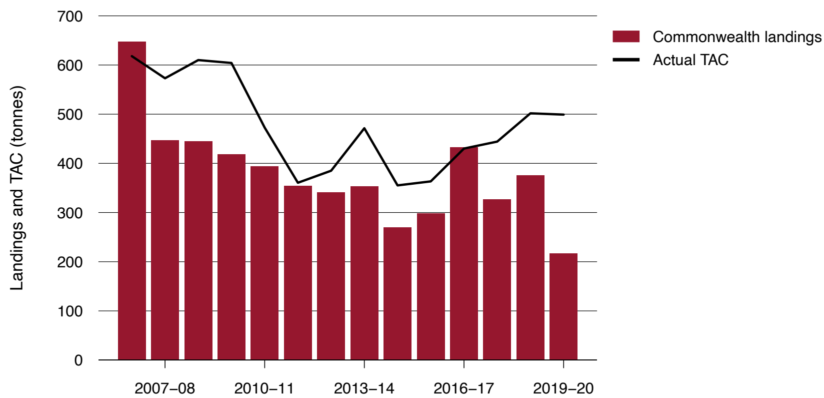
Blue-eye trevalla
Tamre Sarhan, AFMA

FIGURE 9.5a Blue-eye trevalla annual annual catches (CTS, SHS and states) and discards, 1997 to 2017



Source: Sporcic 2018

FIGURE 9.5b Blue-eye trevalla seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Blue-eye trevalla in Commonwealth fisheries is managed as a tier 4 and 5 stock under the SESSF HSF (AFMA 2019a). Analyses by Sporcic (2018) and Haddon and Sporcic (2018a, b) informed the management of the stock for the 2019–20 fishing season.

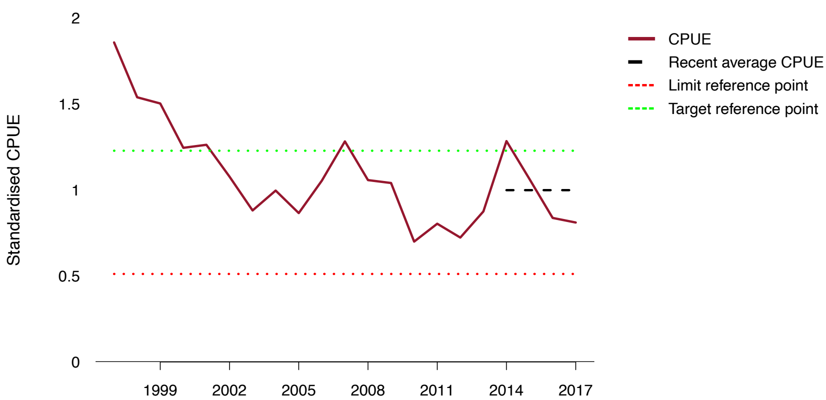
Based on the recent evidence of stock structuring (Williams et al. 2017), the 2018 analysis split the stock into 2 regions (slope and seamount populations) for the first time, with each analysed separately to inform the determination of an RBC for the 2019–20 fishing season. A tier 4 analysis was completed for the slope stock and a tier 5 analysis for the seamount stock (due to unreliable catch-per-unit-effort [CPUE] data) (AFMA 2018b).

The tier 4 slope analysis (Sporcic 2018) suggested that the previous steep decline in CPUE (2013 to 2016) had levelled out and remained between the target and limit reference points as defined by the SESSF HSF (AFMA 2017a). As previously noted by Haddon (2016) this analysis 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 by Haddon (2016) did not detect large effects on CPUE due to the closures, but uncertainty remains about the effect of killer whale depredation on CPUE.

The tier 5 age-structured stock reduction analysis of 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 (Haddon & Sporcic 2018b). Although highly uncertain, a maximum sustainable yield (MSY) analysis of the seamount catch generated an MSY of about 46–50 t, with a depletion estimate of about 33% of the unfished biomass ($0.33B_0$) (Haddon & Sporcic 2018a). It was predicted, based on the catch MSY, that constant catches of 40 t or less would lead to relative stability in depletion (AFMA 2018c, d).

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. The South East Resource Assessment Group (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 2018c, d).

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



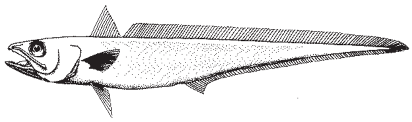
Note: **CPUE** Catch-per-unit-effort.
Source: Sporcic 2018

Stock status determination

The 2018 analyses (Haddon & Sporcic 2018a, b; Sporcic 2018) estimated that the recent average standardised CPUE was between the target and limit reference points for the slope stock and that constant catches of 40 t or less would see biomass maintained at around $0.33B_0$ for the seamount stock. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 243.0 t, which is below the combined RBC of 475 t. This indicates that the fishing mortality in 2019–20 would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Blue grenadier (*Macruronus novaezelandiae*)



Line drawing: Rosalind Poole

Stock structure

Blue grenadier is assessed as a single stock. There are 2 discernible subfisheries: the localised winter spawning fishery off western Tasmania and the widespread activities of the non-spawning fishery.

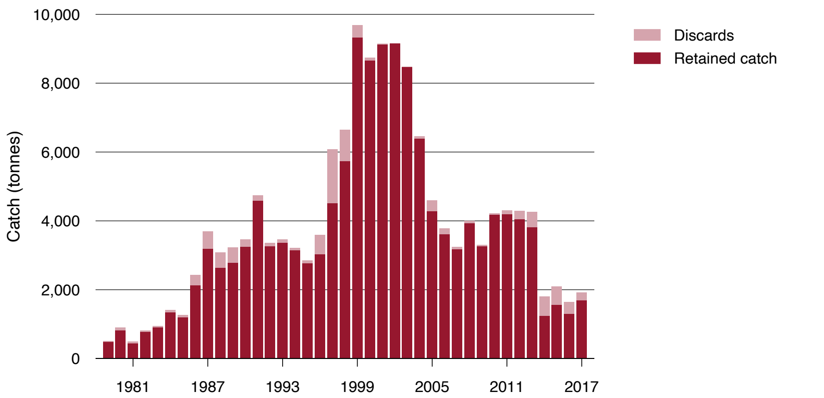
A stock structure study using otolith chemistry and otolith shape (Hamer et al. 2009) has proposed that more than 1 stock of blue grenadier is fished in the SESSF. Specifically, the otolith indicators provided support for separate stocks of blue grenadier being fished by the Great Australian Bight Trawl Sector (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 1 highly mixed south-eastern Australian stock. However, this stock structure hypothesis has not been incorporated into management.

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 around 8,000 t from 1999 to 2003 (Figure 9.7a). Catches since then have varied in response to changes in the TAC and the influence of market conditions, with a large increase in the 2019–20 fishing season.

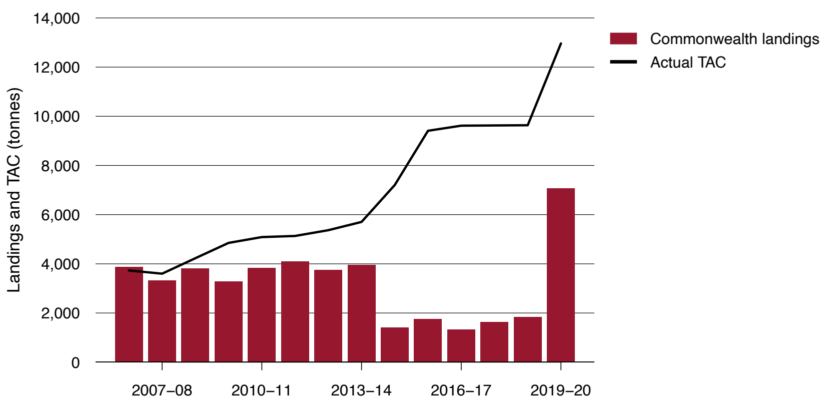
Commonwealth-landed catch in 2019–20 was 7044.5 t, based on CDRs (Figure 9.7b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 540.1 t and 0.1 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 7,584.7 t.

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



Source: Castillo-Jordán & Tuck 2018

FIGURE 9.7b Blue grenadier seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



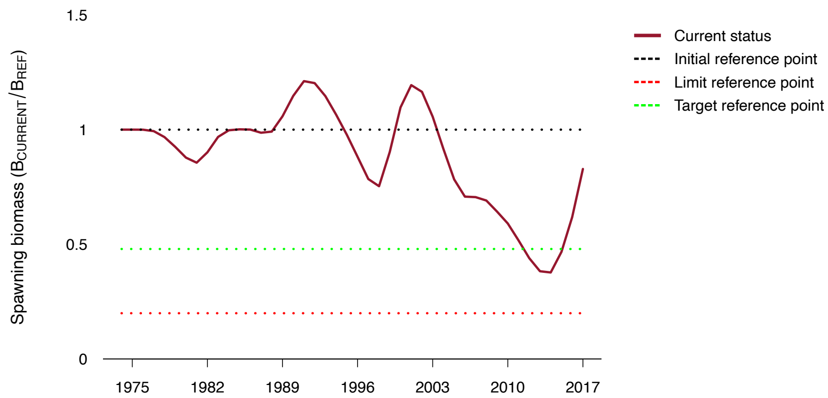
Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Blue grenadier in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a).

The 2018 assessment (Castillo-Jordán & Tuck 2018) informed the management of the stock for the 2019–20 fishing season. It estimated the spawning stock biomass at the start of 2018 to be 83% (or $0.83SB_0$), which was above the target reference point of 48% ($0.48SB_0$). The biomass was estimated to have increased in recent years because of above-average recruitment between 2010 and 2014. This led to an RBC of 13,260 t and a 3-year-average RBC of 12,183 t. AFMA recommended using the 3-year-average RBC to set the first of a 3-year TAC for the 2019–20 fishing season.

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



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

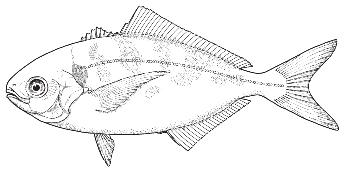
Stock status determination

Since the 2018 spawning stock biomass estimate of 83% of the unfished level ($0.83SB_0$) was above the target reference point of $0.48SB_0$, the stock is classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 7,584.7 t, which is below the 3-year-average RBC of 12,183 t calculated in the 2018 assessment (Castillo-Jordán & Tuck 2018). This indicates that the fishing mortality in 2019–20 would be unlikely to deplete the stock to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Blue grenadier
Heesham Garroun, AFMA

Blue warehou (*Seriolella brama*)



Line drawing: Rosalind Poole

Stock structure

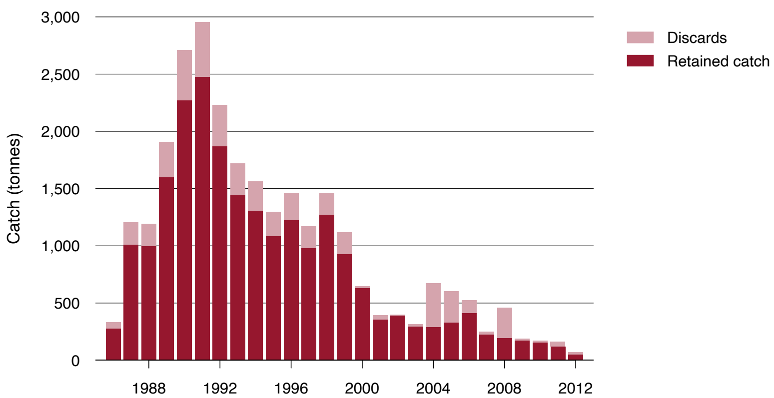
Blue warehou is assumed to have separate eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks (Morison et al. 2013). Although these stocks are assessed separately, status is reported for a combined stock, reflecting the unit of management.

Catch history

Landings of blue warehou peaked in 1991 at 2,478 t before declining to less than 500 t in the first half of the 2000s (Figure 9.9a). Blue warehou was classified as overfished in 2008, and a rebuilding strategy that established blue warehou as an incidental catch-only species was implemented in the same year. The TAC decreased from 365 t in 2008–09 to 183 t in both 2009–10 and 2010–11. The TAC has fallen less abruptly since then—being 133 t in 2011–12 and 118 t since 2012–13. This has seen landings reduce to 2 t in 2015–16 before increasing slightly in recent years.

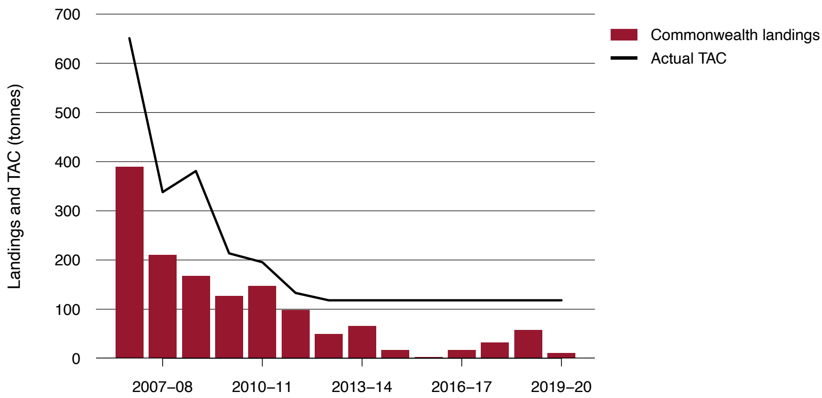
Commonwealth-landed catch in 2019–20 was 10.1 t, based on CDRs (Figure 9.9b). Based on logbook data, around 29% of the catch was from the east and 71% from the west. Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 83.2 t and 7.5 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 100.8 t.

FIGURE 9.9a Blue warehou annual catches (CTS, SHS and states) and discards, 1986 to 2012



Source: Haddon 2013

FIGURE 9.9b Blue warehou seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

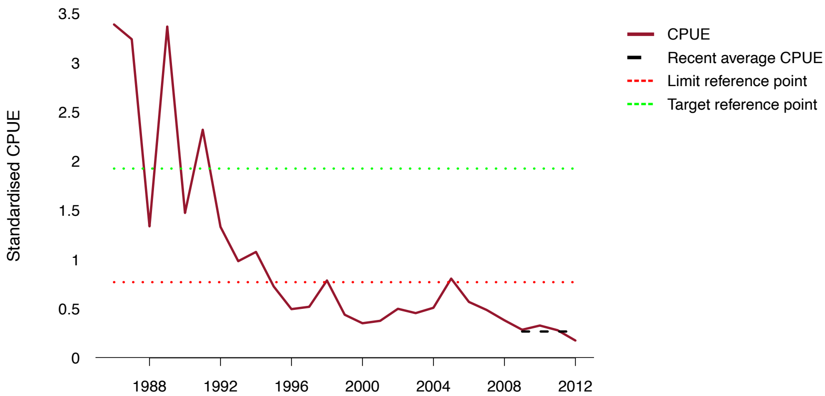
Blue warehou in Commonwealth fisheries was managed as a tier 4 stock under the SESSF HSF (AFMA 2019a), but is currently managed under a rebuilding strategy (AFMA 2014a) with an incidental catch allowance of 118 t.

The last tier 4 assessment, in 2013 (Haddon 2013), used standardised CPUE to determine RBCs and indicated that both the eastern and western stocks were below their limit reference points. 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). There has been no recent tier 4 assessment because CPUE is no longer considered to be a reliable indicator of abundance for this species. Other complications include the apparent sporadic availability of blue warehou, its short life span and schooling behaviour.

In 2008, a rebuilding strategy was implemented for blue warehou (subsequently revised in 2014) with the goal of rebuilding stocks to, or above, the limit reference point by or before 2024 (1 mean generation time plus 10 years). Initially, the 2008 strategy implemented a rebuilding time frame of 1 mean generation time only, which is approximately 6 years to 2014 (AFMA 2014a). However, when assessed in 2013, the standardised CPUE remained below the CPUE 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) (DoE 2015).

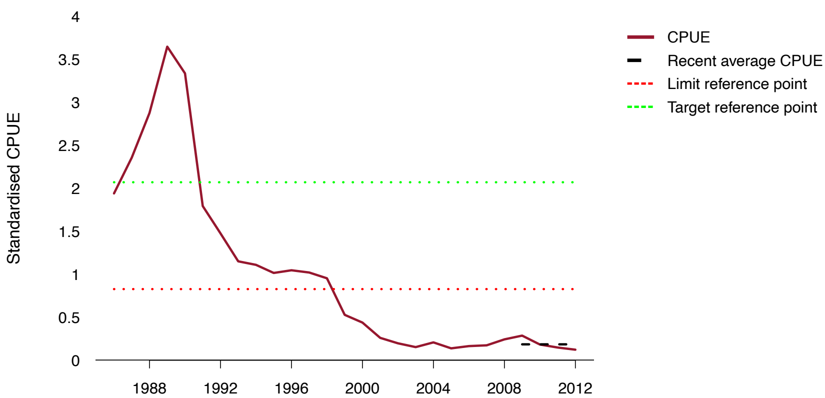
Under the rebuilding strategy, targeted fishing for blue warehou is not permitted. AFMA has set an incidental catch allowance of 118 t since the 2012–13 fishing season, based on a statistical analysis by CSIRO that determined that 118 t of the 154 t of blue warehou caught in 2010 was unavoidable (AFMA 2014a). 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 if the ratio of catches in the east and the west change substantially, resulting in increased reporting requirements for commercial fishers (AFMA 2014a). An alternative index of abundance with which to assess status is a priority for blue warehou, with new genetic approaches (for example, close kin) not reliant on CPUE being considered (AFMA 2018d). AFMA also introduced a move-on provision for the 2019–20 fishing season to reduce the risk of large catches of blue warehou. If an operator catches more than 200 kg of blue warehou in a shot (retained or discarded), the operator must not fish within 3 nm of the location of the previous shot for 24 hours.

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



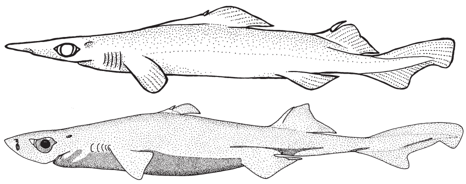
Notes: **CPUE** Catch-per-unit-effort. CPUE outside the reference period (1986 to 1995) is unlikely to accurately reflect biomass.
Source: Haddon 2013

Stock status determination

The most recent indicators of biomass (Haddon 2013) identified that the stock had been reduced to below the limit reference point of $0.20SB_0$. There is no evidence to suggest that the stock has rebuilt to above this level. The stock is therefore classified as **overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 100.8 t, which is below the incidental catch allowance of 118 t. There are no reliable indicators to determine whether the current level of fishing mortality will allow the stock to rebuild to above the limit reference point within a biologically reasonable time frame. 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 shark 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 2 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 1 stock, and the western zone is treated as another stock.

Catch history

Eastern

The eastern deepwater shark fishery started around 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 (Figures 9.12a and 9.12b). In 2019–20, platypus sharks (mixed), roughskin sharks (mixed) and longsnout dogfish (*D. quadrispinosa*) accounted for most of the catch in the east.

Commonwealth-landed catch in 2019–20 was 20.9 t, based on CDRs (Figure 9.12b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards of 38.7 t (Burch, Althaus & Thomson 2019). State catches are unknown. For the 2019–20 fishing season, total catch and discards were estimated to be 59.6 t.

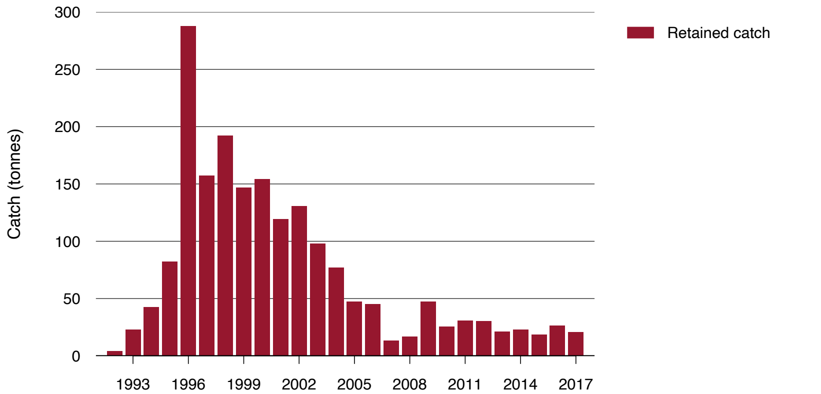
Western

The western deepwater shark fishery started in 1993. Landed catches increased to a peak of about 400 t in 1998, before decreasing steadily to less than 10 t in 2007 (Figure 9.13a). In recent years, landed catches have fluctuated around 50 to 75 t (Figure 9.13b). In 2019–20, platypus sharks (mixed), roughskin sharks (mixed) and longsnout dogfish accounted for most of the catch in the west.

Commonwealth-landed catch in 2019–20 was 85.2 t, based on CDRs (Figure 9.13b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 82 t and 7.3 t, respectively (Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 174.5 t.

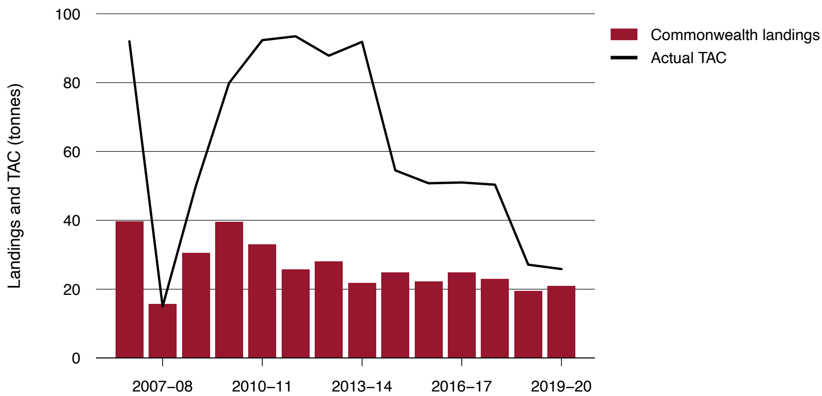
Trawl catch
Tamre Sarhan, AFMA

FIGURE 9.12a Deepwater shark annual catches (CTS and SHS), eastern zone, 1992 to 2017



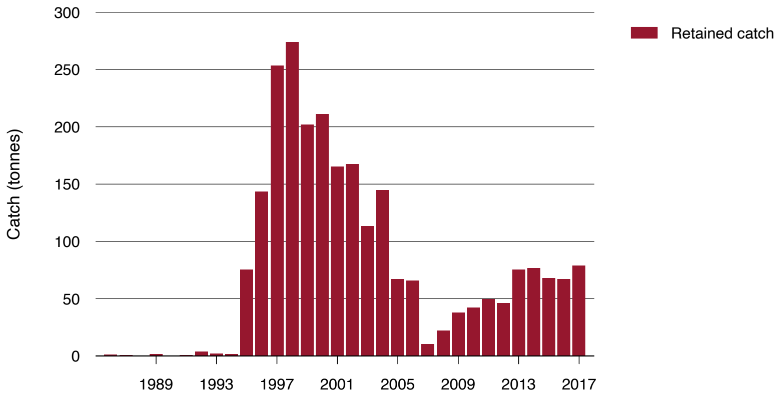
Source: Sporcic 2018

FIGURE 9.12b Deepwater shark seasonal landings (SESSF) and TACs, eastern zone, 2006–07 season to 2019–20 season



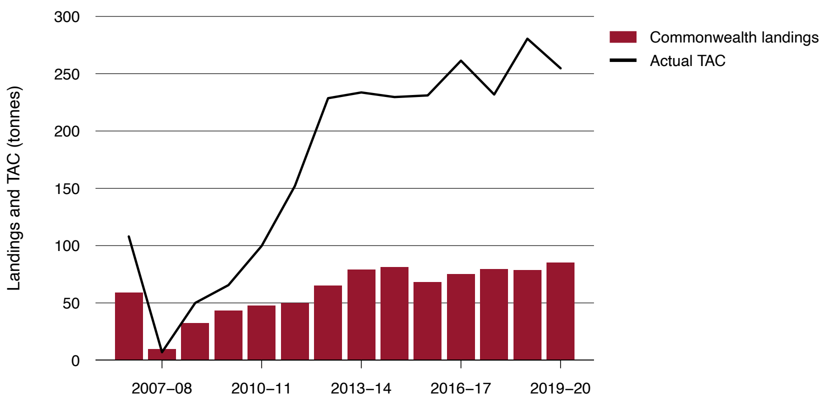
Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

FIGURE 9.13a Deepwater shark annual catches (CTS and SHS), western zone, 1986 to 2017



Source: Sporcic 2018

FIGURE 9.13b Deepwater shark seasonal landings (SESSF) and TACs, western zone, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Both eastern and western deepwater shark stocks are managed as tier 4 stocks under the SESSF HSF (AFMA 2019a). Analyses by Sporcic (2018) informed the management of the eastern and western stocks for the 2019–20 fishing season.

The tier 4 analysis for eastern deepwater sharks (Sporcic 2018), which was based on data up to 2017, identified that CPUE was close to the limit reference point. The 2019–20 RBC for the eastern stock was 9 t (AFMA 2018c). Because catches have consistently been around 24 t, AFMA implemented a TAC of 24 t for the 2019–20 fishing season as the first year of a 3-year MYTAC (AFMA 2019b).

The tier 4 analysis for western deepwater sharks (Sporcic 2018), which was based on data up to 2017, identified that CPUE was above the target reference point. The 2019–20 RBC for the western stock was 235 t (AFMA 2018c). AFMA implemented a TAC of 235 t for the 2019–20 fishing season as the first year of a 3-year MYTAC (AFMA 2019b).

Deepwater closures may differentially affect the CPUE of deepwater sharks in the eastern and western zones because of the different fishing conditions between the 2 areas. In the western zone, the CPUE remains high; however, in the eastern zone, CPUE has declined (Sporcic 2018).

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 is unlikely to be a reliable index of abundance for the stock or its component species.

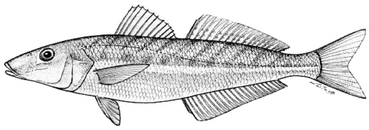
Deepwater sharks are mobile animals that cover a broad range of depths (Morison et al. 2013). A significant area of the fishery—around 54% of the area where catch of this stock was previously taken—has been closed as part of the 700 m depth closures to manage orange roughy stocks. Recently, part of the closure was reopened to allow deepwater trawling for western stocks. However, if 25 t of orange roughy is taken, then the closure is reinstated (AFMA 2017c). 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 2019–20 fishing season, total catch and discards were estimated to be 59.6 t for the eastern stock and 174.5 t for the western stock, which is above the RBC in the east (9 t) but below in the west (235 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

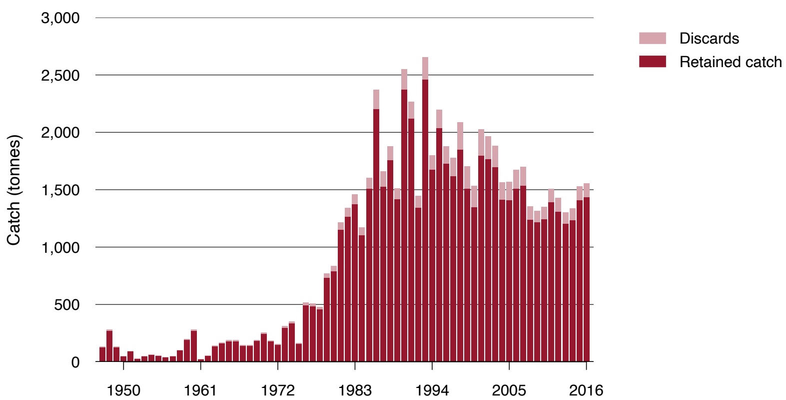
Eastern school whiting occurs from southern Queensland to western Victoria. Genetic studies have suggested 2 stocks in this range, with Dixon et al. (1987) observing a discontinuity in the relatedness between samples near Forster and Coffs Harbour, indicating a possible separation between fish from northern and southern New South Wales. The authors also noted that a significant amount of gene flow would likely occur between them (Dixon et al. 1987). Nevertheless, the current SESSF management and stock assessment assume a single stock because the evidence for the 2-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 (Figure 9.14a). In recent years, most of the total catch of eastern school whiting has come from New South Wales state waters.

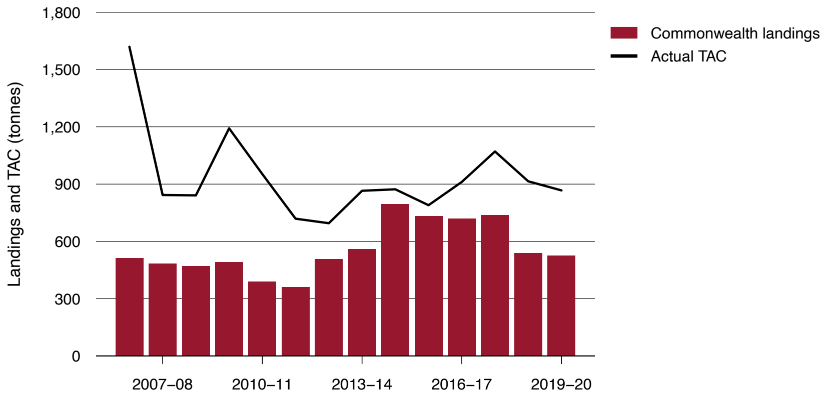
Commonwealth-landed catch in 2019–20 was 526.0 t, based on CDRs (Figure 9.14b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 191.8 t and 1,153.5 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 1,871.3 t.

FIGURE 9.14a Eastern school whiting annual catches (CTS, SHS and states) and discards, 1947 to 2016



Source: Day 2017a

FIGURE 9.14b Eastern school whiting seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

School whiting in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a).

While the 2017 assessment (Day 2017a) informed the management of the stock for the 2019–20 fishing season, the assessment was updated in 2019 (Day 2019a).

The 2017 tier 1 stock assessment (Day 2017a) predicted the spawning stock biomass at the start of 2018 would be 47% ($0.47SB_0$), which was below the target reference point of 48% ($0.48SB_0$) and above the limit reference point of 20% ($0.20SB_0$) (Figure 9.15). SERAG noted that the stock had dropped below the target reference point under the previous long-term RBC due to below-average recruitment, before increasing to 47% at the start of 2018 (AFMA 2017d). SERAG also noted that the estimate of spawning stock depletion was sensitive to assumptions about stock structure, which led to SERAG supporting research (currently underway) into stock structure and spawning season of school whiting (AFMA 2017d, 2018c). The 2017 assessment led to an RBC of 1,606 t and a 3-year-average RBC of 1,615 t. AFMA recommended using the 3-year-average RBC to set the second of a 3-year MYTAC for the 2019–20 fishing season (AFMA 2018d).

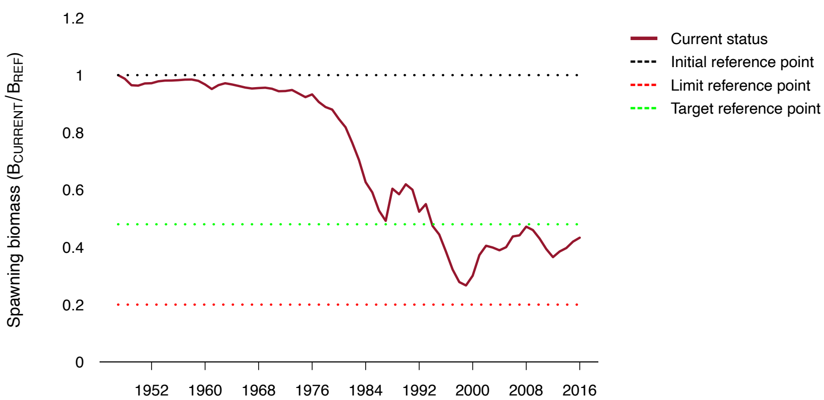
In 2019, the school whiting stock assessment from 2017 was updated with recent (2017 and 2018) Commonwealth and New South Wales catch and Commonwealth CPUE data (Day 2019a). This led to a revised estimated spawning stock biomass of 36% ($0.36SB_0$) at the start of 2018. This reduction in the estimate of spawning stock biomass, when compared with the 2017 assessment, was driven by declining Commonwealth CPUE in 2018 and revisions to the New South Wales catch data from 2017 and 2018 (actual catches were substantially higher than those used for projections in the 2017 assessment). In 2019, projections were made using predicted combined Commonwealth and New South Wales catch data for 2019, with the stock estimated to be at 35% ($0.35B_0$) at the start of 2020. This led to a revised RBC of 1,165 t for 2020–21, and a 3-year-average RBC of 1,318 t (AFMA 2019d).

SERAG requested a range of fixed catch (RBC, 1,600 t, 1,800 t and 1,900 t) projections for 2020 and 2021 to examine the effect of the increase in total catch in recent years (on biomass) (Day 2019a). This was because the model had estimated periods of below-average recruitment (mid 1990s and late 2000s), but SERAG believed there was no evidence of long-term shift in recruitment and considered it reasonable to consider the projections under average recruitment (AFMA 2019c). Such projections indicated that if the RBC was caught in 2020 (1,165 t) and 2021 (1,357 t), the stock would recover to 44% ($0.44SB_0$) at the start of 2022. If 1,800 or 1,900 t was caught, then the spawning stock biomass would remain relatively stable at 36% and 34%, respectively, at the start of 2022.

Under the low recruitment scenario, the stock was projected to decline under all catch scenarios, reaching 22% ($0.22SB_0$) at the start of 2022 with a catch of 1,900 t. These scenarios were provided to the AFMA Commission to assist in their determination of the TAC for the 2020–21 fishing season.

A new stock assessment is expected in late 2020, which is expected to provide insight into total fishing mortality in recent years, recruitment post-2013 and overall spawning stock biomass.

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



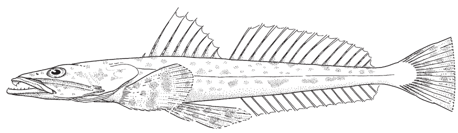
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Day 2017a

Stock status determination

The 2019 update (Day 2019a) to the 2017 assessment (Day 2017a) estimated the spawning stock biomass to be at 36% of the unfished level ($0.36SB_0$) at the beginning of 2018. Since this was below the target reference point of $0.48SB_0$ but above the limit reference point of $0.20SB_0$, the stock is classified as **not overfished**.

While total fishing mortality (F) in recent years relative to the fishing mortality limit reference point (F_{lim}) is uncertain, it is evident that there has been a substantial decline in spawning stock biomass between the assessment undertaken in 2017 and the update in 2019. For the 2019–20 fishing season, total catch and discards were estimated to be 1,871.3 t, which is above the 3-year-average RBC of 1,615 t calculated in the 2017 assessment (Day 2017a). However, based on Day's (2019a) projections, the spawning stock biomass does not appear to be at risk of further substantial declines if catches remain below 1,900 t and the stock experiences average recruitment. On this basis, the stock is classified as **not subject to overfishing**. However, caution should be taken, and the stock monitored closely to see if average recruitment was indeed the correct assumption.

Flathead (*Neoplatycephalus richardsoni* and 4 other species)



Line drawing: Rosalind Poole

Stock structure

Flathead catch in the SESSF is almost entirely tiger flathead (*Neoplatycephalus richardsoni*). For SESSF management purposes, 'flathead' refers to a group of species that also includes southern sand flathead (*Platycephalus bassensis*), toothy flathead (*P. aurimaculatus*), bluespotted flathead (*P. caeruleopunctatus)* and southern bluespotted flathead (*P. speculator*).

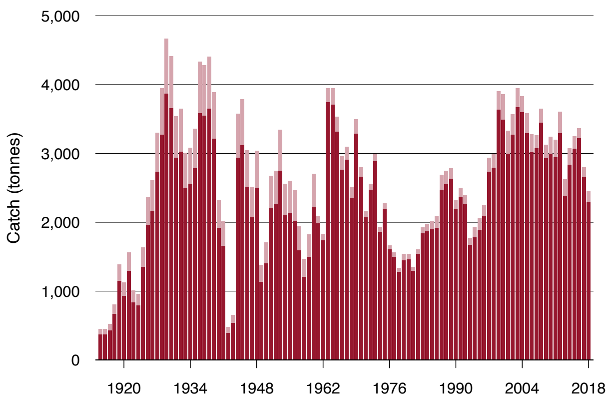
Tiger flathead is endemic to Australia. It is found on sandy or muddy substrates in continental-shelf and upper-slope waters from Coffs Harbour in northern New South Wales through Bass Strait and around Tasmania to south-east South Australia (Kailola, FRDC & BRS 1993). Most of the Australian commercial 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 9.16a). Catch in more recent years has declined to around 2,000 t after fluctuating around 3,000 to 4,000 t per year in the 2000s.

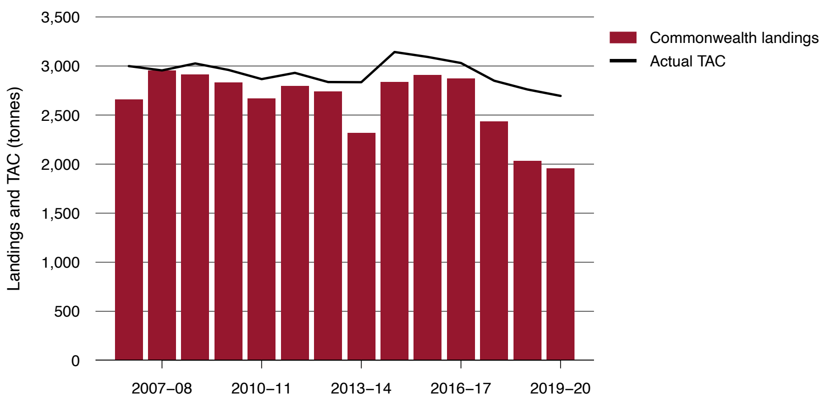
Commonwealth-landed catch in 2019–20 was 1,955.4 t, based on CDRs (Figure 9.16b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was and used to estimate discards and state catches of 82.5 t and 160.3 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 2,198.2 t.

FIGURE 9.16a Flathead annual catches (CTS, SHS and states) and discards, 1915 to 2018



Source: Day 2019b

FIGURE 9.16b Flathead seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

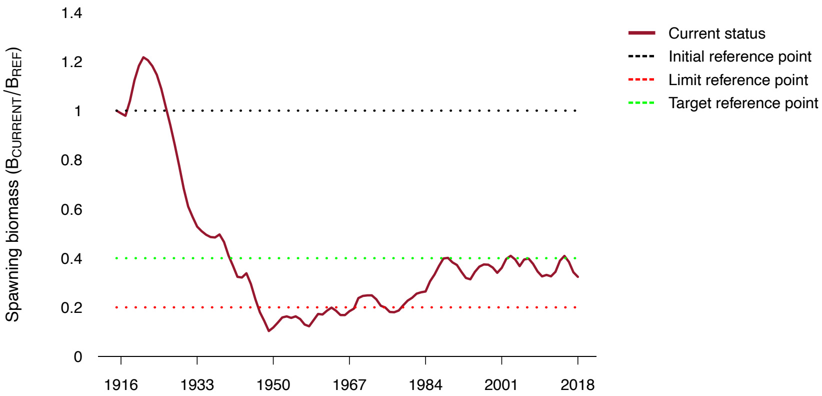
Flathead in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a). While the 2016 assessment (Day 2016) and subsequent amendment (Day 2017b) informed the management of the stock for the 2019–20 fishing season, a new flathead assessment was undertaken in 2019 (Day 2019b). The flathead assessment is based on biological parameters for tiger flathead, which accounts for about 95% of the catch (Morison et al. 2013).

The amendment to the 2016 assessment (Day 2017b) predicted that the spawning stock biomass for the 2019–20 fishing season, based on a step-down TAC, would be 41% ($0.41SB_0$), which was just above the target reference point of 40% ($0.40SB_0$) and above the limit reference point of 20% ($0.20SB_0$). The assessment (Day 2016) indicated that there had been better than average recent recruitment. The 2017 amendments to the assessment (Day 2017b) produced RBCs for the 2018–19 (2.837 t) and 2019–20 fishing seasons (2,826 t). AFMA recommended an RBC of 2,826 t for the 2019–20 fishing season (AFMA 2018d).

The 2019 flathead assessment (Day 2019b, c) estimated the spawning stock biomass to be 32% ($0.32SB_0$) in 2018. This reduced estimate was driven by below-average recruitment in 2013 and 2014 (particularly 2013) and a downwards revision to the 2012 estimate (which still remained above average) (Day 2019b). SERAG noted that the poor recruitment in 2013 was supported by both length and age data (AFMA 2019d). On advice from SERAG, several fixed catch (current RBC and 3 levels below that) and recruitment scenarios (high, average and low) were projected for 3 years (2020, 2021 and 2022) to support advice for TAC setting. Despite a number of years of below-average recruitment, there was uncertainty associated with the persistence of this trend, particularly given that the most recent estimates from 2015 were above average (AFMA 2019c, 2020). Consequently, SERAG agreed to base its RBC advice on the average recruitment scenario, with the aim of returning the spawning stock biomass to $0.40SB_0$. This led to an RBC of 2,334 t for 2020 and a 3-year-average RBC of 2,563 t (Day 2019c). SERAG noted that if a 3-year-average RBC was applied, the spawning stock biomass was expected to increase to 37% ($0.37SB_0$) by 2023 (AFMA 2020; Day 2019c).

Flathead
Heather Patterson, ABARES

FIGURE 9.17 Estimated spawning stock biomass for flathead, 1913 to 2018



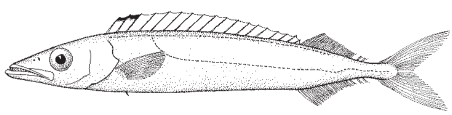
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Day 2019c

Stock status determination

The 2019 tier 1 assessment (Day 2019b, c) estimated the spawning stock biomass to be 32% of the unfished level (or $0.32SB_0$) in 2018. Since this was below the target reference point of $0.40SB_0$ and above the limit reference point of $0.20SB_0$, the stock is classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 2,198.2 t, which is below the 2019–20 RBC of 2,826 t calculated in the amendment to the 2016 assessment (Day 2017b). This indicates that the fishing mortality in 2019–20 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

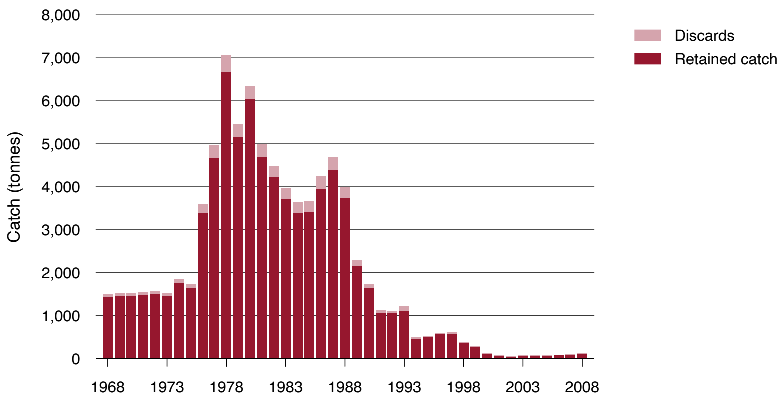
There are 2 biologically distinct stocks of gemfish in Australia: an eastern stock and a western stock, separated by a boundary on the western side of Bass Strait (Colgan & Paxton 1997; Moore, Ovenden & Bustamante 2017).

Catch history

Catch of gemfish in the eastern zone peaked in 1978 at more than 6,000 t. Catch decreased rapidly after 1987, decreasing to between 50 and 100 t between 2000 and 2012 (Figure 9.18a). Eastern gemfish has been classified as overfished since 1992, with TACs consistently being reduced. A rebuilding strategy that established eastern gemfish as an incidental catch-only species was first implemented in 2008. Landed catch in recent years has been below 50 t, increasing to 70 t in the 2019–20 fishing season (Figure 9.18b).

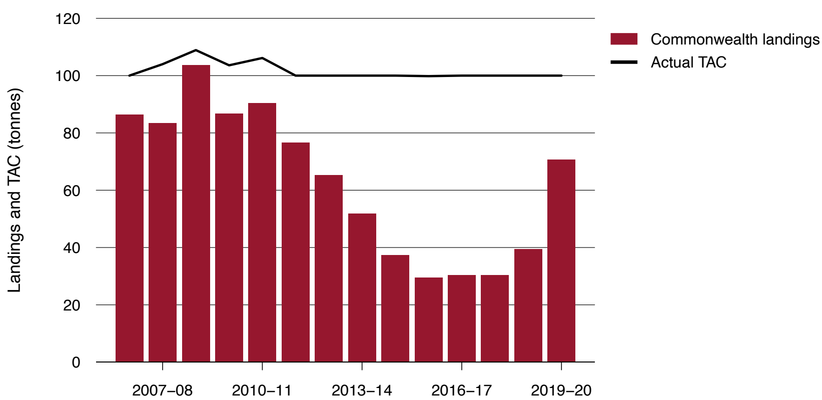
Commonwealth-landed catch in 2019–20 was 70 t, based on CDRs (Figure 9.18b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and by used to estimate discards and state catches of 45.3 t and 4 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 119.3 t.

FIGURE 9.18a Gemfish annual catches (CTS, SHS and states) and discards, eastern zone, 1968 to 2008



Source: Little & Rowling 2010

FIGURE 9.18b Gemfish seasonal landings (SESSF) and TACs, eastern zone, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Eastern gemfish in Commonwealth fisheries was managed as a tier 1 stock under the SESSF HSF (AFMA 2019a). The stock is currently subject to a rebuilding strategy (AFMA 2015a) with an incidental catch allowance of 100 t.

The last tier 1 assessment in 2010 used catch and length-frequency data up to 2009 (Little & Rowling 2010). The base-case model estimated that the spawning stock biomass in 2009 was 16% of the unfished level ($0.16SB_0$) (Figure 9.19). The assessment highlighted that most of the recruitment over the past 25 years had been relatively weak except for 1996 and 2002. The 2010 assessment (Little & Rowling 2010) included projections of eastern gemfish biomass that were based on 2 scenarios: total catches of zero and 100 t each year. The projections for catches of zero and 100 t indicated that the spawning stock biomass may reach the limit reference point of $0.2SB_0$ by 2017 and 2025, respectively, assuming average recruitment.

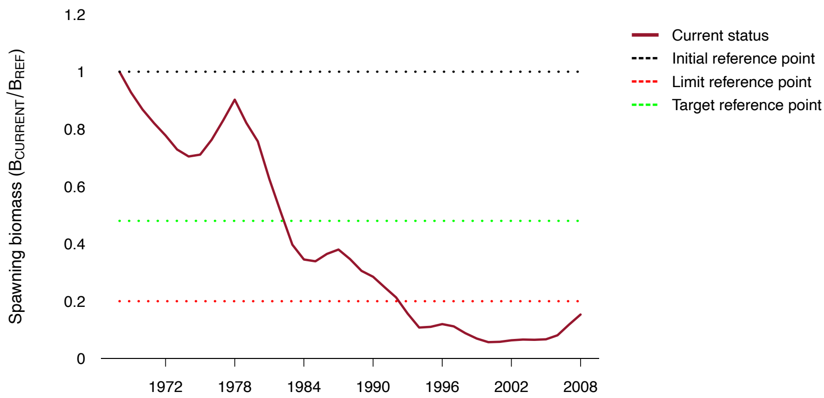
A preliminary update of the 2010 assessment in 2016 (Little 2016), while not accepted by SERAG, indicated that the spawning stock biomass in 2015 had decreased to 8% ($0.08SB_0$), due to a prolonged period of below-average recruitment (AFMA 2016c; Little 2016).

Moore, Ovenden & Bustamante (2017) and Ovenden, Davenport & Moore (2020) estimated the effective population sizes for both the eastern and western stocks of gemfish using molecular 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 each generation or that there is differential selection against recruits. Recent research has confirmed that there is no successful hybridisation and introgression occurring (Ovenden, Davenport & Moore 2020). There was no evidence of gene flow between eastern and western populations, though there is a clear overlap zone between western Bass Strait and Portland. Ovenden, Davenport & Moore. (2020) hypothesise that the genetic differences between eastern and western stocks is maintained by spatial and temporal separation during spawning. It is unclear what is contributing to the decreased effective population size of eastern gemfish.

Knuckey et al. (2018) examined which factors may be contributing to the lack of recovery in overfished species, such as eastern gemfish, despite significant management changes under relevant rebuilding strategies. A workshop with SESSF fishers and other stakeholders identified climate and oceanographic conditions as a potential factor in declining CPUEs, and that climate change would have a major impact on the recovery of overfished species due to changes in productivity, abundance, distribution or species sensitivity.

In 2008, a rebuilding strategy was implemented for eastern gemfish (subsequently revised in 2015) with the goal of rebuilding stocks to, or above, the limit reference point by or before 2027 (1 mean generation time plus 10 years) (AFMA 2015a). Projections to support this time frame from the 2010 assessment (Little & Rowling 2010) assume that total removals are limited to the 100 t incidental catch allowance and rely on at least average levels of recruitment (Morison et al. 2013), but all indications are that recruitment has been below average. In 2009, the species was listed as conservation-dependent under the EPBC Act. An alternative index of abundance with which to assess status is a priority for eastern gemfish, with new genetic approaches (for example, close kin) being considered (AFMA 2019c).

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



Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Little & Rowling 2010

Stock status determination

The most recent indicators of biomass (Little 2016; Little & Rowling 2010) identified that the stock had been reduced to below the limit reference point of $0.20SB_0$. There is no evidence to suggest that the stock has rebuilt to above this level. The stock is therefore classified as **overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 119.3 t, which is above the incidental catch allowance of 100 t. 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. The stock is therefore classified as **uncertain**.

Mixed catch
Heesham Garroun, AFMA

Gemfish, western zone (*Rexea solandri*)

Stock structure

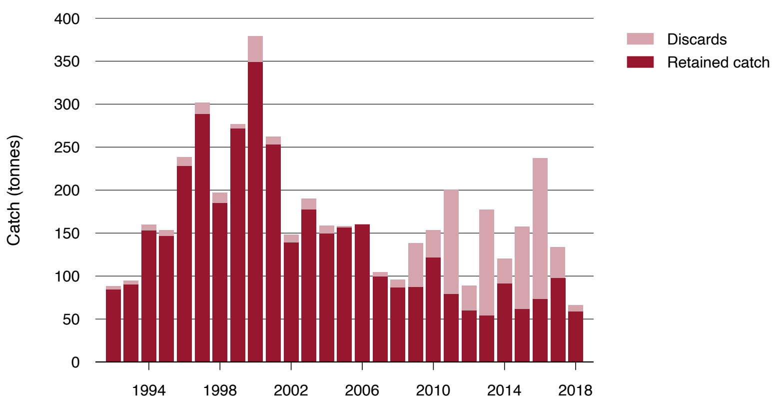
The eastern and western gemfish stocks in Australia are separated by a boundary on the western side of Bass Strait (Colgan & Paxton 1997; Moore, Ovenden & Bustamante 2017). Genetic studies indicate that gemfish throughout the western zone, including in the CTS and in the GABTS, is 1 biological stock (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 from 2004 to 2007, with catches reaching 532 t). 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).

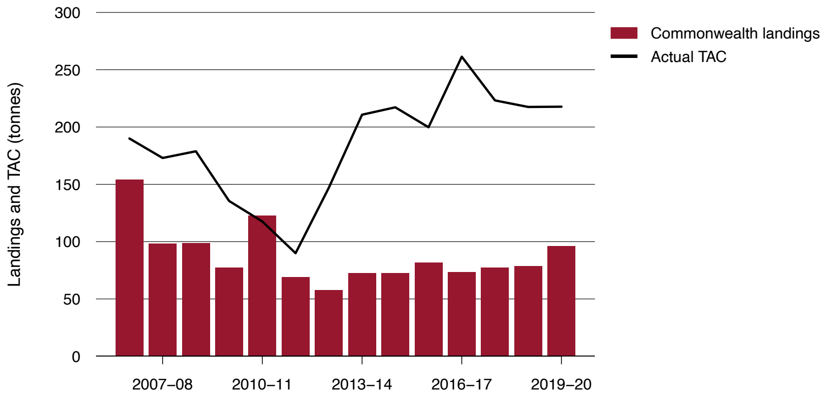
Commonwealth-landed catch in 2019–20 was 96.2 t, based on CDRs (Figure 9.20b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards of 41.7 t (Burch, Althaus & Thomson 2019). There is no state catch. For the 2019–20 fishing season, total catch and discards were estimated to be 137.9 t.

FIGURE 9.20a Gemfish annual catches (CTS and SHS) and discards, western zone, 1992 to 2018



Source: Sporcic 2019b

FIGURE 9.20b Gemfish seasonal landings (SESSF) and TACs, western zone, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Western gemfish in Commonwealth fisheries is managed as a tier 4 stock under the SESSF HSF (AFMA 2019a). Management arrangements for western gemfish currently differ between the CTS and the GABTS. Western gemfish catch in the CTS is currently managed under a 3-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 3 years (AFMA 2018d).

A weight-of-evidence approach based on the results of a tier 1 stock assessment (Helidoniotis & Moore 2016) and a tier 4 analysis (Haddon & Sporcic 2017b) was used to inform the management of the stock for the 2019–20 fishing season. In 2019, a new tier 4 analysis was undertaken (Sporcic 2019b).

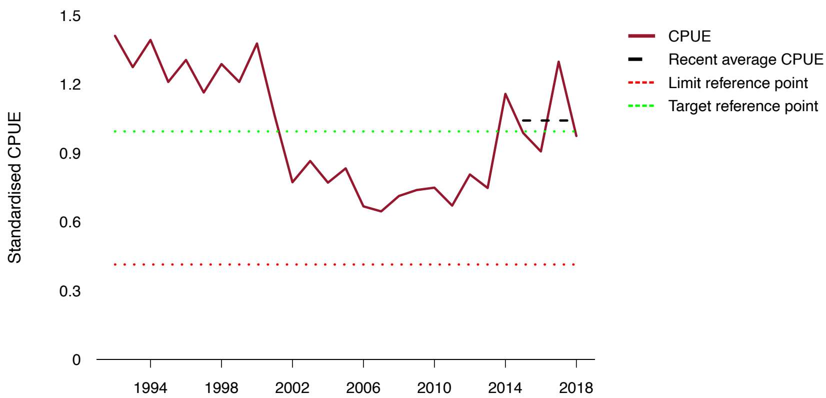
The tier 1 stock assessment by Helidoniotis and Moore (2016) estimated that the spawning stock biomass in 2015 was 43% ($0.43SB_0$), which is below the target reference point ($0.48SB_0$; Figure 9.21). This was based on data from both the CTS (zone 50) and the GABTS (zone 80), and led to an RBC of 200 t for the CTS and 38 t for the GABTS. The Great Australian Bight Resource Assessment Group (GABRAG) noted several issues with the assessment, including (1) the paucity of data on length-frequency and biology (for example, growth parameters and size at maturity), the latter of which was assumed to be similar to eastern gemfish in the assessment; (2) biases in the CPUE data caused by the aggregating nature of gemfish and high discard rates, and (3) the lack of targeting in the GABTS (zone 80) underestimating the productivity of the overall stock. The high level of uncertainty led to GABRAG not accepting the tier 1 assessment (AFMA 2016b).

Two tier 4 analyses by Haddon and Sporcic (2017b) in 2016 used data solely from the CTS (zone 50 and half of zone 40) up to 2015. GABRAG noted that when discards were included in the analysis CPUE improved dramatically, leading to a significant increase in the RBC. The RBCs for western gemfish were 423 t (including discards) and 139 t (without discards). Like tier 1, GABRAG agreed that there were issues with the CPUE data in the tier 4 analysis caused by the aggregating nature of gemfish and high discard rates.

Given deficiencies in the data and the uncertainties with respect to both tier 1 assessment and tier 4 analyses for western gemfish, GABRAG agreed to take a weight-of-evidence approach in recommending an RBC (AFMA 2016b, 2018c). GABRAG noted that there was insufficient evidence to assess the likelihood of western gemfish declining below the limit reference point; however, given the results of the tier 1 assessment for the CTS component and low catches relative to the TAC, it was agreed that there was little risk of the stock declining below the limit reference point (AFMA 2016b). GABRAG therefore recommended an RBC of 200 t for the CTS, and AFMA set a 3-year MYTAC of 200 t.

In 2019, a new tier 4 analysis used data solely from the CTS (zone 50) up to 2018 (Sporcic 2019b). The analysis estimated that the 4-year average CPUE (2015 to 2018), including discards, was above the target reference point. This led to an RBC of 423 t.

FIGURE 9.21 Estimated spawning stock biomass of gemfish, western zone, for the CTS and the GABTS, 1992 to 2018



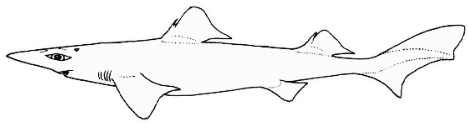
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Sporcic 2019b

Stock status determination

The 2019 tier 4 analysis (Sporcic 2019b) estimated that the recent average standardised CPUE-based proxy for biomass was above the target reference point. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 137.9 t, which is below the RBC of 200 t calculated using a weight-of-evidence approach. There is little confidence in a direct comparison of catch or fishing mortality with the RBC, given the deficiencies in the data used in the 2016 assessments. However, given recent indications of biomass from the 2019 analysis, it is unlikely that the recent catches would deplete the stock below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

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



Line drawing: FAO

Stock structure

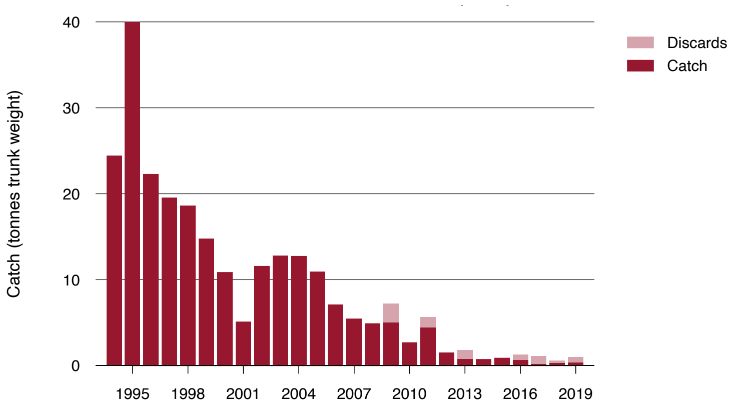
Gulper sharks are assessed as a multispecies stock comprising Harrisson's dogfish (*Centrophorus harrissoni*), southern dogfish (*C. zeehaani*) and endeavour dogfish (*C. moluccensis*). Harrisson's dogfish is endemic to south-eastern Australia, from southern Queensland to south-eastern Tasmania, and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

To support the revision of the AFMA *Upper-slope dogfish management strategy* (AFMA 2012), 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 landings in the 2018–19 and 2019–20 fishing seasons were 0.38 t and 0.20 t, respectively.

FIGURE 9.22 Gulper shark annual catch and discards for the SESSF (all sectors), 1994 to 2019



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 to 2011), demersal and auto-longline fisheries (1992 to 2010), Commonwealth gillnet fisheries (1997 to 2010), and New South Wales state fisheries coincided 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 the post-capture survival rate 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 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 (*Squalus chloroculus*), with fishing mortality still exceeding estimated sustainable levels. The strategy was subsequently revised in 2012 (AFMA 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 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. To further reduce fishing mortality there is a zero-retention limit for 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.

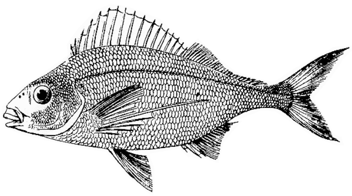
AFMA is currently undertaking a review of the *Upper-slope dogfish management strategy* and will consult broadly with stakeholders to inform the review.

Stock status determination

In the absence of any evidence of recovery to above the specified limit reference point, 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 is expected to take some time. As a result, the level of fishing mortality of gulper sharks is classified as **uncertain**. Resolution of stock structure may result in 1 or more of the subpopulations being classified as not subject to overfishing.

Jackass morwong (*Nemadactylus macropterus*)



Line drawing: FAO

Stock structure

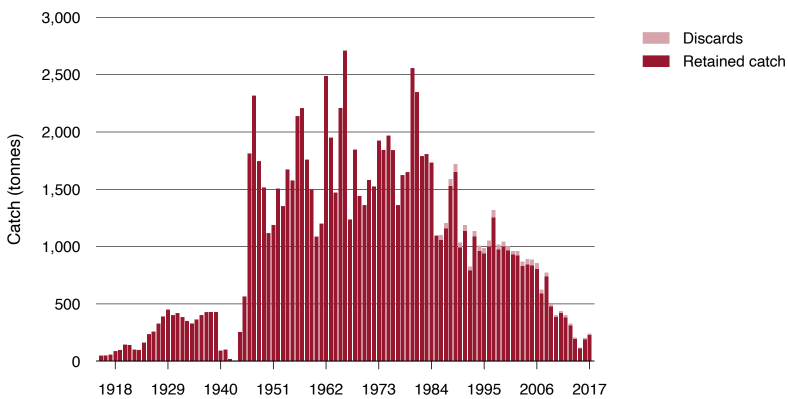
Jackass morwong is distributed around the southern half of Australia (including Tasmania), New Zealand, and St Paul and Amsterdam islands (Indian Ocean); and off south-eastern South America and southern Africa. It occurs to depths of 450 m and, in Australian waters, is most abundant between 100 and 200 m. Genetic studies have shown no evidence of separate stocks in Australian waters, but found that New Zealand and Australian stocks are distinct (Elliot & Ward 1994). Although analysis of otolith microstructure found differences between jackass morwong from southern Tasmania and those off New South Wales and Victoria, it is unclear whether such differences indicate separate stocks (Morison et al. 2013). Nonetheless, it is assumed for the purposes of the stock assessment that there are separate stocks of jackass morwong in the eastern (New South Wales and eastern Victoria) and western zones (western Tasmania and western Victoria) (Morison et al. 2013). Catches of jackass morwong are also reported from the GABTS (Chapter 11) but it is not known whether they form a separate stock, so are currently managed separately.

