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Photo credits (top to bottom)

SBT tow cage—Matt Daniel, AFMA
Tiger prawn—AFMA
Rough conditions—Austral Fisheries
Rock lobster—Kerry Trapnell

Contents

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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.

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- **Geoscience Australia**—coastline, state boundaries, place names, bathymetric features, Australian Fishing Zone and Exclusive Economic Zone boundaries
- **AFMA**—Australian Government fisheries logbook, catch disposal and observer data; fisheries management boundaries
- **Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)**—CCAMLR statistical division boundaries

- **Australian Government Department of the Environment and Energy**—marine protected areas boundaries
- **Commission for the Conservation of Antarctic Marine Living Resources, Commission for the Conservation of Southern Bluefin Tuna, Indian Ocean Tuna Commission, South Pacific Regional Fisheries Management Organisation, Western and Central Pacific Fisheries Commission**—catch-and-effort data.

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Chapter 1
Overview

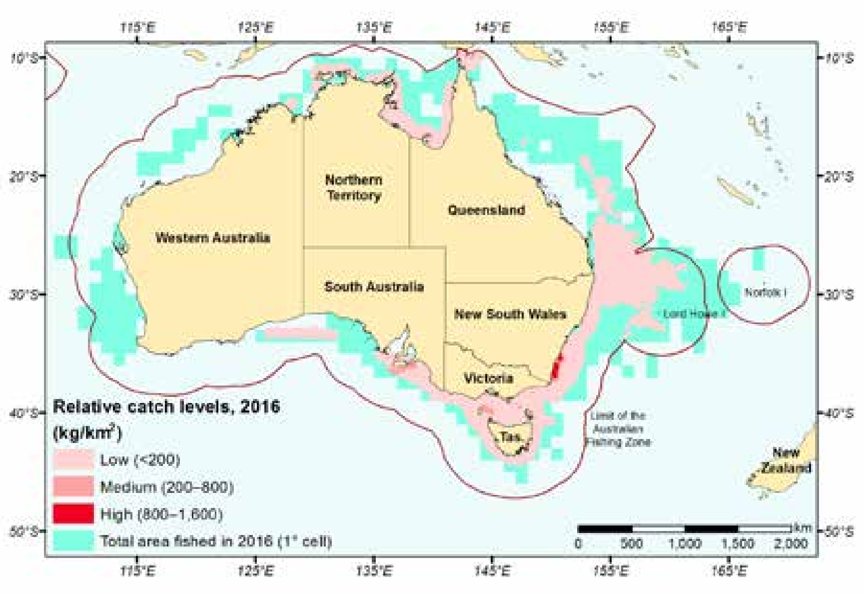
H Patterson, L Georgeson, R Noriega, A Koduah, F Helidoniotis, J Larcombe, S Nicol and A Williams

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 (DAFF 2007). 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 2017 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 2016 and over time, against the requirements of fisheries legislation and policy. The reports assess all key commercial species from Australian Government–managed fisheries and examines the broader impact of fisheries on the environment, including on non-target species.

To complete these reports, ABARES uses data and information sourced from agencies such as the Australian Fisheries Management Authority (AFMA) and regional fisheries management organisations. The reports use information on catch and fishing effort, and other information for the most recent complete fishing season that is available, and the most recent stock assessments. Commonwealth fisheries operate with different fishing season dates, so the currency of catch data in the reports varies. To compare status from year to year, biological and environmental status is presented for 2016. Economic status is presented for the 2015–16 financial year.

FIGURE 1.1 Relative catch levels of all Australian Government–managed fisheries, 2016



Fishing vessels in Hobart
Tim Emery, ABARES

1.1 Assessing biological status

Assessments of stock status provide an indication of whether the current size of a fish stock is above the level at which the stock is considered to be overfished (biomass status) and whether current levels of catch will allow the stock to remain in that state (fishing mortality status). Stock status is expressed in relation to the reference points prescribed by the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007).

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

Fishing mortality (F) status relates to the level of fishing pressure on a stock—specifically, whether fishing mortality in the year 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 meet one or more of the criteria below. Conversely, stocks may be removed from the reports if they do not meet at least one of these criteria:

- a target or key commercial species in a fishery managed solely or jointly by the Australian Government
- a species or stock managed under a total allowable catch (TAC)
- a species or stock previously classified as 'overfished' that has not yet recovered to above the limit reference point.

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

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

1.2 Biological status in 2016

Fishery status reports 2017 assesses 94 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 29 stocks were assessed across 13 fisheries that are managed jointly with other Australian jurisdictions or other countries. One new stock is included in *Fishery status reports 2017*: the toothfish stock in the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) exploratory toothfish fishery in division 58.4.1, which was formally fished by an Australian vessel for the first time in 2016. This is a jointly managed stock because it occurs in the area covered by the Convention on the Conservation of Antarctic Marine Living Resources; it includes both Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*D. mawsoni*).

The status of the 94 fish stocks managed solely or jointly by the Australian Government generally improved in 2016, compared with the previous year (Figures 1.3 and 1.4):

- The number of stocks classified as not subject to overfishing increased to 81 (79 in 2015), and the number of stocks classified as not overfished remained at 69. Of these, 65 stocks were both not subject to overfishing and not overfished (66 in 2015).
- The number of stocks classified as subject to overfishing remained at 3, and the number of stocks classified as overfished remained at 11. Of these, 1 stock (bigeye tuna [*Thunnus obesus*], fished in the Eastern Tuna and Billfish Fishery [ETBF]) was both subject to overfishing and overfished (1 in 2015).
- The number of stocks classified as uncertain with regard to fishing mortality decreased to 10 (11 in 2015), but the number of stocks classified as uncertain with regard to biomass increased to 14 (13 in 2015). Of these, 1 stock was uncertain with respect to both fishing mortality and biomass.

Fishery status reports 2017 shows a continuation of the general trend of improvement in the biological status of fish stocks in Australian Government–managed fisheries—specifically, the increasing number of stocks classified as not subject to overfishing and not overfished (Figures 1.3 and 1.4). Rapid increases in the number of such stocks occurred before 2009; this was associated with increasing numbers of stocks being classified in the reports, as well as the influence of the 2005 Ministerial Direction, and the associated implementation of the HSP and the Securing our Fishing Future structural adjustment. The 2017 reports are the fourth consecutive year that no stocks in fisheries solely managed by the Australian Government have been classified as subject to overfishing. However, there is ongoing uncertainty surrounding the fishing mortality status of some overfished stocks (discussed further below).

In general, the 2017 reports show continued improvements in our ability to classify stock status. The number of stocks classified as uncertain with respect to biomass has shown a general decline after an increase between 2004 and 2007 (Figure 1.4). The increased certainty in stock status has been due to the factors mentioned above, such as the implementation of the HSP, and also investment in the Reducing Uncertainty in Stock Status project (Larcombe et al. 2015). However, the reduction in the number of stocks that are uncertain with respect to their fishing mortality status has plateaued since 2011 (Figure 1.3).

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 performance of fisheries management against the relevant legislation and policy, which may differ between these groups of fisheries.

FIGURE 1.2 Biological status of fish stocks in 2016, by fishery or sector

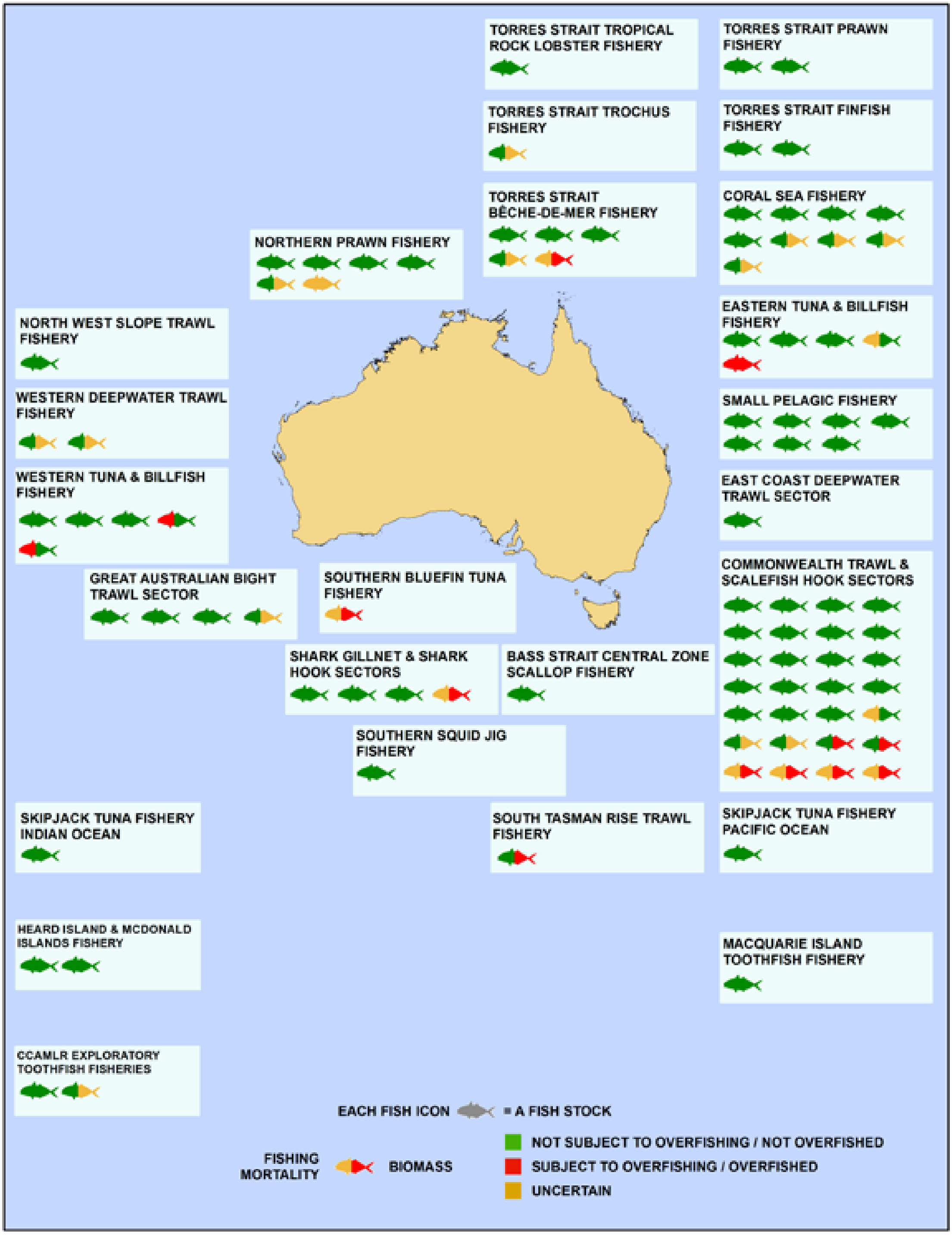


FIGURE 1.3 Fishing mortality status (number of stocks), 2004 to 2016

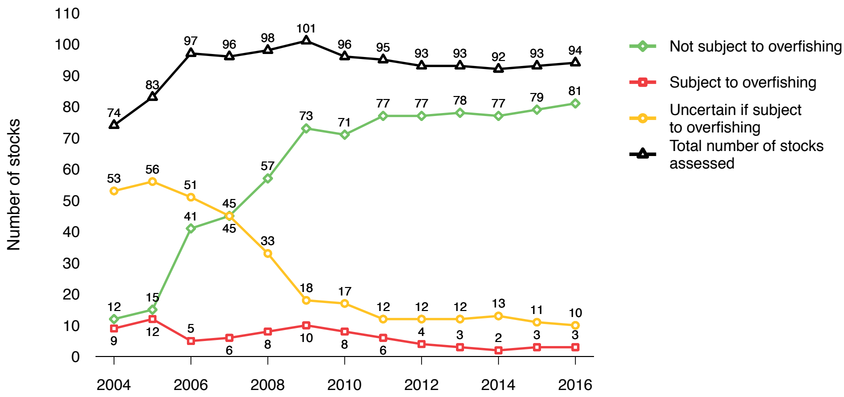
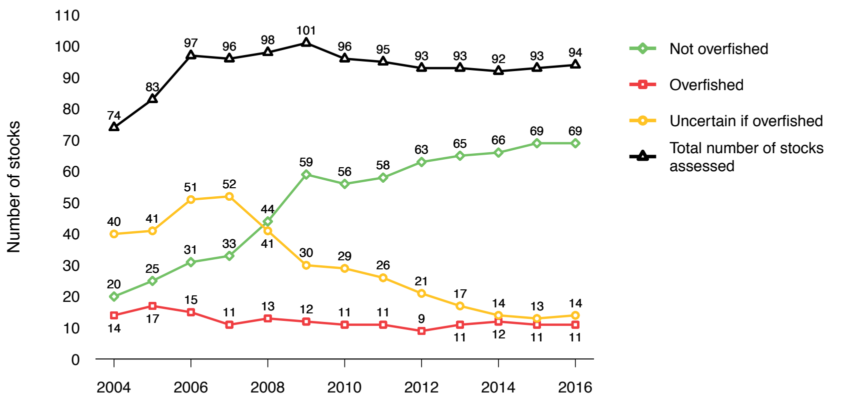


FIGURE 1.4 Biomass status (number of stocks), 2004 to 2016



Stocks that have changed status

The status of four stocks in fisheries solely managed by the Australian Government changed in 2016 (Table 1.1). Two changes reflect increased certainty around the level of fishing mortality, while one stock has become more uncertain in relation to fishing mortality and one stock is more uncertain in relation to biomass. No stocks managed jointly have changed status.

The level of uncertainty around the status of commercial scallop (*Pecten fumatus*) in the Bass Strait Central Zone Scallop Fishery (BSCZSF) decreased as a result of improved biomass estimates from surveys in 2016 and 2017. In addition, the level of escapement (the percentage of the known biomass not caught in a year) has been high. The stock was therefore classified as not overfished and not subject to overfishing.

Similarly, the level of uncertainty around the fishing mortality status of white teatfish (*Holothuria fuscogilva*) in the Coral Sea Fishery decreased because there was no catch in 2015–16. Although the biomass status remains uncertain, the stock is now classified as not subject to overfishing.

In contrast, the level of uncertainty around fishing mortality status increased for ocean perch (*Helicolenus barathri*, *H. percoides*) in the Southern and Eastern Scalefish and Shark Fishery (SESSF) Commonwealth Trawl Sector (CTS). In 2016–17, the total mortality, including discards, exceeded the recommended biological catch (RBC). A review of the past several RBCs compared with total mortality indicated that the RBCs in 2013–14 and 2014–15 were also exceeded. The impact of this mortality on the biomass level is unknown, and the stock is now classified as uncertain for fishing mortality.

Finally, the level of uncertainty around biomass status for red-legged banana prawn (*Fenneropenaeus indicus*) in the Northern Prawn Fishery (NPF) has increased. Although the most recent estimate of biomass (2014) was well above the target reference point, there was no assessment in 2015 and 2016 because of a lack of data following low catch-and-effort levels. In addition, there is uncertainty and some concern about the cause of these lower catch levels. The biomass status of the red-legged banana prawn stock is therefore now uncertain.

TABLE 1.1 Stocks with a changed status in 2016 and their status in 2015, for stocks managed solely by the Australian Government

Fishery	Common name (scientific name)	2015		2016	
		Fishing mortality	Biomass	Fishing mortality	Biomass
Bass Strait Central Zone Scallop Fishery	Commercial scallop (*Pecten fumatus*)				
Coral Sea Fishery	White teatfish (*Holothuria fuscogilva*)				
Northern Prawn Fishery	Red-legged banana prawn (*Fenneropenaeus indicus*)				
Southern and Eastern Scalefish and Shark Fishery: Commonwealth Trawl Sector	Ocean perch (*Helicolenus barathri*, *H. percoides*)				

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

Stocks classified as subject to overfishing and/or overfished

Stocks classified as overfished or subject to overfishing remained the same as in 2015 (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. Seven stocks in fisheries managed solely by the Australian Government were classified as overfished in 2016 (Tables 1.2 and 1.3). These stocks occur in the SESSF and are subject to stock rebuilding strategies, as required by the Commonwealth HSP. Blue warehou, eastern gemfish, orange roughy, gulper sharks and school shark are listed as conservation dependent under the EPBC Act. None of these stocks were classified as subject to overfishing in 2016; however, five were classified as uncertain with respect to fishing mortality status (discussed below).

Six stocks in jointly managed fisheries were classified as either overfished or subject to overfishing in 2016. Classification of these stocks remained the same as in 2015 (Table 1.2).

Assessing fishing mortality status for overfished stocks

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

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

TABLE 1.2 Stocks classified as subject to overfishing and/or overfished in 2016, and their status in 2015

Fishery	Common name (scientific name)	2015		2016		Comments
		Fishing mortality	Biomass	Fishing mortality	Biomass	
Stocks in fisheries managed solely by the Australian Government						
SESSF: CTS and SHS Chapter 9	Blue warehou (*Seriolella brama*)					Total removals are below the incidental catch allowance, but the level of fishing mortality that will allow the stock to rebuild is unknown. There is no evidence that the stock is rebuilding.
SESSF: CTS and SHS Chapter 9	Gemfish, eastern zone (*Rexea solandri*)					Biomass is below the limit reference point. Uncertainty remains around total fishing mortality and rebuilding to the limit reference point within the specified time frame.
SESSF: CTS and SHS Chapter 9	Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)					Populations are likely to be highly depleted, and fishing mortality is uncertain despite low landed catch and protection through closures.
SESSF: CTS Chapter 9	Orange roughy, southern zone (*Hoplostethus atlanticus*)					Closure of most areas deeper than 700 m and negligible catches. No updated stock assessment.
SESSF: CTS Chapter 9	Orange roughy, western zone (*Hoplostethus atlanticus*)					Closure of most areas deeper than 700 m and negligible catches. No updated stock assessment.
SESSF: CTS Chapter 9	Redfish (*Centroberyx affinis*)					Biomass is below the limit reference point. Catch is above the RBC, and it is unclear whether total removals are above the level that will allow rebuilding.
SESSF: SGSHS Chapter 12	School shark (*Galeorhinus galeus*)					Uncertain if total mortality will allow recovery in required time frame. Estimate of pup production is below 20% of unexploited levels.

continued ...

TABLE 1.2 Stocks classified as subject to overfishing and/or overfished in 2016, and their status in 2015 continued

Fishery	Common name (scientific name)	2015		2016		Comments
		Fishing mortality	Biomass	Fishing mortality	Biomass	
Stocks in fisheries managed jointly by the Australian Government						
South Tasman Rise Trawl Fishery Chapter 28	Orange roughy (*Hoplostethus atlanticus*)	Not subject to overfishing	Overfished	Not subject to overfishing	Overfished	Fishery closed under domestic arrangements since 2007 as a result of stock depletion.
Torres Strait Bêche-de-mer Fishery Chapter 19	Sandfish (*Holothuria scabra*)	Uncertain	Overfished	Uncertain	Overfished	Uncertain impact of illegal foreign catch in recent years. Most recent full survey (2009) indicated that the stock was overfished.
ETBF Chapter 21	Bigeye tuna (*Thunnus obesus*)	Subject to overfishing	Overfished	Subject to overfishing	Overfished	Most recent estimate of biomass (2014) is below the limit reference point. Ocean-wide estimates of fishing mortality exceed the level required for MSY to be realised.
SBTF Chapter 23	Southern bluefin tuna (*Thunnus maccoyii*)	Uncertain	Overfished	Uncertain	Overfished	The estimate of spawning biomass is well below 20% of unfished biomass. The global TAC, set in line with the management procedure, should allow rebuilding. Significant uncertainty remains around unaccounted catch, which, if occurring, substantially reduces the probability of the stock rebuilding.
WTBF Chapter 24	Striped marlin (*Tetrapturus audax*)	Subject to overfishing	Not overfished	Subject to overfishing	Not overfished	Most recent estimate of biomass is above the limit reference point. Current fishing mortality exceeds the level required for MSY to be realised.
WTBF Chapter 24	Yellowfin tuna (*Thunnus albacares*)	Subject to overfishing	Not overfished	Subject to overfishing	Not overfished	Most recent estimate of spawning biomass is above the limit reference point. Current fishing mortality exceeds the level required for MSY to be realised.

Note: **CTS** Commonwealth Trawl Sector. **ETBF** Eastern Tuna and Billfish Fishery. **MSY** Maximum sustainable yield. **RBC** Recommended biological catch. **SBTF** Southern Bluefin Tuna Fishery. **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.

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

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

Status of Australian fish stocks reports

In December 2016, the Fisheries Research and Development Corporation (FRDC) released *Status of Australian fish stocks reports 2016*, the third in the series. The reports provide a national assessment of the status of key wild-capture fish stocks that are managed by the Australian Government, the states and the Northern Territory. The reports were initiated in 2012 by the FRDC and ABARES. They are developed collaboratively by the FRDC, ABARES, CSIRO, and government fishery research agencies in all states and the Northern Territory. The 2016 reports provide assessments for 294 stocks across 83 key species (or species complexes). The reports consider the same biological information as the *Fishery status reports*, but interpret that information within a nationally agreed classification system (Appendix A). This national reporting framework is designed to improve the ability to compare the status of fish stocks across Australia.

Southern bluefin tuna
Matt Daniel, AFMA

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992

Fishery	Common name (scientific name)	Status																																		
		1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
											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 spp.)																																			
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 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	Status																																		
											2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
		1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	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	Red-legged banana prawn (*Fenneropenaeus indicus*)																																			
Northern Prawn Fishery	White banana prawn (*Fenneropenaeus merguiensis*)																																			
Northern Prawn Fishery	Brown tiger prawn (*Penaeus esculentus*)																																			
Northern Prawn Fishery	Grooved tiger prawn (*Penaeus semisulcatus*)																																			
Northern Prawn Fishery	Blue endeavour prawn (*Metapenaeus endeavouri*)																																			
Northern Prawn Fishery	Red endeavour prawn (*Metapenaeus ensis*)																																			
North West Slope Trawl Fishery	Scampi (*Metanephrops australiensis*, *M. boschmai*, *M. velutinus*)																																			
Small Pelagic Fishery	Australian sardine (*Sardinops sagax*)																																			
Small Pelagic Fishery	Blue mackerel, east (*Scomber australasicus*)																																			
Small Pelagic Fishery	Blue mackerel, west (*Scomber australasicus*)																																			

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	Status																																	
											2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
		1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	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	Jack mackerel, east (*Trachurus declivis*)	grey	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	green	green
Small Pelagic Fishery	Jack mackerel, west (*Trachurus declivis*)	grey	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	green	green
Small Pelagic Fishery	Redbait, east (*Emmelichthys nitidus*)	grey	grey	grey	grey	grey	grey	grey	grey	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
Small Pelagic Fishery	Redbait, west (*Emmelichthys nitidus*)	grey	grey	grey	grey	grey	grey	grey	grey	yellow	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
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue-eye trevalla (*Hyperoglyphe antarctica*)	yellow	yellow	green	green	green	green	yellow	yellow	yellow	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
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue grenadier (*Macruronus novaezelandiae*)	yellow	green	green	green	green	green	green	green	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	green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue warehou (*Seriolella brama*)	yellow	yellow	green	green	yellow	green	green	red	red	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
SESSF: Commonwealth Trawl Sector	Deepwater sharks, eastern zone (18 spp.)	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	yellow	green	green	green	green	green	green	green	green	green	green	yellow	green	yellow	green	yellow	green	yellow	green	green	green	yellow	green	yellow
SESSF: Commonwealth Trawl Sector	Deepwater sharks, western zone (18 spp.)	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	yellow	green	green	green	green	green	green	green	green	green	green	yellow	green	yellow	green	yellow	green	yellow	green	green	green	yellow	green	yellow
SESSF: Commonwealth Trawl Sector	Eastern school whiting (*Sillago flindersi*)	green	green	green	green	green	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
SESSF: Commonwealth Trawl Sector	Flathead (*Neoplatycephalus richardsoni* and 4 other spp.)	green	green	green	green	green	green	green	green	green	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

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	Status 1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	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
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, eastern zone (*Rexea solandri*)																																			
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, western zone (*Rexea solandri*)																																			
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)																																			
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Jackass morwong (*Nemadactylus macropterus*)																																			
SESSF: Commonwealth Trawl Sector	John dory (*Zeus faber*)																																			
SESSF: Commonwealth Trawl Sector	Mirror dory (*Zenopsis nebulosa*)																																			
SESSF: Commonwealth Trawl Sector	Ocean jacket (*Nelusetta ayraud*)																																			
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ocean perch (*Helicolenus barathri*, *H. percoides*)																																			
SESSF: Commonwealth Trawl Sector	Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)																																			

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	Status																																		
											2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
		1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
SESSF: Commonwealth Trawl Sector	Orange roughy, eastern zone (*Hoplostethus atlanticus*)																																			
SESSF: Commonwealth Trawl Sector	Orange roughy, southern zone (*Hoplostethus atlanticus*)																																			
SESSF: Commonwealth Trawl Sector	Orange roughy, western zone (*Hoplostethus atlanticus*)																																			
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, Cascade Plateau (*Pseudocyttus maculatus*)																																			
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, non–Cascade Plateau (*Pseudocyttus maculatus*)																																			
SESSF: Commonwealth Trawl Sector	Oreodory: other (*Neocyttus rhomboidalis*, *Allocyttus niger*, *A. verrucosus*)																																			
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Pink ling (*Genypterus blacodes*)																																			
SESSF: Commonwealth Trawl Sector	Redfish (*Centroberyx affinis*)																																			
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ribaldo (*Mora moro*)																																			

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	Status																																		
		1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
											Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
SESSF: Commonwealth Trawl Sector	Royal red prawn (*Haliporoides sibogae*)																																			
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Silver trevally (*Pseudocaranx georgianus*)																																			
SESSF: Commonwealth Trawl Sector	Silver warehou (*Seriolella punctata*)																																			
SESSF: East Coast Deepwater Trawl Sector	Alfonsino (*Beryx splendens*)																																			
SESSF: Great Australian Bight Trawl Sector	Bight redfish (*Centroberyx gerrardi*)																																			
SESSF: Great Australian Bight Trawl Sector	Deepwater flathead (*Neoplatycephalus conatus*)																																			
SESSF: Great Australian Bight Trawl Sector	Ocean jacket, west (*Nelusetta ayraud*)																																			
SESSF: Great Australian Bight Trawl Sector	Orange roughy (*Hoplostethus atlanticus*)																																			
SESSF: Shark Gillnet and Shark Hook sectors	Elephantfish (*Callorhinchus milii*)																																			
SESSF: Shark Gillnet and Shark Hook sectors	Gummy shark (*Mustelus antarcticus*)																																			
SESSF: Shark Gillnet and Shark Hook sectors	Sawshark (*Pristiophorus cirratus*, *P. nudipinnis*)																																			
SESSF: Shark Gillnet and Shark Hook sectors	School shark (*Galeorhinus galeus*)																																			

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	Status																																	
		1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
											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
Southern Squid Jig Fishery	Gould's squid (*Nototodarus gouldi*)	Grey	Green	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	Green	Green	Green
Western Deepwater Trawl Fishery	Deepwater bugs (*Ibacus* spp.)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	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
Western Deepwater Trawl Fishery	Ruby snapper (*Etelis carbunculus*)	Grey	Green	Green	Green	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
Macquarie Island Toothfish Fishery	Patagonian toothfish (*Dissostichus eleginoides*)	Grey	Grey	Grey	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
Stocks in fisheries managed jointly by the Australian Government																																				
South Tasman Rise Trawl Fishery	Orange roughy (*Hoplostethus atlanticus*)	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Red	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
Torres Strait Finfish Fishery	Coral trout (*Plectropomus* spp., *Variola* spp.)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	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
Torres Strait Finfish Fishery	Spanish mackerel (*Scomberomorus commerson*)	Grey	Grey	Grey	Grey	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
Torres Strait Tropical Rock Lobster Fishery	Tropical rock lobster (*Panulirus ornatus*)	Green	Green	Green	Green	Green	Green	Yellow	Red	Red	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
Torres Strait Prawn Fishery	Brown tiger prawn (*Penaeus esculentus*)	Green	Green	Green	Green	Green	Green	Green	Green	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	Green
Torres Strait Prawn Fishery	Blue endeavour prawn (*Metapenaeus endeavouri*)	Green	Green	Green	Green	Green	Green	Green	Green	Green	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
Torres Strait Bêche-de-mer Fishery	Black teatfish (*Holothuria whitmaei*)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Red	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

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	Status																																	
											2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
		1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	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
Torres Strait Bêche-de-mer Fishery	Prickly redfish (*Thelenota ananas*)																																			
Torres Strait Bêche-de-mer Fishery	Sandfish (*Holothuria scabra*)																																			
Torres Strait Bêche-de-mer Fishery	White teatfish (*Holothuria fuscogilva*)																																			
Torres Strait Bêche-de-mer Fishery	Other sea cucumbers (up to 18 spp.)																																			
Torres Strait Trochus Fishery	Trochus (*Trochus niloticus*)																																			
Eastern Tuna and Billfish Fishery	Striped marlin (*Kajikia audax*)																																			
Eastern Tuna and Billfish Fishery	Swordfish (*Xiphias gladius*)																																			
Eastern Tuna and Billfish Fishery	Albacore (*Thunnus alalunga*)																																			
Eastern Tuna and Billfish Fishery	Bigeye tuna (*Thunnus obesus*)																																			
Eastern Tuna and Billfish Fishery	Yellowfin tuna (*Thunnus albacares*)																																			
Skipjack Tuna Fishery: Pacific Ocean	Skipjack tuna (*Katsuwonus pelamis*)																																			
Skipjack Tuna Fishery: Indian Ocean	Skipjack tuna (*Katsuwonus pelamis*)																																			
Southern Bluefin Tuna Fishery	Southern bluefin tuna (*Thunnus maccoyii*)																																			

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2016, and their status since 1992 continued

Fishery	Common name (scientific name)	1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03	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
Western Tuna and Billfish Fishery	Striped marlin (*Kajikia audax*)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	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
Western Tuna and Billfish Fishery	Swordfish (*Xiphias gladius*)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Green	Green	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
Western Tuna and Billfish Fishery	Albacore (*Thunnus alalunga*)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Green	Green	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
Western Tuna and Billfish Fishery	Bigeye tuna (*Thunnus obesus*)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Red	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
Western Tuna and Billfish Fishery	Yellowfin tuna (*Thunnus albacares*)	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Green	Green	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
Heard Island and McDonald Islands Fishery	Mackerel icefish (*Champsocephalus gunnari*)	Grey	Grey	Grey	Green	Yellow	Yellow	Green	Green	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	Green
Heard Island and McDonald Islands Fishery	Patagonian toothfish (*Dissostichus eleginoides*)	Grey	Grey	Grey	Green	Yellow	Yellow	Green	Green	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	Green
CCAMLR Exploratory toothfish fisheries 88.2	Toothfish (*Dissostichus eleginoides, D. 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	Grey	Grey	Grey	Green	Green	Green	Green
CCAMLR Exploratory toothfish fisheries 58.4.1	Toothfish (*Dissostichus eleginoides, D. 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	Grey	Grey	Grey	Grey	Grey	Green	Yellow

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

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

1.3 Economic status

Assessing economic status

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

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

Trawl catch
Mike Gerner, AFMA

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 consider explicit costs and revenues in deriving estimates of profits. To assess economic status, movements in NER are assessed alongside other economic indicators, including the extent to which stocks managed in the fishery have moved closer to their respective economic target reference points.

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

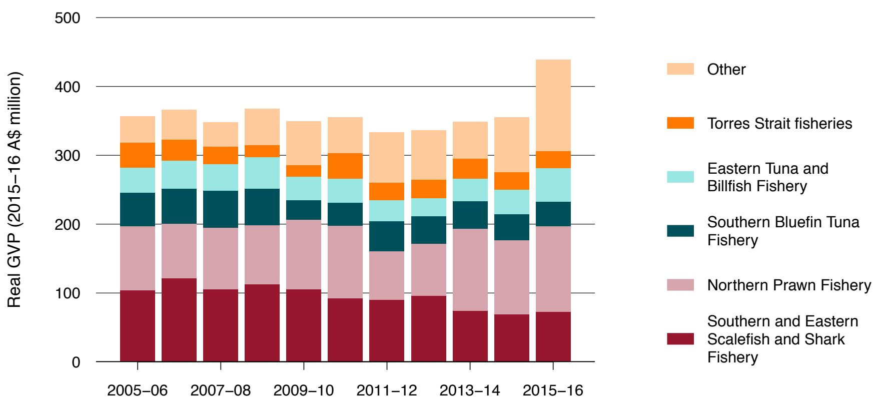
Coral trout
Ashley Williams, ABARES

Economic status in 2015–16

Fishery status reports 2017 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 $439 million in 2015–16, accounting for 26 per cent of wild-catch fisheries GVP in Australia ($1.75 billion).[1] These fisheries also accounted for about 14.5 per cent of Australia's total fisheries and aquaculture GVP in 2015–16.

The Commonwealth fisheries GVP is dominated by production from four major fisheries that together accounted for 65 per cent of total fishery GVP. In 2015–16, the NPF was the most valuable single-method fishery, with a GVP of $124.0 million. The multisector SESSF was the second most valuable Commonwealth fishery, with a GVP of $73.0 million. The ETBF and the wild-catch sector of the Southern Bluefin Tuna Fishery (SBTF) also made substantial contributions to fisheries GVP in 2015–16, with values of $48.8 million and $35.9 million, respectively (Figure 1.5).

FIGURE 1.5 Gross value of production of fisheries managed solely or jointly by the Australian Government, 2005–06 to 2015–16



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 2015–16

Fishery	Performance relative to MEY target	NER trend	Fishing right latency in fishing season	2015–16 fishery GVP (% change from 2014–15)
Bass Strait Central Zone Scallop Fishery	MEY target not specified	Negative in 2009–10 and 2010–11 (–$1.1 million). Likely to be increasing in 2015–16 and 2016–17	Low uncaught TAC	$4.61 million (+65%)
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 approaching B_{MEY} target. MEY targets not specified for banana prawn	Positive and increasing	Low unused effort	$124.08 million (+15%)
North West Slope Trawl Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential
Small Pelagic Fishery	MEY target not specified	Not available	High uncaught TAC, typically above 90%, but reduced latency in the 2015–16 fishing season	Confidential
SESSF: Commonwealth Trawl and Scalefish Hook sectors **a**	Of the five key species, most are close to B_{MEY} targets. Overfished stocks require rebuilding for improvement in economic status	Positive but decreasing	High uncaught TAC (above 50% in the 2015–16 and 2016–17 fishing seasons)	$42.91 million (+10%)
SESSF: East Coast Deepwater Trawl Sector	Fishing mortality below economic target reference point	Not available	High uncaught TAC (100%)	Confidential
SESSF: Great Australian Bight Trawl Sector	Bight redfish and deepwater flathead above B_{MEY} target	Not available but likely to be positive, and have increased	High uncaught TAC (68%)	$7.69 million (–10%)
SESSF: Shark Hook and Shark Gillnet sectors **b**	Gummy shark stock close to, or above, target. Biomass of school shark requires rebuilding	Turned slightly negative in 2010–11 and 2011–12 for GHTS. Estimated to remain negative in 2013–14	Low uncaught TAC	$22.37 million (+6%)
Southern Squid Jig Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential

2015–16 management costs (% share of GVP)	Primary management instrument	Comments about economic status
$0.27 million (6%)	ITQs and spatial management	NER are likely to have improved since 2010–11 (the last available survey year) when NER were –$1.4 million. GVP in the 2015–16 financial year is estimated to be $4.6 million, around $1.3 million higher than GVP in 2010–11. Higher catch per dredge-hour and scallop prices, along with lower fuel prices and management costs, are likely to have improved NER in 2015–16 compared with 2010–11, although it is uncertain whether NER are now positive.
$0.12 million (confidential)	Catch triggers and TACs	Estimates of NER are not available. Catch in the Aquarium Sector increased substantially in 2015–16; however, because of a lack of information about the mix of fish caught, it is unclear how this may have affected NER. A high degree of latent effort in the non-aquarium part of the fishery suggests low NER.
Not available	Input controls	Economic status is unknown.
$1.81 million (1%)	Individual transferable gear units (headrope length)	NER were estimated at $5 million in 2012–13 and continued to improve in 2013–14 to $12 million as a result of improved prawn prices. In 2015–16, catch of tiger prawns increased by 88%, with proportionately less effort, raising the contribution of this high-value species to overall fishery GVP. Combined with higher prices received for tiger prawns and lower fuel prices, this indicates positive signs for NER in the fishery in 2015–16.
$0.07 million (confidential)	Limited entry and catch triggers	Estimates of NER are not available, although the high degree of latent effort indicates that NER are likely to be low.
$1.20 million (confidential)	ITQs	Estimates of NER are not available for 2014–15 or 2015–16. A decrease in the level of catch in 2016–17 compared with the very high level of catch in 2015–16 suggests that GVP is likely to have declined in 2016–17. Changes in NER are uncertain because of a lack of information about changes in cost structures of the industry.
$2.39 million for CTS (6% of CTS GVP)	ITQs	NER for the CTS were $4.3 million in 2012–13 and $1.4 million in 2013–14 (preliminary). NER have been positive since 2002–03, partly driven by increased economic productivity, and lower fuel prices since 2014 have likely maintained this performance. Some key species are close to their B_{MEY} targets, but economic status could still be improved with rebuilding of some overfished stocks. The disinclination of fishers to fish down blue grenadier stock may suggest that the proxy target is misaligned with the MEY objective, at least in the short term.
$0.00 million (confidential)	ITQs	Before 2014–15, high levels of latency indicated low NER. No fishing activity in 2014–15 and 2015–16 indicates that NER were zero in those years.
$0.35 million (5%)	ITQs	NER are likely to have increased slightly in 2015–16. The positive impacts of lower effort and the ongoing fall in the price of fuel are likely to have more than offset the negative impact on NER of lower GVP.
$2.21 million for GHTS (10% of GHTS GVP)	ITQs	NER in 2012–13 were –$2.9 million. Preliminary estimates for 2013–14 indicate that NER are likely to remain negative. Although gummy shark biomass is not constraining NER, the management of non-target species and marine mammal interactions has likely contributed to a fall in NER in recent years.
$0.06 million (confidential)	Individual transferable gear units (jig machines)	Latent effort in the fishery remains high, but catch and effort in the fishery increased from 2015 to 2016. This suggests that the economic incentive to fish and NER in the fishery may have improved.

continued …

TABLE 1.4 Indicators and summary of economic status of Commonwealth fisheries for 2015–16 continued

Fishery	Performance relative to MEY target	NER trend	Fishing right latency in fishing season	2015–16 fishery GVP (% change from 2014–15)
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	$1.28 million (+16%)
Torres Strait Tropical Rock Lobster Fishery	Not applicable **c**	Not available	Low uncaught TAC	$14.28 million (–2%)
Torres Strait Prawn Fishery	Not applicable **c**	Not available	High unused effort	$8.86 million (–7%)
Torres Strait Bêche-de-mer and Trochus fisheries	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 striped marlin, swordfish, yellowfin tuna and bigeye tuna; high for albacore	$48.76 million (+38%)
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 but likely to be positive	Low uncaught TAC	$35.88 million (–4%)
Western Tuna and Billfish Fishery	MEY target not specified	Not available	High uncaught TAC (more than 95% in the 2015 and 2016 fishing seasons)	Confidential
Heard 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

2015–16 management costs (% share of GVP)	Primary management instrument	Comments about economic status
$0.03 million (confidential)	Limited entry	No fishing activity occurred in the fishery during the 2015–16 fishing season. Estimates of NER for previous years are not available, but a decline in effort and a low number of active fishing permits in recent years indicate that NER have been low.
Not available	Non-tradeable quota	Estimates of NER are not available. Economic performance in 2015–16 remains uncertain despite an increase in GVP, because of the lack of clarity around fishing effort levels by the TIB sector. The first export of live coral trout from the fishery in 2016–17 is a positive sign for NER.
Not available	Limited entry, size limits, gear limits and bag limits	NER are likely to have improved in 2015–16. A decrease in effort in the fishery in 2015–16 suggests a reduction in fishing costs, and, when combined with a lower fall in GVP, indicates that NER in the fishery are likely to have increased.
$0.25 million (3%, AFMA costs only)	Tradeable effort units (nights)	NER for the fishery were negative in 2012–13 (–$2.4 million); no estimates of NER are available for 2014–15 and 2015–16, although a significant increase in GVP in 2014–15 and 2015–16 relative to 2012–13 suggests improvement in NER.
Not available	TACs	Estimates of NER are not available. NER are likely to be lower in the 2016 fishing season because of a significant decrease in the catch of valuable species such as black teatfish and prickly redfish, and lower catches of most other species caught in the fishery.
$1.65 million (3%)	ITQs	NER remained positive in 2013–14 (preliminary estimate) and for 2014–15 are likely to have increased as a result of higher GVP, lower fuel prices and reduced latency. In 2015–16, NER are likely to have increased further as prices for all major species increased significantly. Implementation of ITQs and a harvest strategy for some stocks are likely to be supporting increases in NER; however, neither have been implemented long enough to determine whether there has been a positive effect.
$0.04 million (no fishing)	Limited entry	No Australian vessels fished in 2014 or 2015. Fishing is opportunistic, and highly dependent on availability and the domestic cannery market.
$0.92 million (3%)	ITQs	NER are expected to have remained positive, but deteriorating. 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.
$0.23 million (confidential)	ITQs	Latency remained high in 2016, with only a small proportion of the TACC caught, suggesting low NER.
$1.60 million (confidential)	ITQs	Estimates of NER are not available but are likely to be positive. Lower NER are likely for 2015–16 because there was significantly lower catch (a result of a lower TAC) and an increase in the level of uncaught TAC.
$0.37 million (confidential)	ITQs	Estimates of NER are not available but are likely positive between 2013–14 and 2016–17 because the TAC for Patagonian toothfish was mostly caught.
Confidential	Limited entry and TACs	Estimates of NER are not available, and NER remain uncertain. Australian fishers participated in subarea 88.2 in the 2014–15 fishing season and in division 58.4.1 during the 2015–16 season.

a NER estimates and management costs are only available for the Commonwealth Trawl Sector 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. **TACC** Total allowable commercial catch. **TIB** Traditional Inhabitant Boat. 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 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 87 per cent of the GVP of all Australian Government–managed fisheries in 2015–16.

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 $12 million in 2013–14, and continued to improve in 2014–15 as a result of improved prices and a strong catching season for tiger prawns (Bath & Green 2016). The bio-economic modelling of the tiger prawn component of the fishery has allowed the fishery to improve its economic performance for this component of the fishery.

In the CTS and GHTS, MEY is targeted through the application of proxies for B_{MEY} to individual stocks. For the most valuable species targeted in these two sectors, biomass levels are generally estimated to be close to, or above, their respective B_{MEY} targets, meaning that stock levels are not constraining profits. For the CTS, estimates of NER increased from $1.7 million in 2005–06 to $4.5 million in 2011–12. Since then, NER are estimated to have decreased substantially by 2013–14, following a 29 per cent decrease in GVP generated in the fishery in that year. In the GHTS, positive NER were maintained in the decade leading up to, and including, 2008–09. However, NER turned negative in 2009–10, declining to –$0.4 million, as spatial closures aimed at reducing marine mammal interactions and efforts to avoid (overfished) school shark affected the sector's economic performance (Skirtun & Green 2015).

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

Some fisheries that had been small in previous years expanded in 2015–16, including the Small Pelagic Fishery (SPF) and the BSCZSF. Both these fisheries 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. Changes in NER are uncertain, however, because of a lack of information about changes in the cost structures of the fishery.

Low catch-and-effort levels in the other fisheries (Coral Sea Fishery, East Coast Deepwater Trawl Sector, North West Slope Trawl Fishery, Southern Squid Jig Fishery and Western Deepwater Trawl Fishery) indicate low NER in 2015–16. For these fisheries, it is often difficult to assess economic status because of a lack of economic data.

Jointly managed fisheries

Of the fisheries jointly managed by the Australian Government, the major fisheries include the SBTF, the ETBF and the Torres Strait Tropical Rock Lobster Fishery (TSTRLF). Combined, these three fisheries generated a GVP of $98.8 million and accounted for 45 per cent of the GVP of all jointly managed fisheries in 2015–16. Individually, these fisheries generated GVPs of $35.9 million (wild-caught southern bluefin tuna as input to tuna farms), $48.8 million and $14.2 million, respectively, in 2015–16.

Estimates of NER are not available for the SBTF. However, the fishery provides fish to South Australia's southern bluefin tuna aquaculture industry (generating $127 million GVP at the farm gate in 2015–16). Although the stock's current low biomass level poses a risk to the future flow of NER from the fishery, the current international management arrangements, which are designed to allow the stock to rebuild, would be expected to improve NER in future.

Economic status in the ETBF has improved. Based on recent estimates, in 2010–11, NER were positive for the first time since 2000–01 (George & New 2013). From 2011–12 to 2012–13, NER remained positive but slightly lower as a result of higher fuel prices. In 2013–14, preliminary estimates are that NER fell further to $0.1 million; this reduction was mostly driven by higher operating costs and a relatively small increase in fishing income.

Torres Strait fisheries are managed in accordance with the *Torres Strait Fisheries Act 1984*. This Act details a range of management priorities, including acknowledging and protecting the traditional way of life and livelihood of Traditional Inhabitants. As a result, these fisheries are not evaluated against the MEY objective of the HSP in these reports, and achieving the fishery's economic potential needs to be considered alongside the social and cultural objectives of Torres Strait Islander and Aboriginal people. The TSTRLF was the most valuable commercial fishery in Torres Strait in 2015–16, 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. If fishers collectively are fishing below the TAC, they are foregoing economically profitable opportunities, the MEY target has been set too high or there are practical difficulties preventing fishers catching to the MEY 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. For example, the adoption by the SPF of a factory trawler has led to reduced latency in that fishery in the 2015–16 and 2016–17 fishing seasons.

However, for some fisheries, the reasons for persistent high latency remain unclear and warrant further investigation. For example, a number of species in the SESSF have increasingly been undercaught in terms of their TACs in recent seasons; the reasons for the undercatch require investigation so that appropriate management responses can be made.

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

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

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

1.4 Environmental status in 2016

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

Ecological risk assessment

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

Commonwealth Policy on Fisheries Bycatch

The Commonwealth Policy on Fisheries Bycatch 2000 (bycatch policy) was reviewed in 2012. The main objectives of the policy are to reduce bycatch, to improve protection of vulnerable species and to arrive at decisions on the acceptable extent of ecological impacts (DAFF 2013a). The review of the bycatch policy found that a revised policy would be best developed within a framework of policy instruments for fisheries management that address all relevant aspects of fisheries management and its effect on the marine environment.

Cumulative impacts

The wide distribution of many protected species across the Australian Fishing Zone means that some species may interact with a number of fisheries, including fisheries in other jurisdictions and on the high seas. Although interactions in a single fishery may be low, the cumulative impact across several fisheries can be significant. Data constraints limit the assessment and understanding of cumulative impacts across fisheries and jurisdictions (Phillips et al. 2010). The current bycatch policy does not explicitly address the issue of cumulative effects on bycatch species. The bycatch policy review found that a revised policy should identify approaches to assessing and managing cumulative effects as a priority (DAFF 2013a).

Protected species interactions

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

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

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

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

AFMA also introduced new dolphin mitigation strategies in the SPF and the Gillnet, Hook and Trap sector (GHAT) of the SESSF that came into force on 10 May 2017. These strategies apply to all trawling operations in the SPF and the whole gillnet sector of the GHAT, and were developed in consultation with stakeholders, as well as marine mammal experts.

Data collection

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

AFMA has continued to strengthen independent monitoring capabilities by introducing electronic monitoring (e-monitoring) programs in several fisheries and subfisheries to improve logbook reporting and for logbook verification of interactions with protected species. A preliminary comparison of catch-and-discard data for target and bycatch species, as well as wildlife interactions, recorded in logbooks before the introduction of e-monitoring and afterwards shows a marked change in most cases after the introduction of e-monitoring, suggesting that fishers are recording data in their logbooks more accurately than before (Larcombe et al. 2016).

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

At a minimum, 10 per cent of the video footage is analysed at random, and a risk-based approach is used to audit more footage from boats that are suspected of misreporting. In the GHTS, all gillnet hauls are audited in the Australian sea lion management zones, to verify any protected species bycatch. More information on e-monitoring can be found on the AFMA website.[2]

1.5 Policy reviews

In May 2013, the Australian Government Department of Agriculture, Fisheries and Forestry (now the Department of Agriculture and Water Resources) released separate review reports on the HSP (DAFF 2013b) and the Commonwealth Policy on Fisheries Bycatch 2000 (DAFF 2013a). The reviews included public comment on discussion papers, stakeholder workshops, and technical reviews by ABARES, CSIRO and the University of Wollongong.

The review of the HSP concluded that the policy has largely been successful in improving the management of Commonwealth fisheries and has provided a strong foundation for fisheries management. The review noted that, in most respects, the policy and guidelines meet or exceed international obligations and best practice. The review's key recommendations for improving the policy include providing additional direction or guidelines on stock rebuilding strategies and discarding of commercial species; implementing the MEY objective in multispecies fisheries; and ensuring that the policy applies to all commercial species, including byproduct species.

The bycatch policy review recommended the development of a revised bycatch policy, including new policy objectives and principles, and a revised definition of bycatch. Key recommendations of the review included development of a tiered approach to monitoring, assessing and managing bycatch; development of guidelines to underpin implementation of the revised policy (similar to those for the HSP); use of trigger points and decision rules, where appropriate; and development of a performance monitoring and reporting framework to evaluate the implementation and effectiveness of the bycatch policy.

The reports on the HSP and bycatch policy reviews do not provide any policy direction themselves, but are intended to inform the future revision and update of the policy framework for Commonwealth fisheries. These reviews complement the high-level review of Commonwealth fisheries management undertaken by Mr David Borthwick, AO, PSM, in 2012. Both policies are now being revised; the current policy settings will continue to apply until this process is complete and new policies are adopted.

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

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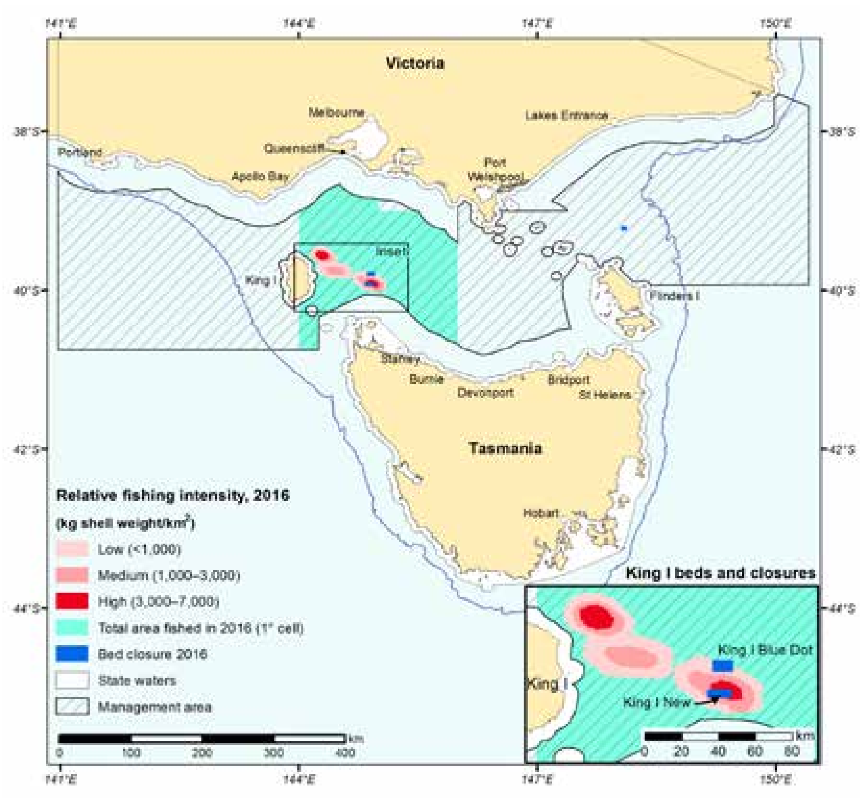
Chapter 2

Bass Strait Central Zone Scallop Fishery

N Marton and D Mobsby

FIGURE 2.1 Area and relative fishing intensity in the Bass Strait Central Zone Scallop Fishery, 2016



Note: The King Island New bed was initially closed under formal arrangements, and the King Island Blue Dot bed was closed under voluntary arrangements pending a survey of the bed. Following the King Island Blue Dot survey, the King Island Blue Dot bed was closed under formal arrangements, and the King Island New bed was opened on 7 October 2016.

TABLE 2.1 Status of the Bass Strait Central Zone Scallop Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Commercial scallop (*Pecten fumatus*)	Uncertain	Uncertain	Not subject to overfishing	Not overfished	Large, stable biomass identified in western Bass Strait. Total allowable catch and catch 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 –$1.1 million. GVP in the 2015–16 financial year is estimated to be $4.6 million, around $1.3 million higher than the GVP in 2010–11. Higher catch per dredge-hour and scallop prices, along with lower fuel prices and management costs, are likely to have improved NER in 2015–16 compared with 2010–11, although it is uncertain whether NER are now positive.				

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

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

2.1 Description of the fishery

Area fished

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

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, except in 2003, this species is either not retained or only retained in very small amounts, because there is no market for it.

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

Management methods have changed considerably since the fishery reopened in 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 (first developed for the 2014 season) uses a tiered management approach, whereby a 150 t TAC can initially be set as a 'default opening', covering the whole BSCZSF management area, to allow operators to search widely for scallop beds (AFMA 2015). The revisions to the harvest strategy in 2014 in part aimed to increase knowledge of the biomass by encouraging exploratory fishing outside known beds. However, in 2015 and 2016, the exploratory period was skipped altogether in favour of returning to survey the known King Island beds.

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

Tier 2 of the harvest strategy states that, if the scientific survey identifies one or more scallop beds with a combined biomass of 3,000 t or more, and those beds are closed to commercial fishing, the TAC can be initially set to at least 2,000 t.

The 2016 fishery operated under tier 2 of the harvest strategy, with a starting TAC of 3,000 t; the TAC could be increased to a maximum of 5,000 t, based on catches during the season.

Fishing effort

The fishery has a history of boom and bust, with the peaks (1982–83, 1994–96, 2003 and 2016) generally becoming progressively smaller, interspersed with fishery-wide closures, the most recent being from 2006 to 2008 (Figure 2.2). At its peak in 1995, 103 vessels operated in the fishery.

The fishery reopened in 2009 with 26 active vessels. The number of active vessels decreased before stabilising at 11–12 vessels (12 in 2016). Despite a decrease in the number of active vessels, dredge-hours increased in 2010 to 4,853—the highest level since 2003; dredge-hours roughly halved each year for the subsequent three years, to a low of 656 in 2013—the lowest level since 2002. Since 2013, dredge-hours have increased each year, to 6,894 in 2016—the highest since 1998 when there were 38 active vessels in the fishery.

TABLE 2.2 Main features and statistics for the BSCZSF

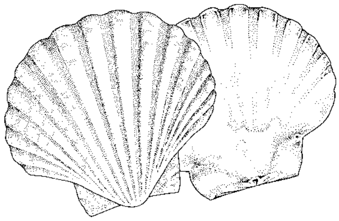
Fishery statistics a	2015 fishing season b			2016 fishing season c		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Commercial scallop	2,500 (+42) **d**	2,260	$2.8 million	3,000 (+60) **d**	2,885	$4.6 million
Doughboy scallop	100	0.2	na	100	0.3	na
Total fishery	**2,642**	**2,260**	**$2.8 million**	**3,160**	**2,885**	**$4.6 million**
Fishery-level statistics						
Effort	4,116 dredge-hours			6,894 dredge-hours		
Fishing permits	65			62		
Active vessels	11			12		
Observer coverage	0 days			0 days		
Fishing methods	Scallop dredge					
Primary landing ports	Apollo Bay and Queenscliff (Victoria); Devonport and Stanley (Tasmania)					
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. Real-value statistics are by financial year and are in 2015–16 dollars. **b** Fishing season was 8 July to 31 December 2015. **c** Fishing season was 22 July to 31 December 2016. **d** A research quota also exists for commercial scallop (42 t in 2015 and 60 t in 2016).
Notes: **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing right. **TAC** Total allowable catch.

Scallop dredge
AFMA

2.2 Biological status

Commercial scallop (*Pecten fumatus*)



Line drawing: FAO

Stock structure

Scallops in the Commonwealth, Tasmanian and Victorian scallop fisheries form one genetically homogeneous population (Semmens et al. 2015) 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 (Semmens et al. 2015).

Catch history

A fishery for commercial scallops has operated in central Bass Strait since 1973 (Young & Martin 1989). The fishery is spatially structured, with the fleet tending to congregate on one or two known beds for the season. These may be revisited for several seasons until the bed is depleted or the fleet moves to more favourable beds, either within the same area or in an entirely different area. In this way, the fishery has moved back and forth between beds in eastern and western Bass Strait several times over 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, following a three-year closure under Ministerial Direction. Operators initially focused on beds north-east of Flinders Island in eastern Bass Strait, before moving to beds east of King Island in western Bass Strait in 2014. The fishery remained there for the following seasons.

In the early years after reopening, the fishery suffered from poor scallop conditions, with die-off events in 2010 (AFMA 2011) and 2011 (AFMA 2012b). In 2012, scallops were reported to be in poor condition in part of the fishery (and, conversely, in good quality 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, and so the fishery moved to beds around King Island.

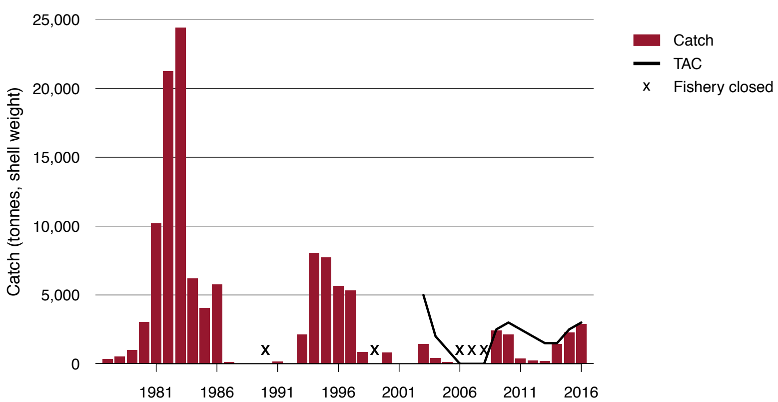
Catch, catch rates (both catch per hour and catch per shot) and scallop quality have all improved since the fishery moved to the King Island region. Three main beds were fished around King Island in 2014; this expanded to five in 2015 and eight in 2016.

The harvest strategy encourages exploratory fishing. While this exploratory fishing period has only been used in 2014, logbook records in both 2015 and 2016 provide some evidence of exploratory fishing around King Island during the main season (that is, outside the formal exploratory fishing period).

The King Island region had not been fished since at least 1998, and unfortunately biomass surveys were not completed for the region before fishing recommenced in 2014. However, a survey in 2015 identified three beds with a total combined biomass of 'adults' (shell length greater than 85 mm) of 9,300 t (Knuckey et al. 2015), and a 2016 survey identified eight beds with a combined biomass of 22,090 t of adult scallops (Knuckey et al. 2016). Surveys in 2017 revisited four of the known King Island beds and estimated biomass in those beds at 16,200 t (Knuckey et al. 2017). The 2017 survey found an additional region with four scallop beds ('Apollo Bay') with an estimated adult biomass of 5,460 t. It also revisited the two Flinders Island beds surveyed in 2016, together with two adjacent beds. The Flinders Island beds have not been commercially fished since 2014, and it appears there has been considerable mortality in these beds, with survey results estimating an adult biomass of only 1,090 t. In comparison, combined biomass estimates for beds in the Flinders Island region were 3,800 t in 2016 (Knuckey et al. 2016) and have been as high as 10,100 t in 2012 (Semmens 2012).

The 2016 fishery opened on 22 July 2016 with a starting TAC of 3,000 t. Fishing generally focused on the same areas as the 2014 and 2015 seasons, and operators reported scallops in good condition. An option existed for the TAC to be increased to a maximum of 5,000 t, based on landed catch and in consultation with industry; however, the catch level to trigger the TAC increase was not reached in the required time frame. The fishery closed on 31 December 2016 with 2,885 t landed.

FIGURE 2.2 Catch and TAC of commercial scallop in the BSCZSF, 1977 to 2016



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: Australian Fisheries Management Authority 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 industry-based surveys (discussed below).

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

Surveys between 2009 and 2017 have covered a large area, encompassing approximately 60 per cent of the 6 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.

Surveys in 2017 covered about 8 per cent of the grids from the historical baseline area. However, adult biomass from these surveyed beds was estimated at almost 22,800 t, the second largest estimated biomass since the fishery reopened in 2009 (surveyed beds in 2016 had an estimated biomass of almost 26,000 t). 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 whole of the 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 in 2014, 4 in 2015, 10 in 2016 and 12 in 2017. 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

A weight-of-evidence approach is used to determine stock status. Considering the 2010 and 2011 die-offs, declining biomass in 2017 around Flinders Island, and the re-emergence of the beds in western Bass Strait, it is clear that the scallop biomass continues to show much variability. Even with the current harvest strategy and independent of fishing, it is possible that biomass will decline in future years due to other influences, such as environmental factors. However, at this stage, biomass of known beds appears substantial and stable.

1 Because different spatial reporting grids were used in the 1970s and 1980s, the total historical fishing area was taken for the period 1991 to 2016. This is not the same as the total management area, which is far larger and the percentage covered therefore far smaller. The 99th percentile was taken to exclude very small catches.

Compared with previous surveys, a relatively large biomass of 26,000 t was surveyed in the BSCZSF in 2016 and 22,800 t in 2017, centred in the west. These 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 catches were unconstrained. Additionally, the escapement (the percentage of the known biomass not caught in a year) has been high in recent years for western Bass Strait (87 per cent in 2016 and 76 per cent in 2015). Since fishing has not occurred in eastern Bass Strait in these two years, escapement there was 100 per cent. As a result, the stock is classified as **not overfished** and **not subject to overfishing**.

2.3 Economic status

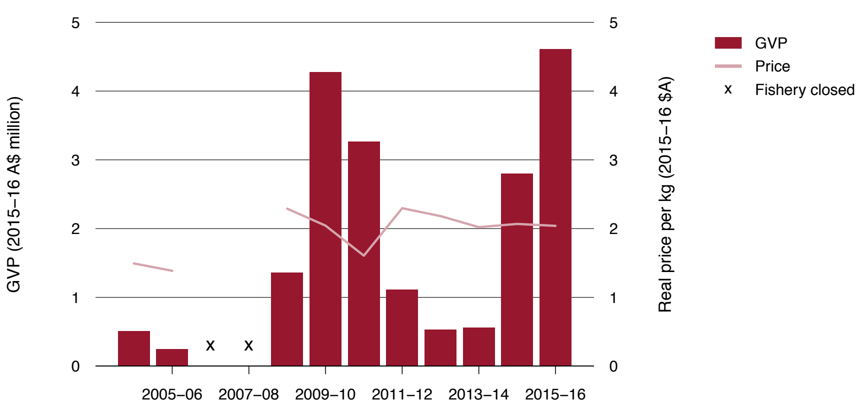
Key economic trends

The most recent economic survey of the BSCZSF estimated that real net economic returns (NER), including management costs, were negative: –$1.2 million in 2009–10 and –$1.1 million in 2010–11 (2015–16 dollars; George et al. 2012). These results are comparable to those from the survey of the fishery for 1997–98 and 1998–99, when real NER were –$1.8 million and –$1.1 million, respectively (2015–16 dollars; Galeano et al. 2001).

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). Before the closure, GVP was $0.5 million in 2004–05 and $0.2 million in 2005–06 (2015–16 dollars). Since the fishery's reopening, higher GVPs of $1.4 million and $4.3 million were achieved in 2008–09 and 2009–10, respectively (noting that 2008–09 only captures the first month of the 2009 season). However, real GVP fell to $1.1 million in 2011–12 and $0.5 million in 2012–13. GVP has increased in 2014–15 and 2015–16. In 2015–16, GVP is estimated to be $4.6 million, the highest in real terms since 1997–98.

Several factors suggest that NER in the BSCZSF may have improved from the –$1.1 million recorded in 2010–11. Estimated GVP in 2015–16 is around $1.3 million higher than the GVP in 2010–11. In 2015–16, scallop prices were higher and fuel prices and management costs lower than in 2010–11.

FIGURE 2.3 Real GVP and real prices received for catch in the BSCZSF, by financial year, 2004–05 to 2015–16



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

Management arrangements

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

Performance against economic objective

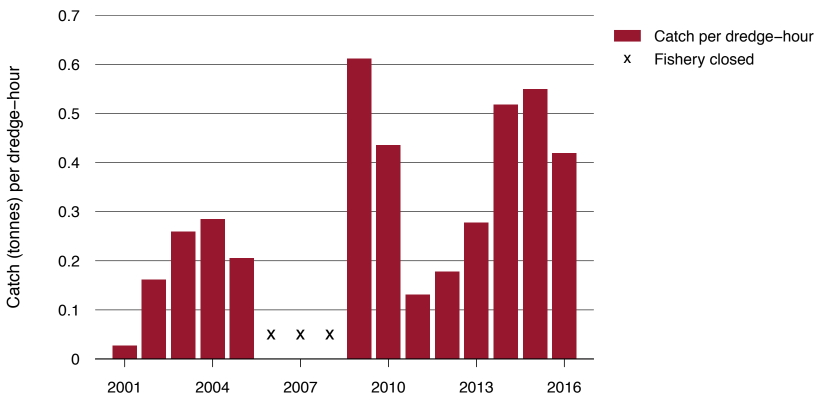
The *Commonwealth Fisheries Harvest Strategy: policy and guidelines* (HSP; DAFF 2007) requires that harvest strategies pursue the economic objective of maximising NER. To meet this objective, the HSP recommends that harvest strategies should be designed to manage stock levels consistent with maximum economic yield (MEY), or, if MEY is unavailable, maximum sustainable yield (MSY). Negative NER in the BSCZSF in 2009–10 and 2010–11 suggest that the economic objective was not being met, and the historical pattern of depletion in the fishery suggests that fishing influences future stock levels.

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

Since 2014, the harvest strategy has used a tiered approach to determining levels of access to the scallop resource, as described under 'Management methods'. It takes a co-management approach and allows fishers some flexibility in where they apply their effort in the fishery. The fishery operated under the tiered harvest strategy for the first time in the 2014 fishing season.

Catch per dredge-hour in the 2015 fishing season (2015–16 financial year) was the second highest it has been since the fishery reopened in 2009 (Figure 2.4), allowing a given volume to be caught with lower inputs. Higher catch per dredge-hour and scallop prices, along with lower fuel prices and management costs, are likely to have improved NER in 2015–16 compared with 2010–11, although it is uncertain whether NER are now positive.

FIGURE 2.4 Catch per dredge-hour in the BSCZSF fishing season, 2001 to 2016



2.4 Environmental status

The BSCZSF has export approval under the *Environment Protection and Biodiversity Conservation Act 1999* until October 2026. The accreditation was accompanied by several recommendations, including that the observer program be reviewed, that the Australian Fisheries Management Authority (AFMA) ensure improvements to the monitoring and analysis of bycatch and byproduct, and that issues identified in a (at the time) draft report examining stock structure of commercial scallop in Bass Strait be considered.

Haddon et al. (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 are now too rare to be effectively sampled with scallop dredges. They also cautioned that certain species are less likely to be retained in scallop dredges, and that their absence from dredge samples in both the fished and unfished areas could mean that they were disturbed but not retained.

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

AFMA publishes quarterly reports of logbook interactions with protected species on its website. No interactions were reported in the BSCZSF in 2016.

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Scallop catch
AFMA

Chapter 3

Coral Sea Fishery

T Emery and K Mazur

FIGURE 3.1 Area fished within the Coral Sea Fishery, 2015–16

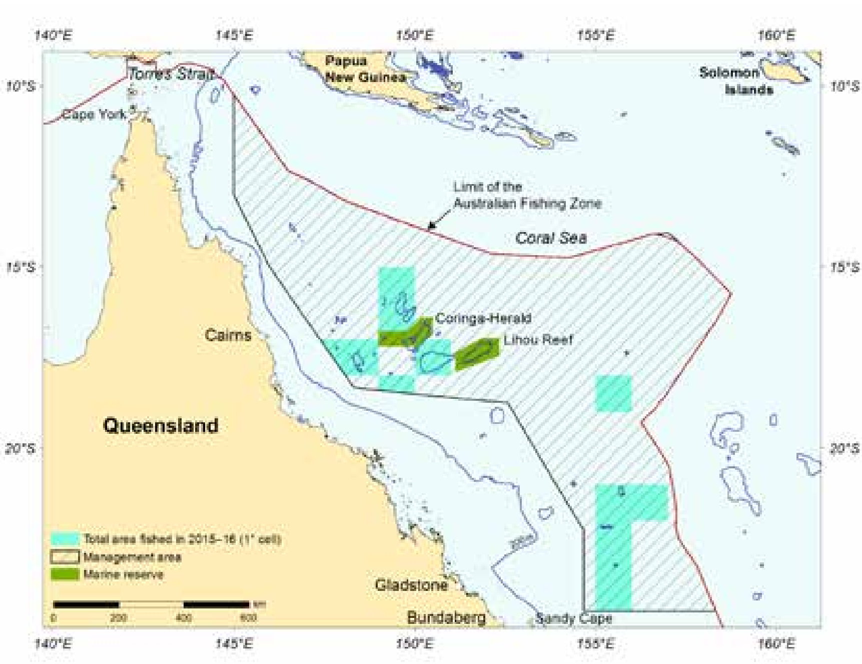


TABLE 3.1 Status of the Coral Sea Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Black teatfish (*Holothuria whitmaei*)					No catch in 2015–16; historical catch is less than plausible sustainable yield.
Prickly redfish (*Thelenota ananas*)					No catch in 2015–16; historical catch is less than plausible sustainable yield.
Surf redfish (*Actinopyga mauritiana*)					No catch in 2015–16; no current assessment to determine biomass status.
White teatfish (*Holothuria fuscogilva*)					No catch in 2015–16; no current assessment to determine biomass status.
Other sea cucumber species (~11 species)					No catch in 2015–16; no current assessment to determine biomass status.
Aquarium Sector (>500 species)					Maximum fishing effort is constrained by management and is unlikely to affect stock status.
Tropical rock lobster (*Panulirus ornatus*)					No catch in 2015–16; historical catch is less than plausible sustainable yield.
Line and Trap Sector (numerous finfish and shark species)					Fishing mortality levels are unlikely to constitute overfishing; no current assessment to determine biomass status.
Trawl and Trap Sector (numerous finfish, shark and crustacean species)					Fishing mortality levels are unlikely to constitute overfishing; no current assessment to determine biomass status.
Economic status	Estimates of NER are not available. Catch in the Aquarium Sector increased substantially in 2015–16; however, because of a lack of information about the mix of fish caught, it is unclear how this may have affected NER. There was no catch in the Sea Cucumber Sector in 2015–16, but catch and fishing effort in the longline and dropline sectors increased in 2015–16 relative to the previous season. A high degree of latent effort in the non-aquarium part of the fishery suggests low NER relative to other fisheries such as the SESSF, where permit holders operate.				

Note: **NER** Net economic returns. **SESSF** Southern and Eastern Scalefish and Shark Fishery.

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 western boundary of the Great Barrier Reef Marine Park.

Fishing methods and key species

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

Management methods

Management of the CSF involves both input (fishing effort) and output (catch) controls, including limited entry, total allowable catches (TACs), spatial closures, move-on provisions, size limits and catch-and-effort triggers, which are used to initiate further analysis and assessment. The harvest strategies for the sectors recognise the low effort and diverse nature of the fishery, and this is taken into account in assessing their performance. ABARES analysed harvest levels within the Sea Cucumber, Lobster and Trochus, Aquarium, and Line and Trap sectors of the CSF (Chambers 2015; Larcombe & Roach 2015; Leatherbarrow & Woodhams 2015; Woodhams et al. 2015). This work, part of the Reducing Uncertainty in Stock Status (RUSS) project, investigated current and historical catches, and indicators of population size to evaluate status. Although it did not explicitly consider the design of harvest strategies, the work may inform revision of harvest strategies in the future. The Australian Fisheries Management Authority (AFMA) is undertaking a review of the individual sector harvest strategies, which is due for completion before the start of the 2018–19 fishing season. It is expected that the updated harvest strategies will identify the key commercial species for each sector and revise associated catch triggers to effectively monitor catches. Given the lack of fishing in the Lobster and Trochus, and Sea Cucumber sectors, and the expectation that this will continue, the focus is primarily on the harvest strategies for the Line and Trap, Trawl and Trap, and Aquarium sectors.

Fishing effort

In 2015–16, five vessels were active in the fishery: three in the Line and Trap Sector and two in the Aquarium Sector.

Catch

Approximately 51.6 t of fish (excluding the Aquarium Sector, where catch is recorded as the number of individuals) was taken in the CSF during 2015–16, representing a large increase from the 14.8 t taken in the 2014–15 season (Table 3.2).

TABLE 3.2 Main features and statistics for the CSF

Fishery statistics a	**2014–15 fishing season**			**2015–16 fishing season**		
Stock	**TAC (t) or catch trigger**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Aquarium Sector	40,000 individuals **b**	19,421 individuals	Confidential	40,000 individuals **b**	32,462 individuals	Confidential
Black teatfish	1	0.52	Confidential	1	0	0
Greenfish and lollyfish	10	0	0	10	0	0
Other sea cucumbers	10	0.23	Confidential	10	0	0
Prickly redfish	20	0.57	Confidential	20	0	0
Sandfish	1	0	0	1	0	0
Surf redfish	10	0.001	Confidential	10	0	0
White teatfish	4	3.3	Confidential	4	0	0
Total sea cucumbers	150	4.6	Confidential	150	0	0
Tropical rock lobster	30 **b**	0	0	30 **b**	0	0
Trochus	30 **b**	0	0	30 **b**	0	0
Line, trap and trawl operations (numerous finfish and shark species)	–	10.1	Confidential	–	51.6	Confidential
Total fishery	**–**	**14.8 c**	**Confidential**	**–**	**51.6 c**	**Confidential**

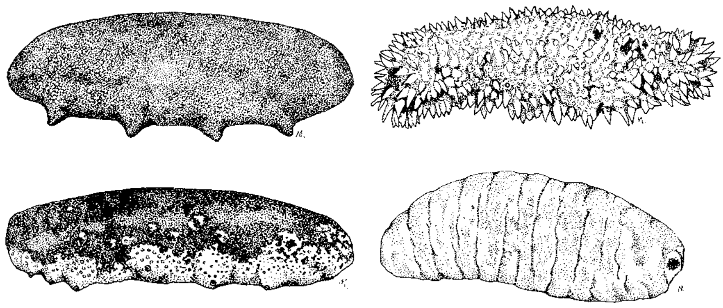
Fishery-level statistics

Effort	Sea Cucumber: 84 dive hours Lobster: 0 dive hours Aquarium: 925 dive hours Line and Trap, and Trawl and Trap: 65,300 hooks, 0 trap lifts, 0 trawl hours	Sea Cucumber: 0 dive hours Lobster: 0 dive hours Aquarium: 1,986 dive hours Line and Trap, and Trawl and Trap: 169,070 hooks, 0 trap lifts, 0 trawl hours
Fishing permits	16 fishing permits across the Line and Trap (8), Trawl and Trap (2), Sea Cucumber (2), Aquarium (2), and Lobster and Trochus (2) sectors	16 fishing permits across the Line and Trap (8), Trawl and Trap (2), Sea Cucumber (2), Aquarium (2), and Lobster and Trochus (2) sectors
Active vessels	5	5
Observer coverage	Sea Cucumber: 0 Lobster: 0 Trochus: 0 Aquarium: 0 Line and Trap, and Trawl and Trap: 0	Sea Cucumber: 0 Lobster: 0 Trochus: 0 Aquarium: 6.2% Line and Trap, and Trawl and Trap: 7.7%
Fishing methods	Hand collection (includes barbless hooks and line, scoop, cast and seine nets), with or without the use of breathing apparatus; line (demersal longline, dropline and trotline); traps and trawl (finfish and crustacean)	
Primary landing ports	Bowen, Innisfail, Mooloolaba (Queensland)	
Management methods	Input controls: limited entry, spatial closures Output controls: catch triggers, size restrictions, TACs for sea cucumbers Other: move-on provisions	
Primary markets	Domestic: fish products—fresh, frozen; aquarium species—live International: South-East Asia—dried sea cucumber (bêche-de-mer); worldwide—live aquarium species	
Management plan	*Management arrangements booklet 2016–17—Coral Sea Fishery* (AFMA 2016)	

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

3.2 Biological status

Sea Cucumber Sector



Line drawing: FAO

Stock structure

Primary target species in the Sea Cucumber Sector include black teatfish (*Holothuria whitmaei*), white teatfish (*H. fuscogilva*), surf redfish (*Actinopyga mauritiana*) and prickly redfish (*Thelenota ananas*). Limited information is available on the stock structure of these four species. For management purposes, each species is assumed to be a single biological stock. Another dozen sea cucumber species have either been taken or could potentially be taken in the fishery, should a market arise (Woodhams et al. 2015). The stock structure of these other sea cucumber species is unknown. Given the lack of information on these species, it is not practical to consider each separately, and they are managed and assessed as a group. Therefore, their status is also reported as a group.

Catch history

Catch of sea cucumbers peaked at 49 t in 2000–01. Following a marked decline in catch and catch rate of black teatfish on some reefs, annual catch limits were reduced. Since 2003–04, the annual sea cucumber catch has fluctuated between 0 t and 9.2 t. Annual catches since 2007–08 have generally been less than 3 t, with no catch recorded in 2015–16.

Stock assessment

Thirteen species or species groups have been reported in historical catches from the Sea Cucumber Sector. No formal quantitative stock assessments have been undertaken for sea cucumber species in this sector. Research by ABARES was used to determine stock status for black teatfish, white teatfish, surf redfish and prickly redfish in 2012 (Woodhams et al. 2015).

Estimates of biomass for the four sea cucumber species used a habitat-based approach. Estimates of habitat area were from a geomorphological classification undertaken as part of the Millennium Coral Reef Mapping Project (Andréfouët et al. 2005), and population densities were derived from survey data collected from the Lihou Reef and Coringa–Herald national nature reserves (Ceccarelli et al. 2008; Oxley et al. 2003, 2004). Average animal weights from commercial catch data were used to estimate biomass, and surplus production models were used to estimate maximum sustainable yield (MSY).

Stock status determination

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

Catches of surf redfish have remained low and well below historical peaks that exceeded 4 t per season. Zero catch was recorded in 2015–16. Given that catches of surf redfish have been less than the median estimate of MSY (879 kg) for 14 of the 18 seasons since 1997–98 (including the 2015–16 season), surf redfish is classified as **not overfished** and **not subject to overfishing**. Since no catch of white teatfish was recorded in 2015–16 and catch remains well below the historical peak of 19.7 t in 1999–2000, white teatfish is classified as **not subject to overfishing**. Permit holders operate in the Queensland state-managed sea cucumber fishery; effort applied to the CSF has been sporadic because of focused effort being applied to the more accessible state fishery. As a result of data limitations, a plausible initial biomass estimate could not be established for white teatfish, and the biomass of this stock remains **uncertain**. Since stock status classification is at the fishery level, caution is required when considering status at the level of an individual reef. Historical catch at some reefs has been high, and impacts of this reef-level catch should be considered further.

Given the lack of stock assessments of the group of other sea cucumber species, the biomass for this multispecies stock is classified as **uncertain**. Since there was no catch from this sector in 2015–16, the stock is classified as **not subject to overfishing**.

Aquarium Sector

Stock structure

The large number of species taken by the Aquarium Sector of the CSF means that it is not practical to assess each species or stock separately; hence, multiple species are aggregated into a multispecies stock. Aquarium fish species also occur in coastal Queensland waters, including around the Great Barrier Reef. Ocean currents may cause high inter-reef dispersal of fish larvae (Ryan & Clarke 2005); however, for management purposes, the aquarium fishes within the boundaries of the CSF are considered as a single stock.

Stock assessment

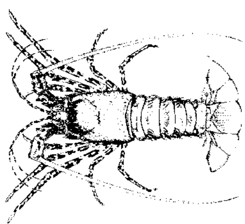
The ABARES assessment of the Aquarium Sector (Leatherbarrow & Woodhams 2015), based on data up to the 2008–09 fishing season, indicated that fishing in the sector was unlikely to be having an adverse impact on the stock. Under current permit conditions, operators can only fish about 7 per cent of suitable habitat within the CSF in any given year. Around 35 per cent 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. Furthermore, a species-specific risk assessment suggests low or very low risk to the species harvested in the fishery (Leatherbarrow & Woodhams 2015).

Since the last assessment (Leatherbarrow & Woodhams 2015), there have been no substantial changes to catch levels, species composition of catches or operational conditions. Although the catch increased in 2015–16, it remains below the trigger and is considered unlikely to have a detrimental impact on the stock. The family-specific triggers in the Coral Sea Fishery—Aquarium Sector harvest strategy are being revised based on the ABARES assessment (Leatherbarrow & Woodhams 2015). It is expected that the harvest strategy will require a species-level catch analysis to be completed if a trigger is met.

Stock status determination

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

Tropical rock lobster



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 only been made on subcomponents of this biological stock (Keag et al. 2012). Although catch records suggest that *P. ornatus* has accounted for most of the historical catch (with smaller quantities of *P. versicolor*; Chambers 2015), recent consultation with fishers has confirmed that lobster catch is unlikely to include *P. ornatus* (CSIRO, 2015, pers. comm.).

Catch history

Catches of tropical rock lobster ranged from less than 200 kg to more than 2 t per year between 2000 and 2004. Annual catches have been less than 2 t since 2005, and no lobster has been caught in the dive sector since 2006–07.

Stock assessment

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

Stock status determination

Based on the number of reefs, the potential reef area and low levels of fishing effort, the tropical rock lobster stock is classified as **not overfished**. Lobster was not harvested in the 2015–16 season, and the stock is classified as **not subject to overfishing**.

Line, trawl and trap sectors

Stock structure

Because of the large number of finfish, shark and crustacean species taken by this sector, it is not practical to assess each species or stock separately. For management purposes, catch in the sectors is considered to be a single stock.

Catch history

The total landed catch across these sectors was 51.6 t in 2015–16, an increase of 41.5 t from 2014–15. No trap effort has been recorded since 2010–11, and no trawl effort has been recorded since 2006–07. The number of hooks deployed increased to 169,070 in 2015–16, from 65,300 in 2014–15 (Table 3.2). The total catch was equally shared between demersal longline (26.4 t) and dropline (25.1 t) fishing methods.

Stock assessment

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

In 2017, the yield scenarios for some species in the deep assemblage were revised based on new natural mortality (M) estimates (Wakefield et al. 2015; Williams et al. 2015), leading to a reduction in both species-specific and deep assemblage MSY estimates. The Coral Sea Fishery—Line, Trawl and Trap Sector harvest strategy is being updated, based on the ABARES revised MSY estimates for the 'combined deep-water assemblage' and updates to taxonomy.

At the fishery level, the total line catch in 2015–16 was higher than the most conservative (low biomass and lowest exploitation constant) revised estimate of all-species sustainable yield (31.5 t) but lower than all others (Larcombe & Roach 2015). In 2015–16, flame snapper (*Etelis coruscans*) constituted approximately 75 and 34 per cent of the auto-longline and dropline catch, respectively, with a total of 28.6 t caught. The combined catch of flame snapper, bar rockcod (*Epinephelus ergastularius* and *E. septemfasciatus*), amberjack (*Seriola dumerili*) and ruby snappers (*Etelis* spp.) constituted approximately 88 and 80 per cent of auto-longline and dropline catch, respectively. Given that flame snapper typically represents a large proportion of the total catch, landings in relation to the sustainable yield estimates should be monitored in future assessments.

In some fishing seasons, sharks have comprised a large component of the total catch for these sectors—for example, blacktip sharks (*Carcharhinus* spp.) were more than 50 per cent of the total line catch in 2005–06. However, no data are available to evaluate the impact of this harvest on shark populations in the CSF or the impact 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 since 2009 has been less than 400 kg, and in 2015–16 was 287 kg. It is unlikely that this low catch would constitute overfishing.

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

Stock status determination

The ABARES analyses indicate that the line catch in 2015–16 was unlikely to constitute overfishing, and there were no trawl or trap fishing operations. Currently, the Line and Trap, and Trawl and Trap sectors are classified as **not subject to overfishing**.

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

3.3 Economic status

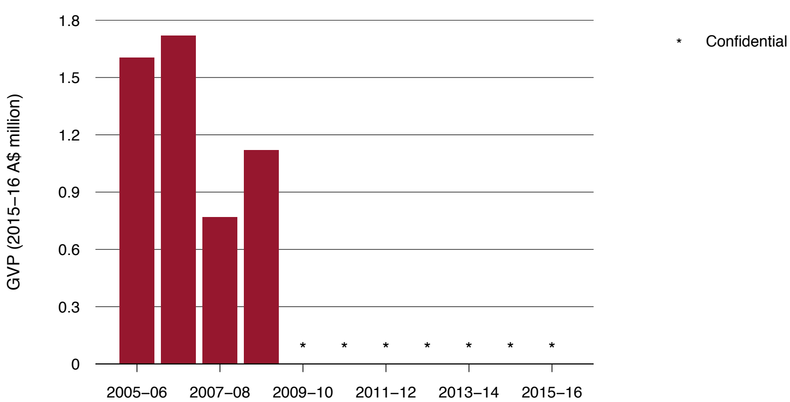
Key economic trends

The Aquarium Sector is likely to have contributed most of the value of the CSF in recent years. The sector's gross value of production (GVP) is difficult to estimate because catch is reported as the number of fish rather than the weight of fish. As well, prices are different for different species, and prices of individual fish vary with sex, colour, size and age. A large proportion of this sector's catch is exported and traded in United States dollars; 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 species of ornamental fish (with no distinction made between marine and non-marine species). In 2015–16, these exports were valued at $2.1 million (compared with $1.9 million in 2014–15), of which exports from Queensland accounted for 71 per cent. It is not possible to determine the CSF's contribution to this total. The Queensland Marine Aquarium Fish Fishery is larger than the CSF in terms of vessel numbers (DEEDI 2010) and is likely to make a larger contribution to total exports than the CSF.

The number of hooks used in the line sector of the fishery increased from 65,300 in 2014–15 to 169,070 in 2015–16 (Table 3.2). The line sector catch increased from 10.1 t in 2014–15 to 51.6 t in 2015–16. The GVP from these sectors also increased, but cannot be reported because of the small number of operators (Figure 3.2).

No sea cucumber, lobster catch or trawl effort occurred in 2015–16, and therefore these sectors did not generate any net economic returns (NER).

FIGURE 3.2 Real GVP for the CSF (excluding the Aquarium Sector), 2005–06 to 2015–16



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

Management arrangements

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

Performance against economic objective

The existence of latent available effort units in the non-aquarium part of the fishery suggests that fishers have had a low incentive to participate in this part of the fishery, reflecting expectations of low profits. For example, only a small number of vessels have been active in the Line and Trap Sector in recent years (five vessels in 2015–16), despite eight permits being available. Despite the increase in fishing effort and catch for this part of the fishery during 2015–16, the influence of this on NER is unclear. Similarly, a lack of information about the mix of fish caught in the Aquarium Sector means that changes in NER remain uncertain, despite the increase in catch (from 19,421 individuals in 2014–15 to 32,462 individuals in 2015–16) and dive effort (from 925 hours in 2014–15 to 1,986 hours in 2015–16).

The CSF is a relatively data-poor fishery, and its performance against the objectives of the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007) is difficult to assess. Given the paucity of data, it is difficult to set management levels (TACs and trigger levels) in accordance with the economic objective of maximising NER.

Aquarium sector fish
AFMA

3.4 Environmental status

The CSF was reaccredited under parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* until 22 December 2017. Conditions placed on the approval relate to evaluating the risks to humphead Maori wrasse (*Cheilinus undulatus*) and implementing additional management measures to mitigate these risks, as appropriate. The catch of humphead Maori wrasse, which is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, is subject to strict trade regulations. An annual take of 50 humphead Maori wrasse in the Aquarium Sector was approved under the non-detriment finding process. Several recommendations were also provided, including reviewing, validating and justifying harvest strategy triggers; determining the impact of fishing on shark species in the Line and Trap, and Trawl and Trap sectors; and developing management measures to mitigate impacts on sharks.

In 2007, a qualitative level 1 (Scale, Intensity, Consequence Analysis) ecological risk assessment of eight sectors in the CSF covered a broad suite of species and associated habitats. A semi-qualitative level 2 ecological risk assessment was then undertaken in 2009 for protected species and chondrichthyans (AFMA 2009). Harvest strategy trigger limits may be updated, depending on the outcome of the Commonwealth Marine Reserves Review process, which is currently underway.

AFMA publishes quarterly reports of logbook interactions with protected species on its website. No interactions were reported in the CSF in 2016.

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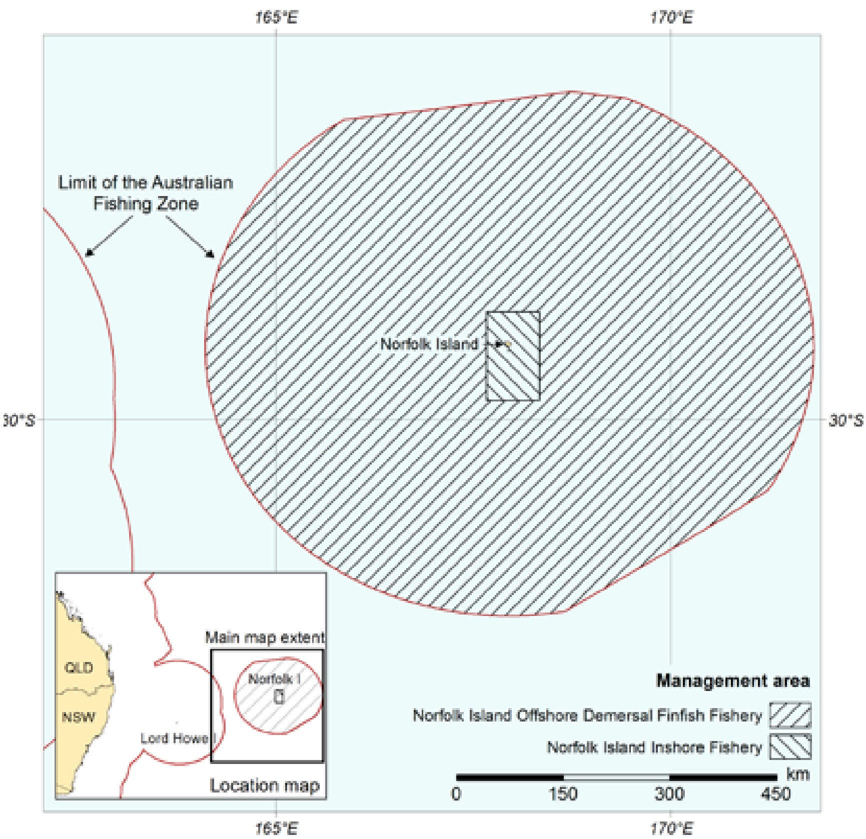
Chapter 4

Norfolk Island Fishery

H Patterson

FIGURE 4.1 Management area of the Norfolk Island Fishery



4.1 Description of the fishery

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

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

No harvest strategy has been developed for the fishery because of the absence of commercial fishing. A harvest strategy will need to be developed if commercial fishing recommences.

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 (*Pagrus 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 failure of vessels 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 activity. Since no fishing occurred in the offshore demersal fishery in 2016, no interactions with protected species were reported.

4.5 References

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Chapter 5

Northern Prawn Fishery

J Larcombe and A Bath

FIGURE 5.1 Relative fishing intensity in the Northern Prawn Fishery, 2016

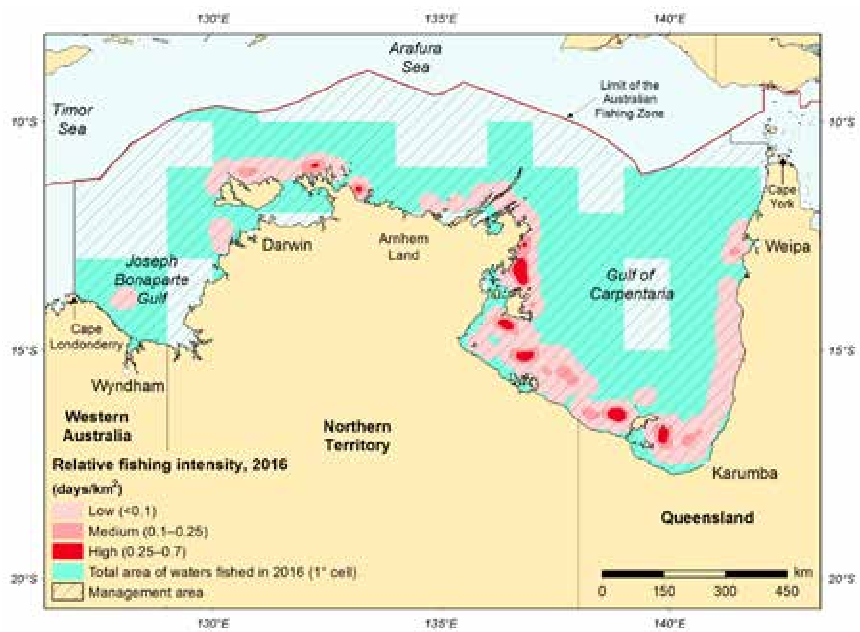


TABLE 5.1 Status of the Northern Prawn Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Red-legged banana prawn (*Fenneropenaeus indicus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Uncertain	Recent catches have been very low. No recent stock assessment and significant uncertainty around status.
White banana prawn (*Fenneropenaeus merguiensis*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	High natural recruitment variability is primarily linked to environmental factors. Harvest strategy aims to provide for adequate escapement.
Brown tiger prawn (*Penaeus esculentus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	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*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	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*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch is below the estimate of MSY. Spawner stock biomass is above the LRP of $0.5S_{MSY}$.
Red endeavour prawn (*Metapenaeus ensis*)	Uncertain	Uncertain	Uncertain	Uncertain	No current stock assessment.
Economic status	NER were estimated at $5 million in 2012–13 and continued to improve in 2013–14 to $12 million as a result of improved prawn prices. Despite lower catch levels, NER in 2014–15 were forecast to remain at 2013–14 levels as a result of lower fuel prices and increasing banana prawn prices. In 2015–16, catch of tiger prawns increased by 88%, with proportionately less effort, raising the contribution of this high-value species to the overall gross value of production for the fishery. This, combined with higher prices received for tiger prawns and lower fuel prices, indicates positive signs for NER in the fishery in 2015–16.				

Notes: 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

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

Fishing methods and key species

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

Management methods

The NPF is managed through a series of input controls, including limited entry to the fishery, individual transferable effort units, gear restrictions, bycatch restrictions, and a system of seasonal and spatial closures. The fishery has two seasons: a 6–12-week predominantly banana prawn season starting in April, and a longer tiger prawn season, running from August to November. Two distinct components of the NPF harvest strategy are used to manage the two seasons of the fishery, because only a few tiger prawns are landed in the first season. Both operate within the management system of input controls (Dichmont et al. 2012), and use season length controls that are informed by the real-time monitoring of catch and catch rates. The harvest strategies have been subjected to management strategy evaluation testing (Buckworth et al. 2013; Dichmont et al. 2006), to assess their performance against the objectives of the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007).

The merits of two NPF management systems—input (effort) and output (total allowable catch)—have been intensively evaluated for several years. In late 2013, mainly because of the difficulty in setting catch quotas for the highly variable white banana prawn fishery, the Australian Fisheries Management Authority (AFMA) determined that the fishery would continue to be managed through input restrictions and units of individual transferable effort. The harvest strategies will be reviewed every five years.

Fishing effort

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

Catch

Total NPF catch in 2016 was 5,807 t, comprising 5,432 t of prawns and 375 t of byproduct species (predominantly squid, bugs and scampi). Annual catches tend to be quite variable from year to year because of natural variability in the banana prawn component of the fishery.

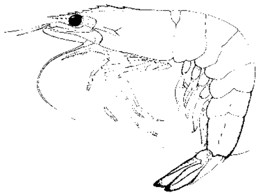
TABLE 5.2 Main features and statistics for the NPF

Fishery statistics a	2015 fishing season		2016 fishing season b	
Stock	**Catch (t)**	**Real value (2014–15)**	**Catch (t)**	**Real value (2015–16)**
Banana prawns	3,931	$62.9 million	2,842	$40.3 million
Tiger prawns	3,168	$34.8 million	2,139	$73.7 million
Endeavour prawns	554	$8.6 million	373	$7.0 million
Other catch (prawns)	43	$0.5 million	78	$0.7 million
Other catch (not prawns)	129	$1.6 million	375	$2.3 million
Total fishery	**7,825**	**$108.4 million**	**5,807**	**$124.0 million**
Fishery-level statistics				
Effort	Banana season: 2,249 boat-days Tiger season: 5,940 boat-days		Banana season: 2,302 boat-days Tiger season: 5,578 boat-days	
Fishing permits	52		52	
Active vessels	52		52	
Observer coverage	Crew member observers: 1,058 days (12.9%) Scientific observers: 159 days (1.94%)		Crew member observers: 893 (11.3%) Scientific observers: 103 days (1.3%)	
Fishing methods	Otter trawl			
Primary landing ports	Darwin (Northern Territory), Cairns and Karumba (Queensland). Much of the catch is offloaded onto motherships at sea.			
Management methods	Input controls: individual tradeable gear units, limited entry, gear restrictions			
Primary markets	Domestic: fresh and frozen International: Japan—frozen			
Management plan	*Northern Prawn Fishery Management Plan 1995* (amended 2012)			

a Fishery statistics are provided by fishing season, unless otherwise indicated. Real-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 9 June; predominantly for tiger prawns: 1 August to 20 November.

5.2 Biological status

Red-legged banana prawn (*Fenneropenaeus indicus*)



Line drawing: FAO

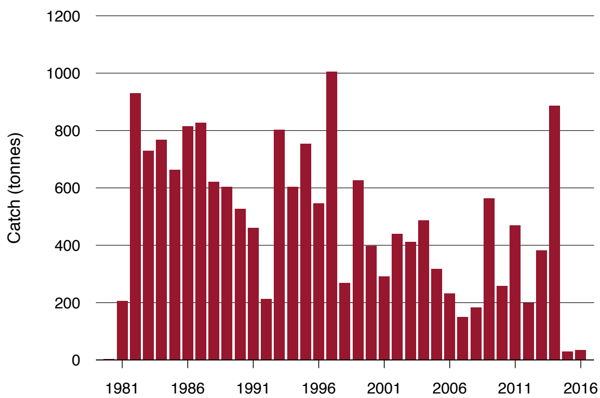
Stock structure

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

Catch history

Most of the NPF red-legged 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 red-legged banana prawn is usually a relatively small component of the total banana prawn catch in the NPF. Catch was 886 t in 2014, which was the highest since 1997, but dropped substantially to under 50 t in both 2015 and 2016 (Figure 5.2).

FIGURE 5.2 Red-legged banana prawn catch, 1980 to 2016



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 red-legged banana prawns. 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 undertaken in 2015 (Buckworth et al. 2015), and includes data up to and including 2014. 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. The base case assumes that the distribution of future catches per quarter will be the average of the patterns seen in 2012 to 2014. The estimate of spawning stock biomass in 2014 was approximately 3.2 times the B_{MSY} and also well above the biomass associated with maximum economic yield (MEY; proxy level $1.2B_{MSY}$) (Figure 5.3). Fishing mortality in 2014 was estimated to be below the level associated with MEY.

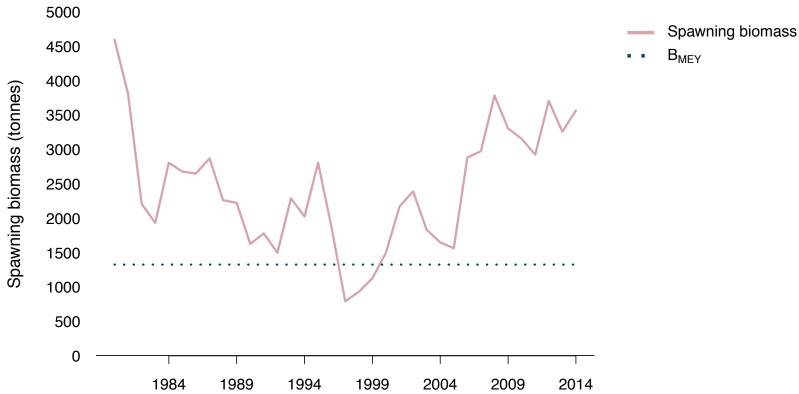
Very low levels of effort occurred in the 2015 and 2016 seasons in Joseph Bonaparte Gulf, and levels of catch were consequently very low. Catch rates were also low, but were poorly sampled because of the low effort. The stock assessment relies heavily on fishery-dependent catch and catch rates; for both 2015 and 2016, the model was not able to provide reliable estimates of stock status.

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

Another hypothesis for the low Joseph Bonaparte Gulf catches is the potential existence of more favourable fishing opportunities in other parts of the multispecies NPF, particularly for tiger prawn fishing in the Gulf of Carpentaria, thereby leading to low fishing effort in Joseph Bonaparte Gulf. Preliminary analysis found some association between lower Joseph Bonaparte Gulf catches and higher catch rates in the tiger prawn fishery, which would contribute to low effort in Joseph Bonaparte Gulf during years of unfavourable environmental factors, as explained above. So, low Joseph Bonaparte Gulf catches may result from a combination of both poor environmental conditions in Joseph Bonaparte Gulf and better fishing opportunities elsewhere.

Under the harvest strategy, when effort is below 100 days in one year, the fishery remains open in both seasons of the following year. There is no precedent for two consecutive years with such low fishing effort; consequently, NPRAG is reviewing the decision rules for red-legged banana prawn under the NPF harvest strategy, with a recommendation that the season opening be modified for years with less than 100 fishing days. The recommendation may also refer to the environmental conditions.

FIGURE 5.3 Estimated spawning biomass for red-legged banana prawn, 1980 to 2014



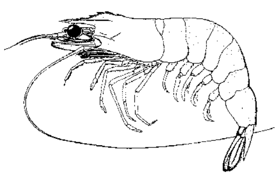
Source: Buckworth et al. 2015

Stock status determination

Recent (2015 and 2016) red-legged banana prawn catches of under 50 t are well below the estimated long-term average MSY range (750–900 t; Buckworth et al. 2015). Given this very low catch and associated low effort levels, the stock is classified as **not subject to overfishing**.

The most recent estimate of biomass (2014) was well above the target reference point. However, no assessment was made in 2015 and 2016 because of a lack of data following low catch-and-effort levels, and there is uncertainty and some concern about the cause of these lower catch levels. The biomass status of red-legged banana prawn stock is **uncertain**.

White banana prawn (*Fenneropenaeus merguiensis*)



Line drawing: FAO

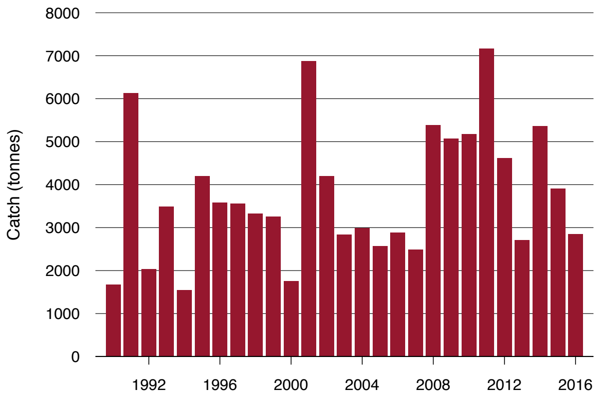
Stock structure

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

Catch history

Catch in 2016 was 2,842 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 2016



Source: CSIRO

Stock assessment

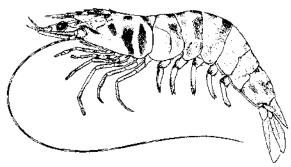
The environmentally driven variability of this resource means that a robust stock–recruitment relationship cannot be determined. Because annual yields are largely dependent on annual recruitment, it has not been possible to develop a stock assessment for white banana prawn. To explore the possibility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

Harvest rates for white banana prawn in the fishery are understood to have been high (>90 per cent of available biomass) in some years (Buckworth et al. 2013), but banana prawns are believed to be resilient to fishing pressure, and recruitment appears to be more closely associated with seasonal rainfall than with fishing mortality. The harvest strategy for the stock has, inter alia, an objective to allow sufficient escapement to ensure an adequate spawning biomass and to allow subsequent recruitment. This is achieved by closing the season when catch rates fall below a trigger level, associated with permitting sufficient prawns to escape to ensure an adequate spawning biomass for subsequent recruitment (based on an analysis of historical data; Dichmont et al. 2012). In addition, the trigger is designed to achieve an economic outcome by closing fishing when catch rates fall below uneconomic levels.

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

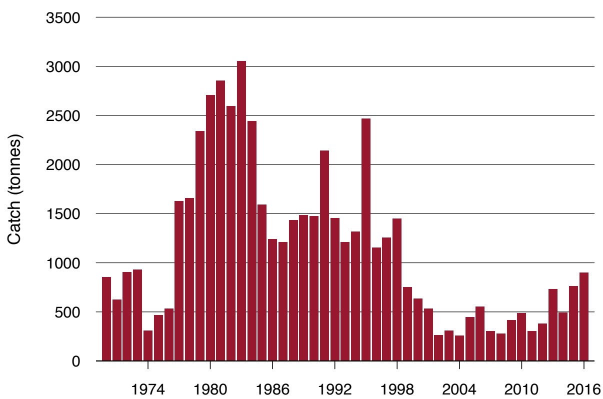
Stock structure

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 first season in the southern and western Gulf of Carpentaria, but also in waters westwards towards Joseph Bonaparte Gulf. Catch of brown tiger prawn in 2016 was 898 t (Figure 5.5).

FIGURE 5.5 Brown tiger prawn catch, 1970 to 2016



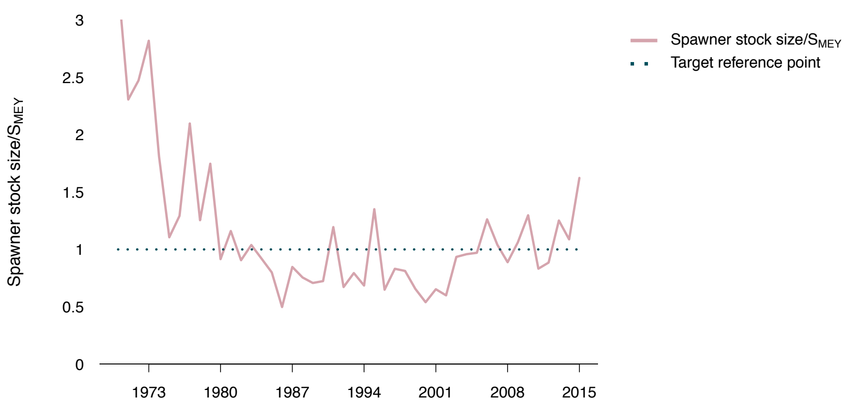
Source: CSIRO

Stock assessment

The stock assessment for the tiger prawn fishery uses a multispecies (covering brown and grooved tiger prawns, and blue endeavour prawn), weekly, sex- and size-structured population model, combined with a Bayesian hierarchical production model for blue endeavour prawn. It is integrated with an economic model that calculates MEY. Full assessments are made every two years, with data collected continuously in intervening years. For the most recent assessment (Buckworth et al. 2016), the base-case estimate of the size of the brown tiger prawn spawner stock at the end of 2015 as a percentage of spawner stock size at MSY (S_{2015}/S_{MSY}) was 175 per cent (range across sensitivities 151–178 per cent). The base-case estimate of the size of the spawner stock as a percentage of stock size at MEY (S_{2015}/S_{MEY}) was 162 per cent (Figure 5.6) (range across sensitivities 136–162 per cent).

For the most recent assessment, the estimate of effort in 2015 as a percentage of effort at MSY (E_{2015}/E_{MSY}) was 36 per cent. The estimate of effort in 2015 as a percentage of effort at MEY (E_{2015}/E_{MEY}) was 35 per cent. Catch of brown tiger prawn was 763 t in 2015 and 898 t in 2016 (Figure 5.5), substantially less than the base-case estimate of MSY (1,186 t).

FIGURE 5.6 Spawner stock size as a proportion of S_{MEY} for brown tiger prawn, 1970 to 2015

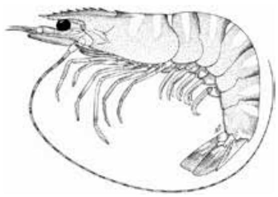


Source: Buckworth 2016

Stock status determination

Effort in recent years has been less than the level associated with MSY and MEY, catches in recent years have been less than MSY, and the estimate of biomass (five-year moving average) for the base-case model (and all other sensitivities) was above the limit reference point ($0.5S_{MSY}$) in the most recent assessment. Brown tiger prawn in the NPF is therefore classified as **not subject to overfishing** and **not overfished**.

Grooved tiger prawn (*Penaeus semisulcatus*)



Line drawing: Karina Hansen

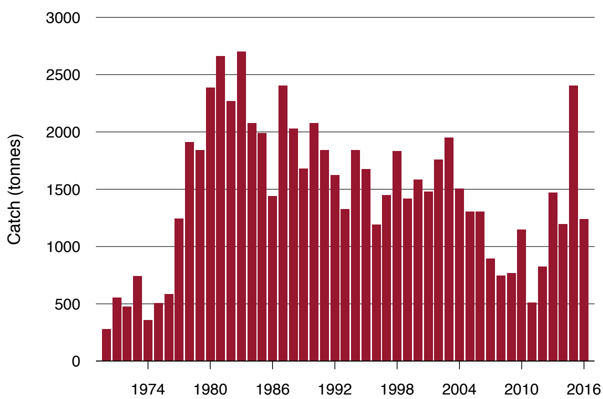
Stock structure

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

Catch history

Annual catches of grooved tiger prawn, which is primarily taken in the second season, peaked in the early 1980s at more than 2,500 t and have shown a declining trend since then (Figure 5.7). Catch of grooved tiger prawn in 2016 was 1,241 t, which was a substantial decrease from the 2015 catch of 2,405 t—the highest catch of this species since the early 1980s.

FIGURE 5.7 Grooved tiger prawn catch, 1970 to 2016



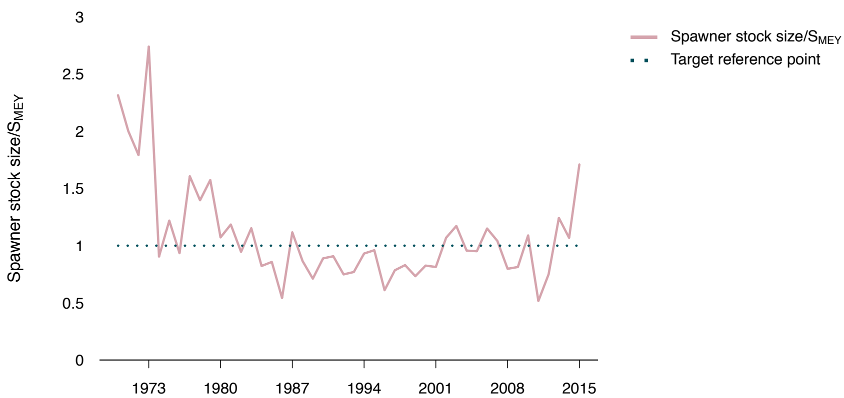
Source: CSIRO

Stock assessment

For the most recent assessment (Buckworth et al. 2016), the base-case estimate of the size of the grooved tiger prawn spawner stock at the end of 2015 as a percentage of spawner stock size at MSY (S_{2015}/S_{MSY}) was 185 per cent (range across sensitivities 177–235 per cent). The base-case estimate of the size of the spawner stock as a percentage of spawner stock size at MEY (S_{2015}/S_{MEY}) was 171 per cent (Figure 5.8) (range across sensitivities 152–171 per cent).

For the most recent assessment, the estimate of effort in 2015 as a percentage of effort at MSY (E_{2015}/E_{MSY}) was 83 per cent. The estimate of effort in 2015 as a percentage of effort at MEY (E_{2015}/E_{MEY}) was 101 per cent. The catch of grooved tiger prawn in 2016 was 1,241 t (Figure 5.7), which was below the base-case estimate of long-term average MSY (1,605 t).

FIGURE 5.8 Spawner stock size as a proportion of S_{MEY} for grooved tiger prawn, 1970 to 2015

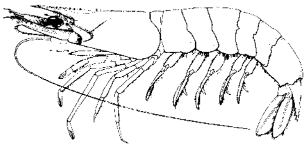


Source: Buckworth 2016

Stock status determination

Although the 2015 catch of grooved tiger prawn exceeded the estimated long-term MSY, the catch was supported by higher than average levels of recruitment in 2015. Additionally, in 2016, catch returned to levels below MSY. The spawning stock biomass for the base-case model (and all other sensitivities) is estimated to be well above the biomass levels associated with MSY and MEY, and therefore also above the limit reference point ($0.5S_{MSY}$). Grooved tiger prawn in the NPF is therefore classified as **not subject to overfishing** and **not overfished**.

Blue endeavour prawn (*Metapenaeus endeavouri*)



Line drawing: FAO

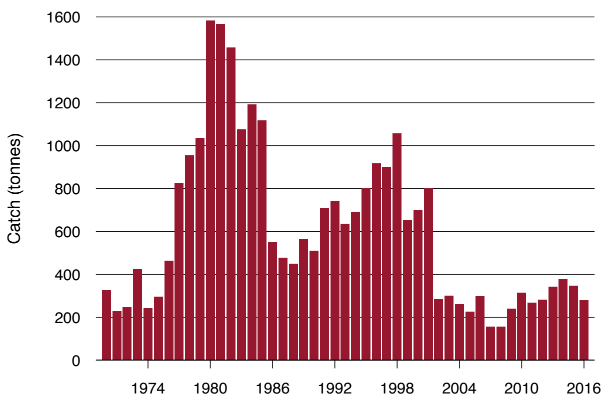
Stock structure

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

Catch history

Annual catches of blue endeavour prawn peaked in the early 1980s at more than 1,500 t, and again in the late 1990s at 1,000 t (Figure 5.9). Since 2002, annual catches have averaged around 300 t, and the 2016 catch was 279 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 2016



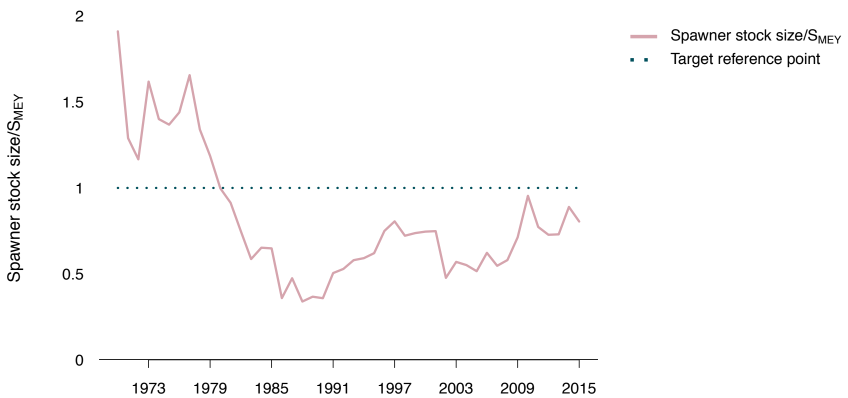
Source: CSIRO

Stock assessment

Stock size is assessed using a Bayesian hierarchical biomass dynamic model, within the same overall bio-economic model system as used for the two tiger prawn species (Buckworth et al. 2016).

The base-case estimate of the size of the blue endeavour prawn spawner stock at the end of 2015 as a percentage of stock size at MSY (S_{2015}/S_{MSY}) was 77 per cent (range across sensitivities 77–97 per cent). The base-case estimate of the size of the spawner stock as a percentage of stock size at MEY (S_{2015}/S_{MEY}) was 80 per cent (Figure 5.10) (range across sensitivities 72–84 per cent). The catch of blue endeavour prawn was 348 t in 2015 and 279 t in 2016 (Figure 5.9), substantially less than the base-case estimate of MSY (813 t).

FIGURE 5.10 Spawner stock size as a proportion of S_{MEY} for blue endeavour prawn, 1970 to 2015

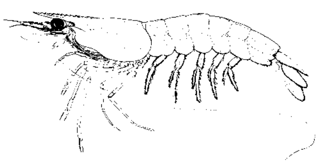


Source: Buckworth 2016

Stock status determination

The catch in 2016 was well under the estimated MSY, and the estimate of spawner stock size (five-year moving average) for the base case was above the limit reference point ($0.5S_{MSY}$). 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

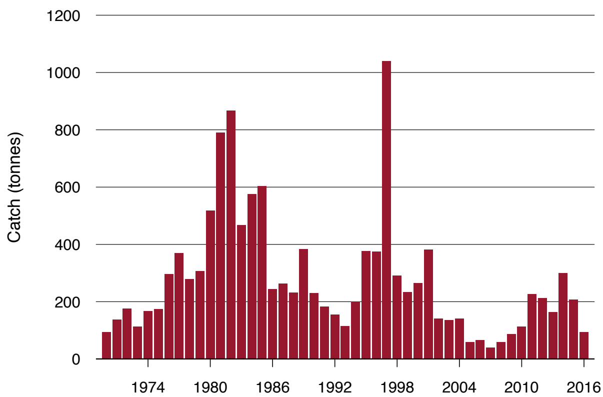
Stock structure

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 in excess of 800 t in 1982 and 1997 (Figure 5.11). Since 1998, catches have been below 400 t, and the 2016 catch was 94 t. Red endeavour prawn is a byproduct of the tiger prawn fishery.

FIGURE 5.11 Red endeavour prawn catch, 1970 to 2016



Source: CSIRO

Stock assessment

Although attempts have been made to assess red endeavour prawn, no reliable assessment is available to determine stock status. Catches during 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 prawn rather than any indication of a fall in red endeavour prawn biomass.

Stock status determination

Given the absence of information on the sustainability of catches or the state of the biomass, this stock is classified as **uncertain** with regard to the level of fishing mortality and biomass.

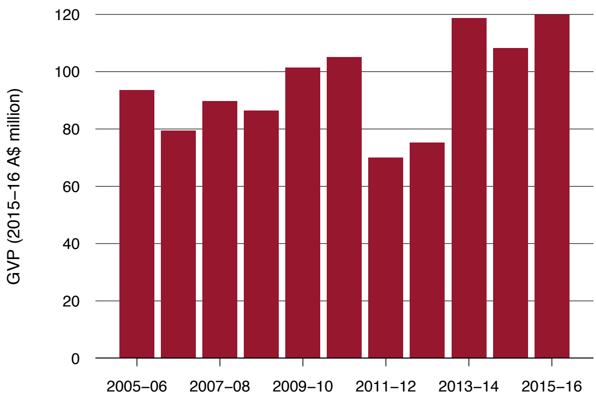
Turtle excluder device in prawn nets
AFMA

5.3 Economic status

Key economic trends

The gross value of production for the NPF fluctuated during the decade to 2015–16, peaking at $124 million in 2015–16 and reaching a low of $70 million (in 2015–16 dollars) in 2011–12 (Figure 5.12).

FIGURE 5.12 GVP for the NPF, 2005–06 to 2015–16



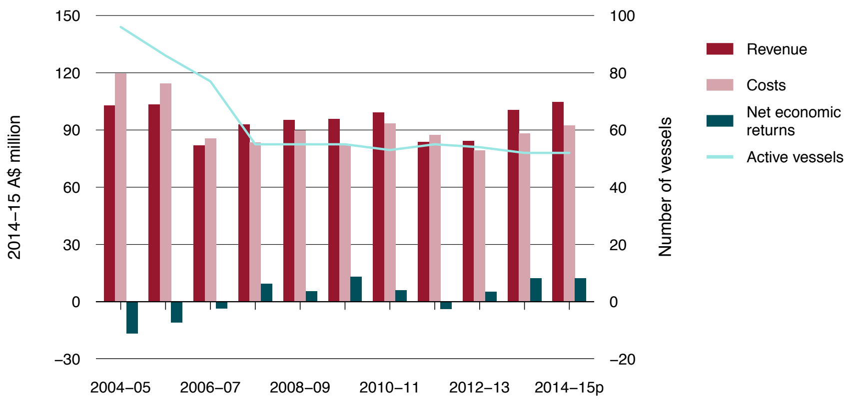
Notes: **GVP** Gross value of production. 2015–16 data are preliminary.

Since the early 1990s, ABARES has used data from economic surveys of the NPF to estimate the level of net economic returns (NER) earned in the fishery. The most recent survey in 2015 provided survey-based estimates of NER for the 2012–13 and 2013–14 financial years, and forecasts for the 2014–15 year (Bath & Green 2016).

The level of real NER in the NPF has varied considerably during the past 15 years (Figure 5.13). In 2000–01, real NER were estimated at $83 million. NER fell sharply in the following years to reach –$17 million in 2004–05 (in 2014–15 dollars). Between 2004–05 and 2006–07, real NER remained negative. During this time of declining profitability, three management changes occurred in the fishery: from 2004–05, the fishery began targeting MEY in the tiger prawn component of the fishery; the Securing our Fishing Future (SOFF) structural adjustment program (which concluded in 2006–07) was implemented, resulting in a 50 per cent reduction in the fleet; and management changes allowed the adoption of quad trawl gear. Together, these changes are likely to have assisted in improving the economic performance of the fishery since 2004–05.

The SOFF 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, except for 2011–12, real NER in the fishery have been positive each year, peaking at $13 million in 2009–10, while active vessel numbers have declined slightly, to 52 in the 2016 fishing season. This improvement was mainly driven by increasing revenue from higher landings of banana prawns (Skirtun et al. 2014), as well as a likely improvement in the fleet's efficiency after structural adjustment and targeting of MEY. In 2011–12, real NER fell by approximately $10 million to –$4 million, as a result of lower landings of banana prawns. NER recovered to $5 million in 2012–13 and continued to improve in 2013–14 to $12 million as a result of improved prices. Despite lower catch levels, NER in 2014–15 were forecast to remain at 2013–14 levels as a result of lower fuel prices and banana prawn prices increasing from $11.96 per kg in 2013–14 to $13.58. In 2015–16, unit prices for banana and tiger prawns increased and fuel prices continued to decrease, showing further positive signs for NER in the fishery. Moreover, catch of tiger prawns increased by 85 per cent, with proportionately less effort, raising the contribution of this high-value species to the overall gross value of production for the fishery from 32 per cent to 59 per cent. These factors indicate positive signs for NER in the fishery in 2015–16.

FIGURE 5.13 Real revenue, costs, NER and active vessel numbers for the NPF, 2004–05 to 2014–15



Notes: **NER** Net economic returns. **p** Preliminary non-survey-based estimates.
Source: Bath & Green 2016

Total factor productivity (a measure of fishers' ability to convert inputs into outputs over time) in the fishery increased from 2004–05 to 2010–11, at a rate robust enough to offset declining terms of trade from declining prices and high fuel costs (Bath & Green 2016; 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 that allowed increases in catch, particularly for banana prawns, rather than just changes in efficiency measures and technology adopted by fishers.

FIGURE 5.14 Total factor productivity index, 2004–05 to 2013–14

FIGURE 5.15 Terms of trade index, 2004–05 to 2013–14

Management arrangements

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

An assessment of the impact of the structural adjustment package by Vieira et al. (2010) suggested that, for the benefits of the package to be preserved, management arrangements in fisheries targeted by the package need to be set in ways that prevent a repeated build-up of fishing capacity. For these reasons, AFMA recommended a range of amendments to the management arrangements in the fishery, to better align banana prawn catch levels with the MEY objective; these amendments were implemented throughout the 2014 and 2015 fishing seasons. In 2014, an MEY catch-rate trigger for banana prawn was introduced to the fishery (AFMA 2015).

Performance against economic objective

The tiger prawn component of the fishery has explicit MEY targets (across two tiger prawn species and one endeavour prawn species), and a bio-economic model is used to estimate annual fishing effort required to move towards spawning stock sizes at MEY (S_{MEY}). Stocks are assessed every two years. Spawning stock sizes of both species of tiger prawn were above S_{MEY} at the end of the 2015 season (Buckworth et al. 2016). Spawner stock size of blue endeavour prawn for the same period was estimated to be below S_{MEY}. Effort levels as a proportion of effort at MEY for brown tiger prawn and grooved tiger prawn were estimated to be at or below effort at MEY. Current effort limits in the fishery are based on outputs from the fishery's bio-economic model, and are designed to achieve an MEY (profit maximisation) target across a seven-year projection period (noting that the target changes with every assessment because of changes in biological and economic parameters).

Recruitment for all species is variable, particularly for white banana prawn, in 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, with mechanisms in place to adjust total annual effort levels to ensure that the fishery remains sustainable and profitable, was implemented for the 2014 banana prawn season (AFMA 2015).

Red-legged banana prawn, primarily caught in Joseph Bonaparte Gulf, was assessed in 2015 (Buckworth et al. 2015), using data up to and including 2014. Spawning stock biomass was estimated to be well above biomass associated with the proxy MEY in the 2014 season. Because of low levels of catch during the 2015 and 2016 fishing seasons, reliable assessments of the stock status could not be undertaken.

Targeting MEY in the fishery is consistent with the economic objective of maximising economic returns, and could be expected to increase NER in the fishery. Targeting MEY of the tiger prawn component of the fishery began in 2004–05. Despite declining terms of trade from 2004–05 to 2010–11, productivity and NER improved. Although the targeting of MEY over this period is likely to have supported these improvements, other factors, such as the structural adjustment package and improved banana prawns 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* on 20 December 2013. The current approval of a wildlife trade operation (part 13A) expires on 9 January 2019. Four recommendations accompanied the strategic assessment, including improvement of the monitoring systems for byproduct and refinement of bycatch mitigation measures.

The NPF was certified as a sustainable fishery by the Marine Stewardship Council in November 2012 (MSC 2012).

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

AFMA publishes quarterly reports of logbook interactions with protected species on its website. In the NPF in the 2016 calendar year, 55 turtle interactions were reported, and all turtles were released alive; 314 sawfish were caught, of which 177 were released alive and the remainder were dead; and 8,498 sea snakes were caught, of which 6,527 were released alive, 5 were injured, 5 had an unknown life status and the remainder were dead. Reports also indicate that 93 seahorses or pipefish were caught—73 were dead and 20 were released alive.

5.5 References

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Prawn trawler
Austral Fisheries

Chapter 6

North West Slope Trawl Fishery

J Woodhams and A Bath

FIGURE 6.1 Area fished in the North West Slope Trawl Fishery, 2015–16

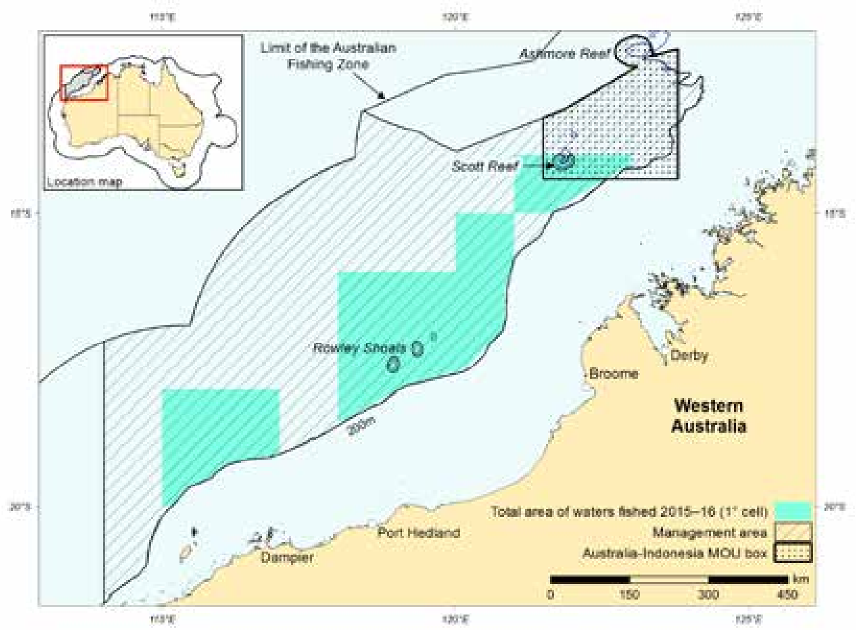


TABLE 6.1 Status of the North West Slope Trawl Fishery

Status	2015		2016		Comments
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
Scampi (*Metanephrops australiensis, M. boschmai, M. velutinus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Trawl effort is 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, although the high degree of latent effort in the fishery indicates that NER are likely to be low.				

Notes: **NER** Net economic returns.

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

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).

Fishing methods and key species

The NWSTF has predominantly been a scampi fishery in recent years, 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. However, the harvest strategy is designed to trigger management responses if fishing increases above recent historical levels. Given the recent boundary amendments to the Western Australia 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 vessels in 1986–87 and declined through the 1990s before increasing to 10 vessels in 2000–01 and 2001–02. Vessel numbers have since decreased to stabilise at one or two vessels each year since 2008–09 (Table 6.2). Historical effort, in trawl hours, in the fishery largely follows the trend in the number of active vessels (Figure 6.2). Fishing effort often increases when boats cease to operate in the Northern Prawn Fishery.

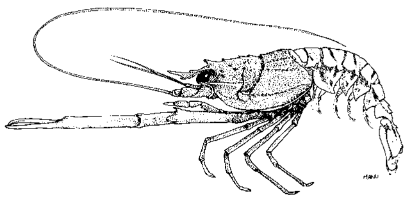
TABLE 6.2 Main features and statistics for the NWSTF

Fishery statistics [a]	2014–15 fishing season			2015–16 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Scampi (*Metanephrops australiensis, M. boschmai, M. velutinus*)	–	33.4	Confidential	–	33.0	Confidential
Total fishery	**–**	**49.1**	**Confidential**	**–**	**54.8**	**Confidential**
Fishery-level statistics						
Effort	115 days; 2,137 trawl hours			117 days; 2,241 trawl hours		
Fishing permits	4			5		
Active vessels	1			2		
Observer coverage	8 days (7%)			16 days (14%)		
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: Perth, Sydney and Brisbane—frozen International: Singapore, Hong Kong, China and Japan—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. Real-value statistics are by financial year.
Notes: **TAC** Total allowable catch. – Not applicable.

6.2 Biological status

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



Line drawing: FAO

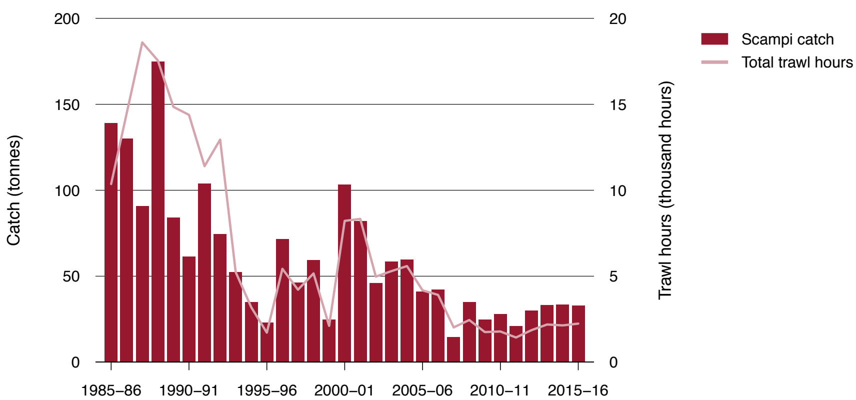
Stock structure

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

Catch history

Trends in total catch have largely followed trends in active vessels and fishing effort (Figure 6.2). Scampi catch in recent years has been relatively stable at around 30 t. Total catch has primarily consisted of scampi, with the exception of 2011–12, when mixed snapper accounted for a large proportion of the catch (32 t of snapper and 21 t of scampi).

FIGURE 6.2 Catch and effort for scampi in the NWSTF, 1985–86 to 2015–16



Source: Australian Fisheries Management Authority

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 per cent and 85 per cent of unfished biomass. The fishing mortality rate in recent years was estimated to have been well below the rate that would achieve maximum sustainable yield.

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

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

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

Stock status determination

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

6.3 Economic status

Key economic trends

Economic surveys of the NWSTF have not been undertaken. The gross value of production for the fishery has been confidential since 2006–07 because five or fewer vessels have been active in the fishery. Five fishing permits were issued for the 2015–16 fishing season, and two vessels were active in the fishery. The low number of active vessels indicates that there is latent effort in the fishery and suggests potentially low net economic returns (NER), because fishers are not fully using their right to fish. The volume landed of the high-value scampi species was mostly unchanged from 2014–15 to 2015–2016; however, overall catch in the fishery increased by 12 per cent. The increase in catch and relatively smaller increase in effort (5 per cent increase in trawl hours) suggest that there may have been some improvement in NER from 2014–15 to 2015–16.

Management arrangements

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

Performance against economic objective

The fishery's performance against the economic objective is uncertain because there is no explicit economic target or supporting analyses. However, the relatively low value of the fishery justifies the low-cost management approach currently applied, given the low levels of effort.

6.4 Environmental status

The NWSTF is included in the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 22 December 2017.

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

AFMA publishes quarterly summaries of logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in the NWSTF in 2016.

6.5 References

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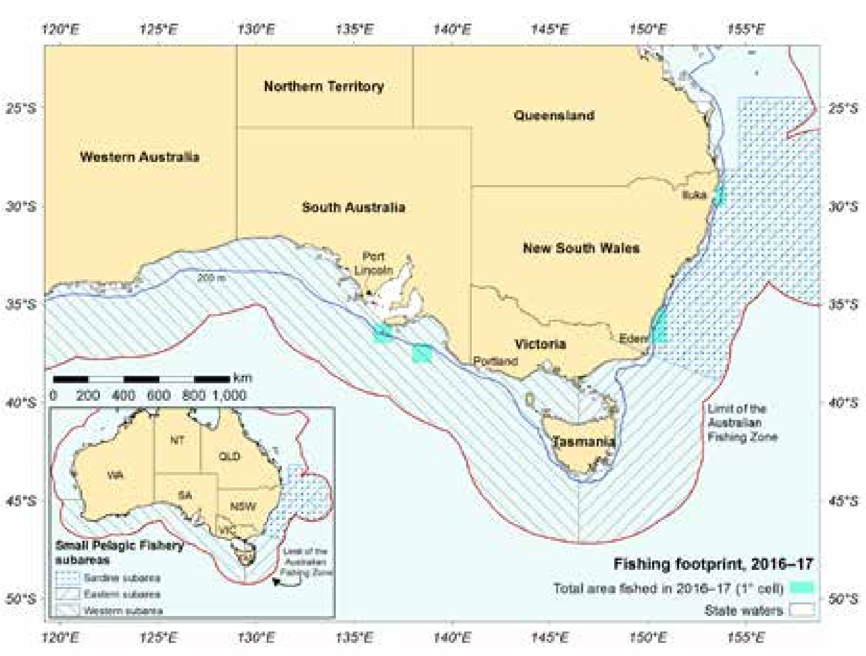
Boxed scampi
Mike Gerner, AFMA

Chapter 7
Small Pelagic Fishery

A Moore and D Mobsby

FIGURE 7.1 Area fished in the Small Pelagic Fishery, 2016–17



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

TABLE 7.1 Status of the Small Pelagic Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Australian sardine (*Sardinops sagax*)					Recent catches have been below the RBC. Historical catches have been low and are not likely to have reduced biomass below the limit reference point.
Blue mackerel, east (*Scomber australasicus*)					Most 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 2015–16 or 2016–17. A decrease in the level of catch in 2016–17 compared with the very high level of catch in 2015–16 suggests that gross value of production is likely to have declined in 2016–17. Changes in NER are uncertain because of a lack of information about changes in cost structures of the industry.				

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

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

7.1 Description of the fishery

Area fished

The Small Pelagic Fishery (SPF) extends from southern Queensland to southern Western Australia (Figure 7.1).

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 exception is the western stock of Australian sardine, which is managed by South Australia and Victoria.

The 2014 SPF harvest strategy (AFMA 2014a), which was used, in combination with updated scientific advice, to set recommended biological catches (RBCs) and total allowable catches (TACs) for the 2015–16 and 2016–17 fishing seasons, included a three-tier system that was applied separately to each stock. The tiered system was designed to allow greater levels of catch when higher-quality research information was available on stock status. Tier 1, for stocks with the highest quality of information (from daily egg production method [DEPM] surveys), provided for the largest potential RBC as a proportion of the estimated biomass. Tier 3, for stocks with relatively poor-quality information, provided for the smallest RBC.

The SPF tier 1 decision rules used a maximum exploitation rate of 15 per cent of estimated spawning biomass from a recent DEPM survey as the basis for setting RBCs. This is more conservative than the internationally recommended exploitation rate of 20–25 per cent of current total biomass (Pikitch et al. 2012). The maximum duration for staying at tier 1 without a new DEPM survey was five years.

Additional precaution was added to the RBC to account for biomass estimates older than five years. If a DEPM survey was not conducted within five years of the previous survey, the resource would be managed under tier 2 harvest control rules. Under tier 2, maximum RBCs are set based on a maximum exploitation rate of 7.5 per cent of the estimated spawning biomass.

For tier 3, the maximum RBC was set at 500 t for each stock, reflecting that a high level of precaution is warranted when information is lacking. Once the RBC was derived, an allowance for current state catches was deducted before setting the TACs.

Testing through management strategy evaluation (MSE) indicated that using the harvest rates detailed in the harvest strategy would result in biomass being maintained above 20 per cent of unfished biomass levels ($0.2B_0$) 90 per cent of the time (Giannini et al. 2010). A review of the harvest strategy (Smith et al. 2015), which included ecosystem and population modelling, recommended that the target reference point for SPF target species should be set at $0.5B_0$ and the limit reference point at $0.2B_0$; that target exploitation rates should be species specific or preferably stock specific; that the average tier 1 exploitation rate of 15 per cent might be too high for lower-productivity species such as redbait and jack mackerel, and potentially too low for higher-productivity species such as sardines and blue mackerel; and that it is generally not safe to apply tier 2 harvest rates unchecked for long periods—for shorter-lived species (blue mackerel and sardine), this can result in unacceptable probabilities of depletion in short periods (five or six years).

Following the review by Smith et al. (2015), the SPF harvest strategy was revised in April 2015 to adopt a target reference point of $0.5B_0$ and a limit reference point of $0.2B_0$ (AFMA 2015a). The exploitation rates were altered to be stock specific and to limit the time a stock can remain at tier 1 and tier 2. Exploitation rates under tier 1 are now 20 per cent of estimated spawning biomass for Australian sardine, 15 per cent for blue mackerel, 12 per cent for jack mackerel and 10 per cent for redbait. The maximum time at tier 1 without an additional DEPM survey is five fishing seasons for all species. Exploitation rates under tier 2 are half that applied at tier 1. The maximum time at tier 2 without an additional DEPM survey is 5 fishing seasons for Australian sardine and blue mackerel, and 10 fishing seasons for jack mackerel and redbait. The April 2015 revision of the harvest strategy also included the introduction of a new tier (tier 2(b) Atlantis), which provides exploitation rates based on estimates from the Atlantis ecosystem model (Fulton 2012, 2013). Smith et al. (2015) did not test tier 3 of the harvest strategy, and tier 2(b) Atlantis arose as an interim step to deal with these stocks until further work on tier 3 could be undertaken. Tier 2(b) Atlantis applies when a stock is not eligible to remain at tier 2 because the maximum time at tier 2 has been exceeded or because a DEPM survey has never been undertaken. It applies the tier 2 exploitation rates to the lower bound (that is, more conservative) of the spawning biomass estimates obtained from the Atlantis-SPF model. An annual assessment of age and length data is also required to monitor the effects of fishing on the population. The revised 2015 harvest strategy was not used to set RBCs and TACs for the 2016–17 fishing season. The TACs were held at 2015–16 levels as further testing of the harvest strategy was not complete.

To minimise any potential impact of localised depletion, the vessel management plan for the factory trawler limits catch in a 30-day period across a series of numbered grids throughout the fishery. Additionally, a maximum of 75 per cent of the concession holders' combined SPF western and eastern quota holdings (for all species) can be taken in a single management zone.

Biomass is difficult to estimate for some small pelagic species because of its high interannual variability. A key assumption for assessing small pelagic stocks is that DEPM assessments are a reliable indicator of abundance; however, these surveys are known to have very wide confidence intervals (CIs). In this chapter, spawning biomass estimates are generally presented with the 95 per cent CI of the range of possible estimates. This CI means that, if the models to derive the biomass estimates are run 100 times, the spawning biomass would be within the stated range 95 per cent of the time. Because these ranges are often broad and there is a possibility that spawning biomass might be outside these ranges, great caution needs to be taken when interpreting fishing mortality and biomass against specified limit and target reference points. If fishing mortality approaches RBCs, it may be necessary to consider alternative scenarios of estimated spawning biomass to assess risks to small pelagic stocks.

Fishing effort

Most historical fishing effort occurred off the east and west coasts of Tasmania. Purse seining was the main method historically, but has been replaced by midwater trawling since 2002. Effort in the SPF increased in 2014–15, 2015–16 and 2016–17 with the operation of a factory trawler.

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 Commonwealth SPF have reflected a lack of markets and processing facilities. The operation of a factory trawler vessel in 2014–15, 2015–16 and 2016–17 has led to increased catches. Total Commonwealth catch in the 2015–16 season was 12,004 t, representing 31 per cent of the total TAC of 39,170 t. Total Commonwealth catch in 2016–17 was 5,892 t, representing 14 per cent of the available TAC (Table 7.2).

Changes to status reporting for the SPF

Previous versions of the *Fishery status reports* reported on the SPF for the fishing season a year before the most recent season. This lag was due to catch data from state jurisdictions not being available for the most recent Commonwealth fishing season. State catch data have been used previously to determine status for Australian sardine and blue mackerel. The catch of jack mackerel and redbait is predominantly from Commonwealth fisheries. The catch for blue mackerel by Commonwealth vessels increased in the 2015–16 and 2016–17 fishing seasons to the extent that the Commonwealth catch was larger than the state catch. Commonwealth catches of jack mackerel increased by an order of magnitude in the 2015–16 season, but decreased in 2016–17. Stock status is now reported for the 2015–16 and 2016–17 seasons because the trend of increasing Commonwealth catch for these two species necessitates more up-to-date status assessments. The status determination for 2016–17 is based on the assumption that state catches in the season remain similar to those of previous years for all species.

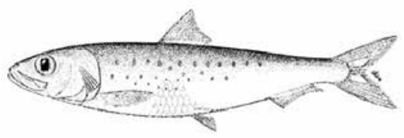
TABLE 7.2 Main features and statistics for the SPF

Fishery statistics a	2015–16 fishing season			2016–17 fishing season	
Stock name	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**	**TAC (t)**	**Catch (t)**
Australian sardine	1,880	114	Confidential	4,000	131
Blue mackerel, east	2,630	2,022	Confidential	3,000	1,248
Blue mackerel, west	6,200	979	Confidential	6,500	766
Jack mackerel, east	18,670	5,342	Confidential	18,900	3,966
Jack mackerel, west	3,600	613	Confidential	3,600	686
Redbait, east	3,310	189	Confidential	3,400	101
Redbait, west	2,880	1,135	Confidential	2,900	1,140
Total fishery	**39,170**	**10,394**	**Confidential**	**42,300**	**8,038**
Fishery-level statistics					
Effort	Purse seine: 128 search-hours Midwater trawl: 316 shots			Purse seine: 114 search-hours Midwater trawl: 156 shots	
Fishing permits	32 entities held quota SFRs in 2015–16.			32 entities held quota SFRs in 2016–17.	
Active vessels	Purse seine: 2 Midwater trawl: 1			Purse seine: 2 Midwater trawl: 1	
Observer coverage	Purse seine: 0% Midwater trawl: 100%			Purse seine: 0% Midwater trawl: 100%	
Fishing methods	Purse seine, midwater trawl				
Primary landing ports	Eden, Iluka (New South Wales); Port Lincoln (South Australia); Triabunna (Tasmania); Geelong (Victoria)				
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. Real-value statistics are by financial year and are not available for 2016–17.
Notes: **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch.

7.2 Biological status

Australian sardine (*Sardinops sagax*)



Line drawing: FAO

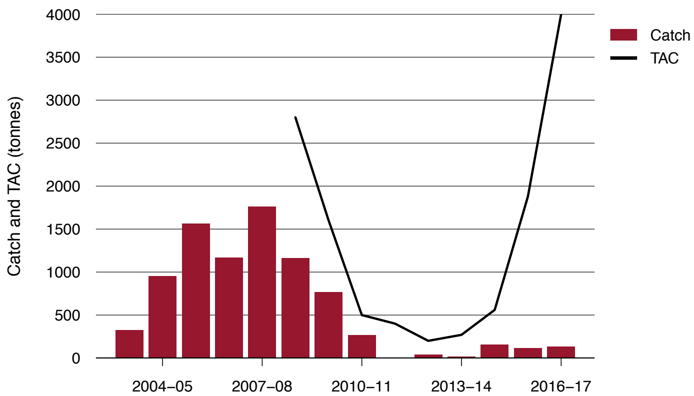
Stock structure

Two early studies indicate genetic structuring (Dixon et al. 1993; Yardin et el. 1998); however, they sampled at different locations and reported different population structures. Izzo et al. (2012) used a weight-of-evidence approach to review all available information on population subdivision in sardines and recommended six stock divisions: southern Queensland and northern New South Wales, southern New South Wales, eastern and western Tasmania and Victoria, South Australia, south-west Western Australia, and west Western Australia. However, these boundaries are not conclusive, and additional sampling and analysis are required to clearly define biological stocks. Izzo et al. (2017), using an integrative assessment including genetic, morphological, otolith, growth, reproductive and fishery data, found evidence for at least four isolated stocks (south-west coast of Western Australia, Great Australian Bight and Spencer Gulf, Bass Strait and Port Phillip Bay, and eastern Australia). Therefore, Australian sardine within the SPF is assessed and managed as a single east coast stock (Figure 7.1).

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 to the Commonwealth TAC. Total sardine catch from Commonwealth and state fisheries (other than that taken in South Australia) peaked in 2008–09 at 4,787 t and decreased to 893 t in 2014–15—its lowest level since 2001–02. The total catch in 2015–16 was 1,434 t. The Commonwealth catch for 2016–17 was 131 t (Figure 7.2; state catches are not available for 2016–17).

FIGURE 7.2 Commonwealth Australian sardine catch and TAC in the SPF, 2003–04 to 2016–17



Note: **TAC** Total allowable catch.

Stock assessment

The 2015–16 RBC and TAC were set using the 2015 harvest strategy control rules and 2004 DEPM biomass estimate, because the results of the 2014 DEPM survey were not available. The 2015–16 TAC deducted state catches. The outcomes of the DEPM survey were available for setting the TAC for the 2016–17 fishing season; however, the Australian Fisheries Management Authority (AFMA) Commission retained the TAC from the previous year to allow additional testing, including MSE, to be completed on the SPF harvest strategy. This testing was completed in 2016 (Pascoe & Hillary 2016; Punt et al. 2016).

As a result, the 2015–16 and 2016–17 RBCs and TACs were based on a 2004 DEPM survey. This survey estimated the spawning biomass for Australian sardine off eastern Australia during July 2004 to be 28,809 t (95 per cent CI 9,161 to 58,673 t) (Ward et al. 2007). The then Small Pelagic Fishery Resource Assessment Group (SPFRAG) considered this to be an underestimate because the survey did not cover the entire spawning area, and revised the estimate to 40,000 t, based on the proportion of unsurveyed area. Because of the age of the DEPM estimate, the RBC for 2015–16 was set using the tier 2 decision rule (using 10 per cent of the 2004 biomass estimate), which resulted in an RBC of 4,000 t (AFMA 2014b). After deductions for expected state catches, AFMA set the 2015–16 TAC at 1,880 t and subsequently maintained the 2016–17 TAC at the same level pending further testing of the SPF harvest strategy (outlined above).

A DEPM survey of Australian sardine off eastern Australia was conducted during August–September 2014 and estimated spawning biomass to be 49,575 t (95 per cent CI 24,200 to 213,300 t) (Ward et al. 2015a). Another DEPM survey during January 2014 around northern Tasmania and southern Victoria estimated the spawning biomass in this region to be 10,962 t, although this survey only covered a partial area of spawning habitat (95 per cent CI 8,000 to 15,000 t; Ward et al. 2015b).

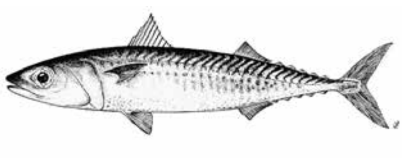
Previous MSE testing for Australian sardine suggests that the harvest strategy is appropriate, and its application would result in a low probability of the stock falling below $0.2B_0$ for more than 90 per cent of the time, in line with the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007; Giannini et al. 2010). However, the 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For Australian sardine, it was suggested that tier 1 harvest rates could be increased from 15 per cent to 33 per cent, that tier 2 harvest rates should be set at 50 per cent of tier 1, and that neither should be applied for longer than five years. A tier 1 harvest rate of 20 per cent was formally adopted in the 2017 SPF harvest strategy.

Total catch (Commonwealth plus state) in 2015–16 was 3 per cent of the August–September 2014 biomass estimate (Ward et al. 2015a) and 36 per cent of the RBC. Total Commonwealth catch in 2016–17 was less than 1 per cent of the 2014 biomass estimate and 3 per cent of the RBC. The peak sardine catch (state plus Commonwealth) of 4,787 t in 2008–09 was about 16 per cent of the spawning biomass estimated by the 2004 DEPM survey and 10 per cent of the most recent biomass estimate. Available age-frequency and length-frequency data show no trends of concern (Ward & Grammer 2017).

Stock status determination

The peak historical harvest from this stock was approximately 9 per cent of the 2014 spawning biomass estimate, and catches have been low as a proportion of estimated spawning biomass. This level of fishing mortality is unlikely to have substantially reduced spawning biomass. Australian sardine is therefore classified as **not overfished** for both years assessed. Fishing mortality remains a small proportion of estimated biomass, and was below the 2015–16 and 2016–17 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Blue mackerel, east (*Scomber australasicus*)



Line drawing: FAO

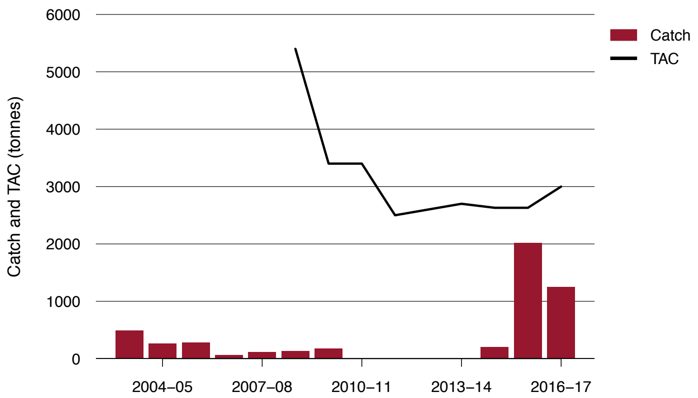
Stock structure

The stock structure of blue mackerel is uncertain. Genetic analysis of samples from southern Queensland, Western Australia and New Zealand indicates population subdivision. 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 et al. 2012). No finer-scale analyses of blue mackerel have been undertaken to further define stock structure. Blue mackerel within the SPF is assessed and managed as separate stocks in the eastern and western subareas (Figure 7.1).

Catch history

Most of the blue mackerel (east) catch has historically been taken in state fisheries. However, with the introduction of a freezer vessel, the Commonwealth catch has recently exceeded state catch. Commonwealth catch increased in 2015–16 to 2,022 t (up from 203 t in 2014–15) and decreased to 1,248 t in 2016–17 (Figure 7.3; state catches are not available for 2016–17). Total state and Commonwealth catch was 2,367 t in 2015–16, which is the peak catch for the fishery.

FIGURE 7.3 Commonwealth eastern blue mackerel catch and TAC, 2003–04 to 2016–17



Note: **TAC** Total allowable catch.

Blue mackerel
AFMA

Stock assessment

The 2015–16 RBC and TAC were set using the 2015 harvest strategy control rules and 2004 DEPM biomass estimate, because the results of the 2014 DEPM survey were not available. The 2015–16 TAC deducted state catches. The outcomes of the DEPM survey were available for setting the TAC for the 2016–17 fishing season; however, the AFMA Commission retained the TAC from the previous year to allow additional testing, including MSE, to be completed on the SPF harvest strategy. This testing was completed in 2016 (Pascoe & Hillary 2016; Punt et al. 2016).

As a result, the 2015–16 and 2016–17 RBCs and TACs for blue mackerel (east) were based on a 2004 DEPM survey. This survey estimated the spawning biomass for blue mackerel (east) to be 23,009 t (95 per cent CI 7,565 to 116,395 t; Ward & Rogers 2007). The SPFRAG considered this to be an underestimate because the survey did not cover the entire spawning area, and revised the estimate to 40,000 t. Because of the age of the assessment, the RBC for 2015–16 was set using the tier 2 decision rule (using 7.5 per cent of the 2004 spawning biomass estimate), which resulted in an RBC of 3,000 t (AFMA 2014b, 2015b). After deducting expected state catches, the Commonwealth TAC was set at 2,630 t for 2015–16. Since setting these TACs, results from a DEPM survey for blue mackerel (east) conducted in 2014 estimated spawning biomass to be 83,300 t (95 per cent CI 35,100 to 165,000 t) (Ward et al. 2015b). The TAC for 2016–17 was set to the same level as the previous year while additional testing was completed.

Total (Commonwealth and state) blue mackerel (east) catch in 2015–16 was 3 per cent of the 2014 spawning biomass estimate. The Commonwealth catch in 2016–17 was 67 per cent of the RBC, 76 per cent of the TAC and less than 2 per cent of the 2014 spawning biomass estimate.

Previous MSE testing for blue mackerel suggests that the harvest strategy is appropriate, and its application would result in a low probability of the stock falling below $0.2B_0$ for more than 90 per cent of the time, in line with the HSP (DAFF 2007; Giannini et al. 2010). However, 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 per cent to 23 per cent, that tier 2 harvest rates should be set at 50 per cent of tier 1, and that neither should be applied for longer than five years. A tier 1 harvest rate of 15 per cent for a maximum of five years and a tier 2 harvest rate of 7.5 per cent for a maximum of five years was adopted by the AFMA Commission in April 2015. The tier 2 harvest control rule was used as the basis for the 2015–16 TAC. The 2016–17 TAC was held at the 2015–16 level pending additional testing on the harvest strategy. This testing was completed in 2016.

There are no trends of concern in the length and age data (Ward & Grammer 2017).

Stock status determination

The peak harvest from the stock was 4 per cent of the 2014 spawning biomass estimate, and catches have been low as a proportion of estimated biomass. This level of fishing mortality is unlikely to have substantially reduced spawning biomass. The blue mackerel (east) stock is therefore classified as **not overfished** for both years assessed. Total catch in the 2015–16 fishing season was a small proportion of spawning biomass, decreasing substantially in 2016–17. The 2015–16 RBC was very conservative in comparison with the most recent spawning biomass estimate (3 per cent), and increased to 12,495 t in 2017–18 as a result of the updated biomass estimate. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Blue mackerel, west (*Scomber australasicus*)

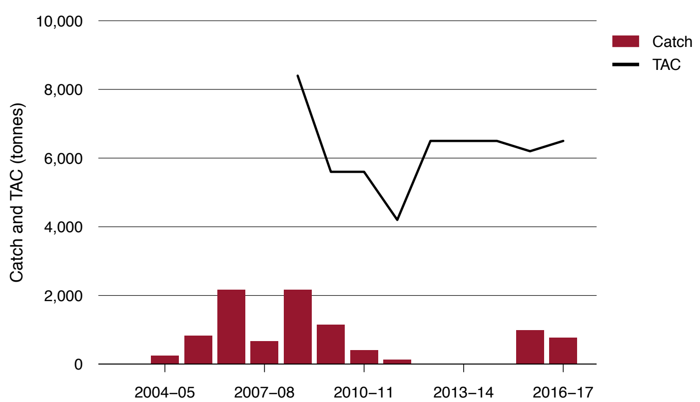
Stock structure

See blue mackerel (east).

Catch history

Very little blue mackerel (west) was caught before 2004–05. Total Commonwealth-landed catch increased in 2005–06, peaking in 2008–09 at 2,164 t and decreasing steadily thereafter. There was negligible catch between 2011–12 and 2014–15 in both the state and Commonwealth fisheries. Commonwealth catch was 979 t in 2015–16 with negligible state catch, and 766 t in 2016–17 (Figure 7.4; state catches are not available for 2016–17).

FIGURE 7.4 Commonwealth western blue mackerel catch and TAC, 2003–04 to 2016–17



Note: **TAC** Total allowable catch.

Stock assessment

The 2015–16 RBC and TAC were set using the 2014 harvest strategy control rules and 2005 DEPM biomass estimate. The AFMA Commission retained the TAC from the previous year for the 2016–17 fishing season to allow additional testing, including MSE, to be completed on the SPF harvest strategy.

The 2015–16 and 2016–17 RBCs and TACs for blue mackerel (west) were based on a 2005 DEPM survey. This survey estimated the spawning biomass to be 56,228 t (95 per cent CI 10,993 to 293,456 t) (Ward & Rogers 2007); however, the SPFRAG considered this to be an underestimate and adjusted the estimate to 86,500 t. Application of the tier 2 decision rule (using 7.5 per cent of the 2005 spawning biomass estimate) resulted in an RBC of 6,500 t for the 2015–16 (AFMA 2015b) and 2016–17 fishing seasons. The Commonwealth TAC was set at 6,200 t for 2015–16 after state catch had been deducted. The TAC for the 2016–17 season was held at the 2015–16 level pending further testing of the harvest strategy. This testing was completed in 2016 (Pascoe & Hillary 2016; Punt et al. 2016).

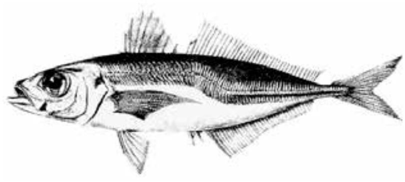
Total landings (Commonwealth and state) peaked in 2008–09 at 2,168 t, which is 4 per cent of the spawning biomass estimated by the 2005 DEPM survey. No catch was reported for 2014–15, and no state catch was reported for 2015–16. Commonwealth catch in 2015–16 (979 t) represented 15 per cent of the RBC and 16 per cent of the 2015–16 TAC. Commonwealth catch in 2016–17 (766 t) represented 12 per cent of the 2016–17 RBC and TAC. Available age-frequency and length-frequency data show no trends of concern (Ward & Grammer 2017).

Previous MSE testing for blue mackerel suggests that the harvest strategy is appropriate, and its application would result in a low probability of the stock falling below $0.2B_0$ for more than 90 per cent of the time, in line with the HSP (DAFF 2007; Giannini et al. 2010). However, the 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). A tier 1 harvest rate of 15 per cent for a maximum of five years and a tier 2 harvest rate of 7.5 per cent for a maximum of five years was adopted by the AFMA Commission in April 2015, with the tier 2 harvest control rule used as the basis for the 2015–16 TAC. The 2016–17 TAC was maintained at 2015–16 levels pending additional testing of the harvest strategy. This testing was completed in 2016.

Stock status determination

The peak harvest from this stock was approximately 4 per cent of the 2005 spawning biomass estimate, and catches have been low as a proportion of estimated spawning biomass. Although this biomass estimate is dated, the level of fishing mortality in any year is unlikely to have substantially reduced spawning biomass. As a result, blue mackerel (west) is classified as **not overfished** for both years assessed. Current fishing mortality remains a small proportion of estimated biomass, and below the 2015–16 and 2016–17 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Jack mackerel, east (*Trachurus declivis*)



Line drawing: FAO

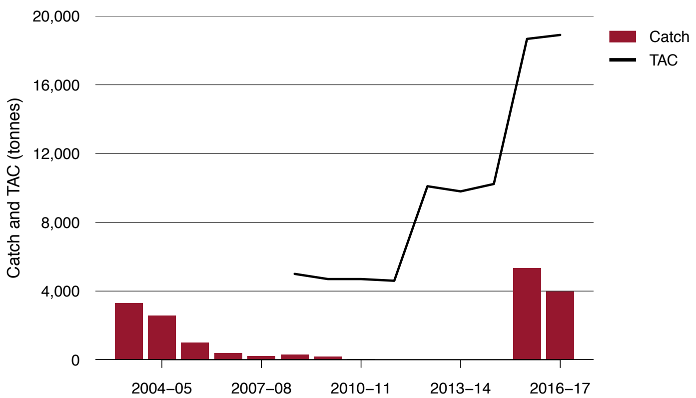
Stock structure

The stock structure of jack mackerel is unclear. A study by Richardson (1982) found evidence of population subdivision between Western Australia, including the Great Australia Bight, and eastern Australia. 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 et al. (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 within 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 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 declined thereafter as a result of decreasing effort in the fishery. Commonwealth catch decreased from 5,342 t in 2015–16 to 3,966 t in 2016–17 (Figure 7.5; state catches are not available for 2016–17).

FIGURE 7.5 Commonwealth eastern jack mackerel catch and TAC, 2003–04 to 2016–17



Note: **TAC** Total allowable catch.

Stock assessment

The most recent DEPM survey for jack mackerel (east) was conducted off eastern Australia in January 2014 (Ward et al. 2015a) and estimated spawning biomass to be 157,805 t (95 per cent CI 59,570 to 358,731 t). The 2015–16 RBC and TAC were set using the 2015 harvest strategy control rules and 2014 DEPM biomass estimate. State catches were deducted from the RBC to obtain the 2015–16 TAC of 18,670 t. The AFMA Commission retained the 2015–16 TAC for the 2016–17 fishing season to allow additional testing, including MSE, to be completed on the SPF harvest strategy. This testing was completed in 2016 (Punt et al. 2016; Pascoe & Hillary 2016).

Total catch (Commonwealth and state) peaked in 2015–16 and was 4 per cent of the 2014 spawning biomass estimate, and 34 per cent of the RBC and TAC. Commonwealth catch in 2016–17 was 2,784 t, representing 2 per cent of the 2014 spawning biomass estimate, and 15 per cent of the RBC and TAC. The length-frequency and age structures of the eastern stock show no signs of concern (Ward & Grammer 2017).

Previous MSE testing for jack mackerel suggests that the harvest strategy is appropriate, and its application would result in a low probability of the stock falling below $0.2B_0$ for more than 90 per cent of the time, in line with the HSP (DAFF 2007; Giannini et al. 2010). However, the 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For jack mackerel, it was suggested that tier 1 harvest rates should be decreased from 15 per cent to 12 per cent, that tier 2 harvest rates should be set at 50 per cent of tier 1, and that neither should be applied for longer than 10 years. A tier 1 harvest rate of 12 per cent for a maximum of 5 years and a tier 2 harvest rate of 6 per cent for a maximum of 10 years was adopted by the AFMA Commission in April 2015, with the tier 1 harvest control rule used as the basis for the 2015–16 TAC. The 2016–17 TAC was held at the 2015–16 level pending additional testing of the harvest strategy.

Stock status determination

The peak harvest during the past 30 years in this fishery was 4 per cent of the spawning biomass estimate, with most catches far below this. This level of fishing mortality is unlikely to have substantially reduced spawning biomass. As a result, jack mackerel (east) is classified as **not overfished** for both years assessed. Current fishing mortality remains a small proportion of biomass, and below the 2015–16 and 2016–17 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Jack mackerel, west (*Trachurus declivis*)

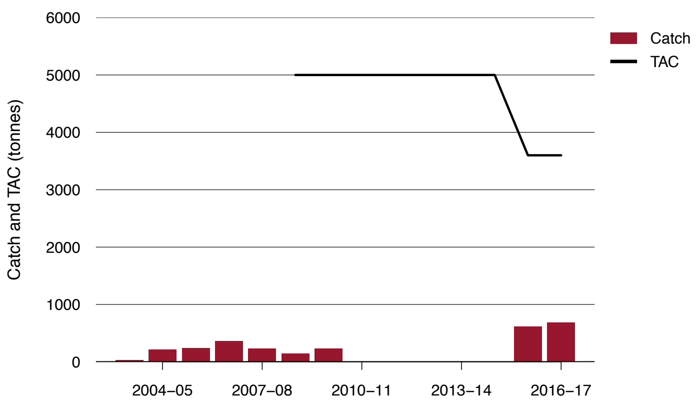
Stock structure

See jack mackerel (east).

Catch history

Total catch (state and Commonwealth) for jack mackerel (west) did not exceed 250 t before 2005–06. Commonwealth catch was zero or negligible from 2011–12 to 2014–15, and increased to 613 t in 2015–16 and 686 t in 2016–17 (Figure 7.6). State catches have been negligible for the past decade.

FIGURE 7.6 Commonwealth western jack mackerel catch and TAC, 2003–04 to 2016–17



Note: **TAC** Total allowable catch.

Stock assessment

No DEPM survey or estimate of spawning biomass has been conducted for jack mackerel (west) for the review period; however, a DEPM conducted in 2016–17 will be used to inform the 2018–19 TAC. Aerial surveys in the 1970s suggested a biomass off western Tasmania of at least 80,000 t (Williams 1981). However, there remains little empirical data on abundance, biomass or life history for this stock in the intervening three decades (AFMA 2014b, 2015b).

The 2015–16 RBC and TAC were set using the 2015 harvest strategy control rules. In the absence of an empirically derived biomass estimate, RBC was based on a model-derived one (Atlantis-SPF ecosystem model) and tier 2 harvest rate, as per tier 2b of the April 2015 harvest strategy.

State catches were deducted from the RBC to obtain the 2015–16 TAC of 3,600 t. The AFMA Commission retained the 2015–16 TAC for the 2016–17 fishing season to allow additional testing, including MSE, to be completed on the SPF harvest strategy. This testing was completed in 2016 (Pascoe & Hillary 2016; Punt et al. 2016).

The peak catch in 2016–17 was less than 1 per cent of the 1970s biomass estimate and 19 per cent of the RBC. There was very little catch of this stock during the previous 16 years. There was no reported catch for 2014–15. The length-frequency and age structures of the eastern stock show no signs of concern (Ward & Grammer 2017).

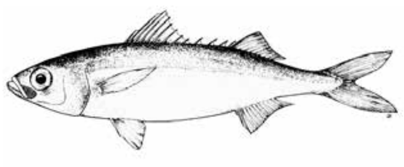
Previous MSE testing for jack mackerel suggests that the harvest strategy is appropriate, and its application would result in a low probability of the stock falling below $0.2B_0$ for more than 90 per cent of the time, in line with the HSP (DAFF 2007; Giannini et al. 2010). However, the 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For jack mackerel, it was suggested that tier 1 harvest rates should be decreased from 15 per cent to 12 per cent, that tier 2 harvest rates should be set at 50 per cent of tier 1, and that neither should be applied for longer than 10 years. However, there is a paucity of information on life history and productivity for jack mackerel (west). Data from jack mackerel (east) were used instead, which may compromise the model outputs for the stock.

The April 2015 harvest strategy adopted by the AFMA Commission includes a tier 1 harvest rate of 12 per cent for a maximum of 5 years and a tier 2 harvest rate of 6 per cent for a maximum of 10 years for jack mackerel. The harvest strategy also has a tier 2(b) Atlantis for use in instances where no DEPM estimate is available or the length of time a stock can be at tier 2 has been exceeded. The time that a stock can remain at tier 2(b) is indefinite. Tier 2(b) applies the maximum tier 2 harvest rate to the lower bound of the 95 per cent CI range of biomass estimates derived from Atlantis-SPF. In the case of jack mackerel west, the Atlantis-SPF biomass estimate was 60,000 t and the tier 2 exploitation rate was 6 per cent. The 2016–17 TAC was held at the 2015–16 level pending additional testing of the harvest strategy. (Tier 2(b) was removed from the April 2017 version of the harvest strategy.)

Stock status determination

The peak harvest from this fishery was less than 1 per cent of the spawning biomass estimate, and catches have been low as a proportion of estimated biomass. Although the biomass estimate is limited and quite dated, this level of fishing mortality is unlikely to have substantially reduced spawning biomass. As a result, jack mackerel (west) is classified as **not overfished** for both years assessed. Current fishing mortality remains a small proportion of biomass, and below the 2015–16 and 2016–17 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Redbait, east (*Emmelichthys nitidus*)



Line drawing: FAO

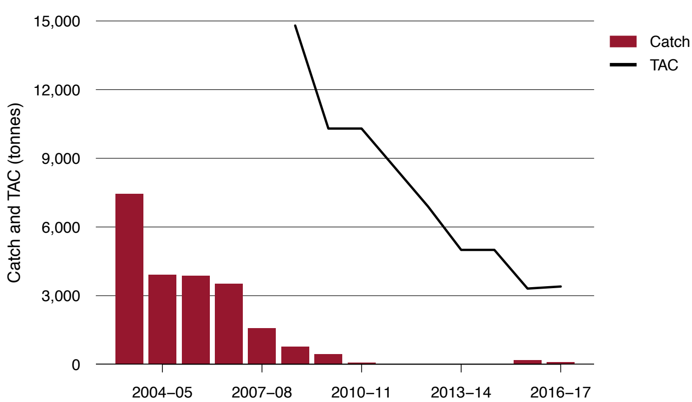
Stock structure

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 in 2015–16 was 189 t, decreasing to 101 t in 2016–17 (Figure 7.7). State catches have been negligible since 2010–11.

FIGURE 7.7 Commonwealth eastern redbait catch and TAC, 2003–04 to 2016–17



Note: **TAC** Total allowable catch.

Stock assessment

The most recent DEPM surveys for redbait (east), in 2005 and 2006 (Neira et al. 2008), provided estimates of spawning biomass of 86,990 t (coefficient of variation [CV] 0.37) and 50,782 t (CV 0.19), respectively. The average of these two spawning biomass estimates (68,886 t) was used to estimate an RBC of 3,400 t for 2015–16 and 2016–17, using the tier 2 decision rule (AFMA 2014b, 2015b). State catch of this stock is negligible; the Commonwealth TAC was set at 3,310 t for the 2015–16 and 2016–17 fishing seasons.

Peak total (Commonwealth and state) catch in 2003–04 was 10 per cent of the estimated spawning biomass average. No catch was reported in 2014–15. Commonwealth catch in 2015–16 increased to 180 t, which is less than 1 per cent of the spawning biomass estimate, and 5 per cent of the RBC and TAC.

Previous MSE testing for redbait suggests that the harvest strategy is appropriate, and its application would result in a low probability of the stock falling below $0.2B_0$ for more than 90 per cent of the time, in line with the HSP (DAFF 2007; Giannini et al. 2010). However, the 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For redbait (east), it was suggested that tier 1 harvest rates should be decreased from 15 per cent to 9 per cent, that tier 2 harvest rates should be set at 50 per cent of tier 1, and that neither should be applied for longer than 10 years. A tier 1 harvest rate of 10 per cent for a maximum of five years and a tier 2 harvest rate of 5 per cent for a maximum of 10 years was adopted by the AFMA Commission for redbait in April 2015. Given the age of the DEPM estimate, the tier 2 harvest control rule was used as the basis for the 2015–16 TAC. The 2016–17 TAC was held at the 2015–16 level pending additional testing of the harvest strategy.

Stock status determination

The peak harvest from this fishery was 10 per cent of the spawning biomass estimate, and catches have been low as a proportion of estimated biomass. Although the biomass estimate is dated, this level of fishing mortality is unlikely to have substantially reduced spawning biomass. As a result, redbait (east) is classified as **not overfished** for both years assessed. Fishing mortality is low as a proportion of estimated biomass, and below the 2015–16 and 2016–17 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Redbait, west (*Emmelichthys nitidus*)

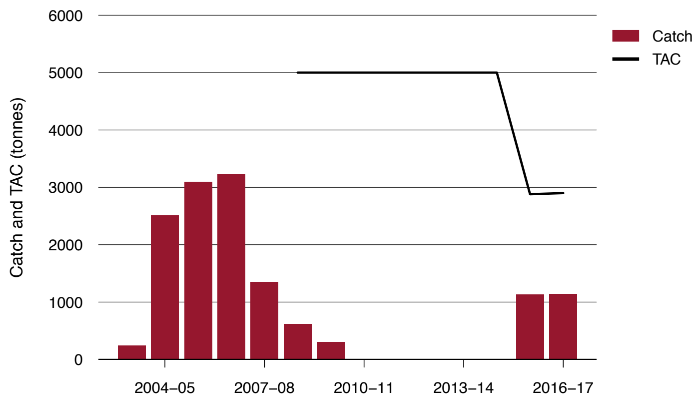
Stock structure

See redbait (east).

Catch history

No catches of redbait (west) were reported before 2001–02. 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 2009–10 and 2013–14. No catch was reported in 2014–15. Commonwealth catch was 1,135 t in 2015–16 and 1,140 t in 2016–17 (Figure 7.8; state catches have been negligible in the past).

FIGURE 7.8 Commonwealth western redbait catch and TAC, 2003–04 to 2016–17



Note: **TAC** Total allowable catch.

Stock assessment

No DEPM survey or estimate of biomass has been undertaken for redbait (west). Because of this lack of data, the SPFRAG estimated a spawning biomass by drawing on expert opinion and experience of similar stocks. The 2015–16 RBC and TAC were set using the 2015 harvest strategy control rules. In the absence of an empirically derived biomass estimate, the RBC was based on a model-derived one (Atlantis-SPF ecosystem model) and tier 2 harvest rate, as per tier 2(b) of the April 2015 harvest strategy.

State catches were deducted from the RBC to obtain the 2015–16 TAC of 2,880 t. The AFMA Commission retained the 2015–16 TAC for the 2016–17 fishing season to allow additional testing, including MSE, to be completed on the SPF harvest strategy. This testing was completed in 2016 (Pascoe & Hillary 2016; Punt et al. 2016).

Previous MSE testing for redbait suggests that the harvest strategy is appropriate, and its application would result in a low probability of the stock falling below $0.2B_0$ for more than 90 per cent of the time, in line with the HSP (DAFF 2007; Giannini et al. 2010). However, the 2015 MSE suggested linking harvest strategy settings to the productivity of the species (Smith et al. 2015). For redbait (west), it was suggested that tier 1 harvest rates should be decreased from 15 per cent to 10 per cent, that tier 2 harvest rates be set at 50 per cent of tier 1, and that neither should be applied for longer than 10 years.

The April 2015 harvest strategy adopted by the AFMA Commission includes a tier 1 harvest rate of 10 per cent for a maximum of 5 years and a tier 2 harvest rate of 5 per cent for a maximum of 10 years for redbait. The harvest strategy also has a tier 2(b) Atlantis for use in instances where no DEPM estimate is available or the length of time a stock can be at tier 2 has been exceeded. The time that a stock can remain at tier 2(b) is indefinite. Tier 2(b) applies the maximum tier 2 harvest rate to the lower bound of the 95 per cent CI range of biomass estimates derived from Atlantis-SPF. In the case of redbait, the Atlantis-SPF biomass estimate was 58,000 t and the tier 2 exploitation rate was 5 per cent. The 2016–17 TAC was held at the 2015–16 level pending additional testing of the harvest strategy. (Tier 2(b) was removed from the April 2017 version of the harvest strategy.)

Stock status determination

The level of redbait (west) spawning biomass estimated by the Atlantis-SPF model is consistent with spawning biomass estimates for other similar stocks; however, there is little empirical evidence to corroborate the ecosystem modelling. Catches have historically been low in this fishery, and this level of fishing mortality is unlikely to have substantially reduced spawning biomass. As a result, redbait (west) is classified as **not overfished** for both years assessed. Current fishing mortality remains low. The stock is therefore classified as **not subject to overfishing** for both years assessed.

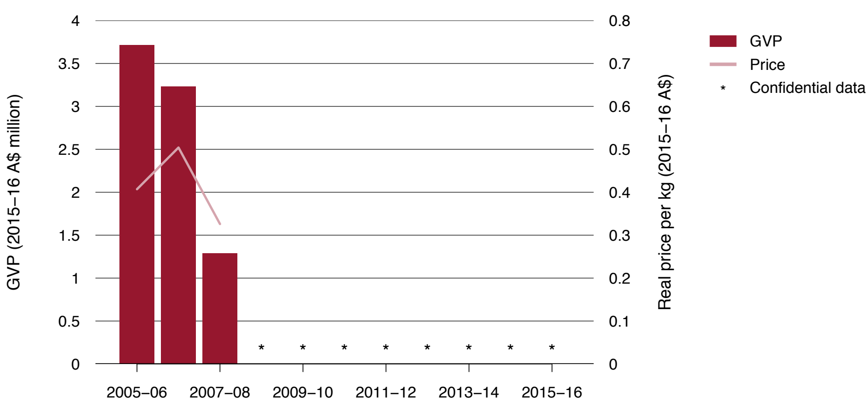
7.3 Economic status

Key economic trends

The gross value of production (GVP) in the SPF was estimated to be $1.3 million in 2007–08 (2015–16 dollars). This was 65 per cent lower than the estimate for 2005–06 ($3.7 million), primarily as a result of a rapid decline in prices and production (Figure 7.9). The GVP has been confidential since 2007–08 because five or fewer vessels have operated in the fishery.

In 2007–08, attributed management costs were about 57 per cent of GVP. This indicates that net economic returns (NER) were likely to have been low in that year, even before fishing costs are considered. Management costs increased 56 per cent between 2014–15 and 2015–16 (from $0.8 million to $1.2 million). The number of vessels remained steady at three in 2016–17. However, fishing effort declined, reflecting the exit from the fishery of a factory trawler part way through 2016–17. A decrease in the level of catch, from 10,394 t in 2015–16 to 8,038 t in 2016–17, suggests that GVP decreased, but is still above the five-year average to 2014–15.

FIGURE 7.9 Real GVP for the SPF, 2005–06 to 2015–16



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

Management arrangements

The fishery is managed largely with output controls, with TACs set for each target species. For the 2016–17 fishing season, 32 entities held statutory fishing rights unchanged from the previous season. Of the combined TACs for small pelagic species that were available in 2015–16, 74 per cent were uncaught. However, the percentage of TACs uncaught increased by 7 percentage points in the 2016–17 fishing season, to 81 per cent. Increased latency in 2016–17 was largely the result of lower catches of eastern blue mackerel and eastern jack mackerel.

Performance against economic objective

A meaningful biomass target to provide maximum economic yield (MEY) is difficult to determine for the SPF because of the high interannual variability in biomass levels (Small Pelagic Fishery Management Plan 2009). The absence of an explicit economic target makes it difficult to determine how effectively the fishery's harvest strategy is delivering maximum NER to the Australian community. Pascoe and Hillary (2016) suggest that, for fisheries that target schooling species where there is no relationship between catch-per-unit-effort and biomass, such as jack mackerel in the eastern subarea of the SPF, maximum sustainable yield could be used as a proxy reference target for MEY. It is apparent from the low volume of catch relative to the TAC that this fishery has not been achieving its MEY over recent years. The exit from the fishery of a factory trawler part way through the 2016–17 season resulted in higher quota latency compared with the previous season, indicating that economic performance of the fishery may have declined. Despite higher latency, changes in NER are uncertain because of the lack of information about changes in cost structures of the industry as a result of introduction of the factory trawler in the latter part of the 2014–15 financial year and its subsequent departure in 2016.

7.4 Environmental status

Under part 2 of the Small Pelagic Fishery Management Plan 2009, AFMA is required to develop and implement a bycatch and discarding workplan. The objective of the workplan is to ensure that information is gathered about the impact of the SPF on bycatch species, that all reasonable steps are taken to minimise incidental interactions with protected species, and that the ecological impacts of fishing on habitats are minimised.

The management plan for the SPF was most recently accredited under part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* on 26 October 2015; this accreditation expires on 26 October 2018. Two conditions were placed on the accreditation: that, before fishing, midwater trawl vessels have mitigation devices in place for dolphins, seals and seabirds; and that new midwater trawl vessels carry one observer for the first 10 trips, with additional observers or monitoring to be implemented after scientific assessment. Minimum levels for observer coverage in the SPF are 10 per cent of days fished for purse-seine vessels and 20 per cent of days fished for midwater trawl vessels.

Because the factory trawler is a new vessel, the vessel management plan accords with the accreditation conditions outlined above, and these conditions are linked to specific risks of interactions with seabirds and marine mammals. For both seabirds and mammals, conditions include the requirement for the concession holder to ensure that an AFMA observer is on board for the first 10 trips or the first 12 months, whichever is longer, and as directed by AFMA thereafter. For seabirds, the concession holder must ensure that the vessel deploys at least one type of physical mitigation measure (tori lines or bird bafflers) at all times while the fishing gear is in the water. For mammals, conditions include the requirement for the vessel to have an AFMA-approved electronic monitoring system operating during all fishing activity. The concession holder must also ensure that the vessel uses a marine mammal excluder device that either allows animals to escape the net or keeps animals out of the net. A series of spatial management controls also apply to the fishery, including the Australian sea lion closures, the Coorong dolphin closure and the Small Pelagic Fishery (Closures) Direction No. 1 2015, amended by the Small Pelagic Fishery (Closures variation) Direction No. 1 2015.

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

Separate ecological risk assessments have been done for the midwater trawl and purse-seine fishing methods used in the fishery; however, these did not specifically assess a factory trawler. 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, 235 species were assessed at level 2, with 26 of these assessed as being at high risk (Daley et al. 2007). No finfish species were assessed as being at high risk from either purse-seine or midwater trawl operations. The ecological risk assessment for trawling in the SPF is due to be updated in 2016–17.

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

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

AFMA publishes quarterly reports of logbook interactions with protected species on its website. A total of 108 interactions with protected species were reported in the SPF during the 2016 calendar year: 7 were with shy albatross (*Thalassarche cauta*), all of which were dead; 1 was with an unidentified albatross, which was dead; 2 were with unidentified cormorants, which were dead; 51 were with Australian fur seals (*Arctocephalus pusillus*), 6 of which were released alive and 45 were dead; 7 were with New Zealand fur seals (*A. forsteri*), all of which were dead; 1 was with an Antarctic fur seal (*A. gazelle*), which was dead; 1 was with a whale shark (*Rhincodon typus*), which was released alive; and 38 were with shortfin mako sharks (*Isurus oxyrinchus*), of which 20 were released alive and 18 were dead.

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Purse seine
AFMA

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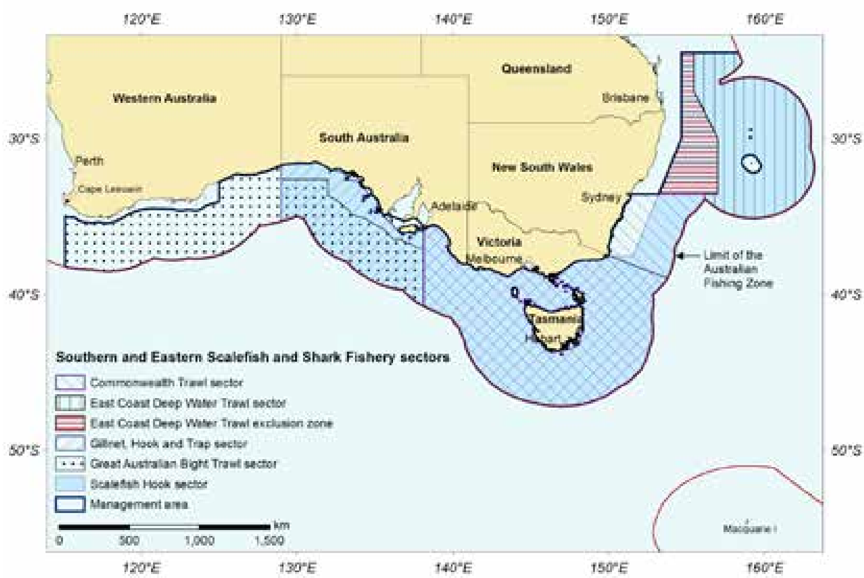
Chapter 8

Southern and Eastern Scalefish and Shark Fishery

F Helidoniotis, A Koduah and S Nicol

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, squid 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 the reserves within the Commonwealth marine reserve network established by the Australian Government fall within the SESSF management area (AFMA 2016).

The SESSF remained the largest Commonwealth fishery in terms of volume caught in the 2015–16 fishing season. In 2015–16, the gross value of production (GVP) of the SESSF was $73 million, accounting for 17 per cent 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 and several byproduct species. 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 observer or video camera coverage and vessel monitoring systems.

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

Landings in the SESSF have generally decreased over time as a result of reductions in fishing effort. In 2016–17, landings in the Commonwealth Trawl Sector (CTS) and the Gillnet Hook and Trap Sector (GHTS) were 8,691 t, representing around 43 per cent of available quota. Landed catches for other sectors of the SESSF are reported in the relevant chapters.

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). Since then, other factors have come into play, and NER for some sectors of the SESSF have declined. Trends in NER are reported in the relevant chapters.

8.2 Sectors of the fishery

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

The status of the stocks taken in these sectors is presented in Chapters 9, 10, 11 and 12, respectively. The GHTS includes the Scalefish Hook Sector (SHS), the Shark Gillnet and Shark Hook sectors (SGSHS), and the Trap Sector. In this report, the SHS is reported with the CTS (Chapter 9) because most of their target species are shared. The SGSHS is reported separately (Chapter 12). The Trap Sector is not reported in detail because of its low fishing effort and landings.

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 Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007). The current SESSF HSF applies to all sectors and each stock under quota, and is assigned to one of five 'tiers' for assessment purposes under the HSF (AFMA 2014; Haddon et al. 2015). The assessment tiers have been developed to accommodate different levels of data quantity, quality or knowledge about stocks. Tier 1 assessments are the highest quality and use a fitted statistical catch-at-age model with high-quality data. Tier 2 are the same but with low-quality data. Tier 3 rely on analysis of catch curves, tier 4 on catch-per-unit-effort data and tier 5 on catch-only, model-assisted data-poor stock assessments. Although described in the HSF, tier 2 assessments are not currently applied in the SESSF.

The target and limit reference points for each tier are prescribed by the HSP. All tier levels generate a recommended biological catch (RBC) through associated harvest control rules that are intended to move stock biomass towards the target reference point (AFMA 2014). RBCs provided by resource assessment groups are translated into TACs through a set of predetermined rules, which include deductions for discarding, recreational catches and state catches. The SESSF HSF has been management strategy evaluation tested to ensure that the harvest control rules are robust to model structure and parameter uncertainties (Fay et al. 2009; Little et al. 2011; Wayte 2009). The level of precaution applied in RBCs increases from tier 1 to tier 5, reflecting the assumption that the level of uncertainty increases with the assessment tiers. Under the HSF, TACs are reduced using discount factors of 5 per cent for species assessed using the tier 3 harvest control rules and 15 per cent for tier 4 harvest control rules, unless other management arrangements are considered to have introduced an equivalent level of precaution. A prescribed discount factor for tier 5 has not been determined under the HSF. The Southern and Eastern Scalefish and Shark Fishery Resource Assessment Group (SESSFRAG) has also produced guidelines on the implementation of various post-assessment 'meta-rules' (for example, the large change–limiting rule and discount factors). Since 2009, there has also been a move towards greater recommendation and implementation of multiyear TACs in the SESSF, whereby an RBC (incorporating appropriate precaution) is estimated for a period longer than one year—typically three, although five years is also used. This provides a basis for setting TACs for longer periods, which provides greater stability for industry, and reduces the number of annual assessments and therefore the assessment cost.

The SESSF includes several stocks that are classified as overfished (that is, the current biomass is estimated to be below the limit reference point). These overfished stocks are blue warehou (*Seriolella brama*), eastern gemfish (*Rexea solandri*), gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*), school shark (*Galeorhinus galeus*), redfish (*Centroberyx affinis*) and orange roughy (*Hoplostethus atlanticus*) in two zones (southern and western).

For overfished stocks, the harvest control rules in the SESSF HSF, in line with the HSP, recommend a zero RBC. AFMA allocates incidental catch allowances to permit small catch volumes of these species when fishers are targeting other species. Although the SESSF HSF does not provide guidelines for setting these catch allowances, the SESSFRAG-agreed process uses companion species analysis and/or quantitative stock assessment models. These provide the SESSFRAG with estimates of the quantities of species likely to be taken as bycatch when fishing for other species and the impact that such fishing mortalities have on time frames for rebuilding to the stocks' limit reference point. These data feed into advice on the appropriate setting of incidental catch allowances. An important aspect of setting an incidental catch allowance is that there is a trade-off between setting a TAC too low, which might then result in discards, or too high, so that rebuilding is not achievable (Haddon et al. 2016). In some cases, the level of fishing mortality that would allow a stock to recover within stipulated rebuilding time frames is uncertain. In other cases, even with zero catch, stocks may not rebuild within stipulated rebuilding time frames because of their low natural productivity at low stock size (Ward et al. 2013), 'non-average' conditions (for example, below-average recruitment), shifts in the ecological relationships between stocks and their environment ('regime shifts'), or changes in other environmental variables. Similarly, the ability to immediately detect recovery of overfished stocks may be limited if fishers actively avoid depleted stocks (for example, move-on rules [Haddon et al. 2016], area closures), because information from fishery logbooks or the Integrated Scientific Monitoring Program (ISMP) is no longer likely to be fully representative of the stock or comparable with historical information.

Gillnet
AFMA

Most quota species caught 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 these models. For species that have had a maximum sustainable yield (MSY) estimated, a $1.2B_{MSY}$ proxy for B_{MEY} is used as the target. For other species, a target that is equivalent to the proxy $0.48B_0$ (48 per cent of the unfished biomass) is applied. Economic performance of the fishery could possibly be improved by optimising targets for a combination of the more valuable quota species, rather than the default proxy applied to individual species. Consideration is also being given to alternative approaches to setting targets for secondary species (that is, those that are not targeted and contribute a small proportion of the NER). Following guidance from the SESSFRAG, the Slope Resource Assessment Group (which is responsible for monitoring, assessment and reporting of upper continental slope and deepwater species) and the Shelf Resource Assessment Group (which is responsible for monitoring, assessment and reporting of species associated with the shallow areas of the continental shelf)[1] recommended targets at B_{MSY} levels, below the B_{MEY} proxy, for several secondary species. AFMA has agreed to adopt these alternative targets (SEMAC 2014). Secondary species managed to the B_{MSY} proxy target include john dory (*Zeus faber*), ocean perch (*Helicolenus barathri*, *H. percoides*), ribaldo (*Mora moro*), sawshark (*Pristiophorus cirratus*, *P. nudipinnis*) and elephantfish (*Callorhinchus milii*).

Differences in the profitability of the various fishing methods, and species that are caught together in the CTS and the GHTS complicate the optimisation of harvests to obtain MEY at the fishery level. Augmenting current stock assessments with available economic survey data may provide a cost-effective means of estimating MEY targets for a broader range of species. Pascoe et al. (2015) noted that, because detailed bio-economic models for many fisheries are unavailable, some form of cost-effective proxy measure is required to estimate approximate target reference points. The research recommended that the designation of a simple default proxy target reference point needs to be reconsidered, particularly in the case of multispecies fisheries. The research also noted that the benefits of identifying an appropriate set of criteria for determining how many and which species should be managed at different targets could result in lower costs and lower discards, and potentially higher profits. This work presented a framework that may inform future research to develop target reference points that are consistent with the HSP in multispecies and mixed fisheries, such as the SESSF.

For the GABTS, the development of a bio-economic model (Kompas et al. 2012) for the sector's two key target species (deepwater flathead—*Platycephalus conatus*, and bight redfish—*Centroberyx gerrardi*) has allowed TACs to be set in line with achieving estimated B_{MEY} targets. Given that the models were published in 2012, the Great Australian Bight Resource Assessment Group has noted that B_{MEY} targets set for the GABTS may need updating to better reflect changes to cost and profit input parameters.

1 The Slope Resource Assessment Group and the Shelf Resource Assessment Group were amalgamated in 2016 to form the South East Resource Assessment Group.

8.4 Biological status

The number of stocks assessed for status in the SESSF increased from 24 in 2004 to 37 from 2009 to the present. The number and percentage of stocks classified in each status are presented below.

With regard to fishing mortality status, of the 37 stocks (34 under quota) assessed across the SESSF in 2016 (Figure 8.2):

- 31 stocks (84 per cent) were classified as not subject to overfishing
- 0 stocks (0 per cent) were classified as subject to overfishing
- 6 stocks (16 per cent) were classified as uncertain with regard to the level of fishing mortality.

For biomass status (Figure 8.3):

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

Controlling fishing mortality is the primary management lever for AFMA. The year 2013 was the first year since 2006 that no stocks had been classified as subject to overfishing. This has continued for subsequent years. Within the SESSF, TACs are determined after considering state catches; discards; recreational catches; social and economic and Indigenous requirements (Haddon et al. 2015). Discarded fish can pose a problem because there is often a high level of uncertainty around discard estimates. Because discarding is poorly reported, it becomes difficult to estimate the true level of fishing mortality (Haddon et al. 2016). With respect to biomass, several stocks that are classified as overfished remain classified as uncertain if subject to overfishing, meaning that it is currently unclear whether the current level of fishing mortality will allow the stocks to rebuild to the limit reference point within a biologically reasonable time frame, as required by the HSP.

Overfished stocks are stocks that are estimated to be below the limit reference point of 20 per cent of unfished levels ($0.2B_0$). The stocks classified as overfished in 2016 are blue warehou, eastern gemfish, gulper sharks, orange roughy (southern and western zones), redfish and school shark. AFMA continues to work with stakeholders to control the level of fishing mortality of these stocks. Overfished stocks with an uncertain fishing mortality status in 2016 are blue warehou, eastern gemfish, gulper sharks, redfish and school shark.

FIGURE 8.2 Fishing mortality status for all stocks assessed in the SESSF, 2004 to 2016

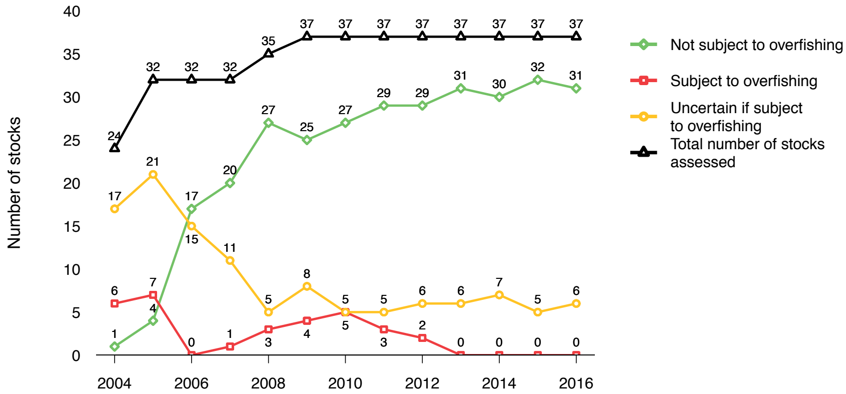
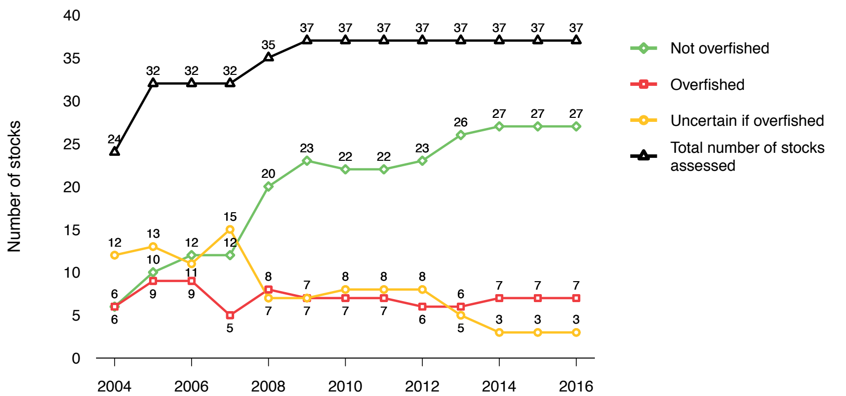


FIGURE 8.3 Biomass status for all stocks assessed in the SESSF, 2004 to 2016



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 species 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 per cent of SESSF GVP in 2015–16 (Figure 8.4). These sectors are therefore key drivers of economic performance in the SESSF. Of these two sectors, only the CTS is surveyed as an individual sector by ABARES as part of its fishery economic surveys program; the SHS is surveyed as part of the GHTS. NER for the CTS followed a positive trend from 2004–05 to a peak of $7.4 million in 2010–11. NER declined in 2011–12 and 2012–13, but remained positive. Based on preliminary estimates, NER for the sector declined in 2013–14. This result was probably driven by lower GVP generated in the CTS as a result of declines in beach prices of some key species caught in the sector, including blue grenadier and tiger flathead, and lower volumes landed of tiger flathead.

The estimated biomass for three of the most valuable species within the sector (blue grenadier—*Macruronus novaezelandiae*, silver warehou—*Seriolella punctata*, and tiger flathead—*Neoplatycephalus richardsoni*) remained above or close to the respective B_{MEY} targets (Chapter 9). This indicates that the economic status of the CTS is positive and has improved substantially since 2004–05. However, it could be further improved if adjustment to proxy target reference points were made to better reflect B_{MEY} for some of the more valuable species in the sector.

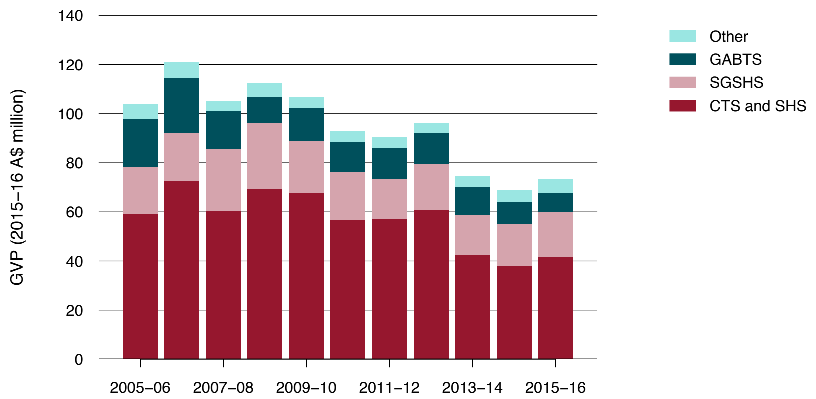
Historically, orange roughy has contributed substantially to GVP for the CTS. The rebuilding of orange roughy stocks over the longer term should improve the economic status of the sector, although sustainable harvests of this species are likely to be much lower than peak historical levels. The recommencement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

Economic indicators for the GHTS were used to assess the economic status of the SGSHS, which accounted for 77 per cent of GVP in the GHTS in 2015–16. For the decade preceding 2009–10, estimates of NER in the GHTS had been positive. Estimates became negative in 2009–10 (–$0.44 million in 2015–16 dollars) and have fluctuated below zero since then. This is despite biomass levels of gummy shark (*Mustelus antarcticus*), the main target species of the sector, being close to or above the target reference point for the stock (Chapter 12). Recent spatial closures aimed at reducing marine mammal interactions in the sector are likely to have contributed to this change, as have school shark controls and the impacts they have on gummy shark catches. A key challenge for the sector is rebuilding the school shark stock, potentially resulting in NER increasing over time. However, the rebuilding of stock is subject to adjustment costs to avoid the species during the rebuilding process.

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

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

FIGURE 8.4 Real GVP in the SESSF by sector, 2005–06 to 2015–16



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

Overall, the current economic status of the SESSF is mixed. The negative change in economic performance in the GHTS has occurred at the same time as positive NER in the CTS; meanwhile, the GABTS continues to pursue estimated B_{MEY} targets for its key species. The deterioration in economic performance in the GHTS demonstrates that management of bycatch and other environmental issues (for example, interactions with protected species) can have economic impacts on a fishery, and such factors should be taken into account when assessing the economic performance of the fishery.

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

8.6 Environmental status

General bycatch and discards

Bycatch is defined in the HSP as 'species taken incidentally in a fishery where other species are the target, and which are always discarded' (DAFF 2007). Tuck et al. (2013) evaluated bycatch and discards (including target and byproduct species) in six Commonwealth fisheries, including the SESSF, and concluded that trawling in the South East Trawl (SET) sector and the GABTS, and Danish-seining account for the greatest volume of bycatch in the Commonwealth fisheries examined. This largely reflects the high level of fishing activity in these sectors and fisheries. Bycatch and discards largely comprise small fish species with little or no commercial value, but also include crustaceans, sharks, molluscs and, more rarely, marine mammals, reptiles and seabirds.

Data collected by the ISMP over 20 years have shown a reduction in the volume of trawl discards since the mid 2000s. 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, probably explains much of the reduction in the volume of discards. Tuck et al. (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, particularly blue grenadier. However, data for bycatch and discards of rarer commercial species are often lacking, because observer coverage is often focused on key commercial species.

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

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

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

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

Trawling impacts

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

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

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

Protected species

The SESSF interacts with various species listed as protected or conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Six former target species in the SESSF are listed as conservation dependent: orange roughy, eastern gemfish, Harrisson's dogfish (*Centrophorus harrissoni*), southern dogfish (*C. zeehaani*), school shark and, most recently, blue warehou. These species, discussed in Chapters 9 and 12, are under rebuilding or recovery strategies. They are currently managed under incidental catch allowances, closed areas and trip limits, to allow for incidental catch when fishers are targeting other species.

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

Fishers are required to take all reasonable steps to avoid interactions with protected species (other than those listed as 'conservation dependent') and are required to report all interactions in their logbooks. An interaction is defined as any physical contact that a person, boat or gear has with a protected species, including catching and colliding with any of these species. Every three months, AFMA reports all interactions with protected species recorded in logbooks to the Australian Government Department of the Environment and Energy. These reports (which are published on the AFMA website) provide the basis for reports of the number of interactions with protected species within the SESSF in 2016. Interactions are known to occur with species groups protected under the EPBC Act, including marine mammals (cetaceans and pinnipeds), seabirds, sharks (white shark—*Carcharodon carcharias*, grey nurse shark—*Carcharias taurus*, shortfin mako shark—*Isurus oxyrinchus*, porbeagle shark—*Lamna nasus*) and syngnathids (seahorses and pipefish). Although these interactions are rare, they can have a significant impact on some species that have small populations. However, it is difficult to obtain robust estimates of total interactions or interaction rates at low levels of observer coverage or monitoring, especially when such interactions are rare. The introduction of electronic monitoring of all fishing activity in the GHTS is expected to improve estimates of interactions with protected species.

Pinnipeds (seals and sea lions)

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

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

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

In 2003, closures were introduced around the Pages Islands (the largest sea lion colony) and around Kangaroo Island in South Australia. In December 2009, interim voluntary closures of 4 nautical miles were introduced around all colonies. The current declaration of the SESSF as an approved Wildlife Trade Operation under the EPBC Act includes a requirement to implement long-term management measures, including formal fisheries closures, which should significantly reduce the impact of fishing on Australian sea lions and facilitate the recovery of subpopulations.

Fishing vessel
Ryan Keightley, AFMA

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

AFMA lowered the trigger limit for sea lion mortalities in December 2011, following advice from marine mammal experts regarding risks to some sea lion subcolonies. The trigger limit was reduced from 52 animals to 15 animals across seven management zones in the Australian sea lion management area (AFMA 2011a). There were two sea lion mortalities in the gillnet sector in the 2015–16 fishing season. As a result, Zone C, which is in waters off South Australia, was closed on 14 January 2016 because the trigger limit for mortalities for Australian sea lions for that zone was reached. This closure remained in place until 18 June 2017.

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

In 2016, 136 pinniped interactions were reported in CTS and GHTS logbooks: 18 with Antarctic fur seals, 2 with Australian sea lions, 6 with New Zealand fur seals, 71 with Australian fur seals and 39 with seals of unknown species. This is a slight increase from the 134 interactions reported in 2015. Of the 136 reported pinniped interactions, 14 of the Antarctic fur seals, 1 Australian sea lion, 5 of the 6 New Zealand fur seals, 65 of the 71 Australian fur seals and 33 of the 39 unspecified seals were reported to be dead.

In the CTS, 89 per cent of all pinniped interactions in 2016 were reported from bottom-trawling operations, and the remainder of interactions (11 per cent) were reported from Danish-seine or midwater trawl operations. Of the pinniped interactions reported in logbooks in the GHTS in 2016, 97 per cent were reported from gillnet operations.

Dolphins

All cetaceans are protected species under the EPBC Act. Increased observer coverage in the SGSHS in 2011 highlighted interactions with dolphins and potential under-reporting in logbooks (AFMA 2011a). Two dolphin mortalities were reported in logbooks between January and September 2010 (AFMA 2011b), and 52 interactions with dolphins were reported from September 2010 to September 2011 (AFMA 2011b). In response, AFMA closed to gillnet fishing an area of about 27,239 km^2 south-west of Kangaroo Island, where most of the interactions had been reported (dolphin gillnet closure). Observer coverage was increased to 100 per cent (onboard observer or camera) in the area adjacent to the dolphin gillnet closure, and 10 per cent 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 dolphin strategy are to reduce dolphin interactions in gillnets to near zero, and strengthen responsible fishing practices through electronic monitoring and individual accountability. On 8 September 2015, AFMA reopened the dolphin gillnet closure to limited gillnet fishing, with 100 per cent electronic monitoring and individual boat-level performance standards. Under the dolphin strategy, fishers that 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 fishing in the former dolphin gillnet closure (Coorong Dolphin Zone) incur escalating management responses if they catch dolphins. This culminates in a six-month closure to gillnet fishing in the Coorong Dolphin Zone if fishers exceed performance standards specified in the dolphin strategy.

In 2016, interactions were reported with 37 dolphins in the GHTS, 34 of which were reported to be dead, and 1 interaction was reported in the CTS, and the dolphin was dead. This is an increase from the 29 interactions reported in 2015 and is likely to reflect the introduction of electronic monitoring in the GHTS.

Seabirds

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

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

As part of their boat-specific seabird management plans, vessels are required to use effective seabird mitigation devices. In late 2014, AFMA completed a trial using observers to test the effect of seabird mitigation devices on seabird interactions with otter trawlers. The trial showed that the use of warp deflectors (large floats attached in front of trawl warps to scare birds away—often called 'pinkies') reduced heavy contact between actively feeding seabirds and warp wires by around 75 per cent (Pierre et al. 2014). Based on the outcomes of the trial, AFMA mandated a minimum requirement in seabird management plans of 600 mm pinkies. SETFIA has also introduced a code of conduct and training program to improve seabird avoidance measures, and undertook a trial of alternative seabird mitigation devices, including water sprayers and bird bafflers. SETFIA reported that water sprayers and bird bafflers used in the trial reduced interactions between seabirds and the warp by 90 per cent and 96 per cent, respectively.

Seabird interactions are probably under-reported for numerous reasons, including that it may be difficult to constantly observe seabirds interacting with fishing gear and vessels, and that seabirds may not have visible injury after interactions such as warp strikes. During 2016, 164 seabird interactions were reported in logbooks or by observers in the SESSF: 143 in the GHTS, 20 in the CTS and 1 in the GABTS. This is an increase from 49 seabird interactions reported in 2014. Of the 164 interactions, most were with the following groups: 77 were reported as unclassified petrels, prions and shearwaters, 76 of which were reported to be dead; 9 were with little penguins (*Eudyptula minor*), 3 of which were dead; 7 were with white-chinned petrels (*Procellaria aequinoctialis*), 4 of which were reported to be dead; 4 were with shy albatross (*Thalassarche cauta*), all of which were released alive; 19 were with unclassified albatrosses, 7 of which were reported to be dead; 11 were with cormorants, all of which were dead; 8 were with flesh-footed shearwaters (*Ardenna carneipes*), all of which were dead; 11 were with unclassified shearwaters, 10 of which were dead; and 6 were with unidentified seabirds, 5 of which were dead. The remaining interactions were with black-browed albatross (*T. melanophris*), Wilson's storm petrels (*Oceanites oceanicus*), Pacific gulls (*Larus pacificus*), white-faced storm petrels (*Pelagodroma marina*), fairy prions (*Pachyptila turtur*), Australian gannets (*Morus serrator*), Buller's albatross (*T. bulleri*) and grey-headed albatross (*T. chrysostoma*).

Sharks

In 2016, 132 interactions with protected sharks were reported in logbooks: 130 in the GHTS (102 of which were dead) and 2 in the CTS (1 of which was dead). The most prevalent shark was shortfin mako, with 102 interactions reported, 90 of which were reported to be dead. Twelve white sharks were reported—11 in the GHTS; 10 were released alive, 1 was reported to be dead and 1 was in unknown condition. Seventeen porbeagle sharks were reported, of which 11 were dead and 6 were injured; and 1 grey nurse shark was reported in the GHTS, which was reported to be dead. The EPBC Act requires all white sharks and grey nurse sharks to be released alive, if possible.

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

Syngnathids (seahorses and pipefish)

Syngnathids are taken as bycatch in the CTS in otter-trawl and Danish-seine nets, but they are often small and difficult to observe among large catches of fish. No interactions with syngnathids were reported in 2016, although one was captured in the GABTS and was noted to be dead.

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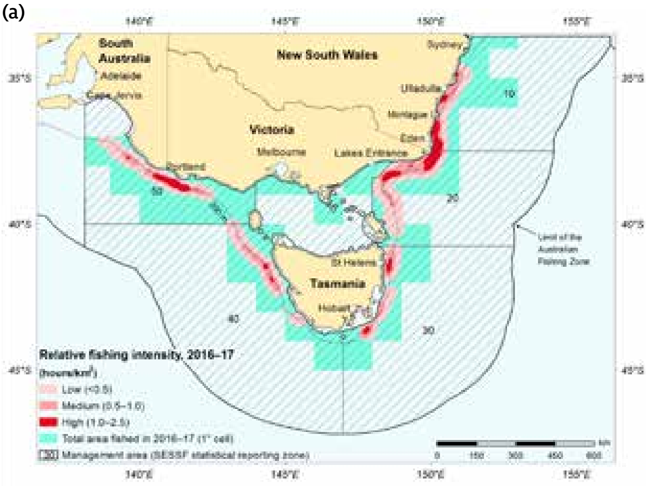
Chapter 9

Commonwealth Trawl and Scalefish Hook sectors

F Helidoniotis, A Koduah, A Moore, N Mazloumi and S Nicol

FIGURE 9.1 Relative fishing intensity (a) in the Commonwealth Trawl Sector and (b) by Danish-seine operations, 2016–17 fishing season

(a)



(b)

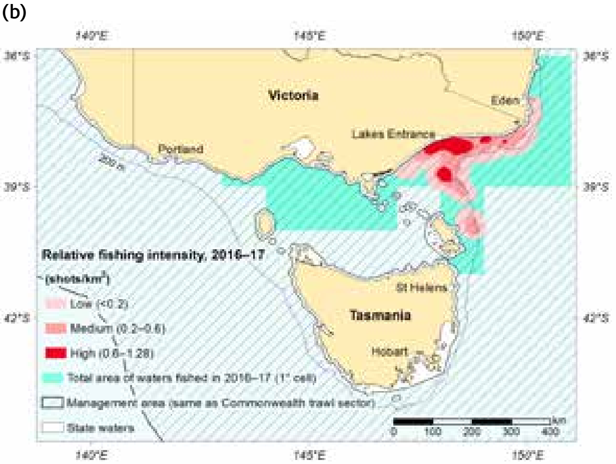
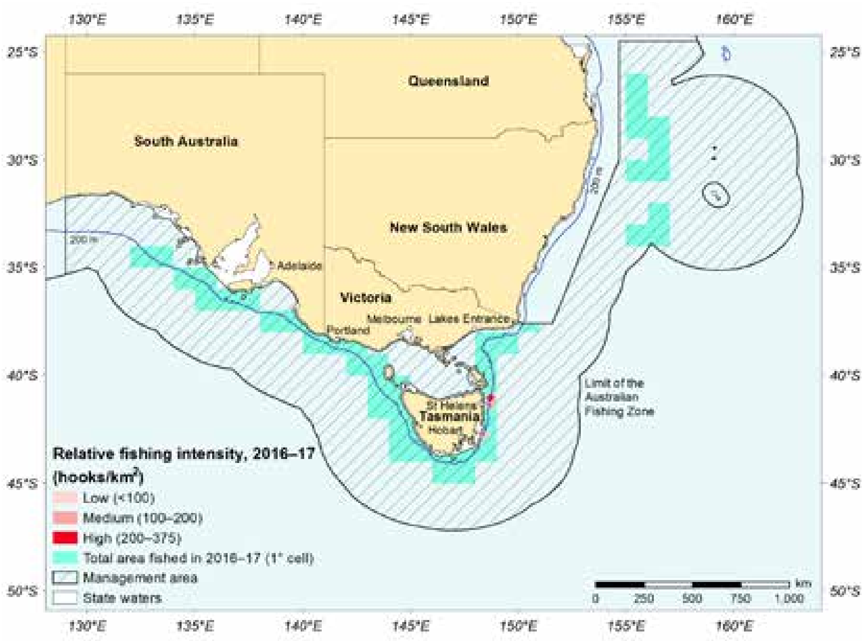


FIGURE 9.2 Relative fishing intensity in the Scalefish Hook Sector, 2016–17 fishing season



Fishing vessel
Andrew Sampaklis, ABARES

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Blue-eye trevalla (*Hyperoglyphe antarctica*)					CPUE is between the limit and target reference points. Fishing mortality is below the most recent RBC.
Blue grenadier (*Macruronus novaezelandiae*)					Estimated spawning biomass was above target in 2012. Total removals have remained below the long-term RBC.
Blue warehou (*Seriolella brama*)					Total removals are below the incidental catch allowance. There is no evidence that the stock is rebuilding.
Deepwater sharks, eastern zone (multiple species)					Substantial areas where historical catch was taken are closed, and less than 50% of the TAC was caught. Multispecies nature of stock makes CPUE potentially unreliable as the index of abundance.
Deepwater sharks, western zone (multiple species)					Substantial areas where historical catch was taken are closed, and less than 50% of the TAC was caught. Multispecies nature of stock makes CPUE potentially unreliable as the index of abundance.
Eastern school whiting (*Sillago flindersi*)					2009 estimate of biomass is above the target reference point, but is becoming increasingly uncertain because of its age. Total removals since 2009 have been below the long-term RBC.
Flathead (*Neoplatycephalus richardsoni* and 4 other species)					Recent estimates of biomass are above the target reference point, and current catches are below the RBC.
Gemfish, eastern zone (*Rexea solandri*)					Biomass is below the limit reference point. Uncertainty remains around total fishing mortality and rebuilding to the limit reference point within the specified time frame.

continued ...

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

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Gemfish, western zone (*Rexea solandri*)					Estimated spawning biomass is above the target reference point. Catches have been stable in recent years and below the RBC.
Gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)					Populations are below the limit reference point, and fishing mortality is uncertain, despite low landed catch and protection from closures.
Jackass morwong (*Nemadactylus macropterus*)					Estimates of spawning biomass are above the limit reference point. Total removals remain below the RBC.
John dory (*Zeus faber*)					Catches and fishing mortality rates are low. Assessment indicates that biomass is above the limit reference point.
Mirror dory (*Zenopsis nebulosa*)					Recent CPUE is above the limit reference point. Total mortality is below RBCs for eastern and western stocks.
Ocean jacket (*Nelusetta ayraud*)					History of stable CPUE, increasing in recent years.
Ocean perch (*Helicolenus barathri*, *H. percoides*)					Recent CPUE (including discards) is above the limit reference point for both species. Total fishing mortality is above the RBC.
Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)					Most recent estimate of spawning biomass (2008) is above the target reference point. Catches since the last estimate have been below the RBC.
Orange roughy, eastern zone (*Hoplostethus atlanticus*)					Most recent stock assessment estimated biomass to be between the limit and target reference points. Fishing mortality has not exceeded TAC.

continued ...

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

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Orange roughy, southern zone (*Hoplostethus atlanticus*)					Negligible catches. Closure of most areas deeper than 700 m. No updated stock assessment.
Orange roughy, western zone (*Hoplostethus atlanticus*)					Negligible catches. Closure of most areas deeper than 700 m. No updated stock assessment.
Smooth oreodory, Cascade Plateau (*Pseudocyttus maculatus*)					Low recent catches. CPUE is above the target reference point.
Smooth oreodory, non–Cascade Plateau (*Pseudocyttus maculatus*)					Closure of most areas deeper than 700 m. Recent CPUE is above the target reference point. New tier 5 assessment indicates catch is below levels that would result in depletion.
Other oreodories (*Allocyttus niger*, *Neocyttus rhomboidalis*, *A. verrucosus*, *Neocyttus* spp.)					Recent CPUE is stable, near the target reference point, and catch is below the RBC. Closure of most areas deeper than 700 m.
Pink ling (*Genypterus blacodes*)					Fishing mortality for both stocks has not exceeded TAC. Western stock is above target. Biomass of eastern stock is between the limit and target reference points.
Redfish (*Centroberyx affinis*)					Biomass is below the limit reference point. Catch is above the tier 1 and tier 4 RBCs. It is unclear if total removals are above the level that will allow rebuilding.
Ribaldo (*Mora moro*)					Standardised CPUE has remained stable and above the target reference point. Catches have remained below RBCs.

continued ...