Catch history

Catches of jackass morwong peaked at more than 2,500 t in the mid 1960s and have declined since the 1980s. Since the late 2000s, catches have continued to decline and have been less than 500 t per year (Figure 9.23a).

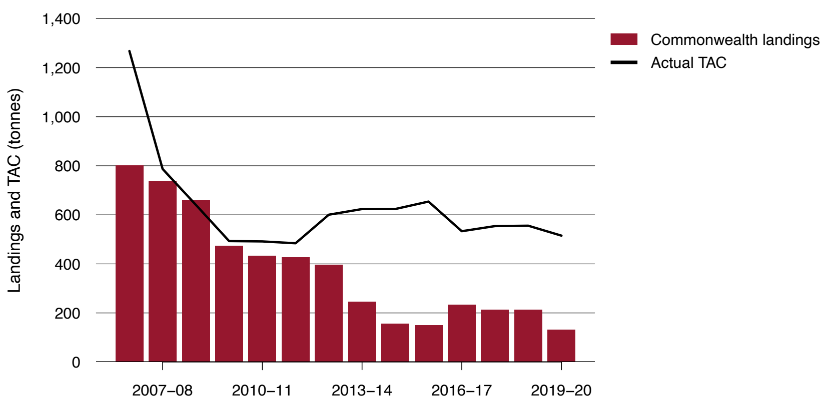
Commonwealth-landed catch in 2019–20 was 109.1 t, based on CDRs (Figure 9.23b). Based on logbook data, around 86% of the catch was from the east and 14% from the west. Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 12.9 t and 7.4 t, respectively, for the eastern stock and 3.8 t and 1.6 t, respectively for the western stock (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards combined were estimated to be 134.8 t.

FIGURE 9.23a Jackass morwong annual catches (CTS, SHS and states) and discards, 1915 to 2017



Sources: Day & Castillo-Jordán 2018a, b

FIGURE 9.23b Jackass morwong seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

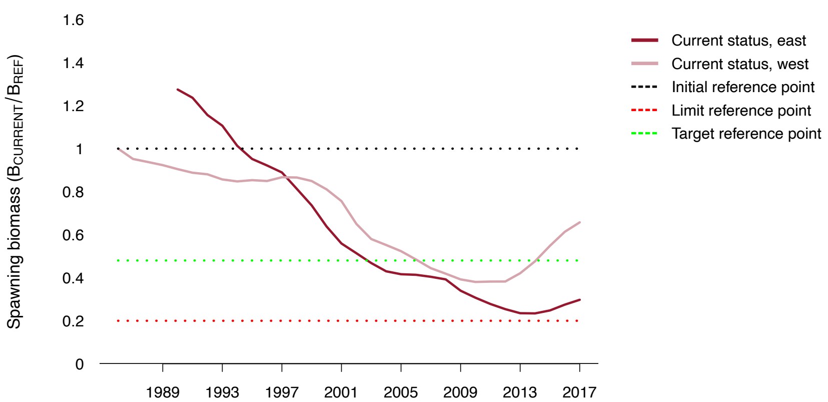
Stock assessment

Jackass morwong in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a). 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. The 2018 assessments (Day & Castillo-Jordán 2018a, b) informed the management of the stock for the 2019–20 fishing season.

For the eastern stock, a new assessment in 2011 involved a change in productivity (a 'regime shift'), attributed to long-term oceanographic changes (Wayte 2012). Compared with previous assessments, the new assessment provided a better fit to the data, but remained sensitive to natural mortality, the last year of recruitment estimation and the stock–recruitment relationship (Wayte 2012, 2013). Wayte's (2013) analyses, which provide evidence for a regime shift, have now been accepted as influencing jackass morwong productivity (AFMA 2018b). The acceptance of a recruitment shift in the assessment resulted in a decrease in the estimate of recent depletion from closer to the limit reference point ($0.20SB_0$) to closer to the target reference point ($0.48SB_0$). 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 in models for non-recovering species (AFMA 2018a, b). The latest tier 1 stock assessment in 2018 (Day & Castillo-Jordán 2018a) estimated that the spawning stock biomass at the start of 2018 was 30% ($0.30SB_0$) in the east (Figure 9.24). This led to an RBC of 261 t and a 3-year-average RBC of 270 t.

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, 2018b). The latest tier 1 stock assessment in 2018 (Day & Castillo-Jordán 2018b) estimated that the spawning stock biomass at the start of 2018 was 0.66% ($0.66\ SB_0$) in the west (Figure 9.24). This led to an RBC of 235 t and a 3-year-average RBC of 223 t.

FIGURE 9.24 Estimated spawning stock biomass for eastern (1988 to 2017) and western (1984 to 2017) stocks of jackass morwong



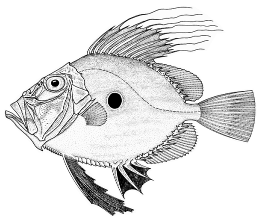
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass. Biomass estimates are available for the eastern stock from 1915 to 1987. However, pre-1988 estimates are not presented for the eastern stock because the new regime shift base case resets the reference biomass to the biomass in 1988.
Sources: Day & Castillo-Jordán 2018a

Stock status determination

The 2018 assessments (Day & Castillo-Jordán 2018a, b) estimated the spawning stock biomass at the beginning of 2018 to be 30% ($0.30SB_0$) and 66% of the unfished level ($0.66SB_0$), in the east and west, respectively. This was below the target reference point of $0.48SB_0$ and above the limit reference point of $0.20SB_0$ in the east, and above the target reference point of $0.48SB_0$ in the west. The stocks in both the east and west are therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards combined were estimated to be 134.8 t, which is below the combined 3-year-average RBC of 505 t calculated from the 2018 assessments (Day & Castillo-Jordán 2018a,b). Based on the catch ratio from the logbook data, around 114.1 t was caught in the east and 20.7 t in the west, both of which were below respective RBCs. This indicates that the fishing mortality in 2019–20 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**.

John dory (*Zeus faber*)



Line drawing: Rosalind Poole

Stock structure

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

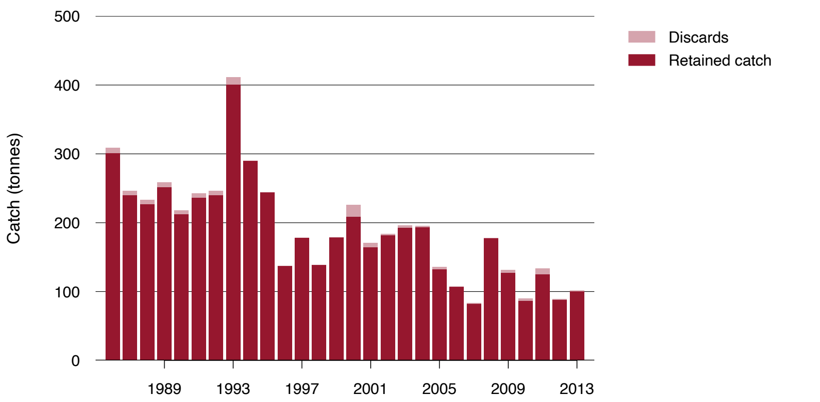
Catch history

The catch of john dory averaged between 200 and 300 t from 1986 to 1995, peaking at about 400 t in 1993. Catches have since decreased and have been below 200 t per year since 2012 (Figure 9.25a).

Commonwealth-landed catch in 2019–20 was 68.3 t, based on CDRs (Figure 9.25b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 1.8 t and 6.7 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 76.8 t.

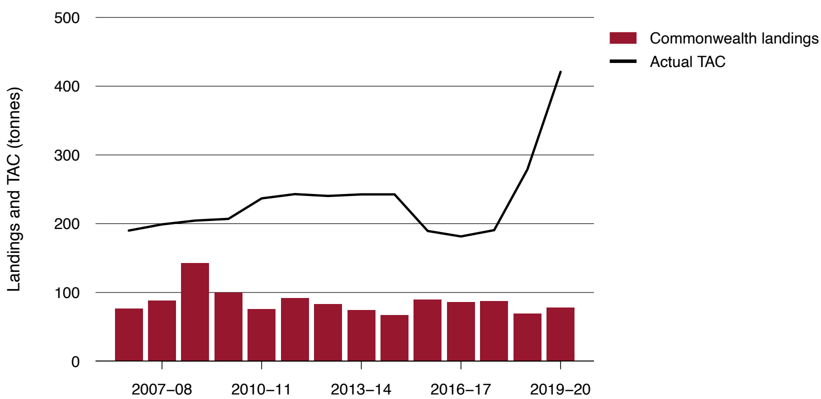
John dory is infrequently targeted in the SESSF. Most of the catch was historically taken as byproduct by trawlers targeting other shelf species, such as redfish and flathead. Because most john dory catches are not targeted, it is considered a 'secondary species' and is managed to a biomass target $0.4SB_0$ (proxy for MSY).

FIGURE 9.25a John dory annual catches (CTS, SHS and states) and discards, 1986 to 2013



Source: Haddon 2014

FIGURE 9.25b John dory seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

John dory in Commonwealth fisheries is managed as a tier 3 stock under the SESSF HSF (AFMA 2019a). The tier 3 analysis (Castillo-Jordán 2017) informed the management of the stock for the 2019–20 fishing season. The analysis 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 a catch-curve analysis, and was an update to the yield analyses presented in Thomson (2014).

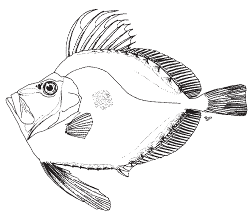
Total mortality was estimated from catch curves constructed from length-frequency information. The assessment estimated an equilibrium fishing mortality rate (F_{CURR}) of 0.036, which was below the target fishing mortality reference point (F_{spr40} = 0.126) that would achieve a target biomass of $0.4SB_0$. 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 $0.4SB_0$ target, generated an RBC of 485 t for the 2019–20 season (AFMA 2018c; Castillo-Jordán 2017). This is higher than the RBC estimated by the 2014 assessment, largely because of the new ageing data. Sporcic and Haddon (2018) analysed standardised CPUE for the stock. The results indicated that the CPUE for the john dory stock in zones 10–20 had stabilised. The 2019–20 TAC was 395 t, the second year of a 3-year MYTAC.

Stock status determination

The 2017 tier 3 analysis (Castillo-Jordán 2017) estimated that the fishing mortality rate was below the target fishing mortality rate that would achieve a spawning biomass of $0.4SB_0$, and there is no evidence to suggest the stock has ever been reduced to below the limit reference point. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 76.8 t, which is below the RBC of 485 t calculated in the 2017 analysis (Castillo-Jordán 2017). This indicates that the fishing mortality in 2019–20 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**.

Mirror dory (*Zenopsis nebulosa*)



Line drawing: FAO

Stock structure

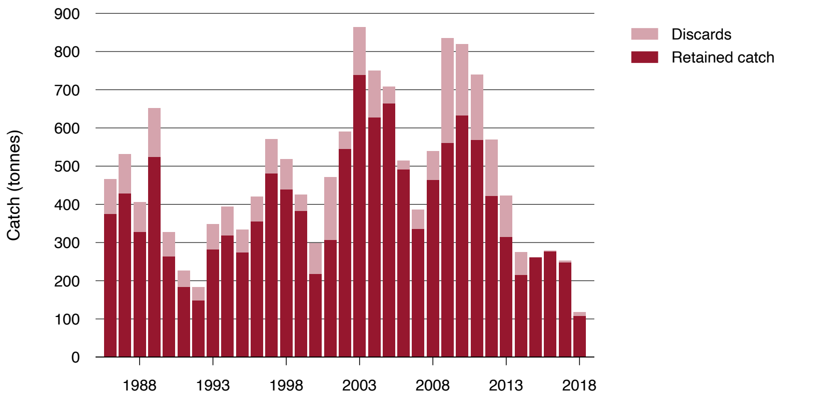
Mirror dory is found throughout the southern Pacific Ocean at depths of 30–800 m. A single stock of mirror dory in the SESSF area is assumed for management purposes (Morison et al. 2013). To make it easier to assess, the stock has been split into eastern and western units of assessment.

Catch history

Mirror dory is predominantly a byproduct species in the CTS and is mainly caught east of Bass Strait. The catch has ranged between 200 and 700 t per year (Figure 9.26a).

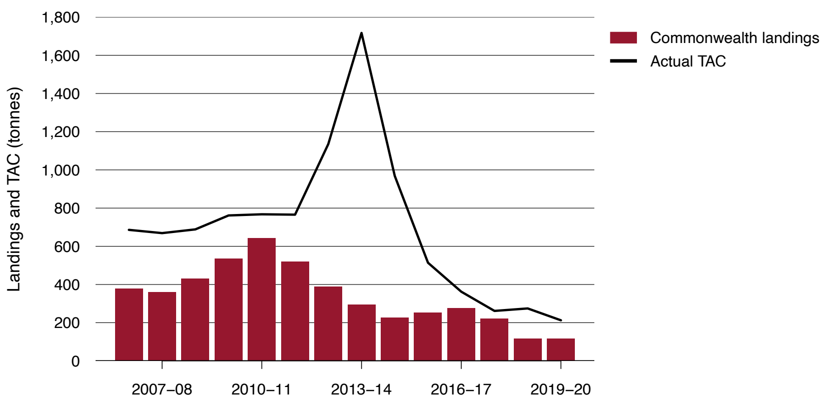
Commonwealth-landed catch in 2019–20 was 116.6 t, based on CDRs (Figure 9.26b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards of 2.4 t in the east and 0.1 t in the west, and state catches of 1.1 t in the east and zero in the west (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards combined were estimated to be 120.2 t.

FIGURE 9.26a Mirror dory annual catches (CTS, SHS and states) and discards, 1986 to 2018



Source: Sporcic 2019a

FIGURE 9.26b Mirror dory seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

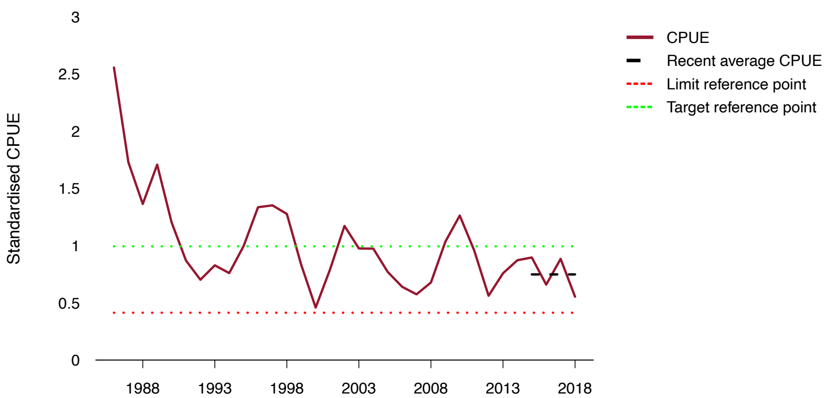
Mirror dory in Commonwealth fisheries is managed as a tier 4 stock under the SESSF HSF (AFMA 2019a). The tier 4 analyses (Sporcic 2018) for both the eastern and western units informed the management of the stock for the 2019–20 fishing season. In 2019, new tier 4 analyses were undertaken (Sporcic 2019a).

The tier 4 analyses in 2018 included discards only for the eastern unit, given the low level of discards from the western unit. CPUE for the eastern unit generally declined from 2009 to 2016 and increased in 2017 (the latest year of data) (Figure 9.27). This increase may be linked to a change in fishing area, since there is some indication that the empirical analysis is more closely reflecting stock availability to the fishery rather than biomass (Sporcic 2018; Sporcic & Haddon 2018). CPUE for the western unit follows a cyclical pattern and, similar to the eastern unit, shows a slight increase in 2017 (Figure 9.28), which may in part be driven by a change in fishing area to shallower waters (Sporcic 2018; Sporcic & Haddon 2018).

For the eastern unit, applying the tier 4 harvest control rule to the standardised CPUE series with discards resulted in an RBC of 140 t (Sporcic 2018). For the western unit, applying the tier 4 harvest control rule to the standardised CPUE series resulted in an RBC of 95 t (Sporcic 2018). The total RBC for the eastern and western units combined for the 2019–20 season was 235 t.

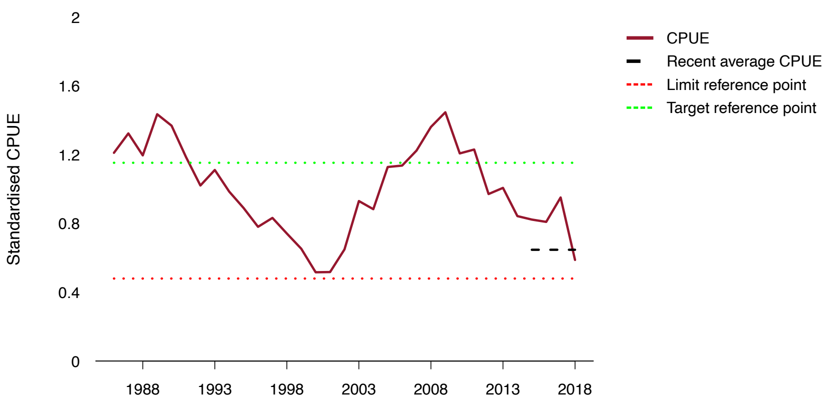
Mirror dory
Quentin Vardy, AFMA

FIGURE 9.27 Standardised CPUE for eastern mirror dory, 1986 to 2018



Note: **CPUE** Catch-per-unit-effort.
Source: Sporcic 2019a

FIGURE 9.28 Standardised CPUE for western mirror dory, 1986 to 2018



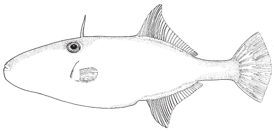
Note: **CPUE** Catch-per-unit-effort.
Source: Sporcic 2019a

Stock status determination

The 2019 tier 4 analyses (Sporcic 2019a) estimated the recent average standardised CPUE to be between the target and limit reference points for both the eastern and western assessment units. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards combined were estimated to be 120.2 t, which is below the combined RBC of 235 t calculated from the tier 4 analyses. This indicates that the fishing mortality in 2019–20 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

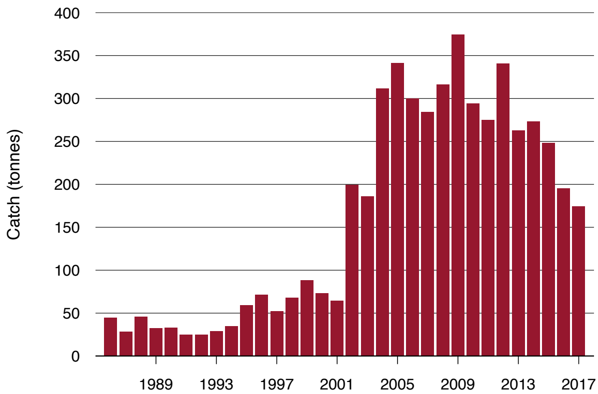
The ocean jacket stock comprises chinaman leatherjacket, which makes up most of the catch, and unspecified leatherjackets. Little is known about the biological structure of this multispecies stock. Ocean jacket taken in the GABTS is assessed separately (Chapter 11). Ocean jacket is a relatively short-lived species 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 9.29a). Since then, ocean jacket has been an important non-quota byproduct species in the SESSF, with current landings of around 150–200 t exceeding those of many quota species.

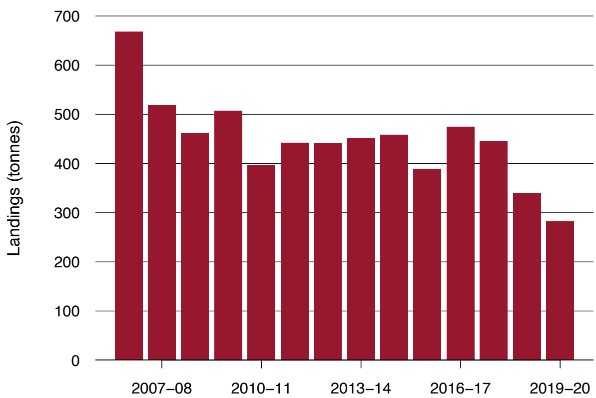
Commonwealth-landed catch in 2019–20 was 173.6 t, based on CDRs (Figure 9.29b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 219.8 t and 339.9 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 733.3 t.

FIGURE 9.29a Ocean jacket annual catches (CTS and SHS) and discards, 1986 to 2017



Note: Catch includes chinaman leatherjacket and unspecified leatherjackets.
Source: Sporcic & Haddon 2018

FIGURE 9.29b Ocean jacket seasonal landings (SESSF), 2006–07 season to 2019–20 season

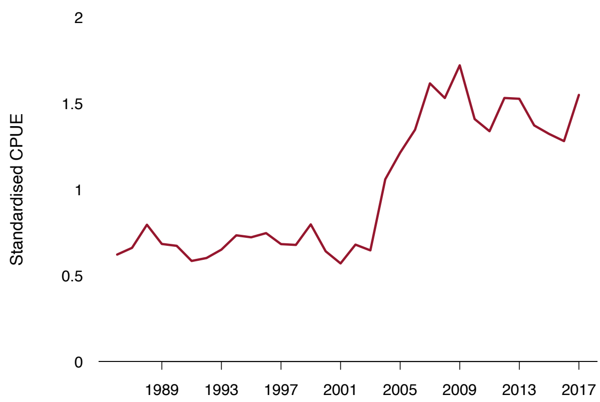


Source: AFMA catch disposal records

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 2018) (Figure 9.30). 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 to 2017



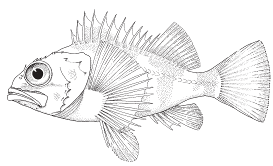
Note: **CPUE** Catch-per-unit-effort. There is no tier 4 assessment for ocean jacket, and so there are no target and limit reference points.
Source: Sporcic & Haddon 2018

Stock status determination

The standardised CPUE series increased substantially between 2003 and 2007, and remains relatively high despite declining slightly from 2007 to 2016 (Sporcic & Haddon 2018). The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 733.3 t, which is a decrease from 2018–19. CPUE remains relatively high compared with historical levels and has remained fairly stable for the past decade, meaning that the fishing mortality is unlikely to have driven the stock below the limit reference point. The stock is therefore classified as **not subject to overfishing**.

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



Line drawing: FAO

Stock structure

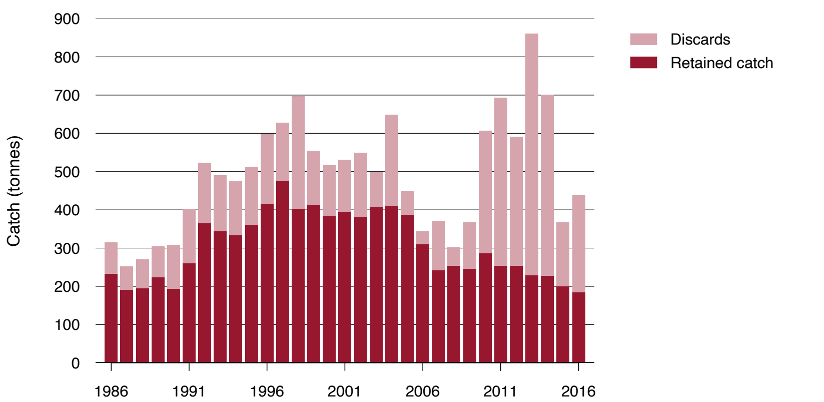
Ocean perch is managed as a single stock that includes 2 species: the inshore reef ocean perch (*Helicolenus percoides*) and the offshore bigeye ocean perch (*H. barathri*). Ocean perch stock structure is uncertain, but there is probably an east–west structuring of stocks (Morison et al. 2013). Reef ocean perch and bigeye ocean perch have been assessed separately since 2009, but a single TAC is set for the 2 species. Based on the depth of capture in 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. Most (inshore) reef ocean perch are discarded because of their smaller size (Figure 9.31a).

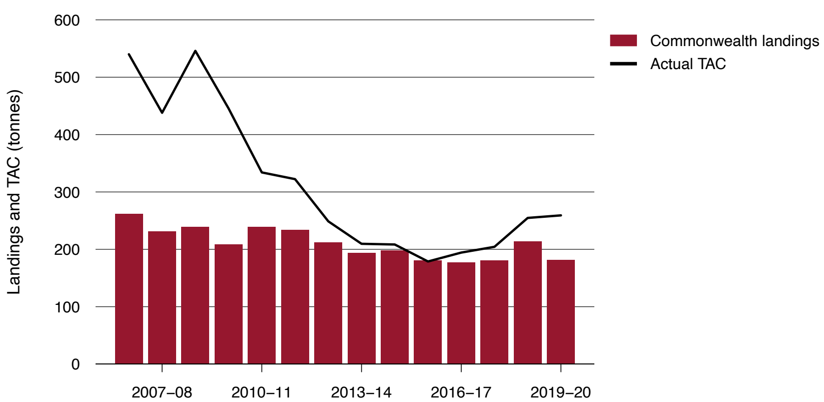
Commonwealth-landed catch in 2019–20 was 169.1 t, based on CDRs (Figure 9.31b). Based on logbook data, around 15% of the catch was inshore reef ocean perch and 85% was offshore bigeye ocean perch. Discards and state catches are not yet available for 2019–20. However, weighted averages of the previous 4 fishing seasons (2015–16 to 2018–19) were calculated and used to estimate discards and state catches of 111.2 t and 3.6 t, respectively, for inshore reef ocean perch, and 39.9 t and 14.4 t, respectively, for offshore bigeye ocean perch (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards combined were estimated to be 338.2 t.

FIGURE 9.31a Total ocean perch (reef and bigeye) annual catches (CTS, SHS and states) and discards, 1986 to 2016



Source: Haddon & Sporcic 2017b

FIGURE 9.31b Total ocean perch (reef and bigeye) seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



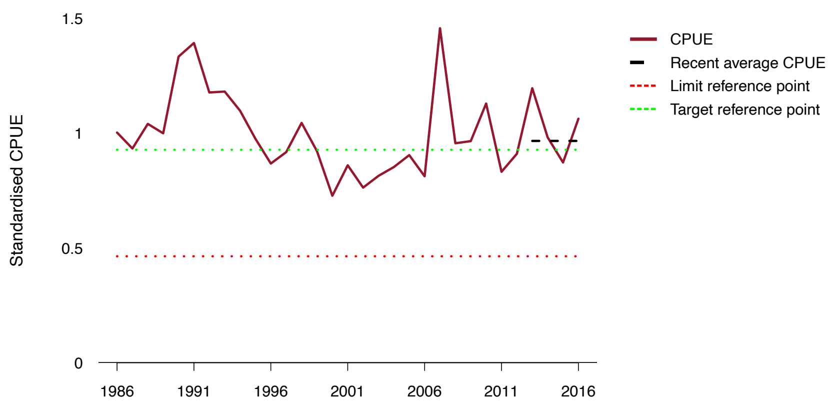
Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Both inshore reef and offshore bigeye ocean perch in Commonwealth fisheries are managed as a tier 4 stock under the SESSF HSF (AFMA 2019a). The tier 4 analyses by Haddon and Sporcic (2017b) informed the management of the stock for the 2019–20 fishing season. A 40% (0.40SB_0) target reference point is applied to both species (Morison et al. 2013).

The tier 4 analyses in 2017 estimated that both species were above their respective target reference points (Figure 9.32), producing an RBC of 248 t for inshore reef ocean perch and 345 t for offshore bigeye ocean perch (Haddon & Sporcic 2017b). SERAG noted that the high discard rate for inshore 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 2018d). SERAG recommended that inshore reef ocean perch be removed from the ocean perch quota basket and that a catch trigger be set for the species instead (AFMA 2018d). Accordingly, the TAC was determined based on the RBC for offshore bigeye ocean perch only and was set at 241 t for 2019–20, the second year of a 3-year MYTAC (AFMA 2018d).

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



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

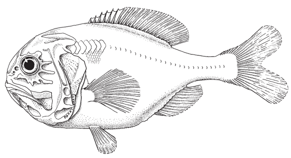
Stock status determination

Since the standardised CPUE for inshore reef ocean perch is no longer accepted by SERAG and is no longer being used to recommend an RBC, future status for the ocean perch stock (following the expiry of the current MYTAC) will likely be based only on information for offshore bigeye ocean perch.

While noting uncertainties in the CPUE series for inshore reef ocean perch, the 2017 tier 4 analyses (Haddon & Sporcic 2017b) estimated that the recent average standardised CPUE was above the target reference point for biomass for both species. The stock is therefore classified as **not overfished**.

Noting uncertainties in the CPUE series for inshore reef ocean perch and the resulting uncertainties in the RBC that was derived from the tier 4 harvest control rules, the total fishing mortality for inshore reef ocean perch was estimated (using the catch ratio from the logbook data) to be 140.2 t, which is below the RBC of 248 t. The total fishing mortality for offshore bigeye ocean perch was estimated (using the catch ratio from the logbook data) to be 198.0 t, which is below the RBC of 345 t. Total fishing mortality of ocean perch was estimated to be 338.2 t, which is below the combined RBC of 593 t. This indicates that the fishing mortality in 2019–20 would be unlikely to deplete the stock (or its component stocks) to a level below its biomass limit reference point. The stock is therefore classified as **not subject to overfishing**.

Orange roughy (*Hoplostethus atlanticus*)



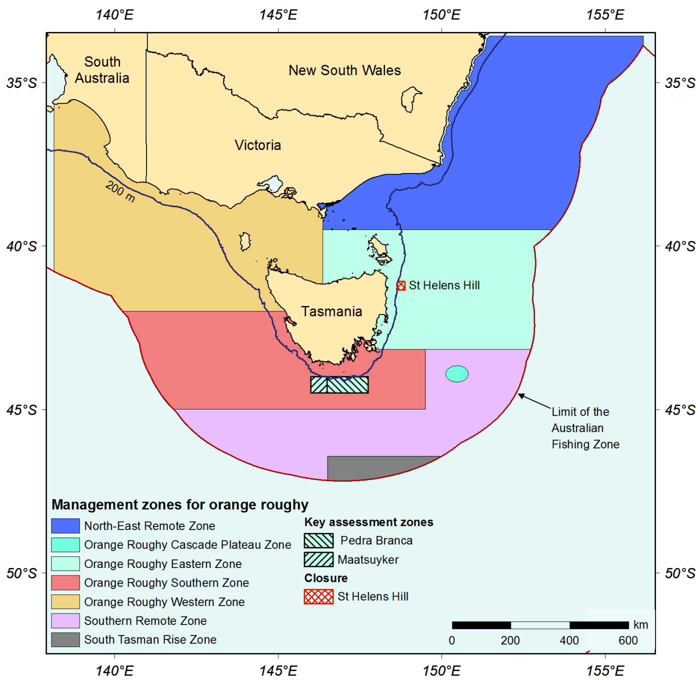
Line drawing: Rosalind Poole

Stock structure

Orange roughy in the CTS is currently broken up into 7 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 also occurs in the Great Australian Bight, reported in Chapter 11.

A study on genetic variation in orange roughy (Gonçalves da Silva, Appleyard & Upston 2012) examined the variation of many 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 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, 9.35a, 9.37 and 9.38, respectively.

In October 2006, orange roughy was listed as conservation-dependent under the EPBC Act and placed under the Orange Roughy Conservation Programme (ORCP) (AFMA 2006). The ORCP was replaced by the Orange Roughy Rebuilding Strategy (ORRS) in 2014 (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 $0.20SB_0$, restricting effort by limiting entry to existing fisheries, and ongoing research and monitoring to support stock assessments.

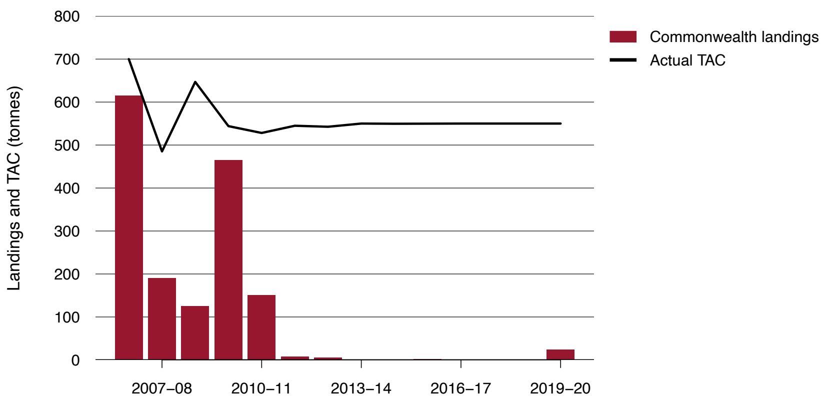
Orange roughy, Cascade Plateau

Catch history

Catch of orange roughy on the Cascade Plateau peaked at 1,858 t in 1990. No catch was taken between 1991 and 1995. While catches have been zero in recent years, 23.6 t was taken in 2019–20. The TAC has remained at 500 t (Figure 9.34).

Commonwealth-landed catch in 2019–20 was 23.6 t, based on CDRs (Figure 9.34). Discards and state catches are not yet available for 2019–20. The weighted average of the previous 4 fishing seasons (2015–16 to 2018–19) is calculated by Burch et al. (2019a). However, for orange roughy on the Cascade Plateau both discards and state catches are not known. For the 2019–20 fishing season, total catch and discards were estimated to be 23.6 t.

FIGURE 9.34 Orange roughy seasonal landings (CTS), and TACs, Cascade Plateau, 2006–07 season to 2019–20 season



Note: TAC total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Orange roughy on the Cascade Plateau in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a).

The last tier 1 assessment in 2006 used acoustic survey abundance indices to assess spawning aggregations on the Cascade Plateau (Wayte & Bax 2007). 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). The base-case model from the 2006 assessment estimated that the spawning stock biomass in 2006 was 73% of the unfished level ($0.73SB_0$) (Wayte & Bax 2007). Because the stock was assessed to be above the $0.6B_0$ reference point, application of the SESSF HSF tier 1 harvest control rules allowed the setting of TACs to enable fish-down towards the target reference point.

An update to this assessment in 2009 used an alternative acoustic biomass estimate for 2005, with the addition of landed catch from 2007 to 2009 (Wayte 2009). The updated assessment estimated that the spawning stock biomass would be $0.64SB_0$ in 2011 if the RBC of 315 t was taken or $0.63SB_0$ in 2011 if the TAC of 500 t was fully caught in 2010 (Wayte 2009).

Low fishing effort for orange roughy on the Cascade Plateau has continued since 2009 and therefore there has been no new data with which to update the assessment. Although updates to the assessment were scheduled for both 2012 and 2014, both were postponed because no new catch or acoustic data (that is, from a new survey) were available. Consequently, due to the low risk to the stock, AFMA has continued to roll over the TAC of 500 t.

Stock status determination

The most recent indicators of biomass identified that the stock was above the target reference point of $0.60SB_0$ (Wayte 2009). Since the last stock assessment update, catches have remained significantly below the long-term RBC, so the stock is expected to be rebuilding. There is no evidence to suggest that the stock has been reduced to below the limit reference point of $0.20SB_0$. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 23.6 t, which is below the long-term RBC of 315 t calculated in the 2009 stock assessment update (Wayte 2009). This indicates that the fishing mortality in 2019–20 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**.

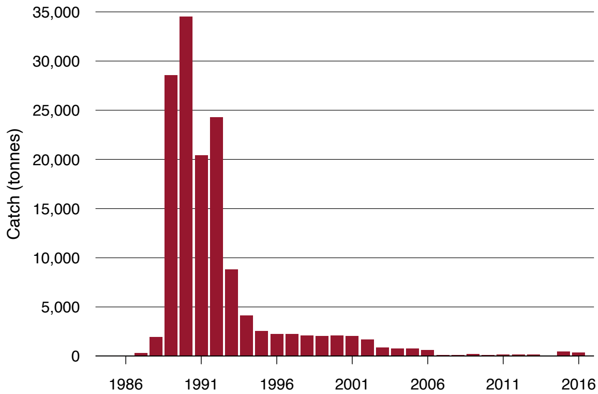
Orange roughy, eastern zone

Catch history

The eastern, southern and western orange roughy fisheries show similar historical 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 9.35a). Following the institution of the ORCP in 2006, orange roughy catch in the eastern zone was limited to incidental catch allowances, to allow for unavoidable catches while targeting other species. Most of the historical fishing grounds for orange roughy deeper than 700 m were 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 that showed the stock was recovering and above the limit reference point of $0.20SB_0$.

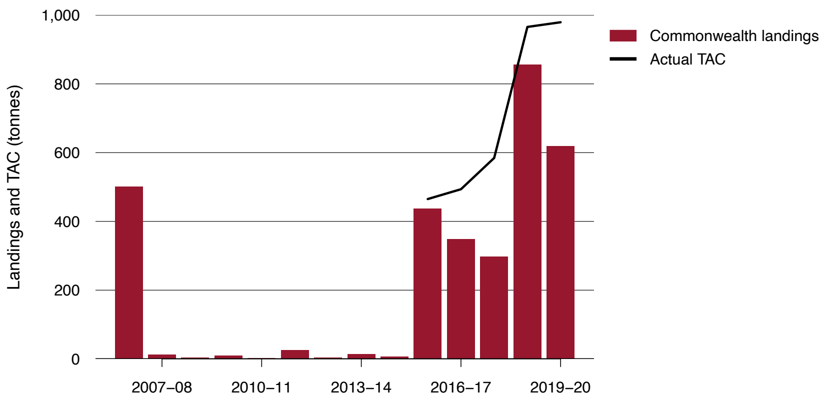
Commonwealth-landed catch in 2019–20 was 618.5 t, based on CDRs (Figure 9.35b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 fishing seasons (2015–16 to 2018–19) was calculated and used to estimate discards of 2.6 t and state catches were zero (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 621.1 t.

FIGURE 9.35a Orange roughy annual catches (CTS), eastern zone, 1985 to 2016



Source: Haddon 2017

FIGURE 9.35b Orange roughy seasonal landings (SESSF) and TACs, eastern zone, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

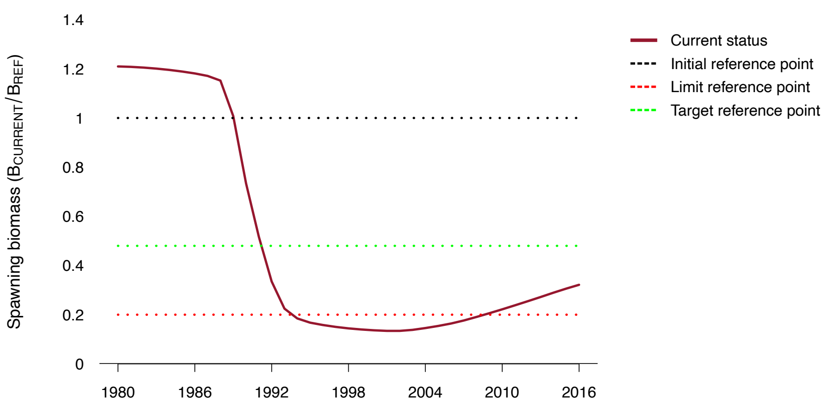
Eastern orange roughy in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a). The 2017 assessment (Haddon 2017) informed the management of the stock for the 2019–20 fishing season. The assumed stock structure is a combination of eastern zone (primarily St Helens Hill and St Patricks Head) and Pedra Branca from the southern zone.

Two models were developed and outlined by Haddon (2017). The first model (base case) 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% ($0.34SB_0$) at the start of 2017. A second, less productive, model was also considered, which used a natural mortality of 0.036 and steepness of 0.6 (M = 0.036; h = 0.6), which resulted in an estimated spawning biomass of 30% ($0.30SB_0$) at the start of 2017.

The consequences of selecting an incorrect model were tested by a risk evaluation. The risk evaluation took the projected catches generated from 1 model and substituted 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). Catches from the less productive model were also substituted into the more productive base-case 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 would gradually recover and possibly reach the target of $0.48B_0$ by 2050 (Haddon 2017). Upon consideration of catch projections, SERAG noted that there was little risk of the stock falling below the limit reference point when adopting an RBC from either model in the short term (that is, the typical 3-year MYTAC period) (AFMA 2017d, 2020).

The 2017 base-case assessment (Haddon 2017) estimated that the spawning stock biomass at the start of 2017 was 34% of the unfished spawning stock biomass ($0.34SB_0$) (Figure 9.36). Forward projection of the base-case assessment led to an RBC of 1,347 t for the 2019–20 fishing season and a 3-year-average RBC of 1,345 t (AFMA 2020; Haddon 2017). AFMA agreed to set the RBC for the 2019–20 fishing season based on the base case of 1,347 t, with an agreement from industry to limit their catches to 900 t in the eastern zone (note this does not include Pedra Branca) (AFMA 2020).

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



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

Stock status determination

The 2017 assessment (Haddon 2017) estimated the spawning stock biomass to be 34% of the unfished level ($0.34SB_0$) at the start of 2017. This was below the target reference point of $0.48SB_0$, but above the limit reference point of $0.20SB_0$. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 621.1 t, which is below the RBC of 1,347 t calculated from the 2017 assessment and below the 900 t TAC. This indicates that the fishing mortality in 2019–20 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**.

Orange roughy, southern and western zones

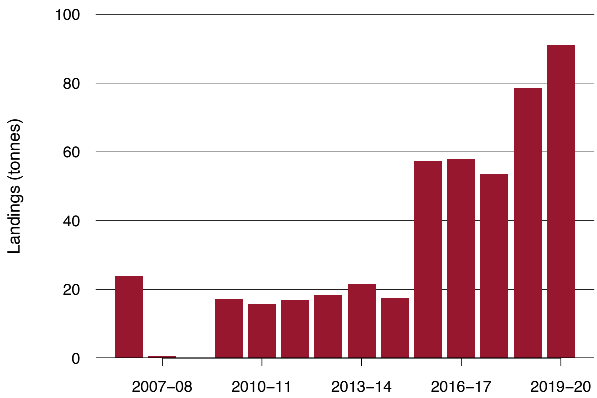
Catch history

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 to 1992 for the eastern and southern zones; 1986 to 1988 for the western zone) and low catches thereafter (Figures 9.36 to 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).

Following the institution of the ORCP in 2006, orange roughy catch in the southern and western zones was limited to incidental catch allowances, to allow for unavoidable catches 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).

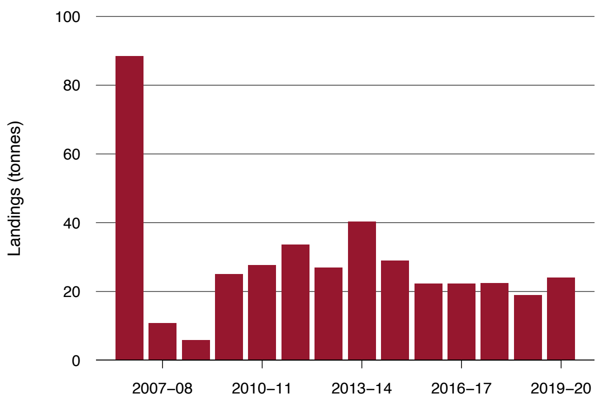
Commonwealth-landed catch in 2019–20 was 115.1 t, based on CDRs, with 91.1 t caught in the southern zone (Figure 9.37) and 24.0 t caught in the western zone (Figure 9.38). Discards and state catches are not yet available for 2019–20. The weighted average of the previous 4 calendar years (2015 to 2018) was calculated by Burch et al. (2019a). Using this method, discards for the 2019–20 season were estimated to be 29.9 t in the west and unknown in the south. State catches are unknown for both west and south. For the 2019–20 fishing season, total catch and discards were estimated to be 145 t.

FIGURE 9.37 Orange roughy seasonal landings (SESSF), southern zone, 2006–07 season to 2019–20 season



Source: AFMA catch disposal records

FIGURE 9.38 Orange roughy seasonal landings (SESSF), western zone, 2006–07 season to 2019–20 season



Source: AFMA catch disposal records

Stock assessment

The southern and western orange roughy stocks are currently managed under the ORRS (AFMA 2015b) with an incidental catch allowance of 94 t and 60 t, respectively.

The last assessment of southern orange roughy in 2000 used standardised catch-per-shot abundance indices from vessels that had regularly fished this zone to estimate abundance in 2001 to be below the limit reference point, at 7% of unfished levels ($0.07SB_0$) (Wayte 2002).

The last accepted assessment of western orange roughy was in 2002. It projected that there was a greater than 90% probability that the 2004 biomass would be less than 30% of the 1985 biomass (Wayte & Bax 2002). A comparison of the age composition in 1994 to 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. 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. In 2020, a Western Orange Roughy Research Plan (WORRP) was approved by the AFMA Commission. The WORRP provides a 200 t research catch allowance for the 2020–21 fishing season to support adequate data collection to inform a tier 1 assessment of the stock to determine if rebuilding has occurred.

Noting recovery of the eastern zone orange roughy stock, and a long period of low TACs in the southern and western zones, SERAG considered that the southern and western zones may be showing some level of recovery (AFMA 2015d, 2019c). Under the ORRS, targeted fishing for both southern and western orange is not permitted, and SERAG continues to advise an RBC of zero. Consequently, AFMA set an incidental catch allowance of 31 t for the 2019–20 fishing season for southern orange roughy, with an additional 63 t allocated for the Pedra Branca area (assessed as part of orange roughy eastern stock described above). AFMA also set an incidental catch allowance of 60 t for the 2019–20 fishing season for western orange roughy.

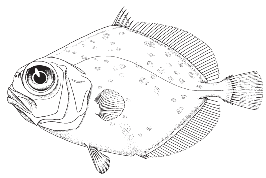
Stock status determination

The most recent indicators of biomass (Wayte 2002; Wayte & Bax 2002) identified that both the southern and western orange roughy stocks were depleted and had been reduced to below their limit reference point of $0.20SB_0$. There is no conclusive evidence to suggest that the stock(s) have rebuilt above this level and therefore they remain classified as **overfished**.

However, given the time that has passed since both 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 orange roughy stocks, and the preliminary age-based surplus production model for the western stock supports this. In the absence of additional information on stock status, it is possible that future biomass status may be classified as uncertain.

For the 2019–20 fishing season, total catch and discards were estimated to be 91.1 t in the south and 53.9 t in the west, which are below the 2019–20 target quota and incidental catch allowance of 94 t and the incidental catch allowance of 60 t, respectively. Spatial closures to trawling of most areas deeper than 700 m are expected to provide an extra layer of protection to both stocks. While in previous years both stocks have been classified as not subject to overfishing, this is inappropriate when (similar to other rebuilding species) 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. To ensure consistency in status across similar stocks, the fishing mortality of both the southern and western orange roughy stocks is classified as **uncertain**.

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.

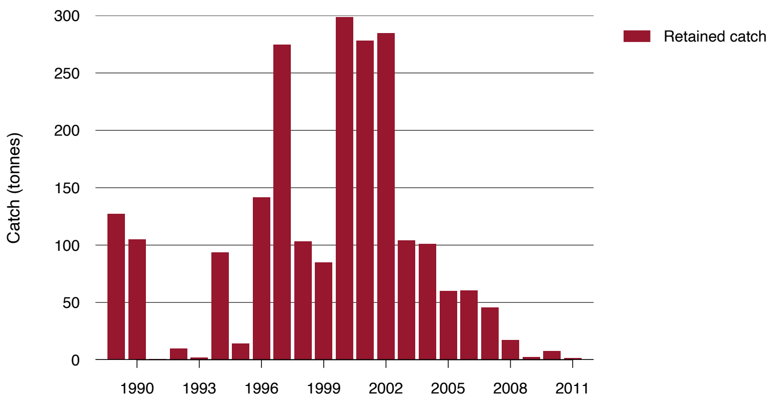
Catch history

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, coinciding with 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 (Figures 9.39a, b). In recent years there has been zero landings. In contrast, catches of smooth oreodory outside the Cascade Plateau exceeded 500 t per year from 1990 to 1995, reaching almost 1,000 t in 1991 and peaking at 2,390 t in 1992 (Figure 9.40a). Catches have been low in the intervening period; however, the recent opening of the Pedra Branca area to orange roughy fishing meant that landings of smooth oreodory have increased (Figure 9.40b) (AFMA 2018b).

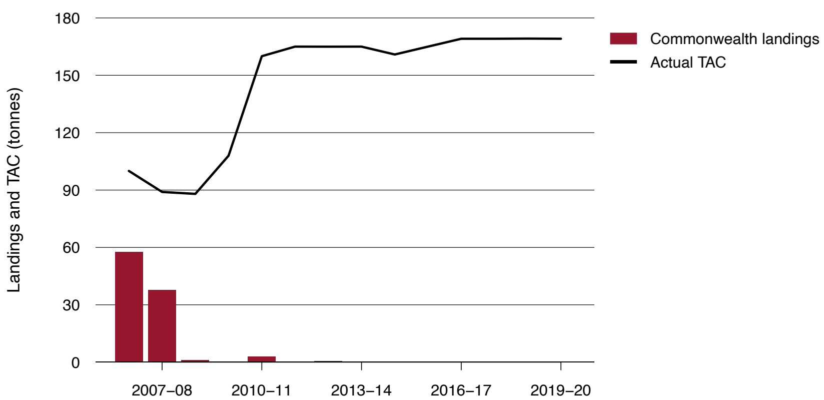
Commonwealth-landed catch in 2019–20 was 75.5 t, based on CDRs (Figure 9.39b and Figure 9.40b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate zero discards for the Cascade Plateau stock and 3.9 t for the non–Cascade Plateau stock (Burch, Althaus & Thomson 2019). State catches are unknown. For the 2019–20 fishing season, total catch and discards were estimated to be 79.4 t.

FIGURE 9.39a Smooth oreodory annual catches (CTS), Cascade Plateau, 1989 to 2011



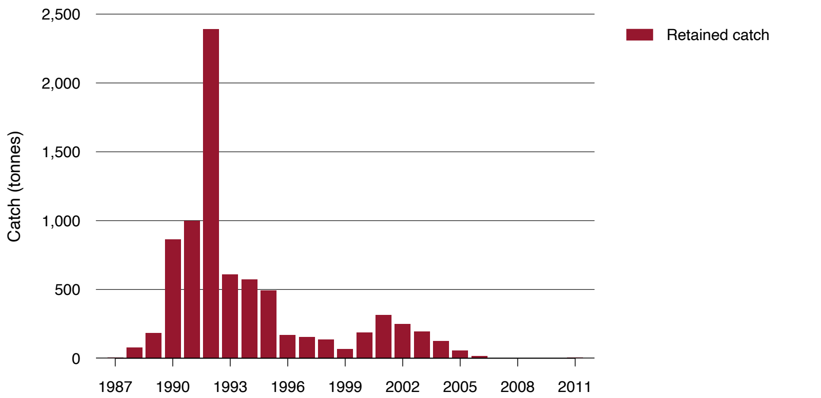
Source: Haddon 2012

FIGURE 9.39b Smooth oreodory seasonal landings (SESSF) and TACs, Cascade Plateau, 2006–07 season to 2019–20 season



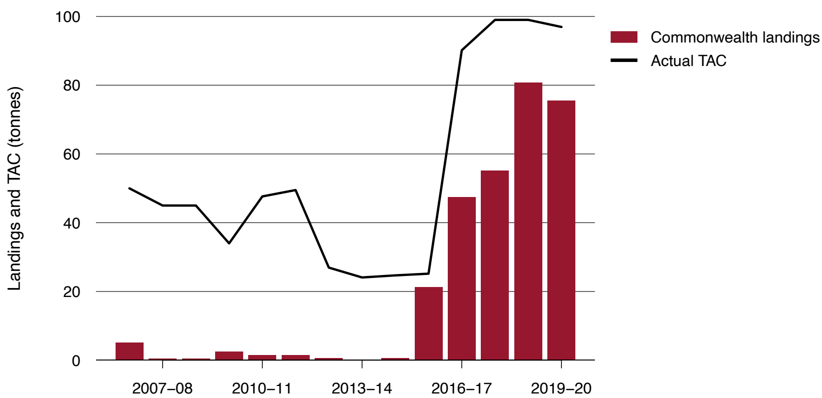
Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

FIGURE 9.40a Smooth oreodory annual catches (CTS), non–Cascade Plateau, 1987 to 2011



Source: Haddon 2012

FIGURE 9.40b Smooth oreodory seasonal landings (SESSF) and TACs, non–Cascade Plateau, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Smooth oreodory (Cascade and non–Cascade Plateau) in Commonwealth fisheries were previously managed as tier 4 stocks under the SESSF HSF (AFMA 2019a). However, due to low catches, the CPUE standardisations in the tier 4 analyses are no longer considered reliable.

The last tier 4 assessment for the Cascade stock in 2010 (using data up to 2009) estimated that the recent average CPUE was above the target reference point; however, the CPUE was extremely variable and considered not indicative of changes in stock status (AFMA 2020). For the 2019–20 fishing season, no RBC was set for the Cascade Plateau stock. The current low effort and catches (less than 10 t per year since 2009) meant that any new tier 4 analysis would be unreliable (AFMA 2018d). Instead, a TAC of 150 t was implemented until catches reach the 10 t trigger (AFMA 2020).

A 2015 tier 5 analysis by CSIRO (Haddon et al. 2015) underpinned the management of non–Cascade Plateau stock for the 2019–20 fishing season. Updating the tier 5 analysis in 2018 was delayed by SERAG, pending work from a subgroup of the Southern and Eastern Scalefish and Shark Fishery Resource Assessment Group to examine 'difficult to assess' stocks, and so the 90 t RBC was rolled over for another year. The tier 5 analysis used 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 to be 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.

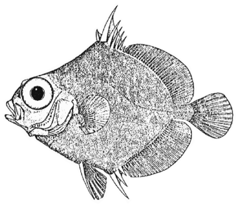
Stock status determination

For the Cascade Plateau stock, the low catches mean that CPUE is unlikely to be a reliable indicator of abundance. The low catches also mean that it is unlikely that there has been 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. The above information suggests it is unlikely that the smooth oreodory stocks have been reduced below the limit reference point, so both stocks (Cascade and non–Cascade Plateau) are classified as **not overfished**.

For the 2019–20 fishing season, there was no catch for the Cascade Plateau stock, and total catch and discards were estimated to be 79.4 t for the non–Cascade Plateau stock, which is below the 90 t RBC calculated using the DBSRA and a weight-of-evidence approach. This indicates that the fishing mortality in 2019–20 would be unlikely to deplete the stocks to a level below their respective biomass limit reference point. Both stocks are therefore classified as **not subject to overfishing**.

Nets
Andrew Sampaklis, ABARES

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



Line drawing: FAO

Stock structure

Other oreodories is 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).

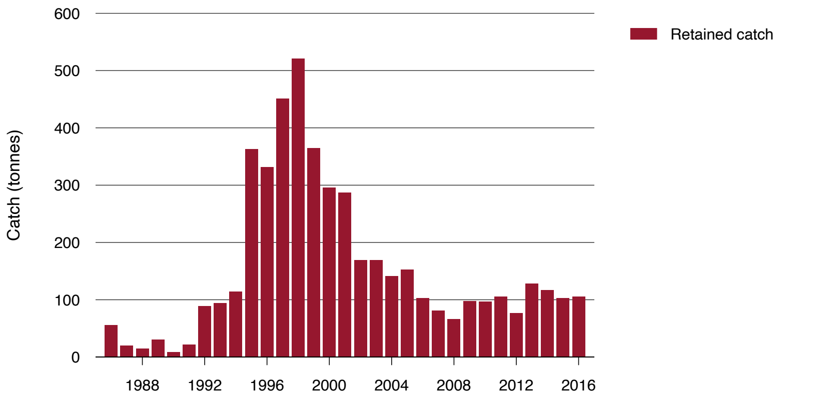
Catch history

Other oreodories have historically been caught as a byproduct of fishing for orange roughy, with catch peaking at 980 t in 1990 (Figure 9.41a). Closure of substantial areas deeper than 700 m (except the Cascade Plateau) to all trawling in 2007 under the ORCP, and then the ORRS in 2014, 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 had 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.

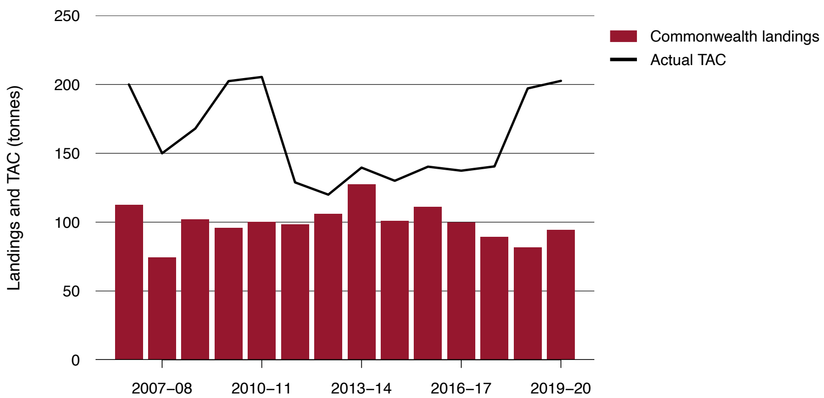
Commonwealth-landed catch in 2019–20 was 169.7 t, based on CDRs (Figure 9.41b). Discards are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards of 156 t (Burch, Althaus & Thomson 2019). It is uncertain if this estimate of discards is reliable after changes to the methodology and an inclusion of another species in the basket since the last assessment. Furthermore, on advice from SERAG, AFMA used the 2017 discard estimate when setting the TAC for the 2020–21 fishing season. State catches are unknown. For the 2019–20 fishing season, total catch and discards were estimated to be 325.7 t.

FIGURE 9.41a Other oreodories annual catches (CTS), 1986 to 2016



Source: Haddon & Sporcic 2017b

FIGURE 9.41b Other oreodories seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

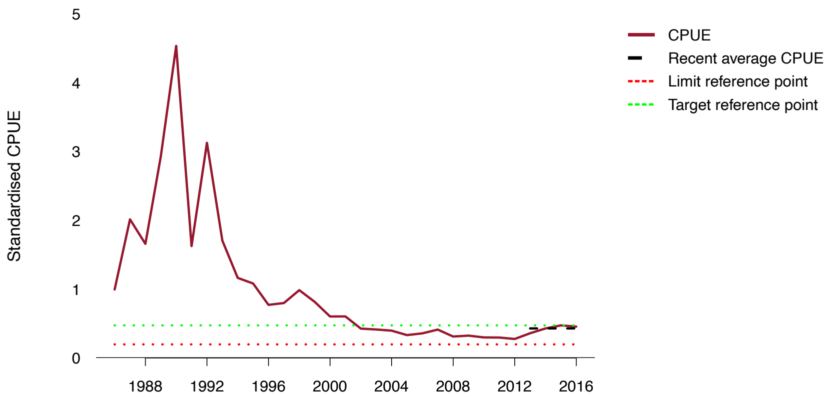
Stock assessment

Other oreodories in Commonwealth fisheries is managed as a tier 4 stock under the SESSF HSF (AFMA 2019a). The 2017 tier 4 analysis (Haddon & Sporcic 2017b) informed the management of the stock for the 2019–20 fishing season.

The tier 4 analysis in 2017 (Haddon & Sporcic 2017b) estimated that recent average CPUE was just below the target reference point of $0.48SB_0$ and produced an RBC of 256 t. In previous analyses, the majority (89%) of the catch has been 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 given the highly aggregating and multispecies nature of the stock. SERAG has previously noted that this stock may also be a potential candidate for a lower target reference point (for example, B_{40}) (AFMA 2019b).

The TAC for the 2019–20 season was set at 185 t, which was the second year of a 3-year MYTAC (AFMA 2019b).

FIGURE 9.42 Standardised CPUE for other oreodories, 1986 to 2016



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

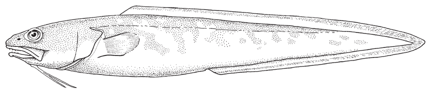
Stock status determination

While noting uncertainties in the CPUE series, the 2017 tier 4 analysis (Haddon & Sporcic 2017b) estimated that other oreodories were just below the target reference point of $0.48SB_0$, but above the limit reference point. The stock is therefore classified as **not overfished**.

Total fishing mortality for the 2019–20 fishing season was estimated to be 325.7 t, which is above the RBC of 256 t calculated from the 2017 analysis. The estimate of discards used in the calculation of total fishing mortality is uncertain after changes to the methodology and inclusion of another species in the basket since the last assessment. When coupled with the uncertainty about the reliability of standardised CPUE as an indicator of biomass, the fishing mortality status of the stock is classified as **uncertain**.

Sorting the catch
Gavin Kewan, AFMA

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 2 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.

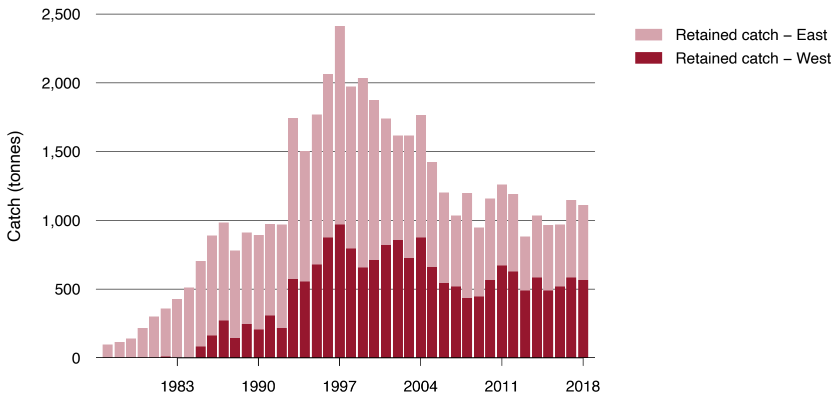
Catches of pink ling are managed under a single TAC. However, AFMA has management arrangements in place to constrain catches of the eastern stock to the eastern catch limit.