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

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Royal red prawn (*Haliporoides sibogae*)					Recent average CPUE is above the limit reference point, and catches have been below the RBC in recent years.
Silver trevally (*Pseudocaranx georgianus*)					Recent average CPUE is above the target, and recent catches have been below the RBC.
Silver warehou (*Seriolella punctata*)					Spawning biomass is between the limit and target reference points. Total removals are below the RBC.
Economic status	NER for the CTS were $4.22 million in 2012–13 and $1.82 million in 2013–14 (preliminary). NER have been positive since 2005–06; likely drivers are increased economic productivity and (from 2014 onwards) falls in the price of fuel. Although key species are close to their B_{MEY} targets, improvements in economic status are still possible by rebuilding certain overfished stocks. The disinclination of fishers to fish down blue grenadier stock may suggest that the proxy target is misaligned with the MEY objective, at least in the short term.				

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

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

Hauling the net
SETFIA

9.1 Description of the fishery

Area fished

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

The distribution of many CTS and SHS stocks extends beyond the fishery's boundaries, including into state waters. Under Offshore Constitutional Settlement arrangements, some state jurisdictions have ceded control of SESSF quota-managed species to the Australian Government. In these cases, the catches in state waters by Australian Government–endorsed vessels are debited against their SESSF total allowable catch (TAC) limits. However, New South Wales retains jurisdiction over non-trawl fishers along the New South Wales coastline out to 80 nautical miles (nm) offshore, and over trawl fishers out to 80 nm offshore north of Sydney and out to 3 nm offshore south of Sydney.

Fishing methods and key species

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

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

Management arrangements

Management of the CTS and the SHS follows the SESSF harvest strategy framework (HSF; AFMA 2009a; see Chapter 8), which is based on the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007). Both the CTS and the SHS are managed under individual transferable quotas (ITQs) for key commercial species. TACs are set for quota species for each fishing season and allocated to quota holders. All TACs are determined by the Australian Fisheries Management Authority (AFMA) Commission each year. To help reduce assessment and management costs, and create greater certainty for industry, use of multiyear TACs has been increasing since 2009–10. The AFMA Commission determines TACs each year, irrespective of whether stocks are on multiyear TACs. Breakout rules specify the circumstances for reviewing the stock during the multiyear TAC period, and allow for management intervention in the event of unexpected deviation from predicted stock status trends. Twenty-six stocks were on multiyear TACs across the SESSF in 2016–17 (AFMA 2016a), with 19 reported in this chapter.

A total of 20,095 t of quota was allocated in the CTS and the SHS across all quota species or species groups for the 2016–17 fishing season (1 May 2016 to 30 April 2017). This was a decrease of 888 t from 2015–16 (Table 9.2). Most of the 2016–17 quota (19,471 t) was for target species. A further 409 t was allocated as 'incidental catch allowances' to permit unintentional catches of eastern gemfish (*Rexea solandri*), blue warehou (*Seriolella brama*), orange roughy (*Hoplostethus atlanticus*—southern and western zones[1]) and redfish (*Centroberyx affinis*). Most of the overall quota decrease resulted from decreased TACs for silver warehou (*Seriolella punctata*; –1,208 t), jackass morwong (*Nemadactylus macropterus*; –124 t), mirror dory (*Zenopsis nebulosa*; –112 t) and smaller decreases for other stocks. These decreases were partially offset by TAC increases for pink ling (*Genypterus blacodes*; +164 t), school whiting (*Sillago flindersi*; +121 t), smooth oreodory non–Cascade Plateau (*Pseudocyttus maculatus*; +67), gemfish (western zone; +64) and smaller increases for other stocks.

Fishing effort

In 2016–17, trawlers reported around 52,215 hours of fishing effort—a slight decrease from the 54,890 hours in 2015–16 (Figure 9.3; Table 9.2). The number of active trawlers decreased from 37 in 2015–16 to 34 in 2016–17 (Table 9.2). Danish-seine effort decreased from 10,876 shots in 2015–16 to 10,034 shots in 2016–17, and the number of vessels remained constant at 16 in 2015–16 and 2016–17. Fishing effort in the SHS remained relatively constant, at 3.168 million hooks in 2015–16 and 3.192 million in 2016–17 (Figure 9.4; Table 9.2).

1 The orange roughy southern zone TAC contains both 'incidental' catch allowance and 'target' quota because quota is apportioned as a result of the orange roughy eastern zone stock assessment. Orange roughy from Pedra Branca in the southern zone is included as part of the assessed eastern stock. The incidental catch component was 31 t in 2016–17.

Catch

The total landings of all species managed under TACs from the CTS in 2016–17 were 7,634 t. Flathead, blue grenadier, pink ling, eastern school whiting and orange roughy (eastern zone) accounted for approximately 77 per cent of the landed catch. Flathead catches increased from 2,317 t in 2013–14 to 2,908 t in 2015–16, and then decreased to 2,873 t in 2016–17. Catches of blue grenadier decreased from 3,887 t in 2013–14 to 1,306 in 2016–17, representing around 17 per cent of the quota in 2016–17. The large reduction in blue grenadier catch can be attributed to one factory vessel not fishing the winter spawning aggregation since the 2013–14 fishing season. The total scalefish landings from the GHTS (of which the SHS comprises the primary component reported in this chapter) in the 2016–17 fishing season were estimated to be 729 t, slightly higher than the 656 t landed in the 2015–16 fishing season. Total catch for both sectors reported in this chapter (quota stocks and ocean jackets—non-quota stock) was 8,696 in 2016–17; 7,634 t was from CTS quota stocks, 774 t was from GHTS quota stocks and 288 t was from ocean jacket non-quota stocks (ocean jacket includes both ocean jacket and leather jacket). This was slightly below the total of 9,025 t landed in 2015–16. Approximately 42 per cent of quota was landed across the two sectors in 2016–17 (excluding discards).

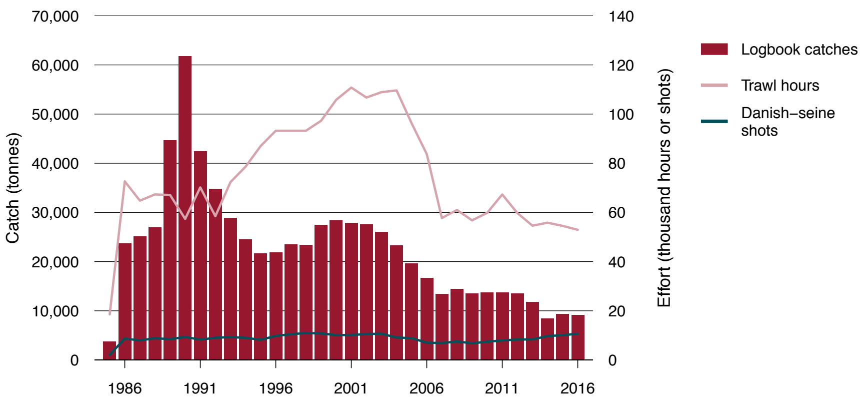
The term ‘landed catch’ refers to the catch that is reported at the port; it excludes discards. Data on discards are collected for the SESSF as part of the Integrated Scientific Monitoring Program. Discard estimates for both the SESSF and state fisheries are presented in Thomson and Upston (2016). The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

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

During 2015–16, scalefish catches in the CTS accounted for 50 per cent of the gross value of production (GVP) in the SESSF. Scalefish GVP in the CTS increased 10 per cent, from $33.53 million in 2014–15 to $36.80 million in 2015–16. The GVP in the SHS increased by 1 per cent, from $4.66 million in 2014–15 to $4.71 million in 2015–16. Overall, the total scalefish GVP in 2015–16 for both sectors was $41.52 million (Table 9.2).

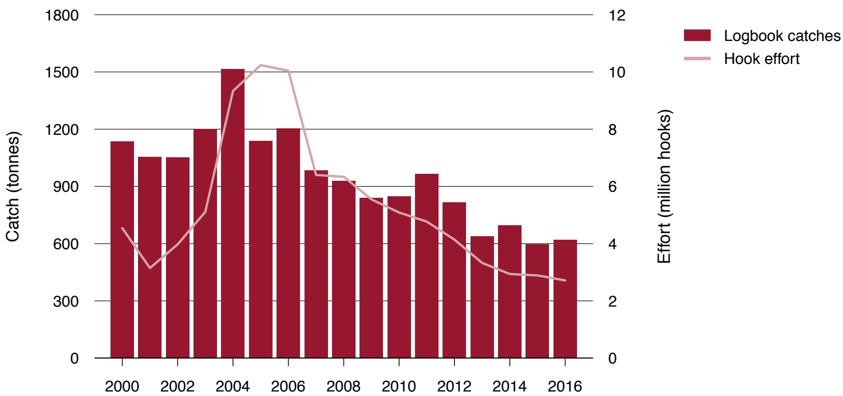
Flathead contributed $18.40 million to GVP in 2015–16, the most of any scalefish (Table 9.2); this was an increase of 16 per cent from $15.64 million in 2014–15. Blue grenadier accounted for $2.24 million, which was 18 per cent higher than in 2014–15 ($1.89 million) but 66 per cent lower than in 2013–14 ($6.66 million). This was the result of lower prices and lower catch. The GVP of pink ling increased slightly (2 per cent), from $4.58 million in 2014–15 to $4.68 million in 2015–16, while the GVP of silver warehou decreased 38 per cent to $0.33 million. The GVP of orange roughy increased 46 per cent to $2.32 million—its highest level in real terms since 2009–10 ($3.46 million).

FIGURE 9.3 Total catch and fishing effort for the CTS, 1985 to 2016



Source: Australian Fisheries Management Authority

FIGURE 9.4 Total catch and fishing effort for the SHS, 2000 to 2016



Source: Australian Fisheries Management Authority

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

Fishery statistics b	2015–16 fishing season			2016–17 fishing season	
Stock	**TAC (t) c**	**Catch (t) (CTS, GHTS)**	**Real value (2015–16)**	**TAC (t) c**	**Catch (t) (CTS, GHTS)**
Blue-eye trevalla	335	298 (20, 278)	$2.57 million	410	432 (45, 388)
Blue grenadier	8,796	1,754 (1 745, 9)	$2.24 million	8,810	1,311 (1,306, 5)
Blue warehou	118 **d**	2 (2, <1)	$0.11 million	118 **d**	16 (16, 0.2)
Deepwater sharks, eastern zone	47	22 (21, 1)	na	47	25 (24, 0.6)
Deepwater sharks, western zone	215	68 (67, 1)	na	215	75 (75, 0.5)
Eastern school whiting	747	733 (733, 0)	$2.10 million	868	718 (717, 0)
Flathead (several species)	2,860	2,908 (2,908, <1)	$18.40 million	2,882	2,874 (2,873, 1)
Gemfish, eastern zone	100 **d**	30 (27, 3)	$0.26 million	100 **d**	30 (24, 6)
Gemfish, western zone **e**	183	81 (76, 5)	0	247	73 (70, 4)
Jackass morwong	598	136 (135, 1)	$0.49 million	474	213 (212, 1)
John dory	169	86 (86, <1)	$0.68 million	167	82 (82, <1)
Mirror dory	437	252 (252, 0)	$0.79 million	325	275 (275, <1)
Ocean perch	166	169 (154, 15)	$0.75 million	190	163 (144, 19)
Orange roughy, Cascade Plateau	500	2	$0 million	500	0
Orange roughy, eastern zone	465	436 (436, 0)	$1.97 million	465	363
Orange roughy, southern zone	66 **f**	57 (57, 0)	$0.19 million	66 **f**	43
Orange roughy, western zone	60 **d**	22 (22, 0)	$0.16 million	60 **d**	22
Smooth oreodory, Cascade Plateau	150	1	na	150	0
Smooth oreodory, non–Cascade Plateau	23	21 (21, 0)	<$0.1 million	90	48 (47, 0.5)
Other oreodories	128	141 (140, <1)	$0.39 million	128	108 (108, <1)
Pink ling	980	825 (519, 306)	$4.68 million	1,144	912 (607, 305)
Redfish	100 **d**	49 (49, <1)	$0.18 million	100 **d**	40 (39, <1)
Ribaldo	335	90 (54, 36)	$0.17 million	355	88 (49, 39)
Royal red prawn	386	183 (183, 0)	$0.69 million	387	127 (127, 0)
Silver trevally	602	72 (72, <1)	$0.29 million	588	53 (52, <1)
Silver warehou	2,417	276 (275, 1)	$0.33 million	1,209	312 (311, <1)

continued ...

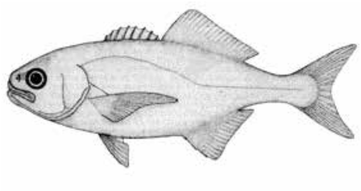
TABLE 9.2 Main features and statistics for the CTS and the GHTS a continued

Fishery statistics b	2015–16 fishing season			2016–17 fishing season	
Non-quota species	**TAC (t) c**	**Catch (t) (CTS, GHTS)**	**Real value (2015–16)**	**TAC (t) c**	**Catch (t) (CTS, GHTS)**
Gulper sharks	na	<1 (<1, 0)	na	na	0.3 (0.3, 0)
Ocean jacket **g**	na	312	$0.52 million	na	289
Total	**20,983**	**9,025**	**$41.52 million**	**20,095**	**8,691**
Fishery-level statistics					
Effort Otter trawl Danish-seine Scalefish hook	 54,890 trawl hours 10,876 shots 3.168 million hooks			 52,215 trawl hours 10,034 shots 3.192 million hooks	
Boat statutory fishing rights	57 trawl; 37 scalefish hook			57 trawl; 37 scalefish hook	
Active vessels	37 trawl; 16 Danish-seine; 18 scalefish hook			34 trawl; 16 Danish-seine; 17 scalefish hook	
Observer coverage CTS Auto-longline (scalefish)	 Trawl: 144 fishing-days Danish-seine: 20 fishing-days 12 sea-days			 Trawl: 129 fishing-days Danish-seine: 25 fishing-days 0 sea-days **h**	
Fishing methods	Trawl, Danish-seine, hook (dropline, demersal longline), trap (minor)				
Primary landing ports	Eden, Sydney and Ulladulla (NSW); Hobart (Tas); Lakes Entrance and Portland (Vic)				
Management methods	Input controls: limited entry, gear restrictions, area closures Output controls: TACs, ITQs, trip limits				
Primary markets	Domestic: Sydney, Melbourne—fresh, frozen International: minimal				
Management plan	*Southern and Eastern Scalefish and Shark Fishery Management Plan 2003*				

a The SHS is managed as part of the GHTS. **b** Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 May to 30 April. Real-value statistics are provided by financial year and were not available for the 2016–17 financial year at time of publication. **c** TACs shown here are the 'agreed' TACs. These may differ from 'actual' TACs, which may include undercatch and overcatch from the previous fishing season. Consequently, catch for some stocks may slightly exceed agreed TACs. **d** Incidental catch allowance. **e** Not including the Great Australian Bight Trawl Sector. **f** Total catch includes a 31 t incidental catch allowance and 35 t of target quota, resulting from apportioning quota from the orange roughy eastern zone stock assessment 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. **h** No human observers deployed in the fishery as electronic monitoring is now mandatory. Video footage of at least 10% of all recorded hauls are reviewed to verify the accuracy of logbooks.
Notes: **CTS** Commonwealth Trawl Sector. **GHTS** Gillnet, Hook and Trap Sector. **ITQ** Individual transferable quota. **na** Not available. **SHS** Scalefish Hook Sector. **TAC** Total allowable catch.

9.2 Biological status

Blue-eye trevalla (*Hyperoglyphe antarctica*)



Line drawing: FAO

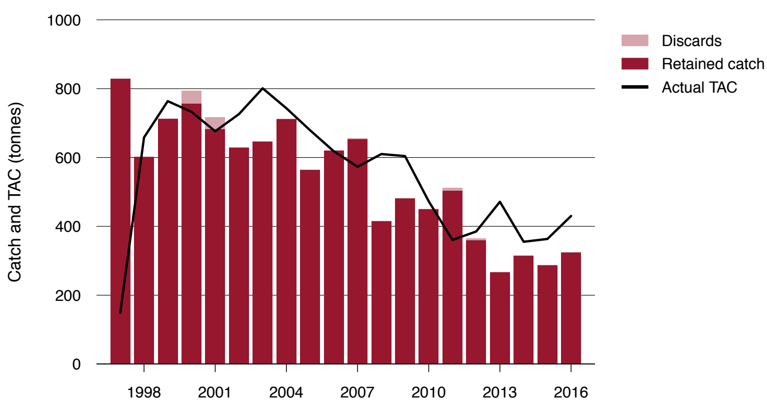
Stock structure

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

Catch history

Commonwealth catches have varied in response to changes in the TAC, but in some years there has been uncaught quota. Blue-eye trevalla catch peaked at over 800 t in 1997 (Figure 9.5). Commonwealth landed catch in the 2016–17 fishing season was 432 t. The weighted average discards between 2012 and 2015 were 0.73 t (Thomson & Upston 2016).

FIGURE 9.5 Blue-eye trevalla annual catches (CTS, SHS and states) and fishing season TACs, 1997 to 2016



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

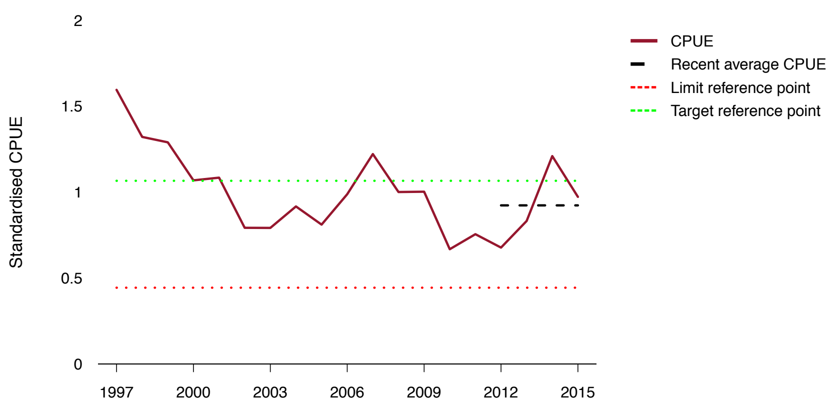
Stock assessment

In 2016, data from 1997 to 2015 were used in a tier 4 analysis of blue-eye trevalla (Haddon 2016a). The data included total catches, total discards and standardised catch-per-unit-effort (CPUE). The catch data used were from the CTS (zones 20 to 50 and the eastern seamounts), but excluded catches from the GABTS (zones 84 and 85). The CPUE standardisation included both the CTS (zones 20 to 50) and the GABTS (zones 84 to 85). The CPUE time series was a combination of catch-per-hook from dropline data (1997 to 2006) and auto-longline data (2002 to 2015)(Figure 9.6). The two time series were combined by setting the mean standardised CPUE in the overlapping period (2002 to 2006) to 1.0, to produce a CPUE time series from 1997 to 2015. This combination was used to provide the earliest possible reference period. Despite not including the GABTS catches, the blue-eye trevalla stock is currently assessed and managed as a single stock across the CTS and the GABTS.

There are various sources of uncertainty in the assessment. Two factors may potentially influence catch rates and fishing behaviour, which may result in CPUE being biased low: the presence of killer whales (orcas—*Orcinus orca*) near fishing operations, and exclusions from historical fishing grounds following closures implemented to rebuild gulper shark stocks (AFMA 2014a). The 2016 assessment did not detect large effects on catch rates due to the closures; however, there remains uncertainty concerning the effect of whale depredations on CPUE.

The 2016 assessment indicates a decrease in CPUE from 2014 to 2015, although this decrease is within the 95 per cent confidence intervals of the mean estimates. Most of the catch is now caught by only a few vessels; consequently, the CPUE is currently more sensitive to changes in the fishing behaviour of these vessels. This is expected to increase the variance of the CPUE (Haddon 2016b).

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



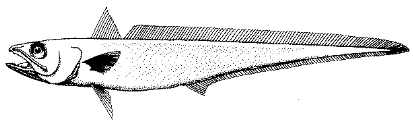
Note: **CPUE** Catch-per-unit-effort.
Source: Haddon 2016b

Stock status determination

The estimated four-year average CPUE (2012 to 2015) is between the limit and the target (Figure 9.6), and the blue-eye trevalla stock is therefore classified as **not overfished**.

For the 2016–17 fishing season, the agreed TAC was 410 t, the actual TAC was 430.121 t and the RBC was 444 t. The catch was 432.91 t, and the weighted average discards were 0.73 t. The catch and discards combined was 433.64 t, which is below the RBC of 444 t. The stock is therefore classified as **not subject to overfishing**.

Blue grenadier (*Macruronus novaezelandiae*)



Line drawing: Rosalind Poole

Stock structure

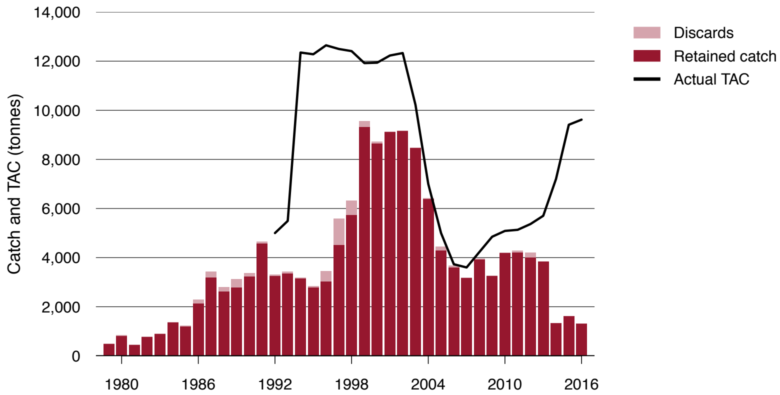
Blue grenadier is assessed as a single stock. There are two defined subfisheries: the winter spawning fishery off western Tasmania and the widely spread catches of the non-spawning fishery.

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

Catch history

The blue grenadier fishery started in the early 1980s, and between 1985 and 1995 mainly targeted non-spawning fish. From 1995 onwards, a fishery developed on spawning aggregations, and total catches increased to average around 8,000 t from 1999 to 2003 (Figure 9.7). Catches since then have varied in response to changes in the TAC and the influence of market conditions. Commonwealth landed catch in the 2016–17 fishing season was 1,311 t. The weighted average discards between 2012 and 2015 were 449 t (Thomson & Upston 2016).

FIGURE 9.7 Blue grenadier annual catches (CTS and SHS) and fishing season TACs, 1979 to 2016



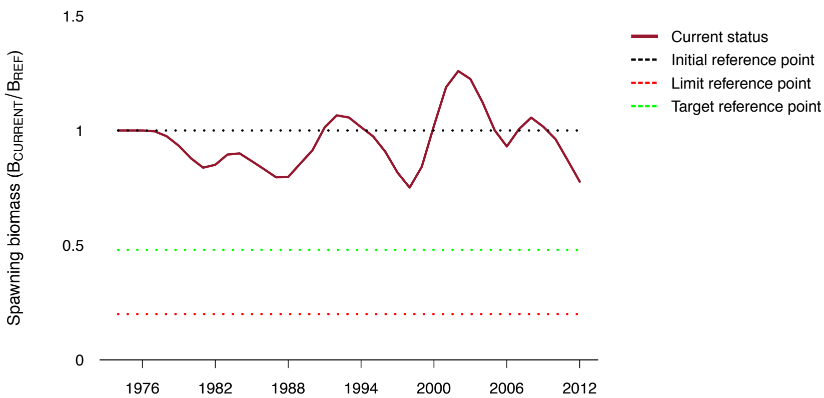
Note: **TAC** Total allowable catch. Data for 2013 to 2016 do not include discards.
Source: Tuck 2013; Australian Fisheries Management Authority catch disposal records (2013 to 2016 data)

Stock assessment

The tier 1 integrated stock assessment was updated in 2013 (Tuck 2013), incorporating data to the end of 2012, as well as estimates of spawning biomass from industry-based acoustic surveys (2003 to 2010) and egg survey estimates of female spawning biomass (1994 to 1995). Results for the base-case model concluded that the spawning biomass in 2012 was around 77 per cent of the unexploited spawning stock biomass (SB_0), and, in 2014, was forecast to be approximately 94 per cent of SB_0 (Tuck 2013; Figure 9.8).

Blue grenadier was subject to multiyear TACs of 4,700 t for the 2009–10 to 2011–12 seasons, and 5,208 t for the 2012–13 and 2013–14 seasons. The 2013 assessment estimated a substantially increased three-year RBC of 8,810 t, starting in 2014–15. A 2014–15 TAC of 6,800 t was implemented, after considering industry's preference for a cautious approach to increasing the TAC, to promote economic stability (AFMA 2014b). The multiyear TAC increased to 8,796 t in the 2015–16 season and to 8,810 t in the 2016–17 season.

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



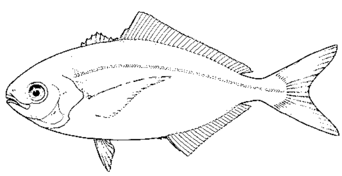
Source: Tuck 2013

Stock status determination

Blue grenadier remains classified as **not overfished** because the most recent assessment (Tuck 2013) indicated that the spawning biomass was above the target reference point.

For the 2016–17 fishing season, the agreed TAC was 8,810 t, the actual TAC was 9,618 t and the RBC was 8,810 t. The landed catch was 1,312 t, and the weighted average discards were 449.15 t. The landed catch and discards combined was 1,761.15 t, which is below the RBC of 8,810 t. As a result, blue grenadier remains classified as **not subject to overfishing**.

Blue warehou (*Seriolella brama*)



Line drawing: Rosalind Poole

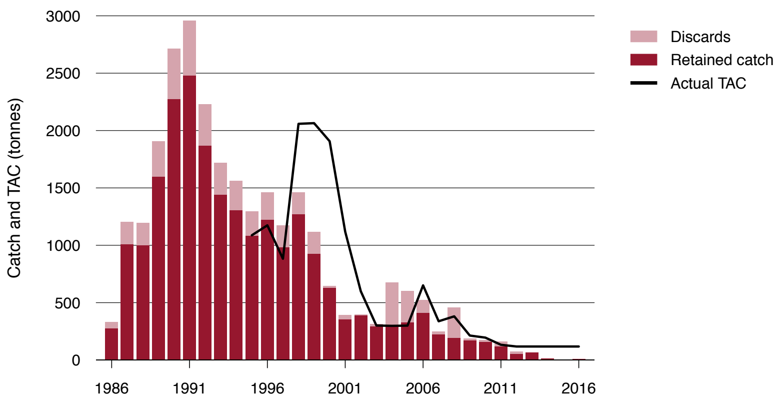
Stock structure

Blue warehou is assumed to have separate eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks (Morison et al. 2013). These stocks are assessed separately, but status represents the combined stocks because the TAC is set at this level.

Catch history

Landings of blue warehou peaked in 1991 at 2,478 t (Figure 9.9). Catch has since declined, with less than 500 t landed per year since 2000. A rebuilding strategy that established blue warehou as an incidental catch-only species was first implemented in 2008, with the objective of rebuilding stocks by 2024. Landed catches since then have shown a continued decline, and most recently decreased from 65 t in 2013–14 to 16 t in 2014–15, and to 2 t in 2015–16. However, 6.5 t was reported in logbooks for 2015–16; the reason for the discrepancy is unclear but may reflect misidentification by fishers. Commonwealth landed catch in the 2016–17 fishing season was 16.03 t. The weighted average discards between 2012 and 2015 were 8.68 t (Thomson & Upston 2016).

FIGURE 9.9 Blue warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2016



Notes: **TAC** Total allowable catch. Data for 2013 to 2016 do not include discards and state catch.
Source: Haddon 2013a; Australian Fisheries Management Authority catch disposal records (2013 to 2016 data)

Stock assessment

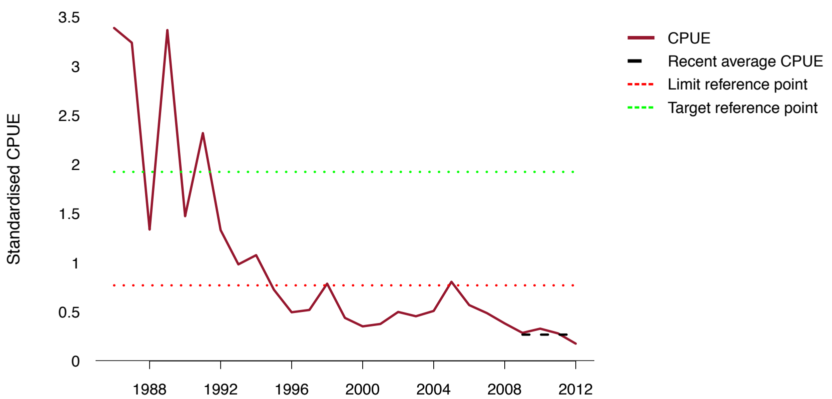
Blue warehou has been classified as overfished since 1999 and is currently subject to a stock rebuilding strategy (AFMA 2014c). In February 2015, the species was listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Department of the Environment 2015). The stocks are managed under the SESSF tier 4 HSF and assessed using standardised CPUE to determine RBCs. The standardised CPUE series of both the eastern and western blue warehou stocks estimate declines after the 1986 to 1995 reference period (Haddon 2013a). 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 all years since 1995, except for 1998 and 2005 (Figures 9.10 and 9.11). Under the HSP, RBCs for overfished stocks are zero.

Although each CPUE series is presented as a continuous line, they should be interpreted in two separate periods for each stock (Figures 9.10 and 9.11). The CPUE for the reference period (1986 to 1995) estimates relative abundance when there was no quota management or rebuilding strategy in place. The period after 1995 includes the period of quota-based management measures and, from around 2000 onwards, efforts by the South East Trawl Fishing Industry Association and AFMA to limit targeting. Consequently, CPUE outside the reference period (1986 to 1995) may not be an accurate index of biomass. The ongoing decline in landed catches may reflect one or more factors, including a better ability by fishers to avoid catches, the low incidental bycatch allowances, lower abundance or lower availability. However, there is no evidence to suggest that blue warehou has rebuilt to above the limit reference point.

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

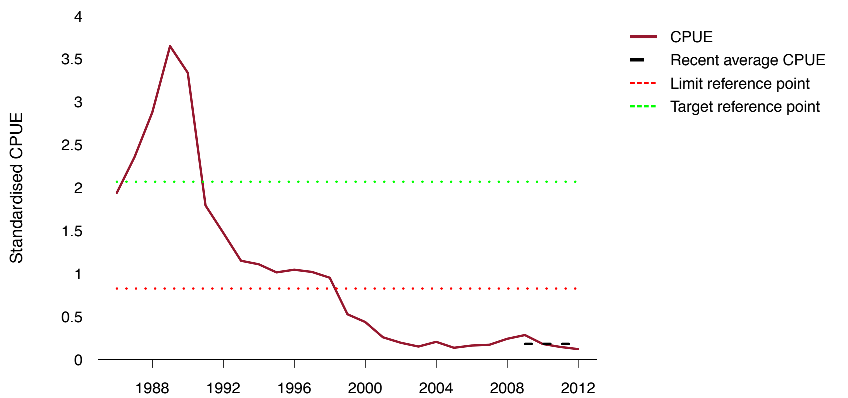
The 2008 rebuilding strategy for blue warehou was revised in 2014. It aims to prevent targeted fishing for blue warehou, minimise incidental catches and improve knowledge of stock status, with the goal of rebuilding blue warehou stocks to the limit reference point by or before 2024. In September 2015, the Shelf Resource Assessment Group (ShelfRAG—the precursor to SERAG) discussed whether the rebuilding strategy for blue warehou was meeting its objectives (AFMA 2015a), and noted range contraction and a lack of signs of recovery. It also noted that current SESSF catches, even with low recruitment, should not be impeding recovery.

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 to 1995) is unlikely to accurately reflect biomass.
Source: Haddon 2013a

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 2013a

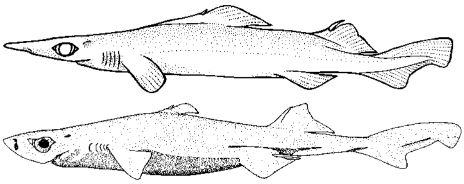
Stock status determination

Blue warehou remains classified as **overfished** because there is no evidence to suggest that the stock has rebuilt to above the limit reference point.

Blue warehou is under a rebuilding strategy. The incidental catch allowance is 118 t. The landed catch for 2016–17 was 16 t, and the weighted average discards were 8.68 t. The catch and discards combined was 24.68 t, which is below the incidental catch allowance of 118 t. The level of fishing mortality that will allow the stock to rebuild is unknown. The stock is therefore classified as **uncertain** with regard to fishing mortality.

Fishing vessels in port
AFMA

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: 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), lantern shark (*Etmopterus* species) and other sharks (Klaer et al. 2014). The black shark is possibly confounded with roughskin and black (roughskin) shark, and Plunket's dogfish is possibly also confounded with the roughskin shark group. The pearl shark group is a combination of the brier and platypus sharks (Haddon 2013a).

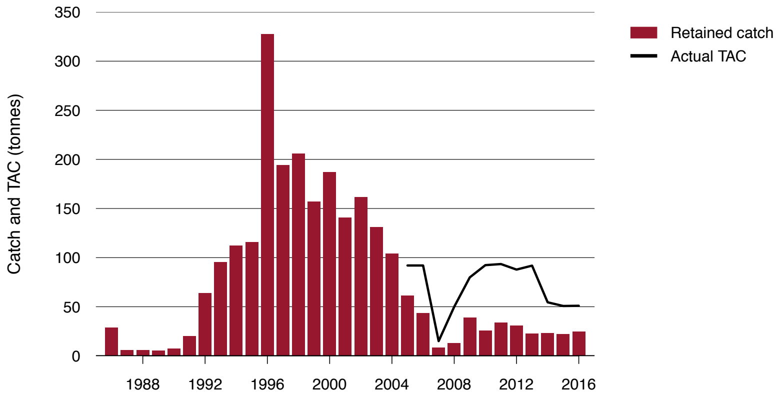
Little is known about the stock structure of these deepwater sharks. They are benthopelagic species that have been sampled in oceanic environments over the abyssal plains, and are distributed widely across ocean basins, and along the middle and lower continental shelves. The management boundary between eastern and western deepwater shark quota is the same as that used for gemfish. The eastern area 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 area includes the remainder of the SESSF, around to Western Australia. This boundary cuts across deepwater shark trawl grounds. The most likely biological boundary for these species is the biogeographical boundary between the two systems dominated by the Eastern Australian Current and the Leeuwin Current off the south coast of Tasmania (Morison et al. 2013).

Catch history

The eastern deepwater shark fishery started in about 1990. Landed catches increased steadily to around 200 t in 1998, with a single higher peak of about 330 t in 1996, before decreasing steadily to around 25 t in recent years (Figure 9.12). The eastern catch in the 2016–17 season was 25 t, below the eastern TAC of 47 t. The western catch followed a similar trend, starting in 1993; it increased to a peak of about 400 t in 1998, before decreasing steadily to less than 10 t in 2007. Catch in the 2016–17 fishing season was 75 t, below the western TAC of 215 t (Figure 9.13).

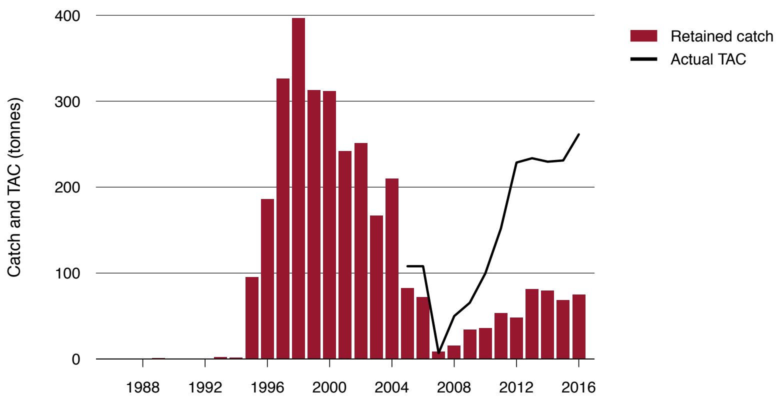
TACs for the deepwater shark multispecies stock are set separately for the eastern and western areas, and cover all deepwater shark species taken in those areas. In 2016–17, platypus sharks (mixed), roughskin dogfishes (mixed) and sleeper sharks (mixed) accounted for most of the catch in the east; and platypus sharks (mixed), longsnout dogfish and sleeper sharks (mixed) accounted for most of the catch in the west. Discards estimates for deepwater shark were not determined (Thomson & Upston 2016).

FIGURE 9.12 Deepwater shark annual catches (CTS) and fishing season TACs, eastern zone, 1986 to 2016



Notes: **TAC** Total allowable catch. Data for 2011 to 2016 include catch disposal records from the CTS and the SHS.
Source: Australian Fisheries Management Authority catch disposal records (2011 to 2016 data)

FIGURE 9.13 Deepwater shark annual catches (CTS) and fishing season TACs, western zone, 1986 to 2016



Notes: **TAC** Total allowable catch. Data from 2011 to 2016 include catch disposal records from the CTS and the SHS.
Source: Australian Fisheries Management Authority catch disposal records (2011 to 2016 data)

Stock assessment

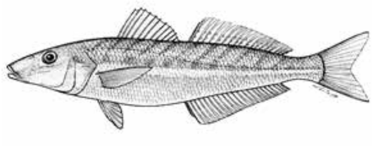
Reliable data on historical catch and discards are lacking. This paucity of data, together with the multispecies nature of the stock and difficulties in species identification by fishers, means that the standardised CPUE series may not be a reliable index of abundance for the individual species or the multispecies stock (Haddon 2013a). In the absence of better data, these stocks are assessed using standardised CPUE under tier 4. Since 2009, the CPUE trend in the eastern zone has been declining, with the recent four-year average being about halfway between the target and limit reference points. SlopeRAG recommended an RBC of 78 t or a multiyear TAC of 47 t, based on the past three years of CPUE. AFMA implemented a three-year multiyear TAC of 47 t for eastern deepwater shark for the 2014–15 to 2016–17 fishing seasons. The recent four-year average CPUE in the west was substantially higher than the target, and SlopeRAG recommended an RBC of 300 t or a TAC of 263 t, based on the past three years of CPUE (AFMA 2013a). Following support for a cautious approach from industry and SlopeRAG, AFMA extended the current TAC into a three-year multiyear TAC of 215 t for western deepwater shark for the 2014–15 to 2016–17 fishing seasons.

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

Stock status determination

Given the large area closed to fishing (from which historical catch was taken) and the low catches in recent years, the eastern and western deepwater shark stocks are classified as **not subject to overfishing**. Because deepwater sharks are multispecies stocks, and robust data on historical catch composition and discards are lacking, CPUE is unlikely to provide a reliable index of abundance for these stocks or their component species. As a result, these stocks are classified as **uncertain** with regard to the level of biomass.

Eastern school whiting (*Sillago flindersi*)



Line drawing: FAO

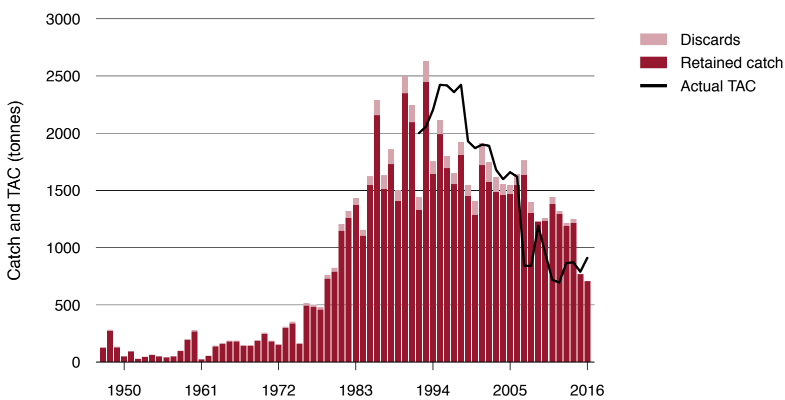
Stock structure

Eastern school whiting occurs from southern Queensland to western Victoria. Genetic studies have suggested two stocks in this range, with the division between a 'northern' stock and a 'southern' stock in the Sydney – Jervis Bay area. However, the evidence for two stocks was weak, and current SESSF management and stock assessment assume a single stock (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. Commonwealth landed catch in the 2016–17 fishing season was 718 t, taken from the CTS (Figure 9.14). The weighted average discards between 2012 and 2015 were 55.13 t (Thomson & Upston 2016).

FIGURE 9.14 Eastern school whiting annual catches (CTS, SHS and state combined) and fishing season TACs, 1947 to 2016



Notes: **TAC** Total allowable catch. Data up to 2014 include Commonwealth and state catches and discards; 2015 to 2016 data do not include state catches and discards.
Source: Australian Fisheries Management Authority catch disposal records (2009 to 2016 catch data); CSIRO Integrated Scientific Monitoring Program (2009 to 2014 discard data)

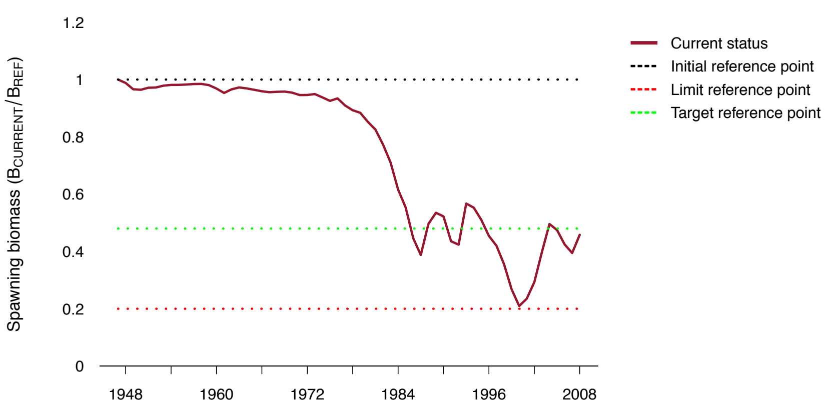
Stock assessment

Estimates of eastern school whiting biomass have varied considerably between successive assessments, largely as a result of the variable and relatively late age of recruitment to the fishery (two to three years) for this short-lived species (with a lifespan of seven years; Day 2012). The most recent full assessment of eastern school whiting was in 2009 (Day 2010), using data up to 31 December 2008. It predicted that the spawning stock biomass would be 50 per cent of the unfished biomass ($0.5SB_0$) in 2010, slightly above the target biomass ($0.48SB_0$) (Figure 9.15). The long-term RBC recommendation at the time was 1,660 t per year. The assessment was updated in 2010 and 2011, using catch, discard, age and length data (Day 2011, 2012). The estimated level of depletion in the updated assessment was approximately 30 per cent of the unfished biomass ($0.3SB_0$; see figure 12.26 in Day 2012).

Day (2012) reported on stock status projections under a range of alternative levels of fixed catch over an 18-year projection period. With a constant catch of 1,700 t per year, the probability of the spawning stock biomass falling below the $0.2SB_0$ limit reference point was estimated to be less than 10 per cent for the base-case model (Day 2012). After taking the uncertainty around biomass estimates into account, ShelfRAG recommended a long-term RBC of 1,660 t for 2013–14 onwards (AFMA 2014d).

Historically, most of the total catch of eastern school whiting has come from New South Wales state waters. In recent years, the catch in these waters has decreased from historical levels of approximately 1,000 t per year to around 400 t. ShelfRAG has expressed concern that biological and fishery information for eastern school whiting has been collected from a relatively small area of the fishery (primarily from the Lakes Entrance Danish-seine fleet) and may not be representative of the species distribution that extends from Queensland to western Victoria. Given these concerns and the variability in model estimates of biomass for eastern school whiting, there is ongoing work on characterising the available school whiting data and proposed stock assessment structure to support a new assessment in the future.

FIGURE 9.15 Spawning stock biomass for eastern school whiting, 1945 to 2008



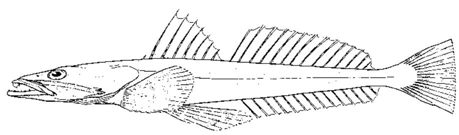
Source: Day 2010

Stock status determination

The most recent full assessment (Day 2010) forecasted spawning stock biomass to be approximately 50 per cent of the unfished level at the beginning of 2010, which is above the target reference point. The updates of this assessment with more recent data estimated levels of biomass depletion at approximately 30 per cent (Day 2012). Standardised CPUE to 2015 (Sporcic & Haddon 2016), and size and age composition data from observers and port sampling (Thomson et al. 2016) do not indicate any concerning trends for stock status. As a result, school whiting is classified as **not overfished**.

For the 2016–17 fishing season, the agreed TAC was 868 t, the actual TAC was 911.2 t and the RBC was 1,660 t. Total landed catch was 717.7 t, and the weighted average discards were 55.13 t. The landed catch and discards combined was 772.83 t, which is below the RBC of 1,660 t. The stock is therefore classified as **not subject to overfishing**.

Flathead (*Neoplatycephalus richardsoni* and four other species)



Line drawing: Rosalind Poole

Stock structure

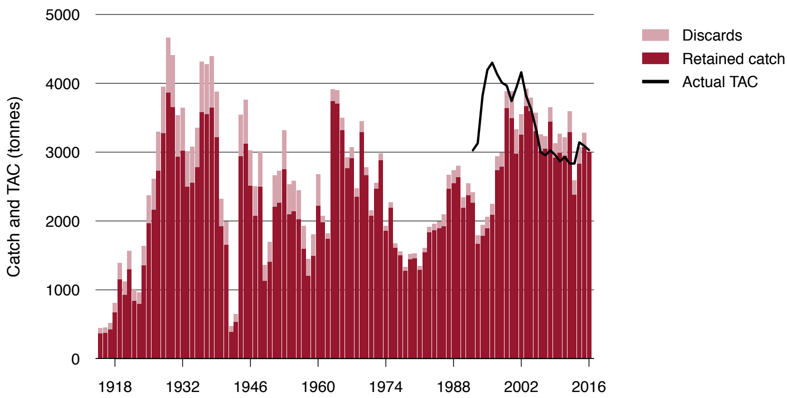
For SESSF management purposes, 'flathead' refers to a group of species. However, the catch is almost entirely tiger flathead (*Neoplatycephalus richardsoni*). It includes sand flathead (*Platycephalus bassensis*) and, from 1996 onwards, southern or 'yank' flathead (*P. speculator*), bluespot flathead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

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. 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 9.16). Catch in recent decades has been relatively stable at approximately 3,000 t (Figure 9.16). The Commonwealth landed catch of flathead in the 2016–17 fishing season was 2,875 t, taken almost fully from the CTS (Table 9.2). The weighted average discards between 2012 and 2015 were 225.18 t (Thomson & Upston 2016).

FIGURE 9.16 Flathead annual catches (CTS and state combined) and fishing season TACs, 1915 to 2016



Notes: TAC Total allowable catch. Data for 2016 do not include discards and state catch.
Source: Day & Klaer 2013; Australian Fisheries Management Authority catch disposal records (2013 to 2016 data)

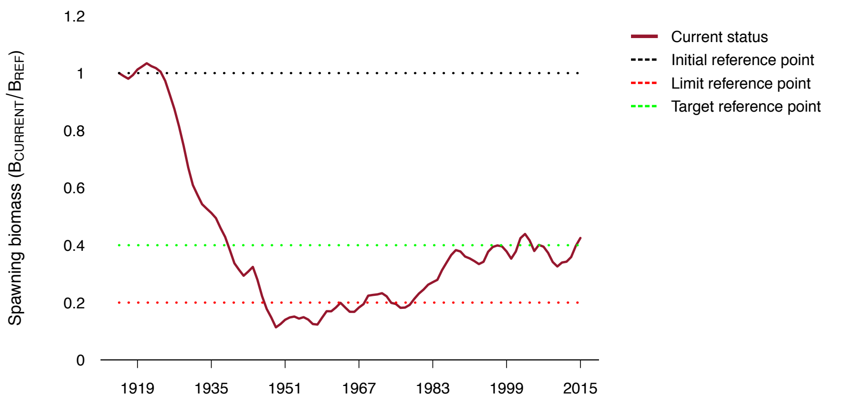
Stock assessment

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

The 2013 tier 1 assessment (Day & Klaer 2013) was updated in 2016 (Day 2016) and finalised in January 2017 (Day 2017). The assessment was updated with catch, discard, CPUE, length and age data, and ageing error data for an additional three years to 2015 (Day 2016). The assessment reports spawning biomass depletion as a percentage of its unfished level. The final base-case model forecasted the 2017 spawning stock biomass to be 42 per cent of unfished spawning biomass (Day 2017; Figure 9.17). This was a reduction from the spawning stock biomass forecast in 2014, which was 50 per cent of unfished spawning biomass (Day & Klaer 2013).

The target reference point for flathead has been set at $0.4B_0$ (Morison et al. 2013), reflecting a more conservative biomass at maximum sustainable yield (B_{MSY}) than the 2013 assessment's model-estimated B_{MSY} and biomass at maximum economic yield (B_{MEY}) of $0.32B_0$ and $0.38B_0$, respectively. Using $0.4B_0$ as the target reference point, the 2013 assessment (which was used to derive the TAC for the 2016–17 fishing season) estimated a three-year RBC of 3,334 t and a five-year RBC of 3,252 t. The TAC for the 2016–17 fishing season was 2,882 t.

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



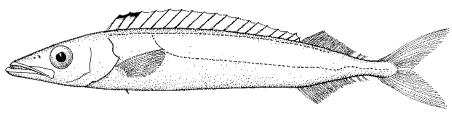
Source: Day 2016, 2017

Stock status determination

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

For the 2016–17 fishing season, the agreed TAC was 2,882 t, the actual TAC was 3,030.6 t and the RBC was 3,334 t. Total landed catch was 2,875 t, and the weighted average discards were 225.18 t. The landed catch and discards combined was 3,100.18 t, which is below the RBC of 3,334 t. The stock is therefore classified as **not subject to overfishing**.

Gemfish, eastern zone (*Rexea solandri*)



Line drawing: Sharne Weidland

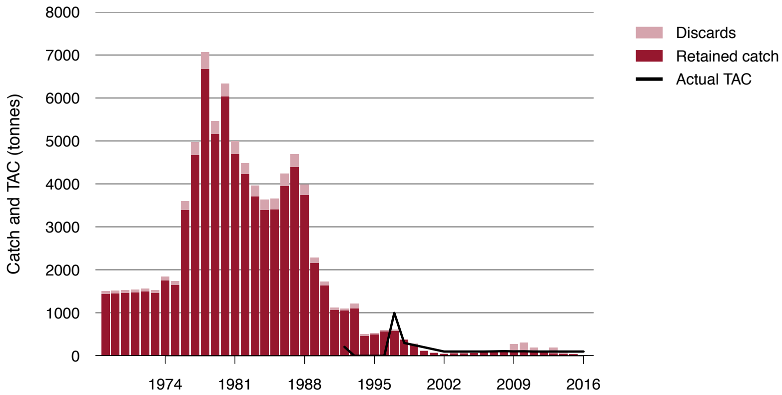
Stock structure

There are two biologically distinct stocks of gemfish in Australia: an eastern stock and a western stock, separated by a boundary at the western end of Bass Strait (Colgan & Paxton 1997; Moore et al. in press).

Catch history

Catch of gemfish (eastern zone) peaked in 1978 at more than 6,000 t. Catch decreased rapidly after about 1987 (Figure 9.18). Commonwealth landed catch in the 2016–17 fishing season was 30.4 t. The weighted average discards between 2012 and 2015 were 46.84 t (Thomson & Upston 2016).

FIGURE 9.18 Gemfish annual catches (CTS, SHS and state combined) and fishing season TACs, eastern zone, 1968 to 2016



Notes: **TAC** Total allowable catch. Data for 2015 to 2016 do not include discards and state catch.
Source: Little & Rowling 2011; Australian Fisheries Management Authority catch disposal records (2009 to 2016 data); CSIRO Integrated Scientific Monitoring Program (2009 to 2014 discard data)

Stock assessment

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

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

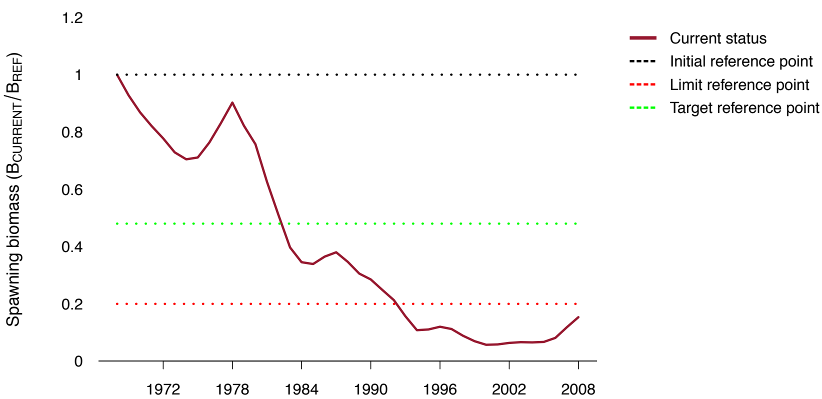
In 2011, ShelfRAG considered an analysis of spawning potential ratio (SPR) based on the 2010 assessment (Little 2012). The SPR provides a measure of annual fishing mortality, expressed as the ratio of the spawning ability of the current stock to that of the unfished ('equilibrium') stock. The SPR analyses (Little 2012) suggest high fishing mortality rates for eastern gemfish until the late 1990s, but much lower rates since 2002. The SPR fell to less than 30 per cent of the unfished level in the late 1980s, but has remained above 80 per cent since 2002 (Little 2012).

The revised eastern gemfish stock rebuilding strategy (AFMA 2015b) states that eastern gemfish should be rebuilt to, or above, the limit reference point by 2027 (19 years from 2008). However, this rebuilding projection is based on average levels of recruitment and assumes that total removals are limited to the 100 t incidental catch allowance.

For the 2016–17 fishing season, trawl (24 t) and non-trawl (6 t) landings (30 t in total) were comparable to the landings in the previous two seasons (37 t in 2014–15 and 30 t in 2015–16). Discards in 2014 and 2015 were 33 t and 35 t, respectively. These are lower than the 2013 discards, which were around 131 t—around double the landed catch at the time (Thomson & Upston 2016). For the 2016–17 season, total removal was 77.24 t (30.4 t was landed and weighted average discards were 46.84 t), which is below the 100 t incidental catch allowance. Stronger year-classes moving through the fishery and high discard rates may be a sign of increased recruitment and stock rebuilding; however, age-frequency data for 2014 show a strong truncation, with few mature fish (Thomson et al. 2015a). The reasons for this are unclear; contributing factors may include industry efforts to avoid the species, unfavourable environmental conditions, or distribution of the fish in the population.

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

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



Source: Little & Rowling 2011

Stock status determination

The most recent (2010) estimate of spawning stock biomass was 15.6 per cent of the 1968 level in 2008, which is below the limit reference point ($0.2SB_0$). As a result, eastern gemfish remains classified as **overfished**.

Total landed catch was 30.3 t, and the weighted average discards were 46.84 t. The landed catch and discards combined was 77.14 t, which is below the incidental catch allowance of 100 t for the 2016–17 fishing season. The recent catch history includes years when the incidental catch allowance was exceeded, indicating that management arrangements may not be sufficient to limit fishing mortality. The stock is therefore classified as **uncertain if subject to overfishing**.

Gemfish, western zone (*Rexea solandri*)

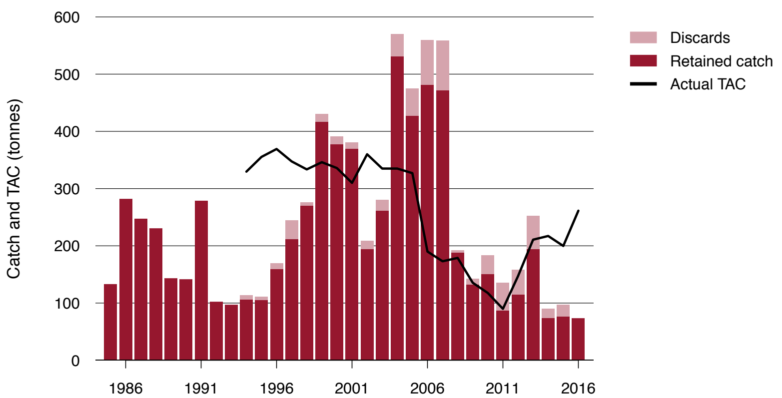
Stock structure

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

Catch history

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

FIGURE 9.20 Gemfish annual catches (CTS and SHS) and fishing season TACs, western zone, 1986 to 2016



Note: **TAC** Total allowable catch. Data for 2016 exclude discards.
Source: Haddon 2013a; Australian Fisheries Management Authority catch disposal records (2013 to 2016 catch data)

Stock assessment

Management arrangements for western gemfish currently differ between the CTS and the GABTS. Western gemfish catch in the CTS is currently restricted by a three-year multiyear TAC. The GABTS has not moved to implement quota for western gemfish, instead relying on a catch trigger, under which a full assessment must be undertaken if catch exceeds 1,000 t over three years (AFMA 2014e).

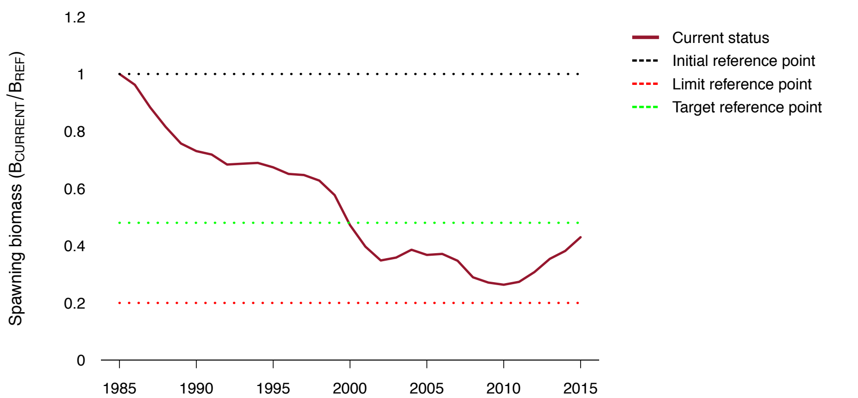
In 2016, western gemfish was assessed using both a tier 4 and a tier 1 analysis, using data from 1986 to 2015 (Haddon 2016b; Helidoniotis & Moore 2016).

The current tier 4 assessment includes updated data for total catches, total discards and the standardised CPUE from the CTS only (zones 40 and 50). There are uncertainties about the discard data—the amount of discarding varies between years, and the reporting of discards is uncertain (Helidoniotis & Moore 2016).

The 2016 tier 1 assessment was an update of the 2014 assessment. It included updated data from both the CTS and the GABTS. Data included catch-and-effort data, and age error data. The estimated spawning biomass depletion for the CTS and the GABTS combined from the tier 1 assessment was 43 per cent, which is between the limit ($0.2SB_0$) and target ($0.48SB_0$) reference points (Figure 9.21).

The standardisation of the CPUE series for western gemfish accounts for vessel participation and gear variability. However, the varying discard rate changes in fishing grounds and the potential for hyperstability in this aggregating species (that is, the CPUE remains stable while stock biomass is changing) are not explicitly accounted for in the standardisation. If CPUE estimates are not indexing stock biomass, then CPUE estimates may mislead both tier 4 and tier 1 assessments (Haddon 2016b).

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



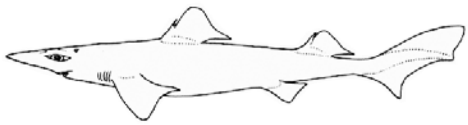
Source: Helidoniotis & Moore 2016

Stock status determination

The estimated spawning biomass depletion for the CTS and the GABTS combined from the tier 1 assessment was 43 per cent, which is between the limit ($0.2SB_0$) and target ($0.48SB_0$) reference points. The stock is therefore classified as **not overfished**.

The agreed and actual TACs were 247 and 261 t, respectively. The landed catch for the 2016–17 season was 73.3 t, and the weighted average discards were 63.07 t, giving a total of 136.37 t, which is below the estimated RBC of 247 t. The stock is therefore classified as **not subject to overfishing**.

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



Line drawing: FAO

Stock structure

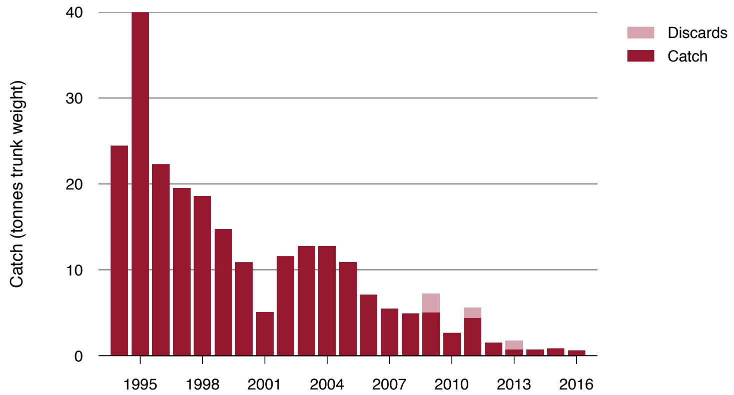
Gulper sharks are assessed as a multispecies stock. Harrisson's dogfish (*Centrophorus harrissoni*) is endemic to south-eastern Australia, from southern Queensland to south-eastern Tasmania, and adjacent seamounts. Southern dogfish (*C. zeehaani*) is endemic to southern Australia, from Shark Bay in Western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

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

Catch history

Estimated landings of gulper sharks (derived from liver oil production from 1994 to 2001) averaged about 20 t (trunk weight) from 1994 to 1998, with a peak of 40 t in 1995. Catches averaged about 10 t from 2002 to 2005 and have since declined. Despite gulper sharks being a no-take multispecies stock, landings for the trawl fishery were 0.3 t in the 2016–17 season (Figure 9.22). This may reflect reporting errors.

FIGURE 9.22 Gulper shark annual catch and discards for the SESSF (all sectors), 1994 to 2016



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, similar to many other deepwater sharks, have very low productivity due to a slow growth rate, late age at maturity and low fecundity. These life-history characteristics place them at higher risk of rapid depletion at low levels of fishing effort, and make their recovery slow once stocks are depleted (Daley et al. 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 coincides with the most depleted areas of Harrisson's and southern dogfish. Post-capture survival of gulper sharks in the trawl sector is low; most gulper sharks are dead when the net is hauled. In the auto-longline sector, post-capture survival is potentially higher (subject to fishing gear soak time and handling practices); a preliminary study by CSIRO estimated post-capture survival at 60–93 per cent for the 70 southern dogfish tagged and released in the study (Williams et al. 2013).

Gulper sharks were historically targeted because they have high squalene (liver oil) content. The resulting historical depletion of gulper sharks off the east coast is well documented (Graham et al. 2001; Wilson et al. 2009). Graham et al. (2001) reported declines in catch rate of 95.8–99.9 per cent between research trawl surveys conducted in 1976–77 and 1996–97 for greeneye spurdog, and endeavour, Harrisson's and southern dogfish on the New South Wales upper slope. Williams et al. (2013) derived depletion estimates for the identified subpopulations of Harrisson's and southern dogfish, expressed as a percentage of the initial relative carrying capacity. For Harrisson's dogfish, the continental margin population was estimated to be at 11 per cent of carrying capacity (range 4–20 per cent) and the seamount population at 75 per cent (range 50–100 per cent). For southern dogfish, the eastern population was estimated to be at 11 per cent of carrying capacity (range 6–19 per cent) and the central population at 16 per cent (range 8–33 per cent). No estimate could be derived for the western population of southern dogfish because of limited data availability. Williams et al. (2013) confirmed that, in some areas, large reductions in abundance had resulted from quite low levels of fishing effort.

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

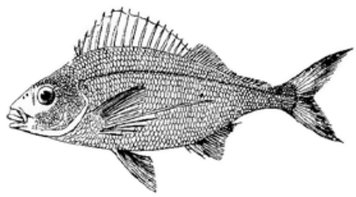
On 30 May 2013, the Minister for Sustainability, Environment, Water, Population and Communities listed Harrisson's dogfish and southern dogfish under the EPBC Act as threatened species in the conservation dependent category. The minister noted that both species have experienced severe historical declines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

Stock status determination

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

The level of reported catch (including discards) has declined over the past decade, and was very low in the 2015–16 and 2016–17 fishing seasons (<1 t and 0.3 t, respectively). However, there is 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. Although it has been estimated that the closures implemented in 2013 will protect 16.2–25 per cent of the core distribution areas of these species, no evidence has yet been obtained showing rebuilding, and the effect of the closures remains to be seen. As a result, gulper sharks are classified as **uncertain** with respect to the level of fishing mortality. Resolution of stock structure may result in one or more of the subpopulations being classified as not subject to overfishing.

Jackass morwong (*Nemadactylus macropterus*)



Line drawing: FAO

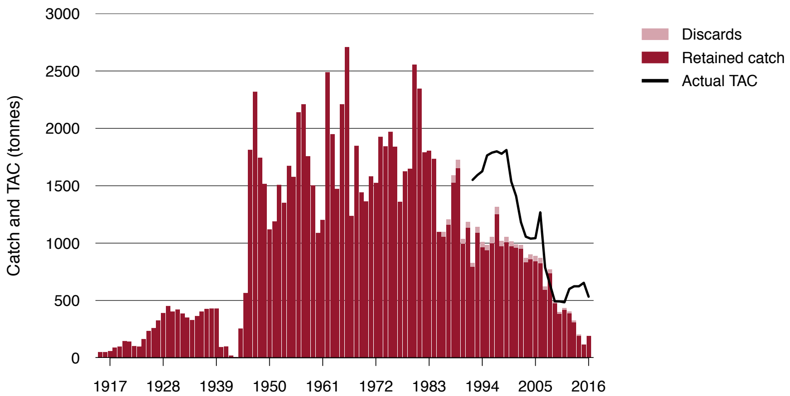
Stock structure

Jackass morwong is distributed around the southern half of Australia (including Tasmania), New Zealand, and St Paul and Amsterdam islands (Indian Ocean); and off south-eastern South America and southern Africa. It occurs to depths of 450 m and, in Australian waters, is most abundant between 100 and 200 m. Genetic studies have shown no evidence of separate stocks in Australian waters, but found that New Zealand and Australian stocks are distinct (Elliott & Ward 1994). Although analysis of otolith microstructure found differences between jackass morwong from southern Tasmania and those off New South Wales and Victoria, it is unclear whether such differences indicate separate stocks (Morison et al. 2013). Nonetheless, it is assumed for the purposes of the stock assessment that there are separate stocks of jackass morwong in the eastern and western zones (Morison et al. 2013), and therefore separate quantitative (tier 1) stock assessment models are undertaken for the eastern (southern New South Wales to eastern Tasmania) and western (western Tasmania to western Victoria) stocks. Catches of jackass morwong are also reported from the GABTS (Chapter 11), but this stock is currently managed separately from the western stock.

Catch history

Catches of jackass morwong peaked at more than 2,500 t in the mid 1960s and have declined since the 1980s. They have continued to decline over the past five years and have been less than 500 t per year (Figure 9.23). Commonwealth landed catch in the 2016–17 fishing season was 213 t. The weighted average discards between 2012 and 2015 were 30.25 t (Thomson & Upston 2016).

FIGURE 9.23 Jackass morwong annual catches (CTS, SHS and state combined) and fishing season TACs, east – and west – stocks combined, 1915 to 2016



Notes: **TAC** Total allowable catch. Data for 2015 to 2016 do not include discards and state catches.
Source: Tuck et al. 2015; Australian Fisheries Management Authority catch disposal records (2016 catch data)

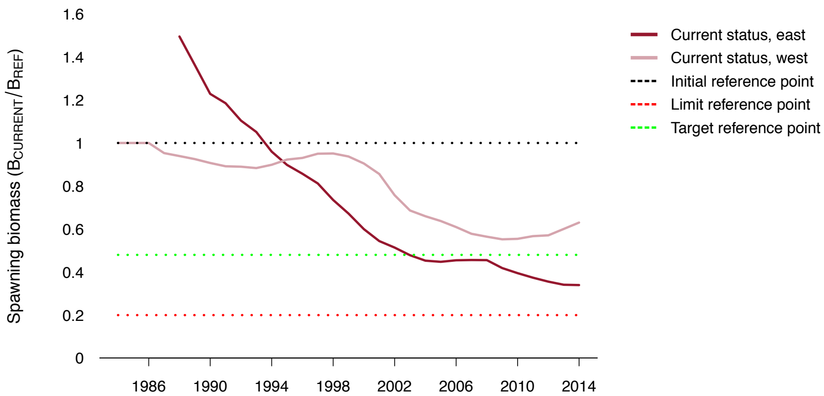
Stock assessment

The eastern and western stocks were assessed in 2011 (Wayte 2012), 2013 (Wayte 2014) and 2015 (Tuck et al. 2015). Assessments of western jackass morwong are uncertain because only sporadic age data are available, length compositions are based on a very low number of sampled fish, and catches in the west are low (only 23 t was reported in logbooks in 2015–16) (AFMA 2015a). While noting these concerns, ShelfRAG accepted the 2015 assessment (AFMA 2015c) because the outcome of the 2015 assessment was reasonably consistent with the 2011 assessment. The 2015 assessment predicted the spawning stock biomass to be $0.69B_0$ in 2016 (compared with $0.68B_0$ in 2012), which is above the target reference point of $0.48B_0$ (Figure 9.24).

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

ShelfRAG (AFMA 2011) noted that model estimates of recruitment for the eastern stock since the late 1980s have been consistently below the average predicted by the stock–recruitment relationship. In 2011, ShelfRAG accepted a new base-case assessment for the eastern stock that involved a change in productivity (a 'regime shift'), attributed to long-term oceanographic changes (Wayte 2013). The assessment for the eastern stock uses separate stock–recruitment relationships before and after 1988, with lower recruitment after 1988. Compared with older assessments, the 2012 and 2015 assessments provided a better fit to the data, although they remained sensitive to the value of natural mortality and the choice of the last year for which recruitment was estimated. Management strategy evaluation predicted a lower risk of the biomass falling below the limit reference point if total removals were consistent with the RBCs derived from the assessments that assumed this recruitment shift (Morison et al. 2013). The 2015 assessment was used to calculate the RBCs for the 2016–17 season of 249 t for the west and 314 t for the east (combined RBC is 563 t).

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



Note: Biomass estimates are available for the eastern stock from 1915 to 1987. However, pre-1988 estimates are not presented for the eastern stock because the new 'regime shift' base case resets the reference biomass to the unfished equilibrium biomass in 1988.
Source: Tuck et al. 2015

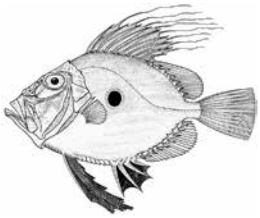
Stock status determination

The most recent assessment (Tuck et al. 2015) estimates that spawning biomass depletion of western jackass morwong in 2016 is 66 per cent ($0.66SB_0$), which is above the target reference point of $0.48SB_0$. Based on logbook data, catch of the western stock (62.7 t in 2016–17) is below the RBC of 249 t estimated by the 2015 assessment, indicating that the western stock is not overfished and not subject to overfishing.

For eastern jackass morwong, acceptance of a recruitment shift in the assessment resulted in decreased estimates of recent depletion, from close to the limit reference point ($0.2B_0$) in 2011 to $0.37B_0$ (37 per cent of the 1988 equilibrium biomass) in 2016. Eastern catches have declined in response to reduced TACs. Based on logbook data, catches of the eastern stock (131 t in 2016–17) are below the RBC of 314 t estimated in the 2015 assessment, and the stock is therefore classified as not overfished and not subject to overfishing.

For the 2016–17 fishing season, the agreed TAC was 474 t, the actual TAC was 533 t and the RBC was 563 t. Total landed catch was 213 t, and the weighted average discards were 30.25 t. The landed catch and discards combined was 243.2 t, which is below the RBC of 563 t. Based on this information, jackass morwong is classified as **not overfished** and **not subject to overfishing**.

John dory (*Zeus faber*)



Line drawing: Rosalind Poole

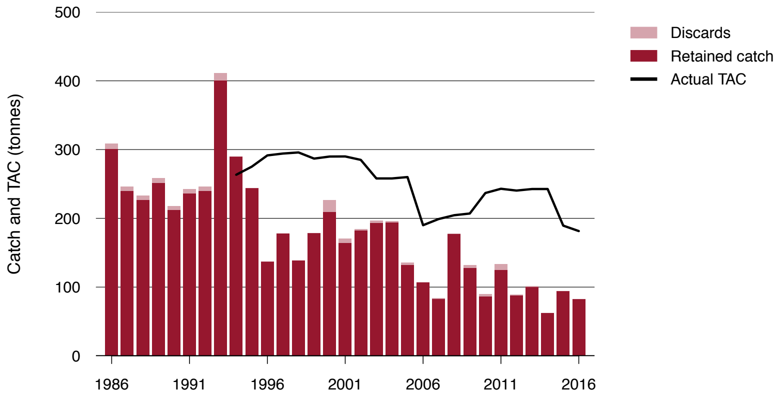
Stock structure

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 then decreased and have been below 200 t per year since 2000. Catches have been below 100 t per year for half of the eight fishing seasons since 2006 (Figure 9.25). Commonwealth landed catch in the 2016–17 fishing season was 81.8 t. The weighted average discards between 2012 and 15 were 1.92 t (Thomson & Upston 2016).

FIGURE 9.25 John dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2016



Notes: **TAC** Total allowable catch. Data for 2014 to 2016 do not include discards and state catch.
Source: Haddon 2013a; Australian Fisheries Management Authority catch disposal records (2014 to 2016 catch data)

Stock assessment

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

The 2014 tier 3 assessment for john dory (Thomson 2014) updated yield analyses presented in Klaer (2013) using a yield-per-recruit model. Recent average total mortality was estimated from catch curves constructed from length-frequency information. The assessment estimated an equilibrium fishing mortality rate (F_{CURR}) of 0.120, which was below the target fishing mortality reference point ($F_{spr40} = 0.159$) that would achieve a biomass of $0.4B_0$. This indicated that the current biomass was above this target. Using the $0.4B_0$ target, the assessment produced an RBC of 203 t for the 2016–17 fishing season. ShelfRAG recommended a three-year multiyear TAC of 169 t (AFMA 2014f). The 2016–17 TAC was set at 167 t.

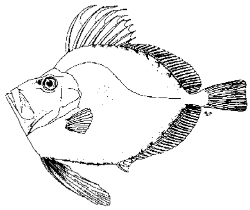
In 2014, ShelfRAG considered suitable breakout rules for the john dory multiyear TAC. It noted that a change in catch rate would not be appropriate because catch rate is not reflected in the tier 3 assessment. ShelfRAG therefore recommended adopting a breakout rule that it would review the available data if more than 80 per cent of the TAC is caught.

Stock status determination

Recent catches are low relative to historical levels, and the tier 3 assessment estimates that fishing mortality is below the level that would achieve the biomass target level.

For the 2016–17 fishing season, the agreed TAC was 167 t, the actual TAC was 181.5 t and the RBC was 203 t. Total landed catch was 82 t, and the weighted average discards were 1.92 t, giving a total of 83.92 t, which is below the RBC of 203 t. As a result, john dory is classified as **not overfished** and **not subject to overfishing**.

Mirror dory (*Zenopsis nebulosa*)



Line drawing: FAO

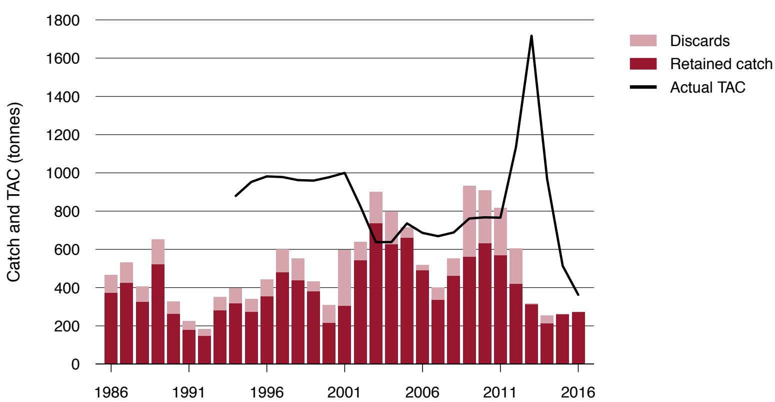
Stock structure

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).

Catch history

Catch of mirror dory has generally been stable over time, ranging between 200 and 700 t per year (Figure 9.26). In the 2016–17 fishing season, the RBC for the eastern stock was 362 t and the RBC for the western stock was 129 t. The total RBC was 491 t. Commonwealth landed catch in the 2016–17 fishing season was 275 t. The weighted average discards between 2012 and 2015 were 14.18 t (Thomson & Upston 2016).

FIGURE 9.26 Mirror dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2016



Notes: **TAC** Total allowable catch. Data for 2015 and 2016 do not include discards and state catch.
Source: Haddon 2015; Australian Fisheries Management Authority catch disposal records (2016 catch data).

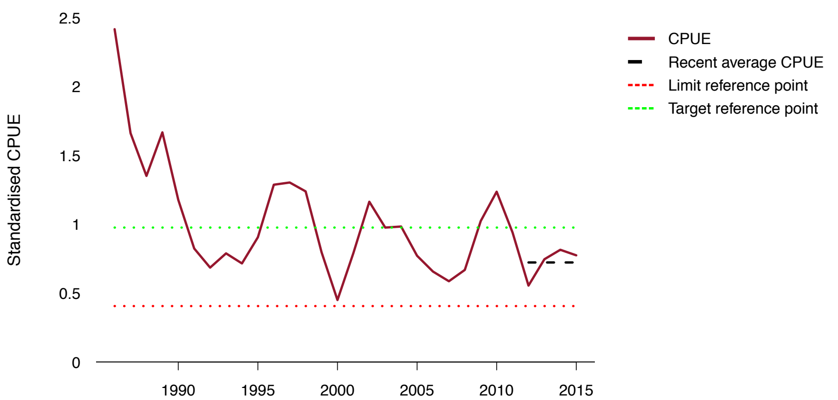
Stock assessment

Most of the mirror dory catch is byproduct in the CTS and is mainly caught east of Bass Strait. A quantitative (tier 1) assessment was attempted in 2010, but ShelfRAG considered that it was not sufficiently robust because there was uncertainty around the natural mortality rate, and a time series of age-composition data was not available (AFMA 2013b).

Previous tier 3 catch-curve assessments of mirror dory have used a growth equation applied to length data to estimate age composition. The 2013 tier 3 assessment estimated current fishing mortality (F_{CURR}) at 0.285, which was above the target fishing mortality reference point (F = 0.147; Klaer 2013). However, in 2013, ShelfRAG rejected the tier 3 assessment, noting that the mortality estimation model was not fitting the descending limb of the age distribution, and had previously underestimated F and overestimated RBCs (AFMA 2013b). Tier 3 assessments were used to determine RBCs for the 2012–13 and 2013–14 fishing seasons; this explains the large increase in TAC in Figure 9.27.

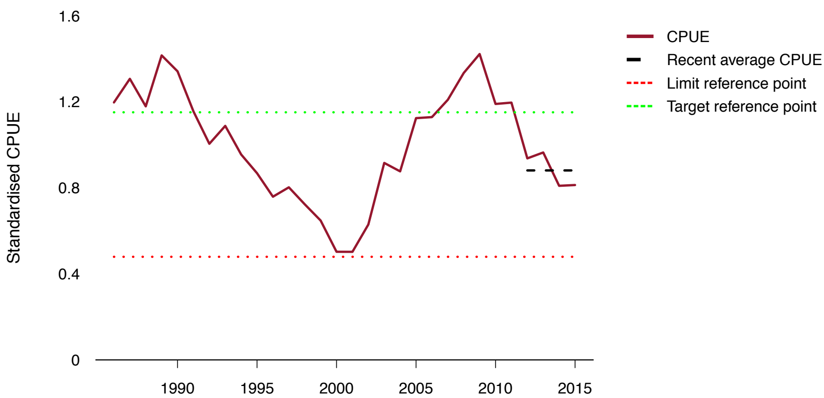
Because of the ongoing uncertainty in the tier 3 assessments, ShelfRAG decided to base advice for 2013–14, 2014–15 and 2015–16 on tier 4 assessments using standardised CPUE, which were conducted separately for mirror dory east (zones 10 to 30) and west (zones 40 and 50) of Bass Strait because spatial catch data were available. The CPUE in the west has fluctuated since 1990, with recent average CPUE between the limit and the target level (Figure 9.27; Haddon 2016b). In the east, CPUE decreased towards the limit from 1993 to around 2000, and then increased back to above the target by 2005 (Figure 9.28); the CPUE trend over the last four years indicates a steady decrease in CPUE, with the recent average CPUE between the limit and the target (Table 6 in Haddon 2016b).

FIGURE 9.27 Standardised CPUE for western mirror dory, 1986 to 2015



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

FIGURE 9.28 Standardised CPUE for eastern mirror dory, 1986 to 2015



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

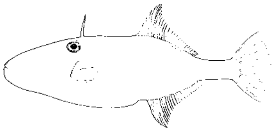
Stock status determination

Recent tier 4 assessments indicate that the recent average CPUE for the eastern and western stocks is above the limit reference point, and the stock is classified as **not overfished**.

For the 2016–17 fishing season, the agreed TAC was 325 t, the actual TAC was 362 t and the RBC was 491 t. Total landed catch was 275.1 t, and the weighted average discards were 14.18 t. The landed catch and discards combined was 289.28 t, which is below the RBC of 491 t. The stock is therefore classified as **not subject to overfishing**.

Mirror dory
AFMA

Ocean jacket (predominantly *Nelusetta ayraud*)



Line drawing: FAO

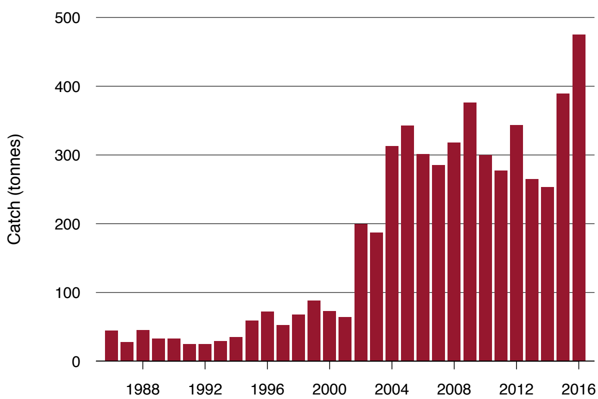
Stock structure

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

Catch history

Total catch of ocean jacket remained stable, at around 50 t, between 1986 and 2001 (Figure 9.29). Since then, ocean jacket has been an important non-quota byproduct species in the SESSF, with current catch levels exceeding those of many quota species. Catch peaked in 2016 at 475 t. Commonwealth landed catch in the 2016–17 fishing season was 288.7 t.

FIGURE 9.29 Ocean jacket catch in the CTS and SHS, 1986 to 2016

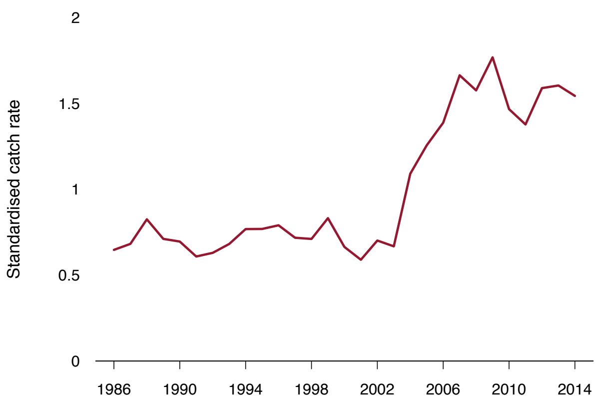


Note: Catch includes chinaman leatherjacket and unspecified leatherjackets.
Source: Sporcic 2015; Australian Fisheries Management Authority catch disposal records (2016 catch data)

Stock assessment

Historical catch data indicate substantial variations in ocean jacket abundance off south-eastern Australia in the 1920s and 1950s (Miller & Stewart 2009). Ocean jacket is a relatively short-lived species (six years), reaching maturity within two to three years and exhibiting large cyclical changes in abundance (Miller & Stewart 2009). As a byproduct species, ocean jacket has not been the subject of formal stock assessments. A standardised CPUE series has been constructed in recent years, which shows a similar trend to landings, suggesting that abundance of ocean jacket increased after 2003 (Figure 9.30; Sporcic & Haddon 2016). Catch rates for ocean jacket from zones 10 to 50 have decreased only slightly (Sporcic & Haddon 2016). There continues to be uncertainty over discarding of this species in the CTS and the GHTS; thus, the effect of discarding on CPUE trends is unknown (Upston & Thomson 2015).

FIGURE 9.30 Standardised CPUE for ocean jacket, 1986 to 2014

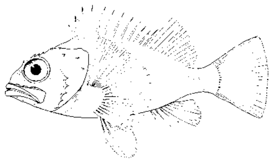


Note: **CPUE** Catch-per-unit-effort. There is no tier 4 assessment for ocean jacket, and so there are no target and limit reference points.
Source: Sporcic & Haddon 2016

Stock status determination

There is no formal stock assessment for ocean jacket. The standardised CPUE index increased substantially between 2003 and 2007, and remains high. Ocean jacket is therefore classified as **not overfished**. Despite recent high catches, catch rates have remained high compared with historical levels, and therefore ocean jacket is classified as **not subject to overfishing**.

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



Line drawing: FAO

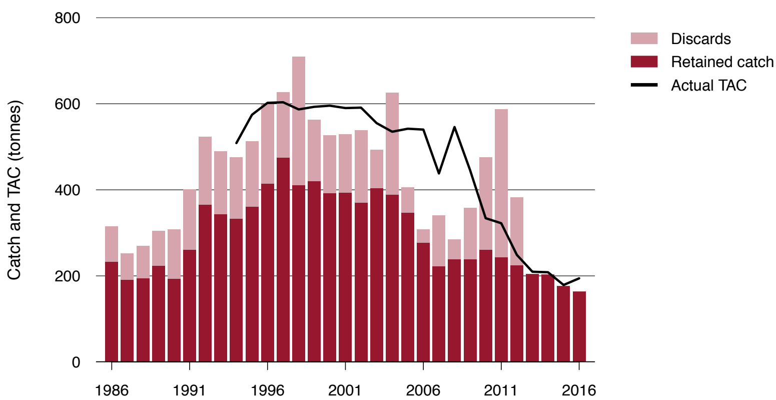
Stock structure

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

Catch history

Bigeye (offshore) 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). Landed catch of ocean perch since the 1970s has generally been between 200 and 400 t, increasing from 200 t in the 1980s to around 400 t from 1995 to 2004, before decreasing again to around 200 t from 2007 to 2014 (Figure 9.31). Commonwealth landed catch in the 2016–17 fishing season was 162.9 t. The weighted average discards between 2012 and 2015 were 148.72 t (Thomson & Upston 2016). Most reef (inshore) ocean perch (around 95 per cent in recent years) are discarded because of their smaller size (Upston & Thomson 2015). Discard rates for bigeye ocean perch are much lower; around 11 per cent of total catch was estimated to have been discarded in 2014 (Upston & Thomson 2015).

FIGURE 9.31 Total ocean perch (reef [inshore] and bigeye [offshore]) annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2016



Notes: **TAC** Total allowable catch. Data for 2013 to 2016 exclude discards and state catch.
Source: Haddon 2013a; Australian Fisheries Management Authority catch disposal records (2013 to 2016 catch data)

Stock assessment

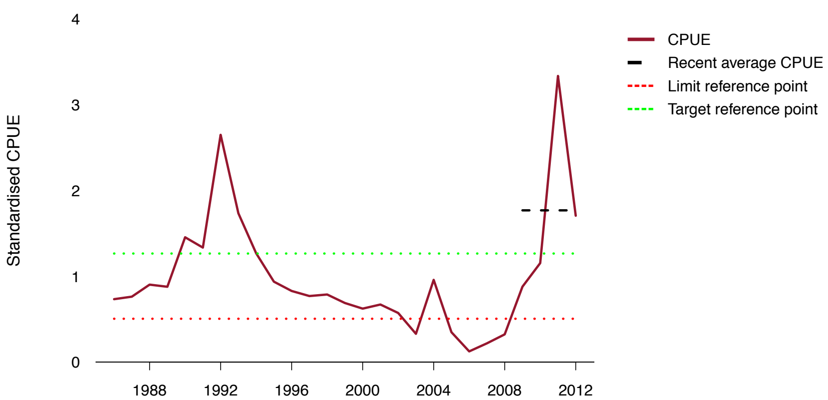
ShelfRAG provides advice based on B_{40} (B_{MSY} proxy) target reference points for both bigeye (offshore) and reef (inshore) ocean perch stocks (Morison et al. 2013).

Tier 4 standardised CPUE assessments were last updated in 2013 (Haddon 2013a). ShelfRAG noted the high but uncertain estimates of discard rates for reef ocean perch and recommended the application of a 15 per cent discount factor to the RBC for added precaution (Morison et al. 2013). Using the B_{40} target, ShelfRAG recommended a three-year RBC of 102 t for reef ocean perch and 283 t for bigeye ocean perch (385 t total). The multiyear TAC set by the AFMA Commission for the 2014–15 to 2016–17 fishing seasons was 195 t, covering both species; however, after the 15 per cent deduction to account for the uncertainty in tier 4 assessment methods, and deductions for state catches and discards, the multiyear TAC was reduced to 190 t. The Commonwealth landed catch in the 2016–17 fishing season was 163 t. Annual landings by New South Wales state fishers have been around 15–36 t since 2000 (Thomson & Upston 2016).

The weighted average discards between 2012 and 2015 were 148.72 t (Thomson & Upston 2016). Although discards of this species are high and variable, and have substantial influence on CPUE values, recent discards are well estimated by the Integrated Scientific Monitoring Program, and ShelfRAG concluded that the inclusion of discards provided a more reliable index of abundance (AFMA 2013c).

The 2013 assessment for reef ocean perch indicated that CPUE (including discards) had dropped below the limit reference point during the period 2005 to 2008, but then increased to above the target after 2010. The recent average CPUE was above the target reference point (Figure 9.32); estimates of recent discards contributed substantially to the high estimates of CPUE in recent years.

FIGURE 9.32 Standardised CPUE, including discards, for reef (inshore) ocean perch, 1986 to 2012



Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.
Source: Haddon 2013a

The CPUE to 2012 for bigeye ocean perch (Haddon 2013a) indicates stability in catch rates since 1996, but a decline for two consecutive years since 2013 (Sporcic & Haddon 2016). Standardised CPUE remained above the limit reference point (Figure 9.33; Sporcic & Haddon 2016).

FIGURE 9.33 Standardised CPUE for bigeye (offshore) ocean perch, 1986 to 2012

Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.
Source: Haddon 2013a

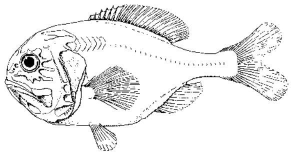
Stock status determination

The 2013 tier 4 assessment, including discards, found reef (inshore) ocean perch to have rebuilt to the target by 2010. Since 2013, CPUE trends have declined but likely remain above the limit reference point (Sporcic & Haddon 2016). In the absence of an updated stock assessment, reef (inshore) ocean perch remains classified as not overfished. Landed catches from logbook data totalled 3 t, and the average weighted discards were 114.77 t (Thomson & Upston 2016). The landed catch and discards combined was 117.77 t, which is higher than the three-year RBC of 102 t (AFMA 2013d). Based on this information and the declining CPUE trends, reef (inshore) ocean perch is determined to be uncertain if subject to overfishing.

The 2013 tier 4 assessment for bigeye (offshore) ocean perch indicates that the stock biomass is above the limit reference point; therefore, the stock is assessed as not overfished. Landed catches from logbook data totalled 92.4 t, and the average weighted discards were 33.95 t (Thomson & Upston 2016). The landed catch and discards combined was 126.4 t, which is lower than the three-year RBC of 283 t (AFMA 2013d). Ocean perch is therefore determined to be not subject to overfishing.

For the 2016–17 fishing season, the agreed TAC was 190 t, the actual TAC was 194.3 t and the RBC was 283 t. Total landings from catch disposal records were 163 t, and the weighted average discards were 148 t, giving a total of 311 t, which is above the RBC of 283 t (AFMA 2016b). Total catches in 2013–14 and 2014–15 also exceeded the RBC by 185 and 176 t, respectively. It is unclear if this level of fishing mortality will move the stock to an overfished state. Based on this information, the combined stock of reef and bigeye ocean perch is classified as **not overfished** but **uncertain if subject to overfishing**.

Orange roughy (*Hoplostethus atlanticus*)

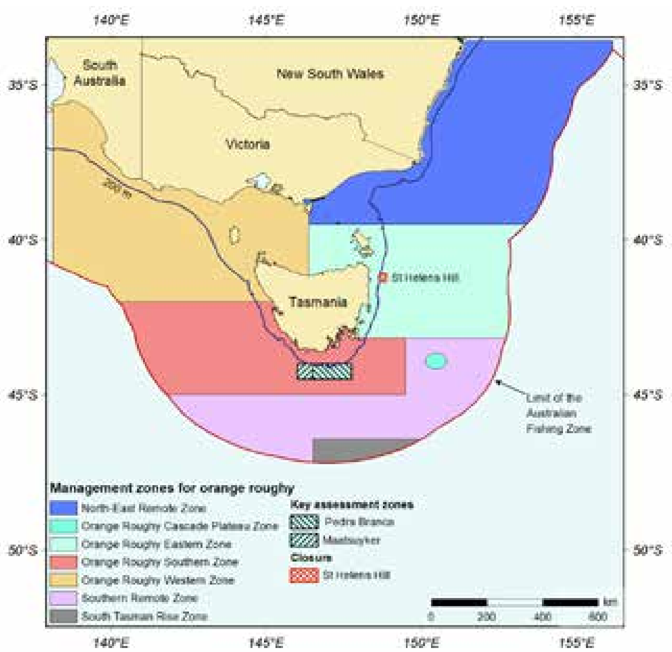


Line drawing: Rosalind Poole

Stock structure

A study on genetic variation in orange roughy (Gonçalves da Silva et al. 2012) examined the variation of a large number of loci using genetic techniques that have the power to detect low levels of genetic differentiation. The study concluded that orange roughy within the Australian Fishing Zone form a single genetic stock, but identified some differentiation between Albany/Esperance, Hamburger Hill (in the Great Australian Bight) and south-eastern Australia. It was noted that the amount of genetic exchange needed to maintain genetic homogeneity is much less than the amount needed for demographic homogeneity, and that residency or slow migration may result in separate demographic units despite genetic similarity (Morison et al. 2013). Orange roughy on the Cascade Plateau has distinct morphometrics, parasite populations, size and age composition, and spawning time, and is considered to be a separate management unit within the Southern Remote Zone (AFMA 2014g). The fishery is managed and assessed as a number of discrete regional management units (Figure 9.34).

FIGURE 9.34 Management zones for orange roughy in the SESSF



Overall catch history

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

In October 2006, orange roughy was listed as conservation dependent under the EPBC Act and placed under the Orange Roughy Conservation Programme (ORCP). The ORCP was replaced by the Orange Roughy Rebuilding Strategy in 2015 (AFMA 2015d), 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 that is consistent with the HSP. Management actions to minimise fishing mortality and support rebuilding include deepwater closures, targeted fishing for orange roughy stocks that are above the limit reference point of 20 per cent of the unfished spawning biomass, restricting effort by limiting entry to existing fisheries, and ongoing research and monitoring to support stock assessments.

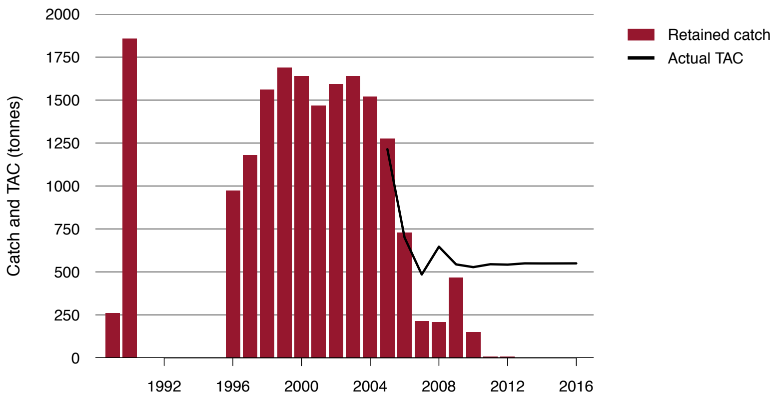
Danish-seine nets
Ryan Keightley, AFMA

Orange roughy, Cascade Plateau

Catch history

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

FIGURE 9.35 Orange roughy catch (CTS), Cascade Plateau, 1989 to 2016



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

Stock assessment

A requirement of the ORCP was to maintain the spawning biomass of orange roughy on the Cascade Plateau at or above $0.6B_0$. This was revised in 2015 to adopt the standard target reference point of $0.48B_0$ and the limit reference point of $0.2B_0$, in line with the default settings of the SESSF HSF (AFMA 2014h). This revised target for the Cascade Plateau stock is reflected in the Orange Roughy Rebuilding Strategy (AFMA 2015d).

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

The 2006 assessment estimated female spawning biomass to be 72–73 per cent of the unfished biomass (Wayte & Bax 2007). Because the stock was assessed to be above the $0.6B_0$ reference point that was in place at the time, application of the SESSF HSF harvest control rules allowed the setting of TACs to enable fish-down towards the reference point. Spawning aggregations did not form in 2007 and 2008, and the TAC was undercaught for the first time in the fishery's history in 2007 (151 t caught out of a TAC of 500 t) and 2008 (121 t caught out of a TAC of 700 t). The 2009 season was initially characterised by 'typical' orange roughy behaviour, with a large spawning aggregation forming on the western side of the plateau (Prince & Hordyk 2009). This subsequently disappeared after easterly winds and a strong easterly current developed, resulting in incursion of warmer water.

Projections from the most recent formal stock assessment for orange roughy on the Cascade Plateau, in 2009, predicted that, if the 315 t long-term RBC was fully caught by 2011, the spawning biomass of the stock would be at $0.64SB_0$ in 2011 (Morison et al. 2012). Taking into account the lower catch levels of 2007 and 2008, the assessment suggested that a TAC of 500 t would maintain the stock at $0.63SB_0$ in 2011. Noting low fishing effort and a lack of new data, AFMA has continued to set an annual TAC of 500 t. This stock was scheduled for an assessment in 2014, but the assessment was postponed because there were no new catch or acoustic data. The landed catch was 0 t in 2013–14, 0.3 t in 2014–15, 2 t in 2015–16 and 0 t in 2016–17 (Figure 9.35).

Stock status determination

The most recent assessment (2009) predicted that the 2011 spawning stock biomass of Cascade Plateau orange roughy would be at 63–64 per cent of unfished levels ($0.63–0.64SB_0$). Because catches in 2015–16 and 2016–17 were 2 t and 0 t, respectively, and the stock biomass was assessed to be above the target, the stock remains classified as **not overfished** and **not subject to overfishing**.

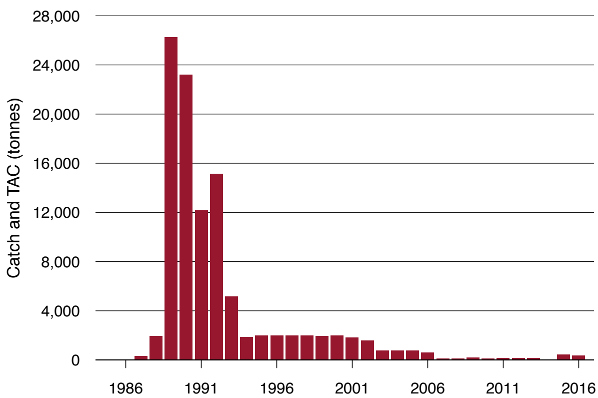
Orange roughy, eastern zone

Catch history

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

Along with the southern and western zones, the eastern zone was declared overfished and placed under the ORCP in 2006. Orange roughy catch in the eastern zone was limited to incidental catch allowances, to allow for unavoidable catches made while targeting other species. Most of the historical fishing grounds for orange roughy deeper than 700 m were also closed to trawling in January 2007 (AFMA 2006). Targeted fishing for orange roughy in the eastern zone recommenced in the 2015–16 fishing season, following acoustic surveys and an updated stock assessment. In the 2015–16 fishing season, 436 t was landed from the eastern zone, compared with 6 t landed in 2014–15 (Figure 9.36). The Commonwealth landed catch in the 2016–17 fishing season was 363 t. The weighted average discards between 2012 and 2015 were 3.6 t (Thomson & Upston 2016).

FIGURE 9.36 Orange roughy catch (CTS), eastern zone, 1985 to 2016



Source: Upston et al. 2014; Australian Fisheries Management Authority catch disposal records (2014 to 2016 catch data)

Stock assessment

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

Compensatory increases in the biological productivity of this stock appear to have occurred as a density-dependent response to the substantial decline in orange roughy abundance during the 1990s. Age at 50 per cent maturity has decreased by up to 2 years, from 30 to 28 years for males, and length-standardised fecundity is estimated to have increased by 73 per cent between 1987 and 2010 (Pitman et al. 2013).

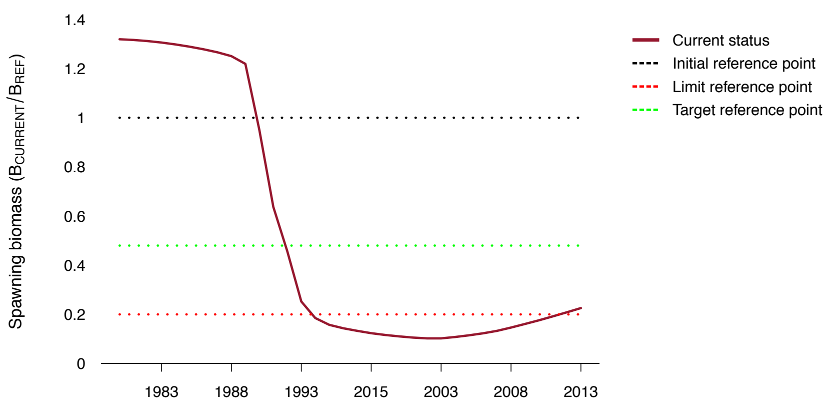
The proportion of the population that spawns each year is uncertain and variable. It was estimated to have increased from 54 per cent in the late 1980s to 71 per cent in the early 1990s (Morison et al. 2013), with the most recent estimates being 70 per cent in 2009 and 52 per cent in 2010 (Kloser et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

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

An assessment update was attempted in 2011 using updated commercial catch data for the eastern and southern (Pedra Branca only) zones from 1985 to 2010, the acoustic biomass indices, an egg-production estimate of spawning biomass from 1992 and age-composition data from spawning aggregations since 1992. However, SlopeRAG could not determine how to reconcile the conflict between the catch-at-age declines and increasing acoustic indices, and could not agree on a base case for the assessment. SlopeRAG did agree that the results of acoustic surveys provided evidence of stock rebuilding (AFMA 2013e).

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

FIGURE 9.37 Estimated female spawning stock biomass for orange roughy, eastern zone, 1980 to 2013



Source: Upston et al. 2014

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

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

Following acceptance of the 2014 assessment by SlopeRAG, CSIRO undertook further work to compare 2018 biomass estimates (at the end of a three-year TAC) under constant-catch scenarios with biomass estimates from the stock assessment that used the tier 1 SESSF HSF harvest control rules (Upston & Punt 2015). The estimates of female spawning biomass at the end of the three-year period were the same for the RBCs calculated under the SESSF harvest control rules and for an annual constant-catch scenario of 513 t, at 31 per cent of unfished biomass.

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

As recommended by SlopeRAG, an acoustic survey was undertaken in 2016. The main finding from the survey was the detection of a large body of orange roughy at St Helens Hill at the start of the survey. This body of orange roughy persisted, although it seemed to get deeper and less abundant by the end of the survey (Kloser et al. 2016).

Stock status determination

Based on the updated assessment showing the high likelihood that eastern zone orange roughy has rebuilt to above the limit reference point, eastern zone orange roughy is classified as **not overfished**.

For the 2016–17 fishing season, the agreed TAC was 465 t, the actual TAC was 493.6 t and the RBC was 512 t. Total landed catch was 363 t, and the weighted average discards were 3.6 t. The landed catch and discards combined was 365.6 t, which is below the RBC of 512 t (AFMA 2016b). Based on this information, eastern zone orange roughy is classified as **not subject to overfishing**.

Orange roughy, southern and western zones

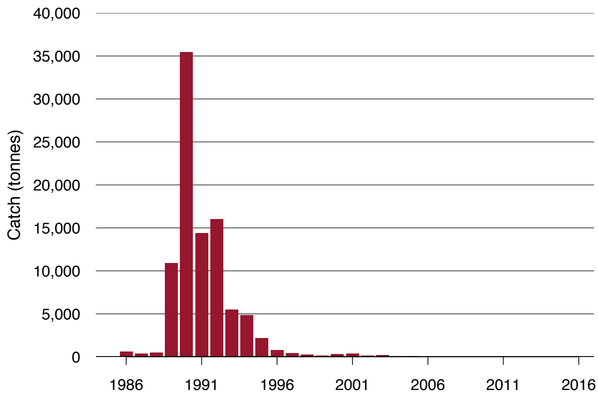
Catch history

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

The southern and western zone stocks were declared overfished and placed under the ORCP in 2006, when targeted commercial fishing ceased. As for the eastern zone, orange roughy catch in southern and western zones was limited to incidental catch allowances.

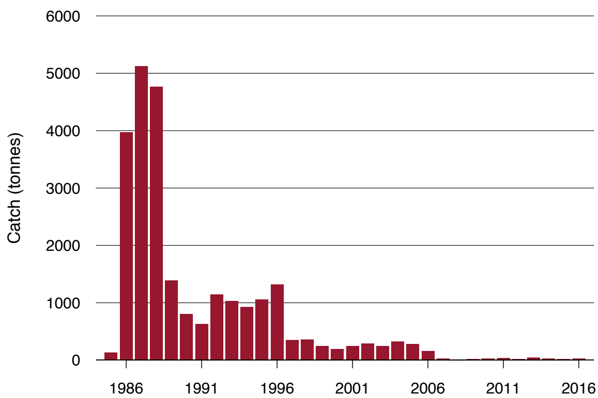
In the 2016–17 fishing season, 43 t of orange roughy was landed from the southern zone (57 t in 2015–16) and 22 t from the western zone (22 t in 2015–16). For 2016–17, the incidental catch allowances were 66 t for the southern zone and 60 t for the western zone. Discard estimates for orange roughy in the western zone and southern zone were not determined (Thomson & Upston 2016).

FIGURE 9.38 Orange roughy catch (CTS), southern zone, 1985 to 2016



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

FIGURE 9.39 Orange roughy catch (CTS), western zone, 1985 to 2016



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

Stock assessment

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

In response to the updated stock assessment for eastern zone orange roughy, which included orange roughy from Pedra Branca in the southern zone, the TAC for the southern zone was 66 t.

The western zone was most recently assessed in 2002. This assessment estimated that there was a greater than 90 per cent probability that the 2004 biomass was less than 30 per cent of the 1985 biomass. No evidence has been found of spawning aggregations in this region. A comparison of the age composition from 1994 to 1996 with that of 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. Because there has been no update to the assessment of the western stock, SERAG continues to advise an RBC of zero.

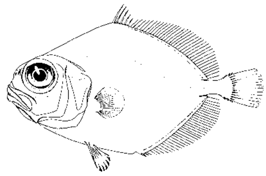
Noting recovery of the eastern zone orange roughy stock, and a long period of low TACs in the southern and western zones, SERAG considered that the southern and western zones may be showing some level of recovery (AFMA 2015e).

Stock status determination

Previous assessments of orange roughy in the southern and western zones indicated that the stocks were substantially depleted, to below $0.2B_0$. Based on the age of the stock assessments for the southern and western zones, and the time since the areas have been closed to targeted orange roughy fishing, the recovery detected in the eastern stock may suggest that similar rebuilding has occurred in the southern and western zones. This suggests increasing uncertainty around the biomass status of the southern and western zone orange roughy stocks. However, in the absence of recent data and assessments to support a hypothesis that these stocks may have rebuilt to above the limit reference point, and recognising that the characteristics of southern and western zone fisheries differ from those in the eastern zone, the southern and western zones stocks remain classified as **overfished**.