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 9.43a). 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 declined and were limited by the TAC. Since 2013–14, catches have been stable at around 800 to 1,000 t.

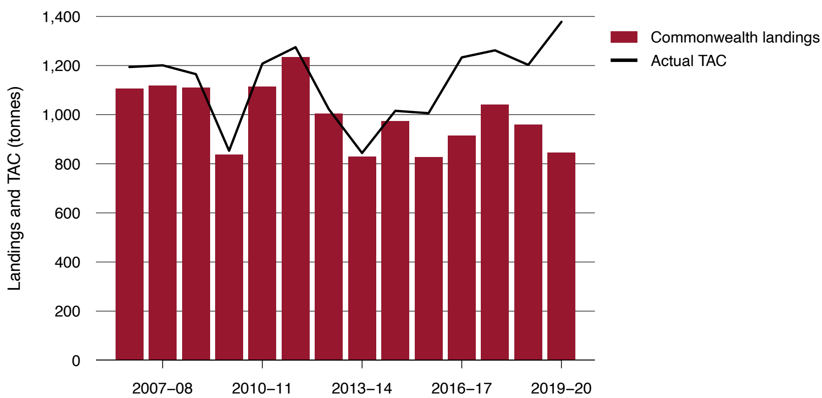
Commonwealth-landed catch in 2019–20 was 834.8 t, based on CDRs (Figure 9.43b). Based on logbook data, around 46% of the catch was from the east and 54% from the west. Discards and state catches are not yet available for 2019–20. However, weighted averages of the previous 4 calendar years (2015 to 2018) were calculated and used to estimate discards and state catches of 22.7 t and 55.5 t, respectively, in the east and 20.8 t and 0.1 t, respectively, in the west (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 933.9 t.

FIGURE 9.43a Pink ling annual catches (CTS, SHS and states) and discards, 1977 to 2018



Source: Cordue 2018

FIGURE 9.43b Pink ling seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

Pink ling in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a). Separate assessments were undertaken for the eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks (Cordue 2018). The 2018 assessment informed the management of the stock for the 2019–20 fishing 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.

For the eastern stock, SERAG noted that there is considerable uncertainty around stock status, as it was heavily dependent on values adopted for natural mortality (M) and which CPUE series is used (that is, whether or not trip limits and fisher avoidance are included) (AFMA 2018a, b). Ultimately, SERAG recommended the use of the most conservative CPUE series, which did not account for management arrangements that restrict catches (for example, trip limits and fisher avoidance), and agreed to use the model-estimated M from the west instead of from the east (AFMA 2018a).

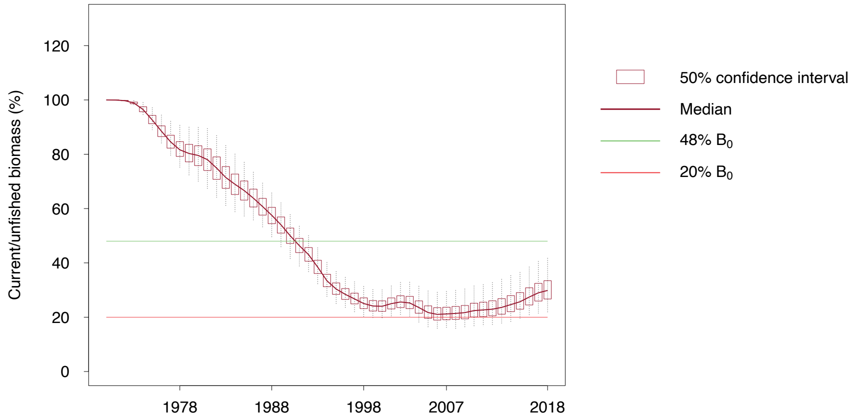
The latest assessment for the eastern stock estimated that the spawning stock biomass at the start of 2018 was 30% of the unfished spawning stock biomass ($0.30SB_0$) (Figure 9.44). This led to an RBC of 260 t for 2019. SERAG recommended setting a notional eastern TAC based on stochastic projections from a range of constant-catch scenarios rather than the RBC (AFMA 2020). Projections of stock response to various constant-catch scenarios indicated that catches up to 550 t posed little (<5%) risk to the stock falling below the limit reference point ($0.20SB_0$) by 2028 (Cordue 2018) (Table 9.3). The stock is expected to be rebuilt to the target reference point ($0.48SB_0$), with at least a 50% probability, in a reasonable time frame (before 2050) for catches up to 500 t per year (Cordue 2018) (Table 9.3). This led to AFMA setting a notional eastern catch limit of 428 t for the 2019–20 fishing season.

For the western stock, SERAG noted that there were no technical difficulties with the assessment, and that both the trawl CPUE time series and spawning stock biomass continue to increase (AFMA 2018a; Cordue 2018).

The latest assessment for the western stock estimated that the spawning stock biomass at the start of 2018 was 84% of the unfished spawning stock biomass ($0.84SB_0$) (Figure 9.45). This led to an RBC of 1,150 t for 2019. Projections of stock response to various constant-catch scenarios indicated that catches up to 1,000 t pose little (<5%) risk to the stock falling below the limit reference point ($0.20SB_0$) by 2028 (Cordue 2018) (Table 9.4).

Pink ling
Andrew Trappett, AFMA

FIGURE 9.44 Estimated spawning stock biomass for eastern pink ling, 1970 to 2018



Note: B_0 unfished biomass.
Source: Cordue 2018

FIGURE 9.45 Estimated spawning stock biomass for western pink ling, 1970 to 2018

Note: B_0 unfished biomass.
Source: Cordue 2018

TABLE 9.3 Base-case 2018 stock assessment performance indicators for eastern pink ling, showing stochastic projections at a range of future constant catches

Annual catch (t)	B_{2021}/B_0	B_{2028}/B_0	Probability $B_{2021}<0.2B_0$	Probability $B_{2028}<0.2B_0$	Rebuild year
0	0.42	0.72	0	0	2023
300	0.37	0.53	0.01	0	2026
400	0.35	0.47	0.02	0.01	2030
450	0.34	0.44	0.02	0.01	2033
500	0.33	0.41	0.04	0.02	>2040
550	0.32	0.38	0.05	0.05	>2050
600	0.32	0.35	0.06	0.11	>2050
650	0.31	0.31	0.08	0.18	>2050

Notes: B_0 Unfished biomass. B_{year}/B_0 Predicted biomass ratio in given year. $B_{year} < 0.2B_0$ Biomass below 20% B_0 in given year. Rebuild year is the projected year for rebuilding to 48%B_0.
Source: Cordue 2018

TABLE 9.4 Base-case 2018 stock assessment performance indicators for western pink ling, showing stochastic projections at a range of future constant catches

Annual catch (t)	B_{2021}/B_0	B_{2028}/B_0	Probability $B_{2021}<0.2B_0$	Probability $B_{2028}<0.2B_0$
600	0.78	0.65	0	0
700	0.76	0.60	0	0
800	0.74	0.54	0	0
900	0.72	0.48	0	0.02
1000	0.70	0.43	0	0.05

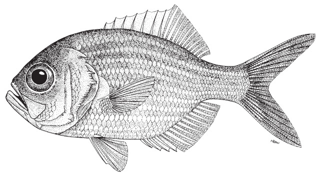
Notes: B_0 Unfished biomass. B_{year}/B_0 Predicted biomass ratio in given year. $B_{year} < 0.2B_0$ Biomass below 20% B_0 in given year.
Source: Cordue 2018

Stock status determination

The 2018 assessment (Cordue 2018) estimated the spawning stock biomass at the beginning of 2018 to be 30% ($0.30SB_0$) and 84% ($0.84SB_0$) of the unfished level (SB_0), in the east and west, respectively. This was below the target reference point of $0.48SB_0$, but above the limit reference point of $0.20SB_0$ in the east and above the target reference point of $0.48SB_0$ in the west. The stocks in both the east and west are therefore classified as **not overfished**.

For the 2019–20 fishing season, total combined catch and discards were estimated to be 834.8 t, which is below the 2019 combined RBC of 1,410 t. The total fishing mortality for eastern pink ling was estimated (using the catch ratio from logbooks) to be 462.2 t, which is above the RBC of 260 t. The total fishing mortality for western pink ling was estimated (using the catch ratio from logbooks) to be 471.7 t, which is below the RBC of 1,150 t. Although total fishing mortality of eastern pink ling was above the RBC, at that mortality level the probability of the biomass being depleted to below $0.2B_0$ in 2021 is less than 0.04% (Table 9.3). Furthermore, the eastern stock is expected to be rebuilt to the target reference point ($0.48SB_0$) with at least a 50% probability in a reasonable time frame (before 2050) for catches up to 500 t per year (Table 9.3). The stock is therefore classified as **not subject to overfishing**.

Redfish (*Centroberyx affinis*)



Line drawing: FAO

Stock structure

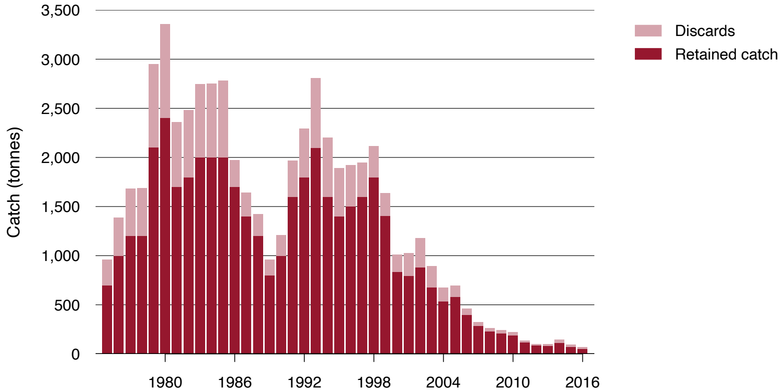
No formal stock delineation studies of redfish have been undertaken in Australia. Tagging studies suggested a single stock of redfish off New South Wales (Morison et al. 2013). However, studies of mean length-at-age suggest differences in growth rates of redfish from the 'northern' and 'southern' sectors of the fishery off eastern Australia (Morison et al. 2013). Previous redfish assessments have therefore assumed that the fishery exploits 2 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, recent assessments in 2014 and 2017 (Tuck & Day 2014; Tuck et al. 2017) assume 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 declined steadily since the late 1990s. TACs have been reduced in recent years, which has led to a further reduction in landings, with recent catches of less than 50 t (Figure 9.46a). A rebuilding strategy that established redfish as an incidental catch-only species was first implemented in 2016 (AFMA 2016a).

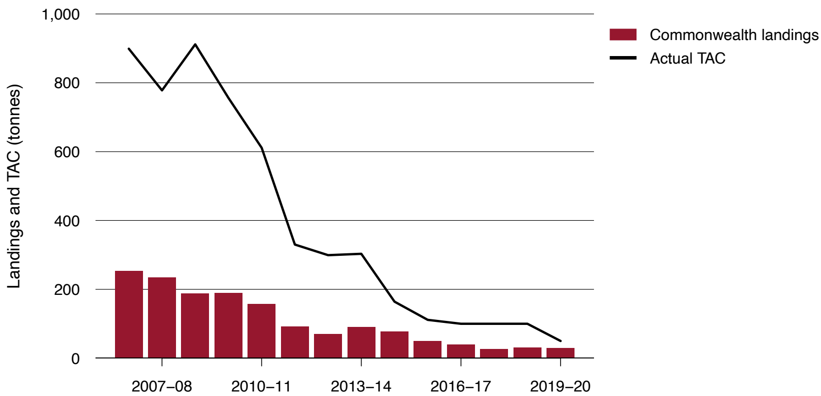
Commonwealth-landed catch in 2019–20 was 29.4 t, based on CDRs (Figure 9.46b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 21.4 t and 6.9 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 57.7 t.

FIGURE 9.46a Redfish annual catches (CTS, SHS and states) and discards, 1975 to 2016



Source: Tuck et al. 2017

FIGURE 9.46b Redfish seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

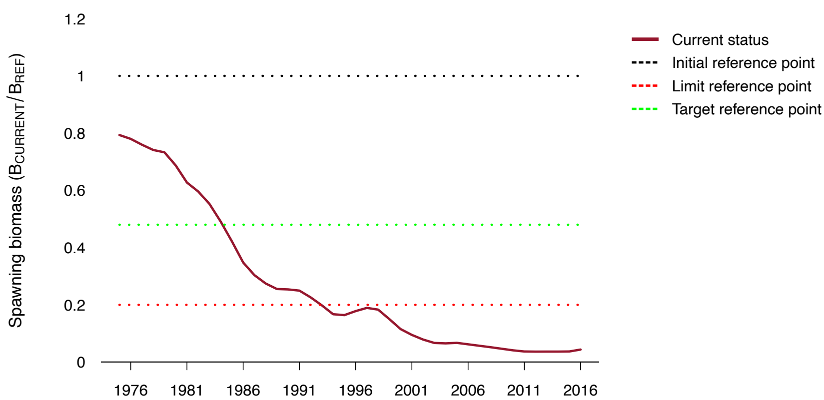
Redfish in Commonwealth fisheries was managed as a tier 1 stock under the SESSF HSF (AFMA 2019a), but has been depleted to below the limit reference point since 1992 (Tuck et al. 2017) and is currently managed under a rebuilding strategy (AFMA 2016a) with an incidental catch allowance of 50 t.

The last tier 1 assessment in 2017 (Tuck et al. 2017) used catch-rate data, length data and conditional age-at-length data up to 2016. The base-case model estimated the spawning stock biomass to be 4% of the unfished level ($0.04SB_0$) in 2016. It also projected that the spawning stock biomass in 2018 would be $0.08SB_0$ (assuming the same catches in 2017 as in 2016) (Figure 9.47). The assessment highlighted that estimates of recruitment since the early 2000s have been lower than average (except for 2011 and 2012), potentially due to environmental changes influencing productivity (Tuck et al. 2017). The assessment included projections of redfish biomass that were based on 2 recruitment (low and average) scenarios. Under the low recruitment scenario (recruitment from 2001 to 2010), the spawning stock biomass took a considerably long time (>40 years) to recover to the limit reference point of $0.2SB_0$, at average annual catches of 50 t, while catches above 150 t were unsustainable (Tuck et al. 2017). Under the average recruitment scenario (recruitment from the stock–recruitment curve), the spawning stock biomass was estimated to reach the limit reference point of $0.2SB_0$ by 2024, based on a zero annual catch (Tuck et al. 2017).

In 2016, a rebuilding strategy was implemented for redfish with the goal of rebuilding stocks to, or above, the limit reference point by or before 2042 (1 mean generation time plus 10 years) (AFMA 2016a). Recruitment will need to be in the order of 'average' to achieve this time frame.

SERAG has also noted that as fishers become more skilled in avoiding redfish, CPUE may become less informative as an index of abundance for the stock, similar to other rebuilding stocks such as blue warehou and eastern gemfish (AFMA 2019d, 2020).

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



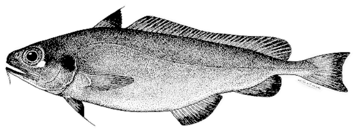
Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Tuck et al. 2017

Stock status determination

The most recent indicators of biomass (Tuck et al. 2017) identified that the stock had been reduced to below the limit reference point of $0.20SB_0$. There is no evidence to suggest that the stock has rebuilt to above this level. The stock is therefore classified as **overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 57.7 t, which is above the incidental catch allowance of 50 t. There is uncertainty as to what effect this level of catch will have on the recovery of the stock. Furthermore, recruitment needs to be at average levels to allow recovery of the stock within the specified time frame, which has been the exception rather than the norm over the past 2 decades. The stock is therefore classified as **uncertain**.

Ribaldo (*Mora moro*)



Line drawing: FAO

Stock structure

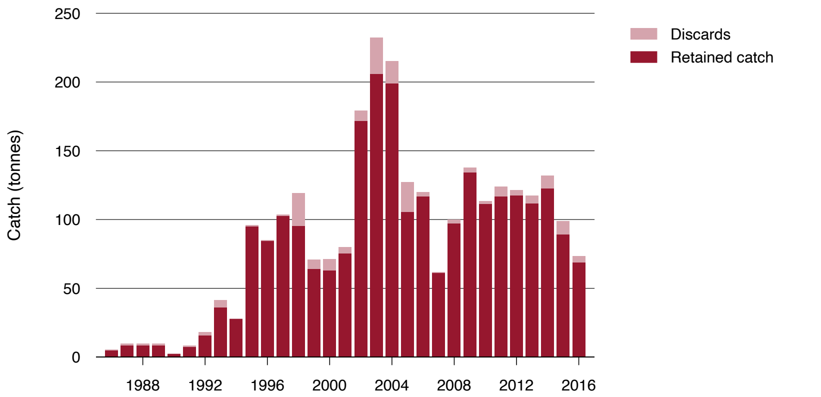
One stock of ribaldo is assumed for assessment and management purposes in the SESSF (Morison et al. 2013).

Catch history

Ribaldo is largely taken as byproduct during fishing for other species, and only 5% of the catch is considered to be targeted (Klaer et al. 2013). Historical catches increased from low levels in 1990 to a peak of more than 200 t in 2003 (Figure 9.48a). Commonwealth-landed catch dropped in 2005 to about 100 t, following implementation of a TAC, and remained below 100 t until the 2018–19 fishing season.

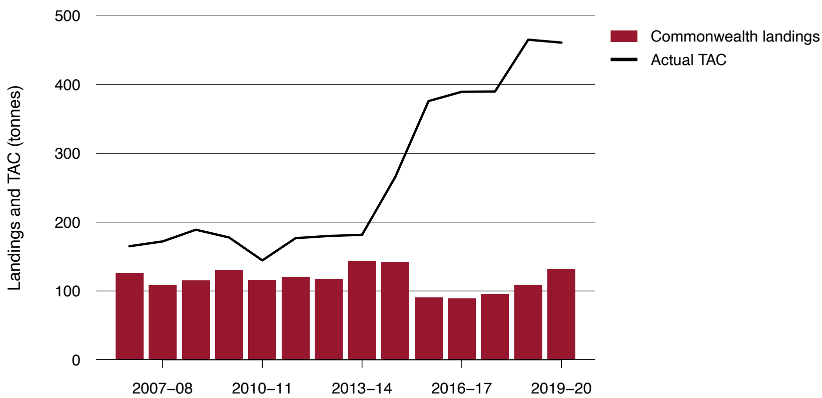
Commonwealth-landed catch in 2019–20 was 128.6 t, based on CDRs (Figure 9.48b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 5.1 t and 2.7 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 136.4 t.

FIGURE 9.48a Ribaldo annual catches (CTS and SHS) and discards, 1986 to 2016



Source: Haddon & Sporcic 2017b

FIGURE 9.48b Ribaldo seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

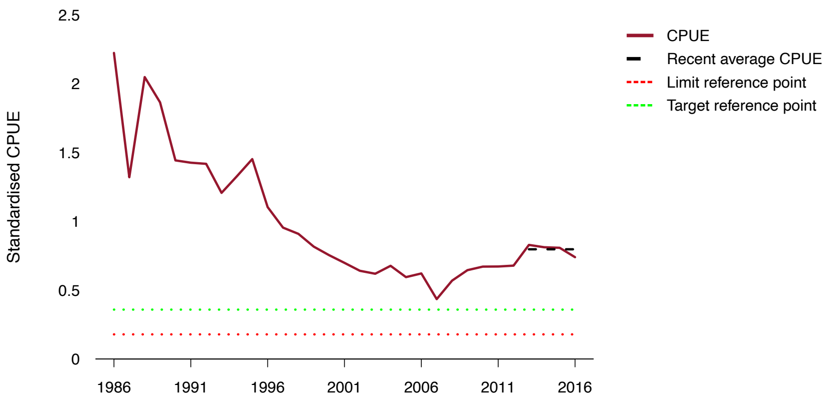
Stock assessment

Ribaldo in Commonwealth fisheries is managed as a tier 4 stock under the SESSF HSF (AFMA 2019a). The 2017 tier 4 analysis (Haddon & Sporcic 2017a) informed the management of the stock for the 2019–20 fishing season. For this stock a 40% ($0.40SB_0$) target reference point is applied.

The tier 4 analysis in 2017 (Haddon & Sporcic 2017b) estimated that the recent average CPUE was above the target reference point, producing an RBC of 430 t (Figure 9.49). An updated CPUE standardisation in 2018 (with data to 2017) showed that CPUE had remained stable (Sporcic & Haddon 2018).

The TAC for the 2019–20 season was set at 422 t, which was the second year of a 3-year MYTAC.

FIGURE 9.49 Standardised CPUE for ribaldo, 1986 to 2016



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

Stock status determination

The 2017 tier 4 analysis (Haddon & Sporcic 2017b) estimated the recent average CPUE to be above the target reference point. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 136.4 t, which is below the RBC of 430 t calculated from the 2017 analysis. This indicates that the fishing mortality in 2019–20 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**.

Royal red prawn (*Haliporoides sibogae*)

Line drawing: FAO

Stock structure

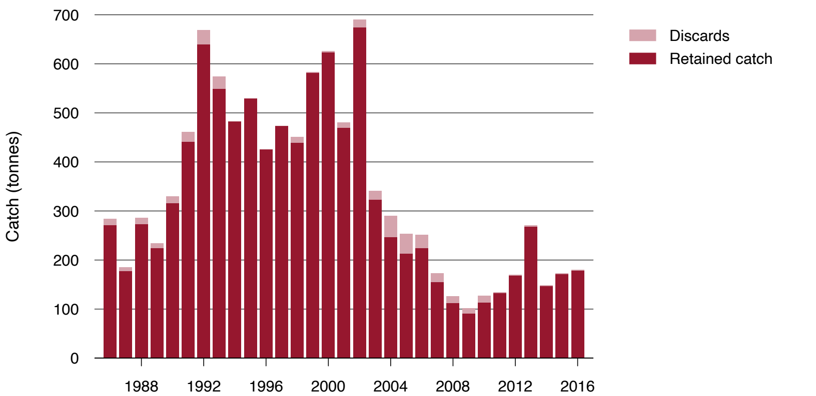
Royal red prawn is widespread, occurring in depths of 350–550 m in the Indian and western Pacific oceans. In Australia, royal red prawn is caught off New South Wales, Queensland and Western Australia between latitudes 10°S and 36°S. Little is known of the stock structure in eastern Australia. Because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

Catch history

Catch of royal red prawn fluctuated around 500 t per year during the 1990s and early 2000s, before declining to stabilise at between 100 and 200 t in recent years (Figure 9.50a). Catch has not approached 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).

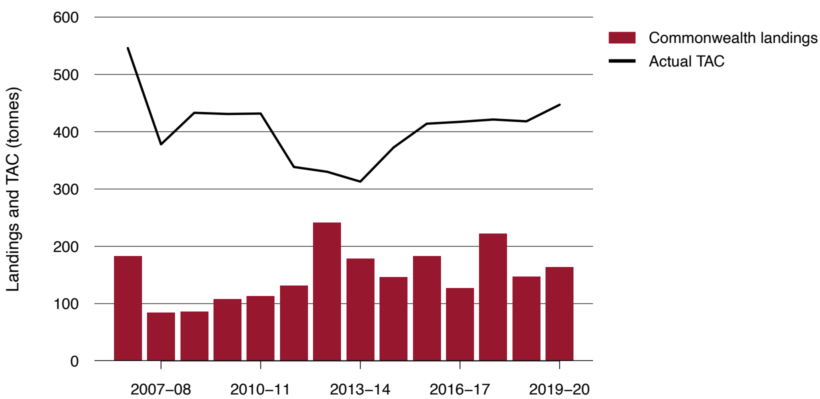
Commonwealth-landed catch in 2019–20 was 163.8 t, based on CDRs (Figure 9.50b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 17.5 t and 9.6 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 190.9 t.

FIGURE 9.50a Royal red prawn annual catches (CTS, SHS and states) and discards, 1986 to 2016



Source: Haddon & Sporcic 2017b

FIGURE 9.50b Royal red prawn seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

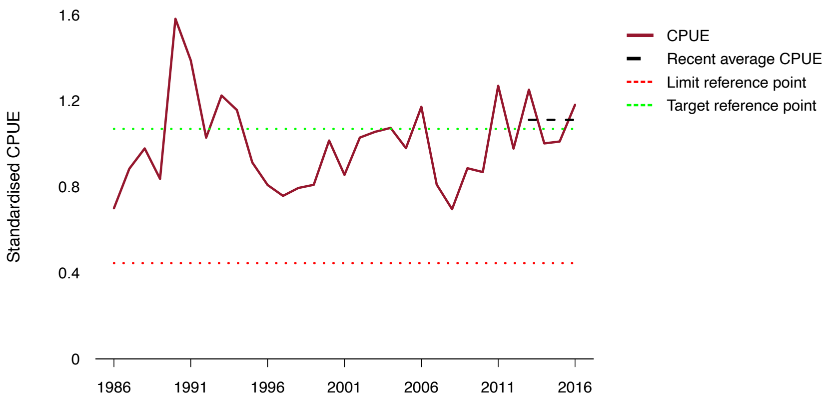
Stock assessment

Royal red prawn in Commonwealth fisheries is managed as a tier 4 stock under the SESSF HSF (AFMA 2019a). The 2017 analysis (Haddon & Sporcic 2017b) informed the management of the stock for the 2019–20 fishing season.

The tier 4 analysis in 2017 (Haddon & Sporcic 2017b) estimated that the recent average CPUE was marginally above the target reference point, producing an RBC of 431 t (Haddon & Sporcic 2017a; see Figure 9.51). 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 2019–20 season was 409 t, which was the second year of a 3-year MYTAC.

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



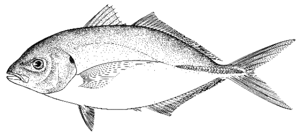
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017b

Stock status determination

The 2017 tier 4 analysis (Haddon & Sporcic 2017b) estimated that the recent average standardised CPUE was above the target reference point. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 190.9 t, which is below the RBC of 431 t calculated from the 2017 analysis. This indicates that the fishing mortality in 2019–20 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**.

Silver trevally (*Pseudocaranx georgianus*)



Line drawing: FAO

Stock structure

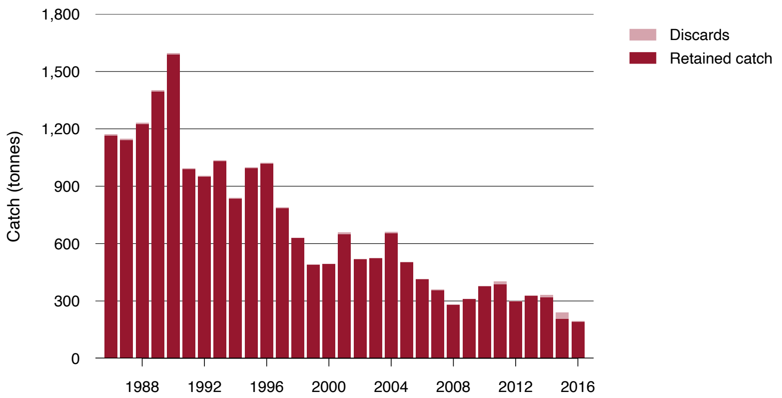
Silver trevally is found in Australian and New Zealand waters. In Australia, it ranges from northern New South Wales, around southern Australia to Western Australia. Little is known of the stock structure, but angler tag–recapture studies on Australia's south-east coast indicate restricted post-settlement movement, potentially leading to ecological stock structuring over moderate (hundreds of kilometers) 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 2 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 9.52a). 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).

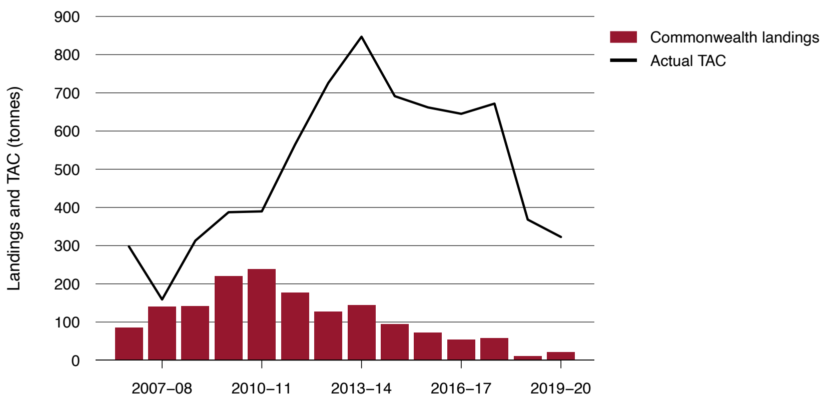
Commonwealth-landed catch in 2019–20 was 21.0 t, based on CDRs (Figure 9.52b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated and used to estimate discards and state catches of 119.6 t and 35.7 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 176.3 t.

FIGURE 9.52a Silver trevally annual catches (CTS, SHS and states) and discards, 1986 to 2016



Source: Haddon & Sporcic 2017b

FIGURE 9.52b Silver trevally seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

Stock assessment

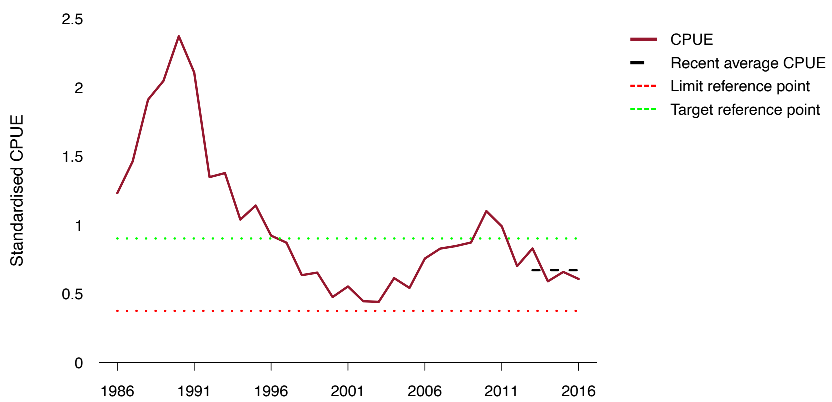
Silver trevally in Commonwealth fisheries is managed as a tier 4 stock under the SESSF HSF (AFMA 2019a). The 2017 analysis (Haddon & Sporcic 2017b) informed the management of the stock for the 2019–20 fishing season.

The tier 4 analysis in 2017 (Haddon & Sporcic 2017b) estimated that the recent average CPUE was below the target reference point of $0.48SB_0$ but above the limit reference point, producing an RBC of 445 t (Figure 9.53). The TAC set for the 2019–20 season was 292 t, which was the second year of a 3-year MYTAC (AFMA 2019b).

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. Analyses in 2013 (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 tier 4 analysis (Haddon & Sporcic 2017b) excluded all data from the marine park. SERAG 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, 2018c). 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 to 2016



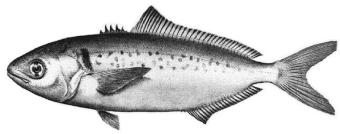
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon & Sporcic 2017b

Stock status determination

The 2017 tier 4 analysis (Haddon & Sporcic 2017b) estimated the recent average standardised CPUE to be between the target and limit reference points. The stock is therefore classified as **not overfished**.

For the 2019–20 fishing season, total catch and discards were estimated to be 176.3 t, which is below the RBC of 445 t calculated from the 2017 analysis. This indicates that the fishing mortality in 2019–20 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**.

Silver warehou (*Seriolella punctata*)



Line drawing: FAO

Stock structure

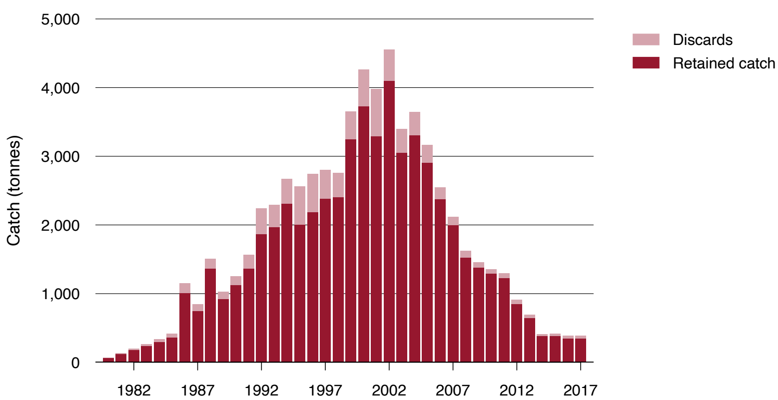
A study on the stock structure of silver warehou using genetics (mitochondrial DNA), morphology, otolith shape and otolith microchemistry did not indicate the presence of separate stocks east and west of Bass Strait, although there were indications of some structuring around Tasmania (Robinson et al. 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 9.54a). Catches have subsequently declined to around 300 t in recent years.

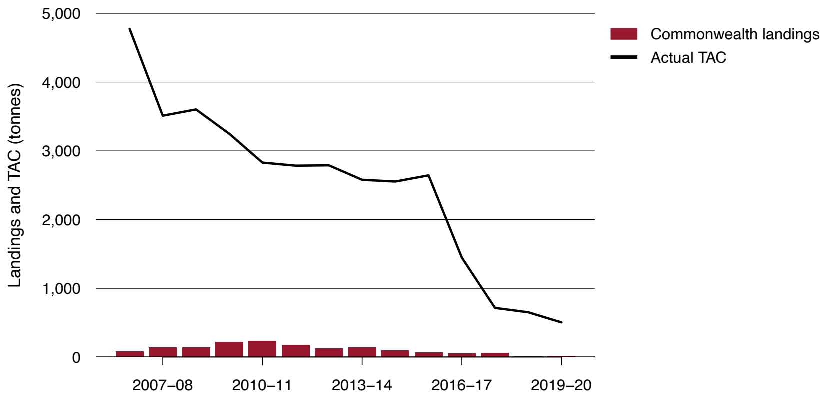
Commonwealth-landed catch in 2019–20 was 306.5 t, based on CDRs (Figure 9.54b). Discards and state catches are not yet available for 2019–20. However, the weighted average of the previous 4 calendar years (2015 to 2018) was calculated an used to estimate discards and state catches of 21.4 t and 6.9 t, respectively (Burch, Althaus & Thomson 2019). For the 2019–20 fishing season, total catch and discards were estimated to be 334.8 t.

FIGURE 9.54a Silver warehou annual catches (CTS, SHS and states) and discards, 1980 to 2017



Source: Burch et al. 2019

FIGURE 9.54b Silver warehou seasonal landings (SESSF) and TACs, 2006–07 season to 2019–20 season



Note: **TAC** total allowable catch.
Source: AFMA catch disposal records

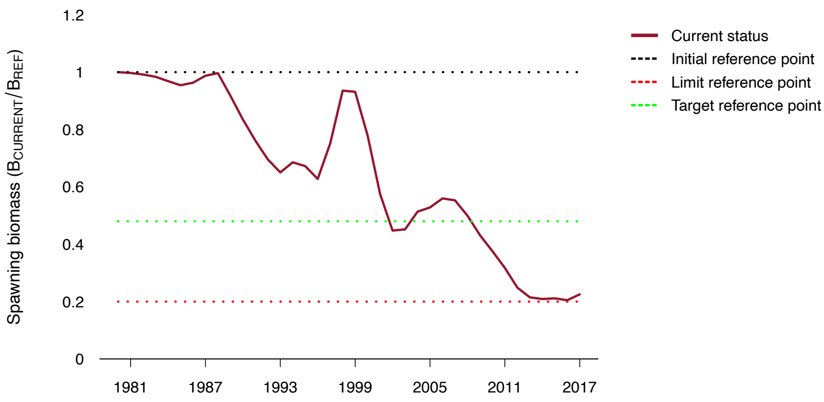
Stock assessment

Silver warehou in Commonwealth fisheries is managed as a tier 1 stock under the SESSF HSF (AFMA 2019a). The 2018 assessment (Burch et al. 2019) informed the management of the stock for the 2019–20 fishing season.

The 2018 assessment (Burch et al. 2019) estimated that the spawning stock biomass at the start of 2018 was 22% ($0.22SB_0$), which was below the target reference point of 48% ($0.48SB_0$) but above the limit reference point of 20% ($0.20SB_0$). This was a reduction from the 2015 assessment (Thomson, Day & Tuck 2015), which predicted the spawning biomass to be 40% ($0.4SB_0$) in 2016. The reduction in the spawning stock biomass between assessments was caused by recent recruitment being revised downwards (Burch et al. 2019). SERAG noted that the spawning stock biomass has been below the target reference point since 2009 and declined to near the limit reference point from 2014 to 2017, before a predicted increase in 2018 (AFMA 2020). The predicted increase through 2018 (to $0.31SB_0$ at the start of 2019) assumes that there will be a return to average recruitment levels (AFMA 2018a). The 2018 assessment led to a single-year RBC of 942 t for 2019.

Because previous assessments have shown a pattern of overly optimistic recent recruitments and increases in stock size, which were not realised in subsequent assessments, SERAG requested that projections be carried out using 2 scenarios of below-average recruitment, assuming stable catches of around 350 t (AFMA 2018b). This included a 'poor' recruitment scenario (the average of a recent 5-year period of poor recruitment) and a 'very poor' recruitment scenario (the average of the worst 3 of these 5 years). Under the assumption of average recruitment (base-case scenario), the return to the target reference point is estimated to occur in about 2030. Projections under the 'poor' recruitment scenario indicate that spawning biomass should increase, but more slowly than under 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 2018b, d). 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 2018b, d). This led to AFMA setting a TAC of 450 t for the 2019–20 fishing season, the first of a 3-year MYTAC.

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



Notes: $B_{CURRENT}$ Current biomass. B_{REF} Unfished biomass.
Source: Burch et al. 2019

Stock status determination

The 2018 assessment estimated the spawning stock biomass to be 22% of the unfished level ($0.22SB_0$) at the beginning of 2018. This was below the target reference point of $0.48SB_0$, but above the limit reference point of $0.20SB_0$. The stock is therefore classified as **not overfished**. Spawning stock biomass for this stock is estimated to be every close to the limit reference point, with a history of poor recruitment. Consequently, this stock should be monitored closely in the future.

For the 2019–20 fishing season, total catch and discards were estimated to be 334.8 t, which is below the 2019–20 RBC of 942 t calculated in the 2018 assessment. Furthermore, catches below 600 t were projected to allow the biomass to gradually increase towards the target reference point, with the risk of falling below the limit reference point being low. This indicates that the fishing mortality in 2019–20 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**.

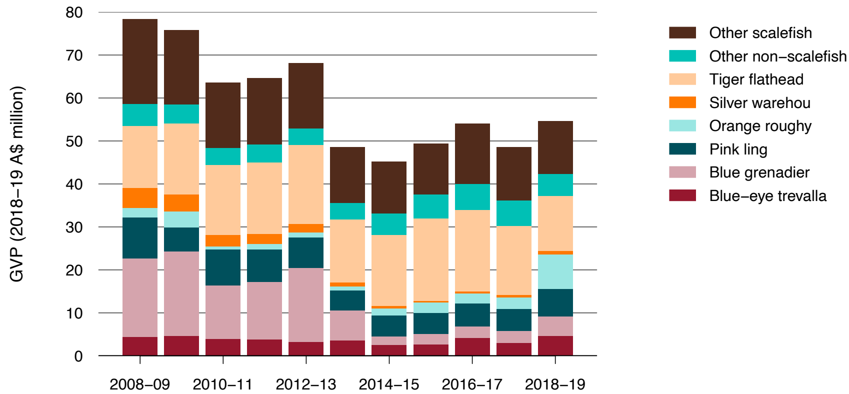
9.3 Economic status

Key economic trends

The CTS and the SHS contributed approximately 49% of total SESSF GVP ($86.85 million) in 2018–19. From 2008–09 to 2012–13, real GVP for the 2 sectors averaged $65.82 million (in 2018–19 dollars; Figure 9.56). By 2013–14, GVP had fallen, and has remained below $50 million since.

Since 2008–09, declines in the value of blue grenadier and silver warehou catches have been the key drivers of the reduction in scalefish GVP. In 2008–09, silver warehou catches were valued at $4.61 million, and blue grenadier catches were valued at $18.26 million. By 2018–19, the GVP of silver warehou catches had declined to $744,000, and blue grenadier catches had declined to $4.55 million. In terms of value during 2018–19, the mix of stocks caught was dominated by tiger flathead ($12.75 million; 26% of total GVP) and pink ling ($6.39 million; 13%).

FIGURE 9.56 Real GVP, by key stocks, for the CTS and the SHS, 2008–09 to 2018–19

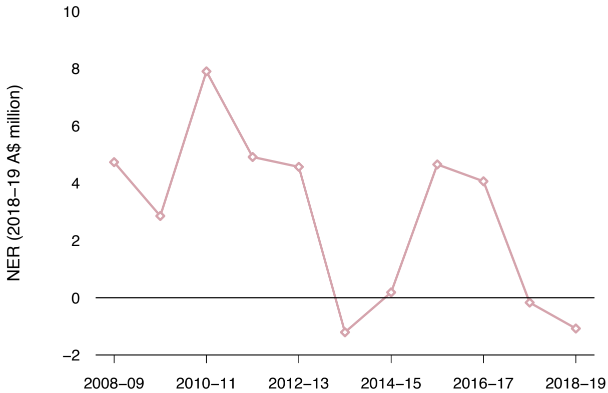


Notes: **GVP** Gross value of production. 'Real' indicates that value has been adjusted for inflation.

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 –$1.21 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 $4.06 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 and –$1.07 million in 2018–19 (Figures 9.57 and 9.58). NER are estimated to have decreased in 2017–18 and 2018–19 because lower levels of income 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.

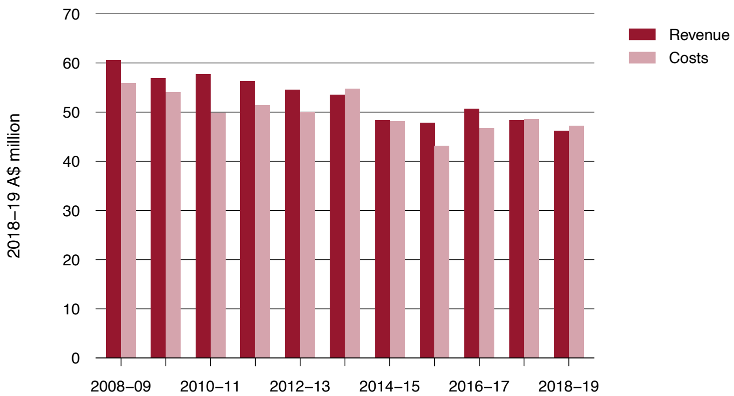
Fish bins
Heather Patterson, ABARES

FIGURE 9.57 NER for the CTS, by financial year, 2008–09 to 2018–19



Notes: **NER** Net economic returns. Results for 2017–18 and 2018–19 are preliminary, non–survey based estimates.

FIGURE 9.58 Revenue and costs for the CTS, by financial year, 2008–09 to 2018–19



Note: Results for 2017–18 and 2018–19 are preliminary, non–survey based estimates.
Source: Mobsby forthcoming

Performance against economic objective

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 maximum economic yield (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 multispecies fisheries and allows management to focus its efforts on optimising the returns gained from key commercial stocks.

The Commonwealth Fisheries Harvest Strategy Policy allows for 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 2018–19, and accounted for 57% of total scalefish GVP in both sectors in 2018–19. 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 4 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). In 2019, a new flathead assessment (Day 2019b, c) estimated spawning stock biomass to be declining to 32% ($0.32SB_0$) in 2018, down from $0.42SB_0$ in the 2016 assessment. As a result, the estimated biomass of tiger flathead in 2018 was below the MEY target. In contrast, the estimated spawning stock biomass for blue grenadier at the start of 2018 was $0.83SB_0$, which was well above the target reference point of $0.48SB_0$. 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 $0.30B_0$, which is below the target reference point. The stock of blue-eye trevalla is between the limit and target reference points. Except for blue grenadier and western pink ling, it can be concluded that economic returns can be increased for the fishery by rebuilding stocks of tiger flathead, eastern pink ling and blue eye trevalla toward the economic target. Improvement in economic returns is also possible if blue grenadier is 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 81% in the 2018–19 fishing season. Latency reduced to 46% in the 2019–20 fishing season. High quota latency in recent years 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 and 2019–20 seasons. 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.

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

9.4 Environmental status

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

9.5 References

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Chapter 10

East Coast Deepwater Trawl Sector

L Georgeson and R Curtotti

FIGURE 10.1 Area of the East Coast Deepwater Trawl Sector, 2019–20

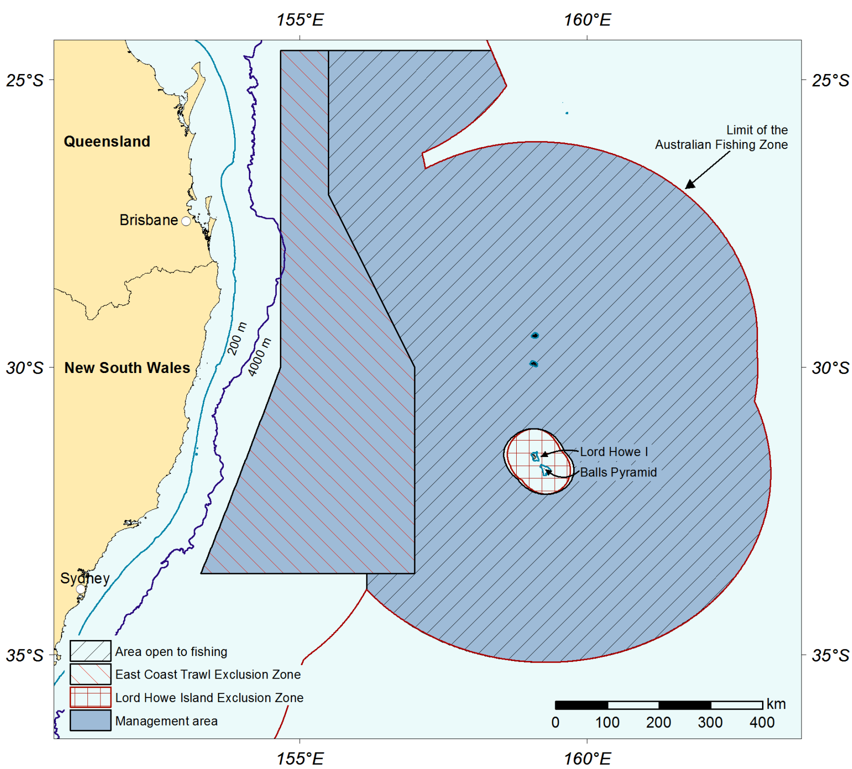


TABLE 10.1 Status of the East Coast Deepwater Trawl Sector

Stock	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
Biological status					
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 and 2019–20. Low historical catch and effort is unlikely to have reduced biomass to below the limit.
Economic status					
The fishery's performance against the economic objective is uncertain. A high level of latency exists for this fishery. No fishing effort between 2013–14 and 2017–18, and low catches in 2018–19 and 2019–20 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 (Figure 10.1). 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 of the SESSF 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*). Historically, important byproduct species have included 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, and AFMA would consider whether any further management or advice is necessary.

Management methods

The fishery operates in accordance with the SESSF harvest strategy framework (AFMA 2019; 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), 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 in the ECDTS has also been variable, with the number of active vessels peaking at 6 in 2001 (108 trawl-hours) and the level of effort in trawl-hours peaking in 2011 (160 trawl-hours), when only 1 vessel was active. There was no effort in the fishery between 2013–14 and 2017–18. A small amount of effort was reported during 2018–19 (9 trawl-hours) and 2019–20 (14 trawl-hours). 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

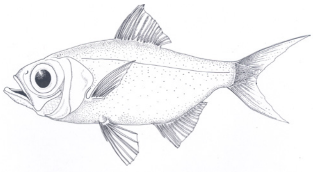
Fishery statistics a	**2018–19 fishing season**			**2019–20 fishing season**	
Stock	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**	**TAC (t)**	**Catch (t)**
Alfonsino	1,017	0	0	1,017	Confidential
Total fishery	**1,267** b	**0**	**0**	**1,267** b	**Confidential**
Fishery-level statistics					
Effort (trawl-hours)	9			14	
Fishing permits	10			9	
Active vessels	1			1	
Observer coverage	0			7 days	
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 to 30 April. **b** Includes a 200 t non-tradeable catch limit for boarfish and a 50 t incidental catch limit for orange roughy. **c** Trawl-hours are currently unable to be reported due to an issue with operators transitioning from hard-copy logbooks to electronic logbooks.

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

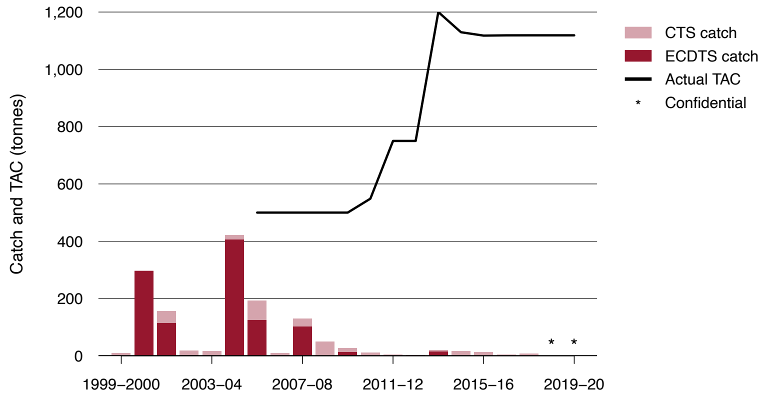
Alfonsino is a widely occurring benthopelagic species that aggregates around seamounts and features on the upper continental slope. Alfonsino in Australia's EEZ is managed as a single management unit across the CTS and the ECDTS, with a single total allowable catch (TAC) that applies only within the 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 and 2019–20 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. Limited catches of alfonsino were reported in logbooks during the 2019–20 season, with catches comprised mostly of frostfish (*Lepidopus caudatus*) and eastern gemfish (*Rexea solandri*). Smaller amounts of blue-eye trevalla, pink ling (*Genypterus blacodes*), tiger flathead (*Neoplatycephalus richardsoni*) and other species comprised the remainder of the catch. Exact quantities of catch taken in 2019–2020 are also withheld, consistent with AFMA's data disclosure policy.

FIGURE 10.2 Catch and TAC for alfonsino in the ECDTS and the CTS, 1999–2000 season to 2019–20 season



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 (derived 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 4 years, was 1,070 t. After applying the tier 3 discount factor (5%; AFMA 2019), AFMA implemented a 3-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 the 2017–18, 2018–19 and 2019–20 fishing seasons.

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. 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 8 hours. There was no fishing activity between 2013–14 and 2017–18. Fishing effort was 9 trawl-hours in 2018–19 and 101 trawl-hours in 2019–20. 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 low levels of activity in the ECDTS.

Performance against economic objective

The fishery's performance against the economic objective is uncertain. The high level of latency, in terms of the proportion of the TAC uncaught, and sporadic catch, suggests that expected profit in the sector is insufficient to justify fishing effort. Given these characteristics, low-cost management arrangements are appropriate. However, management structures may require review if catch begins to trend upwards.

10.4 Environmental status

The ECDTS has not been assessed separately under AFMA's ecological risk assessment process. 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.

In accordance with accreditation under the EPBC Act (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with species protected under the Act were reported in the ECDTS for 2019. Interactions with protected species and impacts on benthic habitats are unlikely to be of concern because of low effort in the fishery in recent years.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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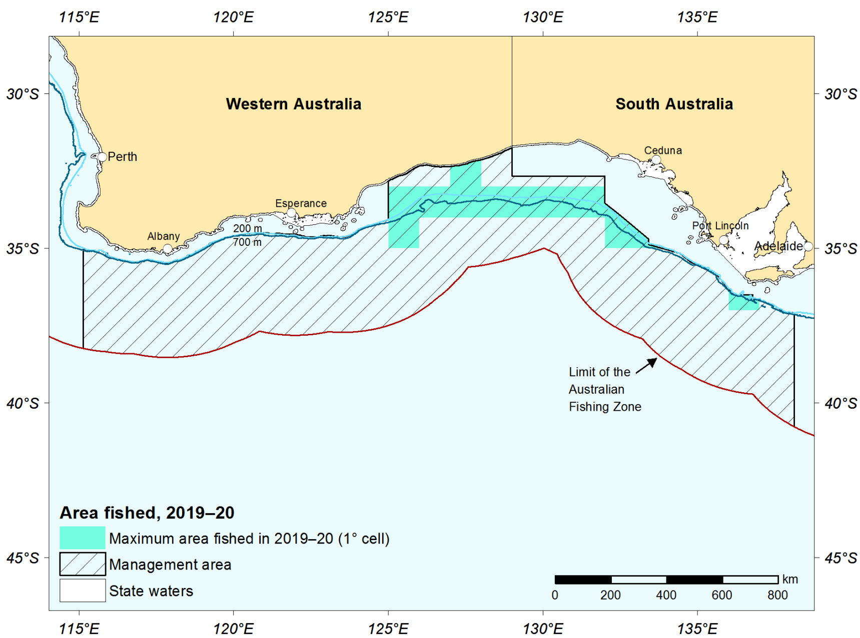
Chapter 11
Great Australian Bight Trawl Sector

A Moore, L Maloney and D Mobsby

FIGURE 11.1 Area fished in the Great Australian Bight Trawl Sector, 2019–20 fishing season



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

TABLE 11.1 Status of the Great Australian Bight Trawl Sector

Stock	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
Biological status					
Bight redfish (*Centroberyx gerrardi*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch is below RBC. Estimate of current biomass is above the target.
Deepwater flathead (*Platycephalus conatus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch is below RBC. Estimate of current biomass is close to the target.
Ocean jacket (*Nelusetta ayraud*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No formal assessment. Recent catches have been low and stable.
Orange roughy (*Hoplostethus atlanticus*)	Not subject to overfishing	Uncertain	Not subject to overfishing	Uncertain	No commercial catch. No formal assessment of biomass, and impact of historical catches is uncertain.

Economic status

An increase in fuel price, together with lower gross value of production, indicate that net economic returns are likely to have been lower in 2018–19 than in 2017–18.

Note: **RBC** Recommended biological catch.

	Green	Red	Yellow
Fishing mortality	Not subject to overfishing	Subject to overfishing	Uncertain
Biomass	Not overfished	Overfished	Uncertain

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 148 t landed in 2019–20. 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 (HSP; 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 rather than the HSP proxy. The Great Australian Bight Resource Assessment Group (GABRAG) considers these estimates of MEY to be appropriate. 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 2019–20 fishing season.

Orange roughy was listed as conservation-dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2006. A deepwater management strategy was implemented to address the requirements of the Orange Roughy Conservation Programme (ORCP; 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. The ORCP was replaced by the Orange Roughy Rebuilding Strategy in 2014 (AFMA 2014), 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. The GABTS Orange Roughy Research Plan was developed by the Great Australian Bight Industry Association (GABIA) to meet the requirements of the ORCP (and now the rebuilding strategy), and was formulated in conjunction with AFMA and relevant RAGs and Management Advisory Committees. 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.

Fishing effort

In 2019–20, total trawl fishing effort across all depths was 13,910 hours, down from the 2004–05 peak of 30,866 hours, but up from the 2018–19 effort of 12,421 hours. The continental shelf continues to be the focus of fishing effort, with 12,659 trawl-hours in 2019–20 (Figure 11.2) compared with 1,122 trawl-hours on the continental slope (Figure 11.3).

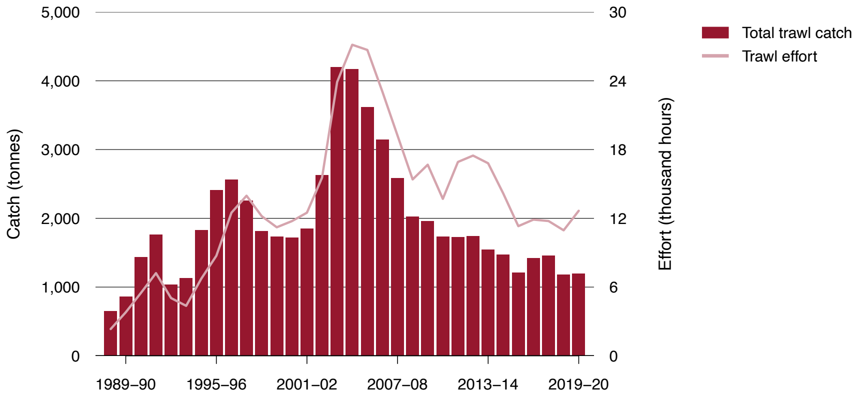
The deepwater fishery historically targeted orange roughy (*Hoplostethus atlanticus*). However, since 2007, most of the historical orange roughy fishing grounds have been closed and little effort has occurred at these depths.

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. Three trawl vessels and 1 Danish-seine vessel operated in the fishery in 2019–20.

Catch

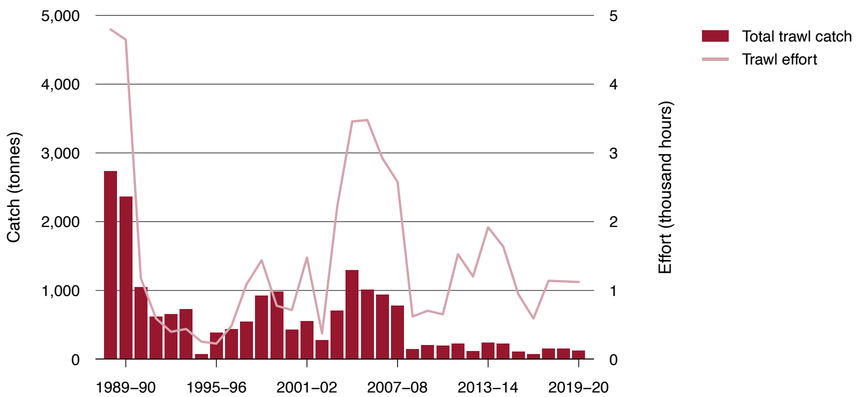
Reduced effort in the fishery has led to reduced catches of key target species over time. Deepwater flathead continues to dominate catches (Table 11.2), with 693 t landed in the 2019–20 fishing season, which was 60% of the TAC (1,128 t in 2019–20). Bight redfish landings in 2019–20 were 170 t, which was 28% of the TAC (600 t in 2019–20). Other species that are important in the GABTS are ocean jacket (148 t), yellow-spotted boarfish (82 t) and angel shark (78 t).

FIGURE 11.2 Catch and effort on the GABTS shelf, 1988–89 season to 2019–20 season



Source: AFMA catch disposal records

FIGURE 11.3 Catch and effort on the GABTS slope, 1988–89 season to 2019–20 season



Source: AFMA catch disposal records

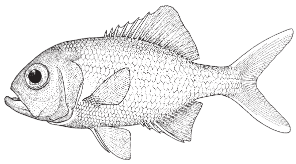
TABLE 11.2 Main features and statistics for the GABTS

Fishery statistics a	2018–19 fishing season			2019–20 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**	**TAC (t)**	**Catch (t)**	**GVP (2019–20)**
Bight redfish	800	220	$1.07 million	600	170	na
Deepwater flathead	1,128	529	$4.14 million	1,128	693	na
Ocean jacket	–	170	$0.41 million	–	148	na
Orange roughy **b**	0 (200, 50)	0 (0, 0)	–	0 (200, 50)	0 (0, 0)	na
Total	**1,928**	**919**	**$8.48 million**	**1,728**	**1,011**	**na**
Fishery-level statistics						
Effort	12,421 trawl-hours; 3,063 shots			13,910 trawl-hours; 3,212 shots		
Fishing permits	10			10		
Active vessels	4 trawl; 1 seine			3 trawl; 1 seine		
Observer coverage	358 trawl-hours (2.88%)			214 trawl-hours (1.54%)		
Fishing methods	Danish-seine, otter 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 to 30 April. Value statistics are by financial year and were not available for the 2019–20 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

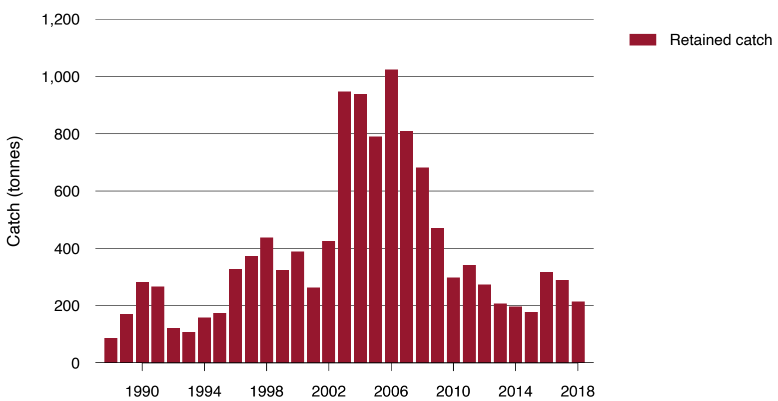
Stock structure

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

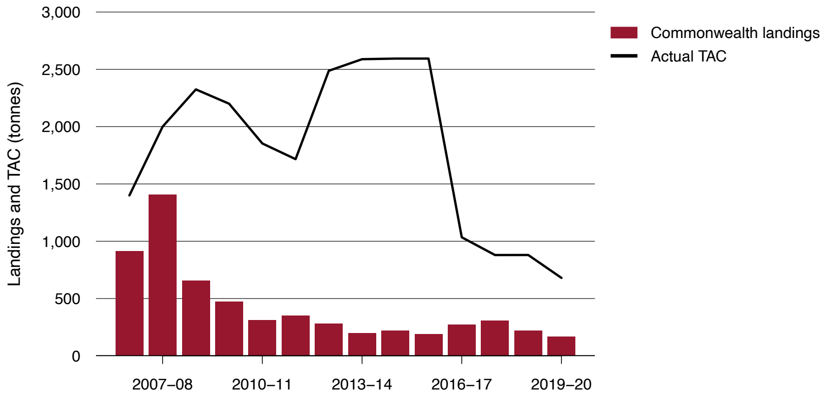
Catch of bight redfish in the GABTS peaked in 2007 at over 1,000 t and has generally declined since then (Figure 11.4a). Commonwealth-landed catch reached a peak of 1,407 t in 2007–08. Most of the additional vessels left the fishery by 2008, and effort decreased to around half of peak levels. Landed catch in the 2019–20 fishing season was 170 t (Figure 11.4b).

FIGURE 11.4a Annual bight redfish catch in the GABTS, 1988 to 2018



Source: Sporcic, Day & Burch 2019

FIGURE 11.4b Annual bight redfish landings and TAC in the GABTS, 2006–07 season to 2019–20 season



Note: **TAC** Total allowable catch.
Source: AFMA catch disposal records

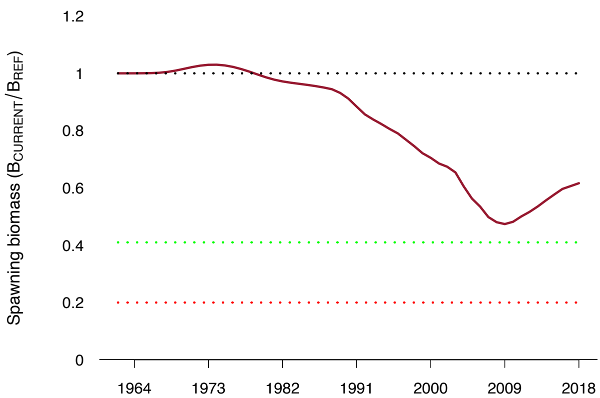
Stock assessment

The target reference point for bight redfish of 41% of the unfished spawning stock biomass ($0.41SB_0$; Kompas et al. 2012) was derived from a bio-economic model of the fishery rather than the HSP proxy and accepted by GABRAG in 2011 (AFMA 2011). The 2015 assessment (Haddon 2015) predicted the spawning biomass at the start of 2016–17 to be $0.62SB_0$.

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) (Knuckey, Koopman & Hudson 2011, 2015). In a 2018 fishery-independent survey, the relative abundance increased to 4,053 t; CV 0.25 (Knuckey, Koopman & Hudson 2018). The GABTS industry has noted a decrease in the availability of bight redfish in recent seasons. Length-frequency data suggest fewer larger bight redfish between 2011 and 2013, but larger fish were found in subsequent years. Ageing data also indicate a reduction in the abundance of older bight redfish, but these reappeared in the most recent data. These changes may reflect movement of fish rather than changes in abundance.

The 2019 tier 1 stock assessment (Sporcic, Day & Burch 2019) estimated the spawning stock biomass in 2018 to be $0.65SB_0$, which is above the target reference point ($0.41SB_0$). The 2019 assessment estimated spawning biomass to be 4,879 t in 2018 (Figure 11.5). While there was an updated assessment in 2019, the 2015 assessment informed the management of the stock for the 2019–20 fishing season. The 2015 tier 1 produced an RBC under the 20:35:41 harvest control rule of 1,024 t for the 2020–21 fishing season and a long-term average RBC of 912 t. The 2019–20 bight redfish TAC was set at 600 t. The TAC was set lower than the RBC due to concerns over the large decrease in relative abundance from the 2015 fishery-independent survey and because the TAC was set for 5 years.

FIGURE 11.5 Estimated spawning biomass of bight redfish in the GABTS, 1962 to 2018

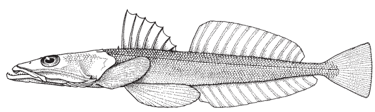


Source: Haddon 2015

Stock status determination

The 2019 stock assessment estimated spawning biomass in 2020–21 to be above the target reference point. Catch in recent seasons continues to be well below the RBC. This indicates that the fishing mortality is unlikely to have depleted the stock to a level below its biomass limit reference point. On this basis, bight redfish is classified as **not overfished** and **not subject to overfishing**.

Deepwater flathead (*Platycephalus conatus*)



Line drawing: Karina Hansen

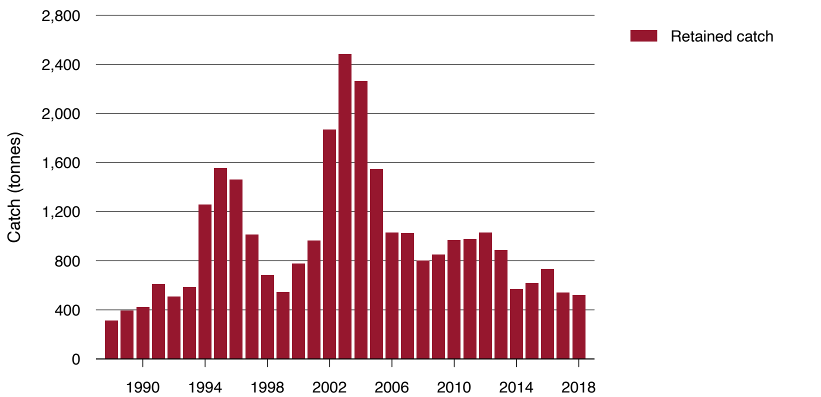
Stock structure

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

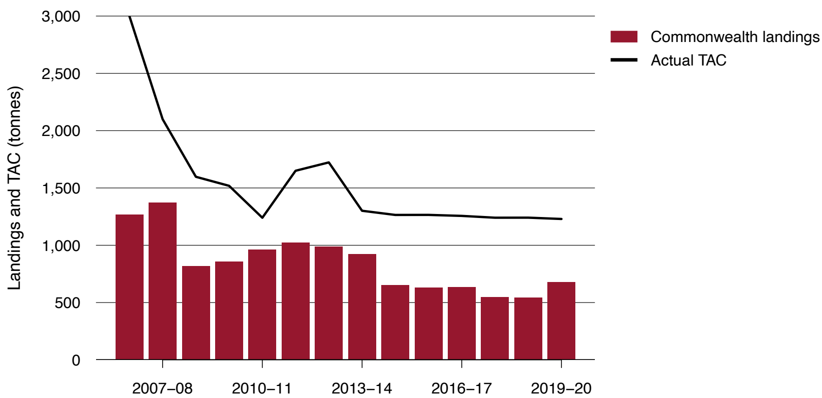
Catch of deepwater flathead peaked at 2,629 t in 2004 (Figure 11.6a). Commonwealth landings have been relatively stable at, or at less than, 1,000 t since 2008–09 (Figure 11.6b). It would appear industry capacity and variability in catch rates are leading to catches consistently below the TAC. Landed catch in the 2019–20 fishing season was 693 t (Figure 11.6b).

FIGURE 11.6a Annual deepwater flathead catch in the GABTS, 1988 to 2018



Source: Tuck, Day & Burch 2019

FIGURE 11.6b Annual deepwater flathead landings and TAC in the GABTS, 2006–07 season to 2019–20 season



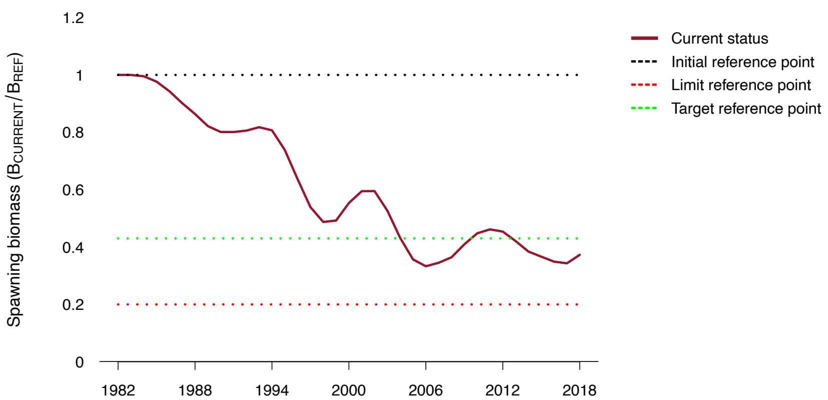
Note: **TAC** Total allowable catch.
Source: AFMA catch disposal records

Stock assessment

The target reference point for deepwater flathead of $0.43SB_0$ was derived from a bio-economic model of the fishery rather than the HSP proxy (Kompas et al. 2012) and accepted by GABRAG in 2011 (AFMA 2011). The 2016 tier 1 stock assessment for deepwater flathead (Haddon 2016) predicted the spawning biomass at the start of 2019–20 to be 44% ($0.44SB_0$) of unexploited biomass. The 2019 tier 1 assessment (Tuck, Day & Burch 2019) predicted spawning biomass at the start of 2018 to be $0.37SB_0$, which was below the target reference point of $0.43SB_0$ (Figure 11.7). The biomass in 2018 was estimated to be 3,358 t. The 2016 assessment using the 20:35:43 harvest control rule produced an RBC of 1,218 t, with a TAC set at 1,128 t for the 2019–20 fishing season. While there was an updated assessment in 2019, the 2016 assessment informed the management of the stock for the 2019–20 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 2011, 2015). The relative biomass estimated from the 2018 fishery-independent survey showed a further decline to 3,396 t (Knuckey, Koopman & Hudson 2018). However, updated stock assessments suggested no change in depletion rate between 2013, 2016 and 2019 (Haddon 2016; Klaer 2013; Tuck, Day & Burch 2019), although the estimate of spawning stock biomass decreased to 4,083 t. The tier 1 assessment provided good fits to the catch rate, length and age data, but a poor fit for the fishery-independent trawl data (Tuck, Day & Burch 2019). These changes may reflect movement of fish rather than changes in abundance. There is no evidence of a truncation in size or age structure of deepwater flathead (Tuck, Day & Burch 2019).

FIGURE 11.7 Estimated spawning biomass of deepwater flathead in the GABTS, 1982 to 2018

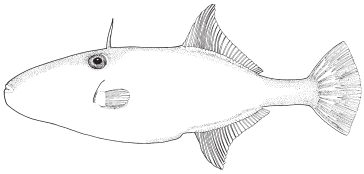


Source: Haddon 2016

Stock status determination

The 2019 stock assessment estimated spawning biomass in 2020–21 to be above the target reference point. Catch in recent seasons continues to be below the RBC. This indicates that the fishing mortality is unlikely to have depleted the stock to a level below its biomass limit reference point. On this basis, deepwater flathead is classified as **not overfished** and **not subject to overfishing**.

Ocean jacket (*Nelusetta ayraud*)



Line drawing: FAO

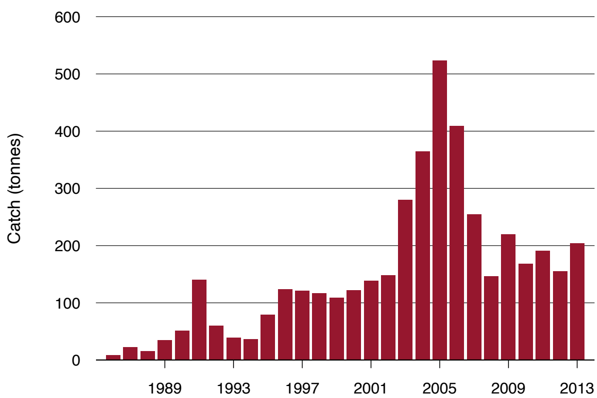
Stock structure

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

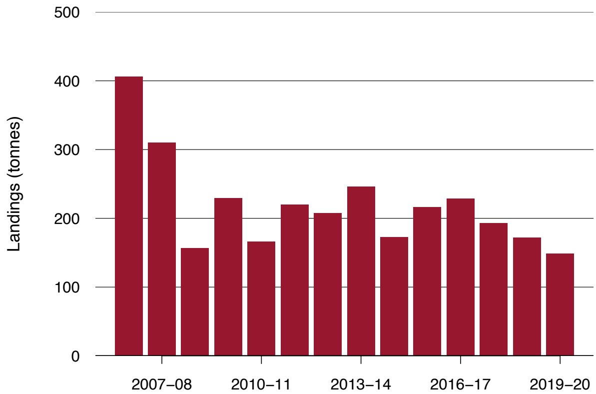
Catch of ocean jacket peaked in 2005 at 527 t (Figure 11.8a). Commonwealth-landed catch has been less than 250 t since 2008–09 and was 148 t in the 2019–20 fishing season (Figure 11.8b).

FIGURE 11.8a Annual ocean jacket catch in the GABTS, 1986 to 2013



Source: Sporcic & Haddon 2014

FIGURE 11.8b Annual ocean jacket landings in the GABTS, 2006–07 season to 2019–20 season



Source: AFMA catch disposal records

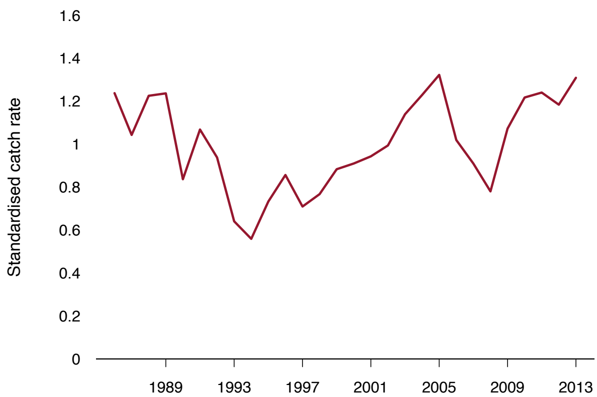
Stock assessment

Formal stock assessments are not conducted for ocean jacket in the GABTS. However, standardised catch rates are analysed for the stock (Sporcic & Haddon 2019). Standardised catch rates have been variable through time, with the most recent catch rates similar to those at the start of the series (1986), and have been relatively stable over the past 5 years (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 6 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 to 2013

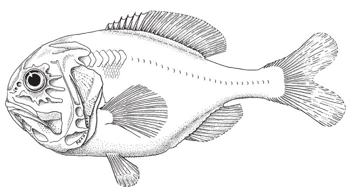


Source: Sporcic & Haddon 2014

Stock status determination

No formal stock assessment for ocean jacket in the GABTS has been done. However, recent catch rates are relatively stable and on par with those at the start of the series. Additionally, recent catches have been low and unlikely to have driven the stock into an overfished state. 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 9.34, Chapter 9).

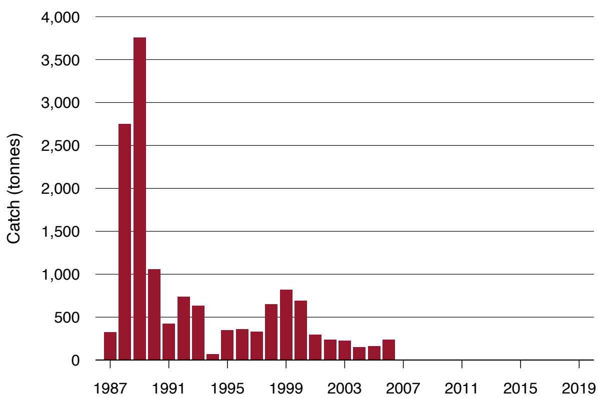
Gonçalves da Silva, Appleyard & Upston (2012) examined variation in a large number of loci using genetic techniques that can detect low levels of genetic differentiation. The study concluded that orange roughy in the AFZ form a single genetic stock, but identified some differentiation between Albany/Esperance, 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 the stock was no longer found on those grounds (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/h) 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. 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 2019–20 fishing season.

FIGURE 11.10 Orange roughy catch in the GABTS, 1987–2019



Source: AFMA catch disposal records

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 in the late 1980s. 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.

More than 96% of the historical catch (1988 to 2005) and more than 99% of the more recent catch (2001 to 2005) was taken in areas that have since been closed to orange roughy fishing through the ORCP (replaced by the Orange Roughy Rebuilding Strategy in 2014; AFMA 2014). Until sustainable harvest levels can be determined, fishing will only be allowed in closed zones under a research program that has been approved by AFMA. The orange roughy incidental catch allowance (Albany and Esperance) remained at 50 t for the 2019–20 fishing season, with zero reported catch.

Stock status determination

Given that there was no catch of orange roughy in the sector in 2019–20, the stock is classified as **not subject to overfishing**. No recent survey or representative catch-trend data are available to determine the abundance of orange roughy in relation to reference points. As a result, the level of biomass of this stock is classified as **uncertain**.

Trawl vessel
Tristan New, AFMA

11.3 Economic status

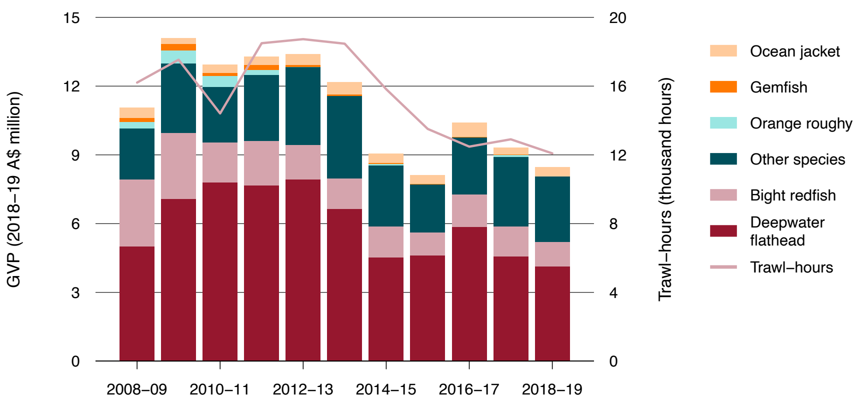
Key economic trends

Gross value of production (GVP) in the GABTS declined by 7% in 2018–19 to $8.5 million. This was the result of a fall in landed catch more than offsetting an increase in average prices. The value of deepwater flathead—a key commercial stock in the sector—declined by 9% to $4.1 million (to be around 50% of total GVP), and the value of bight redfish (the second most valuable stock caught in the sector) fell by 17% to $1.1 million (to be around 13% of total GVP).

Between 2008–09 and 2018–19, GVP in the GABTS declined by 23% in real terms (Figure 11.11). Reductions in GVP occurred across a number of species; however, deepwater flathead and bight redfish accounted for most of the decline. Since 2008–09, there has been a trend of declining GVP, which has been the result of a similar declining trend in landed catch more than offsetting a rise in average prices.

Changes in hours trawled have generally been closely related to changes in GVP over the period 2008–09 to 2018–19 (Figure 11.11). Hours trawled in the sector decreased by 25% from the 2008–09 fishing season to the 2018–19 fishing season, while GVP declined by 23% in real terms between the 2008–09 and 2018–19 financial years.

FIGURE 11.11 Real GVP for the GABTS by key stock and trawl-hours, 2008–09 to 2018–19



Notes: **GVP** Gross value of production. Trawl-hours do not include Danish-seine effort. 'Real' indicates that value has been adjusted for inflation.

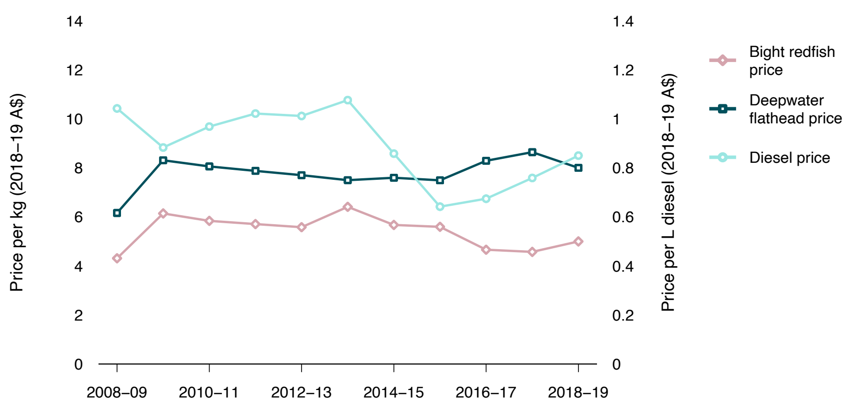
Performance against economic objective

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 2 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 GABIA 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.

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).

FIGURE 11.12 Annual average prices for deepwater flathead and bight redfish, and annual average off-road diesel price, 2008–09 to 2018–19



Note: The off-road diesel price is the price per litre paid by farmers (excludes goods and services tax).

Estimates of net economic returns (NER) for the GABTS are not available. In 2018–19, the average off-road diesel price increased by 14%, while total trawl-hours declined by only 6%. This, combined with lower GVP in 2018–19, suggests that NER are likely to have been lower in 2018–19 than in 2017–18.

The most recent stock assessment for bight redfish estimates biomass to be above the target (Sporcic, Day & Burch 2019), 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 above the MEY target (Sporcic, Day & Burch 2019). Hence, it is unlikely that profitability in the fishery is being constrained by stock size.

11.4 Environmental status

The GABTS ecological risk management report (AFMA 2008, 2012b, 2015) indicated that 2 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 1 of the following mitigation devices: sprayers, bird bafflers or pinkies with zero discharge of fish waste.

In accordance with accreditation under the EPBC Act (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with species protected under the EPBC Act were reported in the GABTS in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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Chapter 12

Shark Gillnet and Shark Hook sectors

J Woodhams, T Emery and R Curtotti

FIGURE 12.1 Fishing intensity in (a) the Shark Gillnet Sector and (b) the Shark Hook Sector of the Southern and Eastern Scalefish and Shark Fishery, 2019–20 fishing season

(a)

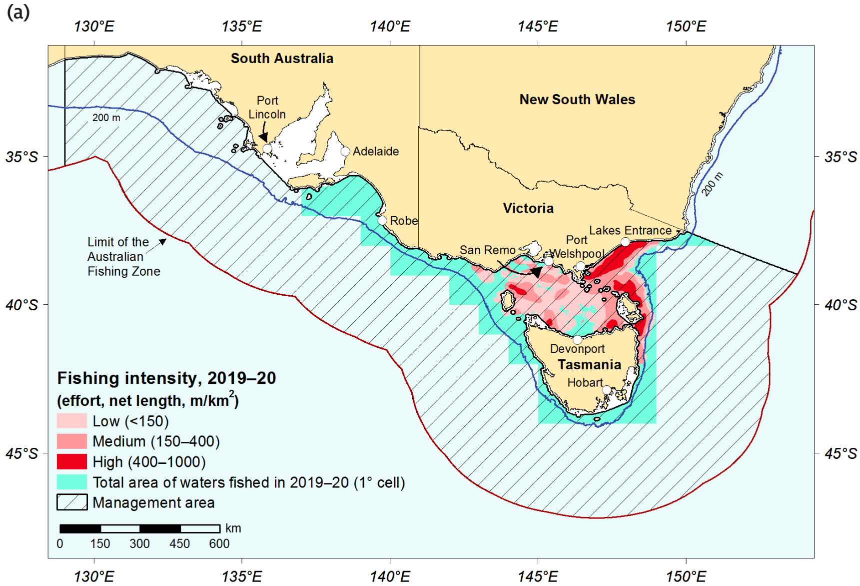
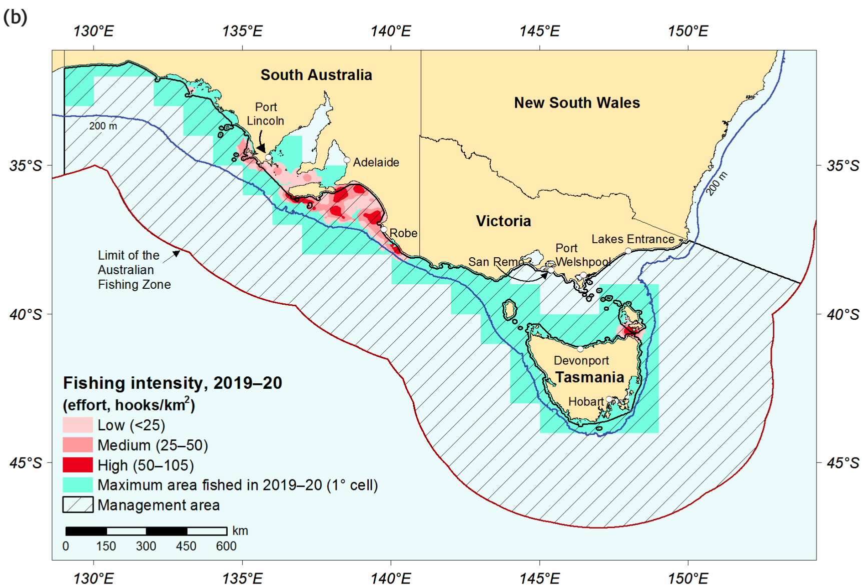


FIGURE 12.1 Fishing intensity in (a) the Shark Gillnet Sector and (b) the Shark Hook Sector of the Southern and Eastern Scalefish and Shark Fishery, 2019–20 fishing season continued



Gummy shark being unloaded
AFMA

TABLE 12.1 Status of the Shark Gillnet and Shark Hook sectors

Biological status					
Stock	2018		2019		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Elephantfish (*Callorhinchus milii*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Recent catches are unlikely to drive the stock into an overfished state. Recent CPUE is relatively stable and above the limit reference point, indicating stability in biomass and fishing mortality.
Gummy shark (*Mustelus antarcticus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Recent catches are below RBC. Estimates of pup production are close to, or above, the target reference point.
Sawsharks (*Pristiophorus cirratus*, *P. nudipinnis*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Recent catch is below RBC; recent CPUE is above the target reference point.
School shark (*Galeorhinus galeus*)	Uncertain	Overfished	Uncertain	Overfished	Uncertain if fishing mortality in 2019–20 will allow recovery within the specified time frame. Biomass is likely to remain below 20% of unexploited levels.

Economic status

NER for the Gillnet, Hook and Trap Sector were $3.4 million in 2016–17. Preliminary estimates indicate that NER were likely negative for 2017–18 and positive $5.6 million in 2018–19. 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 65% 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.

	Green	Red	Yellow
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 of fishing for gummy sharks. 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 4 principle commercial stocks taken in the SGSHS are managed under the SESSF harvest strategy framework (AFMA 2019). 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 are implemented across the fishery to protect school shark breeding populations, pupping and nursery areas, and school and gummy shark habitat, and to promote the recovery of upper-slope dogfish stocks.

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. This meant that some important data from the fishery were not collected. Physical observers were deployed again from September 2017 to July 2018. The Australian Fisheries Management Authority (AFMA) subsequently implemented a crew-collected data program in October 2018, to collect biological data needed to support stock assessments. AFMA is also investigating the use of e-monitoring to collect data previously collected by observers (for example, fish lengths).

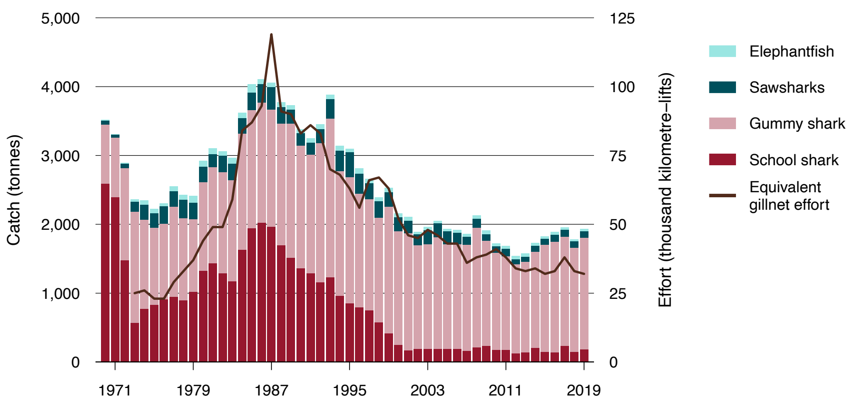
Fishing effort

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 more recently (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 (31,208 km of gillnet hauled in 2019–20). Hook effort has been variable in recent years, increasing from 2.17 million hooks in the 2018–19 season to 2.76 million hooks in the 2019–20 season.

Catch history

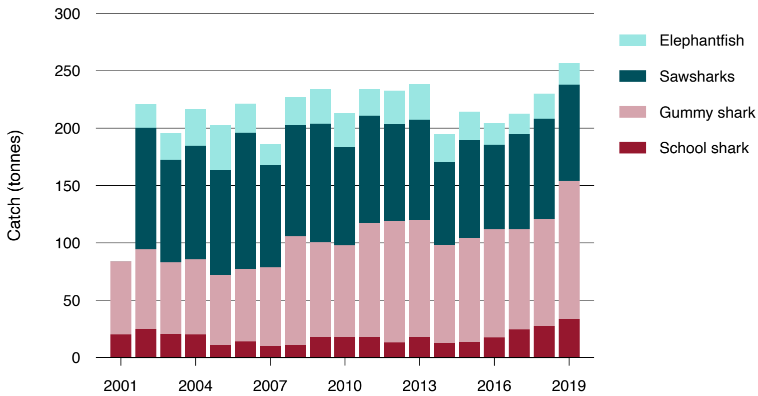
Fishing for sharks in the waters off southern Australia began in the 1920s, using longlines. During the 1970s and 1980s, the sector mainly targeted school shark (Figure 12.2). Adoption of monofilament gillnets and concern about mercury content in large school sharks, coupled with declining school shark 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. Additional information on catch and catch history is provided below for each of the key stocks.

FIGURE 12.2 Annual landings and effort in the SGSHS, by species, 1970 to 2019



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. (1995).

FIGURE 12.3 Annual landings in the CTS, by species, 2001 to 2019



Note: **CTS** Commonwealth Trawl Sector
Source: AFMA catch disposal records

Gillnet vessel
Gavin Kewan, AFMA

TABLE 12.2 Main features and statistics for the SGSHS

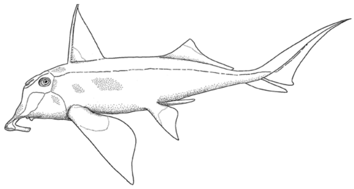
Fishery statistics a	2018–19 fishing season			2019–20 fishing season	
Stock	**TAC (t)**	**Catch (t) (GHTS, CTS + GABTS)**	**GVP (2018–19) (GHTS, CTS)**	**TAC (t)**	**Catch (t) (GHTS, CTS + GABTS)**
Elephantfish	114	50 (28, 22)	<$0.10 million (<$0.10 million, <$0.10 million)	114	47 (31, 16)
Gummy shark	1,763	1,682 (1,512, 170)	$20.94 million ($19.59 million, $1.35 million)	1,785	1,781 (1,590, 191)
Sawsharks	430	179 (82, 97)	$0.60 million ($0.28 million, $0.31 million)	430	189 (102, 86)
School shark	215 **b**	196 (166, 30)	$2.04 million ($1.73 million, $0.31 million)	189 **b**	184 (149, 35)
Total	**2,522**	**2,107 (1,788, 319)**	**$23.66 million ($21.66 million, $2.01 million)**	**2,518**	**2,201 (1,872, 328)**
Fishery-level statistics					
Effort	Gillnet: 32,008 km of net hauled Hook: 2,165,571 hooks set			Gillnet: 31,208 km of net hauled Hook: 2,759,233 hooks set	
Fishing permits **c**	Gillnet: 61 Hook: 13			Gillnet: 61 Hook: 13	
Active vessels	Gillnet: 41 Hook: 37			Gillnet: 35 Hook: 36	
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 1 May to 30 April. Value statistics are by financial year and were not available for the 2019–20 financial year at the time of publication. Components of catch may not sum to totals 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. **GABTS** Great Australian Bight Trawl Sector. **GHTS** Gillnet, Hook and Trap Sector. **GVP** Gross value of production. **ITQ** Individual transferable quota. **TAC** Total allowable catch (for the entire SESSF).

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

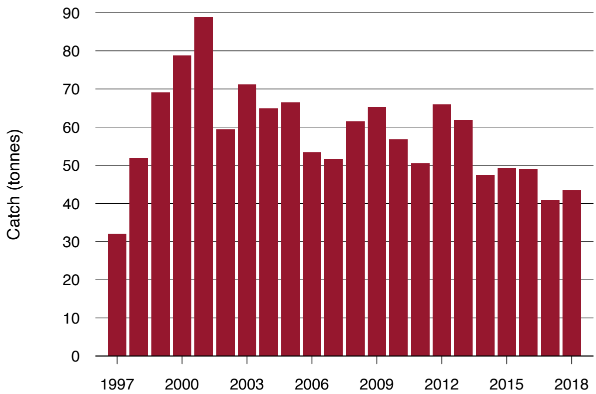
Elephantfish is a small component (~2%) of landed catch of the 4 stocks assessed in this chapter. Catch of elephantfish in the SGSHS increased during the 1970s and peaked at almost 120 t in 1985 (for catch since 1997, see Figure 12.4a). Catch has since declined, and has been relatively stable at around 40–60 t in recent years. Combined landings from the Gillnet, Hook and Trap Sector (GHTS), Commonwealth Trawl Sector (CTS) and Great Australian Bight Trawl Sector (GABTS) in 2019–20 was 47 t (Figure 12.4b; Table 12.2).

Discards of elephantfish reported in logbooks in 2019–20 were 24.4 t (20.3 t in 2018–19 and 16.5 t in 2017–18). The life-state information for this discarded catch is mostly recorded as 'unknown' or with no detail provided. More generally, post-release survival of discarded live elephantfish is uncertain. It is unknown if all discarded catch is reflected in logbooks. Burch, Althaus & Thomson (2019) estimated a total catch in 2018 at 182.5 t, comprising 129.4 t of discards and 53 t of commercial catch (SESSF 50.6 t and state catch 2.4 t).[1]

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 to May 2008. Catch rates and popularity of this fishery have declined more recently (Conron 2016), which presents an uncertainty in assessing the stock.

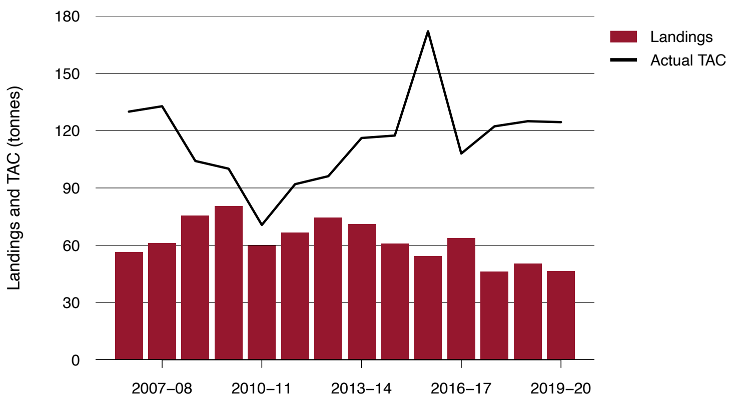
1 Note, this discard estimate is not considered reliable.

FIGURE 12.4a Elephantfish catch in the SGSHS, 1997 to 2018



Source: Sporcic 2019

FIGURE 12.4b Annual elephantfish landings and TAC in the SGSHS, 2006–07 season to 2019–20 season



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season.
Source: AFMA catch disposal records

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 for the stock and proxy for biomass. However, the stock has been increasingly difficult to assess using this method, and as a result the harvest control rules that are typically applied to this method have not been applied in recent years. In 2018, the Shark Resource Assessment Group (SharkRAG) recommended rolling over the total allowable catch (TAC) from the previous year for the 2019–20 season.

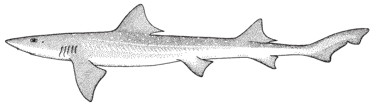
At its January 2020 meeting, SharkRAG discussed the low reliability of generating a recommended biological catch (RBC) through applying the tier 4 harvest control rule, and agreed to recommend rolling over the TAC from the previous season (114 t) to the 2020–21 fishing season (and the subsequent 2 seasons; 2021–22 and 2022–23). In making its recommendation, the RAG noted the low risk rating of the stock from the recent draft ecological risk assessment (ERA) (AFMA 2020). However, the RAG also expressed concerns about its ability to provide robust recommendations on the RBC for the stock due to limited reliable information.

The CPUE standardisations applied to the stock in 2018 show a variable catch rate, with a slight decreasing trend in recent years (Sporcic & Haddon 2018). The recent average CPUE was above the target reference point for both series.

Stock status determination

Although it has not been possible to output a reliable RBC through a harvest control rule for this stock for the last couple of seasons, recent CPUE is above the target reference point, and reported catches have been relatively stable and below previous (and accepted) RBCs. Further, the stock is not actively targeted in the fishery and has been classified as low risk through the draft ERA. The above information indicates that recent catches from the fishery are unlikely to result in the stock becoming overfished. 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 2 stocks in Australian waters: 1 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 4 populations for modelling purposes: the continental shelf of Bass Strait, Tasmania, South Australia and Western Australia. The first 3 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, McAuley & Rowland 2013).

Catch history

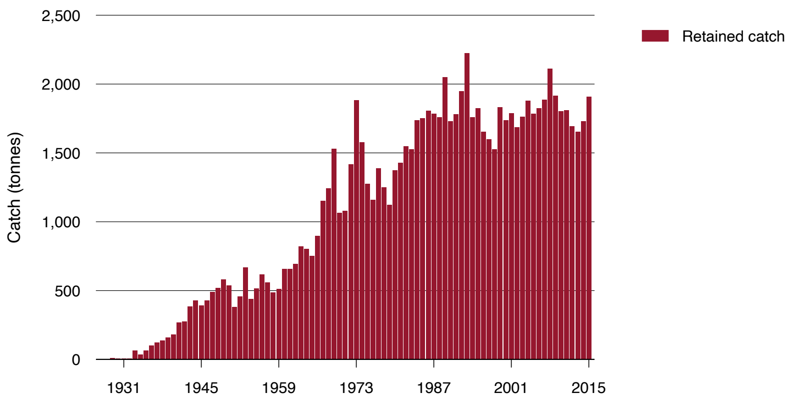
Catch of gummy shark in the SGSHS increased after 1970, initially as byproduct in the school shark fishery, and then increasingly as a target as school shark catches decreased from 1986 (Figure 12.5a). Catch in the SGSHS reached a peak of around 2,300 t in 1993. Catch has been around 2,200 t in recent years (Figure 12.5a). The 2019–20 season was the fourth year of a multiyear TAC for the stock. The initial TAC for 2019–20 was 1,785 t, but the actual TAC was 1,897 t with the carryover of undercaught quota (undercatch provisions) from the previous season (Figure 12.5b). Combined landings for the GHTS, CTS and GABTS in 2019–20 was 1,781 t, which is approximately 81% of the total catch across the 4 stocks assessed in this chapter.

Discards of gummy shark reported in logbooks in 2019–20 were 11.7 t (13.8 t in 2018–19 and 11.1 t in 2017–18). Multiple life states were recorded by fishers for discards, with most (13.6 t) recorded as 'unknown' or with no detail provided. The post-release survival of discarded live gummy shark is uncertain. Burch, Althaus & Thomson (2019) estimated a total catch in 2018 of 1,865.6 t, comprising 73.6 t of discards and 1,791.9 t of commercial catch (SESSF 1,672.6 t and state catch 119.3 t).[2]

Recent state recreational catch is uncertain. 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).

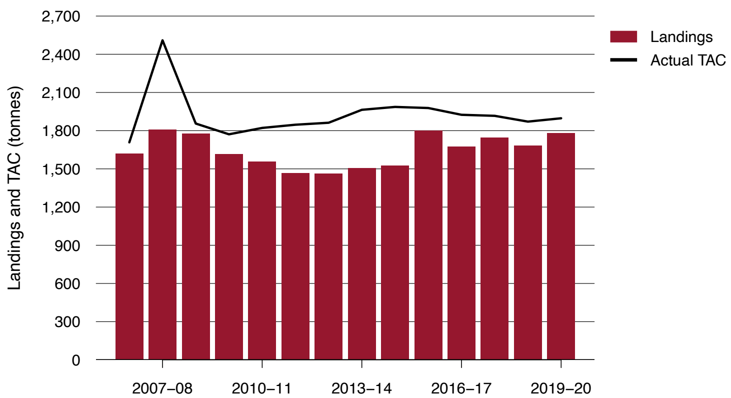
2 Note, this discard estimate is not considered reliable.

FIGURE 12.5a Annual gummy shark catch in the SGSHS, 1927 to 2015



Source: Punt, Thomson & Sporic 2016

FIGURE 12.5b Annual gummy shark landings and TAC in the SGSHS, 2006–07 season to 2019–20 season



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season.
Source: AFMA catch disposal records

Stock assessment

The stock assessment for gummy shark has not been updated since 2016; however, an updated assessment is expected in 2020. The most recent integrated stock assessment model used data to the end of 2015 (Punt, Thomson & Sporcic 2016). Updated inputs to the assessment included catch 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 in previous assessments, the 2016 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 1 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 previous 2014 assessment was run, there was concern that the CPUE data in the South Australian region were less reliable as an index of abundance in recent years (Thomson & Sporcic 2014). Consequently, data after 2009 were not included in the 2014 or 2016 assessments.

The model estimated relative pup production and RBCs (according to the harvest control rule) for each population. The RBCs were then summed to give a stock-level RBC for the fishery (1,961 t). In addition, different gear types are known to catch different size ranges of sharks (selectivities), which affect the RBC calculation. Consequently, a range of RBCs were calculated, based on different catch proportions taken by line and gillnet, which were assessed against their effect 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 48% of virgin pup production ($0.48P_0$) for all 3 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).

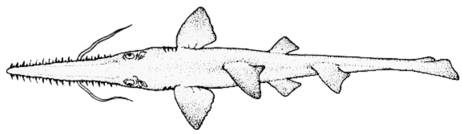
FIGURE 12.6 Estimated pup production as a proportion of unfished level of pup production for gummy shark in (a) Bass Strait, (b) South Australia and (c) Tasmania, 1927 to 2016

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 3 populations modelled. Total catch has been less than the RBC since it was calculated (including in 2019–20) and so is unlikely to have driven the stock into an overfished state. On this basis, gummy shark in the SGSHS is classified as **not subject to overfishing** and **not overfished**.

Sawshark (*Pristiophorus cirratus, P. nudipinnis*)



Line drawing: FAO

Stock structure

Three species of sawshark (common sawshark—*P. 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 2014d). 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

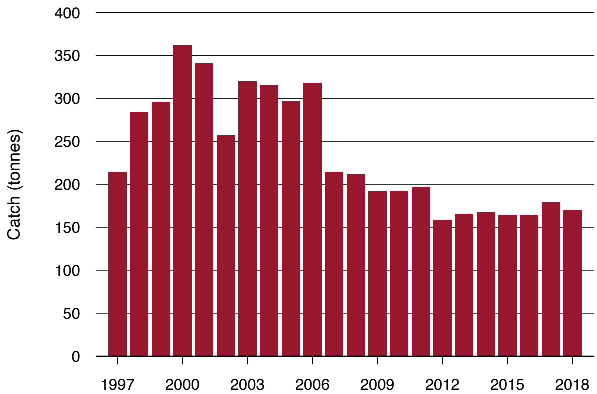
Catch of sawshark in the SGSHS increased in the early 1970s to around 200 t by 1974, and then fluctuated between about 170 and 350 t per year until the early 2000s (Figure 12.7a). Combined landings for the GHTS, CTS and GABTS in 2019–20 was 189 t (Figure 12.7b; Table 12.2), which is approximately 9% of the total catch across the 4 stocks assessed in this chapter.

Discards of sawshark reported in logbooks in 2019–20 were 2.8 t (2.8 t in 2018–19 and 0.4 t in 2017–18). The life state for all discarded catch was recorded in logbooks as ‘unknown’. The post-release survival of discarded live sawshark is uncertain. It is unknown if all discarded catch is reflected in logbooks.

Burch, Althaus & Thomson (2019) estimated a total catch in 2018 of 223.5 t, comprising 26.5 t of discards and 197 t of commercial catch (SESSF 188 t and state catch 8.9 t).[3] State recreational catches are unknown but considered low (Woodhams et al. 2018c).

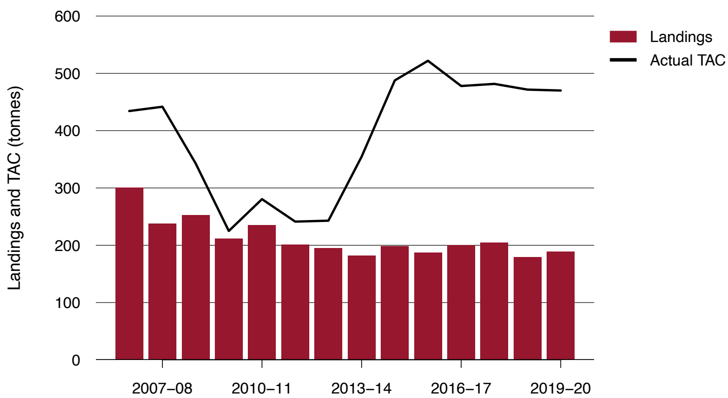
3 Note, this discard estimate is not considered reliable.

FIGURE 12.7a Sawshark catch in the SGSHS, 1997 to 2018



Source: Sporcic 2019

FIGURE 12.7b Sawshark landings and TAC in the SGSHS, 2006–07 season to 2019–20 season



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season.
Source: AFMA catch disposal records

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) when applying the tier 4 harvest control rule.

Haddon and Sporcic (2018) estimated an RBC (using SESSF trawl data to 2017) of 519 t in 2017, which was converted to the first year of a 3-year TAC of 430 t for the 2018–19 fishing season.

In 2014, SharkRAG recommended a decrease in the biomass target reference point (B_{TARG}) for sawshark from 48% to 40% of unfished biomass to reflect the byproduct nature of the stock (AFMA 2014b). The recent average CPUE for sawshark was estimated to be above the target reference point (Figure 12.8).

Stock status determination

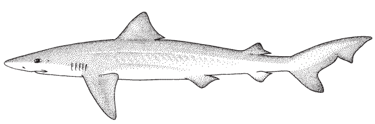
Commercial catch in the SGSHS in 2019–20 (189 t) was below the RBC and the TAC. The addition of available discard estimates will not increase the total catch to a point where it exceeds the RBC. On this basis, the stock is assessed as **not subject to overfishing**.

The recent average CPUE for sawshark was estimated to be above the target reference point. On this basis, the stock is assessed as **not overfished**.

FIGURE 12.8 Standardised CPUE index for sawshark in the CTS, 1995 to 2016 (trawl)

Note: **CPUE** Catch-per-unit-effort. **CTS** Commonwealth Trawl Sector.
Source: Haddon & Sporcic 2018

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 no genetic differences between Australia and New Zealand (Hernández et al. 2015). School shark is managed as a single stock in the SESSF.

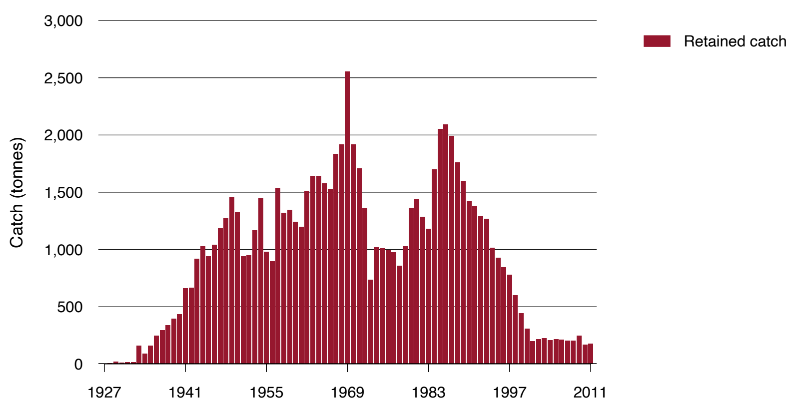
Catch history

Catch of school shark in the SGSHS peaked at more than 2,500 t in 1970 and then declined rapidly to around 700 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 12.9a). In 2009, the species was listed as conservation-dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and since then has been subject to measures to reduce catch. These measures include the implementation of a catch ratio of 20% school shark to gummy shark—whereby a quota holder must hold 5 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).

Combined landings for the GHTS, CTS and GABTS in 2019–20 was 184 t (Figure 12.9b), which is approximately 8% of the total catch across the 4 stocks assessed in this chapter. Discards of school shark reported from logbooks in 2019–20 were 13.4 t (10.9 t in 2018–19 and 7.7 t in 2017–18), with 8.4 t having a recorded life status of 'unknown'. Of the 2.1 t with some information to indicate an 'alive' status upon release, 670 kg was reported as 'alive and vigorous', the balance being either 'alive', 'alive, just' or 'alive sluggish'. The post-release survival of sharks alive upon release in this sector is likely to be variable and influenced by a number of factors. However, this element of fishing mortality is uncertain. Until such time as this uncertainty is rectified, the post-release survival of 'alive' sharks will be assumed to be zero when determining status.

Burch, Althaus & Thomson (2019) estimated a total catch in 2018 of 209.7 t, comprising approximately 177.1 t of commercial catch in the SESSF, 29.4 t of state catch and 3.3 t of discards.[4] The discard estimate was carried over from 2016. Since recent estimates of state recreational catches are not available, total mortality in state fisheries is uncertain.

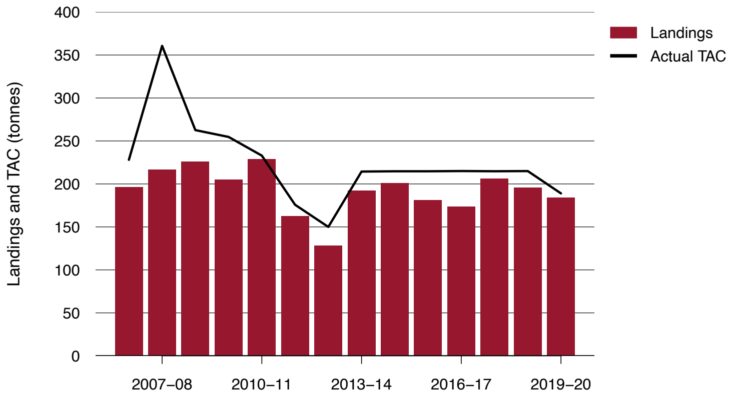
FIGURE 12.9a Annual school shark catch in the SGSHS, 1927 to 2011



Source: Thomson 2012

4 Note, this discard estimate is not considered reliable.

FIGURE 12.9b School shark landings and TAC in the SGSHS, 2006–07 season to 2019–20 season



Notes: **TAC** Total allowable catch. Actual TAC includes carryover of undercatch or overcatch from the previous season.
Source: 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. The most recent full assessment was undertaken in 2009 using data to 2008 (Thomson & Punt 2009). At that time, the base-case model estimated biomass to be at $0.12B_0$. The catch data from 1998 to 2008 used in the assessment comprised low (per vessel) catch levels, and the CPUE derived was considered unlikely to accurately reflect the underlying stock dynamics.

In 2012, the 2009 assessment was re-run with additional catch data for 2009 to 2012 (Thomson 2012), specifically to estimate recovery time frames for the stock under a range of future incidental catch levels and to investigate the impact of a proposed auto-longline shark fishery in South Australia. Under a zero-catch scenario, the stock was projected to rebuild to $0.2B_0$ within 23 years. At a constant catch of 250 t, the stock was projected to rebuild to $0.2B_0$ in 80 years, and a constant catch of 275 t was projected to collapse the stock. These projections were based on assumptions that the gear selectivity, and spatial and temporal distribution of catches remain similar to those in 2011. Uncertainties around these median projections were not provided by the assessment. The school shark rebuilding strategy was revised in 2015 using the outputs of these analyses. It specifies a maximum catch of 225 t, which would allow recovery to the $0.2B_0$ limit reference point in the specified recovery time frame (in this case, set at 3 times the estimated generation time or 66 years) (AFMA 2015b).

In 2018, a close-kin mark–recapture study and a population dynamics model that makes use of those data (termed a 'close-kin model' [CKM]) provided an estimate of current absolute abundance and recent population trend (2000 to 2017) from a single region and population (that is, assuming 1 mixed stock) (Thomson et al. 2019). In contrast to previous assessments, the CKM does not provide an estimate of biomass depletion compared with unfished biomass.

The abundance of school shark (in numbers) estimated by the CKM (c. 50,000 adults; Thomson et al. 2019) was lower than the 2012 assessment model projections (c. 250,000 adults; Thomson 2012).

Thomson et al. (2019) undertook projections based on 4 constant exploitation scenarios (zero, 2016 rate, 2017 rate and the mean exploitation rate for 2013 to 2017). All 4 exploitation rates resulted in a long-term upward trend in population size. SharkRAG agreed to use the mean exploitation rate for 2013 to 2017 to recommend the incidental catch allowance for the stock. This exploitation rate provided for a consistent recovery, as opposed to the 2017 fishing mortality rate, which appeared to lead to an initial reduction in stock size (for the first 2 years) before recovery (AFMA 2018).

The median trend for the stock response to the 2013 to 2017 exploitation rate was upwards; however, the confidence interval was wide enough to allow a downward trend, and Thomson et al. (2019) note that there was no guarantee of the sustainability of these catches. Thomson et al. (2019) note that the collection of close-kin samples for an additional 4 years is expected to greatly reduce these confidence intervals. The 2013 to 2017 exploitation rate resulted in total mortality recommendations of 256 t in 2019–20, 263 t in 2020–21 and 270 t in 2021–22.

The CKM considers the period 2000 to 2017, since this was the period over which the juveniles sampled would have been born. The approach is unable to evaluate biomass relative to an unfished state, as required under the School Shark Rebuilding Strategy (AFMA 2015b). Additionally, Thomson et al. (2019) propose that there are likely to be a number of school shark stocks (that is, units that are reproductively isolated, at least to some degree, and that show differing, but almost certainly overlapping, spatial distribution), some of which are severely depleted. As such, there remains a significant uncertainty associated with assessing the status of the school shark stock as it is currently defined (that is, a single SESSF stock).

In December 2018, SharkRAG supported continued close-kin sampling (for 3 years) and use of the CKM for estimating abundance of school shark. The RAG also discussed the difficulties associated with updating the old school shark assessment with the recent close-kin information and agreed not to pursue such an assessment. SharkRAG also discussed the need for updating the School Shark Rebuilding Strategy (AFMA 2015b), due to be undertaken in 2020.

Stock status determination

Combining Commonwealth commercial catch (184 t) with the estimate of discards from logbooks in 2019–20 (13.4 t, assuming 100% mortality) and the most recent estimate of state catches (29.4 t) provides an estimated total mortality in 2019–20 of 226.8 t. This is above the incidental catch allowance in the rebuilding strategy (215 t), and slightly above the maximum level reported to allow recovery in the time frame specified in the rebuilding strategy (225 t). 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 total (226.8 t) is also below the level of catch estimated through the CKM work to allow for rebuilding, noting the uncertainty associated with these trends and the uncertainty in stock structure.

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 & Haddon 2018), 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.

Given the above information, the fishing mortality of the stock remains classified as **uncertain**.

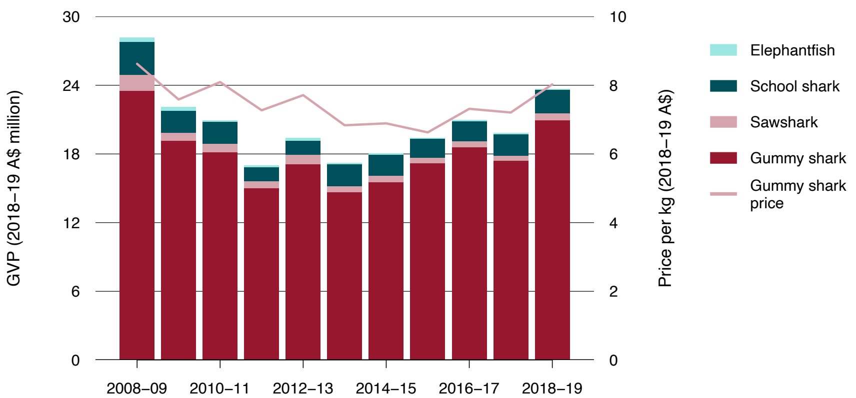
Since the recent CKM work does not provide an estimate of biomass depletion compared with unfished biomass, biomass status in 2019–20 is determined based on the most recent estimate of population depletion. The last full stock assessment in 2009 (Thomson & Punt 2009), which used data up to 2008, estimated 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). Catches have not been zero in the intervening period. On this basis, the stock is unlikely to have recovered to above $0.2B_0$ and as such remains classified as **overfished**.

12.3 Economic status

Key economic trends

The real gross value of production (GVP) in the SGSHS for the 4 shark species taken in the GHTS declined from a peak of $28.2 million in 2008–09 to $17.21 million in 2013–14 and then recovered to $23.66 million by 2018–19 (Figure 12.10). This recent recovery is primarily the result of higher volumes of gummy shark catch. Gummy shark accounts for the majority of GVP in the SGSHS (89% in 2018–19).

FIGURE 12.10 Real GVP for the SGSHS, by key species, and real price for gummy shark, 2008–09 to 2018–19

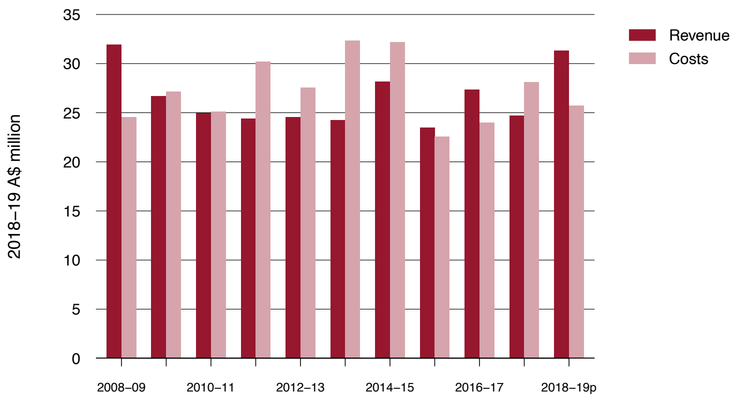


Notes: **GVP** Gross value of production.'Real' indicates that value has been adjusted for inflation.

The 4 shark species that make up the SGSHS—gummy shark, school shark, sawshark and elephantfish—accounted for around 74% of the GHTS GVP in 2018–19, 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.

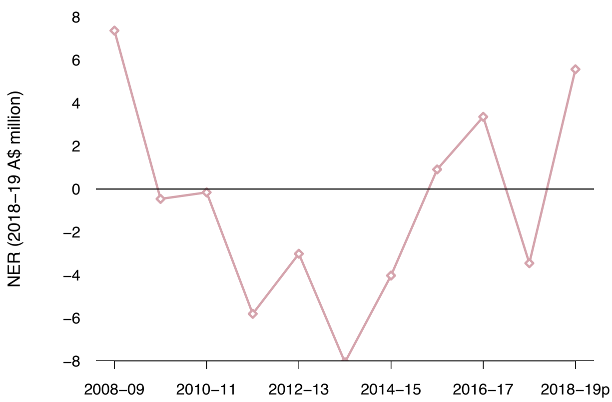
Survey-based estimates of revenue, costs and net economic returns (NER) in the GHTS are available for 2016–17, and preliminary estimates are available for 2017–18 and 2018–19 (Figures 12.11 and 12.12). In 2017–18, non–survey based estimates indicate that NER became negative, –$3.4 million, potentially a result of lower catch volume of gummy shark and higher unit fuel prices. In 2018–19, non–survey based estimates show a strong recovery, with NER estimated to reach $5.6 million, largely driven by a significant increase in fishing revenue from higher catch volumes and lower overall fishing costs.

FIGURE 12.11 Real revenue and costs for the GHTS, 2008–09 to 2018–19



Notes: **GHTS** Gillnet, Hook & Trap Sector. **p** Data for 2018–19 are preliminary.
Source: Mobsby forthcoming

FIGURE 12.12 Real NER for the GHTS, 2008–09 to 2018–19



Note: **GHTS** Commonwealth Trawl Sector. **NER** Net economic returns. NER estimates for 2018–19 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).

Significant spatial closures implemented in recent years have resulted in fishing intensity relocating 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 the 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.

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 89% of SGSHS GVP in 2018–19. The target reference point for gummy shark is the biomass that corresponds to maximum economic yield (B_{MEY}) 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 9% of SGSHS GVP in 2018–19, despite being caught under an incidental catch allowance. School shark biomass remains below the limit reference point, and stock rebuilding measures are likely to be affecting sector profitability. The school shark to gummy shark quota restriction implemented in 2011–12 may have reduced gummy shark catch and therefore current GVP (AFMA 2014c). 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 is accredited against parts 13 and 13A of the EPBC Act until 12 February 2022. 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 ERA, and monitoring of bycatch and discarding.

A level 2 ERA 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 7 species (all chondrichthyan) to be at high risk (Zhou, Fuller & Daley 2012). One species (common sawshark) was removed during the residual risk analysis (AFMA 2014a). The remaining 6 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 5 marine mammal species as high risk (AFMA 2010). A subsequent residual risk analysis removed 2 species (as a result of no interactions being recorded in the fishery) and included 1 further species (as a result of higher than expected interactions), resulting in 4 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 ERAs have been consolidated to form a priority list in an ERA strategy for the SESSF (AFMA 2015a). A revised ERA for the SGSHS is still in draft and expected to be finalised in late 2020.