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

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



Line drawing: FAO

Stock structure

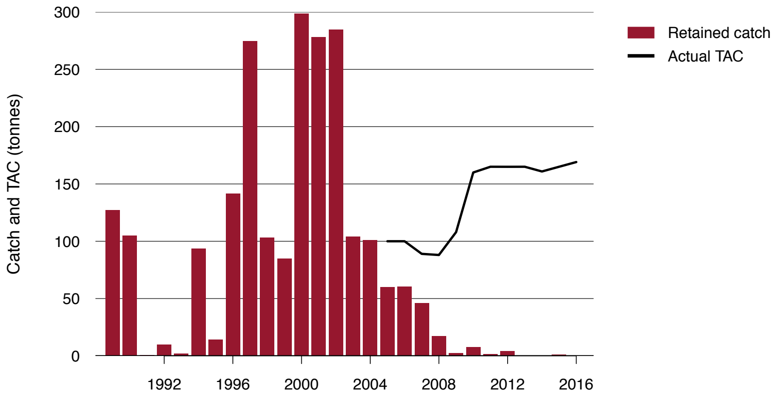
Little is known about the stock structure of smooth oreodory. For assessment and management purposes, smooth oreodory is treated as a single stock throughout the SESSF, excluding the Cascade Plateau and South Tasman Rise, which are managed as separate stocks.

Catch history

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

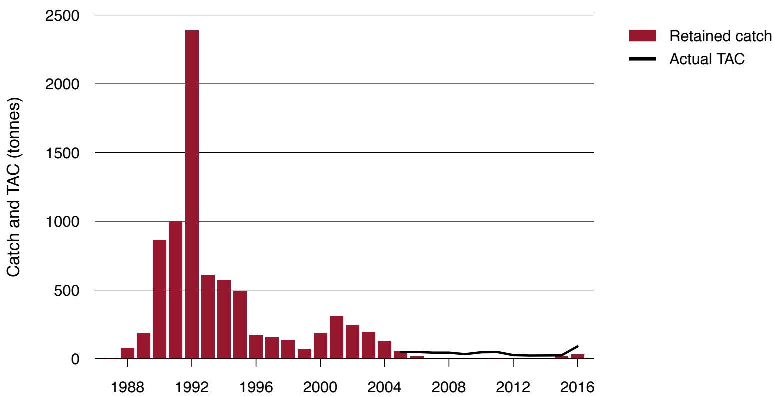
Catches of smooth oreodory on the Cascade Plateau reached maximum levels of 275–300 t in 1997, 2000, 2001 and 2002, but have otherwise remained below 100 t (Figure 9.40). From 2004 to 2009, Cascade Plateau smooth oreodory catches declined to low levels. Only 1 t was landed in 2015–16 and there was zero catch in 2016–17. In contrast, annual smooth oreodory catches in other areas exceeded 500 t from 1990 to 1995, reaching almost 1,000 t in 1991 and peaking at 2,216 t in 1992 (Figure 9.41). Since then, smooth oreodory catches have been negligible until the 2015–16 season, when 21 t was landed. The catch increased in the 2016–17 season to 48 t. Discard rates were not determined (Thomson & Upston 2016).

FIGURE 9.40 Smooth oreodory annual catches (CTS) and fishing season TACs, Cascade Plateau, 1989 to 2016



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

FIGURE 9.41 Smooth oreodory annual catches (CTS) and fishing season TACs, non–Cascade Plateau, 1987 to 2016



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

Stock assessment

Previously, both Cascade Plateau and non–Cascade Plateau stocks were assessed using a tier 4 assessment and CPUE indices (Figures 9.42 and 9.43). In 2015, a tier 5 approach was introduced in response to work on alternative stock assessment options for data-poor fisheries (Haddon et al. 2015). SlopeRAG (AFMA 2015e, f) recommended using a depletion-based stock reduction analysis (DBSRA) and a weight-of-evidence approach to develop an RBC for the non–Cascade Plateau smooth oreodory stock (Haddon 2015). Using this method, the yield level predicted to be sustainable is at least partly dependent on the median value selected for the expected state of depletion in the final year of the analysis. Using the DBSRA in this manner for the non–Cascade Plateau smooth oreodory stock, and assuming it is at the target depletion level of $0.48B_0$, it was determined that a catch of 90 t should prevent the stock from falling below the limit reference point of 20 per cent ($0.2B_0$) and would keep the stock above $0.35B_0$ at least 90 per cent of the time.

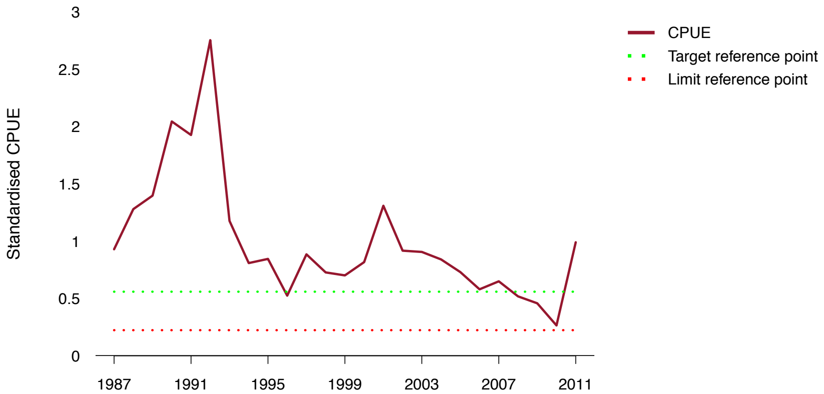
The assumed current stock depletion level of $0.48B_0$ is considered reasonable, given that almost all the stock is deeper than 700 m. Noting that the TAC of 23 t was somewhat arbitrary and that there are no sustainability issues, SlopeRAG recommended an RBC of 90 t in the non–Cascade Plateau for the 2016–17 fishing season and that the large change–limiting rule not be applied when calculating the TAC.

For smooth oreodory in the Cascade Plateau, previous assessments concluded that the standardised CPUE has remained above the target level since 1996 (Haddon 2012; Figure 9.42). However, this estimate was uncertain as a result of the low catch (that is, catches less than 10 t). SlopeRAG concluded that recent fluctuations in CPUE for this species are probably due to uncertainty resulting from low catches, and do not reflect changes in biomass (Morison et al. 2013). Catches of less than 10 t were considered to have little effect on stock biomass, and SlopeRAG recommended that the tier 4 assessment be suspended until catches increase above this level (AFMA 2013a).

FIGURE 9.42 Standardised CPUE for smooth oreodory, Cascade Plateau, 1994 to 2011

Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2011 is not shown because there was no new tier 4 assessment. Catches of smooth oreodory are now so low that catch rates are unlikely to provide reliable indices of abundance.
Source: Haddon 2012

FIGURE 9.43 Standardised CPUE for smooth oreodory, non–Cascade Plateau, 1987 to 2011



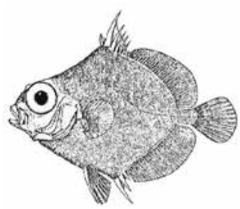
Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2011 is not shown because there was no new tier 4 assessment. Catches of smooth oreodory are now so low that catch rates are unlikely to provide reliable indices of abundance.
Source: Haddon 2012

Stock status determination

CPUE has always remained above the target for the Cascade Plateau stock. Despite the aggregating nature of the species and the fact that low catches mean that CPUE is unlikely to be a reliable indicator of abundance, it is unlikely that recent low catches have resulted in any substantial change in abundance. Similarly, while the DBSRA does not estimate biomass, it assumed that the current depletion level of the stock is $0.48B_0$, which is a reasonable assumption given that almost all the stock is deeper than 700 m. Therefore, the smooth oreodory (Cascade Plateau and non–Cascade Plateau) stocks are both classified as **not overfished**.

The DBSRA for non–Cascade Plateau smooth oreodory produced an RBC of 90 t, and is likely to be a more reliable indicator of the sustainable catch level than the previous TAC. Catch of non–Cascade Plateau smooth oreodory was 48 t in 2016–17, well under the RBC. Similarly, as in previous years, catch of Cascade Plateau oreodory was less than 10 t, and therefore, as noted by SlopeRAG, unlikely to have any impact on the stock biomass. Given the level of catch, both stocks of smooth oreodory are classified as **not subject to overfishing**.

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



Line drawing: FAO

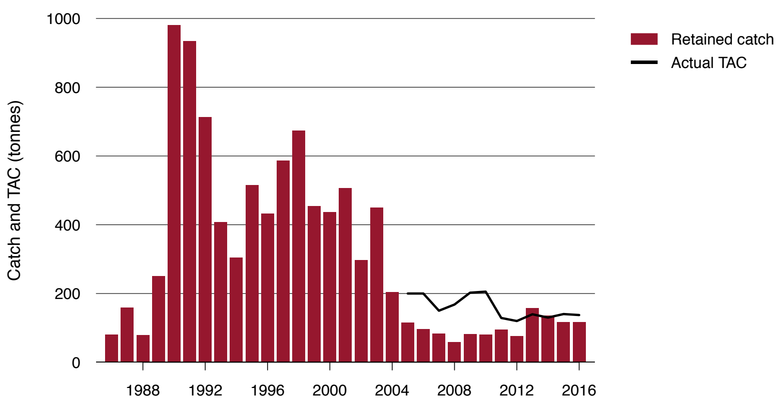
Stock structure

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

Catch history

Catch peaked in 1990 at 980 t, but has since declined to around 100 t in recent years and was 108 t in 2016–17 (Figure 9.44).

FIGURE 9.44 Other oreodories annual catches (CTS) and fishing season TACs, 1986 to 2016



Note: **TAC** Total allowable catch.
Source: Haddon 2013a; Australian Fisheries Management Authority logbook records

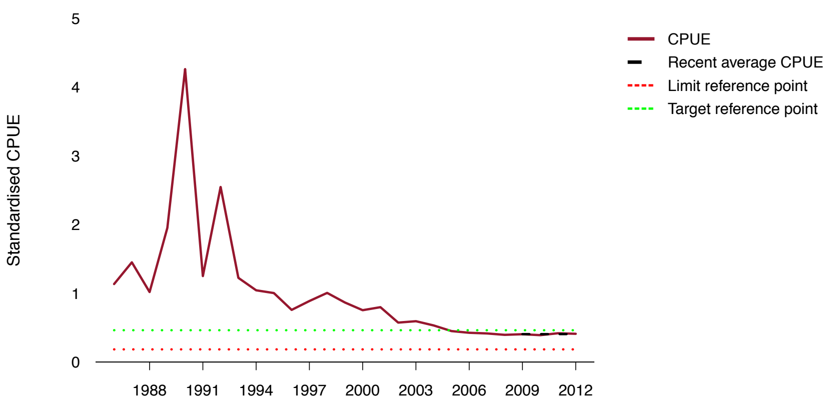
Stock assessment

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

The most recent tier 4 assessment for other oreodories was updated in 2013. The assessment was based only on data from areas currently open to the fishery and used the revised target reference period of 1993 to 2001 (Haddon 2013a; Morison et al. 2013). Standardised CPUE declined steadily from 1998 to 2006, but has since stabilised, remaining near the target CPUE (which is half the average CPUE over the reference period 1993 to 2001; Figure 9.45). Although the tier 4 assessment has not been updated, recent standardised CPUE from 2012 to 2015 indicates very low CPUE indices, and a trend is not apparent (Sporcic & Haddon 2016).

Using the 2013 tier 4 assessment, the RBC for other oreodories for the 2013–14 fishing season was estimated at 132 t (Morison et al. 2013). A three-year multiyear TAC was implemented at this level (132 t for the 2013–14 and 2014–15 fishing seasons) (AFMA 2014b). After consideration of discards, the RBC and resulting TAC for the 2016–17 season were both 128 t (AFMA 2016b).

FIGURE 9.45 Standardised CPUE for other oreodories, 1986 to 2012



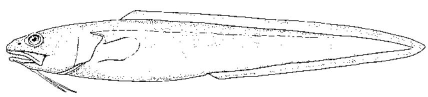
Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.
Source: Haddon 2013a

Stock status determination

Although oreodories are generally considered to be a byproduct of other deepwater fisheries, and much of the deepwater habitat is now closed, catches of these species declined substantially before closures were implemented. It is likely that there was substantial but unquantified discarding during the peak of the orange roughy fishery from 1989 to 1992. However, improving the basis for assessing the status of other oreodories is a low priority, given the protection afforded by current deepwater closures. The latest tier 4 assessment (Haddon 2013a) and recent standardised CPUE (Sporcic & Haddon 2016) indicate that recent average CPUE has remained stable near the target reference level since about 2005. Most (89 per cent) of the catch is reported as spikey oreodory (Sporcic 2015), so the tier 4 assessment largely reflects the status of spikey oreodory. However, there is some uncertainty about the reliability of standardised CPUE as an indicator of biomass for this highly aggregating and multispecies stock.

Because CPUE has remained stable near the target level and catches have remained near RBCs, other oreodories are classified as **not overfished**. The agreed and actual TACs for the 2016–17 fishing season were both 90 t, and the RBC was 128 t. Total landings were 108 t, and no estimate of discards was reported. The total fishing mortality of 108 t is below the RBC of 128 t; therefore, the stock is classified as **not subject to overfishing**.

Pink ling (*Genypterus blacodes*)



Line drawing: Rosalind Poole

Stock structure

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

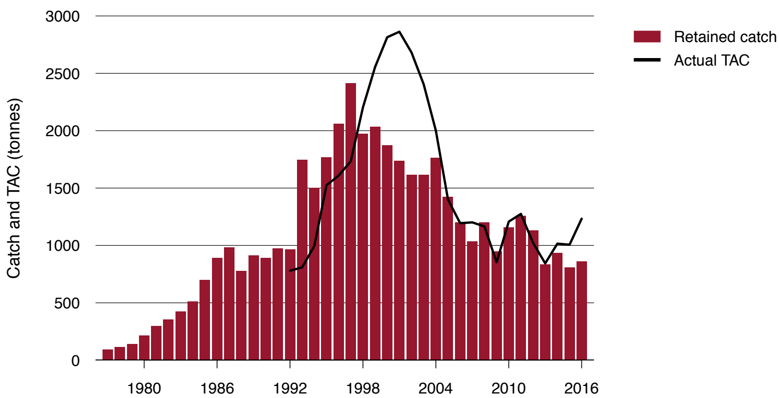
Catches of pink ling are managed under a single TAC. However, AFMA has management arrangements in place to constrain catches of the eastern stock to the eastern catch limit.

Catch history

Combined eastern and western catches of pink ling increased steadily from the start of the fishery in about 1977 to reach a peak of 2,412 t in 1997 (Figure 9.46). Despite TACs continuing to increase from 1997 to 2001, catches declined steadily to about 1,800 t in 2004. From 2004–05 to 2013–14, pink ling catches were limited by the TAC. Commonwealth landed catch in the 2016–17 fishing season was 912.5 t. The weighted average discards between 2012 and 2015 were 32.4 t (Thomson & Upston 2016).

Pink ling is significantly under-reported in logbooks—according to AFMA catch disposal records, 912 t was landed in 2016–17, while only 765 t was reported in logbooks. This makes it difficult to assess the total level of fishing mortality, because logbook data provide information on the split in catch between the eastern and western stocks. In the preparation of catch data used for assessments, logbook data are scaled up to match the data in AFMA's catch disposal records. As a result, any under-reporting in logbooks does not necessarily bias stock assessments. Nonetheless, it will be important to address this discrepancy to reduce uncertainty in assigning status determinations in the future.

FIGURE 9.46 Pink ling annual catches (CTS, SHS and state combined) and fishing season TACs, 1977 to 2016



Notes: **TAC** Total allowable catch. Data for 2014 to 2016 do not include state data.
Source: Cordue 2013; Australian Fisheries Management Authority catch disposal records (2014 to 2016 catch data)

Stock assessment

Pink ling has been assessed using quantitative, model-based (tier 1) stock assessments since 2003. Annual integrated, age-structured assessments using catch-at-age data and standardised CPUE abundance indices were run from 2006 to 2012. During this period, assessment models have incorporated increasingly complex approaches to account for differential male and female growth, cohort-specific growth, changing selectivity, and the possibility of separate eastern and western stocks. An important change in the 2008 and 2009 assessments was the introduction of a split in the CPUE series in 2000 to account for an apparent change in fishing behaviour that resulted in a roughly 30 per cent decrease in catchability (see Morison et al. 2013).

In 2011, a revised assessment was proposed—removing the split in CPUE and instead fitting to CPUE data disaggregated by fishing zone—after a review identified substantial differences in the CPUE and length-frequency data between zones (Punt & Taylor 2011). The initial 2012 revised assessment fitted separate CPUE indices for each fishing zone (Punt et al. 2012) and produced a substantially more pessimistic assessment of the eastern stock, indicating that this stock was below the $0.2B_0$ limit. SlopeRAG did not accept the revised assessment, considering that further time was required to understand how separation of CPUE series and selectivities could produce such a different estimate of depletion for the eastern area, and to determine how CPUE indices should be weighted and combined in a non–spatially segregated model. Instead, advice in 2012 was based on an update of the 2010 base-case aggregated area model, using the disaggregated (zonal) model as one of the sensitivities to the base case. Results predicted the eastern stock to be at $0.26B_0$ and the western stock to be at $0.43B_0$ at the start of 2013 (Morison et al. 2013).

The 2012 assessment (Punt et al. 2012) was updated in 2013. In addition, industry contracted an alternative assessment by Cordue (2013). Comparison of results of initial exploratory runs using both sets of software resulted in changes to the specifications of both models to make them similar. These changes included retaining separate eastern and western stocks; modelling cohort-specific growth and time-varying selectivity; modelling a change in catch rates from 1999 to 2000 (when ling quota was consolidated onto fewer vessels), but using three vessels whose behaviour did not appear to change to link catch rates across these time blocks; and using the weighting approach recommended by Francis (2011) to down-weight length and age-frequency data, and up-weight CPUE indices.

Probability (Markov chain Monte Carlo) analysis for the eastern stock provided estimates of probabilities around results (Cordue 2013). SlopeRAG agreed to use this as the base-case model for providing advice. Results of this model indicated the biomass of the western pink ling stock to be stable at around 58 per cent of the unfished biomass, ranging from 41 to 86 per cent in the probability analyses. The biomass of the eastern pink ling stock was estimated to be around 25 per cent of the unfished biomass, ranging from 17 to 38 per cent, and trending upwards (Cordue 2013). This model estimated an RBC for eastern pink ling of 122 t (although highly uncertain, ranging from 0 to 500 t) and an RBC for the western stock of 807 t (range 430–1,710 t), with a long-term yield of 661 t. Because of the amount of effort required for such an assessment and the availability of projections with associated probabilities, SlopeRAG concluded that there was little additional benefit from updating the assessment every year, and recommended three-year TACs at RBC levels of 122 t and 661 t for the east and west, respectively (AFMA 2013a).

Because of industry concerns that it would be difficult to constrain eastern pink ling catches to this low level (given that ling are caught as bycatch during targeting of a number of other species in the CTS), Cordue (2013) provided a table of projections of future eastern pink ling biomass under a range of constant-catch scenarios, from 0 to 500 t, together with probability estimates of stock status in relation to target and limit reference levels (Table 9.3).

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

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

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

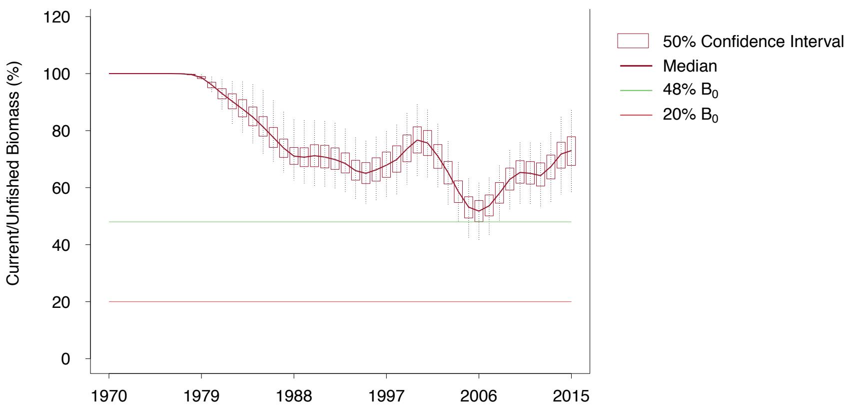
These projections indicate that, under the Cordue (2013) assessment base case, there is a less than 10 per cent probability of eastern pink ling biomass in 2015 being below 20 per cent of B_0 for catches below about 400 t (Cordue 2013). Based on these projections, the South East Management Advisory Committee (SEMAC) recommended that AFMA set three-year TACs, commencing in 2014–15, of 349 t for eastern pink ling and 647 t for western pink ling, if it was possible to administer separate eastern and western quotas. AFMA determined that implementing separate quotas would require a review of statutory fishing rights in the fishery. As a result, a global TAC of 996 t (1,022 t after carryover of undercaught TAC from 2013–14) was set for pink ling for the 2014–15 season, with additional controls to keep eastern catches under the RBC. These controls included a daily catch allowance for the eastern zone and a change in some concession conditions to restrict catch of pink ling from the eastern zone to 25 per cent of quota holdings. These arrangements were continued for the 2016–17 season, but with an agreed TAC of 1,144 t.

RBCs for the western stock have varied in response to the different stock assessments; they were 490 t in 2013–14, and 661 t in 2014–15 and 2015–16. Catches have remained below RBCs in the west. In contrast, RBCs for the eastern stock have declined steadily; they were 122 t in 2014–15 and 2015–16. Logbook-reported catches in the east have exceeded the eastern RBCs since 2011–12. Discarding has generally been low, and industry has reported changes in fishing practices in the east to avoid canyons and gullies known for producing higher catches of ling. These areas were closed on a voluntary basis from 2005, and by AFMA through closure direction during a number of seasons since 2009, in an effort to further reduce eastern catches.

Although TACs have been set for the two stocks combined, for the 2014–15 season, SEMAC recommended a three-year multiyear TAC to be administered as separate eastern and western TACs: 647 t for western pink ling (based on the long-term RBC estimate for this stock) and 349 t for eastern pink ling. The eastern TAC is based on results of Markov chain Monte Carlo constant-catch projections, indicating that this TAC would result in a less than 10 per cent probability of eastern pink ling being below the $0.2B_0$ limit reference point in 2015 (Table 9.3); it is higher than the one-year eastern RBC of 122 t recommended by SlopeRAG. Although the eastern RBCs were exceeded in 2014–15 and 2015–16, the use of a generic control rule under the SESSF harvest strategy that produces these RBCs is not needed to provide management advice on TACs when a full risk analysis is available to show the likelihood of a stock remaining above the limit reference point at least 90 per cent of the time (see Tables 9.3 and 9.4), as required by the HSP (AFMA 2009b).

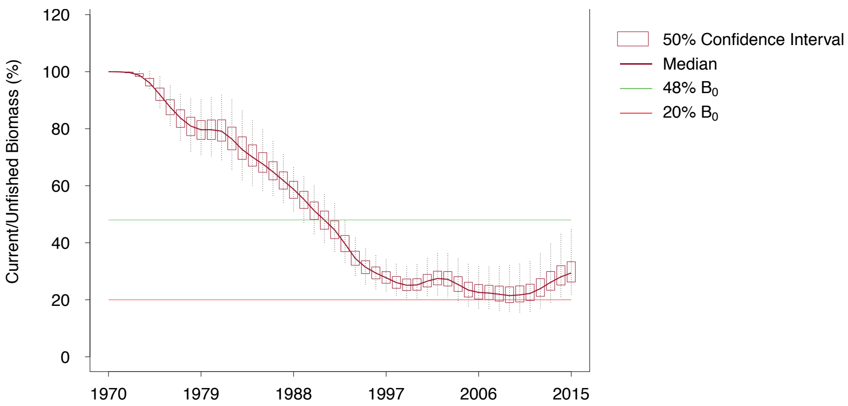
The Cordue (2013) assessment was updated in 2015 (Cordue 2015). The updated assessment estimated the eastern stock biomass in 2015 to be $0.30B_0$ and the western stock biomass in 2015 to be $0.72B_0$ (Figures 9.47 and 9.48). This produced RBCs for the 2016–17 fishing season of 250 t for the east and 990 t for the west. Constant-catch scenarios were run for the eastern stock and indicated that catches in excess of 550 t led to a greater than 10 per cent probability of eastern pink ling declining to below the limit reference point by 2022; catches greater than 500 t increase the time taken to rebuild the stock to the management target ($0.48B_0$) (AFMA 2015g). On this basis, SlopeRAG recommended that, if a TAC greater than the 2016–17 RBC was considered by the AFMA Commission, the updated table showing the range of future constant-catch scenarios should be used as the basis for determining the 2016–17 TAC. Although these constant-catch scenarios from the 2015 stock assessment were not used to determine the TAC for the 2015–16 fishing season, they may provide a more up-to-date indicator of the sustainable level of fishing mortality than the constant-catch scenarios produced by the 2013 stock assessment, and so are included (Table 9.4).

FIGURE 9.47 Estimated spawning stock biomass for western pink ling, 1970 to 2015



Source: Cordue 2015

FIGURE 9.48 Estimated spawning stock biomass for eastern pink ling, 1970 to 2015



Source: Cordue 2015

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

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

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

Stock status determination

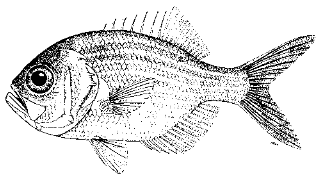
The 2015 assessment indicated that the biomass of the western pink ling stock is around 72 per cent of the unfished biomass and stable, and that the biomass of the eastern pink ling stock is around 30 per cent of the unfished biomass and increasing. The 2015 assessment indicated that the eastern pink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

Western pink ling catches are below the western RBC levels. As a separate stock, the western stock would be classified as not subject to overfishing.

Recent catches of eastern pink ling have exceeded the RBCs produced by the 2013 and 2015 stock assessments. However, the use of a generic control rule that produces these RBCs is not needed to provide management advice on TACs when a risk analysis is available, as has been the case for the 2013 and 2015 assessments that have been used to set TACs since the 2014–15 fishing season. Catch of eastern pink ling reported in logbooks in the 2016–17 fishing season was 338 t. According to projections from the 2015 stock assessment, there is little risk to the stock over the next few years of removals up to 550 t per year. The base-case projections suggested that the stock could be rebuilt to the target reference point (B_{48}) within one mean generation time (8.8 years). If two mean generation times are allowed for the rebuild, total removals can be 400–500 t per year. Consideration of recent fishing mortality against the constant-catch scenarios run as part of the 2013 and updated 2015 stock assessments indicates that, as a separate stock, eastern pink ling would be classified as not subject to overfishing.

Because both pink ling stocks are managed through a single TAC, their status is given a single classification, and so pink ling is classified as **not subject to overfishing**.

Redfish (*Centroberyx affinis*)



Line drawing: FAO

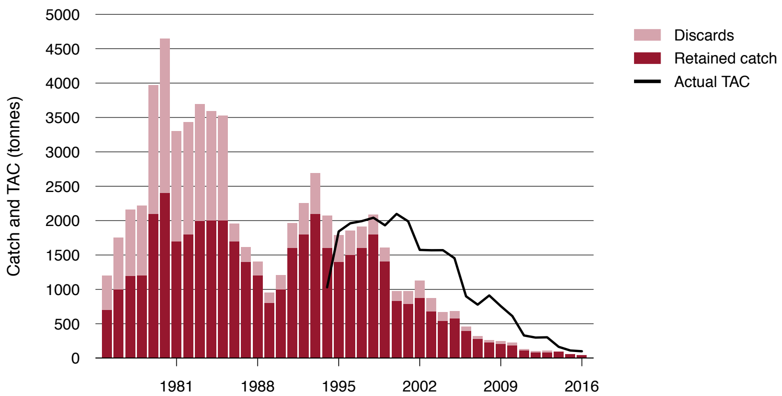
Stock structure

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

Catch history

Catches of redfish peaked in the late 1970s and early 1980s, with significant discards recorded on top of landed catch. Landed catch has decreased steadily since the late 1990s. The 2016–17 catch was 39.5 t (Figure 9.49). Estimated discards were 226 t in 2009, but have returned to lower levels in recent years, being 4 t in 2012, 29 t in 2013, 67 t in 2014 and 68 t in 2015 (Upston & Thomson 2015). Discard rates tend to be high when a pulse of recruits first enters the fishery (Klaer et al. 2014). Estimated discards are not yet available for 2016 and therefore weighted average discards are used as predictors. The weighted average discards between 2012 and 2015 were 58.99 t (Thomson & Upston 2016).

FIGURE 9.49 Redfish annual catches (CTS, SHS and state combined) and fishing season TACs, 1975 to 2016



Note: **TAC** Total allowable catch. Data for 2014 to 2016 do not include discards and state catch.
Source: Tuck & Day 2014; Australian Fisheries Management Authority catch disposal records (2014 to 2016 catch data)

Stock assessment

The redfish TAC has been progressively reduced since 2000. The TAC was 276 t in the 2011–12 to 2013–14 seasons, 138 t in 2014–15 and 100 t in 2014–15. Annual catches remained well below annual TACs from 2000 to around 2013 (Figure 9.49).

ShelfRAG previously assessed redfish as a tier 3 species because reliable samples of the age composition of catches are generally available. Since 2011, ShelfRAG has also taken into account tier 4 results because of concerns about ongoing declining catches and CPUE. Noting the continuing declining trend in catches and CPUE, in 2013, ShelfRAG concluded that there was a risk to the stock if the CPUE signal was correct but ignored (AFMA 2013b). Industry representatives confirmed that redfish was no longer being caught in large numbers.

The tier 3 assessment produced an RBC of 3,791 t for the 2014–15 fishing season. Because of the concerns around conflicting tier 3 and tier 4 assessments, ShelfRAG based its advice for the 2013–14 and 2014–15 seasons on an updated tier 4 analysis. This analysis was based on CPUE from zone 10 off south-eastern New South Wales (Haddon 2013a). Since 2010, the redfish tier 4 assessment has used a split reference period, covering the years 1986 to 1990 and 1999 to 2003. The intervening period is not considered representative of the fishery because it involved large trawlers catching large quantities of redfish for surimi markets.

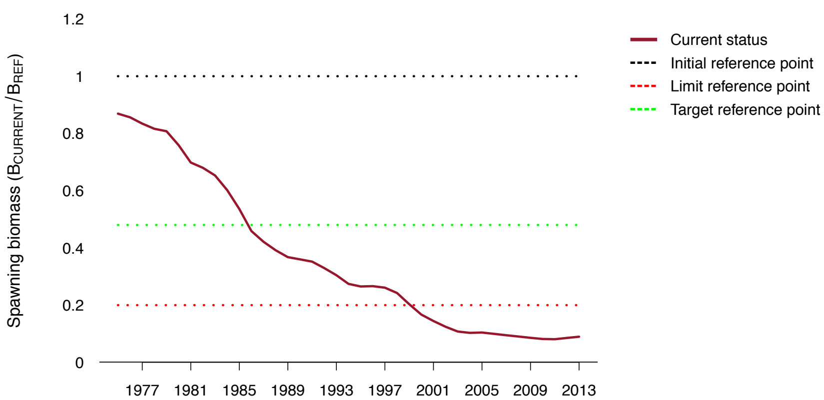
Standardised redfish CPUE (excluding discards) has declined since 2000, with CPUE in 2012 (excluding discards) being the lowest since the series began in 1986, and the recent four-year average CPUE being below the limit reference point. An alternative tier 4 assessment, which included discard estimates, also showed a decline from 1988 to 2012, but with current average CPUE about midway between the revised targets and limits under this assessment (Haddon 2013a). Updated standardised CPUE shows that the CPUE has remained low between 2012 and 2015 (Sporcic & Haddon 2016).

The first quantitative (tier 1) assessment of redfish was undertaken in 2014 (Tuck & Day 2014). The assessment used an age- and size-structured model, and included data up to the end of 2013. The base-case model accepted by ShelfRAG predicted spawning biomass in 2015 to be 11 per cent of unexploited levels ($0.11B_0$; Figure 9.50). Consequently, the RBC was zero. This assessment estimated that the stock should rebuild to above the limit reference point by 2018 or 2019 under total fishing mortality of up to 150 t. Projections from the assessment assume average recruitment. As a result of these projections, AFMA set an incidental catch allowance of 100 t for the 2016–17 fishing season.

The 2016–17 catch was 39.5 t. The level of discarding of redfish has been variable in recent years, and increased to 68.9 t in 2015 (Thomson & Upston 2016). The weighted average discards between 2012 and 2015 were 58.99 t (Thomson & Upston 2016).

The stock is now managed under the redfish stock rebuilding strategy 2016–2021 (AFMA 2016d), the main objective of which is to rebuild redfish to the limit reference point ($0.2B_0$) within 27 years (one mean generation time—16.7 years [Tuck & Day 2014]—plus 10 years). The rebuilding strategy prescribes that the TAC will be set at the minimum amount required to cover the catch of redfish taken incidentally while targeting other species.

FIGURE 9.50 Estimated female spawning stock biomass for redfish, 1975 to 2013



Source: Tuck & Day 2014

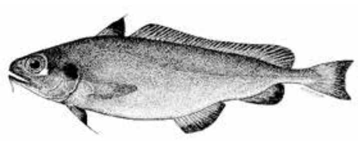
Stock status determination

The recent tier 1 assessment estimated spawning stock biomass for redfish at 11 per cent of unfished levels in 2015. Based on the results of this stock assessment, redfish is classified as **overfished**.

Projections undertaken as part of the stock assessment suggest that redfish will recover to the limit reference point by 2018 or 2019 under a total catch of up to 150 t, assuming average recruitment (Tuck & Day 2014). Recruitment data used in the stock assessment indicated below-average recruitment between 2001 and 2009. The ageing data suggest that there have been three recent years of improved recruitment: 2011 and 2012 (Tuck & Day 2014), and 2013 (Thomson et al. 2015a). Because of this recruitment variability, and the fact that there was only one year of above-average recruitment estimated since 2001, the existence and magnitude of recruitments will need to be closely monitored over the coming years to track progress against the objectives of the rebuilding strategy.

The catch allowance for the 2016–17 fishing season was 100 t, and the RBC was 0 t. Total landings were 39.5 t, and the weighted average discards were 58.99 t, giving a total of 98.49 t. Although mortality may have been constrained to less than the incidental catch allowance, total mortality for the 2016–17 season is unknown, and recruitment is variable and uncertain. Therefore, the stock remains classified as **uncertain if subject to overfishing**.

Ribaldo (*Mora moro*)



Line drawing: FAO

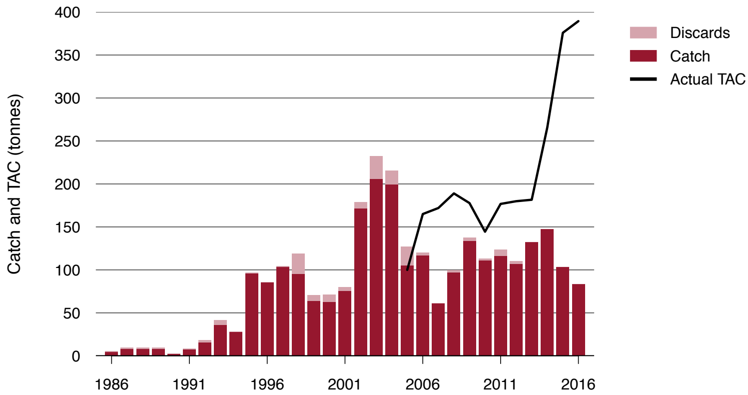
Stock structure

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

Catch history

Ribaldo is largely taken as byproduct during fishing for other species; only 5 per cent of the catch is considered to be targeted (Klaer et al. 2013). Similar proportions of the annual catch are taken by trawl and line. Historical catches increased from low levels in 1990 to a peak of more than 200 t in 2003. Catches dropped in 2005 to about 100 t, following implementation of a TAC (Figure 9.51). Landed catches decreased from 134 t in 2014–15 to 90 t in 2015–16. The Commonwealth landed catch in the 2016–17 fishing season was 87.7 t. The weighted average discards between 2012 and 2015 were 8.6 t (Thomson & Upston 2016).

FIGURE 9.51 Ribaldo annual catches (CTS and SHS) and fishing season TACs, 1986 to 2016



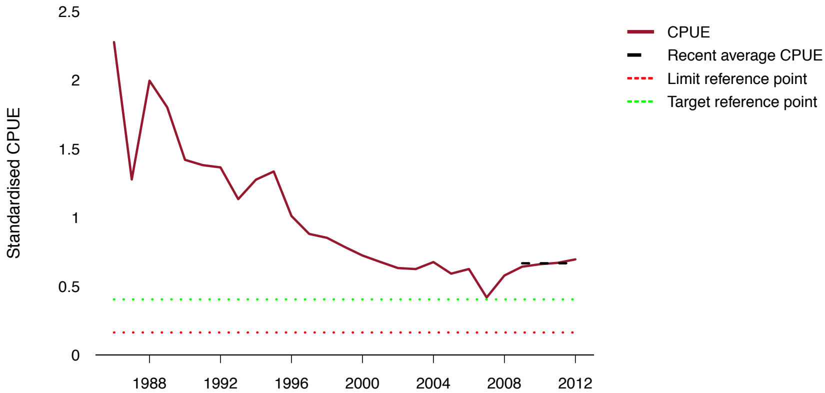
Notes: **TAC** Total allowable catch. Data for 2013 to 2016 do not include discards.
Source: Haddon 2013a; Australian Fisheries Management Authority catch disposal records (2013 to 2016 catch data)

Stock assessment

Ribaldo is assessed as a tier 4 stock using trawl CPUE (Figure 9.52; Morison et al. 2013). Ribaldo fits the criteria agreed by the Southern and Eastern Scalefish and Shark Fishery Resource Assessment Group for secondary species, and SlopeRAG has therefore provided advice on the RBC from the tier 4 assessment using the B_{40} target reference point (Morison et al. 2013).

The most recent tier 4 assessment was revised in 2013 with CPUE data to 2012, and results were provided for both the secondary species B_{40} target and a B_{48} target (Haddon 2013a). Calculations used the period 1995 to 2004 as the reference period (when catches first approached 100 t). Given the lightly exploited nature of the fishery during the reference period, the target CPUE was calculated by dividing the average reference period CPUE by 2, to reflect the likely change in CPUE that would occur as the fishery became fully exploited. Trawl catch rates have been relatively stable since 2000, and auto-longline catch rates have been stable since 2005. Both are above the target level. Throughout this period, catches have remained below the established TACs and below RBCs. The 2013 analysis produced an RBC of 355 t using the B_{40} target (Haddon 2013a). SlopeRAG recommended a three-year RBC of 355 t, with a review if 70 per cent or more of the TAC is caught, if trawl CPUE changes by 50 per cent or more, or if there is a significant change in the proportion of catch by the line sector (AFMA 2013a). SlopeRAG also recommended that a discount factor not apply because of the existing closures for both trawl and auto-longline methods. After applying the large change–limiting rule, AFMA implemented a three-year multiyear TAC of 252 t for 2014–15, and 355 t for 2015–16 and 2016–17.

FIGURE 9.52 Standardised CPUE for ribaldo, 1986 to 2012



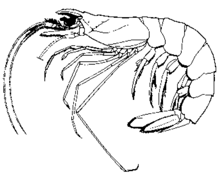
Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.
Source: Haddon 2013a

Stock status determination

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

For the 2016–17 fishing season, the agreed TAC was 355 t, the actual TAC was 389 t and the RBC was 355 t. Total landed catch was 87.7 t, and the weighted average discards were 8.6 t. The landed catch and discards combined was 96.3 t, which is below the RBC of 355 t. The stock is therefore classified as **not subject to overfishing**.

Royal red prawn (*Haliporoides sibogae*)



Line drawing: FAO

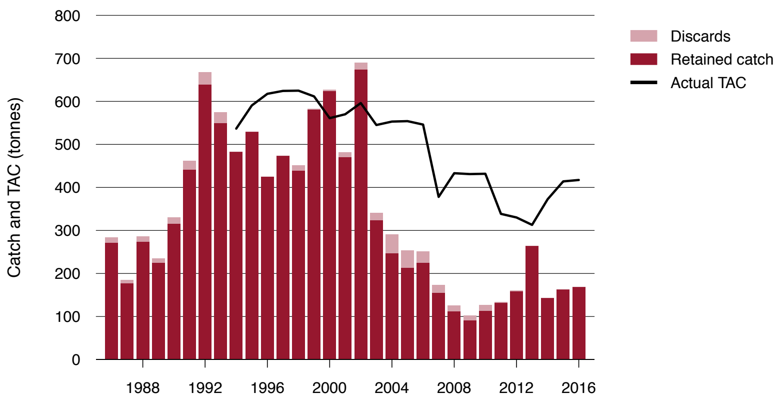
Stock structure

Royal red prawn is widespread, occurring in depths of 350 to 550 m in the Indian and western Pacific oceans. In Australia, royal red prawn is caught off New South Wales, Queensland and Western Australia between latitudes 10°S and 36°S. Little is known of the stock structure in eastern Australia. Because most of the Australian catch is taken off the New South Wales coast between Port Stephens and Ulladulla, for assessment and management purposes, these populations are assumed to comprise a single stock (Morison et al. 2013).

Catch history

Catch of royal red prawn fluctuated around 500 t per year during the 1990s and early 2000s, before declining and stabilising at around 100–200 t in recent years (Figure 9.53). Catch has been below the TAC in recent years, which can largely be attributed to limited availability of processing facilities for this species and low market demand (Morison et al. 2013). The catch of royal red prawn in the 2016–17 fishing season was 126.8 t. The weighted average discards between 2012 and 2015 were 1.9 t (Thomson & Upston 2016).

FIGURE 9.53 Royal red prawn annual catches (CTS and state combined) and fishing season TACs, 1986 to 2016



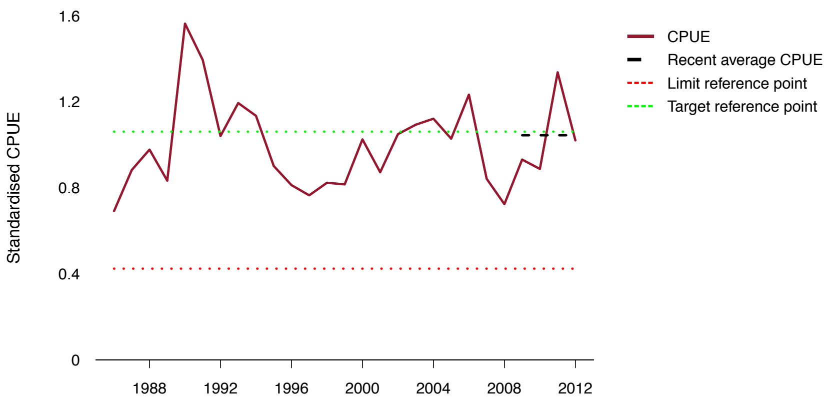
Note: **TAC** Total allowable catch. Data for 2013 to 2016 do not include discards and state catch.
Source: Haddon 2013a; Australian Fisheries Management Authority catch disposal records (2013 to 2016 catch data)

Stock assessment

The RBC for royal red prawn is based on the most recent tier 4 assessment (Haddon 2013a) and harvest control rules, with the limit CPUE ($CPUE_{LIM}$) specified at 40 per cent of the target CPUE ($CPUE_{TARG}$). The assessment indicates that the average standardised CPUE for the four years to 2012 was at the target reference point (Figure 9.54). ShelfRAG determined the stock suitable for a three-year RBC, with the implementation of a breakout rule based on a 50 per cent change in CPUE. Based on the 2013 assessment, ShelfRAG proposed a three-year RBC of 393 t, and AFMA recommended a multiyear TAC of 388 t for the 2014–15 to 2016–17 fishing seasons. After deduction of discard estimates and state catch, the agreed TAC was set at 387 t for the 2016–17 fishing season.

Some concerns about using a tier 4 analysis for this stock have been expressed by ShelfRAG because targeting of royal red prawn is market driven (Morison et al. 2013). Such practices may influence CPUE and the tier 4 assessment.

FIGURE 9.54 Standardised CPUE for royal red prawn, 1986 to 2012



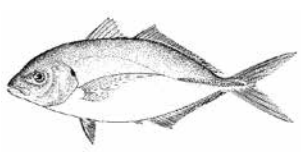
Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.
Source: Haddon 2013a

Stock status determination

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

For the 2016–17 fishing season, the agreed TAC was 387 t, the actual TAC was 417 t and the RBC was 393 t. Total landed catch was 126.8 t, and the weighted average discards were 1.9 t. The landed catch and discards combined was 128.8 t, which is below the RBC of 393 t. The stock is therefore classified as **not subject to overfishing**.

Silver trevally (*Pseudocaranx georgianus*)



Line drawing: FAO

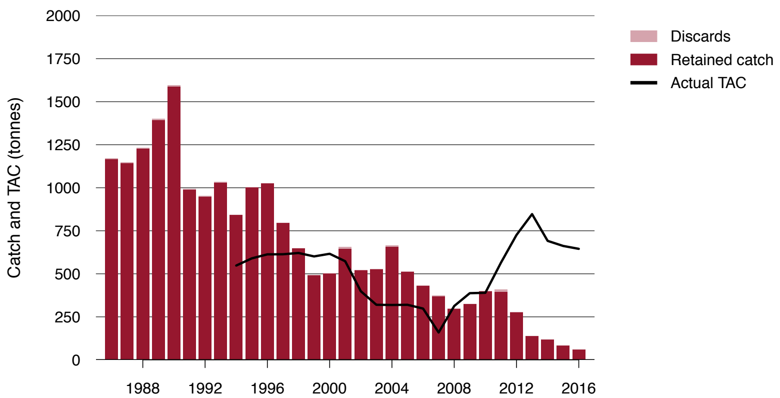
Stock structure

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

Catch history

High catch rates between 1989 and 1991, with a peak catch in 1990 of 1,588 t, were the result of efficient vessels entering the fishery in 1989 (Haddon 2013a). Catch has since declined (Figure 9.55). Catch decreased from 93 t in 2014–15 to 72 t in 2015–16 out of the 615 t multiyear TAC. The Commonwealth landed catch in the 2016–17 fishing season was 52.8 t. Silver trevally is also a popular target for recreational fishers off south-eastern Australia; the recreational catch in New South Wales was estimated to be around 27 t in 2013–14 (West et al. 2015). The weighted average discards between 2012 and 2015 were 19.58 t (Thomson & Upston 2016).

FIGURE 9.55 Silver trevally annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2016



Notes: **TAC** Total allowable catch. Data for 2013 to 2016 exclude discards and state data.
Source: Haddon 2013a; Australian Fisheries Management Authority catch disposal records (2013 to 2016 catch data)

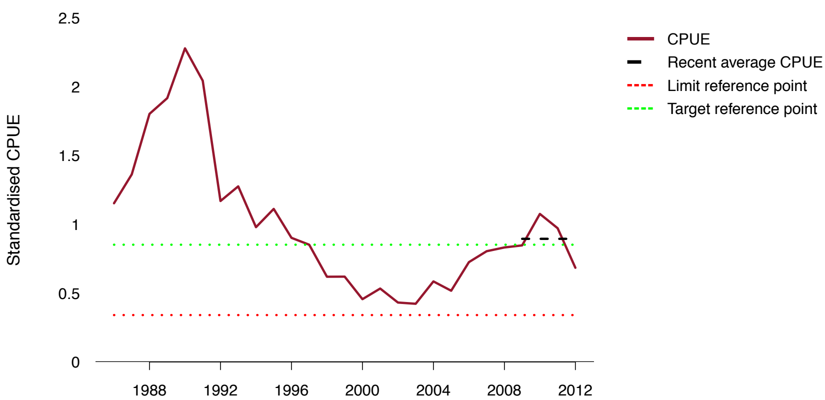
Stock assessment

The 2013 tier 4 assessment (Haddon 2013a) used the reference period 1992 to 2001, since high catch rates before 1992 (Figure 9.56) were not considered to be sustainable (Haddon 2013b). CPUE declined from 1993, to be near the limit by 2002. The fishery exhibited a general trend of increasing CPUE between 2003 and 2010, but CPUE has since declined. Standardised CPUE using catch data to 2012 indicates that recent CPUE decreased to near the target (Haddon 2013a; Figure 9.56). The most recent tier 4 assessment (Haddon 2013a) estimated four-year average CPUE to be near the target level. This assessment estimated a one-year RBC of 858 t and a three-year RBC of 791 t; ShelfRAG recommended a three-year RBC (AFMA 2013b). AFMA subsequently set a three-year multiyear TAC of 615 t for the 2013–14 to 2015–16 seasons. After deduction of state catches and discards, the 2015–16 TAC was 602 t.

The establishment of Batemans Marine Park in June 2007 has affected the estimation of silver trevally RBCs because historical catch data from within the park boundaries are included in the target catch range component of the RBC calculation, but the CPUE analyses do not include historical activities in this area. The RBC derived from the 2013 tier 4 assessment (Haddon 2013a) considered catch rates from both within and outside the marine park, and found little difference in the RBC estimate. Nonetheless, ShelfRAG recommended waiving the default tier 4 discount factor of 15 per cent of the RBC, on the basis that the marine park provides sufficient precaution as a refuge for spawning adults and juveniles across a significant portion of the species' distribution (AFMA 2013b). 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 9.56 Standardised CPUE for silver trevally, 1986 to 2012



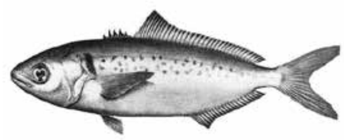
Notes: **CPUE** Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.
Source: Haddon 2013a

Stock status determination

The four-year average standardised CPUE used for the most recent tier 4 assessment is above the target reference level. As a result, silver trevally is classified as **not overfished**.

For the 2016–17 fishing season, the agreed TAC was 588 t, the actual TAC was 645 t and the RBC was 791 t. The landed catch was 52.8 t, and the weighted average discards were 19.5 t. The landed catch and discard, combined was 72.3 t, which is below the RBC of 791 t. The stock is therefore classified as **not subject to overfishing**.

Silver warehou (*Seriolella punctata*)



Line drawing: FAO

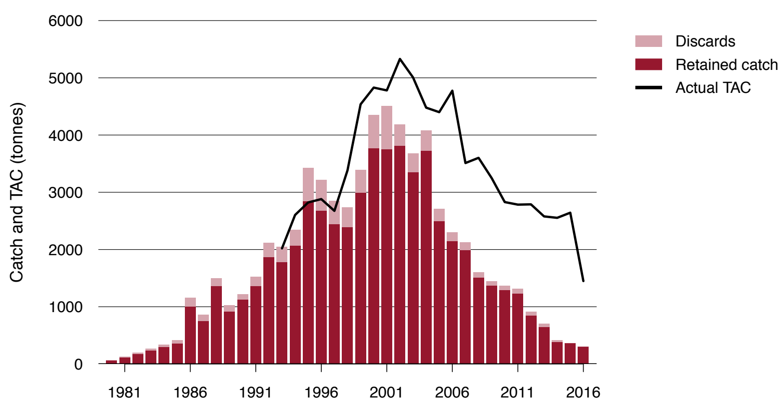
Stock structure

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

Catch history

Silver warehou is caught entirely by trawl in the CTS and has been a targeted species throughout most of the history of the fishery. Silver warehou catches steadily increased from the start of the fishery in 1980 to peaks of 4,450 t in 2002 and 4,435 t in 2004 (Figure 9.57). Catches subsequently declined to 370 t out of the 2,329 t TAC in 2014–15 and 276 t out of the 2,417 t TAC in 2015–16. The Commonwealth landed catch in the CTS for the 2016–17 fishing season was 311 t (the total landed catch in the SESSF was 360 t). The weighted average discards between 2012 and 2015 were 26.66 t (Thomson & Upston 2016).

FIGURE 9.57 Silver warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1980 to 2016



Notes: **TAC** Total allowable catch. Data for 2015 and 2016 do not include discards and state catch.
Source: Thomson et al. 2015b; Australian Fisheries Management Authority catch disposal records (2016 catch data)

Stock assessment

Silver warehou has been managed under tier 1 of the SESSF HSF since the HSF was introduced. The 2009 model-based assessment (Tuck & Fay 2010) predicted the spawning stock biomass in 2010 to be 48 per cent of unfished levels and was used as the basis for a three-year TAC of 2,566 t, commencing in 2010–11. SlopeRAG developed breakout rules to trigger a review of this three-year TAC, including whether the most recent observed value for the standardised CPUE falls outside the 95 per cent confidence interval of the value predicted by the most recent stock assessment (AFMA 2013a).

This breakout rule was triggered in 2012, resulting in an update of the model-based assessment, including updates of catch, discard, length, age and catch-rate data (Day et al. 2012). The 2012 assessment was inconsistent with the CPUE decline over the past two years, instead estimating a biomass increase. This indicated that the model may be optimistic in its forward CPUE estimates. SlopeRAG concluded that the CPUE breakout rule was likely to be triggered again as a result of this lack of fit to the CPUE (AFMA 2013a). However, the base-case assessment projected that the 2013 spawning stock biomass would be $0.47B_0$, indicating that there was little immediate concern about stock status. Following SlopeRAG's recommendations, a three-year TAC of 2,329 t was established based on this assessment, starting in 2013–14.

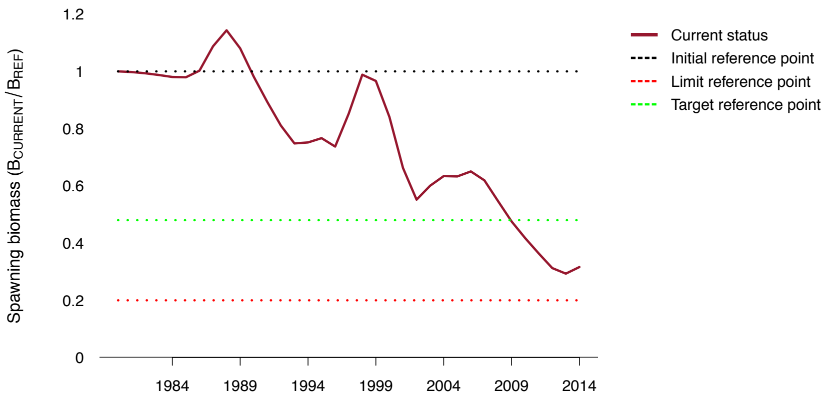
The CPUE breakout rule was again triggered in 2013 and 2014, as expected. SlopeRAG advised against repeating a full stock assessment, because there appeared to be a retrospective problem with the assessment, causing it to repeatedly overestimate biomass in recent years. SlopeRAG recommended that the multiyear TAC continue, and that work be done to determine the reason for the retrospective pattern in analyses before a further update of the silver warehou assessment (AFMA 2013a).

A tier 1 assessment in 2015 (Thomson et al. 2015b) used updated catch, discard, CPUE, length and age data. The updated assessment projected the 2016 spawning biomass to be $0.4B_0$ (Figure 9.58), and produced a 2016–17 RBC of 1,958 t and a long-term yield of 2,281 t. However, these scenarios assume average recruitment; recruitment has been below average since 2003.

In the initial tier 1 assessment, sensitivities were run using a 'poor' recruitment scenario (the average of a recent five-year period of poor recruitment) and a 'very poor' recruitment scenario (the average of the worst three of these five years). A constant catch of 381 t was used in projections under these scenarios, based on the volume of recent landed catches of silver warehou. Neither of these low-recruitment scenarios indicated that the stock would approach the target biomass by 2020 at a catch of 381 t, and the very poor recruitment scenario indicated a decline in spawning biomass to a depletion level below 40 per cent in 2020 (AFMA 2015f). This indicates that, at tested catch levels, future increases in stock are dependent on levels of future recruitment increasing to above the low-recruitment scenarios assumed for these projections. SlopeRAG (AFMA 2015f) noted that the recent series of sequential poor recruitments indicates that there is a risk that silver warehou recruitment may be serially correlated and that future recruitment may remain low.

SlopeRAG (AFMA 2015f) noted that, if one of the objectives of the next silver warehou multiyear TAC is to increase the biomass from the current estimated level, a catch below 600 t is recommended. Recognising the constraints of the large change–limiting rule, SlopeRAG recommended stepping down to the poor-recruitment scenario RBC of 604 t in two years (AFMA 2015h). Consequently, and subject to the change-limiting rule, the TAC for the 2016–17 fishing season was set at 1,209 t.

FIGURE 9.58 Estimated spawning stock biomass for silver warehou, 1980 to 2014



Source: Thomson et al. 2015a

Stock status determination

The 2015 stock assessment predicted spawning biomass in 2016 to be $0.4B_0$. The target reference point is $0.48B_0$. Silver warehou therefore remains classified as **not overfished**.

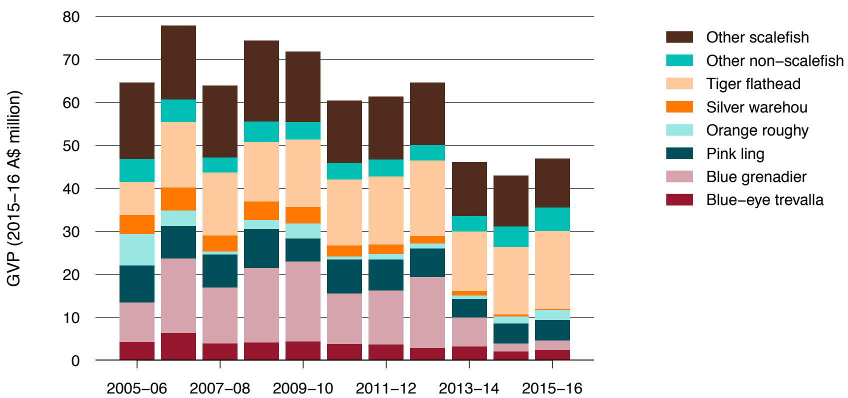
For the 2016–17 fishing season, the agreed TAC was 1,209 t, the actual TAC was 1,449 t and the RBC was 1,958 t. Total landed catch in the CTS was 311.7 t, and the weighted average discards were 26 t. The landed catch and discards combined was 337.7 t, which is below the RBC of 1,958 t. This total fishing mortality was also below the low-recruitment constant-catch scenario that produced an updated 2016–17 RBC of 604 t. The stock is therefore classified as **not subject to overfishing**.

9.3 Economic status

Key economic trends

The CTS and the SHS contributed approximately 57 per cent of total SESSF GVP ($73.25 million) in 2015–16. From 2005–06 to 2012–13, real GVP for the two sectors averaged $67.37 million (in 2015–16 dollars; Figure 9.59). By 2013–14, it had fallen, and has since remained, below $50.00 million. Since 2005–06, the decline in the value of orange roughy and blue grenadier catches were the key drivers of the reduction in scalefish GVP. In 2005–06, orange roughy catches were valued at $7.40 million, and blue grenadier catches were valued at $9.21 million. By 2013–14, the GVP of orange roughy catches had declined to $819,000, and blue grenadier catches had declined to $6.66 million. For orange roughy, this declining trend was due to TAC reductions to recover stocks. In terms of value during 2015–16, the mix of species caught was dominated by tiger flathead ($18.17 million; 39 per cent of the total GVP) and pink ling ($4.68 million; 10 per cent).

FIGURE 9.59 Real GVP, by key species, for the CTS and SHS, 2005–06 to 2015–16



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

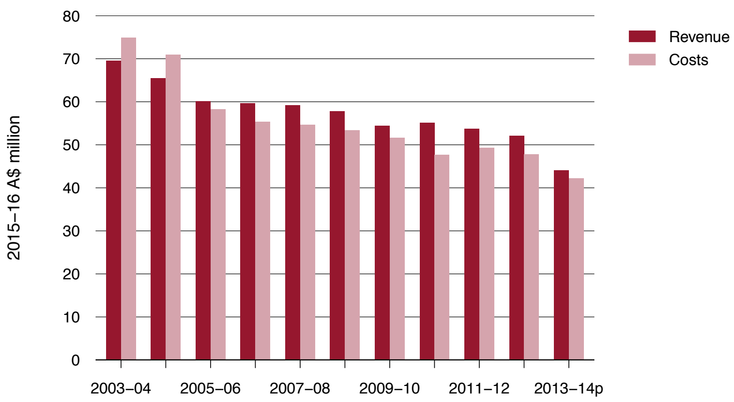
Estimates of the net economic returns (NER) associated with scalefish catches for the CTS and the SHS combined are not available, because ABARES undertakes economic surveys of the CTS separately from the SHS (which is surveyed as part of the GHTS). However, with respect to value, the CTS accounts for the majority of the scalefish catch. Estimates of NER for the CTS have been positive since 2005–06, increasing from $1.83 million in 2005–06 to $7.43 million in 2010–11, then falling to $1.82 million in 2013–14 (2015–16 dollars; Figure 9.60). The reduction in NER since 2010–11 has been due to increasing costs, and a fall in the price of fish between 2012–13 and 2013–14 (Skirtun & Green 2015). Despite the reduction in GVP, a 20 per cent fall in the price of fuel—a major component of costs for trawl vessels, in particular—is likely to have supported positive NER.

The economic performance of the CTS has improved overall since 2003–04, but has declined since a peak in 2010–11. A profit decomposition of the CTS (Skirtun & Vieira 2012) suggested that output prices, followed by more productive use of capital (boat and equipment), have been the key drivers of the overall improvements in profitability. The contribution from improved capital productivity is likely to have been partly associated with the Securing our Fishing Future structural adjustment package, which resulted in removal of around half the boat statutory fishing rights in the CTS. The voluntary tender design of the structural adjustment package is likely to have resulted in the removal of the least efficient vessels from the sector, leading to an increase in the average capital productivity per vessel (Vieira et al. 2010). Productivity declined 8 per cent between 2011–12 and 2012–13. This decline has contributed to the decline in NER since 2010–11 (Figures 9.60 and 9.61; Skirtun & Green 2015). Preliminary work on the efficiency of vessels operating in the CTS supports the hypothesis that efficiency improved following structural adjustment, but declined from 2010–11 to 2012–13, so that the median vessel was operating at only 64 per cent efficiency (Green 2016). The research also indicated that the potential productivity of vessels in the CTS has declined since 2008–09, but further research is required to determine the cause.

FIGURE 9.60 NER for the CTS, 2003–04 to 2013–14

Notes: **NER** Net economic returns. Results for 2013–14 are preliminary, non-survey based estimates.

FIGURE 9.61 Revenue and costs for the CTS, 2003–04 to 2013–14



Note: Results for 2013–14 are preliminary, non-survey based estimates.
Source: Skirtun & Green 2015

Management arrangements

Both the CTS and the SHS are managed under ITQs. TACs are set for key target species for each fishing season and allocated to quota holders. This form of management promotes efficiency, because it allows operators to harvest with greater flexibility (with fewer restrictions on inputs), and often results in quota being acquired by the most efficient and profitable operators. ITQ management in the SESSF has used multiyear TACs for some stocks, which are usually set for three years. In recent years, the latency in key scalefish species in the SESSF has increased (Skirtun & Green 2015). This has coincided with falls in NER in 2013–14, largely as a result of lower prices for key species. The appearance of deteriorating conditions in 2013–14—in the context of a multispecies fishery—and increasing latency may indicate a need to review MEY targets and TACs.

Historically, proxy targets have been set at the species level and have not taken account of interactions between species caught in the sector. If management settings are based on the MEY of individual species, achieving the objective for one species may be constrained by the management settings targeting the MEY of another species. Several resource assessment groups have begun to look at target biomass levels below individual B_{MEY} for these secondary species. Vieira et al. (2013) have provided advice on the potential fishery-wide economic benefits that could be derived from setting MSY-based targets for secondary species in the SESSF. Alternative MSY-based $0.4B_0$ targets have been approved by AFMA for ocean perch, ribaldo and john dory.

Performance against economic objective

With the exceptions listed above, all species groups under quota in the SESSF are managed under a harvest strategy that targets B_{MEY}, the biomass level that is likely to be associated with MEY. Management has generally pursued B_{MEY} by using a proxy target reference point (most often $0.48B_0$). Tiger flathead, blue grenadier, pink ling and blue-eye trevalla accounted for 59 per cent of total GVP in both sectors in 2015–16. The biomass of these species, relative to the respective B_{MEY} targets, therefore provides an indication of performance against the objective of maximising NER.

Of the four key species, only tiger flathead has a quantitatively estimated species-specific MEY target, at $0.38B_0$. This was adjusted to $0.40B_0$ to take a more precautionary approach (Morison et al. 2013; Figure 9.17). At 42 per cent of unfished spawning biomass ($0.42SB_0$), the estimated biomass of tiger flathead in 2016 was above the MEY target (Day 2017). Moreover, the biomass has been increasing since 2008. Similarly, at $0.77B_0$, the biomass estimate for blue grenadier in 2013 was above the target reference point ($0.48B_0$) (Tuck 2013; Figure 9.8). This implies that NER are not constrained by these two stocks and improvements are possible if the species were fished down towards B_{MEY}. However, lower prices in recent years are likely discouraging participation by the factory vessels best suited to exploiting the stock. In 2015, an updated stock assessment estimated that the western pink ling stock was $0.72B_0$, which is significantly above the target reference point; however, in the east, the stock was $0.30B_0$, which is below the target reference point. The stock of blue-eye trevalla is between the limit and reference points. With the exception of eastern pink ling and blue-eye trevalla, it can be concluded that these key species are being managed at levels that are not below B_{MEY} targets. However, the disinclination of fishers to significantly fish-down blue grenadier suggests that the $0.48B_0$ proxy may not be aligned with MEY. Alternatively, this disinclination may be the result of unusually low prices and participation that will be resolved in the medium term.

Blue-eye trevalla
Tamre Sarhan, AFMA

Two other species considered here are silver warehou and orange roughy. Silver warehou accounted for 1 per cent of scalefish GVP in 2015–16, but had accounted for up to 8 per cent immediately after the adoption of the HSP. An assessment update in 2015 projected silver warehou biomass to be $0.4B_0$ in 2016, which is below the target of $0.48B_0$. However, latency is high, with only 26 per cent of the 2016–17 TAC caught by fishers. Whereas orange roughy accounted for 5 per cent of the value of the scalefish catch in 2015–16, it accounted for more than 50 per cent in the early 1990s. Catches at that time were associated with overfishing, and two of the four orange roughy stocks are currently assessed as overfished. Although all four orange roughy stocks are classified as 'not subject to overfishing', rebuilding of these stocks is expected to be slow. The resumption of targeted orange roughy fishing in the eastern zone means that orange roughy is now the fourth most valuable stock in the CTS and, subject to continued rebuilding, may play a larger role in the economic performance of the fishery.

Overall, NER in the CTS have been positive since 2005–06, although there has been a decline since 2010–11. Combined with the reductions in vessel numbers and associated increases in economic productivity, this suggests that, overall, the CTS has moved closer to MEY since 2005–06. Although preliminary estimates for 2013–14 show some deterioration in economic performance, falls in the price of fuel will likely have contributed positively to NER. Additionally, the estimated current biomasses of at least three of the four most valuable species are close to the respective B_{MEY} targets. This indicates that the economic status of the CTS is positive and has substantially improved since the adoption of MEY targeting, despite falls since 2010–11. Economic status in the long term will be improved if orange roughy stocks can continue to rebuild. The large amount of uncaught blue grenadier quota suggests that NER can be improved by fishing down the stock. However, low prices are likely deterring participation by factory vessels best suited to exploiting the stock.

Economic performance could improve further if approaches to setting MEY-based target reference points were improved. In particular, it may be beneficial to develop ways of setting target reference points for a multispecies fishery and derive cost-effective estimates of species-specific B_{MEY} for some of the more valuable species.

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

9.4 Environmental status

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

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Chapter 10

East Coast Deepwater Trawl Sector

L Georgeson and D Mobsby

FIGURE 10.1 Area of the East Coast Deepwater Trawl Sector

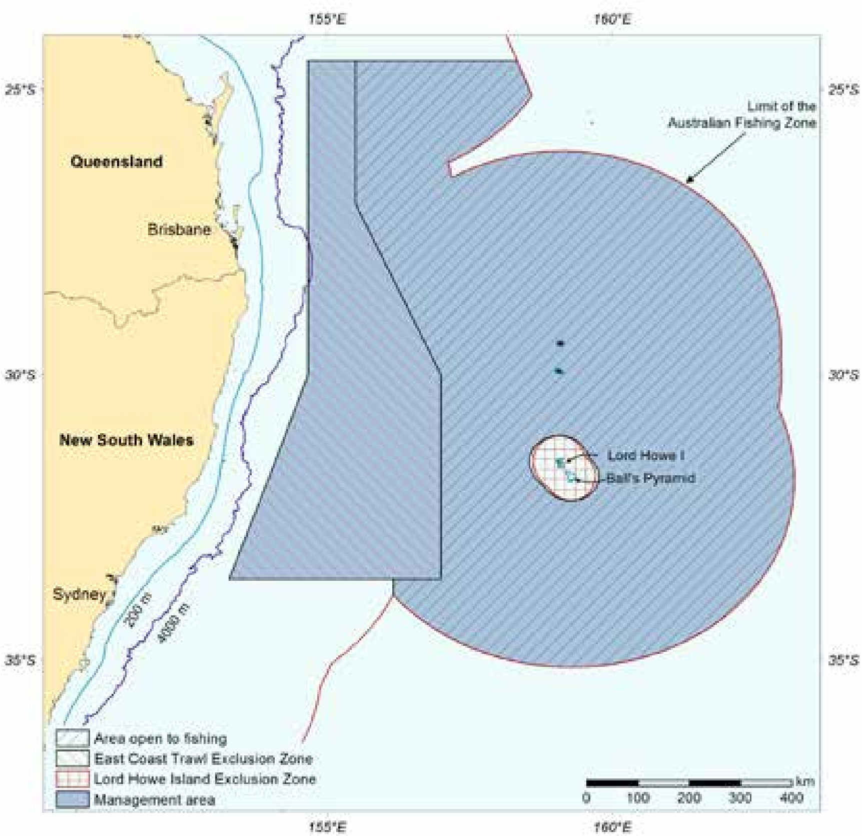


TABLE 10.1 Status of the East Coast Deepwater Trawl Sector

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Alfonsino (*Beryx splendens*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Zero catch and effort in 2016–17.
Economic status	Before 2014–15, high levels of latency indicated low NER. No fishing activity in 2014–15 and 2015–16 indicates that NER were zero in those years.				

Notes: **NER** Net economic returns.

Fishing mortality	Not subject to overfishing (green)	Subject to overfishing (red)	Uncertain (yellow)
Biomass	Not overfished (green)	Overfished (red)	Uncertain (yellow)

10.1 Description of the fishery

Area fished

The East Coast Deepwater Trawl Sector (ECDTS) began as an exploratory fishery in the early 1990s, primarily taking orange roughy (*Hoplostethus atlanticus*) 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

The ECDTS is a demersal and midwater trawl, and bottom-line (longline and dropline) fishery. Fishing in the 1990s mostly targeted orange roughy around Lord Howe Rise. Since 2000, the fishery has targeted mostly alfonsino (*Beryx splendens*). Important byproduct species include blue-eye trevalla (*Hyperoglyphe antarctica*) and boarfish (Pentacerotidae). Boarfish has a catch limit of 200 t to regulate catch, and orange roughy has a 50 t incidental catch limit. If catches exceed these limits, the fishery would be closed for the remainder of the season.

Management methods

The fishery operates in accordance with the SESSF harvest strategy framework (AFMA 2009; 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, the Australian Fisheries Management Authority (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 (SPRFMO) Convention area. The distributions of most deepwater species taken by this sector extend well beyond the Exclusive Economic Zone (EEZ) areas fished by the sector, extending into the high seas, and across Lord Howe Rise and Challenger Plateau to the New Zealand EEZ.

Fishing effort

Effort in the ECDTS has been variable but generally low since the 1990s; in recent years, it has been low and sporadic. There has been no effort in the fishery since 2013–14.

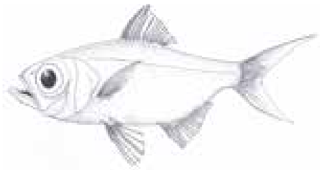
TABLE 10.2 Main features and statistics for the ECDTS

Fishery statistics a	**2015–16 fishing season**			**2016–17 fishing season**	
Stock	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**	**TAC (t)**	**Catch (t)**
Alfonsino	1,016	0	0	1,017	0
Total fishery	**1,266** b	**0**	**0**	**1,267** b	**0**
Fishery-level statistics					
Effort	0			0	
Fishing permits	10			10	
Active vessels	0			0	
Observer coverage	0			0	
Fishing methods	Demersal and midwater trawl				
Primary landing ports	Brisbane (Qld), Sydney (NSW)				
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. Real-value statistics are by financial year and were not available for the 2016–17 financial year at the time of publication. **b** Includes a 200 t non-tradeable catch limit for boarfish and a 50 t incidental catch limit for orange roughy.
Notes: **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 pelagic species that aggregates around seamounts and features on the upper continental slope. Alfonsino in Australia's EEZ is currently managed as a single management unit across the CTS and the ECDTS, with a single total allowable catch (TAC) that applies only within the EEZ. Alfonsino is caught along the continental shelf break in the SESSF and the East Coast Deep Water Zone (ECDWZ). The alfonsino catch in the ECDWZ has largely been taken in an area south-east of Lord Howe Island—approximately half of this area is outside the Australian Fishing Zone (AFZ), effectively straddling both the ECDWZ and the high seas (Morison et al. 2013). The biological stock structure of alfonsino fished in the ECDTS is unknown. It is likely that alfonsino on the northern Lord Howe Rise constitutes a straddling stock, extending from within the Australian EEZ out into the high seas.

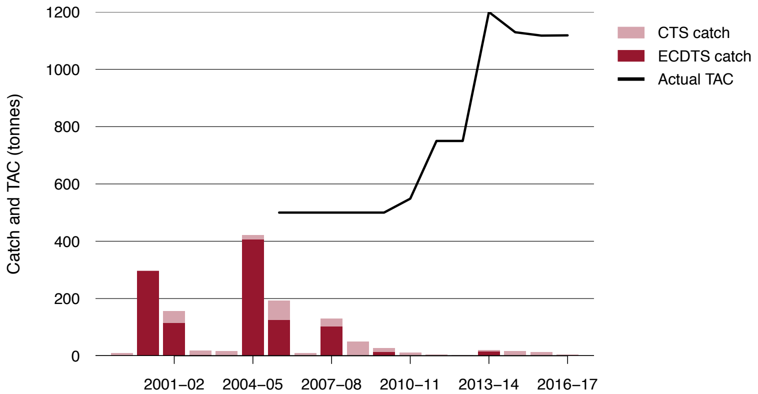
The first meeting of the SPRFMO Scientific Committee in 2013 recommended that the existence and distribution boundaries of alfonsino and orange roughy stocks that straddle EEZ boundaries should be identified (SPRFMO 2013). An assessment of orange roughy in the SPRFMO Convention area was published in 2014 (Tingley 2014), but no assessment of alfonsino has been undertaken.

Catch history

Fishing in the area of the ECDTS has been intermittent, and data are limited. In particular, 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 just over 400 t in 2004–05, and reached 200 t in 2000–01, 2005–06 and 2011–12 (Figure 10.2).

The landed alfonsino catch from the ECDTS decreased from 15 t in 2013–14 to zero in 2014–15, 2015–16 and 2016–17, reflecting zero fishing effort. The 2016–17 alfonsino TAC was 1,017 t.

FIGURE 10.2 Catch and TAC for alfonsino in the ECDTS and the CTS, 1999–2000 to 2016–17



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 (SlopeRAG) rejecting early attempts at a tier 4 assessment in 2007 and recommending that alfonsino be assessed under tier 3.

The 2011 assessment (Klaer 2012) used age-frequency data from length frequencies and otoliths collected in 2007 and 2009. Catch-curve analyses estimated a lower total mortality than previous assessments and indicated that fishing mortality was less than F_{48} (the fishing mortality that would be expected to result in a spawning stock biomass of 48 per cent of the unfished level, on average, in the long term). Application of the SESSF tier 3 harvest control rules resulted in a recommended biological catch (RBC) of 1,160 t. However, application of the 50 per cent change-limiting rule (see Chapter 8) resulted in the TAC being set at 750 t for the 2011–12 season. The TAC was kept at 750 t for 2012–13, because no new data were available and little fishing was occurring in the ECDTS. The 2012 tier 3 assessment estimated an RBC of 1,196 t, which resulted in a TAC of 1,125 t for the 2013–14 fishing season after the 50 per cent change-limiting rule was applied (AFMA 2013).

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

The 2013 assessment update estimated current fishing mortality as F_{CURR} = 0.022, well below the estimated F_{RBC} = 0.149 (Klaer 2013). Fishing mortality has been negligible because catches have remained well below the TAC each year, and have been zero since 2013–14.

Stock status determination

The tier 3 assessment for alfonsino indicates that, since 2000, fishing mortality has remained below the level that would constitute overfishing. The most recent assessment indicates 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, and no fishing effort or catch has occurred in the fishery since 2013–14. 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 have been confidential. Fishing effort in the ECDTS declined by 85 per cent in 2013–14 to 8 hours. There was no fishing activity in 2014–15 and 2015–16.

The long distance to fishing grounds and use of trawl gear mean that fuel costs make up a high proportion of total fishing costs in the ECDTS. The average price for off-road diesel (which excludes goods and services tax) was 38 per cent lower in 2015–16 than in 2013–14. Indicative prices for alfonsino, the major targeted species in the ECDTS, increased in 2014–15 and 2015–16. Given that recent stock assessments have resulted in substantially increased RBCs, the low catches in recent years are not the result of low abundance. Inactivity in the ECDTS in 2014–15 and 2015–16 is likely to be the result of factors other than fuel costs, alfonsino price and alfonsino abundance. Higher expected profit in the CTS and other fisheries that permit holders operate in may be a key driver of inactivity in the ECDTS.

Management arrangements

The alfonsino TAC was 1,016 t in 2015–16 and 1,017 t in 2016–17. Given that recent stock assessments have resulted in substantially increased RBCs, the low catches in recent years are not the result of low abundance.

Performance against economic objective

The high level of latency, in terms of the proportion of the TAC caught, suggests that expected profit in the sector is insufficient to justify fishing effort. No fishing activity in 2014–15 and 2015–16 indicates that NER were zero in those years.

The sector's key target species, alfonsino, is currently managed under the SESSF harvest strategy as a tier 3 species, with a proxy fishing mortality target of F_{48}. This approach to setting TACs for the species is consistent with meeting the economic objective of the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007).

10.4 Environmental status

The ECDTS has not been assessed separately under AFMA's ecological risk assessment process, but was included in the assessment of the CTS (Chapter 8). 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 2014). There is no targeted fishing for this species in the ECDTS, and there has been no reported catch in the fishery since 2003.

AFMA publishes quarterly reports of logbook interactions with species protected under the *Environment Protection and Biodiversity Conservation Act 1999* on its website. No interactions with species protected under the Act were reported in the ECDTS for 2016. Interactions with protected species and impacts on benthic habitats are unlikely to be of concern because of the low effort in the fishery in recent years.

10.5 References

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Chapter 11

Great Australian Bight Trawl Sector

A Moore and A Koduah

FIGURE 11.1 Relative fishing intensity in the Great Australian Bight Trawl Sector, 2016–17 fishing season

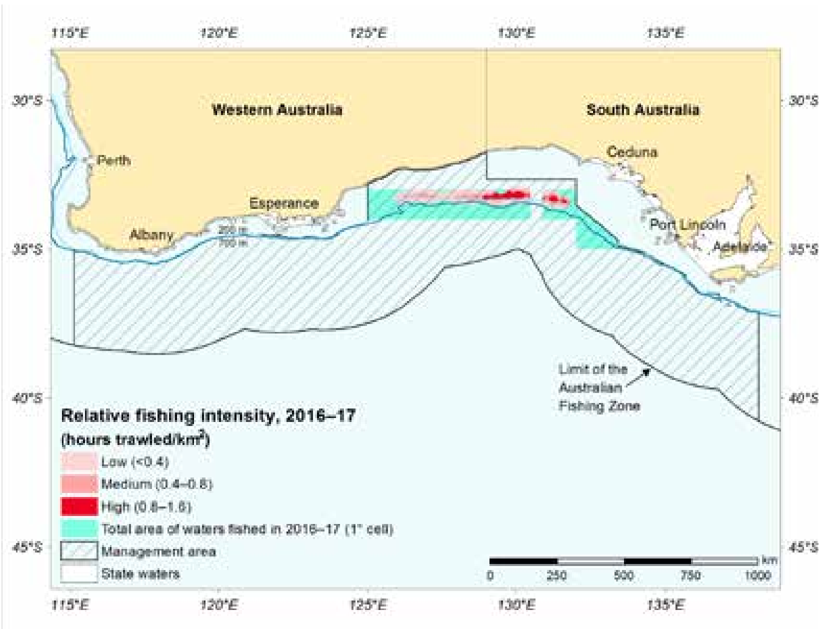


TABLE 11.1 Status of the Great Australian Bight Trawl Sector

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Bight redfish (*Centroberyx gerrardi*)					Catch is below RBC. Estimate of current biomass is above the target.
Deepwater flathead (*Platycephalus conatus*)					Catch is below RBC. Estimate of current biomass is near the target.
Ocean jacket (*Nelusetta ayraud*)					Catch has been stable in recent years. No formal assessment. Fishery-independent survey data indicate stock is not overfished.
Orange roughy (*Hoplostethus atlanticus*)					No commercial catch. No formal assessment of biomass, and impact of historical catches is uncertain.
Economic status	NER are likely to have increased slightly in 2015–16. The positive effects of lower effort and the ongoing fall in the price of fuel are likely to have more than offset the negative effect on NER of a lower gross value of production.				

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

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

Trawl catch
SETFIA

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- 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 year round. 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 228 t landed in 2016–17. 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; DAFF 2007) and the SESSF Harvest Strategy Framework (AFMA 2009) 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 per cent of the unfished biomass ($0.48B_0$), as a proxy for the biomass producing maximum economic yield (B_{MEY}). However, a bio-economic model (Kompas et al. 2012) estimated B_{MEY} target reference points of $0.43B_0$ for deepwater flathead and $0.41B_0$ for bight redfish in the GABTS. These estimated B_{MEY} targets were used by the Australian Fisheries Management Authority (AFMA) Commission to set the total allowable catch (TAC) for bight redfish and deepwater flathead for the 2016–17 fishing season.

Fishing effort

Total trawl fishing effort across all depths in 2016–17 was 12,480 trawl hours, down from the 2004–05 peak of 30,866 trawl hours. The continental shelf continues to be the focus of fishing effort, with 11,888 trawl hours in 2016–17 (Figure 11.2), compared with 591 trawl hours on the continental slope (Figure 11.3).

The deepwater fishery historically targeted orange roughy (*Hoplostethus atlanticus*). However, since 2007, when most of the historical orange roughy fishing grounds were closed under the Orange Roughy Conservation Programme (AFMA 2006), little effort has occurred at these depths.

The fishery has 10 boat statutory fishing rights that allow a boat to fish in the fishery, and separate quota statutory fishing rights that allow quota species to be landed. Four trawl vessels and one Danish-seine vessel operated in the fishery in 2016–17.

Catch

Reduced effort in the fishery has led to reduced catches of key target species over time. Deepwater flathead continues to dominate catches, with 636 t landed in the 2016–17 fishing season, which was 55 per cent of the TAC. Bight redfish landings in 2016–17 were 274 t, which was 23 per cent of the TAC.

FIGURE 11.2 Catch and effort on the GABTS shelf, 1988–89 to 2016–17

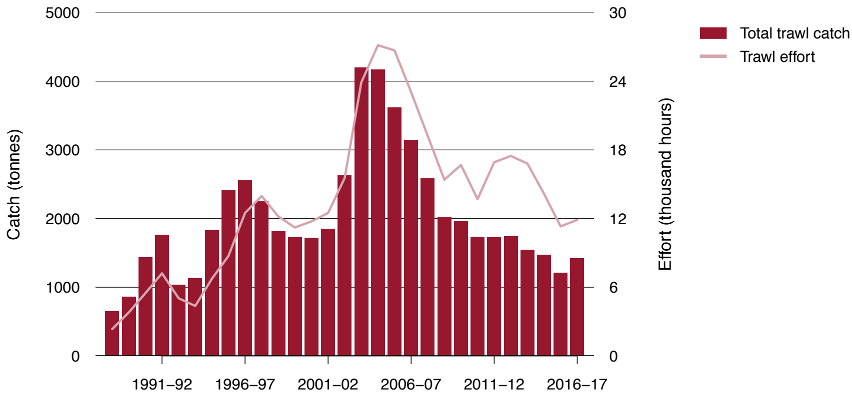


FIGURE 11.3 Catch and effort on the GABTS slope, 1988–89 to 2016–17

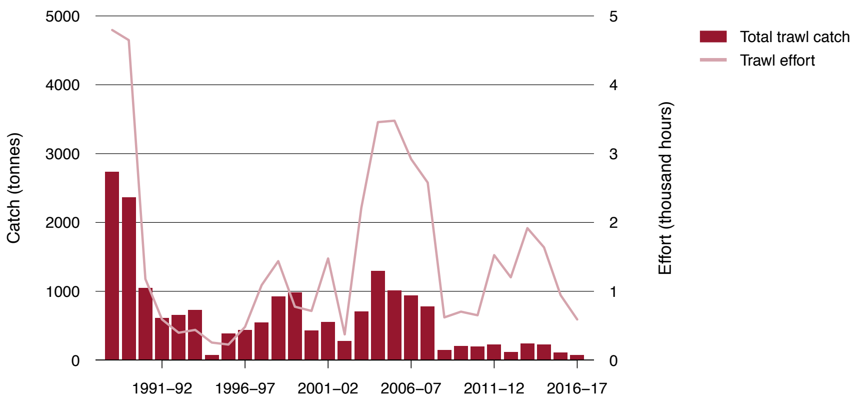


TABLE 11.2 Main features and statistics for the GABTS

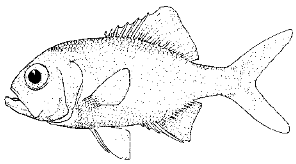
Fishery statistics a	2015–16 fishing season			2016–17 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**	**TAC (t)**	**Catch (t)**	**Real value (2016–17)**
Bight redfish	2,358	191	$940,000	1,179	274	na
Deepwater flathead	1,150	631	$4.38 million	1,150	636	na
Ocean jacket	–	216	$366,000	–	228	na
Orange roughy **b**	0 (200, 50)	0 (0, 0)	0	0 (200, 50)	0 (0, 0)	na
Total	**3,508 (250) c**	**1,038**	**$7.69 million**	**2,329 (250) c**	**1,138**	**na**
Fishery-level statistics						
Effort	13,509 trawl hours; 511 seine shots			12,480 trawl hours; 442 seine shots		
Fishing permits (SFRs)	10			10		
Active vessels	3 trawl; 1 seine			4 trawl; 1 seine		
Observer coverage	182 trawl hours (1.35%)			366 trawl hours (2.93%)		
Fishing methods	Trawl, Danish-seine					
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. Real-value statistics are by financial year and were not available for the 2016–17 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. **c** Research allowance.
Notes: **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing rights. **TAC** Total allowable catch. – Not applicable.

Bight redfish
AFMA

11.2 Biological status

Bight redfish (*Centroberyx gerrardi*)



Line drawing: FAO

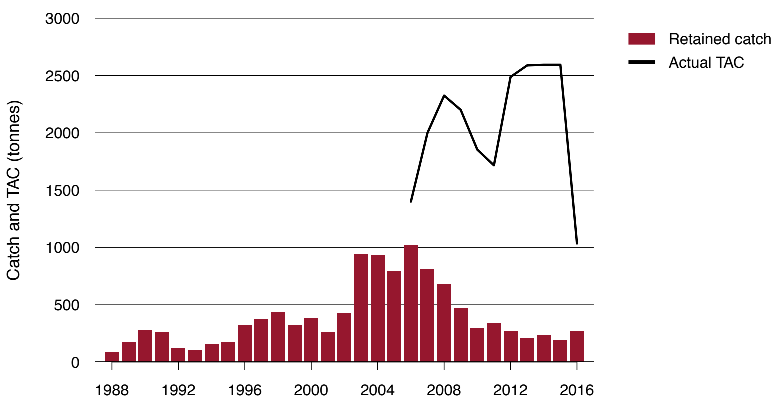
Stock structure

The biological stock structure of bight redfish is unknown. It is considered to be a single biological stock in the GABTS for assessment and management purposes.

Catch history

Catch of bight redfish in the GABTS increased to 572 t in 2003–04, before almost doubling in association with the temporary introduction of a freezer trawler to the fishery. Catch reached a peak of 1,407 t in 2007–08. The freezer trawler departed in 2008, and effort decreased to around half of peak levels. Landed catch in the 2016–17 fishing season was 274 t (Figure 11.4).

FIGURE 11.4 Bight redfish annual catches and fishing season TACs in the GABTS, 1988 to 2016



Note: **TAC** Total allowable catch.

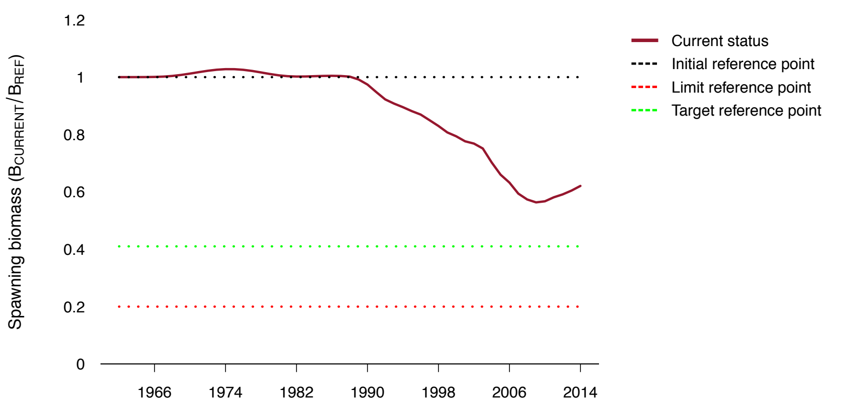
Stock assessment

The target reference point for bight redfish of 41 per cent of the unfished spawning stock biomass ($0.41SB_0$; Kompas et al. 2012) was accepted by the Great Australian Bight Resource Assessment Group (GABRAG) in 2011 (AFMA 2011). The 2011 tier 1 stock assessment for bight redfish (Klaer 2011) was updated in 2015 (Haddon 2015). The base-case assessment predicted the female spawning biomass at the start of 2015–16 to be 63 per cent of unexploited female spawning stock biomass, above the target reference point of $0.41SB_0$. The unexploited female spawning biomass was estimated to be 5,451 t. The large reduction in the estimate of female spawning biomass from the 2011 assessment (26,210 t) reflects that the data now available for the updated assessment are more informative about the unfished biomass and the effects of fishing (Figure 11.5).

Fishery-independent trawl surveys were undertaken each year between 2006 and 2011 (except for 2010), and estimated relative abundance of the main target and byproduct species on the shelf (Knuckey & Hudson 2007; Knuckey et al. 2008, 2009, 2011). A 2015 fishery-independent trawl survey estimated that the relative biomass of bight redfish (2,573 t; coefficient of variation [CV] 0.28) had decreased 80 per cent from the previous 2011 estimate (13,189 t; CV 0.13). The GABTS industry has noted a decrease in available bight redfish in recent seasons. Length-frequency data suggest a truncation of larger bight redfish between 2011 and 2013. Ageing data also indicate a reduction in the abundance of older redfish in recent years.

The updated stock assessment (Haddon 2015) produced an RBC under the 20:35:41 harvest control rule of 862 t for the 2016–17 fishing season, or three- or five-year RBCs of 828 t and 797 t, respectively. Application of the large change–limiting rule limited the reduction in the 2016–17 fishing season TAC to 1,179 t.

FIGURE 11.5 Estimated spawning biomass of bight redfish in the GABTS, 1962 to 2014

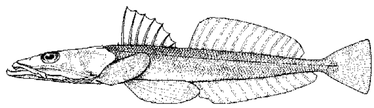


Source: Haddon 2015

Stock status determination

The 2015 stock assessment predicted female spawning biomass to be 63 per cent of unfished levels and above the target reference point of $0.41B_0$. Catch in recent seasons continues to be well below RBCs. On this basis, bight redfish is classified as **not overfished** and **not subject to overfishing**.

Deepwater flathead (*Platycephalus conatus*)



Line drawing: Karina Hansen

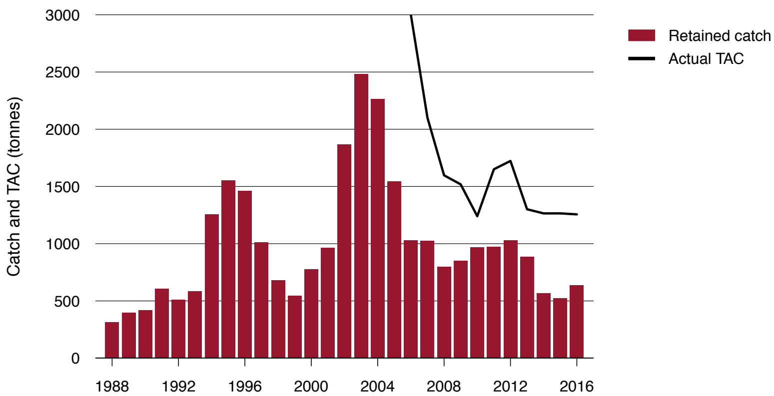
Stock structure

The biological stock structure of deepwater flathead is unknown. The stock is considered to be a single biological stock in the GABTS for assessment and management purposes.

Catch history

Catch of deepwater flathead peaked in 2003–04 at just under 2,500 t, and has been relatively stable at under 1,000 t since 2008–09. Landed catch in the 2016–17 fishing season was 636 t (Figure 11.6).

FIGURE 11.6 Deepwater flathead annual catch and fishing season TACs in the GABTS, 1988 to 2016



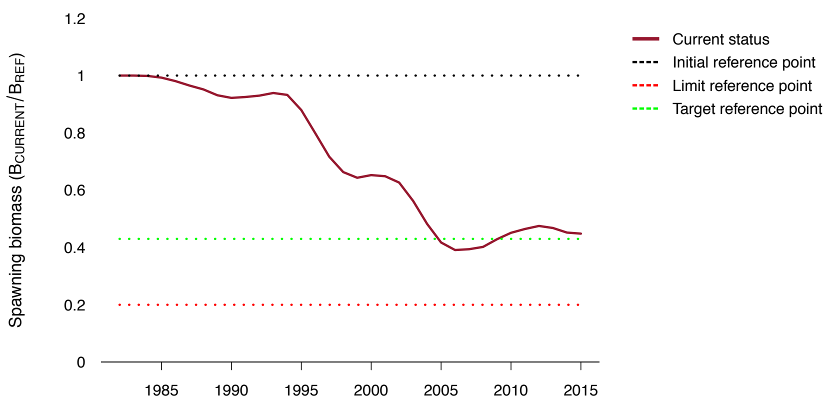
Note: **TAC** Total allowable catch.

Stock assessment

The target reference point for deepwater flathead of 43 per cent of the unfished spawning stock biomass ($0.43SB_0$; Kompas et al. 2012) was accepted by GABRAG in 2011 (AFMA 2011). The 2013 tier 1 stock assessment for bight redfish (Klaer 2013) was updated in 2016 (Haddon 2016). The 2016 base-case assessment predicted the female spawning biomass at the start of 2016–17 to be 45 per cent of unexploited female spawning stock biomass, above the target reference point of $0.43B_0$. This depletion level is consistent with the 2013 assessment. The unexploited female spawning biomass was estimated to be 4,993 t. Application of the 20:35:43 harvest control rule produced an RBC for 2014–15 of 1,146 t. The multiyear TAC of 1,150 t was retained for the 2016–17 fishing season.

The results of the 2015 fishery-independent trawl survey (Knuckey et al. 2015) suggested that estimated relative biomass of deepwater flathead had decreased to 5,065 t (CV 0.09), compared with 9,227 t in the 2011 survey (CV 0.05)—this is a 45 per cent reduction (Knuckey et al. 2009, 2011, 2015). The updated stock assessment suggested no change in depletion level between 2013 and 2016, although the estimate of unexploited female spawning stock biomass had decreased from 9,320 t to 4,993 t. The GABTS industry has noted a decrease in available deepwater flathead in recent seasons, which correlates with decreasing catch. There is no evidence of a truncation in size or age structure of deepwater flathead (Haddon 2016).

FIGURE 11.7 Estimated spawning biomass of deepwater flathead in the GABTS, 1982 to 2015

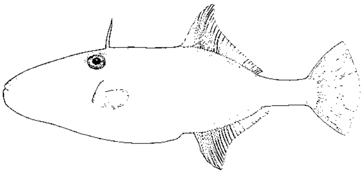


Source: Haddon 2016

Stock status determination

The 2016 stock assessment predicted spawning biomass in 2016–17 to be near the target reference point and above the limit reference point from the HSP ($0.2SB_0$). Catch continues to be below the RBC. On this basis, deepwater flathead is classified as **not overfished** and **not subject to overfishing**.

Ocean jacket (*Nelusetta ayraud*)



Line drawing: FAO

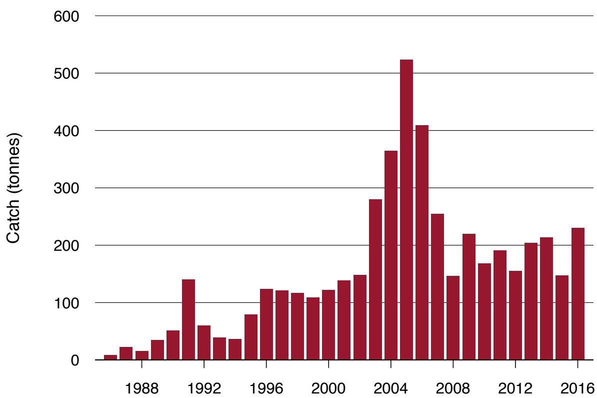
Stock structure

The biological stock structure of ocean jacket is unknown. In the GABTS, it is assessed as a separate stock from the stock in the Commonwealth Trawl and Scalefish Hook sectors.

Catch history

Landed catch of ocean jacket peaked in 2005 at 527 t, but then decreased, and has been less than 250 t since 2008–09 (Figure 11.8). Landed catch in the 2016–17 fishing season was 228 t.

FIGURE 11.8 Ocean jacket catch in the GABTS, 1986 to 2016



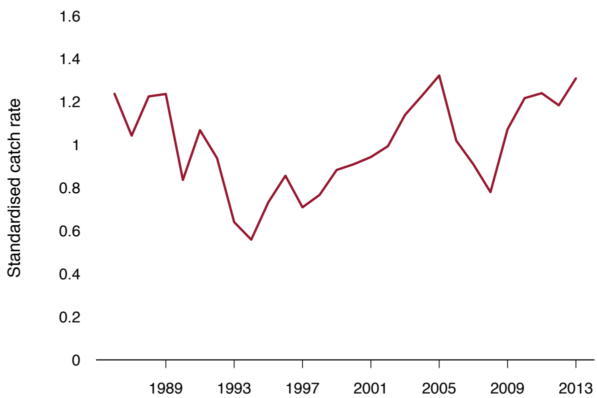
Stock assessment

Formal stock assessments are not conducted for ocean jacket in the GABTS. Standardised catch rates have been variable; the most recent catch rates were similar to those at the start of the series (1986) (Sporcic & Haddon 2015; Figure 11.9).

Ocean jacket represented 16–35 per cent 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 et al. 2008, 2009, 2011). Ocean jacket represented 7 per cent of the catch in the 2015 fishery-independent trawl survey, with an estimated relative biomass of 3,702 t (CV 0.19) (Knuckey et al. 2015) compared with 27,712 t (CV 0.20) in 2011. A bycatch survey of the GABTS in 2002 indicated that ocean jacket is often discarded (Knuckey & Brown 2002), potentially limiting the use of commercial catch-per-unit-effort as an index of abundance for this species.

Ocean jacket is a relatively short-lived species (approximately six years), reaching maturity within 2–3 years. Large cyclical changes in abundance appear to have occurred off eastern Australia (Miller & Stewart 2009). Historical catch data suggest that ocean jacket was fished down off the east coast of Australia in the 1920s and 1950s (Klaer 2001). There are no age data for ocean jacket from the GABTS, and the available historical length-frequency data are too old to be used as an index of abundance.

FIGURE 11.9 Standardised catch rate for ocean jacket in the GABTS, 1986 to 2013

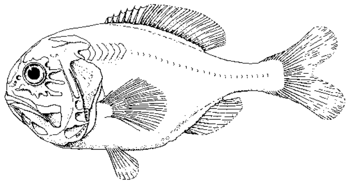


Source: Sporcic & Haddon 2015

Stock status determination

No formal stock assessment for ocean jacket in the GABTS has been done. However, its catch histories and life history characteristics suggest that it is unlikely that the stock is overfished. The level of catch in 2016–17 is unlikely to constitute overfishing. On this basis, ocean jacket in the GABTS is classified as **not overfished** and **not subject to overfishing**.

Orange roughy (*Hoplostethus altanticus*)



Line drawing: Rosalind Murray

Stock structure

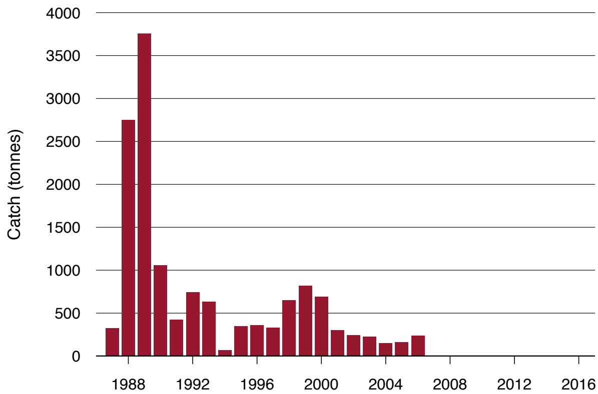
The stock structure of orange roughy in the Australian Fishing Zone (AFZ) is unresolved. Based on the existing data and fishery dynamics, multiple regional stocks of orange roughy are assumed, and the fishery is managed and assessed as a number of discrete regional management units, shown in Figure 9.34 (Chapter 9).

Gonçalves da Silva et al. (2012) examined variation in a large number of loci using genetic techniques that have the power to detect low levels of genetic differentiation. The study concluded that orange roughy in the AFZ form a single genetic stock, but identified some differentiation between Albany/Esperance, Hamburger Hill (in the Great Australian Bight) and south-eastern Australia. It was noted that the amount of genetic exchange needed to maintain genetic homogeneity is much less than the amount needed for demographic homogeneity, and that residency or slow migration may result in separate demographic units, despite genetic similarity (Morison et al. 2013).

Catch history

Catch of orange roughy in the GABTS peaked at 3,757 t in 1988–89 and then declined (Figure 11.10). Since 1990, most of the GABTS catch has come from grounds off Albany and Esperance in the western part of the fishery. Early fishery-independent trawl surveys on the continental slope in the Great Australian Bight reported that orange roughy had the highest maximum catch rate (1,820 kg/hour) of any slope species at that time (Newton & Klaer 1991). The highest catch rates came from the locations of the original aggregations off Kangaroo Island and Port Lincoln, although the surveys found no large aggregations comparable with the historical aggregations. It seems likely that orange roughy across the Great Australian Bight has been depleted, with no large aggregation being seen since 1990. However, the actual level of depletion is unknown. Catch was zero between 2008–09 and 2011–12, and negligible thereafter. No catch was reported in the 2016–17 fishing season.

FIGURE 11.10 Orange roughy catch in the GABTS, 1987 to 2016



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 et al. 2010).

Early catches were reported as coming from temporary feeding aggregations associated with cold-water upwelling off Kangaroo Island and Port Lincoln. Catches from these aggregations ranged from 2,500 t to 3,784 t (Newton 1989). Aggregations have not been found in the same locations since then (Wayte 2004). A spawning aggregation was discovered in 1990 on a ridge 30 nautical miles from the Port Lincoln grounds (Newton & Tuner 1990). This aggregation, which has not been seen since, initially supported trawl catches of around 40 t/shot, typical of lightly exploited orange roughy fisheries, but only yielded a total catch of 800 t before being depleted.

Orange roughy was listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2006. A deepwater management strategy was implemented to address the requirements of the Orange Roughy Conservation Programme (AFMA 2006), under which commercial fishing was closed in several orange roughy zones across the Great Australian Bight, particularly the areas deeper than 700 m. More than 96 per cent of the historical catch (1988 to 2005) and more than 99 per cent of the more recent catch (2001 to 2005) was taken in these closed zones. Until sustainable harvest levels can be determined, fishing will be allowed in these zones only under a research program that has been approved by AFMA. The allocated research quota for 2015–16 was 200 t, but no catch was taken under a research permit during this season. The orange roughy incidental catch allowance remained at 50 t for the 2015–16 fishing season, with zero reported catch. The Orange Roughy Conservation Programme 2006 has been replaced by the Orange Roughy Rebuilding Strategy 2014 (AFMA 2014). Existing arrangements in the GABTS fishery have been maintained under the updated rebuilding strategy.

Stock status determination

There have been no recent surveys or representative catch-trend data to determine the abundance of orange roughy in the Great Australian Bight. As a result, this stock is classified as **uncertain** with regard to the level of biomass. Given that zero or negligible orange roughy catch has been reported in recent years, and that areas where more than 96 per cent of historical catches were taken are now closed, orange roughy is classified as **not subject to overfishing**.

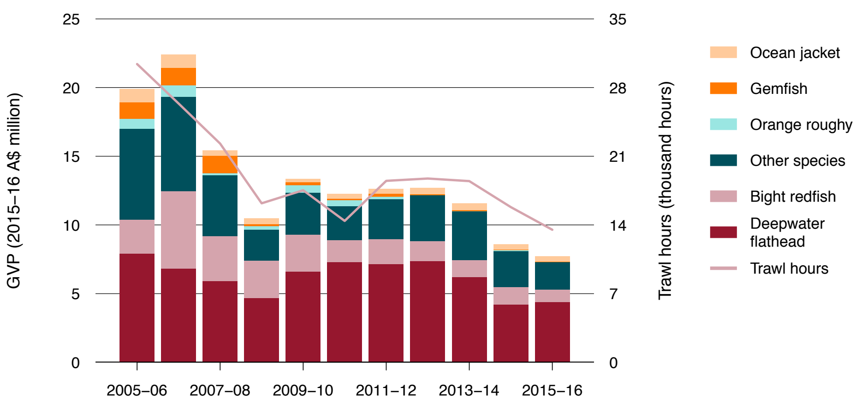
11.3 Economic status

Key economic trends

Estimates of net economic returns (NER) for the GABTS are not available. The real gross value of production (GVP) for the fishery increased from $19.90 million in 2005–06 to a peak of $22.42 million in 2006–07 (in 2015–16 dollars; Figure 11.11). Reductions in the GABTS catch resulted in real GVP declining substantially in the next two years, falling to $10.50 million in 2008–09; GVP then increased in 2009–10 to $13.36 million. Following this, real GVP for the fishery remained steady at around $12.00 million until 2013–14. An average of around $8.00 million was generated over the following two years. GVP in 2015–16 was $7.69 million. In 2015–16, deepwater flathead contributed $4.38 million (57 per cent of total GVP), and bight redfish contributed $940,000 (12 per cent).

Recent declines in catch are consistent with reductions in effort, which would have reduced sector costs. Changes in hours trawled have been closely correlated with changes in GVP over the examined period (Figure 11.11). Hours trawled decreased from 30,399 hours in 2005–06 to 15,820 hours in 2014–15. Hours trawled declined by a further 15 per cent in 2015–16 to 13,509 hours. The decline in effort in 2015–16 coincided with a 23 per cent fall in the price of fuel. Although GVP declined for the second consecutive year (by 33 per cent compared with 2013–14), the decline in effort and unit fuel price suggests that costs in the fishery fell faster than revenue in 2015–16, suggesting an increase in profitability.

FIGURE 11.11 Real GVP for the GABTS by key species and trawl hours, 2005–06 to 2015–16

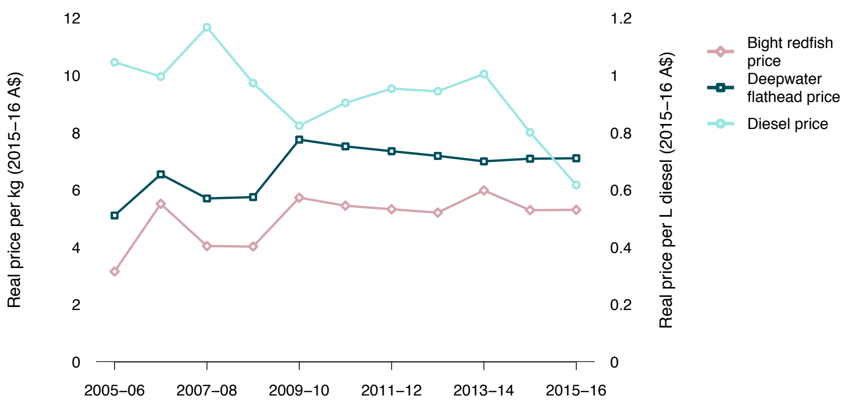


Notes: **GVP** Gross value of production. Trawl hours do not include Danish-seine effort. One Danish-seine vessel was active from 2012–13 to 2016–17.