In accordance with accreditation under the EPBC Act (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE), and these are summarised below.

Reports for the GHTS in the 2019 calendar year indicate 278 interactions: 103 with mammals, 37 with seabirds, 136 with sharks and 2 with little penguins—*Eudyptula minor* (both dead). The mammal interactions comprised 35 interactions with dolphins (all dead), 2 with sea lions (1 alive; 1 dead), 2 with killer whales (both alive), 21 with New Zealand fur seals (all dead), 21 with Australian fur seals (6 alive; 15 dead) and 22 with seals (unclassified; 32 alive and 20 dead). The seabirds caught included albatrosses, petrels, prions and shearwaters; 16 were alive and 21 were dead.

Logbooks reported that 92 shortfin mako sharks—*Isurus oxyrinchus* (2 alive; 82 dead; 8 in unknown condition), 16 longfin mako sharks—*I. paucus* (8 alive; 8 dead), 12 porbeagle sharks—*Lamna nasus* (3 alive, 9 dead) and 16 white sharks (12 alive; 4 dead) were caught during 2019. Measures to reduce interactions with Australian sea lions and dolphins are discussed in Chapter 8.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

12.5 References

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Chapter 13
Southern Squid Jig Fishery

R Noriega and R Curtotti

FIGURE 13.1 (a) Fishing intensity in the Southern Squid Jig Fishery and (b) Commonwealth Trawl Sector squid catch, 2019

(a)

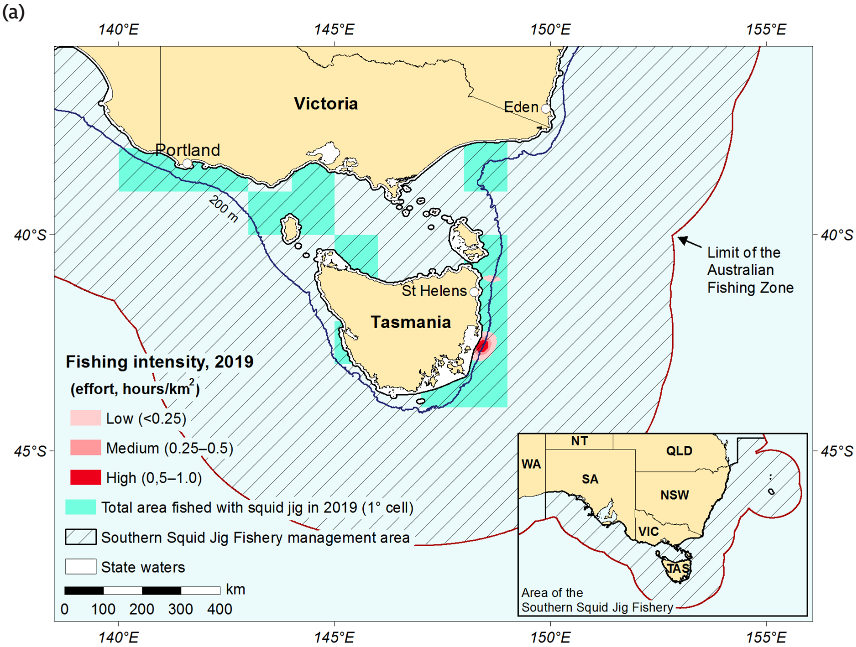
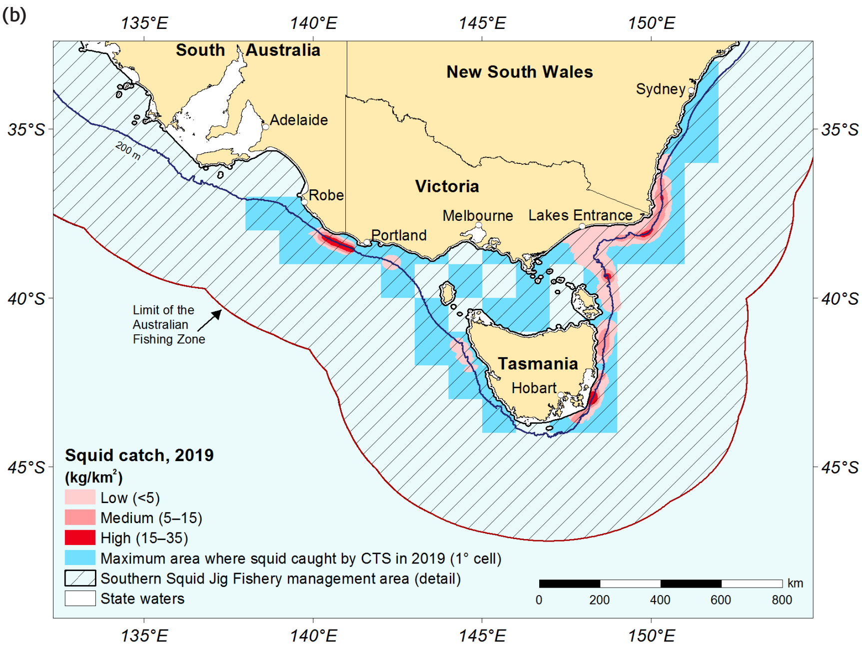


FIGURE 13.1 (a) Fishing intensity in the Southern Squid Jig Fishery and (b) Commonwealth Trawl Sector squid catch, 2019 continued

(b)



Note: **CTS** Commonwealth Trawl Sector.

TABLE 13.1 Status of the Southern Squid Jig Fishery

Stock	Biological status				Comments
	2018		2019		
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Gould's squid (*Nototodarus gouldi*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	In 2019, catch in the SSJF decreased substantially from 2018 levels while effort remained similar. Intermediate or limit catch triggers were not exceeded in 2019.

Economic status

Catch in the fishery decreased significantly in 2019 while effort remained similar to 2018 levels. As a result, nominal catch per unit effort decreased, suggesting possible higher unit fishing costs, while gross value of production more than halved. This suggests that net economic returns in the fishery declined in 2018–19.

Notes: **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 (Figure 13.1). Australian jig vessels typically operate at night in continental-shelf waters between depths of 60 m 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 2 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 taken by commercial fisheries in New South Wales and Tasmania (Noriega et al. 2018).

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) 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 control rules 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. 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.

Following the release of the revised Commonwealth Fisheries Harvest Strategy Policy in 2018 (Department of Agriculture and Water Resources 2018), the Southern Squid Jig Fishery Resource Assessment Group recommended that the SSJF harvest strategy be reviewed. The Australian Fisheries Management Authority (AFMA) is currently reviewing the SSJF harvest strategy (AFMA 2019b).

Fishing effort

In 2019, there were 4,800 gear statutory fishing rights (SFRs), 8 active vessels and a total fishing effort of 2,234 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, combined with the highly variable biomass and/or availability of the stock, are understood to be the main reasons for the reduced effort since 2008. Following increased effort in 2015 and 2016, effort declined in 2017 due to the difficulty in locating squid, resulting in processors not able to source enough squid (AFMA 2017). In 2019, effort remained at a similar level to 2018, mostly due to higher domestic and international squid prices (AFMA 2019b), yet anecdotal reports suggest the fleet experienced some difficulty in locating squid (AFMA 2020).

Higher international prices, coupled with lower domestic landings, is leading to higher domestic prices for squid (AFMA 2019b). Trawling effort in the CTS and the GABTS is discussed in Chapters 9 and 11, respectively.

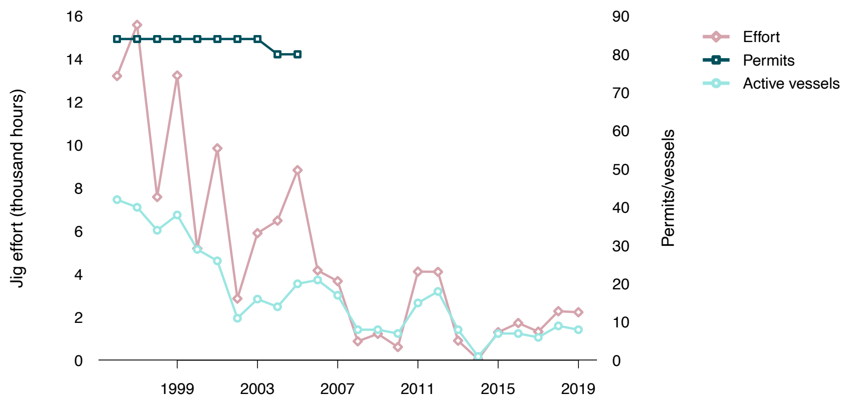
TABLE 13.2 Main features and statistics for the SSJF

Fishery statistics a	2018			2019		
Fishery	**TAE**	**Catch (t)**	**GVP (2017–18)**	**TAE**	**Catch (t)**	**GVP (2018–19)**
SSJF	550 standard jigging machines **b**	811	$2.7 million	550 standard jigging machines **b**	248	$1.0 million
CTS	–	784	$2.4 million	–	425	$1.7 million
GABTS	–	53	$0.16 million	–	49	$0.19 million
Total	**–**	**1,649**	**$5.26 million**	**–**	**722**	**$2.89 million**
Fishery-level statistics						
Effort	2,281 jig-hours			2,234 jig-hours		
Gear SFRs **c**	4,900			4,800 **d**		
Active vessels	9			8		
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 to 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 2 elliptical spools with 1 jig line on each spool. **c** Fishing rights that allow fishers to use a defined type and quantity of fishing gear. Operators in 2019 require 8.91 SFRs to be nominated to their boat for each standard squid jigging machine they use (AFMA 2019a). **d** The number of gear SFRs was 4,900 until October 2019, when AFMA corrected the number of gear SFRs to 4,800.

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 to 2019

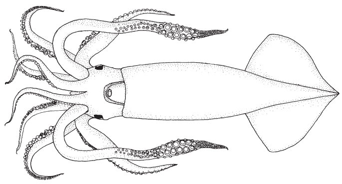


Note: Permits were replaced by gear statutory rights in 2005.

Squid
Dylan Maskey, AFMA

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 different regions off southern Australia (Virtue et al. 2011). The genetic homogeneity seen is more a function of egg mass and juvenile drift as a result of seasonal longitudinal ocean currents rather than of large-scale migrations between waters off Victoria and in the Great Australian Bight (Green et al. 2015).

Catch history

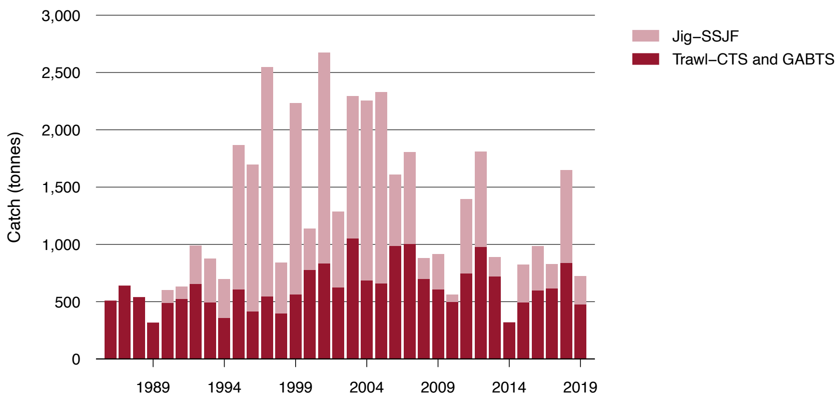
Before the SSJF began, Japanese commercial jig vessels fished waters off southern Australia in the 1970s and in the southern Australian Fishing Zone in the 1980s under joint-venture partnerships with Australian companies. The highest catch of Gould's squid from south-eastern Australian waters (7,914 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 t to 2,309 t.

In 2019, 722 t of squid was reported across 3 sectors—SSJF (248 t), CTS (425 t) and GABTS (49 t)—down from 1,649 t in 2018 (Table 13.2).

During the past 10 years, SSJF annual catches have fluctuated between 832 t in 2012 and 2 t in 2014, increasing to 811 t in 2018 and then decreasing to 248 t in 2019. 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, and then down to 425 t in 2019. In the GABTS, annual catch has remained fairly stable, averaging around 52 t since 2013 (Figure 13.3). In 2019, the nominal average catch rate in the SSJF decreased substantially to 111 kg/h, from 355 kg/h in 2018, the highest catch rate recorded in the fishery in recent history (Figure 13.4).

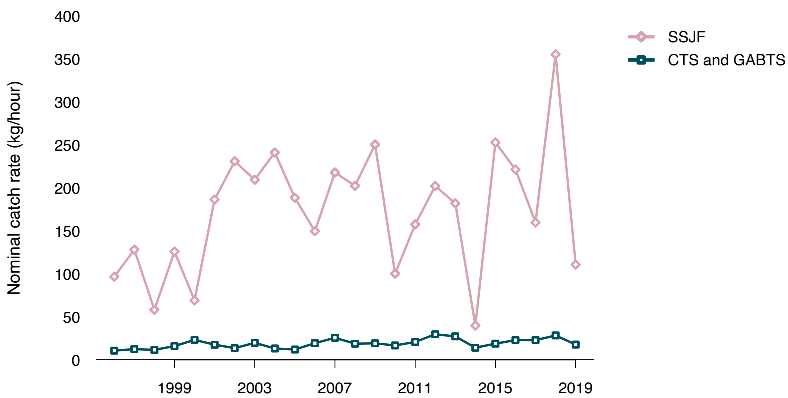
The Gould's squid stock is also fished in waters managed by New South Wales and Tasmania. The total catch of Gould's squid in Tasmanian waters in 2018–19 was 155 t, which was a decrease from 528 t in 2017–18. In New South Wales waters, the total catch of Gould's squid in 2018–19 was 11 t.

FIGURE 13.3 Squid catch in the SSJF, the CTS and the GABTS, 1986 to 2019



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 to 2019



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, their short life expectancy also implies that recruitment to the stock may be susceptible to environmental conditions and fishing pressures (Jackson & McGrath-Steer 2003; Noriega et al. 2018).

ABARES conducted a depletion analysis for the central region of the SSJF from Cape Otway in Victoria to Robe in South Australia for each of the years from 1995 to 2006 (Barnes, Ward & Boero 2015). The results suggested a decline in the stock biomass through the season in most years, with escapement in 5 seasons estimated to be between 30% and 40%. The remaining seasons fluctuated between 50% and 76% escapement. Data for 2 seasons were not included in the analysis. However, these results are for only 1 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). The Southern Squid Jig Fishery Resource Assessment Group recommended an updated depletion analysis be conducted to support the review of the SSJF harvest strategy (AFMA 2018).

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. Total fishing effort and catch in 2019 was low when compared with historical levels and unlikely to drive the stock into an overfished state. The relatively stable CTS catch rates in recent years suggests long-term stability in the availability, and perhaps biomass, of Gould's squid in the areas trawled. On this basis, and in the context of the information provided above, the stock is classified as **not subject to overfishing** and **not overfished**.

13.3 Economic status

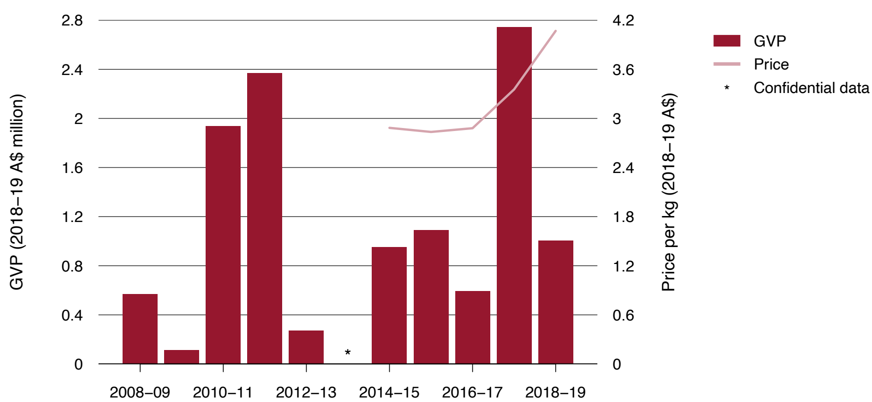
Key economic trends

Catch in the SSJF decreased by 70% in 2019, to 248 t, with a value of $1.0 million in 2018–19 (Figure 13.5). Squid also contributed $1.7 million in the CTS and $0.19 million in the GABTS during 2018–19.

Effort levels in the fishery remained stable in 2019 at 2,234 jig-hours, resulting in significantly lower catch-per-unit-effort, suggesting higher unit fishing costs. Although prices increased significantly for landed catch, overall gross value of production more than halved in 2018–19. Stable effort and significantly lower catch in 2019 suggest that net economic returns (NER) reduced in 2018–19.

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 be expected that NER are also likely to be comparatively low.

FIGURE 13.5 Real GVP and average unit prices in the SSJF, 2008–09 to 2018–19



Notes: **GVP** Gross value of production. 'Real' indicates that value has been adjusted for inflation.
* confidential date.

Performance against economic objective

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 for the SSJF is challenging to achieve. 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 2018 and 2019 fishing seasons, 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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions were reported for the SSJF in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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Squid boat lights
AFMA

Chapter 14

Western Deepwater Trawl Fishery

I Butler and AH Steven

FIGURE 14.1 Area fished in the Western Deepwater Trawl Fishery, 2018–19 fishing season

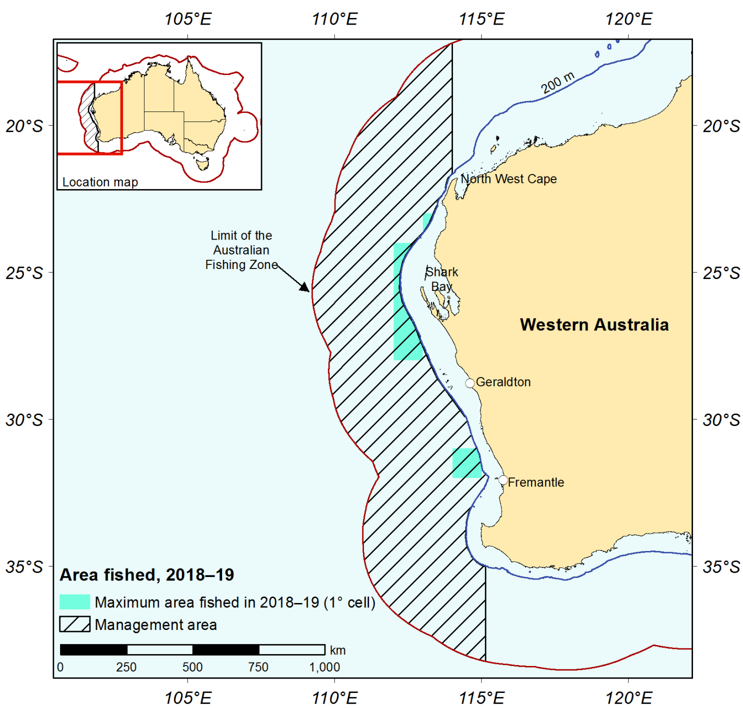


TABLE 14.1 Status of the Western Deepwater Trawl Fishery

Stock	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
Biological status					
Deepwater bugs (*Ibacus* spp.)	Not subject to overfishing	Uncertain	Not subject to overfishing	Uncertain	Fishing mortality levels are unlikely to constitute overfishing. No reliable estimate of biomass.
Ruby snapper (*Etelis carbunculus*, *Etelis* sp.)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Fishing mortality levels are unlikely to constitute overfishing. Biomass likely to be 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. In 2018–19, an increase in catch per active vessel was balanced with an increase in effort per active vessel and higher fuel costs, indicating an uncertain trend in NER.

Note: **NER** Net economic returns.

	Green	Red	Yellow
Fishing mortality	Not subject to overfishing	Subject to overfishing	Uncertain
Biomass	Not overfished	Overfished	Uncertain

Trawl catch
Tamre Sarhan, 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). The boundary of the fishery has recently been changed to align more closely 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 6 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 species have variably made up the catch since then, with deepwater bugs and ruby snapper (*Etelis* sp.) dominating recent catches. In 2018–19, ruby snapper made up nearly half the catch, but there was no reported catch of bugs.

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 then deepwater bugs. Total fishing effort has been variable but relatively low since then. Effort in 2018–19 (492 trawl-hours) was less than half that of 2017–18 (1,108 trawl-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 (Figure 14.2). 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.

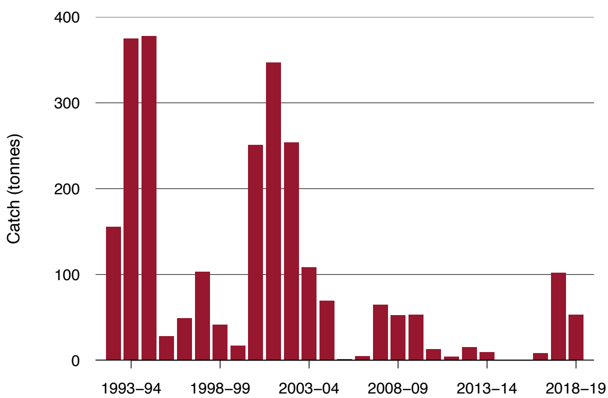
Total catch, primarily comprising finfish and deepwater bugs, has been variable but relatively low in recent years compared with the early 2000s. Catch in 2018–19 was 53 t (Table 14.2), down from 102 t in 2017–18.

TABLE 14.2 Main features and statistics for the WDTF

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)**
Deepwater bugs	–	22	Confidential	–	0	Confidential
Ruby snapper	–	28	Confidential	–	21	Confidential
Total fishery	**–**	**102**	**Confidential**	**–**	**53**	**Confidential**
Fishery-level statistics						
Effort	100 days, 1,108.3 trawl-hours			53 days, 492.3 trawl-hours		
Fishing permits	7			4		
Active vessels	3			1		
Observer coverage	6 days (6%)			0 (0%)		
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 to 30 June. Value statistics are provided by financial year.
Notes: **GVP** Gross value of production. **TAC** Total allowable catch. – Not applicable.

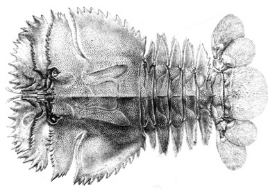
FIGURE 14.2 Total catch in the WDTF, 1992–93 season to 2018–19 season



Source: AFMA

14.2 Biological status

Deepwater bugs (*Ibacus* spp.)



Line drawing: FAO

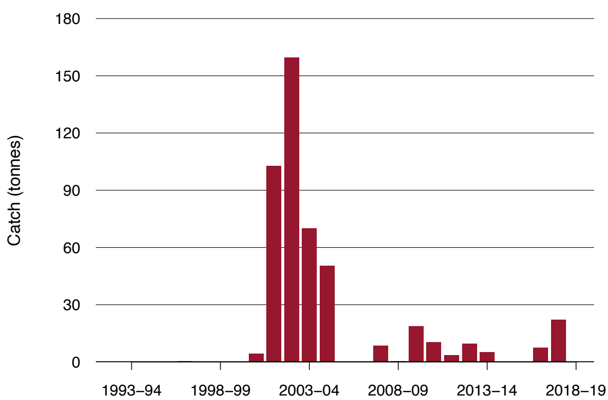
Stock structure

The WDTF targets several species of deepwater bugs. Stock structure of these species is not known, and they are grouped into a single multispecies stock for determining stock status.

Catch history

The catch history of deepwater bugs in the WDTF is characterised by relatively low levels of catch in most years, with 4 years of relatively high catches between 2001–02 and 2004–05, peaking at 160 t in 2002–03 (Figure 14.3). Catch of deepwater bugs in recent years has been relatively localised (see Figure 14.1). No deepwater bugs were recorded for 2018–19, with 22 t reported in 2017–18 (Figure 14.3; Table 14.2).

FIGURE 14.3 Deepwater bug catch in the WDTF, 1992–93 season to 2018–19 season



Source: AFMA

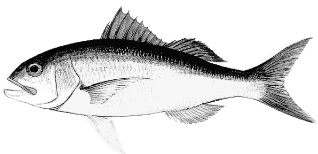
Stock assessment

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

No catch of deepwater bugs was reported in the WDTF in 2018–19. On this basis, the stock is classified as **not subject to overfishing**. Few empirical data are available to inform biomass status for this stock; as a result, the level of biomass of the stock is **uncertain**.

Ruby snapper (*Etelis* sp.)



Line drawing: FAO

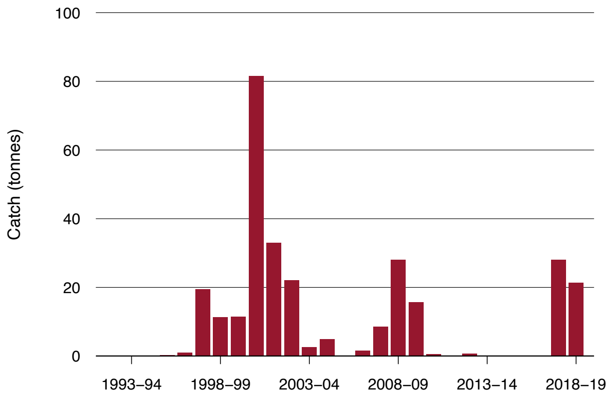
Stock structure

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 2 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 2 species are currently reported as a single species, here referred to as ruby snapper (*Etelis* sp.). The stock structure of ruby snapper caught in the WDTF is uncertain. In the absence of clear information on biological stock structure, a single fishery-level stock is assumed for determining stock status.

Catch history

Catches of ruby snapper in the WDTF peaked in 2000–01 (around 80 t), with a smaller peak in 2008–09 (around 24 t). Catches were relatively small between 2010–11 and 2016–17, increasing to 28 t in 2017–18 and then declining to 21 t in 2018–19 (Figure 14.4).

FIGURE 14.4 Ruby snapper catch in the WDTF, 1992–93 season to 2018–19 season



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 vulnerability of the species 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/h in January 1997, peaked at 900 kg/h in September 1997 and declined to less than 200 kg/h towards the end of the study period in mid 2001. Although Hunter, Dichmont & 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. 2020). Results indicated that in both 1997 and 2011 the stock was at approximately 60% of the unfished biomass level. 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

There is no current or reliable indication of the maximum sustainable yield for this stock. As such, 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 assessments undertaken for Western Australian state-managed fisheries (summarised above), has been used to determine stock status.

Although catches for 2017–18 and 2018–19 were relatively large for the fishery, it is unlikely that these catches would be sufficient to drive the stock into an overfished state. Additionally, catches of ruby snapper in the WDTF in the previous decade have commonly been zero.. 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 both 1997 and 2011. On the basis of the information provided above, 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 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 WDTF is managed through input controls, including limited entry (permits), gear restrictions and catch trigger limits for key commercial species. The number of permits, active vessels, fishing effort and catch all decreased in the 2018–19 fishing season, suggesting decreased incentive to participate in the fishery.

When compared with 2017–18, the average catch per vessel increased by 56%; however, hours per active vessel spent fishing increased in 2018–19 at a slower rate, by 33%. Higher fuel prices are likely to have also increased the total operating cost for the fishery. Therefore, the trend in NER is uncertain.

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 begins 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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with protected species listed under the EPBC Act were reported in the WDTF in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

14.5 References

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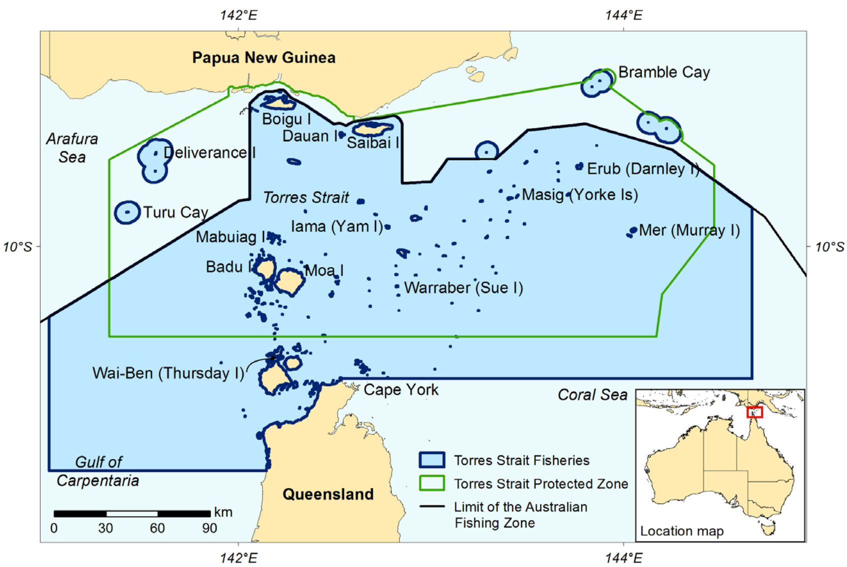
Chapter 15
Torres Strait fisheries

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 2 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.

The commercial fisheries currently managed by the PZJA are prawn, tropical rock lobster, Spanish mackerel, finfish (reef line), bêche-de-mer (sea cucumber), trochus (top shell), pearl shell, and crab. Traditional fishing (including turtle and dugong) is also managed under the TSFA. 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. Traditional inhabitants now have exclusive access to fishing entitlements in the bêche-de-mer, finfish, Spanish mackerel and trochus fisheries. There are 12 TVH licences in the tropical rock lobster fishery, 3 of which are held by the TSRA for the benefit of traditional inhabitants. All licences in the prawn fishery are TVH. The TSRA has leased several licences to non-traditional persons in the finfish and mackerel fishery due to there being latent effort, generating revenue for the region. These are called sunset licences because they are not necessarily renewed beyond a season. There are some inactive TVH licences in the pearl shell fishery. It is PZJA policy that no new TVH licences be granted, giving traditional inhabitants greater opportunity to participate in Torres Strait commercial fisheries.

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. Effort information is provided voluntarily. 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.

Five of the commercial fisheries currently managed by the PZJA—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 $20.5 million (368 t, whole-weight equivalent) in 2018–19. This is followed by the Torres Strait Prawn Fishery (824 t, worth $11.2 million in 2018–19).

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. However, a harvest strategy for the Torres Strait Prawn Fishery was implemented in 2011 (AFMA 2011). In November 2019, the PZJA adopted harvest strategies for the bêche-de-mer and tropical rock lobster fisheries (AFMA 2019a, b). These harvest strategies are modelled on the HSP with settings relevant to the objectives of the treaty. No harvest strategies are currently in place for any other Torres Strait fisheries.

15.1 References

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Fishing vessels
Matt Daniel, AFMA

Chapter 16

Torres Strait Finfish Fishery

A Williams, N Marton and AH Steven

FIGURE 16.1 Area of the Torres Strait Finfish Fishery

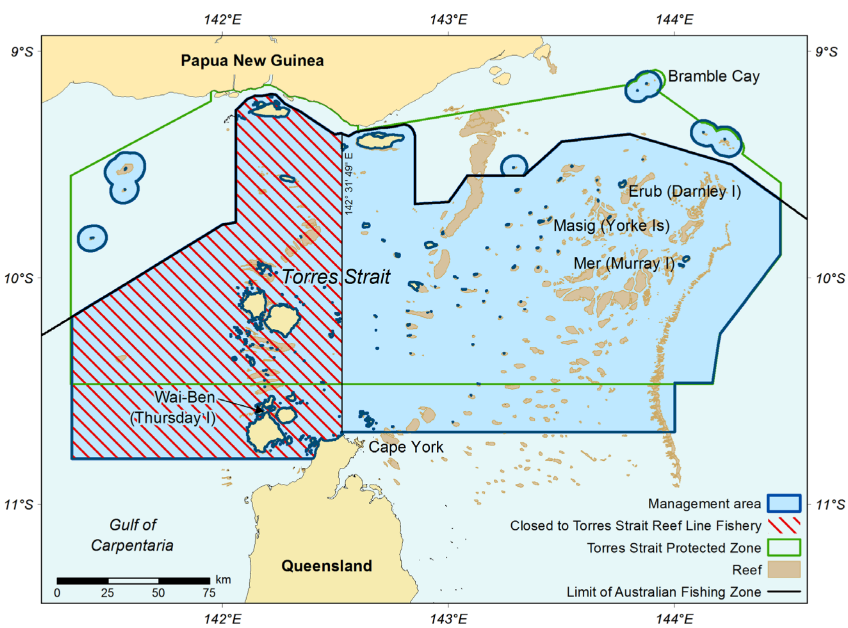


TABLE 16.1 Status of the Torres Strait Finfish Fishery

Stock	Biological status				Comments
	2018		2019		
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Coral trout (*Plectropomus* spp., *Variola* spp.)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Management strategy evaluation testing suggests that current catches are below the level likely to lead to biomass declines. Most recent biomass estimate indicated a biomass above $0.6B_0$.
Spanish mackerel (*Scomberomorus commerson*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	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 gross value of production declined in the 2018–19 fishing season, likely due to lower catch. However, participation from the Traditional Inhabitant Boat Sector increased in 2018–19, indicating a potential increase in the socio-economic benefits for Torres Strait Islander communities.

Notes: **B_0** Unfished biomass. **MSY** Maximum sustainable yield.

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

Coral trout
AFMA

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 by the Torres Strait Finfish (Reef Line) Fishery (TSFRLF). The western closure is currently under review (AFMA 2019d).

The TSFF has 2 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 makes up more than 90% of the retained commercial catch (by weight) for both the TIB and non-TIB sectors, while barramundi cod (*Cromileptes altivelis*) and rock cods represent 5%, and red emperor (*Lutjanus sebae*) represents 2%. Barramundi (*Lates calcarifer*) is also considered part of the TSFRLF, but only small quantities are thought to be harvested by traditional fishing in the inland swamps and shorelines of the islands in the north-west of Torres Strait near the Papua New Guinea coast. As such, barramundi is not considered further here.

Both commercial sectors of the TSFRLF 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 and catch limits).

A management plan for the TSFF was finalised in 2013. The plan provides for the setting of a total allowable commercial catch (TACC), although formal quota units have not yet been created or allocated. Currently, licence conditions are used to limit catch for the non-TIB Sector. TIB catches are not formally limited, but an agreed proportion of the TACC is set aside each season to minimise the risk of exceeding the TACC. In 2008, the Australian Government funded a 100% buyback of non-TIB fishing licences, such that the Torres Strait Regional Authority now holds all the non-TIB licences. 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 2019a). In the interim, the proxy limit reference point specified in the HSP (20% of unfished biomass, $0.2B_0$) is used to determine stock status.

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, and government-funded structural adjustment. The fishery for coral trout on the Queensland east coast focuses primarily on live export (Campbell et al. 2019). 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. Live coral trout were exported for the first time in 2017.

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

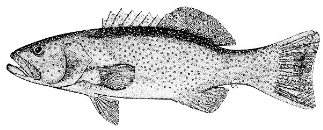
Fishery statistics a	2017–18 fishing season			2018–19 fishing season		
Stock	**TACC (t)**	**Catch (t) b**	**GVP (2017–18)**	**TACC (t)**	**Catch (t) b**	**GVP (2018–19)**
Coral trout	134.9	27.0	Confidential	134.9	17.3	Confidential
Spanish mackerel	132.0	73.2	Confidential	115.0	64.3	Confidential
Other	–	1.8	Confidential	–	2.9	Confidential
Total fishery	**266.9**	**102.0**	**$1 million**	**249.9**	**84.6**	**$0.9 million**

Fishery-level statistics	2017–18	2018–19
Effort (days) TSSMF	Spanish mackerel: TIB—not available Sunset permits **c**—395 operation-days, 748 tender-days	Spanish mackerel: TIB—124 **d** Sunset permits **c**—372 operation-days, 620 tender-days
TSFRLF	Coral trout: TIB—not available Sunset permits—182 coral trout operation-days, 182 tender-days (same for all TSFRLF species)	Coral trout: TIB—201 **d** Sunset permits—92 coral trout operation-days, 92 tender-days (same for all TSFRLF species)
Fishing permits	TIB: 163 mackerel endorsements, 143 line endorsements Sunset permits: 7 mackerel and/or line licences	TIB: 191 mackerel endorsements, 169 line endorsements Sunset permits: 5 mackerel and/or line licences
Active vessels TSSMF	Spanish mackerel: TIB—11 Sunset permits—7	Spanish mackerel: TIB—14 Sunset permits—4
TSFRLF	Coral trout: TIB—13 Sunset permits—3	Coral trout: TIB—15 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 to 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. **d** Reporting of TIB effort for Spanish mackerel and coral trout through the fish receiver system began on 1 December 2017, so only data for 2018–19 are reported as this is the first season with a full year of data. However, TIB effort is likely to be underestimated because the reporting of effort in the fish receiver system is not compulsory.
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

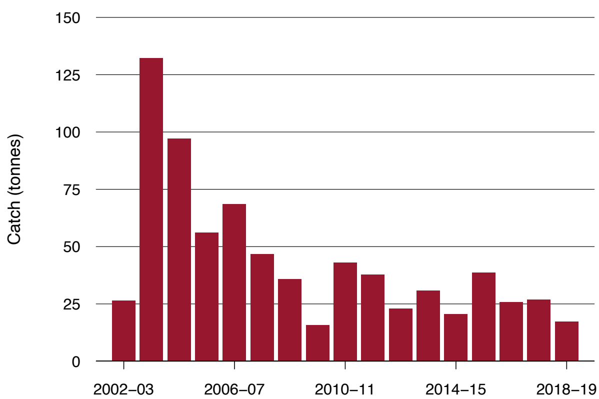
Stock structure

Coral trout in Torres Strait comprise 4 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, stock status is reported for the TSFRLF rather than for individual species or stocks.

Catch history

Commercial catch of coral trout in the TSFRLF peaked in the 2003–04 season at 132 t before falling below 50 t in 2007–08 (Figure 16.2). Catch has remained below 50 t since then and was 17.3 t in 2018–19.

FIGURE 16.2 Catch history for coral trout in the TSFRLF, 2002–03 season to 2018–19 season



Source: AFMA

Stock assessment

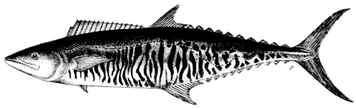
The coral trout stock in the TSFRLF has not been formally assessed. However, a management strategy evaluation (MSE) was undertaken for the stock using catch data up to 2004 (Williams et al. 2007; Williams, Little & Begg 2011). Four constant-catch scenarios, ranging from 80 t to 170 t, were tested. All 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 2019b). The assessment results are considered preliminary and therefore are not used to determine stock status.

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 2018–19 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 4 to 5 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 of the information provided above, the stock is classified as **not overfished** and **not subject to overfishing**.

Spanish mackerel (*Scomberomorus commerson*)



Line drawing: FAO

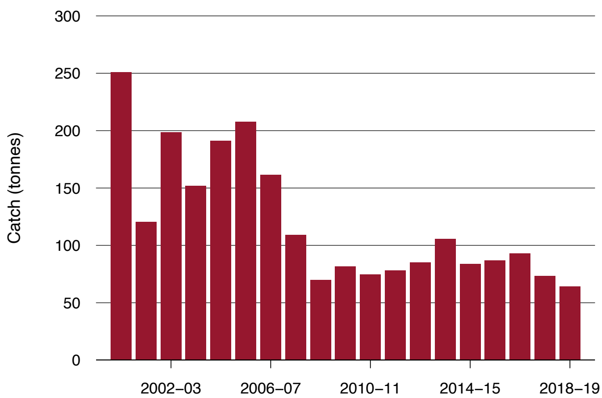
Stock structure

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 remained at around 80–100 t before decreasing to 64.3 t in 2018–19 (Figure 16.3).

FIGURE 16.3 Catch history for Spanish mackerel in the TSSMF, 2000–01 season to 2018–19 season



Source: AFMA

Stock assessment

An updated stock assessment for Spanish mackerel was completed in 2019 using data to 2018–19, as part of the harvest strategy development (AFMA 2019c). The updated assessment used an integrated age-structured model and input data on catch, effort and length-at-age of Spanish mackerel. Recruitment was modelled stochastically, and 4 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 4 standardised CPUE time series indicated a continued decline in abundance since 2009. A total grid of 40 models were run that included combinations of the 4 CPUE series, 5 natural mortality rates (0.25, 0.3, 0.35, 0.4 and 0.44) and 2 historical catch time series, 1 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 35 models.

The median estimated spawning biomass in 2018–19 across the grid of 35 models was $0.23SB_0$ (ranging from 0.14 to $0.37SB_0$). The median estimated harvest rate (F) in 2017–18 across the models was 0.27, which was below the estimated harvest rate at maximum sustainable yield (F_{MSY}) of 0.32.

Projections of the 2019 assessment grid of models included 2 constant harvest rates (F_{40}: fishing mortality that would build the current biomass to B_{40}, and F_{48}: fishing mortality that would build the current biomass to B_{48}) and 2 recruitment scenarios (average recruitment, and a 20% reduction in average recruitment) because the model predicted that recruitment had been below average in recent years. The percentage of years that projections of the 35 models fell below the limit reference point (B_{20}) over a 12-year projection period was 6% (F_{40}) and 5% (F_{48}) for average recruitment scenarios, and 11% (F_{40}) and 7% (F_{48}) for reduced recruitment scenarios. Based on these results, the Torres Strait Finfish Resource Assessment Group recommended decreasing the recommended biological catch from 115 t in 2018–19 to either 56 t (F_{48}) or 71 t (F_{40}) for the 2020–21 season.

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 from 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 4 standardised CPUE series and the potential for hyperstability in catch rates is cause for some concern and will need to be monitored closely in coming years to ensure that the decreased recommended biological catch maintains the stock at a desired level. However, the median estimate of Spanish mackerel spawning biomass in 2018–19 was above $0.2SB_0$. As a result, the stock is classified as **not overfished**. Reported catches since 2017–18, including conservative estimates of TIB catches that are not reported, have been below the estimated catch at F_{MSY} of 91 t. On this basis, the stock is classified as **not subject to overfishing**.

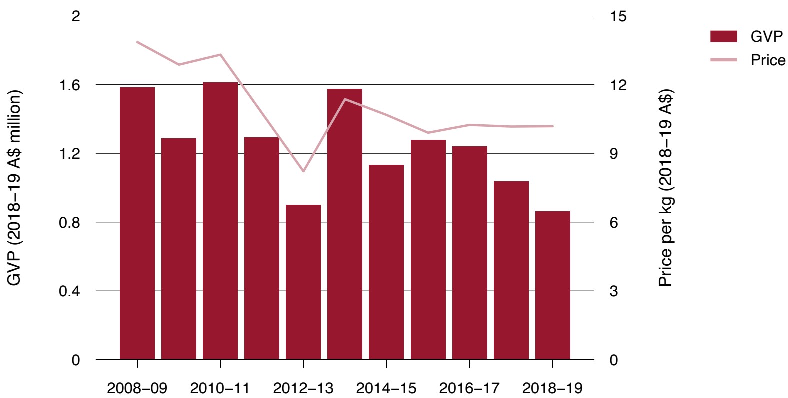
16.3 Economic status

Key economic trends

In the 2018–19 fishing season, coral trout catch declined by 35.9% and Spanish mackerel catch declined by 12.2% from catches in 2017–18. The decline in catch and increased latency for both coral trout and Spanish mackerel has resulted in the lowest gross value of production (GVP) since the 2008–09 fishing season and a decline for the third consecutive year (Figure 16.4). The fall in GVP is consistent with the overall fall in catch and effort.

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 because revenue from leasing activity is invested in capacity building for TIB fishers (TSRA 2015). Revenue generated from leased quota was $189,400 in 2018–19 (TSRA 2019).

FIGURE 16.4 Real GVP and average price per kilogram for the TSFF, 2008–09 to 2018–19



Notes: **GVP** Gross value of production. 'Real' indicates that value has been adjusted for inflation.

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 that is not from the TIB Sector is intended to provide investment funding to build the capacity of traditional inhabitant fishing industries in an economical and environmentally sustainable way in the fishery (TSRA 2019). In 2017–18, no grant payments were made, closing the Finfish Quota Trust account with $1.7 million (TSRA 2018). Grant payments were also not made in the 2018–19 financial year, closing the Finfish Quota Trust account with $1.9 million (TSRA 2019).

Estimates of net economic returns are not available for the fishery. The 2018–19 fishing season's decline in catch have coincided with generally lower effort in the fishery. Total effort by the TIB Sector is broadly unknown; however, the 2018–19 fishing season is the first time that TIB effort days for Spanish mackerel and coral trout have been reported. Although there is uncertainty around the economic performance of the fishery in the 2018–19 fishing season, an increase in the number of active vessels in the TIB Sector may indicate renewed interest in the fishery by customary fishers, thereby meeting fishery objectives to promote socio-economic development for traditional inhabitants.

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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with species protected under the EPBC Act were reported in the TSFF in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

16.5 References

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Spanish mackerel
Adam Leatherbarrow, AFMA

Chapter 17

Torres Strait Tropical Rock Lobster Fishery

T Emery, R Noriega and AH Steven

FIGURE 17.1 Regional map showing the management area of the Torres Strait Tropical Rock Lobster Fishery

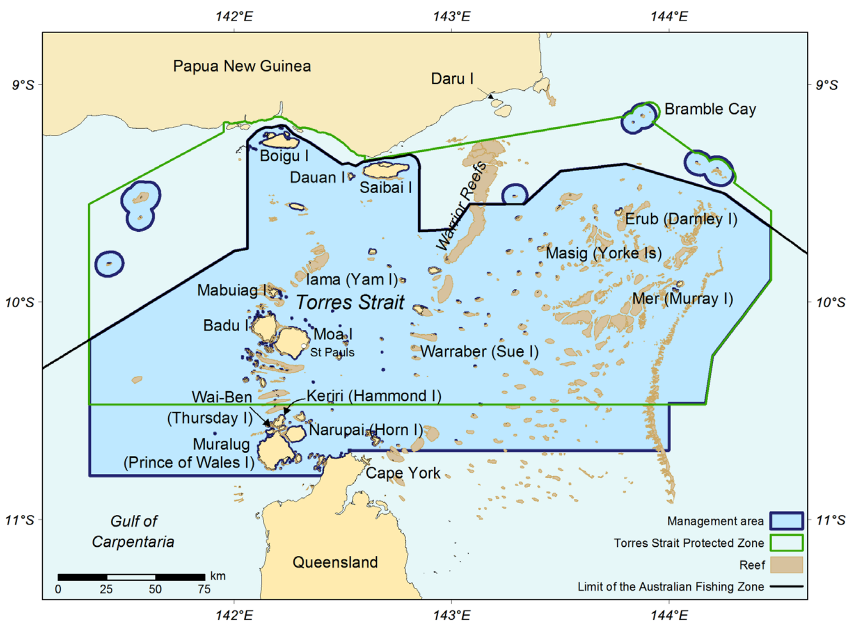


TABLE 17.1 Status of the Torres Strait Tropical Rock Lobster Fishery

Biological status					
Stock	2018		2019		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Tropical rock lobster (*Panulirus ornatus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Spawning stock biomass at the start of 2019 was above the biomass target reference point. Fishing mortality in the 2018–19 fishing season was less than the recommended biological catch.
Economic status					
Economic status	Net economic returns in the fishery are uncertain, although positive economic improvements are likely to have occurred in the 2018–19 fishing season as a result of significant increases in total allowable catch and gross value of product.				

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

Tropical rock lobster
Matt Daniel, 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 Traditional Inhabitant Boat (TIB) licences or Transferable Vessel Holder (TVH) 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 (1 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 fish for a few days to several weeks. In contrast, TIB Sector operators predominantly work from small dinghies (<6 m long) and undertake short trips (1–2 days), with divers working from smaller boats that depart from their local island communities. Since 2012, the TIB Sector has significantly increased its supply to market of live lobsters as opposed to tailed lobster. 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

In 2018–19, the TSTRLF was managed under the Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018 and the Torres Strait Fisheries (Tropical Rock Lobster) Management Instrument 2018. The management plan provides for the introduction and establishment of a fishing quota system for the TSTRLF, following completion of a formal quota allocation process.

Each year a global TAC is set for the TSTRLF, split between Australian waters (85%) and PNG waters (15%). The TAC in Australian waters is initially apportioned 75% to Australian fishers (TVH and TIB) and 25% to cross-endorsed PNG fishers to fish in Australian waters. After catch-sharing negotiations in 2018–19, 91% of the catch in Australian waters was allocated to Australian fishers and 9% was allocated to PNG fishers. The TAC in PNG waters is initially apportioned 75% to PNG fishers and 25% to Australian fishers. After catch-sharing negotiations in 2018–19, 100% was allocated to PNG fishers.

The TAC for 2018–19 was set at 641 t, with 494.85 t allocated to Australian fishers (TIB—327.44 t; TVH—167.41 t) and 50 t allocated to cross-endorsed PNG fishers to fish in Australian waters. A further 96.15 t was allocated to PNG fishers to fish exclusively in PNG waters (Table 17.2).

In addition to the management plan, a range of longstanding input controls were in place for the 2018–19 fishing season, including a limited commercial fishing season (from 1 December to 30 September); a temporal closure between 1 October and 30 November; a ban on the use of hookah gear between 1 October and 31 January and around specified new and full moon periods (known as moon-tide hookah closures); and gear restrictions that allow the collection of lobsters by hand only or 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.

In November 2019 a revised harvest strategy was adopted by the Protected Zone Joint Authority (PZJA), which will be implemented in the 2019–20 fishing season (AFMA 2019a). The revised harvest strategy sets out the objectives for the TSTRLF, how it is to be monitored, what data should be collected, and rules for determining a recommended biological catch (RBC) and the global TAC each fishing season (AFMA 2019b). The updated harvest strategy has a limit reference point for biomass (32% of spawning biomass in 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 the limit biomass reference point (B_{LIM}) and implement rebuilding strategies if the stock falls below the B_{LIM} in 2 successive years (AFMA 2019a).

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 5,217 tender-days in 2003–04 before decreasing to approximately 1,200 in 2007–08. Effort then increased to 3,008 tender-days in 2012–13 before decreasing to 1,910 in 2018–19 (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 was voluntary up until 2017. 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; however, information about fishing method, area and effort (that is, days fished, number of fishers) remains voluntary. Analyses of the TIB effort data (available since 2004) that adjust for under-reporting and remove duplicate records under the docket book system (Campbell 2019) indicate that effort has decreased from more than 9,000 tender-days in 2004–05 to the lowest level of 2,721 in 2011–12. Since then, effort has increased to 6,928 tender-days in 2018–19. 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

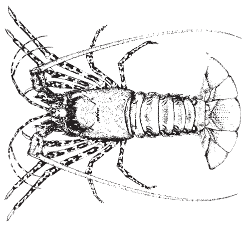
Fishery statistics a	2017–18 fishing season			2018–19 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**
Australian waters (TVH, TIB)	254.15	255.7	$15.0 million	494.85	415.6	$20.5 million
Australian waters (PNG cross-endorsed) **b**	–	–	na	50	0	0
PNG waters	44.85	156.4	na	96.15	167.0 **c**	na
Total fishery	**299**	**412.2**	**na**	**641**	**583**	**na**
Fishery-level statistics						
Effort **d**	TVH: 1,506 tender-days, 558 operation-days TIB: 4,622 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: 398 PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters			TVH: 12 licences, 33 tenders TIB: 449 **e** PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters		
Active vessels	TVH: 9 TIB: 214 PNG: 0 (cross-endorsed)			TVH: 7 TIB: 227 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	Badu Island, Cairns, Iama (Yam) Island, Poruma (Coconut) Island, Thursday Island, Warraber (Sue) 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 5 lobsters per person (or 10 lobsters per dinghy if more than 1 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					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 December to 30 September unless the TAC is reached before that time. Value statistics are by financial year. **b** For 2018–19 there are now separate TACs for PNG cross-endorsed vessels fishing in Australian waters and for PNG vessels fishing in PNG waters, where in 2017–18 they were combined. **c** Catch taken inside and outside the Torres Strait Protected Zone in the PNG part of the fishery for the period 1 December 2018 to 30 November 2019. This includes 139.21 t of catch from official PNG figures for the period 1 January 2019 to 30 October 2019 and TSTRLF Resource Assessment Group average estimated catches of 13.92 t for the months of December 2018 and November 2019. **d** Tender-day is a day of fishing effort using a fishing tender or dory. **e** As at snapshot date 1 July 2019.

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. – Not applicable.

17.2 Biological status

Tropical rock lobster (*Panulirus ornatus*)



Line drawing: Karina Hansen

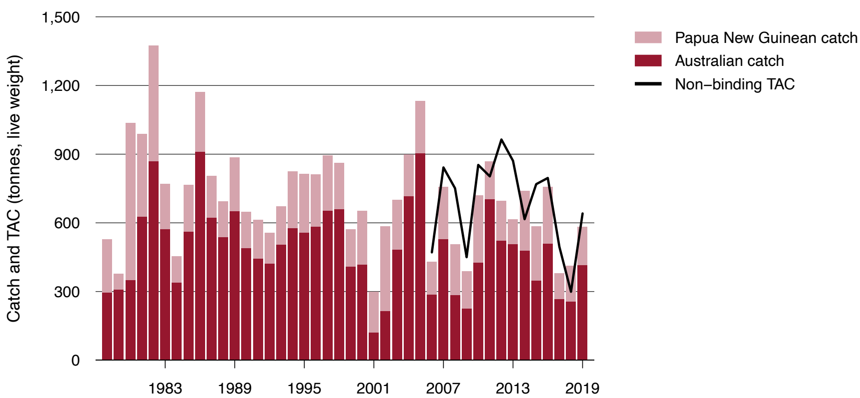
Stock structure

Although postlarval-stage lobsters are locally resident, tropical rock lobster populations in Torres Strait (managed under the PZJA), the Coral Sea (managed by the Commonwealth) and Queensland waters (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. 2018a). 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 132 t and 917 t per year for the Australian sectors (TVH and TIB), and 108 t and 327 t for PNG (Figure 17.2). The total catch from Australian waters in the 2018–19 fishing season was 415.6 t (259.7 t caught by the TIB Sector and 155.9 t caught by the TVH Sector). The total catch from PNG waters (inside and outside the TSPZ) in the 2018–19 fishing season was 167.0 t.

FIGURE 17.2 Catch and TAC of tropical rock lobster in the TSTRLF, 1978 to 2019



Note: **TAC** Total allowable catch.
Sources: AFMA, PZJA

Stock assessment

The statistical age-structured production model developed by Plagányi et al. (2009) was used to inform the RBC for the 2018–19 fishing season (Plagányi et al. 2019). The assessment used a time series of catch data from 1973 to 2018, and incorporated annual fishery-independent preseason (2005 to 2008 and 2014 to 2018) and mid-season (1989 to 2014; 2018) survey data, catch-per-unit-effort (CPUE) data from the TVH (1994 to 2018) and TIB (2004 to 2018) sectors, and length-frequency data from Australian and PNG catches (Plagányi et al. 2019). The stock assessment used to inform the RBC 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), which suggested an RBC of 641 t (90% confidence interval 426–857 t). Estimates of parameters related to maximum sustainable yield (MSY) are 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.

The stock assessment for the 2019–20 season suggested the overall stock levels were higher than those during a preceding period of low recruitment in the fishery (AFMA 2019b; Plagányi et al. 2020). The model estimated the 2019 spawning biomass to be approximately 4,467 t or 93% of the estimated unfished (1973) level ($0.93SB_{1973}$), which is well above the target reference point ($0.65SB_{1973}$) (Plagányi et al. 2020). Under the revised harvest strategy for the TSTRLF, which was adopted in November 2019, the stock assessment model will only be updated every 3 years (unless triggered by a decision rule) and the RBC calculated each year using an empirical (data-based) harvest control rule that uses catch, survey indices and CPUE as data inputs (AFMA 2019a; Plagányi et al. 2018b).

Stock status determination

The model-estimated biomass in 2019 ($0.93SB_{1973}$) was well above the agreed target reference point ($0.65SB_{1973}$) and limit reference point ($0.40SB_{1973}$) from the interim harvest strategy. As a result, this stock is classified as **not overfished**. In 2018–19, the total catch in the TSPZ was below the RBC of 641 t (based on a target fishing mortality rate of $0.15F_{TARG}$ from the interim harvest strategy). 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. Catch and value figures discussed here are often discussed in terms of whole-weight equivalent—that is, catches of lobster tails are adjusted and converted to whole weight, to allow valid comparisons of catch.

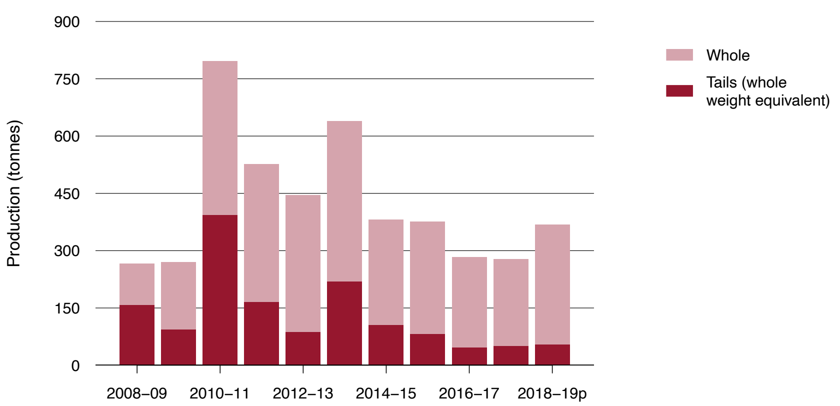
In the 2018–19 fishing season, the total TAC for the TVH and TIB sectors increased by 95%, from 254 t in 2017–18 to 495 t. In line with an increased TAC, landed catch in Australian waters increased by 63% in the 2018–19 fishing season (from 256 t in 2017–18 to 416 t in 2018–19).

In the 2018–19 financial year, 368 t of tropical rock lobster (whole-weight equivalent) was caught in Australian waters equating to a 32% increase in catch from 2017–18 (278 t). Lobster tail volume in 2018–19 increased by 8%, from 51 t in 2017–18 (whole-weight equivalent) to 55 t. Whole tropical rock lobster catch increased by 38%, from 227 t in 2017–18 to 314 t in the 2018–19 fishing season.

The gross value of production (GVP) of the TIB and TVH sectors increased by 37%, from $15 million in 2017–18 to $20.5 million in 2018–19 (Figure 17.4). Although net economic returns in the fishery are uncertain, it is likely that the TSTRLF experienced positive economic improvements in the 2018–19 fishing season.

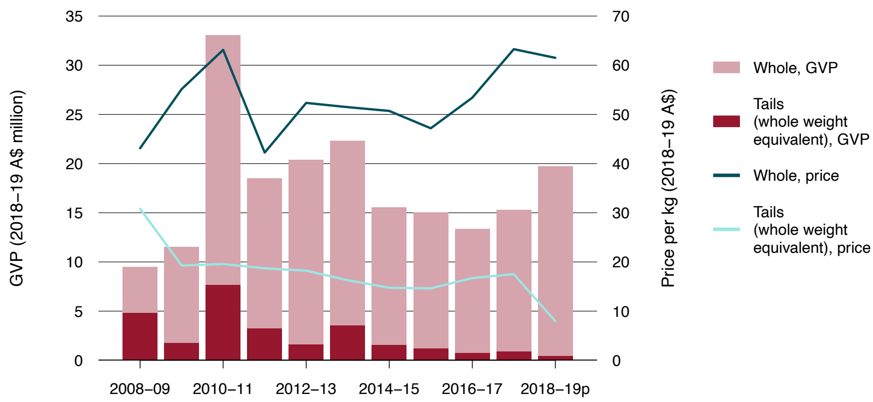
Combined effort in terms of tender-days in the TIB and TVH sectors increased by 44%; however, the aggregated catch per tender-day decreased by 8%, from 45 kg in 2017–18 to 42 kg in the 2018–19 fishing season. This indicates some rise in the cost of fishing, but the negative effect on net economic returns from this is likely to be offset by the significant increase in GVP during the 2018–19 season. Effort in the TIB Sector increased by 50% in the 2018–19 fishing season compared with the 2017–18 season, and the number of active vessels increased by 22%. Fishing effort (by tender-days) increased by 27% in the TVH Sector in the 2018–19 season, while the number of active vessels decreased.

FIGURE 17.3 Volume of whole lobster and lobster tails in the Australian sectors of the TSTRLF, 2008–09 to 2018–19



Note: Lobster tail production has been converted to whole weight. **p** Data for 2018–19 are preliminary.

FIGURE 17.4 Real GVP and price for whole lobster and lobster tails (whole-weight equivalent) in the TSTRLF, 2008–09 to 2018–19



Notes: **GVP** Gross value of production. 'Real' indicates that value has been adjusted for inflation. **p** Data for 2018–19 are preliminary.

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 (PZJA 2015) are relevant to economic performance but have a broader focus on social and cultural factors. They include the objectives of:

- maintaining 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 quota, catch and GVP in the 2018–19 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).