Although lower catches have driven the decrease in GVP in recent years, this has been partially offset by increasing prices received for key species caught in the sector (Figure 11.12). Higher prices in 2009–10, which are considered to partially reflect improvements in product quality (GABMAC 2009, 2010), drove the increase in GVP between 2008–09 and 2010–11. Average prices in 2015–16 were $7.11 per kilogram for deepwater flathead and $5.31 per kilogram for bight redfish, up from $5.11 per kilogram for deepwater flathead and $3.16 per kilogram for bight redfish (2015–16 dollars) in 2005–06.

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 followed a decreasing trend over the period examined (Figure 11.12). It peaked in 2007–08 at $1.17 per litre, before declining to $0.82 per litre in 2009–10, and falling sharply in 2015–16 to $0.62 per litre (all expressed in 2015–16 dollars). A high price of fuel can negatively affect profitability, but increases in fish prices since 2003–04 and the significant fall in the price of fuel in 2014–15 have reduced this impact.

FIGURE 11.12 Annual average prices for deepwater flathead and bight redfish, and annual average off-road diesel price, 2005–06 to 2015–16



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

Management arrangements

Like other SESSF sectors, the GABTS is a limited-entry fishery managed under TACs for target species, allocated as individual transferable quotas. During the 2016–17 fishing season, 636 t of deepwater flathead was caught (55 per cent of the 1,150 t TAC), and 274 t of bight redfish was caught (23 per cent of the 1,179 t TAC). Market prices for bight redfish are sensitive to supply (Kompas et al. 2012), so the high level of latency may be partly explained by fishers not wanting to land large volumes of bight redfish that could drive down the market price. For this reason, the industry has voluntary trip limits in place for bight redfish.

The GABTS began a trial of fishery co-management in July 2009 (AFMA 2012a). This has seen the Great Australian Bight Fishing Industry Association take a greater role in management decisions, including making direct operational recommendations to AFMA, improving fisheries data collection, developing a chain-of-custody process to improve product traceability and developing a boat operating procedures manual. Such an approach should be associated with improvements in the cost, efficiency and adaptability of management (FRDC 2008). The trial of co-management arrangements received positive feedback from those operating in the GABTS (GABMAC 2010), and these arrangements have been maintained in the fishery.

Performance against economic objective

The most recent stock assessments for bight redfish projected biomass levels at the start of 2014–15 to be above the target (Haddon 2015), potentially allowing increased profits from the species as it is fished down to its maximum economic yield (MEY) target reference point. Similarly, the latest assessment for deepwater flathead indicates that the stock is at, or slightly above, the MEY target (Haddon 2016). Hence, it is unlikely that fishery profitability is constrained by stock size.

Estimates of specific bio-economic target reference points for the two key species have improved the ability to manage stocks at levels that maximise NER. However,as noted by Kompas et al. (2012), the accuracy of the target for each species could potentially be improved with information on how prices for each species are influenced by catch levels. Taking these factors into account in the setting of target reference points for each species would allow an improved assessment of economic performance.

11.4 Environmental status

The GABTS ecological risk management report (AFMA 2008; updated 2012b, 2015) indicated that two byproduct invertebrate species groups—cuttlefish (various species) and octopods (various species)—were at high risk in this fishery (level 2 Residual Risk Assessment). However, this risk determination primarily reflected uncertainty resulting from a lack of data. The level 3 Sustainability Assessment for Fishing Effects (SAFE) excluded invertebrates and indicated that fishing mortality did not exceed the reference point for any of the 204 vertebrate species assessed (Zhou et al. 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 per cent (Pierre et al. 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 (SETFIA) has also introduced a code of conduct and a training program to improve seabird avoidance measures, and trialled alternative seabird mitigation devices, including water sprayers and bird bafflers. The trial was completed in June 2016, but the report is not yet publicly available. SETFIA has reported that water sprayers and bird bafflers used in the trial reduced interactions between seabirds and the warp by 90 per cent and 96 per cent, respectively. Following the success of this trial, AFMA announced that from 1 May 2017 all vessels in the Commonwealth Trawl Sector and GABTS fisheries must use one of the following mitigation devices: sprayers, bird bafflers or pinkies with zero discharge of fish waste.

AFMA publishes quarterly reports of logbook interactions with protected species on its website. Two interactions with species protected under the EPBC Act were reported in the GABTS in 2016. One interaction was reported with a seahorse or pipefish, which was reported to be dead.

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Chapter 12

Shark Gillnet and Shark Hook sectors

N Marton and A Koduah

FIGURE 12.1 Relative fishing intensity in (a) the Shark Gillnet Sector and (b) the Shark Hook Sector of the Southern and Eastern Scalefish and Shark Fishery, 2016–17 fishing season

(a)

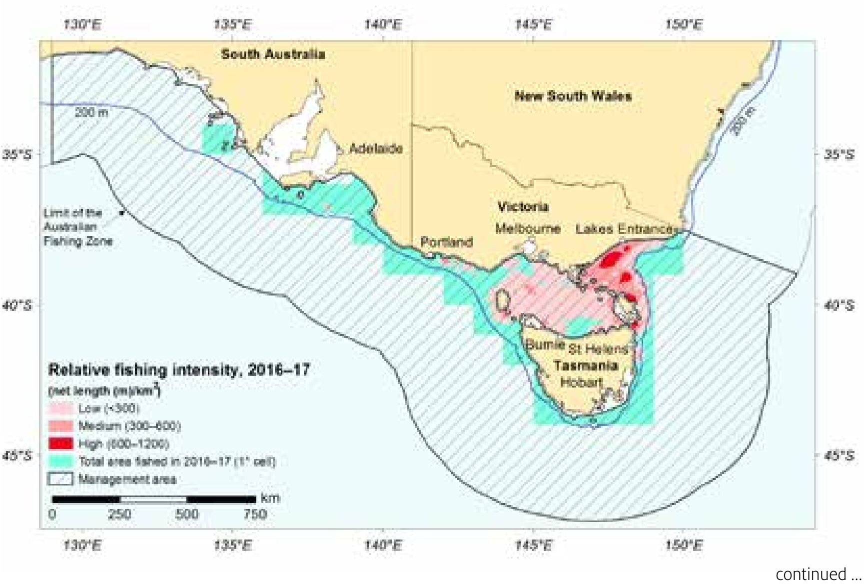

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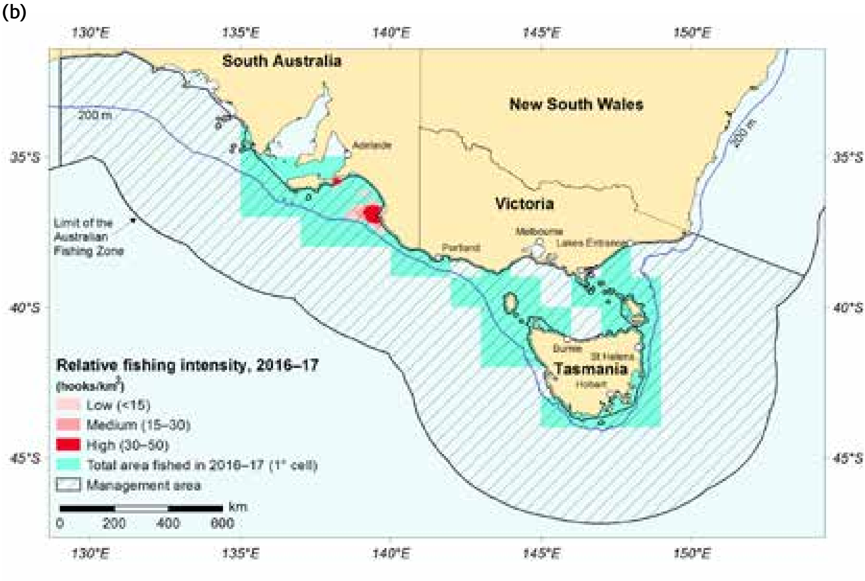
FIGURE 12.1 Relative fishing intensity in (a) the Shark Gillnet Sector and (b) the Shark Hook Sector of the Southern and Eastern Scalefish and Shark Fishery, 2016–17 fishing season continued

(b)



Gillnet vessel
AFMA

TABLE 12.1 Status of the Shark Gillnet and Shark Hook sectors

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Elephantfish (*Callorhinchus milii*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	CPUE is above target; catch is below RBC.
Gummy shark (*Mustelus antarcticus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch is below RBC. Estimates of pup production are close to or above the target.
Sawshark (*Pristiophorus cirratus*, *P. nudipinnis*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	CPUE is above target; catch is below RBC.
School shark (*Galeorhinus galeus*)	Uncertain	Overfished	Uncertain	Overfished	Uncertain if total mortality will allow recovery in required time frame. Estimate of pup production is below 20% of unexploited levels.
Economic status a	NER were –$2.9 million in 2012–13. Preliminary estimates for 2013–14 indicate that NER are likely to remain negative. Although gummy shark biomass is not constraining NER, the management of non-target species and marine mammal interactions has likely contributed to a fall in NER in recent years.				

a NER refer to the entire Gillnet, Hook and Trap Sector; therefore, this figure includes scalefish. Shark species account for around 70 per cent of total Gillnet, Hook and Trap Sector gross value of production.
Notes: **CPUE** Catch-per-unit-effort. **NER** Net economic returns. **RBC** Recommended biological catch.

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

12.1 Description of the fishery

Area fished

The Shark Gillnet and Shark Hook sectors (SGSHS) extend south from the New South Wales – Victoria border, around Tasmania, and west to the South Australia – Western Australia border. Most fishing occurs in waters adjacent to the coastline and throughout Bass Strait (Figure 12.1).

Fishing methods and key species

The SGSHS uses demersal gillnet and longline to target gummy shark (*Mustelus antarcticus*). School shark (*Galeorhinus galeus*), elephantfish (*Callorhinchus milii*) and sawsharks (*Pristiophorus cirratus* and *P. nudipinnis*) are byproducts from the gummy shark fishery. School shark was historically the primary target species in the fishery, but biomass was reduced below the limit reference point around 1990. It remains an important byproduct species and is the second most economically important species in the fishery.

Other important byproduct species (by weight) are snapper (*Pagrus auratus*), whiskery shark (*Furgaleus macki*), broadnose sevengill shark (*Notorynchus cepedianus*), bronze whaler (*Carcharhinus brachyurus*), draughtboard shark (*Cephaloscyllium laticeps*) and blue morwong (*Nemadactylus valenciennesi*).

Management methods

The fishery is managed using a combination of input controls (gear restrictions and closed areas) and output controls (individual transferable quotas and limits on the proportion of school shark to gummy shark catch). The four key commercial stocks taken in the SGSHS are managed under the Southern and Eastern Scalefish and Shark Fishery (SESSF) harvest strategy framework (AFMA 2009). The harvest strategy is summarised in Chapter 8. School shark is subject to incidental catch limits, and other measures to reduce targeting and catch for a number of seasons. Additional current measures include closure of waters deeper than 183 m to gillnet fishing, closure of waters shallower than 183 m to auto-longline fishing (except in South Australia for shark), and various spatial closures to protect pupping areas.

A number of gear and area closures (primarily off South Australia) have been introduced in the SGSHS 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.

In response to the gillnet spatial closures, a recent project looked at increasing the use of demersal longlines instead of using gillnets to target gummy shark (Knuckey et al. 2014). However, this is still an experimental fishery, with temporary hook permits being made available for holders of gillnet statutory fishing rights operating in South Australian waters (AFMA 2015a).

From 1 July 2015, electronic monitoring (e-monitoring) has been mandatory for all full-time vessels in the SGSHS. Video footage of at least 10 per cent of all recorded hauls is reviewed to verify the accuracy of logbooks. In addition, gillnet boats operating off South Australia's Australian Sea Lion Zones are subject to 100 per cent review of video footage for interactions with protected species. Logbooks must be completed for 100 per cent of shots.

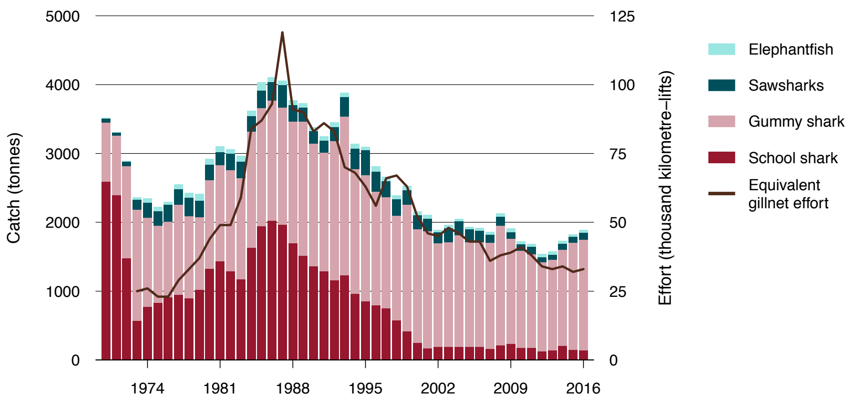
Fishing effort

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 discussed above have resulted in gillnet effort being concentrated off Victoria (Figure 12.1). Effort in the gillnet sector peaked in 1987 at 99,000 km of gillnet hauled, but has decreased to around one-third of this level in recent years.

Catch history

Fishing for sharks in the waters off southern Australia began in the 1920s, using longlines. During the 1970s and 1980s, the sector mainly targeted school shark (Figure 12.2). Adoption of monofilament gillnets and concern about mercury content in large school sharks, coupled with declining school shark catches, resulted in gummy shark becoming the principal target species from around 1986 (Figures 12.2 and 12.3). This transition occurred in the early 1970s in Bass Strait, and later in the waters off South Australia and Tasmania. Recent catch records indicate that trawl operations in the SESSF are now landing as much sawshark as gillnet operations. Most of the landed catch of elephantfish is taken using gillnets in eastern Bass Strait.

FIGURE 12.2 Annual landings and effort in the SGSHS, by species, 1970 to 2016



Note: 'Equivalent gillnet effort' is an estimate of total effort after converting hook effort to the equivalent gillnet effort using the methods in Walker et al. (1994).

FIGURE 12.3 Annual landings in the CTS, by species, 2001 to 2016

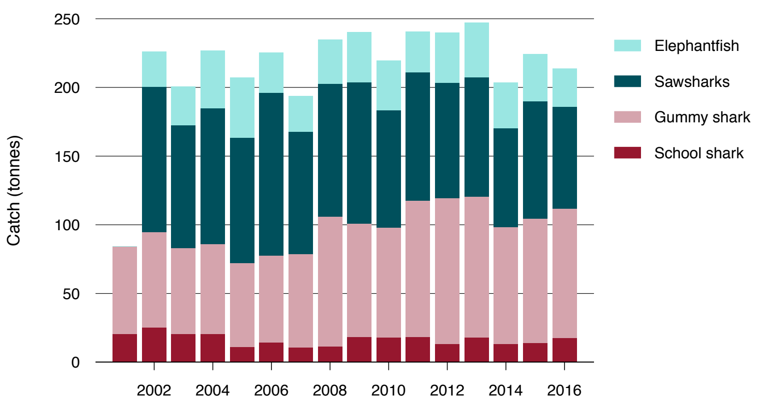


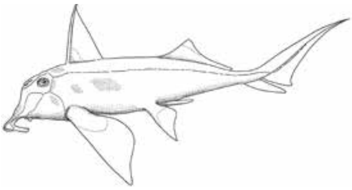
TABLE 12.2 Main features and statistics for the SGSHS

Fishery statistics a	2015–16 fishing season			2016–17 fishing season	
Stock	**TAC (t)**	**Catch (t) (GHTS, CTS)**	**Real value (2015–16) (GHTS, CTS)**	**TAC (t)**	**Catch (t) (GHTS, CTS)**
Elephantfish	163	67 (35, 32)	<$0.10 million (<$0.10 million, <$0.10 million)	163	76 (45, 31)
Gummy shark	1,836	1,798 (1667, 131)	$16.31 million ($15.46 million, $0.85 million)	1,836	1,669 (1526, 143)
Sawsharks	482	187 (93, 94)	$0.48 million ($0.26 million, $0.22 million)	482	200 (112, 88)
School shark	215 **b**	181 (165, 16)	$1.58 million ($1.44 million, $0.14 million)	215 **b**	173 (149, 24)
Total fishery	**2,696**	**2,233 (1,960, 273)**	**$18.42 million ($17.21 million, $1.22 million)**	**2,696**	**2,118 (1832, 286)**
Fishery-level statistics					
Effort	Gillnet: 29,876 km of net hauled Hook: 1,695,313 hooks set			Gillnet: 31,814 km of net hauled Hook: 1,103,912 hooks set	
Fishing permits **c**	Gillnet: 61 Hook: 13			Gillnet: 61 Hook: 13	
Active vessels	Gillnet: 37 Hook: 26			Gillnet: 36 Hook: 26	
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. Real-value statistics are by financial year and were not available for the 2016–17 financial year at the time of publication. Components of catch may not sum to total due to rounding. **b** Incidental catch allowance. **c** In the GHTS, additional permit types limit gear use and access to state waters. **d** Numbers of hooks observed relate only to the Shark Hook Sector. **d** From 1 July 2015, e-monitoring is 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 Zones are subject to 100% review of video footage for interactions with protected species.
Notes: **CTS** Commonwealth Trawl Sector. **GHTS** Gillnet, Hook and Trap Sector. **ITQ** Individual transferable quota. **TAC** Total allowable catch (for the entire Southern and Eastern Scalefish and Shark Fishery).

12.2 Biological status

Elephantfish (*Callorhinchus milii*)



Line drawing: Karina Hansen

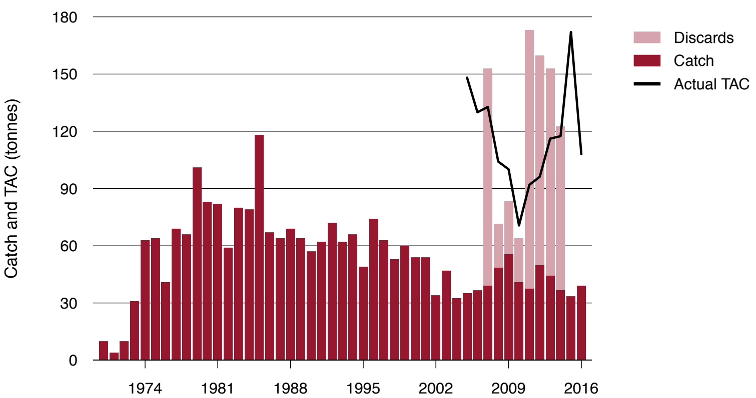
Stock structure

Stock structure of elephantfish is not known, and populations are considered to constitute a single stock for management purposes.

Catch history

Elephantfish contribute a small component (<5 per cent) of landed catch in the SGSHS. Catch of elephantfish in the SGSHS increased during the 1970s and peaked at almost 120 t in 1985 (Figure 12.4). Catch has since declined, and has been relatively stable at 30–60 t in recent years. Combined catch in 2016–17 in the Gillnet, Hook and Trap Sector (GHTS) and the Commonwealth Trawl Sector (CTS) increased slightly to 75 t (Table 12.2). The four-year rolling average (2012 to 2015) of elephantfish discards for state fisheries and the SGSHS was 140.9 t. In 2015, discards from the SGSHS only were 180.4 t, which is more than double the 2014 estimate (Thomson & Upston 2016). There is some uncertainty about the level of discards, especially for earlier years (AFMA 2012a). Discarding can be high in some areas of the fishery at certain times of the year. There is little information on recreational catches. The most recent stock assessment scenario accepted by the Shark Resource Assessment Group (SharkRAG) assumes that recreational catches increased from 29 t in 2002 to 45 t in 2008 and then remained at 45 t per year from 2008 to 2014 (Sporcic & Thomson 2015).

FIGURE 12.4 Annual elephantfish catch and fishing season TAC in the SGSHS, 1970 to 2016



Notes: **TAC** Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data are only available by calendar year and for the period 2007 to 2014.

Stock assessment

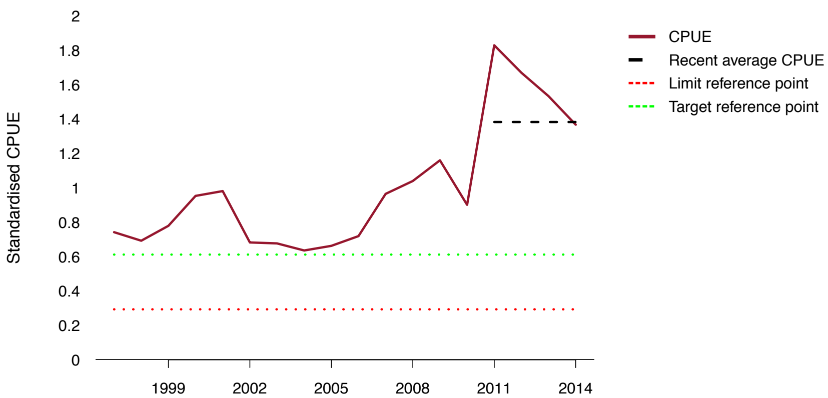
Elephantfish has been assessed as a tier 4 stock under the SESSF harvest strategy framework since 2009. The tier 4 assessment framework uses standardised CPUE. The tier 4 assessment was revised in 2015 (Sporcic & Thomson 2015).

In 2014, SharkRAG recommended a decrease in the biomass target (B_{TARG}) from 48 per cent to 40 per cent of unfished biomass (AFMA 2014a). In recommending the decrease in B_{TARG}, SharkRAG noted that elephantfish was a byproduct species in the gillnet sector and that commercial catch largely depended on effort targeted at gummy shark (AFMA 2014a). As such, catch of elephantfish was not a key driver of the economics of the fishery, so a B_{MEY} (biomass at maximum economic yield) proxy (B_{48}) was not appropriate. SharkRAG further noted that they were not concerned about the sustainability of elephantfish. SharkRAG recommended the lower B_{TARG} in 2015 (AFMA 2015a).

The most recent assessments of elephantfish (four alternative tier 4 assessments) in 2015 used data up to 2014. These assessments used scenarios including and excluding discards, and either constant recreational catches of 29 t or increased from 29 t in 2002 to 45 t in 2008 and then a constant 45 t per year from 2008 to 2014 (Sporcic & Thomson 2015). Trawl data were not analysed because of limited catch data, so only CPUE data from gillnet fishing were used. Concerns about the data used have been raised previously; the inclusion of discards was thought to bias estimates high, and the exclusion of discards was thought to bias estimates low (AFMA 2014b). All four assessments in 2015 estimated CPUE to be above the target (Sporcic & Thomson 2015).

Although the tier 4 assessment that included discards is thought to bias estimates high (AFMA 2014b), it was thought to more closely reflect the fishery dynamics (Sporcic & Thomson 2015). SharkRAG recommended using the tier 4 assessment that included discards in the CPUE with a B_{TARG} of $0.4B_0$ (Figure 12.5) and the updated estimate of recreational catches to develop a recommended biological catch (RBC), since this was thought to be more conservative than other scenarios (AFMA 2015b). This resulted in an RBC of 306 t. TAC was constrained by the large change rule (which limits increases in TAC to 1.5 times the previous year's TAC). SharkRAG recommended a multiyear TAC for the 2015–16 to 2017–18 seasons of 163 t. In comparison, the landed catch of elephantfish in the 2016–17 season was 76 t.

FIGURE 12.5 Standardised gillnet CPUE index (including discards) for elephantfish in the SGSHS, 1997 to 2014

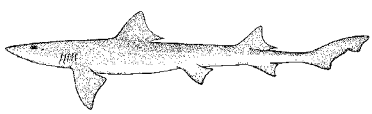


Notes: **CPUE** Catch-per-unit-effort. Discard data are only available by calendar year and for 2007 to 2014.
Source: Sporcic & Thomson 2015

Stock status determination

The average recent CPUE for elephantfish was estimated to be above the target and well above the limit reference points. On this basis, the stock is assessed as **not overfished**. Catch (excluding discards) in the 2016–17 season was below the TAC and below the RBC from the 2015 stock assessment. On this basis, the stock is assessed as **not subject to overfishing**.

Gummy shark (*Mustelus antarcticus*)



Line drawing: Karina Hansen

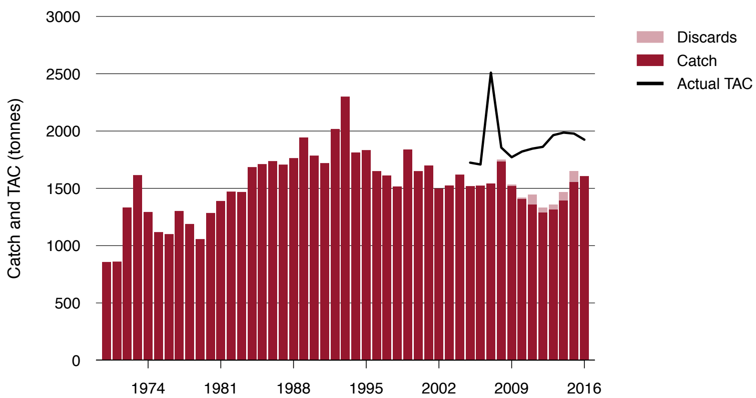
Stock structure

The most recent research on stock structure for gummy shark indicates that there are most likely two stocks in Australian waters: one in southern Australia, extending from Bunbury in Western Australia to Jervis Bay in New South Wales, and another in eastern Australia, extending from Newcastle to the Clarence River in New South Wales (White & Last 2008). The southern Australian biological stock is split into four populations for modelling purposes: the continental shelf of Bass Strait, Tasmania, South Australia and Western Australia. The first three are assessed together by the Commonwealth (Punt et al. 2016) and are reported here. The fourth is assessed separately by Western Australia (Braccini et al. 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 12.6). Catch in the SGSHS reached a peak of around 2,300 t in 1993. Catch dropped to a low of 1,288 t in 2012, before increasing since then to 1,667 t in 2015 and then decreasing slightly to 1,526 t in 2016 (Figure 12.6). Total Commonwealth catch (including from the CTS) in 2016–17 was 1,669 t. Estimates of discards have been stable in recent years, at 3–6 per cent of total catch. The four-year rolling average (2012 to 2015) of gummy shark discards for state fisheries and the SGSHS was 96 t (Thomson & Upston 2016).

FIGURE 12.6 Annual gummy shark catch and fishing season TAC in the SGSHS, 1970 to 2016



Notes: **TAC** Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data are only available by calendar year and for 2007 to 2015.

Stock assessment

The most recent update of the integrated stock assessment model for gummy shark was in 2016, using data to the end of 2015 (Punt et al. 2016). Updated inputs to the assessment included landings data from 2013–15, 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, with catches by the different gear types now assumed to occur simultaneously, rather than sequentially; the 'hook fleet' separated into its components; and made allowances for age-reading errors. As in previous assessments, Bass Strait, South Australian and Tasmanian stocks were treated as three separate populations, with no movement of animals between these regions and no density-dependent effects of one population on another. However, the stocks have a number of common biological parameters, including age–length and length–weight relationships, fecundity, gear selectivity, and overall availability as a function of age. The assessment uses pup production as an indicator of biomass because of the close relationship between pup production and female spawning biomass.

The gillnet closures off South Australia have influenced catch and CPUE of gummy shark in this area. When the 2014 update was run, there was concern that the South Australian CPUE data were less reliable as an index of abundance in recent years (Thomson & Sporcic 2014). Consequently, South Australian CPUE data after 2009 were not included in the 2014 update, a change that has been retained for the 2016 update.

The model treats the three regions separately and develops RBCs and pup production relative to P_0 for each. These RBCs are then summed to an overall RBC. In addition, different gear types are known to have different selectivities, which result in differences in the average size of sharks caught. Consequently, a range of RBCs are calculated, based on different catch proportions taken by line and gillnet, which can be assessed against their impact on pup production at a regional level (Punt et al. 2016).

The base-case assessment estimated 2016 pup production as a proportion of the unfished level of pup production (1927) to be above $0.48P_0$ (48 per cent of virgin pup production) for all three gummy shark populations: $0.53P_0$ for Bass Strait (Figure 12.7a), 0.63 P_0 for South Australia (Figure 12.7b) and 0.75 P_0 for Tasmania (Figure 12.7c). These are all slightly reduced from the 2014 updated assessment (Thomson & Sporcic 2014). The sensitivities of the model to density dependence were examined through nine alternative models. Seven of the nine alternative models estimated pup production to be below $0.48P_0$ in Bass Strait (range $0.31P_0$ to $0.57P_0$), while the other models were all above $0.48P_0$ for South Australia (range $0.52P_0$ to $1.00P_0$) and Tasmania (range $0.59P_0$ to $0.79P_0$).

The three-year RBC for the base-case assessment resulted in an initial increase in RBC followed by reductions in each of the two following years. SharkRAG noted the importance of stable TACs for industry (AFMA 2016a) and requested that three additional scenarios be explored: the continuation of the current TAC, the average RBC when the base-case model is run to 2035, and the three-year average RBC from the base-case model (that is, when it is run to 2019). All three scenarios resulted in the Bass Strait population decreasing to below the target reference point by 2021 at the latest (continuation of the current TAC resulted in $P_{2019} = 0.471P_0$ and was therefore discounted as an option). SharkRAG recommended that either the 2016–35 average RBC (1,961 t) or the 2016–19 average RBC (1,922 t) be applied as a three-year TAC. The group noted that, while either of these would provide stability for industry to 2019, the RBC would likely decrease when a new assessment is run in 2019 following fishing down to the target reference point (AFMA 2016b). The 2016–35 average RBC (1,961 t) was agreed to by the Australian Fisheries Management Authority (AFMA) Commission as the basis for a three-year TAC for the 2017–18 to 2019–20 seasons.

State allocations are deducted from the RBC (2.9 per cent of the RBC for catches in South Australian internal waters and 1.7 per cent of the RBC for catches in Victorian bays and inlets [AFMA 2013a]).

The Commonwealth catch of gummy shark in 2016–17 was 1,673 t, below the 2016–17 TAC. The catch was also below the 2017–18 RBC generated by the updated model.

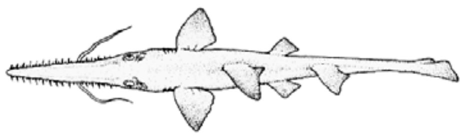
FIGURE 12.7 Estimated pup production as a proportion of unfished level of pup production for gummy shark in (a) Bass Strait, (b) South Australia and (c) Tasmania, 1927 to 2016

Note: Scenario 1 refers to base-case scenario from the 2016 assessment.
Source: Punt et al. 2016

Stock status determination

The results of the 2016 stock assessment estimate that 2015 pup production (used as the index of gummy shark biomass) for each of the three subpopulations is above the target reference point ($0.48P_0$) and well above the limit reference point. As a result, gummy shark is classified as **not overfished**. Since catch was less than the RBC generated by both the 2014 and 2016 models and the 2016–17 TAC, the stock is classified as **not subject to overfishing**.

Sawshark (*Pristiophorus cirratus, P. nudipinnis*)



Line drawing: FAO

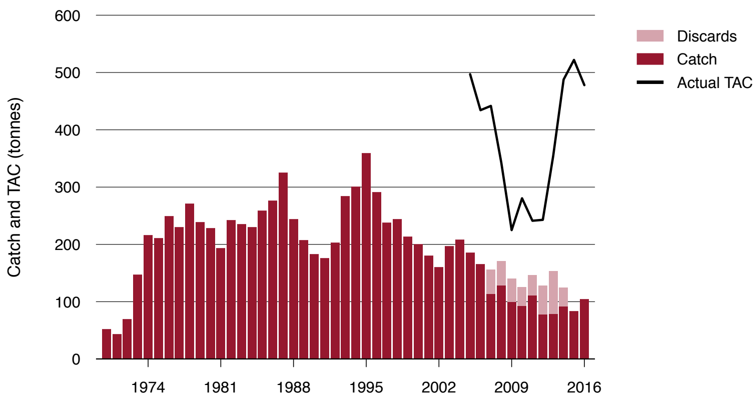
Stock structure

Three species of sawshark (common sawshark—*Pristiophorus cirratus,* southern sawshark—*P. nudipinnis,* and eastern sawshark—*P. peroniensis*) are caught in southern Australian waters. Little is known about the stock structure or movements of sawshark. Two species dominate reported sawshark catches in this sector: common sawshark and southern sawshark. For assessment purposes, all sawsharks found south of the Victoria – New South Wales border are assumed to be common or southern sawshark, and those found north of that border are assumed to be eastern sawshark (AFMA 2014c). Around 90 per cent 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 the status assessment is reported for the 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. Catch in the SGSHS declined steadily after 2004 and has remained below 100 t since 2012 (Figure 12.8). Combined catch in the SGSHS and the CTS in 2016–17 was 200 t (Table 12.2). The four-year rolling average (2012 to 2015) of sawshark discards for state fisheries and the SGSHS was 43.5 t. In 2015, discards from Commonwealth waters only were 35.4 t (Thomson & Upston 2016).

FIGURE 12.8 Sawshark catch and TAC in the SGSHS, 1970 to 2016



Notes: **TAC** Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data are only available by calendar year and for the period 2007 to 2015.

Stock assessment

Sawshark has been assessed as a tier 4 stock under the SESSF harvest strategy framework since 2009. The most recent assessments of sawshark (four alternative tier 4 assessments) were conducted in 2015. The assessments used scenarios including and excluding discard estimates, and using either trawl or gillnet data. The assessments used data to 2014. The CPUE derived from the gillnet data was considered to be less reliable because of anecdotal reports of gillnet fishers actively avoiding sawshark (AFMA 2015b). The assessments based on trawl data have been used in recent years because they are considered to be less affected by avoidance (AFMA 2014b, 2015d). The assessment that excluded discard data was used for status determination because the uncertainty in discard data was thought to result in an overestimate of CPUE (AFMA 2015d).

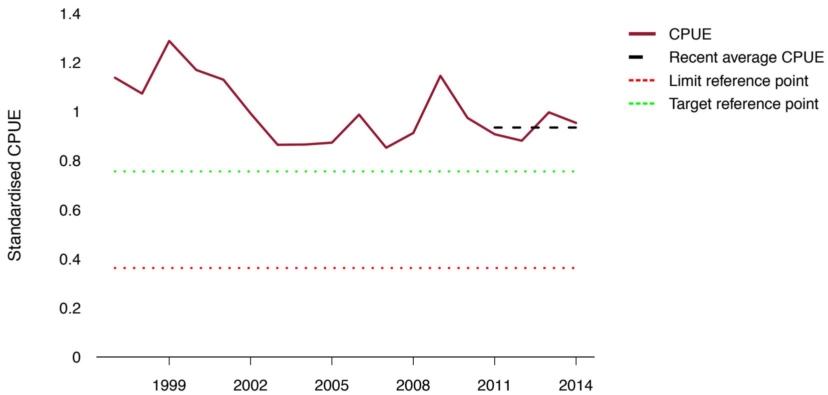
In 2014, SharkRAG recommended a decrease in the biomass target (B_{TARG}) from 48 per cent to 40 per cent of unfished biomass. Since sawshark is currently a byproduct species in the gillnet sector, SharkRAG noted that commercial catch largely depends on effort targeted at gummy shark (AFMA 2014a). As such, catch of sawshark was not a key driver of the economics of the fishery, so a B_{MEY} proxy (B_{48}) was not appropriate. SharkRAG further noted that it was not concerned about the sustainability of sawshark and recommended a decrease in B_{TARG} for the species (AFMA 2014a). SharkRAG recommended retaining the biomass target of $0.4B_0$ in 2015 (AFMA 2015a). The tier 4 assessment based on trawl data, excluding discards with a B_{TARG} of $0.4B_0$, gave an RBC of 535 t before the tier 4 discount factor (15 per cent discount) was applied (Sporcic & Thomson 2015).

SharkRAG recommended a TAC for the 2015–16 to 2017–18 seasons of 482 t. In comparison, the landed catch of sawshark in the 2016–17 season was 200 t.

Stock status determination

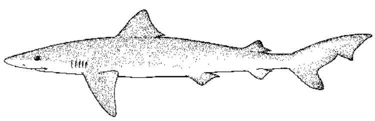
The average recent CPUE for sawshark was estimated to be above the target reference point and well above the limit reference point (Figure 12.9). On this basis, the stock is assessed as **not overfished**. Catch in the 2016–17 season was below the TAC and below the RBC from the 2015 stock assessment. On this basis, the stock is assessed as **not subject to overfishing**.

FIGURE 12.9 Standardised CPUE index for sawshark in the CTS, 1997 to 2014 (trawl)



Note: **CPUE** Catch-per-unit-effort.
Source: Haddon 2014

School shark (*Galeorhinus galeus*)



Line drawing: Karina Hansen

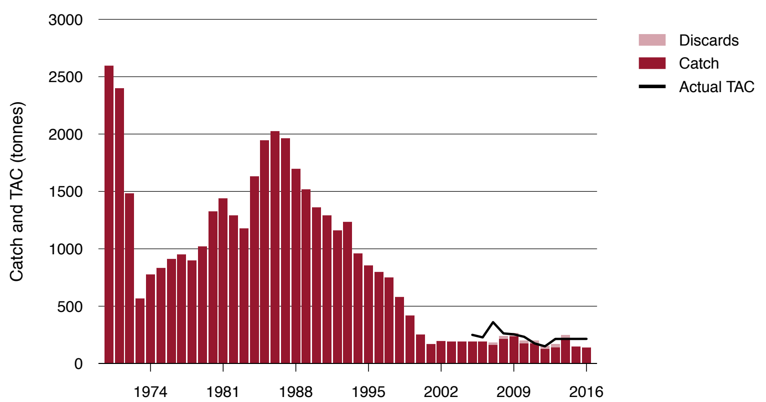
Stock structure

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. A single genetic stock exists in Australian waters, and school shark is managed as a single stock in the SESSF area.

Catch history

Catch of school shark in the SGSHS peaked at more than 2,500 t in 1970 and then declined rapidly to around 500 t in 1973. Catch in the sector again increased, to around 2,000 t in 1986, before declining steadily through the late 1980s and 1990s, and then stabilising from 2000 onwards at around 200 t per year (Figure 12.10). In 2009, the species was listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* and has been subject to other measures to reduce catch, including the implementation of a catch ratio of 20 per cent school shark to gummy shark—whereby a fisher must hold five times more gummy shark quota than their school shark catch (2011–12 season)—and the requirement that all live caught school shark be released (2014–15 season). Catch in 2016–17 was 173 t. The four-year rolling average (2012 to 2015) of school shark discards for both state and Commonwealth waters was 34.4 t. In 2015, discards from Commonwealth waters only were 32.7 t, a decrease of 10 t from 2014 (Thomson & Upston 2016).

FIGURE 12.10 Annual school shark catch and fishing season TAC in the SGSHS, 1970 to 2016



Notes: **TAC** Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data are only available by calendar year and for 2007 to 2015.

Stock assessment

School shark has been considered to be below the $0.2B_0$ limit since about 1990. The base case of the most recent full stock assessment in 2009, using data to 2008, estimated the biomass at $0.12B_0$ (Thomson & Punt 2009). 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 to explicitly specify a recovery time frame of 66 years to the $0.2B_0$ limit (AFMA 2015c), based on advice from SharkRAG.

The reliability of the current school shark stock assessment model to estimate the state of the stock is limited, as a result of increasingly uncertain input data over the past decade. The low TACs in recent years and the reported avoidance behaviour of gillnet fishers have meant that the CPUE index for that sector has potentially become less reliable as an index of abundance. The coefficient of variance associated with the fishery-independent survey data is also very high.

There are indicators that school shark biomass may be increasing. These include a preliminary index of abundance based on trawl CPUE, which estimates a generally increasing trend (Sporcic 2016). Trawl CPUE data may be a better representation of biomass than CPUE from other methods, because trawl does not target, nor can it avoid, school shark (AFMA 2016c); however, it is unclear how reliable an index of abundance trawl CPUE is, because the trawl fishery primarily operates outside the main part of the gummy shark fishery (AFMA 2016a). Data from the Integrated Scientific Monitoring Program (ISMP) show an increase in the catch of small school sharks (Thomson et al. 2015). Preliminary results of survey work by the Institute for Marine and Antarctic Studies (IMAS) in school shark pupping areas off Tasmania indicate higher numbers of pups than during the 1990s (McAllister et al. 2015). Industry participants on SharkRAG have reported signs of increasing availability of school shark, including increasing presence of juvenile school shark and increasing difficulty in avoiding school shark (AFMA 2014a, c; 2013b).

A project to develop a fishery-independent index of abundance using close-kin genetic approaches is currently underway, and should further inform rebuilding targets and time frames when results become available (by the end of 2017) (AFMA 2013c, 2016a). A new stock assessment will be run after results from the close-kin genetics project are finalised (likely in 2018) (AFMA 2016a).

The reported landed catch in the SGSHS in 2016–17 was 173 t, a decrease from the 2015–16 catch of 181 t and below the incidental catch allowance of 215 t. State catches and discards are not available by season; however, in the 2015 calendar year, discards from the SGSHS were 15 per cent of catch (32.7 t; Thomson & Upston 2016). Overall, state catches in 2015 were higher than in 2014 (24 t in 2015; 22 t in 2014), with South Australia reporting most (17 t) of this. South Australia's catch continues to exceed its allocation of 6.2 t under the Offshore Constitutional Settlement.

Stock status determination

The last full stock assessment of school shark, undertaken in 2009, estimated the 2008 biomass to be below the limit reference point. Projections of this model undertaken in 2012 indicate that the stock was likely to recover to a level above the limit reference point in 2035 if the catch was zero. School shark catches have been between 129 t and 230 t in each year since these analyses were run. The stock therefore remains classified as **overfished.**

Commonwealth discards and state catches are only available for the 2015 calendar year. Additionally, state discards are not known. If state catches in 2016–17 were similar to those in recent years, and similar to discards from the SGSHS, total catch (retained and discarded) from the SGSHS and state fisheries may have been around 230 t. A constant catch of 250 t was estimated to enable recovery to the limit reference point within 80 years, while a catch of 275 t was projected to collapse the stock.

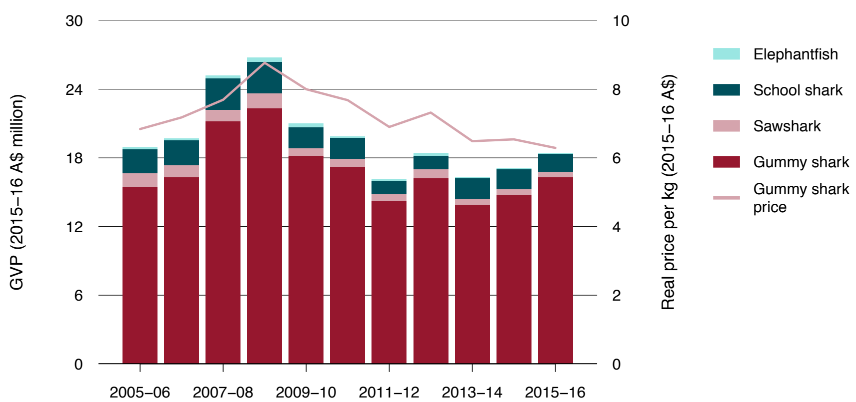
Some evidence indicates that the stock may be rebuilding under current catches (for example, trawl CPUE, IMAS surveys, ISMP data and anecdotal reports from industry). However, there is uncertainty around total catch estimates for the 2016–17 season, because South Australian catch has consistently increased in recent years, and the latest available state and discarding data relate to the 2015 calendar year. In addition, there is uncertainty around the rebuilding projections resulting from uncertainty in the stock assessment. Given these issues, whether the level of fishing mortality will enable rebuilding within the time frame is uncertain, and school shark is therefore classified as **uncertain** with regard to the level of fishing mortality.

12.3 Economic status

Key economic trends

The real gross value of production (GVP) in the SGSHS, which reflects the four shark species taken in the GHTS, declined from a peak of $26.74 million in 2008–09 to $18.42 million in 2015–16 (Figure 12.11). This long-term fall is primarily the result of a 27 per cent fall in the price of gummy shark, despite experiencing a slight (2 per cent) increase in volume. Since 2013–14, GVP for the SGSHS has trended upwards, largely as a result of higher volumes of gummy shark landings. Gummy shark accounts for the majority of GVP in the SGSHS (89 per cent in 2015–16).

FIGURE 12.11 Real GVP for the SGSHS, by key species, and real price for gummy shark, 2005–06 to 2015–16

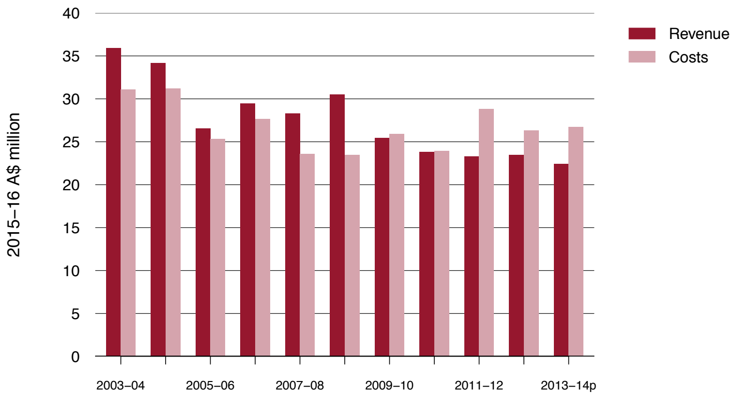


Note: **GVP** Gross value of production.

The four shark species that make up the SGSHS—gummy shark, school shark, sawshark and elephantfish—account for around 77 per cent of the GHTS GVP, with scalefish species making up the remainder. Therefore, overall economic performance in the GHTS may contribute to an understanding of economic status in the SGSHS.

Survey-based estimates of revenue, costs and net economic returns (NER) in the GHTS are available for 2012–13, and preliminary estimates are available for 2013–14 (Figure 12.12). NER in the GHTS were positive between 2003–04 and 2008–09, peaking at $7.04 million in 2008–09 (Figure 12.13). NER reached a low of –$5.55 million in 2011–12. Preliminary estimates for 2013–14 indicate that NER are likely to remain negative. The falling price of fuel is unlikely to improve NER, as the price of fuel is not a significant input in gillnet and hook fisheries, unlike in trawl fisheries.

FIGURE 12.12 Real revenue and costs for the GHTS, 2003–04 to 2013–14



Note: Data for 2013–14 are preliminary.
Source: Skirtun & Green 2015

FIGURE 12.13 Real NER for the GHTS, 2003–04 to 2013–14

Notes: **NER** Net economic returns. NER estimates for 2013–14 are preliminary non–survey based estimates.
Source: Skirtun & Green 2015

A profit decomposition of the gillnet sector of the GHTS (Skirtun & Vieira 2012) showed that the key driver of profitability in the sector in the period 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 within the fishery. Productivity has improved recently, but this has been offset by falls in the terms of trade for fishers, providing downward pressure on NER (Skirtun & Green 2015). Factors related to recent management changes in the fishery (discussed below) are also likely to have played a role.

Management arrangements

Significant spatial closures have been implemented in recent years to reduce the catch of protected species, primarily in South Australian waters (see Chapter 8). This started with voluntary closures in 2009–10, followed by mandatory closures in 2010–11. As a result, it is likely that fisher incentives have changed, leading to a relocation of fishing intensity to other areas, particularly for operators where closures have covered the full extent of their usual fishing grounds. 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. However, these changes would have reduced the profitability of gillnet operations in South Australia, contributing to the negative NER in the GHTS following the closures.

South Australian gillnet operators (subject to specific qualification criteria) are allowed to use hook methods in areas where gillnetting is prohibited (or restricted), so that fishers can continue to operate. However, anecdotal reports from industry suggest that vessel-level economic efficiency is lower using this hook method (AFMA 2011b). Anecdotal information also indicates that allowing gillnet permit holders to use hooks has had a negative impact on the value of hook permits in the sector, as rights provided by hook permits have become less exclusive. One adaptive management zone (zone C) was closed in 2016 (reopened 18 June 2017).

School shark biomass remains below the limit reference point, and stock rebuilding measures are likely to be affecting sector profitability. These measures include low incidental catch allowances and the prohibition of targeted fishing. Given the relatively high beach prices of school shark, changes in its catch allowance can have a relatively large influence on the revenue of the sector. Additionally, school shark is often caught with gummy shark, the main target species of the sector. Operators who do not hold quota for school shark, or actively avoid it when targeting gummy shark, are forfeiting a potential means of profit. The substantial time projected for school shark stock rebuilding means that it may be some time before these issues are resolved.

Trials to test the efficiency of longer gillnets (4,200–6,000 m) have been undertaken; SharkRAG, in January 2016, considered the preliminary results inconclusive (AFMA 2016d). Giving fishers the option to use longer nets provides them with greater flexibility to operate under individual transferable quotas, potentially improving efficiency and NER. However, some industry members previously expressed concerns about introducing larger nets at a time when the sector is already facing significant challenges to reduce bycatch (AFMA 2011b). The AFMA Commission has since approved the removal of net length restrictions, subject to the roll-out of dolphin management arrangements across the fishery.

Performance against economic objective

Additional information on the economic status of the SGSHS is possible by comparing the biomass levels of key species with harvest strategy targets. Gummy shark is the primary driver of economic performance in the SGSHS, accounting for 89 per cent of the SGSHS GVP in 2015–16. The target reference point for gummy shark is the B_{MEY} proxy of $0.48P_0$ (48 per cent of virgin pup production). The results of the 2013 stock assessment indicate that the biomass for 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.

The SGSHS is a multispecies fishery, and its economic performance must also be interpreted in terms of the other species caught in the fishery. The incidental catch allowance for school shark makes it the second most valuable species in the sector, accounting for 9 per cent of SGSHS GVP in 2015–16. The school shark to gummy shark quota restriction implemented in 2011–12 may have reduced gummy shark catch and therefore current GVP (AFMA 2014d). Efforts to rebuild the school shark stock towards target levels should lead to future 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 recently observed declines in the GHTS NER and may be related to increased gummy shark quota latency since 2009. The falling price of gummy shark is another contributor to the reduced gummy shark catch since 2009.

Demersal longline hooks
AFMA

12.4 Environmental status

The SESSF was accredited against parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* in February 2016. Conditions associated with the accreditation relate to the impact of fishing on bycatch species, particularly Australian sea lions (*Neophoca cinerea*), dolphins, seals and seabirds. Further recommendations associated with the accreditation relate to requirements for ecological risk assessment, and monitoring of bycatch and discarding.

A level 2 ecological risk assessment of 329 species resulted in 21 assessed as being at high risk (16 chondrichthyans and 5 marine mammals; Walker et al. 2007). A level 3 Sustainability Assessment of Fishing Effects (SAFE) assessment was completed for all 195 chondrichthyan and teleost species identified in the shark gillnet fishery, regardless of their level 2 Productivity Susceptibility Analysis (PSA) risk score. The assessment found seven species (all chondrichthyan) to be at high risk (Zhou et al. 2012). One species (common sawshark—*Pristiophorus cirratus*) was removed during the residual risk analysis (AFMA 2014e). The remaining six species considered to be at high risk are all sharks: bronze whaler (*Carcharhinus barchyurus*), white shark (*Carcharodon carcharias*), whiskery shark (*Furgaleus macki*), smooth hammerhead shark (*Sphyryna zygaena*), school shark (*Galeorhinus galeus*) and broadnose sevengill shark (*Notorynchus cepedianus*). A 2010 residual risk assessment of PSA results for non-teleost and non-chondrichthyan species identified five marine mammal species as high risk (AFMA 2010). A subsequent residual risk analysis removed two species (as a result of no interactions being recorded in the fishery) and included one further species (as a result of higher than expected interactions), resulting in four marine mammal species considered to be at high risk in the fishery: Australian fur seal (*Arctocephalus pusillus doriferus*), Australian sea lion, New Zealand fur seal (*A. forsteri*) and common dolphin (*Delphinus delphis*) (AFMA 2012b). The results of the ecological risk assessments have been consolidated to form a priority list in an ecological risk assessment strategy for the SESSF (AFMA 2015d).

AFMA publishes quarterly reports of logbook-reported interactions with protected species on its website. Reports for the GHTS in the 2016 calendar year indicate 349 interactions: 76 with mammals, 143 with seabirds, and the remainder with sharks. The mammal interactions comprised 37 interactions with dolphins (2 alive; 34 dead; 1 in unknown condition), 10 with Australian fur seals (all dead), 2 with Australian sea lions (1 dead), 6 with New Zealand fur seals (all dead), 1 with a killer whale (dead) and 20 with seals (3 unclassified; 17 dead). In 2016, 143 seabirds (21 of which were released alive) were caught, including albatrosses, cormorants, petrels, prions and shearwaters, and gannets.

Logbooks reported that 101 shortfin mako sharks (3 alive; 89 dead; 7 injured; 2 unknown condition), 17 porbeagle sharks (6 injured; 11 dead), 1 grey nurse shark (dead) and 11 great white sharks (9 alive; 1 dead; 1 unknown condition) were caught during 2016. Measures to reduce interactions with Australian sea lions and dolphins are discussed in Chapter 8.

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Chapter 13
Southern Squid Jig Fishery

T Emery and A Bath

FIGURE 13.1 (a) Commonwealth Trawl Sector squid catch and (b) relative fishing intensity in the Southern Squid Jig Fishery, 2016

(a)

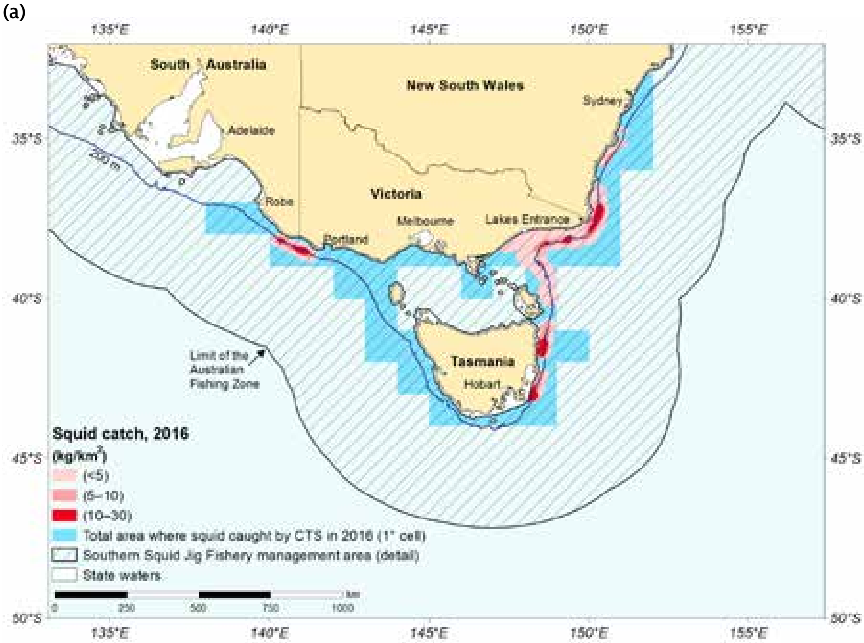

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FIGURE 13.1 (a) Commonwealth Trawl Sector squid catch and (b) relative fishing intensity in the Southern Squid Jig Fishery, 2016 continued

(b)

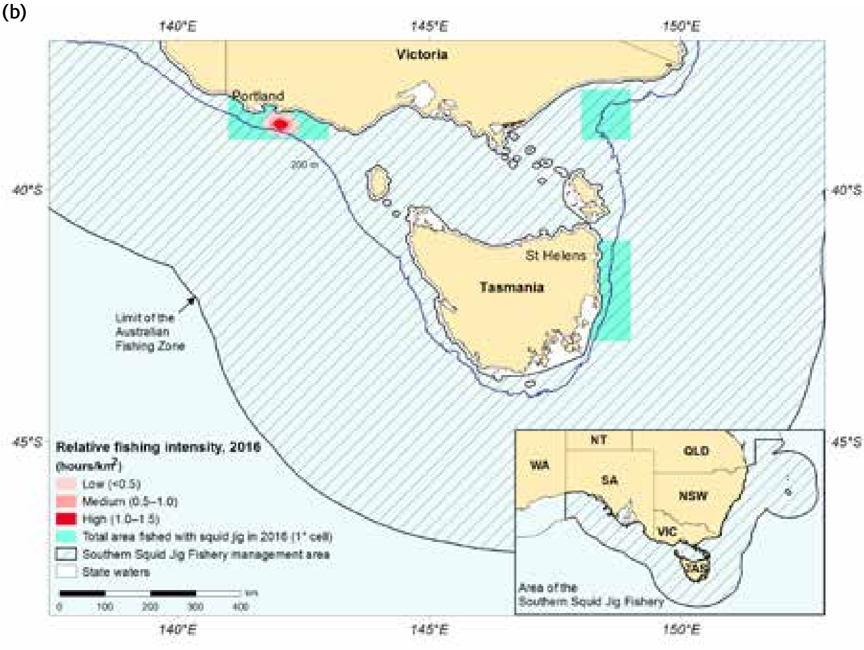


TABLE 13.1 Status of the Southern Squid Jig Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Gould's squid (*Nototodarus gouldi*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	In 2016, catch and effort in the SSJF and the CTS were similar to 2015 and remain, lower than the long-term average. Catch rates in the CTS are stable.
Economic status	Latent effort in the fishery remains high, but catch and effort in the fishery increased from 2015 to 2016. This suggests that the economic incentive to fish and NER in the fishery may have improved.				

Notes: **CTS** Commonwealth Trawl Sector. **NER** Net economic returns.

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

13.1 Description of the fishery

Area fished

The Southern Squid Jig Fishery (SSJF) is located off New South Wales, Victoria, Tasmania and South Australia, and in a small area off southern Queensland. Most fishing takes place off Portland, Victoria (Figure 13.1). Australian jig vessels typically operate at night in continental-shelf waters between depths of 60 and 120 m. Squid are also caught in the Commonwealth Trawl Sector (CTS) and the Great Australian Bight Trawl Sector (GABTS). In recent years, more squid has been landed collectively from these sectors than from the SSJF.

Fishing methods and key species

The SSJF is a single-method (jigging), single-species fishery, targeting Gould's squid (*Nototodarus gouldi*). Up to 10 automatic jig machines are used on each vessel; each machine has two spools of heavy line, with 20–25 jigs attached to each line. High-powered lamps are used to attract squid. Squid are also caught 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 managed by the relevant state government.

The species' short life span, fast growth and sensitivity to environmental conditions result in highly variable recruitment and strongly fluctuating stock sizes, making it difficult to estimate biomass before a fishing season. Therefore, the SSJF harvest strategy (AFMA 2007) relies on within-season monitoring against catch triggers for the jig and trawl sectors. Exceeding catch, fishing effort or catch-per-unit-effort triggers may signal the need for assessment and review of management arrangements. The current harvest strategy does not set escapement targets (that is, a proportion of the spawning biomass that is not fished and allowed to spawn) to limit the percentage of biomass removed in a season. Current harvest strategies based on catch-and-effort triggers have been implemented because of difficulties in collecting real-time catch, effort and size data, and growth estimates needed for within-season depletion analyses. Because of the current low fishing effort and conservative trigger limits, a move towards a more responsive management approach is not currently considered a high priority.

Squid are listed as a 'permitted species' in the state-managed commercial fisheries of Tasmania, South Australia and New South Wales, whereas no regulations apply to squid in Victorian commercial fisheries (AFMA 2014).

Fishing effort

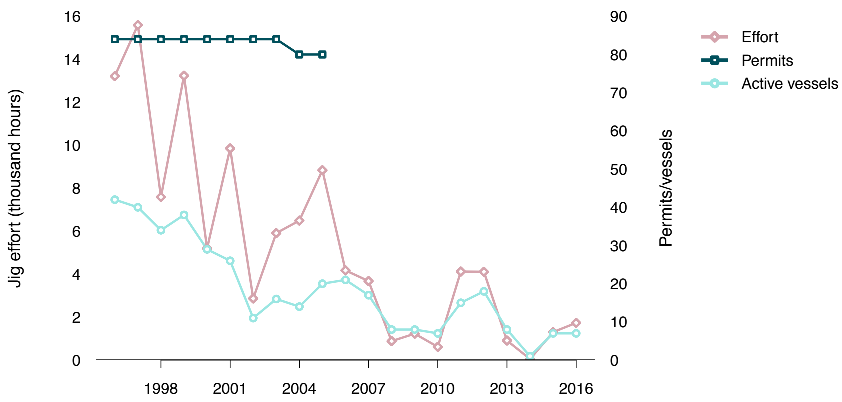
In 2016, there were 5,100 gear statutory fishing rights (SFRs), seven active vessels and a total fishing effort of 1,733 jig hours in the SSJF (Table 13.2). Despite brief increases in effort in 2011 and 2012, annual jig fishing effort has been below the long-term average since 2006 (Figure 13.2). High costs relative to revenue, combined with the highly variable biomass or availability of the stock, are the main reasons for the reduced effort since 2008. Effort increases in 2015 and 2016 resulting from higher and stable market prices and improved access to domestic markets have created greater certainty in the fishery (AFMA 2016). 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	2015			2016		
Fishery	**TAE**	**Catch (t)**	**Real value (2014–15)**	**TAE**	**Catch (t)**	**Real value (2015–16)**
SSJF	550 standard jigging machines **b**	330	$0.90 million	550 standard jigging machines **b**	384	$1.03 million
CTS	–	450	$1.27 million	–	542	$1.40 million
GABTS	–	44	$0.16 million	–	55	$0.14 million
Total	**–**	**824**	**$2.33 million**	**–**	**981**	**$2.57 million**
Fishery-level statistics						
Effort	1,304 jig hours			1,733 jig hours		
Gear SFRs **c**	5,500			5,100		
Active vessels	7			7		
Observer coverage	0			0		
Fishing methods	Squid jig					
Primary landing ports	Portland and Queenscliff (Victoria), Hobart (Tasmania)					
Management methods	Input controls: gear SFRs, number of jig machines					
Primary markets	Domestic: Melbourne—fresh International: China, Hong Kong, Canada					
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 and are in 2015–16 dollars. **b** Defined in the Southern Squid Jig Fishery Management Plan 2005 as a squid jigging machine that has two elliptical spools with one jig line on each spool. **c** Gear SFRs are fishing rights that permit fishers to use a defined type and quantity of fishing gear. Operators in 2016 require 9.27 SFRs to be nominated to their boat for each standard squid jigging machine they use.
Notes: **CTS** Commonwealth Trawl Sector. **GABTS** Great Australian Bight Trawl Sector. **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 2016

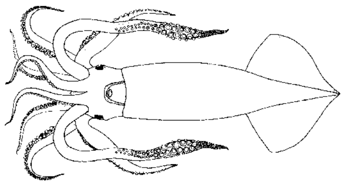


Note: Permits were replaced by gear statutory rights in 2005.

Squid jig lights
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 a number of different regions off southern Australia (Virtue et al. 2011), with genetic homogeneity more a function of egg mass and juvenile drift as a result of seasonal longitudinal ocean currents rather than of large-scale migrations between the two areas (Green et al. 2015).

Catch history

Before the commencement of the SSJF, 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-east waters, particularly in western Bass Strait, proving the feasibility of a fishery for Gould's squid. Taiwanese and Korean vessels were also licensed to fish in Bass Strait until 1988, with annual catches ranging from 13 to 2,309 t.

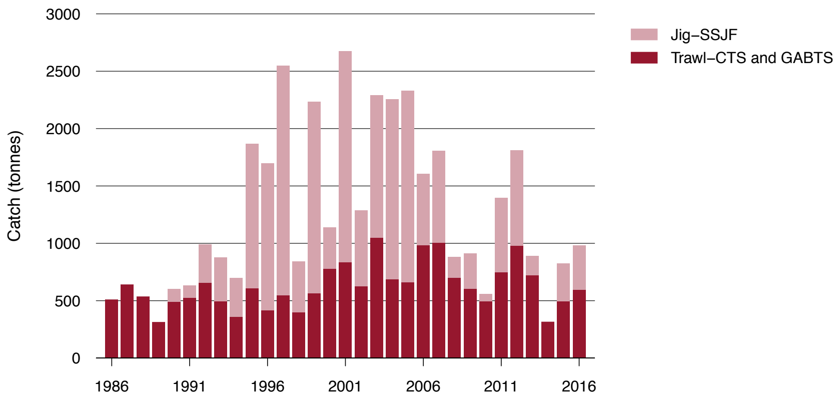
In 2016, 981 t of squid was reported across the three squid fishery sectors—SSJF (384 t), CTS (542 t) and GABTS (55 t)—an increase from 824 t in 2015 (Table 13.2). Total annual reported catch of Gould's squid by all methods was less than 1,000 t between 2008 and 2010, before the brief period of higher catches in both the CTS and the SSJF in 2011 and 2012 (Figure 13.3). Low catch levels in 2014 were largely attributed to lower levels of fishing effort and exploratory fishing of new fishing grounds (Figure 13.2).

During the past 10 years, SSJF annual catches have fluctuated between 1,569 t in 2005 and 2 t in 2014. In the CTS, the annual catch has ranged between 260 and 944 t, increasing to 542 t in 2016, up from 450 t in 2015. In the GABTS, the annual catch peaked in 2006 at 261 t, but has been much lower in recent years.

In 2016, the nominal annual average catch rate from the jig fishery was 221 kg/hour, which was the third highest catch rate over the past decade, down slightly from a historical high of 253 kg/hour in 2015 and up from a historical low of 40 kg/hour for the small amount of fishing in 2014 (Figure 13.4).

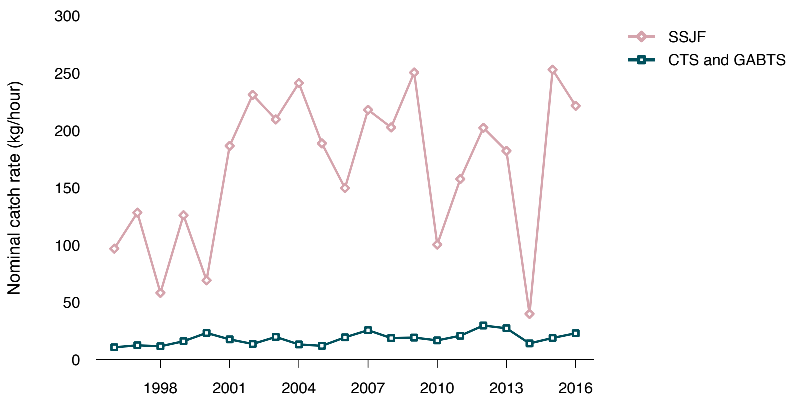
The total catch of Gould's squid in Tasmanian-managed waters in 2015–16 was 325 t. This was an increase from 19 t in 2014–15, but below the more than 1,000 t in 2012–13, taken by the Tasmanian Scalefish Fishery.

FIGURE 13.3 Squid catch in the SSJF, the CTS and the GABTS, 1986 to 2016



Notes: **CTS** Commonwealth Trawl Sector. **GABTS** Great Australian Bight Trawl Sector.

FIGURE 13.4 Nominal catch rate of Gould's squid in the SSJF, the CTS and the GABTS, 1996 to 2016



Notes: **CTS** Commonwealth Trawl Sector. **GABTS** Great Australian Bight Trawl Sector.

Stock assessment

Gould's squid is short lived, with a maximum life span of 12 months (Jackson & McGrath-Steer 2003). The fishery is therefore entirely dependent on annual recruitment. The squid display highly variable growth, and size and age at maturity. Once mature, they will spawn until they die, and recruitment is highly variable (Jackson & McGrath-Steer 2003; Virtue et al. 2011). These characteristics mean that stock biomass can rapidly increase when environmental conditions are favourable and fluctuate substantially between years.

In 2008, the Squid Resource Assessment Group analysed catch, catch rates and effort from 2000 to 2007 for four regions in the SSJF. Only one region—the central region from Cape Otway in Victoria to Robe in South Australia—had fishing levels that could cause depletion. During the 2001 fishing season, high catch rates were reported for the central region, and the total jig fishery catch was the second highest on record (Figure 13.3). A preliminary depletion analysis of the central region using jig catch-and-effort data indicated that, despite the high catches, the stock was not overfished in that region in that year.

ABARES conducted further depletion analyses for the central region of the SSJF for 1995 to 2006 (Barnes et al. 2015). The initial depletion curve results show stock declines during most seasons, with escapement in five seasons estimated to be between 30 and 40 per cent. However, these results are for only one region of the fishery and do not indicate exploitation rates for the whole stock. Limited data are available on squid growth in this region. Interpretation of the depletion estimates is further complicated by the lack of an agreed estimate of natural mortality, the possible presence of multiple cohorts each year (as a result of multiple spawning events) and a lack of knowledge about squid movement in the region. Application of a depletion analysis to guide within-season management decisions under the harvest strategy will require improved real-time fishery monitoring throughout the fishing season.

Squid are visual predators, and poor jig catch rates in some seasons (1998 and 2000) have been reported by industry as being due to rough seas and reduced water clarity. Furthermore, nominal jig catch rates might not provide a reliable index of squid abundance because of the aggregating effect of lights used during fishing operations.

Trawl catch rates from the CTS have been stable over the past 15 years, suggesting long-term stability in the availability, and perhaps biomass, of Gould's squid in the areas trawled (see the CTS and GABTS in Figure 13.4). The 2012 average trawl catch rate for Gould's squid in the CTS was the highest reported in the past 20 years. The extent to which squid are targeted on trawl grounds is unclear.

Stock status determination

The high historical catches taken by foreign vessels in the late 1970s and 1980s indicate that a high annual harvest can be taken from the stock in years of high abundance without greatly reducing recruitment and biomass for subsequent seasons. The results of retrospective depletion analysis, stable catch rates in the trawl fishery over an extended period and higher average catch rates (with the exception of the 2014 season, when effort declined) indicate that the stock has not been overfished in any season. As a result, the Gould's squid stock is classified as **not overfished**. Reduced SSJF catch levels during 2014 were attributed to a low availability of squid in traditional fishing grounds, combined with unfavourable prices that discouraged fishing. In 2015 and 2016, effort in the fishery increased as a result of higher market prices and improved access to domestic markets; however, total effort remains lower than the long-term average, and both squid jig and trawl nominal annual average catch rates have been relatively stable with the exception of 2014. The stock is thus classified as **not subject to overfishing**.

13.3 Economic status

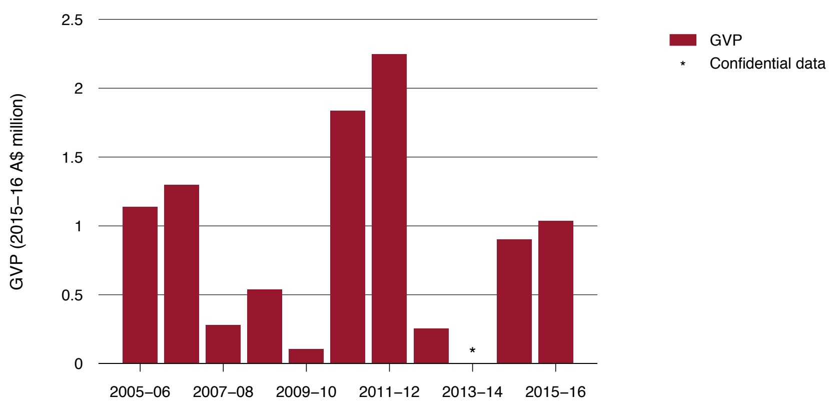
Key economic trends

Low fishing effort resulted in the lowest SSJF catch on record in 2014 (2 t). Catch in the SSJF has since increased to 330 t in 2015 and 384 t in 2016, reaching a value of $1.03 million in 2015–16 (Figure 13.5). Squid also contributed $1.40 million in the CTS and $0.14 million in the GABTS during 2015–16.

Effort levels in the fishery increased from 1,304 jig hours in 2015 to 1,733 jig hours in 2016. Increased effort and catch from the low levels of 2014 suggest that the incentive to fish and potentially net economic returns (NER) improved during 2015 and 2016.

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, 2005–06 to 2015–16



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

Management arrangements

The short life span of squid, a weak relationship between recruitment and stock abundance, and high interannual variability in squid abundance or availability mean that a biomass target such as B_{MEY} (the biomass producing maximum economic yield) is not considered to be appropriate for the SSJF. Instead of a biomass target, the fishery's harvest strategy has a 3,000 t catch trigger to initiate a formal stock assessment. This aims to prevent depletion in the SSJF, by allowing catches above the trigger level only if they are justified by assessment results (AFMA 2007). The trigger has not been reached since the harvest strategy was implemented in 2007.

The SSJF is managed using input (effort limit) controls. In the absence of formal stock assessments, total allowable effort (TAE) in the fishery has been set by the Squid Resource Assessment Group and the South East Management Advisory Committee at levels that maintain the capacity of the fleet to respond to changes in markets or the availability of squid. There has been no economic basis for setting the fishery's TAE (AFMA 2007).

While there is a high degree of latent effort in the fishery, the increased catches and nominal catch rates since 2014, combined with stable market prices, may result in increased targeting of squid in the future (AFMA 2016). The number of squid jigging machines allocated to each gear SFR is determined by dividing the TAE for the fishing year by the total number of gear SFRs for the fishing season. In 2016, the TAE was 550 standard jigging machines, with 5,100 gear SFRs present in the fishery, meaning that each jigging machine required 9.27 gear SFRs. A squid jigging vessel can use up to 10 jigging machines, meaning that 55 vessels could have operated in the fishery during 2016, when only 2 vessels were active. Although the level of gear SFR latency (unused gear) has been variable in the SSJF, it has persisted at high levels since 1996. This suggests that market factors rather than management arrangements have constrained effort.

Performance against economic objective

The catch trigger approach implemented in the SSJF has no clear link to economic performance, so it is difficult to determine how well the fishery is meeting the economic objective of the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007).

Despite effort increasing in the past two 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.

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 as a result of line weights.

The Australian Fisheries Management Authority publishes quarterly reports of logbook interactions with species that are protected under the EPBC Act. No interactions were reported for the SSJF in 2016. The occurrence of fur seals (*Arctocephalus* spp.) near working jig vessels has been raised as a possible concern in the past. However, observers on jig vessels in 2002 found no evidence of negative effects on seals from jigging. Observer records in 2005 and 2007 did not identify any effects on seals (Arnould 2002).

13.5 References

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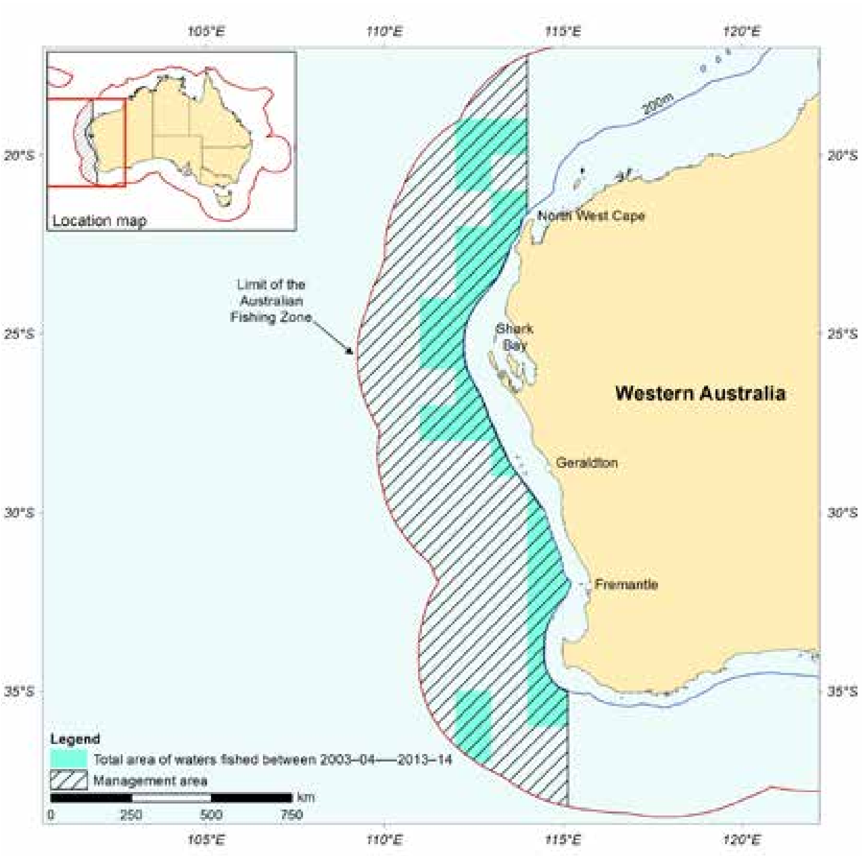
Chapter 14

Western Deepwater Trawl Fishery

J Woodhams and A Bath

FIGURE 14.1 Area fished in the Western Deepwater Trawl Fishery, 2005–06 to 2015–16



Note: 2013–14 was the last year when there was catch in the fishery.

TABLE 14.1 Status of the Western Deepwater Trawl Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Deepwater bugs (*Ibacus* spp.)					No fishing effort in 2015–16. No reliable estimate of biomass.
Ruby snapper (*Etelis carbunculus*, *Etelis* spp.)					No fishing effort in 2015–16. No reliable estimate of biomass.
Economic status	No fishing activity occurred in the fishery during the 2015–16 fishing season. Estimates of NER for previous years are not available, but a decline in effort and a low number of active fishing permits in recent years indicate that NER have been low.				

Notes: **NER** Net economic returns.

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

Trawl net and haul
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).

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 depth contour, in habitats ranging from temperate–subtropical in the south to tropical in the north. Catches in the WDTF were historically dominated by six commercial finfish species or species groups: orange roughy (*Hoplostethus atlanticus*), oreos (Oreosomatidae), boarfish (Pentacerotidae), eteline snapper (Lutjanidae: Etelinae), apsiline snapper (Lutjanidae: Apsilinae) and sea bream (Lethrinidae). Between 2000 and 2005, deepwater bugs (*Ibacus* spp.) emerged as the most important target species, although fishing effort (and consequently catch) has decreased substantially in recent years.

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 (*Etelis carbunculus* and *Etelis* spp.) and then deepwater bugs. Total fishing effort has been comparatively low since 2005–06, although still variable, and mostly targeted at deepwater bugs. No vessels were active in the 2015–16 fishing season.

Catch

Total catch has generally remained below 100 t, apart from peaks in the early to mid 1990s, when it reached 378 t, and in 2001–02, when it reached 347 t. The peak in catch in the early to mid 1990s consisted mostly of orange roughy, while the peak in catch at the turn of the century consisted mostly of orange roughy, deepwater bugs and, to a lesser extent, ruby snapper.

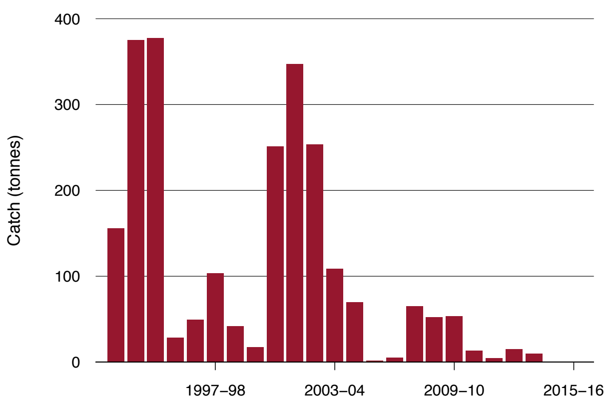
Total catch has been relatively low in recent years, consisting mostly of deepwater bugs, with minimal catch of finfish. There was no catch or effort in 2015–16 (Table 14.2; Figure 14.2).

TABLE 14.2 Main features and statistics for the WDTF

Fishery statistics a	**2014–15 fishing season**			**2015–16 fishing season**		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Deepwater bugs	–	0	0	–	0	0
Ruby snapper	–	0	0	–	0	0
Total fishery	**–**	**0**	**0**	**–**	**0**	**0**
Fishery-level statistics						
Effort	0			0		
Fishing permits	11			11		
Active vessels	0			0		
Observer coverage	0 days (0%)			0 days (0%)		
Fishing methods	Demersal trawl					
Primary landing ports	Fremantle, Carnarvon					
Management methods	Input controls: limited entry (11 permits), gear restrictions					
Primary markets	Domestic: Perth, Sydney, Brisbane—frozen, chilled International: United States, Spain, Japan—frozen					
Management plan	*North West Slope Trawl Fishery and Western Deepwater Trawl Fishery: statement of management arrangements 2012* (AFMA 2012)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 July to 30 June. Real-value statistics are provided by financial year, which is also 1 July to 30 June.
Notes: **TAC** Total allowable catch. **–** Not applicable.

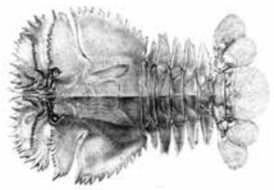
FIGURE 14.2 Total catch in the WDTF, 1992–93 to 2015–16



Source: Australian Fisheries Management Authority

14.2 Biological status

Deepwater bugs (*Ibacus* spp.)



Line drawing: FAO

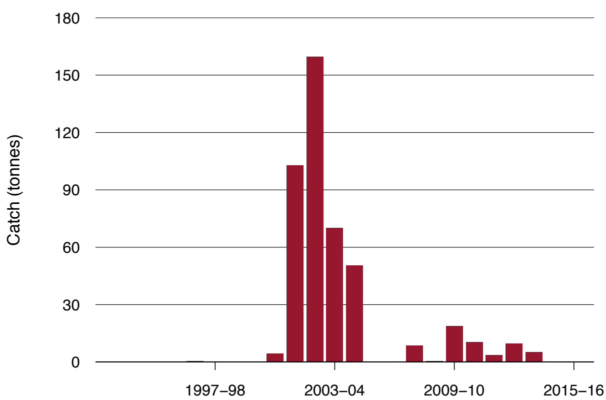
Stock structure

The WDTF catches several species of deepwater bugs. Stock structure of these species is not known, and they are grouped into a multispecies stock for status assessment.

Catch history

The catch history of deepwater bugs in the WDTF is characterised by four years of relatively high catches from 2001–02 to 2004–05, peaking at 160 t in 2002–03 (Figure 14.3). Apart from this brief period, annual catches of deepwater bugs have been less than 20 t. There was no catch in 2015–16.

FIGURE 14.3 Deepwater bug catch in the WDTF, 1992–93 to 2015–16



Source: Australian Fisheries Management Authority

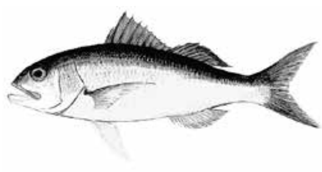
Stock assessment

A formal stock assessment for deepwater bugs has not been done, and little information is available with which to assess stock status. The low fishing effort, low catch levels and sporadic targeting of key commercial species make it difficult to assess stock status.

Stock status determination

There was no fishing in the WDTF in 2015–16 (Figure 14.3). As a result, deepwater bugs are classified as **not subject to overfishing**. There is currently little empirical data that would inform status for this stock. As a result, the stock is **uncertain** with regard to the level of biomass.

Ruby snapper (*Etelis carbunculus* and *Etelis* spp.)



Line drawing: FAO

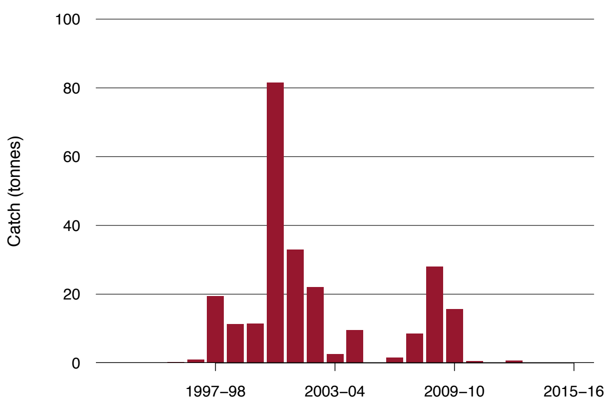
Stock structure

Stock structure of ruby snapper caught in the WDTF is not known, so the stock is assessed here at the fishery level.

Catch history

Catches of ruby snapper in the WDTF peaked in 2000–01, with a smaller peak in 2008–09. Catches have been negligible since 2010–11, with no effort in the fishery in 2015–16 (Figure 14.4).

FIGURE 14.4 Ruby snapper catch in the WDTF, 1992–93 to 2015–16



Source: Australian Fisheries Management Authority

Stock assessment

The only stock assessment for ruby snapper was published in 2002 (Hunter et al. 2002). However, the reliability and accuracy of outputs from this assessment were weakened by the poor quality and limited quantity of data. The assessment identified biological characteristics that potentially increase the species' vulnerability to overfishing: the species is relatively long lived, has a high age at maturity, has a slow growth rate and aggregates in restricted continental-shelf habitats. Hunter et al. (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/hour in January 1997, peaked at 900 kg/hour in September 1997 and declined to less than 200 kg/hour towards the end of the study period in mid 2001. Although Hunter et al. (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.

Status determination for ruby snapper in the WDTF is further complicated because the same stock is also harvested by fishers operating inshore from the WDTF—in state fisheries that are under the jurisdiction of the Western Australian Department of Fisheries. Additionally, recent multivariate analyses of otolith morphology suggest that records of historical ruby snapper catch have actually comprised distinct species (*E. carbunculus* and *Etelis* spp.) that are almost indistinguishable apart from differences in otolith shape (Wakefield et al. 2014). The Western Australian Department of Fisheries is currently undertaking a stock assessment to estimate recent fishing mortality of ruby snapper in the Pilbara demersal fishery (Stephen Newman, Western Australian Department of Fisheries, 2015, pers. comm.). The results of this assessment may provide an improved basis for future assessments of the status of ruby snapper in the WDTF.

Stock status determination

A weight-of-evidence approach based on catch and landing data since the 1992–93 fishing season (Figure 14.4), together with information published with the 2002 stock assessment (summarised above), has been used to determine stock status. There was no catch of ruby snapper in the WDTF in 2015–16. As a result, ruby snapper is classified as **not subject to overfishing**. The absence of a reliable estimate of population size and the stock's relatively long history of exploitation result in the stock biomass being classified as **uncertain**.

14.3 Economic status

Key economic trends

Fishing is opportunistic in the fishery, and catch levels have been variable in the past. Since 2003–04, catch has not exceeded 100 t. Eleven permits were held for both the 2014–15 and 2015–16 seasons; however, there were no active vessels in the fishery for either season. The limited effort, relatively low catch and small number of active fishing permits in previous years indicate that net economic returns have been low. For 2015–16, the lack of any fishing activity indicates that fishers expect limited economic return from operating in the fishery.

Management arrangements

The fishery has the same harvest strategy as the NWSTF (Chapter 6). The WDTF is managed through input controls (11 permits with a five-year duration).

Performance against economic objective

The fishery's performance against the economic objective is uncertain. Fishing has been opportunistic, with a range of species caught in low volumes, typically generating low overall value. Given these characteristics and no fishing activity during 2014–15 and 2015–16, low-cost management arrangements are appropriate.

14.4 Environmental status

The WDTF is included in the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 22 December 2017.

The Western Trawl fisheries (NWSTF and WDTF) have been assessed to level 3 of the Australian Fisheries Management Authority (AFMA) ecological risk assessment (Zhou et al. 2009). No species were found to be at high risk at the current level of fishing effort.

AFMA publishes quarterly summaries of logbook reports of interactions with protected species on its website. As there was no fishing effort, no interactions with protected species listed under the EPBC Act were reported in the WDTF in 2016.

14.5 References

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

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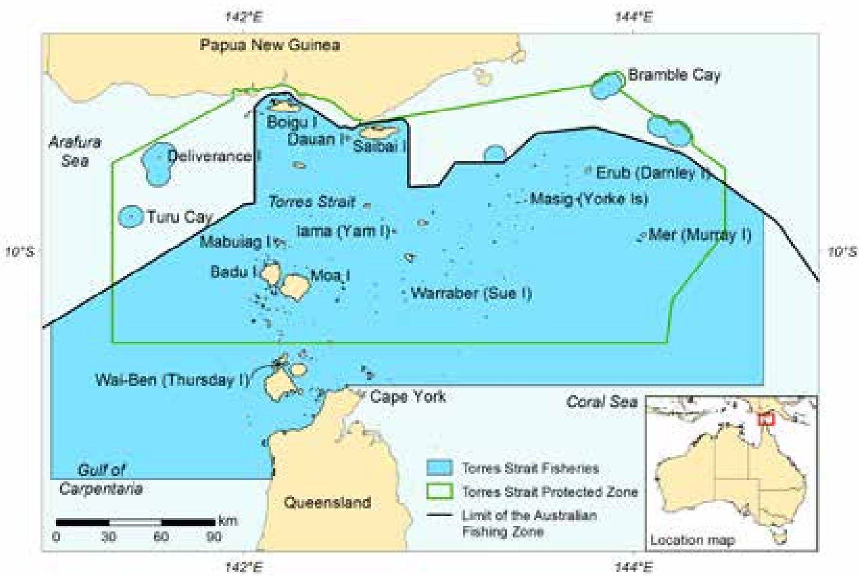
Chapter 15
Torres Strait fisheries

A Williams and K Mazur

FIGURE 15.1 Area of the Torres Strait fisheries



Torres Strait is located between Cape York Peninsula (north Queensland) and Papua New Guinea (PNG; Figure 15.1). It connects the Arafura and Coral seas, and is an important shipping route. There are hundreds of islands and reefs in Torres Strait, with 17 island communities plus several communities in the Northern Peninsula Area on Cape York. The area produces seafood for local consumption, and for sale in Australia and overseas. Local seafood is a primary food source for Torres Strait Islanders, as well as being central to traditional island culture and an important source of income.

The 1985 Torres Strait Treaty between Australia and PNG established the boundaries between the two nations and provides for joint management of the shared marine resources. The treaty is concerned with sovereignty and maritime boundaries, protection of the marine environment, and optimum use of commercial resources in the region. It also establishes the Torres Strait Protected Zone (TSPZ; Figure 15.1), in which each nation exercises sovereign jurisdiction over migratory fish and sedentary species in its own waters. The principal purpose of establishing the TSPZ is to acknowledge and protect the way of life and livelihood of the Traditional Inhabitants of the area. This includes protecting traditional fishing methods and rights of free movement.

The management area for each Australian fishery in Torres Strait extends south of the TSPZ (Figure 15.1). In each fishery, this area of the management zone is referred to as the 'outside but near area'. The boundary of the outside but near area for each fishery varies; these boundaries are shown in the fishery maps in subsequent chapters.

Under the treaty, Australia and PNG are required to cooperate on the conservation and management of the commercial fisheries in the TSPZ; they also engage in regular bilateral discussions. This cooperation includes negotiating and setting catch-sharing provisions for several Torres Strait fisheries under article 23 of the treaty. Catch sharing includes the development of subsidiary conservation and management arrangements under article 22 of the treaty.

In Australia's area of the TSPZ, traditional fishing and commercial fisheries are managed by the Torres Strait Protected Zone Joint Authority (PZJA), which was established under the *Torres Strait Fisheries Act 1984* (TSF Act). The PZJA comprises the ministers from the Australian and Queensland governments responsible for fisheries, and the Chair of the Torres Strait Regional Authority (TSRA). The TSRA (an Australian Government statutory authority) was established in 1994 under the *Aboriginal and Torres Strait Islander Commission Act 1989* (now the *Aboriginal and Torres Strait Islander Act 2005*), and has responsibility for managing programs that aim to improve the way of life and livelihood of Torres Strait Islanders and Aboriginal people living in Torres Strait.

On 7 August 2013, the High Court of Australia held that Commonwealth and Queensland legislation that prohibited fishing for commercial purposes without a licence did not extinguish the native title rights of certain Torres Strait communities to take resources from defined areas. In practice, this means that native title holders are still required to comply with Commonwealth and Queensland licensing requirements to undertake commercial fishing, but may do so without extinguishing their non-exclusive native title rights.

Two Australian commercial fishing sectors operate in Torres Strait: the Traditional Inhabitant sector, operating under Traditional Inhabitant Boat (TIB) licences; and the non–Traditional Inhabitant sector, operating under Transferable Vessel Holder (TVH) licences. TIB licences are available only to fishers who satisfy the Traditional Inhabitant requirements. TVH licences are issued to other commercial fishers. Catch-and-effort reporting using logbooks is mandatory for TVH licence holders, whereas a voluntary docket-book system is used by fish receivers for recording the commercial catch of TIB fishers.

The commercial fisheries currently managed by the PZJA are prawn, tropical rock lobster, Spanish mackerel, reef line, bêche-de-mer (sea cucumber), trochus (top shell), pearl shell, crab, barramundi and traditional fishing (including turtle and dugong). Five of these fisheries—prawn, tropical rock lobster, pearl shell, Spanish mackerel, and turtle and dugong—are article 22 fisheries that are jointly managed by PNG and Australia. For Australian fishers, the Torres Strait Tropical Rock Lobster Fishery is the most commercially valuable of the Torres Strait fisheries, with a gross value of production of $14.3 million (376 t) in the 2015–16 financial year. This is followed by the Torres Strait Prawn Fishery (590 t, worth $8.9 million in 2015–16).

The Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007) does not prescribe management arrangements for fisheries jointly managed by the Australian Government and other (domestic or international) management agencies, such as the fisheries in Torres Strait. The PZJA has asked its management forums to provide advice on the application of the HSP to the Torres Strait fisheries, and a harvest strategy for the Torres Strait Prawn Fishery was implemented in 2011 (AFMA 2011). There are no harvest strategies currently in place for any other Torres Strait fisheries.

15.1 References

AFMA 2011, *Harvest strategy for the Torres Strait Prawn Fishery*, Australian Fisheries Management Authority, Canberra.

DAFF 2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Chapter 16
Torres Strait Finfish Fishery

N Marton, A Williams and K Mazur

FIGURE 16.1 Area of the Torres Strait Finfish Fishery

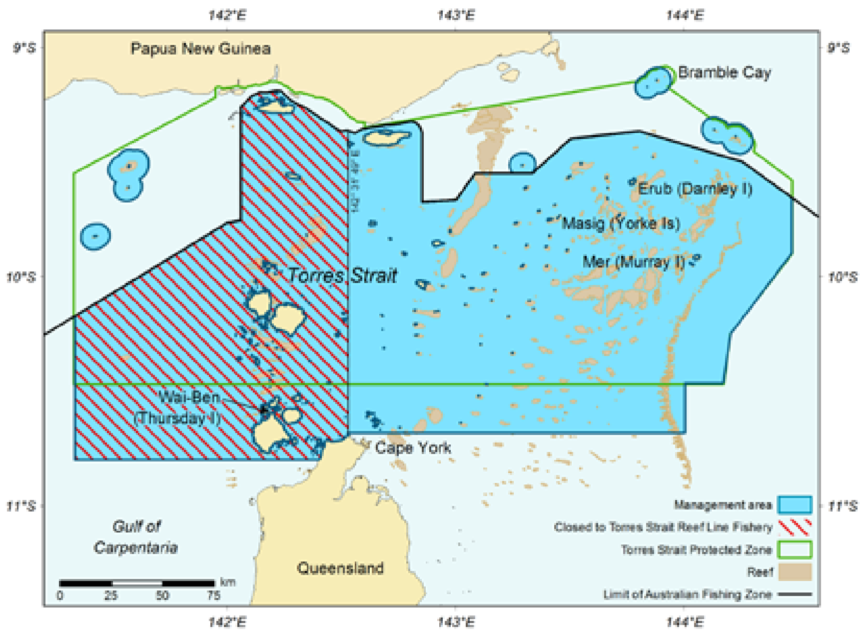


TABLE 16.1 Status of the Torres Strait Finfish Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Coral trout (*Plectropomus* spp., *Variola* spp.)					Management strategy evaluation testing suggests that current catches are well below the level likely to lead to biomass declines. Most recent biomass estimate indicated a biomass above $0.6B_0$.
Spanish mackerel (*Scomberomorus commerson*)					Current fishing mortality rate is below that required to produce MSY. Most recent estimates of biomass are above B_{20}.
Economic status	Estimates of NER are not available. Economic performance in 2015–16 remains uncertain despite an increase in GVP, because of the lack of clarity around fishing effort levels by the TIB sector. The first export of live coral trout from the fishery in 2016–17 is a positive sign for NER.				

Notes: **B_0** Unfished biomass. **B_{20}** 20 per cent of unfished biomass. **GVP** Gross value of production. **MSY** Maximum sustainable yield. **NER** Net economic returns. **TIB** Traditional Inhabitant Boat.

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

16.1 Description of the fishery

Area fished

Most commercial fishing in the Torres Strait Finfish Fishery (TSFF) takes place in the north-eastern region of Torres Strait (Figure 16.1). A large area of the fishery west of 142°32'E is closed to commercial fishing for the Torres Strait Finfish (Reef Line) Fishery (TSFRLF).

Fishing methods and key species

The TSFF has two components: the Torres Strait Spanish Mackerel Fishery (TSSMF) and the TSFRLF. Two commercial fishing sectors—the Traditional Inhabitant Boat (TIB) and non-TIB sectors—and the Islander subsistence sector participate in the TSSMF and the TSFRLF.

The TSSMF targets Spanish mackerel (*Scomberomorus commerson*), primarily by trolling from small dories or dinghies tendered to a primary vessel or operating independently. Byproduct is a relatively minor component of catch in the TSSMF. 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.), with smaller catches of other groupers (Serranidae), mackerels (Scombridae), snappers (Lutjanidae), emperors (Lethrinidae) and trevally (Carangidae). The most recent data indicate that coral trout make up around 90 per cent of the retained commercial catch (by weight) for both the TIB and non-TIB sectors, while barramundi cod and rock cods represent 5 per cent, and red emperor, other emperors and trevally represent 3 per cent.

Both sectors have historically discarded more than half their total catch, in numbers, as bycatch (Williams et al. 2008). The TIB sector retains a wider range of species than the non-TIB sector, mainly for subsistence (Busilacchi et al. 2012, 2013).

A variety of fishing gears, including hook and line, nets, spears and traps, are used by subsistence fishers in the TSSMF and the TSFRLF. Estimated yields of reef fish for the subsistence fishing sector are similar to those for the TIB and non-TIB commercial sectors combined (Busilacchi 2008; Busilacchi et al. 2013). However, the species composition of the subsistence and commercial catches differs: traditional subsistence fishing takes predominantly trevallies (Carangidae), mullet (Mugilidae), sardines (Clupeidae) and rabbitfish (Siganidae).

Management methods

The fishery is managed through both input controls (limited entry, vessel restrictions and prohibited species) and output controls (size limits and amount of leased quota).

A management plan for the TSFF was finalised in 2013. The plan provides for the setting of a total allowable commercial catch. Quota in the TSFF is entirely owned by Traditional Inhabitants, and non-TIB fishers are required to operate by leasing a quota under a temporary licence (called a 'sunset licence'). These operators lease quota for Spanish mackerel, coral trout and other TSFRLF species each year through the Torres Strait Regional Authority.

Although the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007) 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.

Fishing effort

Effort in the fishery has decreased from peaks in the early 2000s. Several factors have contributed to the decline, including the voluntary surrender of Transferable Vessel Holder (TVH) fishing licences, government-funded structural adjustment and logistical difficulties relating to freezer capacity. The fishery for coral trout on the Queensland east coast focuses primarily on live export (QDAFF 2013). The removal of the ban on live exports in Torres Strait has previously done little to increase activity in the TSFRLF, primarily because of difficulties and costs associated with transporting live fish from remote areas. In 2017, live coral trout were exported for the first time.

Catch

Catch in the TIB and TVH sectors has followed the trends in effort, discussed above.

TABLE 16.2 Main features and statistics for the TSFF

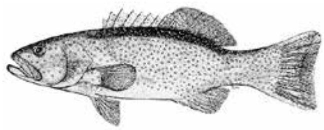
Fishery statistics [a]	2014–15 fishing season		2015–16 fishing season	
Stock	**Catch (t) [b]**	**Real value (2014–15)**	**Catch (t) [b]**	**Real value (2015–16)**
Coral trout	20.6	Confidential	38.7	Confidential
Spanish mackerel	83.9	Confidential	86.9	Confidential
Other	1.7	Confidential	3.9	Confidential
Total fishery	**106.1**	**$1.06 million**	**129.5**	**$1.2 million**
Fishery-level statistics				
Effort (days) TSSMF	Spanish mackerel: TIB—not available Sunset permits [c] —394 operation-days, 721 tender-days		Spanish mackerel: TIB—not available Sunset permits—412 operation-days, 764 tender-days	
TSFRLF	Coral trout: TIB—not available Sunset permits—151 (coral trout operation- and tender-days), 153 (all TSFRLF species operation- and tender-days)		Coral trout: TIB—not available Sunset permits—344 coral trout operation-days, 344 tender-days (same for all TSFRLF species)	
Fishing permits	TIB: 210 mackerel endorsements, 194 line endorsements Sunset permits: 6 mackerel and/or line licences		TIB: 143 mackerel endorsements, 123 line endorsements Sunset permits: 7 mackerel and/or line licences	
Active vessels TSSMF	Spanish mackerel: TIB—not available Sunset permits—5		Spanish mackerel: TIB—not available Sunset permits—5	
TSFRLF	Coral trout: TIB—not available Sunset permits—2		Coral trout: TIB—not available Sunset permits—2	
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. Real-value statistics are provided by financial year and are in 2015–16 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 are permits that allow non–Traditional Inhabitant fishers to fish in Torres Strait, and take finfish and Spanish mackerel leased from the TIB Sector. Sunset permits are issued each year and expire on 30 June each year. Six sunset permits are available for primary boats that carry a small number of tenders.

Notes: **TIB** Traditional Inhabitant Boat. **TSFRLF** Torres Strait Finfish (Reef Line) Fishery. **TSSMF** Torres Strait Spanish Mackerel Fishery.

16.2 Biological status

Coral trout (*Plectropomus* spp., *Variola* spp.)



Line drawing: FAO

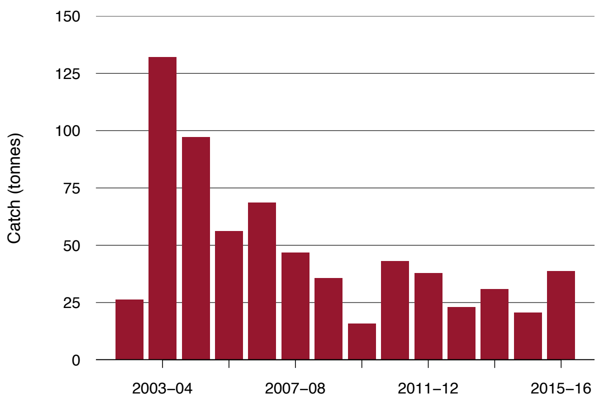
Stock structure

The biological stock structure of coral trout in Torres Strait remains uncertain. Therefore, the status is reported for the Torres Strait fishery rather than for individual stocks.

Catch history

Commercial catch of coral trout in the TSFRLF peaked in 2003–04 at 132 t before falling to below 50 t in 2007–08 (Figure 16.2). Catch has remained below this level since then.

FIGURE 16.2 Catch history for coral trout in the TSFRLF, 2002–03 to 2015–16



Source: Australian Fisheries Management Authority

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, 2011). Four constant-catch scenarios, ranging from 80 to 170 t, were tested. All achieved a biomass of at least 70 per cent 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 will be required to estimate the current level of relative biomass.

Stock status determination

In the absence of a formal stock assessment, the status of the coral trout stock is evaluated against the results of the MSE, combined with a comparison of the 2015–16 catch with the historical catch record (Figure 16.2). The biomass in 2004 was estimated to be more than 60 per cent of unfished levels (Williams et al. 2011, 2007). 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 per cent of the unfished biomass within 20 years at that catch level (Williams et al. 2007, 2011). As a result, the stock is classified as **not overfished** and **not subject to overfishing**.

Spanish mackerel (*Scomberomorus commerson*)

Line drawing: FAO

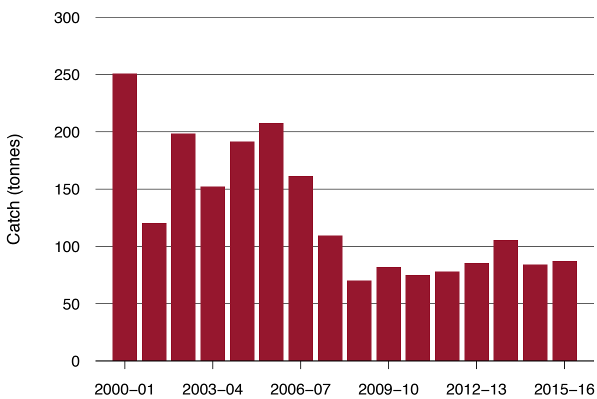
Stock structure

Spanish mackerel in Torres Strait is thought to comprise a separate biological stock from stocks on the east coast and further west (Begg et al. 2006; Buckworth et al. 2007).

Catch history

Annual catches of Spanish mackerel declined from a peak of 251 t in 2000–01 to around 70 t in 2008–09 and have remained at approximately 80 to 100 t since (Figure 16.3).

FIGURE 16.3 Catch history for Spanish mackerel in the TSSMF, 2000–01 to 2015–16



Source: Australian Fisheries Management Authority

Stock assessment

The stock assessment of Spanish mackerel in 2006 (Begg et al. 2006) was updated in 2016 using data to 2014 (O'Neill & Tobin 2016). The updated assessment used an integrated age-structured model and input data on catch, effort and length-at-age of Spanish mackerel. The updated assessment did not use the model region structure or spatial catch data used by Begg et al. (2006) because of a large amount of missing or imprecise location data.

Four separate analyses were run to examine the effects of uncertainty in natural mortality, assumed historical catches and changes in catch reporting since the implementation of a new non-Indigenous commercial logbook in 2003. Each analysis used a different combination of two alternative scenarios for natural mortality, historical catch series and catch-per-unit-effort (CPUE). Natural mortality was either estimated by the model, or fixed at 0.3 to be consistent with values used in the previous assessment. The two historical catch series assumed that Indigenous catches were 18.5 per cent of non-Indigenous catches in years when Indigenous catch data were considered to be under-reported, or that reported non-Indigenous catches were multiplied by 1.75 in all years to examine the effects of larger historical harvests (under-reporting) on stock status outcomes. The two alternative CPUE standardisations assumed that the implementation effects of the new logbook were either constant across vessels or varied among vessels.

Across the four analyses, maximum sustainable yield (MSY) estimates ranged from approximately 140 to 210 t, and the effort required to maintain MSY (E_{MSY}) ranged from 800 to 2,000 primary vessel-days. The 2014 spawning biomass was estimated to be between approximately 40 and 60 per cent of unfished (1940) levels (SB_{2014}/SB_{1940} = 0.4–0.6), and the current (2014) fishing mortality rate was estimated to be below the level that would produce MSY (F_{2014}/F_{MSY} = 0.2–0.6) (O'Neill & Tobin 2016). However, the maximum fishing mortality estimated across the past five years (2010 to 2014) was approximately equal to F_{MSY} for two of the analyses, including the analysis with inflated historical non-Indigenous catches.

Unlike the 2006 stock assessment, the updated assessment was not used to evaluate the performance of different fishing strategies through formal MSE. However, the assessment was reviewed by the Torres Strait Finfish Scientific Technical Working Group, which recommended that the Torres Strait Finfish Working Group consider a recommended biological catch of 125 t of Spanish mackerel for the 2017–18 fishing season (AFMA 2016). This recommendation was based on the need for a precautionary approach to account for uncertainties in the assessment, and a preference to maintain the stock at levels above B_{40} and closer to B_{60}.

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. Hyperstability is frequently observed in fisheries that target schooling species such as the Spanish mackerel fishery, where most fishing activity is concentrated on large spawning aggregations around Bramble Cay. Although Begg et al. (2006) recommended the collection of finer-scale spatial and temporal data to be reported by fishers to improve the standardisation of catch rates and provide a more robust index of abundance, the reporting of more precise catch and effort data has not improved.

Stock status determination

Although there is no formal target or limit reference point for the fishery, $0.2B_0$ is the proxy limit reference point specified in the HSP and is used for status determination in the absence of an agreed limit reference point. The 2014 estimates of Spanish mackerel biomass (between $0.4B_0$ and $0.6B_0$) were above $0.2B_0$. As a result, the stock is classified as **not overfished**. Reported catches since 2007–08 have been below the range of MSY estimates in the 2016 assessment, and fishing mortality in 2014 was estimated to be below F_{MSY}. On this basis, the stock is classified as **not subject to overfishing**.

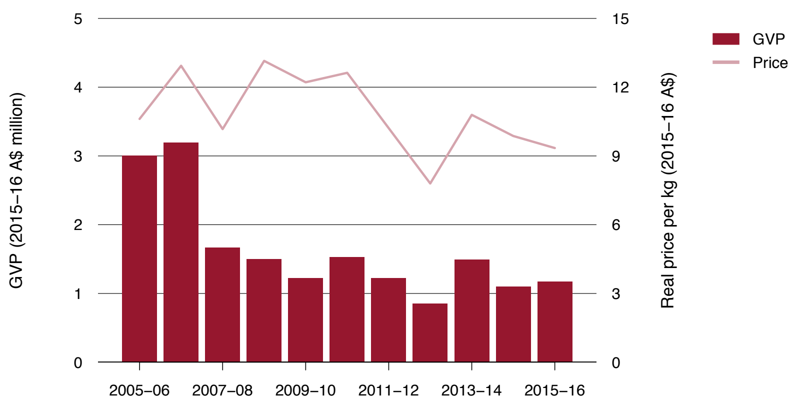
16.3 Economic status

Key economic trends

In 2015–16, the catch of coral trout increased but the prices declined (Figure 16.4). The increase in catch of Spanish mackerel and coral trout was reflected in higher gross value of production, which increased by 7 per cent to $1.2 million in 2015–16.