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with species protected under the EPBC Act were reported in the TSTRLF in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

17.5 References

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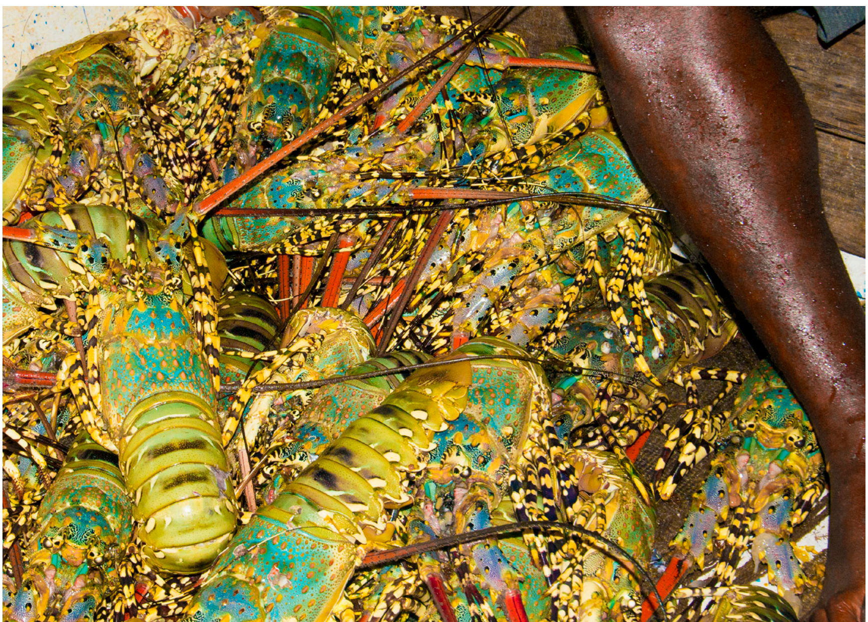


Tropical rock lobsters
Matt Daniel, AFMA

Chapter 18

Torres Strait Prawn Fishery

I Butler and AH Steven

FIGURE 18.1 Fishing intensity in the Torres Strait Prawn Fishery, 2019

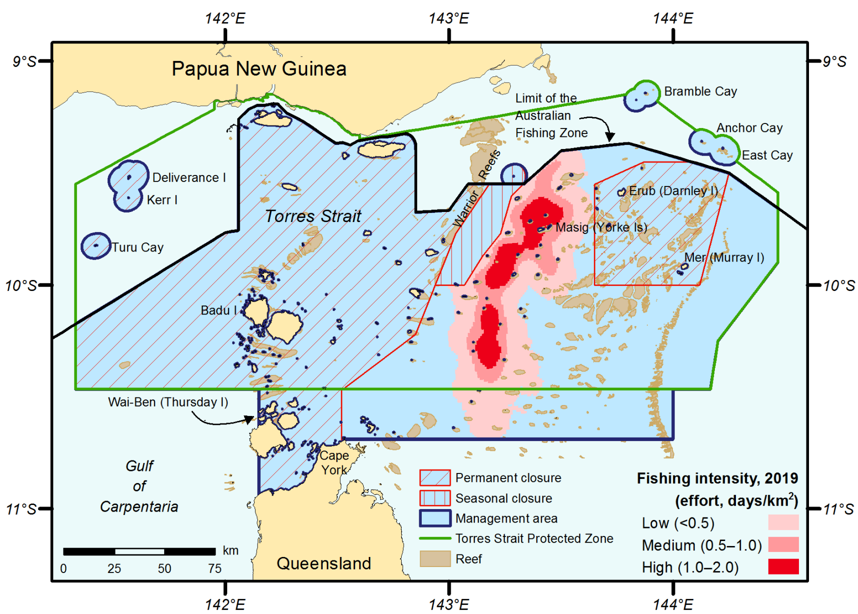


TABLE 18.1 Status of the Torres Strait Prawn Fishery

Biological status					
Stock	2018		2019		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Brown tiger prawn (*Penaeus esculentus*)	Uncertain	Uncertain	Not subject to overfishing	Not overfished	Updated assessment indicates that catch is below MSY and effort at MSY has fallen. Biomass is above the limit reference point.
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 average GVP per vessel was matched by a similar increase in hours trawled per vessel, indicating that NER remained steady in 2018–19. The strong increase in GVP and increased vessel participation indicate positive NER.

Notes: **GVP** Gross value of production. **MSY** Maximum sustainable yield. **NER** Net economic returns.

	Green	Red	Yellow
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 4 nets divided into 2 pairs, with a pair of nets towed from a boom on each side of the fishing vessel. Trawl tows last between 2.5 and 4 hours at an average speed of around 3 knots. Fishers normally complete 3 or 4 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*) (Turnbull et al. 2009).

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 (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). The proxy used for B_{MEY} is $1.2B_{MSY}$, equating to $0.34B_0$ where $B_{MSY} = 0.28B_0$.

Fishing effort

Peak effort in the TSPF occurred from the early 1990s to the early 2000s, with effort of around 8,000 to 10,000 days per year. Effort has since dropped off and, in the most recent decade, has been variable between 935 and 3,000 days per year (Figure 18.2), largely as a result of economic conditions in the fishery. According to logbook entries, effort in 2019 was 2,624 days, up from 2,078 days in 2018 (Figure 18.2; Table 18.2)

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 from 2011 to 2015 (Figure 18.2). The total combined catch in 2019 was 824 t, up from 420 t in 2018 (Table 18.2), which was the highest for the past decade (Figure 18.2). The proportion of brown tiger prawn in the total catch has increased from below 30% in 1999 to above 60% in each year since 2010 (63% in 2019) (Figure 18.2).

FIGURE 18.2 Prawn catch by species, and fishing effort, in the TSPF, 1989 to 2019

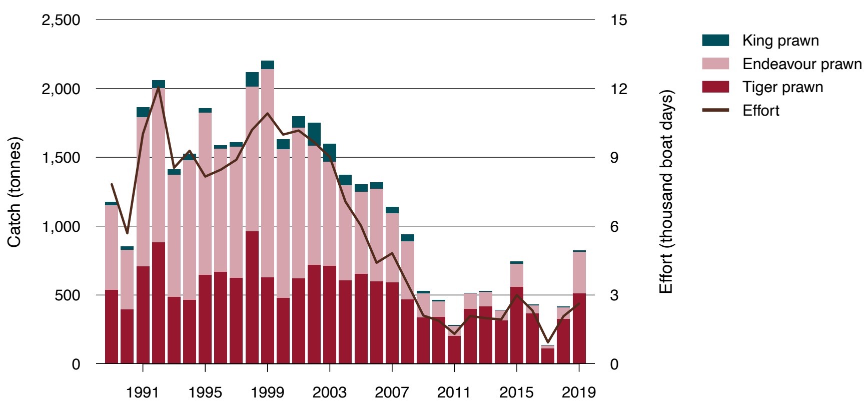


TABLE 18.2 Main features and statistics for the TSPF

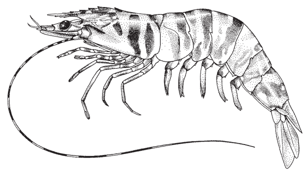
Fishery statistics a	2018			2019		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**
Brown tiger prawn	–	329	$3.9 million	–	515	$8.3 million
Blue endeavour prawn	–	81	$0.4 million	–	299	$1.7 million
Total fishery b	**–**	**420**	**$4.6 million c**	**–**	**824**	**$11.2 million c**
Fishery-level statistics						
Effort (days)	2,078			2,624		
Fishing permits	60 (37 inactive licences)			60 (32 inactive licences)		
Active vessels	23			28		
Observer coverage	39 days (1.9% of active effort)			51 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 to 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.

Prawns
James Woodhams, ABARES

18.2 Biological status

Brown tiger prawn (*Penaeus esculentus*)



Line drawing: FAO

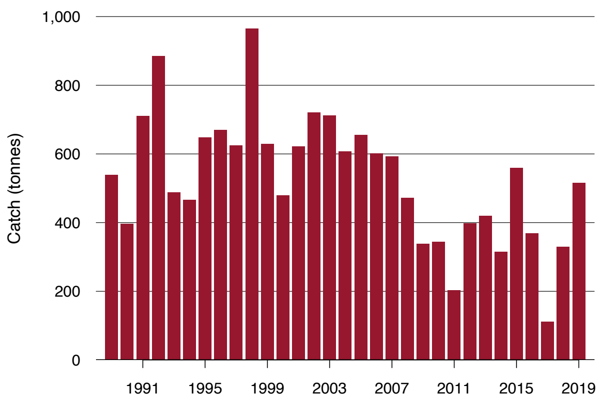
Stock structure

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, closely linked to effort, ranging from a high of 965 t in 1998 to a low of 111 t in 2017. Catch has recently increased to 329 t in 2018 and 515 t in 2019 (Table 18.2; Figure 18.3).

FIGURE 18.3 Brown tiger prawn catch in the TSPF, 1989 to 2019



Source: AFMA

Stock assessment

The last full stock assessment, using fishery-independent surveys and biological data, of brown tiger prawn in Torres Strait was completed in 2006 (O'Neill & Turnbull 2006). Since the 2006 assessment, additional biological and stock structure information has been collected (Turnbull et al. 2009) and further assessments using updated catch-and-effort data have been conducted. The most recent assessment update was in 2019, using updated information on fishing power and catch-and-effort data up to 2018 (Turnbull 2019).

The 2019 assessment update indicates that tiger prawn biomass has been steady over the recent decade, between 60% and 88% of the unfished (1980) biomass ($0.6B_0$ and $0.88B_0$). The updated delay-difference model, using a Beverton–Holt spawner–recruitment curve and recent estimates of catch-per-unit-effort (CPUE), calculated MSY for tiger prawns to be about 617 t (90% confidence interval [CI] 507–763 t), which is comparable with the 2006 assessment of MSY (676 t) (O'Neill & Turnbull 2006). Results are similar using a Ricker stock–recruitment curve.

The calculated effort at MSY (E_{MSY}) has dropped substantially, from 8,389 to 3,846 fishing nights[2] (90% CI 3,165–4,757 nights), because of the substantial increase in recent CPUE (mean ~160.3 kg/day) relative to that used in the 2006 assessment (mean ~73.5 kg/day) (O'Neill & Turnbull 2006; Turnbull 2019).

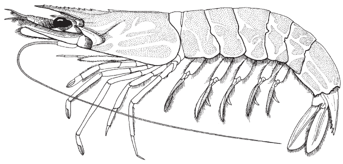
Except for 2017, recent nominal CPUE for brown tiger prawn (100–200 kg/day) has remained generally well above levels reported in the 1990s and early 2000s (50–90 kg/day) (Turnbull & Cocking 2019).

Stock status determination

Although some uncertainty remains for this stock due to the absence of fishery-independent data (and particularly an independent index of abundance), total effort and total catch in 2019 were substantially below the updated E_{MSY} and MSY, and biomass appears to be substantially above the limit reference point. On this basis, the stock is classified as **not subject to overfishing** and **not overfished**.

2 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.

Blue endeavour prawn (*Metapenaeus endeavouri*)



Line drawing: FAO

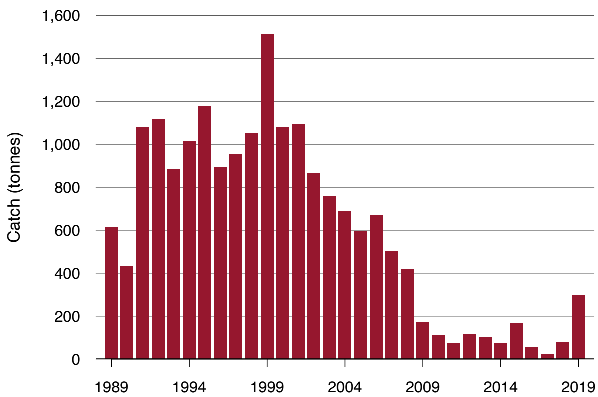
Stock structure

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. This decline reflects decreasing fishing effort through the 2000s and increased targeting of tiger prawn because of its higher market value (Turnbull & Cocking 2019). Reported catch increased to 81 t in 2018 and 299 t in 2019 (Table 18.2; Figure 18.4).

FIGURE 18.4 Endeavour prawn catch in the TSPF, 1989 to 2019



Source: AFMA

Stock assessment

The last stock assessment for blue endeavour prawn was completed in 2009, using survey and catch data to the end of 2007 (Turnbull et al. 2009). The 2009 stock assessment is still used to inform management decisions for endeavour prawn. The 2009 assessment indicated that endeavour prawn biomass was around 80% of unfished biomass ($0.8B_0$), and considerably higher than the calculated B_{MSY} of $0.43B_0$. Effort in the fishery has been well below historic levels since the last stock assessment (Turnbull & Cocking 2019).

Unlike tiger prawn, mean annual CPUE for endeavour prawn has largely remained at low levels (30–31 kg/day), though it rose to around 117 kg/day in 2019. This most recent CPUE is similar to CPUE from earlier years, when blue endeavour prawn was a higher-value, targeted species (Turnbull & Cocking 2019).

Stock status determination

Although the CPUE and total catch of blue endeavour prawn have increased in 2019, there is no contemporary assessment of what a sustainable extraction rate might be (for example, MSY). Further, there is no contemporary assessment of the current biomass of the stock. On this basis, the stock is classified as **uncertain** for both fishing mortality and biomass.

18.3 Economic status

Key economic trends

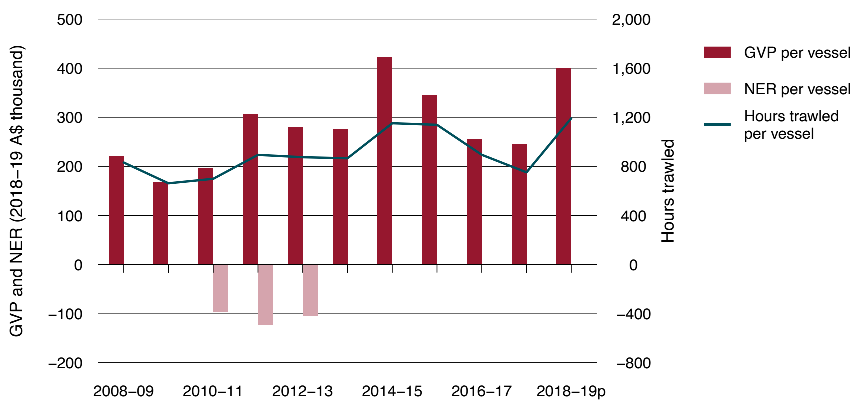
Historical data per vessel for gross value of production (GVP), net economic returns (NER) and hours trawled between 2008–09 and 2018–19 are shown in Figure 18.5. Estimates of NER are not available for 2008–09, 2009–10 or from 2012–13 to 2018–19 because economic surveys of the fishery were not undertaken for these years. 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 (Skirtun et al. 2015).

In the 2018–19 financial year, the TSPF experienced a 144% increase in GVP from the previous year. Hours trawled per vessel in 2018–19 (an indicator of fishing costs) increased by 59% from 2017–18, while GVP per active vessel (an indicator of vessel revenue) increased at a similar rate of 63%. This indicates that NER are likely to have remained stable during the year. In 2018–19, tiger prawn accounted for the largest share of fishery GVP (74%; $8.3 million), an increase of 113% from the previous financial year, followed by endeavour prawn (15%; $1.7 million) with a 325% increase from the previous financial year. Other prawn species and other non-prawn byproduct species accounted for the remainder of the GVP (11%; $1.2 million), a 300% increase from the previous financial year.

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, which followed a declining trend from 2007–08, reaching its lowest level in 2009–10 before increasing significantly in the period 2009–10 to 2014–15 and declining again in 2016–17 and 2017–18 (Figure 18.5). In 2018–19, the number of vessels increased by 47%, and GVP per vessel increased by 66% to $400,944, indicating that there were incentives to fish in the 2018–19 fishing season, likely reflecting positive NER from the fishery. This is reinforced by the effort per active vessel being at its highest level since 2007–08.

High levels of latent effort, in terms of inactive vessels, are a feature of 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.

FIGURE 18.5 GVP, NER and hours trawled per vessel in the TSPF, 2008–09 to 2018–19



Notes: **GVP** Gross value of production. **NER** Net economic returns. **p** Data for 2018–19 are preliminary.

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 (2019), the biomass levels of brown tiger prawn 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 2 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* 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 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*).

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE) and these are summarised below.

In 2019, 1035 sea snakes of unknown species were caught in the TSPF, of which 642 were released alive, 21 were dead and the remaining snakes were released in an unknown condition. One green turtle (*Chelonia mydas*) and 1 hawksbill turtle (*Eretmochelys imbricatea*) were released alive. Two narrow sawfish (*Anoxypristis cuspidata*) were caught; 1 was released alive and 1 was dead.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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Prawn trawler
Mike Gerner, AFMA

Chapter 19

Torres Strait Bêche-de-mer and Trochus fisheries

I Butler and AH Steven

FIGURE 19.1 Area of the Torres Strait Bêche-de-mer and Trochus fisheries

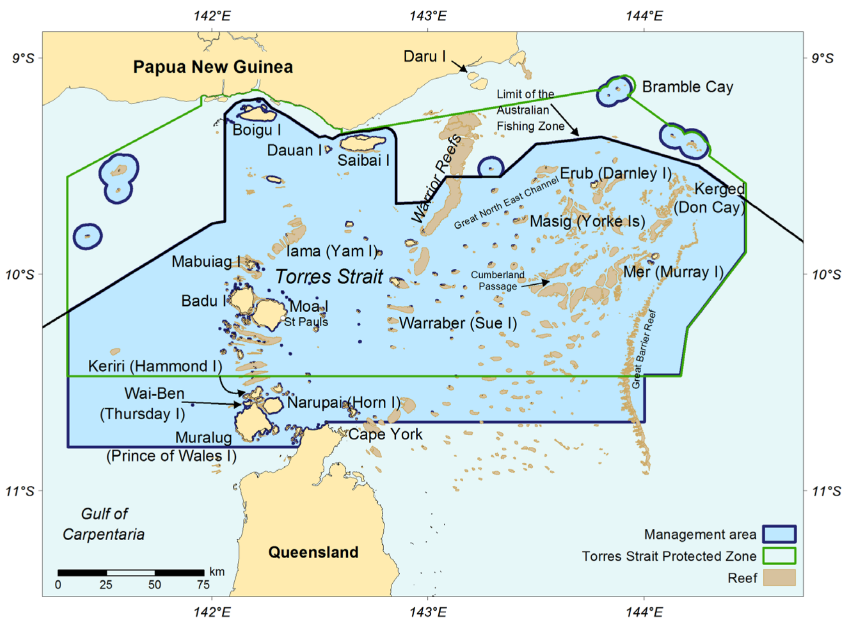


TABLE 19.1 Status of the Torres Strait Bêche-de-mer and Trochus fisheries

Stock	Biological status				Comments
	2018		2019		
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Black teatfish (*Holothuria whitmaei*)					Fishery closed. No reported catch in 2019. Last full survey (2009) indicated that stock was recovering.
Prickly redfish (*Thelenota ananas*)					Catch is below TAC. Last full survey (2009) indicated relatively stable densities.
Sandfish (*Holothuria scabra*)					Fishery closed. No reported catch in 2019. Last full survey (2009) indicated that stock was overfished.
White teatfish (*Holothuria fuscogilva*)					Catch is below TAC. Last full survey (2009) indicated relatively stable densities.
Other sea cucumbers (up to 18 species)					Uncertain biomass and fishing mortality status for at least 2 species taken in 2019.
Trochus (*Trochus niloticus*)					No catch in 2019. Uncertain biomass status.

Economic status

Estimates of NER and gross value of production are unavailable. Despite a decline in catch in 2019, NER are likely positive for this fishery. Increasing opportunities and participation for traditional inhabitants in the fishery are important objectives for this fishery.

Notes: **NER** Net economic returns. **TAC** Total allowable catch.

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

The main species of sea cucumber harvested are 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 2 or 3 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 various input and output controls. Input controls include limiting participation in the fishery to Traditional Inhabitant Boat (TIB) licence holders, limiting fishers to using vessels no longer than 7 m, restricting trochus harvest to hand fishing using non-mechanical devices, and prohibiting the use of hookah and scuba gear. There is currently no limit on the number of TIB licences that can be issued. The feasibility of using hookah for certain species is being investigated.

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. There is currently no limit on the number of TIB licences that can be issued. 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. A new harvest strategy was developed for the TSBDMF in 2019 (AFMA 2019b). The harvest strategy applies a tiered approach with different harvest control rules depending on the type and quality of information available, and rules for reopening closed fisheries. The strategy also includes minimum size limits, options for spatial closures and an ability to accommodate traditional community management initiatives.

Fishing effort

Effort in the TSBDMF is currently reflected by the numbers of active TIB fishers reporting catch (previously referred to as 'sellers' in the docket book system). In the 2018 published status report for the TSBDMF, the number of receivers was reported for effort instead of number of fishers reporting catch. This statistic has been corrected for 2018 in this report. The number of fishers reporting catch has been increasing in recent years. The number of fishing permits granted in both the TSBDMF and the TSTF was higher in 2019 than in 2018; however, the number of active permits fluctuates throughout the year depending on application/expiry dates (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, the species targeted 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).

Catch data from the TSBDMF improved in recent years as a result of a concerted effort by the Australian Fisheries Management Authority (AFMA) in 2017 to follow up on unreported catch and implement a fish receiver system. This process resulted in substantially higher catches being reported for some sea cucumber species in some years.

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. The data from fish receivers has continued to improve through 2019 as a result of effort by AFMA to improve the quality and timeliness of reporting. In 2019, AFMA confiscated some illegal catch of sea cucumber (229 kg of white teatfish, 27 kg of prickly redfish and 6 kg of deepwater black fish) from unlicensed fishers or because the fish did not go through licensed receivers. In addition, approximately 1 t of curryfish—a more difficult species to process—had spoiled and was rejected by receivers. Both of these sources of mortality have been incorporated into the catch statistics below.

Total catch for the TSBDMF in 2019 was 37.3 t, down from 64.3 t in 2018, largely as a result of increased targeting of tropical rock lobster and reduced targeting of curryfish (AFMA, 2020, pers. comm.). No catch of trochus was reported in 2019 (Table 19.2).

Black teatfish
Tim Skewes

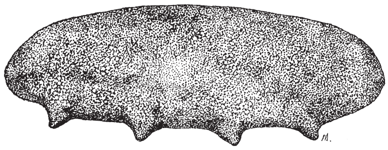
TABLE 19.2 Main features and statistics for the TSBDMF and the TSTF

Fishery statistics a	2018			2019		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**
Black teatfish	0	0	0	0	0	0
Prickly redfish	15	12.4	na	15	11.8	na
Sandfish	0	0	0	0	0	0
White teatfish	15	1.4	na	15	1.6	na
Other sea cucumber species (18 species)	80	47.8	na	80	23.7	na
Total fishery (TSBDMF)	**110**	**61.6**	**na**	**110**	**37.1**	**na**
Trochus	150	0.04	na	150	0	0
Total fishery (TSTF)	**150**	**0.04**	**na**	**150**	**0**	**0**
Fishery-level statistics						
Effort (no. of sellers)	Bêche-de-mer: 34 Trochus: 1			Bêche-de-mer: 40 Trochus: 0		
Fishing permits	Bêche-de-mer: 123 **b** Trochus: 59 **b**			Bêche-de-mer: 138 **c** Trochus: 78 **c**		
Active vessels	33			40		
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; however, the bêche-de-mer harvest strategy was formally adopted by the Protected Zone Joint Authority in November 2019 and will be implemented for the 2020 fishing season.					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 January to 31 December. Value statistics are by financial year. Reported catch is understood to be gutted wet weight. **b** As at 1 July 2018. **c** As at 1 July 2019.
Notes: **GVP** Gross value of production. **na** Not available. **TAC** Total allowable catch.

19.2 Biological status

Black teatfish (*Holothuria whitmaei*)



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Stock structure

Black teatfish in Torres Strait is assumed to represent a single biological stock (T 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).

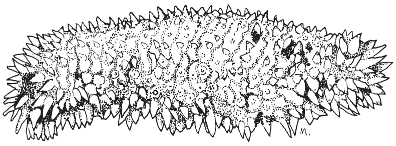
In November 2011, the Protected Zone Joint Authority (PZJA) Hand Collectables Working Group considered options for increasing the zero TAC, taking into account results from the work by Skewes et al. (2010). The working group noted that increasing the TAC would result in increased targeting of this species, 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 1-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 has been in place since then, pending improvements to catch reporting.

CSIRO surveyed sea cucumbers, including black teatfish, in late 2019 and early 2020, so an updated estimate of biomass is expected to be available later in 2020. Another trial opening of the black teatfish stock may occur later in 2020 as a result of improved catch reporting (AFMA 2019a).

Stock status determination

No catch was reported in 2018 or 2019. On this basis, the stock is classified as **not subject to overfishing**. Given the results of the 2009 survey and the low levels of catch since then, 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 (T 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. 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.

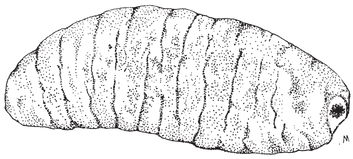
The TAC for prickly redfish in 2019 (15 t) is based on an estimate of maximum sustainable yield (MSY), using a biomass estimate from the 2002 survey (Skewes et al. 2004). The TAC was reduced from 20 t to 15 t during 2017 due to sustainability concerns coming from previous overfishing and inadequate catch 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 $0.2MB_0$ (where B_0 is the unfished biomass), 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.

CSIRO surveyed sea cucumbers, including prickly redfish, in late 2019 and early 2020, so an updated estimate of biomass is expected to be available later in 2020.

Stock status determination

Catches of prickly redfish have been sporadic over recent years. Reported catch has been below the TAC in every year except 2015, when it exceeded 28 t. Catch of prickly redfish decreased from 12.4 t in 2018 to 11.8 t in 2019. 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 t and below the TAC. 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 (T 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 survey 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 3 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). 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).

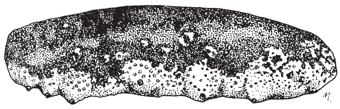
A recent survey of sea cucumbers by CSIRO in late 2019 and early 2020 did not cover the Warrior Reefs complex and so will not provide an update to the biomass of sandfish.

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 previous years, but no such reports have been received since the 2017 to 2018 fishing season (AFMA, 2020, pers. comm.). On this basis, the stock is classified as **not subject to overfishing**. Since no recovery in overall density was observed between 1998 and 2010, and there is no other robust information to inform stock status, the stock remains classified as **overfished**.

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 3 sites surveyed for sandfish in previous years (N Murphy, CSIRO, 2013, pers. comm.).

White teatfish (*Holothuria fuscogilva*)



Line drawing: FAO

Stock structure

White teatfish in Torres Strait is assumed to represent a single biological stock (T 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 has remained 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.

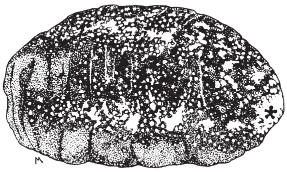
CSIRO surveyed sea cucumbers, including white teatfish (and those in waters below 20 m) in late 2019 and early 2020, so an updated estimate of biomass is expected to be available later in 2020.

Stock status determination

Recent catches of white teatfish have been sporadic, with all but 2 years (2013 and 2014) being below the 15 t TAC. Although the data that support the current TAC are close to 15 years old, average catch since 2010 has been approximately 6 t, which is substantially below the 15 t TAC.

The reported catch in 2019 was 1.6 t, which is below the 15 t TAC, includes catch confiscated from unlicensed fishers. 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. Given that 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. 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—*H. echinites*). 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 species level.

CSIRO surveyed sea cucumbers, including those in this basket, in late 2019 and early 2020, so updated estimates of biomass are expected to be available later in 2020. With the implementation of the new harvest strategy in late 2019, TACs will be set for a number of the basket species in the 2020 fishing season.

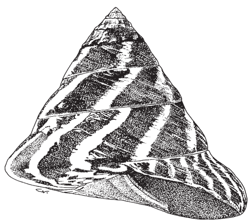
Stock status determination

Catch of this stock in 2019 comprised a number of species, at least 2 of which (deepwater redfish and hairy blackfish) were considered to have been reduced to low levels and therefore to have a recommended TAC of zero (Skewes et al. 2004). The 2019 catch for the basket was 23.7 t, less than half of reported catch from 2018 (47.8 t), and well below the 80 t TAC set by the PZJA (Table 19.2). Curryfish made up over half of the catch (14.5 t), including the estimate of spoiled disposed catch.

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 (50 kg) and hairy blackfish (3,475 kg) were above the zero TACs recommended by Skewes et al. (2004). It is unclear if the catches in 2019 (and for other years since TACs were calculated) would impede effective recruitment and recovery of redfish or blackfish species. As such, the level of fishing mortality of the stock as a whole is considered to be **uncertain**.

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 (noting updated survey results are expected to be available later in 2020). 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 (T 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 sea cucumbers. 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

No catch of trochus was reported in 2019. 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. NER are likely to have declined in the 2019 season owing to an increased level of quota latency. For Torres Strait Islanders, the TSBDMF is considered an important commercial fishery (PZJA 2014). Low levels (2018) to no participation (2019) in the TSTF are likely due to limited overseas market demand for shells.

Overall, catch in the TSBDMF declined by 42% in 2019 compared with the 2018 season. Most of the decline was for lower-value species, with catch for prickly-redfish (a high-value species) declining by 21% in the same period. There was no reported catch of trochus. Despite an increase in fishing permits for sea cucumbers and trochus in 2019, and unchanged TAC settings, latency increased in the 2019 season. Generally, demand for sea cucumber is high, particularly from Hong Kong (Purcell, Williamson & Ngaluafe 2018). In the 2017–18 financial year, 90% of sea cucumber exports were destined for Hong Kong; in 2018–19, this increased to 92%. The total value of all Australian sea cucumber exports was $17.4 million in 2017–18 ($62.88 per kilo), increasing to $18.3 million in 2018–19 ($88.88 per kilo), with most product exported dried, salted or brined.

Performance against economic objective

Management arrangements for the TSBDMF are consistent with both the Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2018 (HSP) and consistent with objectives of the Torres Strait Fisheries Act 1984. The harvest control rules for the fishery and the objectives for the fishery are provided in the Torres Strait Beche-de mer Fishery Harvest strategy (AFMA 2019b), which will enter into force in the 2020 fishing season. The development of a harvest strategy that considers and incorporates the objectives of the Torres Strait Fisheries Act provide a sound basis for managing the fishery in future seasons.

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 (AFMA 2019b). The anticipated reopening of the black teatfish part of the fishery (when catch reporting improves) will improve the economic performance of the fishery, as will rebuilding the sandfish stocks to a level that allows resumption of catch of this stock.

For the TSTF, the PZJA aims to optimise resource use, maximise opportunities for traditional inhabitants and encourage participation in the fishery (AFMA 2019b).

The socio-economic and environmental objectives of the TSBDMF harvest strategy that will be in effect in the 2020 season include (AFMA 2019b):

- sustainable use of sea cucumbers in Torres Strait with a long-term view of sustainability for future generations
- development of sea cucumber populations for the benefit of traditional inhabitants and to take into account commercial considerations
- consideration of an ecosystem approach to management
- development of long-term recovery strategies for species, where appropriate.

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. In 2019, Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora listed black teatfish as 'vulnerable' and white teatfish as 'endangered'.

No ecological risk assessments have been conducted for the TSBDMF or the TSTF. 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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with species protected under the EPBC Act were reported in either fishery in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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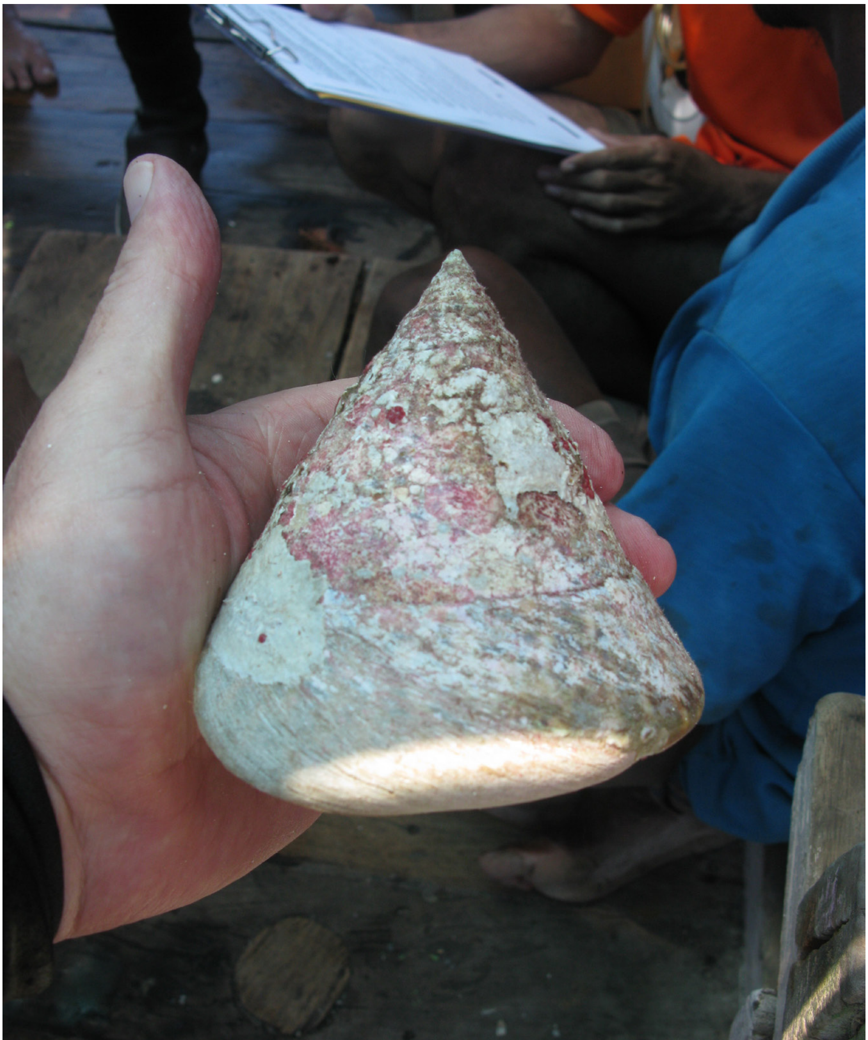
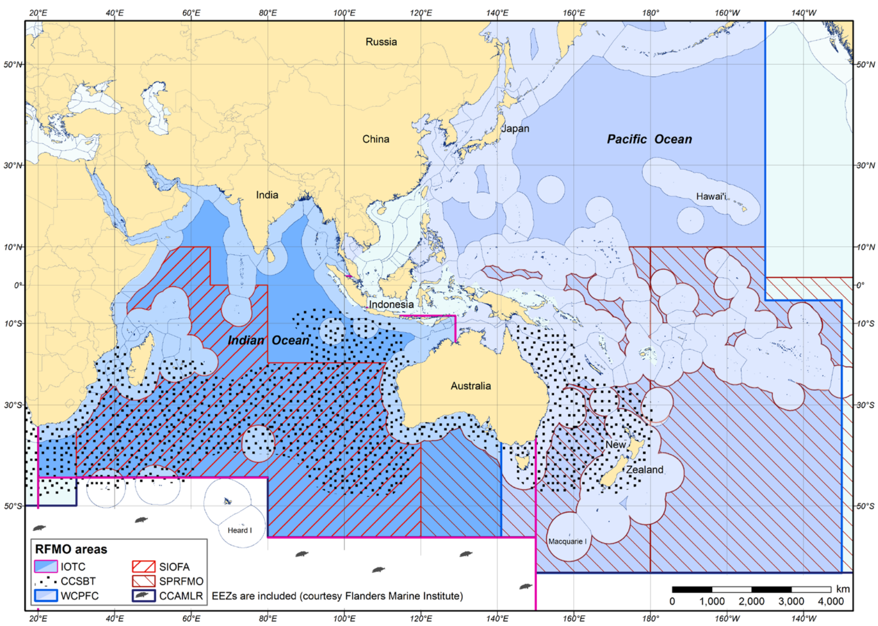


Trochus
Tim Skewes

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 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 introduces the 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 implements 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, 5 treaties have been established to manage such species and species groups; Australia is party to 3 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 is also a party to treaties that manage 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.

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 2018, the total tuna catch from the fishery was worth more than US$6.01 billion and constituted about 55% of the global tuna catch. The WCPFC area of competence includes the Exclusive Economic Zones 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 many 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 South Pacific Regional Fisheries Management Organisation, 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.

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Tuna products in Japan
Lee Georgeson, ABARES

Chapter 21

Eastern Tuna and Billfish Fishery

J Larcombe, H Patterson and D Mobsby

FIGURE 21.1 Fishing intensity in the Eastern Tuna and Billfish Fishery, 2019

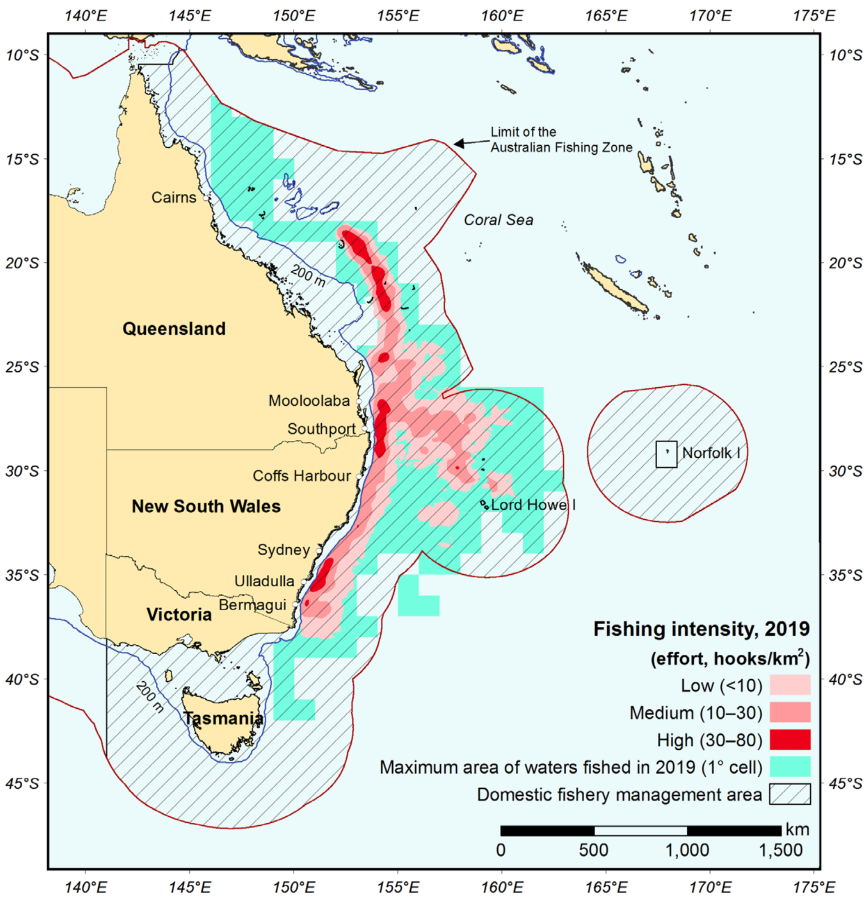


TABLE 21.1 Status of the Eastern Tuna and Billfish Fishery

Biological status					
Stock	2018		2019		Comments a
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Striped marlin (*Kajikia audax*), south-west Pacific	[green]	[green]	[green]	[red]	Most recent estimate of spawning biomass (2019) is below the default limit reference point of $0.2SB_0$. Current fishing mortality rate is below F_{MSY}.
Swordfish (*Xiphias gladius*), south-west Pacific	[green]	[green]	[green]	[green]	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	[green]	[green]	[green]	[green]	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	[green]	[green]	[green]	[green]	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	[green]	[green]	[green]	[green]	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

NER followed an increasing trend over the decade to 2016–17 and became positive in 2010–11. Non-survey-based estimates of NER for 2017–18 show an increase to $5.7 million, largely as a result of a 10% increase in fishing income. For 2018–19 non-survey-based estimates indicate a 34% reduction in NER to $3.7 million. largely reflecting income falling more than fishing costs. A decline in total number of fishing days is expected to have contributed to lower overall fishing costs in 2018–19.

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 determining stock status.

Notes: **$0.2SB_0$** Spawning biomass at 20% of unfished biomass. **F_{MSY}** Fishing mortality at maximum sustainable yield. **NER** Net economic returns.

Fishing mortality	[green] Not subject to overfishing	[red] Subject to overfishing	[yellow] Uncertain
Biomass	[green] Not overfished	[red] Overfished	[yellow] Uncertain

21.1 Description of the fishery

Area fished

The Eastern Tuna and Billfish Fishery (ETBF) operates in the Exclusive Economic Zone and adjacent high seas, 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 5 main species. For reasons set out below, this harvest strategy framework has been discontinued for the 3 tuna species, and is being redeveloped for swordfish (*Xiphias gladius*) and striped marlin (*Kajikia audax*).

Australia's annual catch of bigeye tuna (*T. obesus*), yellowfin tuna (*T. albacares*) and albacore (*T. alalunga*) in the ETBF represents only a small percentage of the total catch from all nations in the Coral and Tasman seas (averaging 16%, 27% and 6%, respectively, since 2006) (Campbell 2019a). As a consequence, in 2013, the Tropical Tuna and Billfish Fisheries Resource Assessment Group (TTRAG) concluded that the ETBF harvest strategy was not likely to achieve its objectives (including achieving the target catch rate) according to the requirements of the HSP for these species. 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 tuna, and to instead prepare information on the stock status of these tunas (Campbell 2019b). In the absence of an accepted domestic harvest strategy, and noting that WCPFC harvest strategies for these species are still under development and the WCPFC has not yet allocated tuna catches, 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.

Unlike the 3 tuna species, Australia's annual catch of swordfish and striped marlin in the ETBF represents more than half the total catch from all nations in the Coral and Tasman seas (averaging 67% and 56%, respectively, since 2006) (Campbell 2019a). Changes in Australia's catch of these species could therefore be expected to result in a change in stock status. Nevertheless, the harvest strategies for swordfish and striped marlin were reviewed in 2017–18, including a management strategy evaluation. The review determined that the harvest strategies were not likely to achieve HSP objectives (including achieving the set target and appropriate responsiveness of the harvest rate to stock biomass conditions) 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 (Campbell 2019b).

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.

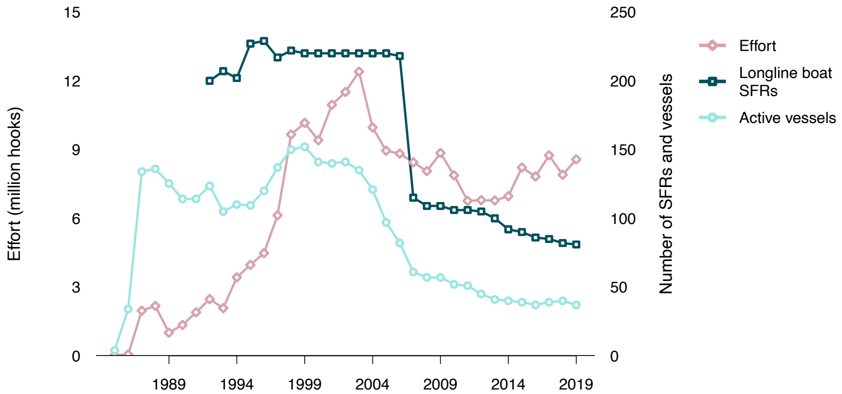
In 2017, the WCPFC Scientific Committee adopted key changes to the way it treats uncertainty in the stock assessments and communicates that uncertainty. Management statistics and stock status are based on a structural uncertainty grid that incorporates all plausible models across all combinations of 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 2 decades (from around 152 in 1999 to 37 in 2019), 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). Similarly, the effort in hooks set has declined (though to a lesser extent) from a peak of over 12 million in 2003 to around 8 million per annum in recent years (Figure 21.2).

FIGURE 21.2 Longline fishing effort, number of boat SFRs and active vessels in the ETBF, 1985 to 2019

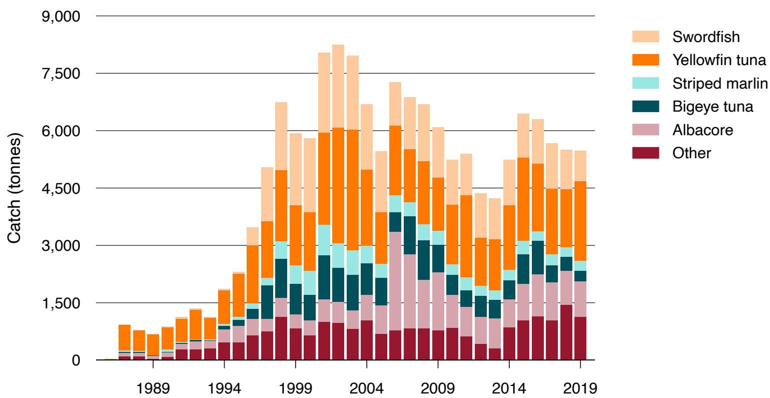


Note: **SFR** Statutory fishing right.
Source: AFMA

Catch

Following a decrease in effort from 2003, 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 increased from 4,046 t in 2018 to 4,341 t in 2019 (Figure 21.3). Swordfish, yellowfin tuna and bigeye 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 to 2019



Source: AFMA

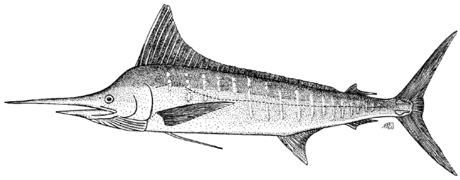
TABLE 21.2 Main features and statistics for the ETBF

Fishery statistics a	2018			2019		
Stock	**TACC (t)**	**Catch (t)**	**GVP (2017–18)**	**TACC (t)**	**Catch (t)**	**GVP (2018–19)**
Striped marlin	311	246	$1.6 million	351	251	$0.9 million
Swordfish	960	1,027	$9.2 million	1,250	793	$7.3 million
Albacore	2,351	889	$2.7 million	2,500	924	$2.7 million
Bigeye tuna	957	367	$4.3 million	1,056	284	$4.6 million
Yellowfin tuna	2,054	1,517	$18.8 million	2,400	2,089	$14.7 million
Total fishery	**6,633**	**4,046**	**$38.4 million**	**7,557**	**4,341**	**$32.1 million**
Fishery-level statistics						
Effort	Longline: 7.90 million hooks Minor line: na			Longline: 8.57 million hooks Minor line: 0		
Fishing permits	Longline boat SFRs: 82 Minor-line boat SFRs: 84			Longline boat SFRs: 81 Minor-line boat SFRs: 84		
Active vessels	Longline: 40 Minor line: 0			Longline: 37 Minor line: 0		
Observer coverage	Longline: 10.8% b Minor line: zero			Longline: 11.7% 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 because the fishing season transitioned to a calendar year; as of 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

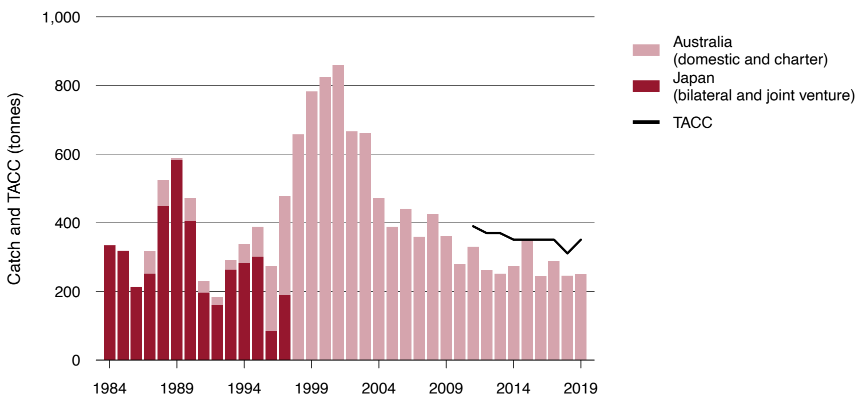
Stock structure

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

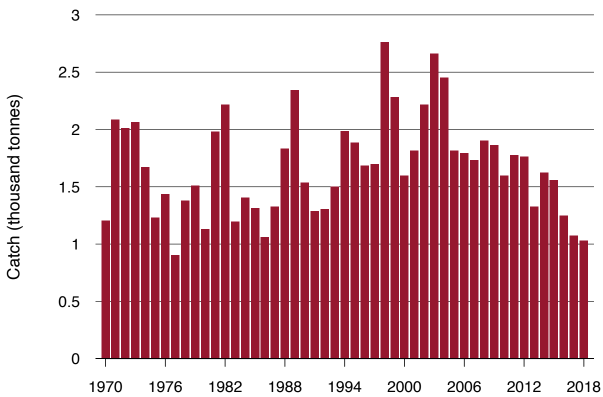
Catch for the ETBF increased slightly in 2019 to 251 t (Figure 21.4), while catch in the WCPFC area south of the equator decreased slightly from 1,074 t in 2017 to 1,029 t in 2018. (Figure 21.5).

FIGURE 21.4 Striped marlin catch and TACC in the ETBF, 1984 to 2019



Note: **TACC** Total allowable commercial catch. TACC in 2018 was adjusted for a 10-month season.
Source: AFMA

FIGURE 21.5 Striped marlin catch in the WCPFC area south of the equator, 1970 to 2018



Source: WCPFC

Stock assessment

The last stock assessment for striped marlin in the SWPO (0–40°S, 140°E–130°W) was in 2019 (Ducharme, Pilling & Hampton 2019). Influential changes from the previous (2012) assessment included use of standardised catch-per-unit-effort for the Japanese and Chinese Taipei fisheries calculated using a geostatistical model, and updating the biological information on maturity and defining maturation as a function of length rather than age. The full stock assessment comprises a grid of 300 individual assessment models covering 6 axes of uncertainty, all with equal weighting.

The grid median recent spawning stock biomass was 19.8% of the levels predicted to occur in the absence of fishing ($SB_{recent}/SB_{F=0}$ = 0.198; 80% confidence interval [CI] 0.09–0.46). There was a 50.3% probability that the recent spawning stock biomass had breached the Commonwealth default limit reference point ($0.2SB_0$). This was more pessimistic than the previous (2012) assessment where spawning biomass was estimated to be 34% of the levels predicted to occur in the absence of fishing ($SB_{2006\text{-}2009}/SB_{F=0}$ = 0.34).

In terms of maximum sustainable yield (MSY), the median recent spawning biomass was clearly below the level associated with MSY (SB_{recent}/SB_{MSY} = 0.74; 80% CI 0.33–1.63). There was a 68.6% probability that the recent spawning biomass depletion was below the spawning biomass associated with MSY.

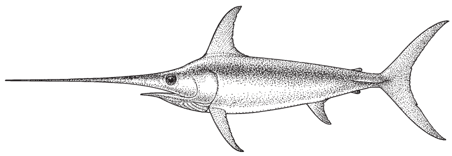
The median recent fishing mortality was 91% of the level associated with MSY (F_{recent}/F_{MSY} = 0.91; 80% CI 0.31–1.89). There was a 44.3% probability that the recent fishing mortality was above F_{MSY}. This is slightly more pessimistic than the previous (2012) assessment where fishing mortality was at 81% of the level associated with MSY.

Stock status determination

The most recent median estimate of the SWPO spawning biomass of striped marlin is estimated to be very close to, but just below, the $0.2SB_0$ limit reference point adopted in the HSP and in the WCPFC for tunas (specifically, 20% of the levels predicted to occur in the absence of fishing: $0.2SB_{F=0}$). The most recent median estimate of fishing mortality (and a majority of the grid outcomes) were below the level associated with MSY (F_{MSY}). As a result, the striped marlin stock in the SWPO (including the ETBF) is classified as **overfished** but is **not subject to overfishing**. The WCPFC Scientific Committee 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.

Radio beacons
Gavin Kewan, AFMA

Swordfish (*Xiphias gladius*)



Line drawing: Gavin Ryan

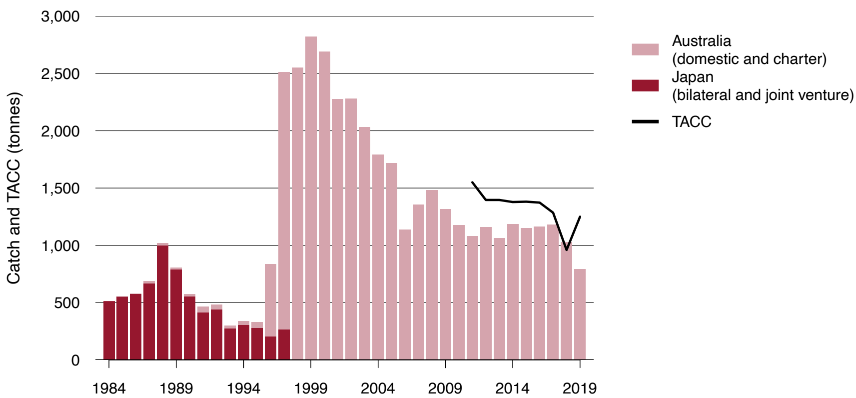
Stock structure

Although studies of swordfish have generally indicated a low level of genetic variation in the Pacific Ocean (Kasapidis et al. 2008), the WCPFC assesses 2 stocks separately: a north Pacific stock and an SWPO stock. The information reported here is for the SWPO stock (0–50°S, 140°E–130°W).

Catch history

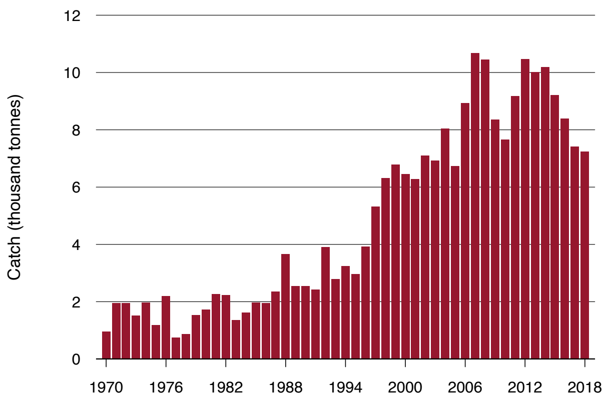
Swordfish catch in the ETBF decreased in 2019 to 792 t (Figure 21.6). Catch in the WCPFC area south of the equator declined from 7,415 t in 2017 to 7,239 t in 2018. (Figure 21.7).

FIGURE 21.6 Swordfish catch and TACC in the ETBF, 1984 to 2019



Note: **TACC** Total allowable commercial catch. TACC in 2018 was adjusted for a 10-month season.
Source: AFMA

FIGURE 21.7 Swordfish catch in the WCPFC area south of the equator, 1970 to 2018



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 was based on a structural uncertainty grid that included 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).

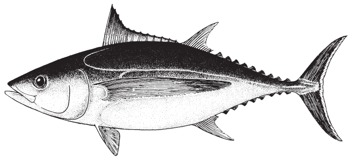
Across all models in the uncertainty grid, the spawning biomass declined steeply between the late 1990s and 2010, but the rate of decline has been less since then. These declines are greater in eastern region 2 (0–50°S, 165°E–130°W), where fishing mortality is also greater, compared to western region 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% CI 0.29–0.43). The probability that the recent spawning stock biomass has breached the limit reference point was very low. The median recent fishing mortality was 86% of the fishing mortality associated with MSY (F_{recent}/F_{MSY} = 0.86; 80% CI 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 $0.2SB_{F=0}$ 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 (including the ETBF) 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

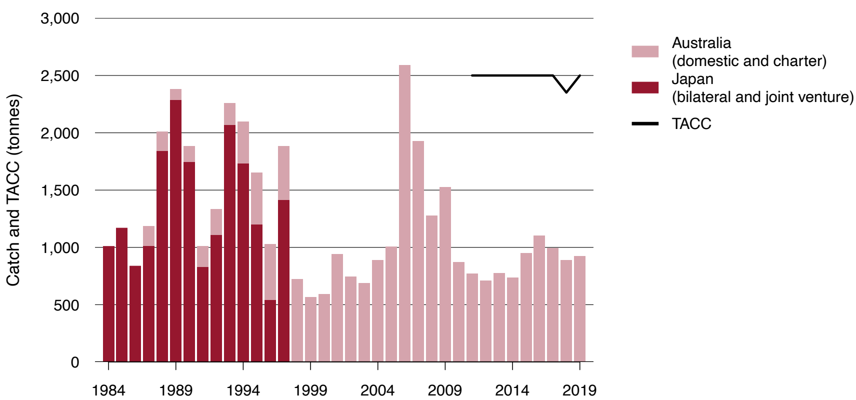
Stock structure

Two distinct stocks of albacore (north Pacific and south Pacific) are found in the Pacific Ocean, generally associated with the 2 oceanic gyres. These 2 stocks are assessed separately (WCPFC 2015). Information for the south Pacific albacore stock (0–50°S, 140°E–130°W) is reported here.

Catch history

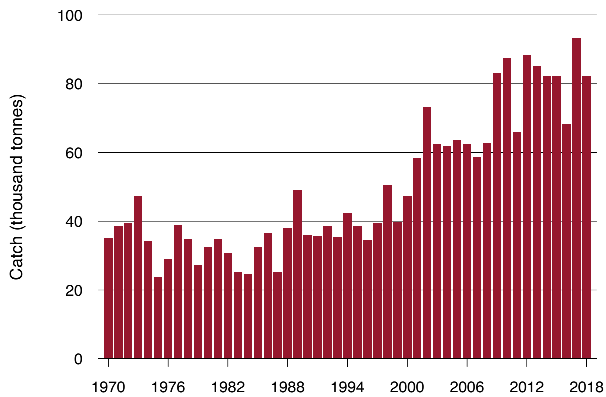
Catches in the ETBF increased slightly to 923 t in 2019 (Figure 21.8). Catches in the south Pacific (Pacific-wide south of the equator) have been somewhat variable over recent years, in the range of 68,000 t to 93,000 t (Figure 21.9). The WCPFC Scientific Committee recommended that longline fishing mortality be reduced if the WCPFC goal is to maintain economically viable catch rates.

FIGURE 21.8 Albacore catch and TACC in the ETBF, 1984 to 2019



Note: **TACC** Total allowable commercial catch. TACC in 2018 was adjusted for a 10-month season.
Source: AFMA

FIGURE 21.9 Albacore catch in the south Pacific, 1970 to 2018



Source: WCPFC

Stock assessment

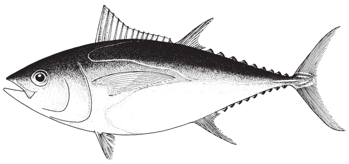
The assessment for albacore in the south Pacific was updated in 2018 using MULTIFAN-CL (Tremblay-Boyer et al. 2018). Significant improvements in the 2018 stock assessment included modifications to the catch rate index of abundance, inclusion of a higher natural mortality (0.4) in the grid, inclusion 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% CI 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% CI 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 (including the ETBF) is classified as **not subject to overfishing** and **not overfished**.

Bigeye tuna (*Thunnus obesus*)



Line drawing: FAO

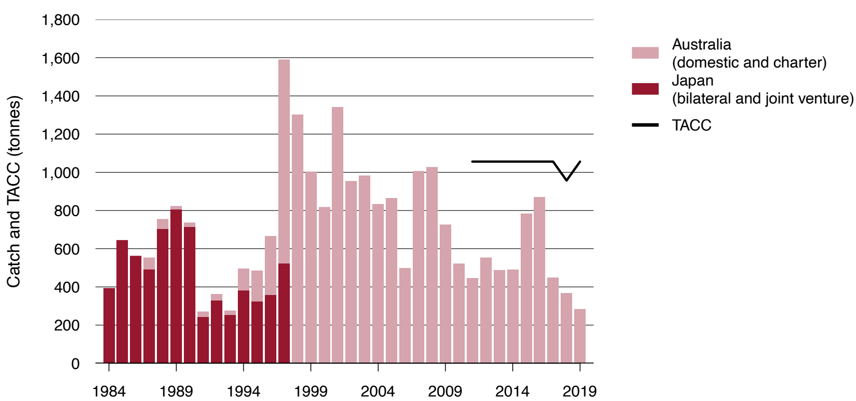
Stock structure

Genetic data have indicated that bigeye tuna in the Pacific Ocean is a single biological stock (Grewe & Hampton 1998).

Catch history

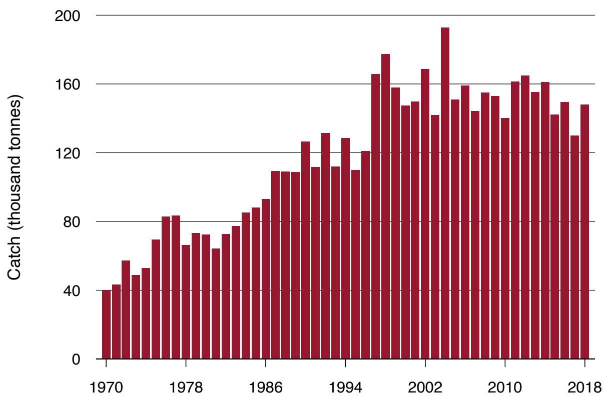
Catches of bigeye tuna decreased in the ETBF in 2019, from 367 t in 2018 to 284 t (Figure 21.10), the lowest catch since 1996. Catches increased in the WCPFC area in 2018 (Figure 21.11). Recent bigeye tuna catch in the WCPFC area (147,985 t in 2018) is below the estimated MSY (median 158,551 t). Catches 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 to 2019



Note: **TACC** Total allowable commercial catch. TACC in 2018 was adjusted for a 10-month season.
Source: AFMA

FIGURE 21.11 Bigeye tuna catch in the WCPFC area, 1970 to 2018



Source: WCPFC

Stock assessment

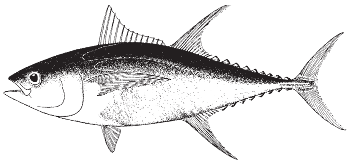
The bigeye tuna stock in the western and central Pacific Ocean (WCPO) was most recently assessed in 2017 (McKechnie, Pilling & Hampton 2017) using the assessment package MULTIFAN-CL. The assessment was re-evaluated in 2018, incorporating an updated growth curve resulting from analysis of an enhanced 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% CI 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% CI 0.67–0.93). There was a 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 20%$SB_{F=0}$ 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 WCPO stock (including the ETBF) is classified as **not subject to overfishing**.