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 $215,000 in 2014–15 (TSRA 2015).

FIGURE 16.4 Real GVP and average price per kilogram for the TSFF, 2005–06 to 2015–16



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

Management arrangements

The switch from TVH endorsements to the new leasing arrangements aims to increase community revenue to Traditional Inhabitants of Torres Strait. Leasing arrangements allow quota to be leased to non-TIB fishers, with the leasing revenue used for capacity building of the TIB fishing industry (TSRA 2013).

The Torres Strait Finfish Fishery Management Plan 2013 requires harvest levels to be set at or below levels that maintain biologically viable stocks of target and non-target species, following consultation with the Torres Strait Fisheries Management Advisory Committee and other stakeholders.

Performance against economic objective

The key objectives of the TSFF management plan are to acknowledge and protect the traditional way of life of Traditional Inhabitants, including their rights in relation to traditional fishing for finfish, and to conserve resources in a way that minimises the impact on the marine environment. Optimising economic viability of the fishery is one objective, but, unlike fisheries solely managed by the Australian Government, targeting maximum economic yield is not a key focus. The quota leasing arrangements in the fishery provide a means to meet the objectives under the Torres Strait Treaty to promote economic development and employment for Traditional Inhabitants (TSFMAC 2012).

Leasing revenue is intended to provide investment funding to build the capacity of Traditional Inhabitant fishing industries. In 2014–15, $4,000 in grant payments were disbursed, leaving the Finfish Quota Trust account with a closing balance of $1.1 million at the end of the financial year (TSRA 2015). In 2015–16, $1,000 in grant payments were disbursed, leaving the Finfish Quota Trust account with a closing balance of $1.3 million at the end of the financial year (TSRA 2016). TSFF grants provided to Torres Strait Islander communities have helped them to purchase equipment, such as portable freezers, outboards, dinghies and other fishing gear; this is likely to have positively affected profitability for the TIB Sector (AFMA, 2015, pers. comm.)

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 22 December 2017.

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 via 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.

AFMA publishes quarterly logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in the TSFF in 2016.

16.5 References

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Spanish mackerel
Ashley Williams, ABARES

Chapter 17
Torres Strait Tropical Rock Lobster Fishery

A Williams and K Mazur

FIGURE 17.1 Regional map showing the management area of the Torres Strait Tropical Rock Lobster Fishery

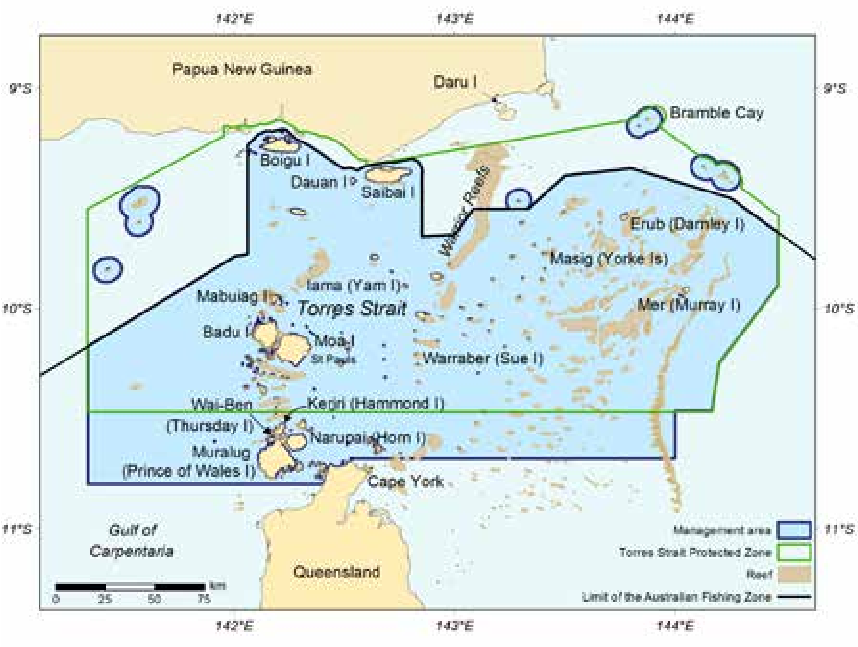


TABLE 17.1 Status of the Torres Strait Tropical Rock Lobster Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Tropical rock lobster (*Panulirus ornatus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Current catches are unlikely to result in biomass falling below the target and limit reference points. Spawning stock biomass is above the target level.
Economic status	NER are likely to have improved in 2015–16. A decrease in effort in the fishery in 2015–16 suggests a reduction in fishing costs and, when combined with a lower fall in gross value of production, indicates that NER in the fishery are likely to have increased. This result has been achieved in the context of other objectives, including positive social and cultural outcomes.				

Notes: **NER** Net economic returns.

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

17.1 Description of the fishery

The Torres Strait Tropical Rock Lobster Fishery (TSTRLF) is commercially fished in the Torres Strait Protected Zone (TSPZ) by Australian and Papua New Guinean nationals. Australians hold Transferable Vessel Holder (TVH) licences or Traditional Inhabitant Boat (TIB) licences (see Chapter 15).

Area fished

The TSTRLF extends from Cape York to the northern border of the TSPZ (Figure 17.1). Most catch comes from the western and south-eastern parts of the fishery, where the densities of tropical rock lobster are highest (AFMA 2013). Access to this fishery is shared by Australia and Papua New Guinea (PNG) under formal arrangements in the Torres Strait Treaty (see Chapter 15).

Fishing methods and key species

The TSTRLF is based on a single species: tropical rock lobster (*Panulirus ornatus*). It is predominantly a dive-based, hand-collection fishery. Divers use surface-supplied air (hookah) or free-dive, and work from 4–6 metre tenders (one diver per tender). Some lobsters are also collected at night on shallow reef flats by fishers using a light and handheld spear or scoop net.

The TVH Sector uses motherships (large catch-storage vessels) in conjunction with smaller fishing tenders, generally using hookah gear. A small fleet of 12 TVH vessels undertake trips to fishing grounds and fish for a few days to several weeks. In contrast, most fishing trips in the TIB Sector last for only a day or two, with divers working from smaller boats that depart from their local island communities. In recent years, however, an increasing number of TIB Sector operators have used motherships in conjunction with fishing tenders and hookah equipment. This has allowed TIB Sector operators to target live rock lobster, which attracts a higher and more consistent market price than frozen rock lobster tails.

Management methods

The TSTRLF is currently managed primarily through effort restrictions (input controls). In 2016, the Protected Zone Joint Authority (PZJA) released a draft management plan, the Torres Strait Fishery (Quotas for Tropical Rock Lobster [Kaiar]) Management Plan 2016, for public comment. The draft plan proposes the introduction of a quota-based allocation system (output controls) based on catch history between 1997 and 2001, with provisions for leasing quota. The draft plan is not in force.

As part of the transition planning, the Tropical Rock Lobster Resource Assessment Group (TRLRAG) is developing a harvest strategy for the TSTRLF, and fishery-specific target and limit reference points are being defined. The interim harvest strategy uses a limit reference point for biomass (32 per cent of spawning biomass in 1973 [SB_{1973}]—$0.32SB_{1973}$), a trigger reference point for biomass ($0.48SB_{1973}$), a target reference point for biomass ($0.65SB_{1973}$) and a target reference point for fishing mortality rate ($F_{TARG} = 0.15$). The proposed harvest control rule uses a constant exploitation rate ($F_{TARG} = 0.15$ per year) while the stock size is at or above the trigger reference point for biomass. The exploitation rate then decreases linearly to zero as the spawning biomass decreases from the trigger to the limit reference point. The interim harvest strategy is used to determine a nominal (non-binding) total allowable catch (TAC). However, since the TAC is currently non-binding, it is not used to control harvest.

Allocations for the TVH, TIB and PNG sectors have been based on agreed shares of the non-binding TAC recommended for the TSPZ by the TRLRAG each year. For the 2015–16 fishing season, shares for the three commercial fishing sectors were approximately 29 per cent for the TVH Sector, 38 per cent for the TIB Sector and 33 per cent for PNG.

The input controls that currently apply to the TSTRLF include a limited commercial fishing season (from 1 December to 30 September); a ban on the use of hookah gear between 1 October and 31 January, and around some new and full moon periods; minimum size limits for commercially caught lobsters of 90 mm carapace length or 115 mm tail length; collection of lobsters only by hand or by handheld implements such as snares, nets or spears; 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.

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), in tender-days, for the TVH Sector reached a peak of 5,200 in 2003–04 before decreasing to approximately 1,300 in 2008–09. Effort then increased to 3,008 tender-days in 2012–13 before decreasing to 2,604 in 2015–16 (Table 17.2). Fishing effort in the TIB Sector has been more difficult to estimate because of under-reporting and duplication in the docket book system used to collect catch-and-effort data. Analyses of the TIB effort data (available since 2004) that adjust for under-reporting and remove duplicate records (Campbell 2017) indicate that effort, in tender-days, has decreased from more than 9,000 in 2004–05 to the lowest level of 2,619 in 2012–13. Since then, effort in tender-days has increased to 5,852 in 2014–15 and 5,359 in 2015–16. 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.

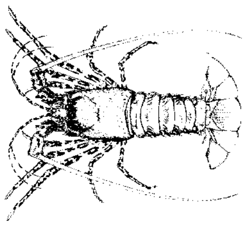
TABLE 17.2 Main features and statistics for the TSTRLF

Fishery statistics a	2014–15 fishing season			2015–16 fishing season		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t) b**	**Real value (2015–16)**
Australia (TVH, TIB)	515 (226, 289)	327 (153, 174)	$14.5 million	534 (234, 300)	445 (238, 207)	$14.3 million
PNG	254	236	na	262	127	na
Total fishery	**769**	**563**	**na**	**796**	**572**	**na**
Fishery-level statistics						
Effort c	TVH: 2,682 tender-days, 1,173 operation-days TIB: 5,852 tender-days PNG: 0 tender-days (in Australian waters)			TVH: 2,604 tender-days, 1,146 operation-days TIB: 5,359 tender-days PNG: 0 tender-days (in Australian waters)		
Fishing permits	TVH: 12 licences, 33 tenders TIB: 294 PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters			TVH: 12 licences, 33 tenders TIB: 294 PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters		
Active vessels	TVH: 11 TIB: 294 PNG: 0 (cross-endorsed)			TVH: 11 TIB: 294 PNG: 0 (cross-endorsed)		
Observer coverage	0			0		
Fishing methods	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	Thursday Island, Cairns (Queensland); Daru (PNG)					
Management methods	Input controls: gear controls, seasonal and lunar closures Output controls: minimum size limit (>115 mm tail length or >90 mm carapace length), bag limit of 3 lobsters per person (or 6 lobsters per dinghy if more than one person aboard the boat) for traditional and recreational fishing					
Primary markets	Domestic: live lobsters and frozen tails International: United States (frozen tails), Hong Kong/China (live lobsters)					
Management plan	None					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 December to 30 September. Real-value statistics are by financial year. **b** Estimate at time of publishing; this figure is preliminary and likely to be updated in future editions of this publication. **c** Tender-day is a day of fishing effort using a fishing tender or dory.
Notes: **na** Not available. **PNG** Papua New Guinea. **TAC** Total allowable catch. **TIB** Traditional Inhabitant Boat. **TVH** Transferable Vessel Holder.

17.2 Biological status

Tropical rock lobster (*Panulirus ornatus*)



Line drawing: Karina Hansen

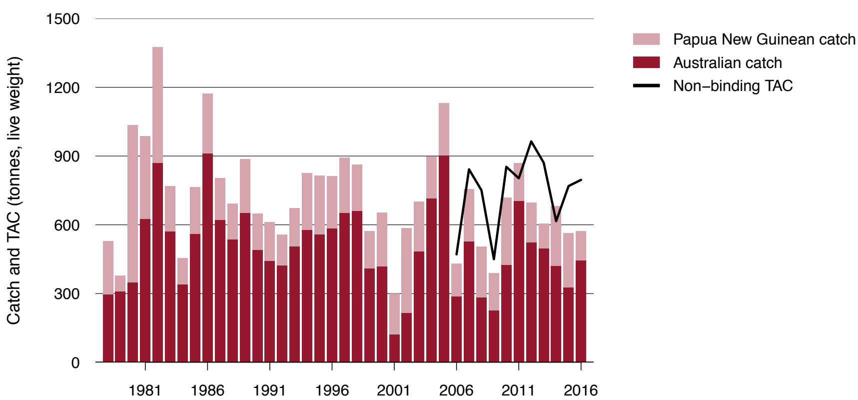
Stock structure

Although postlarval-stage lobsters are locally resident, tropical rock lobster populations in Torres Strait (managed under the PZJA), the Coral Sea (managed by the Commonwealth) and Queensland (managed by Queensland) are considered to comprise a single biological stock as a result of the mixing of larvae in the Coral Sea (Pitcher et al. 2005). 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 121 and 911 t per year for the Australian sectors (TVH and TIB) and 69 and 686 t for PNG (Figure 17.2). Average catches over the past five years were 442 t for the Australian sectors and 181 t for PNG.

FIGURE 17.2 Catch and TAC of tropical rock lobster in the TSTRLF, 1978 to 2016



Note: **TAC** Total allowable catch.
Source: Torres Strait Protected Zone Joint Authority, Australian Fisheries Management Authority

Stock assessment

The statistical catch-at-age model developed by Plagányi et al. (2009) was used for the 2016 assessment (Plagányi et al. 2017). The assessment used a time series of catch data from 1973 to 2016, and incorporates annual fishery-independent preseason survey (2005 to 2008, and 2014 to 2016) and mid-season (1989 to 2014) survey data, and catch-per-unit-effort data from the TVH (1994 to 2016) and TIB (2004 to 2016) sectors (Plagányi et al. 2017).

The assessment estimated the 2016 spawning biomass to be 5,877 t (90 per cent confidence interval 3,671 to 8,083 t), or 119 per cent of the estimated unfished (1973) level ($1.19SB_{1973}$) (Plagányi et al. 2017). Estimates of maximum sustainable yield (MSY)–based parameters are considered to be uncertain because of highly variable annual recruitment and a limited number of age classes in the fishery. For such recruitment-driven fisheries, annual yields can be expected to fluctuate widely about deterministic quantities such as MSY. The (non-binding) 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 roughly current levels. For 2016, the TRLRAG recommended a non-binding TAC of 796 t, of which 572 t was caught (Table 17.2). The recommended non-binding TAC for 2017 is 495 t, based on the outputs from the reference case assessment model (Plagányi et al. 2017). The recommended 2017 TAC is lower than for previous years because of the low densities of recruits observed in 2016 and subsequent model predictions that the spawning biomass in 2017 will drop to 63 per cent of unfished levels ($0.63SB_{1973}$).

Stock status determination

The model-estimated biomass in 2016 ($1.19SB_{1973}$) was well above the target ($0.65SB_{1973}$) and limit ($0.32SB_{1973}$) reference points. As a result, this stock is classified as **not overfished**. The total catch of 572 t in 2016 was lower than the non-binding TAC of 796 t, and equated to a fishing mortality of 0.1, which is lower than the target reference point of 0.15. Therefore, the stock is classified as **not subject to overfishing**.

17.3 Economic status

Key economic trends

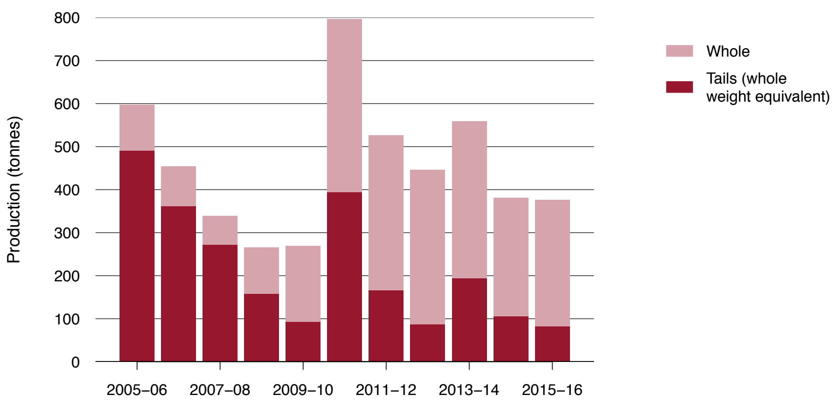
Catch in the fishery is landed as either whole lobster or lobster tails, with whole lobsters generally being landed live. All catch and value figures discussed here have been converted to whole weight to allow comparisons of catch composition.

Landed catch in the fishery decreased by 1 per cent in the 2015–16 financial year, from 381 t in 2014–15 to 376 t in 2015–16 (Figure 17.3).[1] The quantity of whole lobster increased from 275 t (whole-weight equivalent) in 2014–15 to 293 t (whole-weight equivalent) in 2015–16. The quantity of tails landed in 2015–16 decreased by 22 per cent (to 82 t [whole-weight equivalent]) compared with the previous year. Effort in the TIB Sector of the fishery declined by 8 per cent between the 2014–15 fishing season (5,852 tender-days) and the 2015–16 fishing season (5,359 tender-days). The commercial fishing season runs from 1 December to 30 September and so spans financial years (Table 17.2).

1 Catch weights and gross value of production in this section are given by financial year.

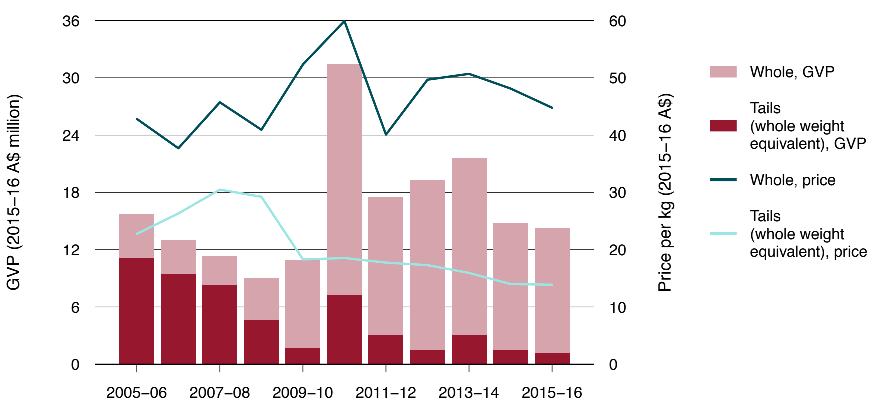
The gross value of production (GVP) of the Australian fishery (not including PNG) decreased by 1 per cent, from $14.5 million in 2014–15 to $14.3 million in 2015–16 (Figure 17.4). Because less tails were landed, the value of rock lobster tails decreased by 23 per cent, from $1.5 million in 2014–15 to $1.1 million in 2015–16. The decline in effort over the same period suggests a reduction in fishing costs and, when combined with the lower fall in GVP, indicates that net economic returns to the fishery are likely to have increased.

FIGURE 17.3 Production volumes of whole lobster and lobster tails in Torres Strait (for the Australian sectors), 2005–06 to 2015–16



Notes: Lobster tail production has been converted to whole weight.

FIGURE 17.4 Real GVP and price for whole lobster and lobster tails (whole-weight equivalent) in the TSTRLF, 2005–06 to 2015–16



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

A management strategy evaluation (MSE) for the TSTRLF was completed in 2012 (Plagányi et al. 2012). The MSE tested a range of management strategies and fishery scenarios, taking into account biological, economic, cultural and social factors. It included a bio-economic model that estimated subsector profit using data collected from fishers, processors and catch logbooks (Hutton et al. 2016). The analysis assumed four subsectors: a full-time, largely non-Indigenous commercial TVH subsector; a full-time commercial TIB subsector (which includes TIB fishers who catch more than 1,000 kg per year); a part-time semicommercial TIB subsector (TIB fishers who catch 50–1,000 kg per year); and a 'casual' TIB subsector (TIB fishers who catch less than 50 kg per year).

The MSE-generated, model-based scenario estimates of average profit for the subsectors take into account the high variability in characteristics of the mothership fleet. These estimates are calculated per calendar year in the final model run for each management strategy and scenario combination. Profitability[2] was estimated to vary substantially between fleets, with the TVH subsector being the most profitable. The average TVH boat (representing a mothership) was estimated to earn $675,000 in revenue and $269,000 in profit. This equated to an estimated profit for the entire TVH fleet of about $3 million (note that these figures are not survey-based estimates as discussed for other fisheries surveyed by ABARES). For the TIB subsectors, model-based estimates of profit were only determined for the full-time commercial TIB subsector, for which profit per boat was estimated at $25,000 and total fleet profit was estimated at $1.1 million. For the remaining TIB subsectors, economic returns to owner–operator labour were determined to be a more relevant measure of economic performance, given the livelihood focus of TIB operators and the fact that economic performance reflects the earnings of owner–operators from their input into the fishing business. The sum of commercial profit (TVH Sector) and returns to owner–operators in the TIB Sector was estimated at around $6 million.

Management arrangements

The fishery is currently managed under input controls, including seasonal closures, temporal restrictions on the use of hookah equipment and minimum size limits (Table 17.2; AFMA, 2013, pers. comm.; PZJA 2015). A voluntary buyout of fishing licences for non–Traditional Inhabitants commenced in 2011, aimed at increasing the ownership and participation of Traditional Inhabitants in the fishery (PZJA 2013a). The buyback, through an open tender process, resulted in a 2 per cent increase in the Traditional Inhabitants' share of fishery catch, to 56.2 per cent of the Australian share (PZJA 2013a). The buyback was completed in 2012, with the PZJA committed to developing a management plan for the fishery that ensures the sustainability of the resource. The PZJA is currently considering the next steps in view of the buyback outcome (PZJA 2013b), but has acknowledged and agreed to support the aspiration of 100 per cent ownership of Torres Strait fisheries by Torres Strait Islander and Aboriginal traditional owners (PZJA 2014).

2 In bio-economic assessments that are part of an MSE, estimates of profit and returns to owner–operators are based on summing average values (whereas individual operations vary considerably); these indices are used as output performance indices to check for relative differences between scenarios.

The MSE results of the three potential management options predicted that an individual transferable quota (ITQ) system is unlikely to achieve the aim of increasing the TIB share of total Australian catch in the fishery to 70 per cent (Pascoe et al. 2012). Monitoring in the TIB Sector is difficult because of its small scale, and an ITQ system requires a substantial investment in science and accurate reporting of catches (van Putten et al. 2013). Pascoe et al. (2012) noted that a competitive quota arrangement for the TIB fleet might limit the benefits of quota management if there is a race to fish, although effort in the TIB Sector remains well below the sector's nominal allocation. They discussed a community-based arrangement as a potential option. However, van Putten et al. (2013) noted that this type of arrangement is associated with several challenges, including concerns about potentially undermining the supply chain that all fishers rely on, and concerns about maintaining the principles of equity and continued community access to the resource.

Performance against economic objective

Like other Torres Strait fisheries, the TSTRLF is managed against objectives that differ from those of solely Australian Government–managed fisheries. The TSTRLF management objectives are relevant to economic performance, but have a broader focus on social and cultural factors. They include the objectives of (PZJA 2015):

- maintaining the fishing mortality at a level below the level that produces MSY (F_{MSY}), accounting for all sources of fishing mortality
- in accordance with the Torres Strait Treaty, protecting the traditional way of life and livelihood of Traditional Inhabitants, particularly in relation to their traditional fishing for tropical rock lobster
- providing for optimal utilisation, cooperative management with Queensland and PNG, and catch sharing with PNG
- monitoring interactions between the prawn and lobster fisheries
- maintaining appropriate controls on fishing gear allowed in the fishery, to minimise impacts on the environment
- promoting economic development in the Torres Strait area, with an emphasis on providing the framework for commercial opportunities for Traditional Inhabitants, and ensuring that the opportunities available to all stakeholders are socially and culturally appropriate for Torres Strait, and the wider Queensland and Australian community
- optimising the value of the fishery.

17.4 Environmental status

The TSTRLF is included in the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 27 October 2017.

The fishery has little direct impact on the marine environment or other fish species, since hand-collection fishing methods allow careful selection of catch. The level 1 ecological risk assessment did not identify any species at medium or high risk, and found that interactions with protected species were negligible or low because of the nature of the fishery (Furlani et al. 2007). Therefore, no further risk assessments were undertaken (AFMA 2009).

The Australian Fisheries Management Authority publishes quarterly summaries of logbook reports of interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in the TSTRLF in 2016.

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Tropical rock lobsters
Department of Agriculture and Water Resources

Chapter 18

Torres Strait Prawn Fishery

A Williams and K Mazur

FIGURE 18.1 Relative fishing intensity in the Torres Strait Prawn Fishery, 2016

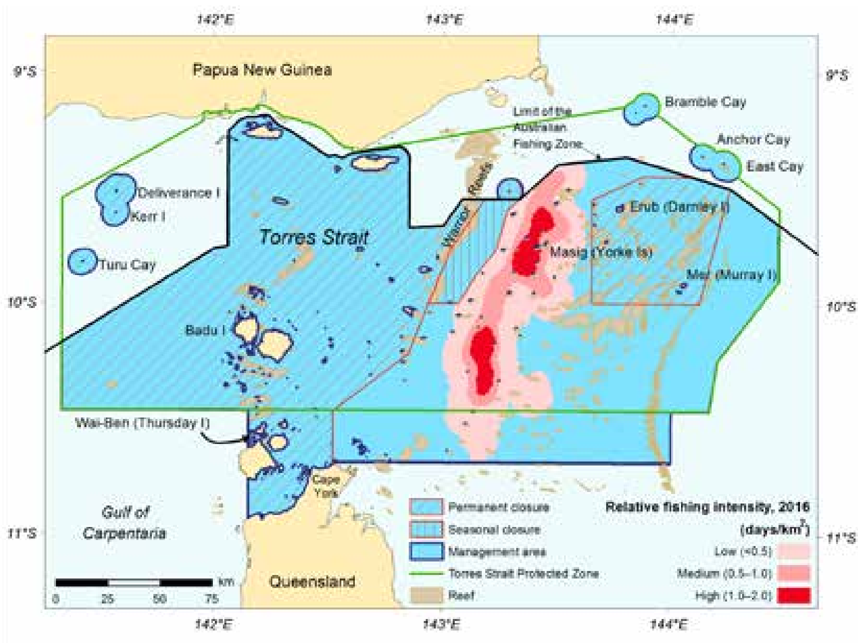


TABLE 18.1 Status of the Torres Strait Prawn Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Brown tiger prawn (*Penaeus esculentus*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch in recent years is below MSY. Most recent estimate of biomass is above B_{MSY}.
Blue endeavour prawn (*Metapenaeus endeavouri*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch in recent years is below MSY. Most recent estimate of biomass is above B_{MSY}.
Economic status	NER for the fishery were negative in 2012–13 (–$2.3 million); no estimates of NER are available for 2014–15 and 2015–16, although a significant increase in gross value of production in 2014–15 and 2015–16 relative to 2012–13 suggests improvement in NER.				

Notes: B_{MSY} Biomass at maximum sustainable yield. **MSY** Maximum sustainable yield. **NER** Net economic returns.

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

Prawn trawling gear
AFMA

18.1 Description of the fishery

Area fished

The Torres Strait Prawn Fishery (TSPF) operates in the eastern part of the Torres Strait Protected Zone (TSPZ) and south of the TSPZ in nearby Queensland waters (called the 'outside but near area') (Figure 18.1). This fishery is shared by Australia and Papua New Guinea (PNG) under formal arrangements in the Torres Strait Treaty (see Chapter 15).

Fishing methods and key species

Prawns are harvested at night using demersal otter trawl (prawn trawl). Fishers usually deploy four nets divided into two pairs, with a pair of nets towed from a boom on each side of the fishing vessel. Trawl tows last between two and a half and four hours at an average speed of around 3 knots. Fishers normally complete three or four tows per night (DSEWPaC 2013; Turnbull et al. 2007).

The target species of the fishery are brown tiger prawn (*Penaeus esculentus*) and blue endeavour prawn (*Metapenaeus endeavouri*). Byproduct species include redspot king prawn (*Melicertus longistylus*),[1] slipper lobster (*Scyllarides* spp.), Moreton Bay bugs (*Thenus* spp.), octopus (Octopodidae), cuttlefish (*Sepia* spp.) and squid (Teuthoidea).

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* (Cwlth). Currently, all licences in the fishery are held by the non-Indigenous Transferable Vessel Holder (TVH) Sector.

Under the Torres Strait Treaty, PNG is entitled to 25 per cent of the TSPF resource in the Australian jurisdiction (excluding the effort in nearby Queensland waters), and Australia is entitled to 25 per cent 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 TSPZ.

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.

1 Although small volumes of other king prawn species (*M. latisulcatus*, *M. plebejus*) are recorded in logbook records, research surveys in Torres Strait suggest that the commercial catch largely consists of a single species for each prawn group—that is, brown tiger prawn (*P. esculentus*), blue endeavour prawn (*M. endeavouri*) and redspot king prawn (*M. longistylus*) (C Turnbull, AFMA consultant, 2015, pers. comm., 23 July).

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 also exists 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 reduce fishing effort, there is concern that reducing the available fishing days to achieve a proxy economic target would put additional economic pressure on operators who are fishing, when effort is already well below target levels.

The harvest strategy's limit reference point is 20 per cent of unfished biomass ($0.2B_0$), consistent with the default provided for in the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007). The current target reference point (B_{TARG}) is based on the maximum sustainable yield (MSY) of the most sensitive of the target species—tiger prawn—so that $B_{TARG} = B_{MSY}$. In contrast, the triggers in this fishery are aligned with the concept of 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 per cent of Australia's portion of total allowable catch (or expending 75 per cent of Australia's portion of the total allowable effort [TAE]). The proxy used for B_{MEY} is $1.2B_{MSY}$, equating to $0.34B_0$ where $B_{MSY} = 0.28B_0$.

Fishing effort

From 1999 to 2011, fishing effort in the TSPF decreased steadily from more than 10,000 days to less than 1,500 days, largely as a result of economic conditions in the fishery (Figure 18.2). Effort since 2011 has averaged around 2,000 fishing days per year, but increased to 2,993 days in 2015 and 2,248 days in 2016. The 2016 effort (2,248 days) represents 32.7 per cent of the TAE for the Australian fishery.[2]

Catch

In addition to brown tiger prawn and blue endeavour prawn, king prawns (*Melicertus longistylus*, *M. latisulcatus* and *M. plebejus*) have 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 2011, the total combined catch has increased steadily with increasing effort, peaking at more than 720 t in 2015 (Figure 18.2; Table 18.2). The proportion of brown tiger prawn in the total catch has increased from below 30 per cent in 1999 to more than 70 per cent in each year since 2010, and was 85 per cent in 2016.

2 The 9,200 days of TAE in the fishery are shared between Australia and PNG, with Australian operators able to access 6,867 fishing days before an option to access unused PNG days is considered by the PZJA (Cocking 2016); 2,070 fishing days are available to PNG operators and 263 days are held in trust by the Australian Government.

FIGURE 18.2 Prawn catch by species, and fishing effort, in the TSPF, 1989 to 2016

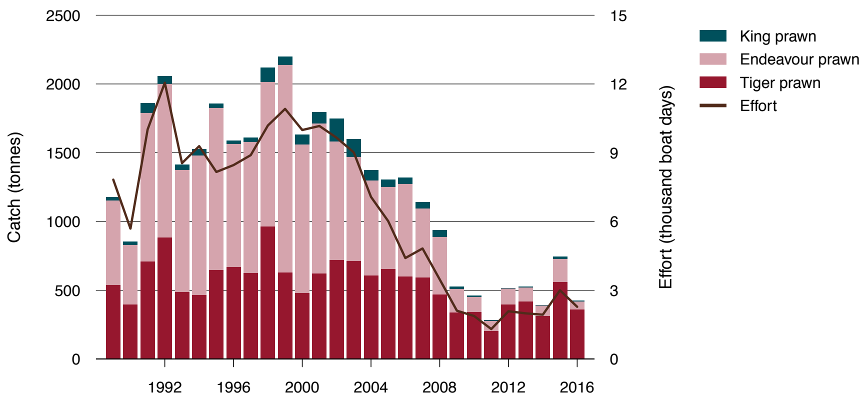


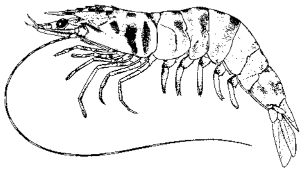
TABLE 18.2 Main features and statistics for the TSPF

Fishery statistics a	2015			2016		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Brown tiger prawn	–	560	$8.2 million	–	362	$7.3 million
Blue endeavour prawn	–	166	$0.9 million	–	56	$1.0 million
Total fishery	**–**	**742 b**	**$9.5 million c**	**–**	**412 b**	**$8.9 million c**
Fishery-level statistics						
Effort (days)	2,993			2,248		
Fishing permits	60 (15 inactive licences not attached to vessels)			60 (38 inactive licences)		
Active vessels	24			22		
Observer coverage	59 days (2% of active effort)			34 days (3% 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 since 2016 is from 1 February to 1 December. Fishing season before 2016 was from 1 March to 1 December. Real-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: **TAC** Total allowable catch. – Not applicable.

18.2 Biological status

Brown tiger prawn (*Penaeus esculentus*)



Line drawing: FAO

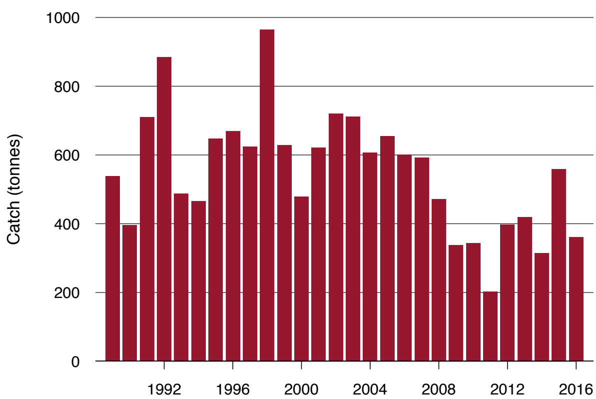
Stock structure

Brown tiger prawn is endemic to tropical and subtropical waters of Australia. There is evidence of genetic separation of brown tiger prawns from the east and west coasts of Australia (Ward et al. 2006); however, the stock structure across northern Australia is uncertain. Brown tiger prawns are considered to constitute a single stock in Torres Strait for assessment and management purposes.

Catch history

Catch of brown tiger prawn has fluctuated over time, peaking in 1998 at 965 t. Catch decreased to 204 t in 2011 but has since increased, reaching 560 t in 2015 and 362 t in 2016 (Figure 18.3).

FIGURE 18.3 Brown tiger prawn catch in the TSPF, 1989 to 2016



Source: Australian Fisheries Management Authority

Stock assessment

The most recent stock assessment of brown tiger prawn in Torres Strait was completed in 2006 using data to the end of 2003 (O'Neill & Turnbull 2006). Since the 2006 assessment, further assessment model runs with updated data have been conducted (Turnbull & Rose 2007), but no full assessments have been undertaken. The most recent model runs (Turnbull & Rose 2007) indicate that tiger prawn biomass steadily increased from 2000 to 2006, and was between 60 and 80 per cent of the unfished (1980) biomass ($0.6B_0$ and $0.8B_0$). This was considerably higher than estimates of B_{MSY}, which were $0.28B_0$ to $0.38B_0$, depending on the spawner–recruitment relationship used (O'Neill & Turnbull 2006). A delay-difference model (O'Neill & Turnbull 2006) estimated MSY for tiger prawns to be 606 t (90 per cent confidence interval [CI] 436 to 722 t), and effort at MSY (E_{MSY}) to be 8,245 fishing nights[3] (90 per cent CI 5,932 to 9,823 nights) using the Ricker spawner–recruitment relationship. Using the Beverton–Holt spawner–recruitment relationship, MSY was estimated to be 676 t (90 per cent CI 523 to 899 t) and E_{MSY} to be 9,197 nights (90 per cent CI 7,116 to 12,231 nights).

The 2006 assessment is still used to inform management decisions in the fishery. However, brown tiger prawn is a relatively short-lived species, with variable recruitment that can be influenced by environmental factors. Changes in fleet dynamics and vessel efficiency are also likely to influence the long-term relevance of the 2006 assessment, as are increases in catch and effort since 2011. As a result, the outputs from the 2006 stock assessment will become less relevant over time. Mediating this risk is the substantial underuse of fishing effort, with less than 50 per cent of available fishing nights being used each year since 2008, and annual catches remaining below the 2006 mean estimate of MSY since 2005 (Figure 18.3). In addition, the harvest strategy for the fishery (AFMA 2011) imposes conservative trigger points—set at 4,000 days and 680 t of tiger prawn, which corresponds to approximately 75 per cent of the Australian portion of the estimated effort and catch at B_{34} (B_{MEY}), respectively. When these trigger points are reached, additional research, a revised harvest strategy to develop decision rules for setting the TAE based on B_{MEY}, and an updated stock assessment are required. Although increasing since 2011, catch and effort in the fishery remain below the trigger points.

Stock status determination

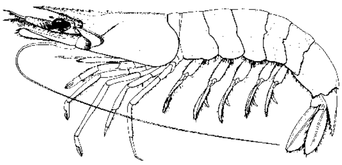
Assessment of brown tiger prawn status in 2016 is based on a comparison of recent catches (Figure 18.3) with estimates of MSY from the 2006 assessment (O'Neill & Turnbull 2006), a comparison of recent effort with estimates of E_{MSY} from the 2006 assessment (O'Neill & Turnbull 2006) and the 2006 estimates of biomass (Turnbull & Rose 2007).

The tiger prawn catch has been below the 2006 estimates of MSY for both Ricker (606 t) and Beverton–Holt (676 t) spawner–recruitment relationships since 2005. The effort in the fishery has been below the 2006 estimates of E_{MSY} for the Beverton–Holt (9,197 nights) and Ricker (8,245 nights) spawner–recruitment relationships since 2003 and 2004, respectively. As a result, the stock is classified as **not subject to overfishing**.

3 The terms 'day' and 'night' are both used in this chapter when discussing fishing effort because effort units are allocated in notional 'days' (referring to a 24-hour period), but fishing actually occurs at night.

Although the HSP does not apply to the jointly managed TSPF, the default HSP proxy limit of $0.2B_0$ is used to inform status evaluations. The 2006 estimate of tiger prawn biomass (between $0.6B_0$ and $0.8B_0$) was considerably higher than the estimate of B_{MSY} and well above the HSP proxy limit reference point of $0.2B_0$. However, uncertainty around the current level of biomass is increasing with time since the most recent stock assessment. Since biomass was well above the limit reference point and B_{MSY} in 2006, and fishing effort has been below the estimated E_{MSY} for at least 13 years, the stock is classified as **not overfished**.

Blue endeavour prawn (*Metapenaeus endeavouri*)



Line drawing: FAO

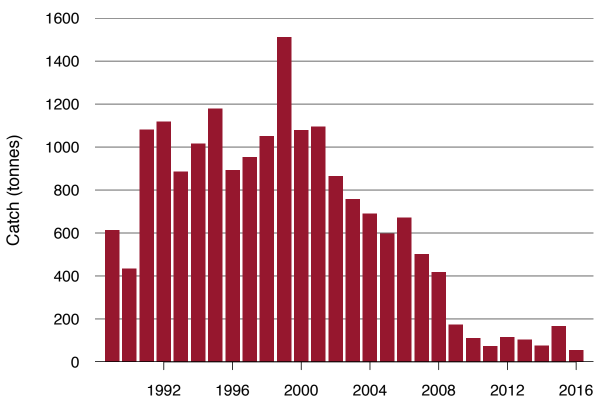
Stock structure

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 to below 200 t in recent years, and the catch in 2016 was 56 t. This reflects decreasing fishing effort through the 2000s and increased targeting of tiger prawns because of their higher market value (Turnbull 2014).

FIGURE 18.4 Endeavour prawn catch in the TSPF, 1989 to 2016



Source: Australian Fisheries Management Authority

Stock assessment

The most recent stock assessment for blue endeavour prawn was completed in 2009, using data to the end of 2007 (Turnbull et al. 2009). This assessment evaluated abundance of cohorts (annual year-classes) of the stock through time, allowing tracking of size-related variability in productivity.

A deterministic size- and age-structured model with a fixed stock–recruitment steepness value of 0.5 provided an MSY estimate of 1,105 t (90 per cent CI 1,060 to 1,184 t) and an E_{MSY} estimate of 10,079 nights (90 per cent CI 9,667 to 10,800 nights). A stochastic size- and age-structured assessment was also run, but this model did not achieve convergence of parameter estimates and was not accepted. Similarly, a deterministic model with a fixed steepness of 0.7 did not achieve convergence. The biomass estimate from the deterministic model, with steepness fixed at 0.5, was approximately $0.8B_0$, which is considerably higher than the estimate of $0.43B_0$ for B_{MSY}.

The 2009 stock assessment is still used to inform management decisions in the fishery. However, similar to brown tiger prawn, the outputs from the 2009 stock assessment for blue endeavour prawn have become less relevant over time, with increased uncertainty in current status due to highly variable recruitment, short life span, changes in fleet dynamics and vessel efficiency, and changes in catch and effort.

Stock status determination

The stock status classification of blue endeavour prawn in 2016 is based on a comparison of recent catches with estimates of MSY from the 2009 assessment, a comparison of recent fishing effort with estimates of E_{MSY}, and the 2009 estimates of biomass. Since 2002, catch has been below the lower 90 per cent CI of estimated MSY (1,060 t), and effort has been below the lower 90 per cent CI of E_{MSY} (9,667 nights). As a result, the stock is classified as **not subject to overfishing**.

Although the HSP does not apply to the TSPF, in the absence of a prescribed limit reference point for this stock, the default HSP proxy limit reference point of $0.2B_0$ is used to determine stock status. The 2007 biomass estimate of $0.8B_0$ is above the estimated B_{MSY} of $0.43B_0$ and well above the HSP proxy limit reference point of $0.2B_0$. However, uncertainty around the current level of biomass is increasing with time since the most recent stock assessment. Since fishing effort has been below the estimated E_{MSY} since 2002, the stock is classified as **not overfished**.

18.3 Economic status

Key economic trends

Economic surveys by ABARES of key Commonwealth fisheries since the early 1990s provide information that allows calculation of net economic returns (NER) and financial performance measures for the TSPF. Figure 18.5 presents the historical data per vessel for gross value of production (GVP), NER and hours trawled between 2005–06 and 2015–16.

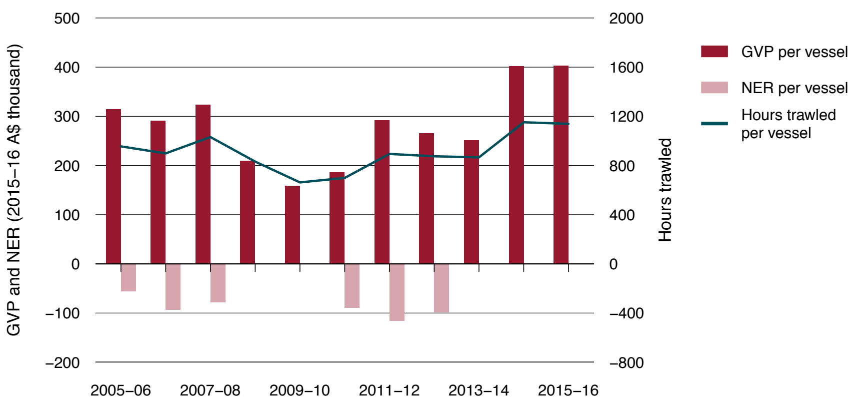
Estimates of NER are not available for 2008–09, 2009–10 or from 2012–13 to 2015–16 because economic surveys of the fishery were not done for these years. NER for the TSPF have been negative since 2004–05 (Skirtun et al. 2015). Based on the latest survey in 2013, it was estimated that NER remained negative at –$2.3 million in the 2012–13 financial year, an improvement from –$2.7 million in 2011–12. High input costs and low prices in 2011–12 and 2012–13 made it difficult to operate profitably in the fishery (Skirtun et al. 2015).

A significant increase in GVP in 2014–15 and 2015–16 relative to 2012–13 (the last survey year available) suggest an improvement in NER in these two years. Moreover, these two years coincide with a period of lower diesel fuel input costs and Australian dollar exchange rate relative to 2012–13, both factors that contribute positively to NER.

In 2015–16, GVP in the TSPF was $8.9 million, 48 per cent higher than the GVP recorded for the fishery in 2012–13. Tiger prawn accounted for the largest share of GVP (83 per cent; $7.3 million), followed by endeavour prawn (11 per cent; $1 million) and king prawn (3 per cent; $0.2 million). Other prawn species and other species caught as byproducts accounted for the remainder (3 per cent) of the GVP of the fishery.

Between 2005–06 and 2009–10, the number of hours trawled per vessel almost halved in response to declines in profitability. This is reflected in the GVP per vessel (an indicator of vessel revenue), which followed a declining trend from 2007–08, reaching its lowest level in 2009–10 before increasing significantly to 2015–16 (Figure 18.5). In 2015–16, GVP per vessel increased by 2 per cent to $403,000, and the effort input for the season averaged 1,139 trawl hours per vessel. The effort input per vessel declined slightly (by 1 per cent) in 2015–16.

FIGURE 18.5 GVP, NER and hours trawled per vessel in the TSPF, 2005–06 to 2015–16



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

Management arrangements

The fishery is managed using input controls. Limits on the number of boat licences and tradeable fishing nights are the main input controls, and these are combined with other restrictions on gear and vessel characteristics (Cocking 2016). In their analysis of profit trends in the TSPF, Skirtun and Vieira (2012) suggested that management arrangements in the fishery may have been a constraint on greater productivity gains and, therefore, higher profitability. The recent divergence in trends in economic performance of the Northern Prawn Fishery (NPF) and the TSPF may also be linked to differences in management arrangements. Although both the NPF and the TSPF are managed with input controls, the TSPF is also managed through limits on maximum vessel size (AFMA 2011). This restriction may have constrained autonomous adjustment in the TSPF and, as a result, fishery-level efficiency. High levels of latent effort have remained in the TSPF and are likely to have reduced the incentive to trade in effort entitlements, limiting the movement of effort entitlements to the most efficient fishers. In 2016, 22 of the 60 licences in the fishery were active, resulting in a licence latency of 63 per cent.

The TSPF has limits on maximum vessel size (AFMA 2011). As larger vessels tend to have larger fuel and catch-holding capacities, such vessels can stay at sea longer and are better able to operate in geographically isolated fisheries such as the TSPF. By preventing the use of larger vessels, this management arrangement may be constraining economic performance in the fishery. In recognition of these issues, in early 2011, the Torres Strait Prawn Management Advisory Committee (TSPMAC) recommended trials of alternative fishing gear and vessel size configurations (PZJA 2011). In 2013, the TSPMAC recommended providing supplementary information to the PZJA to be considered with the original decision for the trial to take place (PZJA 2013a). Subsequently, research was commissioned by the Australian Fisheries Management Authority (AFMA) to consider the flow of economic benefits from the prawn fishery to Traditional Inhabitants and local communities (PZJA 2013b). The research identified a number of possible ways to increase the flow of benefits from the TSPF to communities. The TSPMAC has been considering the options and any requirement for further research (PZJA 2016).

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).

The biomass levels of brown tiger and blue endeavour prawns are well above B_{MSY}, and so economic performance is currently not constrained by biomass. Although estimates of NER for 2015–16 are not available, a significant improvement in fishery level GVP and GVP per vessel relative to 2012–13, and improvement in the operating environment as a result of lower diesel fuel input costs and a lower Australian dollar exchange rate suggest an improvement in economic performance of the fishery. Despite these positive signs, the high level of licence latency remains a concern for the fishery.

18.4 Environmental status

Prawn trawling is a relatively non-selective fishing method. As a result, a variety of byproduct and bycatch species are caught with the target species. Bycatch typically includes finfish, cephalopods, crabs, lobsters, scallops, sharks and rays. Trawling also has potential impacts on benthic communities and protected species, including turtles, sea snakes and syngnathids (seahorses and pipefish). Research surveys between 2004 and 2006 collected independent data on the weight, composition and distribution of bycatch in the TSPF (Turnbull & Rose 2007). The surveys were in two areas: the main prawn trawling grounds, and adjacent areas that are seasonally or permanently closed to trawling. No major differences were found in the overall composition and abundance of bycatch species between areas that are open, partially closed and entirely closed to trawling. However, there were some differences in the relative proportions of different bycatch species between open and closed areas.

The TSPF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is exempt from export controls until 22 December 2017.

A level 1 (Scale, Intensity, Consequence Analysis) ecological risk assessment has been conducted for the TSPF (Turnbull et al. 2007). The fishery also has a bycatch and discard workplan that was updated in early 2015 (AFMA 2015). Pitcher et al. (2007) provided comprehensive data on the biodiversity of seabed habitats in Torres Strait, cataloguing more than 3,600 species, comprising fishes, crustaceans and other species that make up the benthos. Examination of the likely extent of past effects of trawling on the benthos and bycatch in the TSPZ indicated that trawling has had an effect on the biomass of 21 of the 256 species analysed. Of the 21 species, 9 have shown a negative response, while 12 have shown an increase in biomass in association with trawling. This research was updated using data to 2011, and showed that, because of a substantial reduction in effort and the trawl footprint since 2005, there is little to no sustainability risk to any species at the current levels of fishing effort (Pitcher 2013).

Since the beginning of the 2002 fishing season, the PZJA has required operators in the TSPF to use turtle excluder devices in trawl gear. In 2004, the use of bycatch reduction devices became mandatory. In May 2008, the PZJA also agreed to implement trawl exclusion zones around Deliverance Island, Kerr Islet and Turu Cay (Figure 18.1) to protect important nesting areas for green turtle (*Chelonia mydas*) and flatback turtle (*Natator depressus*).

AFMA publishes quarterly summaries of logbook-reported interactions with protected species on its website. In 2016, 636 sea snakes of unknown species were caught in the TSPF, of which 341 were released alive, 9 were dead, 1 was injured and the remaining 285 had an unknown life status. One flatback turtle (*Natator depressus*), one hawksbill turtle (*Eretmochelys imbricata*) and two turtles of unknown species were caught; all were released alive. Nine unidentified seahorses or pipefish were caught, eight of which were dead and one of which had an unknown life status. One narrow sawfish (*Anoxypristis cuspidata*) and one common sawshark (*Pristiophorus cirratus*) were released alive.

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Tiger prawns
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Chapter 19

Torres Strait Bêche-de-mer and Trochus fisheries

J Woodhams and K Mazur

FIGURE 19.1 Area of the Torres Strait Bêche-de-mer and Trochus fisheries

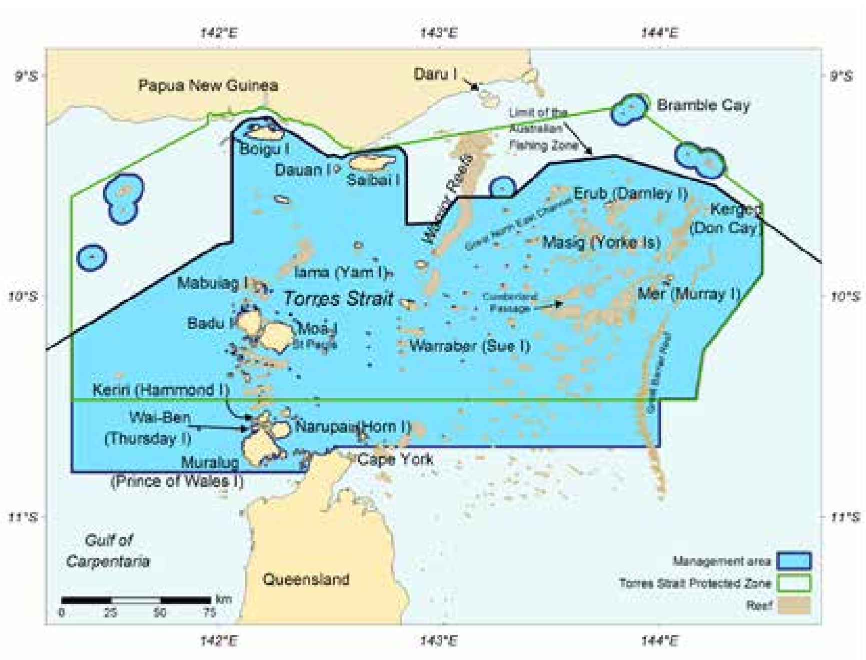


TABLE 19.1 Status of the Torres Strait Bêche-de-mer and Trochus fisheries

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Black teatfish (*Holothuria whitmaei*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	No catch in 2016. Recent survey indicates a recovering stock.
Prickly redfish (*Thelenota ananas*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch is below TAC. Survey indicates relatively stable densities.
Sandfish (*Holothuria scabra*)	Uncertain	Overfished	Uncertain	Overfished	Uncertain impact of illegal, unreported and unregulated catch in recent years. Most recent full survey (2009) indicated that stock was overfished.
White teatfish (*Holothuria fuscogilva*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catch is below TAC. Survey indicates relatively stable densities.
Other sea cucumbers (up to 18 species)	Not subject to overfishing	Uncertain	Not subject to overfishing	Uncertain	Catch in 2016 is unlikely to constitute overfishing. Uncertain biomass status for a number of species.
Trochus (*Trochus niloticus*)	Not subject to overfishing	Uncertain	Not subject to overfishing	Uncertain	No recorded take in 2016. Uncertain estimates of population size from most recent survey.
Economic status	Estimates of NER are not available. NER are likely to be lower in the 2016 fishing season because of a significant decrease in the catch of valuable species such as black teatfish and prickly redfish, and lower catches of most other species caught in 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

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).

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).

Trochus has not been fished 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 regions (AFMA 2011).

Fishing methods and key species

Historically, the main species of sea cucumber harvested in Torres Strait have been black teatfish (*Holothuria whitmaei*), prickly redfish (*Thelenota ananas*), sandfish (*H. scabra*), white teatfish (*H. fuscogilva*), surf redfish (*Actinopyga mauritiana*), deepwater redfish (*A. echinites*) and blackfish species (*Actinopyga* spp.). 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 usually occurs from dinghies, crewed by two or three fishers. Although the depth range of most targeted species is between 0 and 20 m, a 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, smoking and drying (AFMA 2013).

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.

Management methods

The TSBDMF is managed using a range of input and output controls. Input controls include limiting participation in the fishery to Traditional Inhabitant Boat (TIB) licence holders. Traditional Inhabitants who wish to fish commercially for sea cucumbers are required to hold a TIB licence and use a boat no longer than 7 m. Collection is limited to hand fishing, including use of non-mechanical handheld devices; use of hookah and scuba gear is prohibited. Output controls include minimum size limits on 10 species; zero total allowable catch (TAC) for sandfish and surf redfish; and TACs for white teatfish (15 t), prickly redfish (20 t) and other sea cucumber species combined (80 t). Torres Strait Islanders are also entitled to take three sea cucumbers per person per day, or six sea cucumbers per dinghy per day, for personal use.

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 vessels of a maximum of 20 m, restricting trochus harvest to hand fishing using non-mechanical devices, and prohibiting the use of hookah and scuba gear. Output controls include minimum (80 mm) and maximum (125 mm) basal diameter size limits, and a TAC of 150 t.

Although the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007) does not apply to fisheries jointly managed by the Australian Government and other (domestic or international) management agencies, the HSP does represent the government's preferred approach to management. The Torres Strait Protected Zone Joint Authority (PZJA) has asked its management forums to provide advice on the application of the HSP to Torres Strait fisheries. No formal harvest strategies are in effect in the TSBDMF or the TSTF; however, a formal harvest strategy for the TSBDMF is being developed.

Fishing effort

Effort in the TSBDMF has increased in recent years in response to developmental permits and fishing trials. No catch has been recorded in the TSTF since 2010.

The Papua New Guinea (PNG) Bêche-de-mer Fishery (all species) was closed in 2009. The moratorium on take and/or possession of bêche-de-mer was lifted on 1 April 2017. Quotas set for various provinces were quickly reached, and the Western Province fishery, among others, was again closed by 1 June 2017.

Ongoing monitoring of illegal, unreported and unregulated (IUU) activity, and enforcement action by authorities in Australia and PNG continues, including cooperative patrols and capacity building between the two nations. The IUU catch in PNG waters is unknown.

Catch

Historically, sandfish was a primary target species in the TSBDMF, mostly fished on the Warrior Reef complex (Figure 19.1). Following a considerable decline in sandfish abundance and the subsequent introduction of a zero TAC in 1998, targeting shifted to black teatfish, and what was thought to be surf redfish but is now understood to be primarily deepwater redfish and blackfish species (Skewes et al. 2010).

ABARES received substantial updates to catch data for the TSBDMF in 2017 as a result of a concerted effort by the Australian Fisheries Management Authority (AFMA) in early 2017 to follow up on unreported catch records. This process has resulted in substantially higher catch totals for some sea cucumber species in some years.

Total catch for the TSBDMF in 2015 was previously reported as approximately 31 t (Patterson et al. 2016). This figure is now understood to be closer to 73 t, bolstered by relatively large increases in the reported catch of prickly redfish and white teatfish (Table 19.2). Total reported catch dropped to just under 15 t in 2016, with prickly redfish making up more than 70 per cent of this catch (Table 19.2).

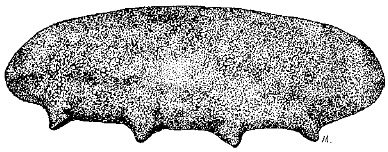
TABLE 19.2 Main features and statistics for the TSBDMF and the TSTF

Fishery statistics a	**2015**			**2016**		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Black teatfish	15	23.3 **b**	na	0	0	0
Prickly redfish	20	28.1	na	20	11.2	na
Sandfish	0	1 **c**	na	0	0.5 **c**	na
White teatfish	15	4.2	na	15	1	na
Other sea cucumber species (18 species)	80	16.4	na	80	2.2	na
Total fishery (TSBDMF)	**130**	**73**	**na**	**115**	**14.9**	**na**
Trochus	150	0	0	150	0	0
Total fishery (TSTF)	**150**	**0**	**0**	**150**	**0**	**0**
Fishery-level statistics						
Effort (no. of sellers)	Bêche-de-mer: 81 Trochus: 0			Bêche-de-mer: 24 Trochus: 0		
Fishing permits (as at 30 June)	Bêche-de-mer: 95 Trochus: 77			Bêche-de-mer: 124 Trochus: 71		
Active vessels	na			na		
Observer coverage	0			0		
Fishing methods	Hand collection—free-dive or reef walking					
Primary landing ports	Island processors and mobile product buyers					
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 Hong Kong, Singapore and China Domestic: minimal International: historically, markets have included China, France, Germany, Italy, Japan, the Philippines, Spain, Thailand, the United Kingdom and the United States					
Management plan	No formal management plans					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 January to 31 December. Real-value statistics are by financial year. Reported catch is understood to be gutted wet weight. **b** Catch taken during trial; the black teatfish fishery remains closed. **c** Illegal, unreported and unregulated catch from foreign vessels.
Notes: **na** Not available. **TAC** Total allowable catch.

19.2 Biological status

Black teatfish (*Holothuria whitmaei*)



Line drawing: FAO

Stock structure

Black teatfish in Torres Strait is assumed to represent a single biological stock (T Skewes, CSIRO, 2013, pers. comm.).

Stock assessment

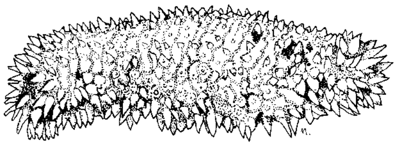
The Torres Strait black teatfish stock was last surveyed in 2009 (Skewes et al. 2010). This survey showed increases in the mean density (from fewer than 1 individual per hectare to just over 10 individuals per hectare), mean length (an increase of almost 6 per cent) and mean weight (an increase of more than 11 per cent) 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 per cent 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 per cent of the virgin biomass were likely to be sustainable (Uthicke et al. 2003).

In November 2011, the Hand Collectables Working Group, informed by the outcomes of Skewes et al. (2010), considered options for increasing the zero TAC. It noted that increasing the TAC would result in increased targeting of this species, which would likely stimulate interest in the fishery. It also acknowledged that a level of precaution is required in developing the fishery to minimise the risks of exceeding the TAC, localised depletion and unsustainable harvest of other species. As a result, the PZJA endorsed a one-month trial of fishing for black teatfish in 2014 and 2015, operating under a 15 t TAC. Some overcatch was recorded in both years (see Table 19.2). A zero TAC was set for 2016.

Stock status determination

There was no reported catch in 2016. On this basis, the stock is classified as **not subject to overfishing**. Given the indications of recovery from the most recent survey, black teatfish is classified as **not overfished**.

Prickly redfish (*Thelenota ananas*)



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Stock structure

Prickly redfish in Torres Strait is assumed to represent a single biological stock (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. Between 2005 and 2009, the density increased from 1.44 to 1.99 prickly redfish per hectare. The mean size of prickly redfish increased from 2,147 to 2,812 g between 2005 and 2009. Well-established and consistent methodologies were used in the surveys, but considerable uncertainty remains around these estimates.

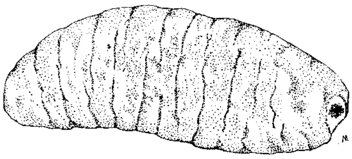
The current TAC for prickly redfish (20 t) is based on an estimate of maximum sustainable yield (MSY), using a biomass estimate from the 2002 survey (Skewes et al. 2004). MSY was estimated using a simplified surplus production model that relies on estimates of biomass and natural mortality (M). The surplus production model assumed an MSY of $0.2MB_0$ and used the lower bound of the 90 per cent 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 per cent confidence interval for biomass, using a 0.2 scaling factor for natural mortality (instead of the more typical 0.5) and halving the final MSY estimate (to account for previous exploitation) resulted in a TAC that is considered to be conservative.

Stock status determination

Since calculation of the TAC in 2004, catches of prickly redfish have been sporadic, but increasing. Reported catch[1] has been below the 20 t TAC in every year except 2015, when it exceeded 28 t. While the data that support the current TAC are close to 15 years old, the average catch for the period since the TAC was calculated (2004) has been substantially below the 20 t TAC (around 6 t per year). On this basis, the stock is classified as **not subject to overfishing**. Densities, lengths and weights of prickly redfish remained relatively stable between 1995 and 2009, and there are no more recent data to indicate that this situation has changed. As a result, the stock is classified as **not overfished**.

1 Reported catches of sea cucumbers are understood to be gutted wet weight.

Sandfish (*Holothuria scabra*)



Line drawing: FAO

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 per cent 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 Reef may have reduced fertilisation success, because remaining sandfish are widely dispersed. Murphy et al. (2011) also noted that sandfish can burrow into the sand, making them difficult for survey observers to see. However, Murphy et al. (2011) considered it unlikely that the proportion of buried sandfish would have differed from one survey to the next. This is because, all surveys sampled the same sites during the same season, lunar phase, tide and time of day, providing confidence in comparability of density estimates between years. Low density estimates in recent surveys are therefore likely to indicate actual low density, rather than underestimates resulting from increased proportions of buried sandfish.

In 2012, CSIRO and AFMA conducted a small-scale experimental fishing trial of the Warrior Reef sandfish stock (Murphy et al. 2012). Methodology differed significantly from that used in previous surveys. Differences included sampling at different 'locations'[2] from the previous surveys (only three previous 'sites' were included), walking random search tracks rather than straight-line transects and choosing fishing areas of known high density (see Murphy et al. 2012). 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).

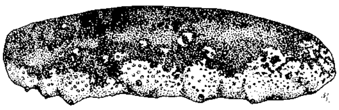
ABARES has received information confirming the illegal catch of sea cucumbers on Warrior Reef by PNG nationals in recent years (AFMA, 2017, pers. comm.). Approximately 0.4 t of catch was found on apprehended vessels in 2016, and approximately 1 t of catch in 2015. These catches are understood to be made up primarily of sandfish.

Stock status determination

Sandfish has been subject to a zero TAC since 1998. Illegal catch taken by PNG nationals has been reported in recent years. However, it is not clear whether the level of illegal catch found on apprehended vessels would impair recovery of the stock. It is also unclear whether the level of catch found on apprehended vessels represents the full extent of IUU catch. On this basis, fishing mortality status is **uncertain**. Since no recovery in overall density was observed between the full-scale surveys in 2004 and 2010, and there is no other robust information to inform stock status, the stock remains classified as **overfished**.

2 The term 'location' was used in the 2012 experimental fishing trial rather than 'site'. These locations were data logger tracks that indicated where experimental fishing occurred. They were labelled locations rather than sites because they were not generally separated by 500 m, a characteristic of the sites used in previous full-scale stock surveys. Locations were chosen by individual fishers rather than being specified by experimental design. Of the 37 locations fished, 14 were next to three sites surveyed for sandfish in previous years (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 was relatively stable (or possibly increased) between 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 among 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.

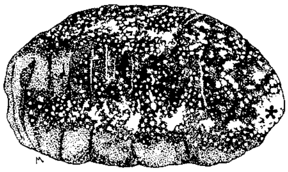
The 2009 survey estimated the biomass of white teatfish to be 110 t. The resulting TAC for white teatfish (using the same methods described for prickly redfish) was 15 t. However, it is likely that this survey underestimated the biomass, as a result of the 20 m safety limit imposed on diving depth for survey operations. White teatfish can occur at depths of more than 40 m, and previous research indicates that the majority inhabit waters deeper than 20 m (SPC 1994). Furthermore, the northern Don Cay region (Figure 19.1) was not included in the survey, potentially contributing to an underestimate of stock size. Past surveys may also have underestimated abundance and biomass for similar reasons. Given the historical restrictions on the use of breathing apparatus in this fishery, the depth preference of white teatfish is also likely to have protected the species from some level of fishing effort.

Stock status determination

Recent catches of white teatfish have been sporadic, with all but two years (2013 and 2014) being below the TAC. Although the data that support the current TAC are close to 15 years old, the average catch for the period since the TAC was calculated (2004) has been substantially below the 15 t TAC (around 5.5 t per year).

The reported catch in 2016 was around 1 t, substantially less than the 15 t TAC. This stock is therefore classified as **not subject to overfishing**. The relatively stable densities, mean weights and lengths from surveys up to 2009 indicate that the portion of stock available to the fishery has remained relatively stable. Because there are no more recent data to indicate that this situation has changed, this 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 made up of up to 18 species of sea cucumber. Together, these species are considered to constitute a single stock for management purposes.

Stock assessment

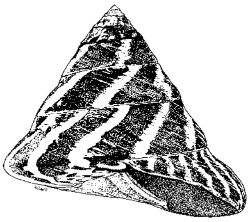
Many of the individual species within this multispecies stock have been included in previous surveys (1995, 2002, 2005 and 2009) of sea cucumbers in Torres Strait. The results of the 2002 survey were used to estimate MSY, and subsequently TACs, for 15 of the species (see section on prickly redfish for methodology for MSY and TAC calculation). For species considered to be 'unexploited' (that is, little or no fishing currently or in the recent past), the recommended TAC was equal to the estimate of MSY; for species currently or previously fished, but showing no evidence of severe depletion, the recommended TAC was half of MSY; and 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. Because of the multispecies nature of this stock, the PZJA has established an 80 t TAC for all species combined. This TAC is not biologically meaningful at the individual species level. The reported catch for this multispecies stock in 2015 was around 2 t.

Stock status determination

Catch of this stock in 2016 comprised a number of species, none of which are considered to have been depleted to low levels. As such, the stock is considered to be **not subject to overfishing**.

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. Further, it has been a number of years since the last survey was undertaken. 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 trochus has quite different habitat requirements from those of bêche-de-mer. When suitable trochus habitat was identified and specifically targeted, animals were commonly found. In the 2009 survey, the average density of trochus was estimated at 25 individuals per hectare (lower 90th percentile: 5 individuals per hectare), with a standing stock estimate of 634 t (lower 90th percentile: 138 t). The density of trochus in 2009 was similar to that observed in 1995, and the authors suggested that it was comparable to that of unfished stocks in other South Pacific locations.

Despite the well-established and repeated methodology used in the surveys, the reliability of the estimates of density and standing stock is uncertain because of the small number of sites at which trochus was found (only 12 of 113 sites), the low total number of trochus observed (73) and the resulting high variability around mean estimates of density. Murphy et al. (2010) concluded that the density estimates had very low precision and that the probability of detecting even large changes in trochus density was low.

Murphy et al. (2010) recommended setting a trigger catch level of 75 t (live shell weight), based on historical information, anecdotal harvest patterns and a 20 per cent exploitation rate of the estimated standing stock. It was recommended that the TAC should be reassessed and a stock assessment undertaken 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

There was no reported catch of trochus in 2016. 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) are not available for the TSBDMF or the TSTF. Estimates of the gross value of production are also not available for either fishery.

Because it is relatively easy to collect sea cucumbers, and the value of, and demand (mostly from Asia) for, sea cucumber are increasing, the stock needs to be closely monitored to avoid overfishing. Most of Australia's export of sea cucumber is to China, Hong Kong and Singapore. The level of participation in the TSTF is relatively low because of a decline in overseas market demand for shells.

Management arrangements

Both fisheries are managed under TACs and a range of input controls. For the TSBDMF, only a trial TAC for black teatfish was caught in 2015. With the increased TAC for black teatfish, the catch of other species, such as prickly redfish, increased significantly during the trial. For the TSTF, no catch has been recorded since 2010, suggesting that it is not profitable.

The trial TAC of black teatfish in the TSBDMF contributed to increased catches in the 2014 and 2015 fishing seasons, which likely increased NER during this period. The trial TAC ended in 2016, resulting in lower activity in the fishery and therefore lower catches—mostly of prickly redfish and black teatfish—suggesting a decline in NER.

Performance against economic objective

The HSP is not prescribed for Torres Strait fisheries, and there are no explicit economic targets for the TSBDMF or the TSTF.

For the TSBDMF, the PZJA aims to provide for the sustainable use of the resource, develop stocks for the benefit of Australian Traditional Inhabitants and develop a long-term strategy for sandfish (PZJA 2014a). The trial of black teatfish catch in 2014 and 2015, and hookah gear trials in 2011–12 appear to have generated increased activity in the TSBDMF. Rebuilding the sandfish stock should increase the potential benefits to local communities from the fishery.

For the TSTF, the PZJA aims to make best use of the resource, maximise opportunities for Traditional Inhabitants and encourage participation in the fishery (PZJA 2014b). Expectations of low economic returns are likely to have contributed to low participation in the fishery.

19.4 Environmental status

Both the bêche-de-mer and trochus fisheries are included in 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 27 October 2017, and the TSTF is exempt until 22 December 2017.

No ecological risk assessments have been conducted for the bêche-de-mer fishery or the trochus fishery. The most recent EPBC Act assessments of the fisheries (Department of the Environment 2014) assume that impacts on the ecosystem of each fishery would be restricted to exploitation of target species; translocation of species through anchor and hull fouling; and impacts on reef ecosystems related to anchoring, mooring and other anthropogenic activities, such as reef-top walking.

AFMA publishes quarterly reports of logbook interactions with protected species on its website. No interactions with species protected under the EPBC Act were reported in either fishery in 2016.

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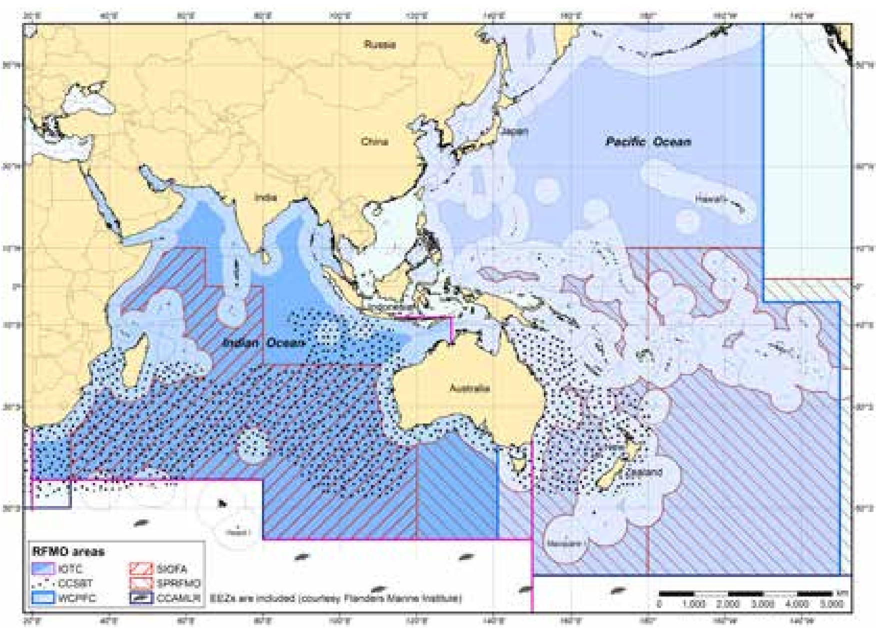
White teatfish
Tim Skewes, CSIRO

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. **RFMO** Regional fisheries management organisation. **SIOFA** Southern Indian Ocean Fisheries Agreement. **SPRFMO** South Pacific Regional Fisheries Management Organisation (see Chapter 28 for full extent). **WCPFC** Western and Central Pacific Fisheries Commission. IOTC and WCPFC areas of competence include EEZs.

Several fish stocks of commercial importance to Australia have ranges extending outside the Australian Fishing Zone (AFZ) into the high seas and the Exclusive Economic Zones (EEZs) of other countries. These stocks are important for Australia in providing a source of economic benefits for the Australian fishing industry, and require regional cooperative action for effective management. Management responsibility is shared by multiple governments through international instruments (conventions and agreements), which are often implemented through a regional fisheries management organisation (RFMO) or other international body (Figure 20.1). As a party to these international instruments, Australia implements measures agreed by the relevant body in managing its domestic fishery; in a number of cases, Australia's domestic standards exceed those agreed internationally. Australia's continued engagement in international fisheries processes is critical to supporting access for the Australian fishing industry, and promoting responsible management to ensure sustainability of the fisheries and the ecosystems that support them.

This chapter provides an introduction to international fisheries arrangements to which Australia is a party. Status reports of the domestic fisheries involved are provided in Chapters 21–28. Although the fisheries of Torres Strait are also managed under an international agreement, they differ substantially from the fisheries described here and are therefore addressed separately in Chapters 15–19.

Through participation in RFMOs and other international fisheries bodies, Australia aims to implement its commitments and obligations under overarching international instruments, including the:

- 1982 United Nations Convention on the Law of the Sea (UNCLOS)
- 1995 Agreement for the Implementation of the Provisions of the UNCLOS relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement)
- 1995 United Nations Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries
- 1995 Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas
- 2006 and 2009 United Nations General Assembly (UNGA) Resolutions on Sustainable Fisheries (UNGA 61/105, UNGA 64/72)
- 2009 Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.

Globally, the species targeted on the high seas vary by area and fishing fleet. Some of the most extensive high-seas fisheries are pelagic fisheries catching highly migratory tunas, billfishes and sharks (defined under UNCLOS Annex 1). Currently, five conventions or agreements have been established to manage such species and species groups; Australia is party to three of these:

- Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
- Convention for the Conservation of Southern Bluefin Tuna
- Agreement for the Establishment of the Indian Ocean Tuna Commission.

Australia has also participated in the development of newer agreements where there are gaps in the international management of other non–highly migratory stocks in the high seas. Australia is party to the:

- 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 managed in line with CCAMLR arrangements.

The Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007) 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 policy notes that the Australian Government will advocate the principles of the policy when negotiating with these bodies. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) adopted a management procedure in 2011, which is analogous to a harvest strategy (Chapter 23). There has also been considerable progress in the adoption of harvest strategy principles and revised reference points in the Indian Ocean Tuna Commission (IOTC), and the Western and Central Pacific Fisheries Commission (WCPFC) over 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 in the case of the WCPFC and the IOTC the limit reference points adopted 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 2015, the total tuna catch of the fishery was worth more than US$4.8 billion and constituted about 56 per cent of the global tuna catch. The WCPFC area of competence includes the EEZs of many developing Pacific island states (Figure 20.1), for which tuna fishing is a significant source of income. The WCPFC has a specific mandate to manage fishing impacts on all highly migratory fish species listed in UNCLOS Annex 1, except sauries (Scomberesocidae). See Chapter 21 for more information.

Commission for the Conservation of Southern Bluefin Tuna

The Convention for the Conservation of Southern Bluefin Tuna, which established the CCSBT, originated from discussions between Australia, Japan and New Zealand in the mid 1980s, following an observed decline in stock biomass. The convention applies to southern bluefin tuna (*Thunnus maccoyii*) throughout its range, rather than within a specified geographic area. Therefore, it covers areas of the Indian, Atlantic and Pacific oceans (Figure 21.1), 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 and the Fishing Entity of Taiwan hold the majority (93 per cent) 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 21.1). The IOTC's area of competence covers a large number of countries, and both artisanal and industrial fishing vessels. Membership of the IOTC is open to Indian Ocean coastal countries, and countries or regional economic integration organisations that are members of the United Nations or one of its specialised agencies that actively fish for tunas in the Indian Ocean. 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 from the other multilateral fisheries conventions. The strategies result in conservative TACs that aim to reduce the potential 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.

20.2 References

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Tuna processing in Indonesia
Heather Patterson, ABARES

Chapter 21

Eastern Tuna and Billfish Fishery

J Larcombe, H Patterson and J Savage

FIGURE 21.1 Relative fishing intensity in the Eastern Tuna and Billfish Fishery, 2016

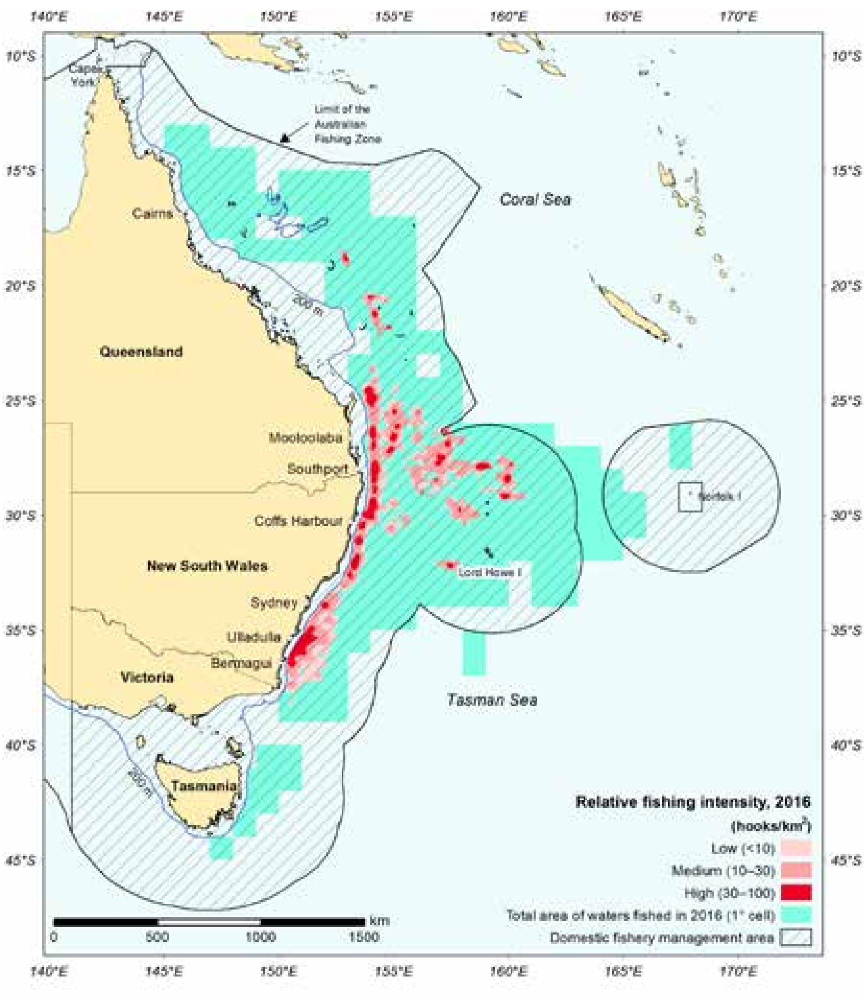


TABLE 21.1 Status of the Eastern Tuna and Billfish Fishery

Status	2015		2016		Comments a
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Striped marlin (*Kajikia audax*), south-west Pacific					Most recent estimate of spawning biomass (2012) is above the default limit reference point of B_{20} but below B_{MSY}. Current fishing mortality rate is below MSY levels.
Swordfish (*Xiphias gladius*), south-west Pacific					Most recent estimates of biomass (2013) are above the default limit reference point of B_{20}. Fishing mortality estimates vary depending on uncertain growth schedule.
Albacore (*Thunnus alalunga*), south Pacific					Most recent estimate of spawning biomass (2015) is above the default limit reference point. Recent ocean-wide catches are at, or slightly less than, MSY, and fishing mortality is below MSY levels.
Bigeye tuna (*Thunnus obesus*), western and central Pacific					Most recent estimate of spawning biomass (2014) is below the limit reference point. Ocean-wide catches exceed MSY, and current fishing mortality rate exceeds that required to produce MSY.
Yellowfin tuna (*Thunnus albacares*), western and central Pacific					Most recent estimate of biomass (2014) is above the limit reference point. Ocean-wide estimates of fishing mortality are below MSY levels.
Economic status	NER remained positive in 2013–14 (preliminary estimate) and for 2014–15 are likely to have increased as a result of higher GVP, lower fuel prices and reduced latency. In 2015–16, NER are likely to have increased further as prices for all major species increased significantly. The implementation of individual transferable quotas and a harvest strategy for some stocks is likely to be supporting increases in NER; however, neither have been implemented long enough to determine whether there has been a positive effect.				

a Regional assessments of species and the default limit reference points from the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007) are used as the basis for status determination.

Notes: **B_{20}** 20 per cent of unfished biomass. **B_{MSY}** Biomass at MSY. **GVP** Gross value of production. **MSY** Maximum sustainable yield. **NER** Net economic returns.

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

21.1 Description of the fishery

Area fished

The Eastern Tuna and Billfish Fishery (ETBF) operates in the Exclusive Economic Zone, from Cape York to the Victoria – South Australia border, including waters around Tasmania and the high seas of the Pacific Ocean (Figure 21.1). Domestic management arrangements for the ETBF are consistent with Australia's commitments to the Western and Central Pacific Fisheries Commission (WCPFC; see Chapter 20).

Fishing methods and key species

Key species in the ETBF are shown in Table 21.1. Most of the catch in the fishery is taken with pelagic longlines, although a small quantity is taken using minor-line methods (Table 21.2). Some ETBF longliners catch southern bluefin tuna (*Thunnus maccoyii*) off New South Wales during winter, after fishing for tropical tunas and billfish earlier in the year, while others take them incidentally when targeting other tunas. All southern bluefin tuna taken must be covered by quota and landed in accordance with the Southern Bluefin Tuna Fishery Management Plan 1995. Recreational anglers and game fishers also target tuna and marlin in the ETBF. Many game fishers tag and release their catch, especially marlins. The retention of blue marlin (*Makaira mazara*) and black marlin (*M. indica*) has been banned in commercial fisheries since 1998, and catch limits have been introduced on longtail tuna (*Thunnus 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; DAFF 2007) is not prescribed for fisheries managed under international agreements. However, a harvest strategy framework has been developed for the ETBF (Campbell 2012a). The framework has been used to set the total allowable commercial catch (TACC) for swordfish (*Xiphias gladius*) and striped marlin (*Tetrapturus audax*) since 2011, but is not currently used for tuna species.

Australia's catch in the ETBF as a percentage of the total catch from all nations in the Coral and Tasman seas has been declining across the major target species. This is due primarily to an increase in the catch by other nations for some species. The Tropical Tuna Resource Assessment Group (TTRAG) noted that the ETBF catch as a proportion of the total catch within the Coral and Tasman seas was relatively high for swordfish and striped marlin, and that the ETBF harvest strategy would therefore be effective. In 2013, TTRAG made some adjustments to the target reference catch rates used in the ETBF harvest strategy for swordfish and striped marlin. These provide better alignment with the HSP default reference points of 48 per cent of unfished biomass (B_{48}) for the target and 20 per cent of unfished biomass (B_{20}) for the limit.

In 2013, TTRAG found that the ETBF harvest strategy was not likely to achieve its objectives according to the requirements of the HSP for bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*) and albacore (*T. alalunga*). Australia's catch of these species was low in proportion to total regional catch, and, under these circumstances, changes to Australia's catch could not be expected to result in a change in the stock status (because of a lack of feedback to the stock as a whole).

The Australian Fisheries Management Authority (AFMA) Commission subsequently directed TTRAG to cease using the harvest strategy to calculate recommended biological commercial catch levels for bigeye tuna, yellowfin tuna and albacore, and to prepare information on stock status of tunas. In the absence of an accepted harvest strategy, and because there has been no allocation of tuna catches by the WCPFC, AFMA has applied TACCs based on historical catch levels in the fishery, and in accordance with any limits determined by the WCPFC or agreed through regional arrangements, such as the Tokelau Arrangement for the Management of the South Pacific Albacore Fishery.

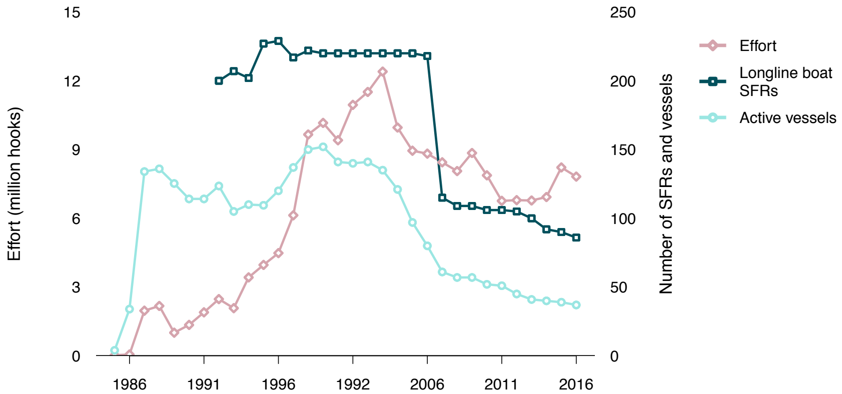
The status of ETBF tuna and billfish is derived from the regional assessments undertaken for the WCPFC. Assessment results over the relevant geographic area modelled are used to determine stock status, but supplementary management advice may also be derived from the region most relevant to Australia. The WCPFC has agreed limit reference points for some stocks, but, in where agreed limit reference points are absent, status determination was informed by the proxies specified in the HSP.

From 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 per cent of video footage of all hauls is reviewed to verify the accuracy of logbooks, which must be completed for 100 per cent of shots.

Fishing effort

The number of active vessels in the fishery (Figure 21.2) has decreased substantially in the past decade (from around 150 in 2002 to 37 in 2016), probably as a result of a decline in economic conditions in the fishery and the removal of vessels through the Securing our Fishing Future structural adjustment package in 2006–07 (Vieira et al. 2010).

FIGURE 21.2 Longline fishing effort, number of boat SFRs and active vessels in the ETBF, 1985 to 2016

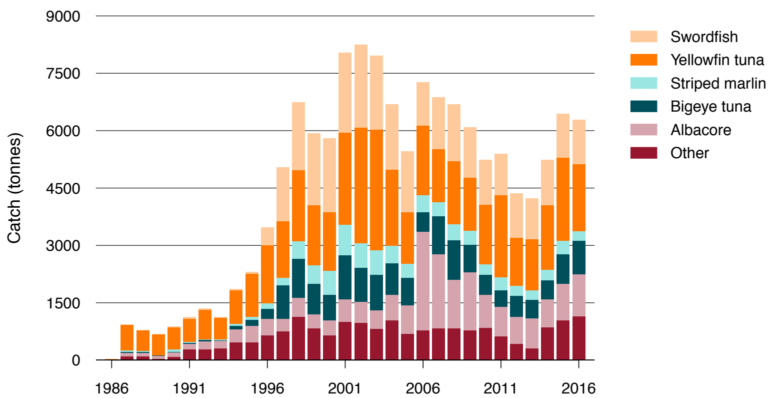


Note: **SFR** Statutory fishing right.
Source: Australian Fisheries Management Authority

Catch

Following a decrease in effort, the total retained catch of all species in the ETBF declined from a high of more than 8,000 t in 2002 to around 4,200 t in 2013, but has since increased to above 6,000 t in 2016 (Figure 21.3). Swordfish and yellowfin tuna continue to be the main target species.

FIGURE 21.3 Total catch (from logbook data) for all methods, by species, in the ETBF, 1987 to 2016



Source: Australian Fisheries Management Authority

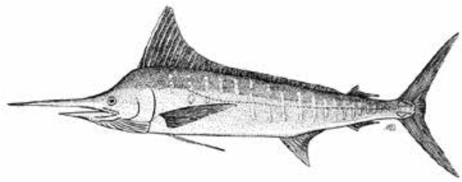
TABLE 21.2 Main features and statistics for the ETBF

Fishery statistics a	2015			2016		
Stock	**TACC (t)**	**Catch (t)**	**Real value (2014–15)**	**TACC (t)**	**Catch (t)**	**Real value (2015–16)**
Striped marlin	351	347	$1.4 million	351	244	$1.4 million
Swordfish	1,381	1,150	$6.8 million	1,373	1,161	$9.1 million
Albacore	2,500	949	$2.0 million	2,500	1,101	$3.9 million
Bigeye tuna	1,056	785	$5.4 million	1,056	870	$8.0 million
Yellowfin tuna	2,200	2,177	$17.4 million	2,200	1,763	$24.7 million
Total fishery	**7,488**	**5,408**	**$33.0 million**	**7,480**	**5,139**	**$47.1 million b**
Fishery-level statistics						
Effort	Longline: 8.22 million hooks Minor line: na			Longline: 7.82 million hooks Minor line: na		
Fishing permits	Longline boat SFRs: 90 Minor line boat SFRs: 101			Longline boat SFRs: 86 Minor line boat SFRs: 93		
Active vessels	Longline: 39 Minor line: 5			Longline: 37 Minor-line: 2		
Observer coverage	Longline: 5.87% c Minor-line: zero			Longline: 8.7% Minor line: zero		
Fishing methods	Pelagic longline, minor line (trolling, rod and reel, handline)					
Primary landing ports	Cairns, Mooloolaba and Southport (Queensland); Bermagui, Coffs Harbour and Ulladulla (New South Wales)					
Management methods	Output controls: limited entry, gear restrictions Input controls: TACC and ITQs					
Primary markets	Domestic: fresh International: Japan, United States—mainly fresh; Europe—frozen; American Samoa, Thailand, Indonesia—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. Real-value statistics are by financial year and are expressed in 2014–15 dollars. **b** Since 1 July 2015, e-monitoring is 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: **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing right. **TACC** Total allowable commercial catch.

21.2 Biological status

Striped marlin (*Kajikia audax*)



Line drawing: FAO

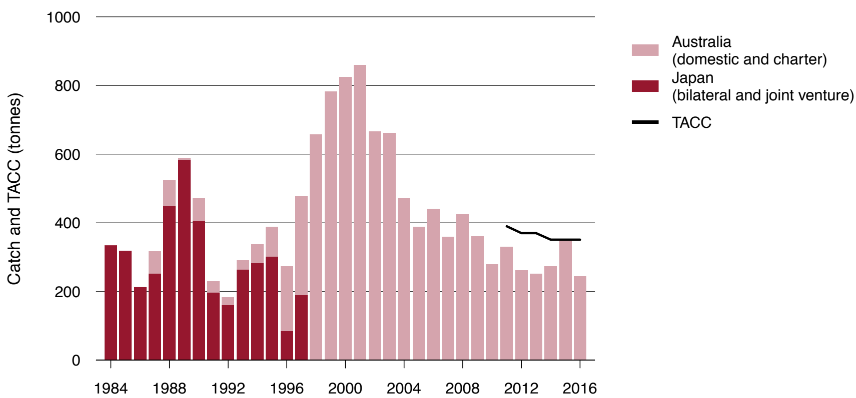
Stock structure

Genetic studies have identified multiple stocks of striped marlin in the Pacific Ocean (for example, McDowell & Graves 2008 ; Purcell & Edmands 2011). As a result, the north Pacific Ocean and south-west Pacific Ocean (SWPO) stocks are assessed separately (WCPFC 2013). Information for the SWPO stock is reported here.

Catch history

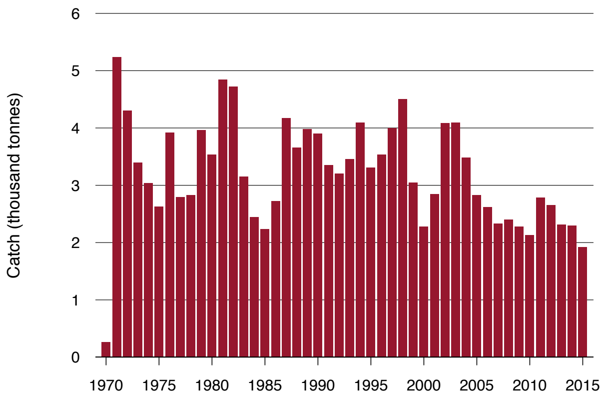
Catch for the ETBF decreased slightly in 2016 to 244 t (Figure 21.4), while catch in the south Pacific decreased from 2,300 t in 2014 to 1,924 t in 2015 (Figure 21.5). An increase in south Pacific catch in 2011–12 was driven in part by increases in catch in the north that are not subject to the current conservation and management measure (CMM) for striped marlin—WCPFC CMM 2006-04—which only applies south of 15°S.

FIGURE 21.4 Striped marlin catch and TACC in the ETBF, 1984 to 2016



Note: **TACC** Total allowable commercial catch.
Source: Australian Fisheries Management Authority

FIGURE 21.5 Striped marlin catch in the south Pacific, 1970 to 2015



Source: Western and Central Pacific Fisheries Commission

Stock assessment

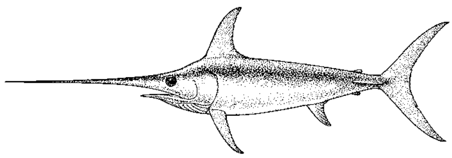
The last stock assessment for striped marlin in the SWPO was conducted in 2012 (Davies et al. 2012). Significant changes in the base case from the previous (2006) assessment included a 50 per cent reduction in Japanese longline catches over the entire model time period (because catches in the previous assessment were erroneously counted twice), faster growth rates, and the steepness of the stock–recruitment relationship being fixed at a higher level (0.8 rather than 0.55). A decreasing trend in recruitment through time was found, particularly from 1950 to 1970. There were conflicts among the standardised catch-per-unit-effort (CPUE) time series, and a series from the Japanese longline fishery was considered to be the most representative. Estimates of equilibrium maximum sustainable yield (MSY) and the associated reference points were highly sensitive to the assumed values of natural mortality and steepness in the stock–recruitment relationship. Estimates of stock status relative to MSY-based reference points, as used by the WCPFC, are therefore uncertain.

The base case in the assessment estimated that the latest (2010) spawning biomass had been reduced to 34 per cent of the levels predicted to occur in the absence of fishing ($SB_{CURRENT}/SB_{F=0}$ = 0.34 for the base case; range 0.32–0.44 across the base case and sensitivities). It was estimated that the spawning biomass was below the level associated with MSY ($SB_{CURRENT}/SB_{MSY}$ = 0.87; range 0.67–1.14). Fishing mortality (2007 to 2010) was below F_{MSY} ($F_{CURRENT}/F_{MSY}$ = 0.81; range 0.51–1.21), and catches during this period were close to the estimated MSY (2,081 t; range 1,914–2,276 t). Annual catches over the most recent five years since the assessment (2011 to 2014) have averaged around 2,400 t, which exceeds the estimated MSY.

Stock status determination

The most recent estimate of the SWPO spawning biomass of striped marlin is above the WCPFC limit reference point of 20 per cent of the levels predicted to occur in the absence of fishing. The most recent base-case estimates of fishing mortality and most sensitivity analyses are below the level associated with MSY; however, recent catches are somewhat above the estimated MSY level. SWPO striped marlin is classified as **not subject to overfishing** and **not overfished.** The recent catch levels and the age of the stock assessment both contribute to increased uncertainty around the stock status of striped marlin in 2016. This trend is likely to affect future status determination. The Scientific Committee of the WCPFC recommended measures to control overall catch, through expansion of the geographical scope of CMM 2006-04 to cover the distribution of the stock; the WCPFC has not yet adopted this recommendation.

Swordfish (*Xiphias gladius*)



Line drawing: Gavin Ryan

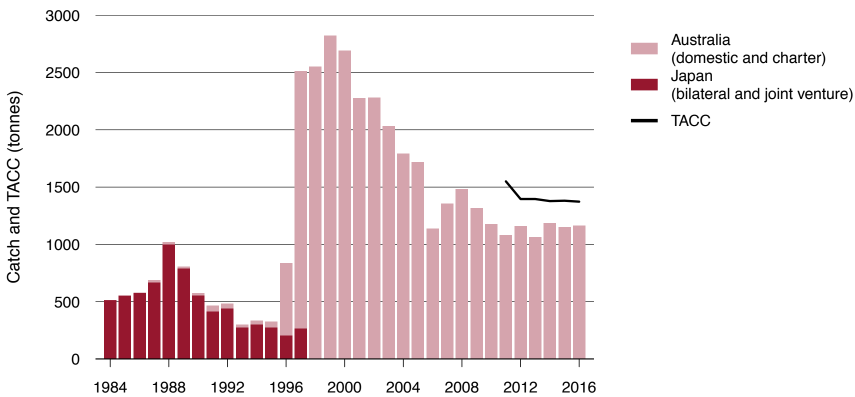
Stock structure

Although studies of swordfish have generally indicated a low level of genetic variation in the Pacific Ocean (Kasapidis et al. 2008), the WCPFC assesses two stocks separately: a north Pacific stock and an SWPO stock. The information reported here is for the SWPO stock.

Catch history

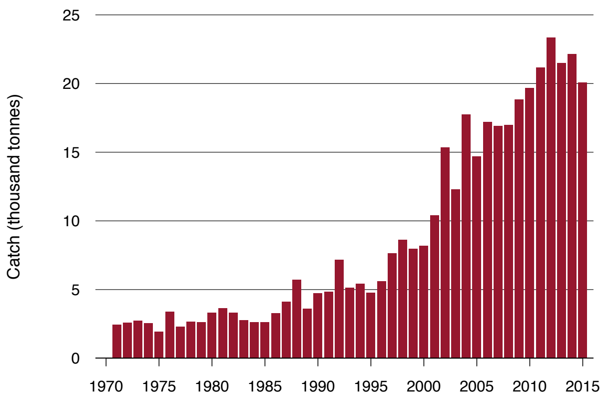
Swordfish catch in the ETBF increased slightly in 2016 (Figure 21.6). Catch in the south Pacific has generally been increasing since 2001, but decreased slightly in 2015 to 20,090 t (Figure 21.7).

FIGURE 21.6 Swordfish catch and TACC in the ETBF, 1984 to 2016



Note: **TACC** Total allowable commercial catch.
Source: Australian Fisheries Management Authority

FIGURE 21.7 Swordfish catch in the south Pacific, 1970 to 2015



Source: Western and Central Pacific Fisheries Commission

Stock assessment

The SWPO stock of swordfish was most recently assessed in 2013 (Davies et al. 2013) using the assessment package MULTIFAN-CL. This assessment builds on the 2008 assessment and is underpinned by several other analyses examining standardised CPUE series (for example, Campbell 2012b; Hoyle et al. 2013). The main uncertainty in the assessment pertains to swordfish growth, maturity and mortality-at-age schedules. Two schedules were used in the assessment: one derived from Hawaiian estimates and the other from Australian estimates. Although the schedule used affected the stock status of swordfish, the WCPFC Scientific Committee was unable to decide which schedule was more reliable (WCPFC 2013).

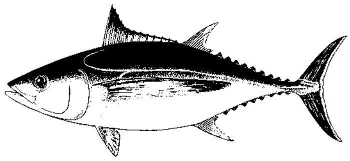
Model runs for both growth schedules indicated that the current (2007 to 2010) level of spawning biomass was above the level that would result in MSY (Australian estimate: $SB_{CURRENT}/SB_{MSY}$ = 1.15–1.80; Hawaiian estimate: $SB_{CURRENT}/SB_{MSY}$ = 1.86–2.54). The range of key model runs also indicated that current spawning biomass was above 20 per cent of the spawning biomass predicted to occur in the absence of fishing ($SB_{CURRENT}/SB_{F=0}$ = 0.26–0.60). However, estimates of fishing mortality relative to F_{MSY} varied under the growth schedules, with the Hawaiian schedule indicating that overfishing was not occurring ($F_{CURRENT}/F_{MSY}$ = 0.40–0.70) and the Australian schedule indicating that overfishing was occurring ($F_{CURRENT}/F_{MSY}$ = 1.06–1.77).

Stock status determination

The most recent estimates of spawning biomass, from all models and sensitivities, are above the HSP default limit reference point of 20 per cent of the spawning biomass predicted to occur in the absence of fishing. As a result, the swordfish stock in the SWPO is classified as **not overfished.** However, the most recent estimates of fishing mortality relative to the F_{MSY} reference point vary greatly, depending on the growth schedule assumed in the model. The WCPFC Scientific Committee was unable to decide which growth schedule was more reliable, and further research on growth schedules is underway to resolve this issue. The stock is classified as **uncertain** with regard to the level of fishing mortality.

Yellowfin tuna
AFMA

Albacore (*Thunnus alalunga*)



Line drawing: FAO

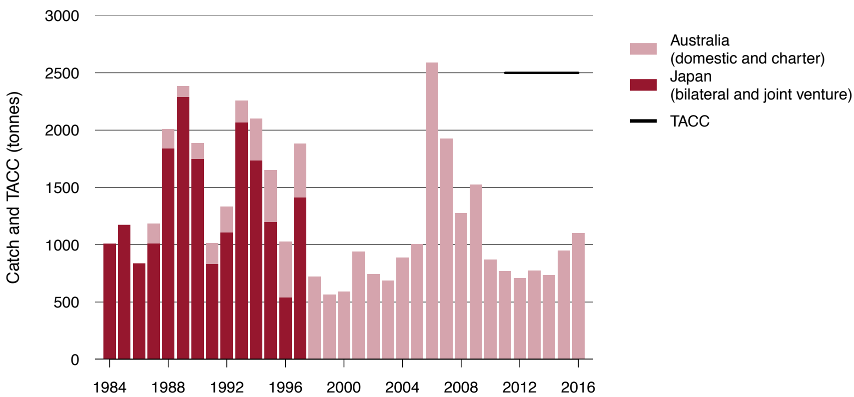
Stock structure

Two distinct stocks of albacore (north Pacific and south Pacific) are found in the Pacific Ocean, generally associated with the two oceanic gyres. These two stocks are assessed separately (WCPFC 2015). Information for the south Pacific albacore stock is reported here.

Catch history

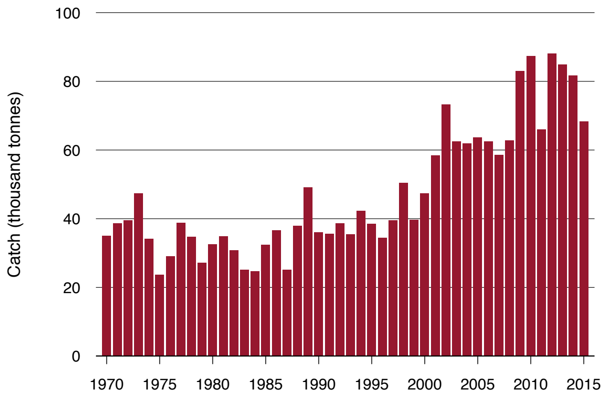
Catches in the ETBF increased to 1,101 t in 2016, the highest since 2009 (Figure 21.8). Catches in the south Pacific have increased in recent years, but decreased in 2015 to 68,306 t (Figure 21.9). The WCPFC Scientific Committee recommended that longline fishing mortality be reduced if the WCPFC's goal is to maintain economically viable catch rates.

FIGURE 21.8 Albacore catch and TACC in the ETBF, 1984 to 2016



Note: **TACC** Total allowable commercial catch.
Source: Australian Fisheries Management Authority

FIGURE 21.9 Albacore catch in the south Pacific, 1970 to 2015



Source: Western and Central Pacific Fisheries Commission

Stock assessment

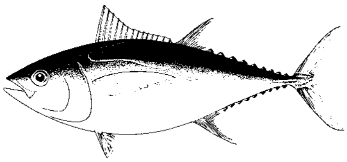
The assessment for albacore in the south Pacific was updated in 2015 using MULTIFAN-CL (Harley et al. 2015). Substantial improvements in the 2015 stock assessment included improvements to the MULTIFAN-CL modelling framework, use of a regional disaggregated framework, use of operational data for construction of CPUE indices and regional weights, changes to some key biological parameters, inclusion of direct age-at-length data to improve growth estimation, and inclusion of additional tagging data (Harley et al. 2015). Two influential changes were a change in the natural mortality assumption (from 0.4 to 0.3 per year) and exclusion of the eastern Pacific from the assessment. Although the results of the assessment are broadly consistent with the 2012 assessment, the changes to the assessment combined with the additional years of fishing resulted in a more pessimistic picture, with substantially lower biomass and higher fishing mortality.

The base-case model in the assessment estimated that the latest (2013) spawning biomass was above the level associated with MSY (SB_{LATEST}/SB_{MSY} = 2.86; range 1.74–7.03) and above the adopted limit reference point ($SB_{LATEST}/SB_{F=0}$ = 0.40; range 0.30–0.60). It should be noted that the estimate of the biomass at MSY (B_{MSY}) for south Pacific albacore is around 14 per cent of unfished levels, which is below the adopted limit reference point of 20 per cent—a target of B_{MSY} would be inconsistent with the adopted limit reference point. Current (2009 to 2012 average) fishing mortality is below F_{MSY} ($F_{CURRENT}/F_{MSY}$ = 0.39; range 0.13–0.62), and recent catches are likely at, or slightly less than, estimates of MSY.

Stock status determination

The most recent estimate of spawning biomass is above the HSP default limit reference point of 20 per cent of initial unfished levels. The most recent estimates of fishing mortality are well below the levels associated with MSY, and recent catches are around MSY. As a result, albacore in the south Pacific Ocean is classified as **not subject to overfishing** and **not overfished.**

Bigeye tuna (*Thunnus obesus*)



Line drawing: FAO

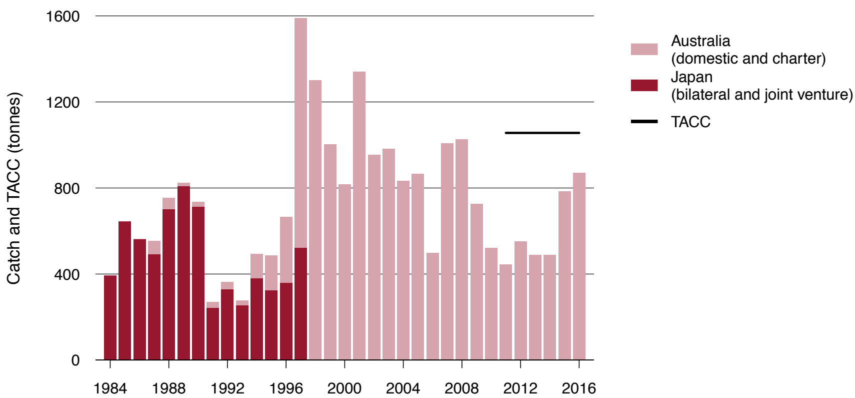
Stock structure

Genetic data have indicated that bigeye tuna in the Pacific Ocean is a single biological stock (Grewe & Hampton 1998).

Catch history

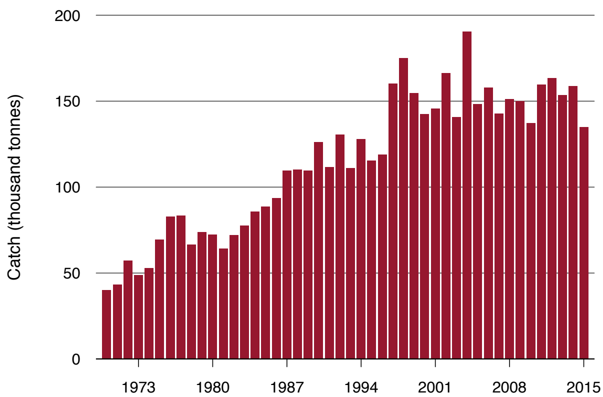
Catches of bigeye tuna increased to 870 t in the ETBF in 2016, the highest levels since 2009 (Figure 21.10). Catches decreased in the WCPFC area in 2015 (Figure 21.11). Recent bigeye tuna catch in the WCPFC area (134,682 t in 2015) is well above the estimated MSY (108,520 t). Catch has been above this level since around 1987–88 (Figure 21.11).