Yellowfin tuna (*Thunnus albacares*)



Line drawing: FAO

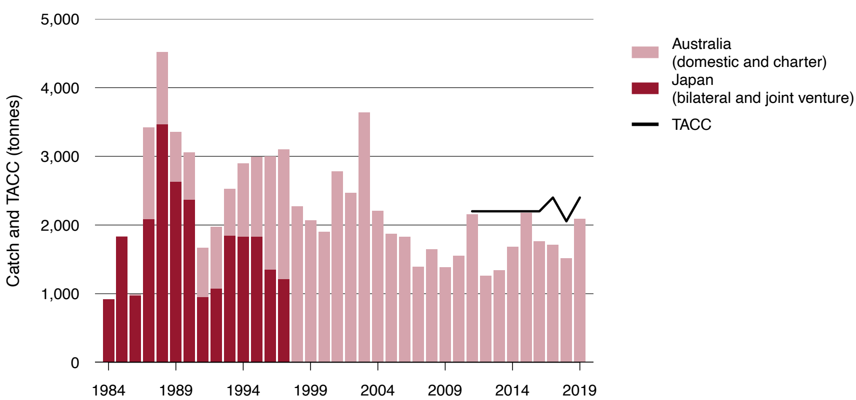
Stock structure

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 3 sites (Coral Sea, Tokelau and California) across the Pacific Ocean (Grewe et al. 2015). Further work is underway to confirm and expand on this preliminary study.

Catch history

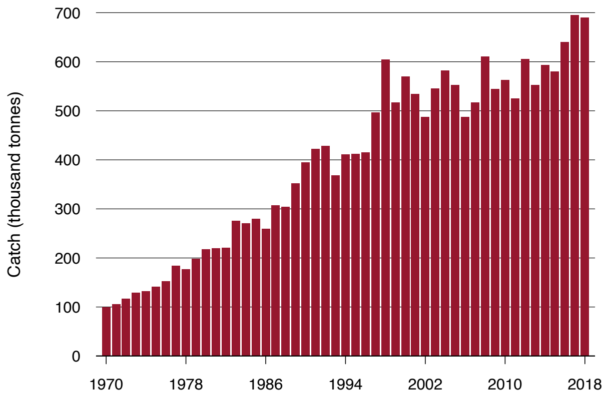
Catch increased slightly in the ETBF in 2019 to 2,089 t (Figure 21.12). In the wider WCPFC area catches have increased progressively and have risen 6-fold since 1970 to 690,207 t in 2018 (Figure 21.13), which is above the estimated MSY (median 670,800 t).

FIGURE 21.12 Yellowfin tuna catch and TACC in the ETBF, 1984 to 2019



Note: **TACC** Total allowable commercial catch. TACC in 2018 was adjusted for a 10-month season.
Source: AFMA

FIGURE 21.13 Yellowfin tuna catch in the WCPFC area, 1970 to 2018



Source: WCPFC

Stock assessment

The yellowfin tuna stock in the WCPO was most recently assessed in 2017 (Tremblay-Boyer et al. 2017) using the assessment package 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% CI 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% CI 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 $0.2SB_{F=0}$ adopted for tunas. As a result, the WCPFC stock (including the ETBF) 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**.

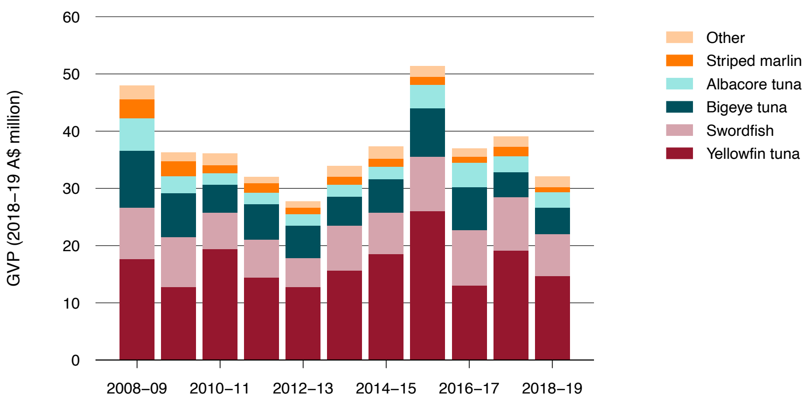
21.3 Economic status

Key economic trends

Gross value of production (GVP) in the ETBF declined in real terms (2018–19 dollars) from $119.0 million in 2001–02 to $27.7 million in 2012–13, reflecting lower landed catch and falling average prices. During this period, the number of active vessels and fishing effort fell significantly, suggesting unfavourable economic conditions in the fishery. Additionally, a number of active longline permits were taken out of the fishery through the boat fishery concession buyback component of the Securing Our Fishing Future structural adjustment package (Vieira et al. 2010). Declining prices and rising input costs during this period may have also reduced fishing effort and catch.

In 2015–16, GVP reached an 11-year high in real terms of $51.4 million as a result of increased catch and generally improved prices that year. GVP has since remained below the value achieved in 2015–16, largely as a result of lower catch volume. GVP in the ETBF decreased by 16% in 2018–19 to $32.1 million (Figure 21.14). This decline in GVP was largely the result of lower catch value of key targeted ETBF species: yellowfin tuna and swordfish.

FIGURE 21.14 Real GVP for the ETBF, 2008–09 to 2018–19



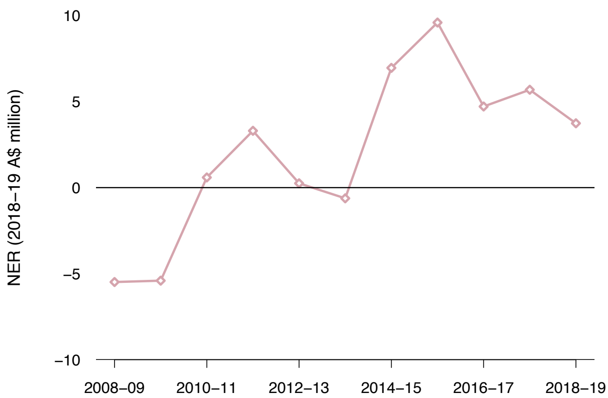
Notes: **GVP** Gross value of production. 'Real' indicates that value has been adjusted for inflation.

ABARES has conducted economic surveys of the ETBF since the early 1990s. The survey data are used to estimate the net economic returns (NER) earned in the fishery. 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 and 2018–19 financial years.

In 2015–16, NER for the ETBF are estimated to have increased to $9.6 million—the highest net return to the fishery in real terms since economic surveys of the ETBF began (Figure 21.15). 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 $4.7 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 $5.7 million, largely as a result of a 10% increase in fishing income. Non-survey-based estimates for 2018–19 indicate a 34% reduction in NER to $3.7 million, largely reflecting income falling more than fishing costs. A decline in total number of fishing days is expected to have contributed to lower overall fishing costs in 2018–19.

FIGURE 21.15 NER for the ETBF, 2008–09 to 2018–19



Note: **NER** Net economic returns.
Source: Mobsby forthcoming

Performance against economic objective

Quota latency when the TACC is set at the economic target of maximum economic yield (MEY) can indicate whether the fishery is maximising economic returns. The potential lack of association between domestic management actions and changes in stock biomass for tuna species in the ETBF means that stock-wide biomass at maximum economic yield (B_{MEY}) may not be relevant (Larcombe, Patterson & Savage 2017). In 2017–18, the harvest strategies for swordfish and striped marlin were reviewed and found not likely to be achieving their HSP objectives. AFMA is in the process of redeveloping harvest strategies tested by a management strategy evaluation for these species.

Without an economic-based target for catch (that is, B_{MEY}), the level of catch in the fishery cannot be assessed against MEY. In lieu of meaningful B_{MEY} targets for highly migratory and internationally managed fisheries, increasing total factor productivity in the fishery is consistent with minimising inputs (costs) relative to output (revenue) and thus a movement towards maximising economic returns from the fishery. The productivity index for the ETBF followed an upward trend and increased by an annual average rate of 5% from 2002–03 to 2016–17, suggesting that the fishery is moving towards maximising returns to the fishery (Mobsby forthcoming).

NER are estimated to have been positive for 7 of the 8 years since the harvest strategy for the fishery was implemented in 2010–11. However, 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 (such as improving terms of trade). It is difficult to untangle the effects of the introduction of ITQs, reduced fleet size, total factor productivity and terms of trade changes on overall improvements in economic performance; further research is required to quantify the individual effects of these variables on NER.

21.4 Environmental status

Product from the ETBF currently has export approval under inclusion on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Act 1999* until 19 August 2022. 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.

The most recent ecological risk assessment (ERA) for the ETBF was finalised in 2019 (Sporcic et al. 2018). Of 261 species evaluated at ERA level 2, 8 species were found to be at *potential* high risk after productivity–susceptibility analysis or sustainability assessment for fishing effects. The subsequent residual risk analysis examining logbook and observer data demonstrated that there was a low or zero level of reported interactions and/or higher survivability than assumed in the initial analyses, reducing the risk posed by the fishery to these species to medium or low. There was no requirement to progress to a level 3 analysis in the most recent ERA.

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 2019.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE) and these are summarised below.

In 2019, logbooks indicated that 1,659 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the ETBF. Of these, 7 were alive, 574 were dead and 1,078 were released in unknown condition. Five longfin mako sharks (*I. paucus*) were also hooked, with 4 dead and 1 released in unknown condition. One porbeagle shark (*Lamna nasus*) was released in an unknown condition. Fifty-four silky sharks (*Carcharhinus falciformis*) were also released in unknown condition, as were 4 dusky whalers (*C. obscurus*) and 1 white shark (*Carcharodon carcharias*). Fifty-two green turtles (*Chelonia mydas*) were hooked; 42 were released alive and 10 were dead. Fifty-two leatherback turtles (*Dermochelys coriacea*) were hooked, with 51 released alive and 1 dead. Similarly, 12 loggerhead turtles (*Caretta caretta*) were hooked; 5 were released alive and 7 were dead. Eight hawksbill turtles (*Eretmochelys imbricata*) were hooked, with 4 dead and 4 released alive. Eight olive ridley turtles (*Lepidochelys olivacea*) were caught, with 7 released alive and 1 dead. One flatback turtle (*Natator depressus*) was dead after being hooked. Eighteen unidentified turtles were hooked, with 13 alive, 4 dead and 1 released in an unknown condition.

Two black-browed albatrosses (*Thalassarche melanophris*), 3 wandering albatross (*Diomedea exulans*) and 1 shy albatross (*T. cauta*) were all dead after being hooked. Fifty unidentified albatrosses were hooked, with 15 released alive and 35 dead. Two short-tailed shearwater (*Puffinus tenuirostris*) were hooked with 1 dead and 1 released alive. Thirty-seven unidentified shearwaters were hooked, with all except 1 being dead. One cape petrel (*Daption capense*) was hooked and dead, and 4 unidentified birds were released alive.

A number of interactions with marine mammals were recorded; these comprised 7 unidentified dolphins (5 released alive), 1 bottlenose dolphin (*Tursiops truncatus*) released alive, 3 common dolphin (*Delphinus* spp.) hooked, with 2 alive and 1 dead, 4 short-finned pilot whales (*Globicephala macrorhynchus*; 3 alive and 1 released in an unknown condition), 4 false killer whales (*Pseudorca crassidens*) were released alive, 1 unidentified whale was dead, and 2 New Zealand fur seals (*Arctocephalus forsteri*), 1 dead and 1 released alive.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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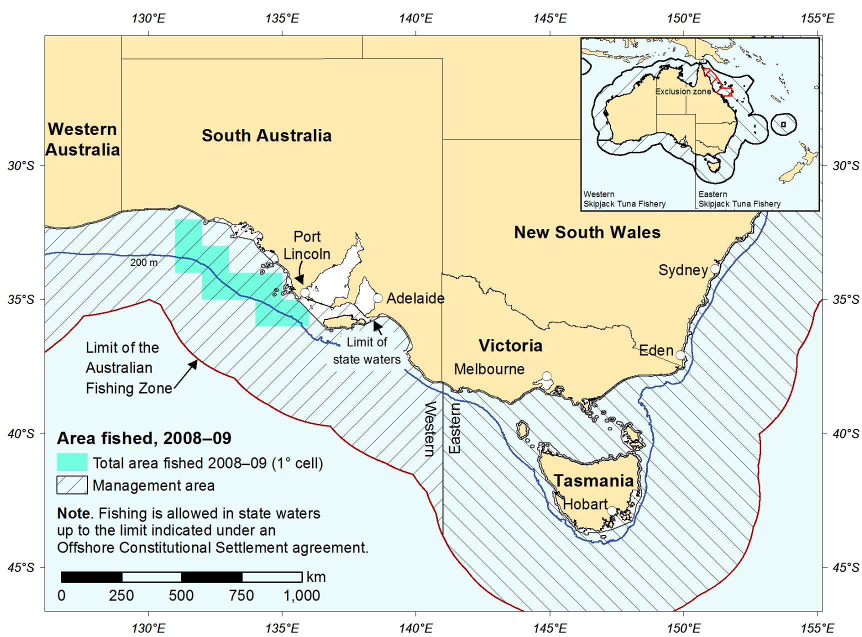
Tuna longline catch
Steve Hall, AFMA

Chapter 22

Skipjack Tuna Fishery

H Patterson and D Mobsby

FIGURE 22.1 Area fished in the Skipjack Tuna Fishery, 2008–09 to 2018–19



Note: The last effort in the fishery occurred in 2008–09.

TABLE 22.1 Status of the Skipjack Tuna Fishery

Stock	Biological status a,b				Comments
	2018		2019		
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Indian Ocean skipjack tuna (*Katsuwonus pelamis*)					No Australian vessels fished in 2019. 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*)					No Australian vessels fished in 2019. 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: 1 on the east coast that is part of a broader stock in the Pacific Ocean and 1 on the west coast that is part of a larger stock in the Indian Ocean. The 2 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 2 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 by 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 the 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

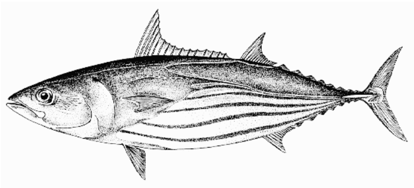
Fishery statistics a	2017–18 fishing season			2018–19 fishing season		
Fishery	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**
ESTF	–	0	$0	–	0	$0
WSTF	–	0	$0	–	0	$0
Total fishery	**–**	**0**	**$0**	**–**	**0**	**$0**
Fishery-level statistics						
Effort	0			0		
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 2015* (AFMA 2015)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 July to 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.

Skipjack tuna
AFMA

22.2 Biological status

Indian Ocean skipjack tuna (*Katsuwonus pelamis*)



Line drawing: FAO

Stock structure

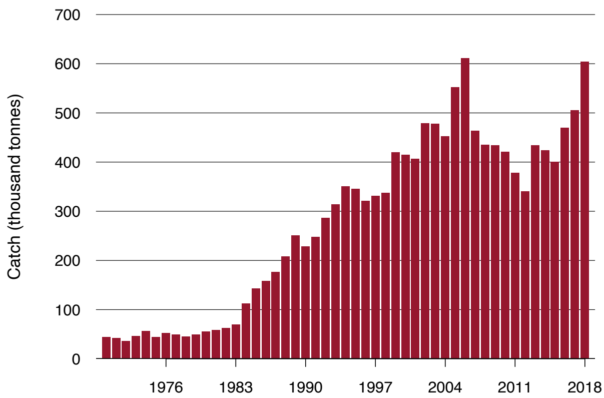
Skipjack tuna in the Indian Ocean is considered to be a single stock for stock assessment purposes. Preliminary population analysis of 261 individuals did not provide evidence of genetic differentiation among locations across the Indian Ocean (Davies et al. 2019). Tagging studies have shown large movements 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 505,175 t in 2017 to 604,465 t in 2018 (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 to 2018



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 spawning biomass (SB) at or above the target reference point of 40% of unfished biomass ($0.4SB_0$), while avoiding the limit reference point of 20% of unfished biomass ($0.2SB_0$). The HCR requires stock to be assessed every 3 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 3 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 previous 5 years (2012 to 2016; 407,450 t) was lower than the estimated catch required to maintain the stock at the target biomass level ($C_{0.4SB_0}$ = 510,100 t; range 455,900–618,800 t; Figure 22.2). Although catches since 2016 have increased significantly, the catch in 2018 (604,465 t) and the average catch over the last 5 years (2014 to 2018; ≈ 480,801 t) are still within the estimated range of $C_{0.4SB_0}$.

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 to 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 $0.4SB_0$.

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 average catch over the previous 5 years, and the catch in 2018, are proxies for recent fishing mortality, and both were in the estimated range to maintain the stock at the target biomass level. Therefore, the current level of fishing mortality is unlikely to have reduced the stock below the limit reference point and the stock is classified as **not subject to overfishing**.

Western and central Pacific Ocean skipjack tuna (*Katsuwonus pelamis*)

Stock structure

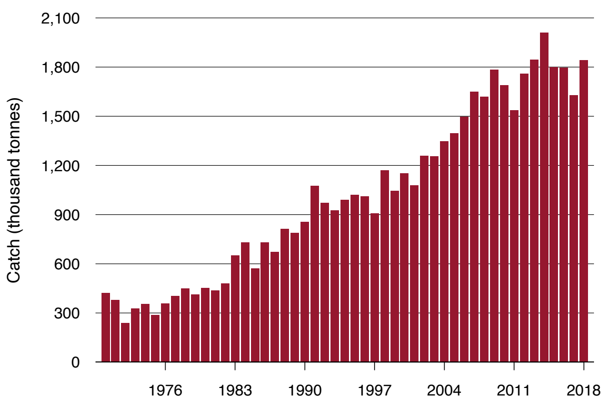
Skipjack tuna in the WCPO is considered to be a single stock for stock assessment purposes (Rice et al. 2014).

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 12 years (Figure 22.3).

Historically, effort in the ESTF has been very low. Catch has only been registered once in the past 14 years, with 44 t caught in 2005–06.

FIGURE 22.3 Skipjack tuna catch in the WCPFC area, 1970 to 2018



Source: WCPFC

Stock assessment

The skipjack tuna stock assessment for the WCPO was updated in 2019 using MULTIFAN-CL software (Vincent, Pilling & Hampton 2019) and data to the end of 2018. Key changes from the 2016 assessment included the adoption of a new 8-region model structure (compared with the previous 5-region structure); updated maturity and length information; and changes to a range of other inputs and assumptions, including treatment of tagging data, growth, length–weight and data weightings. The assessment grid included only the 8-region model structure (considered to best capture the biology of skipjack tuna) and 4 axes of uncertainty, with some relatively minor down-weighting of the values on 2 axes (steepness and length composition influence).

The median recent spawning biomass ($SB_{recent}/SB_{F=0}$) was 44% of the levels predicted to occur in the absence of fishing ($SB_{recent}/SB_{F=0}$ = 0.44; 80% probability interval = 0.37–0.53). There was a 0% probability that the recent spawning biomass had breached the adopted limit reference point. The median recent fishing mortality was 45% of the level associated with maximum sustainable yield (MSY) (F_{recent}/F_{MSY} = 0.45; 80% probability interval = 0.34–0.60). There was a 0% probability that the recent fishing mortality was above F_{MSY}. However, fishing mortality has continued to increase year on year for almost 5 decades.

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, expected net economic returns (NER) are estimated to be slightly negative, due to 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.

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 14 companies, 7 of which hold 1 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). 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).

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). To date, no protected species interactions have been reported in the STF.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

22.5 References

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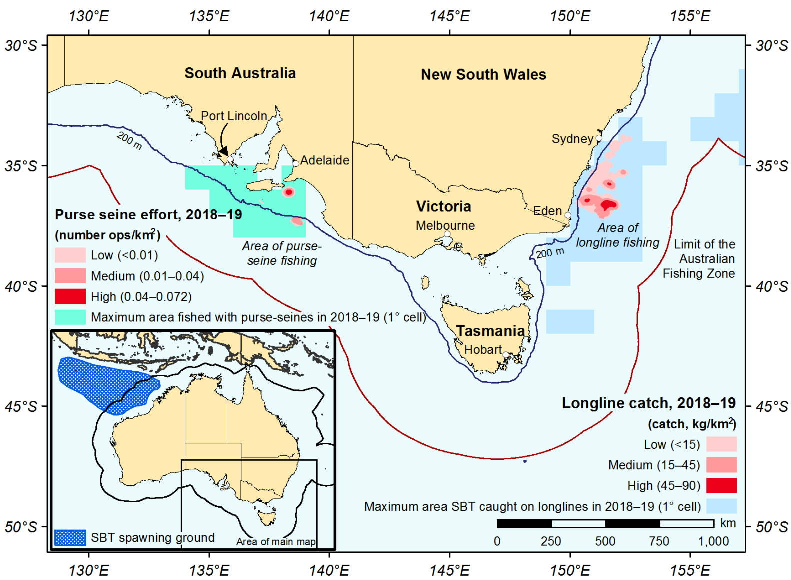
Chapter 23

Southern Bluefin Tuna Fishery

H Patterson, A Williams and D Mobsby

FIGURE 23.1 Purse-seine effort and longline catch in the Southern Bluefin Tuna Fishery, 2018–19 fishing season



Note: **SBT** Southern bluefin tuna.

TABLE 23.1 Status of the Southern Bluefin Tuna Fishery

Stock	Biological status a				Comments
	2018		2019		
	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 2018–19, 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. 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 by 2035, with 70% probability.

In 2019, the CCSBT adopted a new management procedure (the Cape Town Procedure) that aims to achieve rebuilding of the southern bluefin tuna stock to 30% of its initial unfished biomass by 2035, with 50% probability. However, this new procedure maintains the 70% probability that the stock rebuilds to 20% by 2035. This new management procedure will be used to set the global TAC from 2021 onwards. 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 sets the TAC for the SBTF with reference to Australia's CCSBT allocation.

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 considered 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 5 to 8 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

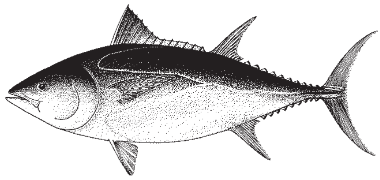
Fishery statistics a	2017–18 fishing season			2018–19 fishing season		
Fishery/sector	**TAC (t)**	**Catch (t)**	**GVP (2017–18)**	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**
Purse seine	6,528 **b**	5,124	$32.63 million	6,284 **c**	5,291	$34.51 million
Pelagic longline	–	1,035 **d**	$7.11 million	–	783 **d**	$8.9 million
Total fishery	**–**	**6,159**	**$39.74 million**	**–**	**6,074**	**$43.41 million**
Fishery-level statistics						
Effort **e**	Purse seine: 1,137 search-hours; 198 shots			Purse seine: 1,366 search-hours; 166 shots		
Fishing permits	84 SFR owners initially allocated			82 SFR owners initially allocated		
Active vessels	Purse seine: 7 Longline: 31			Purse seine: 7 Longline: 20		
Observer coverage **f**	Purse seine: 40 shots (20.9%) Longline: 10.8% (of hooks) in ETBF; 13.0% (of hooks) in WTBF			Purse seine: 22 shots (14.3%) Longline: 11.7% (of hooks) in ETBF; 12.8% (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 to 30 November. Value statistics are by financial year. **b** Australia carried forward ~363 t of undercatch to the 2017–18 TAC. **c** Australia carried forward ~119 t of undercatch to the 2018–19 TAC. The TAC set by the Australian Fisheries Management Authority 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 pens
AFMA

23.2 Biological status

Southern bluefin tuna (*Thunnus maccoyii*)



Line drawing: FAO

Stock structure

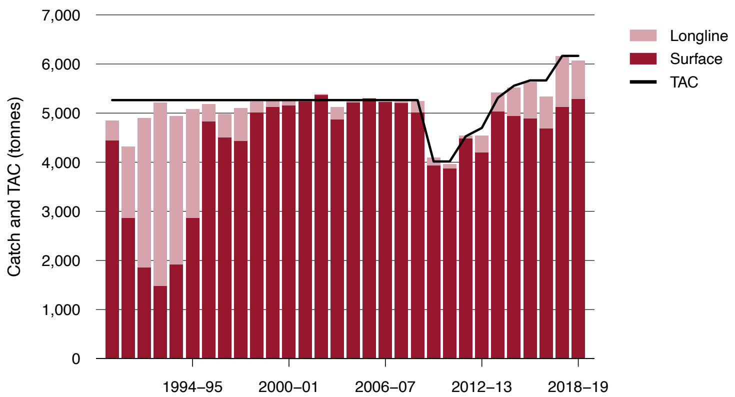
Southern bluefin tuna constitutes a single, highly migratory stock that spawns in the north-east Indian Ocean (off north-western Australia, south of Indonesia; Figure 23.1) and migrates throughout the temperate southern oceans.

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).

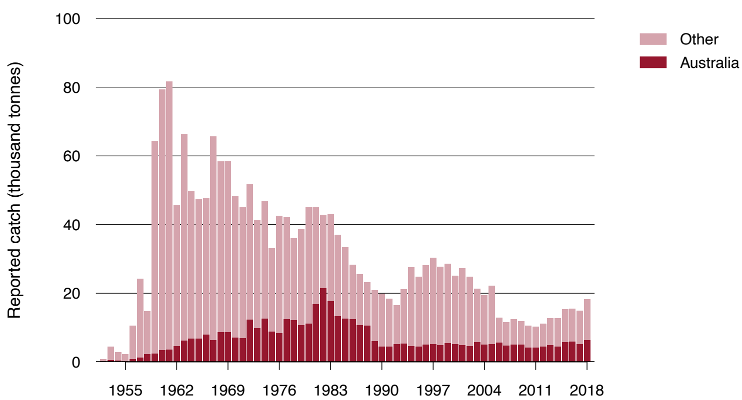
Recreational angling for southern bluefin tuna in Australia has been popular among game fishers for many years, and activity among the general recreational fishing sector has increased in previous years (for example, Rowsell et al. 2008). At present, limited data are available on the recreational catch 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 survey of recreational fishing for southern bluefin tuna estimated a catch of 270 t with 6% error in 2018–19 (Tracey et al. 2020). Based on these results, and other considerations, the Australian Government announced that 5% of Australia's CCSBT allocation should be set aside for recreational fishing each year.

FIGURE 23.2 Southern bluefin tuna catch and TAC (Australia), 1989–90 season to 2018–19 season



Note: **TAC** Total allowable catch.
Source: AFMA

FIGURE 23.3 Southern bluefin tuna catch (global), 1952 to 2018



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 3 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). An updated stock assessment will be undertaken in 2020 and the results reported in the *Fishery status reports 2021.*

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 2019 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

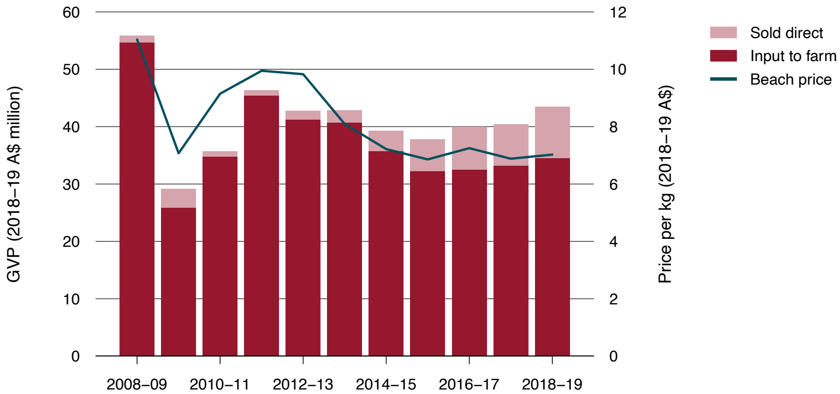
Assessment of economic performance in the wild-catch sector is complicated by the vertical integration of the wild-catch and aquaculture sectors. As noted above, most southern bluefin tuna caught are transferred to aquaculture farms off Port Lincoln. The beach price paid for live fish at the point of 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 2018–19, 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 9% to $43.4 million (Figure 23.4). The increase in production value was driven by higher catch and an increase in average prices. The increase in catch volume consisted of more southern bluefin tuna being transferred into aquaculture farms as well as increased longline catch. Despite an increase in farm input in 2017–18, a generally declining share of southern bluefin tuna has been ranched in recent years. Conversely, catch from eastern Australia has increased (predominantly caught by the Commonwealth Eastern Tuna and Billfish Fishery fleet).

The average price for southern bluefin tuna increased by 4% in 2018–19, although there has been a longer-run decline in southern bluefin tuna prices. Between 2002–03 and 2018–19, the total production value of the SBTF declined by 62% in real terms. Most of the decline in gross value of production (GVP) occurred from 2002–03 to 2010–11 as a result of prices falling and a reduction in quota. Since 2010–11, increases in quota have supported GVP in the fishery, with prices remaining below those in 2010–11 in recent years.

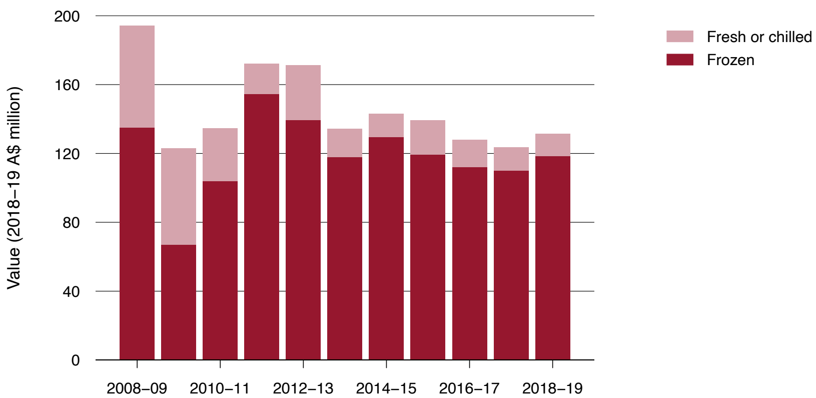
For exports, the value of southern bluefin tuna fell by 66% in real terms between 2002–03 and 2018–19, which was the result of a decline in unit export prices (Figure 23.5). Australia's southern bluefin tuna industry is highly export oriented, and the decline in price is the result of a number of related 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.

FIGURE 23.4 Real GVP of southern bluefin tuna production, 2008–09 to 2018–19



Notes: **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, 2008–09 to 2018–19



Note: 'Real' indicates that value has been adjusted for inflation.

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 11 November 2022. Conditions placed on the export approval include increasing confidence in the estimates of purse-seine catches, that the management arrangements start accounting for all sources of mortality of southern bluefin tuna, including recreational and Indigenous catch, and that the management arrangements continue to support the recovery of the stock.

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).

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). No interactions with protected species were reported for the SBTF in 2019. Interactions with sharks and other protected species using longline gear are discussed in Chapters 21 and 24.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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Southern bluefin tuna
Jarrad James, AFMA

Chapter 24

Western Tuna and Billfish Fishery

A Williams, H Patterson and D Mobsby

FIGURE 24.1 Area of the Western Tuna and Billfish Fishery, 2019

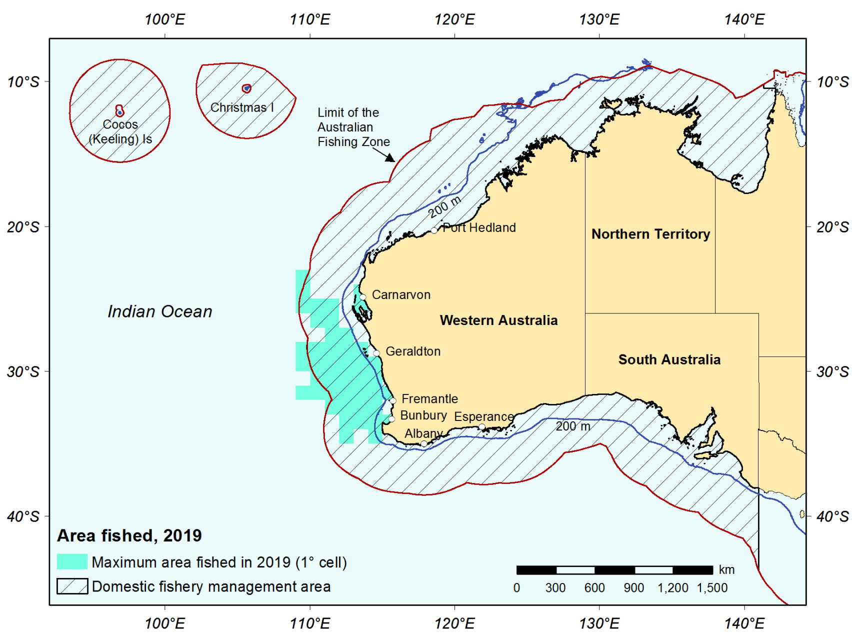


TABLE 24.1 Status of the Western Tuna and Billfish Fishery

Stock	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
	Biological status a				
Striped marlin (*Kajikia audax*)	Subject to overfishing	Overfished	Subject to overfishing	Overfished	Most recent estimates of biomass (2018) indicate that the stock is below the default Commonwealth limit reference point. Current fishing mortality rate exceeds that required to produce MSY.
Swordfish (*Xiphias gladius*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	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*)	Not subject to overfishing	Not overfished	Subject to overfishing	Not overfished	Most recent estimate of spawning biomass (2019) is above the default Commonwealth limit reference point. Current fishing mortality rate is above that required to produce MSY.
Bigeye tuna (*Thunnus obesus*)	Not subject to overfishing	Not overfished	Subject to overfishing	Not overfished	Most recent estimate of spawning biomass (2019) is above the default Commonwealth limit reference point. Current fishing mortality rate is above that required to produce MSY.
Yellowfin tuna (*Thunnus albacares*)	Subject to overfishing	Not overfished	Subject to overfishing	Not overfished	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 2019, suggesting little economic incentive to fish and relatively low 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 determining stock status.
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 (*T. 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	**2018**			**2019**		
Stock	**TACC (t)** b	**Catch (t)**	**GVP (2017–18)**	**TACC (t)** b	**Catch (t)**	**GVP (2018–19)**
Striped marlin	125	1	Confidential	125	1	Confidential
Swordfish	3,000	174	Confidential	3,000	117	Confidential
Albacore	–	12	Confidential	–	16	Confidential
Bigeye tuna	2,000	49	Confidential	2,000	38	Confidential
Yellowfin tuna	5,000	42	Confidential	5,000	46	Confidential
Total	**10,125**	**278**	**Confidential**	**10,125**	**218**	**Confidential**
Fishery-level statistics						
Effort	Pelagic longline: 404,880 hooks Minor line: na			Pelagic longline: 366,821 hooks Minor line: na		
Fishing permits	94 boat SFRs			94 boat SFRs		
Active vessels	Pelagic longline: 2 Minor line: 1			Pelagic longline: 2 Minor line: 2		
Observer coverage	13.0% c			12.8% c		
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** The TACC for each stock was first set in 2010, then revised in 2012, and was based on an approximation of the proportion of the total potential yield for the Indian Ocean that is available to the WTBF. **c** 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 4 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 significantly 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.

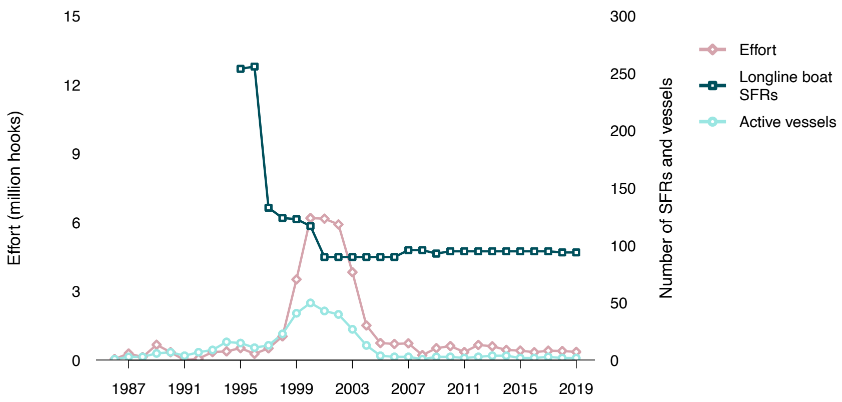
The default limit reference points in the Commonwealth Fisheries Harvest Strategy Policy (Department of Agriculture and Water Resources 2018) are used to determine stock status in the WTBF. The limit reference point for biomass is 20% of the unfished biomass ($0.2B_0$). For fishing mortality, the limit 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 pelagic longline vessels that fished for more than 30 days in the previous or current season 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 shots.

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 5 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 to 2019

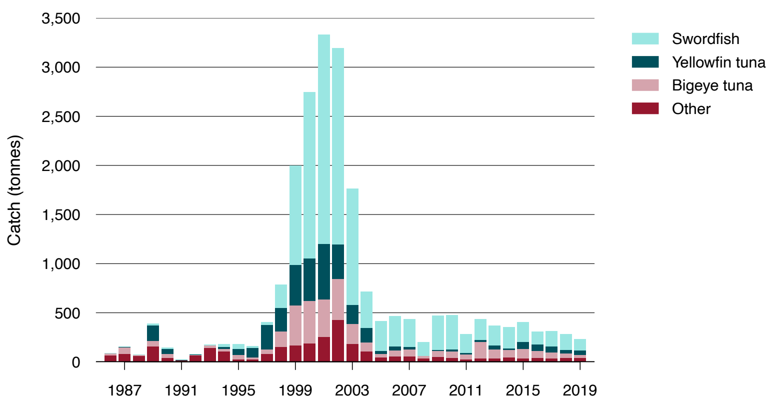


Note: **SFR** Statutory fishing right.
Source: AFMA

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.

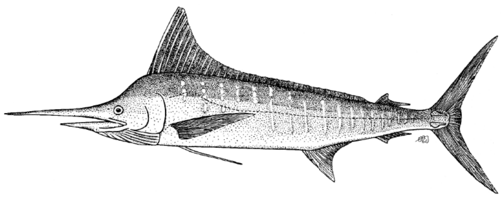
FIGURE 24.3 Total annual catch, by species, in the WTBF, 1986 to 2019



Source: AFMA

24.2 Biological status

Striped marlin (*Kajikia audax*)



Line drawing: FAO

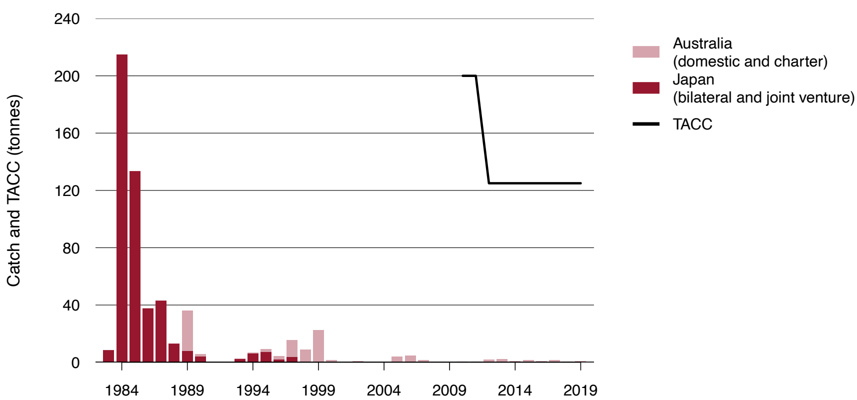
Stock structure

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 (8 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 biological stock for assessments in the Indian Ocean.

Catch history

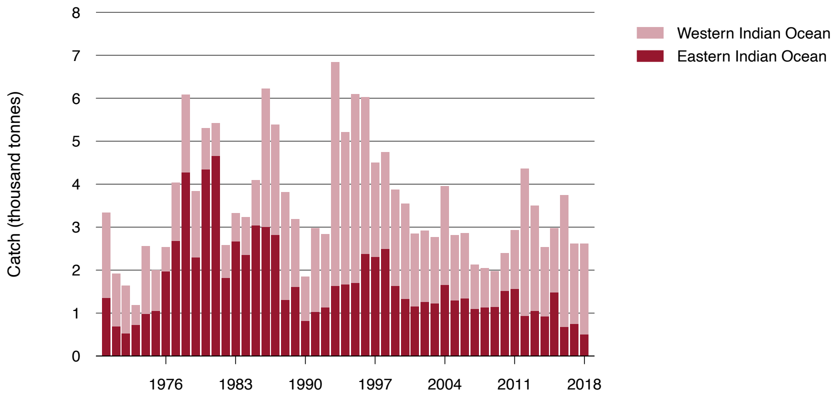
Catches of striped marlin in the WTBF have been relatively low (<50 t) since the mid 1980s and very low (<5 t) since 2000, with less than 1 t taken in 2019 (Figure 24.4). Total international catches in the IOTC area of competence declined from around 6,000 t in 1995 to around 2,000 t in 2009 (Figure 24.5). Annual catches in 2018 were 2,612 t, which is below the estimated maximum sustainable yield (MSY) (4,730 t).

FIGURE 24.4 Striped marlin catch and TACC in the WTBF, 1983 to 2019



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.5 Striped marlin catch in the IOTC area, 1970 to 2018



Source: IOTC

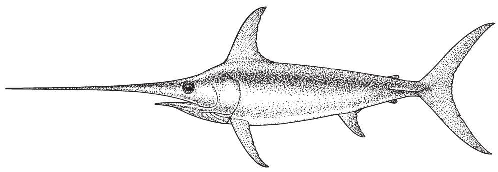
Stock assessment

A stock assessment in 2018 for the Indian Ocean–wide stock used 2 assessment models: JABBA, a Bayesian state-space production model, and Stock Synthesis 3 (SS3) (IOTC 2019). 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 2019). Fishing mortality for the Indian Ocean–wide stock 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 stock assessment models indicate that the Indian Ocean–wide 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**. Despite relatively small domestic catches of striped marlin in the WTBF, fishing mortality for the Indian Ocean–wide stock was estimated to be well above F_{MSY}, so the stock is classified as **subject to overfishing**.

Swordfish (*Xiphias gladius*)



Line drawing: Gavin Ryan

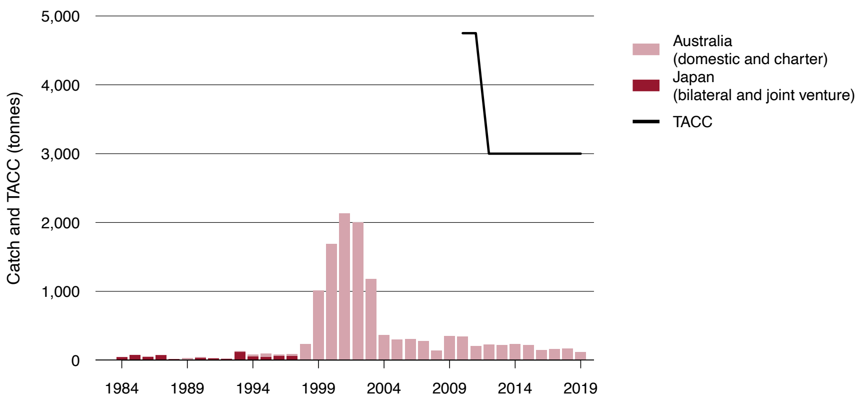
Stock structure

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. Similarly, preliminary genetics and otolith microchemistry analysis from a more recent study of a relatively large sample across the Indian Ocean also suggests a single stock (Davies et al. 2019). Swordfish in the Indian Ocean is therefore considered to be a single biological stock.

Catch history

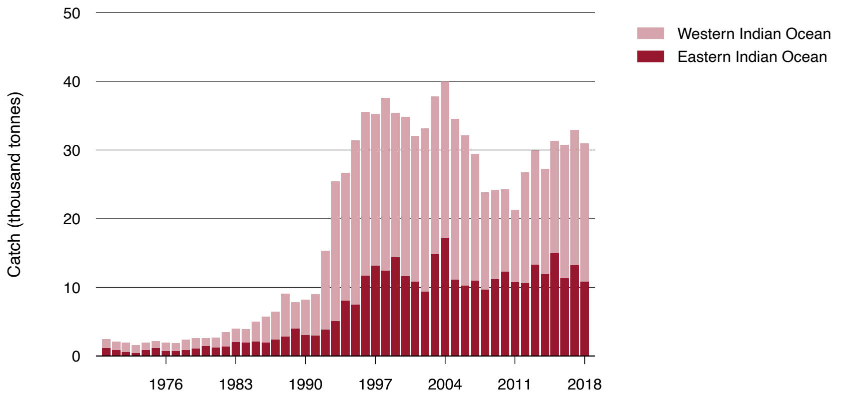
Annual swordfish catch in the WTBF peaked at around 2,000 t in the early 2000s but has declined to below 350 t since 2005. In 2019, the annual catch was 117 t, a slight decrease from the 2018 catch of 174 t (Figure 24.6). Total international catches of swordfish in the IOTC area of competence peaked 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 30,936 t in 2018, which is just below the 2017 estimate of MSY (31,590 t).

FIGURE 24.6 Swordfish catch and TACC in the WTBF, 1983 to 2019



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.7 Swordfish catch in the IOTC area, 1970 to 2018



Source: IOTC

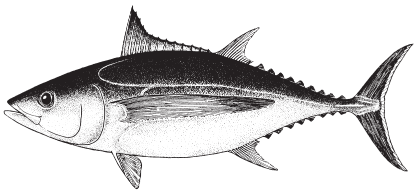
Stock assessment

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; 80% CI 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 for the Indian Ocean–wide stock 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 Indian 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

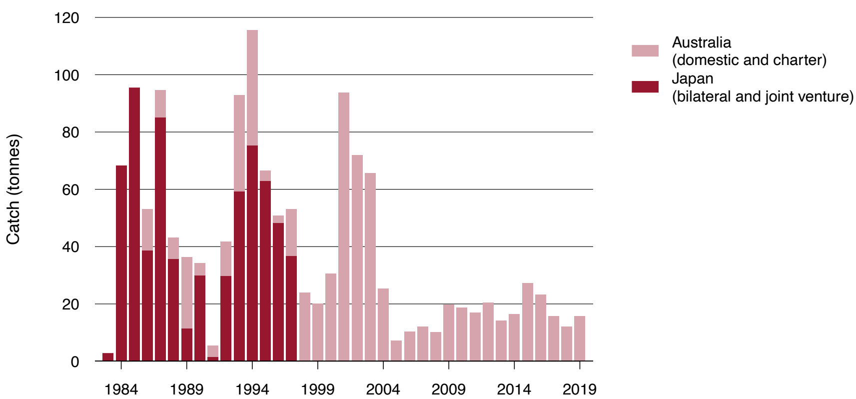
Stock structure

A global genetic 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). Similarly, a preliminary analysis from a recent genetics and otolith microchemistry study of a relatively large sample suggests a single stock within the Indian Ocean (Davies et al. 2019). Therefore, albacore is assumed to be a single biological stock in the Indian Ocean for assessments.

Catch history

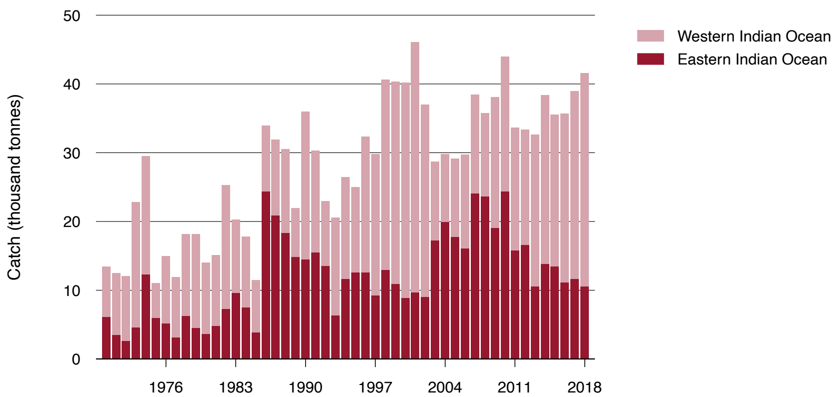
Historically, albacore catches in the WTBF have been low, peaking at 115 t in 1994 and again at 94 t in 2001 (Figure 24.8). Since 2004, annual catches have been below 30 t, and were approximately 16 t in 2019. Total international catches in the IOTC area of competence peaked at more than 43,000 t in 2010, and have fluctuated between 30,000 t and 42,000 t since 2011 (Figure 24.9). The average annual catch during the past 5 years (2014–2018) was approximately 38,030 t, which is higher than the 2019 estimate of MSY (35,700 t) (IOTC 2019).

FIGURE 24.8 Albacore catch in the WTBF, 1983 to 2019



Source: AFMA

FIGURE 24.9 Albacore catch in the IOTC area, 1970 to 2018



Source: IOTC

Stock assessment

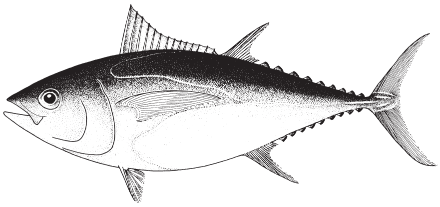
In 2019, 5 assessment models were used to assess the Indian Ocean albacore stock: SS3, ASPIC, a statistical catch-at-age model (SCAA) and a Bayesian state-space production model. The results from the SS3 model were used to determine the current status of albacore and provide management advice (IOTC 2019), although the results from all the models were generally consistent. Considerable uncertainty remains in the SS3 model results because of conflicts in key data inputs (IOTC 2019).

The result of the SS3 model indicated that the current (2017) biomass for the Indian Ocean–wide stock was above the limit reference point (SB_{2017}/SB_{1950} = 0.26; CI not available) and above the level that supports MSY (SB_{2017}/SB_{MSY} = 1.28; 95% CI 0.57–2.07). Fishing mortality for the Indian Ocean–wide stock was estimated to be above the level that supports MSY (F_{2017}/F_{MSY} = 1.35; 95% CI 0.59–2.17) (IOTC 2019), which is an increase since the last assessment in 2016 due an increase in catches by several countries since 2015 across the Indian Ocean.

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**. Despite relatively small domestic catches of albacore in the WTBF, fishing mortality for the Indian Ocean–wide stock is above F_{MSY}, and so the stock is classified as **subject to overfishing**.

Bigeye tuna (*Thunnus obesus*)



Line drawing: FAO

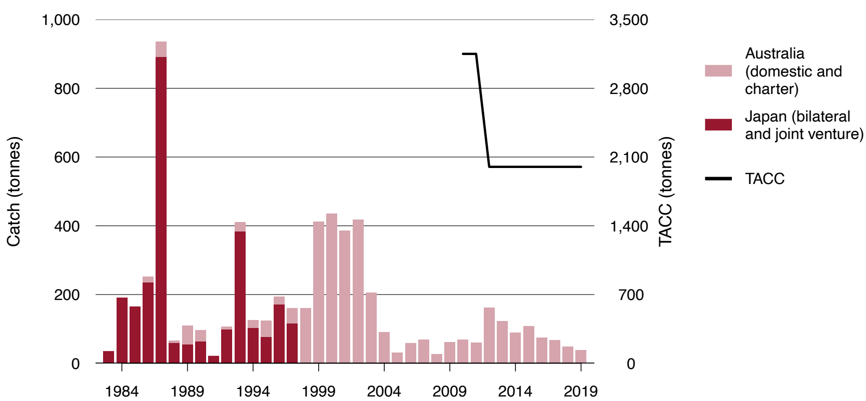
Stock structure

The stock structure of bigeye tuna in the Indian Ocean is uncertain, but the species is considered to be a single 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

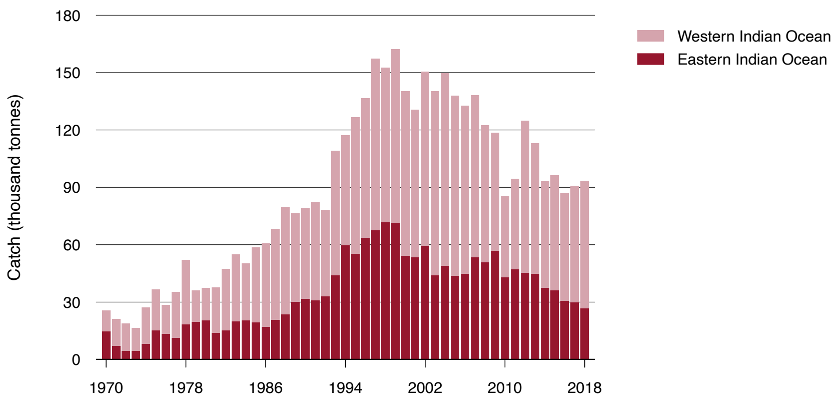
Annual catches of bigeye tuna in the WTBF varied widely between 1983 and 2004, with the highest catch of more than 900 t in 1987 and the lowest catch of less than 22 t in 1991 (Figure 24.10). Catches have been more stable since 2004, and have not exceeded 200 t; catches over the past 4 years are below 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 93,493 t in 2018 and averaged 92,108 t over the past 5 years, both of which are above the 2019 MSY estimate of 87,000 t.

FIGURE 24.10 Bigeye tuna catch and TACC in the WTBF, 1983 to 2019



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.11 Bigeye tuna catch in the IOTC area, 1970 to 2018



Source: IOTC

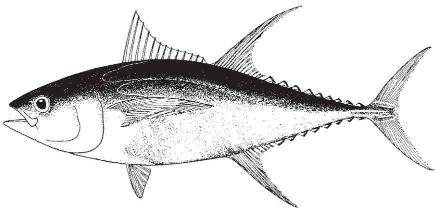
Stock assessment

In 2019, the 2016 Indian Ocean–wide stock assessment for bigeye tuna was updated using SS3 and JABBA (IOTC 2019). The SS3 assessment was used to provide management advice, and consisted of 18 model configurations that were designed to account for the uncertainty in the stock–recruitment relationship, the influence of the tagging data, and selectivity of longline fleets (IOTC 2019). Current (2018) spawning stock biomass in the Indian Ocean was estimated to be above the level that would produce MSY (SB_{2018}/SB_{MSY} = 1.22; 80% CI 0.82–1.81). Similarly, the assessment indicated that Indian Ocean spawning biomass was above 20% of the initial unfished level (SB_{2018}/SB_0 = 0.31; 80% CI 0.21–0.34). Fishing mortality for the Indian Ocean–wide stock was above the level associated with MSY (F_{2015}/F_{MSY} = 1.20; 80% CI 0.70–2.05), which is an increase since the last assessment in 2016 due to a significant increase in estimated purse seine catches in 2018 in the Indian Ocean.

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**. Despite relatively small domestic catches of bigeye tuna in the WTBF**,** fishing mortality for the Indian Ocean–wide stock is above the level that would produce F_{MSY}, so the stock is classified as **subject to overfishing**.

Yellowfin tuna (*Thunnus albacares*)



Line drawing: FAO

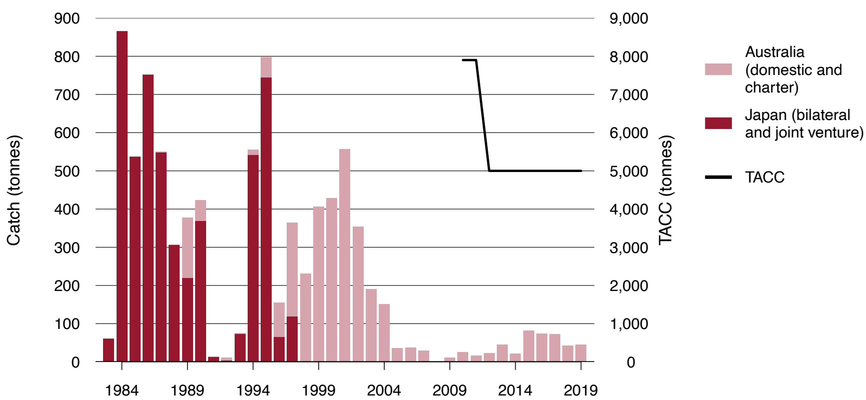
Stock structure

Preliminary analysis from a recent genetics and otolith microchemistry study found evidence for 2 distinct groupings of yellowfin tuna in the Indian Ocean, but the spatial delineation of these groups remains unclear (Davies et al. 2019). The stock structure of yellowfin tuna in the Indian Ocean remains uncertain, and the species is considered to be a single biological stock for assessments until the stock structure can be resolved.

Catch history

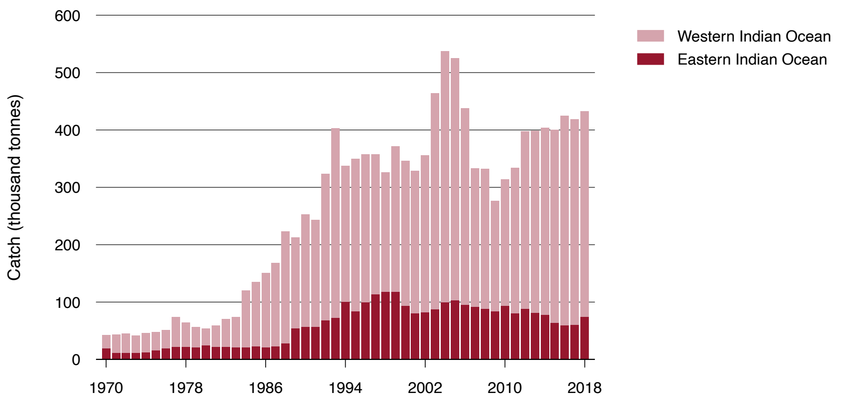
Historical catches of yellowfin tuna in the WTBF have varied widely from peaks of around 800 t in 1984 and 1995 to less than 15 t in 1991 and 1992 (Figure 24.12). Since the early 2000s, declining effort in the WTBF has resulted in reduced catches of yellowfin tuna. Catches have not exceeded 100 t since 2004 (Figure 24.12). Total international catches in the IOTC area of competence peaked at more than 500,000 t in 2004, then declined for several years (2007 to 2011) because of the effects of piracy in the north-west Indian Ocean. Average catches from 2014 to 2018 were 416,026 t, which is above the level of MSY (approximately 403,000 t). Catches in 2018 were approximately 432,401 t.

FIGURE 24.12 Yellowfin tuna catch and TACC in the WTBF, 1983 to 2019



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: AFMA

FIGURE 24.13 Yellowfin tuna catch in the IOTC area, 1970 to 2018



Source: IOTC

Stock assessment

In 2018, the 2016 Indian Ocean–wide yellowfin tuna assessment was updated using SS3 and incorporating catch data, size frequency data, tagging data and longline catch-per-unit-effort series (IOTC 2019). The results were largely similar to previous assessments, and indicate that 2017 levels of fishing mortality for the Indian Ocean–wide stock were above the level that would achieve MSY (F_{2017}/F_{MSY} = 1.20; 80% CI 1.00–1.71). Current spawning biomass for the Indian Ocean–wide stock 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

Despite relatively small domestic catches of yellowfin tuna in the WTBF, the assessments indicate that fishing mortality for the Indian Ocean–wide stock is above the level associated with MSY. As a result, the Indian Ocean 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 2018 and 2019, 94 fishing permits were issued in the fishery although only a small number of vessels operated in the fishery in those years (Table 24.2): 3 vessels (2 pelagic longline and 1 minor line) in 2018 and 4 vessels (2 pelagic longline and 2 minor line) in 2019. Pelagic longline vessels account for around 97% of catch volume, so the entry of 1 minor line vessel in 2019 was insignificant for the fishery. Total effort in the fishery decreased by 9%, from 404,880 hooks in 2018 to 366,821 hooks in 2019—the lowest number of hooks since 2016. Total catch in the WTBF fell in the same proportion as the number of hooks, declining 9% to 218 t (Table 24.2).

As in previous years, landed catch in the fishery was a small proportion of the TACC during 2019. 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, and relatively low net economic returns are achieved from the fishery.

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. Constraints to further fishing appear to be market-related rather than arising from management arrangements. Hence, the economic objective of maximising net economic returns is likely being met for the fishery.

24.4 Environmental status

The WTBF has been granted continued export approval under the *Environment Protection and Biodiversity Conservation Act 1999*, expiring on 11 November 2022. Conditions of export approval include a requirement to determine the impact of fishing on shark species and to make demonstrable progress in improving the status of shark bycatch in the WTBF, as well as working with the IOTC to improve the understanding of the status of stocks currently classified as overfished or uncertain.

AFMA's ecological risk assessment conducted in 2009 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 (AFMA 2010) 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 1 shark species exceeds 50 t within a year. Trip limits on sharks apply, depending on species.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE) and these are summarised below.