FIGURE 21.10 Bigeye tuna catch and TACC in the ETBF, 1984 to 2016



Note: **TACC** Total allowable commercial catch.
Source: Australian Fisheries Management Authority

FIGURE 21.11 Bigeye tuna catch in the south Pacific, 1970 to 2015



Source: Western and Central Pacific Fisheries Commission

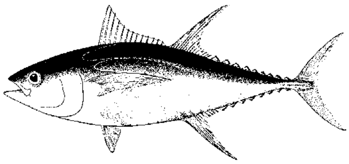
Stock assessment

The bigeye tuna stock in the western and central Pacific Ocean (WCPO) was most recently assessed in 2014 (Harley et al. 2014) using MULTIFAN-CL. The assessment was subject to significant changes and improvements following a review in 2012. It indicated that spawning biomass had declined to approximately half of initial levels by the mid 1970s and continued to decline after that. The base case in the assessment estimated that the 2012 spawning biomass had been reduced to 16 per cent of the levels predicted to occur in the absence of fishing ($SB_{LATEST}/SB_{F=0}$ = 0.16 for the base case; range 0.14–0.18 across the base case and three sensitivities). The 2012 spawning biomass was also below the level that will support MSY (SB_{LATEST}/SB_{MSY} = 0.77 for the base case; range 0.62–0.96). The assessment indicated that current (2008 to 2011 average) fishing mortality is 1.57 times the fishing mortality that will support MSY ($F_{CURRENT}/F_{MSY}$ = 1.57 for the base case; range 1.27–1.95). Repeated runs of the assessment model resulted in inconsistencies in the parameter estimates, which were most likely due to conflicts in the input data (relating to growth, regional recruitment distributions and movement parameters). However, the stock status outcomes were consistent among model runs.

Stock status determination

The base case (and all sensitivities) in the latest assessment (Harley et al. 2014) indicates that bigeye tuna spawning biomass is below the 20 per cent depletion reference point adopted by the WCPFC ($0.2SB_{F=0}$). This reference point corresponds with the limit reference point in the HSP. As a result, the stock is classified as **overfished.** The current fishing mortality across the WCPO is well in excess of levels needed to maintain MSY and has driven the stock to below the limit reference point (B_{20}); consequently, the stock is classified as **subject to overfishing.** The WCPFC Scientific Committee has recommended a reduction of at least 36 per cent in fishing mortality from the average levels for 2008 to 2011, to reduce the fishing mortality rate to F_{MSY}.

Yellowfin tuna (*Thunnus albacares*)



Line drawing: FAO

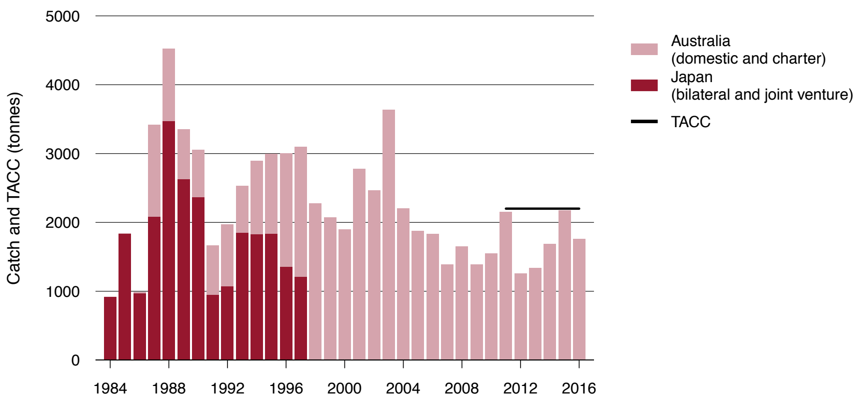
Stock structure

Yellowfin tuna in the WCPO is currently considered to be a single biological stock (Langley et al. 2012). However, a recent study using newer genomic techniques provided strong evidence of genetically distinct populations of yellowfin tuna at three sites (Coral Sea, Tokelau and California) across the Pacific Ocean (Grewe et al. 2015). Further work is underway to confirm and expand on this initial study.

Catch history

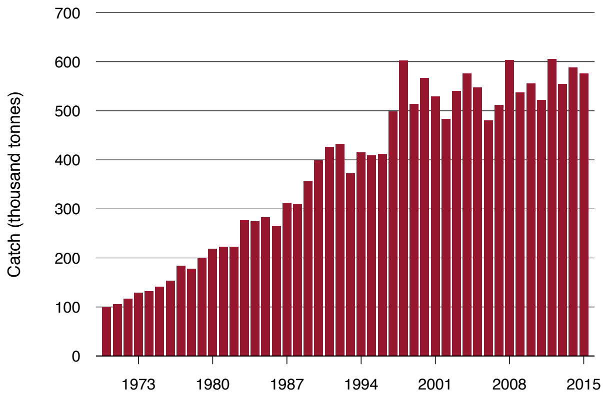
Catch decreased in the ETBF in 2016 (Figure 21.12). In the wider WCPFC area, the 2015 catch was slightly lower than the 2014 catch, at 575,901 t (Figure 21.13), which is below the estimated MSY (586,400 t).

FIGURE 21.12 Yellowfin tuna catch and TACC in the ETBF, 1984 to 2016



Note: **TACC** Total allowable commercial catch.
Source: Australian Fisheries Management Authority

FIGURE 21.13 Yellowfin tuna catch in the south Pacific, 1970 to 2015



Source: Western and Central Pacific Fisheries Commission

Stock assessment

The yellowfin tuna stock in the WCPO was most recently assessed in 2014 (Davies et al. 2014) using MULTIFAN-CL, with data up to and including 2012. The base case in the assessment estimated that the 2012 spawning biomass had been reduced to 38 per cent of the levels predicted to occur in the absence of fishing ($SB_{LATEST}/SB_{F=0}$ = 0.38 for the base case; range 0.35–0.40 across the base case and three sensitivities). The 2012 spawning biomass was above the level that will support MSY (SB_{LATEST}/SB_{MSY} = 1.24 for the base case; range 1.05–1.51). The assessment indicated that current (2008 to 2011 average) fishing mortality is 0.72 times the fishing mortality that will support MSY ($F_{CURRENT}/F_{MSY}$ = 0.72 for the base case; range 0.58–0.90).

Stock status determination

The results of the 2014 assessment indicate that the spawning biomass of yellowfin tuna is above the 20 per cent depletion reference point adopted by the WCPFC ($0.2SB_{F=0}$). This reference point corresponds with the limit reference point in the HSP. As a result, the stock is classified as **not overfished.** The 2014 catch is slightly above the base-case MSY; however, the current fishing mortality for the base-case assessment is below that required to achieve MSY. As a result, the stock is classified as **not subject to overfishing.**

21.3 Economic status

Key economic trends

ABARES has conducted economic surveys of the ETBF since the early 1990s. The survey data are used to estimate the level of net economic returns (NER) earned in the fishery. The most recent survey results for the ETBF cover the 2011–12 and 2012–13 financial years. Non–survey based estimates for economic performance are available for 2013–14. Survey results show that NER were positive from 2010–11 to 2012–13; 2010–11 was the first year with positive NER since 2000–01 (Bath et al. 2016; Figure 21.14). This improvement was attributed to a reduced number of active vessels and lower associated costs. These changes followed the exit of vessels from the fishery in response to market forces and the Securing our Fishing Future structural adjustment package (Vieira et al. 2010), which removed 99 longline permits and 112 minor-line permits.

Between 2009–10 and 2010–11, improved economic performance in the fishery was driven primarily by a reduction in operating costs. In 2011–12, NER were estimated to have increased to $3.0 million. Revenue and operating costs were both estimated to have declined, with the fall in operating costs proportionately larger than the fall in revenue. The main drivers for the reduction in operating costs were falls in boat numbers, total effort, catch (which affects some key variable costs) and the estimated distance travelled by the ETBF fleet. From 2011–12 to 2012–13, NER remained positive but slightly lower as a result of higher fuel prices. Preliminary estimates for 2013–14 are that NER fell further to $0.1 million, a reduction mostly driven by higher operating costs and a relatively small increase in fishing income.

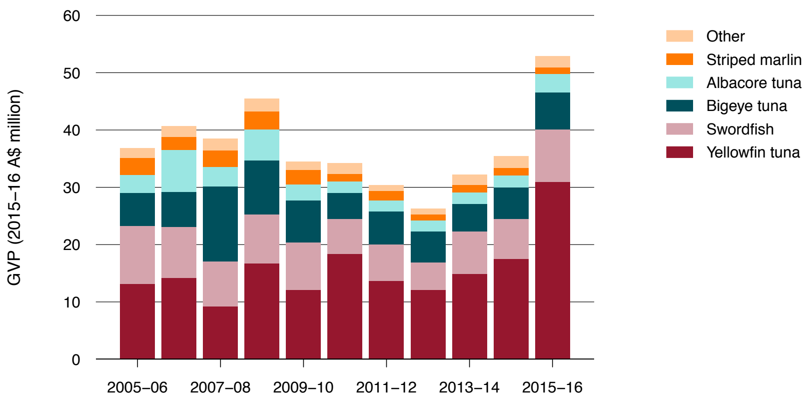
Previous improvements in the economic performance of the fishery are consistent with generally increasing productivity since the early 2000s (Stephan & Vieira 2013). Total factor productivity has followed a generally increasing trend since 1999–2000, although the rate of growth increased after 2001–02. The increased rate of growth occurred at the same time as the reduction in fleet size, driven primarily by market forces in the early 2000s and, later in that decade, by the Securing our Fishing Future structural adjustment package. This is likely to have left the more efficient vessels continuing to operate in the fishery, which may be the principal driver for the increasing productivity trend during the latter part of the decade.

Cost and NER estimates are not yet available for 2014–15 or 2015–16. Between 2014–15 and 2015–16, effort fell (from 8.22 million hooks to 7.82 million hooks), and the number of active vessels in the fishery fell from 39 to 37. Consistent with the decrease in effort, the total retained catch in the fishery decreased from 5,408 t to 5,139 t in 2015–16, indicating marginal improvements in productivity in terms of quantity of fish caught per hook deployed. Prices for all major species in the fishery increased significantly in 2015–16, leading to a strong increase in gross value of production despite falls in catch. The gross value of production increased in 2015–16 by 35 per cent (Figure 21.15). NER in 2015–16 are still uncertain; however, the available economic information indicates that NER in the fishery increased in 2015–16.

FIGURE 21.14 NER for the ETBF, 2003–04 to 2013–14

Note: **NER** Net economic returns. Data for 2013–14 are preliminary.
Source: Bath et al. 2016

FIGURE 21.15 Real GVP for the ETBF, 2005–06 to 2015–16



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

Management arrangements

Despite being a managed fishery, the ETBF has previously exhibited some of the economic characteristics of an unmanaged, open-access fishery (Kompas et al. 2009). Estimates suggest that the fishery earned negative NER between 2000–01 and 2009–10. Low NER are likely to have been a major reason for a large proportion of the fishery's permits being inactive. This is a sign that the fishery was overcapitalised. The structural adjustment under the Securing our Fishing Future package addressed these issues to a degree—it left fewer vessels sharing a similar amount of catch and revenue.

In March 2011, output controls were introduced for five key target species in the form of TACCs, allocated as ITQs. The removal of some input controls under ITQs can provide fishers with more flexibility to fish with a more efficient combination of inputs (Elliston & Cao 2004). The transferability of statutory fishing rights among fishers also allows more efficient allocation of these rights. This is likely to result in the catch being taken by the most efficient operators in the fishery.

The setting of TACCs in the ETBF is complicated by uncertainty around what level of TACC is consistent with maximising NER from an internationally shared stock (see 'Performance against economic objective'). If TACCs are set too high so that they do not constrain a species' catch, the incentive for quota trade and the associated positive impacts for fishery-level efficiency are reduced (Elliston et al. 2004). If TACCs are set too low (based on a stock's biological and economic status), some level of NER will be foregone.

Performance against economic objective

International sharing of stocks complicates both the selection of economic-based targets and the assessment of economic status against the objective of maximum economic yield (MEY), intended to maximise NER to the Australian community. Stock assessment is particularly complicated for the ETBF because the catch may be a relatively small proportion of the total WCPFC catch, and the degree of connectivity between the Australian population and that in the wider region remains uncertain for some species. For some internationally shared stocks, a reduction in the Australian catch may not necessarily lead to response in stock abundance and, therefore, profitability in the long term. For two stocks in the ETBF—swordfish and striped marlin—Australia's share of the catch is considered to be high enough for domestic action to have a more direct influence on stock abundance. These two stocks are managed under a harvest strategy designed to achieve a catch rate target biomass for prime-size fish consistent with the HSP economic target proxy of 48 per cent of unfished levels. Recent implementation of the harvest strategy indicates that since 2008 swordfish stock levels have been close to, but just below, the target reference point (Campbell 2016). For striped marlin, catch rates have been between the target and limit reference points for more than a decade, but have approached the target since 2013 (Campbell 2016). As a result, these two species have increased their contribution to overall NER from the fishery. The potential lack of association between domestic management actions and changes in stock biomass for the tuna species in the ETBF means that stock-wide B_{MEY} may not be relevant.

The species-specific biomass targets in this fishery are based on the expected catch rates and the size proportion that is expected to occur when the level of mean spawners per recruit is at 48 per cent of initial unfished levels. This is assumed to be consistent with the MEY target recommended by the HSP. It is unclear how accurately the target reflects MEY. Since the harvest strategy for the fishery was implemented in 2010, NER have been positive. However, it is unclear to what extent the targets are responsible for this. 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.

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 Conservation Act 1999* until 22 August 2019. Conditions under this approval, in addition to standard conditions of reporting and monitoring, include updating the ecological risk assessment for the ETBF, developing and implementing a framework for the management of non-quota and bycatch species, and continuing to determine the impact of fishing in the ETBF on shark species.

Under the level 3 Sustainability Assessment for Fishing Effects (for fish only), two species of sunfish and three species of shark were identified as being at high risk from the effects of fishing in the ETBF (Zhou et al. 2007). A 2012 review of the ecological risk assessment, using new information on sunfish, has reclassified both sunfish species as medium risk. The priorities of the ecological risk management response are to reduce interactions with marine turtles, seabirds and whales because of their protected status (AFMA 2012), and to reduce the capture and mortality of sharks by implementing the 20-shark trip limit. The ecological risk management report also lists specific actions for the priority groups—for example, all vessels in the ETBF are required to carry line cutters and de-hookers so that sharks, turtles and other protected species can be easily removed from fishing gear, should they become hooked or entangled. Results from a new ecological risk assessment in the ETBF in 2017 will be reported in *Fishery status reports 2018*.

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 2016, reported below.

In 2016, logbooks indicated that 2,005 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the ETBF. Of these, 744 were dead and 1,261 were released in unknown condition. Eight longfin mako sharks (*I. paucus*) were also hooked; two were dead and six were in unknown condition. Nine porbeagle sharks (*Lamna nasus*) were hooked and released, with eight in unknown condition. Forty-one silky sharks (*Carcharhinus falciformis*) were hooked and released in unknown condition. Thirty-nine green turtles (*Chelonia mydas*) were hooked; 30 were released alive and 9 were dead. Thirty-two leatherback turtles (*Dermochelys coriacea*) and nine loggerhead turtles (*Caretta caretta*) were also hooked; all were released alive except for three loggerheads that were dead. Two hawksbill turtles (*Eretmochelys imbricate*) were hooked, with one dead and one released alive; and one flatback turtle (*Natator depressus*) was caught and was dead. Seventeen unidentified turtles were hooked, with 12 alive and 5 dead.

Five black-browed albatrosses (*Thalassarche melanophris*) were caught, with one released alive and four dead, and one wandering albatross (*Diomedea exulans*) was released alive. Twenty unidentified albatrosses were hooked, with 4 released alive and 16 dead. Two flesh-footed shearwaters (*Ardenna carneipes*) and four unidentified shearwaters were hooked, with all being dead except one flesh-footed shearwater. One Australian gannett (*Morus serrator*) was released alive, and one unidentified bird was dead.

Several interactions with marine mammals were also recorded; these comprised three unidentified dolphins (released alive), one unidentified whale (released alive), two toothed whales (Parvorder Odontoceti; released alive), five short-finned pilot whales (*Globicephala macrorhynchus*; released alive), one long-finned pilot whale (*G. melas*; released alive), one unidentified seal (released alive) and one Australian fur seal (*Arctocephalus pusillus*; released alive).

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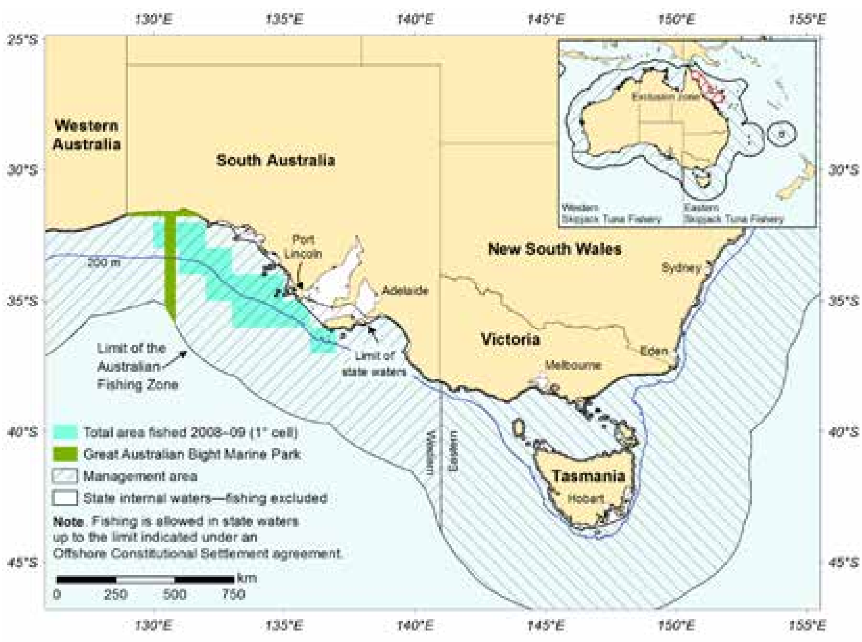
Radio beacons
AFMA

Chapter 22

Skipjack Tuna Fishery

H Patterson and A Bath

FIGURE 22.1 Area fished in the Skipjack Tuna Fishery, 2005–06 to 2015–16



Note: The last effort in the fishery occurred in 2008–09.

TABLE 22.1 Status of the Skipjack Tuna Fishery

Status	2015		2016		Comments
Biological status a,b	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Indian Ocean skipjack tuna (*Katsuwonus pelamis*)					No Australian vessels fished in 2016. Current estimates of catch in the Indian Ocean are less than MSY. Spawning biomass is above the limit reference point.
Western and central Pacific Ocean skipjack tuna (*Katsuwonus pelamis*)					No Australian vessels fished in 2016. 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 2015 or 2016. 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. **MSY** Maximum sustainable yield. **WCPO** Western and central Pacific Ocean.

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

22.1 Description of the fishery

Area fished

Two stocks of skipjack tuna (*Katsuwonus pelamis*) are thought to exist in Australian waters: one on the east coast and one on the west coast. The two stocks are targeted by separate fisheries: the Eastern Skipjack Tuna Fishery (ESTF) and the Western Skipjack Tuna Fishery (WSTF). These are collectively termed the Skipjack Tuna Fishery (STF), but the two stocks are assessed separately. The ESTF and the WSTF extend through the same area as the Eastern Tuna and Billfish Fishery (ETBF; Chapter 21), and the Western Tuna and Billfish Fishery (WTBF; Chapter 24), respectively, with the exception of an area of the ETBF off northern Queensland (Figure 22.1). Australian waters are at the edge of the species' range, with centres of abundance in the equatorial waters of the Indian and Pacific oceans. Availability of skipjack tuna in both the ESTF and the WSTF is highly variable. The Indian Ocean stock of skipjack tuna is managed under the jurisdiction of the Indian Ocean Tuna Commission (IOTC), whereas the stock found in the western and central Pacific Ocean (WCPO) is managed under the jurisdiction of the Western and Central Pacific Fisheries Commission (WCPFC).

Fishing methods and key species

Historically, the majority of fishing effort has used purse-seine gear (about 98 per cent 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.

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 harvest strategy, but have been defined in both the IOTC (on an interim basis) and the WCPFC. These reference points are consistent with those prescribed by the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007). The decision rules in the Australian harvest strategy for skipjack are not sufficient to restrict effort in a short time frame, if required, because they simply call for monitoring and revision of trigger levels. This would add a substantial time lag to any response. 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

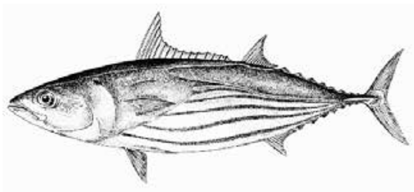
Fishery statistics a	2014–15 fishing season			2015–16 fishing season		
Fishery	**TAC (t)**	**Catch (t)**	**Value (2014–15)**	**TAC (t)**	**Catch (t)**	**Value (2015–16)**
ESTF	–	0	$0	–	0	$0
WSTF	–	0	$0	–	0	$0
Total fishery	**–**	**0**	**$0**	**–**	**0**	**$0**
Fishery-level statistics						
Effort	0			0		
Fishing permits	ESTF: 18; WSTF: 14			ESTF: 17; WSTF: 14		
Active vessels	0			0		
Observer coverage	ESTF purse seine: 0 WSTF purse seine: 0			ESTF purse seine: 0 WSTF purse seine: 0		
Fishing methods	Purse seine (predominant), pole-and-line methods (when poling is used on its own, it is managed as a minor-line component of the ETBF and the WTBF)					
Primary landing ports	None; previously Port Lincoln (South Australia) cannery, which closed in May 2010					
Management methods	Input controls: limited entry, gear (net size), area controls, transhipment controls Output controls: bycatch limits					
Primary markets	Domestic and international: currently none					
Management plan	*Skipjack Tuna Fishery management arrangements 2009* (AFMA 2009)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 July to 30 June. Real-value statistics are provided by financial year.
Notes: **ESTF** Eastern Skipjack Tuna Fishery. **ETBF** Eastern Tuna and Billfish Fishery. **TAC** Total allowable catch. **WSTF** Western Skipjack Tuna Fishery. **WTBF** Western Tuna and Billfish Fishery. – Not applicable.

Unloading skipjack tuna
Kevin McLoughlin, ABARES

22.2 Biological status

Indian Ocean skipjack tuna (*Katsuwonus pelamis*)



Line drawing: FAO

Stock structure

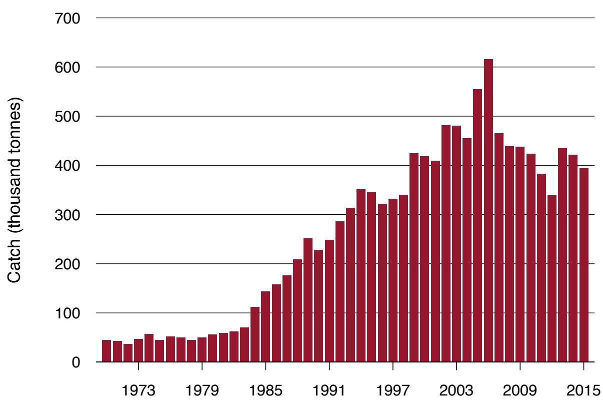
Skipjack tuna in the Indian Ocean is considered to be a single stock for stock assessment purposes. Tagging studies have shown large movements of skipjack tuna in the Indian Ocean and support the assumption of a single biological stock (IOTC 2014).

Catch history

Total catch of skipjack tuna in the Indian Ocean increased slowly from the 1950s, reaching around 50,000 t in the 1970s. With the expansion of the purse-seine fleet in the early 1980s, catch increased rapidly to a peak of 610,000 t in 2006. Since the peak, purse-seine catch has declined, particularly in the areas off Somalia, Kenya and Tanzania, and around the Maldives. A similar decline in the catch taken by Maldivian pole-and-line vessels has also occurred. 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 decreased from 421,408 t in 2014 to 393,947 t in 2015 (Figure 22.2).

Historically, effort in the WSTF has been low. Catch has been reported in just three fishing seasons in the past 10 years. 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 2015



Note: **IOTC** Indian Ocean Tuna Commission.
Source: IOTC

Stock assessment

The Indian Ocean skipjack tuna stock assessment was updated in 2014 using two methods: Stock Synthesis 3 (SS3) and a catch-based method. The SS3 assessment was used for advice on stock status, and updates the 2011 and 2012 assessments of this stock using revised input parameters and catch-per-unit-effort (CPUE) indices. However, considerable uncertainty remains in the assessment, including uncertainty in the annual catch levels, particularly for artisanal fisheries where the level of reporting is generally poor. In addition, recent declines in catch and CPUE in pole-and-line and purse-seine fisheries are not fully understood, and are therefore of some concern (IOTC 2014). Noting these uncertainties, the updated assessment indicated that the current (2013) spawning biomass (SB) was relatively high—above the level needed to achieve maximum sustainable yield (MSY; SB_{2013}/SB_{MSY} = 1.59; range 1.13–2.14) and 58 per cent of the initial unfished biomass (SB_{2013}/SB_0 = 0.58; range 0.53–0.62) (IOTC 2014). Given the difficulty in estimating fishing mortality from the model, a proxy for fishing mortality (catch; C) was used and was estimated to be below the level that would support MSY (C_{2013}/C_{MSY} = 0.62; range 0.49–0.75). The catch in the IOTC area in 2015 (393,947 t) was below the estimated level of MSY (684,000 t; range 550,000–849,000 t; Figure 22.2), and just below the five-year average of 394,298 t.

Stock status determination

Despite the uncertainties in the assessment noted above, the results of the current assessment indicate that the spawning biomass is well above the HSP limit reference point of 20 per cent of initial unfished biomass. As a result, the stock is classified as **not overfished.** The current level of the fishing mortality proxy is also below that required to achieve MSY, so the stock is classified as **not subject to overfishing.**

Western and central Pacific Ocean skipjack tuna (*Katsuwonus pelamis*)

Stock structure

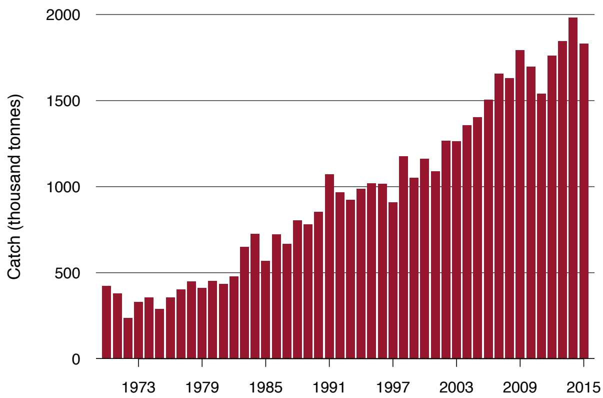
Skipjack tuna in the WCPO is considered to be a single stock for stock assessment purposes (Rice et al. 2014).

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 10 years (Figure 22.3).

Historically, effort in the ESTF has been very low. Catch has only been registered once in the past 10 years, with 44 t caught in 2005–06.

FIGURE 22.3 Skipjack tuna catch in the WCPFC area, 1970 to 2015



Note: **WCPFC** Western and Central Pacific Fisheries Commission
Source: WCPFC

Stock assessment

The skipjack tuna stock assessment for the WCPO was updated in 2016 using MULTIFAN-CL software (McKechnie et al. 2016) and incorporated three additional years of data, including a period of El Niño conditions, and the recommendations of the previous assessment (Rice et al. 2014). The outcome of the updated assessment is largely similar to that of the previous assessment. The base case in the assessment estimated that the latest (2015) spawning biomass was 58 per cent of the level predicted to occur in the absence of fishing ($SB_{latest}/SB_{F=0}$ = 0.58; range 0.39–0.68 across the base case and sensitivities) and well above the adopted limit reference point of 0.2 $SB_{F=0.}$ Current fishing mortality (2011 to 2014 average) was estimated to be below the fishing mortality that will support MSY ($F_{current}/F_{MSY}$ = 0.45; range 0.38–0.64 across the base case and sensitivities). In 2015, the catch in the WCPFC area was 1,831,440 t; this is below the updated estimate of MSY (1,891,000 t; Figure 22.3). The 2015 catch was above the five-year average of 1,791,788 t.

Stock status determination

The results of the assessment indicate that the spawning biomass is relatively high and above the WCPFC limit reference point of 20 per cent 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, no net economic returns (NER) have been generated. Few vessels have fished in either the ESTF or the WSTF since 2003–04, suggesting that there is little economic incentive to fish and therefore low NER during this period.

Opportunistic fishing was previously prominent in the STF, since the stock availability in Australian waters is highly variable from year to year. Historically, effort has largely depended on both fish availability and the existence of a domestic tuna canning market. Currently, there is no domestic cannery with active contracts for skipjack tuna.

Management arrangements

The harvest strategy in place for the fishery is based on catch-level triggers that initiate management action and close monitoring of the fishery once catches exceed a certain level. Currently, 17 permits are issued in the ESTF and 14 in the WSTF. These are held by 15 companies, 7 of which hold one or more permits for both fisheries (AFMA 2016, 2017). 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 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 where 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 the low levels of activity in the fishery in recent years (no catch 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* (EPBC Act). Approval is on the condition that the Australian Fisheries Management Authority reviews its 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 et al. 2009). However, 25 species of marine mammals were identified as high risk in the level 2 ERA process (Daley et al. 2007). Mammals were not considered in the level 3 assessment. The ecological risk management report for the fishery is therefore designed to achieve adequate monitoring to establish the level of interaction that may occur if effort increases, and to quantify the effect of the fishery on the marine mammal species identified as being at high risk (AFMA 2010).

To date, no interactions have been recorded of skipjack tuna purse-seine nets with species protected under the EPBC Act, such as marine mammals or turtles.

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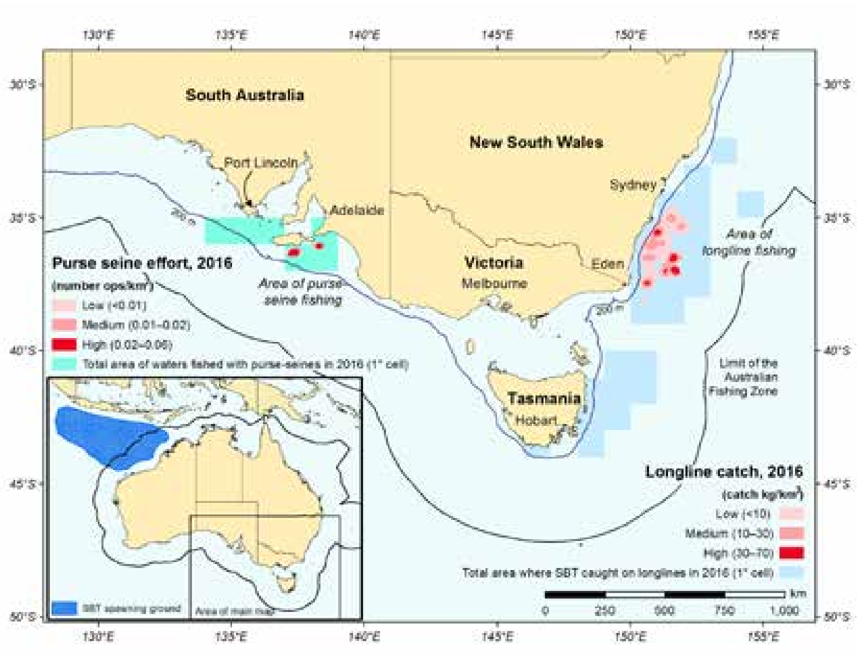
Chapter 23

Southern Bluefin Tuna Fishery

H Patterson, S Nicol and R Curtotti

FIGURE 23.1 Purse-seine effort and longline catch in the Southern Bluefin Tuna Fishery, 2016



Note: **SBT** Southern Bluefin Tuna.

TABLE 23.1 Status of the Southern Bluefin Tuna Fishery

Status	2015		2016		Comments a
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Southern bluefin tuna (*Thunnus maccoyii*)					The estimate of spawning biomass is well below 20% of unfished biomass. The global TAC, set in line with the management procedure, should allow rebuilding. Significant uncertainty remains around unaccounted catch, which, if occurring, would reduce the probability of the stock rebuilding.
Economic status	NER are expected to have remained positive. 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 (DAFF 2007) 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

Southern bluefin tuna
Matt Daniel, AFMA

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) 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). The majority of the Australian catch is taken in the Great Australian Bight, with smaller amounts 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) 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 (DAFF 2007) 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), which is analogous to a harvest strategy, and this has been used to set the global total allowable catch (TAC) since 2012. The management procedure aims to achieve rebuilding of the southern bluefin tuna stock to 20 per cent of its initial unfished biomass (the interim rebuilding target) by 2035, with 70 per cent probability. The global TAC is allocated to members and cooperating non-members as agreed by the CCSBT under the 2011 CCSBT Resolution on the Allocation of the Global Total Allowable Catch. The Australian Fisheries Management Authority (AFMA) sets the TAC for the SBTF in accordance with Australia's allocation.

The Commission has noted that levels of unaccounted mortality may be substantial in the global fishery. A high level of unaccounted mortality may constitute exceptional circumstances because it was not taken into consideration when the management procedure was developed. The Commission has agreed to a definition of attributable mortality, and members have agreed to manage all sources of mortality within their national allocations. The Commission is also working to better account for non-member catch.

Fishing effort

Most of the Australian catch and effort 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 relatively stable, ranging from five to eight since the 1994–95 fishing season. In 2009, and 2011 to 2016, the catch was taken more to 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 has been more variable over time. 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, but has been relatively 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, the global TAC has increased.

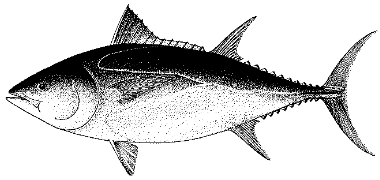
TABLE 23.2 Main features and statistics for the SBTF

Fishery statistics a	**2014–15 fishing season**			**2015–16 fishing season**		
Fishery/sector	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Purse seine	5,557 **b**	4,947	$33.90 million	5,703 **c**	4,904	$30.57 million
Pelagic longline	–	572 **d**	$3.39 million	–	731 **d**	$5.27 million
Total fishery	**5,557**	**5,519**	**$37.29 million**	**5,703**	**5,636**	**$37.29 million**
Fishery-level statistics						
Effort **e**	Purse seine: 1,016 search hours; 154 shots			Purse seine: 906 search hours; 127 shots		
Fishing permits	89 SFR owners initially allocated			89 SFR owners initially allocated		
Active vessels	Purse seine: 6 Longline: 18			Purse seine: 6 Longline: 19		
Observer coverage **f**	Purse seine: 14 shots (9.1%) Longline: 5.87% in ETBF; 7.22% in WTBF			Purse seine: 25 shots (18.9%) Longline: 8.7% (of hooks) in ETBF; 10.2% (of hooks) in WTBF		
Fishing methods	Purse seine, pelagic longline (southern bluefin tuna is a byproduct in the longline fishery), 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. Real-value statistics are by financial year. **b** Australia voluntarily reduced its effective TAC for 2014–15 by 108 t, to account for overcatch in the 2013–14 season. The actual TAC set by the AFMA Commission was 5,665 t. **c** Australia carried forward ~38 t of undercatch to the 2015–16 TAC. The TAC set by the AFMA Commission was 5,665 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 by both human observers and the electronic monitoring system in 2014–15, and electronic monitoring only in 2015–16.
Notes: **ETBF** Eastern Tuna and Billfish Fishery. **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch. **WTBF** Western Tuna and Billfish Fishery. – Not applicable.

23.2 Biological status

Southern bluefin tuna (*Thunnus maccoyii*)



Line drawing: FAO

Stock structure

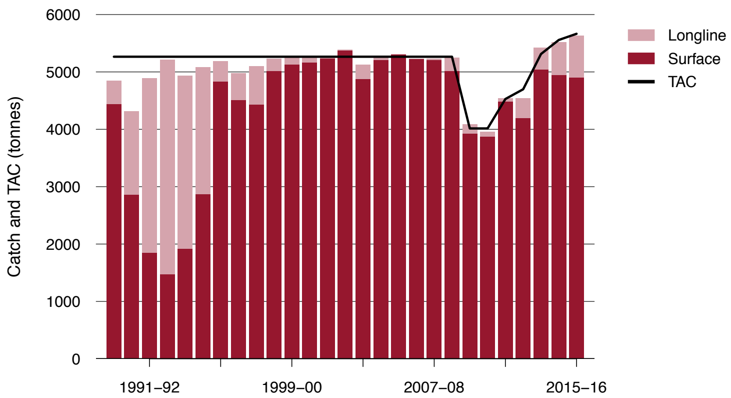
Southern bluefin tuna constitutes a single, highly migratory stock that spawns in the north-east Indian Ocean (off north-western Australia, south of Indonesia; Figure 23.1) and migrates throughout the temperate southern oceans.

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. Reported global catch peaked in the early 1960s at more than 80,000 t before declining steadily until around 2007 (Figure 23.3).

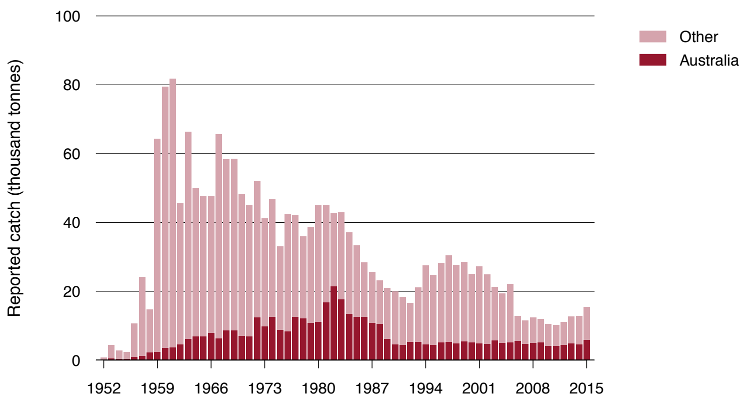
Recreational angling for southern bluefin tuna in Australia has been popular among game fishers for many years, and activity among the general recreational fishing sector has increased in recent years (for example, Rowsell et al. 2008). At present, the data available on the recreational catch of southern bluefin tuna are limited, 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 per cent (Giri & Hall 2015). In 2015, a report on methods to estimate recreational catch of southern bluefin tuna was released (Moore et al. 2015). A national survey, based on this methodology, is currently under consideration.

FIGURE 23.2 Southern bluefin tuna catch and TAC (Australia), 1989–90 to 2015–16



Note: **TAC** Total allowable catch.
Source: Australian Fisheries Management Authority

FIGURE 23.3 Southern bluefin tuna catch (global), 1952 to 2015



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: Commission for the Conservation of Southern Bluefin Tuna

Stock assessment

The management procedure specifies that a full quantitative stock assessment should be undertaken every three years; 2014 was the first full assessment since the 2011 adoption of the management procedure. In 2014, 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 2014). The updated assessment incorporated the results of studies of close-kin genetics (Bravington et al. 2014) and the most recent data, including a scientific aerial survey index of the relative abundance of juveniles. The previous (2011) assessment reported the estimated biomass of fish 10 years and older (B10+) as a proxy for spawning biomass. Information from the close-kin genetics study indicated that fish as young as eight years of age may spawn as well, although probably not every year. Therefore, the 2014 assessment provided a revised estimate of spawning stock biomass, which took into account relative fecundity, residency time on the spawning grounds and resting times, which vary with age. Thus, although the rebuilding target of the management procedure was specified in terms of the B10+ group as spawning biomass, the updated assessment also provided an estimate of the newly defined spawning group. This newly defined group includes younger fish than the B10+ group and results in an increase in the size of the spawning stock estimate.

The 2014 assessment examined a range of sensitivity tests, including scenarios for unaccounted catch mortalities. The potential sources of unaccounted catch mortalities included recreational catches, unreported catch by members and non-members, mortalities of releases, and discarding of fish. The CCSBT Extended Scientific Committee noted that it was constrained by the lack of information and data on sources of unaccounted mortalities, and so developed a set of scenarios for sensitivity tests.

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 per cent of the unfished level. Spawning stock biomass (B8+ group) was estimated at 9 per cent of the initial unfished level (80 per cent confidence interval [CI] 8 to 12 per cent) and below the level needed to produce the maximum sustainable yield (MSY; CCSBT 2014). The spawning stock biomass of the B10+ group was estimated to be at 7 per cent of initial levels (80 per cent CI 6 to 9 per cent); the 2011 estimate was 5 per cent of initial levels (CCSBT 2014). The ratio of current fishing mortality to the level associated with MSY (F_{MSY}) was 0.66 (range 0.39–1.00).

The estimates of current stock status varied little across the sensitivity tests, including the scenarios for unaccounted mortalities. However, the unaccounted mortality scenarios impacted on projections under the management procedure. Projections based on the reference set had a probability of rebuilding by 2035 of 74 per cent, which is in line with the 70 per cent probability level set by the CCSBT. The unaccounted mortality scenarios reduced the probability of rebuilding below the 70 per cent level. The most substantial impact was the scenario that included 1,000 t of large fish, 1,000 t of small fish and a 20 per cent underestimate of the Australian purse-seine catch. This scenario reduced the probability of rebuilding to 49 per cent. These levels of unaccounted mortality were not considered in the design of the management procedure, and the Extended Scientific Committee noted that, if they were true, they would amount to exceptional circumstances.

Stock status determination

The current mean estimate for spawning stock biomass of southern bluefin tuna is 9 per cent of unfished levels. As a result, the stock remains classified as **overfished.**

The global TAC that was set for 2016 was based on the management procedure's recommendation, 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. However, there remains substantial uncertainty about the level of unaccounted catch mortality and its potential impact on stock rebuilding.

The reported 2014 global catch indicated that some members had exceeded their allocation. In addition, the Extended Scientific Committee considered the sources of unaccounted catch mortality extensively at the 2014 meeting, with new sensitivity tests added to the operating model. Further information was considered at the 2015 meeting of the Extended Scientific Committee. The total level of mortality from all sources (including releases and discards from the high-seas longline fleets, recreational fishing catch, and unreported catches by non-members and members) is unknown. However, the Extended Scientific Committee noted that it appeared that significant levels of unaccounted mortality may have occurred, and for some scenarios there was a substantial impact on the probability of achieving the rebuilding target by 2035. Therefore, it was uncertain whether the total level of fishing mortality was at the level required for rebuilding to occur in line with the management procedure. Given the uncertainty around the current level of fishing mortality and the impact on the recovery of the stock, the stock is classified as **uncertain** with regard to fishing 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.

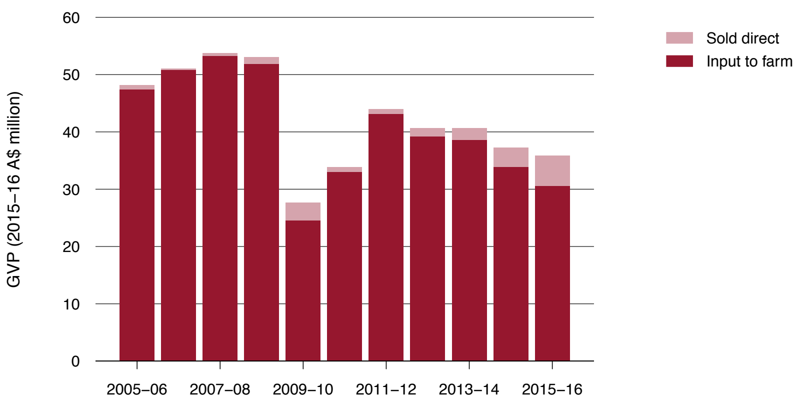
In 2015–16, the gross value of production (GVP) for the SBTF—the value of the catch at the point of transfer to farming pens—was estimated as $35.8 million (Figure 23.4). This is 4 per cent lower (in real terms, 2015–16 dollars) than the value of production estimated for 2014–15. In 2015–16, export unit prices achieved for farm-gate product continued to decline—by 9 per cent, to $13.92 per kilogram—placing downward pressure on beach prices. It was the third consecutive year in which real export unit value declined for farm-gate product. In real terms, the export unit value in 2015–16 was the lowest level achieved over the 10-year period to 2015–16, and well below the average level of $21.50 achieved in the period 2005–06 to 2012–13.

The estimated value of the SBTF catch declined substantially (by 48 per cent) in 2009–10, to $28 million, following a reduction in the estimated average unit beach price from $10.47 per kilogram in 2008–09 to $6.71 per kilogram in 2009–10 (in real terms, 2015–16 dollars), and a 19 per cent decline in the quantity of southern bluefin tuna caught in the fishery. Prices then recovered, with the estimated average beach price being around $8.85 per kilogram from 2010–11 to 2013–14, and production quotas increased. Since 2013–14, GVP has declined by 12 per cent, in line with lower unit export prices achieved for farm-gate product.

The SBTF typically has very little quota latency within a fishing season, indicating that net economic returns (NER) are likely to be positive. However, in 2015–16, GVP declined, indicating that the NER of the fishery are likely to have declined in 2015–16.

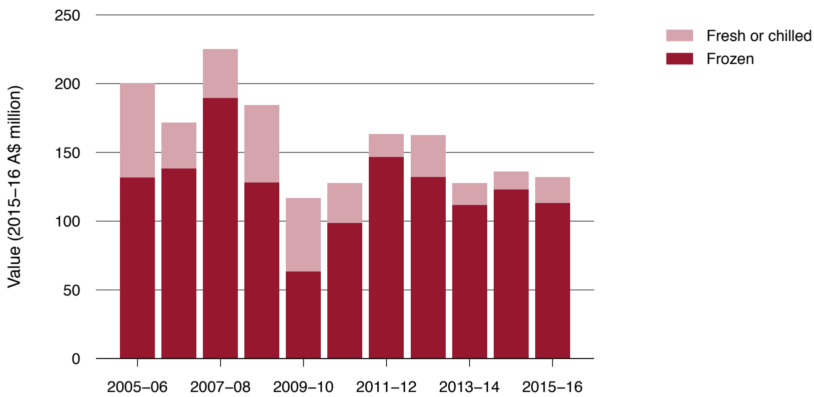
The value of farmed southern bluefin tuna exports in 2015–16 (after ranching) was $132 million, a decrease of $4 million from the value achieved in 2014–15 ($136 million). Most of the farmed southern bluefin tuna is exported, mainly to Japan. In 2015–16, the Australian dollar unit price for exported southern bluefin tuna decreased by 9 per cent, despite a fall in the exchange rate of the Australian dollar relative to the yen. Export returns were supported by an increase in the volume exported, but not enough to offset the negative effect on returns from lower unit prices (Figure 23.5).

FIGURE 23.4 Real GVP of southern bluefin tuna production, 2005–06 to 2015–16



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

FIGURE 23.5 Real value of southern bluefin tuna exports, by processing method, 2005–06 to 2015–16



Management arrangements

The Australian TAC is allocated to holders of statutory fishing rights in the fishery via individual transferable quotas (ITQs). The ITQs give fishers flexibility to use input combinations that result in the most efficient operation. Theoretically, transferability of ITQs between fishers also allows the catch to be taken by the most efficient operators in the fishery, since quota is expected to gravitate to the most efficient operators. However, other factors are often considered by quota holders when deciding to lease or sell quota, sometimes resulting in quota not being allocated to the most efficient user. This may limit quota transaction activity between the purse-seine operators and longline operators in some years.

Performance against economic objective

The SBTF 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. If current management arrangements allow the southern bluefin tuna stock to rebuild, this would be considered an improvement in the fishery's economic status. The management procedure is a significant step in the right direction. Because the procedure was only recently introduced, it is too early to assess its impact on economic performance.

23.4 Environmental status

The SBTF has approval for export until 13 December 2019. Conditions placed on the export approval include increasing confidence in the estimates of purse-seine catches, and that the management arrangements start accounting for Australia's attributable catch, including recreational and Indigenous catch, by 2018.

A level 3 ecological risk assessment (Sustainability Assessment for Fishing Effects) of 83 non-target species (6 chondrichthyans and 77 teleosts) to determine the impact of southern bluefin tuna fishing on these species assessed the risk as low (Zhou et al. 2009). The priority of the ecological risk management report is to respond to interactions with protected species (AFMA 2009).

No interactions with protected species were reported for the SBTF in 2016. Interactions with sharks and other protected species using longline gear are discussed in Chapters 21 and 24.

Southern bluefin tuna in the tow cage
Matt Daniel, AFMA

23.5 References

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Chapter 24

Western Tuna and Billfish Fishery

A Williams, H Patterson and A Bath

FIGURE 24.1 Area of the Western Tuna and Billfish Fishery, 2016

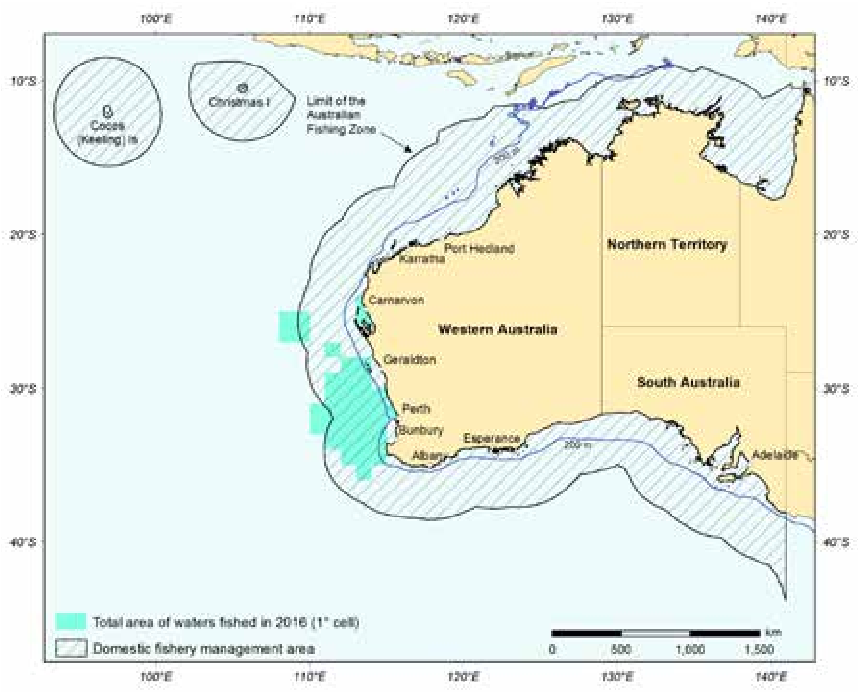


TABLE 24.1 Status of the Western Tuna and Billfish Fishery

Status	2015		2016		Comments
Biological status a	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Striped marlin (*Kajikia audax*)					Most recent estimate of biomass is above the default Commonwealth limit reference point. Current fishing mortality rate exceeds that required to produce MSY.
Swordfish (*Xiphias gladius*)					Most recent estimate of spawning biomass is above the default Commonwealth limit reference point. Current fishing mortality rate is below that required to produce MSY.
Albacore (*Thunnus alalunga*)					Most recent estimate of spawning biomass is above the default Commonwealth limit reference point. Current fishing mortality rate is below that required to produce MSY.
Bigeye tuna (*Thunnus obesus*)					Most recent estimate of spawning biomass is above the default Commonwealth limit reference point. Current fishing mortality rate is below that required to produce MSY.
Yellowfin tuna (*Thunnus albacares*)					Most recent estimate of spawning biomass is above the default Commonwealth limit reference point. Current fishing mortality rate exceeds that required to produce MSY.
Economic status	Latency remained high in 2016, with only a small proportion of the TACC caught, suggesting low NER.				

a Ocean-wide assessments and the default limit reference points from the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007) are used as the basis for status determination.
Notes: **MSY** Maximum sustainable yield. **NER** Net economic returns. **TACC** Total allowable commercial catch.

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 the high seas of the Indian Ocean (Figure 24.1). In recent years, effort has concentrated off south-west Western Australia and South Australia. Domestic management arrangements for the WTBF reflect Australia's commitment to the Indian Ocean Tuna Commission (IOTC; see Chapter 20).

Fishing methods and key species

Key species in the WTBF are bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), striped marlin (*Kajikia audax*) and swordfish (*Xiphias gladius*). Some albacore (*Thunnus alalunga*) is also taken. Fishing in the WTBF mainly uses pelagic longline; some minor-line fishing also occurs (Table 24.2).

Management methods

The management plan for the fishery began in 2005, although the Australian Fisheries Management Authority (AFMA) first granted statutory fishing rights in 2010. Under the management plan, output controls have been implemented in the fishery through individual transferable quotas (ITQs) for the four key commercial species. 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 has been developed for the WTBF (Davies et al. 2008), with the intention that it be implemented if fishing effort increases in the fishery and sufficient data are available for use in the strategy. The framework includes a decision tree that defines rules and subsequent adjustments to the recommended biological catch (or level of fishing mortality) in response to standardised size-based catch rates.

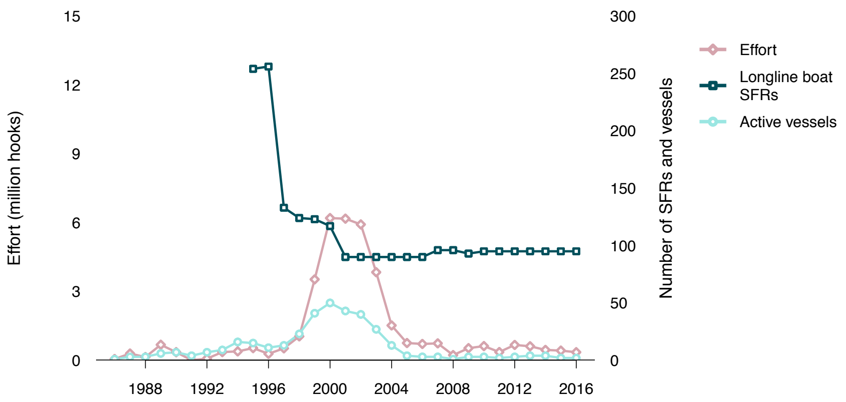
The default limit reference points contained in the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007) are used to determine stock status in the WTBF. The limit reference point for biomass is 20 per cent of the unfished biomass ($0.2B_0$), and for fishing mortality the limit reference point 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.

As of 1 July 2015, electronic monitoring (e-monitoring) was made mandatory for all full-time pelagic longline vessels in the Eastern Tuna and Billfish Fishery and the WTBF. At least 10 per cent of video footage of all hauls is reviewed to verify the accuracy of logbooks, which are required to be completed for 100 per cent 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 five vessels have been active in the fishery each year.

FIGURE 24.2 Longline fishing effort, boat statutory fishing rights and active vessels in the WTBF, 1986 to 2016

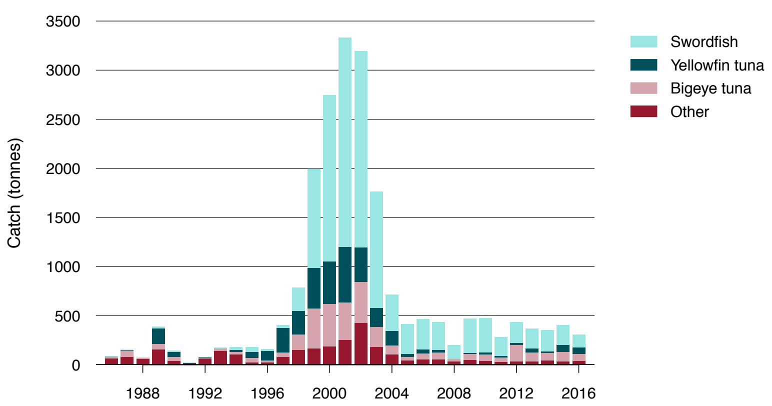


Note: **SFR** Statutory fishing rights.
Source: Australian Fisheries Management Authority

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 2016



Source: Australian Fisheries Management Authority

TABLE 24.2 Main features and statistics for the WTBF

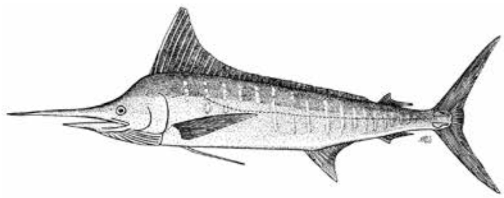
Fishery statistics a	2015			2016		
Stock	**TACC (t)**	**Catch (t)**	**Value (2014–15)**	**TACC (t)**	**Catch (t)**	**Value (2015–16)**
Striped marlin	125	2	Confidential	125	1	Confidential
Swordfish	3,000	220	Confidential	3,000	147	Confidential
Albacore	–	27	Confidential	–	23	Confidential
Bigeye tuna	2,000	109	Confidential	2,000	75	Confidential
Yellowfin tuna	5,000	82	Confidential	5,000	74	Confidential
Total	**10,125**	**440**	**Confidential**	**10,125**	**320**	**Confidential**

Fishery-level statistics		
Effort	Pelagic longline: 421,185 hooks Minor line: na	Pelagic longline: 352,274 hooks Minor line: na
Fishing permits	95 boat SFRs	95 boat SFRs
Active vessels	Pelagic longline: 2 Minor line: 1	Pelagic longline: 2 Minor line: 1
Observer coverage	7.1% **b**	10.2% **b**
Fishing methods	Pelagic longline (monofilament mainline), minor line (handline, rod and reel, troll and poling), purse seine	
Primary landing ports	Fremantle and Geraldton (Western Australia)	
Management methods	Input controls: limited entry, gear and area restrictions Output controls: TACCs, ITQs, byproduct restrictions	
Primary markets	International: Japan, United States—fresh, frozen Domestic: fresh, frozen	
Management plan	*Western Tuna and Billfish Management Plan 2005* (amended 2016); SFRs issued 2010	

a Fishery statistics are provided by calendar year to align with international reporting requirements. Value statistics are by financial year and are in 2015–16 dollars. **b** As of 1 July 2015, e-monitoring was made mandatory for all full-time pelagic longline vessels in the WTBF. At least 10% of video footage of all hauls are reviewed to verify the accuracy of logbooks, which are required to be completed for 100% of shots.
Notes: **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing right. **TACC** Total allowable commercial catch. – Not applicable.

24.2 Biological status

Striped marlin (*Kajikia audax*)



Line drawing: FAO

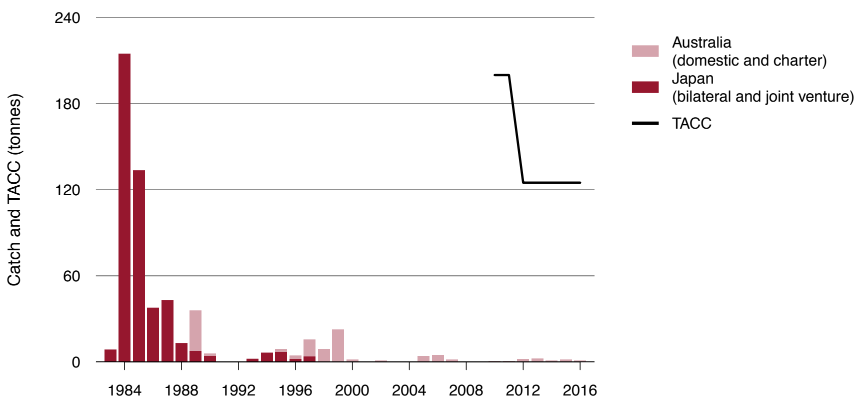
Stock structure

The stock structure of striped marlin in the Indian Ocean is uncertain, but the species is considered to be a single distinct biological stock for assessments. No genetic studies have evaluated striped marlin population structure in the Indian Ocean, and tagging efforts have been limited. Several transoceanic movements of striped marlin have occurred in the Indian Ocean, supporting the assumption of a single biological stock (IOTC 2014).

Catch history

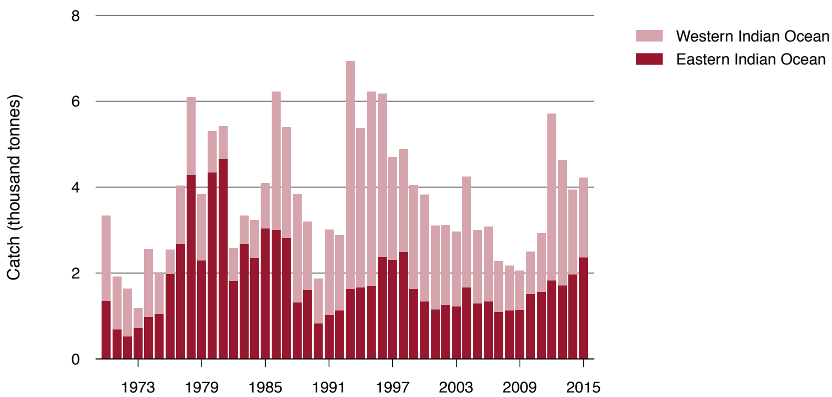
Catches of striped marlin in the WTBF have always been relatively low—less than 50 t since the mid 1980s and very low (<5 t) in recent years, with 2 t taken in 2015 and 1 t in 2016 (Figure 24.4). Total international catches in the IOTC area of competence declined from around 6,000 t in 1995 to around 2,000 t in 2009 (Figure 24.5). Annual catches have increased since 2009, reaching 4,213 t in 2015, which is below the 2015 estimate of MSY (5,220 t).

FIGURE 24.4 Striped marlin catch and TACC in the WTBF, 1983 to 2016



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: Australian Fisheries Management Authority

FIGURE 24.5 Striped marlin catch in the IOTC area, 1970 to 2015



Note: **IOTC** Indian Ocean Tuna Commission.
Source: IOTC

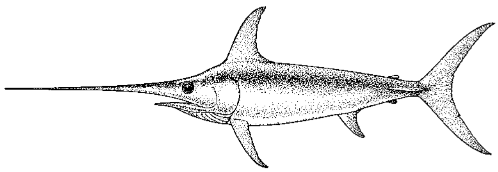
Stock assessment

Stock assessments for striped marlin were made most recently in 2015 at the IOTC Working Party on Billfish. Three models were used: A Stock Production Model Incorporating Covariates (ASPIC), a Bayesian surplus production model and a stock reduction analysis. Results from the ASPIC model were used to provide management advice, although all models provided similar conclusions regarding stock status. The 2014 biomass was estimated to be 24 per cent of unfished (1950) levels (B_{2014}/B_{1950} = 0.24) and below the level that would support MSY (B_{2014}/B_{MSY} = 0.65; range 0.45–1.17) (IOTC 2016). Fishing mortality was estimated to be above the level that would result in MSY (F_{2014}/F_{MSY} = 1.09; range 0.62–1.66).

Stock status determination

The ASPIC assessment indicates that the current biomass is above the default limit reference point ($0.2B_0$). As a result, the Indian Ocean striped marlin stock is classified as **not overfished.** Fishing mortality is above F_{MSY}, so the stock is classified as **subject to overfishing.**

Swordfish (*Xiphias gladius*)



Line drawing: Gavin Ryan

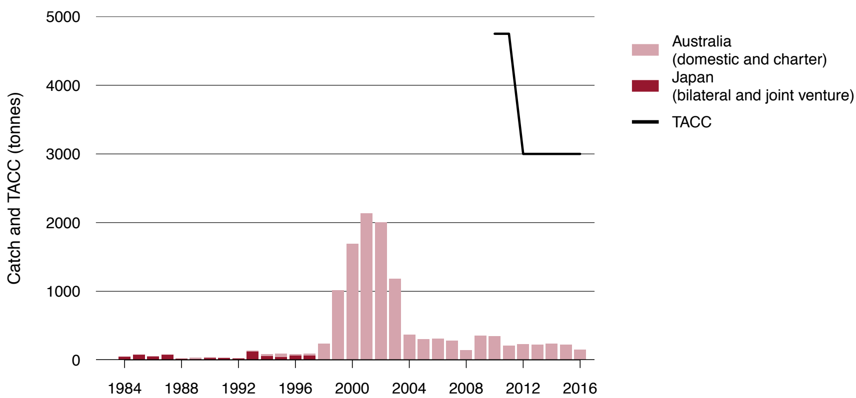
Stock structure

Swordfish in the Indian Ocean is considered to be a single distinct biological stock. The possibility of a separate south-west Indian Ocean stock was examined in the Indian Ocean Swordfish Stock Structure project—a genetic study focused on the links between the south-west and other regions. The study found that genetic markers were consistent with a single stock in the Indian Ocean (Muths et al. 2013).

Catch history

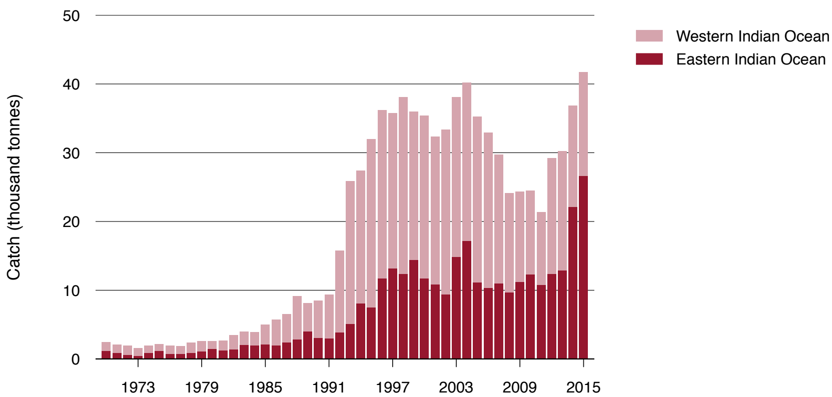
Annual swordfish catch in the WTBF peaked at around 2,000 t in the early 2000s but has declined to below 350 t since 2005. In 2016, the annual catch was 147 t, the lowest level since 1997 (Figure 24.6). Total international catches of swordfish in the IOTC area of competence peaked in 2004 at more than 40,000 t, but declined to around 21,000 t in 2009 (Figure 24.7), likely as a result of the impacts of piracy in the western Indian Ocean. Annual catches in the IOTC area of competence have increased since 2009, reaching the highest level on record in 2015 at 41,743 t, which is above the 2015 estimate of MSY (39,400 t).

FIGURE 24.6 Swordfish catch and TACC in the WTBF, 1983 to 2016



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: Australian Fisheries Management Authority

FIGURE 24.7 Swordfish catch in the IOTC area, 1970 to 2015



Note: **IOTC** Indian Ocean Tuna Commission.
Source: IOTC

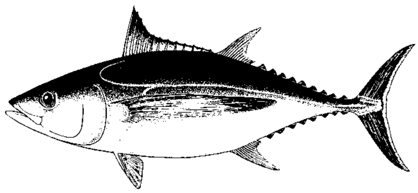
Stock assessment

In 2014, four assessment models were used to assess to the Indian Ocean–wide swordfish stock: Stock Synthesis 3 (SS3), ASPIC, a Bayesian Biomass Dynamic Model (BBDM) and an Age-Structured Integrated Analysis (IOTC 2016). The SS3 assessment was considered to be the most reliable and informative for determining the current status of the stock. The 2013 spawning biomass for the Indian Ocean–wide stock was estimated to be 74 per cent of unfished (1950) biomass ($SB_{2013}/SB_{1950} = 0.74$; range 0.58–0.89) and well above the level that supports MSY ($SB_{2013}/SB_{MSY} = 3.10$; range 2.44–3.75) (IOTC 2016). Fishing mortality was estimated to be well below F_{MSY} ($F_{2013}/F_{MSY} = 0.34$; range 0.28–0.40).

Stock status determination

Assessments of the ocean-wide stock indicate that swordfish biomass is above the default limit reference point ($0.2B_0$) and that fishing mortality is below F_{MSY}. As a result, the stock is classified as **not overfished** and **not subject to overfishing.**

Albacore (*Thunnus alalunga*)



Line drawing: FAO

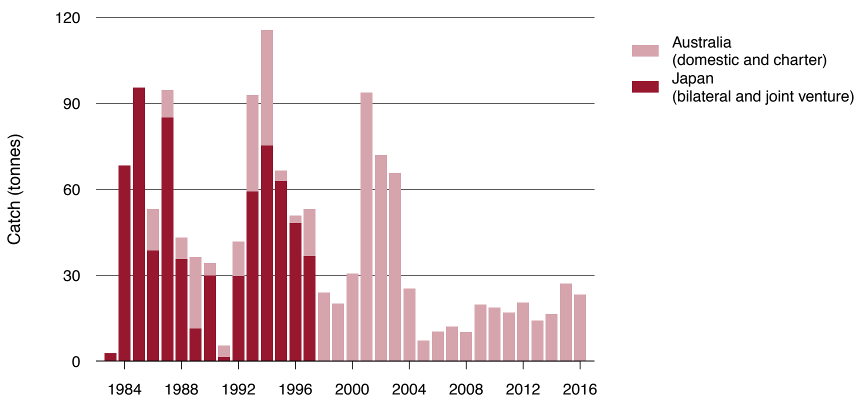
Stock structure

The stock structure of albacore in the Indian Ocean is uncertain, but the species is assumed to be a single biological stock for assessments. A global genetics study of albacore found that the Atlantic Ocean and Indian Ocean populations were not genetically distinguishable, and found no evidence of genetic heterogeneity within the Indian Ocean (Montes et al. 2012). However, the study was based on relatively small sample sizes, and samples were not collected across the entire distribution of albacore in the Indian Ocean. Two distinct stocks of albacore occur in the Atlantic and Pacific oceans, associated with distinct northern and southern ocean gyres. There is no northern gyre in the Indian Ocean, supporting the assumption of a single Indian Ocean albacore stock (IOTC 2014).

Catch history

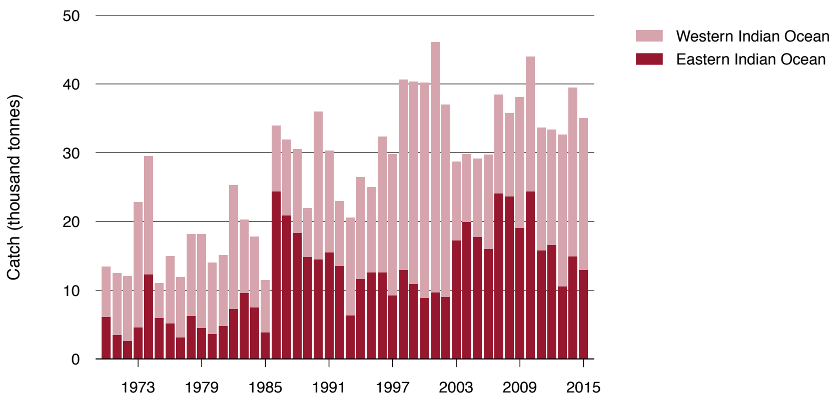
Historically, albacore catches in the WTBF have been low, peaking at 115 t in 1994 and again at 94 t in 2001 (Figure 24.8). Since 2004, annual catches have been below 30 t. Total international catches in the IOTC area of competence peaked at more than 46,000 t in 2011, and have fluctuated between 30,000 t and 45,000 t since (Figure 24.9). The average annual catch over the past five years (2011–15) was approximately 35,000 t, which is lower than the 2015 estimate of MSY (38,800 t).

FIGURE 24.8 Albacore catch in the WTBF, 1983 to 2016



Source: Australian Fisheries Management Authority

FIGURE 24.9 Albacore catch in the IOTC area, 1970 to 2015



Note: **IOTC** Indian Ocean Tuna Commission.
Source: IOTC

Stock assessment

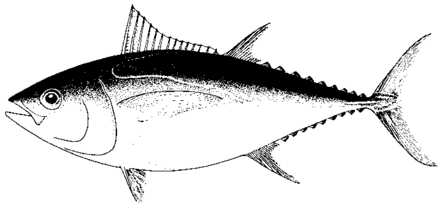
In 2016, five assessment models were used to assess the Indian Ocean albacore stock: SS3, ASPIC, a Statistical Catch at Age Model (SCAA), a Bayesian State-Space Production Model (BSPM) and a BBDM. The results from the SS3 model were used to determine the current status of albacore (IOTC 2016), although the results from all the models were generally consistent. Considerable uncertainty exists in the SS3 model results because of uncertainty in catch-per-unit-effort data and length composition data, and a lack of biological information on albacore stocks in the Indian Ocean (IOTC 2016).

The result of the SS3 model indicated that the current (2014) biomass was above the limit reference point (SB_{2014}/SB_{1950} = 0.37; range 0.28–0.46) and above the level that supports MSY (SB_{2014}/SB_{MSY} = 1.80; range 1.38–2.23). Fishing mortality was estimated to be below the level that supports MSY (F_{2014}/F_{MSY} = 0.85; range 0.57–1.12) (IOTC 2016).

Stock status determination

The assessment indicates that the spawning biomass is above the default limit reference point ($0.2B_0$), and so the stock is classified as **not overfished**. Fishing mortality across the entire IOTC area is below F_{MSY}, and so the stock is classified as **not subject to overfishing**.

Bigeye tuna (*Thunnus obesus*)



Line drawing: FAO

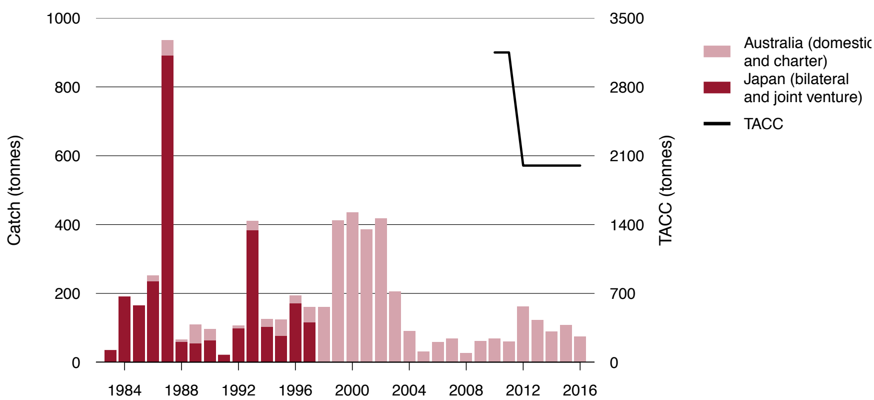
Stock structure

The stock structure of bigeye tuna in the Indian Ocean is uncertain, but the species is considered to be a single distinct biological stock for assessments. The assumption of a single stock is based on a genetic study (Chiang et al. 2008) that indicated no genetic differentiation within the Indian Ocean, and tagging studies that have demonstrated large-scale movements of bigeye tuna (IOTC 2014).

Catch history

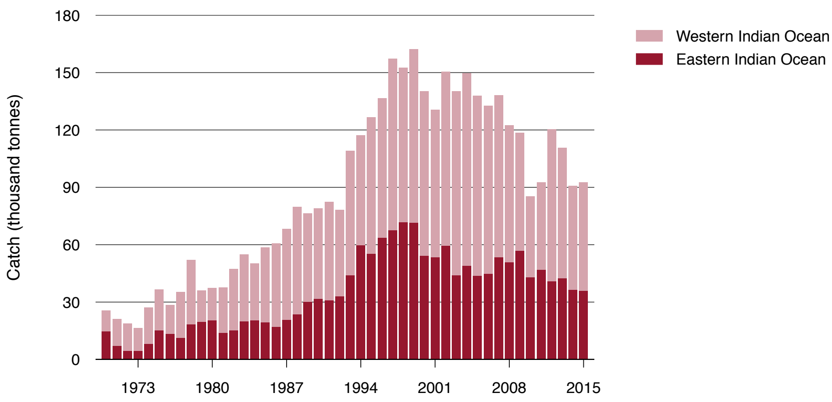
Annual catches of bigeye tuna in the WTBF varied widely between 1983 and 2004, with the highest catch of more than 900 t in 1987 and the lowest catch of less than 22 t in 1991 (Figure 24.10). Catches have been more stable since 2004, and have not exceeded 200 t. Total international catches in the IOTC area of competence have been declining 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 92,672 t in 2015, which is below the 2015 MSY estimate of 132,000 t, as is the five-year average catch.

FIGURE 24.10 Bigeye tuna catch and TACC in the WTBF, 1983 to 2016



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: Australian Fisheries Management Authority

FIGURE 24.11 Bigeye tuna catch in the IOTC area, 1970 to 2015



Note: **IOTC** Indian Ocean Tuna Commission.
Source: IOTC

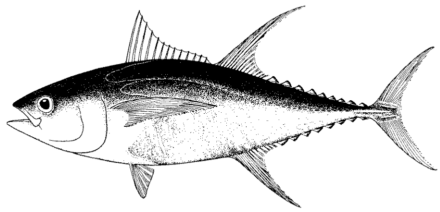
Stock assessment

Six assessment models were used to assess the Indian Ocean bigeye stock in 2016: SS3, ASPIC, SCAA, an Age Structured Assessment Program (ASAP), a BBDM and a BSPM (IOTC 2016). The results from these assessments were similar to 2014 assessments, although with lower relative biomass and higher relative fishing mortality. The SS3 assessment captured uncertainty in the stock–recruitment relationship, as well as the influence of tagging data on the model outcomes, and was used to provide management advice. Current (2015) spawning stock biomass was estimated to be above the level that would produce MSY (SB_{2015}/SB_{MSY} = 1.29; range 1.07–1.51). Similarly, the assessment indicated that spawning biomass was above 20 per cent of the initial unfished level (SB_{2015}/SB_0 = 0.38; range not available). Fishing mortality was below the level associated with MSY (F_{2015}/F_{MSY} = 0.76; range 0.49–1.03).

Stock status determination

The SS3 assessment indicates that bigeye tuna spawning stock biomass is above the default limit reference point ($0.2B_0$). As a result, the Indian Ocean bigeye tuna stock is classified as **not overfished.** Since the current spawning biomass is above the level that would produce MSY, and fishing mortality is below F_{MSY}, the stock is classified as **not subject to overfishing.**

Yellowfin tuna (*Thunnus albacares*)



Line drawing: FAO

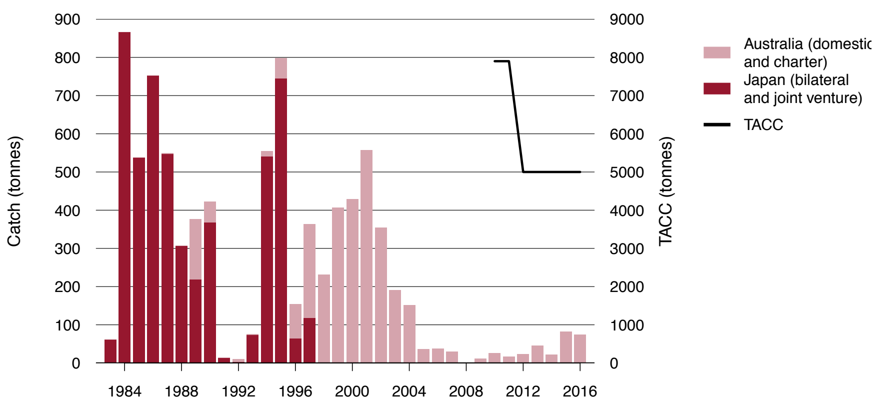
Stock structure

The stock structure of yellowfin tuna in the Indian Ocean is uncertain, but the species is considered to be a single biological stock for assessments. There have been no ocean-wide genetic studies for yellowfin tuna in the Indian Ocean, but tagging studies have demonstrated large-scale movements of yellowfin tuna in the Indian Ocean, which is consistent with the assumption of a single stock (Langley et al. 2012).

Catch history

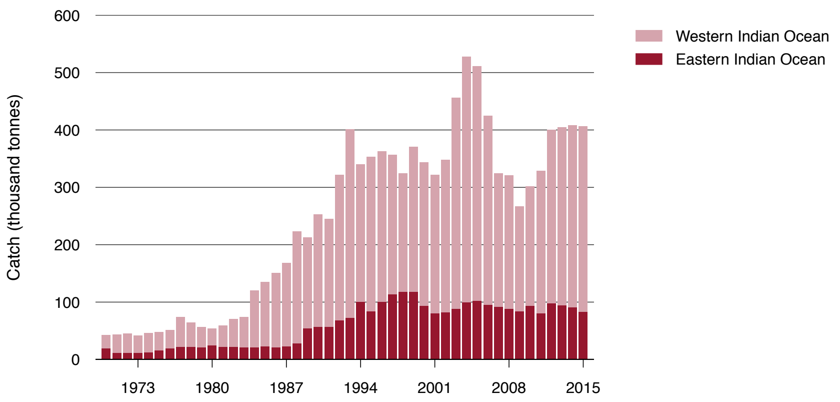
Historical catches of yellowfin tuna in the WTBF have varied widely from peaks of around 800 t in 1984 and 1995 to catches less than 15 t in 1991 and 1992 (Figure 24.12). Since the early 2000s, declining effort in the WTBF has resulted in reduced catches of yellowfin tuna. Catches have not exceeded 100 t since 2004 (Figure 24.12). Total international catches in the IOTC area of competence have generally increased with increasing demand, but declined for several years (2007–2011) because of the impacts of piracy in the north-west Indian Ocean. From 2012 to 2015, catches have remained relatively stable at around 400,000 t (Figure 24.13), which is slightly below the 2015 MSY estimate of 421,000 t.

FIGURE 24.12 Yellowfin tuna catch and TACC in the WTBF, 1983 to 2016



Note: **TACC** Total allowable commercial catch; initial TACC for 19 months.
Source: Australian Fisheries Management Authority

FIGURE 24.13 Yellowfin tuna catch in the IOTC area, 1970 to 2015



Note: **IOTC** Indian Ocean Tuna Commission.
Source: IOTC

Stock assessment

In 2016, the 2015 yellowfin tuna assessment was updated using a revised composite catch-per-unit-effort series and revised catch estimates. Two assessment models were used (BDM and SS3; IOTC 2016), although management advice for the stock is based on the results of the SS3 analysis. The results indicate that 2015 levels of fishing mortality were above the level that would achieve MSY (F_{2015}/F_{MSY} = 1.11; range 0.86–1.36). Current spawning biomass was estimated to be below the level associated with MSY (SB_{2015}/SB_{MSY} = 0.89; range 0.79–0.99) but above the default limit reference point (SB_{2015}/SB_0 = 0.29; range not available).

Stock status determination

The assessments indicate that fishing mortality is above the level associated with MSY. As a result, the yellowfin tuna stock is classified as **subject to overfishing.** The biomass is above the default limit reference point ($0.2B_0$), and, as a result, the stock is classified as **not overfished.**

24.3 Economic status

Key economic trends

Economic surveys have not been conducted in the WTBF since 2001–02 because of the low level of fishing activity. During 2015 and 2016, 95 fishing permits were issued in the fishery. A small number of vessels have been operational in the fishery during that time (Table 24.2), with three vessels active in both the 2015 and 2016 fishing seasons. Effort decreased in the fishery from 421,185 hooks in 2015 to 352,274 hooks in 2016, and catch also decreased from 440 t in 2015 to 320 t in 2016. As in previous years, landed catch in the fishery continued to be a small proportion of the TACC during 2016. This high level of latent quota in the fishery (the extent to which the TACC is not fully caught) indicates that permit holders expect low or negative profitability from operating in the fishery.

Management arrangements

Before 2010, the WTBF was managed solely under an input control regime in which entry was limited, and gear and operating areas were restricted. In 2010, output controls were introduced in the form of species-specific TACC, allocated as ITQs. The impact of the move to ITQs has not been measured because of the low participation in the WTBF in recent years. In general, ITQs allow fishers to use input combinations that are more efficient, particularly after any unnecessary input controls are relaxed. The transferability of fishing rights between fishers can also allow more efficient allocation of fishing rights so that catch is taken by the most efficient operators in the fishery. However, the very low levels of catch relative to the TACC in the WTBF are unlikely to provide any incentive for such trade to occur, minimising any efficiency gains.

Longline hooks
AFMA

Performance against economic objective

Although a harvest strategy has not been implemented because of low levels of effort in the fishery, the current management arrangements are unlikely to be constraining fishers' ability to operate profitably. The high levels of latency experienced in the fishery are more likely to arise from market factors that affect business input costs and international tuna prices. Furthermore, since the WTBF accesses a relatively small component of broader, internationally managed ocean-wide stocks, domestic management actions to control catch are likely to have limited impact on the biomass of these stocks and, therefore, on fishers' ability to access the resource for profitable operations. Hence, the economic objective of maximising net economic returns is likely being met for the fishery, as constraints to further fishing appear to be market related rather than arising from management arrangements.

24.4 Environmental status

The WTBF has been granted continued export approval under the *Environment Protection and Biodiversity Conservation Act 1999,* expiring on 28 November 2019. Conditions of export approval include a requirement to develop and implement a harvest strategy in the WTBF. Because of the very low effort in the fishery, the harvest strategy has not been implemented. A revised harvest strategy that takes different levels of effort into account is currently being developed.

AFMA's ecological risk assessment examined 187 fish species in the WTBF (38 chondrichthyans and 149 teleosts), all of which were classified as being at low risk of potential overfishing, based on the level 3 Sustainability Assessment for Fishing Effects analysis (Zhou et al. 2009). Although no shark species were identified as high risk, an increase in effort could move some species to a higher-risk category. A priority action identified in the WTBF ecological risk management report is to monitor the catch of and level of interaction, with sharks. Management of shark interactions in this fishery will be reviewed if the landed amount of any one shark species exceeds 50 t within a year (AFMA 2010). Trip limits on sharks apply, depending on species.

AFMA publishes quarterly reports of logbook interactions with protected species on its website. In 2016, 300 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the WTBF; all were released in an unknown condition. One bentfin devil ray (*Mobula thurstoni*) was hooked and released in an unknown condition. Three leatherback turtles (*Dermochelys coriacea*) were also hooked and released alive, as were two green turtles (*Chelonia mydas*) and one flatback turtle (*Natator depressus*). One black-browed albatross (*Thalassarche melanophris*) was dead after being hooked. Finally, three Australian sea lions (*Neophoca cinerea*) were hooked and released alive.

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Tori lines and streamers
Dave Cranston, AFMA

Chapter 25

Heard Island and McDonald Islands Fishery

H Patterson and J Savage

FIGURE 25.1 Area of the Heard Island and McDonald Islands Fishery, 2016

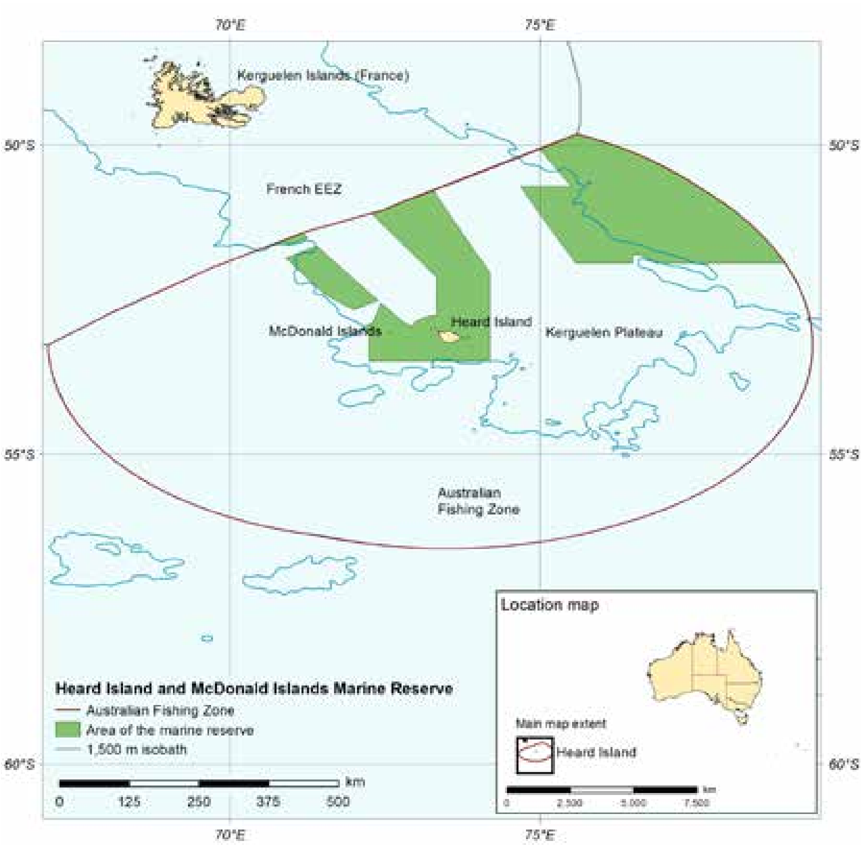


TABLE 25.1 Status of the Heard Island and McDonald Islands Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
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 but are likely to be positive. Lower NER are likely for 2015–16 as there was significantly lower catch (a result of a lower TAC) and an increase in the level of uncaught TAC.				

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 the Environment and Energy. A 1 nm buffer zone around the territorial waters of HIMI extends the area closed to fishing to 13 nm. The HIMI Marine Reserve was declared in October 2002 and then expanded in March 2014 by proclamation after scientific assessment. The reserve now totals 71,200 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 2014–24,* 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 et al. 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 Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Scientific Committee and the CCAMLR Commission, and are considered precautionary. Demersal trawl and demersal longline are the main methods used in the fishery. 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 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 MacDonald Islands Fishery (HIMIF) are considered more precautionary than the guidelines of the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007). For mackerel icefish, the reference point dictates that the spawning stock biomass be maintained at 75 per cent of the level that would occur in the absence of fishing at the end of a two-year model projection. 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 per cent of median pre-exploitation level and that the probability of the spawning biomass dropping below 20 per cent of its pre-exploitation median level is less than 10 per cent over the projection.

The importance of the target species (especially mackerel icefish) as prey in the subantarctic ecosystem is taken into account, and catch limits must be sufficiently precautionary to ensure that the abundance of these species meets the ecological needs of dependent species (for example, seabirds and marine mammals). Mackerel icefish in the HIMIF was initially certified as sustainable by the Marine Stewardship Council (MSC) in March 2006 and was recertified in July 2016. Patagonian toothfish in the HIMIF 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 relatively stable, with two to four vessels active at any one time since a total allowable catch (TAC) was first set in the mid 1990s. However, as a result of the higher TAC, seven vessels were active in 2014–15. Four vessels were active in 2015–16.

Catch

Catches of mackerel icefish have been variable over time. It is a short-lived species, exhibiting periodic, large, dominant year-classes. This allows high catches for a year or two. Once that year-class dies out and the next cohort is growing, catches are reduced because less biomass is available to the fishery.

Catches of Patagonian toothfish have been more stable over time, with little variation between 2000–01 and 2013–14. Catch in the 2014–15 fishing season increased in response to the increased TAC. Catch in 2015–16 was below the TAC by 606 t. This was due to a decrease in catch rates during the fishing season. Possible reasons for this drop in catch rates are currently being investigated by the AAD and the Sub-Antarctic Resource Assessment Group of the Australian Fisheries Management Authority (AFMA) and may relate to environmental factors.

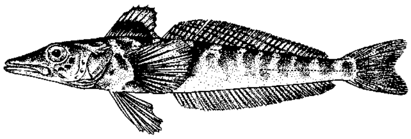
TABLE 25.2 Main features and statistics for the HIMIF

Fishery statistics a	**2014–15 fishing season**			**2015–16 fishing season**		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Mackerel icefish	309	10	Confidential	482	491 **b**	Confidential
Patagonian toothfish	4,410 **c**	2,744	Confidential	3,405	2,799	Confidential
Fishery-level statistics						
Effort	57 trawl days 16,139,770 hooks 0 pots hauled			80 trawl days 14,690,716 hooks 0 pots hauled		
Fishing permits	4 quota SFR holders			4 quota SFR holders		
Active vessels **d**	7			4		
Observer coverage	100% vessel coverage			100% vessel coverage		
Fishing methods	Demersal longline, demersal trawl, midwater trawl, pot (fish traps)					
Primary landing ports	Port Louis (Mauritius), Nelson (New Zealand), Albany (Western Australia)					
Management methods	Input controls: limited entry, gear restrictions, temporal and spatial closures Output controls: TACs and ITQs Other: move-on provisions if bycatch thresholds are reached					
Primary markets	International: United States, Japan, China, eastern Europe—frozen					
Management plan	*Heard Island and McDonald Islands Fishery Management Plan 2002* (amended 2011)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Season is 1 December to 30 November. Real-value statistics are by financial year. **b** 9 t will be deducted from the 2016–17 season quota to take account of the overcatch. **c** 14 t was deducted from the 2014–15 season quota to take account of the overcatch of the previous year. **d** All vessels carry two observers on each trip.
Notes: **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch.

25.2 Biological status

Mackerel icefish (*Champsocephalus gunnari*)



Line drawing: FAO

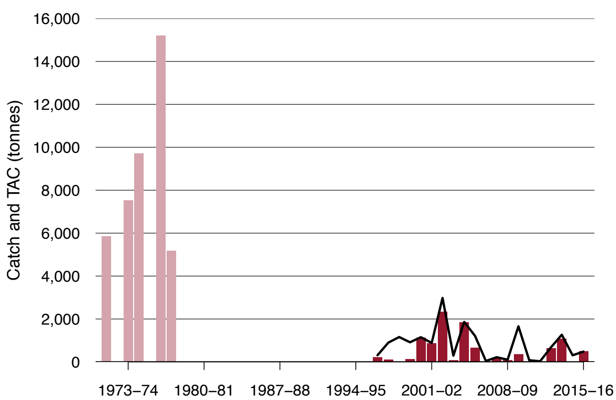
Stock structure

A single stock of mackerel icefish is considered to exist at HIMI; no genetic variation among sites around HIMI has been found (Williams et al. 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. Considerable uncertainty exists about 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 conducted 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. This was a result of fishers concentrating their efforts in 2014–15 on the more valuable Patagonian toothfish, for which the TAC was higher than in recent years.

FIGURE 25.2 Catch and TAC of mackerel icefish in the HIMIF, 1971–72 to 2015–16



Note: **TAC** Total allowable catch.
Source: Australian Fisheries Management Authority

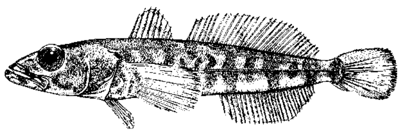
Stock assessment

A random stratified trawl survey in April 2016 provided information on the abundance and age structure of the mackerel icefish stock (Nowara et al. 2016). As noted in previous years, multiple year-classes were present, with the 2+ year-class estimated to account for 42 per cent of the biomass (Maschette & Welsford 2016). The stock assessment estimated the current biomass at 5,490 t (Maschette & Welsford 2016). Yields of 561 t for the 2016–17 season and 402 t for the 2017–18 season were estimated to satisfy the CCAMLR decision rules, assuming that the entire 2015–16 TAC was taken. Because the dominant 2+ year-class cohort is made up of relatively small fish and may not be well sampled by the survey gear, the estimated yields may change following the 2017 survey. A TAC of 561 t for the 2016–17 season was endorsed by the CCAMLR (CCAMLR 2016a, 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

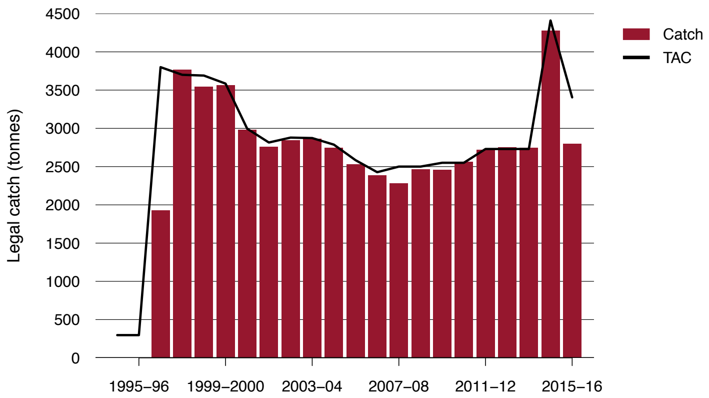
Stock structure

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 et al. 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 et al. 2004; Toomey et al. 2016). Data from tagging studies (for example, Williams et al. 2002; Welsford et al. 2011) indicate that, while adult toothfish at HIMI are relatively sedentary and usually recaptured within 15 nm of their point of release, in some cases they travel significant distances. For example, toothfish tagged at HIMI have been recaptured approximately 800 nm and 1,000 nm away on the Kerguelen and Crozet plateaus, respectively. Thus, toothfish in the Indian Ocean sector of the Southern Ocean may form a metapopulation, with some limited connectivity between the populations. The stock structure of toothfish on the Kerguelen Plateau is being further investigated in collaboration with French scientists so that population models of toothfish in the area can be refined and management can be improved across the Kerguelen Plateau (Péron et al. 2016; Welsford et al. 2011). For the purposes of the assessment, the HIMI toothfish population is considered to be distinct.

Catch history

Catch of Patagonian toothfish in the HIMIF has declined slightly since the late 1990s, but was relatively stable from the early 2000s to 2013–14 and has mirrored the TAC (Figure 25.3). Because of the higher TAC, catches were greater in 2014–15 and the highest since 1994–95. As noted above, catch rates dropped in the 2015–16 fishing season.

FIGURE 25.3 Catch and TAC of Patagonian toothfish in the HIMIF, 1994–95 to 2015–16



Note: **TAC** Total allowable catch.
Source: Australian Fisheries Management Authority

Stock assessment

The most recent assessment for Patagonian toothfish (Ziegler & Welsford 2015) used the most recent version of the integrated assessment model CASAL, and included abundance estimates obtained from the survey, standardised catch-per-unit-effort and catch-at-age proportions, and other fishery and biological data inputs. Recommendations from the 2014 CCAMLR Working Group on Fish Stock Assessment (WG-FSA), and the 2015 Working Group on Statistics, Assessment and Modelling were also considered. These recommendations included using updated ageing data up to 2014; using full tagging data from 2014 and partial tagging data from 2015; updating the growth model; and changing the assumptions (priors) for catchability, unfished biomass (B_0) and year-class strength (Ziegler & Welsford 2015).

The assessment agreed by the 2015 WG-FSA estimated that the spawning biomass was 64 per cent of unfished levels ($SB_{2015}/SB_0 = 0.64$; range 0.59–0.69). A catch limit of 3,405 t satisfied the CCAMLR decision rules and was the recommended TAC for 2015–16 and 2016–17 (CCAMLR 2016a, b). This TAC is lower than that set for 2014–15 because of the inclusion of tagging data in the model, which resulted in a lower estimate of unfished biomass.

Stock status determination

Given the relatively high spawning biomass, the precautionary TAC that satisfies the CCAMLR decision rules, the robust nature of the stock assessment and the extensive CCAMLR review process, the stock is classified as **not overfished** and **not subject to overfishing.**

25.3 Economic status

Key economic trends

The TAC for Patagonian toothfish has been fully caught in recent years, indicating that positive net economic returns (NER) are likely to have been generated for this species. Patagonian toothfish has constituted, on average, more than 90 per cent of the fishery's annual gross value of production over the past decade. Patagonian toothfish is a very high-value species compared with mackerel icefish, with strong demand and high prices for exports to Europe. As such, Patagonian toothfish is the main targeted species in this fishery and consequently drives NER movements.

Since 2012–13, a commercial TAC has been re-established for mackerel icefish, reflecting increased estimated abundance. Only a small percentage of the TAC was left uncaught in both the 2012–13 and 2013–14 fishing seasons, and the full TAC was caught in the 2015–16 season. The mackerel icefish TAC was not caught in 2014–15 because natural fluctuations in the stock size resulted in a sharp reduction of the TAC, and the stock was therefore not strongly fished.

The Patagonian toothfish TAC was almost entirely caught in 2014–15, strongly indicating positive NER. In 2015–16, the uncaught TAC for Patagonian toothfish increased significantly, likely due to environmental conditions, indicating that NER for the fishery have fallen from the previous years.

Bringing up a Patagonian toothfish
Austral Fisheries

Management arrangements

A harvest strategy, consistent with the principles of the CCAMLR, is in place for the fishery. The primary management control uses individual transferable quotas (ITQs), in conjunction with input controls. The use of ITQs provides the best chance of achieving maximum efficiency, subject to the fishery's precautionary harvest strategy and strict operational constraints on vessels. Given the low levels of quota latency, positive NER are likely to be generated in the fishery in a manner that is consistent with the conservative ecological objectives.

25.4 Environmental status

The HIMIF is exempt from export controls under the EPBC Act until 9 October 2026. No additional recommendations apply under this exemption, beyond standard recommendations pertaining to reporting.

Three ecological risk assessments were completed in the HIMIF by gear type: demersal trawl, midwater trawl and demersal longline. No risk assessment has been done for fish pots. The Sustainability Assessment for Fishing Effects (level 3) assessment for all gear types found that the estimated fishing mortality was generally low for all non-target fish species, and that no species was at high risk (Zhou et al. 2009). Ecological risk management for all gear types focuses on how AFMA will continue to monitor interactions with bycatch and protected species in a manner consistent with CCAMLR principles (AFMA 2009a, b, c).

AFMA publishes quarterly reports of logbook interactions with species protected under the EPBC Act on its website. In the HIMI longline fishery in 2016 (calendar year), eight southern elephant seals (*Mirounga leonina*) became entangled in the longlines and died, as did two crabeater seals (*Lobodon carcinophagus*) and one unidentified seal. Five white-chinned petrels (*Procellaria aequinoctialis*) became entangled in the longline and died, and one died in the trawl. Finally, one macaroni penguin (*Eudyptes chrysolophus*) and one grey-headed albatross (*Thalassarche chrysostoma*) died after being entangled in the longline.

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Fishing in rough conditions
Austral Fisheries

Chapter 26

Macquarie Island Toothfish Fishery

H Patterson and J Savage

FIGURE 26.1 Area of the Macquarie Island Toothfish Fishery, 2016

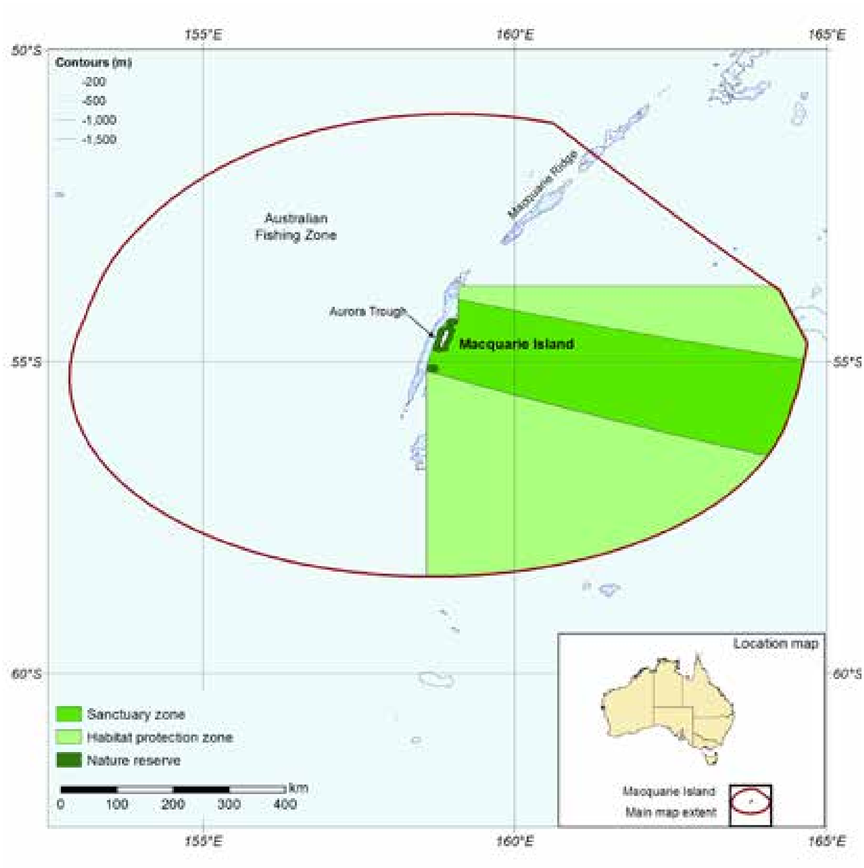


TABLE 26.1 Status of the Macquarie Island Toothfish Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Patagonian toothfish (*Dissostichus eleginoides*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	TACs are set in accordance with a precautionary harvest strategy. Most recent estimate of biomass is above the limit reference point.
Economic status	Estimates of NER are not available but are likely positive between 2013–14 and 2016–17 because the TAC for Patagonian toothfish was mostly caught. NER most likely fell in 2015–16 because difficult operating conditions led to lower catch, despite an increase in the TAC and effort in that year. NER likely increased in 2016–17 because catch per longline day was slightly higher than the previous season.				

Notes: **NER** Net economic returns. **TAC** Total allowable catch.

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

26.1 Description of the fishery

Area fished

Macquarie Island is a subantarctic island about 1,500 km south of Tasmania (Figure 26.1). The island is a nature reserve in the Tasmanian reserve system and is included on the World Heritage List (UNESCO 1998). The waters within 3 nautical miles (nm) of the island are under Tasmanian jurisdiction, while waters between 3 nm and the 200 nm outer boundary of the Australian Fishing Zone are managed by the Australian Government. The south-eastern quadrant of the Macquarie Island region out to 200 nm is a marine reserve (Figure 26.1). The Macquarie Island Toothfish Fishery (MITF) is outside the area covered by the Convention on the Conservation of Antarctic Marine Living Resources; however, the ecosystem-based management approach used by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has been adopted for the fishery, including comprehensive observer coverage and precautionary harvest control rules.

Fishing methods and key species

Historically, trawling was the main fishing method used in the MITF. In 2011, longlining was added as an approved fishing method (AFMA 2010). This followed a longlining trial over four seasons (2007 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, with the exception of a trial of pots in the 2013–14 fishing season. Bycatch is generally low and is regulated by a 50 t limit for any one species. The bycatch, primarily grenadier (*Macrourus* spp.) and violet cod (*Antimora rostrata*), has never exceeded the 50 t limit for any one species in a season.

Management methods

The harvest strategy for Patagonian toothfish is consistent with the precautionary approach of the CCAMLR and is considered more precautionary than the guidelines of the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007).

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 per cent of median pre-exploitation level and that the probability of the spawning biomass dropping below 20 per cent of its pre-exploitation median level is less than 10 per cent over the projection. The total allowable catch (TAC) was previously set separately for the two main areas (Aurora Trough and Macquarie Ridge). However, based on scientific advice that it is highly likely that there is a single stock of Patagonian toothfish around Macquarie Island (see 'Stock structure', below), the management plan was amended in January 2012 to merge the two areas, and a single TAC is now set for the entire fishery. The MITF was recertified as sustainable by the Marine Stewardship Council in July 2017.

Fishing effort

The effort in the fishery has been consistent over time, with one or two vessels active in the fishery every year since the fishery began in 1994.

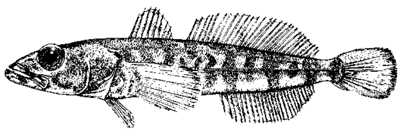
TABLE 26.2 Main features and statistics for the MITF

Fishery statistics a	**2015–16 fishing season**			**2016–17 fishing season**		
Stock	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Patagonian toothfish	460	324	Confidential	450	434	Confidential
Fishery-level statistics						
Effort (longline days)	92			116		
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	Nelson (New Zealand); Devonport and Hobart (Tasmania)					
Management methods	Input controls: limited entry, gear restrictions, closures Output controls: TACs, ITQs					
Primary markets	International: United States, Japan—frozen					
Management plan	*Macquarie Island Toothfish Fishery Management Plan 2006* (amended 2012)					

a Fishery statistics are provided by fishing season, unless otherwise indicated. The 2016–17 fishing season was 15 April 2016 to 14 April 2017. Real-value statistics are provided by financial year. **b** All vessels carry two observers on each trip.
Notes: **ITQ** Individual transferable quota. **SFR** Statutory fishing right. **TAC** Total allowable catch.

26.2 Biological status

Patagonian toothfish (*Dissostichus eleginoides*)



Line drawing: FAO

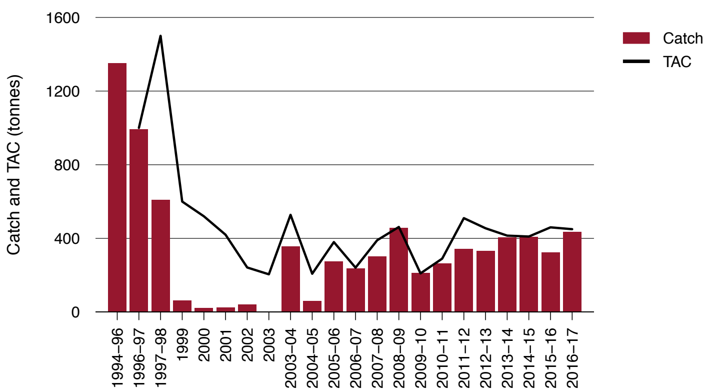
Stock structure

The Patagonian toothfish stock at Macquarie Island is considered to be distinct from other regional toothfish populations in the Southern Ocean (Appleyard et al. 2002). Genetic studies (for example, Appleyard et al. 2002) and toothfish tagging programs (for example, Williams et al. 2002) indicate that a single stock exists in the MITF area.

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 2015–16 season was below the TAC as a result of a number of factors, including lost gear, and extreme weather and currents. In addition, fishers balanced their vessel time between the MITF and the Heard Island and McDonald Islands Fishery, where the TAC was substantially increased in 2015. Catch in the 2016–17 season was very near the TAC.

FIGURE 26.2 Catch and TAC of Patagonian toothfish in the MITF, 1994–95 to 2016–17



Note: **TAC** Total allowable catch.
Source: Australian Fisheries Management Authority

Stock assessment

In 2016, Stock Synthesis 3 software was used to assess the Patagonian toothfish stock (Day et al. 2016). This integrated two-area assessment fits to tag–recapture, length composition and age-at-length data. The assessment assumes a single stock in the MITF but with spatial structuring of fishing and movement between two areas (northern and southern), with recruitment to both areas. Using this assessment, 2016 female spawning biomass was estimated at 67 per cent of unfished levels (SB_0). Following the CCAMLR control rule (which uses a target of 50% SB_0 rather than 48% SB_0), a two-year TAC was calculated for the MITF for 2016–17 and 2017–18, 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 ($0.67SB_0$) and the robust nature of the assessment result in the stock being classified as **not overfished.** The conservative TAC-setting process, based on the application of precautionary CCAMLR control rules, and the maintenance of catch generally below the TAC result in the stock being classified as **not subject to overfishing.**

26.3 Economic status

Key economic trends

Latency can be variable in this fishery. In the 2014–15 fishing season, the TAC was fully caught with less effort than in the 2013–14 season. The TAC was not fully caught in 2015–16 (latency was 30 per cent), despite an increase in effort, indicating negative effects on catch from difficult operating conditions. Catch in 2016–17 returned to near TAC again as a result of improving conditions, indicating a rise in net economic returns from 2015–16. Catch per longline day remained within usual bounds at approximately 3.7 t in 2016–17 (3.5 t in 2015–16), although this compares with a catch per longline day of 6.0 t in 2014–15.

The estimated biomass of $0.67SB_0$ in 2016 is well above the targeted level of $0.50SB_0$. This high abundance is likely to result in lower fishing costs and improved profitability. Given that only one operator has fished in the MITF in recent years, it is also likely that individual profit-maximising decisions are aligned with optimum use of the resource, within the constraints of the fishery's precautionary objective.

Management arrangements

The harvest strategy for this fishery is conservative, reflecting the CCAMLR ecosystem-based management approach. Therefore, catch limits aim to maintain stock biomass at levels that are higher than recommended target reference points for other Commonwealth fisheries managed under the HSP.

Average vessel economic performance is likely to have improved since longlining was approved in 2011. The initial demersal longline trial in 2007 found a number of benefits of longline fishing compared with trawl fishing, including increased access to Patagonian toothfish in deeper waters and reduced levels of bycatch (AFMA 2010). These benefits are likely to have improved vessel-level productivity, moderating the negative effects of rough sea conditions experienced in recent years.

26.4 Environmental status

The MITF is included on the List of Exempt Native Specimens under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and has export approval until 9 October 2026. No additional recommendations apply under this exemption, beyond standard recommendations pertaining to reporting.

The ecological risk assessment process was completed to level 3 (Sustainability Assessment for Fishing Effects) for trawling and demersal longline for sharks and scalefish. No species was at high risk from trawling in the MITF (Zhou et al. 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 suggest that the level 3 assessment tends to be overly precautionary, and it is likely that the mortality rate was overestimated. This is supported by the low recorded catch for the two species (two southern lantern sharks and nine southern sleeper sharks) over the three years. Further analyses should take place as data become available. The MITF ecological risk management reports for trawling and demersal longline both outline how the Australian Fisheries Management Authority (AFMA) will continue to monitor bycatch, and interactions with protected species under the EPBC Act, in a manner consistent with CCAMLR principles (AFMA 2009, 2011).

All the catch in the MITF is now taken by longline. No seabird or marine mammal interactions were observed in the longline trial. AFMA publishes quarterly reports of logbook interactions with species protected under the EPBC Act on its website. In 2016, seven porbeagles (*Lamna nasus*) were hooked. Two were released alive and five were dead.

Patagonian toothfish
Australian Longline

26.5 References

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Chapter 27

CCAMLR Exploratory Toothfish Fisheries

H Patterson and J Savage

FIGURE 27.1 CCAMLR Convention area

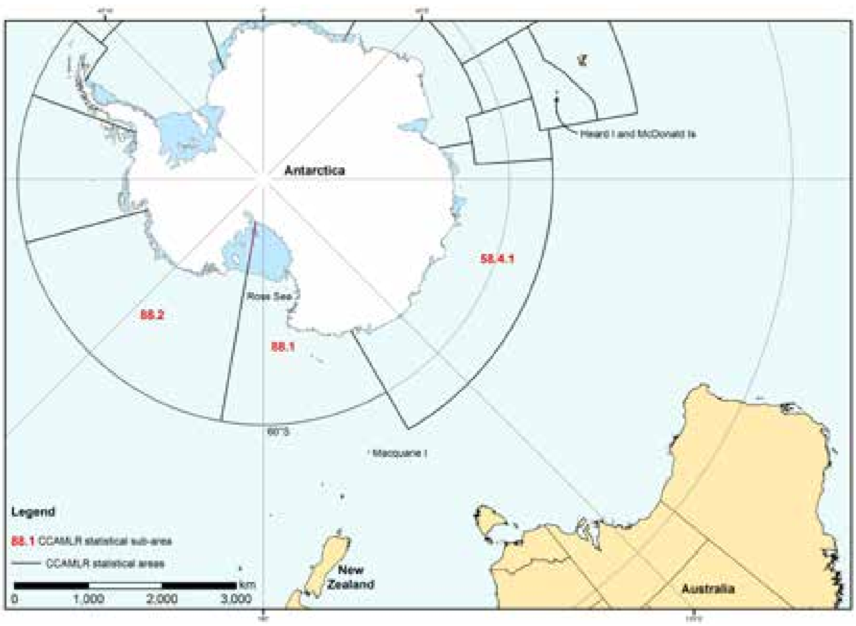


TABLE 27.1 Status of the CCAMLR Exploratory Toothfish Fisheries

Status	2015 a		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Division 58.4.1, toothfish *(Dissostichus mawsoni, D. eleginoides)*					No estimate of current biomass available.
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 participated in subarea 88.2 in the 2014–15 fishing season and in division 58.4.1 during the 2015–16 season.				

a This stock was not assessed in 2015.
Notes: **CCAMLR** Commission for the Conservation of Antarctic Marine Living Resources. **NER** Net economic returns. **TAC** Total allowable catch.

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

27.1 Description of the fishery

Area fished

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) was established in 1982 to conserve and manage the Southern Ocean Antarctic ecosystem, mainly in high-seas areas. The objective of the CCAMLR is the conservation and rational use of Antarctic marine living resources. The CCAMLR Convention area is defined as the area south of the Antarctic Convergence, as well as the area south of 60°S where the Antarctic Treaty (1959) applies (Figure 27.1).

The CCAMLR defines 'new and exploratory' fisheries for particular areas, and places emphasis on acquiring biological and other information during the development of the fisheries. Participation in such fisheries requires member states to implement management measures, and a research plan detailing the scientific data that a country plans to collect and contribute to the CCAMLR.

Exploratory fisheries are defined under Conservation Measure 21-02:

i. an exploratory fishery shall be defined as a fishery that was previously classified as a 'new fishery', as defined by Conservation Measure 21-01

ii. an exploratory fishery shall continue to be classified as such until sufficient information is available

a. to evaluate the distribution, abundance and demography of the target species, leading to an estimate of the fishery's potential yield

b. to review the fishery's potential impacts on dependent and related species

c. to allow the Scientific Committee to formulate and provide advice to the Commission on appropriate harvest catch levels, as well as effort levels and fishing gear, where appropriate.

The Ross Sea and Amundsen Sea area is encompassed by CCAMLR subareas 88.1 and 88.2 (Figure 27.1). These two subareas are CCAMLR Exploratory Toothfish Fisheries and are managed separately, with distinct stock assessments. An Australian vessel nominated to fish in subareas 88.1 and 88.2 in the 2014–15 fishing season (Figure 27.1), but only subarea 88.2 was fished, so subarea 88.1 is not reported on here. There was no fishing in subareas 88.1 or 88.2 in 2015–16. In addition, division 58.4.1, which is adjacent to subarea 88.1, was fished by an Australian vessel in 2015–16.

Fishing methods and key species

Demersal longline is the primary method used to target Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian toothfish (*D. eleginoides*) in CCAMLR toothfish fisheries. 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 catch limits may be based on a percentage of the catch of toothfish (for example, 5 per cent 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 more precautionary than the guidelines of the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007). 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 per cent of its median pre-exploitation level, and that the probability of the spawning biomass dropping below 20 per cent of its median pre-exploitation level is less than 10 per cent over the projection period. In exploratory fisheries, total allowable catches (TACs) are then fished by approved vessels that have nominated to fish specific subareas or divisions. Shares of the TAC are not allocated to particular CCAMLR members; however, members may receive allocations to conduct specific research programs. Fishing is closed when the catch limit for the subarea is reached, based on daily catch-and-effort reporting required by all vessels. Vessels fishing in exploratory fisheries are required to carry scientific observers, and to tag and release toothfish at pre-specified levels as part of the scientific data collection process.

Fishing effort

Australia began fishing in subarea 88.2 in 2014–15. There was no previous effort by Australian vessels in this subarea, although other CCAMLR members have fished there since 2002. In 2015–16, however, there was no effort in this subarea by Australian vessels. Division 58.4.1 was fished for the first time by an Australian vessel in 2015–16 (excluding some experimental trawling in the division in 1999–2000).

TABLE 27.2 Main features and statistics for the CCAMLR Exploratory Toothfish Fisheries

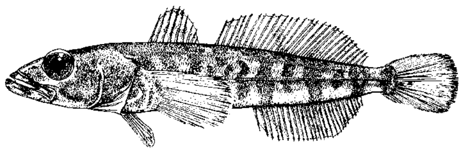
Fishery statistics a	2014–15 fishing season			2015–16 fishing season		
Fishery	**TAC (t)**	**Catch (t)**	**Real value (2014–15)**	**TAC (t)**	**Catch (t)**	**Real value (2015–16)**
Subarea 88.2, toothfish	619 **b**	213 **c**	Confidential	619 **b**	0	Confidential
Division 58.4.1, toothfish	–	–	–	660 **b**	51 **c**	Confidential
Fishery-level statistics						
Effort	Division 58.4.1: 0 hooks Subarea 88.2: 697,850 hooks			Division 58.4.1: 348,605 hooks Subarea 88.2: 0 hooks		
Fishing permits	Division 58.4.1: 0 Subarea 88.2: 1			Division 58.4.1: 1 Subarea 88.2: 1		
Active vessels	Division 58.4.1: 0 Subarea 88.2: 1			Division 58.4.1: 1 Subarea 88.2: 0		
Observer coverage **d**	100% vessel coverage			100% vessel coverage		
Fishing methods	Demersal longline					
Primary landing ports	Nelson (New Zealand); Hobart (Tasmania)					
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: United States, Japan, China—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. Real-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 and 27.3. **d** All Australian vessels carry two observers on each trip.
Notes: **CCAMLR** Commission for the Conservation of Antarctic Marine Living Resources. **TAC** Total allowable catch. **–** No Australian vessels participated in the fishery in division 58.4.1 in 2014–15.

Iceberg
Australian Longline

27.2 Biological status

Toothfish (*Dissostichus mawsoni, D. eleginoides*) in subarea 88.2



Line drawing: FAO

Stock structure

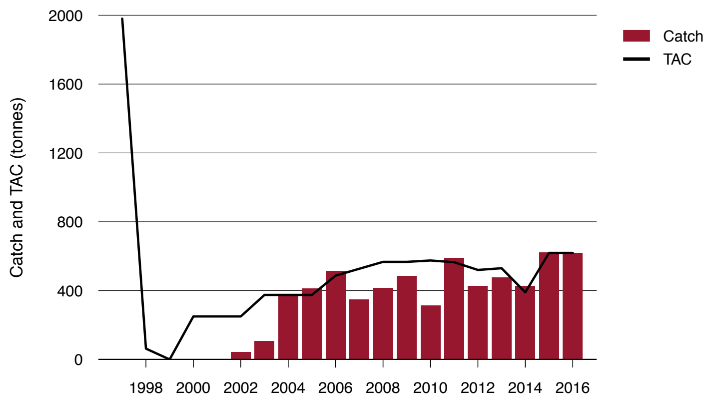
Genetic examination of Antarctic toothfish from widely separated CCAMLR statistical areas (Atlantic Ocean sector, Pacific Ocean sector, Indian Ocean sector) has produced mixed results. Early studies found some weak variation by ocean sector (Smith & Gaffney 2005; Kuhn & Gaffney 2008), whereas a more recent study was unable to detect any genetic variation among fish from the different sectors (Mugue et al. 2014). However, tagging studies from numerous locations in the CCAMLR Convention area have indicated that the majority of adult toothfish are sedentary and are recaptured relatively close to where they were tagged (<50 km) (Petrov & Tatarnikov 2010; Welsford et al. 2011). This should result in genetic differentiation. Newer genomic techniques may be needed to better understand stock structure. Preliminary otolith chemistry work has also provided evidence of regional stock structuring (Tana et al. 2014).

CCAMLR subarea 88.2 is divided into smaller areas known as small-scale research units (SSRUs) that are labelled A to H. The stock assessment boundaries for the Ross Sea region include subarea 88.1, and SSRUs A and B in subarea 88.2, whereas the stock assessment for the Amundsen Sea region (described here) considers SSRUs C–H to be a distinct stock (Hanchet & Parker 2014; Parker et al. 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 in the early years of the fishery (1997–2001). Catches have generally increased since 2002 as the TAC has increased (Figure 27.2). All reported catches are of Antarctic toothfish, although the TAC is for a combined 'toothfish' category (both species). There was no effort by Australian operators in 2015–16.

FIGURE 27.2 Total catch and TAC for CCAMLR subarea 88.2, 1997 to 2016



Note: Catches from SSRU 88.2 A and 88.2 B are included in the total catches, despite being assessed as part of subarea 88.1.
Source: CCAMLR

Stock assessment

The most recent full stock assessment of Antarctic toothfish from CCAMLR subarea 88.2 SSRUs C–H was conducted in 2013 using the CASAL integrated assessment model (Mormede et al. 2013). The assessment included catch data and catch-at-age frequencies from 2003 to 2013 for each SSRU. In addition, tag–recapture data for SSRU H were included because fishing in the other SSRUs has been inconsistent. Constant recruitment was assumed across the SSRUs.

There were some conflicting results among the model runs, with some runs estimating unfished biomass to be lower than that estimated by earlier assessments completed in 2011 and 2013. The conflict was largely driven by the tagging data from SSRU H, which was considered reliable as a result of improved tagging and data collection procedures. In addition, the model runs with a reduced estimate of unfished biomass down-weighted the age data, which were limited and did not include SSRU H, the area from which most of the catch was taken.

The recommended model run down-weighted the age data and used the tagging data (Mormede et al. 2013). This model estimated the current level of biomass as 65 per cent of unfished levels ($B_{2013}/B_0 = 0.65$; range 0.52–0.75). This is lower than the 2011 estimate of 82 per cent of unfished biomass, but remains above the target reference point of 50 per cent. The 2013 Working Group on Fish Stock Assessment could not reach consensus on the assessment. It noted that the assessment may not be representative of SSRUs C–G because most of the data driving the results came from SSRU H (CCAMLR 2013).

The CCAMLR Scientific Committee provided updated advice on the TAC in 2014 based on two biomass estimates for SSRU H, using the mark–recapture data and Petersen models (Goncharov & Petrov 2014; Parker & Mormede 2014). These were simple models using tagging data for SSRU H only, and excluded all the other data that would be used in an integrated assessment. They did not provide new biomass depletion estimates for subarea 88.2, and consequently the estimate from the 2013 integrated assessment (65 per cent) remains the best biomass depletion estimate available.

Based on the results of the Petersen models, the TAC for subarea 88.2 SSRUs C–H was set at 619 t, with 200 t designated for SSRU H and the remaining 419 t for SSRUs C–G (CCAMLR 2015a, b). A yield of 619 t equates to 3 per cent of the estimated current biomass. Previous research has demonstrated that toothfish stocks that are fished at a rate of 3 per cent are likely to rebuild to the target level within two decades, even if currently near the limit reference point of 20 per cent of unfished biomass (Welsford 2011). Given the relatively high estimate of current biomass in subarea 88.2, 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 and was fully taken. Illegal, unreported and unregulated (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.**

Toothfish (*Dissostichus mawsoni, D. eleginoides*) in division 58.4.1

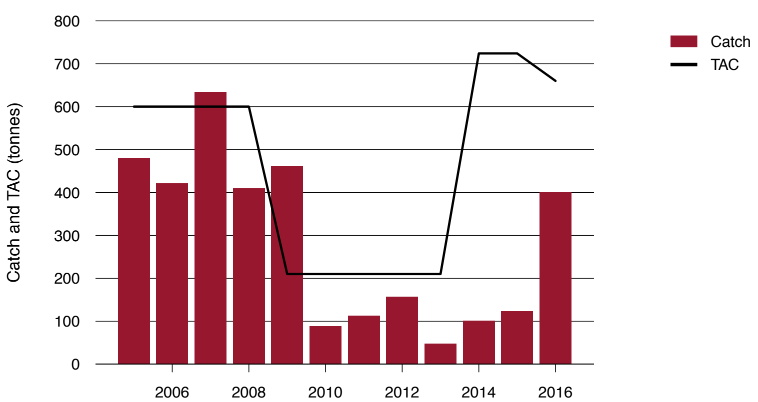
Stock structure

Toothfish in division 58.4.1 is considered a single stock for management purposes.

Catch history

CCAMLR division 58.4.1 contains research blocks where exploratory fishing is permitted. Fishing has occurred in the division under licence since 2005, with TACs ranging from 210 to 724 t (Figure 27.3). Australia did not participate in the fishery before 2015–16, although some experimental trawling did occur in 1999–2000.

FIGURE 27.3 Total catch and TAC for CCAMLR division 58.4.1, 2005 to 2016



Note: TAC Total allowable catch. Contains small catches of Patagonian toothfish in some years.
Source: CCAMLR

Stock assessment

No reliable and accepted integrated stock assessment is available for division 58.4.1. Although some earlier studies applied different tag-based methods to obtain some indication of stock status, these were considered unreliable because of low tag returns (Agnew et al. 2008). The current level of biomass in division 58.4.1 is therefore unknown.

Fishing in the established research blocks, where previous tagging occurred and is ongoing, is intended to provide data for a future stock assessment. The participation of CCAMLR members in the fishery is restricted, and participants must provide a multiyear research plan that will provide data for a future stock assessment. 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 mean catch rate compared with an assessed area scaled by the seabed area in the block. The catch limits are then set so they do not exceed 3–4 per cent of estimated stock size. Previous modelling work has demonstrated that this level of harvest will likely allow an overfished stock (<20 per cent B_0) to recover in the long term (Welsford 2011); it is unknown if 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 eliminated and participation in the fishery restrained to a very low level. Given these factors, the stock is considered **not subject to overfishing**.

Fishing vessel and iceberg
Australian Longline

27.3 Economic status

Key economic trends

Australia began fishing subarea 88.2 in 2014–15. The total TAC for the subarea was caught in that period—with Australia capturing almost one-third of the TAC—indicating positive net economic returns (NER) for the fishery. Subarea 88.2 was not fished in 2015–16. Australia began fishing division 58.4.1 in 2015–16, catching 8 per cent of the TAC. Toothfish is a high-value species with well-established markets and supply chains, but fishing is undertaken in remote areas and under difficult operating conditions. While there is some potential for positive NER being generated by fishers, fishing has been sporadic, indicating some uncertainty for NER.

Management arrangements

The CCAMLR harvest strategy requires that the spawning biomass be 50 per cent of pre-fished levels at the end of a 35-year projection period. For subarea 88.2, however, the TAC was set by calculating current biomass and setting the TAC at 3 per cent of that biomass. This has previously been shown to be a precautionary method of setting the TAC, which is likely to allow stocks near the limit reference point to recover to the target level within two decades. A similar method is used to set the TAC for the research blocks in division 58.4.1. Since the current biomass in subarea 88.2 is estimated to be above the target reference point, the TAC is considered conservative. When the TAC is fully caught, the fishery is closed. Given the incomplete catch of the TAC, NER are uncertain in the fishery in a manner that is consistent with the conservative ecological objectives.

27.4 Environmental status

The fishery for toothfish in CCAMLR subareas 88.1 and 88.2 has been assessed as exempt from export controls under the *Environment Protection and Biodiversity Conservation Act 1999* until 31 October 2019. The fishery in CCAMLR divisions 58.4.1 and 58.4.2 are 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.

In the 2015–16 fishing season, no logbook or observer reports noted interactions between the Australian vessel and protected species in CCAMLR division 58.4.1.

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Chapter 28

High-seas fisheries for non–highly migratory species

R Noriega, L Georgeson and S Nicol

A small number of Australian fishing vessels target demersal fish species (those associated with the sea floor) in high-seas areas of the south Pacific and southern Indian oceans. The fisheries resources in these areas fall under the jurisdiction of two regional fisheries management treaties: the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean (South Pacific Regional Fisheries Management Organisation [SPRFMO] Convention), and the Southern Indian Ocean Fisheries Agreement (SIOFA). The SPRFMO Convention entered into force on 24 August 2012 and the SIOFA on 21 June 2012. Annual meetings of the SPRFMO Commission and Scientific Committee have been held since 2013. SIOFA has held annual meetings of the Meeting of the Parties, its decision-making body, since 2015; and annual meetings of its Scientific Committee 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 28.2).

The Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007) 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 HSP does not apply directly to these high-seas fisheries; there is therefore no formal harvest strategy required for domestic components of these fisheries.

The South Tasman Rise (STR) is an undersea ridge that stretches beyond the AFZ and into the SPRFMO Convention area (Figure 28.3). The South Tasman Rise Trawl Fishery (STRTF) is reported in this chapter because it has not operated within the AFZ since 2007. (In previous versions of this report, the STRTF was reported separately.)

The orange roughy (*Hoplostethus atlanticus*) stock is the only high-seas stock that is assigned a status classification in this chapter. Orange roughy in the STR is classified as overfished. Since the fishery is closed, the stock is classified as not subject to overfishing.

Because of a lack of catch data, stock assessments and stock structure information, we are unable to provide a stock status determination for other demersal stocks caught in the SPRFMO and SIOFA areas. Stock assessments for demersal stocks caught by Australian vessels in these areas may be included in future editions of *Fishery status reports*.

FIGURE 28.1 South Pacific Regional Fisheries Management Organisation Convention area

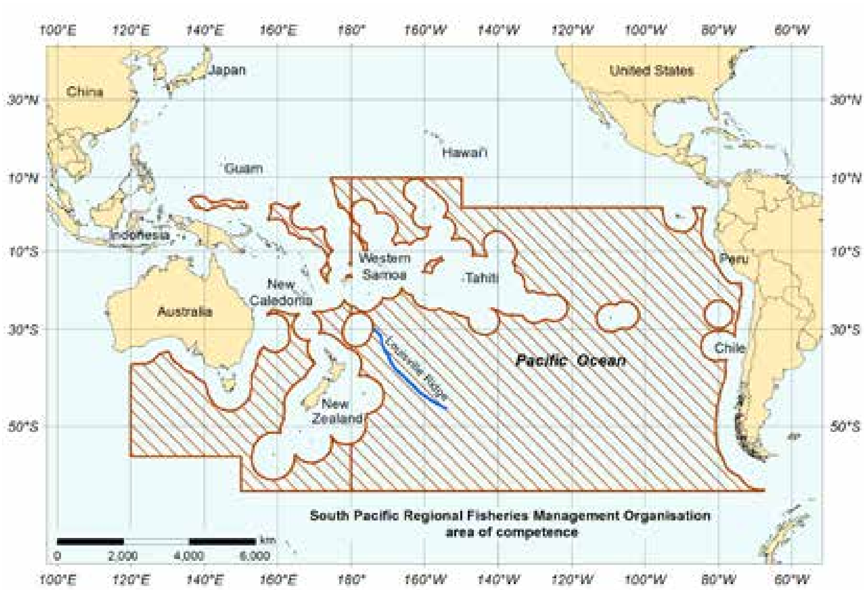


FIGURE 28.2 Southern Indian Ocean Fisheries Agreement area

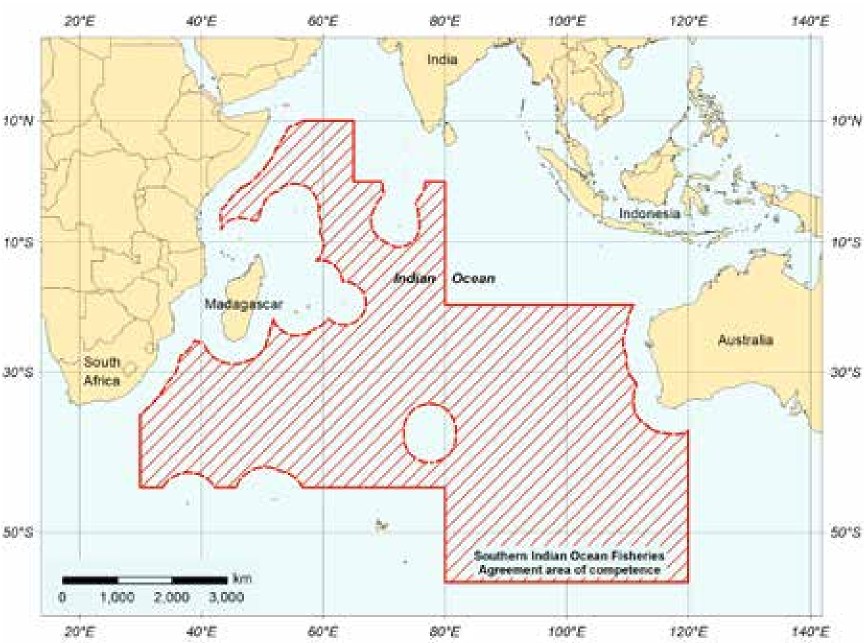
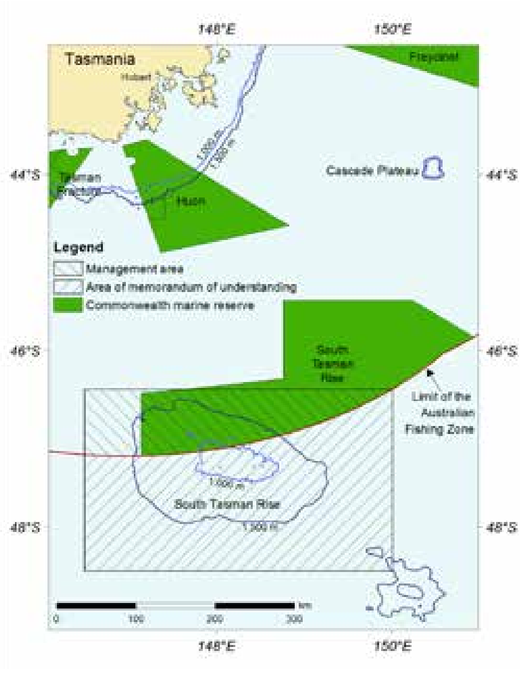


FIGURE 28.3 Area of the South Tasman Rise Trawl Fishery



28.1 Description of the fisheries

South Pacific Regional Fisheries Management Organisation Convention area

The SPRFMO Convention covers non–highly migratory fisheries resources and 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 include Chilean jack mackerel (*Trachurus murphyi*), jumbo flying squid (*Dosidicus gigas*) and lower-volume demersal species such as orange roughy.

The bottom fisheries target demersal species associated with seamounts, ridges and plateaus in the central, eastern and western areas of the south Pacific Ocean. 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).

Expansion of Australia's and New Zealand's fisheries into the high seas saw the establishment of a fishery on the Louisville Ridge in 1993 and on the STR in 1997. These fisheries were predominantly fished by New Zealand and Australian vessels; other nations, including Norway, Japan, the Republic of Korea, Belize, Ukraine and Panama, also accessed these deep-sea resources, although taking lower catches (Gianni 2004).

The species composition of catches from 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 blue-eye trevalla (*Hyperoglyphe antarctica*), also occurred. Limited Australian gillnet effort has occurred in the past; no gillnet fishing has been recorded since 1999. 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 Conservation and Management Measure (CMM 1.02), adopted in January 2013 (SPRFMO 2013).

Australia, as specified in SPRFMO CMM 03-0217 and since 2007, has restricted bottom-fishing effort or catch to the average annual level between 2002 and 2006. In addition, no bottom fishing occurs for the remainder of the season within 5 nautical miles of any area where fishing activities encounter evidence of a vulnerable marine ecosystem (VME). On receiving a report of the triggered area, AFMA will assess whether the area should be reopened in following seasons. Although Australia has not expanded bottom-fishing activities in areas outside the 2002 to 2006 footprint, new and exploratory fishing may be considered and approved by the SPRFMO Commission, consistent with SPRFMO CMM 03-2017. CMM 03-0217 will be reviewed at the regular meeting of the Commission in 2018. Consistent with SPRFMO CMM 02-2017 regarding its 'Standards for the collection, reporting, verification and exchange of data' (SPRFMO 2013), Australian high-seas fishing permits require the implementation of vessel monitoring systems, mandatory observer coverage on all trawl vessels and a target of 10 per cent observer coverage per vessel on all non-trawl vessels.

In 2011, Australia completed a bottom fishery impact assessment in the SPRFMO Convention area to examine whether individual bottom-fishing activities by Australian vessels have significant adverse impacts on VMEs (Williams et al. 2011a). The study concluded that the current overall risk of significant adverse impacts on VMEs by Australian bottom trawl and bottom longline operations is low, and the impact caused by midwater trawling and droplining is negligible (Williams et al. 2011a).

The SPRFMO has adopted various CMMs, including CMMs relating to prohibiting large-scale pelagic driftnets and all deepwater gillnets, data standards, management measures for bottom fisheries, establishing a vessel monitoring system, new and exploratory fisheries, regulation of at-sea and in-port transshipments, and minimising bycatch of seabirds.

South Tasman Rise Trawl Fishery

Fishing commenced in the STRTF in 1997 when demersal trawl was used to target orange roughy. In the later years of activity in the fishery, very little orange roughy was caught; the catch was mostly smooth oreodory (*Pseudocyttus maculatus*) and spikey oreodory (*Neocyttus rhomboidalis*). The fishery has not operated since 2007.

Under the United Nations Fish Stocks Agreement,[1] other countries are entitled to access the high-seas portion of the stock, provided that a cooperative management regime with consistent measures for both portions of the stock (inside and outside the EEZ) is established.

Australia and New Zealand established a memorandum of understanding for cooperative management of the orange roughy stock in the STR in 1998. The arrangement has been revised since, with both governments agreeing to set a total allowable catch of zero tonnes, but providing for the possibility of a research quota. Through this process, Australia agreed to cease fishing orange roughy in the EEZ portion of the STR.

Southern Indian Ocean Fisheries Agreement area

The SIOFA area is predominantly a bottom fishery, with limited pelagic fishing. Fishing in the SIOFA area occurs on or near seamounts and ridges in the southern Indian Ocean. 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 (Romanov 2003; Clark et al. 2007; Bensch et al. 2009). No catch has been recorded by Ukraine since 2001.

Deep-sea trawlers from New Zealand and Australia were reportedly fishing in the SIOFA area before 1999. In 1999, deep-sea trawling in the area increased substantially after orange roughy stocks were discovered (Japp & James 2005). In 2000, the combined catch of all deepwater species for all international vessels in the area was estimated at 40,000 t (Bensch et al. 2009), which was taken by up to 50 vessels from more than 12 nations. Accurate catch data are not available for many of these vessels because of the unregulated nature of the high-seas fishery at that time (Bensch et al. 2009). Although more vessels were thought to be fishing, only eight reported participating in the fishery to the Food and Agriculture Organization of the United Nations (FAO) in 2001.

1 www.un.org/depts/los/convention_agreements/convention_overview_fish_stocks.htm

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 allowed 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).

SIOFA has adopted various CMMs, including CMMs relating to prohibiting large-scale pelagic driftnets and deepwater gillnets; interim management measures for bottom fisheries; an authorised vessel list; an illegal, unreported and unregulated vessel list; vessels without nationality; data standards and data confidentiality; and measures to regulate at-sea and in-port transshipment and vessel monitoring systems.

28.2 Catch-and-effort statistics

South Pacific Regional Fisheries Management Organisation Convention area

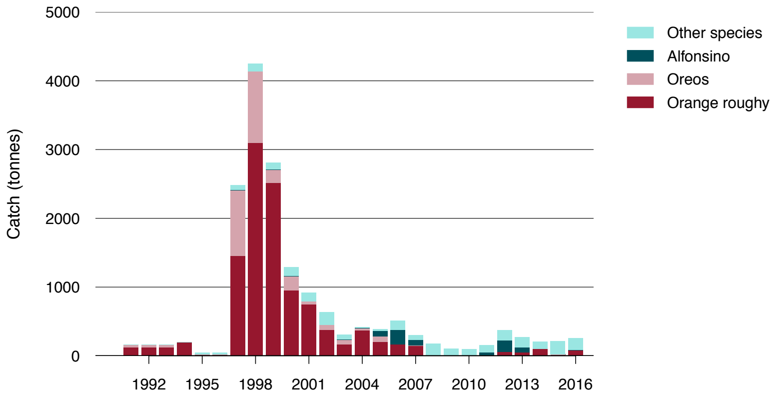
The total reported catch by Australian vessels in the SPRFMO Convention area was 204 t in 2014, 216 t in 2015 and 241 t in 2016 (Figure 28.4). Three Australian vessels were active in the SPRFMO Convention area in 2016: one trawl and two longline vessels.

After a peak of 4,143 t in 1998, annual catches by Australian trawl vessels in the SPRFMO Convention area have been less than 500 t for the past 10 years. The trawl catch for 2016 was 84 t, increasing from 21 t in 2015. Orange roughy comprised 99 per cent of the 2016 trawl catch (83 t).

Total non-trawl catch by Australian vessels in the SPRFMO Convention area was 157 t in 2016, a decrease from 195 t reported in 2015. Bottom longline was the only non-trawl method used in 2016. Redthroat emperor (*Lethrinus miniatus*) accounted for 28 per cent (44 t) of the 2016 non-trawl catch; the remainder comprised yellowtail kingfish (*Seriola lalandi*; 18 per cent; 28 t), Robinson's seabream (*Gymnocranius grandoculis*; 16 per cent; 26 t), flame snapper (*Etelis coruscans*; 8 per cent; 13 t), jackass morwong (*Nemadactylus macropterus*; 5 per cent; 8 t) and other species (24 per cent; 38 t).

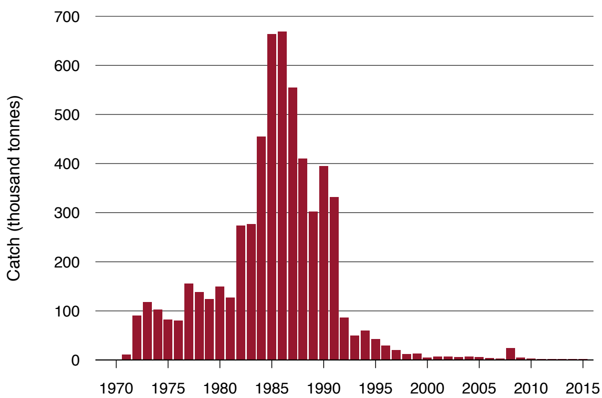
Total reported catch of demersal species by all fleets in the SPRFMO Convention area was 1,743 t in 2014 and 1,992 t in 2015 (Figure 28.5). Most of this catch was reported from the western SPRFMO Convention area, primarily by New Zealand and Australian vessels.

FIGURE 28.4 Australian trawl-and-line catch, by species, in the SPRFMO area of competence, 1990 to 2016



Source: Australian Fisheries Management Authority

FIGURE 28.5 Total SPRFMO catch of demersal species, 1969 to 2015



Source: SPRFMO

Southern Indian Ocean Fisheries Agreement area

Midwater and demersal trawl have contributed most of Australia's catch from the SIOFA area. Fewer than 10 catch records have been attributed to non-trawl methods over the history of the fishery, and these methods are not considered further here.

Because of confidentiality restrictions, catch data for the SIOFA area cannot be disclosed. The main species caught include blue-eye trevalla, alfonsino (*Beryx splendens*), hapuku (*Polyprion oxygeneios*) and rubyfish (*Plagiogeneion* spp.). One Australian-flagged vessel was active in the SIOFA area in 2016.

South Tasman Rise Trawl Fishery

TABLE 28.1 Status of the South Tasman Rise Trawl Fishery

Status	2015		2016		Comments
Biological status	**Fishing mortality**	**Biomass**	**Fishing mortality**	**Biomass**	
Orange roughy *(Hoplostethus atlanticus)*	Not subject to overfishing	Overfished	Not subject to overfishing	Overfished	Fishery has been closed under domestic arrangements since 2007 as a result of stock depletion.
Economic status	Fishery closed.				

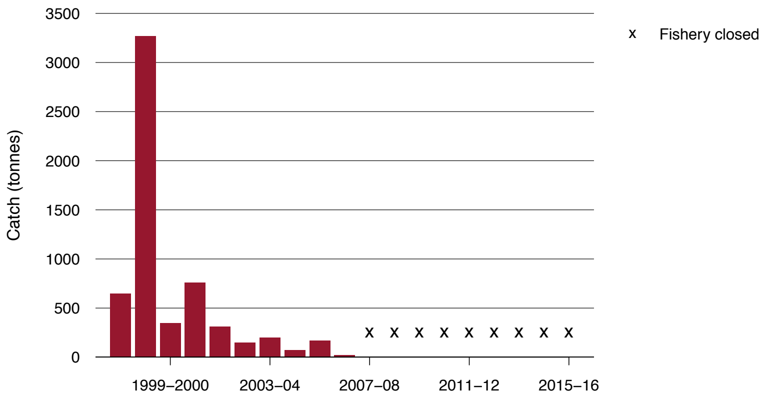
Fishing mortality	Not subject to overfishing	Subject to overfishing	Uncertain
Biomass	Not overfished	Overfished	Uncertain

Catch history

Fishing commenced in the STRTF in 1997 after the orange roughy stock was discovered. Orange roughy catches peaked at 3,270 t in 1998–99 and declined thereafter (Figure 28.6). From 2001 to 2006, when fishing was occurring, less than 10 per cent 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 and spikey oreodory. 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 28.6 Australian orange roughy catch, 1997–98 to 2015–16



28.3 Stock status

Stock structure

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 are not sustainable, and typically lead to rapid declines in abundance and availability (Norse et al. 2012). Long-term sustainable yields are only a small percentage of initial high catches.

The biological stock structure of orange roughy, alfonsino and oreodories in the southern oceans—including the SPRFMO Convention area, the SIOFA area and the adjoining STRTF—is uncertain. Research indicates that there is a greater level of genetic structure in global orange roughy populations than has previously been detected (Varela et al. 2013). However, genetic studies have not detected differences between orange roughy from New Zealand and Australia. Past studies on catches and estimated biomass have identified separate and geographically distinct fishing areas for orange roughy due to substantial distances or abyssal-depth waters. These fishing areas are the STR, the northern Lord Howe Rise, the southern Lord Howe Rise, the Challenger Plateau and the West Norfolk Ridge.

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 (Chapter 9). 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 the northern Lord Howe Rise and orange roughy on the Challenger Plateau, both within the SPRFMO Convention area, constitute such straddling stocks. Under the SPRFMO Convention, such stocks should be subject to compatible management arrangements within EEZs and on the high seas. Since there is no active management of catches of these species in the high-seas areas, management units have not been defined for these stocks.

Stock assessment

The only assessment of the orange roughy stock in the STRTF used catches and catch rates in a standardised catch-per-tow analysis, as well as examining acoustic data collected during the winter spawning seasons of 1998 to 2002 (Wayte et al. 2003). Annual reported catches in the fishery declined after the first couple of years (Figure 28.6). Standardised catch-per-tow analysis (Wayte et al. 2003) indicated that catch rates declined by 92 per cent 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 per cent 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.

The only other stock for which an assessment has been published is orange roughy in the western SPRFMO area of competence (Clark et al. 2010). Several methods have been used to make preliminary assessments of orange roughy stocks fished by New Zealand vessels. Clark et al. (2010) present two analyses:

- a standardised catch-per-unit-effort (CPUE) analysis using tow-by-tow data between 1992–93 and 2006–07, at the level of all fishing grounds and individual fishing grounds
- a meta-analysis that related unexploited orange roughy biomass to physical characteristics of each seamount; 59 seamounts were analysed, and yield estimates were based on a proportion of estimated unfished biomass.

Outcomes from the catch rate–based analyses indicated that the CPUE for the north-west Challenger Plateau ground was variable, with perhaps a slow increase overall. However, Clarke et al. (2010) concluded that caution was needed when interpreting these CPUE trends as indices of stock abundance. The CPUE data for all subareas examined showed sequential fishing of locations and a subsequent reduction in the CPUE at locations fished in the past, indicating that the overall CPUE is biased upwards over time; high catch rates may be maintained by sequential movement of activity to new fishing areas.

The seamount meta-analysis gave a total biomass estimate for orange roughy on all 59 seamounts of 83,800 t. Estimated biomass on two of the major fishing grounds was 8,800 t for the north-west Challenger Plateau and 4,130 t for Lord Howe Rise. The estimated maximum constant yield (MCY) for the north-west Challenger Plateau was 130 t, and the maximum annual yield (MAY) was 170 t. The estimated MCY for Lord Howe Rise (north and south structures combined) was 60 t per year, and the MAY was 80 t per year. Using the analyses of Clark et al. (2010), Penney (2010) provided sustainable yield estimates based on $0.5MB_0$ (half the natural mortality rate × unexploited biomass; Gulland 1971) of 198 t for the north-west Challenger Plateau and 93 t for Lord Howe Rise.

Clark et al. (2010) noted that the number of seamount features identified within the area used for the meta-analysis is lower than the true number. As a result, potential total biomass of orange roughy in the area could be higher than that estimated through the habitat-based method. The authors also highlighted uncertainties with these assessment methods that reduce the reliability of the results. These uncertainties include the utility of broadscale catch rate–based analyses for spatially and temporally aggregating species, the impact of potential underestimation or overestimation of habitat area, and the potential overestimation of productivity through the use of long-term average recruitment and accumulated biomass.

Woodhams et al. (2012) assessed the sustainability of harvest rates of species targeted by Australian vessels in these high-seas fisheries. The study concluded that only a small proportion of the total assumed habitat area for the target species has been fished by Australian vessels and none of the stocks targeted by Australia's high-seas fishing operations have been classified as overfished or subject to overfishing. In 2013, Australia's high-seas fisheries were reaccredited for five years under part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). One of the conditions associated with this renewed accreditation is that the Australian Government Department of Agriculture and Water Resources, in conjunction with AFMA, must continue to investigate key non–highly migratory species or stocks harvested under Australia's high-seas permits, with a view to improving certainty in future stock assessments. This has been translated into several recommendations in the SPRFMO scientific work plan adopted by the SPRFMO Commission.

Stock status determination

Insufficient information is available to enable the fishery-wide determination of stock status for any of the high-seas demersal fish stocks in the SPRFMO or SIOFA areas. However, the assessment of orange roughy in the STR indicates that the stock biomass had been overfished (Table 28.1). The life history characteristics of orange roughy may make the recovery of the stock a very slow process—possibly in the order of decades, given the estimated level of depletion. Although the fishery has not been surveyed since 2002, in the absence of any new information, the stock remains classified as **overfished**. Since the fishery is closed, the stock is classified as **not subject to overfishing**.

28.4 Economic status

The gross value of production is not available for the SPRFMO and SIOFA areas for confidentiality reasons. The number of active vessels operating during the 2016 fishing season was fewer than five in the two fisheries combined. Given limited catches in recent years, the value of the fisheries would be relatively low compared with other Australian fisheries.

The STRTF has been assessed as overfished, and so stocks are below the level associated with maximum economic yield. The fishery has been closed since 2007, so its economic status has not been assessed.

28.5 Environmental status

Deep-sea fisheries generally operate at depths of 200–1,600 m, on continental slopes or isolated oceanic structures such as ridges, seamounts and banks (FAO 2012). The depths and distances from the coast pose challenges to research, assessment and management of the effects of fishing on the environment and on target stocks (FAO 2012).

Impact assessment of bottom fishing

Under the United Nations General Assembly resolutions on sustainable fisheries (specifically, paragraph 83a of resolution 61/105, and paragraph 119(a) of resolution 64/72), states are called on to assess, on the basis of the best available scientific information, whether individual bottom-fishing activities would have a significant adverse impact on VMEs, and to ensure that these activities are managed to prevent such impacts or are not authorised to proceed. This obligation was reflected in the SPRFMO interim measures (SPRFMO 2007), resulting in the development and adoption by the SPRFMO of a standard for impact assessment of bottom fisheries (SPRFMO 2012), compatible with the FAO deepwater guidelines (FAO 2009). The 2014 meeting of the SPRFMO adopted a binding CMM to give effect to these resolutions (SPRFMO 2014).

The STRTF is included as a high-seas fishery under the List of Exempt Native Specimens under the EPBC Act until 18 May 2018. No ecological risk assessment has been done because the STRTF has been closed since 2007.

The South Tasman Rise Commonwealth Marine Reserve, which came into effect in 2007, overlaps with the STRTF (Figure 28.3). The reserve covers 27,704 km^2, including several seamounts. Commercial fishing is not permitted in the reserve. Several other marine reserves occur in the vicinity of the STRTF (Figure 28.3).

As noted in Section 28.1, Australia completed bottom-fishing impact assessments for demersal fishing activities in the south Pacific and southern Indian oceans in 2011 (Williams et al. 2011a, b). The impact assessments for both areas concluded that the current overall risk of significant adverse impacts on VMEs by Australian vessels fishing with bottom trawls and bottom-set auto-longlines was low, primarily because of the low fishing effort and the small number of areas of high fishing intensity. The assessments also concluded that the current overall risk of significant adverse impacts on VMEs from midwater trawling and droplining by Australian vessels was negligible (Williams et al. 2011a, b), based on the low level of fishing effort, the small number of areas of high fishing intensity and the effects of current management arrangements.

List of exempt native specimens

Under part 13A of the 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. High-seas permits are authorised under the EPBC Act until 18 May 2018.

Since 2010, AFMA observers have recorded few interactions with protected species. No interactions with protected species were reported by AFMA observers or in logbooks in 2016.

28.6 References

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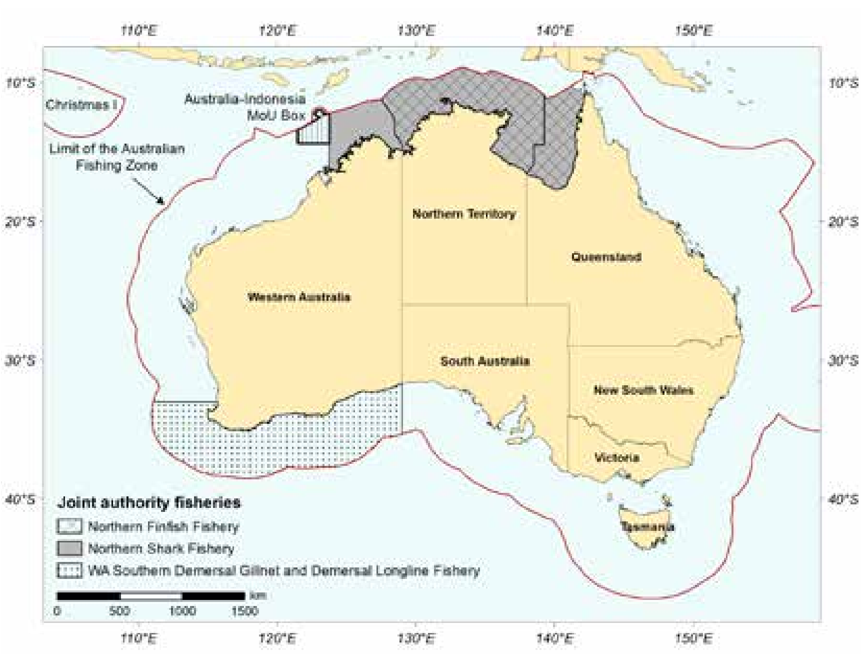
Chapter 29

Joint authority fisheries

T Emery

FIGURE 29.1 Geographic extent of the joint authority fisheries



The Australian Government is a party to several fisheries managed under joint authority arrangements with state governments or the Northern Territory Government. These arrangements are species or area based, and recognise that stocks are likely to be shared with adjacent national or international jurisdictions. In northern Australian waters, several shark and finfish joint authority fisheries (JAFs) are collectively referred to as the Northern Shark Fishery and the Northern Finfish Fishery (Figure 29.1). This chapter reports on these northern fisheries and on the Western Australian Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australian JAF). In each case, strategic directions are provided by members of the joint authority, while the day-to-day management of the fishery is undertaken by the relevant state or territory government, under its legislation. The relevant jurisdictions assess and report on the management and status of the fisheries. The stocks harvested in these fisheries are not formally classified in this report.

Since 1988, the Western Australian Government has managed the Western Australian JAF on behalf of a joint authority comprising the Western Australian and Australian governments. In 1995, under the Offshore Constitutional Settlement (OCS), jurisdiction of the finfish resources (except for tuna and tuna-like species) in the waters off northern Western Australia, west of 123°45'E, was passed to the Western Australian Government. These resources are not further addressed here.

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* (Cwlth) (see Chapter 15).

29.1 Western Australian Temperate Demersal Gillnet and Demersal Longline Fisheries

Currently, two shark fisheries operate off the south and west coasts of Western Australia: the Western Australian JAF (Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery) and the state-managed West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDF). Collectively, these fisheries are managed as the Temperate Demersal Gillnet and Demersal Longline Fisheries. The Western Australian JAF extends south-east from south of Cape Bouvard (just north of Bunbury on the southern west coast) to the Western Australia – South Australia border (Figure 29.1); it had 21 active vessels in 2015 (Marton et al. 2016a). The WCDF, which is managed under a complementary management plan, extends north from Cape Bouvard and catches many of the same species; it had 5 active vessels in 2015 (Marton et al. 2016a). The status of species taken in these two fisheries is determined by the Western Australian Department of Fisheries, using catch-and-effort information from both fisheries. Statistics provided here are from either Marton et al. (2016a) or Braccini and O'Malley (2017).

The principal species targeted in the Western Australian JAF are gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark (*Furgaleus macki*) and sandbar shark (*C. plumbeus*). Another 25 species of shark and scalefish are also caught regularly, the most common being hammerhead sharks (Sphyrnidae), spinner shark (*C. brevipinna*) and wobbegong sharks (Orectolobidae) (McAuley et al. 2015). School shark (*Galeorhinus galeus*) was historically targeted in the south-eastern region of the fishery but is currently only taken incidentally as a minor byproduct species. Principal target species in the WCDF are dusky shark, sandbar shark and whiskery shark.

Combined 2014–15 logbook data for the Western Australian JAF and the WCDF indicated a total shark and ray catch of 1,040 t (an increase from 994 t in 2013–14), comprising mostly gummy shark (492 t), dusky shark (197 t), sandbar shark (46 t) and whiskery shark (147 t) (Braccini & O'Malley 2017). Catches of scalefish in both fisheries totaled 156 t in 2014–15 (a decrease from 192 t in 2013–14). The catch included blue groper (*Achoerodus gouldii*), queen snapper (*Nemadactylus valenciennesi*), pink snapper (*Chrysophrys auratus*) and dhufish (*Glaucosoma hebraicum*) (McAuley et al. 2015).

Status of stocks

The fishery is managed primarily by setting maximum fishing effort levels. These are intended to achieve acceptable catches and maintain biomass at greater than 40 per cent of initial unfished levels for the key target species (gummy, whiskery and dusky sharks) (Braccini & O'Malley 2017). The time frame for achieving the target biomass varies from species to species, and some species are already considered to have reached this target (McAuley et al. 2015).

The last formal stock assessment of Western Australian gummy shark was in 1997–98. It indicated that biomass was 43 per cent of the initial unfished level, slightly above the target level of 40 per cent of unfished biomass. Combined total catch in the Western Australian JAF and the WCDF in 2014–15 was 492 t. An increase in catch-per-unit-effort (CPUE) between the mid 1990s and the mid 2000s is thought to have resulted from reduced fishing effort from 1992 onwards, leading to increases in breeding stock biomass (Braccini & O'Malley 2017). Although CPUE has fluctuated in recent years following a peak in 2007–08, the breeding stock biomass is considered to be adequate (Braccini & O'Malley 2017).

Previous stock assessments of whiskery shark indicate that biomass declined significantly from the 1980s to less than 40 per cent of the unfished level in the early 1990s. Recent modelling, however, suggests that biomass may have fallen only as low as 45 per cent by 1995–96 and that a modest recovery has taken place, resulting in a biomass of 52 per cent of unfished levels in 2009–10, which is above the target level of 40 per cent of unfished biomass. Catches since the late 2000s have been at levels that would allow gradual recovery of the breeding stock biomass, so the stock is considered to be adequate (Braccini & O'Malley 2017).

Most dusky sharks taken in the Western Australian JAF are neonates (the young of the year) and 1–2-year-old fish. Demographic analyses, updated in 2005, estimated that the current fishing mortality on these age classes was sustainable, but that a very low level of fishing mortality (1–2 per cent per year) for older dusky sharks (>10 years) would result in negative rates of population growth. Although spatial closures have been implemented to protect adult dusky sharks, they continue to be captured in fisheries within and outside Western Australia's jurisdiction (such as the Commonwealth Western Tuna and Billfish Fishery and the South Australian Marine Scalefish Fishery). Previous estimates indicated that the breeding stock had been depleted by low, but poorly quantified, levels of fishing mortality. However, management changes since 2006 are considered suitable to allow gradual recovery of the breeding stock. The recent declines in CPUE will be considered in more detail during the development of new stock assessment models (Braccini & O'Malley 2017).

School shark is taken as byproduct in the Western Australian JAF. Management of this species takes into account its overfished status in the Southern and Eastern Scalefish and Shark Fishery (SESSF; Chapter 8). Assessments of school shark in the SESSF incorporate catch information from the JAF. Combined catch of school shark in the Western Australian JAF and the WCDF in 2015 was 1.2 t (Marton et al. 2016b).

29.2 Northern Shark Fisheries

Australian gillnetters began fishing in northern Australian waters in about 1980, although there was fishing from foreign vessels before then, and gillnetting by foreign vessels continued until 1986. The Northern Shark Fisheries were developed during the 1980s and 1990s, and transferred to the relevant joint authorities in 1995. They include the Northern Territory Offshore Net and Line Fishery, the Queensland Gulf of Carpentaria Inshore Fin Fish Fishery and the Western Australia Joint Authority Northern Shark Fishery (WANSF). These fisheries cover waters off Australia's northern coast, encompassing the Gulf of Carpentaria, the Timor and Arafura seas, Joseph Bonaparte Gulf, and the north-east coast of Western Australia (Figure 29.1).

The primary fishing methods are gillnetting and longlining, with most activity and catch occurring in waters off the Northern Territory. Historically, the main commercial species have been blacktip sharks (Australian blacktip—*Carcharhinus tilstoni*, and common blacktip—*C. limbatus*), spot-tail shark (*C. sorrah*) and grey mackerel (*Scomberomorus semifasciatus*). The Australian and common blacktip sharks are difficult to differentiate and so have been treated as a species complex, with the assumption that most are Australian blacktip, although genetic analyses have challenged this assumption (discussed in 'Status of stocks', below). Other shark species, including hammerheads (*Sphyrna* spp.), bull shark (*C. leucas*), pigeye shark (*C. amboinensis*) and tiger shark (*Galeocerdo cuvier*), are also caught. Sharks are also taken as bycatch and byproduct in other fisheries in the area.

Northern Territory Offshore Net and Line Fishery

This fishery is managed by the NTFJA, in accordance with the *Fisheries Act* (NT, 1988). Most fishing in the waters off the Northern Territory occurs in inshore waters (less than 12 nautical miles [nm] from the coast), targeting blacktip sharks and grey mackerel. Catch-and-effort data for 2016 were provided directly to ABARES from the Northern Territory Department of Primary Industry and Resources. Pelagic gillnets (limited to 2,000 m net length) are the main gear. Although longlines can also be used, they have not been used in the fishery since 2013 (Northern Territory Government 2015). Of the 17 licences currently issued for the fishery, 11 were active in 2016. A total of 555 boat-days were recorded during 2016, well below the peak of 1,801 boat-days in 2003.

The highest domestic catch was reported in 2003 (1,687 t), including 899 t of shark (of which 501 t was blacktip shark) and 766 t of grey mackerel. Total landings have decreased since 2003, to a total catch of 465 t in 2016 (a decrease from the 2015 catch of 530 t). The 2016 catch included 36 t of blacktip shark and 332 t of grey mackerel. Export accreditation was reassessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2012, and the fishery was declared an approved Wildlife Trade Operation until 27 October 2017.

Queensland Gulf of Carpentaria Inshore Fin Fish Fishery

The QFJA manages shark fishing in Gulf of Carpentaria waters off Queensland as part of the Gulf of Carpentaria Inshore Fin Fish Fishery. An annual summary of this fishery is provided by the Queensland Department of Agriculture and Fisheries (QDAF 2017). The fishery has two sectors: an offshore sector (7–25 nm) that targets tropical sharks and grey mackerel, and an inshore sector (within 7 nm of the shore) that targets barramundi (*Lates calcarifer*), threadfins (Polynemidae) and sharks. The main gear used is gillnets; operators in the offshore sector are limited to a maximum net length of 1,800 m. In 2016, 4 licences were issued in the offshore sector (3 licences for operation beyond 7 nm from shore and within the AFZ, and 1 licence for operation beyond 25 nm from shore and within the AFZ) and 85 licences in the inshore sector (QDAF 2017). Of these 89 licences, 77 were active in 2016. In 2016, reported catch of blacktip sharks was 210 t (an increase from 100 t in 2015; QDAF 2017).

Queensland considers most barramundi stocks to be 'sustainable', except for the southern Gulf of Carpentaria stock, which is classified as 'transitional depleting'. The east coast stock of king threadfin (*Polydactylus macrochir*) is considered 'sustainable'; however, the Gulf of Carpentaria stock is considered 'transitional depleting' (QDAF 2016). 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 7 September 2017.

Western Australia Joint Authority Northern Shark Fishery

The Western Australian Government manages the WANSF. For reporting and assessment purposes, this fishery is combined with the adjacent Western Australia North Coast Shark Fishery (WASF) and reported as part of the 'northern shark fishery'. The WANSF extends from longitude 123°45'E to the Northern Territory border, and the WASF extends from longitude 114°06'E to 123°45'E. Western Australia reported on the status of these fisheries in McAuley and Rowland (2012), and Molony et al. (2013); however, the WANSF and the WASF are no longer included in the Western Australian state of the fisheries report. Since 2005, demersal gillnets and longlines have been permitted in both fisheries, with longlines being the main gear used. Fishing activity has not been reported in the northern shark fishery since 2008–09.

An increase in effort occurred in this fishery between 1999–2000 (less than 100,000 hook-days) and 2004–05 (1.2 million hook-days). The total catch showed a corresponding increase, from approximately 100 t (1999–2000) to 1,294 t (2004–05). Fishing practices also changed, with a shift from primarily gillnetting in the north-eastern region of the fishery to increased demersal longline effort in the south-western region (McAuley & Baudains 2007). The changes reflected increased targeting of sandbar shark and other large species.

The stock assessment for sandbar shark, which considers all take of the species across Western Australian fisheries, suggested that cumulative levels of fishing mortality were increasingly unsustainable between 2001 and 2004, and had probably been unsustainable since at least 1997–98 (McAuley et al. 2015). Three-quarters of the total catch in 2004–05 was from the northern shark fishery alone. A decline in breeding stock abundance has been inferred from fishery-independent survey data from the north-coast region (McAuley et al. 2015).

Management measures to prevent targeting of sandbar shark in the WASF were put in place in 2005; these included closure of about 60 per cent of the fishery to protect breeding stock and limits on the permitted number of fishing days. At the same time, management arrangements to limit effort were established in the WANSF. These measures resulted in a substantial decline in total fishing effort and an associated decrease in total reported catch.

In 2008, the WANSF's Wildlife Trade Operation approval under the EPBC Act was revoked because a formal management plan had not been finalised. The WASF's approval expired in early 2009 and has not been renewed. Therefore, product from these fisheries cannot be exported.

Other catches, including illegal fishing

Across the area of the Northern Shark Fisheries, sharks are caught as bycatch and byproduct in other Commonwealth, state and territory fisheries. In Western Australia, the 2014–15 catch of sharks by other state-managed fisheries was negligible—less than 10 t (it peaked at 31 t in 2005–06)—as a result of a ban on retention in all but three non-shark fisheries (McAuley & Baudains 2007; Molony et al. 2013). The Northern Territory Government estimates that incidental catch in other Northern Territory fisheries is around 1 per cent 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 ongoing activity that aims to estimate catches by traditional Indonesian fisheries operating in these waters (Marshall et al. 2016). In 2015, genetic analysis of 152 shark fins from nine fishing vessels identified 16 species belonging to the families Carcharhinidae (whaler sharks) and Sphyrnidae (hammerhead sharks). The two most abundant species by number were sandbar shark and tiger shark, which made up 43.4 per cent and 29.6 per cent of the catch, respectively, followed by spinner shark (*Carcharhinus brevipinna*; 7.2 per cent) and grey reef shark (*Carcharhinus amblyrhynchos*; 5.3 per cent) (Marshall et al. 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 et al. 2016).

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). A large number of foreign fishing vessels were caught in Australian waters in 2015–16 (20) compared with 2014–15 (6), but numbers are well down relative to 2005–06 (367) because of enforcement measures and collaborative programs in Indonesia (AFMA 2016). The estimated total catch from illegal fishing in 2006 was 290–1,071 t (Marshall 2011). A study of illegal, unreported and unregulated catch in northern Australian waters indicated that illegal catches by Indonesian and Taiwanese vessels included seven high-risk shark species, with these species constituting more than half the total catch (Marshall 2011). A number of sharks listed in 2014 under the Convention on International Trade in Endangered Species of Wild Fauna and Flora were caught on Indonesian and/or Taiwanese vessels in the Marshall (2011) study, including scalloped hammerhead shark (*Sphyrna lewini*), great hammerhead shark (*S. mokarran*), smooth hammerhead shark (*S. zygaena*) and oceanic whitetip shark (*Carcharhinus longimanus*).

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 had 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 per cent of MSY for common blacktip shark and 12 per cent of MSY for Australian blacktip shark), and the current level of fishing effort was sustainable. Current biomass is estimated to be at 81 per cent of unfished biomass for common blacktip shark and 90 per cent for Australian blacktip shark.

Genetic studies (Ovenden et al. 2009) of spot-tail and Australian blacktip sharks show little genetic variation in either species across the north, suggesting that it may be appropriate to manage each species as a single stock across the region. In contrast, common blacktip shark may have genetic subdivisions in Australian waters (Ovenden et al. 2009). Genetic studies also detected an apparent change in the relative proportion of common and Australian blacktip sharks in the catch. In the 1980s, Australian blacktip shark was understood to be the major component of the catch, and common blacktip shark was caught in much lower numbers (the ratio of Australian to common blacktip shark was estimated to be 300:1; Stevens & Davenport 1991). More recent studies have indicated a ratio closer to 1:1 (Morgan et al. 2012). In 2011, genetic research demonstrated that hybridisation was occurring between the species (Morgan et al. 2012). The results have increased the uncertainty in the status of the stocks, and the implications have yet to be fully assessed.

29.3 Northern Finfish Fishery

Foreign pair and stern trawlers (Japanese, Taiwanese, Thai and Chinese) have fished waters off northern Australia periodically since the 1930s. After the AFZ was declared, foreign trawlers were licensed to fish in the northern AFZ until 1990. The main regions fished were the Timor and Arafura seas, and the North West Shelf off Western Australia. The foreign fleets' highest catches were 37,100 t on the North West Shelf (1973), 9,100 t in the Timor Sea (1974) and 10,000 t in the Arafura Sea (1983). Australian trawlers started fishing in the area in 1985; a domestic trap-and-line fishery began on the North West Shelf in 1984, and droplining in the Timor Sea began in 1987.

The main species targeted are large red snappers (saddletail snapper—*Lutjanus malabaricus,* and crimson snapper—*L. erythropterus*) and goldband snappers (primarily *Pristipomoides multidens*, but also *P. typus* and *P. filamentosus*). The joint authorities include trawl, dropline and trap fisheries, which have developed differently over time.

Northern Territory

The NTFJA manages two fisheries targeting tropical snappers: the Timor Reef Fishery and the Demersal Fishery. The Timor Reef Fishery operates offshore north-west of Darwin in a specific area of the Timor Sea. The Demersal Fishery operates in waters from 15 nm out to the AFZ boundary, excluding the area of the Timor Reef Fishery. Until recently, the NTFJA also managed a third snapper fishery, the Finfish Trawl Fishery, but, in February 2012, this was amalgamated into the Demersal Fishery under a new management framework (Saunders et al. 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 et al. 2014). Individual transferable quotas were introduced into the new management framework of the Demersal Fishery in 2012.

Vessels in the Demersal and Timor Reef fisheries use vertical droplines and baited traps to target goldband snappers, but also catch red snappers (Lutjanidae), red emperor (*Lutjanus sebae*) and cods (*Epinephelus* spp.). The Demersal Fishery also permits semipelagic finfish trawl gear in two multigear areas. Dropline fishing takes mostly goldband snappers, whereas traps catch nearly equal proportions of goldband snappers and red snappers. Trawl vessels mainly target saddletail snapper and crimson snapper. The status of these fisheries is reviewed in Martin and McKey (2014a, b). Catch-and-effort data for 2016 were provided directly to ABARES from the Northern Territory Department of Primary Industry and Resources.

In 2016, four vessels were active in the Timor Reef Fishery, recording 605 vessel-days, and seven vessels were active in the Demersal Fishery, recording 1,297 vessel-days. The Timor Reef Fishery reported a total catch of 948 t in 2016 (an increase from 737 t in 2015), including 221 t of goldband snappers and 407 t of red snappers. The Demersal Fishery reported a total catch of 3,463 t in 2016, including 2,510 t of red snappers and 318 t of goldband snappers. The Timor Reef Fishery was reassessed in 2013 and was granted an exemption from export restrictions under the EPBC Act for five years, until 2018. The Demersal Fishery has been granted an exemption from export restrictions until 27 October 2017.

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 2017). Three fishing permits are issued for access to the fishery; however, logbook returns indicate that no fishing activity was reported between April 2013 and June 2015. Following the recommencement of fishing, two vessels were active, with an effort level of 60 vessel-days in 2015–16. The total catch in 2015–16 was 231 t, of which 173 t was red snappers (104 t of crimson snapper and 69 t of saddletail snapper) and 19 t was goldband snappers (QDAF 2017). Catch and effort in this fishery have declined substantially from 2009–10, when total catch was reported to be 781 t from 389 vessel-days. The fishery has been granted export approval until 22 November 2019.

The Queensland Gulf of Carpentaria Line Fishery is primarily a troll fishery for Spanish mackerel (*Scomberomorus commerson*). Red snappers are not considered to be target species for the fishery. There are 46 licences in the fishery; 15 were active in 2016. Total catch in 2016 was 177 t, with an effort level of 587 vessel-days. Spanish mackerel accounted for 99 per cent of the catch in 2016 (QDAF 2017).

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 red snapper caught in this area. An Australian–Indonesian project in 1999–2000, supported by the Australian Centre for International Agricultural Research (ACIAR), examined the connectivity 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 2015, the commercial catch of goldband snappers in the Northern Territory was 501 t; 19 t was caught in Queensland (Martin et al. 2016a). While there is no total allowable commercial catch (TACC) for goldband snappers in Queensland because of relatively low catches, the Northern Territory has a TACC of 1,300 t (900 t in the Timor Reef Fishery and 400 t in the Demersal Fishery).

The northern Australian goldband snapper stock was assessed in 2011 and 2013 using a stochastic stock reduction analysis model. Egg production was estimated to be around 65 per cent of production before the start of the fishery, and the current harvest rate was estimated to be below that required to achieve MSY (Martin et al. 2016a). 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 the stock assessment is limited.

In 2015, the commercial catch of red snappers was 2,454 t (1,756 t of saddletail snapper and 698 t of crimson snapper) in the Northern Territory and 167 t (67 t of saddletail snapper and 100 t of crimson snapper) in Queensland (Martin et al. 2016b). In Queensland, the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery operates under a TACC of 450 t for quota species (crimson snapper, saddletail snapper and other tropical snappers; QDAF 2017). This is based on a 1994 assessment that estimated an annual sustainable yield for the total Gulf of Carpentaria of 2,900–9,000 t (Leslie & Roelofs 2011). In the Northern Territory, crimson and saddletail snappers are managed together as 'red snappers' (Martin et al. 2016b) with a combined TACC of 3,800 t.

The northern Australian saddletail snapper stock was assessed in 2013 using a stochastic stock reduction analysis model. Egg production was estimated to be around 80 per cent 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 (Martin et al. 2016c).

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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* assess the performance of Commonwealth fisheries against the objectives of the *Fisheries Management Act 1991* (FM Act); in particular:

Part 3

a. ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (which include the exercise of the precautionary principle), in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment; and

b. maximising the net economic returns to the Australian community from the management of Australian fisheries; and

c. ensuring accountability to the fishing industry and to the Australian community in AFMA's management of fisheries resources.

Commonwealth Fisheries Harvest Strategy Policy

The Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007) was developed to support the implementation of the objectives of the FM Act. The objective of the HSP is 'the sustainable and profitable utilisation of Australia's Commonwealth fisheries in perpetuity, through the implementation of harvest strategies that maintain key commercial stocks at ecologically sustainable levels and, within this context, maximise the economic returns to the Australian community'.

The HSP and associated guidelines provide a framework for an evidence-based approach to the management of Commonwealth fish stocks. The HSP makes the following observations on what constitutes good fisheries management:

- Fisheries are more efficient, profitable, stable and sustainable when stocks are larger than the stock size (biomass) that produces maximum sustainable yield (MSY), referred to as B_{MSY}.

- Future productivity is at greater risk when stocks are reduced to a level at which the recruitment of young fish, relative to the portion of the stock subject to fishing, declines precipitously (referred to as 'recruitment failure').
- Fisheries should be managed on a whole-stock basis, and in a way that takes species' life history characteristics (such as longevity, fecundity and recruitment variability) into account.
- Economic returns can be maximised and, in general, overcapitalisation can be avoided when fish stocks are maintained, on average, at a target adult biomass level that produces maximum economic yield (MEY), referred to as B_{MEY}.

The HSP requires that harvest strategies are developed that pursue MEY and ensure that stocks remain above levels at which risk becomes unacceptably high. Specifically, harvest strategies need to have the following aims:

- Seek to maintain fish stocks, on average, at a target biomass (B_{TARG}) equal to B_{MEY}. Where B_{MEY} is unknown, a proxy of $1.2B_{MSY}$ (or a level 20 per cent higher than a given proxy for B_{MSY}) is to be used for a single-species fishery. For a multispecies fishery, judgement needs to be exercised in setting targets to optimise multispecies MEY. An alternative proxy for B_{MEY} may be used if it can be demonstrated that it is more appropriate.
- Ensure that fish stocks remain above a biomass level below which the risk to the stock is regarded as too high—referred to as the limit biomass level (B_{LIM}).
- Ensure that the stock stays above B_{LIM} at least 90 per cent of the time. For highly variable species that may naturally breach B_{LIM} in the absence of fishing, the harvest strategy for the species must remain consistent with the intent of the policy.

A harvest strategy sets out the management actions necessary to achieve defined biological and economic objectives in a given fishery. Harvest strategies must include:

- a process for monitoring and conducting assessments of the biological and economic conditions of the fishery
- rules (referred to as control rules) that control the intensity of fishing activity according to the biological and economic conditions of the fishery (as defined by the assessment).

The HSP requires harvest strategies to be developed for all Commonwealth fisheries, except for those that are managed under the joint authority of the Australian Government and another Australian jurisdiction, or under an international management body or arrangement. However, the HSP also notes that the Australian Government will advocate the principles of the policy within jointly managed fisheries.

In March 2012, the then Minister for Agriculture, Fisheries and Forestry announced a review of the HSP. The review found that the policy is widely regarded as a very successful initiative for improving the management of Commonwealth fisheries and that it remains a strong foundation for Commonwealth fisheries management. The results of this review (Penney et al. 2013; Vieira & Pascoe 2013; Ward et al. 2013) are being used to revise and update the HSP. A revised policy is currently being developed by the Department of Agriculture and Water Resources, in consultation with the Australian Fisheries Management Authority (AFMA) and other stakeholders.

30.2 Assessing biological status

Fish stock definitions

Where feasible, status is reported for the biological stock, defined as discrete populations of the same species that are typically reproductively isolated from each other in space or time, 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. For each species reported on, available information on biological stock structure is summarised, and definitions are provided for the biological stocks or management units being assessed.

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, the Indian Ocean Tuna Commission (IOTC), the South Pacific Regional Fisheries Management Organisation 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

The biological status of a stock depends on its current stock size (biomass) and the rate of catches (fishing mortality). Two independent aspects of stock status are classified: 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).

In terms of biomass status, stocks are classified as one of the following:

- not overfished, where the biomass is above B_{LIM} and likely to be adequate to sustain the stock in the long term. This indicates that the biomass (or biomass proxy) 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 unlikely to be adequate to sustain the stock in the long term. The B_{LIM} threshold reflects the point at which the risk to future levels of recruitment is unacceptable. The HSP requires that fish stocks remain above a biomass level at which the risk to the stock is regarded as too high (B_{LIM} or a proxy) at least 90 per cent of the time. Two common proxies for that limit are half the biomass required for MSY ($0.5B_{MSY}$) and 20 per cent of the unfished biomass ($0.2B_0$)
- uncertain, where there is inadequate information to determine the state of a stock's biomass and the risk to future recruitment.

The guidelines of the HSP do not define if B_{LIM} relates 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 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 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. The HSP indicates that an overfished stock should not be subject to any directed (targeted) fishing. Also
  - when stock levels are at or above B_{MSY}, F_{MSY} will be the default level for F_{LIM}
  - fishing mortality exceeding F_{LIM} will not be defined as overfishing if the stock is above the target level (B_{TARG}) and a formal 'fish-down' or similar strategy has been implemented

  - 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}
  - any fishing mortality will be defined as overfishing if the stock level is below B_{LIM}, unless that fishing mortality is below the level that will allow the stock to recover (to or above B_{LIM}) within a biologically meaningful time frame. The HSP gives a period of 10 years plus one mean generation time, or three times the mean generation time (whichever is less) as examples of typical recovery time frames
- 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, although these reference points may be defined differently from those in the HSP. The limit reference points adopted by the WCPFC and the IOTC are the same as those prescribed in the HSP. However, the IOTC determines stock status relative to target reference points, not limit reference points. For jointly managed stocks, ABARES determines stock status using the limit reference points described in the HSP and considers the impacts of fishing mortality from all fleets on the stocks. Consequently, the status of some jointly managed stocks reported by RFMOs may differ from that reported by Australia.

Changes to the stock status classification system

The classification system for stock status has been modified several times since the first *Fishery status reports* (1992). In 2004, the 'underfished' and 'fully fished' categories were replaced by a combined category of 'not overfished'. This change was made partly because of potential confusion about the meaning of 'fully fished'. It was also difficult to classify a stock as 'underfished' because data were often lacking for stocks likely to fall into this category.

Another change in 2004 was inclusion of a distinction between a stock's biomass status and its 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 the stock's 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 and actions in line with the HSP

Biomass (B)	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)
$B \geq B_{TARG}$ (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: no targeted fishing permitted	Overfished: adopt and follow a rebuilding strategy to rebuild biomass above B_{LIM} within a required time frame Overfishing may not be occurring, provided that fishing mortality will allow rebuilding towards target within a required time frame; no targeted fishing permitted	Overfished: adopt a rebuilding strategy to rebuild biomass above B_{LIM} within a required time frame Overfishing is occurring: reduce fishing mortality; no targeted fishing permitted High risk to stock

Note: Colours show how these reference points relate to stock status classifications used for each stock.

Fishing mortality Not subject to overfishing (green) Subject to overfishing (red)

Status determination framework

A weight-of-evidence decision-making framework for biological status determination was a key output of the Reducing Uncertainty in Stock Status (RUSS) project, undertaken from 2009 to 2012 (Larcombe et al. 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, which has been applied in the compilation of the *Fishery status reports* since 2009. 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. The decision-making process is undertaken separately for biomass and fishing mortality.

30.3 Assessing economic status

The economic status of each Commonwealth fishery (excluding jointly managed Torres Strait fisheries) is determined by assessing management performance against the economic objective of the FM Act, which is to maximise net economic returns (NER) to the Australian community from the management of Australian fisheries. Performance against this objective is evaluated using three criteria: key economic trends, management arrangements, and performance against the HSP's economic objective.

The economic status of Torres Strait fisheries is also evaluated. However, as 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 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 the most valuable Commonwealth fisheries. For other fisheries, indicators of fishery revenue and costs are analysed to evaluate likely changes in profitability. Although estimates of a fishery's gross value of production are readily available and provide an indicator of revenue, information on costs is more difficult to obtain. Measures of fishing effort and fuel prices are used for some fisheries to provide an indication of total fishery costs. For data-poor fisheries, the level of unused fishing rights ('latency') can provide an indication of NER. High latency suggests that the fishery is operating at or above a point equivalent to its theoretical open-access equilibrium—at this point, average NER are zero, and all potential resource rents from using the resource are likely to be lost.

Changes in a fishery's NER reflect changes in factors that are both external and internal to the control of fishers and fishery managers. External factors include fish prices and fuel prices, while internal factors include catch and fishing effort. The evaluation of a fishery's economic status primarily focuses on factors that are under the control of fishery managers. However, external factors can be highly variable and complicate the determination of economic status. Therefore, a fishery's NER should be interpreted over time (that is, in terms of its NER trend), and use other fishery information and performance indicators. For example, if a fishery generates positive NER, this does not necessarily mean a positive economic status in the context of maximising NER from the resource. Management arrangements may be impeding the generation of additional NER. Similarly, the catches generating these positive NER may be associated with overfishing. In these cases, economic status could be improved by reducing management constraints or rebuilding stock status.

Economic productivity measures support the interpretation of a fishery's trend in NER and its overall economic status. Productivity measures indicate how effectively a fishery's inputs (such as fuel, labour, capital and the fish stock) are converted into output (catch). At given output prices, an improvement in fishery productivity will be associated with an improvement in NER. Productivity growth in a fishery over time will reflect some combination of improved production decisions by fishers and improvements in fishery management.

Management arrangements

Management arrangements can be a key influence on whether a fishery achieves its full economic potential. The assessment of economic status therefore considers whether a fishery's NER could be improved under alternative arrangements. An informed assessment requires an understanding of a fishery's characteristics, which can vary considerably across fisheries. This allows evaluation of the relative advantages and disadvantages of alternative management arrangements for that fishery.

Management arrangements in Commonwealth fisheries can be categorised as either input controls (for example, effort limits) or output controls (for example, catch limits). Input controls restrict a fishery's effort—for example, by restricting gear use, fishing time or fishing areas. If a fishery manager is trying to control a fishery's catch, input controls alone provide no guarantee that a catch target will be met. Over time, such controls can lead to overcapacity and lower economic returns, especially if the controls are not frequently adjusted to counteract an increased efficiency of the limited number of fishing effort units. However, input controls are often associated with lower implementation and monitoring costs than output controls (Rose 2002). They can also have advantages where attempts to control catch are complicated by a stock's high variability and unpredictability.

Output controls restrict a fishery's harvest through the setting of total allowable catches (TACs). Individual transferable quotas (ITQs) are the dominant form of output control used in Commonwealth fisheries—a stock's TAC is allocated to holders of ITQs. Each quota entitles its owner to a share of the TAC in a given season, which can then be sold or leased. An advantage of ITQs is that, once fishers have been allocated a TAC share, the incentive to race to fish against other operators may be diminished and replaced with an incentive to maximise profit for their given catch allocation (Grafton 1996). By directly controlling catch, the need to restrict inputs (and operator efficiency) to indirectly limit catch is reduced, and operators are afforded greater flexibility to choose the most efficient mix of fishing units. However, input controls may still be required to meet other management objectives (for example, controlling bycatch). The transferability of ITQs also means that quota can gravitate to the most efficient fishers, improving overall economic performance of the fishery. However, ITQs can have drawbacks, including high set-up and monitoring costs, and incentives to discard and high-grade catch (Copes 1986; Rose 2002).

Another key management consideration for determining economic status is latency. High levels of latency over a long period indicate low levels of NER and suboptimal fishery economic performance. Latency creates additional issues for fisheries managed with tradeable fishing rights (such as ITQs or effort). These mechanisms can capture efficiency gains through having fishing rights traded towards their most efficient use, but, if TAC or effort levels are maintained above economically viable levels so that latency prevails, the value of fishing rights will be low. This reduces the incentive to trade fishing rights and limits the potential efficiency improvements through the movement of rights to more efficient users (Elliston et al. 2004). Interpretation of latency must consider the characteristics of the fishery. For example, if a fishery targets a highly variable stock, fluctuations in fishing rights latency would be expected.

Management in pursuit of other FM Act objectives relating to sustainability, bycatch and the environment can affect a fishery's profitability. Whether these objectives have been met with the lowest possible cost should also be a key consideration when determining economic status. Costs include not only the management costs incurred in meeting these objectives, but also costs associated with any reduction in NER that results from such management.

Performance against economic objective

The HSP supports the implementation of the economic objective of the FM Act by recommending that harvest strategies are designed to achieve a stock's MEY biomass level (B_{MEY})—the biomass level that is expected to maximise a fishery's 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 an MEY target for that fishery. For some fisheries, target reference points are biomass based (that is, B_{MEY}), and the evaluation will focus on whether the adopted target is consistent with MEY, given the biological and economic characteristics of the stock. For other fisheries, alternative targets are used because biomass targets are considered inappropriate (for example, if the fishery is data poor or targets highly variable stocks). Such alternatives include catch-rate targets, catch triggers and effort triggers. In these cases, the evaluation focuses on how well the economic objective of the HSP is being met by these alternative approaches.

If a fishery's harvest strategy targets are consistent with MEY, performance indicators can be compared with targets to assess whether the fishery is achieving MEY. For multispecies fisheries, performance against harvest strategy targets is evaluated across the predominant and most valuable stocks caught in the fishery. Performance indicators that are close to target for these stocks will indicate that management is meeting the HSP's economic objective for the fishery. If the performance indicators are off target but moving towards target, performance against MEY is improving. If neither is occurring, then management settings have resulted in suboptimal outcomes for the stock, and management adjustments may be required. Such evaluation focuses on recent historical performance over a number of years (rather than just one year), given the variability in factors that influence a fishery's MEY. If harvest strategy targets do not exist for a fishery, the evaluation focuses on how well the intent of the HSP is being met under the current harvest strategy.

30.4 Assessing environmental status

The Australian Government's fisheries management objectives recognise the need to consider the broader impacts of fishing on bycatch species (including species protected under the *Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act]), marine habitats, communities and ecosystems. *Fishery status reports 2017* reports on key bycatch issues in each fishery and information from ecological risk assessments (ERAs) by AFMA.

Bycatch species

A species is considered to be a bycatch species if it is (a) incidentally taken in a fishery and returned to the sea because it has no commercial value or regulations preclude it being retained, or (b) incidentally affected by fishing activity, but not landed or retained (DAFF 2000). The FM Act states that fishery management plans must include measures to reduce bycatch to a minimum. The *Commonwealth policy on fisheries bycatch* (DAFF 2000) recognises that different fisheries will have different ways of addressing bycatch issues. The policy requires fishery-specific bycatch action plans (now referred to as bycatch and discarding workplans) to be developed and implemented. The outcomes of these workplans are considered when the environmental status of fisheries is examined. A review of the *Commonwealth policy on fisheries bycatch* was completed in 2013. Reports and supporting research are available on the website of the Department of Agriculture and Water Resources. A revised policy is currently being developed by the department, in consultation with AFMA, the Department of the Environment and Energy, and other stakeholders.

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, such as target, bycatch and byproduct species; protected species; habitats; and communities. The ERA methodology (Hobday et al. 2007) 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). Low-risk activities and species are screened out at each step in this process. AFMA's responses to the ERA results are detailed in fishery risk management reports, which are linked to the bycatch and discarding workplans for a fishery.

EPBC Act and its interactions with fisheries management

The EPBC Act is the key piece of 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 fishery assessments use *Guidelines for the ecologically sustainable management of fisheries* (DEWR 2007), which outlines specific principles and objectives to ensure strategic and transparent evaluation of the ecological sustainability of fishery management arrangements. These guidelines have two main principles:

- A fishery must be conducted in a manner that does not lead to overfishing. For stocks that are overfished, the fishery must be conducted such that there is a high probability that the stock(s) will recover.
- Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.

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 under species recovery plans, wildlife conservation plans and threat abatement plans 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.

30.5 Presentation of fisheries data

Graphing

Data presented in *Fishery status reports 2017* 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 Commission for the Conservation of Southern Bluefin Tuna database, the Commission for the Conservation of Antarctic Marine Living Resources, and the South Pacific Regional Fisheries Management Organisation database.

Mapping

Relative fishing intensity has been mapped where five or more vessels have fished within a certain area. This fishing intensity is mapped using the kernel density function in ArcGIS and an appropriate radius from each fishing operation point, depending on the extent and spacing of fishing operations. The density function results in a smoothing and spreading of estimated fishing effort, and can result in the total area over which fishing operations take place appearing larger than it is. Where necessary, fishing intensity maps have been truncated to limit fishing to management areas.

Fishing intensity is usually mapped as effort, but, in some fisheries (for example, the Bass Strait Central Zone Scallop Fishery), it is mapped as catch. Three levels of fishing intensity are shown, arbitrarily classified as low, medium and high. As far as possible, the same range classes have been used as in previous years. However, if there has been a major shift in effort or catch, this may not be possible. Fishing operations have been mapped for the 2016 calendar year or the 2015–16 financial year.

The total area fished has been mapped for most fisheries, except for those fisheries with a restricted range, such as the Torres Strait fisheries. For these fisheries, the total area fished is mapped at 111 km^2 (the equivalent of one degree of latitude squared) and does not show catch or fishing effort. This conforms with AFMA's information disclosure policy (AFMA 2010).

Fishery management area boundaries are shown for reference, but area closures are not shown except for certain major closures. The 200 m isobath (bathymetric contour) is shown on all maps, where relevant. This approximates the edge of the continental shelf. Place names, including ports, capes, islands and seas, have been included for reference and orientation.

In most cases, the maps are in the geographic coordinate system (that is, without being projected). All maps of domestic fisheries use the geocentric datum for Australia (GDA94).

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Fishing vessel
Lee Georgeson, ABARES

Appendix A

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	=		↑ Transitional–recovering **a**
Not overfished	+	Subject to overfishing	=		↓ Transitional–depleting
Overfished	+	Subject to overfishing	=		Overfished **b**
Uncertain if overfished	OR	Uncertain if subject to overfishing	=		Undefined

a For a stock to be considered transitional–recovering in the national reports, there must also 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 'overfished' in the national reports rather than 'transitional–recovering'.

Note: *Status of Australian fish stocks reports 2016* includes an additional classification of 'environmentally limited'. This is described as when spawning stock biomass has been reduced to the point where average recruitment levels are significantly reduced, primarily as a result of substantial environmental changes and impacts, or disease outbreaks, and fisheries management has responded appropriately to the environmental change in productivity. There is currently no equivalent classification in the *Fishery status reports*.

Acronyms and units

AAD	Australian Antarctic Division
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ACIAR	Australian Centre for International Agricultural Research
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
ASPIC	A Stock Production Model Incorporating Covariates
BBDM	Bayesian Biomass Dynamic Modelling
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
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
DBSRA	depletion-based stock reduction analysis
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* (Cwlth)
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 2007
IMAS	Institute for Marine and Antarctic Studies
IOTC	Indian Ocean Tuna Commission
ISMP	Integrated Scientific Monitoring Program
ITQ	individual transferable quota
IUU	illegal, unreported and unregulated (fishing)
JAF	joint authority fisheries
MEY	maximum economic yield
MITF	Macquarie Island Toothfish Fishery
MSE	management strategy evaluation
MSY	maximum sustainable yield
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
PNG	Papua New Guinea
PZJA	Torres Strait Protected Zone Joint Authority
QDAFF	Queensland Department of Agriculture, Fisheries and Forestry
QFJA	Queensland Fisheries Joint Authority
RBC	recommended biological catch
RFMO	regional fisheries management organisation
SB	spawning biomass
SBTF	Southern Bluefin Tuna Fishery
ScallopRAG	Bass Strait Central Zone Scallop Fishery Resource Assessment Group
SEMAC	South East Management Advisory Committee
SE	standard error
SESSF	Southern and Eastern Scalefish and Shark Fishery
SESSFRAG	Southern and Eastern Scalefish and Shark Fishery Resource Assessment Group

SETFIA	South East Trawl Fishing Industry Association
SFR	statutory fishing right
SGSHS	Shark Gillnet and Shark Hook sectors (of the SESSF)
SharkRAG	Shark Resource Assessment Group
ShelfRAG	Shelf Resource Assessment Group
SHS	Scalefish Hook Sector (of the SESSF)
SIOFA	Southern Indian Ocean Fisheries Agreement
SlopeRAG	Slope Resource Assessment Group
SPF	Small Pelagic Fishery
SPFRAG	Small Pelagic Fishery Resource Assessment Group
SPR	spawning potential ratio
SPRFMO	South Pacific Regional Fisheries Management Organisation
SS3	Stock Synthesis 3
SSJF	Southern Squid Jig Fishery
SSRU	small-scale research unit
STF	Skipjack Tuna Fishery
STR	South Tasman Rise
STRTF	South Tasman Rise Trawl Fishery
SWPO	south-west Pacific Ocean
TAC	total allowable catch
TACC	total allowable commercial catch
TAE	total allowable effort
TEP	threatened, endangered or protected (species)
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
TSRA	Torres Strait Regional Authority
TSSMF	Torres Strait Spanish Mackerel Fishery
TSTF	Torres Strait Trochus Fishery
TSTRLF	Torres Strait Tropical Rock Lobster Fishery
TTRAG	Tropical Tuna Resource Assessment Group
TVH	Transferable Vessel Holder
UNCLOS	United Nations Convention on the Law of the Sea

UNGA	United Nations General Assembly
USSR	Union of Soviet Socialist Republics
VME	vulnerable marine ecosystem
WANSF	Western Australia Joint Authority Northern Shark Fishery
WASF	Western Australia North Coast Shark Fishery
WCDF	West Coast Demersal Gillnet and Demersal Longline Managed Fishery
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	western and central Pacific Ocean
WDTF	Western Deepwater Trawl Fishery
WG-FSA	CCAMLR Working Group on Fish Stock Assessment
WSTF	Western Skipjack Fishery
WTBF	Western Tuna and Billfish Fishery

Units

'	minutes of latitude or longitude (for example, 34˚20'S)
˚C	degrees Celsius
˚E, ˚N, ˚S, ˚W	degrees east, north, south, west
cm	centimetre
g	gram
kg	kilogram
km	kilometre
km^2	square kilometre
m	metre
mm	millimetre
nm	nautical mile
t	tonne (1,000 kg)

The following conventions have been used to express year ranges:

2013–14	financial year or season
2013 or 2014; 2003 to 2005	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 has a tendency 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 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). The point beyond which the risk to the stock is regarded as unacceptably high.

B_{MEY} (biomass at maximum economic yield). Average biomass corresponding to maximum economic yield.

B_{MSY} (biomass at maximum sustainable yield). Average biomass corresponding to maximum sustainable yield.

B_{TARG} (target biomass). The 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 (a) incidentally taken in a fishery and returned to the sea, or (b) incidentally affected by interacting with fishing equipment in the fishery, but not taken.

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 during fishing for another species. The species is retained for sale because it has some commercial value.

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.

Catchability. The extent to which a stock is susceptible to fishing; quantitatively, the proportion of the stock removed by one 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 seaward from the territorial sea baseline to a distance of 3 nautical miles. 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. The continental shelf has been defined in a number of ways. It can mean 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. Continental shelf is also a defined maritime zone and comprises the continental shelf where it extends beyond the limit of the Exclusive Economic Zone to the limit of the continental margin. This area 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. Agreed responses that management must make under predefined circumstances regarding stock status. Also called 'harvest control rules' or 'decision rules'.

D

Daily egg production method (DEPM). A method of estimating the spawning biomass of a fish population from the abundance and distribution of eggs and/or larvae.

Danish-seining. A trawling method used by relatively small vessels in shallow waters (up to about 200 m). Lengths of weighted ropes of up to 2,800 m are laid out on the sea floor in a diamond pattern, with the vessel at one end of the diamond and the net at the other. As the vessel moves forward, bringing in the net, the diamond becomes elongated, allowing the fish to be herded into the path of the net (c.f. Purse seining).

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. Returning of any part of the catch, whether dead or alive, to the sea.

Domestic fishery. Fishery within the Australian Fishing Zone operated by Australian-flagged vessels.

Driftnet. Gillnet suspended by floats so that it fishes the top few metres of the water column. *See also* Gillnet.

Dropline. Fishing line with one or more hooks, held vertically in the water column with weights.

E

E_{MSY}. The 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 is improved.

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 particular 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).** Australia's national environment law. The legislation focuses on protecting matters of national importance, such as World Heritage sites, national heritage places, wetlands of international importance (Ramsar wetlands), nationally threatened species and ecological communities, migratory species, Commonwealth marine areas and nuclear actions.

Escapement. The number, expressed as a percentage, of fish that survive through a particular event (for example, predation, natural mortality, fishing mortality), often to spawn.

Exclusive Economic Zone (EEZ). The area that extends from the limit of the territorial sea, which is 12 nautical miles offshore from the territorial sea baseline, to a maximum of 200 nautical miles, measured from the territorial sea baseline. The EEZ is less than 200 nautical miles in extent where it coincides with the EEZ of another country. In this case, the boundaries between the two countries are defined by treaty. Within its EEZ, Australia has sovereign rights and responsibilities over the water column and the seabed, including the exploration and exploitation of natural resources.

Exploitation rate. The fraction of total animal deaths caused by fishing, usually expressed as an annual value. Can also be defined as the proportion of a population caught during a year.

F

F (fishing mortality). The instantaneous rate of fish deaths due to fishing a designated component of the fish stock. F reference points may be applied to entire stocks or segments of stocks and should match the scale of management unit. Instantaneous fishing mortality rates of 0.1, 0.2 and 0.5 are equivalent to 10 per cent, 18 per cent and 39 per cent of deaths of a stock due to fishing. *See also* Mortality, M (natural mortality).

$F_{Curr.}$ The current level of fishing mortality.

F_{LIM} (fishing mortality limit reference point). The point above which the removal rate from the stock is too high.

F_{MEY} (fishing mortality at maximum economic yield). The fishing mortality rate that corresponds to maximum economic yield.

F_{MSY} (fishing mortality at maximum sustainable yield). The fishing mortality rate that achieves maximum sustainable yield.

F_{TARG} (fishing mortality target). The target fishing mortality rate.

Farm-gate value. *See* Beach price.

Fecundity. Number of eggs an animal produces each reproductive cycle; the potential reproductive capacity of an organism or population.

***Fisheries Management Act 1991*.** One of two main pieces of legislation (the other is the *Fisheries Administration Act 1991*) that details the responsibilities and powers of the Australian Fisheries Management Authority.

Fishery-independent survey. Systematic survey carried out 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 particular 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, as 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 strategy. Strategy outlining how the catch in a fishery will be adjusted from year to year depending on the size of the stock, the economic or social conditions of the fishery, conditions of other interdependent stocks or species, and uncertainty of biological knowledge. Well-managed fisheries have an unambiguous (explicit and quantitative) harvest strategy that is robust to the unpredictable biological fluctuations to which the stock may be subject.

Headrope (headline). In a trawl, the length of rope or wire to which the top wings and cover netting are attached.

High grading. A type of discarding motivated by an output control system. Depending on the costs of fishing, and price differences between large and small fish of the same species, fishers may have an incentive to discard small, damaged or relatively low-value catch so that it does not count against their quota. They then hope to fill the quota with higher-value fish.

High seas. Waters outside national jurisdictions—that is, outside Exclusive Economic Zones.

Hookah. Underwater breathing apparatus consisting of an onboard air compressor and an air-supply tube attached to a diver's mouthpiece or helmet.

I

Index of abundance. Relative measure of the abundance of a stock (for example, catch per unit of effort).

Individual transferable effort. Shares of a total allowable effort that are allocated to individuals. They can be traded permanently or temporarily. Analogous to individual transferable quotas in a fishery managed with a total unit allowable catch. Usually issued at the start of a fishing season.

Individual transferable quota (ITQ). Management tool by which portions of the total allowable catch quota are allocated to fishers (individuals or companies). The fishers have long-term rights over the quota but can trade quota with others. *See also* Quota.

Input controls. Management measures that place restraints on who fishes (licence limitations), where they fish (closed areas), when they fish (closed seasons) or how they fish (gear restrictions).

Inshore waters. Waters of the shallower part of the continental shelf, usually less than 3 nautical miles from the coast.

Isobath. Contour line linking points of the same depth.

J

Jig. Vertical line with lures, which is moved up and down, or jigged, by hand or machine.

Joint authority. An Offshore Constitutional Settlement arrangement whereby a fishery is managed jointly by the Australian Government and one or more states or territories under a single (Commonwealth, or state or territory) jurisdiction.

Joint venture. Collaborative fishing operation, usually involving two companies from different countries.

K

Key commercial species. A species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.

Key threatening process. The *Environment Protection and Biodiversity Conservation Act 1999* defines a key threatening process as a process that threatens the survival, abundance or evolutionary development of a native species or ecological community, requiring the formal development of a threat abatement plan. A threatening process is eligible to be treated as a key threatening process if (a) it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent, or (b) it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment, or (c) it adversely affects two or more listed threatened species (other than conservation dependent species), or two or more listed threatened ecological communities.

L

Latency. Fishing capacity that is authorised for use but 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).

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 main line at regular intervals. Pelagic longlines are suspended horizontally at a predetermined depth with the help of surface floats. The main lines can be as long as 100 km 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 except fishing. 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). 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 stock assessment of fisheries.

N

Nautical mile (nm). A unit of distance derived from the angular measurement of one minute of arc of latitude, but standardised by international agreement as 1,852 metres.

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 (*see* Opportunity cost). The concept of NER is very closely related to economic efficiency, a necessary condition for NER to be maximised.

Non-detriment finding. Relating to a species listed in an appendix of the Convention on International Trade in Endangered Species (CITES), a conclusion by a scientific authority that the export of specimens of the species will not negatively affect the survival of that species in the wild. A non-detriment finding is required before an export or import permit, or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-I species, and before an export permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-II species.

Non-target species. Species that is unintentionally taken by a fishery or not routinely assessed for fisheries management. *See also* Bycatch, Byproduct.

Not overfished. *See* Overfished.

O

Oceanic. Open-ocean waters beyond the edge of the continental shelf.

Offshore Constitutional Settlement (OCS). The 1982 package of uniform national, state and territory laws that forms the basis for Australian governments at those levels to enter into agreements for specified fisheries to be managed by a particular government or group of governments. A fishery might be managed by the Australian Government, one or more state or territory governments, or any combination of the two acting through a joint authority. Fisheries for which OCS arrangements are not in place may be managed under joint control or continue under current management arrangements.

Open-access fishery. Fishery in which there is no limit on the number of operators or vessels allowed to operate in the fishery (c.f. Limited-entry fishery). Such a fishery is liable to suffer the 'tragedy of the commons', where a 'race to fish' generally leaves a fish stock below its maximum sustainable yield and unable to support an economically sustainable fishery. Under open access, a fishery operates with a harvest and effort that result in total revenue equalling costs, with no economic profits being generated. The fishing effort employed at this point exceeds the level that would achieve maximum economic yield.

Operating model. Simulation of stock dynamics (and the impact of fishing) used in management strategy evaluation.

Opportunity cost. The compensation a resource forgoes by being employed in its present use and not in the next best alternative. For example, the opportunity cost incurred by the skipper of a fishing vessel is the amount they would have received by applying their skill and knowledge in the next best alternative occupation. The opportunity cost of owning a fishing vessel might be the interest that could be earned if the vessel were sold and the capital invested elsewhere. Although these costs are not usually reflected in a firm's financial accounts, they are very important.

Otoliths. Bone-like structures formed in the inner ear of fish. The rings or layers can be counted to determine age.

Otter trawl. Demersal trawl operated by a single vessel in which the net is held open horizontally by angle-towed otter boards (large rectangular 'boards' of timber or steel), and vertically by a combination of floats on the headrope and weights on the ground line. Attached between the head and ground ropes and the towing warps, the otter boards are spread apart by the hydrodynamic forces acting on them when the net is towed.

Output controls. Management measures that place restraints on what is caught, including total allowable catch, quota, size limits and species limits.

Overfished. A fish stock with a biomass below the biomass limit reference point. 'Not overfished' implies that the stock is not below the threshold, and is now used in place of the status classifications of 'fully fished' or 'underfished' that were used in earlier editions of *Fishery status reports*.

Overfishing, subject to. A stock that is experiencing too much fishing, and the removal rate from the stock is unsustainable. Also:

- Fishing mortality (F) exceeds the limit reference point (F_{LIM}). When stock levels are at or above B_{MSY}, F_{MSY} will be the default level for F_{LIM}.
- Fishing mortality in excess of F_{LIM} will not be defined as overfishing if a formal 'fish-down' or similar strategy is in place for a stock and the stock remains above the target level (B_{TARG}).
- When the stock is less than B_{MSY} but greater than B_{LIM}, F_{LIM} will decrease in proportion to the level of biomass relative to B_{MSY}.
- At these stock levels, fishing mortality in excess of the target reference point (F_{TARG}) but less than F_{LIM} may also be defined as overfishing, depending on the harvest strategy in place and/or recent trends in biomass levels.
- Any fishing mortality will be defined as overfishing if the stock level is below B_{LIM}, unless fishing mortality is below the level that will allow the stock to recover within a period of 10 years plus one mean generation time, or three times the mean generation time, whichever is less.

P

Pair trawling. Trawling by two vessels steaming in parallel with the net towed between them. Very large nets can be held open and towed in this way. The net may be hauled aboard the two vessels alternately for processing of the catch.

Parameter. Characteristic feature or measure of some aspect of a stock, usually expressed as a numerical value (for example, see M [natural mortality]).

Parental biomass. Weight of the adult (reproductively mature) population of a species. *See also* SB (spawning biomass).

Pelagic. Inhabiting surface waters rather than the sea floor. Usually applied to free-swimming species such as tunas and sharks (c.f. Demersal).

Pole-and-line fishing (poling). Fishing method in which fishers attract schools of fish to the vessel with live or dead bait, get them into a feeding frenzy with more bait and water sprayed onto the sea surface to simulate the behaviour of small baitfish, and then use poles with short, fixed lines and lures to 'pole' the fish aboard. Also called 'pole-and-live-bait fishing'.

Population structure. Composition of a population in terms of size, stock (genetic or regional), age class, sex and so on.

Precautionary approach. Approach to resource management in which, where there are threats of serious irreversible environmental damage, a lack of full scientific certainty is not used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary approach, uncertainties should be evaluated and taken into account in a risk assessment, and decisions should be designed to minimise the risk of serious or irreversible damage to the environment.

Productivity (biological). An indication of the birth, growth and death rates of a stock. A highly productive stock is characterised by high birth, growth and mortality rates, and can sustain high harvesting rates.

Productivity (economic). The ability of firms or an industry to convert inputs (for example, labour, capital, fuel) into output. Economic productivity is often measured using productivity indices, which show whether more or less output is being produced over time with a unit of input. The index is calculated by comparing changes in total output (fish) with changes in total inputs such as fuel, labour and capital.

Profit, economic. The difference between total revenue and explicit costs and opportunity costs (*see* Opportunity cost). Explicit costs include wages, fuel, repairs, maintenance and depreciation of physical capital (for example, vessels). Economic profit differs from accounting profit in that it includes opportunity cost.

Protected species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Purse seining. Harvesting of surface-schooling pelagic fish by surrounding the school with a net. A line that passes through rings on the bottom of the net can be tightened to close the net so that the fish cannot escape (c.f. Danish-seining).

Q

Quad gear. Four fishing nets towed simultaneously by a vessel, with the opening of each net being controlled by otter boards.

Quota. Amount of catch allocated to a fishery as a whole (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 plan. Management plan 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 plans 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 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. Indicator of the level of fishing (or stock size); used as a benchmark for assessment.

Ricker curve/function. Mathematical function that describes the relationship between stock size and recruitment.

S

SB (spawning biomass). The 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 a particular 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 at maturity. Length or weight of fish when they reach reproductive maturity.

Size frequency. *See* Length-frequency distribution.

Slope (mid-slope; upper slope). 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 particular 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 per cent 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 spend part of their life cycles in two or more jurisdictions, especially those that migrate 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 species. *See* Key commercial species.

Taxonomic group. An organism's location in the biological classification system; used to identify and group those with similar physical, chemical and/or structural composition.

Territorial sea baseline. The baseline from which all the zones (for example, Exclusive Economic Zone) of Australia's maritime jurisdiction are measured. The baseline is defined as the level of lowest astronomical tide along the coast. Straight baselines may be drawn along deeply indented coastlines or to encompass islands fringing the coast. The baseline may also be drawn straight across the entrances to bays and estuaries, rather than following the coast inshore.

Threat abatement plan. Plan formalised under endangered species legislation to counter the effects of a listed key threatening process.

Threatened species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Tori line. Line with streamers, towed as a scaring device over the area behind a vessel where sinking, baited hooks are within range of diving seabirds; attached to a tori pole (boom) at the vessel's stern.

Total allowable catch (TAC). For a fishery, a catch limit set as an output control on fishing (*see also* Output controls). Where resource-sharing arrangements are in place between commercial and recreational fishers, the term total allowable commercial catch (TACC) will apply. The term 'global' is applied to TACs that cover fishing mortality from all fleets, including Commonwealth, state and territory fleets.

Total allowable catch (TAC), actual. The agreed TAC for a species with amendments applied, such as carryover or debits from the previous year.

Total allowable catch (TAC), agreed. The TAC for individual quota species as determined by the Australian Fisheries Management Authority Commission.

Total allowable commercial catch (TACC). *See* Total allowable catch (TAC).

Total allowable effort. An upper limit on the amount of effort that can be applied in a fishery.

Total length. The length of a fish from the tip of the snout to the tip of the longer lobe of the caudal fin, usually measured with the lobes compressed along the midline. It is a straight-line measure, not measured over the curve of the body.

Trap fishing. Fishing by means of traps, often designed to catch a particular species (for example, rock lobster pots).

Trawl fishing. Fishing method in which a large, bag-like net is drawn along behind a vessel to target either demersal or pelagic fish species. There are many variations.

Trigger catch limit. When catches reach this limit, management actions are triggered.

Trigger points. Pre-specified quantities (for example, total catch, spawning biomass) that indicate the need for a management response.

Trolling. Fishing method in which lines with baits or lures are dragged by a vessel at 2–10 knots. Used widely to catch fish such as Spanish mackerel, yellowtail kingfish and several tuna species.

Trotline. A dropline of hooks suspended from a mainline.

Turtle excluder device. A device fitted to a net or a modification made to a net that allows turtles to escape immediately after being captured in the net.

U

Uncertain. Status of a fish stock for which there is inadequate or inappropriate information to make a reliable assessment of whether the stock is overfished or not overfished, or subject to overfishing or not subject to overfishing.

V

Vessel-level efficiency. Vessel-level efficiency requires that revenues be maximised and catching costs be minimised for a given quantity of catch. The choice of management regime will have a substantial bearing on whether vessel-level efficiency is achieved, because it largely defines the incentive structure within which fishers operate.

Vessel monitoring system. Electronic device that transmits the identity and location of a vessel.

Virgin biomass. Biomass of a stock that has not been fished (also called the 'unfished' or 'unexploited' biomass).

Vulnerable species. Species that will become endangered within 25 years unless mitigating action is taken. *See also* Endangered species. 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.

The ‘Biosphere’ Graphic Element

The biosphere is a key part of the department’s visual identity. Individual biospheres are used to visually describe the diverse nature of the work we do as a department, in Australia and internationally.

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