In 2019, 127 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the WTBF; all were released in an unknown condition. Eight porbeagles (*Lamna nasus*) were also released in unknown condition. Eight leatherback turtles (*Dermochelys coriacea*) were also hooked and released alive, as were 6 olive ridley turtles (*Lepidochelys olivacea*), 1 flatback turtle (*Natator depressus*), 4 hawksbill turtles (*Eretmochelys imbricata*) and 2 green turtles (*Chelonia mydas*). Four loggerhead turtles (*Caretta caretta*) were captured, with 3 released alive and 1 injured. Two flesh-footed shearwaters (*Ardenna carneipes*) were released alive and 1 unidentified shearwater was released in an unknown condition. One unidentified albatross was dead. Finally, 1 short-finned pilot whale (*Globicephala macrorhynchus*) was released alive.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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Longline hooks
Heesh Garroun, 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, 2019

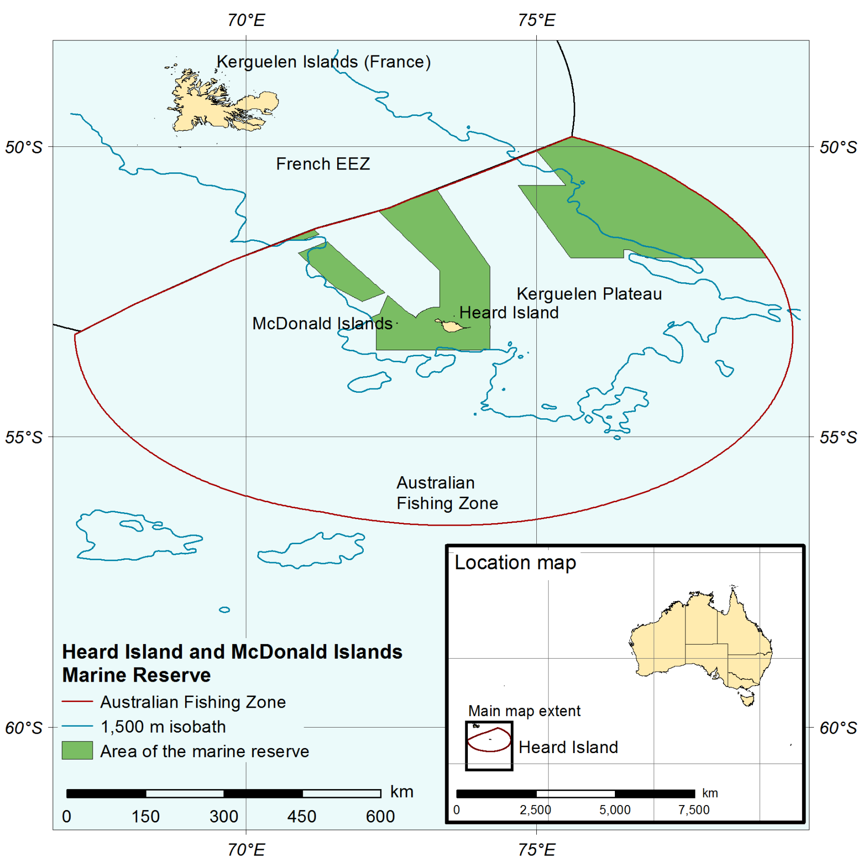


TABLE 25.1 Status of the Heard Island and McDonald Islands Fishery

Stock	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
Biological status					
Mackerel icefish (*Champsocephalus gunnari*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	TACs are set in accordance with a precautionary harvest strategy.
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 estimates of biomass are above the limit reference point.
Economic status					
Estimates of NER are not available. Relatively low levels of latency for the 2017–18 and 2018–19 fishing seasons indicate positive NER from the fishery.					

Notes: **NER** Net economic returns. **TAC** Total allowable catch.

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

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 Agriculture, Water and the Environment. 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 km^2. 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* (AAD 2014), 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 and by 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 2-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).
The HIMIF mackerel icefish fishery was initially certified as sustainable by the Marine Stewardship Council (MSC) in March 2006 and was recertified in July 2016. Patagonian toothfish in the HIMIF, originally certified in 2012, was recertified as sustainable by the MSC 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 2–4 vessels active at any one time since a total allowable catch (TAC) was first set in the mid 1990s, with the exception of the 2014–15 season when the TAC was very high and 7 vessels fished. Five vessels were active in the 2018–19 fishing season.

Catch

Catches of mackerel icefish have been variable over time because it is a short-lived species, exhibiting periodic, large, dominant year-classes that contribute to high catches for a year or two. Once a strong 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. Catches over the past 2 seasons have been closer to the TACs.

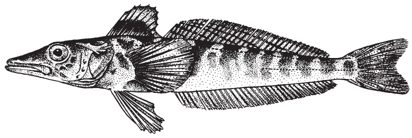
TABLE 25.2 Main features and statistics for the HIMIF

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)**
Mackerel icefish	526	401	Confidential	443	443	Confidential
Patagonian toothfish	3,525	3092	Confidential	3,525	3,390	Confidential
Fishery-level statistics						
Effort	61 trawl-days 16,415,948 hooks 0 pots hauled			64 trawl-days 17,745,965 hooks 0 pots hauled		
Fishing permits	4 quota SFR holders			4 quota SFR holders		
Active vessels	4			5		
Observer coverage b	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 pro vided by fishing season, unless otherwise indicated. Season is 1 December to 30 November. Value statistics are by financial year. **b** All vessels carry 2 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.

25.2 Biological status

Mackerel icefish (*Champsocephalus gunnari*)



Line drawing: FAO

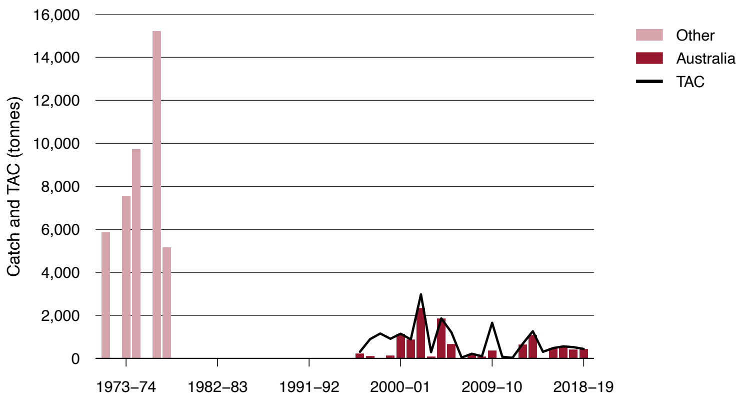
Stock structure

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). The full TAC was taken in 2018–19.

FIGURE 25.2 Catch and TAC of mackerel icefish in the HIMIF, 1971–72 season to 2018–19 season



Note: **TAC** Total allowable catch.
Source: AFMA

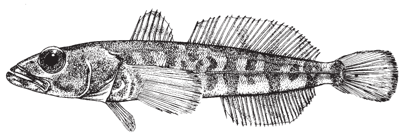
Stock assessment

A random stratified trawl survey in late March to early April 2019 provided information on the abundance and age structure of the mackerel icefish stock (Nowara, Lamb & Ziegler 2019). The age classes up to 3+ were estimated to account for 67% of the biomass, with the 4+ class accounting for 33% (Maschette, Nowara & Welsford 2019). The stock assessment estimated the current biomass at 5,539 t (Maschette, Nowara & Welsford 2019). Yields of 527 t for the 2019–20 season and 406 t for the 2020–21 season were estimated to satisfy the CCAMLR decision rules and maintain the stock at 75% of the level that would occur in the absence of fishing. These TACs were endorsed by the CCAMLR (CCAMLR 2019a, 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

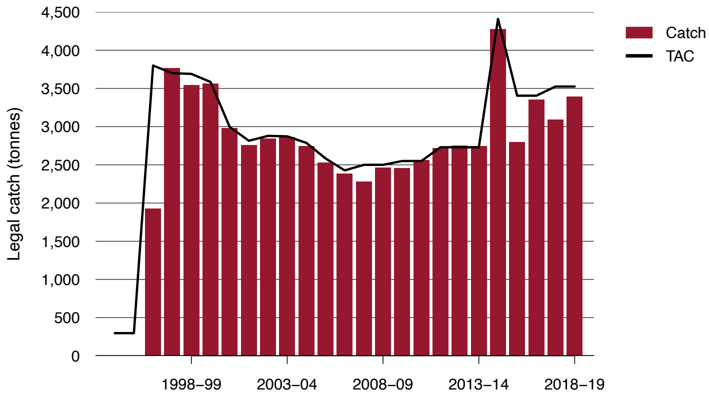
Stock structure

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. Catch rates dropped in the 2015–16 fishing season, but catches in the 2017–18 (3,092 t) and 2018–19 (3,390 t) seasons were closer to the TAC.

FIGURE 25.3 Catch and TAC of Patagonian toothfish in the HIMIF, 1994–95 season to 2018–19 season



Note: **TAC** Total allowable catch.
Source: AFMA

Stock assessment

The most recent assessment for Patagonian toothfish (Ziegler 2019) was similar to the 2017 assessment, but included catch data to 2019; fishery observations, including tagging and ageing data to the 2017–18 season; estimated fishing mortality from gear loss; updated growth, length–weight and maturity-at-age parameters; and a simplification of the longline selectivity functions. The assessment was run using the agreed version of CASAL. This assessment also included catches from Williams Ridge, which is in the Southern Indian Ocean Fisheries Agreement area adjacent to the Kerguelen Plateau and the HIMI EEZ. As catches in this area are considered to be part of the same population fished in the HIMIF, they were accounted for in the stock assessment.

The 2019 estimated biomass was 51% of unfished levels ($SB_{2019}/SB_0 = 0.51$; 95% confidence interval 0.49–0.53). This decline from the 2017 estimate of 61% of unfished levels is due to the combination of 3 additional years of fishing, and updated observations and biological parameter estimates. The trajectory of the biomass is likely to decline below the target level of 50% SB_0 during the projection period because of recent weak year-classes. However, if average recruitment is assumed, the stock will rebuild to 50% by the end of the 35-year projection period. Independent of the assumed recruitment, the stock is projected to be approximately 46% of unfished biomass by the time of the next assessment in 2021. The Working Group on Fish Stock Assessment recommended additional work be presented in 2020, including updated recruitment indices from the trawl survey, and updated age-frequency and tag–recapture data. It also recommended that the Working Group on Statistics, Assessments and Modelling develop advice on alternative harvest strategies that may be more precautionary for stocks around the target reference point and where weak recent year-classes may be present.

A catch limit of 3,030 t satisfied the CCAMLR decision rules, and was the recommended TAC for the 2019–20 and 2020–21 fishing seasons (CCAMLR 2019a, b).

Stock status determination

Given the 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

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. Low levels of TAC latency for both mackerel icefish and Patagonian toothfish in the 2017–18 and 2018–19 fishing seasons are indicative of overall positive net economic returns (NER) for the fishery.

It is likely that daily operating costs increased slightly in 2018–19 compared with the 2017–18 fishing season due to a small increase in fuel price and an increase in the number of hooks used per tonne. This is despite a slight increase in overall catch per longline days in 2018–19 (60.3 t/day) compared with 2017–18 (60.0 t/day).

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.

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, 3 ecological risk assessments were completed for the HIMIF using the 'ecological risk assessment for effects of fishing' method. The assessments covered the 3 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 3 assessments were all improved from the previous assessments in 2009. The 2 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 in 2009, improved research and mitigation resulted in only 1 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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE) and these are summarised below.

In the HIMI longline fishery in 2019 (calendar year), 1 porbeagle shark (*Lamna nasus*) died when it became entangled, while 1 Antarctic sleeper shark (*Somniosus antarcticus*) was released alive after being hooked. One southern elephant seal (*Mirounga leonina*) became entangled in the longline and died. Finally, 3 white-chinned petrels (*Procellaria aequinoctialis*) and 1 grey petrel (*Procellaria cinerea*) also became entangled in the longline and died, while 1 southern giant petrel (*Macronectes giganteus*) was released alive.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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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, 2019

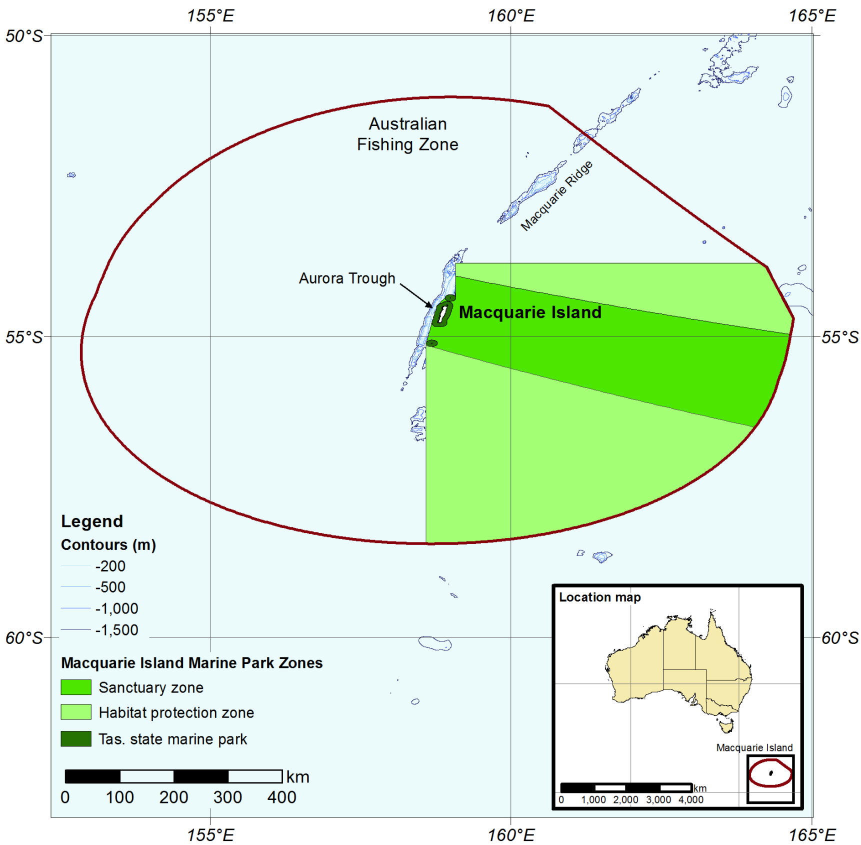


TABLE 26.1 Status of the Macquarie Island Toothfish Fishery

Stock	2018 Fishing mortality	2018 Biomass	2019 Fishing mortality	2019 Biomass	Comments
Biological status					
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 2018–19 and 2019–20 fishing seasons due to low TAC latency for Patagonian toothfish in both seasons. NER for the 2018–19 are likely to be higher than for 2017–18 because of a higher catch per longline-day and lower latency in that year. The growth in NER in 2018–19 is likely to have been moderated by higher fuel prices in the 2018–19 year.

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 4 seasons (2007 to 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 1 species. The bycatch, primarily grenadier (*Macrourus* spp.) and violet cod (*Antimora rostrata*), has never exceeded the 50 t limit for any 1 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 period. The total allowable catch (TAC) was previously set separately for the 2 main areas (Aurora Trough and Macquarie Ridge). However, the management plan was amended in January 2012 to merge the 2 areas and set a single TAC for the entire fishery, based on evidence that Patagonian toothfish is a single stock around Macquarie Island (see 'Stock structure', below). 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 1 or 2 vessels active in the fishery every year since the fishery began in 1994.

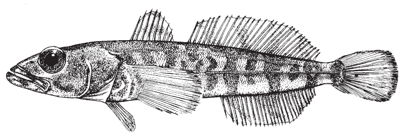
TABLE 26.2 Main features and statistics for the MITF

Fishery statistics a	2018–19 fishing season			2019–20 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**GVP (2018–19)**	**TAC (t)**	**Catch (t)**	**GVP (2019–20)**
Patagonian toothfish	450	448	Confidential	450	451	Confidential
Fishery-level statistics						
Effort (longline days)	95			81		
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	Hobart; Nelson (New Zealand)					
Management methods	Input controls: limited entry, gear restrictions, closures Output controls: TACs, ITQs					
Primary markets	International: China, 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 2019–20 fishing season was 15 April 2019 to 1 April 2020. Value statistics are provided by financial year. **b** All vessels carry 2 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

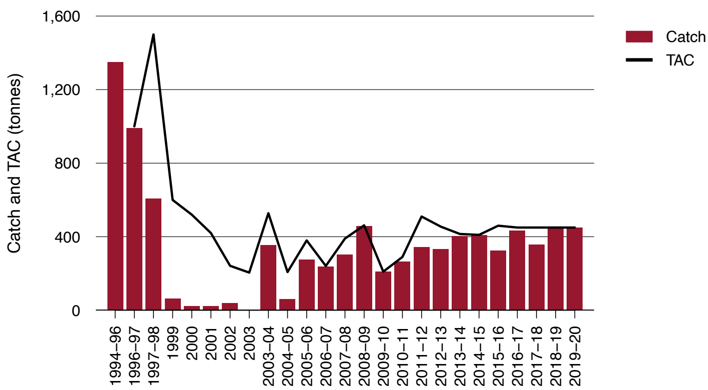
Stock structure

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 2019–20 season was 1 t above the TAC.

FIGURE 26.2 Catch and TAC of Patagonian toothfish in the MITF, 1994–95 season to 2019–20 season



Note: **TAC** Total allowable catch.
Source: AFMA

Stock assessment

The Stock Synthesis 3 (SS3) modelling framework was used to assess the Patagonian toothfish stock in 2019 (Day & Hillary 2019). An integrated 2-area assessment model was fitted to tag–recapture, length composition and age-at-length data. The assessment assumed a single stock in the MITF but with spatial structuring of fishing and movement between 2 areas (northern and southern), and recruitment to both areas. Using this assessment, 2019 female spawning biomass was estimated at 70% of unfished levels ($0.70SB_0$).

However, because SS3 is now unsupported, a custom-designed model was developed using Template Model Builder so that assessments can be continued in future (Hillary & Day 2019a). The bespoke model features a sex and length structured spatial Brownie tagging model that contains the abundance and migratory information in 1 likelihood function. Updated growth parameters were also used in the bespoke assessment (Hillary 2019a). The new assessment model also estimated female spawning biomass to be $0.70SB_0$.

The maturity estimates used in the 2019 SS3 assessment of Macquarie Island toothfish (1.40 m and 1.86 m for length at 50% and 95% maturity, respectively) were considered to be too high and differed from the values used to assess other Patagonian toothfish stocks (Hillary 2019b). Therefore, a revised maturity-at-length relationship was estimated using the maturity information from the extensive tagging data, which indicated that the female length at 50% maturity is approximately 40 cm lower than the previous value (Hillary 2019b). Maturity parameters have a substantial effect on the stock assessment, as the maturity-at-length relationship is used to define the abundance of the female spawning population. The revised, bespoke assessment model was re-run using the new maturity-at-length estimate and the female spawning biomass was estimated to be $0.85SB_0$ (Hillary & Day 2019b).

The new model with the updated maturity-at-length estimates was accepted by the Sub-Antarctic Resource Assessment Group. Following the CCAMLR control rule (which uses a target of $0.50SB_0$ rather than $0.48SB_0$), a 2-year TAC was calculated for the MITF for 2021–22 and 2022–23, 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 ($0.85SB_0$) 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

Estimates of net economic returns are not available but are likely positive for the 2018–19 and 2019–20 fishing seasons due to low TAC latency for Patagonian toothfish in both seasons. In the 2018–19 fishing season, TAC was nearly fully caught and the catch per longline-day increased by 1.5 t per day to 4.7 t. Despite an increase in fuel prices (14% increase from 2017–18), the increase in catch per day, from 20% in the 2017–18 fishing season to negligible levels in the 2018–19 fishing season, combined with significantly lower quota latency, indicates lower marginal operating costs, likely resulting in increased net economic returns in the 2018–19 fishing season.

The estimated biomass of $0.85SB_0$ in 2019 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 1 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.

The harvest strategy for this fishery is conservative, reflecting the CCAMLR ecosystem-based management approach. Catch limits aim to maintain stock biomass at levels that are higher than at 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 were 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 2 species (2 southern lantern sharks and 9 southern sleeper sharks) over the 3 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.

In accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE) and these are summarised below.

In 2019, 27 interactions with porbeagles (*Lamna nasus*) were recorded; 12 were released alive and 15 were dead. Three Antarctic sleeper sharks (*Somniosus antarcticus*) were also captured; 1 was released alive and 2 were dead.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

26.5 References

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Snow on the deck
Gavin Kewan, AFMA

Chapter 27

CCAMLR exploratory toothfish fisheries

H Patterson and AH Steven

FIGURE 27.1 CCAMLR Convention area

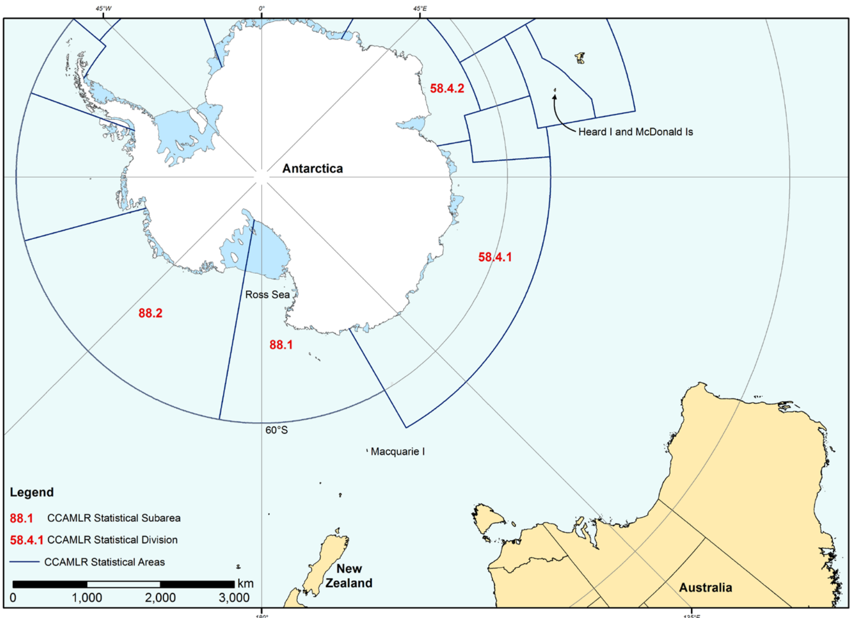


TABLE 27.1 Status of the CCAMLR exploratory toothfish fisheries

Biological status					
Stock	**2018**		**2019**		**Comments**
	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*)					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 2018–19.

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 Antarctic marine life and manage the Southern Ocean Antarctic ecosystem. 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 in some fisheries 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 2018–19 season, 1 Australian vessel participated in these exploratory fisheries.

CCAMLR divisions 58.4.1 and 58.4.2 lie adjacent to East Antarctica (Fig. 27.1), and exploratory fisheries operate in both these divisions. During the 2018–19 fishing season, division 58.4.1 was closed to fishing while 1 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*), with a small catch of 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 at least 2 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, and 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. After experimental trawling by Australia in divisions 58.4.1 and 58.4.2 in 1999–2000, division 58.4.1 was fished for the first time by an Australian longline vessel in 2015–16 and division 58.4.2 in 2017–18.

Iceberg
Australian Longline Pty

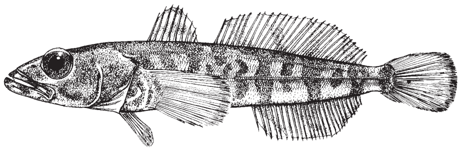
TABLE 27.2 Main features and statistics for the CCAMLR exploratory toothfish fisheries

Fishery statistics a	**2017–18 fishing season**			**2018–19 fishing season**		
Fishery	**TAC (t)** b	**Catch (t)** c	**GVP (2017–18)**	**TAC (t)** b	**Catch (t)** c	**GVP (2018–19)**
Division 58.4.1, toothfish	545	91	Confidential	579	0	Confidential
Division 58.4.2	42	28	Confidential	50	33	Confidential
Subarea 88.1, toothfish	3,157	100	Confidential	3,157	12	Confidential
Subarea 88.2, toothfish	619	43	Confidential	1,000	176	Confidential
Fishery-level statistics						
Effort	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			Division 58.4.1: 0 hooks Division 58.4.2: 175,000 hooks Subarea 88.1: 40,800 hooks Subarea 88.2: 539,325 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: 2 Division 58.4.2: 1 Subarea 88.1: 1 Subarea 88.2: 1			Division 58.4.1: 0 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 to 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 2 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.

27.2 Biological status

Antarctic toothfish (*Dissostichus mawsoni*) in division 58.4.1



Line drawing: FAO

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 more recent studies were unable to detect any genetic variation among fish from different sectors (Maschette et al. 2019; Mugue et al. 2014). Maschette et al. (2019) conducted the largest genetics study to date of *D. mawsoni* in terms of sampling locations, sample size and single nucleotide polymorphism markers. The study indicated that there is no genetic stock structuring within the CCAMLR area, likely due to the distribution of eggs and larvae by the Antarctic Circumpolar Current. However, this lack of genetic division of stocks does not preclude the presence of local biological stocks in the Southern Ocean.

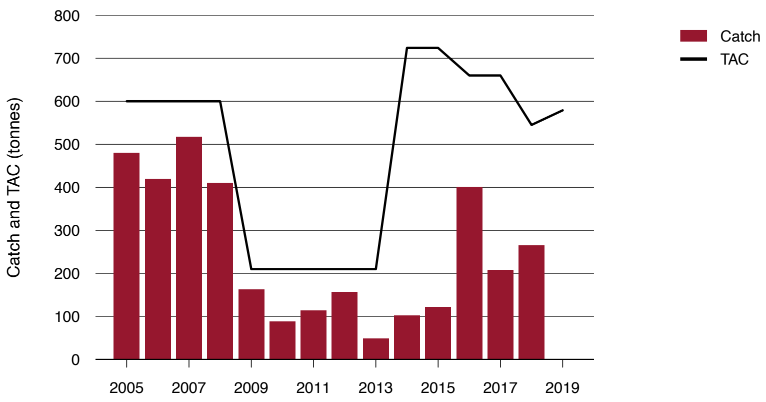
Tagging studies from numerous locations in the CCAMLR Convention area have indicated that most adult toothfish are sedentary and are recaptured relatively close (<50 km) to where they were tagged (Hanchet et al. 2008; Petrov & Tatarnikov 2010; Welsford et al. 2011). However, a small proportion of tagged fish has 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.

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 t 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. Fishing was not permitted in this division in 2018–19.

FIGURE 27.2 Total catch and TAC for CCAMLR division 58.4.1, 2005 to 2019



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). Yates and Ziegler (2018) developed an initial integrated stock assessment for divisions 58.4.1 and 58.4.2, but the model indicated a systematic lack of fit to the tag–recapture and catch-at-age data. 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 low level. Given these factors, the stock is considered **not subject to overfishing**.

Antarctic toothfish (*Dissostichus mawsoni*) in division 58.4.2

Stock structure

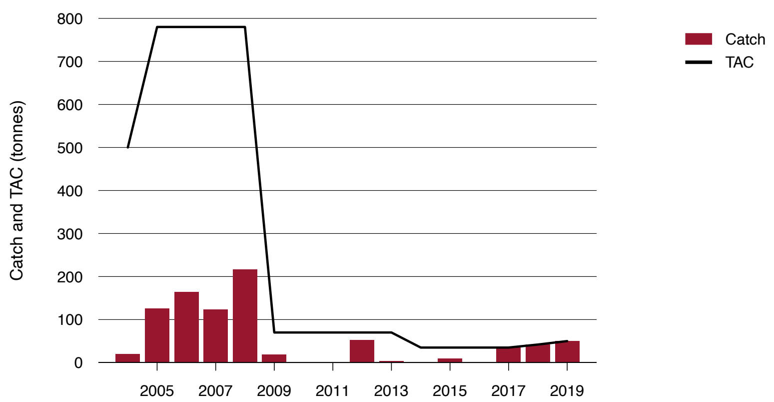
See division 58.4.1.

Toothfish in division 58.4.2 is considered a single stock for management purposes.

Catch history

CCAMLR division 58.4.2 contains 1 research block where exploratory fishing is permitted. Fishing has occurred in the division under licence since 2004, with TACs ranging from 35 t to 780 t (Figure 27.3). Australia did not participate in the fishery before 2017–18, although some experimental trawling occurred in 1999–2000.

FIGURE 27.3 Total catch and TAC for CCAMLR division 58.4.2, 2004 to 2019



Note: **TAC** Total allowable catch.
Source: CCAMLR

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). Yates and Ziegler (2018) developed an initial integrated stock assessment for divisions 58.4.1 and 58.4.2, but the model indicated a systematic lack of fit to the tag–recapture and catch-at-age data. 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 did not exceed the TAC. In addition, IUU fishing has been largely eliminated, and participation in the fishery has been restrained to a low level. Given these factors, the stock is considered **not subject to overfishing**.

Antarctic toothfish (*Dissostichus mawsoni*) in subarea 88.1

Stock structure

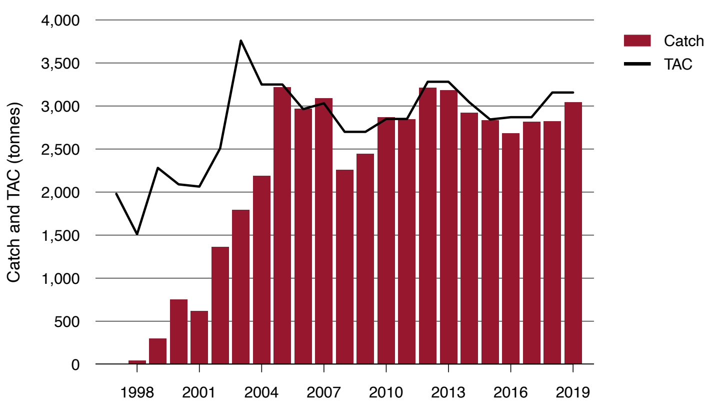
See division 58.4.1.

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 less than 5% of the catch since 2010.

FIGURE 27.4 Total catch and TAC for CCAMLR subarea 88.1, 1997 to 2019



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 2019 using the CASAL integrated assessment model; it is a Bayesian sex- and age-structured assessment (Dunn 2019). The assessment included catch data, tag–recapture data and catch-at-age frequencies from 1998 to 2019 for the 3 areas of the Ross Sea (shelf, slope and north). In addition, the model included local abundance estimates and catch-at-age frequencies from a survey of the Ross Sea shelf (Parker & Jones 2019), and revised growth and length–weight parameters (Dunn & Parker 2019).

The recommended model estimated the current level of biomass at 66% of unfished levels (B_{2019}/B_0 = 0.66; range 0.63–0.69). This is lower than the 2017 estimate of unfished biomass. This difference is likely the result of an increase in the number of tag captures in 2018 and 2019, the inclusion of 2 years of additional catch, and the revised length–weight and growth parameters.

All the estimates for yield (3,100–3,140 t) were with the range of 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 3,140 t for the 2019–20 and 2020–21 seasons was recommended (CCAMLR 2019a, 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 2 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

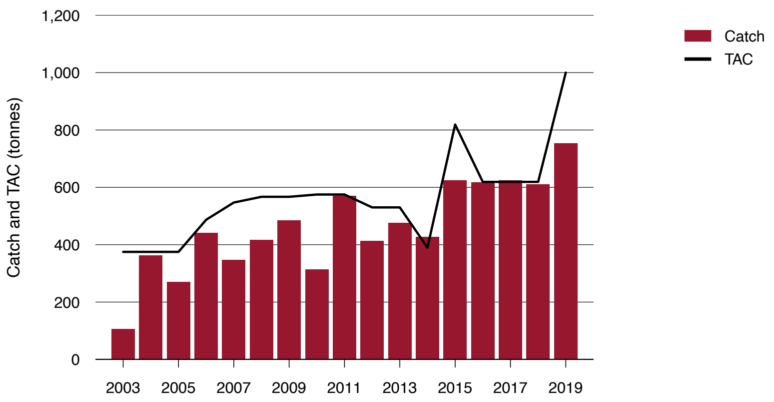
See division 58.4.1.

The stock assessment boundaries for the Amundsen Sea region (described here) consider subarea 88.2 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, 2003 to 2019



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

An integrated stock assessment of Antarctic toothfish for CCAMLR subarea 88.2 SSRUs C–H in 2013 used CASAL (Mormede, Dunn & Hanchet 2013). The assessment included catch data and catch-at-age frequencies from 2003 to 2013 for each SSRU, and tag–recapture data for SSRU H where the data were considered most reliable and most catch had been taken. However, the assessment was not considered to be representative of SSRUs C–G (CCAMLR 2013).

Based on the results of the Petersen models, the total TAC for subarea 88.2 SSRUs C–H in 2015 was set at 619 t, with 200 t designated for SSRU H and the remaining 419 t for SSRUs C–G (CCAMLR 2015a, b). Within SSRUs C–G, no more than 200 t could be taken in any 1 research block. A yield of 619 t equated 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 2 decades, even if currently near the limit reference point of 20% of unfished biomass (Welsford 2011).

In 2018, progress was made on updating the full assessment for SSRUs C–H using age-structured population models developed in CASAL (Mormede & Parker 2018). While the model runs provide information on the biomass in 2 areas (north and south) and migration rates, the model was not used for management advice 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. The catch limits for SSRU H and each research block in SSRUs C–G were set at 200 t.

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. Fishing for toothfish is undertaken in remote areas and under difficult operating conditions such as the CCAMLR fishery. Fishing has been sporadic and opportunistic in the CCAMLR exploratory fisheries, indicating some uncertainty for net economic returns (NER). However, positive NER could be generated by fishers. Overall, 262 t of toothfish was caught in the CCAMLR exploratory fisheries in the 2017–18 fishing season, decreasing to 221 t in the 2018–19 fishing season, despite an increase in TAC in most CCAMLR fisheries.

Subarea 88.2 was first 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 7% of the global TAC in 2017–18 and 18% in 2018–19.

Australia first started fishing in division 58.4.1 in the 2015–16 fishing season. Australia caught 17% of the global TAC in 2017–18 and did not operate in the fishery in the 2018–19 fishing season, highlighting the sporadic and opportunistic nature of the CCAMLR fisheries.

Australia first began fishing subarea 88.1 in the 2016–17 fishing season, catching 3% of global TAC in the 2017–18 fishing seasons. In the 2018–19 fishing season, Australia caught 0.4% of the global TAC.

Australia began fishing in division 58.4.2 in 2017–18, catching 67% of the global TAC and 66% in 2018–19.

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 27 November 2020. 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 accordance with accreditation under the *EPBC Act 1999* (see Chapter 1, 'Protected species interactions') AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). In the 2018–19 fishing season, no logbook or observer reports noted interactions between an Australian vessel and protected species in the CCAMLR exploratory fisheries.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

27.5 References

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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 2 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, 2019; 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, 1 '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 confidential, 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. Attempts are currently being made to assess alfonsino (*Beryx splendens*) stocks in the SIOFA area.

Catch of orange roughy and alfonsino 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.

Demersal fisheries target 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).

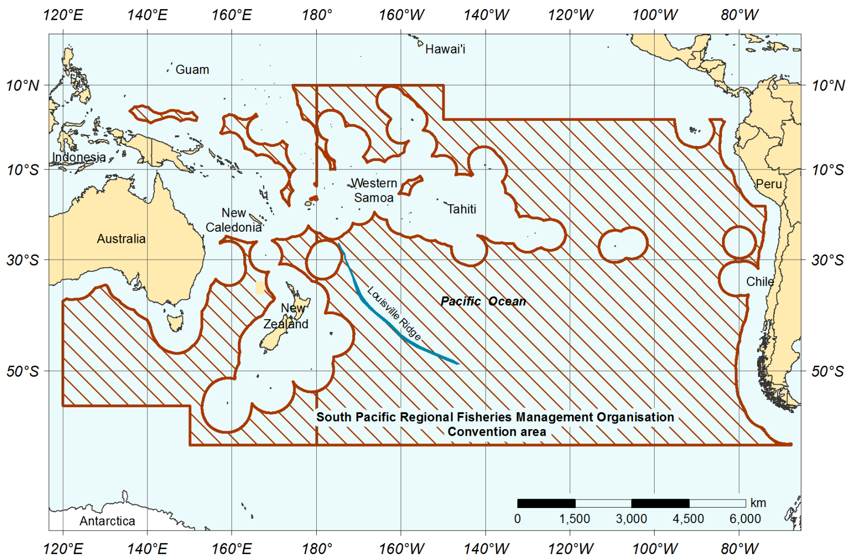
The species composition of catches from Australia's line and trawl fishing has varied over time. Historically, Australian high-seas fishing effort targeted orange roughy using demersal and midwater trawl gear. A low level of non-trawl activity, predominantly dropline and auto-longline methods targeting 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), sweetlips (Haemulidae) 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 an 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 to 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 habitat suitability models and other spatial analysis tools to define and close areas that are likely to contain vulnerable marine ecosystem (VME) habitats, while allow fishing to continue in key productive areas. In accordance with CMM 03a-2019, catch of species other than orange roughy is limited to the average annual level between 2002 and 2006.

Consistent with these and other SPRFMO CMMs, Australian high-seas fishing permits require the implementation of vessel monitoring systems, 100% observer coverage on all trawl vessels and for the first trip of the season (for all methods), and a minimum of 10% observer coverage annually on all non-trawl vessels.

In 2011, Australia completed a bottom fishery impact assessment in the SPRFMO Convention area to examine whether bottom-fishing activities by Australian vessels within the 2002 to 2006 footprint 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 03-2020, Australia and New Zealand submitted a cumulative bottom fishery impact assessment on 4 August 2020, which is subject to review by the SPRFMO Scientific Committee in late 2020. The conclusions of this assessment were not finalised at the time of writing but will be included in next year's *Fishery status reports*.

FIGURE 28.1 South Pacific Regional Fisheries Management Organisation Convention area



Catch and effort

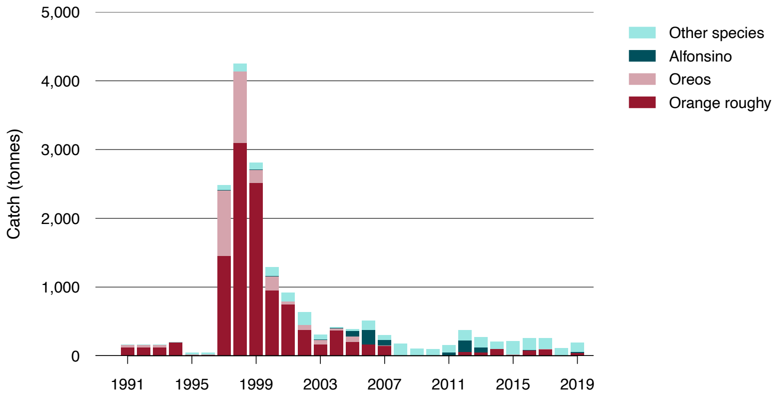
Two Australian longline vessels and 1 Australian trawl vessel were active in the SPRFMO Convention area in 2019. The total reported catch retained by these vessels was 123 t for the longline vessels and 62 t for the trawl vessel, totaling 186 t for both gears (Figure 28.2). Effort using line gears was 657,700 hooks. Effort using trawl gears could not be calculated due to errors in the logbooks, but attempts will be made to include this in the next *Fishery status reports*.

Spotcheek emperor (*Lethrinus rubrioperculatus*) accounted for 32% (39 t) of the longline catch; the remainder comprised yellowback bream (*Dentex spariformis*; 13%; 16 t), flame snapper (*Etelis coruscans*; 10%; 13 t), redthroat emperor (*L. miniatus*; 8%; 10 t) and other species (38%; 46 t). Logbook-reported discards in the longline fishery were 33 t, with most discards comprised of sharks.

Orange roughy accounted for 70% (44 t) of the trawl catch; the remainder comprised alfonsino (21%; 13 t) and other species (8%; 5 t). Logbook-reported discards in the trawl fishery were 48 t, with most discards comprised of sharks.

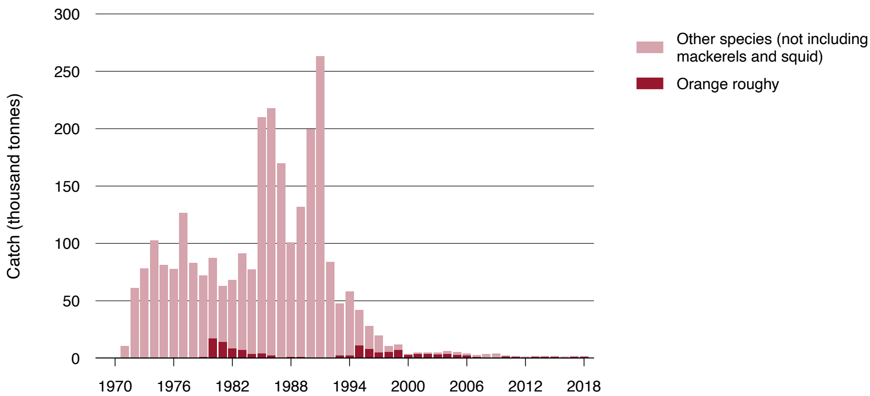
Total reported catch of demersal species by all fleets in the SPRFMO Convention area was 1,680 t in 2017 and 1,900 t in 2018 (Figure 28.3). Most of this catch was reported from the western SPRFMO Convention area, primarily by New Zealand vessels.

FIGURE 28.2 Australian trawl-and-line catch, by species, in the SPRFMO Convention area, 1990 to 2019



Source: AFMA

FIGURE 28.3 Total SPRFMO catch of demersal species, 1969 to 2018



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 assessments

Several assessments have been attempted for orange roughy management units in the SPRFMO Convention area (Clark, Dunn & Anderson 2010; Cordue 2017, 2019; 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 5 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, 5 of the 7 SPRFMO management units were very likely to have been above a limit reference point of 20% of unfished biomass ($0.2B_0$).[1] There was an indication that the north-west Challenger Plateau and Lord Howe Rise management units may be below this limit reference point, and that recent exploitation rates would not enable stock biomass to increase.

1 Reference points for orange roughy have not been adopted by the SPRFMO.

The Cordue (2017) assessment for the 3 Louisville Ridge management units was updated in 2019 (Cordue 2019). The 2019 assessment uses age and length composition data from the Louisville Central orange roughy stock and assumes a maximum exploitation rate of 67%. The biological parameters and year-class strengths for Louisville Central were then used to update catch-history based assessments for Louisville North and Louisville South. No biomass indices (for example, from acoustic surveys) were available, but the composition data were adequate to rule out very high exploitation rates for Louisville Central in 1995 (when there was a spike in catches), and eliminate low values of B_0 and current stock status. The estimates of unfished and current biomass for the Louisville stocks remain uncertain, but the new data have enabled more precise stock assessments (that is, there is likely to be less error in the models). The new estimate of natural mortality (M) of 0.03 indicates the potential for lower yields per unit of biomass for these stocks compared with New Zealand stocks (where M is ~0.045). Although stock status remains uncertain, the models suggest that Louisville Central is probably above $0.5B_0$ and that Louisville North is probably above $0.3B_0$. There is a small possibility that Louisville South is below $0.2B_0$, but it is likely well above this level. The updated assessment gave very similar results to the 2017 assessment for these stocks; consequently, the SPRFMO Commission agreed to roll over the catch limit for the 3 Louisville Ridge management units that was set using the 2017 assessment.

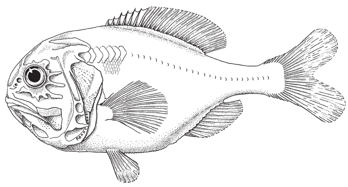
SPRFMO CMM 03a-2020 (first implemented in 2019 as CMM 03a-2019) sets catch limits for orange roughy for the management areas to the east and west of New Zealand. These catch limits are a combined 1,140 t for the 3 Louisville Ridge management units, and a combined 346 t for the 3 Tasman Sea management 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 3 subunits without compromising the sustainability of any one subunit.

It should be noted that the results of the Cordue 2017 and 2019 assessments are conditional on the stock hypotheses being approximately correct, and have a high level of uncertainty for most management units. 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. Work is currently underway to update the assessments for the Tasman Sea management units.[2]

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

Biological status					
Stock	2018		2019		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Orange roughy (*Hoplostethus atlanticus*)					Fishery has been closed under domestic arrangements 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

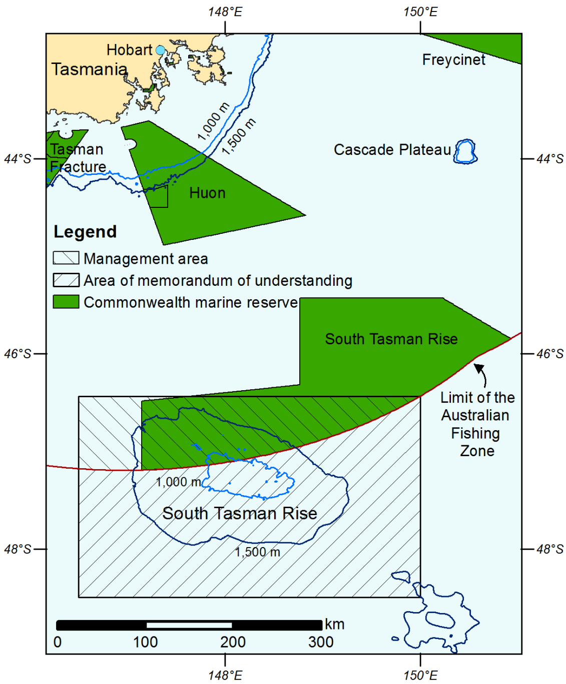
Description of the fishery

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.

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

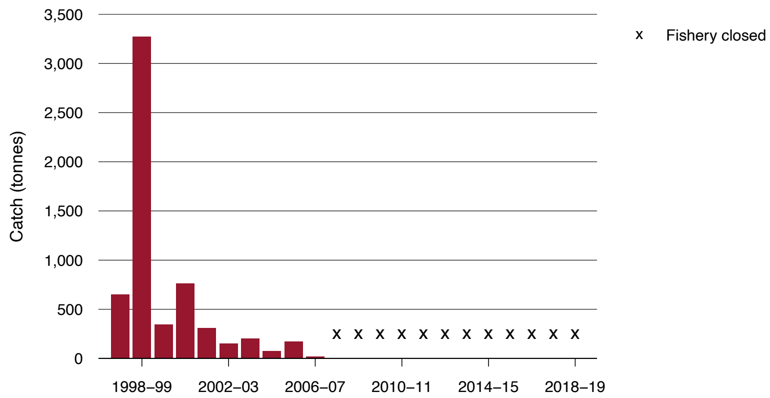


Catch history

Orange roughy catches by Australian vessels 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 season to 2018–19 season



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 to 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**.

However, given the time that has passed since this stock has been fished and the recovery that has been detected in the eastern zone orange roughy stock in the Commonwealth Trawl Sector (see Chapter 9), it is possible that similar rebuilding has occurred in the STR. This suggests increasing uncertainty around the biomass status of the stock. In the absence of additional information on stock status, it is possible that future biomass status may be classified as uncertain.

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 mostly on or near seamounts and ridges in the southern Indian Ocean and on the Saya de Malha bank in the north-western 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.

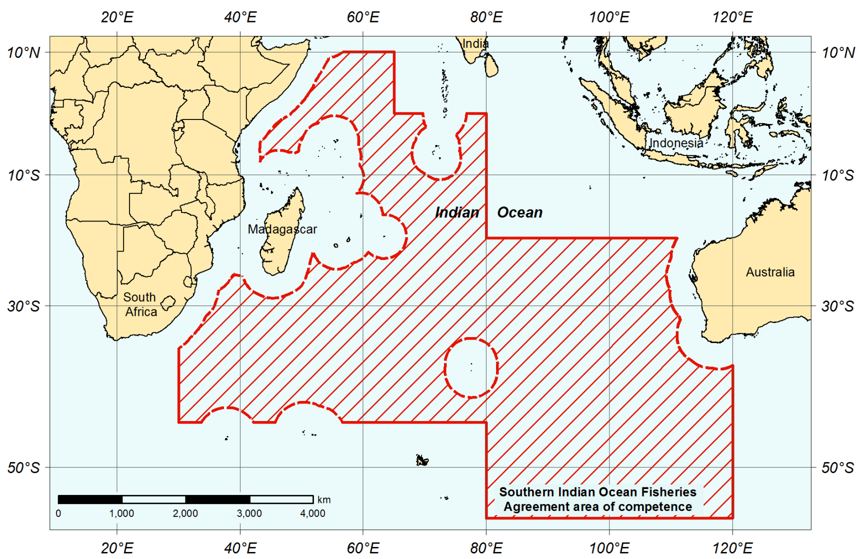
Deep-sea trawlers from Australia and New Zealand were reportedly fishing in the SIOFA area before 1999. In 1999, deep-sea trawling in the area increased substantially after orange roughy stocks were discovered (Japp & James 2005). In 2000, the combined catch of all deepwater species for all international 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 8 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. 2011b), 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. 2011b). 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. 2011b). In 2020, Australia updated its bottom fishery impact assessment to consider the impact of fishing using longline gears on Williams Ridge, near Australia's Heard Island and McDonald Islands toothfish fishery (see Chapter 25), as well as to consider the impacts of fishing using potting gears in Australia's historical fishing footprint within the SIOFA area (Welsford et al. 2020). This assessment concluded that the impact of fishing in both cases would be low for target stocks, associated species and VMEs.

SIOFA has adopted various CMMs, including CMMs relating to large-scale pelagic driftnets and deepwater gillnets; interim management measures for bottom fisheries; management measures for demersal stocks; 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 trans-shipment 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 and effort from the SIOFA area, with orange roughy and alfonsino being the main species targeted using these gears. In 2016, 1 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.

Catch-and-effort data for the SIOFA area can be disclosed in accordance with AFMA's data disclosure policy. Total retained catch taken by bottom line gears reported in logbooks in 2019 was 34 t, with discards of <1 t. Total effort was 54,200 hooks, comprised of 48,300 hooks for bottom longline and 5,900 hooks for dropline gears. The main species caught in 2019 using bottom line gears were *Polyprion* species (26 t), with small quantities of jackass morwong (*Nemadactylus macropterus*; 3 t), yellowtail kingfish (*Seriola lalandi*; 2 t) and other mixed species comprising the remainder of the catch.

Stock structure

The biological structure of stocks in the SIOFA area is uncertain; however, it is known that a number of stocks cross jurisdictional boundaries (for example, the Patagonian toothfish [*Dissostichus eleginoides*] stock that straddles Australia's Heard Island and McDonald Islands toothfish fishery within Australia's EEZ [see Chapter 5] and Williams Ridge in the SIOFA area). For orange roughy, 7 regional management 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 assessments

Assessments have recently been attempted for 7 orange roughy management units in the SIOFA area (Cordue 2018a, b). The assessment for the Walters Shoal unit (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 6 management units, a catch history–based assessment was undertaken (Cordue 2018b). For 3 of these, 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 unit and $0.43SB_0$ for the South Ridge unit. All other stocks were estimated to be above $0.5SB_0$ under this assumption.

28.4 Economic status

The gross value of production is not available for the SPRFMO and SIOFA areas for confidentiality reasons. In 2019, 3 vessels were active in the SPRFMO area, and 1 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.

One orange roughy stock is assessed in the STRTF, which is classified as overfished. As such, biomass is 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 commitment 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). The SPRFMO bottom-fishing impact assessment standard was updated in 2019 (SPRFMO 2019). SIOFA adopted a similar bottom-fishing impact assessment standard in 2017. Australia and New Zealand submitted a cumulative assessment of bottom-fishing impacts in accordance with the updated SPRFMO bottom-fishing impact assessment standard on 4 August 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 have been established 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) and an updated assessment for the SIOFA area in 2020 (Welsford et al. 2020). The Williams et al. (2011a, b) 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, based on the low level of fishing effort, the small number of areas of high fishing intensity and the effects of current management arrangements. The Welsford et al. (2020) assessment for the SIOFA area concluded that the impact of fishing using longline gears on Williams Ridge and using potting gears within Australia's historical fishing footprint in the SIOFA area would be low for target stocks, associated species and VMEs.

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 8 years under the EPBC Act.

In accordance with accreditation under the EPBC Act (see Chapter 1, 'Protected species interactions'), AFMA publishes and reports quarterly on interactions with protected species on behalf of Commonwealth fishing operators to the Department of Agriculture, Water and the Environment (DAWE). Since 2010, AFMA observers have recorded few interactions with protected species in the SPRFMO and SIOFA fisheries. One interaction with a basking shark (*Cetorhinus maximus*; dead) was reported in the SPRFMO trawl fishery in 2019.

These reported interactions with protected species form a part of the ongoing monitoring by DAWE of the performance of fisheries within their accreditation under the EPBC Act.

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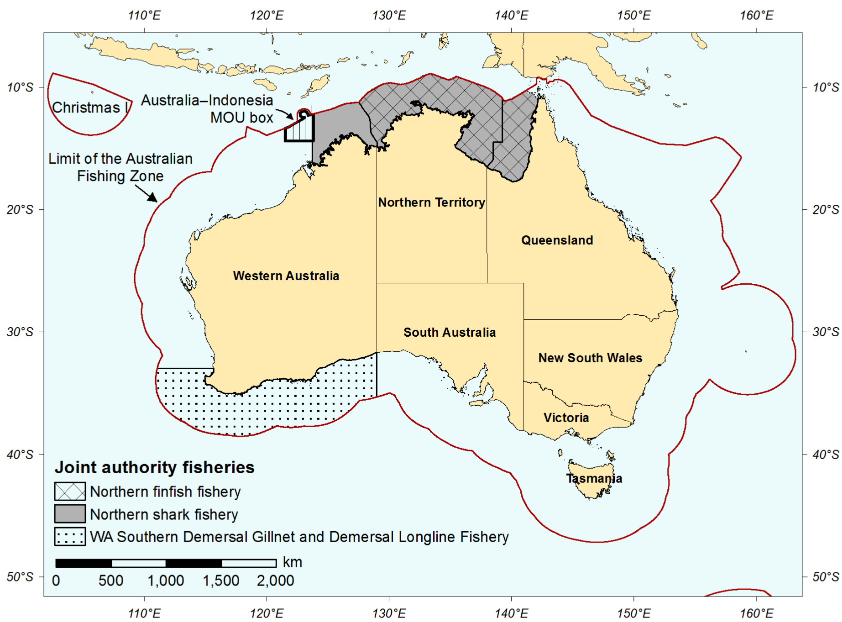
Chapter 29
Joint authority fisheries

R Noriega

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 are collectively referred to in this report as the 'northern shark fishery' and the 'northern finfish fishery' (Figure 29.1). In each case, strategic directions are provided by members of the joint authority, while the relevant state or territory government provides day-to-day management of the fishery 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.

In 1995, under the Offshore Constitutional Settlement (OCS), the Western Australia Fisheries Joint Authority (WAFJA) was given responsibility for the management of the northern shark fishery in accordance with the provisions of the *Western Australian Fish Resources Management Act 1994*.

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 Northern shark fishery

Australian gillnetters began fishing in northern Australian waters in about 1980, although foreign vessels were fishing in the area before then and continued to do so until 1986. Fisheries comprising the northern shark fishery 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 (JANSF). 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 used are gillnets and longlines, 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; genetic analyses have, however, 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 shark and grey mackerel. 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).

Catch-and-effort data for 2019 were provided directly to ABARES from the Northern Territory Department of Primary Industry and Resources. Of the 24 licences issued in 2019, 13 were active, recording 751 boat-days fished—well below the peak of 1,801 boat-days in 2003. The highest domestic catch was reported in 2003 at 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 538 t in 2019 (down from 694 t in 2018). The 2019 catch included 44 t of blacktip shark and 350 t of grey mackerel.

Export accreditation has been granted under the *Environment Protection and Biodiversity Conservation Act 1999* (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. The fishery has 2 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.

Catch-and-effort data for 2019 were provided directly to ABARES from the Queensland Department of Agriculture and Fisheries. Of the 89 licences issued in 2019, 71 were active—3 in the offshore sector and 68 in the inshore sector. In 2019, reported catch of blacktip shark was 110 t (a slight decrease from 112 t in 2018).

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 to be depleting (QDAF 2017; Whybird et al. 2018). 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

This fishery is managed by the WAFJA. For reporting and assessment purposes, it is combined with the adjacent Western Australia North Coast Shark Fishery (WANCSF) and reported as part of the northern shark fishery. The JANSF extends from longitude 123°45'E to the Northern Territory border, and the WANCSF 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 JANSF and the WANCSF 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.

Effort increased 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 (*Carcharhinus plumbeus*) and other large species. Fishing activity has not been reported in the JANSF since 2008–09.

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 JANSF 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 WANCSF 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 JANSF. These measures resulted in a substantial decline in total fishing effort and an associated decrease in total reported catch.

In 2008, the JANSF's Wildlife Trade Operation approval under the EPBC Act was revoked because a formal management plan had not been finalised. The WANCSF'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 fishery, sharks are caught as bycatch and byproduct in other Commonwealth, state and territory fisheries. In Western Australia, the 2016–17 catch of sharks by other state-managed fisheries was negligible—less than 10 t (it peaked at 31 t in 2005–06) (Gaughan, Molony & Santoro 2019)—as a result of a ban on retention in all but 3 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 9 fishing vessels identified 16 species belonging to the families Carcharhinidae (whaler sharks) and Sphyrnidae (hammerhead sharks). The 2 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 (*Carcharhinus brevipinna*; 7.2%) and grey reef shark (*C. 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 2018–19, 5 illegal foreign fishing vessels (all Indonesian) were apprehended in Australian waters (AFMA 2019). In 2017–18, 14 illegal foreign fishing vessels were apprehended (9 Indonesian and 5 Papua New Guinean). Overall numbers are well down on the 367 vessels apprehended in 2005–06, reflecting a sustained and coordinated effort by Australian Government agencies to reduce the number of vessels being apprehended each year.

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.

A 2015 stock assessment of sharks encountered by Queensland commercial fishers concluded that commercial catches of blacktip sharks are below MSY limits (Leigh 2015). However, the assessment also acknowledged data limitations with respect to accuracy of species identifications and the quantity and reliability of available catch data. As a result, current catch levels and their impact on the biological stock are unknown, and there is insufficient information to confidently classify the status of the stock in the Gulf of Carpentaria (Johnson et al.2018).

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.

29.2 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 2 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 2 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 stocks is reviewed in *Status of key Northern Territory fish stocks report 2017* (Northern Territory Government 2019). Catch-and-effort data for 2019 were provided directly to ABARES from the Northern Territory Department of Primary Industry and Resources.

In 2019, 6 vessels were active in the Timor Reef Fishery, recording 650 vessel-days, and 6 vessels were active in the Demersal Fishery, recording 1,250 vessel-days. The Timor Reef Fishery reported a total catch of 439 t in 2019 (837 t in 2018), including 212 t of goldband snappers and 124 t of red snappers. The Demersal Fishery reported a total catch of 3,375 t in 2019, including 215 t of goldband snappers and 2,608 t of red snappers.

The Timor Reef Fishery and the Demersal Fishery have been granted an exemption from export restrictions until 13 June 2020.

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 3 fishing permits are issued to access the fishery, there has been no fishing activity since 2016–17. 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's export approval expired on 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 2019. Total catch in 2019 was 157 t, with an effort level of 809 vessel-days. Spanish mackerel accounted for 99% of the catch in 2019. The fishery has been granted export approval until 22 November 2022.

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 2019, the commercial catch of goldband snappers in the Northern Territory was 427 t; 45 t was caught in Queensland. Although 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 with data up to 2016 using a stochastic stock reduction analysis model (Northern Territory Government 2019). Egg production was estimated to be between 60% and 70% 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. 2018b). 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 2019, the commercial catch of red snappers was 2,732 t (2,055 t of saddletail snapper and 677 t of crimson snapper) in the Northern Territory and 69 t (58 t of saddletail snapper and 11 t of crimson snapper) in Queensland. In the Northern Territory, crimson and saddletail snappers are managed together as 'red snappers' (Saunders et al. 2018c) with a combined TACC of 3,800 t.

The northern Australian saddletail snapper stock was assessed in 2016 using a stochastic stock reduction analysis model (Northern Territory Government 2019). Egg production was estimated to be around 60% 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. 2018c).

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Chapter 30

The status determination process

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30.1 Legislation and policy

Fisheries Management Act 1991

The *Fishery status reports* assesses 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 includes exercising 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 2018b) 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 2018d).

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 ABARES.

In situations where biomass or fishing mortality have not been generated from a stock assessment, 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.

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 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 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 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 3 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.

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 targets are consistent with MEY, given the biological and economic characteristics of the stocks. 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 1 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 2020* reports on key bycatch issues in each fishery and information from ecological risk assessments (ERAs) by AFMA.

Bycatch species

In 2018, the *Commonwealth Fisheries Bycatch Policy* was released (Department of Agriculture and Water Resources 2018a). 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 2018c).

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 2020* 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 5 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 2019 calendar year or the 2018–19 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 1 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: *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 a 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
BSCZSF	Bass Strait Central Zone Scallop Fishery
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CDR	catch disposal record
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
ITQ	individual transferable quota
IUU	illegal, unreported and unregulated (fishing)
JANSF	Joint Authority Northern Shark Fishery (of Western Australia)
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
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
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
SHS	Scalefish Hook Sector (of the SESSF)
SIOFA	Southern Indian Ocean Fisheries Agreement
SPF	Small Pelagic Fishery
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
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
TVH	Transferable Vessel Holder
UNCLOS	United Nations Convention on the Law of the Sea
USSR	Union of Soviet Socialist Republics
VME	vulnerable marine ecosystem
WAFJA	Western Australia Fisheries Joint Authority
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
ha	hectare
kg	kilogram
km	kilometre
km²	square kilometre
m	metre
mm	millimetre
nm	nautical mile
t	tonne (1,000 kg)

The following conventions have been used to express year ranges:

2018–19	financial year or season
2018 or 2019; 2015 to 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.

Catchability. The extent to which a stock is susceptible to fishing; quantitatively, the proportion of the stock removed by 1 unit of fishing effort.

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).

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 a depth of 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 1 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 Commonwealth Fisheries 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 2 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 2 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 arrangements 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. Handheld 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.

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.

High seas. Waters outside national jurisdictions—that is, outside Exclusive Economic Zones.

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 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 1 or more states or territories under a single (Commonwealth, or state or territory) jurisdiction.

Joint venture. Collaborative fishing operation, usually involving 2 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 2 or more listed threatened species (other than conservation-dependent species), or 2 or more listed threatened ecological communities.

L

Landings (or landed catch). Refers to catch that is reported at port in catch disposal records; discards are excluded.

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.

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).

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.

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 of Wild Fauna and Flora (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, 1 or more state or territory governments, or any combination of the 2 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 1 mean generation time, or 3 times the mean generation time, whichever is less.

P

Pair trawling. Trawling by 2 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 2 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 1 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.

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.

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.

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 2 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. A defined limit at which 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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